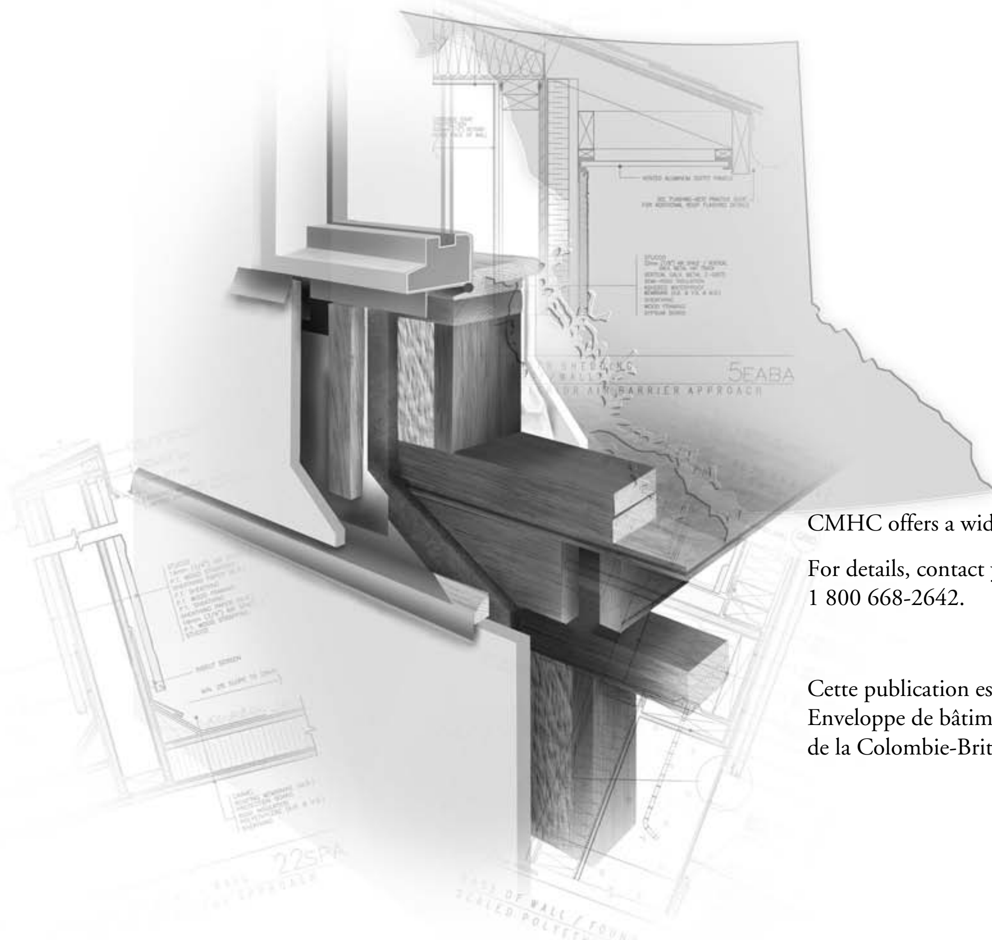
WOOD-FRAME ENVELOPES IN THE COASTAL CLIMATE OF BRITISH COLUMBIA

BEST PRACTICE GUIDE
BUILDING TECHNOLOGY



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slow absorption, panels need to be installed with a 3-mm space between them to allow for the expected expansion.

Since engineered wood I-joists are made using kiln dried lumber or composite lumber flanges, and plywood or oriented strandboard webs, they are relatively dry products and are more dimensionally stable than lumber under normal protected conditions. Bowing, warping or twisting distortions are seldom experienced. These products need to be protected from moisture during shipping and storage at the building site.

