Moisture Risk Management Strategies for Mass Timber Buildings

A guide for designers, construction professionals, and building developers

RDH BUILDING SCIENCE

V3.0

Moisture Risk Management Strategies for Mass Timber Buildings

A guide for designers, construction professionals, and building developers

Training & Publications

2101 N 34th St., Ste 150
Seattle, WA 98103
www.rdh.com

March 2025 | Version 3.0

About This Guide

Moisture management is an essential component of a successful mass timber building project. RDH Building Science (RDH) created this guide to educate designers, construction professionals, and building developers on best practice design and construction strategies for the moisture management of mass timber buildings. The guide outlines a three-step process that project teams can use to assess the moisture risks of a mass timber building project and create a building-specific moisture management plan that will be executed during the construction phase. RDH recommends that readers become familiar with all of the moisture management steps prior to beginning the process on a mass timber project. The content in this guide was informed by RDH's experience providing mass timber enclosure design and moisture management services to projects throughout North America and beyond. It also incorporates information from publicly available resources that RDH authored or contributed to.

What's New in Version 3?

This updated Version 3 of the guide describes best practices learned from recent boots-on-the-ground mass timber project experiences. Mass timber projects require a tailored plan rather than a one-size-fits-all approach to managing moisture. This update has been greatly expanded with guidance on balancing active and passive moisture protection strategies and adapting the recommended tools to develop a project-specific moisture management plan.

The guide describes strategies that the design and construction team may take for each step in the process to mitigate moisture exposure risks during construction and occupancy. These mitigation efforts apply to the mass timber enclosure and other elements, including roofs, floors, and walls. Step 3 – Execute the Design and Moisture Management Plan has been greatly expanded with information on best practices for moisture measurement and adapting the plan to shifting project timelines and conditions. It also provides considerations for drying and cleaning mass timber elements that have been exposed to moisture.

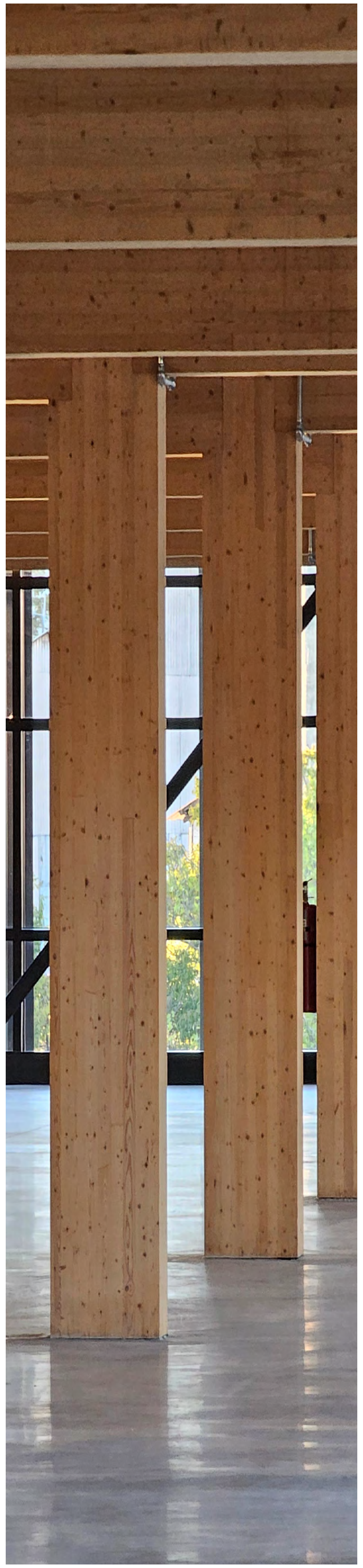
Case studies have been added to illustrate how RDH and other professionals have applied the recommended steps and guidance to real mass timber projects.

Where Can I Find More Information?

This guide is a companion to *Mass Timber Building Enclosure Best Practice Design Guide*, also published by RDH Building Science. The best practice design guide provides foundational knowledge and serves as a resource for common topics covered in this companion moisture management guide.

The design guide as well as many of the resources used to inform this document are included in the Resources section at the end of this guide. To find these resources, scan the QR code to access RDH's Technical Library.

RDH Technical Library



Acknowledgments

This guide is a result of RDH's dedication to sharing our collective knowledge and experience with the industry. We extend our gratitude to all the professionals who contributed to the current and previous versions, including the following primary contributors:

Graham Finch
Savannah Gillette
Bailey Brown
James Higgins
Colin Shane
Margaret Thayer
Kara Greenetz

Contents

Foreword

Welcome to Version 3 of RDH's *Moisture Risk Management Strategies for Mass Timber Buildings* guide. We are proud of this latest update and to be able to share the latest industry knowledge with you.

The mass timber industry in North America is rapidly evolving along with a greater appreciation for construction moisture management and protecting the beauty of the wood we are building with. We created the first version of this guide in 2019 in response to a need we saw in the mass timber industry and to help designers, contractors, and owners be more proactive with practical and effective construction moisture management. We also wanted to share our latest research and testing work with respect to moisture protection solutions to inform the industry about what works or doesn't and why. Being experienced with several mass timber projects, we were consistently seeing similar moisture challenges on construction sites and getting inquiries from others across the world with similar challenges and questions. This work has also included research and monitoring of various drying out methods on mass timber buildings where moisture protection was unfortunately not well managed, though these projects provided good lessons for the industry to learn from.

Regular updates to the guide, including this Version 3, bring together the latest practical solutions for effective management of moisture during construction of mass timber projects. Experience has shown that there is no "one size fits all" or perfect protection strategy, so we have developed a risk-managed approach to help create unique moisture management plans for every mass timber building project, schedule, and climate in which a mass timber building is being built. At this point in 2025, we understand that many insurers now see moisture as a larger risk than fire in the mass timber sector. Many insurers are now requiring project-specific moisture management plans for underwritten mass timber projects.

Hopefully the content of this guide will help you understand that moisture risk can be safely managed during construction in various ways, and this knowledge will help insurers to provide fair policies that match the actual risk profile of these projects. Numerous successfully built mass timber projects demonstrate how teams have utilized the knowledge and process within this guide to develop effective moisture management plans. We hope that you find this guide useful, and as the industry is still learning best practices and new solutions are being developed, stay tuned for future updates.

Graham Finch, Dipl.T, MASc, P. Eng

RDH Principal and Senior Building Science Specialist

March 2025

A cross-laminated timber (CLT) floor with post and beam structure. Successful moisture management during construction of this project preserved the finish aesthetic of the mass timber elements exposed to the interior. Wood Innovation Design Centre (Michael Green Architecture). Photo credit: Ema Peter

Mass Timber & Moisture

The moisture management best practices for a mass timber building keep the mass timber elements dry throughout the building's construction and occupancy. Mass timber elements are kept dry by using the key strategies before and during construction identified below.

Before construction:

- Design the building enclosure with the necessary layers to control the liquid water and water vapor loads acting on the enclosure in-service.
- Design the mass timber assemblies with protection from unplanned in-service water exposure, such as during a plumbing leak, or design the assemblies to allow them an opportunity for drying.

During construction:

- Effectively manage the moisture exposure of the mass timber elements.
- Avoid trapping moisture under vapor-impermeable materials such as roof membranes or concrete toppings.

An adequately designed mass timber building controls many loads on the enclosure, including water, air, thermal, and water vapor loads. The long-term durability of a mass timber building is best when the interior relative humidity (RH) values are maintained between 30% and 50% RH. Values between 20% and 60% RH are considered acceptable. Important elements for regulating the indoor environment within mass timber buildings include HVAC and humidity control systems.

To learn more about best practice design principles for the control layers in mass timber building enclosures and the impacts of in-service ambient relative humidity conditions, see RDH's companion document, *Mass Timber Building Enclosure Best Practice Design Guide*.

The remainder of this guide discusses moisture management during all phases of a mass timber building's life with an emphasis on the construction phase. In this guide, moisture refers to liquid water (such as rain or snowmelt), moisture contained within materials (built-in moisture), and water vapor. The guide discusses moisture management strategies for various types of mass timber, including glue-laminated timber (glulam), cross-laminated timber (CLT), nail-laminated timber (NLT), dowel-laminated timber (DLT), and mass plywood panels (MPPs).

Appropriate moisture management for mass timber buildings begins in the design phase with building-specific risk assessments. It continues into the construction and occupancy phases with the execution of a moisture management plan.

To successfully execute a moisture management plan for mass timber buildings, the entire project team—including the design team, construction team, and building ownership—must be aware of the building's unique moisture management needs. With this awareness, the project team can design strategies to manage these risks.

Understanding Moisture Risks

Mass timber can safely absorb and dry some amount of moisture; however, moisture risks occur when the mass timber elements cannot readily dry or if the elements go through repeated wetting and drying cycles (wet-dry cycles). In this guide, an occurrence when mass timber is exposed to liquid water leading to absorption is referred to as "wetting" or a "wetting event." The combination of factors that contribute to the likelihood of a wetting event is referred to as the "moisture exposure level." Long-term or persistent exposure to moisture is likely to have a greater impact on mass timber elements than the overall quantity of water. [1]

When mass timber assemblies experience long-term exposure or standing water, moisture can penetrate deep into the mass timber. This moisture becomes trapped within the pore structure of the wood, within the adhesives, at gaps between the wood elements, and at other locations. Some of the locations susceptible to deep absorption and trapped moisture include prefabricated panel interfaces, lamination interfaces, splices, exposed end grain, and between laminations and sheathing layers (see **Figure 1**). The end grain of mass timber absorbs water more quickly than its surface; therefore, the panel edges and penetrations are more susceptible to moisture-related risks.

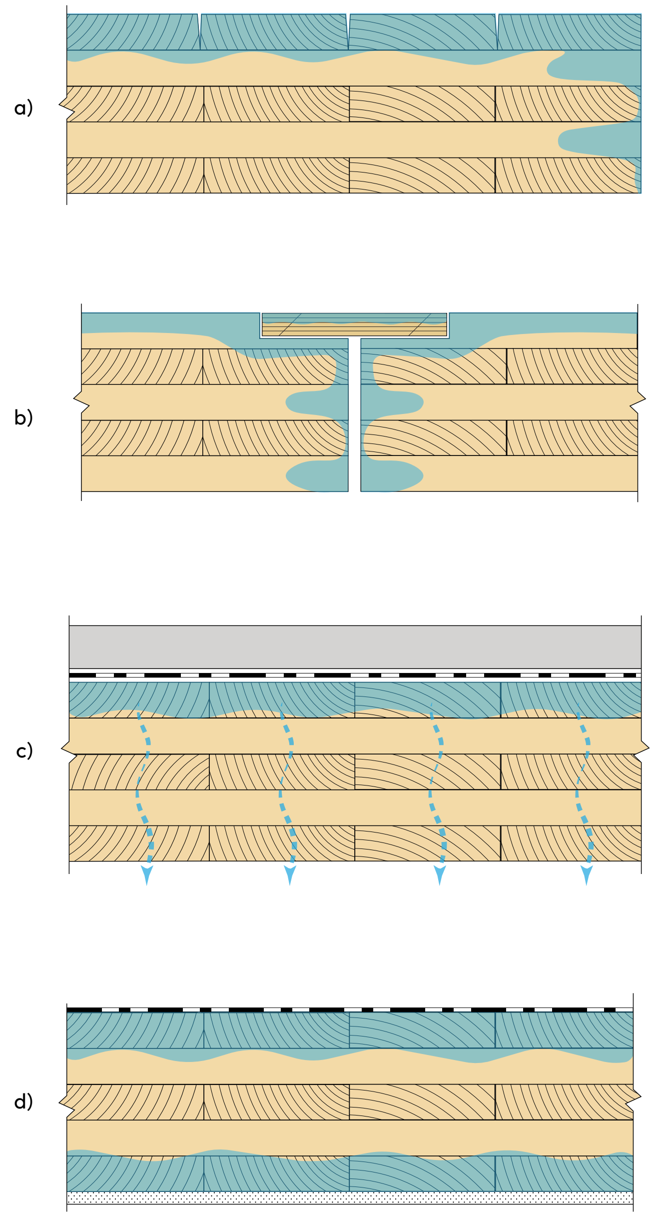


Figure 1 Moisture can penetrate deep into mass timber elements and become trapped a) between laminations and at end grains, b) at splice connections, c) at covered assemblies, and d) at encapsulated assemblies.

Wood naturally loses and gains moisture to reach an equilibrium with the moisture of its environment. The measure of how much moisture is in wood is known as the moisture content, which is the percent of the material's mass that is water. The equilibrium moisture content of mass timber will vary with exterior climates and weather but is typically below 16% in North America. [2, 3] Therefore, it has become standard practice to target keeping mass timber below 16% moisture content throughout the duration of construction.

Figure 2 shows the five primary risks associated with exposing mass timber to moisture. Each project will typically have some level of tolerance for the first two risks (moisture-related schedule delays and visible defects). However, the remaining three risks pose safety-related concerns for occupants, including potential health and structural implications and therefore are intolerable on projects. Extensive movement, microbial growth, and decay will also affect the project budget and schedule due to the cost of time, materials, and labor to remediate the issue.

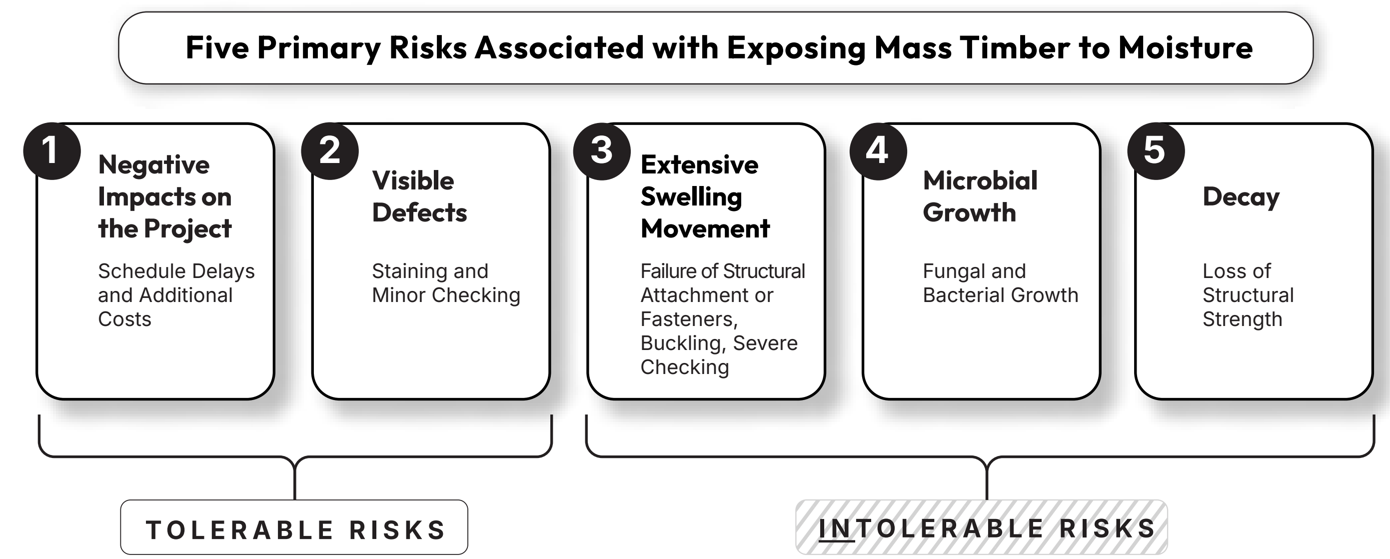


Figure 2 The five primary risks associated with exposing mass timber to moisture.

Figure 3 shows several examples of these risks occurring due to inadequate moisture management.

Schedule delays and added costs typically occur when mass timber needs to be dried (see **Figure 3a**), when wet material such as encapsulation material must be replaced (see **Figure 3b**), or when remediation of risks 2 through 5 is necessary.

Staining occurs when moisture through the wood causes tannins in the wood to migrate (see **Figure 3c**) or moisture causes a chemical reaction to occur between structural attachments and the wood (see **Figure 3d**). Wood swells as its moisture content increases and shrinks when its moisture content decreases. Repeated wet-dry cycles that produce repeated swelling and shrinking cause visible cracks in the mass timber, known as checking (see **Figure 3e**). Checking is typically a superficial defect that affects only the appearance of the wood.

Extensive swelling movement occurs when the mass timber is wet for a long duration (see **Figure 3f**). Severe checking can degrade the wood and glue of the mass timber elements. Additionally, the swelling of wet wood can place increased stress on structural attachments and fasteners; in some scenarios, this stress results in fastener failure (see **Figure 3g**).

Microbial growth may occur when the wood experiences an elevated moisture content (see **Figure 3h**). Research has determined that microbial growth on wood products can begin when the moisture content is above 19%; [4] therefore, drying of the wood is necessary.

Decay occurs when moisture is trapped within the wood and is not able to dry. When decay occurs, it is typically found under roofing membranes and concrete toppings (see **Figure 3i**). To avoid trapping moisture during mass timber construction, it has become a standard requirement to keep the moisture content below 16% prior to covering, encapsulating, or installing a concrete topping.

a) Moisture ponding on and absorbing into a timber-concrete composite (TCC) floor panel before the concrete is scheduled.

b) Moisture accumulation within a mass timber ceiling cavity due to the installation of interior gypsum board before the installation of adequate moisture protection on the floor panel above.

c) Staining on a CLT wall and intermediate floor panels due to ponding water on the floor panels above.

Figure 3 The results of inadequate moisture management during the construction phase.

d) Visible staining on the underside of a CLT floor panel due to the damp wood being in direct contact with unfinished steel, resulting in a chemical reaction between the wood tannins and metal.

e) Checking of CLT due to repeated wet-dry cycles.

f) Built-up timber panel damage and distortion resulting from moisture-related panel expansion.

g) Failure of structural fasteners caused by swelling of the wood and corrosion on fasteners.

h) Microbial growth and deterioration of an unprotected CLT roof panel.

i) Severe deterioration of a CLT floor/soffit condition due to water intrusion from the wall above and the use of low-permeance membranes on both the top and bottom of the floor panel.

Figure 3 (continued) The results of inadequate moisture management during the construction phase.

Moisture Management Process

Successful moisture risk mitigation of a mass timber building begins early in the design phase and continues throughout a project's construction phase. To help project teams mitigate the moisture risks in a mass timber building, this guide outlines the following three-step moisture management process:

- **Step 1:** Complete a Moisture Risk Assessment for Mass Timber Assemblies
- **Step 2:** Develop a Construction Phase Moisture Management Plan
- **Step 3:** Execute the Design and Moisture Management Plan

This three-step process leads to the development of a moisture management plan that can be executed during the construction phase of the project. A moisture management plan anticipates the sources of moisture the building might experience and identifies design and construction strategies to reduce the risks associated with moisture exposure. The plan also outlines ways to respond to moisture exposure when it occurs during construction.

The planning process outlined in this guide is intended to be collaborative among the design, construction, and ownership teams. This collaboration allows each team's specific needs to be considered, and their unique foresight to be leveraged, when anticipating challenges and making design and planning decisions.

Protecting mass timber during construction requires time, effort, and cost. Project teams that understand and commit to the design and construction teams' roles and responsibilities related to moisture management early in the process will support the successful execution of the moisture management plan. Therefore, it is best practice to identify and document moisture management requirements as early as the contract bidding stage. See the sidebar "Documenting Moisture Management Project Requirements" for examples of relevant documents.

Each step in the moisture management process is summarized in the following section and described in more detail on the following pages. **Figure 4** illustrates the three-step process relative to the project phase during which each step occurs.

Documenting Moisture Management Project Requirements

A best practice is to document the mass timber moisture management requirements and team member responsibilities in the project construction drawings and specifications. Moisture-related items to incorporate in project documents that are of particular interest for mass timber buildings include the following:

- Submittal requirements for the general contractor and/or mass timber subcontractor to submit and follow a written moisture management plan. This plan will contain clear depictions of moisture protection methods on drawings, including at common building interfaces.
- Requirements for pre-construction meeting(s) with the general contractor, architect, third-party reviews, and other relevant subcontractors.
- Mass timber assembly mock-up requirements, including the required moisture protection methods (protection type, joint treatment, and common building interfaces).
- Allowable limits for wetting of the mass timber during construction prior to covering or encapsulating.
- Third-party quality assurance review requirements.
- On-site moisture content monitoring, quality control, and reporting requirements.

See also **Appendix A** for a moisture management plan example specification.

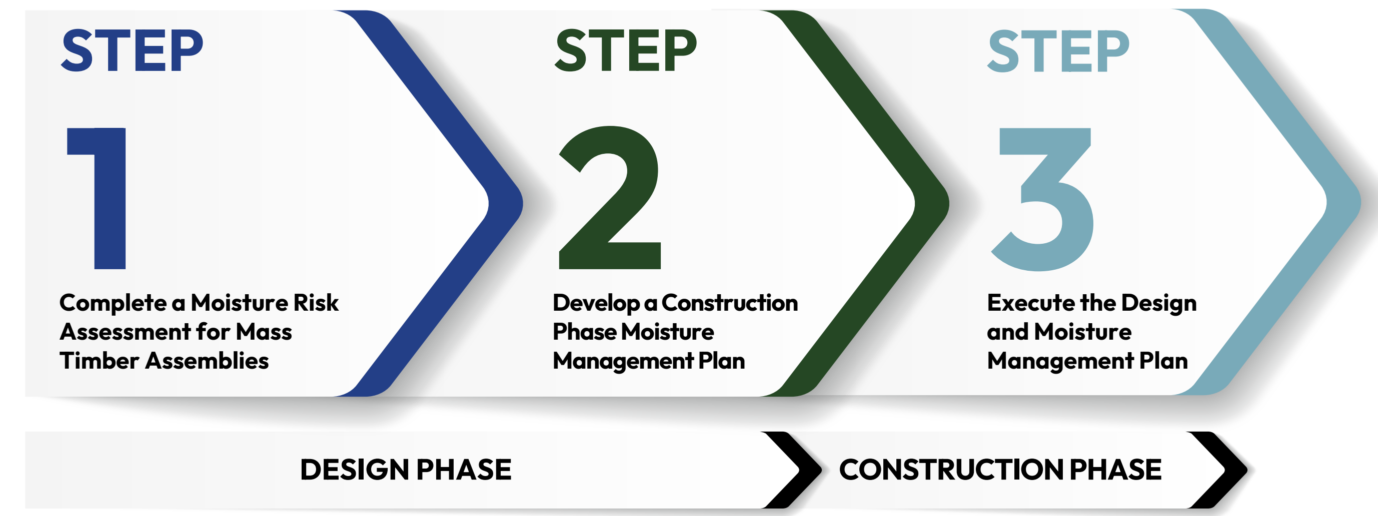


Figure 4 The three-step moisture management process relative to the project phase.

Summary of the Three-Step Moisture Management Process

Step 1: Complete a Moisture Risk Assessment for Mass Timber Assemblies

The first step of the moisture management process is to perform a moisture risk assessment for each mass timber assembly. This step guides the project team through an assembly-specific risk assessment that considers the assembly design. It also informs design revisions (if needed) and construction planning. The risk assessment acknowledges all factors that may contribute to an assembly's moisture exposure during the construction and occupancy of the building. These factors typically include climate, rainfall, construction schedule, length of exposure to moisture, and type of mass timber element. The assessment also accounts for the project's ability to tolerate moisture-related risks, such as schedule delays and visible defects.

Through this assessment process, the project team will identify solutions for factory- or site-installed moisture protection membranes and additional assembly design features and detailing needs. Depending on the flexibility of the design and construction schedule, this assessment can be an iterative process to reduce the anticipated moisture exposure level, and therefore risks, when possible.

By the end of Step 1, the project team will have identified the moisture risks for every mass timber element on the project and selected passive moisture management strategies (protection types) appropriate for the moisture exposure.

Step 2: Develop a Construction Phase Moisture Management Plan

The second step is to create an on-site construction phase moisture management plan during the project's design phase. This plan is informed by the decisions made in Step 1, such as the selection of factory-applied protection of exposed mass timber surfaces. These decisions determine the methods and actions required of the construction team to appropriately manage and respond to both anticipated and unexpected moisture exposure events on-site. On-site moisture management efforts combine passive protection strategies (membranes, tarping, tenting, and protection details) and active removal strategies (water removal with squeegees and blowers).

The moisture management plan defines all activities of the construction team to reduce moisture-related risks. It also defines roles and responsibilities for active on-site water management personnel and a mechanical drying contingency.

Developing this plan during the project's design phase allows anticipated construction phase actions to be reasonably incorporated into the project's overall construction schedule and budget.

By the end of Step 2, the contractor will have a clear understanding of protection and active management requirements and will be able to coordinate equipment, material, and labor accordingly. The contractor will also have created a written plan that documents their moisture management responsibilities during construction. The team can anticipate that the plan will require updating throughout the design and construction phase as factors affecting the moisture-related risks change.

Step 3: Execute the Design and Moisture Management Plan

The third step is to execute the design and moisture management plan during construction. This step puts into play the early planning work performed by the design, construction, and ownership teams during Step 1 and Step 2.

During the execution of this plan, protective membranes are installed and maintained, and bulk water is actively drained and removed. The mass timber elements of the building are also monitored and evaluated to assess the plan's effectiveness at protecting the mass timber.

If the moisture management plan is followed, the project will be protected in alignment with the design, construction, and ownership teams' expectations. The entire project team will also be well prepared to respond to unexpected moisture exposure events. During unexpected moisture exposure plans, the on-site team will implement drying and dehumidification procedures as outlined in the written plan. Additional contingency efforts such as cleaning, sanding, and refinishing of the mass timber may also be required in this step.

Moisture management efforts have added benefits during project commissioning and during occupancy. Keeping the mass timber dry and closer to the anticipated in-service moisture content during construction reduces post-construction drying, dehumidification, and commission efforts.

Navigating This Guide

Starting on the next page, use the step number icon in the upper right corner of the page to follow along with this three-step process.

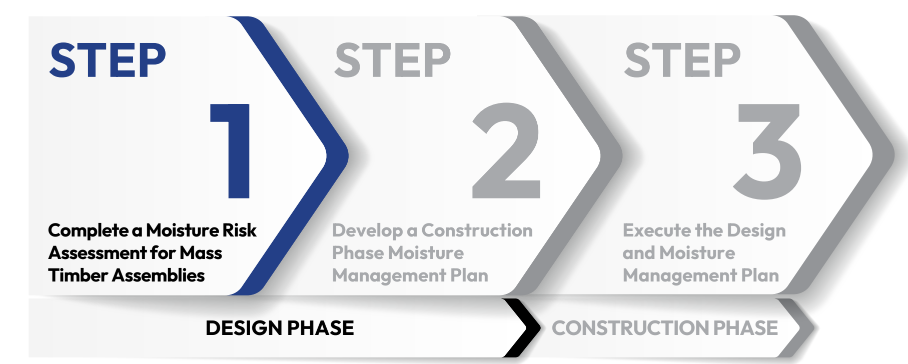
The remainder of this guide offers tools and resources to plan for and manage moisture risks associated with mass timber building elements, specifically floor, roof, and wall assemblies. RDH recommends that readers become familiar with all three of the moisture management steps prior to applying the process on a mass timber project. To see how the moisture management planning steps have been applied to real-world mass timber projects, review the case studies within each step of this guide.

The appendixes in this guide contain numerous tools intended to help project teams carry out the moisture management process for a mass timber building. Refer to **Appendix A** for an example specification for a moisture management plan. Consult the risk assessment tools in **Appendix B** to assess moisture risks and select appropriate materials and products. To learn how all three steps and the tools provided in this guide come together in a mass timber project, review the Applied Example in **Appendix C**.

Select bolded text to jump to the locations of figures, headings, and appendixes.

Mid-construction of a mass timber building with CLT floor panels, and glulam beams and columns, with staining visible on the mass timber elements at the perimeter of the building.

Step 1 | Complete a Moisture Risk Assessment for Mass Timber Assemblies



Step 1 Methodology

During Step 1, the project team will use the risk assessment tools and other considerations presented in this section to select moisture protection strategies. These strategies are intended to reduce the moisture risks to a level that is tolerable to the project. If a misalignment exists between project risks and tolerance levels, the project team will reevaluate and adjust their design or moisture management strategies accordingly.

To begin this step, the project team will complete a risk assessment and select appropriate moisture protection strategies for their project using the following methodology:

1. The assembly-specific moisture considerations and risks described in the section **Assembly Considerations** are identified.
2. The sources of moisture are identified, and the factors described in the section **Moisture Exposure** that contribute to the moisture exposure level during the construction phase are evaluated.
3. The protection strategies discussed in the section **Moisture Protection Strategies** are narrowed down to a final selection for the project. The risk assessment tools described in the following sections are used to support the selection of moisture management strategies based on the assembly considerations, moisture exposure level, protection robustness, and other project-specific considerations.

While reading through Step 1 in this guide, follow along with the risk assessment tools provided in **Appendix B**. The tools follow the same methodology described above.

Risk Assessment Matrix

Not all assemblies or climates and seasons require the same level of moisture protection during construction. If the project team carefully assesses the strategies needed for each assembly application, they may avoid unnecessary construction costs.

The Risk Assessment Matrix in **Figure 5** shows the correlation between the mass timber's exposure to moisture and applicable protection strategies. The moisture exposure level is the combination of factors that contribute to the likelihood of a wetting event. The protection robustness level indicates the ability of a membrane or coating to resist wetting.

