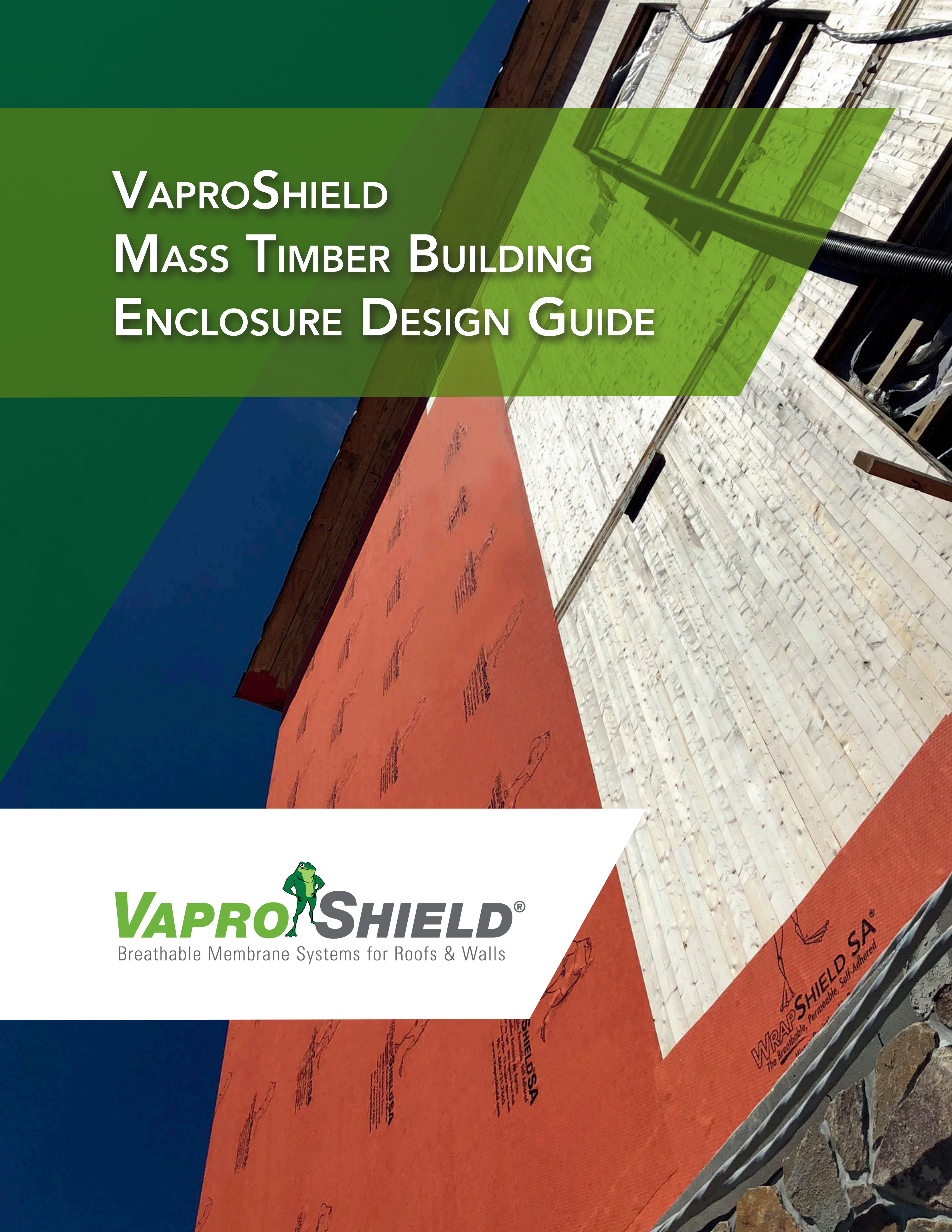
VaproShield Mass Timber Building Enclosure Design Guide



VaproShield®
Breathable Membrane Systems for Roofs & Walls

VaproShield Mass Timber Building Enclosure Design Guide

Authored by:

RDH BUILDING SCIENCE

VAPROSHIELD®
Breathable Membrane Systems for Roofs & Walls

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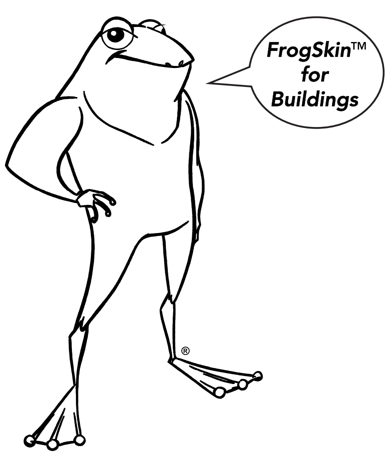

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Figure 1-1 (Right)
WrapShield SA Self-Adhered applied over CLT walls

Project: Candlewood Suites
Architect: Lendlease

Chapter 1

Introduction

Modern mass timber buildings are constructed of engineered wood products, often manufactured from multiple layers of sawn lumber, attached to form a solid panel, beam, or column. By forming solid wood sections, mass timber differs from the conventional, lightweight wood-framed construction that has long dominated the low-rise residential construction market in North America. As of late, there has been a growing interest in using mass timber as a means to diversify the use of wood—a renewable resource—as a building material within mid-rise and high-rise structures. At the forefront of the mass timber movement is the relatively recent innovation of cross-laminated timber (CLT). Figure 1-1 shows an example of a building constructed of CLT. CLT panels offer strength, rigidity, and dimensional stability, making them ideal for floor, wall, and roof applications. The panelization potential of CLT also lends itself to streamlining the construction process and shortening the construction schedule.

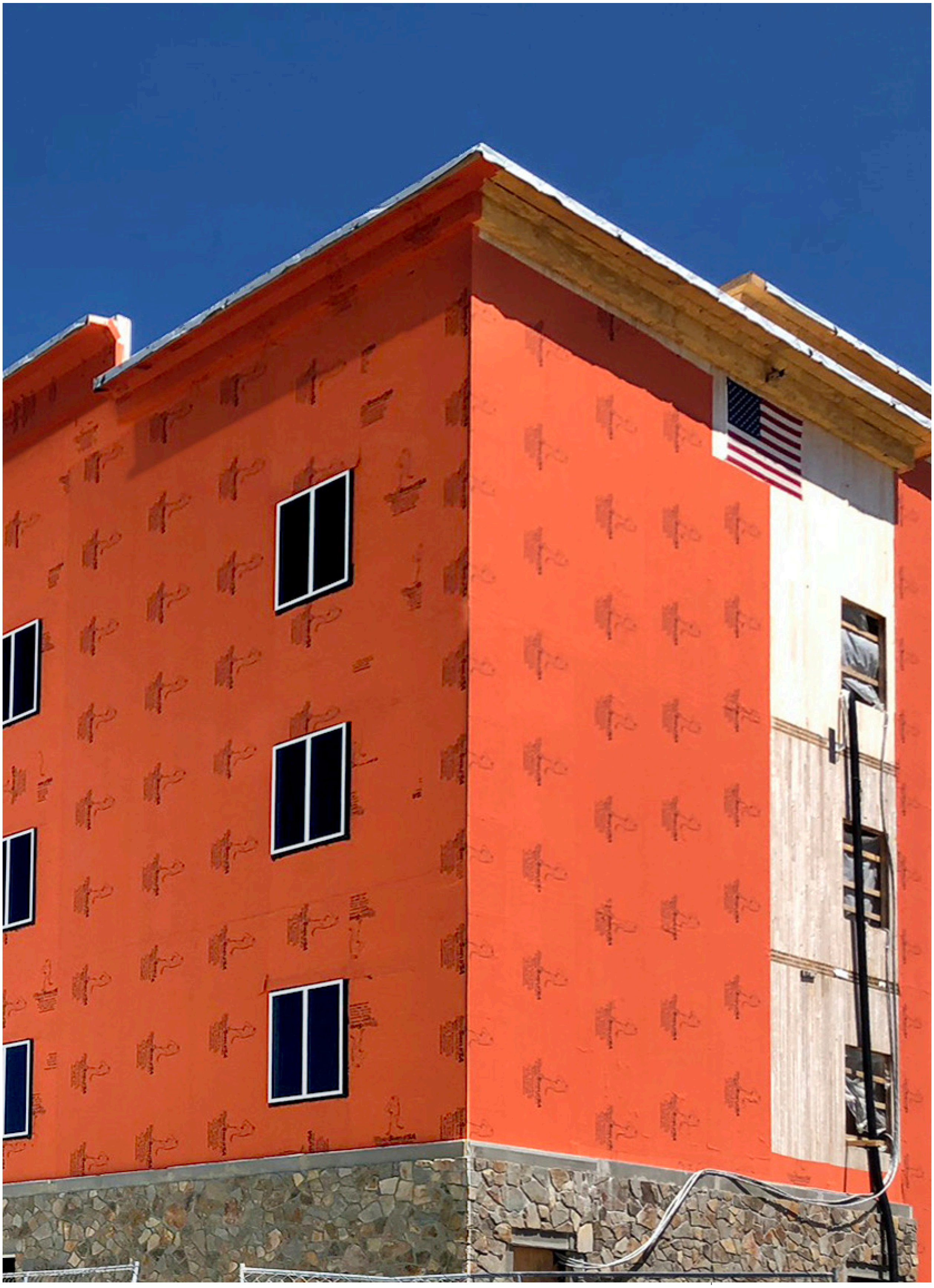
Many other mass timber products widely used across North America offer similar benefits to CLT, such as:

- Nail-laminated timber (NLT)
- Dowel-laminated timber (DLT)
- Interlocking cross-laminated timber (ICLT)
- Glue-laminated timber (GLT)
- Vertically laminated veneer lumber (LVL)
- Laminated strand lumber (LSL)

Multiple mass timber products can be used in the same building. For example, Figure 1-2 shows an example of a CLT floor supported by a GLT structure.

The primary focus of this design guide is CLT in building enclosure applications; however, much of the information applies to other types of mass timber products.

CLT, when used as an element of the building structure and/or the building enclosure, presents unique design and construction



considerations. CLT panels are constructed of wood, a moisture sensitive material, that is slow to dry if wetted due to its hygric mass. Wetting for prolonged periods can result in dimensional changes, moisture damage, and microbial growth. As a result, keeping CLT products dry during construction and throughout the building's service life is critical. The speed at which CLT panels may be erected also creates unique field challenges where CLT panels are exposed to the elements for periods of time while awaiting cover.

VaproShield's self-adhered water-resistive barrier (WRB) and air barrier membranes and roof underlayment products offer a high-performance solution for the many unique construction and design considerations of CLT. Figure 1-3 shows VaproShield's WrapShield SA Self-Adhered WRB membrane applied over a CLT wall. VaproShield's sheet membranes are vapor permeable, simultaneously managing bulk water while allowing for some drying of underlying materials. The proprietary adhesive backing on VaproShield's self-adhered sheet products bonds directly to wood substrates, offering primerless adhesion for paralleling the speed of membrane installation with that of the CLT panel erection process. VaproShield's products also lend themselves to pre-application, taking advantage of the prefabrication process inherent to CLT panel construction and the quality control and weather protection that shop fabrication can provide.

This guide covers best practices for the design and construction of high-performance CLT wall and roof assemblies using VaproShield's line of self-adhered vapor permeable WRB and air barrier membranes, roof underlayments, and flashing accessories in moderate to cold North American climates, including International Energy Conservation Code (IECC) Climate Zones 4 through 8. While CLT assemblies in warmer climates are not covered in this guide, VaproShield products may still provide solutions for a successful enclosure design in these regions. VaproShield's products can also be used with many other forms of mass timber construction following similar installation techniques and detailing.

Featured Products

Refer to page 12 for an overview of VaproShield's products commonly used in CLT and other mass timber applications. These products are the focus of the details and installation techniques described throughout the remainder of this guide. For more information regarding VaproShield's complete product offering, visit VaproShield.com.

Figure 1-2 (Left, above)
Mass timber construction—CLT floor supported by GLT structure.

Project: First Tech Credit Union
Architect: Hawker Architects

Figure 1-3 (Left, below)
WrapShield SA Self-Adhered applied over CLT walls.

Project: Candlewood Suites
Architect: Lendlease

WrapShield SA® Self-Adhered

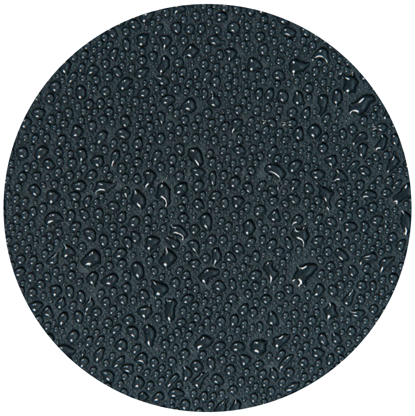
Self-adhered, vapor permeable water-resistive barrier and air barrier sheet membrane.

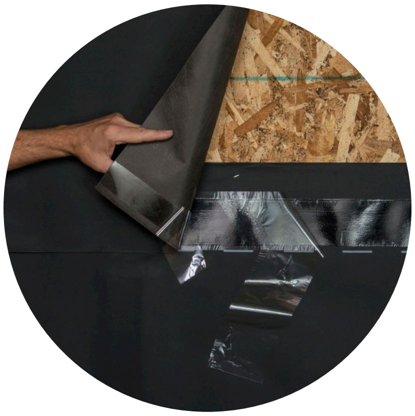
Application: Vertical walls behind closed joint cladding systems. Use with the WrapFlashing SA transition membrane.

RevealShield SA™ Self-Adhered

Self-adhered, vapor permeable, UV-stable WRB and air barrier sheet membrane.

Application: Vertical walls requiring up to 12 months of UV exposure prior to cover or while in-service behind open joint cladding systems. Can also be used when a flame spread index of zero per ASTM E84 is required. Use with the RevealFlashing SA transition membrane.





RevealShield™ IT Integreated Tape

Mechanically attached, vapor permeable, UV-stable WRB and air barrier sheet membrane with integrated tape at horizontal seams.

Application: UV protection layer and supplemental drainage plane directly behind open joint wall cladding systems.

VaproMat™

Drainage matrix with attached filter fabric.

Application: Inboard of the cladding system or roof finish system where required to maintain clear drainage and/or ventilation.