Decay in Wood

Wood-frame structures have generally withstood the test of time in the British Columbia coastal climate and most of these structures have remained free of decay. **The most effective way to prevent decay is to keep the wood dry**. However, in certain conditions, decay will occur and can cause costly damage to the building structure. Knowing why it happens and how to avoid it are therefore important to envelope design. Decay, or rot, occurs due to the growth of specific fungi, which feed on cellulose fibres. Fungal spores are found throughout the environment and will grow on wood in the presence of

- oxygen
- moisture, and
- warm temperatures

Air is found throughout the cellular structure of wood, so oxygen is nearly always available. Spores of decay fungi will germinate at 25 to 28 per cent moisture content and flourish when the moisture content of wood is between 35 and 50 per cent. The spores will not germinate on wood that has a low moisture content. Other non-decay fungi can grow and flourish when the temperature is warm enough and relative humidity at the surface of the wood or other material is 85 per cent or higher. Decay fungi, once they have taken hold, may continue to grow at a sustained moisture content as low as 20 per cent. **At or below 19 per cent moisture content, wood is considered immune to fungal growth** (Figure 2.6). Building codes require that the moisture content of the lumber be no greater than 19 per cent at the time of installation in a building. Although there can be local wet pockets in the lumber, the 19 per cent moisture content limit results in satisfactory long-term performance under most conditions, because further drying is expected in an appropriately designed and constructed building envelope.

The temperature range for optimal fungal growth is 18°C to 35°C (65°F to 95°F). Above this range, the growth decreases and will cease at about 38°C (100°F). As the temperature falls, the growth slows. In cold temperatures, fungi become dormant but will be activated again when it gets warmer. **In the coastal climate zone, the temperature gradient through the wall assembly, combined with the relatively warm exterior winter temperatures, can result in conditions conducive to fungal growth throughout the winter if the moisture content requirements are also present**. If wood has been previously infected with decay fungi, and not subsequently kiln-dried the fungi can be revived from dormancy if moisture content increases to a suitable level.

When wood is kiln dried, the decay organisms are killed. If the wood is rewetted to sustained higher moisture levels, it can be re-infected in most environments. The use of kiln dried wood ensures that the likelihood of decay in the end product is far lower, unless defects in the envelope lead to the accumulation of moisture suitable for fungal growth.

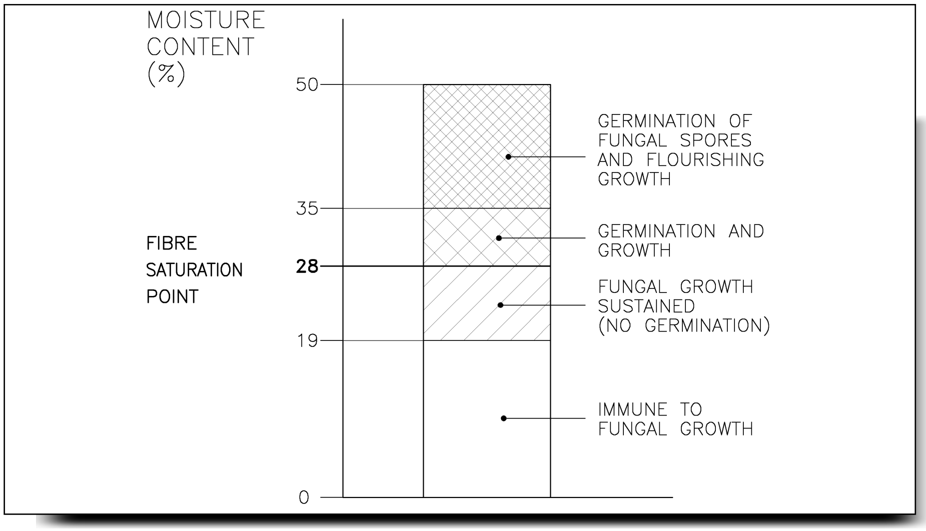


Figure 2.6: *Fungal growth in wood*

The heartwood of some species of wood, such as western red cedar and Pacific Coast yellow cedar, contains naturally occurring chemicals, which inhibit the growth of fungi and provide greater protection against decay. Western red cedar is classified as decay resistant, Douglas fir is moderately decay resistant, and the spruce-pine-fir group and hemlock are considered non-decay resistant. The sapwood of all of these species is not decay resistant and therefore cannot be used in high moisture conditions without the onset of early decay. However, lumber may be pressure treated with chemicals to suitable levels to prevent the growth of fungi or attack by insects. Western red cedar has relatively low strength properties so it is mainly used for non-structural applications such as shakes, shingles, siding and fascia boards.