Typically, it is recommended that low, moderate, and high moisture exposures be managed with protection types having low, moderate, and high protection robustness, respectively. The upcoming Step 1 sections **Protection Robustness Level** and **Moisture Exposure** define and describe factors that impact the high, moderate, and low categorization for each level.

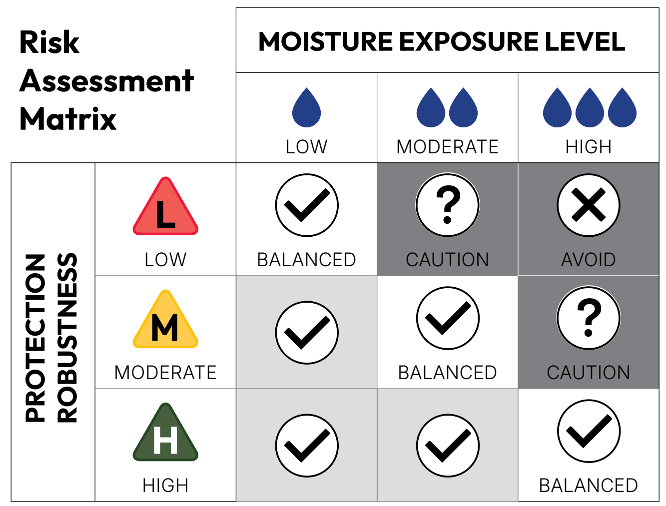


Figure 5 Risk Assessment Matrix.

The Risk Assessment Matrix recognizes that it is impossible to eliminate risk in a mass timber project. As used in the matrix, the term "balanced" means the following:

- It is the point of diminishing returns. The cost of protection is balanced with the risk reduction of that protection. Thus, if increasing the membrane robustness past the "balanced" level would still reduce risk, it is a smaller reduction of risk than if robustness was increased from "caution" to "balanced."
- It is the best practice for protection selection. The protection costs and efforts are balanced with active water management efforts on-site. Reducing the robustness to the "caution" level would result in increased moisture-related risks and requirements for active management on-site. Increasing active management is a feasible management approach, but the increased labor needed to manage water can be more costly and timely than passive protection.

Risk Assessment Tools

Appendix B provides risk assessment tools to assist the project team with decision-making during Step 1 of the moisture management process. These tools include:

- **Mass Timber Moisture Protection Product Types, Uses, and Properties**
- **Moisture Management Design Tool: CLT (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: NLT & DLT (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: MPP (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: Timber-Concrete Composite (TCC) Roof and Floor Assemblies**

The table of moisture protection types includes a list of available product types on the market that may be considered for mass timber moisture protection. For each product type, the table describes when and where the product is intended to be used, how it is applied (such as loose-laid, self-adhered, etc.), product properties, key considerations, and the assigned protection robustness level.

The assembly moisture management design tools are flow charts. When used in combination with the Risk Assessment Matrix, these tools will guide the project team through a series of assessment queries. The order of queries follows the same methodology as Step 1 by starting with the assembly type, then moving to the moisture exposure level. The answers to these queries will lead to the selection of various factory- or site-installed protection methods suitable for a project-specific anticipated moisture exposure level to achieve a balanced risk level.

As previously discussed in the section **Understanding Moisture Risks**, the tolerance to moisture-related risks such as schedule delays, cost additions, and visible defects can differ by project. For example, if a school has a strict construction timeline to ensure the building will open in the fall, that project would have a lower tolerance to schedule delays than an apartment building with a more flexible completion date; and a project with a lot of visible mass timber elements wold have lower tolerance to visible defects than a project with drywall interior finishes. The level of risk tolerance will influence early decisions such as the assembly design and protection budget.

The tolerable risk level is at the discretion of the project team; therefore, the combination of moisture exposure level and protection robustness may differ from what is presented in the tools.

Assembly Considerations

Each assembly type has unique considerations that influence the potential severity of moisture risks and protection selection. Likewise, different mass timber materials such as CLT, NLT, DLT, MPP, and glulam are affected differently by moisture. This section identifies limitations in the ability of different assemblies to manage moisture and other factors to consider when selecting moisture management strategies during the risk assessment process. Some of these considerations include encapsulation and concrete toppings. This section also identifies ways to alter the assembly design to reduce the anticipated moisture exposure and associated risks.

Protection selection strategies will be discussed for the following assembly types:

- Floor assemblies
- Roof assemblies
- Timber-concrete composite (TCC) floor and roof assemblies
- Wall assemblies
- Beams and columns

Mass Timber Panel Types

The type of mass timber panel can affect its response to moisture. **Table 1** summarizes how moisture sensitivity can differ by panel type.

As noted previously, wood swells when its moisture content increases. However, the degree of dimensional changes from swelling depends on the direction of the wood grain. This can cause variable responses to moisture depending on the type of mass timber panel.

Table 1 Mass Timber Panel Moisture Considerations.

Mass Timber Type	Description	Moisture Sensitivity Considerations
 **CLT** Cross-Laminated Timber	A solid wood structural element made of several layers of lumber boards (typically 3 to 7 or more) glued together in alternating directions. Typically, boards are glued on their wide face but may also be glued on their edge. [6]	→ Dimensionally stable when wetting occurs. → The end grain is exposed on all perimeters. → End-grain water absorption is the primary concern because the panel surfaces and glued laminations limit deep water absorption through the tops of panels.
 **NLT OR DLT** Nail-Laminated Timber Dowel-Laminated Timber	A solid wood structural element made of 2x dimension lumber stacked on edge and fastened together with nails (NLT) or dowels (DLT). Plywood or OSB sheathing may be added to one face for increased shear strength. [5]	→ Dimensional changes across the face of the lumber (tangential and radial to the wood grain) are greater than through the length of the lumber, making it more susceptible to buckling. → Increased risk of trapping moisture under plywood or OSB. → Plywood and OSB are prone to warping when wet. → Water can travel between laminations and absorb deeper into the panel than other panel types. → More susceptible to staining on the underside caused by water traveling though laminations.
 **MPP** Mass Plywood Panel	A wood element made of wood veneer sheets adhered together and with wood fibers primarily oriented with the long axis of the member, though engineered with cross orientation to improve dimensional stability over parallel laminated veneer timber.	→ Edge grain water absorption is the primary concern because the panel surfaces and glued laminations limit deep water absorption through the tops of panels. → When wetted, dimension changes due to wetting are consistent in all directions but have more significant thickness swelling than CLT/NLT/DLT.

Encapsulated Assemblies

Encapsulating mass timber mid-construction is sometimes required for either fire protection or construction scheduling reasons. Encapsulating mass timber in non-combustible material such as gypsum or other moisture-sensitive materials (see **Figure 6**) greatly enhances the need for water protection at the levels above these elements. In locations where moisture-sensitive materials must be installed prior to enclosure of the roof and walls, the floors or roof above need to be made watertight quickly. For this reason, a low risk tolerance for schedule delays and material replacement cost may serve as a reason for enhanced moisture protection, such as using a waterproof membrane to create a waterproof floor.

Figure 6 Fire-rated gypsum installed on the underside of the CLT floor mid-construction.

Concrete Topping

The concrete toppings that are sometimes part of mass timber assemblies have a high level of moisture-related risks, even in moderate moisture exposure conditions. Therefore, assemblies with these toppings need more protection efforts than assemblies without them.

A concrete topping installed over mass timber enhances the acoustic, fire resistance, and structural performance of the mass timber; however, the concrete topping also increases the likeliness of moisture-related risks occurring. The concrete topping introduces additional moisture to the mass timber during the pour, prevents drying of the timber once placed, and can trap water under the topping.

Trapped moisture that is not dried and removed will eventually decay the mass timber over time (see **Figure 7**), which is very expensive and time-consuming to remediate. Great care needs to be taken to minimize the assembly's exposure to moisture following placement of the topping. Therefore, to mitigate the moisture risks, it is a recommended practice to modify the project sequencing and schedule so concrete topping is never installed before the mass timber assembly is shielded by walls or hoarding and a watertight level above (roof or floor with membrane; see **Figure 8**).

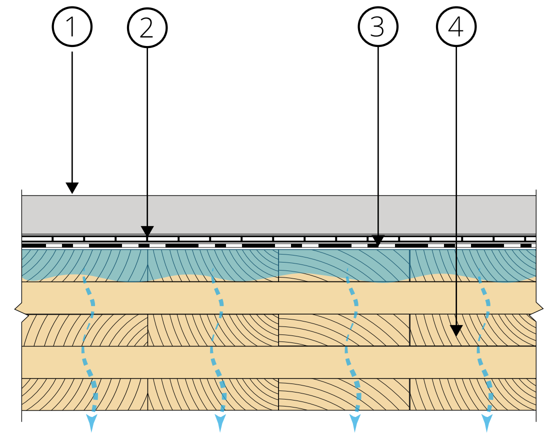
Figure 7 A CLT floor with concrete topping removed to reveal decay of the wood.

Figure 8 A mass timber building with prefabricated wall panels being installed prior to concrete topping placement.

Coatings and membranes that can protect the mass timber panel from moisture within the cementitious topping are generally recommended to reduce risks for the following reasons:

1. The concrete cannot be introduced to additional water during the curing process. Dry timber (<16% moisture content) can safely tolerate the amount of water in a concrete mix during a pour; however, if additional moisture is introduced, such as rainwater falling onto the wet concrete, the mass timber moisture content will surpass a safe level, increasing the risk of decay.
2. The mass timber panel must be dried to a moisture content of 16% or less prior to being covered by concrete topping to avoid trapping water. The installation of a membrane and the topping prevents drying of the mass timber (see **Figure 9**). Therefore, if the moisture content is above 16%, then the concrete topping pour needs to be delayed until the wood can dry. A protective coating or membrane can reduce the risk of project schedule delays and drying efforts.
3. Paths for water to travel under the concrete occur at penetrations, column connections, the perimeter of the assembly, and cracks in the concrete. A membrane with adequate detailing installed can better protect the mass timber water introduced during construction or occupancy.

When used, protective coatings and membranes are installed directly to the mass timber. Therefore, the installation and detailing must be completed prior to installation of acoustic mats.



Legend

1. Concrete topping
2. Acoustic mat
3. Protective membrane
4. CLT

Figure 9 Concrete topping over a CLT floor assembly. Areas where wet wood cannot dry are shown in blue.

A Note from RDH About Concrete Topping Risks

In recent years, RDH has been asked to review several mass timber projects in which water has gotten underneath concrete topping while the buildings were under construction. In all of these cases, the moisture got under the concrete at the floor perimeter or columns when the floor/roof above and walls were not installed prior to pouring concrete. In all but one of these cases, the concrete topping had to be removed to allow the CLT to be dried, mold removed, and decay remediated, resulting in significant delays and expenses.

In the exception case, the severely wetted CLT below the concrete topping was able to be dried because there was an air space between the CLT and the concrete topping (due to an acoustic mat with profile that created a large, interconnected airspace). The air space allowed water to be pumped out, hot air to be pumped in, and the moisture content to be monitored. This drying process took weeks and was also extremely costly.

These remediation costs have also begun to impact the insurance rates for mass timber buildings.

RDH's experience on these cases has demonstrated that it is always high risk to pour concrete before the perimeter walls and floor/roof above have been installed and sealed. The construction schedule needs to be modified to allow for the wall installation to proceed with concrete topping placement.

Floor Assemblies

Although floors are not part of the final building enclosure and therefore do not manage exterior water during occupancy, they still require consideration during the moisture management process. During construction, there will be a period of time when the floors are not shielded from rain (including wind-driven rain) by a floor, roof, or walls (see **Figure 10**). The main moisture management consideration for floor assemblies is whether a cementitious topping will be used. As discussed in previous sections, protection of floors is usually necessary when the project has a low tolerance to risk of staining, encapsulation requirements, or floors with concrete toppings.

In lower-exposure conditions, it may be appropriate to use only targeted protection at the perimeters of the floor (see **Figure 11**), at panel interfaces (see **Figure 12**), or at areas at risk for occupancy moisture.

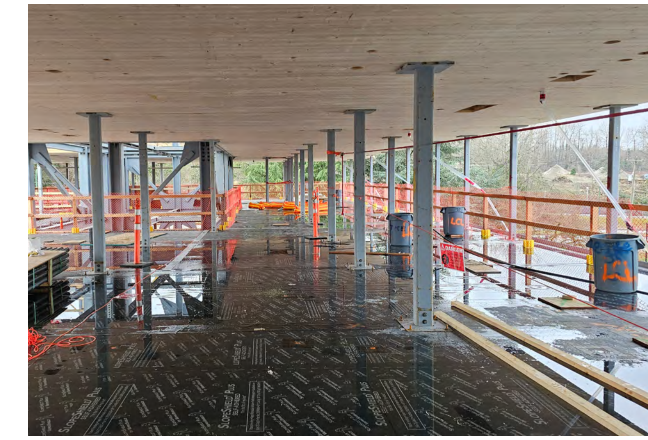


Figure 10 A mass timber floor exposed to rainwater during construction. A membrane is installed over full panels to reduce moisture-related risks.

Figure 11 A protective membrane is installed over the end grain at the perimeter of a CLT floor to reduce moisture-related risks.

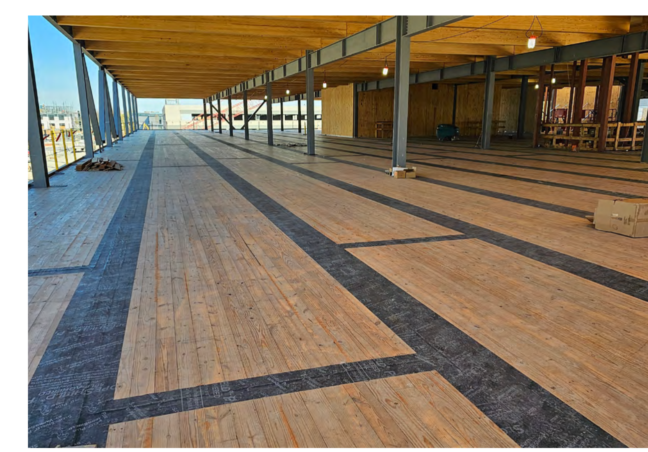


Figure 12 A protective membrane is installed along panel joints to protect the end grain from moisture-related risks.

Roof Assemblies

In roof assemblies, the moisture protection membrane is often utilized as a temporary roof during construction, and often it can be used as the air or vapor control layer of the final assembly (see **Figure 13**). This membrane is often factory installed, but it may be a site-installed component.

The protection membrane selected is based on the type of roof assembly and how slope in the assembly is achieved. There are two main roof types: a conventional roof and a protected membrane roof (also known as an inverted roof).

Conventional roof assemblies shed water at the roof membrane plane, which is the outermost surface of the assembly. The slope of this membrane is often created by tapered rigid board insulation products (see **Figure 14**). In this case, the mass timber panel structure is flat and lacks slope that would otherwise encourage water to drain across the panel surface.

In a protected membrane roof assembly, the roof membrane is located on top of the structure, where it is concealed by additional drainage, insulation, and overburden layers. Slope for assembly drainage is created by either sloping the mass timber panel (see **Figure 15a**) or adding layers of tapered insulation and sheathing (see **Figure 15b**). The sloped panel option will also provide the opportunity of using the final roof membrane for temporary moisture protection, but only if the membrane is well protected from trade damage and thoroughly reviewed for needed repairs prior to cover (see **Figure 16**). If the panel is flat, an additional temporary membrane over the mass timber panel may be required to protect the panel until the buildup of sloped materials and final roof membrane are installed.

For either roof type, sloping the panel increases water drainage and therefore reduces the risk of water absorbing into the panel or bypassing discontinuities in a protected membrane (such as unsealed laps, pinholes, or damage). An assembly with a sloped mass timber panel has a lower moisture exposure than an unsloped panel and therefore may have reduced protection needs.

The roof manufacturer must review and approve the mass timber roof protective membrane for warranty requirements, such as wind uplift resistance and material compatibility. In circumstances where the moisture protection membrane does not meet wind uplift requirements, a mechanically fastened insulation and coverboard system (see **Figure 17**), or a fastened-adhered hybrid, can be used instead of an adhered system so that the uplift resistance does not rely on the adhesion of the membrane (see **Figure 18**).

Figure 13 A mass timber roof assembly. Once all laps of the membrane are sealed, the air and vapor barrier membrane visible in this photo will temporarily protect the mass timber from moisture (Catalyst, Spokane, WA).

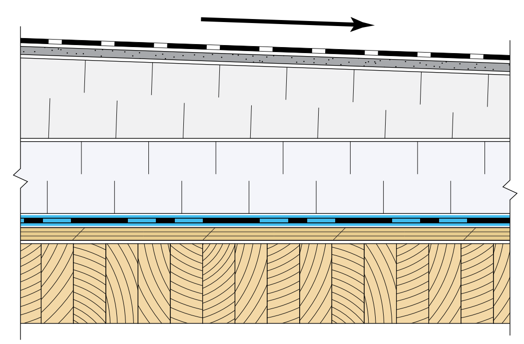


Figure 14 Conventional roof assembly with tapered rigid insulation. The assembly layer that could potentially be utilized as the construction phase moisture protection is highlighted in blue.

a)

b)

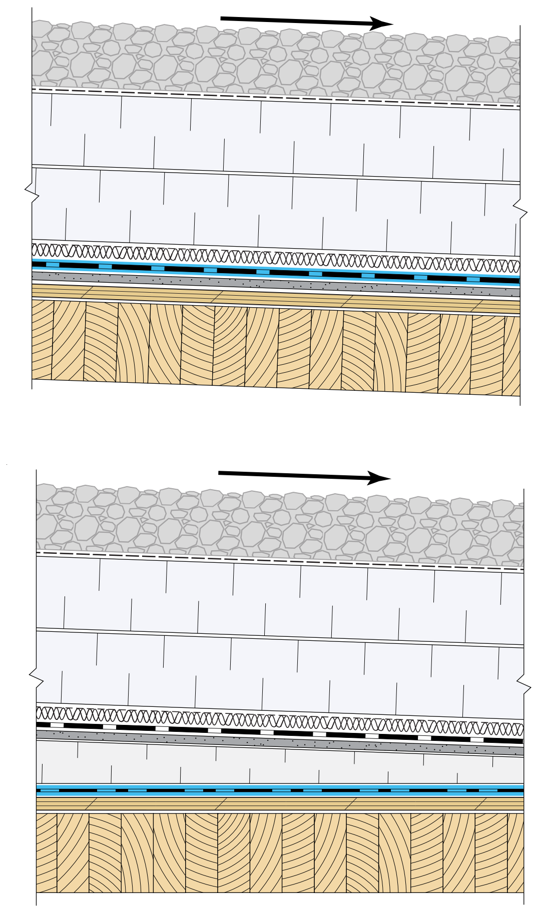


Figure 15 Protected membrane roof assembly with a) sloped mass timber panel, and b) tapered rigid insulation to create slope. The assembly layer that could potentially be utilized as the construction phase moisture protection is highlighted in blue.

Figure 16 A sloped CLT roof panel with a vapor-impermeable roofing base sheet acting as the moisture protection membrane during construction. The membrane will act as the base ply of the final 2-ply roof membrane. The panel slopes to the roof perimeter.

Figure 17 A roof assembly with mechanically fastened insulation and coverboard system. The fasteners are installed through the membrane, which acts as the construction phase moisture protection and the permanent air and vapor barrier.

Figure 18 A roof assembly with a fastened-adhered hybrid attachment system. The first layer of insulation is mechanically fastened, but subsequent insulation layers are adhered. The fasteners are installed through the membrane, which acts as the construction phase moisture protection and the permanent air and vapor barrier.

Roof Leak Risk Reduction Strategies

Mass timber can absorb a significant amount of moisture, which can make it difficult to identify a roof leak during building occupancy. Panel thickness and interior finishes further mask the presence of water. If a roof leak occurs, visible indications of the leak may not be obvious until damage has already begun. To reduce the risk of damage caused by a roof leak, the assembly can be designed to promote drying by venting to the interior, and/or include a leak detection system.

Venting the topside of the mass timber panel to the building interior provides an opportunity for the panel to dry to both the topside and underside. In interior vented assemblies, an air cavity is provided directly above the CLT and MPPs, and between the structural plywood or OSB sheathing of NLT or DLT (see **Figure 19**). This air cavity can be achieved with battens (see **Figure 20**) or sloped over-framing; however, the project's structural engineer will need to confirm the air cavity's impact on the structural sheathing boundary and edge nailing requirements. These requirements may block the air cavity connection to the interior, which eliminates the drying benefits.

Note that venting the mass timber roof panel to the building interior may exclude the timber from the assembly's effective thermal performance calculations for energy code compliance calculations in some jurisdictions. Additionally, the fire code may require the air cavity to be filled with insulation for some building types and roof assembly ratings, partially negating the purpose of the open cavity.

Leak detection systems may also be used in roofs to reduce moisture-related risks. Due to the moisture sensitivity of the mass timber, leak detection systems can reduce the probability of a leak going undetected long enough to result in decay of the wood elements. More information on electronic leak detection systems and best practice design guidance is provided in the *Mass Timber Building Enclosure Best Practice Design Guide*.

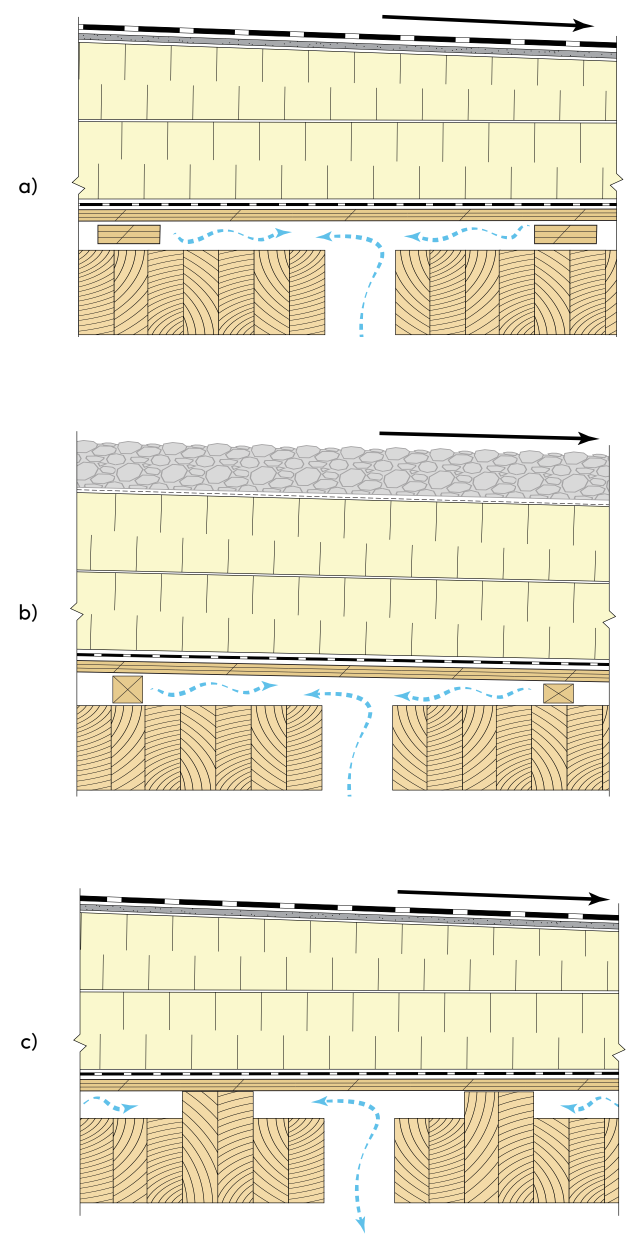


Figure 19 Vented roof assembly with a) flat battens across a mass timber panel, b) tapered strapping with sloped over-framing over a mass timber panel, and c) staggered or variable-height laminations of an NLT or DLT panel. Ventilation pathways to the interior are shown with arrows.

Topside

Underside

Figure 20 An example of a vented roof using the flat batten venting approach as viewed from the topside and underside of the CLT panel (Wood Innovation and Design Centre, Prince George, BC).

For more information on mass timber assembly layers and best practice design guidance, refer to the *Mass Timber Building Enclosure Best Practice Design Guide*.

Timber-Concrete Composite Floor and Roof Assemblies

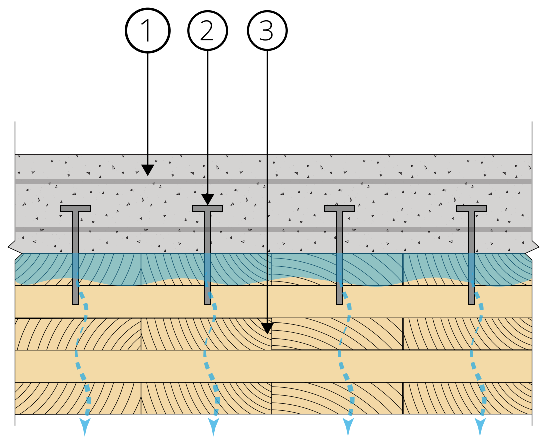
Timber-concrete composite (TCC) assemblies may be used on either floor or roof assemblies. A TCC assembly is comprised of a reinforced concrete topping mechanically attached to a horizontal mass timber panel with shear connectors (see **Figure 21**) such as screws, perforated plates, "Nelson®" type studs, and high-strength bolts.

This type of assembly is often chosen to meet seismic requirements but has the added benefit of enhancing the acoustic, fire resistance, and structural performance of the mass timber. A TCC assembly may be either precast or poured-in-place; this guide focuses on a poured-in-place application.

The concrete topping mix used for TCC systems has less excess water compared to self-leveling cementitious screeds or gypsum concrete. However, the drying capability of the mass timber is limited. The drying capability is affected by concrete thickness, mass timber thickness, and weather. Pouring wet concrete introduces water to the mass timber panels. When evaluating any design that may use a composite assembly, consider the following situations:

- If the mass timber is wet prior to a concrete pour, the moisture in the concrete can exceed the mass timber's safe storage capacity. This excess moisture could result in elevated and risky moisture levels at the wood-to-concrete and shear connection interface.
- If additional water is introduced to the concrete following the pour (such as during a rainfall event), the excess moisture will eventually make its way to the mass timber panel below.

Both of these situations present a high risk for trapping moisture within the assembly, increasing the likelihood of long-term moisture damage. Thus, great care must be taken to minimize the introduction of additional moisture to the TCC assembly before and after placing the topping.



Legend

1. Structural concrete topping
2. Shear connectors
3. CLT floor or roof panel

Figure 21 Timber-concrete composite assembly. The installation of a temporary membrane in addition to the topping essentially eliminates drying of the topside of the mass timber panel; therefore, the mass timber needs to be confirmed dry (i.e., less than 16% moisture content) prior to the placement of a topping.

If the moisture exposure level of a TCC floor assembly is anticipated to be low, moisture protection methods may not be necessary (see **Figure 22**). However, in a TCC roof assembly, the concrete topping will eventually be covered by an air and vapor barrier. This barrier will significantly limit the ability for moisture to dry through the topside of the assembly. As a result, it is recommended that appropriate moisture protection be installed on the mass timber panel. The images shown in **Figure 23** illustrate the results of a two-dimensional hygrothermal modeling exercise and demonstrate the need for moisture protection to separate the concrete topping from the mass timber elements at both the panel top and, most critically, the panel edge.

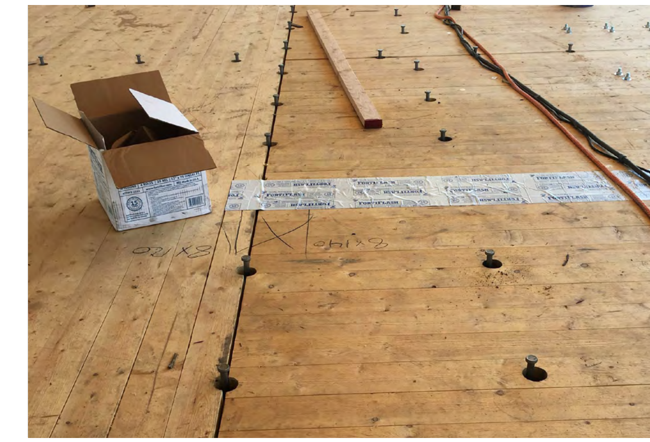
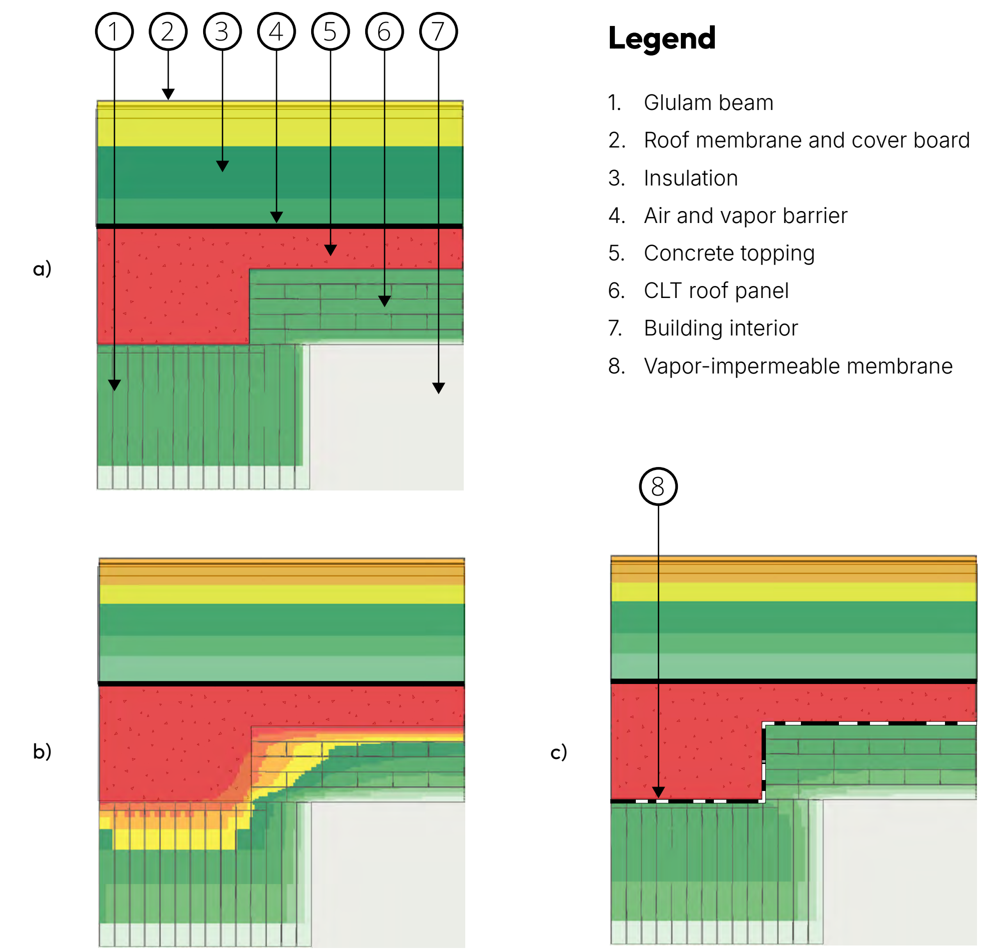


Figure 22 Timber-concrete composite CLT floor with shear connectors installed prior to concrete pour.