SlopeShield® Plus Self-Adhered

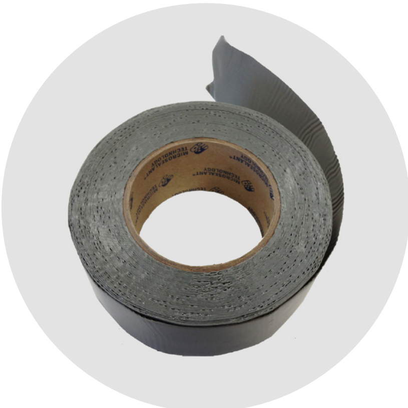
Self-adhered, vapor permeable, UV-stable air barrier and roof underlayment with slip resistant top surface.

Application: CLT roof panels sloped at 2:12 or greater or as a temporary protection membrane at low-slope CLT roof or floor panels.

VaproTape UV Black

UV stable tape accessory product.

Application: Field-applied transition membrane at roof panel joints when SlopeShield Plus Self-Adhered is pre-applied off-site. Can also be used to treat vertical RevealShield™ IT integreated tape seams.



VaproLiqui-Flash™

Vapor permeable liquid applied flashing.

Application: Flashing penetrations, openings, and transitions at WrapShield SA Self-Adhered, RevealShield SA Self-Adhered, and SlopeShield Plus Self-Adhered membranes.

VaproBond™

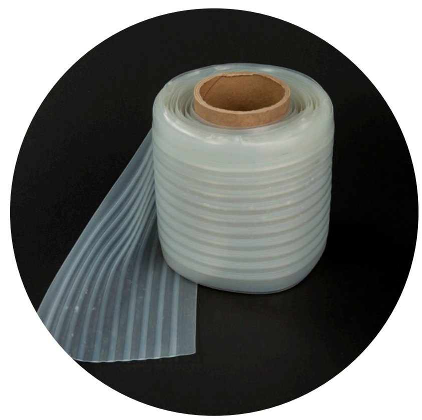
Single-component 100% silicone sealant and UV-stable liquid-applied flashing that bonds to VaproShield membranes and tapes.

Application: Flashing penetrations, openings, and transitions at WrapShield SA Self-Adhered, RevealShield SA Self-Adhered, and SlopeShield Plus Self-Adhered sheet membranes. Can be used behind open joint cladding systems.

Vapro-SS Flashing™

Multipurpose self-adhered flashing membrane with stainless steel facer.

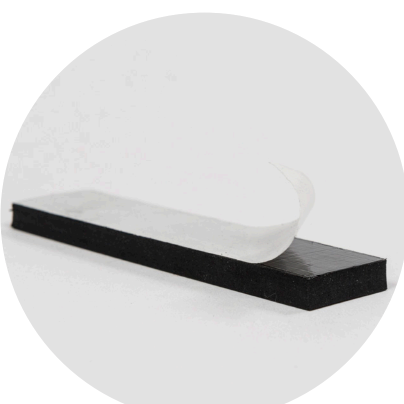
Application: Transition membrane and window sill flashing.



VaproSilicone Transition™ Materials

Preformed silicone elastomer sheet.

Application: Transition material for VaproShield's WRB and air barrier membranes at expansion joints, glazing systems, and other construction interfaces.



VaproShim SA™ Self-Adhered

Self-adhered neoprene/EPDM shim.

Application: Behind cladding attachment components to maintain a clear drainage path and to seal fastener penetrations per ASTM E331.

Chapter 2

Building Enclosure Design for CLT

Figure 2-1 (Left)
Building enclosure under construction with WrapShield SA Self-Adhered.

Project: First Tech Credit Union
Architect: Hacker Architects

The building enclosure, also known as the building envelope, separates interior building spaces from the exterior environment (see Figure 2-2). In the context of CLT mass timber construction, the enclosure may be composed of vertical panels at exterior walls and horizontally laid or sloped panels at the roof. Interior floors may also be constructed with CLT or other panelized mass timber products. The internal mass timber structure may be provided by GLT, LVL, or similar structurally engineered wood products in a post and beam layout. Of course, not all mass timber projects must be constructed exclusively with wood products and many hybrid construction combinations are possible, such as a structural concrete or steel core with a CLT enclosure, or a mass timber structure with a more traditional framed wall enclosure as shown in Figure 2-2. The focus of this guide is wall and roof enclosures incorporating CLT, and as previously noted, much of the guidance applies to other types of mass timber enclosure elements.

Over its service life, the building enclosure is subjected to environmental loads of water, air, heat, and water vapor (i.e. vapor), in addition to other loads such as fire, smoke, light, sound, and insects. The enclosure must also counteract lateral wind loads and provide support of its own weight and other vertical loads (if it is load-bearing). These loads are transferred back to the building's primary structure. Thoughtful design of the building enclosure considers all loads imposed on the enclosure over its service life. The focus of this guide is controlling the water, air, heat, and water vapor loads that act on the enclosure.

While CLT panels can be designed to meet the anticipated structural loads, CLT alone is not capable of adequately controlling air, water, heat, and water vapor; thus, CLT must rely on an assembly of materials and other components to meet the building's performance expectations. Performance can have a variety of meanings, but in the context of this guide, it demonstrates a building enclosure that will effectively manage water (both liquid and vapor), reduce the building's need for heating and cooling energy, and minimize the unintentional exchange of air between the interior and exterior environments.

Figure 2-2 (Above)
Mass timber building under construction.

1. *Mass timber post and beam structure.*
2. *CLT roof.*
3. *CLT floors.*
4. *Framed exterior walls. Note that CLT wall panels may be used in place of framed walls.*

Project: First Tech Credit Union
Architect: Hacker Architects

Figure 2-3 ***(Above)*** *Rain droplets on VaproShield's WrapShield SA Self-Adhered.*

Design and performance considerations for CLT enclosures differ from those of more traditional lightweight or mass concrete enclosures. CLT has unique physical properties such as its moisture sensitivity, relatively high capacity to store moisture, and relatively low vapor permeability. This chapter introduces the environmental factors that determine the enclosure loads and the building science fundamentals that govern the performance of CLT enclosures in moderate to cold climates. Considerations regarding fire and termite protection are also briefly described.

Environmental Loads

The outdoor environment will vary depending on climate and local site conditions, and the indoor environment will differ by building use and occupant behavior. Thus, climate, microclimate, site conditions, and building use and operation are all important considerations when evaluating the environmental loads acting on the enclosure. Liquid water, predominately rainwater but also snow melt and runoff, is typically the most critical environmental load. Other environmental loads—air, heat, and water vapor—are caused by differences between the indoor and outdoor conditions.

Water

The enclosure's exposure to liquid water is often treated as the most critical load and is ever more important in CLT enclosures due to the moisture sensitivity of wood products. As rainwater is the most predominate liquid water source, this guide refers to water control in terms of rainwater control.

If water contacts CLT surfaces for a prolonged period, particularly if exposed at the wood's end grain, the wood panel may absorb water, increasing its moisture content. Wood expands and contracts with changes in moisture content, so wetting of CLT will cause dimensional changes, potentially opening up gaps between laminations and panel interfaces that can adversely affect the aesthetic qualities and long-term performance of CLT. When dimensional changes occur too quickly, this can also cause CLT surface checking or cracks, which may allow water to penetrate further into the panel or cause visual irregularities if exposed to view. Prolonged exposure to moisture may also cause decay, microbial growth, corrosion of metal fasteners and connections, and potential damage to the interior finish if the panel is intended to be exposed. Limiting the CLT exposure to water during both construction and building service can reduce these risks.

Selection of VaproShield's Water Control Membranes

WrapShield SA® self-adhered and ***RevealShield SA™ self-adhered***, shown in Figure 2-3 and Figure 2-4, are designed to resist water in vertical applications. ***SlopeShield® Plus self-adhered*** is designed to resist water in sloped roof applications or temporarily in unsloped roof applications. These three products are self-adhered sheet membranes, offering primerless adhesion to CLT.

In North America, the amount of annual rainfall can vary from low in desert and arid climates to more extreme levels in coastal regions. Rainfall levels can be exacerbated by high wind speeds resulting in wind-driven rain (i.e., driving rain). Wind speeds generally increase with height; thus, taller wood buildings made possible by CLT and other mass timber innovations are likely to see greater water loads than traditional wood-framed structures.

When rain falls can be as important as *how much* rain falls. This is because the seasonal distribution of precipitation can affect the drying potential of the enclosure after a wetting event. For example, a heavy rainfall followed by colder temperatures and/or high humidity levels provide little opportunity for drying. This consideration can have a significant impact on CLT panels that may have been erected but are not yet properly protected from construction-phase moisture.

While wall cladding elements and roof finish elements in a sloped roof application are responsible for shedding liquid, water is expected to bypass these elements at some point during the building's service life due to natural deterioration of the materials or construction defects. Additionally, some cladding and finish systems are designed in a discontinuous manner (such as open joint cladding systems). As a result, a WRB or roof membrane/underlayment is necessary to protect the CLT, structure, and interior finishes from water ingress. Several of VaproShield's self-adhered products are designed to serve this function by resisting bulk water infiltration, with select products also offering extended UV and high-temperature stability. For considerations regarding CLT moisture management during shipping, site staging, and construction, refer to Chapter 4.

Figure 2-4 ***(Above)*** *Rain droplets on VaproShield's RevealShield SA Self-Adhered.*

***Figure 2-5* (Above)**
Small gaps between CLT laminations may not be completely airtight, thus requiring a separate air barrier membrane.

Air

Air movement across the building enclosure is caused by a pressure differential between the inner and outer enclosure surfaces. This pressure differential can usually be attributed to a combination of wind, the stack effect, and mechanical ventilation systems.

A continuous air barrier is a requirement of both the 2018 IECC[1] and the National Building Code of Canada[2] to control air flow across the enclosure. Limiting the air flow across the CLT enclosure, both inward and outward, has significant performance benefits such as reduced energy consumption for building heating and cooling, improved occupant comfort by limiting drafts, reduced risk for interstitial condensation from moisture-laden air, and minimized transfer of other undesirable substances such as sound, smoke, fire, and pollutants.

The air barrier is not a single component or material but rather requires a system of materials, components, and assemblies that provide continuous air control throughout the building enclosure. Newly manufactured CLT panels may be shown to be impermeable to air when tested in a laboratory setting; however, CLT panels will rarely remain airtight over the course of their transportation, construction, and service life due to potential dimensional changes that may cause delamination and/or cracks to form (see Figure 2-5).[3]

Air barrier continuity at joints and interfaces of erected CLT panels must also be considered for a complete air barrier system. An air barrier membrane over the CLT panel or the use of flashing/tape products at these interfaces are required for the long-term airtightness of the enclosure.

For an air barrier to be effective, it must be impermeable to air, continuous, stiff, strong, and durable.[4] VaproShield's line of self-adhered membranes meets these essential air barrier characteristics; thus, they can be used as an air barrier in addition to the WRB.

VaproShield Air Barrier Characteristics

Air Impermeability

The 2018 IECC requires that air barrier materials provide a maximum air leakage rate of 0.004 cfm/ft^2 (0.02 L/s m^2) under a pressure differential of 0.3 inches of water (75 Pa) and that assemblies provide a maximum air leakage rate of 0.04 cfm/ft^2 (0.2 L/s m^2) under a pressure differential of 0.3 inches of water (75 Pa).[1] VaproShield's sheet membrane products and accessories have been tested to meet these requirements as noted on each product's data sheet. When used throughout the building, VaproShield materials and assemblies can be used to help meet the maximum air leakage target for the whole building—a performance requirement that has become increasingly common with the introduction of code-mandated, whole-building air leakage testing in some regions/municipalities and voluntary energy efficiency standards.

Continuity

When fully adhered to a CLT substrate, VaproShield's sheet membrane products can improve continuity of the air barrier by resisting lateral air movement between the membrane and the CLT should unintentional discontinuities arise through damage or improper installation. For air barrier continuity at roof and wall transitions and interfaces, such as window and door rough openings, vent/electrical penetrations, CLT panel joints, and structural projections, VaproShield offers several accessory products that are compatible with VaproShield's suite of self-adhered sheet membranes, including ***VaproLiqui-Flash*™** and ***VaproBond*™** liquid applied flashing products, ***VaproTape UV Black*** and ***Vapro-SS Flashing*™** tape products, and ***VaproSilicone Transition*™ *Materials*** preformed silicone sheets. In addition, many common weather-grade sealants are compatible with VaproShield's products where dimensioned sealant joints are required to seal open joints between adjacent assemblies and systems. Refer to VaproShield's Sealant Compatibility Chart for more information regarding sealant testing results found at VaproShield.com.

Stiffness and Strength

An air barrier must be able to resist air pressure forces without tearing, deforming, or deflecting in such a way that it impedes the air barrier's ability to resist air flow as intended. The air barrier system will also be subjected to wind loads and other air pressure forces; thus, it must be strong enough to transfer these loads back to the building structure. VaproShield's proprietary adhesive, pre-applied at the backside of ***WrapShield SA*® *self-adhered*** ***RevealShield SA*™ *self-adhered*** and ***SlopeShield*® *Plus self-adhered*** sheet membranes, is designed to resist typical positive and negative building air pressures when fully adhered to an appropriate substrate such as CLT, transferring these loads back to the structure. The fully adhered application of these products also acts to spread air pressures uniformly over the entire membrane contact area, avoiding concentrated stresses at discrete attachment points common with mechanically attached air barrier systems.

Durability

An air barrier must be durable to avoid damage that could affect its intended performance during construction and throughout its service life. Specific to UV ray exposure, ***WrapShield SA*® *self-adhered*** can be left exposed for up to 6 months, and ***SlopeShield*® *Plus self-adhered*** for up to 6 months, prior to cover. If construction schedules or the cladding system dictates longer exposure periods, ***RevealShield SA*™ *self-adhered*** can be left fully exposed for up to 12 months on vertical walls, or permanently if partially concealed behind open joint cladding systems with joints up to 2 inches (51 mm) wide. ***RevealShield SA*™ *self-adhered*** and ***SlopeShield*® *Plus self-adhered*** are also rated for high service temperatures up to 225°F (107°C).

Figure 2-6 ***(Above)*** *Photo of mineral fiber insulation installation being installed between vertically oriented fiberglass girts.*

Figure 2-7 ***(Above)*** *Vertical wood furring with long-screw fastener attachments and rigid mineral fiber insulation installed over VaproShield WrapShield SA Self-Adhered/CLT.*

Heat

Heat will flow across the building enclosure when there is a temperature difference between the interior and exterior environments—the greater the temperature difference, the greater the thermal load. Thus, the heat or thermal load tends to be more influential in colder climates where the outdoor temperature dips below indoor temperatures throughout much of the year. Insulation is an essential component for energy efficient buildings in most, if not all, North American climate zones. Selection and placement of the insulation can also improve occupant thermal comfort, provide a buffer from outdoor noise, and help manage condensation risk within the CLT enclosure.