Moisture-Tolerant Wood: Naturally Decay Resistant or Pressure-Treated

For interior applications, the use of moisture-tolerant or treated wood products should be unnecessary unless there is a reasonable expectation that the design, construction, building operation or maintenance/renovation processes will lead to a moisture content repeatedly above 25 per cent. For ground-contact exterior applications, non-decay resistant and moderately-decay resistant woods should always be pressure treated if they are to last more than a few years. For above-ground exterior applications, the decision to use naturally decay resistant or pressure treated wood is more complicated. It depends on the climate, the design, the degree of exposure, the design life, the maintenance/replacement requirements and the consequences of premature failure.

The climate region covered by this Guide is highly conducive to the decay of wood. While careful design can promote deflection and drainage of water from exterior wood elements, and small dimension lumber will dry out rapidly after rain, these three lines of defence (deflection, drainage and drying) may not be adequate. Rain can be trapped in joints, on horizontal surfaces or in cracks, and the end-grain of the wood readily absorbs this moisture. If wood is not protected from exposure to rain, including wind-blown rain and leaks, it can remain at a suitable moisture content long enough for decay to begin. Paint alone is not adequate protection under these circumstances. Paint or stain can be applied to wood that has been pressure treated with waterborne preservatives and will weather better than it does on untreated wood.

Exterior Moisture: Enters from the outside environment into a completed building. It has several forms, including (in decreasing order)

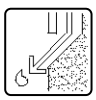
- rain penetration
- groundwater
- snow melt
- condensation of vapour from high outdoor humidity or wet materials driven by outdoor heat to a colder inside surface
- wind-driven snow

Interior Moisture: Generated from inside by the use and occupancy, when moisture migrates, via air movement or vapour diffusion, to a surface cold enough to allow condensation. When the vapour touches colder surfaces within the envelope, condensation occurs.

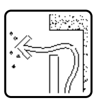
Construction Moisture: Built into the structure by use of wet lumber or other building materials or by precipitation during construction.

Drying Mechanisms

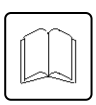
Water in an envelope assembly can be removed by several mechanisms:

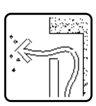


Drainage: Gravity will tend to draw water down. Elements like sloped flashings use gravity to divert and drain water to a safe disposal area, usually the outside. Drains that go through, but not into, inside space are common on flat roofs and some skylight systems.



Drying to outside: Moisture in an envelope assembly will move by diffusion and venting (air exchange between the envelope cavities and a dryer environment) to an atmosphere of lower vapour pressure. Vapour pressure is governed by relative humidity and temperature. In winter when a building is heated, the outdoor atmosphere usually has a lower vapour pressure than a wet building envelope assembly. Even under warmer conditions, this is usually true since the outdoor relative humidity is below 100 per cent. Drying to outside is restricted by use of materials on the outside of the assembly that have low permeability to vapour diffusion and air movement. Drying will also be restricted if the face of the assembly is wet. Recent experimental work (Envelope Drying Rates Experiment, conducted by Forintek Canada Corp.) indicated that the width of the drainage cavity as well as top and bottom venting arrangements also impact the drying rates of wall assemblies.





Drying to inside: Drying to the inside after construction is not a normal operating condition in new buildings since heated indoor environments drive moisture outward. Our building codes require placement of a material of low vapour permeability (vapour barrier) on the inside of the insulation, and the insulation is normally located within the stud space. Some less traditional assemblies are presented in Chapter 5 which will allow the stud wall assembly to dry to the interior because the insulation and vapour barrier are placed on the exterior side of the wall or roof sheathing. In addition, the ability to dry out construction moisture to the inside before closing the assembly may be important.

Vapour Transfer from Exterior Sources

There is one other mechanism of moisture transfer from outside which is worth mentioning. Vapour from a high humidity outdoor environment may be driven into the wall assembly by diffusion and air movement, where it may condense on surfaces cooled by air conditioning.