Legend

1. Glulam beam
2. Roof membrane and cover board
3. Insulation
4. Air and vapor barrier
5. Concrete topping
6. CLT roof panel
7. Building interior
8. Vapor-impermeable membrane

Figure 23 Two-dimensional hygrothermal model of TCC roof assembly at a column-to-panel interface where the moisture level is visualized from red (wet) to green (dry) to light green (very dry). The conditions shown are a) initial conditions immediately after a concrete pour, b) moisture migration into the wood beam and column after 12 months if no moisture protection was provided between the mass timber and concrete topping, and c) the mass timber elements maintained in a dry condition when a vapor-impermeable membrane is installed on the top and edge surfaces of the mass timber.

The need for moisture protection in TCC assemblies depends on the anticipated moisture exposure level and whether the assembly is a floor or a roof. The assembly design tool in **Appendix B** describes recommended protection methods for TCC assemblies describes recommended protection methods for TCC assemblies. When the moisture exposure level demands a protective membrane, it is recommended that the project team install a vapor-impermeable roofing membrane with heat-fused laps prior to installing the shear connectors and to detail around the connectors once installed. If the shear connectors are already installed, it is recommended that the project team use a liquid-applied, vapor-impermeable membrane. Shear connectors in a TCC assembly prevent uniform waterproofing, so some water is expected to reach the panel; therefore, standing water still needs to be avoided.

Project teams are strongly advised to avoid installing TCC assemblies when the anticipated moisture exposure level is determined to be high.

Moisture exposure also needs to be monitored and managed after the concrete is installed. Covering the concrete reduces the rate of the concrete's ability to dry. It is best practice to pour concrete for TCC floor assemblies after the enclosure walls are in place and the floor above is installed (with penetrations sealed) to reduce rain exposure, and to avoid covering the concrete during the curing process.

If the concrete topping of a TCC roof is poured during the dry season with no anticipated precipitation, the recommended approach is to delay the roof membrane installation over the top of the concrete (weather permitting) to allow as much moisture as possible in the concrete to evaporate. However, any precipitation on the concrete will cancel the drying benefit of delaying the membrane installation and potentially exceed the mass timber's safe storage capacity; therefore, project teams are advised to continuously monitor the weather forecast during installation of TCC and concrete-topped assemblies. If precipitation is anticipated during the concrete pour, the concrete will need to be protected with tenting or other appropriate protection strategies.

When protecting the TCC roof assembly with tenting or other strategies, it is important to remove the protection as soon as possible during the curing process to allow moisture to leave the concrete. If the protection is not removed, the tenting needs to be used in combination with drying methods (heaters, fans, dehumidifiers).

Wall Assemblies

The anticipated moisture exposure level for wall assemblies is typically low to moderate depending on the season in which panels will be installed. However, high moisture exposure levels may occur if panel transport and storage cannot provide the appropriate seasonal protection, if the walls are experiencing excessive quantities of runoff (see **Figure 24**), drained water, or water splashing off surrounding conditions (i.e., splash back), or if the base of wall is in contact with wet conditions.

For all moisture exposure levels, protecting mass timber wall panels from wetting during the construction phase includes either factory- or site-installed application of water-resistive barrier (WRB) membranes installed at the exterior face of the mass timber (see **Figure 25**) that act as part of the final assembly. Best practice design guidance is provided in the *Mass Timber Building Enclosure Best Practice Design Guide*. These practices include guidance that promotes panel drying and drainage of the cladding system.

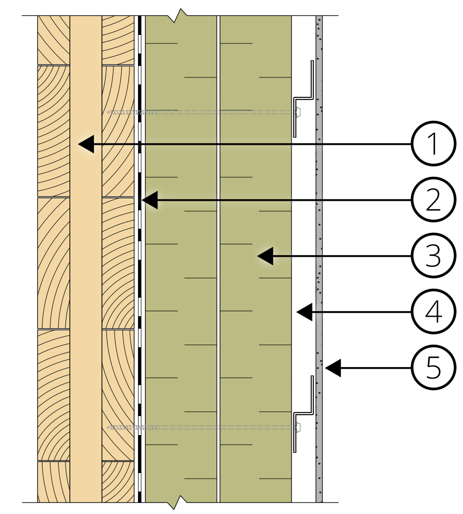
Factory-installed WRB membranes are applied during the panel manufacturing process and prior to the panels' delivery to the project site (see **Figure 26**). These membranes protect the panels during shipping and on-site staging and can reduce the building's dry-in period. Once the mass timber panels are erected on-site, the exposed faces and edges of the mass timber wall panel (including the panel joints, rough openings, and penetrations) receive additional protection from membranes or hoarding.

If factory installation of WRB membranes is not feasible, then it is best practice that the WRB membrane is installed in parallel with, or shortly following, the erection of the mass timber panels on-site.

Whether factory- or site-installed, and regardless of exposure level, a vapor-permeable WRB membrane is desirable. A vapor-permeable WRB allows the wood to dry while protecting it against further water absorption. Applying a vapor-impermeable membrane over mass timber panels that are already wet can be problematic for two reasons: the membrane may not adhere well to the wet wood, and the membrane will prevent drying of the timber. If the panels are wetted before the protective membrane is applied, it may be necessary to provide temporary shelter above the wall assembly to dry the panels.

Figure 24 Water staining on mass timber wall due to excessive rainwater runoff from the roof wetting the face of the wall panel.

Figure 26 CLT wall panels with factory-installed air barrier and WRB membrane and window rough opening membranes prior to on-site installation of windows and panel joints.



Legend

1. Mass timber panel
2. Air barrier and water-resistive barrier
3. Exterior insulation
4. Ventilated and drained cavity
5. Cladding

Figure 25 Exterior-insulated CLT wall assembly (plan view).

The exposed end grain of the mass timber wall panel at joints, rough openings, and penetrations, such as those shown in **Figure 27**, consist of horizontal, unsloped surfaces that are unable to readily shed water. These end-grain details are at the highest risk for moisture absorption of ponding water during construction and therefore have a higher moisture exposure level than field-of-wall areas. Additionally, the end grain at the base of wall can be at risk of absorbing moisture during construction and in-service. These wall details require appropriate and effective moisture protection methods to minimize moisture-related risks.

To manage moisture during construction until the remaining wall assembly layers are installed, the following strategies are standard practices:

- Install isolated tarping of openings, taking care not to damage any finishes that will remain exposed during in-service conditions.
- Pre-strip rough openings and penetrations with WRB membranes/flashings.
- Actively remove any ponding water (including snow and ice) from horizontal surfaces with unprotected edges or vapor-permeable membranes using vacuums, squeegees, and other water-removal tactics in a timely manner.
- Drain water from assemblies above and divert runoff and water at grade away from the walls.
- Protect the base of wall from splash back.

Even with these precautions, it is likely that mass timber panels will experience some wetting during construction, and that they will be installed with built-in moisture in localized areas. Therefore, the most durable wall design strategies will use vapor-permeable materials to allow excess moisture to escape the assembly, thereby minimizing damage and deterioration. In cases where exterior materials with low vapor permeance are selected, the mass timber panels need to be dry (with a moisture content below 16%) prior to their installation to prevent trapping water beneath the low-permeance material.

To prevent moisture absorption at the base of the wall during construction and during occupancy, the following detailing strategies (as shown in **Figure 28**) are typical design practices:

- Separate the wall from concrete surfaces using a vapor-impermeable material or a structural attachment to prevent the mass timber from absorbing moisture in the concrete.
- Elevate the mass timber walls a sufficient height above grade to reduce the wall's exposure to water at grade (such as groundwater runoff).

Figure 27 CLT wall panels with exposed penetrations and rough openings prior to on-site application of a WRB membrane.

Figure 28 A CLT wall is installed onto a concrete curb to elevate the base of wall above grade level. The CLT and concrete curb are separated with a metal attachment.

Columns and Beams

Like floors, mass timber columns and beams are not typically part of the final building enclosure. However, it is still important to consider their exposure to wind-driven rain until the walls are installed and exposure from floors above. Due to their structural connections, columns and beams are susceptible to iron staining. Column connections in particular tend to be more susceptible to staining due to water traveling from the floors above (see **Figure 29**).

Protection for mass timber columns and beams typically includes a coating and the use of factory wrapping as protection (see **Figure 30**). Installing tarps or hoarding to reduce moisture exposure at the perimeter may also be considered. Prior to erection, the protective factory wraps need to be cut on the underside to allow drainage of any incidental water that may penetrate the covering.

Like the base of wall conditions, base of columns are also susceptible to moisture risks from wet ground conditions and splash back (see **Figure 31**). To mitigate these risks, it is best practice to design the column with a separation between the base of column and the concrete below.

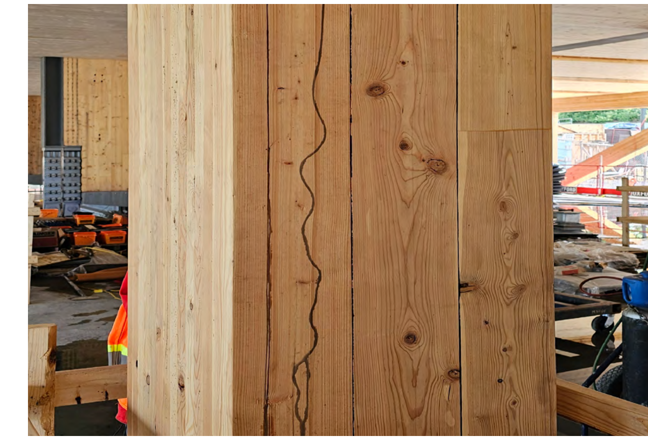


Figure 29 A glulam column with dark iron staining from water traveling down the column from the level above.

Figure 30 Glulam columns and beams protected using the factory wrapping. The factory wrapping is removed at structural connection, and the wrapping at the underside of beams and bottom of the column is opened to allow for water drainage.

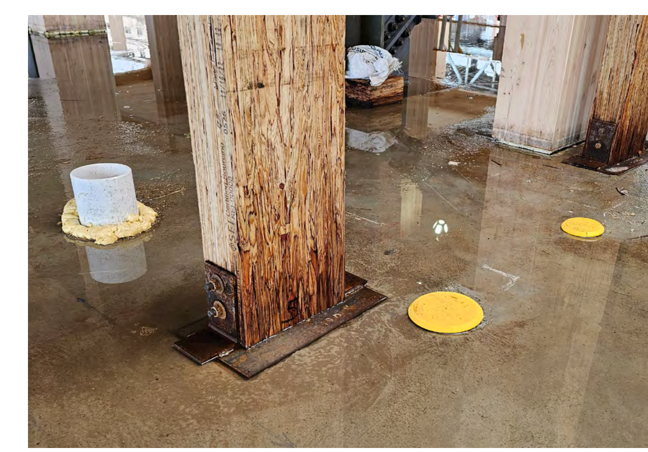


Figure 31 Water absorption at the base of a parallel strand lumber (PSL) column due to contact with wet surface conditions.

Moisture Exposure

Mass timber is exposed to many possible moisture sources that can contribute to greater risk to the assembly. The combination of factors that contribute to the likelihood of a wetting event is referred to as the “moisture exposure level.” To start evaluating the moisture exposure level, the project team will inventory the ways the mass timber elements may be exposed to moisture, such as shown in **Figure 32**. Then the team will estimate the volume of water, the duration of wetting events, and the drying potential to get the approximate moisture exposure level.

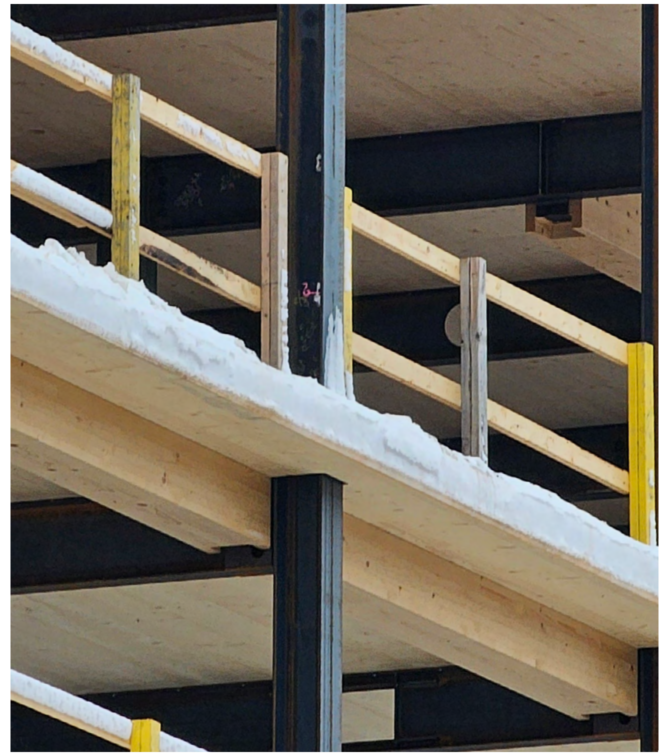


Figure 32 A mass timber floor experiencing snow buildup at the perimeter of the floors. The snow will create a wetting risk once it begins to melt.

Moisture Sources

Mitigating moisture risks requires attention to moisture management beginning as soon as the mass timber leaves the factory and continuing until the building is in-service. **Table 2** presents the primary sources of moisture that mass timber may be exposed to during the construction and occupancy phases.

Table 2 Sources of Mass Timber Moisture Exposure.

Construction Phase	Occupancy Phase
→ Rainfall and snowmelt	→ Failure of the building enclosure’s water control layers (such as roof leaks)
→ Night-sky condensation (dew)	→ Plumbing or appliance failures
→ Plumbing leaks	→ Occupant activities such as bathing and food preparation
→ Water absorption from the ground during storage	→ Activation of a fire sprinkler system
	→ Exterior flooding conditions (such as flash floods)

Construction Phase Moisture Exposure

The factors that contribute to the moisture exposure level of a mass timber assembly during the construction phase are summarized below.

- **Climate and Season.** The local climate and season include rainfall and snowfall levels and frequency; wind; and the opportunity for drying events. **Figure 33** shows that the amount of annual rainfall throughout the U.S. and Canada can vary from low levels in desert and arid climates to more extreme levels in coastal regions.

  The timing of rainfall events can be as important as the amount of rain that falls. Timing is a factor because the seasonal distribution of precipitation can affect the drying potential of the enclosure after a wetting event. For example, a heavy rainfall that is followed by colder temperatures and/or high humidity levels will provide little opportunity for drying. The lack of drying can have a significant impact on mass timber panels that may have been erected but are not yet protected from construction phase moisture. Alternatively, high-intensity but low-frequency rainfall events separated by sufficient dry and sunny conditions result in lower moisture risks.

  Moisture exposure levels can be intensified by high wind speeds that drive rainfall to areas that would otherwise not be exposed. Wind speeds generally increase with height; thus, taller mass timber buildings are likely to see more wind-driven rain than traditional shorter wood-framed structures.

- **Water Drainage Strategies During Construction.** Panel slope, water diversion/deflection, and drains impact a building’s exposure level. A sloped mass timber panel or water diversion/deflection mechanisms will encourage water to shed away toward drains and roof or floor edges, thus reducing the moisture exposure level. However, if not adequately managed, they can also increase the risk of concentrated runoff or pooled water at poorly drained areas. Drains can reduce exposure if they are continuously connected for discharge to the building exterior.
- **Exposure Duration.** The duration in which mass timber panels are exposed is influenced by overhead protection, the speed of construction for subsequent building levels, and construction delays.
- **Shipping and Storage.** Shipping protection, travel distance from the manufacturing facility and transit time, and site storage can all impact the mass timber panels’ exposure to moisture prior to panel placement.

Legend

- Extreme - Over 60" (1500 mm)
- High - 40" - 60" (1000 mm - 1500 mm)
- Moderate - 20" - 40" (500-1000 mm)
- Low - Under 20" (500 mm)

Figure 33 Rainfall distribution across the U.S. and Canada. [2]

To assess construction phase moisture levels, this guide uses the "low, "moderate," and "high" exposure levels described in **Figure 34**. The greater an assembly's moisture exposure level during construction, the greater the risk for wetting. With an increased risk of getting wet comes a greater need for moisture protection. Through evaluating all moisture exposure factors, the project team can assign an anticipated moisture exposure level to an assembly and then use the **Risk Assessment Matrix** on page 12 and assembly design tools in **Appendix B** to select coatings or membranes.

Risk assessment sometimes needs to be repeated and updated throughout the three-step moisture management process. During this iterative process, the team may find that, given the moisture exposure level, no coating or membrane can sufficiently reduce the risk to a tolerable level. In this case, other moisture management strategies may be required to reduce exposure during construction. For example, increasing the speed of wall installation will reduce the duration when the floors are exposed to wind-driven rain. Unanticipated project changes can also change the moisture exposure level. If the construction schedule shifts from panel installation during a dry season to installation during a wet season, the moisture exposure level may increase. In such cases, further considerations for construction phase moisture protection may be required.

Construction Phase Moisture Exposure Level

The moisture exposure level identifies the likelihood of a project's mass timber panel being exposed to wetting events that may occur in transport, in storage, or after placement. The descriptions below identify examples relative to the building schedule and duration of exposure; however, all factors that may contribute to a project-specific moisture exposure need to be cumulatively considered.

LOW — Low Exposure

- Roof above with perimeter protected with tarps or hoarding, *or*
- Exposed during dry/drought season when precipitation is unlikely or limited enough to allow full drying of the mass timber.

MODERATE — Moderate Exposure

- Roof above, but open at perimeter with periodic precipitation and limited risk of wind-driven rain, *or*
- No roof above, but surface is sloped to drain water.

HIGH — High Exposure

- No roof above with precipitation expected during exposure duration, *or*
- Roof above but open perimeter with wind-driven precipitation expected during exposure duration.
- Extended exposure timeline that increases the risk of wetting potential.

Figure 34 Construction phase moisture exposure levels summary for mass timber assemblies.

Occupancy Phase Moisture Exposure

Water control doesn't end with rainfall or snowmelt during construction. Water control for moisture exposure sources (like those shown in **Figure 35** and **Figure 36**) during building occupancy can also impact mass timber. Wetting of mass timber caused by these sources is sometimes difficult to discover because it is concealed by interior finishes, including concrete toppings. If leaks and other moisture exposure goes undetected for long periods of time, the risk of moisture-related decay is compounded. Moisture issues during occupancy can also disrupt the occupants and building use while leaks are identified, the mass timber elements are dried, and any damage is remediated.

It is best practice to consider occupancy phase moisture during the risk assessment process. This assessment process includes identifying locations at greater risk of moisture exposure during occupancy such as bathrooms, kitchens, and mechanical rooms, and evaluating their need for moisture protection. The protective membranes selected to protect a building from construction phase moisture may have the added benefit of protecting the building from occupancy phase moisture. If the building has no protection, or the protection level used for construction phase moisture management is not adequate, then additional targeted protection may be appropriate at these locations (such as installing membranes only at bathrooms).

Figure 35 A fire suppression sprinkler system in a mass timber building. If the sprinkler system is used during occupancy, it will be necessary to identify locations where water may have traveled beneath the concrete topping.

Figure 36 A mechanical room in a mass timber building. Installing targeted moisture protection at the mechanical room floor assembly, and regular inspection and maintenance of the equipment and piping, is recommended to reduce the risk of wetting the mass timber during occupancy.

Moisture Protection Strategies

The final part of the risk assessment is the selection of moisture management strategies. Moisture management requires a combination of strategies, and no one-size-fits-all solution exists. Based on the project-specific tolerance to risk, assembly-specific requirements, and anticipated moisture exposure levels, the project team can narrow down and select moisture protection strategies.

Moisture management on a project includes both passive and active moisture protection strategies:

- Passive moisture management refers to any moisture protection measures pre-applied or site-applied that are intended to limit exposure to water and also absorption of water directly into the wood. Passive protection can generally be thought of as a material.
- Active moisture management refers to any method used by the on-site construction team to safely remove and drain bulk water from the mass timber elements. Active protection can generally be thought of as a labor effort.

Examples of passive moisture protection and active moisture removal are listed in **Table 3**. Additional moisture management strategies such as the use of just-in-time delivery methods or adaptive scheduling and sequencing may also be used. Active moisture removal is further discussed in Step 3. See the two case studies at the end of Step 3 for a comparison between plans that focus on passive versus active moisture management strategies.

Moisture Protection Types

When selecting protection, it is important to consider the protection's ability to manage the anticipated moisture exposure. The primary characteristic for water management is the ability to resist ponding water to prevent wetting of the mass timber. The following protection types have different abilities to resist wetting:

- Water-resistant coatings allow water to bead on the surface for a short duration (see **Figure 37a**); however, if the beaded water is not removed, it eventually absorbs through the coating.
- Tapes, loose-laid protection, and targeted protection (see **Figure 37b** and **c**) will prevent water wetting through the material, but they allow water to travel underneath the tape or protection at the edges.
- Water-shedding, vapor-permeable membranes (see **Figure 37d**) may resist surface water temporarily, but they will eventually lead to wetting of the mass timber through the membrane surface and the laps.
- Water-shedding, vapor-impermeable membranes (see **Figure 37e**) may resist surface water temporarily, but they are not designed to hold water and will eventually lead to wetting of the mass timber through the laps.
- Waterproof membranes (see **Figure 37f**) such as roofing membranes will withstand surface water and ponding indefinitely at the surface of the membrane and the laps.

Many protection types are available with a variety of properties. For a summary of protection types, refer to the table of mass timber moisture protection types included in **Appendix B**. This table also includes the **Protection Robustness Level** and **Moisture Protection Types** (which are discussed further in the next sections) for each protection type.

Table 3 Types of Passive Moisture Protection and Active Moisture Management.

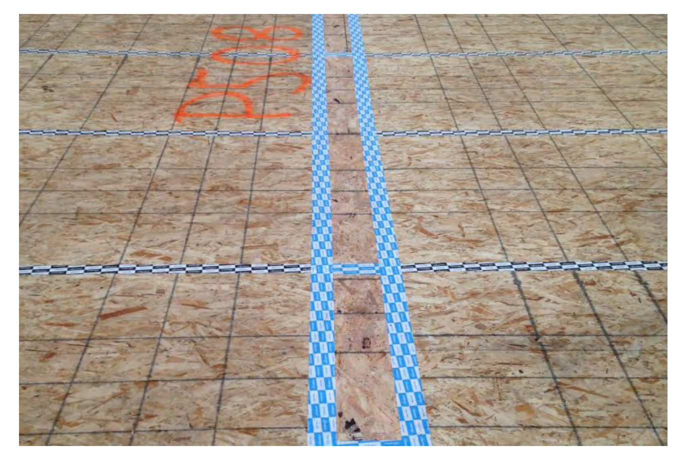
Passive Moisture Management (Protection)	Active Moisture Management (Removal and Drainage)
→ Whole building, roof, or façade tenting or hoarding	→ Drain water off mass timber with vacuums or squeegees
→ Water-resistant coatings	→ Install and remove temporary tarps
→ Water-shedding membranes	→ Remove snow and ice using shovels or snow blowers
→ Waterproof membranes	→ Implement drying efforts using intentional exposure and schedule time for wind/sun, fans, heaters, and dehumidifiers; may be applied locally or to the whole floor/building

a) Hydrophobic coating.

d) Vapor-permeable self-adhered membrane.

b) Wide strip of vapor-permeable self-adhered membrane at panel joints.

e) Vapor-impermeable self-adhered membrane.



c) Vapor-impermeable tape installed at sheathing joints.

f) Vapor-impermeable self-adhered SBS roofing base sheet.

Figure 37 Examples of moisture protection types.

Protection Robustness Level

For the purpose of this guide, the protection types have been categorized based on their ability to adequately prevent wetting of mass timber by resisting ponding water. The categorization has been defined as "protection robustness." A materials robustness level is also an indication of the active moisture management efforts that will be required on-site. **Figure 38** includes a description of each protection robustness level. RDH developed and categorized these levels of protection robustness based on laboratory material testing, field observations, and our experience in forensic investigations of mass timber buildings.

The protection robustness and moisture exposure level categorization are used to select protection types appropriate for the project's risk tolerance using the **Risk Assessment Matrix** on page 12 and the assembly design tools in **Appendix B**.

Protection Robustness

Robustness level of the mass timber panel achieved by applying protective membranes or coatings.

L
LOW

Low Protection Robustness

- → Water-resistant coatings, loose-laid protection, or targeted protection.
- → Immediate action required in a wetting event.

M
MODERATE

Moderate Protection Robustness

- → Water-shedding membranes with self-adhered laps.
- → Action required in a timely manner in a wetting event.

H
HIGH

High Protection Robustness

- → Waterproof membranes with heat-welded laps.
- → No immediate action required in a wetting event.

Figure 38 Protection robustness levels for mass timber moisture protection types.

Moisture Protection Properties

The ability to resist ponding water to prevent wetting (protection robustness level) is the main property of interest when selecting a protective product. Note that numerous products are available on the market for each protection type and robustness level; therefore, additional properties will need to be evaluated to determine the most suitable product for a specific project. The vapor permeability (or permeance) and other properties will differ by product and manufacturer. Vapor permeability is the degree to which a material allows vapor to flow through it via diffusion, and it is a key property to evaluate when selecting a protective membrane. There are no industry standards to specify products for mass timber protection uses; therefore, all moisture protection products should be carefully considered by a building enclosure or mass timber professional for their applicability to each unique project condition. **Table 4** provides general categorizations and moisture control considerations for permeable, semi-permeable, and impermeable protection products.

Products may be liquid-applied (or fluid-applied), loose-laid, or self-adhered sheet membranes as described below:

- Liquid-applied products are coatings or liquid membranes applied with a paint-roller, brush, or sprayer. Liquid-applied coatings applied in the factory are commonly used. Liquid-applied membranes do not bridge well over gaps in the wood and are less commonly used except for targeted locations, end grains, or flashing details.
- Loose-laid products are sheet products that are not adhered to the substrate. Moisture control in these products is extremely dependent on the sealing of laps, transitions, and fastener locations. Any water bypassing the surface of a loose-laid product can travel in all directions and can lead to widespread wetting.
- Self-adhered membranes are sheet products adhered to the substrate. Moisture control in these products is superior to loose-laid products because any moisture bypassing the membrane remains localized as it cannot travel under the adhered membranes.

Table 4 Comparison of Moisture Protection Between Impermeable, Semi-Impermeable, Semi-Permeable, and Permeable Membranes.

	Impermeable	Semi-Impermeable and Semi-Permeable	Permeable
Product Definition	Vapor-impermeable products have a permeance of 0.1 perm or less. These products restrict the rate of water vapor diffusion across the material to a very high degree.	These products restrict the rate of water vapor diffusion across the material less than impermeable products but more than permeable products.	Vapor-permeable products have a permeance greater than 10 perms. These products are considered to have a high vapor permeance.
Product Considerations	→ Does not allow drying through it, thus increasing the risk of trapped moisture. → May be used at the final assemblies' air and vapor control layers. → May be considered as water-shedding or waterproof (moderate or high protection robustness, respectively) depending on that specific product's resistance to ponding water.	→ The degree of wetting and drying will vary by product. → A permeance of 1 perm or less cannot be relied upon for drying ability. → Products are typically considered water-shedding (moderate protection robustness).	→ Allows drying through it, thus reducing the risk of trapped moisture. → Allows some wetting through if standing water is not removed. → May be considered water-shedding or water-resistant (moderate or low protection robustness, respectfully) depending on that specific product's resistance to ponding water.

Construction moisture protection is either factory-installed (factory-applied) or site-installed. In most instances, both factory- and site-installed protection are necessary to protect the mass timber assembly from moisture. An example of factory-installed protection is shown in **Figure 39**. Factory-installed protection is a recommended best practice whenever available. The conditions in a factory setting promote the application of the materials in a dry and accessible environment that is most favorable to appropriate material application and quality assurance standards. Additionally, site-installed protective membranes must be installed on dry material. Therefore, the risk of schedule delays and trapping moisture under the membrane increases if the mass timber gets wet during delivery, storage, or in place prior to the installation of protection.

