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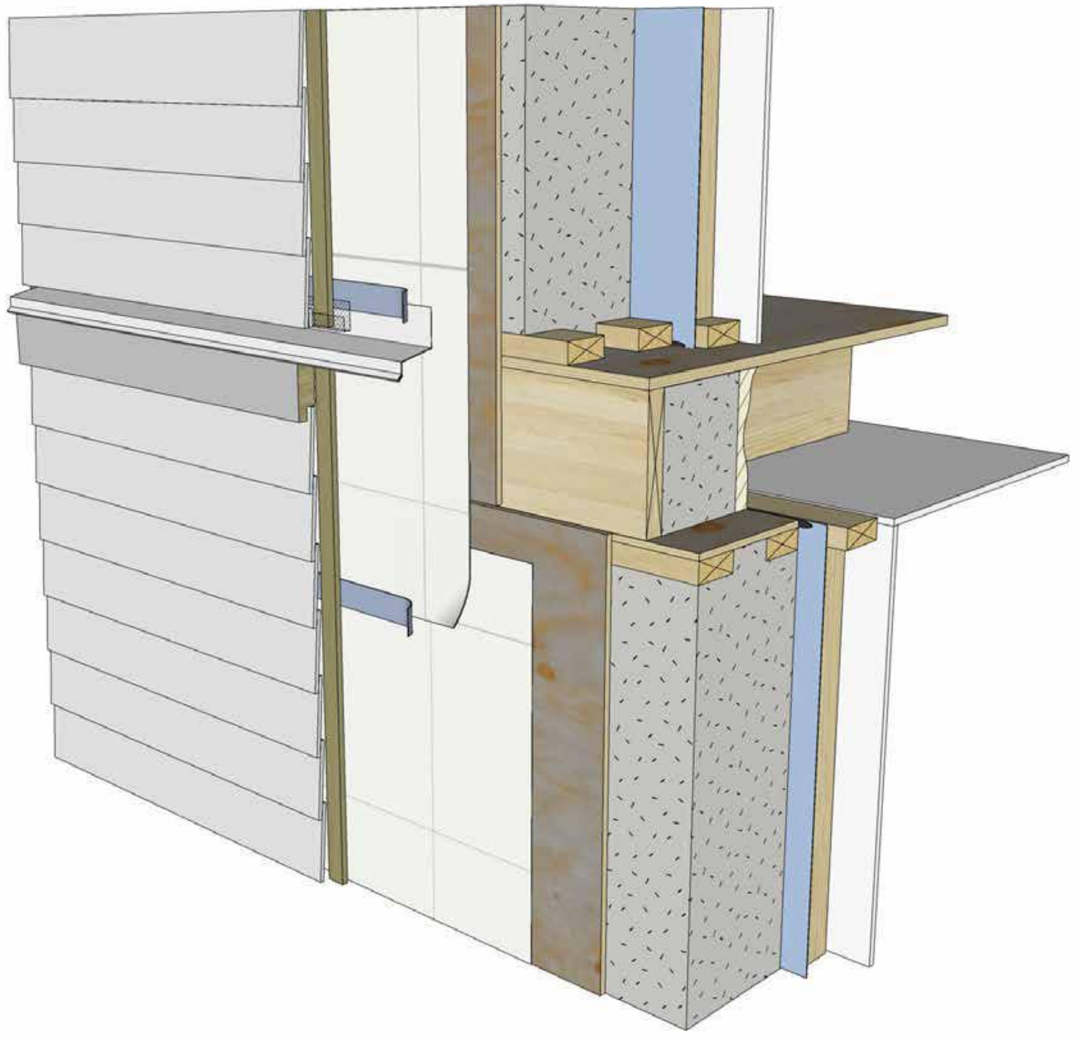
LEEP LOCAL ENERGY EFFICIENCY PARTNERSHIPS NET ZERO ENERGY Wall Assembly #4

Double Stud Wall with Interior Service Wall



Developed by Natural Resources Canada's
Local Energy Efficiency Partnerships (LEEP) team

CanmetENERGY

Canada

LEEP Net Zero Energy Wall Assembly #4
Double Stud Wall with Interior Service Wall

M154-165/4-2024E-PDF (On-line) ISBN 978-0-660-70704-4
(Set) M154-165/2024E-PDF ISBN 978-0-660-70699-3
Aussi disponible en français sous le titre:
«LEEP ENZ Assemblage du mur #4 Mur à double colombage avec mur de service intérieur»

Acknowledgements

The *Local Energy Efficiency Partnerships* (LEEP) team at CanmetENERGY would like to thank the many Canadian builders who have participated in our programs. Builders were contacted by their regional Home Builders Associations and invited to participate in LEEP technical forums and workshops. Their feedback identified the need for this series of guides. Builder groups repeatedly requested technical forums on high-performance above-grade wall assemblies and focused on four commonly used, generic wall assemblies. These wall assemblies were studied by building science experts and manufacturers and were upgraded for energy efficiency and for use in net zero buildings. Response to the resulting presentations has been positive and builders have gone on to trial these wall assemblies.