Coastal British Columbia rarely sees extended periods of hot weather, but it is possible that hot, humid conditions can be created locally at a wall. A porous cladding, such as brick or stucco, can absorb a large quantity of water in a rainstorm. The sun heating the cladding creates high vapour pressures that can drive moisture inward to cooler surfaces. This phenomenon is of particular relevance in face seal or concealed barrier assemblies. A rainscreen cavity wall provides much greater resistance to this inward vapour drive.

INTERIOR MOISTURE SOURCES

Moisture accumulation by condensation of interior humidity is generally of less concern in British Columbia's coastal climate than rain penetration, but it can add to the moisture load in building assemblies, particularly in buildings with higher than normal humidity, which is usually considered to be 40 to 60 per cent. Designers need to control this wetting mechanism.

Condensation

Condensation occurs on surfaces which are colder than the dewpoint of the air to which they are exposed. Dewpoint is a measure of the absolute humidity (kg water/kg air) of the air. Three conditions are required for condensation

- a sufficiently cold surface
- a source of humidity
- a mechanism to get the humid air to the cold surface

In a heated insulated building, condensation can occur on inside surfaces of building envelope materials or components of low thermal resistance, such as windows, or where there are strong thermal bridges. This occurs when indoor humidity migrates to cooler surfaces that are isolated from indoor heat by the insulation.

Moisture transfer through the envelope from the building interior can occur due to air movement and water vapour diffusion. In most cases, **air movement is the dominant interior moisture transfer mechanism**.

For example, consider a wall constructed of 38 x 89 mm studs with a Type II vapour barrier (whose water vapour permeance is 60 ng/Pa•s•m^2). At exterior design conditions of -15°C and 60 per cent relative humidity and interior conditions of 21°C and 58 per cent relative humidity, moisture can condense within the cavity at a rate of approximately 4 g/ m^2/day due to vapour diffusion alone. If indoor air exfiltrates through the cavity at a rate of ± 1.4 l/m^2/s (a realistic example for older homes), the resulting rate of condensation can increase to 480 g/ m^2/day. This is more than 100 times the amount of moisture that can potentially condense due to water vapour diffusion.

As a rule of thumb, the vapour barrier should have a vapour permeance three to five times less than that of the surfaces outside the insulation. Selection of an appropriate vapour barrier should be done on the basis of the permeability of other materials in the assembly. Where relatively low water vapour permeability sheathing is used, such as plywood or oriented strandboard, a Type I vapour barrier, such as polyethylene sheet or aluminum foil, may be necessary in cold climates or high humidity buildings. Where the sheathing has a high permeability to moisture, such as laminated fibreboard or spun olefin faced fibreglass board, a Type II vapour barrier or some paints are generally satisfactory.

In the British Columbia coastal climate zone, polyethylene is not required in the wall assembly to control vapour diffusion. In most commonly used wall assemblies, the quantity of moisture potentially transported through this mechanism is small and can be controlled with other vapour barriers. This is a design decision that can be made knowing the characteristics of the particular wall assembly proposed for use.

However, since polyethylene is also one of the materials commonly used to perform the function of the air barrier, its removal must be accompanied by the inclusion of an alternate air barrier strategy.

It is important to note that **the presence of polyethylene did not cause the moisture problems in the wall assemblies examined in the *Survey*, nor will its removal from wall assemblies prevent problems from occurring in the future.**

The maximum water vapour permeance of a Type I vapour barrier defined in CAN/CGSB-51.33M, *Vapour Barrier Sheet, Excluding Polyethylene, for Use in Building Construction*, is 15 ng/Pa•s•m^2. This permeance can be met by a broad range of materials including polyethylene sheet, foil, metal, and glass. A Type II vapour barrier has a maximum permeance of 60 ng/Pa•s•m^2 or less before aging.

The water vapour permeance of some materials is listed in Table 3.2. Others may be found in the *1997 ASHRAE Handbook (SI)*.

Keeping Surfaces Warm

Another way of limiting condensation is to keep surfaces above the dewpoint temperature of the air in contact with them. Windows are the most visible demonstration of this principle. Windows with high thermal resistance avoid condensation as well as save energy. The circulation of warm air at the surface of the window (or to another cold surface) also increases its temperature.