Figure 39 A CLT floor panel with a factory-installed membrane being hoisted into place at a project site.

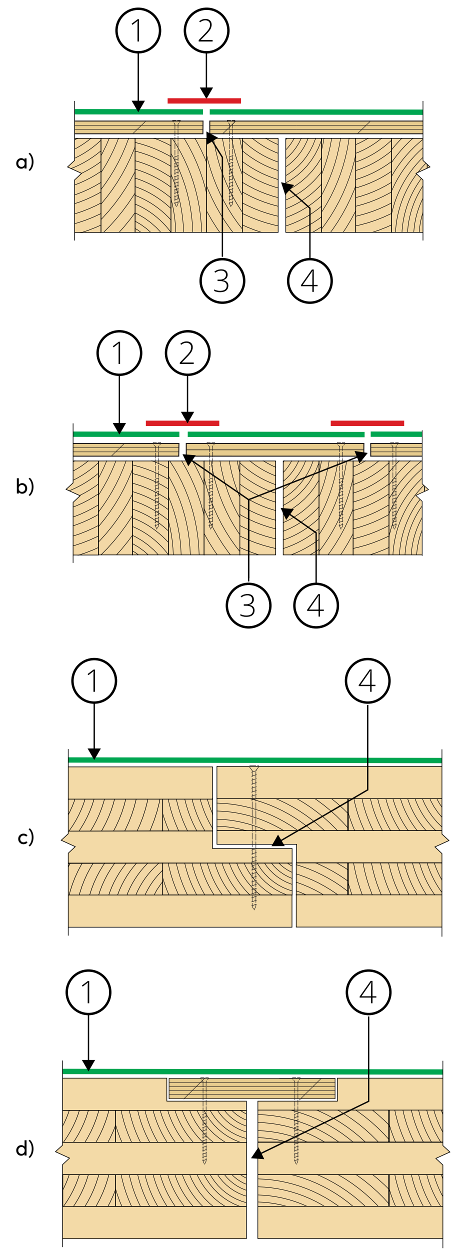
Moisture Protection Details

In addition to protection of the panel faces, site-installed protection measures are needed at building details and interfaces where the edge grain of the wood is exposed or in areas where moisture may penetrate deep into the panels. It is best practice to install protection details directly after mass timber panel placement. Protection details use materials like those in the moisture protection types shown in the table of mass timber moisture protection types included in **Appendix B** or membrane accessory products such as tapes and sealants.

Depending on project-specific requirements, protective membranes will be used in one of three ways:

- Short-term (removed prior to final assembly).
- Sacrificially (left in place but not considered part of the control layers).
- Permanently as part of the final assembly.

The edge grain absorbs water more quickly than the surfaces, so protection can greatly benefit moisture risk mitigation. Common details and interfaces that may need edge grain protection include joints, such as those between mass timber panels; and common building details, such as roof-to-wall interfaces, column-to-floor connections, penetrations, wall edges, structural attachments, and parapets. Additional photos of protection detailing examples are included in Step 3 of this guide. Additional steps may be needed to coordinate the joint detailing with structural and even fire requirements. Several examples of panel-to-panel connections are shown in **Figure 40** and typical moisture protection building details are described in **Table 5**.



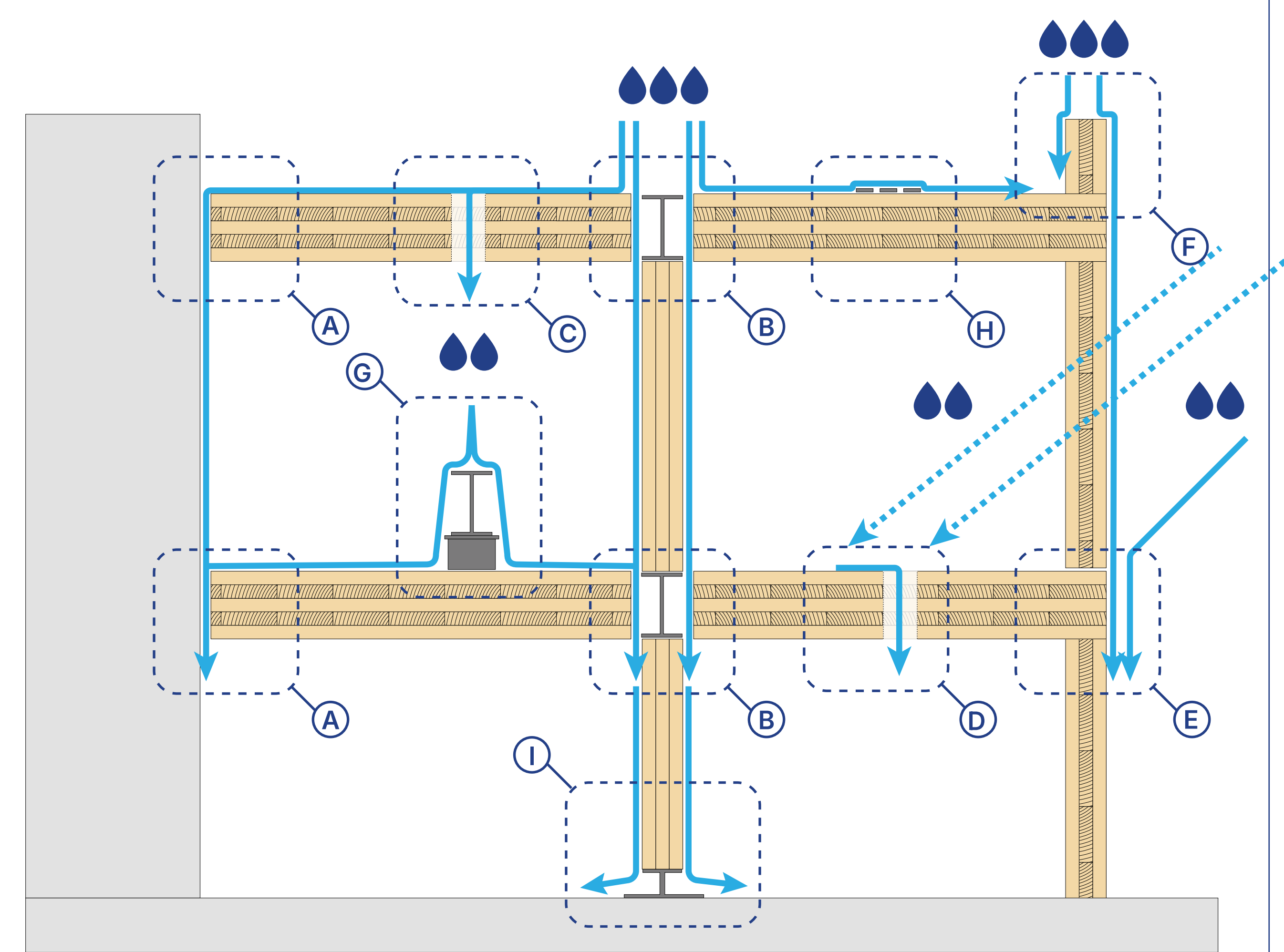
Legend

1. Moisture protection membrane or coating
2. Joint treatment such as tape or membrane
3. Structural sheathing break
4. Panel joint

Figure 40 Various panel-to-panel connections with joint treatment. Joints shown in a) and b) consider a single layer of structural sheathing over an NLT or DLT panel joint with a moisture protection membrane that has been pre-applied to the panel sheathing layer. Joints shown in c) and d) depict two options for CLT splice joint designs with a continuous moisture protection membrane across the panel top.

Table 5 Treatment of Common Mass Timber Building Details.

DETAIL KEY



Legend

- Low moisture exposure level
- Moderate moisture exposure level
- High moisture exposure level
- Moisture runoff path
- Wind-driven rain
- Common building detail; reference the lettered details on subsequent pages of this table for more information (X)

Table 5 (continued) Treatment of Common Mass Timber Building Details.

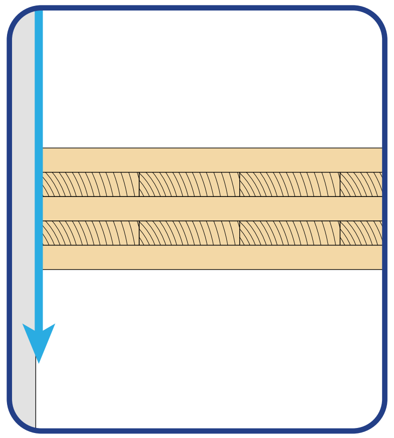
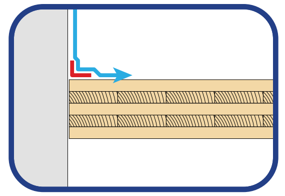
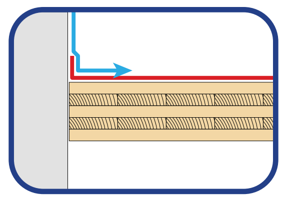
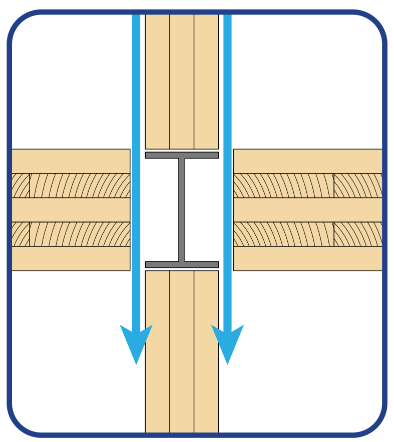
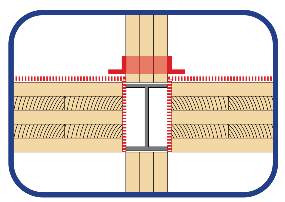
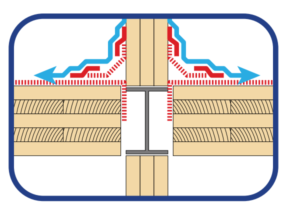
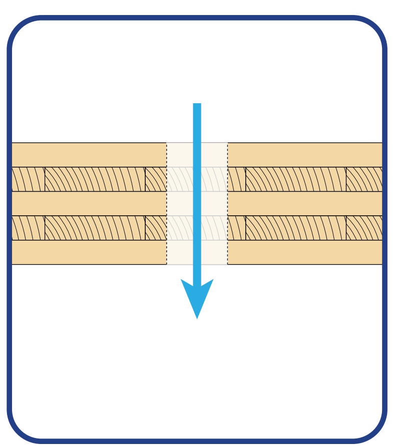
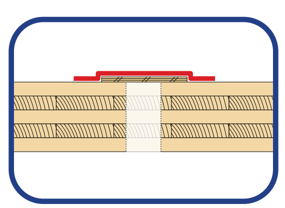
DETAIL	DESCRIPTION	DETAIL	EXAMPLE PHOTO
A	 Vertical-to-horizontal interface	 Tape or flashing	
		 Extend horizontal membrane up wall	
B	 Column penetration	 Seal around penetrations	
		 Tent at column	
C	 Penetrations through mass timber	 Plywood and membrane over penetration	

Table 5 (continued) Treatment of Common Mass Timber Building Details.

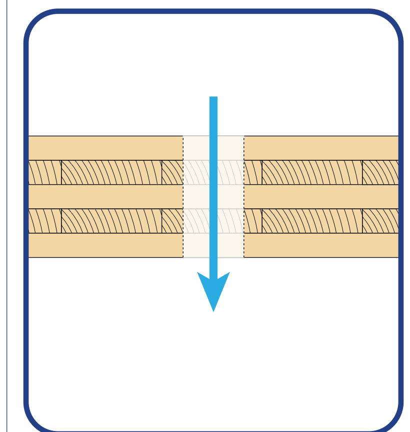
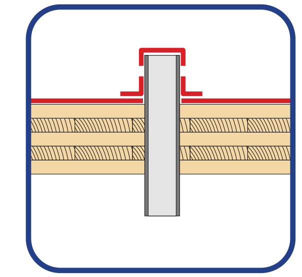
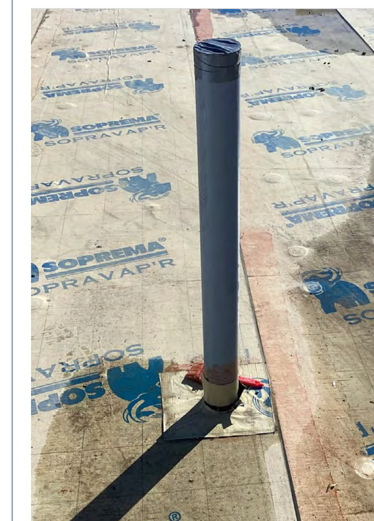
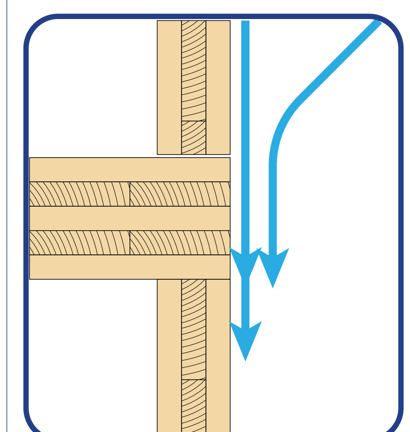
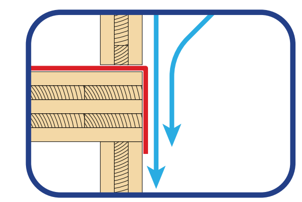
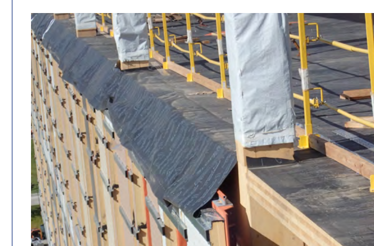
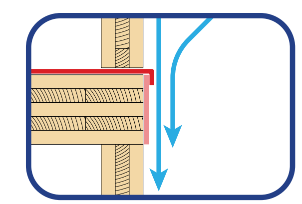
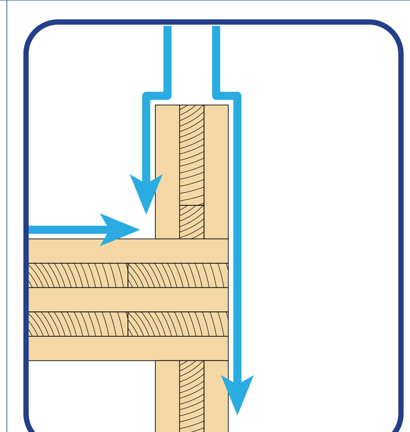
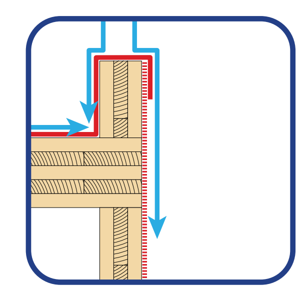
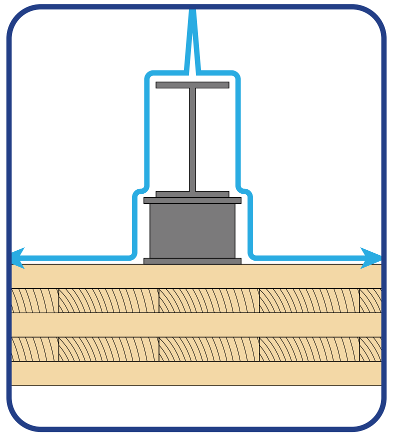
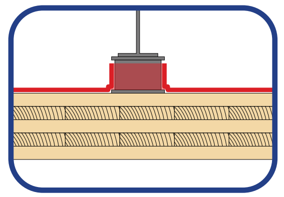
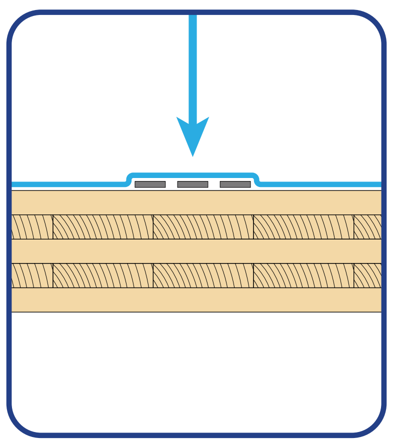
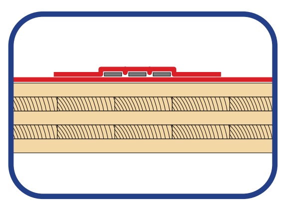
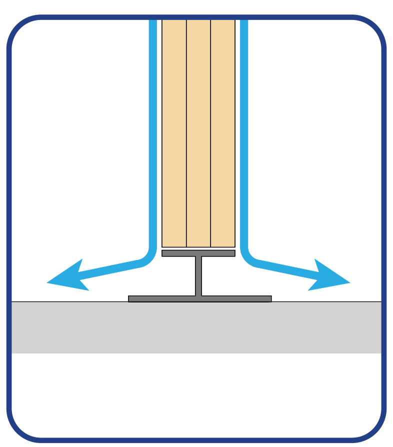
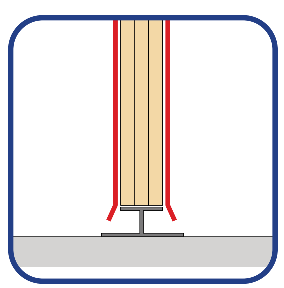
DETAIL	DESCRIPTION	DETAIL	EXAMPLE PHOTO
D	 Penetrations through mass timber	 Detailed penetration with temporary cover	
E	 Mass timber edge	 Overhanging house wrap or floor/roof membrane	
		 Wax coat and counterflash with floor/roof membrane	
F	 Mass timber parapet	 Membrane lapped up and over parapet	

Table 5 (continued) Treatment of Common Mass Timber Building Details.

DETAIL	DESCRIPTION	DETAIL	EXAMPLE PHOTO
G	 Structural connection	 Membrane around connection	
H	 Structural strapping	 Membrane over structural components	
I	 Column at concrete	 Factory wrap opened at bottom for drainage	

Step 1 Recap

During Step 1, the team will complete a risk assessment to evaluate the moisture protection strategies needed to adequately reduce the moisture risks to a level that is tolerable to the project. The following summarizes the planning efforts needed to complete Step 1:

- Before beginning a risk assessment, confirm that the project team is familiar with the five primary risks associated with exposing mass timber to moisture included in the section **Understanding Moisture Risks**, and make sure the team is on the same page regarding the project's tolerance to risk.
- Begin the risk assessment process by identifying the project's assembly design factors that will influence the potential severity of moisture risks and protection selection. Recall from the **Assembly Considerations** section that in some circumstances, such as for encapsulation requirements and the use of concrete toppings, the risk level is high even in moderate moisture exposure conditions.
- Next, categorize the construction moisture exposure level based on the factors in the section **Construction Phase Moisture Exposure**. The team can use these categories to identify when and where the mass timber experiences the highest risk to moisture during construction.
- Identify locations at higher risk of occupancy phase moisture exposure that can be factored into the moisture protection strategy selection.
- Finally, select moisture protection strategies. These strategies will include a combination of passive protection and active removal efforts. For passive protection, use the **Risk Assessment Matrix** on page 12 and Step 1 Risk Assessment Tools in **Appendix B**.

The combination of risk tolerance, moisture exposure level, and protection strategies will often differ between projects, and even differ between mass timber elements on the same building. Therefore, the process of selecting passive protection will typically be complete for each unique assembly or condition and as conditions change.

Throughout Steps 1 through Step 3, it is critical to be aware of the moisture exposure-protection-risk relationship represented in the **Risk Assessment Matrix**. Any changes to the assembly, moisture exposure, or protection measures should be reassessed for their impact on the anticipated moisture-related risk.

For an example of this process, refer to the **RDH Case Study: Step 1** on page 43 and the Applied Example in **Appendix C**.

Figure 41 Mid-construction of the mass timber Science Collaboration Centre in Chalk River, Ontario. Perimeter hoarding is installed as each floor is completed to protect the mass timber from moisture exposure (Canadian Nuclear Laboratories).

RDH Case Study: Step 1

Building name:	Science Collaboration Centre
Location:	Chalk River, Ontario
Use:	Mixed-use office building (office space, meeting rooms, auditoriums with theater seating, data center)
Number of stories:	6
Owner:	Atomic Energy of Canada Limited
Operator:	Canadian Nuclear Laboratories
Architect:	HDR Architecture Associates Inc.
Contractor:	Sullivan Chandos (CNL) JV Corp.
RDH role:	Mass timber moisture management consultant

About This Project

The Science Collaboration Centre (SCC) building incorporates a central concrete core, a ground-level and below-grade foundation, and a mass timber structure on levels 2 to 6. The primary structural system consists of CLT floor and roof panels and glulam beams.

During construction, the project team planned to use the level 3 CLT roof deck as lift access and material storage. All floors were to receive concrete topping. Due to project-specific requirements, installation of the fifth-floor construction would lag four months behind the completion of the fourth floor; therefore, the level 4 CLT floor panels needed to function as a temporary roof. The project team opted to use hoarding and tarping at the perimeter to maintain a warmer construction condition and provide moisture protection from wind-driven rain and snow (see **Figure 41**).

Step 1 Implementation

RDH was brought on as a consultant during the design phase of the project to make recommendations for protection methods and moisture control strategies during construction. RDH's scope included an educational presentation to ensure all members of the project team had a common understanding of the project's moisture risks. RDH also reviewed the SCC drawings to identify locations at highest risk for moisture-related damage and completed a level-by-level risk assessment of the mass timber elements.

During the design phase and prior to the start of construction, the project team held multiple collaborative meetings to discuss the project's moisture protection options. These meetings were attended by RDH, the architect, the contractor, and various subtrades (such as roofers). The focus of the meetings was to compile information on project-specific moisture exposure and requirements, the project team's risk tolerance, and any additional input from the meeting attendees.

Outcome

From the information gathered in the pre-construction meetings, RDH recommended protection methods and strategies that aligned with the goals of the project. Nearly every floor and roof had a unique protection type to reflect the unique robustness requirements and project-specific considerations. A summary of these assessments and recommendations is shown in **Table 6**.

By evaluating the protection types shown in **Table 6**, RDH was able to narrow down the protection choices to a few specific products that would meet the needs of the SCC project. For example, given the anticipated moderate moisture exposure for both the level 3 roof deck and level 3 floor, the team considered a vapor-impermeable self-adhered membrane (VIMP SAM). However, in this instance, the protective VIMP SAM at the floor did not need to be as durable, did not need to meet wind uplift requirements, and was exposed for a shorter duration than the VIMP SAM at the roof. Therefore, RDH recommended different VIMP SAMs for these locations. The VIMP SAM at the floor was a lower cost per square foot than the roof, but given the different project requirements, it was still able to achieve a level of risk appropriate for the project.

Due to the project team's early initiation of moisture management planning, the general contractor was able to use the information gathered during the pre-construction planning and RDH's recommendations to develop their own project-specific, written moisture management plan to be executed on-site.

Table 6 Level-by-Level Risk Assessment and Membrane Recommendations.

Mass Timber Element	Project-Specific Considerations	Moisture Exposure	RDH Recommended Protection Type*	Risk Assessment
Beams and Columns	→ Protected by floor above and perimeter hoarding	Low	Coatings, and use delivery wrap for protection on-site L	Balanced
Level 3 Roof Deck	→ High traffic with scaffolding and lifts (highly durable required) → Protection membrane to be part of the finished roof assembly → No option for factory-installed membranes	High	VIMP roof H	Balanced
			VIMP SAM M	Caution
			OR	
Level 3 Floor	→ Moisture exposure reduced when floor above is installed → No option for factory-installed membrane	Moderate	VIMP SAM M	Balanced
Level 4 Floor	→ Moisture exposure reduced when floor above is installed → Limited ability for active moisture removal due to safety concerns → No option for factory-installed membrane	High	VIMP roof H	Balanced
Levels 5 and 6 Floor	→ Concrete topping → Moisture exposure reduced when floor above is installed → Installed during drier months → No option for factory-installed membrane	Low	Top Coat and Edge Coat with taped joints L	Balanced
Upper Roof	→ Multiple options for factory production → High traffic with storage (highly durable required) → Protection membrane to be part of the finished roof assembly	High	Factory-installed VIMP roof H	Balanced
			OR	
			Factory-installed VIMP SAM M	Caution

* See the moisture protection types in **Appendix B**.

Drains in the mass timber roof structure are connected to discharge to the building exterior and away from wall areas, minimizing the risk that water will reach the floor below.

Step 2 | Develop a Construction Phase Moisture Management Plan

The Written Moisture Management Plan

Early design considerations that limit the moisture exposure of the mass timber elements can reduce the moisture-related risks. However, effective moisture management depends on the contractor executing both passive and active moisture management strategies throughout the construction phase. The following sections provide guidance for developing a construction phase moisture management plan from pre-delivery to project completion. This plan will help prepare the project team for managing construction phase moisture and possible unexpected exposure risks.

A mass timber moisture management plan is a package of documents that includes a written plan plus supplemental documents that support the execution of the written plan. The list of **Common Moisture Management Plan Documents** on page 49 identifies documents commonly included in a moisture management plan package that is submitted to the design team prior to construction.

The written moisture management plan includes moisture protection efforts for all stages of construction: from the factory (factory-installed protection) to delivery to site, storage, site installation (erection, site-installed protection), and the moisture management strategies used throughout construction until the building is considered watertight.

A project may include design requirements in the construction documents similar to the example of the moisture management specification included in **Appendix A**. Specification requirements can be used as a starting point to develop the moisture management plan document package. Contractors can also use the self-guided **Construction Mass Timber Moisture Management Tool** on page 50 to understand typical scenarios that may occur during construction. Contractors can apply this understanding to develop a written plan that accounts for multiple scenarios in their own project-specific moisture management plan. A thorough plan will include written instructions for expected and unexpected scenarios, like those in the tool, that arise on-site.

The contractor's written plan is customized to the project-specific design. Additionally, the plan documents the protection methods identified in Step 1 of the moisture management process. The written plan will typically cover the following topics:

- ❑ **Schedule of materials and moisture protection methods.** This schedule is an inventory of all mass timber elements and the moisture protection methods selected in Step 1. The methods may be articulated as written descriptions or through redlines on the assembly drawings.
- ❑ **Construction schedule and delivery plans.** This schedule may include plans for just-in-time delivery to minimize staging needs and moisture exposure risks. It also may include plans to schedule installers (such as a waterproofing subcontractor or roofing subcontractor) at the time of panel installation to ensure moisture protection membrane detailing work is performed in parallel or shortly following panel placement.
- ❑ **Water removal and drainage plans.** These plans may include instructions about when an on-site active water management team will be employed and what methods will be used to remove standing water from unsloped mass timber areas using mops, squeegees, and shop vacuums.
- ❑ **Monitoring plans.** These plans will include protocols for monitoring the mass timber throughout all construction stages (factory, transportation, storage, and installation). They may also describe the frequency that quality control and quality assurance (QC/QA) checklists or forms will be completed. For instructions on taking moisture content readings that can also be included in a written plan, refer to the section **Moisture Content Reading** in Step 3.
- ❑ **Drying plans.** These plans will identify a strategy to add heat and/or ventilation to dry the mass timber elements if exposed to moisture. Drying plans will include measures to monitor humidity and may recognize that the overall depth of the mass timber and the extent of water intrusion (should it occur) will determine the most effective drying strategy.
- ❑ **Stain removal plans.** These plans will identify a strategy to clean, sand, or refinish the mass timber if wetting or staining occurs and the resources that will be ready on-site for use if needed.

The moisture management process Applied Example in **Appendix C** demonstrates how the **Construction Mass Timber Moisture Management Tool** can be used to guide construction phase activities. It also contains an excerpt of the project-specific construction phase moisture management plan.

Common Moisture Management Plan Documents

In addition to the written plan described in the previous section, the documents listed below are commonly included in a moisture management plan package that is submitted to the design team prior to construction.

1. **Mass Timber Delivery Acceptance Checklist.** This checklist or form will be filled out on-site at the time of a mass timber delivery. The document will identify the minimum number of moisture content readings to be taken at delivery acceptance, moisture content limits established by the project team, procedure if the mass timber does not meet the moisture content limit, and contact information for the person to contact if the mass timber does not meet the moisture content limits established by the project team.
2. **Site Plan.** This document will include a site plan of the project site and identify the designated material storage area(s). The plan will also provide other relevant information, such as the location of the on-site moisture meter.
3. **Moisture Management Details Package.** This document includes sketches or redlined details that identify the moisture protection methods to be used at mass timber building details and panel joints and edges.
4. **Drainage Plan.** This plan identifies the appropriate drainage paths for controlling site water. It will also include where to direct water off roof edges, at piped drains, etc., for all floors and the roof. The drainage plan may vary by stage of construction (for example, water may no longer be directed over the edge of the roof or over exterior walls if parapet installation is complete).
5. **Daily/Weekly Checklists.** These checklists or forms will be filled out on-site at regular intervals. The checklists include items monitored or performed at regular intervals such as moisture readings, monitoring moisture protective membranes for damage, monitoring the weather forecast, and reviewing the underside of mass timber panels for leaks. They include specific information on the locations to take moisture measurements (such as at different depths and at areas where water can become trapped), how many locations, and the documentation protocol.
6. **Pre- and Post-Pour Checklists.** These checklists or forms will be filled out on-site before and after a concrete pour onto a mass timber element. The document identifies the minimum number of moisture content readings to be taken prior to concrete pours and the moisture content limits established by the project team. They may also outline the required sequencing requirements prior to pouring concrete and post-pour protection methods and monitoring.
7. **Pre- and Post-Membrane Checklists.** These checklists or forms will be filled out on-site before and after a membrane is installed on or over the mass timber elements. Membranes include temporary protection or parts of the final assembly such as roofing or the roofing vapor barrier. These checklists identify the minimum number of moisture content readings to be taken prior to membrane installation and the moisture content limits established by the project team. They may also outline the required sequencing requirements prior to membrane installation. Post-membrane protection methods, repair methods, and monitoring are also included.
8. **Other.** Any other documents or information pertaining to construction moisture management not included in the above items may be included in the written plan or as separate documents. Examples include:
   - Clarification on roles and subcontractor responsibilities
   - Clarifications on any field visits requirements by a third-party building enclosure firm/ commissioning agent
   - Mock-up requirements

Construction Mass Timber Moisture Management Tool

On-site moisture management for mass timber construction from delivery to enclosure completion.