We would like to thank RDH Building Science for their work in developing and illustrating the guides, updating them based on broad feedback, and developing the technical presentations for LEEP initiatives that provided the foundation for this work. We would also like to thank Morrison Hershfield for providing a technical and code review.

We want to acknowledge the essential contribution made by our partners and their help in delivering regional and local LEEP initiatives that led to this guide series. These partners include: BC Housing, BC Hydro, FortisBC, BCIT, the Nova Scotia Ministry of Energy and Mines, and Efficiency Nova Scotia. We would particularly like to thank the provincial and local Home Builders Associations that made this possible, including CHBA British Columbia, HAVAN, CHBA Central Okanagan, CHBA Central Interior, CHBA Northern BC, CHBA Vancouver Island, CHBA Kelowna, CHBA Fraser Valley, CHBA New Brunswick, CHBA Nova Scotia, and CHBA Newfoundland.

The LEEP NZE Wall Guide Series was developed by Graham Finch and James Higgins of RDH Building Science. Project management was provided by Clarice Kramer with support from James Glouchkow and Patric Langevin of the NRCan LEEP Team, CanmetENERGY Ottawa. Funding for this work was provided by *Natural Resources Canada* through the *Green Infrastructure Fund*.

Disclaimer

This document does not provide assurances or information related to structural systems, seismic performance, or fire safety. It is intended only as a guide on building enclosure science and wall assembly selection, detailing, materials and performance. The aim of this publication is to provide builders and designers with a framework for making decisions on the type of wall assemblies to use for individual homes and for new communities.

Natural Resources Canada assumes no liability for injury, property damage, or loss resulting from the use of information contained in this publication. This guide is intended to provide information only and does not express views of the Government of Canada nor does it constitute an endorsement of any commercial product, manufacturer or any individual.

Building science, related products, and construction practices change and improve over time, and it is advisable to regularly consult up-to-date technical publications on building science, products, and practices rather than relying solely on this publication. Seek specific information on the use of products, the requirements of good design and construction practices, and requirements of the applicable building codes before undertaking a construction project. Consult the manufacturer's instructions for construction products, and also speak with and retain professional consultants who hold a valid license and have appropriate engineering or architectural qualifications. Work with your municipality or local authority having jurisdiction to ensure compliance with issues of design, zoning and construction practices, including life and fire safety.

The effective R-value ranges and assemblies illustrated in this guide represent potential strategies to reach high-performance targets including the upper tiers of the National Building Code of Canada. As with any performance-based energy target, energy modelling must be used to determine appropriate designs for each individual project. Compliance strategies may be influenced by design choices such as building form, window placement, orientation, mechanical systems, and equipment efficiency.

The information included in these guides is generic in nature and is not tied to any specific voluntary labeling program. Builders and renovators looking to qualify their homes under the Canadian Home Builders' Association (CHBA) *Net Zero Home Labeling Program* must ensure their homes meet all the Technical Requirements of that Program.

LEEP LOCAL ENERGY EFFICIENCY PARTNERSHIPS Net Zero Energy Wall Assemblies Introduction

LEEP Context

The LEEP Team at CanmetENERGY works with groups of builders, through their Home Builders Associations (HBAs). LEEP programs offer opportunities to identify barriers and gaps in technology and to discuss and evaluate Net Zero Energy (NZE) and high-performance home building strategies. Builders use forums and workshops to identify key technology challenges and invite experts and manufacturers to respond by proposing solutions, innovations and direction on how to integrate these ideas into construction practices. Through their HBAs, builders use LEEP to define and solve technology challenges, and to connect with design professionals who can help them deliver the homes of tomorrow. The goal is builder-driven enhancement to local building practices.

The Need

There is a need for fundamental change in wall design and construction. Canadian builders are moving beyond typical wood-framing practices to wall assemblies that reach higher levels of performance. LEEP technical forums have been delivered in many locations across Canada. Regional LEEP builder-groups have consistently identified high-performance walls as a key technological challenge. They have requested information on:

- Increased effective R-values; continuous insulation and reduced thermal bridging
- Continuous air barrier and airtight building enclosures; improved thermal performance, reduced heating and cooling loads, reduced risk of condensation within wall cavities
- Water-protection systems; reduced risk of bulk water intrusion from rain, snow and wind, reliable water-shedding details
- Effective vapour barrier; reduced risk of trapping moisture within the wall assembly, assurance that double vapour barriers are not created

There is great diversity in Canadian light wood construction. Wall details and assembly types vary by region and climate zone. Local construction practices can also vary, along with access to reliable technical information and training. Coordination with trades and consultants is critical when introducing new technology and this should not be overlooked. It is our hope that by providing these guidelines for wall assemblies with construction details, we will help builders select, plan and construct robust wall assemblies with success. Project-specific details should always be developed to account for the unique conditions of each project.

We see the LEEP NZE Wall Guides not as the end goal, but as part of the foundation for a new generation of high-performance housing.