CLT panels contribute to the assembly's thermal performance because wood has a relatively low thermal conductivity when compared to other common structural materials such as concrete and steel. Most building codes across North America typically reference some version of the IECC,[1] ASHRAE 90.1,[5] or the National Energy Code of Canada for Buildings (NECB)[6] to set the minimum required level of insulation. Minimum insulation requirements generally fall within the R-15 to R-31 (RSI 2.6 to RSI 5.5) range for walls, and R-29 to R-48 (RSI 5.1 to RSI 8.5) for roofs; however, project-specific performance requirements may require greater levels of insulation than that required by code.

The thermal resistance of wood per inch varies based on moisture content and species, but for most commonly used North American softwood species, a thermal resistance of R-1.2 (RSI 0.21) per inch can be used.[7] Thus, a 5-ply, 5-5/8 inch (143 mm) thick CLT panel can be expected to contribute R-6.8 (RSI 1.9) to the enclosure assembly's thermal performance. In most scenarios, the thermal resistance of the CLT panel alone will not be great enough to meet the required thermal performance of the assembly, and additional insulation will be needed. It is typically desirable to locate insulation outboard of the CLT to keep the CLT panel closer to the indoor temperature, minimizing condensation risk and limiting temperature and relative humidity fluctuations that may result in dimensional cycling of the CLT.

When a more highly conductive element, such as metal, bridges the insulation layer, it creates a path of lower resistance to heat flow. This path is commonly called a thermal bridge and will degrade the thermal performance of the insulation layer and overall assembly thermal performance. For CLT assemblies, it is common to locate the insulation exterior of the CLT, keeping the large structural connections inboard of the insulation layer; thus, thermal bridges at CLT assemblies tend to result from a need to transfer wind loads and cladding loads back to the structure. Cladding and roof attachments/fasteners can have a significant impact on the thermal performance of the enclosure and can vary widely based on the system used. Generally, more thermally efficient options for these attachment points rely on less thermally conductive materials such as stainless steel, fiberglass, and/or intermittent attachments through the insulation, such as clips or fasteners, in lieu of continuous metal furring.[8] Two examples of thermally efficient cladding attachment solutions are shown in Figure 2-6 and Figure 2-7. The attachment method will depend on the type of insulation used. Additionally, sealing may be required for some cladding attachment components where the attachments penetrates the VaproShield WRB and air barrier membrane.

The mass of the CLT panel can also impact the thermal performance of the assembly by moderating heat flow through thermal storage. Depending on climate and other building factors, this thermal storage and throttling effect may reduce both annual and peak heating and cooling requirements, particularly in warmer climates with large daily temperature variations. Building codes that reference the IECC or ASHRAE 90.1 may credit this thermal mass effect with less stringent prescriptive insulation requirements for mass wall and floor assemblies. A CLT assembly may exceed the minimum heat capacity required by IECC/ASHRAE 90.1 to meet the definition of a mass wall or floor; however, this will largely depend on the thickness of the panel, the wood species used, and code interpretations by the local governing jurisdiction.

Vapor Retarder Classes per the 2018 IBC[9]

Class 1 Vapor Retarder:
Less than 0.1 perm

Class 2 Vapor Retarder:
Between 0.1 and 1 perms

Class 3 Vapor Retarder:
Between 1 and 10 perms

Vapor

Water vapor molecules diffuse through materials from areas of high concentration to low concentration (i.e., from high humidity to low humidity). The resulting "vapor drive" can be an important consideration in the design of CLT enclosures. An accumulation of water vapor in the CLT assembly can result in interstitial condensation and/or excessive moisture uptake by the CLT. In most applications, the resulting direction of the vapor drive is from the warm side to the cold side of the enclosure such that in colder weather, the direction of the vapor drive is from indoors to outdoors. It is important to consider that the direction of the vapor drive may switch throughout the year as seasons change; however, vapor diffusion through most materials is a relatively slow process. Therefore, the more prevailing environmental conditions are most often considered. Additionally, depending on the space conditioning needs, some interior environments may not subscribe to this rule of thumb and should be carefully considered during enclosure design.

While controlling air leakage across the enclosure is an effective means of managing water vapor, providing a separate vapor retarder is often also required to moderate the diffusion of water vapor across the materials within an assembly. The 2018 International Building Code (IBC) defines three classes of vapor retarding materials as defined to the left.[9] At typical indoor humidity levels, the permeance of a 3-ply, 3-1/2 inch (89 mm) CLT panel is between 0.05 to 0.6 US perms (3 ng/Pa·s·m^2 to 35 ng/Pa·s·m^2) and thicker CLT panels are even less permeable, corresponding to a Class 1 or 2 vapor retarder.[3]

When insulation is located entirely outboard of the CLT panel in cold, heating-dominated climates (i.e., ASHRAE/IECC Climate Zones 4 through 8), a separate vapor retarder is likely not necessary, and is often not advisable. Omitting the vapor retarder allows the panel to dry to the interior as needed from seasonal wetting or construction.

VaproShield's WRB and air barrier sheet membranes, roof underlayment sheet membranes, and most flashing membranes are vapor permeable to allow for some seasonal drying of the CLT panel. In these scenarios, it is also beneficial to use exterior insulation that is vapor permeable to allow drying to the exterior environment and to avoid trapping vapor behind the insulation, as shown in Figure 2-8.

Fire Protection

While fire protection is not the focus of this guide, the combustibility of the CLT assembly may need to be considered to meet local building and fire code requirements. Often, the CLT itself will meet the required fire rating for the assembly; however, in some cases, an additional noncombustible thermal barrier may be required, such as exterior gypsum sheathing. In these instances, VaproShield's products can be applied directly to the gypsum sheathing, similar to a typical installation over a framed wall.

In taller CLT buildings, the combustibility of the WRB membrane may also need to be considered. For construction exceeding 40 feet (122 m), section 1402.5 of the 2018 IBC requires that CLT wall assemblies with a combustible WRB membrane are tested following NFPA 285[10] procedures to demonstrate conformance with fire performance requirements. The code currently does list exceptions for the testing requirements where the assembly is deemed to comply if the WRB is the only combustible component and has: (1) a peak heat release rate (HRR) of less than 150 kW/m^2, a total heat release of less than 20 MJ/m^2, an effective heat of combustion of less than 18 MJ/kg when tested per ASTM E1354; and (2) a flame spread index of 25 or less and a smoke-developed index of 450 or less when tested per ASTM E84.[9] Table 2-1 on page 22 lists the tested fire performance values, among other test results, for the VaproShield sheet membrane products discussed in this guide. Note that RevealShield SA conforms to the maximum heat release values and flame and smoke spread indices noted in the code exception above.

It should be noted that CLT construction practices are still relatively new in North America, and codes are continuously being updated to accommodate more prescriptive paths to fire compliance for CLT assemblies. This guide recommends that project-specific fire protection requirements are confirmed with the local jurisdiction having authority. Contact a local VaproShield representative should more information be required regarding the combustibility and fire performance of VaproShield's products.

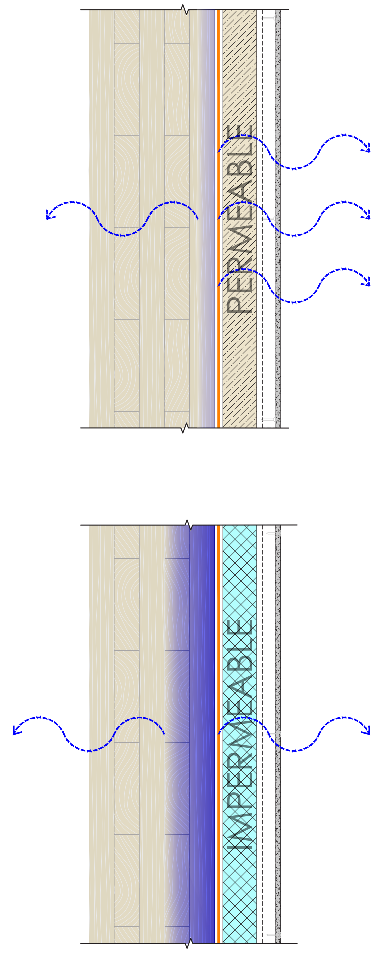


***Figure 2-8** (Above)* *Vapor-permeable exterior insulation (top) and vapor impermeable exterior insulation (bottom) over a vapor permeable membrane such as WrapShield SA Self-Adhered (orange). Vapor impermeable insulation can impede the drying of moisture stored in the outer CLT laminations.*

Table 2-1 WrapShield SA Self-Adhered, RevealShield SA Self-Adhered, and SlopeShield Plus Self-Adhered tested performance values.

Tested Performance Values			
	WrapShield SA Self-Adhered	**RevealShield SA Self-Adhered**	**SlopeShield Plus Self-Adhered**
Description	WRB and Air Barrier Sheet Membrane	WRB and Air Barrier Sheet Membrane, designed for long-term UV resistance and open joint cladding	Roofing underlayment
Air Permeance (ASTM E2178 @75 Pa)	0.0000 cfm/ft² (0.0001 L/s•m²)	0.0000 cfm/ft² (0.0001 L/s•m²)	0.00086 cfm/ft² @ 1.57 psf (0.00437 L/s·m² @ 75 Pa)
Water Resistance	No Leakage (ASTM D779 Boat Test)	No Leakage (ASTM D779 Boat Test)	No Leakage (Hydrostatic Pressure Test, 24 inches H_20 for 24 hours)
Maximum UV Exposure Before Cover	6 months	12 months	6 months
Water Vapor Permeance (ASTM E96 Procedure B)	50 Perm (grain/h•ft²•inchHg)	63 Perm (grain/h•ft²•inchHg)	30 Perm (grain/h•ft²•inchHg)
	2886 ng/Pa•s•m²	3632 ng/Pa•s•m²	1716 ng/Pa•s•m²
Fire Testing (ASTM E84)	Flame Spread 5	Flame Spread 0	Flame Spread 5
	Smoke Developed 15	Smoke Developed 75	Smoke Developed 45
ASTM E 1354 Testing			
Peak HRR	263 kW/m²	98 kW/m²*	156 kW/m²
Total Heat Release	6.4 MJ/m²	4.0 MJ/m²*	7.4 MJ/m²
Average Effective Heat of Combustion	15.9 MJ/kg	5.1 MJ/kg*	6.6 kJ/kg (0.0066 MJ/kg)

*Meets the 2018 IBC section 1402.5 exemptions for combustible WRBs.

Termite and Pest Protection

In areas where termites and other wood-burrowing pests are prevalent, local codes may require protective measures for insect damage at CLT. These measures can be especially important at exposed areas of CLT and at grade where CLT is in contact with the foundation. To protect against termites and other pests, pest-sensitive CLT areas can be preservative treated and termite soil barriers introduced into the foundation design, such as termiticide soil treatments and separation membranes between the foundation and CLT. Regardless of the local termite risk, pest control measures discussed in Chapter 3, such as insect screens at cladding openings and separation membranes at footings, are best practices in all regions.

Chapter 3

CLT Building Enclosures

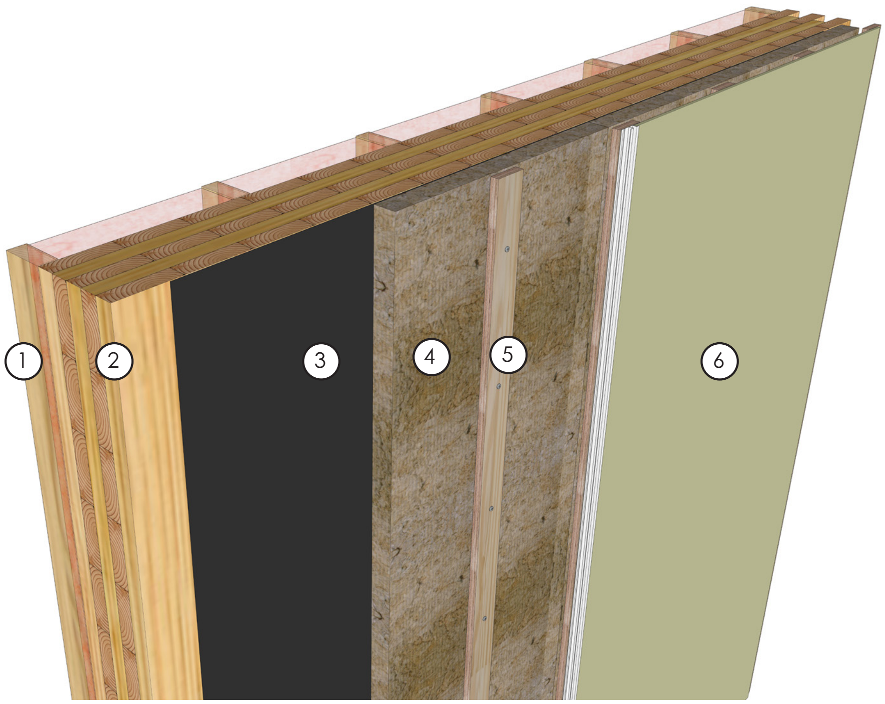
In this chapter, the building enclosure design principles introduced in Chapter 2 are applied to CLT wall and roof assemblies.

CLT Wall Design and Best Practices

Two options for CLT wall assemblies in cold climates (i.e., Climate Zones 4 through 8) are shown in Detail 1 and Detail 2. The assembly shown in Detail 1 includes a closed joint cladding system and Detail 2 includes an open joint cladding system. Both assemblies rely on a rainscreen strategy for managing rainwater. In some North American regions, this is known as a drained and ventilated strategy.[11] In a CLT structure, exterior cladding surfaces, flashings, and enclosure projections shed and deflect most of the incident rainwater. Incidental water that bypasses the exterior cladding of a rainscreen system is then managed by the following means:

- The WRB that serves as a drainage plane. Either ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED*** may serve as the WRB in the assemblies shown in Detail 1 and Detail 2.
- A clear air gap to allow water to drain. This air gap is also ideally designed to allow ventilation to improve the drying potential for moisture contained in the drainage cavity and at the backside of the cladding material.
- Deflection mechanisms such as flashings to drain water back to the exterior.