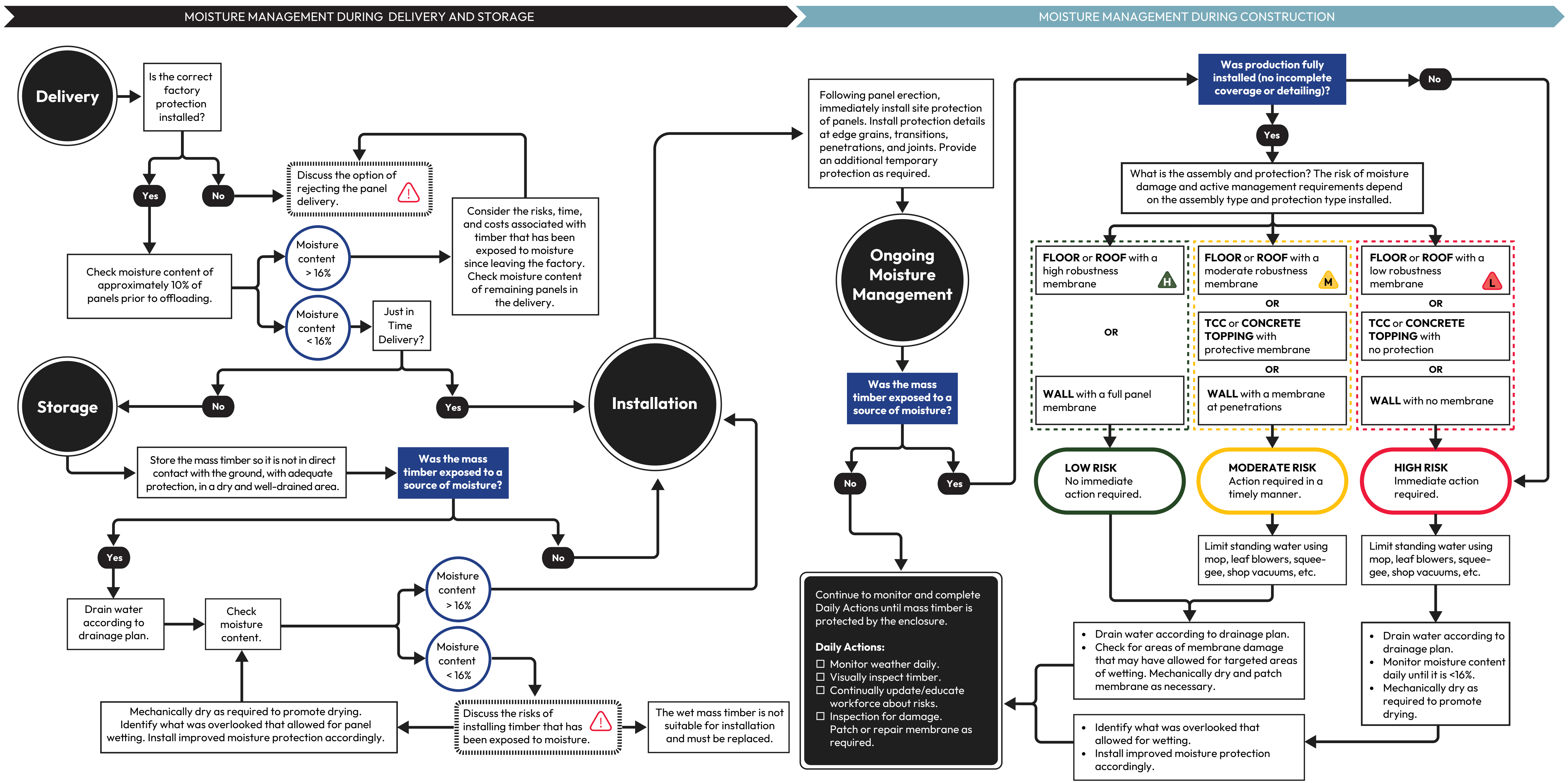


Figure 42 Tall Timber Student Housing, Burnaby, BC.

RDH Case Study: Step 2

Building name:	Tall Timber Student Housing
Location:	Burnaby, British Columbia
Use:	Post-secondary student campus housing
Number of stories:	12 (two connected perpendicular wings)
Owner:	British Columbia Institute of Technology (BCIT)
Architect:	Perkins&Will
Contractor:	Ledcor
RDH role:	Enclosure and facade consultant

About This Project

The 12-story Tall Timber Student Housing building on the BCIT campus comprises two perpendicular, rectangular wings designed to provide affordable housing for 469 students (see **Figure 42**). The primary structure is a post and plate design with CLT floor and roof panels and steel columns. Steel-braced frame stair and elevator cores provide lateral resistance. The project design also includes a panelized façade system to allow the exterior of the building to be enclosed quickly and efficiently.

As a high-rise mass timber building under construction during BC's rainy winter season, the project was at high risk for moisture exposure and mitigation concerns. The project team was aware of the need to enclose the building as quickly as possible.

Step 2 Implementation

The general contractor, Ledcor, in consultation with RDH and other members of the project team, produced a detailed moisture management plan to address mass timber-related moisture risks during construction. The written plan was updated several times to address new and unforeseen risks. For example, the temporary moisture protection for the CLT floor panels was upgraded when the erection schedule for the timber shifted to the wetter winter months.

The construction team's mass timber moisture protection strategy relied on a tiered implementation approach:

1. Minimize wetting of the CLT through rapid erection of the structure and exterior façade (see **Figure 43**).
2. Install a robust, factory-installed, vapor-permeable self-adhered membrane at the floors (see **Figure 44**) and vapor-impermeable roofing base sheet at the roof (**Figure 45**).
3. Use temporary waterproofing details and passive drainage.
4. Take frequent measurements of the CLT panel moisture contents to identify and address wetted wood before "over-wetting" could occur.
5. Apply active water management strategies, including removal of standing water from active floor levels.
6. Dry CLT panels (if needed) with heaters and dehumidifiers.

Developed with the support of 4D construction simulations, the plan considered the schedule and sequencing of the mass timber erection as needed to minimize mass timber moisture exposure. It also included delivery and handling of mass timber elements when they arrived on-site as well as monitoring measures for the mass timber elements when they were erected on-site. A series of project-specific QC checklists were developed to ensure that the general contractor and mass timber-related subtrades completed the necessary inspections and moisture surveys during the construction to mitigate risk.

The plan included both passive and active moisture protection measures for the mass timber elements. Since the roof CLT panels were anticipated to experience extended exposure, the plan called for installation of a factory-applied waterproofing membrane at the mass timber fabrication facility. The floor CLT panels were scheduled to receive factory-installed temporary moisture protection to mitigate exposure to precipitation prior to and after the façade installation. A series of temporary waterproofing details and drainage plans were also devised to protect the mass timber during construction and to allow for effective removal of standing water.

The moisture management plan also included drying and remediation measures in the event of mass timber wetting. These measures included fans, electric heaters, dehumidifiers, and mold and stain remediation measures if needed.

Outcome

Due to Ledcor's proactive approach to mass timber moisture management, the project team was equipped with a comprehensive plan that identified the responsibilities of key construction team members and limited project risk. The early planning completed by Ledcor and the project team was critical to the successful execution of the project during construction.

To learn about the execution of this project's moisture management plan, read the **RDH Case Study: Step 3** on page 79.

For an example of the preparation and execution of a moisture management plan, see the Applied Example in **Appendix C**.

Figure 43 Prefabricated facade walls being hoisted into position for installation.

Figure 44 Factory-applied vapor-permeable moisture protection membrane over CLT at the intermediate floor level.

Figure 45 Factory-applied roofing base sheet moisture protection over CLT at the roof level.

An on-site crew is mobilized to remove the snow buildup on a mass timber floor using a variety of active removal strategies during construction.

Step 3 |
Execute the Design and Moisture Management Plan

Construction Phase Project Execution

The design of the mass timber building and its enclosure elements comes to life during Step 3 when the design and moisture management plan is executed. The careful planning performed by the design, construction, and ownership teams is put into action (see **Figure 46** and **Figure 47**). During Step 3, the team will continue to supervise and maintain the plan to make sure it is being executed as intended. They will also adapt the plan as necessary to address changing needs or conditions.

The following list summarizes the features of a successfully executed moisture management plan.

1. **On-Site Responsibilities**: understanding of the moisture risks and each individual's responsibility by all members of the project team.
2. **Installation of Moisture Protection Measures**: quality installation of moisture protection measures during the shipping, storage, and installation of mass timber elements, including the installation of detailing, and maintenance of the measures.
3. **Active Water Removal and Drainage**: consistent, active water management and safe water drainage.
4. **Moisture Content Monitoring**: ongoing monitoring of moisture content and QC/QA of the mass timber elements and protection.
5. **Mechanical Drying**: timely response to wetting events if they occur.
6. **Enclosure Close-In Tasks**: successful execution of additional tasks, including stain removal and building commissioning, that are completed after enclosure close-in.

The written construction moisture management plan completed in Step 2 will typically cover most of the items listed above. However, the thoroughness of the written plan can often influence the team's success with the plan's execution.

This Step 3 section of the guide will discuss the above features and provide examples of their successful execution as well as lessons learned from past projects. The Step 3 section demonstrates the value of a thorough written plan and provides a resource for on-site best practices.

Figure 46 CLT panel with factory-applied protection being craned into position.

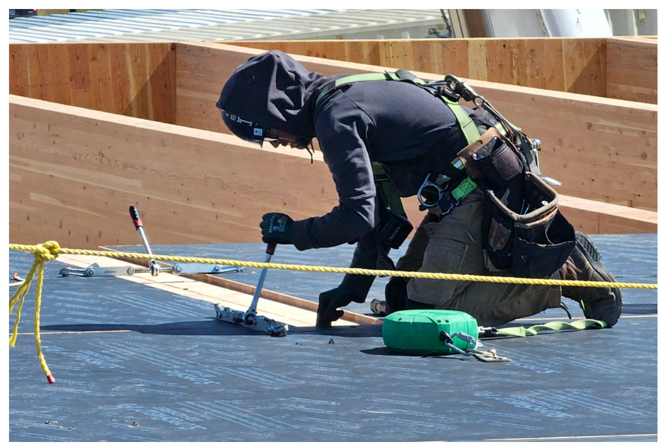


Figure 47 A mass timber installer securing the CLT panel placement.

Moisture Management Execution Examples

For examples of successful moisture management execution, refer to the case studies included at the end of Step 3 and the Applied Example in **Appendix C**. These examples show how the project team may execute the written plan and may need to adapt their plan to maintain a tolerable level of risk through changing circumstances.

On-Site Responsibilities

Successful reduction of moisture-related risks depends on the on-site efforts of the general contractor team, installers, and general on-site crew. Clear communication of roles and responsibilities typically results in better accountability from the construction team.

It is typically best practice to have a few key individuals be responsible for understanding and overseeing the execution of the moisture management plan. Often, a superintendent of the general contractor serves in this role. The responsibilities of these individuals will differ by project but will typically include:

- Coordination of various laborers and subtrades crews for water removal (see **Figure 48**) and stain removal.
- Oversight of protection installation quality.
- Review of QA/QC checklists.
- Serving as the main contact and decision-maker for moisture-related events.

It is also valuable to educate the general site workforce on moisture-related risks, encourage them to report leaks or damage, and help them understand their responsibility to protect the mass timber from their work. **Figure 49** and **Figure 50** show examples of damage to the membrane and mass timber caused by construction work. Signage on-site that specifies the moisture risks, what to report, and contact information for reporting is often recommended.

Figure 48 An on-site crew is mobilized to remove water from a mass timber floor using squeegees and shop vacuums.

Figure 49 Holes in the protective membrane where a temporary fall protection anchor was installed. A membrane patch was not installed once the anchor was removed.

Figure 50 Mass timber beam with discolorations caused by staining from iron filings.

Installation of Moisture Protection Measures

Mass timber may be exposed to construction moisture during transportation, on-site storage, and installation until the final building enclosure is complete. During all of these phases, passive moisture protection measures are needed to prevent wetting of the mass timber.

Transportation Moisture Protection Measures

A water-resistant coating is usually applied to the mass timber in the factory; however, this coating is not adequate to protect the mass timber from water experienced during transportation. Typically, in the factory, the mass timber elements are individually wrapped and/or the truck transporting the elements will be completely covered by a durable tarp. This moisture protection also protects the mass timber elements from dirt, damage, and discoloration from exposure to sunlight experienced during transportation.

If the mass timber is anticipated to experience higher volumes of rain or it is transported a significant distance, factory wrapping and truck coverage may be used together for increased moisture protection. If the mass timber panels have a factory-installed membrane, the panels are stacked protection side up (see **Figure 51**), and extra care is taken to prevent damaging the membrane during the loading and unloading process.

Quality installation of transportation moisture protection includes confirming all factory wrapping is free from damage, tarping is secure and sloped to drain water, and the mass timber elements are elevated off the truck bed to separate them from any moisture on the surface (see **Figure 52**).

Figure 51 Panels are delivered to site and installed directly from the truck. The panels have a protection membrane installed to the face of the timber.

Figure 52 A mass timber panel is transported to the construction site on a truck bed. The mass timber is completely covered in a secure, heavy-duty tarp.

Storage Moisture Protection Measures

It is best practice to utilize just-in-time delivery to eliminate the need to store mass timber elements on-site. However, if storage is required, best practices for storage moisture management include the following:

- The mass timber members are stored flat on level blocking off the ground.
- The storage location is well drained.
- The storage location is protected from rainwater or covered with a secure and durable tarp that is sloped to allow for drainage. See **Figure 53** for an example of inadequately stored CLT.
- Blocking is placed between stacked bundles to promote drainage and airflow. Blocking is aligned vertically.
- The factory protective wrapping is kept on the mass timber elements, but the wrap is cut on the underside of the timber to allow airflow and to drain any water.

Even if the mass timber is stored according to these best practices, the timber and protection are regularly reviewed with visible inspections, and moisture content readings are taken after rain events.

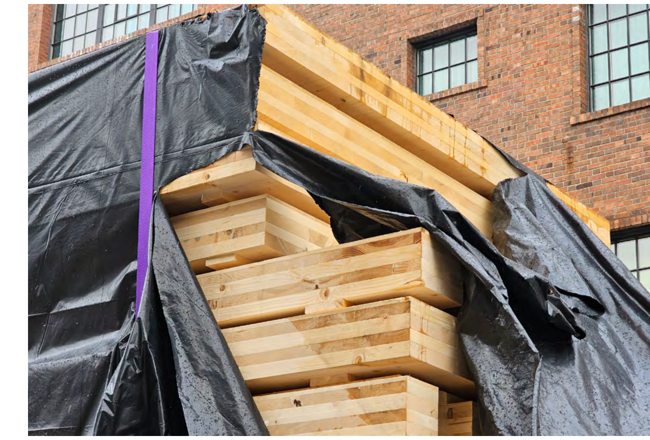


Figure 53 CLT panels covered in plastic when stored on-site. The plastic was not durable and not secured, leading to the exposure and wetting of the stored panels.

On-Site Moisture Protection Measures

Water can travel into discontinuities in the protective membrane, such as unsealed laps, unsealed penetrations, or areas of damage. This water leakage will lead to wetting of the mass timber elements. Therefore, successful moisture protection depends on the quality of the installation of the protective measures and details, the transition detail's design, and maintenance of the protection.

Even if the protection measures are not part of the final assembly, it is best practice to confirm that all protective measures are adequately installed. When loose-laid protection is used, such as tarps, it is important to adequately drape and secure the protection so that it does not collect water or blow off (see **Figure 54**). Water can often collect in the tarps, so strategies to safely remove the water will need to be considered. Typically, hoarding and tenting (see **Figure 55**) are more effective than loose protection.

Quality installation includes confirming that the protective membrane installation is consistent with the membrane manufacture requirements and all laps are adequately sealed (see **Figure 56**). At areas of high moisture exposure and low tolerance to moisture risks, consider installing additional accessory products such as sealant, tapes, or transition flashing at membrane laps or transitions to further reduce the risk of wetting the mass timber.

Figure 54 A tarp installed over the mass timber parapet at a roof has left a portion of the roof exposed and at risk of wind-driven rain migrating under the edges of the tarp. Water is not able to drain from the tarp, so removal with shop vacuums or pumps is required.

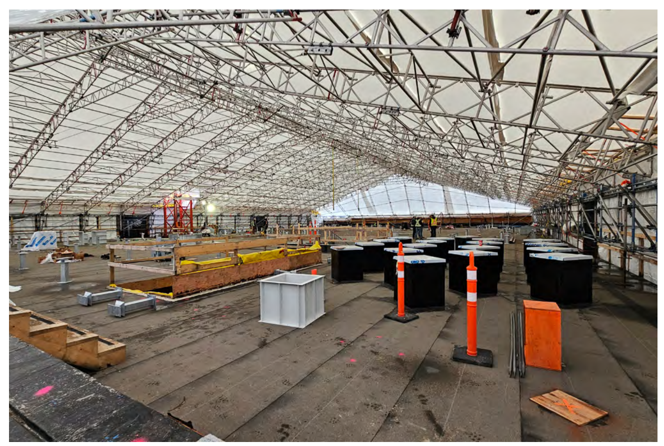


Figure 55 A tent installed over the roof of a mass timber building.

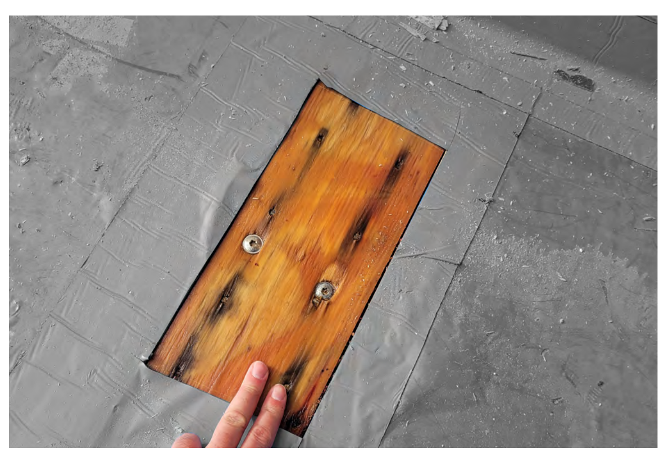


Figure 56 A vapor-impermeable roof membrane with laps that were insufficiently sealed. The poor seal resulted in water migrating under the membrane and wetting the CLT. In this case, the membrane had to be removed at wet locations to allow the CLT to dry, which increased costs due to project schedule delays and purchase of replacement materials.

Transition details are the most sensitive to moisture exposure because the end grain of mass timber absorbs water more readily than its surface, and transition details are more susceptible to trapping moisture. It is recommended to document the intention of temporary protection detailing in the moisture management planning package. The documentation makes it easier to communicate detailing intentions to the relevant installer and prevents the installation of details that do not effectively protect or manage water on-site.

Figure 57 and **Figure 58** show two examples of temporary moisture protection details of variable quality. In **Figure 57**, the column temporary protection detail sealed the bottom of the CLT floor panel to the top of the column on the floor below with sealant. This seal created a basin for water to collect against the end grain of the CLT floor panel. The end grain of the CLT is not protected by the floor membrane. This detail is at high risk for staining and water absorption deep into the CLT panel through the end grain, which will need to be mechanically dried.

The column temporary protection detail in **Figure 58** used a liquid-applied membrane to continuously transition the floor membrane to the column, effectively protecting the end grain at the column connection installed at the base of a column.

Once the membrane is installed, maintenance efforts are needed to adequately protect the mass timber (see **Figure 59**). As part of the on-site QA/QC process, it is recommended that the team regularly review the membrane for damage and construction progress that creates new discontinuities. Early considerations for sequencing can sometimes reduce the amount of on-site repair and patching needed.

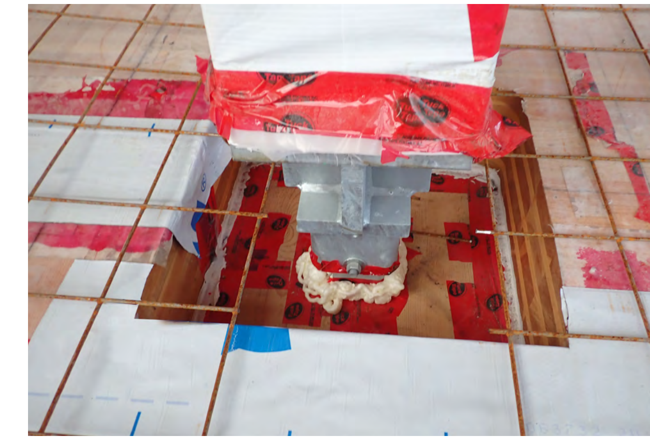


Figure 57 A temporary column detail that could collect water and does not adequately protect the end grain.

Figure 58 A temporary column detail that prevents water from traveling into the column connection.

Figure 59 A mass timber roof where the protective membranes were regularly repaired and patched. Membrane patches and strips were installed over panel joints, areas of damage, and structural steel connections.

Active Water Removal and Drainage

On-site moisture management is a combination of passive management (membranes, tarping, tenting, protection details) and active management. Passive moisture management is not enough on its own. Consistent active water management and safe water drainage are essential to reduce moisture-related risks.

It is important that equipment and labor are available on-site for active water removal tasks. The amount of active management will be dictated by the protection robustness level of the selected membrane. Following a rain event, the team can proceed with the level of active management appropriate to the level of protection robustness installed (refer to the Step 1 discussion of robustness for more information).

The need for active water removal will fluctuate due to the season and weather conditions, the construction stage (such as whether the floor above or the walls are installed), and other variables. Variables such as those listed in the section **Construction Phase Moisture Exposure** affect the moisture exposure level; therefore, the available labor will need to fluctuate as well. The equipment needed on-site may change as construction conditions or seasons change. See **Figure 60** for examples of different active water removal methods.

a) Store-bought squeegee.

b) Handmade squeegee.

c) Push broom.

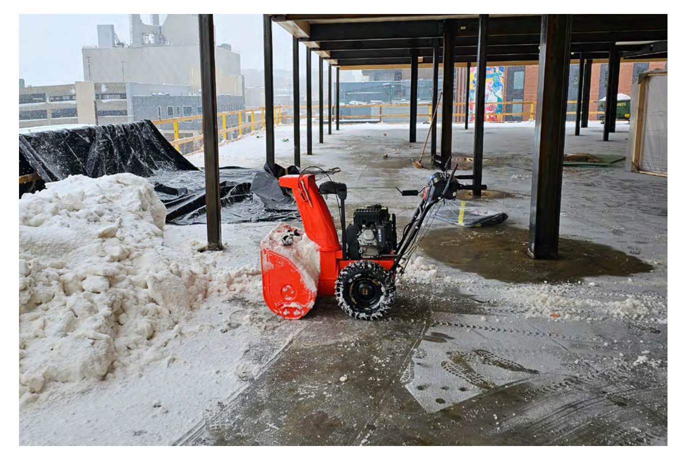
Figure 60 Examples of active water management.

d) Vacuum/pump.

g) Commercial floor cleaner.

e) Snow shovel.

h) Water collection with kiddie pools (other collection devices like pails can also be used). The collected water is regularly removed from the building.



f) Snow blower.

i) A tarp used to collect snow, which is then removed from the building using the overhead crane.

Figure 60 *(continued)* Examples of active water management.

The RDH case studies on page 75 and page 79 demonstrate the key differences between projects that rely more on passive versus active moisture management strategies. As shown in the case studies, more reliance on active management can be an effective strategy when done correctly. The most common problems occur when active management is not maintained and when water is not safely drained. Water that can pond and is not actively drained is at higher risk of bypassing the membrane laps or areas of membrane damage; water can also wet through vapor-permeable membranes (see **Figure 61**).

Water needs to be safely drained away from moisture-sensitive material. When developing the moisture management plan, the team is advised to consider drainage paths during all stages of the project's construction. Multiple drainage and removal strategies may be required as the building progresses. The most common drainage strategies are temporary or edge drains. When using temporary floor or roof drains, the team is advised to coordinate their installation as soon as possible after the panels are installed and to ensure that the water through the drains is collected or redirected out of the building (see **Figure 62**). When draining water off the edge of a roof or floor, it is important that the edge of the wood panel and any moisture-sensitive material below are protected.

Figure 61 Mass timber roof where ponding water is not being removed. Water has gotten underneath the protective membrane through laps and areas of damage to the membrane, resulting in wet mass timber and staining.

Figure 62 A temporary roof drain connected to hosing that directs the water outside.

Moisture Content Monitoring

A key part of executing a moisture management plan is to visually inspect (see **Figure 63**) and take moisture content readings (see **Figure 64**) of mass timber elements on an ongoing basis. When done effectively, moisture readings are a valuable tool that will help the construction team with these tasks:

- Make improvements to the passive/active moisture management methods.
- Identify any areas where moisture is becoming trapped.
- Monitor active/natural drying trends.
- Provide baseline data of the wood structure ahead of encapsulation, roofing, or other activities that will conceal the wood.

Taking moisture readings at only the surface of the panels will not be helpful. It is also not an effective use of time to fully map out with precision the moisture content of all areas of the mass timber. Taking moisture readings at appropriate times (see **Figure 65**) is the best use of project resources and will generate the most relevant and useful results.

The moisture content reading guidance in the following section can be a useful addition to any moisture management written plan package.

Figure 63 Visual inspection of mass timber floor during the construction phase to identify areas of damaged membrane, trapped water, etc.

Figure 64 Moisture content reading taken at the base of a mass timber column that has been exposed to moisture.

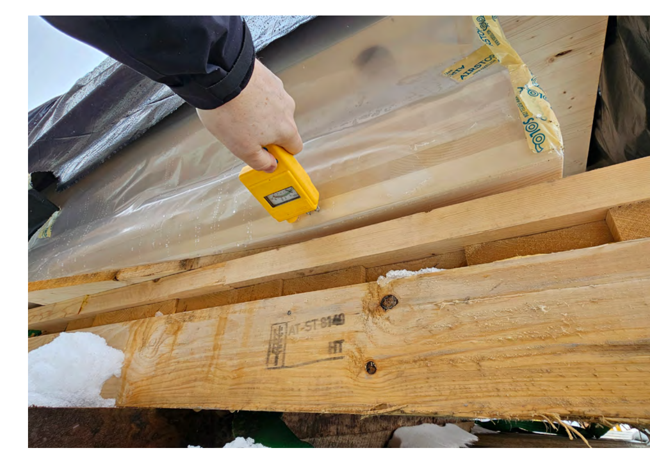


Figure 65 A worker takes a moisture content reading of a CLT panel that is stored on-site as part of the regular monitoring requirements outlined in the project's moisture management written plan.

Moisture Content Reading

Why to Take Readings

Any elevated moisture that remains trapped within mass timber post-construction may lead to long-term decay and damage. Areas of elevated moisture content are not always visible and may go undetected under spline material, membranes, and elsewhere if the moisture content is not monitored (see **Figure 66**).

When to Take Readings

On-site moisture measurements and monitoring are performed beginning with the on-site delivery of the mass timber elements. Measurements and monitoring continue periodically during construction as part of regular QC plans.

It is best practice to take and document readings following rainfall or other wetting events. If construction occurs in the rainy season, it may be more appropriate to take regularly scheduled readings (such as weekly or twice a week). Standard QC practices involve taking and documenting readings prior to covering the mass timber with an impermeable material or before applying a concrete topping.

Surface water can affect the moisture meter's ability to take accurate readings; therefore, it is not typically recommended to take readings during a rain event. Moisture measurements are generally more beneficial if taken after a rain event when most of the moisture has evaporated or has been removed from the horizontal surfaces. If a wet mass timber element is identified, the team can take regular readings more often until the wood is confirmed to be dry (that is, when its moisture content is less than 16%).

How to Take Readings

Moisture readings are taken using a moisture meter with pin probes and extension pin probes for deeper measurements (see **Figure 67**). Moisture meters need to be calibrated, and their readings may need to be adjusted based on the temperature and wood species of the panel identified by the meter's manufacturer requirements. When larger pin probes are used, the hole in the membrane made by the probes will need to be patched.