Documents in This Series

Further to the guidance presented in the wall guides, Appendix A and B present guidance on material and product selection for each assembly. The following is a list of the documents in the NRCan LEEP Net Zero Energy Wall Assembly Technical Guide series:

- **Introduction**: LEEP NZE Wall Guide Series & The Wall Selection Guide
- **Wall #1** Split-Wall: Vapour Permeable Exterior Insulation
- **Wall #2** Split-Wall: Wood Fibre Exterior Insulation
- **Wall #3** Split-Wall: Low-Permeance Exterior Insulation
- **Wall #4** Double Stud Wall with Interior Service Wall
- **Appendix A:** Building Material and Product Selection Guide
- **Appendix B:** Selection Process for Exterior Insulation in Split-Walls

YOU ARE HERE (Wall #4)

This guide-series examines four generic above grade wall assemblies. Builders, from different regions in Canada, repeatedly selected these common wall types in LEEP workshops and asked for technical guidance on modifications and performance upgrades.

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Preface

There is a need for a fundamental change in wall design, detailing and construction. To reach Net Zero Energy (NZE) levels of performance in homes and multi-family buildings, builders need to achieve superior levels of airtightness and higher effective insulation levels in walls. This means reduced air leakage, higher levels of insulation and reduced thermal bridging. This guide series is intended to establish common wall assembly designs that the industry can use or modify for building NZE housing. It does not provide information related to structural systems, seismic performance, or fire safety.

Overview of Wall Assembly #4

This above-grade wall assembly consists of a deeper stud cavity created by an additional framed wall inside a conventional wood-frame wall. High effective R-values of the assembly are achieved by filling the increased cavity depth with blown-in insulation.

In cold climates, the additional depth of insulation installed on the interior side of the exterior sheathing decreases the sheathing temperature and increases the risk of condensation on the moisture-sensitive wood sheathing and framing. As a result, continuity of the air barrier and installation of an interior vapour barrier are critical to the performance of this assembly. Multiple air barriers should be considered. The quality of the insulation installation is also important to reduce airflow within the assembly (i.e., convective looping).

This wall assembly includes an interior service cavity. See page 15 for more information on service walls.

Note that the information provided in this guide also applies to deep-stud wall assemblies where 2x or engineered studs are used, and the same interior-insulated deep cavity is formed. However, the guidance does not specifically reference these wall assemblies.

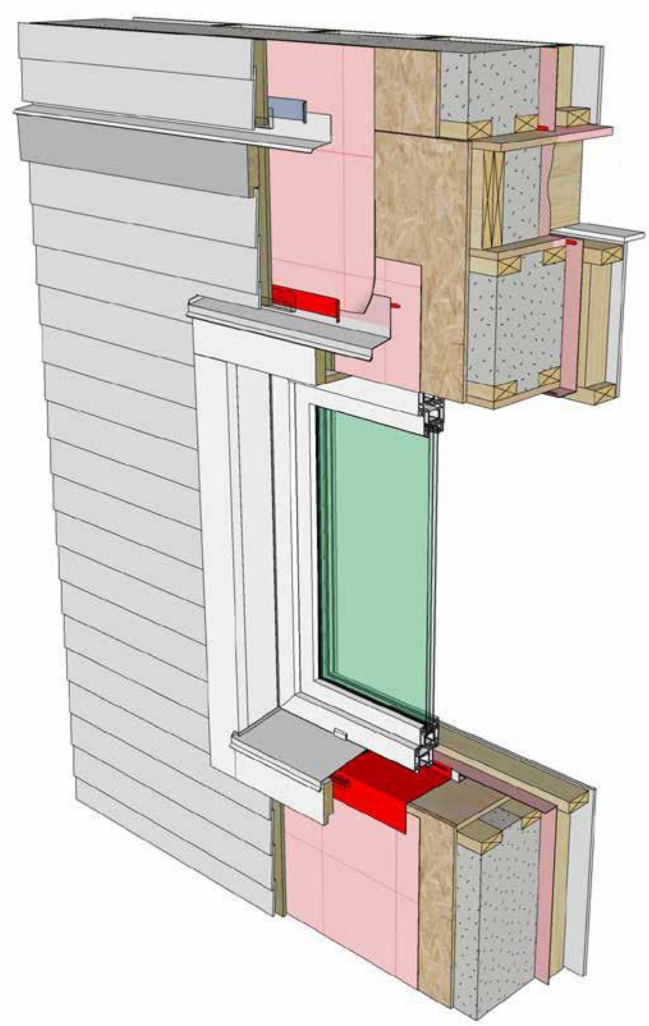


Figure 1 Interior-insulated double stud wall with interior and exterior air barriers shown

Cladding

Any type of cladding can be used with this wall assembly and can be fastened directly to the wall using vertical strapping (i.e., furring) and standard rainscreen details. The cladding is intended to control the majority of bulk water, and any water that does penetrate past the cladding must be able to drain out via the cavity created by the vertical strapping.