In these assemblies, the ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED*** WRB also functions as the air barrier. The wall assemblies are exterior insulated with vapor permeable mineral fiber insulation to permit outward drying. If a vapor impermeable insulation type is used, this guide recommends that the assembly is carefully evaluated by a design professional to ensure the wall design does not increase risk for moisture accumulation within the wall assembly. Considerations for the cladding attachment through the exterior insulation and the WRB membrane are discussed on page 28 and page 29. In some cases, batt insulation may be added inboard of the CLT panel if required for sound attenuation or to improve the thermal performance of the assembly; however, the amount of interior insulation must be carefully balanced with the

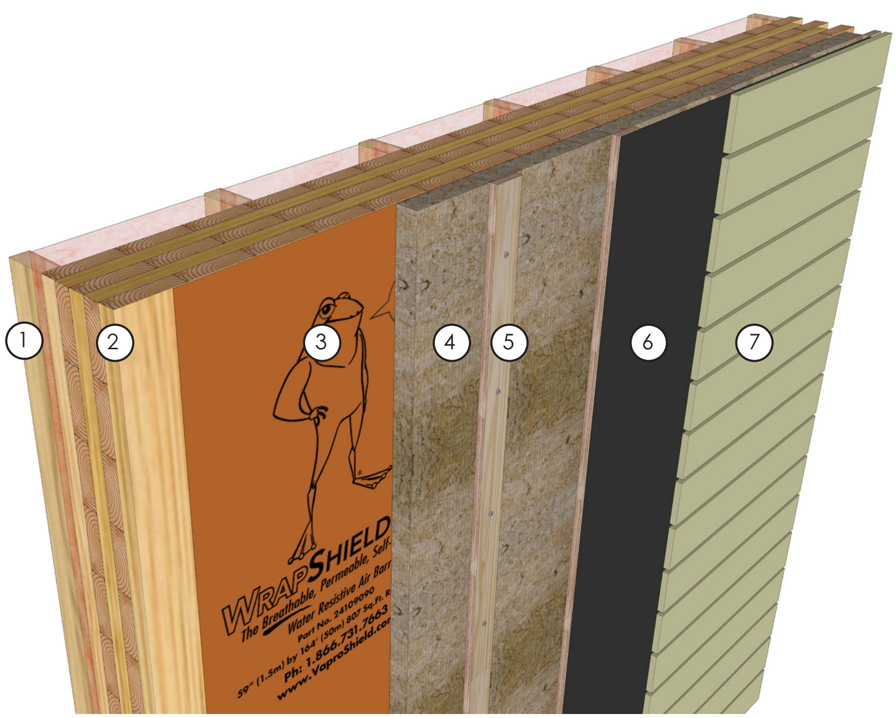


Detail 1
Closed joint cladding assembly.

Legend

(listed from interior to exterior)

1. Interior finishes and insulation if required by the design (optional)
2. CLT wall panel
3. ***REVEALSHIELD SA™ SELF-ADHERED*** (shown) or ***WRAPSHIELD SA® SELF-ADHERED*** WRB and air barrier membrane
4. Mineral fiber insulation; rigid or semi-rigid depending on the cladding attachment strategy
5. Furring strips and rainscreen drainage cavity; see page 28 and page 29 for additional cladding attachment options
6. Closed joint cladding



Detail 2
Open joint cladding assembly.

Legend

(listed from interior to exterior)

1. Interior finishes and insulation if required by the design (optional)
2. CLT wall panel
3. ***WRAPSHIELD SA® SELF-ADHERED*** (shown) or ***REVEALSHIELD SA™ SELF-ADHERED*** WRB and air barrier membrane
4. Mineral fiber insulation; rigid or semi-rigid depending on the cladding attachment strategy
5. Furring strips and rainscreen drainage cavity; see page 28 and page 29 for additional cladding attachment options
6. ***REVEALSHIELD™ IT INTEGREATED TAPE***
7. Open joint cladding

exterior insulation. This guide recommends that interior insulated assemblies are evaluated by a design professional to minimize the risk that condensation may form within the assembly.

For the open joint cladding system shown in Detail 2, a sheet of ***REVEALSHIELD™ IT INTEGRATED TAPE*** is provided directly behind the cladding material and attached to the vertical furring. The ***REVEALSHIELD™ IT INTEGRATED TAPE*** serves to protect the insulation, the WRB, and other UV-sensitive components from UV rays. The ***REVEALSHIELD™ IT INTEGRATED TAPE*** also serves as an additional drainage plane immediately behind the cladding to shed the increased water load resulting from the open cladding joints.

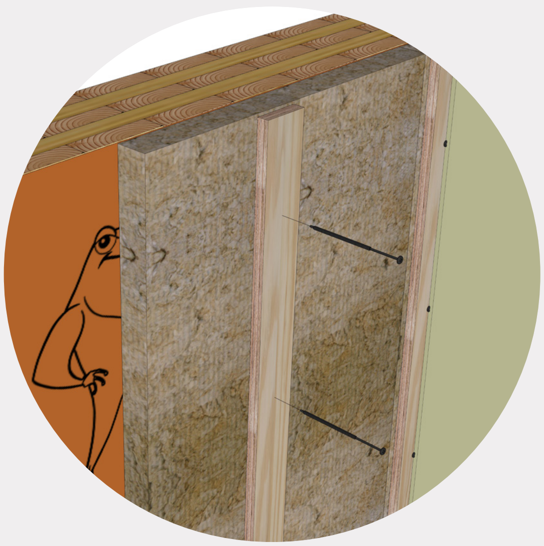


Figure 3-1

Long screw with wood furring strips.

Long screws through the insulation can be a cost-effective and thermally efficient option for the attachment of light to medium weight claddings. With this system, the cladding is attached to treated vertical wood furring strips placed against the face of a rigid mineral fiber insulation. The furring strips are fastened back through rigid mineral fiber insulation to the CLT panel. Additional detailing is typically not required where the fastener penetrates ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED***.

Figure 3-2

Clip and rail system.

With clip and rail systems, the cladding is attached to vertical or horizontal metal girts. The girts, or rails, are attached to intermittent clips that bridge the insulation and are attached to the CLT structure. The insulation may be rigid or semi-rigid mineral fiber; however, semi-rigid insulation is typically easier to fit around the clips. Additional detailing is typically not required at clip fastener penetrations through ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED*** when the clips are installed tight to the membrane. However, when clips are not installed snug to the wall, the gap created behind the clip can trap water, increasing the risk for water ingress at fastener penetrations. ***VAPROSHIM SA™ SELF-ADHERED*** or ***VAPROBOND™*** are used at fastener locations to seal around the fastener in these scenarios.

Cladding Attachment Considerations

Cladding attachment penetrations through the ***WrapShield SA*® *self-adhered*** or ***RevealShield SA*™ *self-adhered*** membrane require careful consideration. As discussed in Chapter 2, cladding attachments can impact the thermal performance of the assembly as well as disrupt the WRB and air barrier if not carefully designed. Discussion for four common cladding attachment systems is provided in Figure 3-1 through Figure 3-4.

Figure 3-3

Vertical girt.

Vertically oriented girts are a common form of cladding attachment with rigid or semi-rigid mineral fiber insulation types. Continuous metal girts significantly degrade the performance of exterior insulation but more thermally efficient girts made of less thermally conductive materials are available. Similar to the clip and rail system, girt fastener penetrations through ***WrapShield SA*® *self-adhered*** or ***RevealShield SA*™ *self-adhered*** do not typically require additional detailing if the girt is installed tight to the wall. Where girts are not tight, ***VaproShim SA*™ *self-adhered*** or ***VaproBond*™** are used at fastener locations to improve the seal at fastener penetrations.

Figure 3-4

Horizontal girt.

Continuous horizontal girts can significantly degrade the performance of exterior insulation unless non-metal girts are used. Horizontal girts without flutes or perforations installed tight to the WRB may block the drainage path at the WRB plane. VaproShield requires that horizontal girts are shimmed with ***VaproShim SA*™ *self-adhered*** to provide a continuous drainage plane and to seal around girt fastener penetrations through the membrane. Rigid or semi-rigid mineral fiber insulation types can be used with this attachment approach.

Window Rough Opening Detailing

Typical window rough opening details are shown in Detail 3a through Detail 3d. The typical window rough opening wrap sequence, including integration with the WRB and air barrier membrane at the field of wall areas, is shown in Detail 4.

The interface where the window system meets the CLT panel is important because it can be a common source for water leakage if not designed and constructed appropriately. Appropriate detailing to provide continuous protection against water and air leakage requires that the WRB is flashed into the rough opening and a continuous air and water seal (typically a backer rod and sealant joint) is provided around the window perimeter.

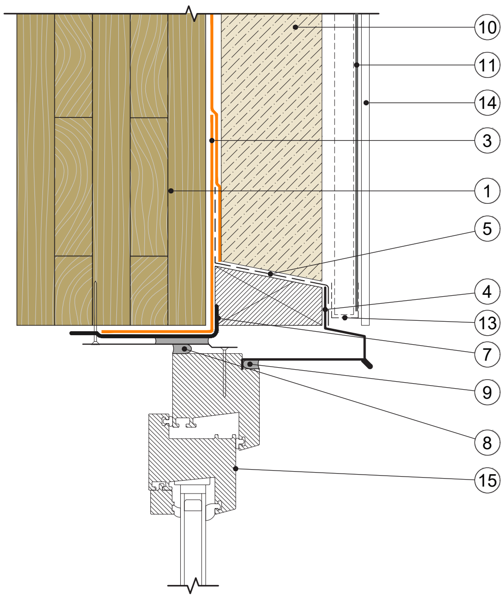
Best practice in some markets may dictate a metal back dam angle at the rough opening sill to form a sill pan. This angle may also serve as the structural attachment point for the window sill to avoid fastener penetrations down through the rough opening sill. Details for both a sill with a back dam angle and without a back dam angle are shown in Detail 3c and Detail 3d.

A sloped wood nailer is shown above the window as a thermally efficient attachment method for the window head flashing and to provide a solid substrate for the ***Vapro-SS Flashing***™ membrane.

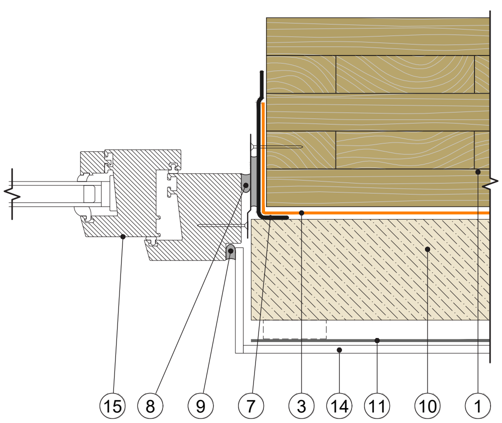
Detail 3
Window rough opening.

VAPROSHIELD®
Breathable Membrane Systems for Roofs & Walls

***Detail 3**a* *Window head detail.*



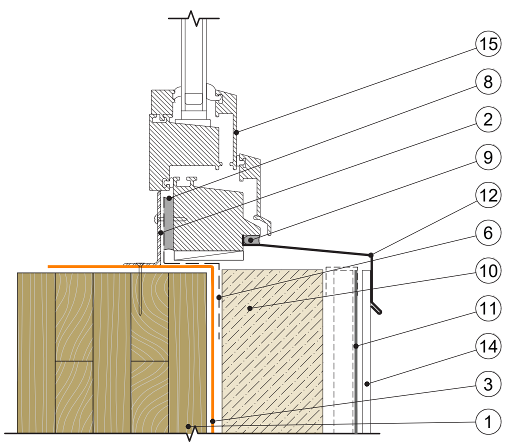
Detail 3b *Window jamb detail.*



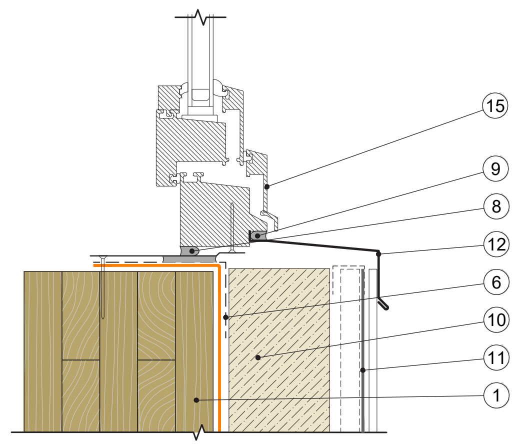
Legend

1. CLT wall panel
2. Metal back dam angle at sill
3. ***WRAPFLASHING SA™ SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED*** (or strip of ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED***) prestrips per the Detail 4 wrap sequence
4. Sheet-metal head flashing (sloped) with folded end dams attached to sloped wood blocking
5. ***VAPRO-SS FLASHING™*** membrane material
6. ***VAPRO-SS FLASHING™*** sill pan per the Detail 4 wrap sequence
7. ***VAPROLIQUI-FLASH™*** or ***VAPROBOND™*** at jamb and head conditions per Detail 4 wrap sequence
8. Continuous perimeter air and water seal at window head, jamb, and sill conditions. Seal is continuous on both sides of window clips (where provided)
9. Exterior backer rod and sealant joint (not to block window weeps at sill condition)
10. Mineral fiber insulation; rigid or semi-rigid depending on the cladding attachment strategy
11. ***REVEALSHIELD™ IT INTEGREATED TAPE*** (behind open joint cladding systems)
12. Sheet-metal sill flashing with folded end dams
13. Insect screen
14. Cladding (open or closed joint)
15. Window on intermittent shims

Detail 3c *Window sill detail (with back dam angle).*



Detail 3d *Window sill detail (without back dam angle).*



Detail 4

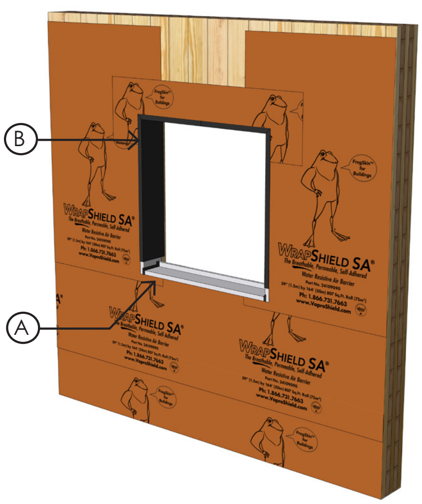
Window wrap sequence.

Breathable Membrane Systems for Roofs & Walls

Step 1 ***WrapShield SA***® ***SELF-ADHERED*** or ***RevealShield SA***™ ***SELF-ADHERED*** sill piece applied directly to the CLT panel and installed into the rough opening to the depth of the air and water seal for the window system.

Step 2 (A) ***WrapShield SA***® ***SELF-ADHERED*** or ***RevealShield SA***™ ***SELF-ADHERED*** jamb pieces applied directly to the CLT panel and installed into the rough opening to the depth of the air and water seal for the window system. Maintain minimum 3 inches (76 mm) material laps.