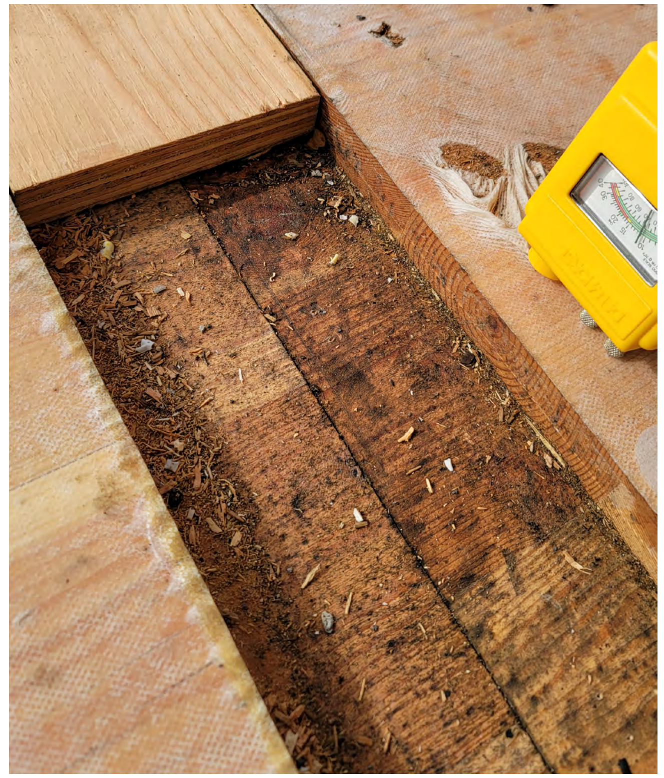


Figure 66 Mass timber joint with its spline removed and wet wood visible. Moisture was trapped undetected under the spline.

Figure 67 Moisture content reading taken through the panel spline using a moisture meter with extension pin probes.

Where to Take Readings

The goal of moisture content reading is to help the team understand what areas are wet and how wet the wood is within different materials and at depth in the most practical manner possible. Therefore, it is best practice to take readings that reflect the overall wetting/drying conditions at each level and condition, and at areas that are more susceptible to moisture absorption. The following locations are valuable to measure:

- Locations where the membrane has not yet been installed.
- Locations where water is able to get past the protection. These locations may include areas where the membrane is damaged (see **Figure 68**), at unsealed structural attachments, and at fastener penetrations.
- Edge grain locations such as panel perimeters and penetrations.
- Along protective membrane laps/seams.
- Typical concealed locations, including panel splines (see **Figure 69**), within the panels below roofing membranes, at structural beam and column interfaces, and at embedded structural connections.

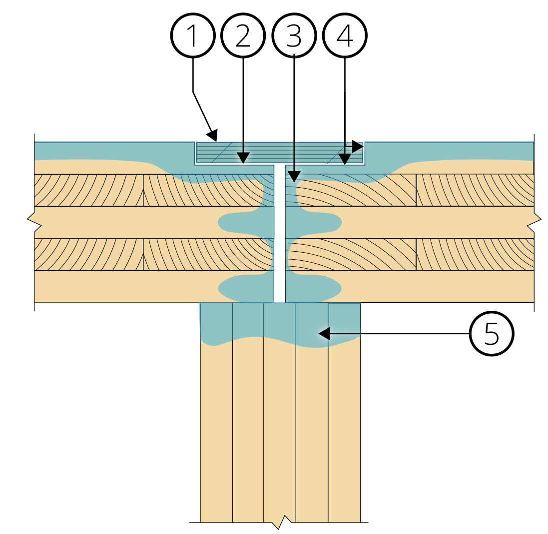
How to Document Readings

When documenting moisture contents for project QC checklists or reports, the following observations will provide context for the documented measurements:

- Weather and rainfall amount beginning 48 hours ahead of the visit
- Current air temperature
- Current relative humidity
- Active weather conditions on-site during the site visit

It is recommended that the reports include floor plan drawings that identify mass elements (including panels, spline material, and glulam beams), moisture measurements, and observations. When recording moisture measurements, it is sufficient to record the nearest whole percentage. Typically, the documentation of the moisture readings is part of QC checklists like those included in the **Common Moisture Management Plan Documents** on page 49.

Figure 68 Moisture content reading taken at area of membrane damage.



Legend

1. Absorbed into the spline material
2. Between the spline and panel
3. Absorbed into the panel edge grain
4. Absorbed into the recess in the panel
5. Pooling or absorbed at the top of the column

Figure 69 Concealed wetting at panel splines.

Mechanical Drying

Wood can typically dry out over time when the water source is removed under favorable environmental conditions (sun, wind, or dry air). Cool and damp weather conditions will reduce the ability of the mass timber elements to dry out naturally. If some wetting of the mass timber does occur and the moisture content is elevated, the following conditions may trigger the need for contingency drying efforts. If one or more of these conditions exist, then mechanical drying efforts may be considered.

- **Significant or deep wetting.** The mass timber has a high moisture content deep into the panel of end grain.
- **Trapped water.** The mass timber is wet and covered by membranes, finishes, or other materials that will slow/prevent drying.
- **Natural drying limitations.** The mass timber has a high moisture content and the weather predicts more wetting or cool temperatures that will reduce/prevent the ability for natural drying.
- **Scheduling restriction.** The mass timber that is scheduled to be covered or encapsulated has an elevated moisture content (above 16%) and waiting for natural drying is not tolerable to the construction schedule.

Post-installation drying should not be considered a regular step in the construction of a mass timber building. Post-installation drying of mass timber elements may be identified as an emergency response only if wetting exceeds the recommended moisture content thresholds. When the construction team uses mechanical drying in lieu of natural ventilation, it is advised to use generalized heating and dehumidification (see **Figure 70**) in combination with ventilation.

Checking can occur when the mass timber is dried too much or too fast, and if drying occurs unevenly. Therefore, the drying process may be adjusted whether the wet mass timber will be covered or visible in-service (and depending on the risk tolerance to checking). Fans that increase air movement without additional heat have the lowest risk of causing checking, but this method may take more time. When drying mass timber, temporary heating units (space heaters) are not typically used for direct heating applications; instead, a tented area is heated using fans or other ventilation methods (see **Figure 71**).

Membranes on the mass timber panels typically need to be removed to allow for drying. If the need for drying is for significant areas of mass timber or is a recurring event, tenting may be considered.

Figure 70 Heater and dehumidifier used in response to a moisture exposure event.

Figure 71 Localized drying under plastic sheets to address wet splines.

Enclosure Close-In Tasks

After the mass timber structure and the building enclosure are installed, additional steps may be needed prior to project close-out. These steps may include stain removal and controlling the drying and dehumidification of the mass timber.

Stain Removal

Post-installation stain removal may be required if the project has visible mass timber elements. The project's planned moisture management strategies are intended to prevent a concerning or severe level of water staining and iron staining. Most projects have some tolerance to staining, and it is standard practice to include a budget for labor and materials associated with treating these stains. Stain removal through chemical treatment or sanding can remove some level of staining. However, if water is not properly managed, excessive staining like that shown in **Figure 72** and **Figure 73** is difficult and costly to remove, and may still be visible after cleaning, sanding, and refinishing.

Stain removal is typically performed after the building is watertight.

Sanding can remove some surface stains; however, coatings that may exist on mass timber elements may need to be reapplied after sanding. The reapplied coating may produce visual differences between the sanded and unsanded areas (see **Figure 74**).

Chemical treatment of the mass timber may also remove some staining. The products used may depend on the extent and type of staining (water or iron staining). When using chemical treatments, it is recommended that the project team contact the mass timber supplier for recommended products and techniques. Safety considerations such as PPE and ventilation may be needed. Some areas may require multiple stain removal treatments.

Figure 72 An example of general wood staining caused by wood tannins migrating with the water in a mass timber project exposed to wetting from above.

Figure 73 An example of staining caused by a reaction between iron and wood tannins in a mass timber project exposed to wetting from above.

Figure 74 An example of color differences in the wood observed after staining was removed via sanding.

Building Commissioning and Operation

As noted in the **Mechanical Drying** section, checking can occur when the mass timber is dried too much or too fast, or if drying occurs unevenly. The drying rate for large-dimension wood panels needs to be controlled to minimize checking. Therefore, the project team may need to control the building's indoor conditions (indoor relative humidity and temperature) following completion of the enclosure to reduce checking the mass timber.

For more information on how mass timber's equilibrium moisture fluctuates with the content of wood, refer to the water vapor control section in RDH's companion document, *Mass Timber Building Enclosure Best Practice Design Guide*.

Once the building is enclosed (see **Figure 75**), the indoor conditions should be adjusted slowly and in a controlled manner until the equilibrium moisture content of the wood's desired in-service conditions are met. The time it takes will depend on the moisture content of the mass timber elements during construction and the relative difference compared to the desired indoor operating conditions.

Figure 75 The underside of a mass timber roof and exterior windows that are a part of the building enclosure.

Figure 76 Tall Timber Student Housing, Burnaby, BC.

RDH Case Study: Step 3

with Focus on Passive Moisture Management

Building name:	BCIT Tall Timber Student Housing
Location:	Burnaby, British Columbia
Use:	Post-secondary student campus housing
Number of stories:	12 (two connected perpendicular wings)
Owner:	British Columbia Institute of Technology (BCIT)s
Architect:	Perkins&Will
Contractor:	Ledcor
RDH role:	Enclosure and facade consultant

About this Project

The 12-story BCIT Tall Timber Student Housing (see **Figure 76**) building is constructed of large, prefabricated CLT panels. As a high-rise mass timber building under construction during BC's wet winter season, the project was at high risk for moisture exposure. The general contractor, Ledcor, took a proactive approach to moisture management by producing a comprehensive moisture mitigation plan to guide the project team. To learn about the development of this project's moisture management plan, read the **RDH Case Study: Step 2** on page 53.

The written moisture mitigation plan provided a "blueprint" to allow the team to coordinate their mass timber moisture management efforts. The plan included a Gantt chart of the installation cycle to visually depict the length of time allotted for installation of different mass timber elements on the various levels of the building. Quarterly installation schedules were provided for both the wetter and drier months.

Step 3 Implementation

During the CLT panel manufacturing process, RDH visited the supplier and reviewed the installation of the factory-applied moisture protection membranes prior to delivery to site. The CLT panels were typically delivered "just in time" with crane installation directly from the truck bed (see **Figure 77**). Each building floor was erected and enclosed on a two-week cycle with crane time shared between the hybrid mass timber structure and the prefabricated façade system. This sequence limited exposure of the moisture-sensitive mass timber during construction and was a key component of project success.

Once the CLT floor panels were erected, the panel joints, edges, and details were immediately sealed to mitigate moisture exposure until the floors and façade were completed several floors above. The site team removed standing water on the floor level at regular intervals via squeegee or shop vacuum and directed it to temporary drain ports in the CLT panels. The drain ports were stripped in with tape/self-adhered membrane on the topside of the slab with the water directed to the exterior of the floor (see **Figure 78**).

Once the temporary moisture protection measures were completed at the floor above and the façade was installed, the construction team immediately began to dry the level to allow for concrete topping and drywall encapsulation. Ledcor commissioned a testing agency to complete regular moisture surveys of the mass timber to ensure that the CLT moisture content was sufficiently low to proceed with encapsulation.

Due to the roof's extended exposure time, a roofing-grade waterproofing membrane was installed on the CLT roof panels as the permanent air/vapor barrier membrane at the mass timber supplier's factory. During the erection of the CLT roof panels, including completion of the necessary structural connections, a small roofing crew was present on-site to promptly seal/waterproof CLT panel joints, penetrations, and details. These actions were performed as the panels were installed to protect the mass timber of the roof and floors below. This strategy and sequencing played a significant role in project success.

Outcome

Due to the project team's proactive approach to moisture mitigation planning prior to construction, the execution of the work, including installation of the CLT panels, went as smoothly as possible with minimal disruption. The project illustrated the value of early and detailed planning for mass timber moisture management. As a result, much of the potential drying and remediation work was avoided. The level of planning was key to the rapid completion of the superstructure and façade, ensuring the moisture exposure of the mass timber elements was limited.

A key factor in the moisture management success of this project was early buy-in from all team members. The moisture mitigation plan was well executed thanks to this communication and coordination effort. Due to early involvement with the trades, different installers were informed about the work being performed by other trades and the amount of time those trades would need to complete their work. This early knowledge also allowed trades to prepare and maximize elements that could be prefabricated in advance.

Figure 77 CLT floor panels delivered on-site for installation of the next level.

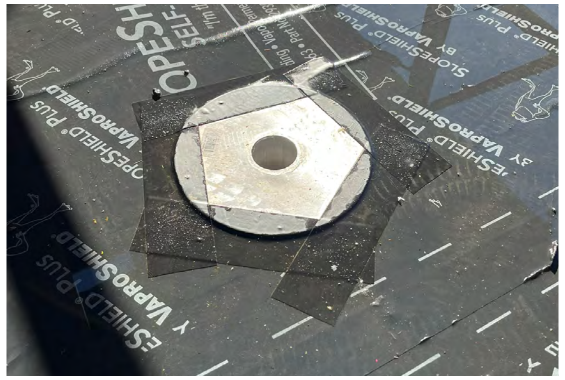


Figure 78 Drain port stripped in with tape/self-adhered membrane.

Figure 79 Northlake Commons, Seattle, Washington. Image by Built Work Photography.

RDH Case Study: Step 3

with Focus on Active Moisture Management

Building name:	Northlake Commons
Location:	Seattle, Washington
Use:	Mixed (office, level 1 retail, lumber shop storage)
Number of stories:	4/5 (two buildings connected by bridges)
Owner:	HessCallahanGrey Group
Architect:	Weber Thompson
Contractor:	Swinerton
RDH role:	Building enclosure consultant

About this Project

The Northlake Commons mass timber project (see **Figure 79**) demonstrates the benefit of getting buy-in on moisture management efforts from all interested parties prior to construction. Effective coordination among the ownership, general contractor, architect, and RDH on this project helped to mitigate an increase in moisture risks due to a shift in the project's construction schedule.

The revised schedule meant the team would be installing the CLT and glulam structure in early spring, during Seattle's rainy season. With the mass timber elements arriving on-site during very wet conditions, the wood would be exposed to rain, runoff, and other sources of moisture—and therefore would be at a greater risk of both material and aesthetic damage (see **Figure 80**). These conditions required the team to reassess its moisture management plans and seek recommendations for mitigating the increased risk.

As the project's building enclosure consultant from the schematic design phase to finished construction, RDH provided detailing, submittal and shop drawing review, site review, and ongoing troubleshooting assistance. When the project's moisture exposure risk increased, RDH recommended the team develop a comprehensive plan to address the increased moisture risks during construction.

Step 3 Implementation

RDH coordinated with all interested parties to develop a range of moisture mitigation solutions. The solutions that were implemented included the following:

- The use of a vapor-impermeable self-adhered membrane (VIMP SAM) to protect the CLT and glulam during shipping to site (see **Figure 81**).
- The use of an off-site, covered storage facility to limit the wood's exposure to sources of moisture.
- Continual and extensive active water removal from the CLT and glulam on-site.
- Continual measuring to monitor the moisture levels in the wood.
- Ongoing troubleshooting of any moisture issues that arose.

The project team took an active, 24/7 approach to managing on-site moisture and implementing the moisture mitigation recommendations. By storing the wood in a nearby storage facility, the team was able to implement a just-in-time approach. The wood elements were installed as soon as they arrived on-site to limit weather-exposed site storage. Workers used squeegees around the clock, including weekends, to remove standing water from the site. When the structures were assembled in place, the project team continually monitored the VIMP SAM system to identify locations where any water got past the membrane.

Typical construction work that occurred around and on the VIMP SAM caused some expected wear to the VIMP SAM over time, resulting in areas of increased moisture content. To adapt to the increased moisture content, all parties agreed to remove targeted areas of the VIMP SAM and other protective wrapping to promote drying. At columns and beams, workers cut open the wrap at the base of the glulam columns and underneath the CLT structure to allow the water to drain away. Heat lamps and fans were used as needed to promote drying of the system (see **Figure 82**).

Outcome

Construction on Northlake Commons was completed and the building was ready for occupancy by mid-2024. Due to the project team's commitment to executing on-site active moisture management strategies, the glulam and CLT beams show minimal to no water staining. This mass timber project was a success for three key reasons:

1. The team's proactive response to the schedule change and subsequent increase in moisture risks.
2. Moisture monitoring during the full construction phase.
3. Active, continuous moisture removal and drainage efforts.

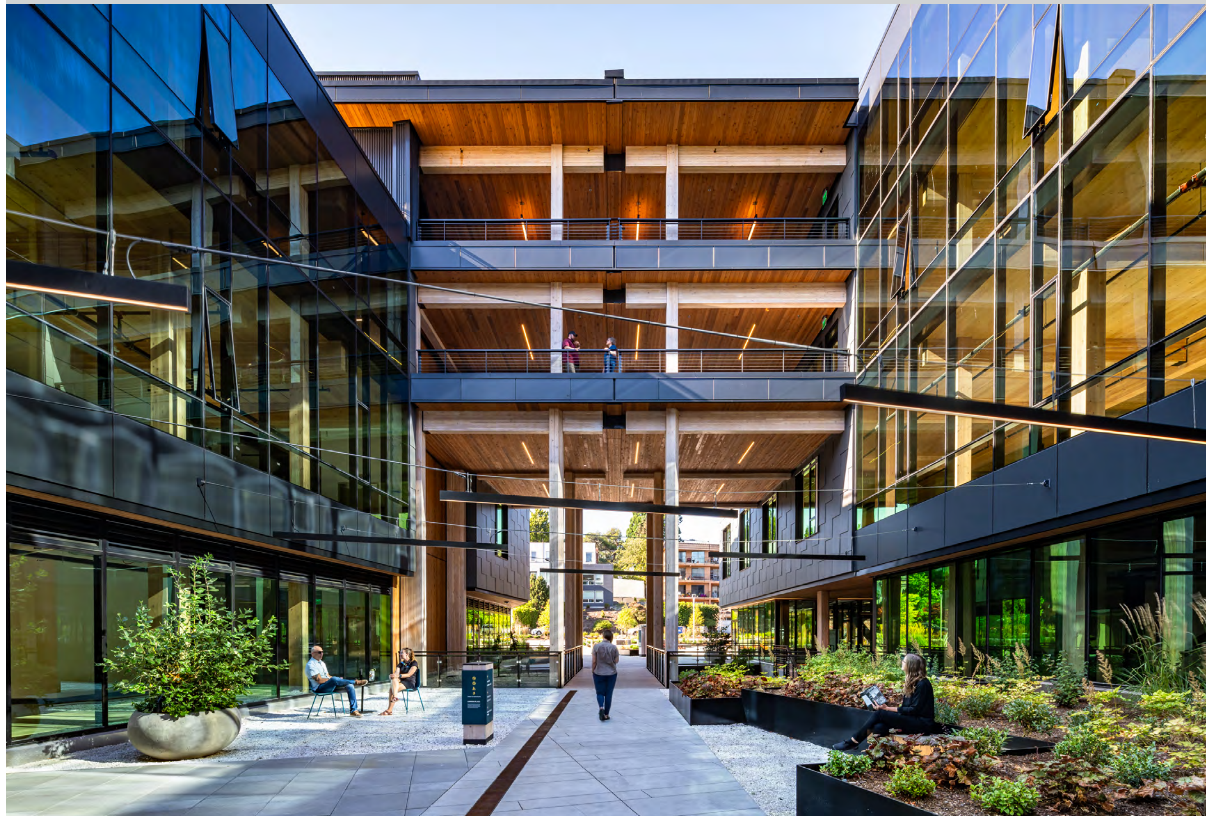


Figure 80 The open and exposed bridges showcase the beauty of the CLT and glulam. Image by Built Work Photography.

Figure 81 Glulam beams during construction.

Figure 82 The protective membrane provided protection to the CLT and glulam even in very wet conditions.

A mass timber floor structure.

Appendix A | Moisture Management Plan Example Specification

The example specification section included in this appendix outlines requirements for the development of a plan, identifies content to include in the plan, and outlines execution requirements. For the ownership and design teams, this example specification may be used as a starting point for your project-specific specification. For the construction team, this example specification may act as an outline for your own project- specific mass timber moisture management plan.

This example specification is limited to moisture management written planning requirements and would be supplemental to a comprehensive mass timber specification.

SECTION 01 43 42
MASS TIMBER MOISTURE MANAGEMENT PLAN

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for Moisture Management Plan for Mass Timber.

B. Coordinate Plan with the Work of other related sections.

1.02 REFERENCE STANDARDS

A. If applicable, comply with requirements of the Authorities Having Jurisdiction over the location of the Project.

1.03 DEFINITIONS

A. Moisture Management Plan: A written plan for the temporary protection of specified materials from moisture during transportation, storage, and construction.

B. Moisture Protection Strategy: A method for the protection of a specified material from moisture, including but not limited to tenting, wrapping, application of temporary or permanent water-resistant coatings or membranes, use of just-in-time delivery methods or adaptive scheduling and sequencing of the Work, and active methods to remove accumulated moisture in a timely fashion.

C. Moisture: Humidity, condensation, precipitation, ground water, snow, snow-melt, ice, frost or water from other sources with which a specified material may come into contact.

1.04 SUBMITTALS

A. Develop and submit complete Moisture Management Plan prior to product shipment or prior to any Work, whichever occurs sooner.
   1. Submit to Architect for Owners review and approval.

B. Contact Information:
   1. Provide contact details for a representative of the Contractor who will be responsible for the Moisture Management Plan and its implementation.

C. If Contractor does not have staff qualified to prepare a Moisture Management Plan, engage a qualified building enclosure specialist registered in the location of the project with a minimum of 5-years experience to prepare a plan on the Contractor's behalf.
   1. Approved Building Enclosure Firms:
      a. RDH Building Science Inc.; www.rdh.com.
      b. Pre-approved alternative.

1.05 QUALITY ASSURANCE

A. See requirements in Mass Timber Section 06 ______.

B. Perform regular field inspections of the materials, construction and moisture control strategies to ensure compliance with the Moisture Management Plan and the Contract Documents.

C. Submit monthly reports of field inspections to the Architect.

1.06 MOISTURE MANAGEMENT PLAN

A. Owner requires that this project implement strict moisture management controls to protect the mass timber elements.

B. Prepare Moisture Management Plan. Reference Moisture Risk Management Strategies for Mass Timber Buildings V3.0 prepared by RDH Building Science Inc.

C. Develop Plan to achieve less than 16 percent moisture content.

D. In addition to the recommendations in the Risk Management Stretegies for Mass Timber Buildings document, include the following in the Plan:

   1. Provide descriptions for Moisture Protection Strategies identified.
   2. Schedule of Materials:
      a. Identify specified materials that may be at risk from moisture damage.
      b. For each material identified, include in the Plan the following:
         1) Risk of exposure to moisture during fabrication, transportation, storage, and construction.
         2) Risk of structural or functional damage.
         3) Risk of visible damage, distortion, discoloration, staining, or moulding.
   3. Moisture Protection Strategies: Identify and provide the following in the Plan:
      a. Identify robust and appropriate Moisture Protection Strategies compatible with site conditions and constraints.
   4. Site Monitoring - Outline in the Plan:
      a. Protocols for monitoring and evaluation of adopted Moisture Protection Strategies throughout the duration of the Work, including inspection and testing of moisture content of wood products and other materials where appropriate.
      b. Protocols for identifying and correcting deficiencies in adopted strategies.
   5. Provide a template for monthly written reports.
   6. Contact Information:
      a. Provide contact details for a representative of the Contractor who will be responsible for the Moisture Management Plan and its implementation.

E. Maintain and make available a copy of the Moisture Management Plan at the job site.

F. Perform testing and inspections as necessary to comply with the Moisture Management Plan.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 MOISTURE MANAGEMENT PLAN IMPLEMENTATION

A. Conduct Work and comply with Moisture Management Plan for the duration of the Project.

B. Manager: Designate an on-site person or persons responsible for instructing workers and overseeing and documenting results of Moisture Management Plan.

C. Distribute copies of the Moisture Management Plan to job site foreman, each subcontractor, Owner, Architect, and Consultant.

D. Arrange for periodic field visits by third-party building enclosure firm/commissioning agent.

E. Provide on-site instruction of appropriate moisture protection strategies expectedto be performed by all parties at the appropriate stages of the project.

F. Provide written documentation of moisture protection strategies organized by each stage of the Work and assigned responsible party.
   1. Distribute to job site foreman, each subcontractor, Owner, Architect, and Consultant.
   2. Documentation to aid decision-making for selection and implementation of moisture protection measures in relation to environmental conditions.

G. Meetings: Discuss moisture protection measures, goals and issues at pre-construction meeting and regular job-site meetings. Record these discussions in regular job-site meeting reports.

END OF SECTION

Origine, Quebec City, Canada (Yvan Blouin Architecte). Photo credit: Stephane Groleau

Appendix B | Step 1 Risk Assessment Tools

Appendix B provides risk assessment tools to assist the project team with decision-making during Step 1 of the moisture management process. These tools include:

- **Mass Timber Moisture Protection Product Types, Uses, and Properties**
- **Moisture Management Design Tool: CLT (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: NLT & DLT (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: MPP (Non-Composite) Roof and Floor Assemblies**
- **Moisture Management Design Tool: Timber-Concrete Composite (TCC) Roof and Floor Assemblies**

These risk assessment tools can be used with the **Risk Assessment Matrix** on page 12 to support the selection of moisture management strategies based on the assembly considerations, moisture exposure level, protection robustness, and other project-specific considerations.