Water-Resistive Barrier

A vapour-permeable sheathing membrane should be installed on the exterior of the wall sheathing, behind the vertical strapping. There are a variety of loose-laid (i.e., mechanically fastened) and self-adhered sheet products, as well as some liquid-applied products that can be used in this application. The sheathing membrane should be vapour-permeable to facilitate some outward drying of the assembly.

Air Barrier

This assembly can accommodate several air barrier strategies. However, often the most straightforward one to use is the exterior sheathing membrane. Structural support of the sheathing membrane is provided by sandwiching between the vertical strapping and sheathing on either side, or else through adhesion to the sheathing. Alternatively, a sealed sheathing approach can be used for the air barrier. In this approach, joints in the sheathing must be taped and sealed.

Due to the significant depth of the insulated space, an interior layer (i.e., polyethylene sheet, sheathing or drywall) should also be detailed as airtight to provide a secondary air barrier to prevent the flow of air into the insulated cavity from the interior and reduce the potential for convective looping.

The 2x4 service wall is constructed on the interior to allow for running of electrical, plumbing, and HVAC services without penetrating the interior air barrier.

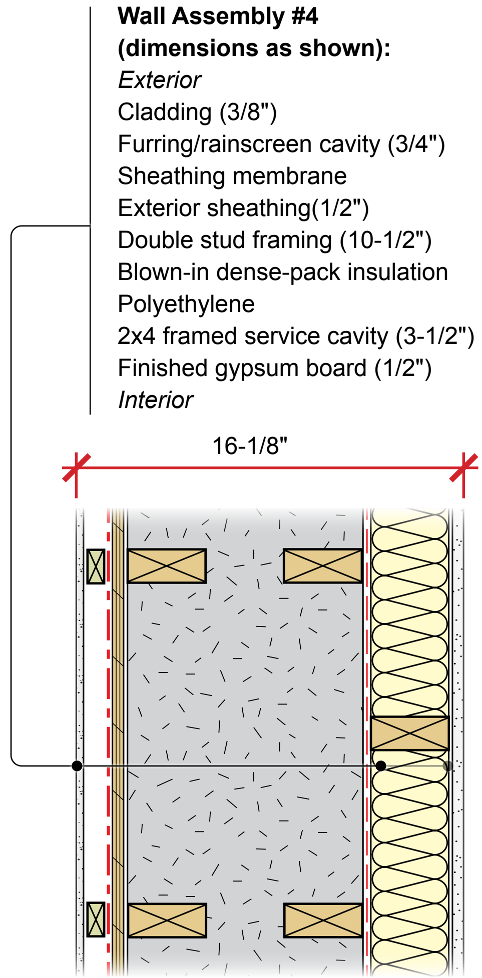


Figure 2 Typical assembly layers of the interior-insulated double stud wall

Airtightness is a fundamental aspect of Net Zero Energy construction. NZE homes are designed with very high levels of building airtightness (which must be tested once the building is complete), typically in the range of **1.0 ACH_{50}** or lower regardless of the wall assembly or air barrier strategy used. Airtightness is a primary means of achieving energy performance and should be one of the builder's foremost concerns. Continuity of the air barrier at transitions and penetrations is critical to building airtightness. Increasing airtightness also reduces the potential for condensation within wall cavities thereby reducing the risk of moisture damage. See further information in Wall Air Barrier Systems on page 19 and in the Builder Checklist for Net Zero Wall Construction on page 35.

Vapour Barrier

The relatively large amount of insulation installed to the interior of moisture-sensitive wood framing and sheathing increases the risk of moisture accumulation within this assembly. A vapour barrier is needed on the interior of double stud wall to control the outward flow of water vapour. Typically, a polyethylene sheet is used.

Insulation Types & R-value

The stud space can be insulated using a variety of different insulation types including blown-in fibrous insulation (i.e., cellulose), batt (i.e., mineral wool or high-density fibreglass), or open-cell spray foam. With fibrous fill insulations, high-density products with integral binders should be used to prevent settlement within the deep wall cavity. Higher density insulation can also reduce the potential for convective looping and the related potential for moisture, mold and rot on the interior side of the sheathing. The service wall stud space can either be left empty or it can be insulated.

The insulation types used in this assembly have a range of R-values (measured as R-value per inch of continuous insulation). In general, most insulation types are between R-3.4 and R-4 per inch. The following table provides a range of values based on insulation type, thickness of the gap between the 2x4 double studs, and whether an insulated or empty service cavity is included.

Wall Effective R-values: Interior-insulated double stud with R-3.4 and R-4/inch insulation, with or without service cavity

Thickness of Gap Between Studs (inches)	With no service wall		With empty 2x4 service wall*		Thickness of Gap Between Studs (inches)
	R-3.4/inch	R-4/inch	R-3.4/inch	R-4/inch	
1.5	25.7	28.4	29.1	30.0	1.5
2.0	27.4	30.4	30.8	32.0	2.0
2.5	29.1	32.4	32.5	34.0	2.5
3.0	30.8	34.4	34.2	36.0	3.0
3.5	32.5	36.4	35.9	38.0	4.0
4.0	34.2	38.4	37.6	40.0	5.0
5.0	37.6	42.4	41.0	44.0	6.0
6.0	41.0	46.4	44.4	48.0	7.0
7.0	44.4	50.4	47.8	52.0	8.0
8.0	47.8	54.4	51.2	56.0	9.0

*A 19% framing factor is assumed (i.e., advanced 24” o.c. stud framing practices in Part 9 construction) for the exterior and interior stud walls and service wall.
*Add **R-8.7** for walls with service cavity where R-12 batt insulation is installed.