Condensation within walls or other building assemblies can be reduced by placing some insulation outside the building frame and sheathing. This keeps surfaces inside warmer, which will reduce or eliminate condensation.

The presence of thermal bridges such as metal window sub-sills, which pass completely from the interior to the exterior, can result in colder interior surfaces and thus can create a greater potential for condensation.

DETAIL 4–RIM JOIST

Frame Shrinkage

A 6-mm gap is recommended between sheathing panels at the level of the top plates. The size of this gap has been based on the assumption that the structure has been constructed with wood members with a moisture content of 19 per cent or less.

Placement of the cross-cavity flashing at the level of the rim joist effectively creates a control joint to accommodate the shrinkage of the rim joist and plates.

Venting

At this time there are two schools of thought as to whether the top of the cavity should be vented at the level of the cross-cavity flashings. Venting the cavity at the cross-cavity flashing will increase the volume of air that passes through the cavity and hence will increase the potential to dry moisture from the cavity. However, venting at the top of the cavity may, under some circumstances, result in a negative pressure in the cavity which may draw water into the cavity, or alternately wind-driven rain may enter under its own momentum.

If the top of the cavity is to be vented, the blocking used to support the flashing should be discontinuous and the flashing should project 12 mm from the face of the cladding.

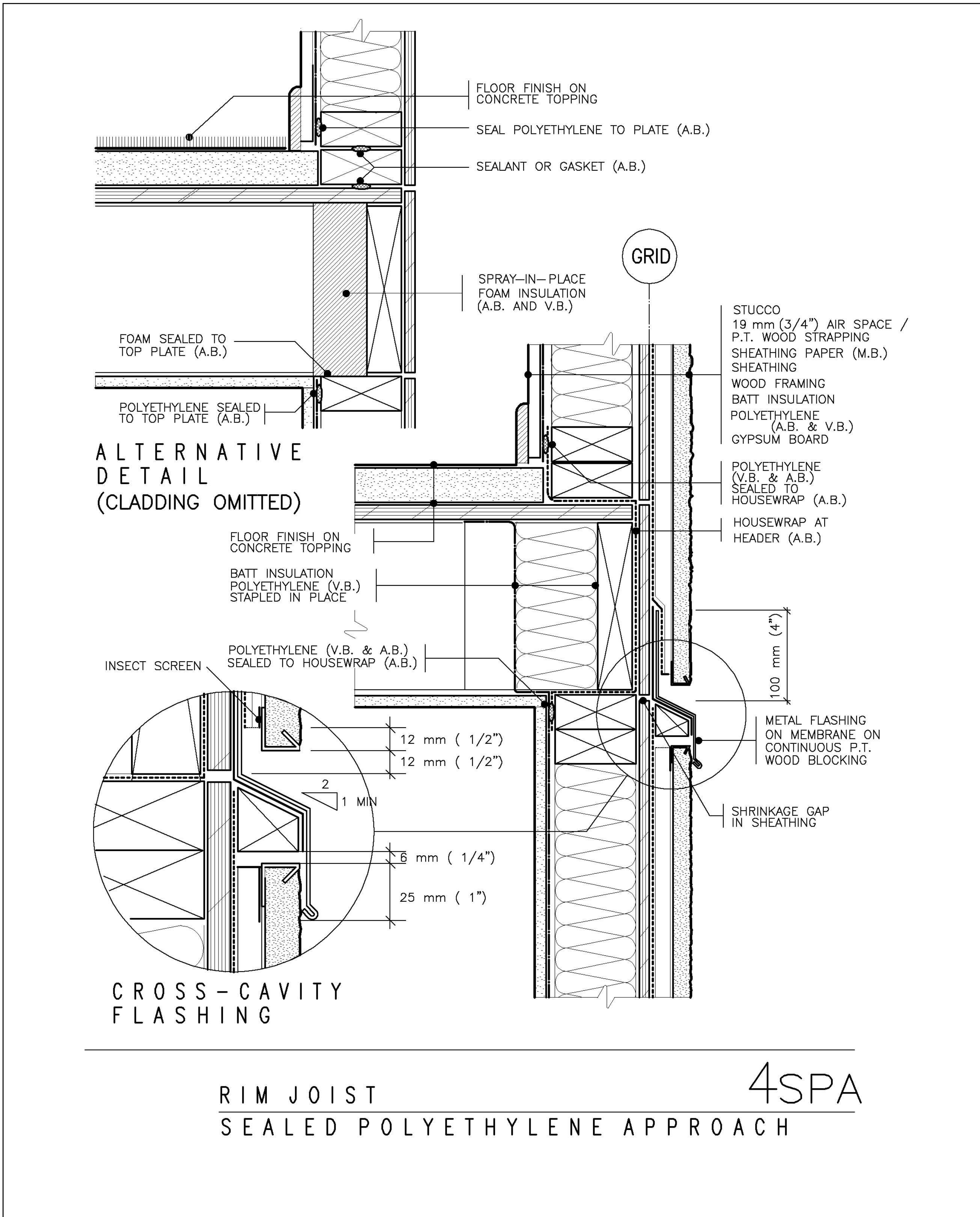
Cross-Cavity Flashing

The joints in the cross-cavity flashing should be designed and constructed to minimize the potential for water penetration. Joints at inside and outside corners should be standing seam. Joints in the straight run sections should be S-lock. Alternatively, as shown in this detail, a self-adhered membrane flashing may be used below the metal flashing and simpler lap joints may be used. Utilizing a 2:1 slope on the cross-cavity flashing reduces the potential for water to leak through at the joints.