(B) ***WrapFlashing SA***™ ***SELF-ADHERED*** or ***RevealFlashing SA***™ ***SELF-ADHERED*** (or strip of ***WrapShield SA***® ***SELF-ADHERED*** or ***RevealShield SA***™ ***SELF-ADHERED***) head piece applied directly to the CLT panel and installed into the rough opening to the depth of the planned primary air and water seal for the window system.



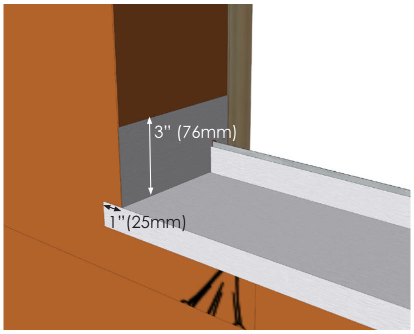
Step 3 (A) Prepare the rough opening with ***Vapro-SS Flashing***™ applied to the sill membrane per Steps 5 and 6.

(B) ***VaproLiqui-Flash***™ or ***VaproBond***™ at the jamb and head conditions per Step 7. See page 33.

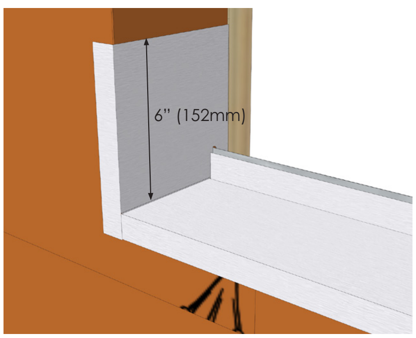
Step 4 ***Vapro-SS Flashing***™ membrane applied over the wood blocking and head flashing. ***WrapShield SA***® ***SELF-ADHERED*** or ***RevealShield SA***™ ***SELF-ADHERED*** field membrane from above laps the ***Vapro-SS Flashing***™ a minimum of 3 inches (76 mm).

Detail 4 cont.

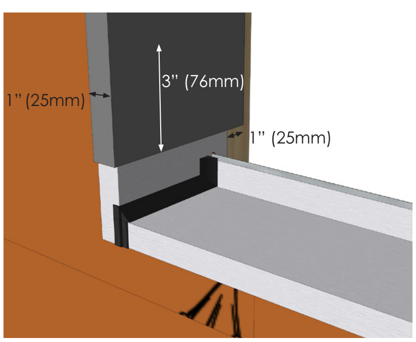
Option 1: Sill Flashing with Back Dam Angle



Step 5 ***VAPRO-SS FLASHING™*** at sill 1 inch (25 mm) down onto the face of the wall. ***VAPRO-SS FLASHING™*** to extend up the back dam angle. Fold end tabs a minimum of 3 inch (76 mm) up the jamb and notch around the back dam angle.

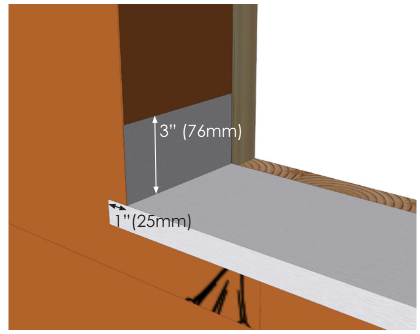


Step 6 ***VAPRO-SS FLASHING™*** at sill-to-jamb corners into the rough opening to the depth of the air and water seal for the window system and 1 inch (25 mm) onto the face. Corner pieces extend up jambs a minimum of 6 inches (152 mm) and are notched tight around the back dam angle.

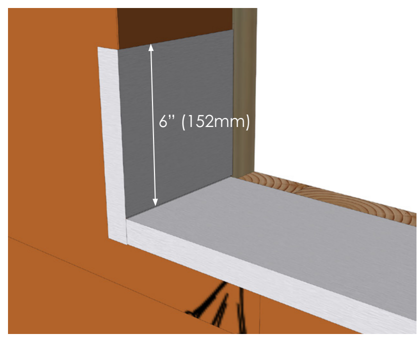


Step 7 ***VAPROLIQUI-FLASH™*** or ***VAPROBOND™*** ½ inch (13 mm) tooled fillet bead at ***VAPRO-SS FLASHING™*** seams, including back dam angle to jamb interface. ***VAPROLIQUI-FLASH™*** at head and jambs a minimum of 1 inch(25 mm) onto the face, 3 inches (76 mm) onto the ***VAPRO-SS FLASHING™*** corners, and 1 inch (25 mm) directly onto the CLT inside the rough opening.

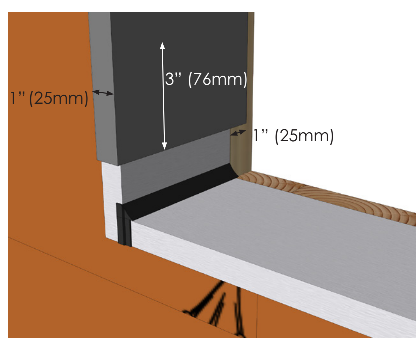
Option 2: Sill Flashing without Back Dam Angle



Step 5 ***VAPRO-SS FLASHING™*** at sill 1 inch (25 mm) down onto the face of the wall. ***VAPRO-SS FLASHING™*** to extend into the rough opening to the depth of the air and water seal for the window system. Fold end tabs a minimum of 3 inch (76 mm) up the jamb.



Step 6 ***VAPRO-SS FLASHING™*** at sill-to-jamb corners into the rough opening to the depth of the air and water seal for the window system and 1 inch (25 mm) onto the face. Corner pieces extend up jambs a minimum of 6 inches (152 mm).



Step 7 ***VAPROLIQUI-FLASH™*** or ***VAPROBOND™*** ½" inch (13 mm) tooled fillet bead at ***VAPRO-SS FLASHING™*** seams. ***VAPROLIQUI-FLASH™*** at head and jambs a minimum of 1 inch (25 mm) onto the face, 3 inches (76 mm) onto the ***VAPRO-SS FLASHING™*** corners, and 1 inch (25 mm) directly onto the CLT inside the rough opening.

Typical Wall Penetration Detailing

Penetrations through the ***WrapShield SA® self-adhered*** or ***RevealShield SA™ self-adhered*** membrane are flashed with ***VaproBond™*** or ***VaproLiqui-Flash™*** to maintain continuity of the drainage plane and air barrier. Typical penetrations encountered in the field may include CLT strap anchors, conduits, and flanged boxes as illustrated in Detail 5.

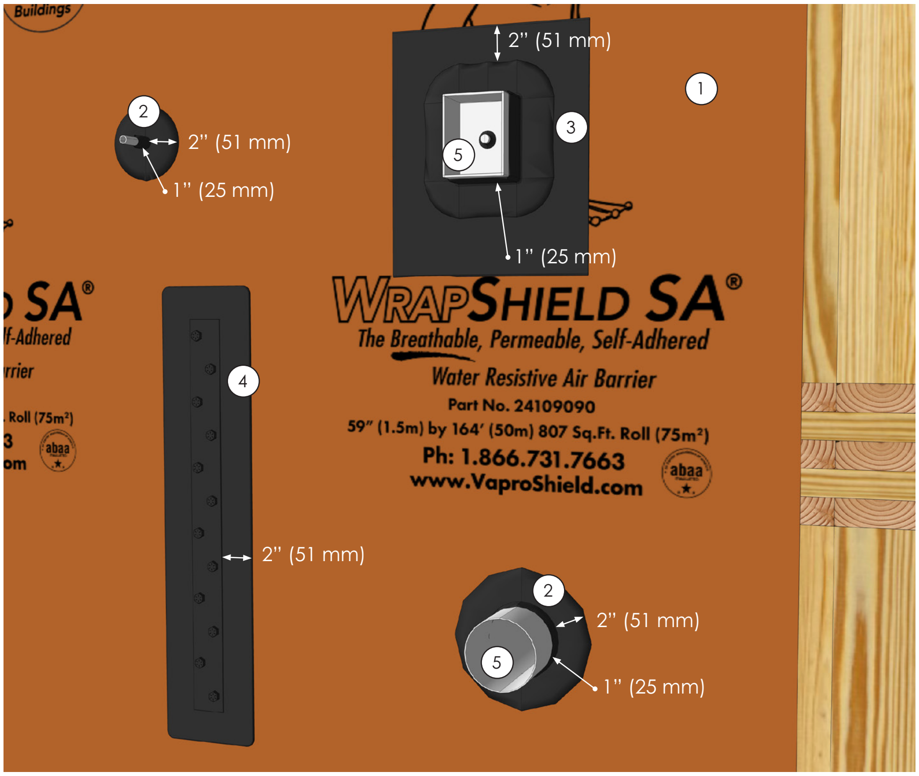
Penetrations are typically cut or cored through the CLT panel. It is best practice to preplan locations to ensure that no conflicts exist with other physical building components or with the construction sequencing.

Base of Wall Detailing

A typical CLT base of wall condition is depicted in Detail 6.

CLT is not used in below-grade applications and local building codes dictate the minimum required clearance between the finish ground elevation and structural wood components that are supported by exterior foundation walls and footings. Typically, this requirement is 6 inches to 8 inches (152 mm to 203 mm) or the wood is required to be preservative-treated. Regardless of the CLT wood treatment and minimum code requirements, 8 inches (203 mm) of clearance is best practice for CLT wall panels at exterior foundation walls and footings.

Best practice also dictates that the CLT is separated from the foundation using a vapor-impermeable membrane to provide a capillary break and barrier against burrowing insects. In Detail 6 this membrane is provided by the ***Vapro-SS Flashing™***. The sheet-metal flashing at the base of the CLT deflects drained moisture out of the assembly and away from the below-grade assembly. The insect screen at the bottom of the cladding opening helps to prevent pests from burrowing into the assembly cavity. Additional protective measures may be required in termite-prone areas.

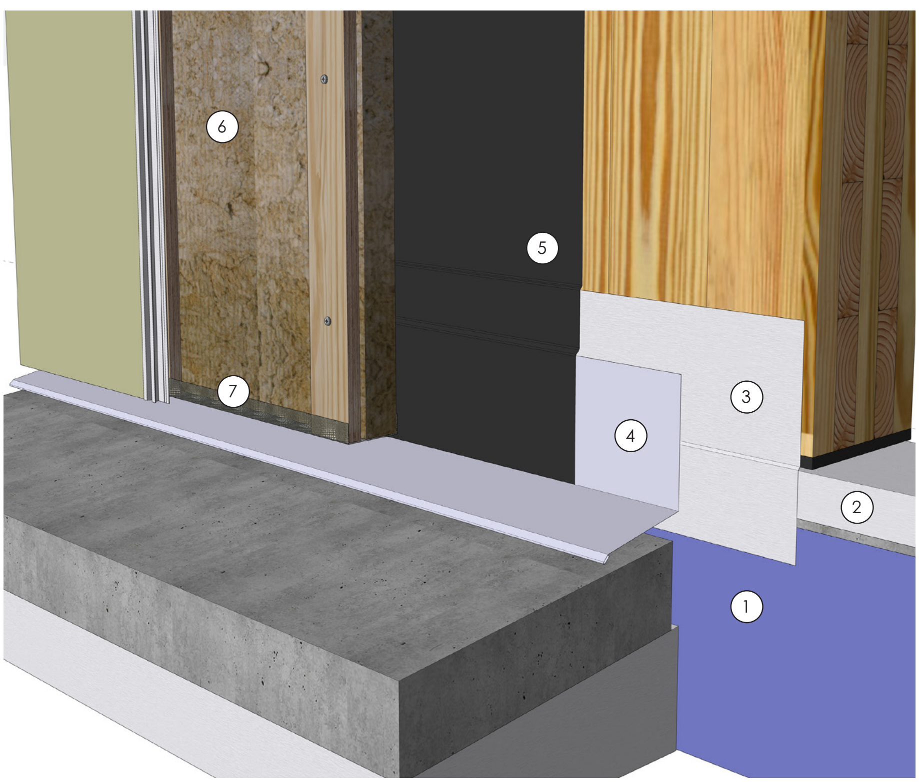


Detail 5

Typical penetration and CLT strap anchor detail.

Legend

1. **WRAPSHIELD SA® SELF-ADHERED** or **REVEALSHIELD SA™ SELF-ADHERED** field membrane
2. Pipe penetrations: **VAPROBOND™** or **VAPROLIQUI-FLASH™** minimum 1 inch (25 mm) onto the penetration and 2 inches (51 mm) onto the **WRAPSHIELD SA® SELF-ADHERED** field membrane
3. Box penetrations: **VAPROBOND™** or **VAPROLIQUI-FLASH™** completely covering flanges and fasteners
4. CLT straps: **VAPROBOND™** or **VAPROLIQUI-FLASH™** to coat CLT strap anchors and 2 inches (51 mm) onto the **WRAPSHIELD SA® SELF-ADHERED** field membrane
5. Air and water seal at penetrations through conduits/electrical boxes



Detail 6

Base of wall detailing.

Legend

(listed exterior to interior)

1. Below-grade waterproofing or damp proofing
2. **VAPRO-SS FLASHING™** capillary break
3. **VAPRO-SS FLASHING™** lapped a minimum of 3 inches (76 mm) over the below-grade waterproofing/ damp proofing
4. Base of wall sheet-metal flashing
5. **WRAPSHIELD SA® SELF-ADHERED** or **REVEALSHIELD SA™ SELF-ADHERED** field membrane, lapped a minimum of 3 inches (76 mm) over the **VAPRO-SS FLASHING™** and the back leg of the sheet-metal flashing
6. Insulation and cladding components
7. Insect screen

CLT Roof Design and Best Practices

Roof structures can be classified by their pitch. The approach to water and moisture management at roof assemblies typically varies based on roof pitch. Strategies for the design of CLT roof enclosures sloped at a pitch of 2:12 or greater, as shown in Figure 3-5, and at less than 2:12 are discussed separately. Only exterior insulated CLT roof assemblies are discussed in this guide; CLT roofs that are insulated from the interior are atypical in cold climates and require careful consideration of the air permeance and vapor permeance properties of their interior insulation.