Mass Timber Moisture Protection Product Types, Uses, and Properties

	Product Description	Short Form	Intended Use and Application	Protection Properties	Key Considerations	Protection Robustness Level
Membranes	**Vapor-impermeable loose-laid sheet**	**VIMP SHEET**	→ Not intended for large areas of coverage → Emergency or short-term protection of targeted areas and tarping/hoarding → Site-installed	→ Water-shedding and waterproof → Vapor impermeable; does not allow drying through the membrane → Loose laid; not adhered to the substrate, so it requires fastening or weighing down → Laps require sealing and/or taping	→ Any water bypassing the sheet can freely travel around beneath the surface and can become trapped below → Easily damaged, often slippery	L
Membranes	**Vapor-permeable self-adhered membrane**	**VP SAM**	→ Temporary protection, typically for floors or short-term exposed roof panels → Often used for permanent air barrier and water-resistive barrier functions → Not a vapor barrier → Factory- or site-installed	→ Water-shedding, not completely waterproof → Vapor permeable; does allow drying through it; however, it can also allow some wetting → Self-adhered to the substrate with self-adhered laps; lap joints/seams may require additional sealing beyond self-adhesive	→ Properties (e.g., water repellency, vapor permeability, life span) dependent on product, chemistry, and exposure → Most membranes originally designed for wall applications are not intended for horizontal applications; ensure product selected is suitable for ponding water → Thin and easily damaged by construction activities and traffic → May require a primer to install → Adhesion to damp wood is challenging for most products → Most products have not been tested for adhesion/uplift capacity in roof assemblies	M
Membranes	**Vapor-semi-permeable self-adhered membrane**	**VSP SAM**	→ Temporary mass timber protection, typically for floors or short-term exposed roof panels → Can be used for permanent air barrier and water-resistive barrier functions → Not a vapor barrier → Factory- or site-installed	→ Water-shedding, not completely waterproof → Low vapor permeance (1 US perm); does allow limited drying through it; however, it can also allow some wetting → Self-adhered to the substrate with self-adhered laps; lap joints/seams may require additional sealing beyond self-adhesive	→ Limited number of available products → Properties (e.g., water repellency, vapor permeability, life span) dependent on product, chemistry, and exposure → Thin and easily damaged by construction activities and traffic → Adhesion to damp wood is challenging for most products → Has not been tested for adhesion/uplift capacity in roof assemblies	M
Membranes	**Vapor-impermeable self-adhered membrane (with sealed laps)** **A variety of product types are available but often bituminous based with polyethylene facers**	**VIMP SAM**	→ Temporary mass timber protection, typically for short-term exposed roof panels → Often used for permanent air barrier/vapor barrier/water-resistive barrier functions → Is a vapor barrier → Is often listed as part of the finished roof assembly → Factory- or site-installed	→ Water-shedding and waterproof → Vapor impermeable; does not allow drying through it → Self-adhered to substrate; laps are self-adhered but require sealant or additional membrane/tape and primer beyond self-adhesive to maintain waterproofing	→ Large variety of widely available products → Can be slippery; however, products are available with a texture suitable for slip resistance → Moderately easy to damage by construction activities and traffic → Often requires a primer to wood and for tested adhesive characteristics → Adhesion to damp wood can be challenging for many products → Wood must have a moisture content below 16% prior to application to avoid trapping moisture beneath → Prone to blistering if mass timber below is damp and membrane is exposed to solar radiation → Many membranes have been tested for adhesion/uplift capacity in roof assemblies	M
Membranes	**Vapor-impermeable self-adhered SBS roofing base sheet (with heat-fused laps)**	**VIMP Roof**	→ Temporary mass timber protection typically for roof panels → Often used for permanent air barrier/vapor barrier/water-resistive barrier functions → Is a vapor barrier → Is often listed as part of the finished roof assembly → Factory- or site-installed	→ Water-shedding and waterproof; higher degree of waterproofness than VIMP SAM → Vapor impermeable; does not allow drying through it → Self-adhered to substrate; laps are heat-fused and may be torched (site) or electrically welded (factory or site) → Cold adhesives for SBS can also be used to achieve similar fused lap joints	→ Readily available from SBS roofing manufacturers → Available with sanded texture for slip resistance and enhanced toughness → Harder to damage than VIMP SAM by construction activities and traffic → Often requires a primer to wood and for tested adhesive characteristics → Adhesion to damp wood can be challenging → Wood must have moisture content below 16% prior to application to avoid trapping moisture beneath → Prone to blistering if mass timber below is damp and membrane is exposed to solar radiation → Is a vapor barrier, which in a roof assembly may be required for the final roofing system → Many membranes have been tested for adhesion/uplift capacity in roof assemblies	H

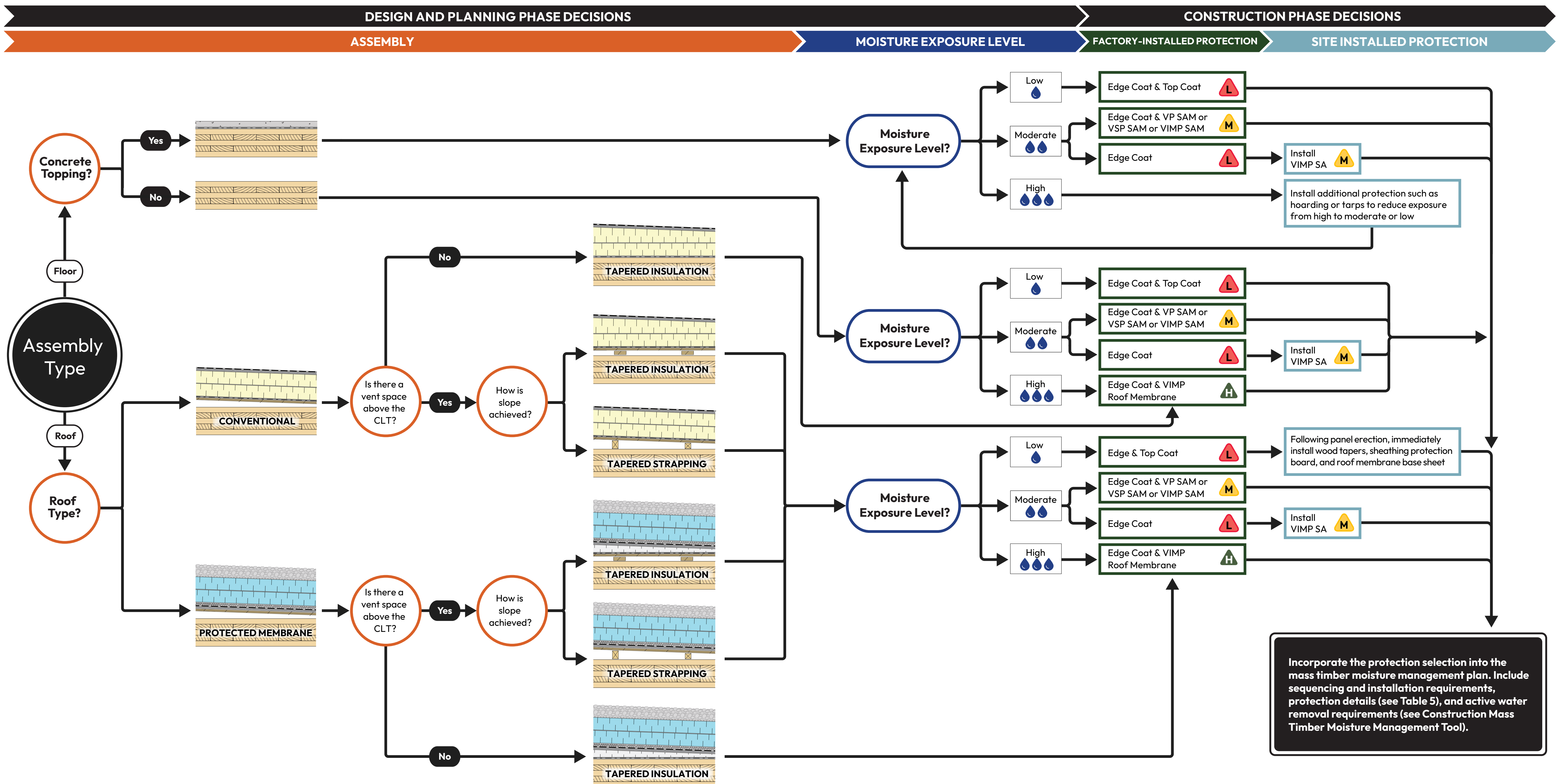
Mass Timber Moisture Protection Product Types, Uses, and Properties (continued)

	Product Description	Short Form	Intended Use and Application	Protection Properties	Key Considerations	Protection Robustness Level
Coatings	**Thin film hydrophobic (water-repellent) coating to coat surfaces**	**Top Coat**	→ Surface of CLT and MPP panels → Typically factory-installed, though it can also be site-installed	→ Beads water at the surface and reduces water absorption into the mass timber surface, which aids in easier surface management	→ Limited effective life span; easily worn out by construction activities and wear → Film forming and penetrating stain/sealer/paint products available in a range of chemistries → Properties (e.g., water repellency, vapor permeability, life span) dependent on product, chemistry, and exposure	L
Coatings	**High build paraffin wax or thick film hydrophobic (water-repellent) coating to seal end grain**	**Edge Coat**	→ Edge grain of CLT and MPP panels → Typically factory-installed	→ Beads water at the surface and reduces water absorption into the mass timber end grain, which protects panel edges and penetrations	→ Limited life span in-service, though it is suitable for short-term construction phase protection → Effectiveness depends on the roughness of the edge grain, thoroughness of the application, and thickness of the coating → Paraffin wax coatings are easily damaged → Only coatings intended for wood end grain are recommended (i.e., Top Coat products are not very effective on end grain)	L
Sheathing and Joint Protection	**OSB with factory-applied water-resistive barrier coating or painted plywood**	**Coated Sheathing**	→ NLT or DLT panels → Typically factory-installed	→ Repels water at the surface of the sheathing and reduces water absorption, which aids in easier surface management	→ Not uniform due to joints in between sheathing boards → Limited effective life span; easily worn out by construction activities and wear → Film forming and penetrating stain/sealer/paint products available in a range of chemistries → Properties (e.g., water repellency, vapor permeability, life span) dependent on product, chemistry, and exposure	L
Sheathing and Joint Protection	**Vapor-impermeable or semi-permeable tape installed at joints in panels or sheathing**	**Taped Joints**	→ Suitable for joints protection or sealing laps of compatible membranes → Site-installed	→ Water-shedding → Vapor impermeable or semi-permeable; allows limited drying or no drying through depending on product	→ Properties (e.g., water repellency, vapor permeability, life span) dependent on product, chemistry, and exposure → Adhesion to damp wood can be challenging; however, some tapes do bond to damp wood → Due to targeted application, water can often bypass tape at checks in wood → Wood must have moisture content below 16% prior to application to avoid trapping water beneath → Compatibility with different substrates varies by product	L
Sheathing and Joint Protection	**Coated sheathing with vapor-impermeable or semi-permeable tape installed at joints**	**Coated Sheathing with Taped Joints**	→ Wood sheathing over NLT or DLT panels → Some sheathing and tape systems used for permanent air barrier/vapor barrier functions	→ The combination of coated sheathing helps repel water at the surface, reduces absorption, and prevents water migrating into joints between sheathing boards → See Coated Sheathing and Taped Joints product descriptions in this table for additional properties	→ See Coated Sheathing and Taped Joints product descriptions in this table for additional properties	M

APPENDIX B

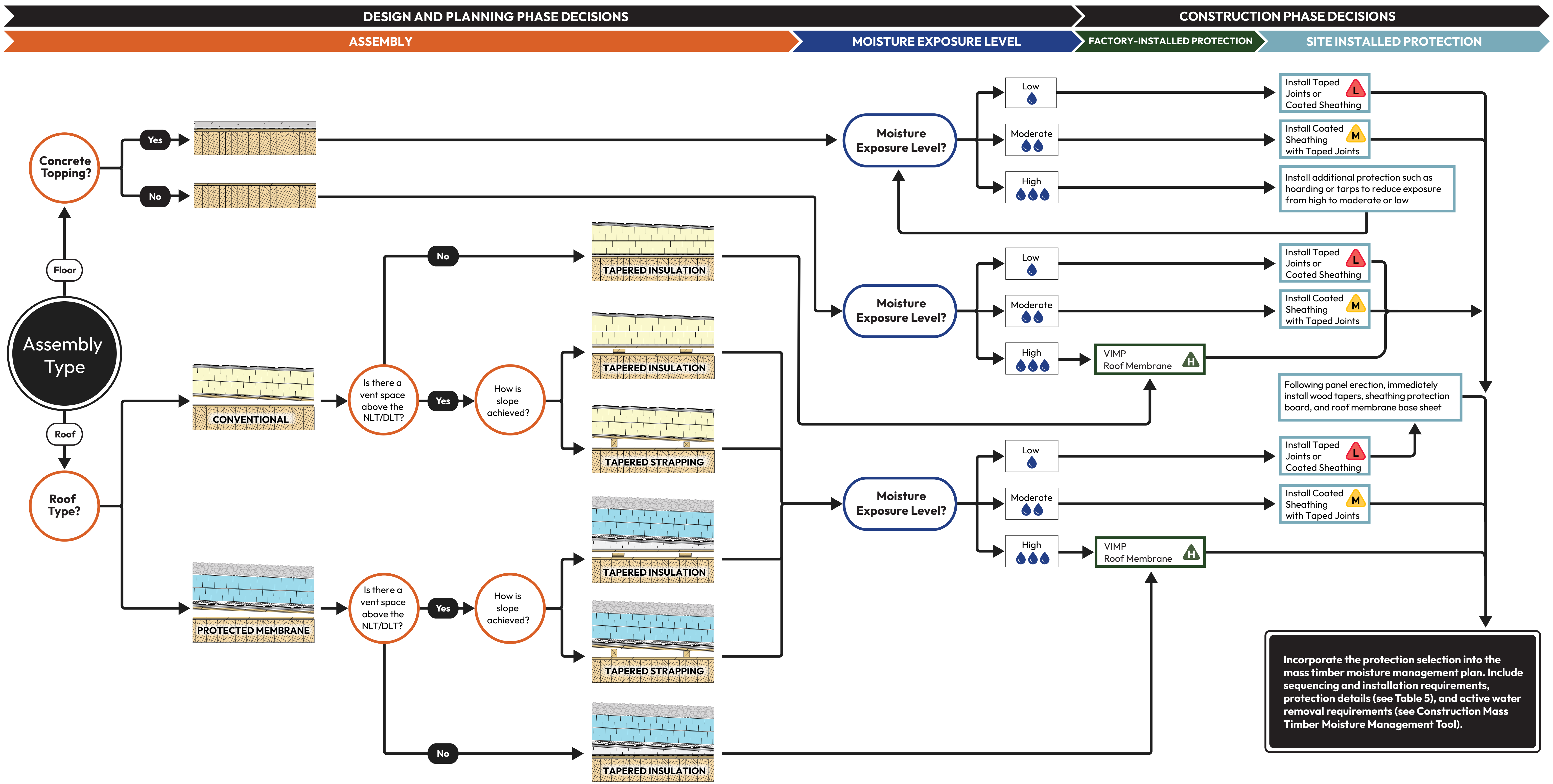
Moisture Management Design Tool: CLT (Non-Composite) Roof and Floor Assemblies

All protection levels and exposure combinations presented in this tool are deemed to be a balanced risk level.
Refer to **Risk Assessment Matrix** on page 12.



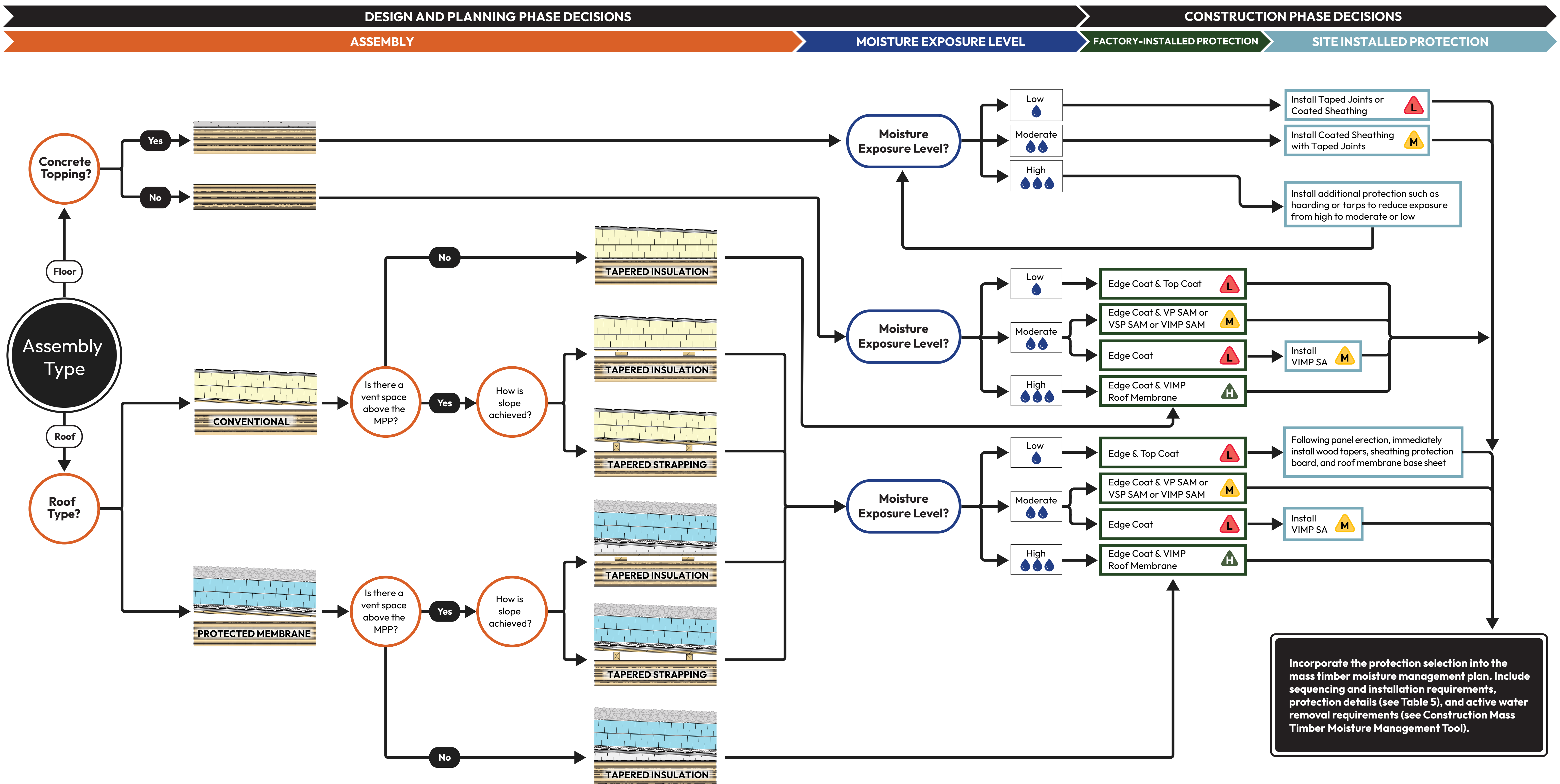
Moisture Management Design Tool: NLT & DLT (Non-Composite) Roof and Floor Assemblies

All protection levels and exposure combinations presented in this tool are deemed to be a balanced risk level.
Refer to **Risk Assessment Matrix** on page 12.

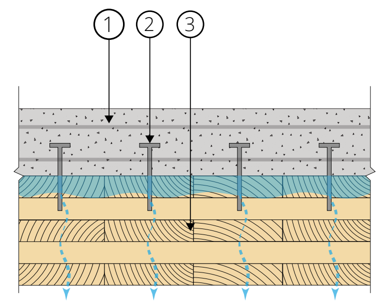
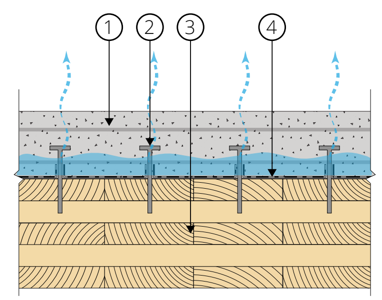
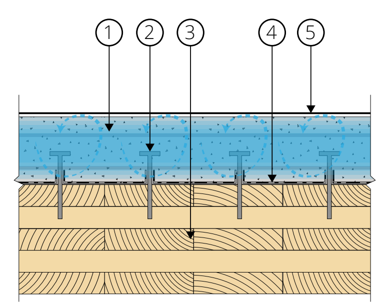


Moisture Management Design Tool: MPP (Non-Composite) Roof and Floor Assemblies

All protection levels and exposure combinations presented in this tool are deemed to be a balanced risk level.
Refer to **Risk Assessment Matrix** on page 12.



Moisture Management Design Tool: Timber-Concrete Composite (TCC) Roof and Floor Assemblies

	Moisture Exposure Level	Recommended Moisture Protection	Assembly	
TCC Floor without Moisture Protection	Low moisture exposure level. ***AND*** No panel edge exposure to concrete.	No protection		**Legend** 1. Structural concrete topping 2. Shear connectors 3. CLT floor panel
	Pre-pour considerations: Mass timber to be <16% moisture content prior to pouring concrete. Avoid pouring concrete until the enclosure walls are in place and the floor or roof above is installed (with penetrations sealed).			
TCC Floor with Moisture Protection	Low to moderate moisture exposure level. ***OR*** Panel edge of mass timber will be exposed to concrete during pour.	Vapor-impermeable membrane on surface. If the panel edge of mass timber is exposed to concrete, install vapor-impermeable membrane on edges.		**Legend** 1. Structural concrete topping 2. Shear connectors 3. CLT floor panel 4. Vapor-impermeable membrane
	Pre-pour considerations: Mass timber to be <16% moisture content prior to installing protection. Shear connectors will penetrate a membrane and increase the risk for water intrusion at connection points; thus, limit standing water. Avoid pouring concrete until the enclosure walls are in place and the floor or roof above is installed (with penetrations sealed).			
TCC Roof	Low to moderate moisture exposure level.	Vapor-impermeable liquid-applied membrane on mass timber. ***AND*** Watertight vapor barrier with consideration for adhesion to damp concrete (e.g., vented SBS base sheet) as recommended by the roofing supplier.		**Legend** 1. Structural concrete topping 2. Shear connectors 3. CLT floor or roof panel 4. Vapor-impermeable membrane 5. Watertight vapor barrier
	Pre-pour considerations: Mass timber to be <16% moisture content prior to installing on-site protection. Shear connectors will penetrate a membrane (where used) and increase the risk for water intrusion at connection points; thus, limit standing water. **Post-pour considerations:** Install site protection of a partially adhered vented membrane for adhesion to damp concrete.			

*Refer to page 30 for Moisture Exposure Levels. It is strongly advised to not install TCC assemblies in unprotected conditions or high exposure levels.

Prefabricated wall assemblies being installed in a mass timber building. Photography by Kristopher Grunert, copyright by Intelligent City.

Appendix C | Applied Example

The example in this appendix explores how the three-step moisture management process, including the tools and information provided throughout this guide, can be applied to a project with mass timber floor and roof assemblies. The project described in this example is conceptual and does not represent a specific building project.

This Applied Example demonstrates how a project team may identify multiple moisture protection and risk assessment options. The construction phase scenarios present both expected and unexpected moisture exposure events and how the project team could respond. An excerpt of an example moisture management plan is also included.

Applied Example Step 1 - Complete a Moisture Risk Assessment for Mass Timber Assemblies

The floor and roof moisture management planning design tools on included in **Appendix B** and the **Risk Assessment Matrix** on page 12 can be used to determine the best suited protection for a project to achieve "balanced" risk.

Step 1 Project Information

An architect designed an 8-story building located in the Pacific Northwest with a concrete elevator core. Floors 2 through 8 and the roof are CLT (see **Figure 83**). The CLT floors are designed with a concrete topping and an acoustic mat between the CLT and topping. The CLT roof is a conventional assembly with a tapered insulation package and no vented cavity.

The project team began the moisture management process early. They considered what design decisions had been made up to that point and how those decisions influenced the protection options considered. The following pages describe the risk assessment process performed by the project team and the moisture protection options that were considered for both the floor and roof assemblies.

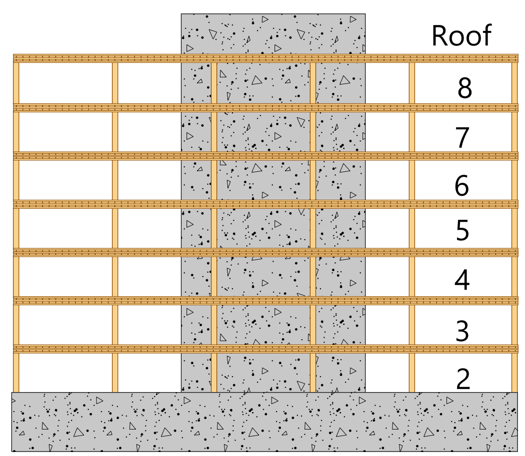


Figure 83 Sketch of the Applied Example mass timber building.

Floor Risk Assessment
Understanding project-specific assembly risk, moisture exposure level, and available protection strategies.

DESIGN AND PLANNING PHASE CONSIDERATIONS

The assembly design was finalized and the project team was limited to membrane and on-site protection options to manage moisture.

FLOOR ASSEMBLY CONSIDERATIONS

- The concrete topping would add moisture to the mass timber floor panel.

MOISTURE EXPOSURE LEVEL CONSIDERATIONS

- The construction schedule anticipated 3 weeks from panel installation before the enclosure walls would be installed.
- Floor installations would be exposed for approximately 1.5 weeks until the next floor level was installed.
- The floors were scheduled to be complete between the end of summer and start of fall, and some rain was expected.

CONSTRUCTION PHASE CONSIDERATIONS

Based on the moisture exposure levels defined in this guide, it was determined that the CLT roof panels had a moderate ( ) exposure level.

Given the moisture exposure level, moderate protection robustness (M) was identified to achieve balanced risk level.

FACTORY-INSTALLED PROTECTION CONSIDERATIONS

- The option to factory-install a membrane was limited to the types of protection that the panel manufacturer had experience with and the factory was currently set up to install.
- If a factory-installed membrane was not an option, Top and Edge Coat protection (L) could be installed in the factory for short-term protection until a membrane was installed on-site.

SITE-INSTALLED PROTECTION CONSIDERATIONS

- Site-installed membranes would require immediate application to reduce wetting risk for the mass timber.
- If the CLT was to be exposed to moisture, the membrane application would need to be delayed until the CLT was dried to 16% moisture content or less.

Risk Assessment Matrix

PROTECTION ROBUSTNESS	MOISTURE EXPOSURE LEVEL: LOW	MODERATE	HIGH
L LOW	BALANCED	CAUTION	AVOID
M MODERATE		BALANCED	CAUTION
H HIGH			BALANCED

Floor Risk Assessment (continued)

Narrowing Down the Options

After taking stock of all relevant information that could impact the protection options for the CLT floor assembly and reviewing the potential membranes in the **Mass Timber Moisture Protection Product Types, Uses, and Properties** table in Appendix B, the project team narrowed their options down to three possibilities as illustrated in **Figure 84** and described below.

Option 1: Factory-Installed VIMP SAM

Option 1 was the balanced protection scenario, taken directly from Assembly Design Tool 1. Given the floor assembly and the moisture exposure level, a factory-installed membrane of high robustness was identified to achieve a balanced risk level.

Option 2: Site-Installed VIMP SAM

Option 2 is the same membrane as Option 1. However, the factory manufacturing the CLT panels is unsure whether schedule constraints will allow for a factory-installed membrane to be installed prior to shipping. If the project team was to achieve a final balanced risk level, they would need to consider having only a Top and Edge Coat installed when the panels are delivered and site installation of the moisture protection membrane.

Option 3: Site-Installed Taped Joints

Due to budgeting reasons, the project team considered taking on a higher risk and using a method that provided low protection robustness (L). Option 3 considered taping joints and not installing a membrane. The cost savings of using a less robust material compared to potential costs of ongoing active water management would be evaluated prior to making a final decision.

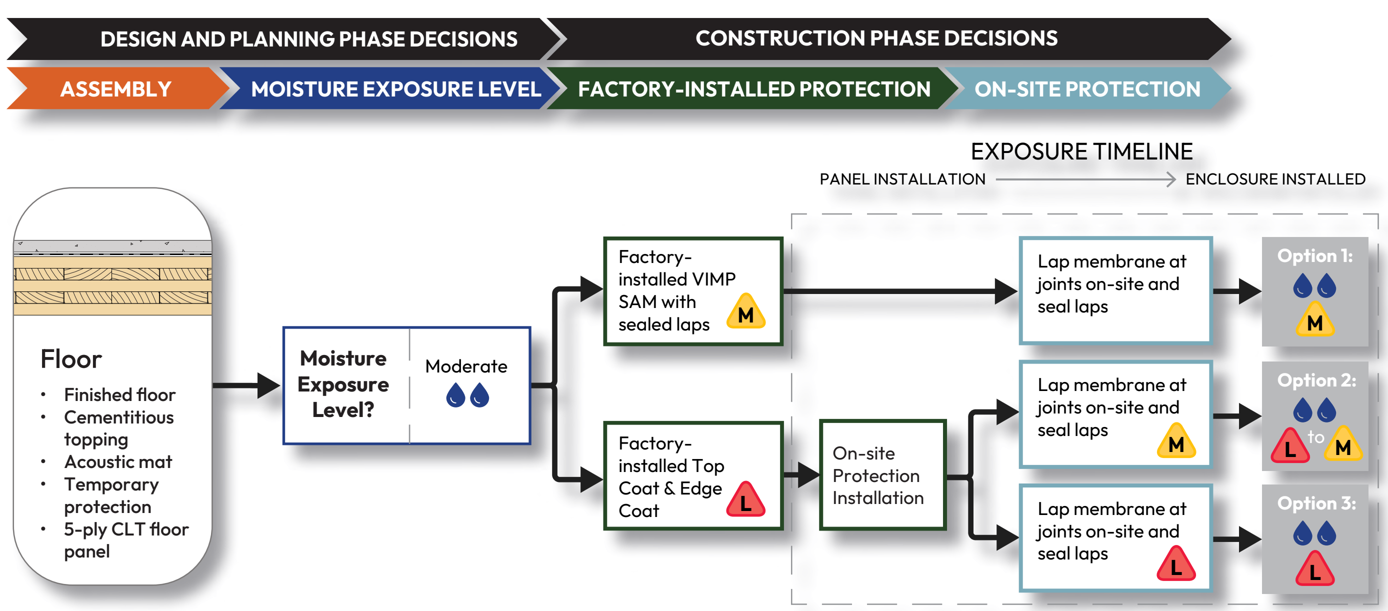


Figure 84 Moisture management planning flowchart for the Applied Example building with a CLT floor and concrete topping showing three options.

Floor Risk Assessment (continued)

Assessing the Risk with the Risk Assessment Tool

Option 1

OPTION 1 Balanced Factory-Installed Membrane

Vapor-impermeable self-adhered membrane with sealed laps

Moisture Exposure Level: Moderate
Membrane Robustness Level: Moderate
Risk Assessment: Balanced

Considerations:

- → The membrane robustness level is moderate; therefore, in a wetting event, action would need to be taken in a timely manner to avoid standing water. There is a risk of standing water migrating under the membrane laps.
- → When the CLT floor panels are installed, the membrane will need to be lapped and sealed at the joints between the panels on-site and an additional membrane will need to be installed over the drag struts.

Option 2

OPTION 2 Factory-Installed Membrane not an Option

Factory-installed water-repellent sealer on panel surface (Top Coat) and high build paraffin wax on the end grain (Edge Coat) + site-installed vapor-impermeable self-adhered membrane with sealed laps (VIMP SAM)

Moisture Exposure Level: Moderate
Membrane Robustness Level: Low upon panel delivery. Moderate after membrane is installed.
Risk Assessment: Medium risk upon panel delivery (Caution). Balanced risk after membrane is installed.

Considerations:

- → Prior to installation of the membrane, the panel would have a Top Coat and edge sealer with a low protection robustness. In a wetting event, immediate action would be required and mechanical drying or delay of the membrane installation may be required.
- → The membrane is vapor impermeable so there would be limited drying potential after the membrane is installed. The moisture content of the mass timber would need to be less than 16% before membrane installation.
- → After membrane installation, the protection robustness level would be moderate; therefore, in a wetting event, action would need to be taken in a timely manner to avoid standing water. There is a risk of standing water migrating under the membrane laps.

Option 3

OPTION 3 Taking On Greater Risk

Factory-installed water-repellent sealer on panel surface (Top Coat) and high build paraffin wax on the end grain (Edge Coat) + site-installed vapor-impermeable tape at the joints and splines

Moisture Exposure Level: Moderate
Membrane Robustness Level: Low
Risk Assessment: Moderate risk (Caution)

Considerations:

- → Protection robustness level would be low throughout the entire exposure duration; therefore, in a wetting event, immediate action would be needed and mechanical drying or delay of the concrete pour may be required. If standing water was not removed, it could absorb into the CLT and there is a risk of standing water migrating under the tape.
- → The tape is vapor impermeable, so there would be no drying potential at joints after the tape is installed.
- → The moisture content would need to be less than 16% before tape installation and before the concrete topping is poured.

Roof Risk Assessment

Understanding project-specific assembly risk, moisture exposure level, and available protection strategies.

DESIGN AND PLANNING PHASE CONSIDERATIONS

The assembly design was finalized and the project team was limited to membrane and on-site protection options to manage moisture.

ROOF ASSEMBLY CONSIDERATIONS

- The roof assembly design had no vented cavity, so moisture in the mass timber would not have the ability to dry to the topside after the roof assembly layers were installed.
- The moisture protection membrane that would protect the mass timber in the roof assembly would also serve as the air/vapor barrier in the final roof assembly. This membrane would be required to be approved by the manufacturer for warranty considerations, such as wind uplift and material compatibility.