Figure 3 Wall #4 effective R-values table

Design & Construction Considerations

The double stud wall uses many conventional framing and construction techniques, though modifications are needed to produce a deeper stud cavity that can be filled with insulation. The various important design and construction aspects of this approach are outlined in this section.

Double Stud Framing

The deep stud cavity is often framed using "advanced framing" techniques, where studs are placed at 24" on centre, and vertical load-bearing elements are aligned where possible to minimize the amount of framing needed (see Figure 3). This reduces the amount of thermal bridging through the wood components compared to typical framing, and optimizes the use of the insulation.

Advanced framing can in some cases allows the headers that would normally be placed above openings below the floor joists to be eliminated or moved up and integrated with the floor rim joist. Floor rim joists can be double- or triple-plys of engineered rim joist or 2x headers if needed, though advanced framing should serve to minimize this. In most cases, the exterior stud wall is the only structural element of the assembly.

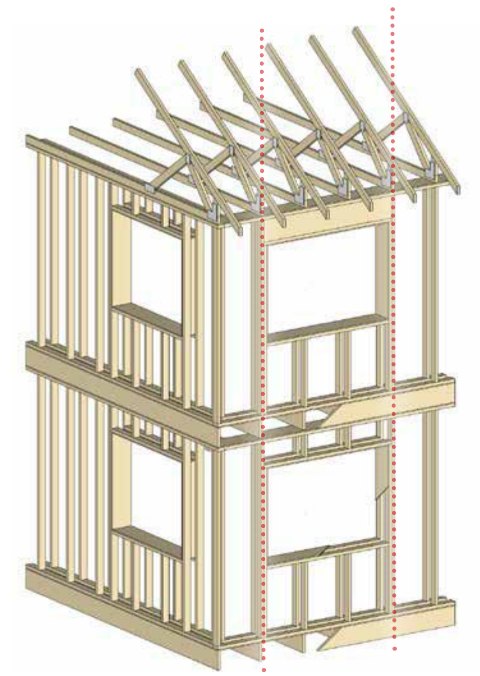


Figure 4 Double stud advanced framing with structural elements aligned and the need for headers minimized

The deeper cavity is produced by including a gap between the interior and exterior stud walls. Walls in the range of R-35 effective can be achieved with a 3.5" gap or greater. This gap allows for a "layer" of mostly continuous insulation within the stud cavity between studs, with some minimal framing components connecting the stud walls. Connections are typically made with plywood or OSB sheathing strips/gussets above the top plates and mid-point of the studs if needed.

Note that the interior and exterior studs should be aligned, rather than offset/staggered horizontally. Thermal modelling and calculations show that for gaps more than 1", the potential thermal improvement from staggered studs is negligible and not worth the additional framing effort and complication.

Moisture Risk & Durability

The increased depth of insulation inside the wall's exterior sheathing allows less heat flow during cold weather to the outer components of the wall assembly. As a result, the surface temperature of the exterior sheathing is likely to be close to or at the exterior ambient temperature (see Figure 5). The cold sheathing is therefore at a higher risk of condensation from interior moisture sources compared to conventional wall assemblies, and has less overall drying capacity. These risks can be minimized by using the following key practices for walls with insulated deep stud cavities.

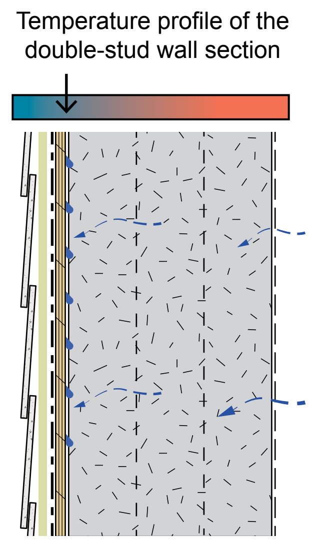


Figure 5 Deep wall cavity insulation decreases the temperature of the exterior insulation and can lead to increased condensation risk and minimal drying potential.

Interior Vapour Control: Interior moisture flow into the wall cavity from vapour diffusion must be avoided. A dedicated high-quality vapour barrier membrane such as polythene should be installed at the interior of the double stud wall, behind finishes or a service cavity. As discussed in the following paragraph, it is also prudent to detail this layer as the air barrier.