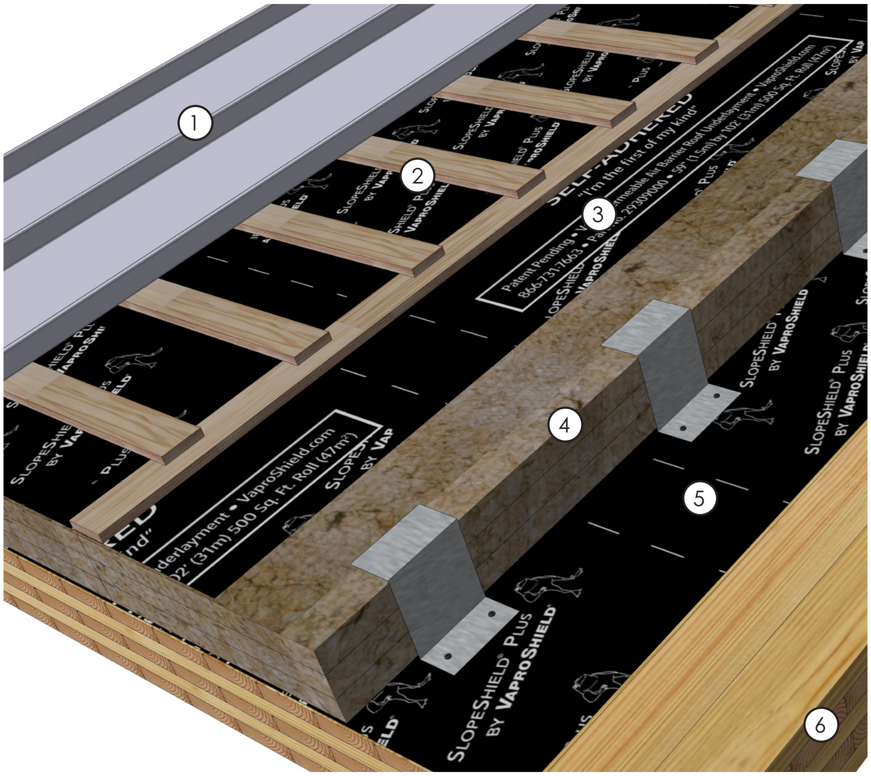
CLT Roof Design (≥ 2:12 Pitch)

Two options for CLT roof assemblies with a 2:12 or greater slope are shown in Detail 7 and Detail 8. These assemblies use ***SlopeShield® Plus self-adhered*** at two key locations:

- As a roof underlayment beneath the finish roof material. At this location, the membrane sheds water that may bypass the finish roof material and also protects components below from moisture.
- Over the top of the CLT. At this location, the membrane serves as the air barrier and also minimizes the risk that the CLT panel is exposed to moisture should a failure in the assembly components above occur. This membrane layer also serves as a temporary roof membrane, to protect the CLT structure from construction phase moisture until the remaining assembly materials are installed.

In both assemblies, vapor control is provided by the CLT panel. Unlike most common self-adhered roof underlayment products, ***SlopeShield® Plus self-adhered*** is vapor permeable to allow for some drying of the CLT substrate after application. ***SlopeShield® Plus self-adhered*** also offers extended UV stability and can be left exposed for up to 6 months prior to cover to provide greater flexibility in the construction schedule when compared to less UV-stable underlayment products. It is also important to consider that some finish roof materials, such as metal panels, may require a high-temperature underlayment membrane. ***SlopeShield® Plus self-adhered*** can be used in high-temperature roofing applications with acceptable service temperatures up to 225°F (107 °C).

Depending on project-specific requirements, the assembly shown in Detail 7 can be made more durable by fully adhering

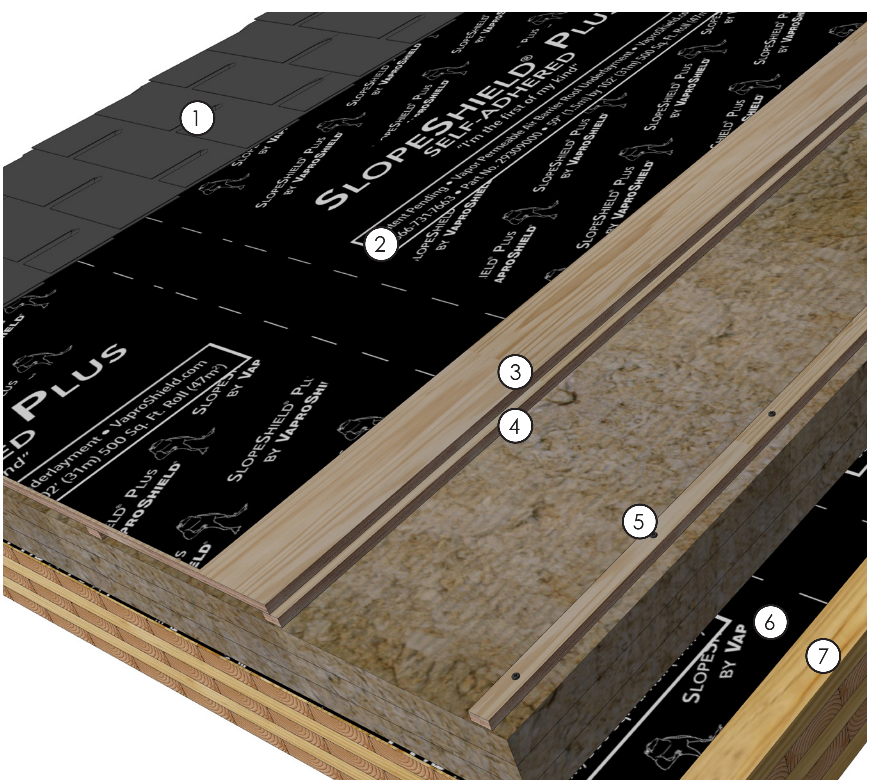


Detail 7
Metal roof assembly (≥ 2:12 pitch).

Legend

(listed exterior to interior)

1. Metal roof panel
2. Treated wood cross batten
3. ***SlopeShield® Plus Self-Adhered*** roof underlayment (water barrier)
4. Rigid or semi-rigid mineral fiber insulation between intermittent metal clips
5. ***SlopeShield® Plus Self-Adhered*** air barrier and temporary moisture protection
6. CLT panel and structure



Detail 8
Shingle roof assembly (≥ 2:12 pitch).

Legend

(listed exterior to interior)

1. Roof shingles
2. ***SlopeShield® Plus Self-Adhered*** roof underlayment (water barrier)
3. Structural sheathing
4. Strapped, ventilated air cavity
5. Mineral fiber insulation; rigid or semi-rigid depending on the finish roof attachment strategy
6. ***SlopeShield® Plus Self-Adhered*** air barrier and temporary moisture protection
7. CLT panel and structure

the top layer of ***SlopeShield® Plus self-adhered*** underlayment to a solid sheathing layer such as plywood, similar to that shown in Detail 8. ***VaproMat™*** may also be added above the ***SlopeShield® Plus self-adhered*** underlayment membrane where a ventilated and drained cavity is required by the finish roof manufacturer if the finish roof is not attached using a batten system or similar standoff.

The remaining assembly layers in Detail 7 and Detail 8 include:

- Layers of mineral fiber insulation as required to meet the targeted thermal performance of the roof assembly. Rigid mineral wool insulation is required when long screws are used for the direct attachment of the nail base sheathing to the CLT, and semi-rigid insulation may be used when the attachment is through a system of clips or similar methods.
- A strapped and ventilated air cavity to further encourage drying below the finish roof materials.
- Finish roof materials (e.g., metal panels, slate tiles, asphalt shingles, etc.) attached to a plywood substrate or treated wood cross battens.

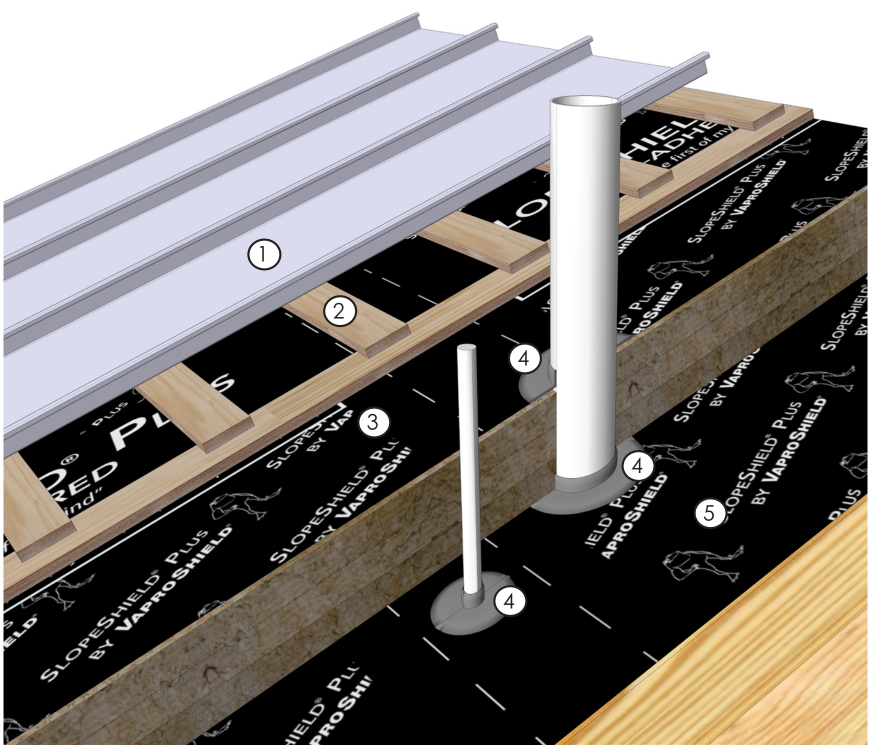
Roof Penetration Detailing

A typical penetration detail for a CLT roof assembly sloped at 2:12 or greater is shown in Detail 9. Similar to wall penetrations, the placement of roof penetrations requires planning to prevent conflicts from arising during construction. Penetrations through both ***SlopeShield® Plus self-adhered*** planes are flashed for continuity of the water barrier, air barrier, and/or temporary moisture protection layer.

Fastener penetrations at structural clips and similar penetrations used for the attachment of the finish roof and sub framing may also need to be considered. At slopes less than 4:12, VaproShield requires that ***VaproLiqui-Flash™*** or ***VaproShim SA™ self-adhered*** is provided under metal clips and similar penetrations to improve the sealing around fasteners. VaproShield does not require additional treatment at clips for roof slopes of 4:12 or greater.

Figure 3-5 SlopeShield SA underlayment, similar to SlopeShield Plus Self-Adhered, over a gabled CLT roof.

Project: Haus Gables
Architect: Jennifer Bonner

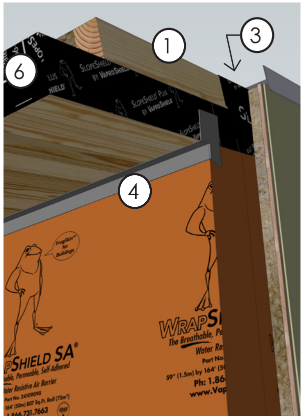


Detail 9
Roof penetration detail (≥ 2:12 pitch).

Legend

(listed exterior to interior)

1. Metal roof panel
2. Treated wood cross batten
3. ***SlopeShield® Plus self-adhered*** roof underlayment (water barrier)
4. ***VaproBond™*** or ***VaproLiqui-Flash™*** minimum 1 inch (25 mm) onto the penetration and 2 inches (51 mm) onto the ***SlopeShield® Plus self-adhered***
5. ***SlopeShield® Plus self-adhered***, air barrier and temporary moisture protection



Detail 10a *Roof rake and eave detail from underside.*

See ***Detail 10b*** *legend for numbered components.*

Rake and Eave Detailing

A typical CLT roof assembly rake and eave detail is shown in Detail 10a and Detail 10b. Here, ***SlopeShield® Plus self-adhered*** laps over the CLT panel edge to protect the wood end-grain. ***VaproLiqui-Flash™*** flashing extends from the wall membrane to the underside of the CLT roof panel to provide an air barrier transition at the roof-to-wall interface.

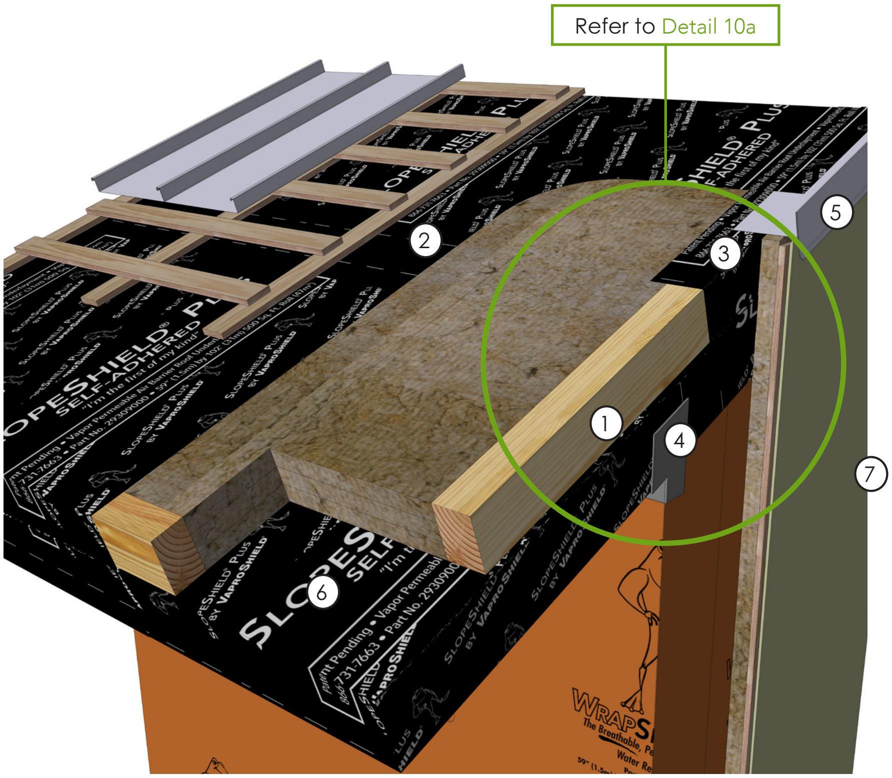
The roof rake flashing is shown stripped into the ***SlopeShield® Plus self-adhered*** underlayment to ensure that all water shedding is directed downslope towards the eave. Typically, the drainage strategy will include a gutter system at the eave to collect and drain the water runoff.

CLT Roof Design (< 2:12 Pitch)

Typical components of a conventional roof assembly with a slope less than 2:12 are shown in Detail 11. In this assembly, the roof membrane is intended to act as a perfect barrier against water ingress and the ***SlopeShield® Plus self-adhered*** membrane serves as a temporary roof membrane to protect the CLT panels during the construction phase.