MOISTURE EXPOSURE LEVEL CONSIDERATIONS

- The construction schedule anticipated 2 months between panel installation and final roof installation.
- The roof was scheduled to be completed in autumn, and rain was expected.
- There was no overhead protection, such as tenting, planned for the project.

CONSTRUCTION PHASE CONSIDERATIONS

Based on the moisture exposure levels defined in this guide, it was determined that the CLT roof panels had a high (●●●) exposure level.

Given the moisture exposure level, high protection robustness (H) is recommended to achieve balanced risk level.

FACTORY-INSTALLED PROTECTION CONSIDERATIONS

- The option to factory-install a membrane was limited to the types of protection that the panel manufacturer had experience with and the factory was currently set up to support.
- If a factory-installed membrane was not an option, Top and Edge Coat protection (red) could be installed in the factory for short-term protection until a membrane was installed on-site.

SITE-INSTALLED PROTECTION CONSIDERATIONS

- Site-installed membranes would require immediate application to reduce wetting risk for the mass timber.
- If the CLT was to be exposed to moisture, the membrane application would need to be delayed until the CLT was dried to 16% moisture content or less.

Risk Assessment Matrix

PROTECTION ROBUSTNESS \ MOISTURE EXPOSURE LEVEL	LOW	MODERATE	HIGH
L LOW	✓ BALANCED	? CAUTION	✗ AVOID
M MODERATE	✓	✓ BALANCED	? CAUTION
H HIGH	✓	✓	✓ BALANCED

Roof Risk Assessment (continued)

Narrowing Down the Options

After taking stock of all relevant information that could impact the protection options for the CLT roof assembly and reviewing the potential membranes in the **Mass Timber Moisture Protection Product Types, Uses, and Properties** table, the project team narrowed their options down to three possibilities as illustrated in **Figure 85** and described below. A detailed description of each option is included on page 108.

Option 1: Factory-Installed VIMP Roof Membrane

Option 1 was the optimal protection scenario, guided by Assembly Design Tool 1. Given the roof assembly and the moisture exposure level, a factory-installed membrane of high robustness was identified to achieve an optimal risk level.

Option 2: Site-Installed VIMP Roof Membrane

Option 2 was identified as the same membrane as Option 1, but the factory responsible for manufacturing the CLT panels was unsure if factory installation of the moisture protection membrane could occur within the factory due to schedule constraints. If the project team was to still achieve an optimal risk level, they would need to consider a factory-installed Top and Edge Coat and site-installed membrane.

Option 3: Site-Installed VIMP SAM

Due to budgeting reasons, the project team considered taking on greater risk by using a membrane that provided moderate protection robustness (M) such as a VIMP SAM. The VIMP SAM was selected from the other moderately robust membranes identified in the **Mass Timber Moisture Protection Product Types, Uses, and Properties** table because the VIMP SA membranes could serve as the air barrier membrane for the final roof assembly and had been tested for adhesion/uplift capacity in roof assemblies. The cost savings of using a less robust material compared to potential costs of a moisture contingency plan would be evaluated prior to making a final decision.

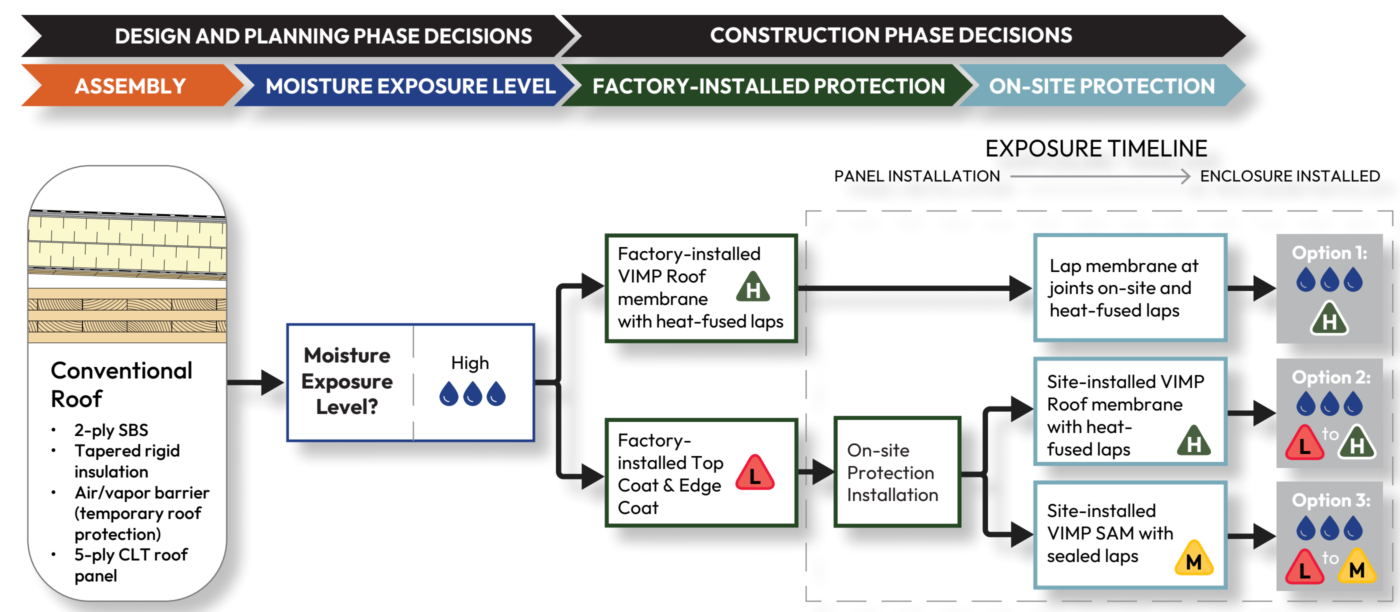
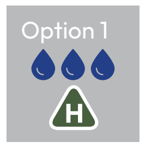


Figure 85 Moisture management planning flowchart for the Applied Example building's CLT conventional roof assembly with three options.

Roof Risk Assessment (continued)
Assessing the Risk with the Risk Assessment Tool

OPTION 1 Optimal Factory-Installed Protection



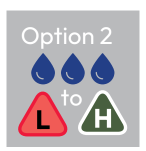
Factory-installed, vapor-impermeable, self-adhered SBS roofing base sheet with heat-fused laps (VIMP Roof)

Moisture Exposure Level: High
Membrane Robustness Level: High
Risk Assessment: Balanced

Considerations:

- The membrane robustness level is high; therefore, in a wetting event, no immediate action would be required. The membrane would act as a temporary roof until the final roof assembly was installed.
- During CLT panel installation, the membrane would be lapped and heat-welded at splines between panels on-site and an additional membrane would be installed over drag struts and other penetrations through the membrane.

OPTION 2 Factory-Installed Membrane Not an Option



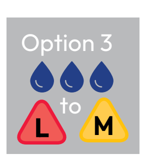
Factory-installed water-repellent sealer on panel surface (Top Coat) and high build paraffin wax on the end grain (Edge Coat) + site-installed, vapor-impermeable, self-adhered SBS roofing base sheet with heat-fused laps (VIMP Roof)

Moisture Exposure Level: High
Membrane Robustness Level: Low upon panel delivery. High after membrane is installed.
Risk Assessment: High risk upon panel delivery (Avoid if possible). Balanced risk after membrane is installed.

Considerations:

- Prior to installation of the membrane, the panel would have a Top Coat and Edge Coat that provides low protection robustness. In a wetting event, immediate action would be required and mechanical drying or delay of the membrane installation would also be required.
- The membrane is vapor impermeable, so there would be limited drying potential after the membrane is installed. The moisture content of the mass timber would need to be less than 16% before membrane installation.
- After the membrane is installed, the protection robustness level would be high; therefore, in a wetting event, no immediate action would be required. The membrane would act as a temporary roof until the final roof assembly is installed.

OPTION 3 Taking On Greater Risk



Factory-installed water-repellent sealer on panel surface (Top Coat) and high build paraffin wax on the end grain (Edge Coat) + site-installed, vapor-impermeable, self-adhered membrane with sealed laps (VIMP SAM)

Moisture Exposure Level: High
Membrane Robustness Level: Low upon panel delivery. Moderate after membrane is installed.
Risk Assessment: High risk upon panel delivery (Avoid if possible). Moderate risk after membrane is installed (Caution).

Considerations:

- Prior to installation of the membrane, the panel would have a Top Coat and Edge Coat that provide low protection robustness. In a wetting event, immediate action would be required and mechanical drying or delay of the membrane installation would also be required.
- The membrane is vapor impermeable, so there would be limited drying potential after the membrane is installed. The moisture content of the mass timber would need to be less than 16% before membrane installation.
- After the membrane is installed, the protection robustness level would be moderate; therefore, in a wetting event, action would need to be taken in a timely matter to avoid standing water. There would be a risk of standing water migrating under the membrane laps.
- Taped and/or sealant applied to all laps is recommended with a vapor-impermeable SA membrane to enhance the robustness of membrane laps. Unsealed laps would result in a low level of protection and would be at high risk for trapping moisture under the membrane.

2

Applied Example Step 2 - Develop a Construction Phase Moisture Management Plan

After all relevant protection options are considered, the project team can discuss and select a final option based on desired risk levels and other considerations, such as budget. Step 2 can now begin, and the project team can develop a construction phase moisture management plan.

The **Construction Mass Timber Moisture Management Tool** on page 50 lays out key steps in a moisture management plan. The tool provides an overview of considerations but does not compare to the value of a project-specific moisture management plan. Step 2 of this Applied Example outlines important content in a written plan. It also highlights the key documents that will create accountability within the project team so the moisture management strategies are followed throughout the construction schedule. This plan is specific to the Applied Example; a construction management plan does not need to be limited to the information shown on the following pages, and this guide encourages teams to develop a plan suited to the unique characteristics of each project.

Step 2 Project Information

After performing the risk assessment for Step 1 of the Applied Example, the project team decided that the roof would use a factory-installed VIMP roof membrane with heat-fused laps (high protection robustness level in high moisture exposure conditions).

The project team also decided the floors would have a factory-installed Top Coat and Edge Coat, and site-installed vapor-impermeable tape at joints and splines (low protection robustness in moderate moisture exposure conditions). Because there is less protection, the project will have a greater need for a moisture contingency plan for the mass timber floors.

Excerpt of the Written Moisture Management Plan

Note: Referenced plan documents are not included within this excerpt, but a summary of commonly included documents is included in the section **Common Moisture Management Plan Documents** on page 49.

DELIVERY TO SITE

- Upon delivery to site, the team accepting panel delivery will review a sample of the panels to confirm the correct factory protection is installed and that the maximum moisture content of the panels meets the project-specific requirements (see **Mass Timber Delivery Acceptance Checklist**).

JUST-IN-TIME DELIVERIES

- The CLT will be hoisted directly from the truck to the installation location to avoid double handling, thus mitigating additional damage to the membrane.

STORAGE

- After the concrete first floor is complete, an area will be assigned for temporary storage until the material is required for install (see the included Site Plan with location marked).
- The material will be positioned on adequate supporting dunnage, 8" off the ground.
- The material will remain in the factory wrapping until it is required for install.

GENERAL INSTALLATION

- Slits will be cut in the bottom of the factory wrapping to provide ventilation and prevent water from being trapped in the wrapping once mass timber components are installed.
- Penetrations and interfaces will be covered the same day as panel erection (see the included **Moisture Management Details Package**).

FACTORY-INSTALLED PROTECTION CONSIDERATIONS

- The option to factory-install a membrane was limited to the types of protection that the panel manufacturer had experience with and the factory was currently set up to support.
- If a factory-installed membrane was not an option, Top and Edge Coat protection (red) could be installed in the factory for short-term protection until a membrane was installed on-site.

INSTALLATION OF CLT FLOOR PANEL (WITH FACTORY-INSTALLED TOP AND EDGE COATINGS)

- The CLT panels and spline material will be installed first. Immediately following panel erection, tape will be installed on-site at splines.

Contingency for precipitation during installation:

- ☑ In the case of an extreme weather event during installation, general laborers on-site will assist with water management atop CLT panels. To manage the water, the laborers will squeegee water off the flooring surface to designated areas along the face of the building where water is to be pushed off the deck surface (see the included **Floor Drainage Plan** with marked location where water is to be removed).
- ☑ Taping of joints will be delayed until the wood has been allowed to dry and the moisture content will be measured prior to tape installation. If required, electric heaters and fans will be used to mechanically dry the mass timber.

Excerpt of the Written Moisture Management Plan (continued)

INSTALLATION OF CLT ROOF PANEL (WITH VIMP SA ROOFING MEMBRANE)

- First the CLT panels and spline material will be installed.
- Immediately following panel erection, the roofer will be coordinated to be on-site to heat-fuse laps and detail penetrations.

Contingency for precipitation during installation:

- ☑ In the case of an extreme weather event, the SBS membrane will be temporarily lapped and general laborers on-site will assist with water management atop the CLT panels. To manage the water, the laborers will squeegee water off the flooring surface to designated areas along the face of the building where water is to be pushed off the deck surface (see the included **Roof Drainage Plan** with the marked location where water is to be removed).

GENERAL CONSIDERATIONS

- Moisture management strategies and the importance of early leak detection and membrane upkeep will be included in onboarding site orientation for new workers.
- Checklists will be completed every Monday to ensure ongoing moisture management (see the included **Weekly Checklist**).
- The protection installed is a low robustness membrane. In a wetting event, immediate action will be taken to reduce the risk of permanent damage. Water will be squeegeed off the flooring surface to designated areas along the face of the building where water is to be pushed off the deck surface (see the included **Floor Drainage Plan** with the marked location where water is to be removed).

Contingency for weather:

- ☑ In the case of an extreme weather event, general laborers on-site from Monday to Friday will assist with water management of the floor CLT panels.
- ☑ On weekends, the lead contractor will monitor the weather. In the case of extreme weather on a weekend, an on-call team will be called to remove water atop CLT floor panels.
- ☑ If required, electric heaters and fans will be used to mechanically dry the mass timber.

CLT ROOF PANEL (WITH VIMP SA ROOFING MEMBRANE)

- Protection installed is a high robustness membrane. In a wetting event, no immediate action is required and there is a low risk of moisture damage.
- Water will be removed in accordance with the drainage plan as necessary to carry out work in the area (see the included **Roof Drainage Plan** with the marked location where water is to be removed). Water will be removed by squeegeeing to the designated area. Once parapet walls are installed, water will be removed using portable pumps and directed to the designated areas.

Contingency for weather:

- ☑ Excessive standing water will be removed from panel areas in accordance with the drainage plan.

CONCRETE TOPPING INSTALLATION

- Concrete floor topping placement will be completed after enclosure walls are installed. Prior to placement, a sampling of moisture readings will be taken to confirm the panels are dry (see included **CLT Pre-Pour Checklist**).
- If required, electric heaters and fans will be used to mechanically dry the mass timber.

3

Applied Example Step 3 - Execute the Design and Moisture Management Plan

When the team has completed Step 1 and Step 2, the team has performed a moisture risk assessment of each mass timber assembly and created a moisture management plan through many discussions about moisture protection methods, contingency plans, and construction schedules. Now construction can begin. The more thorough the moisture management plan, the more prepared the construction team will be. But unforeseen circumstances can always appear. Step 3 of this Applied Example presents three example scenarios a project team may encounter when executing the moisture management plan.

Step 3 Project Information

The team planned that the CLT floors would have a Top Coat and Edge Coat installed in the factory and vapor-impermeable tape installed on-site at panel joints and splines (low protection robustness in moderate moisture exposure conditions). Due to the low membrane robustness, the project team planned to squeegee water off floors during rain events. The CLT roof membrane was planned to have a VIMP roof membrane (high protection robustness in high moisture exposure conditions). Due to the high membrane robustness, it is anticipated that in a rain event, only water drainage and monitoring of the mass timber are needed by the construction team.

The Applied Example project team encountered the following three scenarios during Step 3 of the moisture management process.

Scenario 1: Implementing Contingency Plans

Floors 2 to 6 were installed in early fall with a Top Coat, Edge Coat, and vapor-impermeable tape at joints and splines. During the installation of the floors, the site experienced periodic rain. When rainfall was significant enough to pond water, on-site laborers used squeegees or leaf blowers to remove water off the CLT floor panels to an appropriate drainage location, as identified in the drainage plan.

After one rain event, it was discovered that several penetrations were unprotected and exposed to moisture. The area was temporarily protected from additional wetting with tarps while the penetrations were dried with fans and electric heaters.

Once the moisture content of the CLT at these penetrations was confirmed to be in an acceptable range according to the project documents, the penetrations were protected so there would be no more risk of wetting in future rainfall events.

Some additional chemical stain removal and sanding was required to address moisture staining of the exposed CLT and glulam beams, drawing from contingency funds.

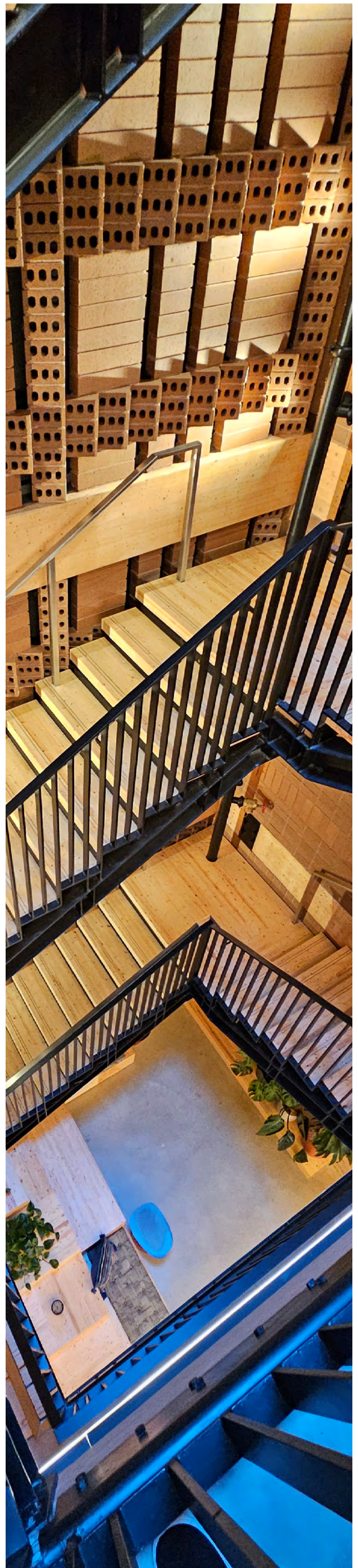
Scenario 2: Iterating Moisture Management Plans

Due to an unforeseen construction delay, the upper two floors were not constructed until later in the fall when the amount of rainfall was higher. Therefore, the actual moisture exposure level was higher than originally anticipated in the Step 1 risk assessment. Rather than frequently executing the weather contingency plan, which would have required around-the-clock squeegeeing and would increase the likelihood of fans and heaters being needed to dry the panels, the project team met and re-evaluated their current strategies.

The team decided to install a vapor-impermeable self-adhered membrane (VIMP SAM) with sealed laps (moderate robustness) on-site for floors 7 and 8. This approach reduced the need for the team to follow a weather contingency plan during rain events. The team performed regular visual reviews of these floors to confirm the membrane was sufficiently protecting the CLT and that no areas of water intrusion had occurred.

Scenario 3: According to Plans

The roof CLT panel had a VIMP SAM roof membrane with heat-fused laps installed. Due to the high protection robustness that this membrane provides and regular patching of any membrane damage by the project waterproofing subcontractor, no leaks occurred during rain events and there was no need for mechanical drying. As a result, staining of the CLT was minimal and the additional sanding and finishing contingency for the project was not required.



References

[1] T. C. Sheffer, "A climate index for estimating potential for decay in wood structures above ground," *Forest Products Journal* 21, no. 10 (1971): 25–31.

[2] Canadian Wood Council. *Introduction to Wood Design: A Learning Guide to Complement the Wood Design Manual*. Canadian Wood Council, 2005. Table 5.3.

[3] Forest Products Laboratory. *Wood Handbook—Wood as an Engineering Material*. General Technical Report FPL-GTR-190. U.S. Department of Agriculture, National Forest Service, Forest Products Laboratory, 2010. Table 13-1.

[4] Canadian Wood Council. *Managing Moisture and Wood*. Building Performance Bulletin Series 6, Canadian Wood Council, 2004. p. 6.

[5] FPInnovations. *Cross-Laminated Timber Handbook*, 2019.

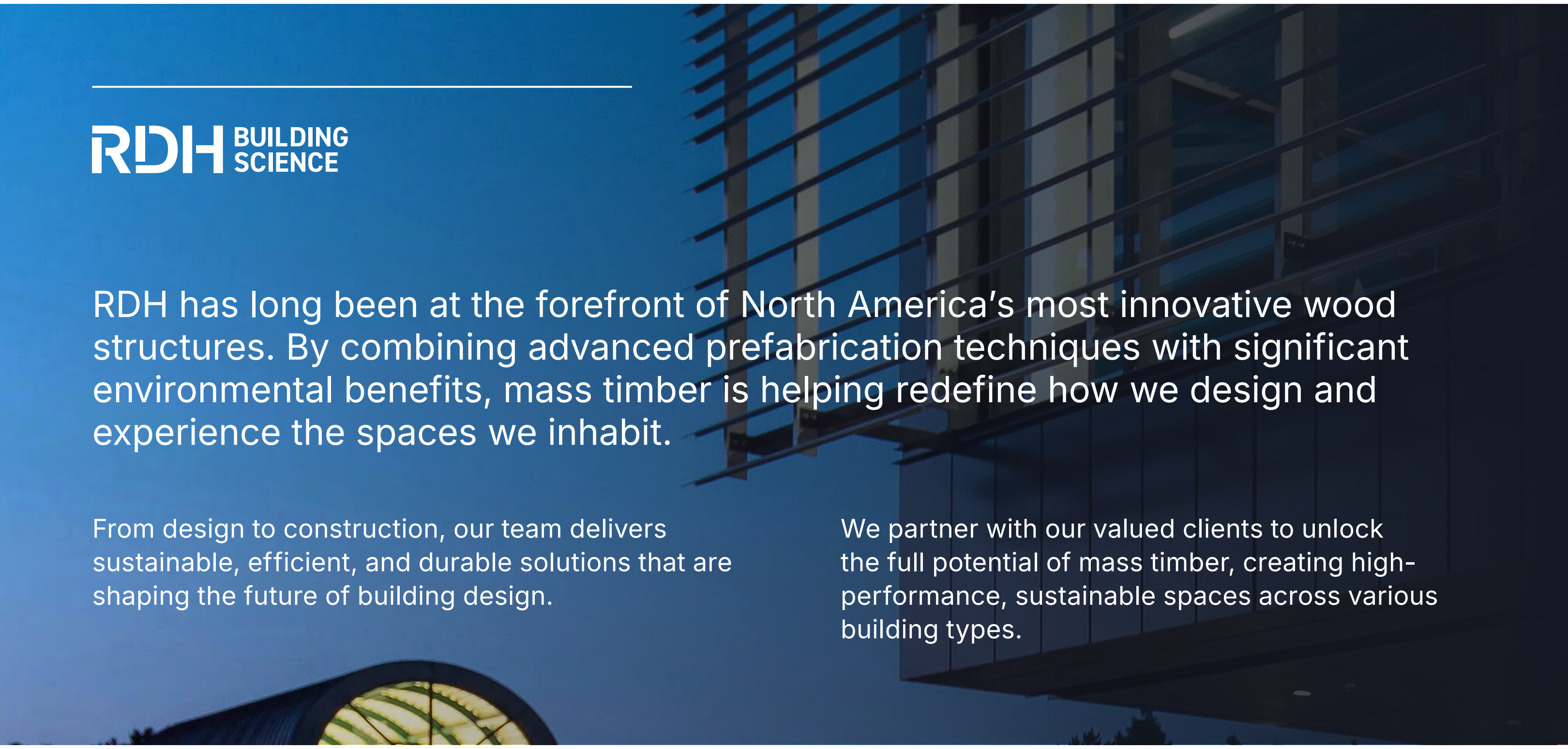
[6] Binational Softwood Lumber Council. *Nail Laminated Timber: U.S. Design & Construction Guide*, 2017.

Additional Resources

For additional guidance on best practice enclosure design principles for mass timber construction, consult these additional resources:

- ANSI/APA PRG 320: Standard for Performance-Rated Cross-Laminated Timber, American National Standards Institute and APA–The Engineered Wood Association
- *Cross-Laminated Timber Handbook* (Canadian CLT Handbook), FPInnovations
- *Encapsulated Mass Timber Construction Up to 12 Storeys*, Architectural Institute of British Columbia and Engineers & Geoscientists British Columbia
- *Mass Timber Building Enclosure Best Practice Design Guide*, RDH Building Science
- *Mass Timber Building Science Primer*, Mass Timber Institute
- *Nail-Laminated Timber: Canadian Design & Construction Guide v. 1.1*, Binational Softwood Lumber Council and Forestry Innovation Investment
- *Nail-Laminated Timber: U.S. Design and Construction Guide v.1.0*, Binational Softwood Lumber Council
- *Technical Guide for the Design and Construction of Tall Wood Buildings in Canada, 2022 - 2nd Editon*, FPInnovations

Many of the above resources can be accessed through RDH's online technical library at https://www.rdh.com/technical-library/.



RDH BUILDING SCIENCE

RDH has long been at the forefront of North America's most innovative wood structures. By combining advanced prefabrication techniques with significant environmental benefits, mass timber is helping redefine how we design and experience the spaces we inhabit.

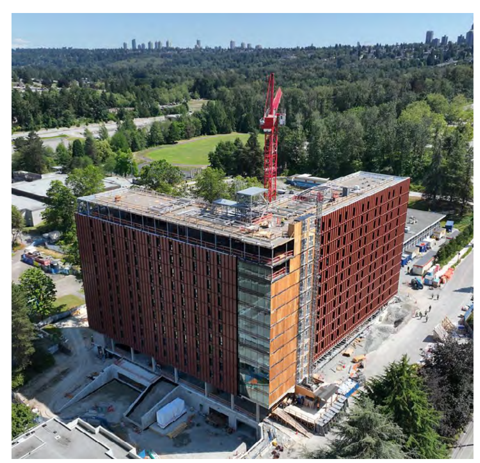
From design to construction, our team delivers sustainable, efficient, and durable solutions that are shaping the future of building design.

We partner with our valued clients to unlock the full potential of mass timber, creating high-performance, sustainable spaces across various building types.

RDH integrates multiple engineering disciplines to address key aspects of mass timber projects, **a holistic approach provides smooth integration and maximum performance** through both design and construction.

UVic Student Housing and Dining
Victoria, BC

Bakers Place
Madison, WI



BCIT Tall Timber Student Housing
Vancouver, BC

Mass Timber Services and Capabilities

Enclosure Consulting, Engineering & Commissioning
We provide consulting, engineering, and commissioning services for mass timber projects and bring extensive experience in designing, engineering, and testing prefabricated façade systems for mass timber buildings.

Research & Development (R&D)
Our R&D includes laboratory testing, hygrothermal simulations, and field monitoring of mass timber assemblies. We've developed methods for evaluating moisture protection systems and studying the long-term performance of mass timber buildings.

Moisture Management Consulting
Moisture management is vital during mass timber construction. RDH offers specialized consulting to address this challenge. We've authored papers and created a guide on moisture management strategies to help design and construction teams implement effective protection during and after construction.

Specialized Resources & Guidance
RDH provides valuable resources to support professionals in mass timber construction, available through our Technical Library (QR code located on the back), including:

Moisture Risk Management Strategies for Mass Timber Buildings: A detailed, step-by-step guide offering strategies and tools for identifying and managing moisture risks during construction.

Mass Timber Building Enclosure Best Practice Design Guide: A comprehensive reference covering design principles for high-performance enclosures, including discussions on energy performance and fire protection.

Making Buildings Better™

Why Choose RDH?

Holistic Engineering Expertise
Our multiple engineering disciplines and deep knowledge of wood moisture, durability, and façade engineering allows us to offer comprehensive solutions for complex mass timber projects.

Leadership in Research & Resources
RDH has co-authored key publications that set industry standards and position us as leaders in the mass timber space.

Tailored, Practical Solutions
We deliver customized, actionable solutions throughout every phase of a project. From design to construction, we focus on practical strategies that address challenges and provide long-term sustainability and performance.

Canada's Earth Tower
Vancouver, BC

RDH BUILDING SCIENCE

Vancouver
4333 Still Creek #400
Burnaby, BC V5C 6S6

Victoria
740 Hillside Ave #604
Victoria, BC V8T 1Z4

Courtenay
730 Grant Avenue #208
Courtenay, BC V9N 2T3

Northern Canada
PO Box 31300
Whitehorse, YT Y1A 2C0

Toronto
26 Soho Street #350
Toronto, ON M5T 1Z7

Waterloo
167 Lexington Court #6
Waterloo, ON N2J 4R9

Seattle
201 N 34th Street #150
Seattle, WA 98103

Portland
5331 S Macadam Ave #314
Portland, OR 97239

Oakland
1901 Harrison St Suite 1210
Oakland, CA 94612

Denver
6145 Broadway
Denver, CO 80216

Boston
18 Tremon Street #530
Boston, MA 02108

Making Buildings Better™

rdh.com
/rdhbuildingscience/
@rdhbuildingscience

RDH Technical Library