Interior & Exterior Air Barrier: Air movement into and through the wall assembly can carry large amounts of moisture to the exterior sheathing and result in heavy condensation. While an exterior air barrier is typically a simpler approach compared to an interior air barrier, the potential for air movement can be greatly reduced if both are used on this assembly. The exterior air barrier can serve as the primary airtight layer, but the interior air barrier using the polyethylene or other dedicated layer serves to further minimize the risk of airflow into the assembly. As discussed in the following paragraph, other airflow mechanisms can lead to airflow within the cavity regardless of the airtightness of the exterior air barrier.

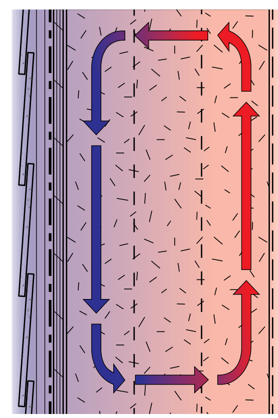


Figure 6 Convective looping can occur through loose-fill insulation or in gaps around insulation

Low Air Permeability Insulation: Convective looping is the phenomenon in vertical insulating cavities where the density difference between cooled and heated air causes airflow in a looping pattern (see Figure 6): If the air at the exterior surfaces in a wall cavity is able to "sink" as it is cooled, and the air at the interior surfaces is able to "rise" as it is heated and replaced with cooler air, then a looping airflow pattern can form.

This can occur regardless of the airtightness of the cavity boundaries, since it affects air already within the cavity. However, this looping can also draw in warm interior air. If this occurs, the moisture risk from additional airflow into the wall is increased. As previously noted, a good interior air barrier can minimize the amount of air potentially drawn into the assembly.

However, a way to reduce the risk of convective looping is to use **denser, low air permeability insulation in the stud cavity**. This stops air from easily moving within the cavity due to convective forces. The insulation must also fully fill the cavity to avoid airflow pathways around it. Dense-pack blown-in insulation is typically sufficient to achieve both these objectives.

Good Exterior Water Management: As with all wall assemblies, good water management is important for long-term durability. The double stud wall is especially prone to damage from any incidental moisture from leaks, since the drying capacity of the sheathing is limited. The drying potential from interior warmth and vapour drive that may occur in other typical wall assemblies is not present in this assembly. Therefore, wetting can result in long-term moisture storage and potential degradation. Typical rainscreen details with good water-shedding characteristics should be used with double stud wall assembles to minimize the risk of wetting from exterior sources. This includes:

- Through-wall flashing above openings and at cladding transitions
- Vented rainscreen space between the cladding and the water-resistive barrier (WRB)
- Roof overhangs where possible
- Carefully detailed WRB with correct positive laps and all penetrations flashed and sealed

Insulation Types & Installation

Blown-in insulation is typically the insulation type used in deep wall cavities. The potentially complex framing and sequencing of the double-stud wall can make manually installed batt insulation difficult and time consuming. The details and guidance in this guide assumes a blown-in dense-pack cellulose insulation is used with the double stud wall assembly. However, assuming the wall assembly has an airtight layer on the interior and the exterior, blowing insulation into an airtight cavity is not possible with traditional insulation guns. The air and resulting pressurization from the blowing gun would damage the air barrier, and the cavity would not be fully filled. This challenge is usually avoided by **using an air permeable mesh at the interior of the wall to contain the insulation but allow airflow, and installing the interior air barrier, usually polyethylene, after the insulation is in place**. This process requires additional work and sequencing efforts.

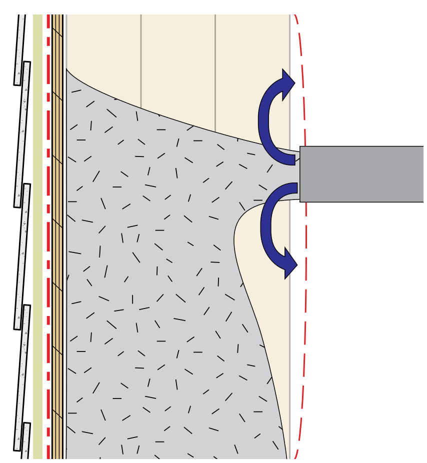


Figure 7 Pressurization in an airtight cavity from traditional blown-in insulation methods

The insulation installation can be simplified by using a pressure-equalizing insulation blower. This device uses a blower gun with an attachment at the cavity penetration that allows airflow out of the cavity and prevents pressurization. The insulation to be blown in to all areas to the correct density inside a fully airtight cavity. The interior retention membrane can be installed and detailed as the air barrier before the insulation is in place and without needing a dedicated mesh or separate polyethylene layer. This is the recommended insulation approach for deep wall cavities with blown-in insulation.