An un-sloped CLT roof panel is unable to readily shed water so it is particularly sensitive to wetting during construction. To provide temporary moisture protection until the remaining roof assembly layers are installed, the ***SlopeShield® Plus self-adhered*** membrane is applied over the un-sloped CLT roof panel. ***SlopeShield® Plus self-adhered*** is vapor permeable and demonstrates water-resistive properties; thus, it can facilitate some panel drying while still protecting the underlying panel from bulk water when laps, penetrations, and terminations are appropriately detailed and when a means for draining the roof area of standing water is provided. Refer to Chapter 4 for additional moisture management discussion.

Best practice is to slope the roof membrane to the roof's drainage and overflow system, such as with roof drains or scuppers. Sloped over-framing provides the slope in the roof assembly shown in Detail 11. It also creates an air gap that can be used for observations to facilitate locating roof leaks (should they occur) or to provide a ventilated cavity to the interior to encourage panel drying should it be required at any stage during construction or occupancy. The vent space and over-framing provides the added

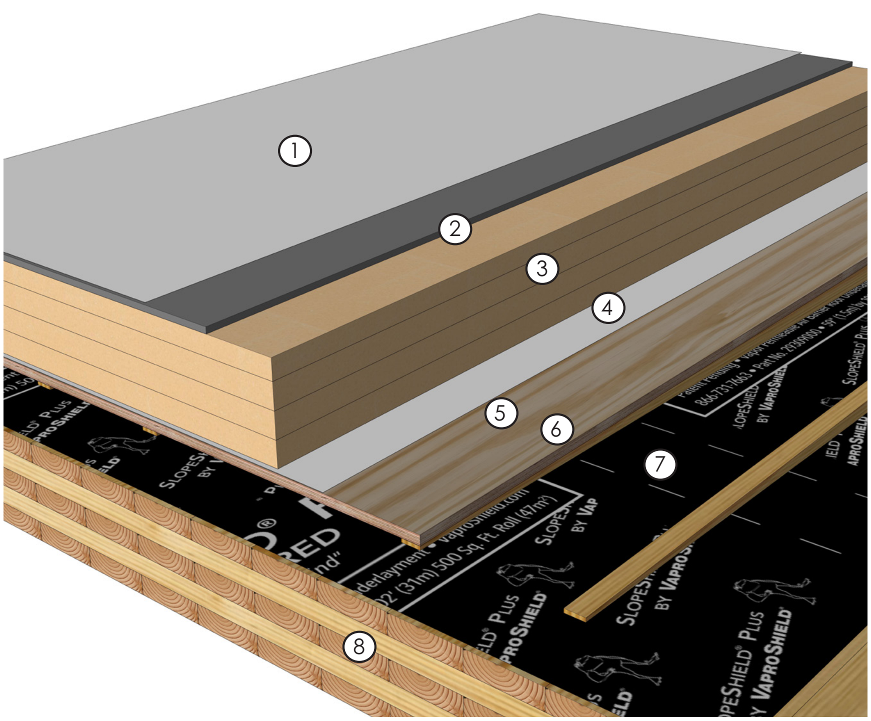


Detail 10b
Roof rake and eave detail.

Legend

(listed exterior to interior)

1. Wood blocking/nailer
2. ***SlopeShield® Plus Self-Adhered***, roof underlayment (water barrier)
3. ***SlopeFlashing™***, roof edge flashing
4. ***VaproLiqui-Flash™*** liquid-applied flashing a minimum of 2 inches (51 mm) onto CLT and ***WrapShield SA® Self-Adhered***/***RevealShield SA™ Self-Adhered*** at wall below
5. Sheet-metal rake flashing
6. ***SlopeShield® Plus Self-Adhered***, air barrier and temporary moisture protection
7. Wall assembly; see CLT Wall Design and Best Practices starting on page 26



Detail 11
Conventional roof assembly (< 2:12 pitch).

Legend

(listed exterior to interior)

1. Roof membrane
2. Coverboard
3. Continuous rigid insulation
4. Air and vapor barrier membrane
5. Structural sheathing
6. Over-framed, vented air cavity
7. ***SlopeShield® Plus Self-Adhered*** temporary moisture protection
8. CLT panel and structure

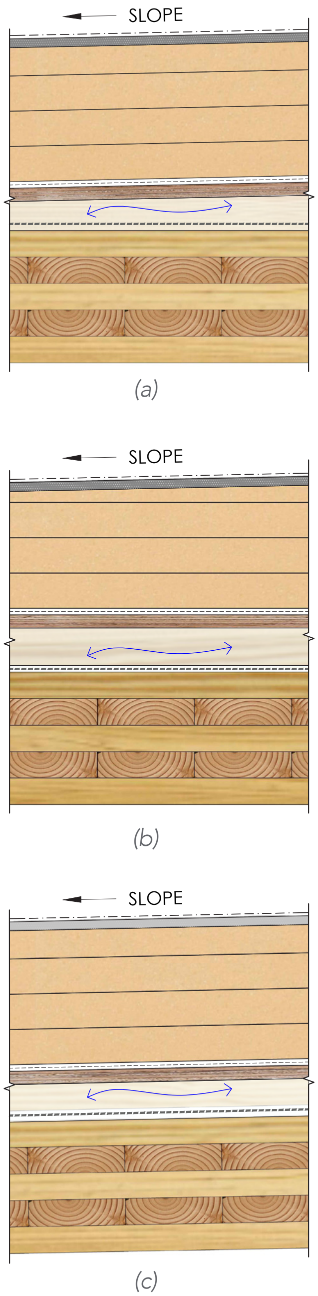


Figure 3-6 (Above)
Options for providing roof slope:
(a) sloped over-framing,
(b) tapered insulation, and
(c) sloped CLT structure

benefit of helping to avoid damage to the CLT panel during future reroofing activities. The ventilation gap should not be vented to the outdoors once inservice. Local fire safety requirements, however, may not allow a clear ventilation gap in this assembly; confirm fire safety requirements prior to incorporating a vent space in this assembly.

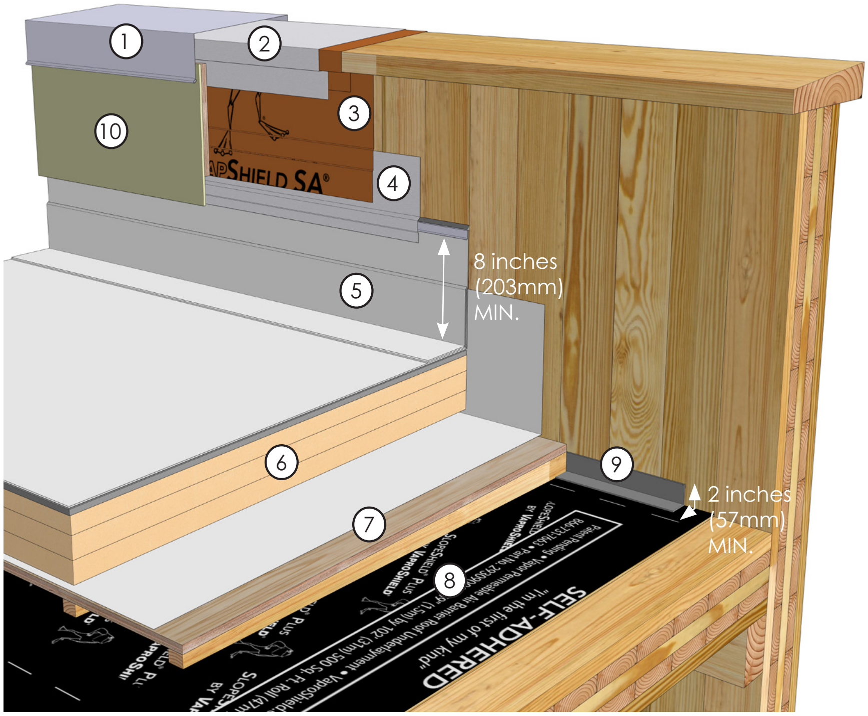
Alternatively, slope may be provided by the roof insulation or the CLT panel/structure itself as shown in Figure 3-6 to the left. In all cases, the air and vapor barrier membrane is provided below the insulation to prevent air leakage and vapor diffusion into the roof assembly.

Roof Parapet Detailing

A roof-to-parapet transition is shown in Detail 12.

When using ***SlopeShield® Plus self-adhered*** as a temporary moisture protection membrane over the CLT roof panel, the perimeter is sealed at the parapet to close off this joint to water ingress. This seal can be accomplished with a strip of ***VaproLiqui-Flash™***.

The parapet blocking and coping slopes to the roof side of the parapet; ***Vapro-SS Flashing™*** over ***VaproFlashing SA™ self-adhered*** or ***RevealFlashing SA™ self-adhered*** provides the primary moisture protection for the top of the CLT wall panel. ***Vapro-SS Flashing™*** is rated for service temperatures up to 200°F (93°C), so it can be used in most high-temperature coping applications.



Detail 12

Roof parapet detail.

Legend

1. Sloped sheet-metal coping
2. ***VAPRO-SS FLASHING™*** over ***WRAPFLASHING SA™ SELF-ADHERED***
3. ***WRAPSHIELD SA® SELF-ADHERED*** or ***REVEALSHIELD SA™ SELF-ADHERED***
4. ***VAPRO-SS FLASHING™***
5. Roof base flashing, per manufacturer
6. Roof membrane, coverboard, rigid insulation, and air/vapor barrier
7. Structural sheathing over sloped over-framing
8. ***SLOPESHIELD® PLUS SELF-ADHERED*** temporary moisture protection membrane
9. ***VAPROLIQUI-FLASH™*** minimum 2 inches (51 mm) onto ***SLOPESHIELD® PLUS SELF-ADHERED*** and 2 inches (51 mm) onto the CLT wall panel
10. Cladding system; see CLT Wall Design and Best Practiced starting on page 26

Chapter 4

Construction Phase Considerations

The design process and construction phase planning are often heavily intertwined in successful mass timber projects (see Figure 4-1). Inappropriate moisture management of CLT during construction and building service can lead to dimensional changes, microbial growth, or general deterioration of the CLT panels and other enclosure components.[3] Therefore, it is important that a moisture management plan is developed to outline steps taken during all phases of construction to minimize the CLT moisture exposure.

Building codes typically require the moisture content of wood to be less than 16% to 19% prior to cover; however, many of these guidelines were developed with lightweight wood-framed construction in mind and do not consider the hygric mass of mass timber elements. Thus, it is typically advisable to limit the moisture content of CLT wall, floor, and roof panels to the lower end of this range—approximately 16% at all locations—prior to cover.

If CLT is wetted to above the maximum moisture levels during construction, drying of the CLT panel can take a substantial amount of time and can lead to costly construction delays. Drying can be encouraged using a combination of heat and ventilation; however, drying of an already wetted panel does not eliminate the risks for permanent damage and panel distortions caused by fluctuating moisture content and rapid dimensional changes, particularly if the drying rate is too high.

Construction tenting can help eliminate moisture-related risks during construction, but some projects do not have the means to provide this protection. As an alternative, one step to reduce the potential moisture exposure is to take advantage of the pre-application of water-resistive membranes off-site. Pre-applying a CLT panel with a water-resistive membrane, such as VaproShield's primerless self-adhered membranes, offers the benefit of protection during shipping and staging on-site and can reduce the building dry-in period. VaproShield's membranes also remain part of the building's final enclosure design; thus, an additional membrane application or the removal of temporary membranes is often not necessary. Once the CLT panels are erected on-site, the exposed faces and edges of the CLT panel, including joints,

Figure 4-1 ***(Left)*** *Mass timber building under construction.*

Project: First Tech Credit Union
Architect: Hacker Architects

rough openings, and penetrations need to be treated. A sequence specific to preinstalling VaproShield's ***WrapShield SA®* self-adhered** or ***RevealShield SA™* self-adhered** over CLT wall panels is shown on Detail 13 on page 50. Once erected in the field, VaproShield's recommended detailing for panel joints at wall areas is shown in Detail 14a on page 51 and for roof areas in Detail 14b on page 52.

In horizontal roof and floor applications, the CLT panel will be laid horizontal (or near horizontal) to form the roof or floor deck, increasing the CLT's moisture exposure when compared to wall or sloped roof applications; thus, extra precautions and planning may be required. ***SlopeShield® Plus* self-adhered** may be used as a temporary protection membrane over unsloped or low sloped CLT in most instances (as shown in Detail 11). ***SlopeShield® Plus* self-adhered** is a vapor-permeable membrane, so ponded water may begin to slowly pass through the membrane to wet the CLT over time. VaproShield has tested the ***SlopeShield® Plus* self-adhered** membrane to demonstrate that 24 inches (210 mm) of standing water over the ***SlopeShield® Plus* self-adhered** membrane will not result in water leakage over a 24-hour period. This tested water depth exceeds what would be reasonably expected in the field; however, it should be noted that this test is performed in the middle of the sheet membrane. Laps, penetrations, and terminations are at the highest risk for moisture intrusion; so they require appropriate detailing and effective moisture management practices during the construction phase to minimize wetting risks.

While the vapor permeable properties of ***SlopeShield® Plus* self-adhered** offers many benefits for the moisture management of CLT by permitting outward drying, ***SlopeShield® Plus* self-adhered** may not be appropriate for use as a temporary roof protection membrane in regions with a high risk for wood decay due to this same property. The *Nail-Laminated Timber Design & Construction Guide* classifies regions as high risk for wood decay when the local Scheffer Climate Index exceeds 70. Within the scope of this guide, high-risk regions include some coastal areas of the north Pacific and some Appalachian regions.[12] A more appropriate option for moisture protection in these regions may be a factory-applied, fully-adhered vapor-impermeable waterproof membrane if installation is expected to occur during wet seasons. If this strategy is followed, it is especially important that a durable membrane is used and that all membrane laps are fully sealed prior to water exposure, because any moisture that bypasses the protective membrane will be very difficult to dry without removal of the vapor-impermeable membrane.

Additional methods and measures that may be included in the moisture management plan include the following:

- **Water-repellent coatings:** A factory-applied water-repellent coating can be used to limit the moisture uptake of CLT. Ideally, the coating is moderately vapor-permeable to maintain the drying potential of the CLT. Pre-applied coatings can be particularly valuable at panel edges where moisture uptake through the wood end-grain is quicker. Water-repellent coatings may not be appropriate as the sole form of protection in the higher-risk regions for wood decay since these coatings are not 100% effective if exposed to moisture for prolonged periods.[13] It should also be noted that water-repellent coatings do not address potential gaps between CLT laminations or water ingress at CLT panel joints, which can otherwise be bridged by sheet membrane products. Water-repellent coatings should also not be relied upon to provide in-service water control, and thus a separate water-resistive membrane will still be required for CLT enclosures. Many of the commonly used water-repellent coatings can be effectively used with VaproShield's self-adhered products. When water-repellent coating is used on the CLT, consult with a VaproShield's representative for compatibility with VaproShield's product offerings.