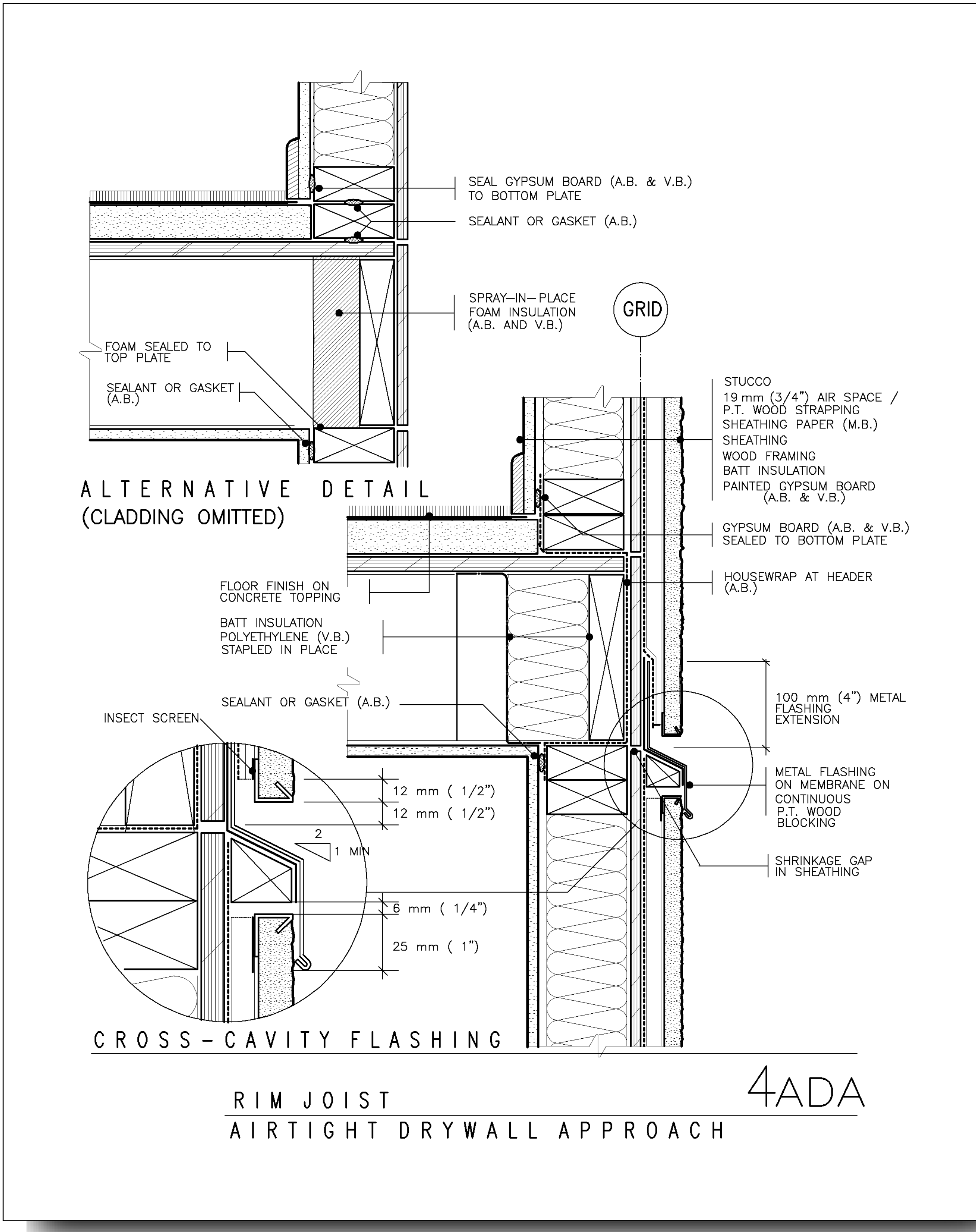
Alternative Detail

The alternative detail illustrates a second method of achieving airtightness at the rim joist. Implementation of this detail alleviates the problem of the header wrap being damaged during construction. This detail could be utilized if the header wrap is not installed before the upper level wall framing is constructed.

No vapour barrier is required when spray-in-place urethane foam insulation is used.



Detail 4 SPA: *Rim Joist–Sealed Polyethylene Approach*



Detail 4 ADA: *Rim Joist–Airtight Drywall Approach*

***Table 7.2:** Typical Insulation Properties (continued)*

Type	Typical Properties	Typical Uses
Extruded Polystyrene CAN/ULC-S701	RSI= 0.88 @ 25 mm Resistance to vapour flow: Med. Resistance to air flow: Med. Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing membrane • Roof insulation for inverted roof systems • Concrete wall insulation below ground • Under concrete slabs on grade
Polyurethanes CGSB 51-GP-21M	RSI= 0.97 to 1.1 @ 25 mm Resistance to vapour flow: High Resistance to air flow: High Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing • Roof insulation for conventional roof systems • Spray-on capabilities for wall cavity, roofing, and air barrier applications, perimeters of windows and doors
Polyisocyanurate CGSB 51-GP-21M	RSI= 0.97 to 1.1 @ 25 mm for permeable facings; RSI=1.27 @ 25 mm for impermeable facings Resistance to vapour flow: Med. Resistance to air flow: Med. Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing membrane • Roof insulation for conventional roof systems