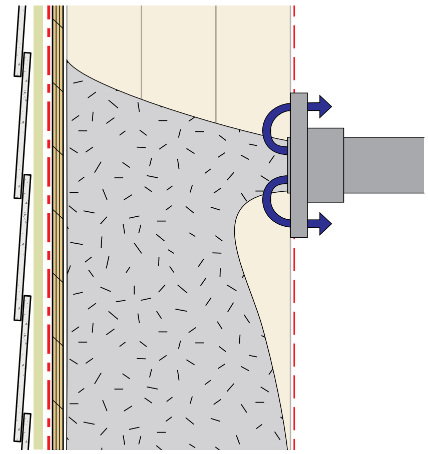


Figure 8 Modern pressure-equalized blown-in insulation method to avoid pressurizing the cavity

Service Cavity

Interior air barriers that align with the interior finishes are inherently difficult to make airtight due to the many penetrations they must accommodate. Interior electrical switches and receptacles alone can account for dozens of potential air leakage locations, and each one has to be individually detailed to make as airtight as possible.

A service cavity is a dedicated cavity installed with 2x framing or cross-strapping that contains the various electrical, plumbing and mechanical services. The various associated wall penetrations are relocated so that they no longer penetrate the wall interior air barrier. This system minimizes the number of penetrations, which makes the interior air barrier more airtight and simpler to install.

The service cavity allows the air barrier to be "protected" during the remainder of the construction and the service life of the building. Drywall, cabinet and even fixture installation that would all normally risk damaging the air barrier no longer pose a risk. The service cavity is recommended where excellent airtightness is needed.

Note that it can also be insulated to increase the wall R-value, and it should be insulated to provide support for the air barrier membrane. See the Typical Construction Details starting on page 23.

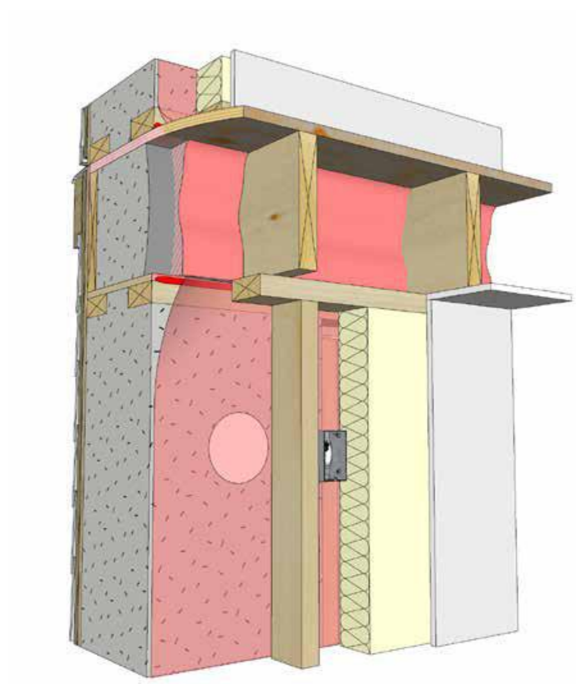


Figure 9 A wall service cavity reduces the penetrations through the interior air barrier and protects it from damage

Code Compliance and Performance Verification

The design and construction of wall assemblies used in Part 9 Housing and Small Buildings must comply with the requirements and restrictions set out in the local applicable building code, whether it is the NBC or the provincial/local versions. These include:

1. Considerations for the **materials and methods** used in the assemblies themselves, and
2. How the resulting wall thermal performance is accounted for in the **building energy performance**.

As with all code items, responsibility for code compliance always lies with the building owner. If the owner has a legally binding Contractual Agreement with a designer or builder, then this responsibility would pass to them, as defined by the contract. The Building Official is only there to oversee and apply the local code compliance process and serve in an auditing role.

Materials and Methods: Check the applicable code sections and their referenced standards to confirm how each material and installation approach must comply. Part 9 of the NBC consists of subsections for most of the "layers" of typical wood-frame wall assemblies, including the framing, the various enclosure control layers, and even interior finishes, which outline the various requirements for the materials used and how they are installed. Most materials in typical wall assemblies must comply with an applicable CSA standard. The Canadian Construction Materials Centre (CCMC) offers testing and review services to assess product compliance with building codes. However, other methods of assessing compliance and establishing "equivalency" can be used including professional engineering services. The product manufacturer will often provide the documentation relating to code compliance, but it must always be checked against the local building code. New enclosure control layer technology such as specialty membranes may come to market faster than they can be assessed, so this requires caution.

Energy Performance: Code requirements for effective thermal insulation are set out prescriptively in Part 9 of the NBC. Calculating wall assembly thermal performance for the purpose of demonstrating code compliance can be done with relative ease using code-defined methodology and online resources such as the Effective R Calculator from the Canada Wood Council. However, where performance-based energy code compliance is needed, the methodology is more nuanced. The various effective R-values must all be accounted for in a unique building energy model; the documentation and energy modelling must follow the code requirements, but the approach to meeting the energy performance requirements will vary across buildings (i.e., using different assemblies and energy efficiency approaches). Exactly how code compliance is demonstrated to the authority having jurisdiction (i.e., through submissions, reviews, inspections, and approvals) is up to each jurisdiction to establish and for the project team to understand and follow. Most importantly, on-site verification is becoming a bigger part of designing and building. This includes confirmation of assembly insulation R-value on site, as well as airtightness testing. Consult with your local authority having jurisdiction to confirm the performance verification and submissions requirements relating to demonstrating code compliance with performance-based code requirements.