- **Shipping coordination and protection:** By coordinating shipping with the construction schedule, just-in-time delivery principles can be used to limit the period that CLT panels will be staged on-site, therefore reducing CLT exposure to on-site sources of moisture. Pre-installation of VaproShield's membranes during panel fabrication can provide some protection of the panels during shipping; however, additional protection may be required depending on the season, climate, and distance of the fabrication facility from the job site.

- **Site protection:** CLT panels may need to be stored on-site prior to being erected onto the building. Site protection may be necessary to reduce the panel's exposure to moisture, depending on the season and climate. Best practices for panel storage are highlighted in various industry resources.[3,12] Where VaproShield's membrane products are pre-installed prior to delivery, moisture protection during storage may be minimized.

- **General water management:** Moisture uptake occurs over time, and thus short-term exposure periods may be tolerated provided that conditions for drying exist after the wetting event.[12] General procedures for limiting the bulk water exposure time during erection and prior to final cover are imperative for managing the wetting risk. This should include plans to clear ponding water from horizontal CLT areas, including snow and ice, in a timely manner. Pre-applying VaproShield membranes and treating penetrations and joints once the panels are erected can also be used to reduce the exposure; however, as previously mentioned, removal of ponded water over vapor-permeable membranes should still be a priority during construction.

While an effective use of these strategies can reduce the risk for introducing construction moisture into CLT, the in-service moisture performance of the enclosure can still significantly impact the CLT structure. For this reason, it is important to follow the guidelines in Chapter 2 and Chapter 3 to ensure that the CLT assembly is able to effectively manage in-service water and vapor loads.

Detail 13 Pre-applied membrane sequence.

Step 1 Pre-applied strip of ***WrapShield SA® self-adhered*** or ***RevealShield SA™ self-adhered*** wraps onto the underside of the panel for its full depth to cover all wood end-grain and minimum 9 inches (229 mm) onto the face of the panel.

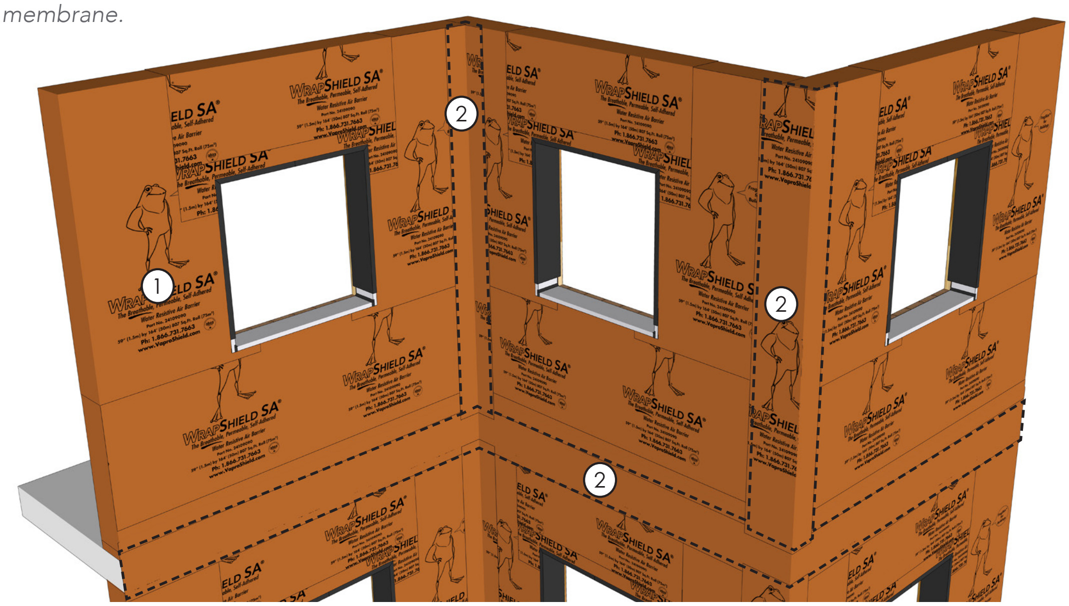
Step 2 Pre-applied ***WrapShield SA® self-adhered*** or ***RevealShield SA™ self-adhered*** sill piece. The bottom 6 inches (152 mm) of the release paper is retained and the loose flap secured using ***VaproCaps™*** or other method for transport. ***VaproCaps™*** penetrations are repaired with ***VaproLiqui-Flash™*** once the panel is installed on-site.

Step 3 Pre-applied ***WrapShield SA® self-adhered*** or ***RevealShield SA™ self-adhered*** sill, jamb, and head pieces, flashing membranes, and field membrane. Follow Steps 2 through 7 on Detail 4, except wrap ***WrapShield SA® self-adhered*** or ***RevealFlashing SA™ self-adhered*** over the CLT panel edges at the sides and top. If installing the head flashing on-site, retain the bottom of the release paper of the head field membrane and secure the loose flap for transport similar to Step 2 above. Alternatively, adhere the head membrane in-shop and strip in the head flashing on-site using ***WrapFlashing SA™ self-adhered*** or ***RevealFlashing SA™ self-adhered***, treating reverse laps with a strip of ***VaproLiqui-Flash™*** or ***VaproBond™***.

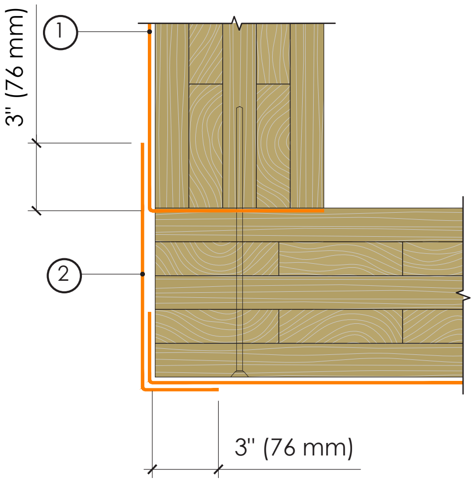
Detail 14 *Field application of CLT wall panel joints.*

VAPROSHIELD®
Breathable Membrane Systems for Roofs & Walls

Detail 14a *Erection of CLT wall panels on-site with pre-applied membrane.*



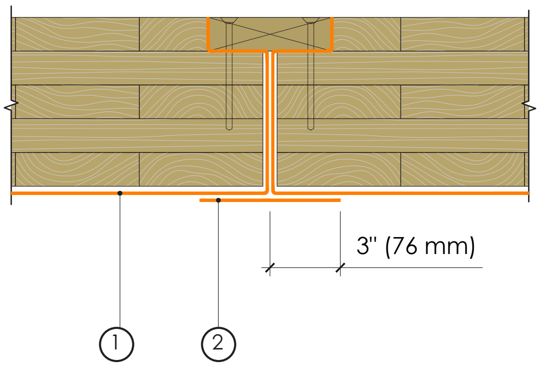
Detail 14b *Outside wall corner plan view.*



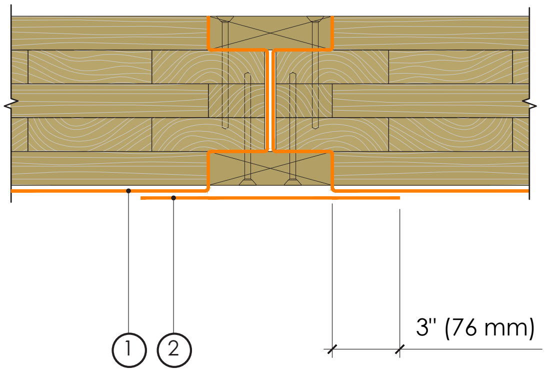
Legend

1. Pre-applied **WRAPSHIELD SA® SELF-ADHERED** or **REVEALSHIELD SA™ SELF-ADHERED**
2. Field-applied **WRAPFLASHING SA™ SELF-ADHERED** or **REVEALFLASHING SA™ SELF-ADHERED**. Alternatively, use a 6" strip of **WRAPSHIELD SA® SELF-ADHERED** or **REVEALSHIELD SA™ SELF-ADHERED** centered at CLT panel joints to maintain a minimum 3 inches (76 mm) laps

Detail 14c *Single splice-joint plan view.*



Detail 14d *Double splice-joint plan view.*



Detail 15 *Field application at CLT roof panel joints.*

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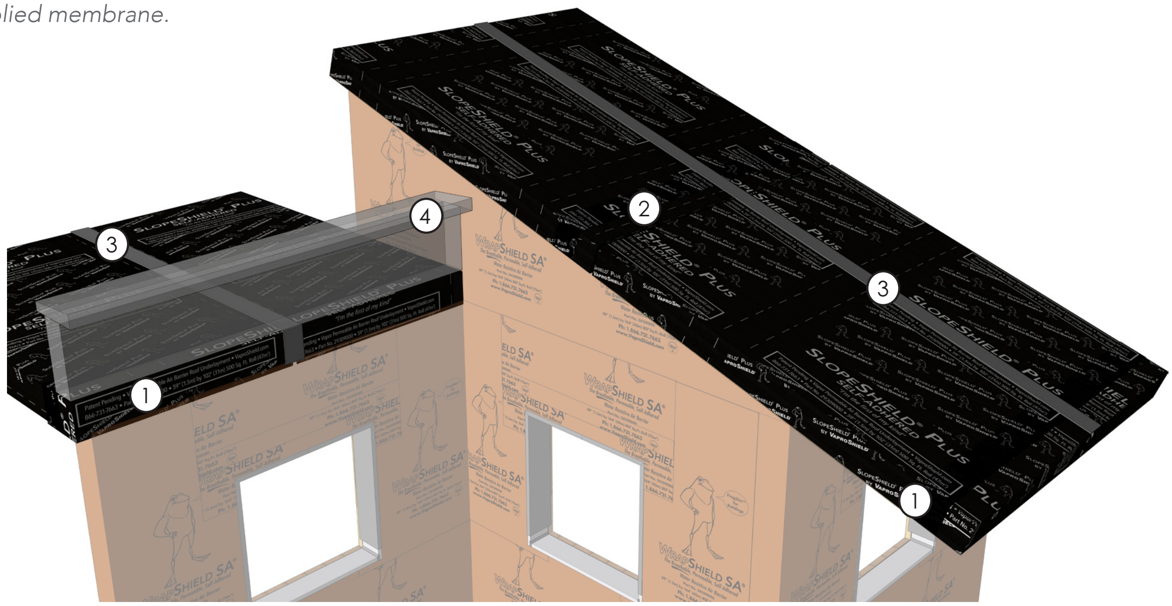
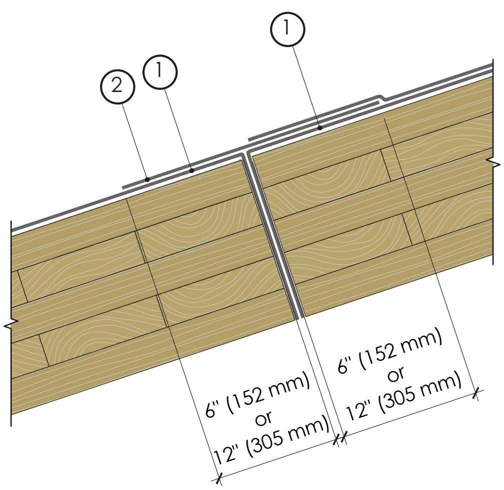
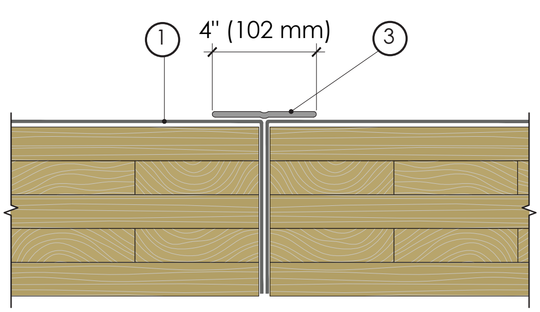
Detail 15a *Erection of CLT roof panels with pre-applied membrane.*



Detail 15b *Sloped CLT roof panel end joint field detail.*



Detail 15c *Flat CLT roof panel joint.*



Legend

1. Pre-applied
   SLOPESHIELD® PLUS SELF-ADHERED
2. Field-applied
   SLOPESHIELD® PLUS SELF-ADHERED
   transition membrane, maintaining minimum 6" (152 mm) laps at slopes of 4:12 and greater or 12" (305 mm) laps at slopes less than 4:12 at roof panel end joints
3. Field-applied 4" (102 mm) strip of ***VAPROBOND™*** or ***VAPROTAPE UV BLACK*** transition membrane at side joints and horizontal CLT panel joints
4. Parapet to receive field-applied ***WRAPSHIELD SA® SELF-ADHERED/ REVEALSHIELD SA™ SELF-ADHERED, VAPRO-SS FLASHING™***, and ***VAPROLIQUI-FLASH™*** per Detail 14

Summary

Mass timber and CLT construction offers many advantages, such as enhanced modularity, reduced construction schedules, improved thermal performance, and material sustainability. However, mass timber's propensity to absorb moisture from the environment and the relative vapor impermeability of CLT panels introduces unique challenges when incorporated with the building enclosure. These challenges should be considered during design and construction phases to ensure long-term performance. VaproShield's self-adhered products—***WrapShield SA® self-adhered***, ***RevealShield SA™ self-adhered***, and ***SlopeShield® Plus self-adhered***—and their accessories can be used to effectively manage water and air in CLT wall and roof assemblies. These self-adhered barrier membranes are also vapor permeable to allow outward drying of the CLT while in service. Additionally, ***RevealShield SA™ self-adhered*** and ***SlopeShield® Plus self-adhered*** offer enhanced fire and UV performance.

Foresight and planning are required during the construction phase to effectively manage CLT exposure to construction moisture and to minimize risks of in-service enclosure performance issues or construction delays. Pre-applying the VaproShield membrane to the CLT off-site can play an integral role in the construction phase water management strategy, in addition to potentially reducing the construction schedule. More general water management strategies should also be in place to provide additional protection and to prevent prolonged periods of ponded water depending on the climate and season.

Supplemental Information

For more information on the use of VaproShield's products, including installation instructions, technical data sheets, and typical details, visit VaproShield.com

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