Cellulose Fibre CAN/CGSB-51.60M	RSI= 0.55 to 0.65 @ 25 mm Resistance to vapour flow: Low Resistance to air flow: Low Material type: Organic Combustible	• Between wood studs in walls • Between joists or trusses in attic spaces

SHEATHING MEMBRANES

Sheathing Membranes–Breather Type

Design and Selection References

- CAN 2-51.32 Sheathing Membrane, Breather Type
- CMHC, Canadian Wood-Frame House Construction

Breather type membranes are permeable to water vapour and will allow some drying from the interior of the wall to the exterior for very small quantities of residual construction moisture or condensation in the wall assembly. The Canadian standard CAN2-51.32-M requires breather type membranes to have permeability ratings in the order of 170 ng/Pa•s•m^2 (2 perms) to 1 400 ng/Pa•s•m^2 (16 perms). Because these membranes are permeable to vapour, they are not intended to be used as vapour retarders in the wall assembly. Breather type membranes are not usually fully adhered to the sheathing. Typical breather type membranes include building papers and housewrap products.

Because of their inherent material properties, breather type membranes do allow water to move through the membrane if they are exposed to liquid water for long periods of time. The Canadian standard does not require a minimum level of watertightness. The rate at which liquid water moves through the membrane is typically measured using a water resistance test or "boat test". This test is

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