Window Installation

The deep wall assembly presents some unique sequencing challenges for window and door installations. **The window and door detailing must:**

- Accommodate both flange and non-flange windows,
- Allow windows to be installed at the face of the opening or aligned further within the wall,
- Anticipate the future flashing, strapping, and cladding components, and
- Maintain robust air sealing and water management strategies

The following figures show installation methods that achieve these objectives. Figure 10 shows basic rough opening preparation steps and window installation approaches. Figure 11 shows three examples of the sill membrane material and installation method to achieve a continuous air and water seal.

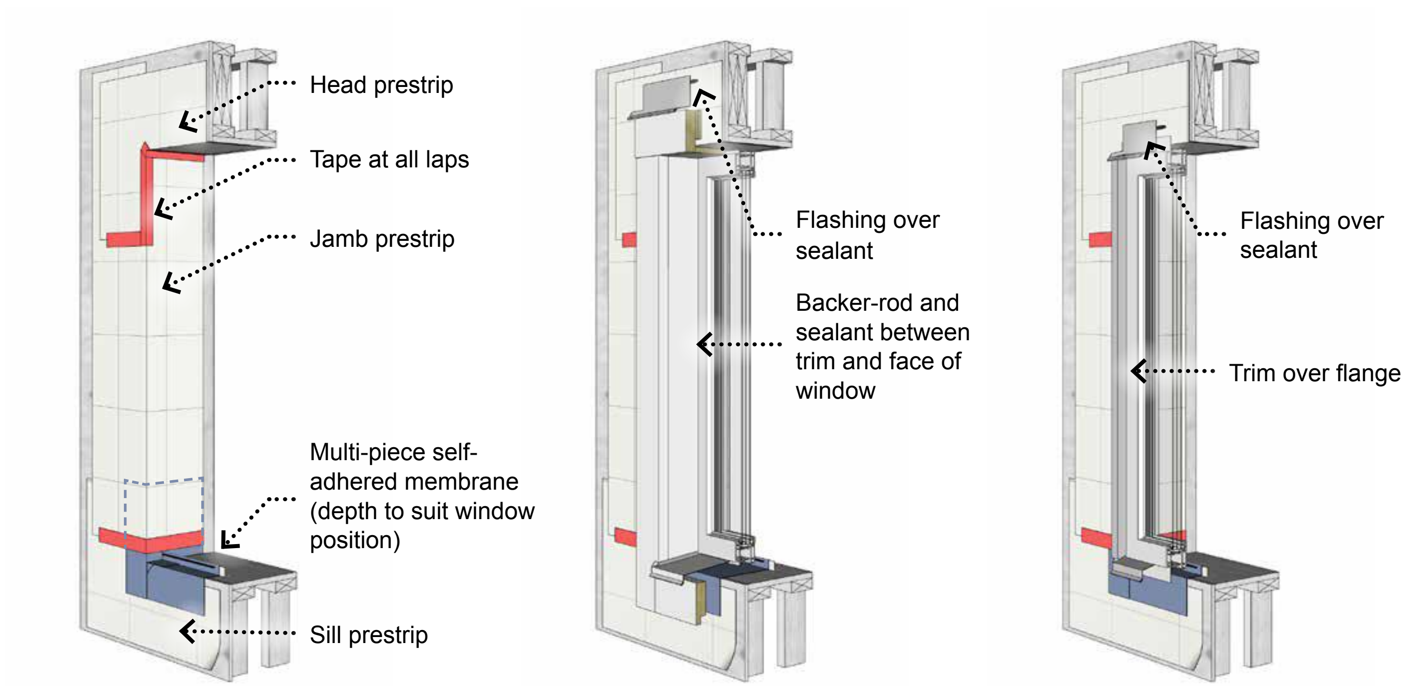


Figure 10 Rough opening membrane preparation (left), non-flange window installation (centre) and flange window installation (right)

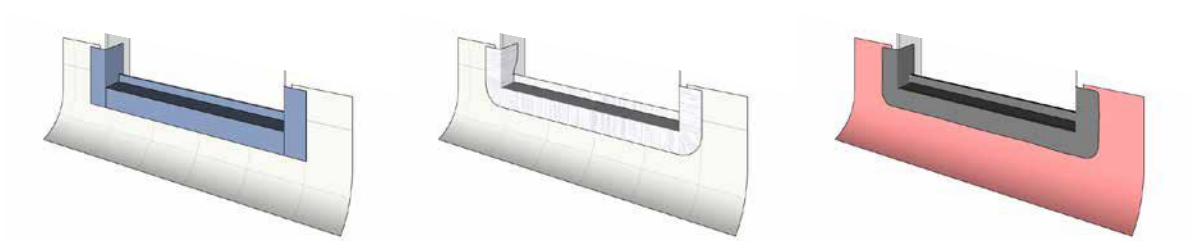


Figure 11 Common window sill membrane options: Multi-piece self-adhered membrane (left), flexible/formable membrane (centre) and liquid-applied membrane (right)

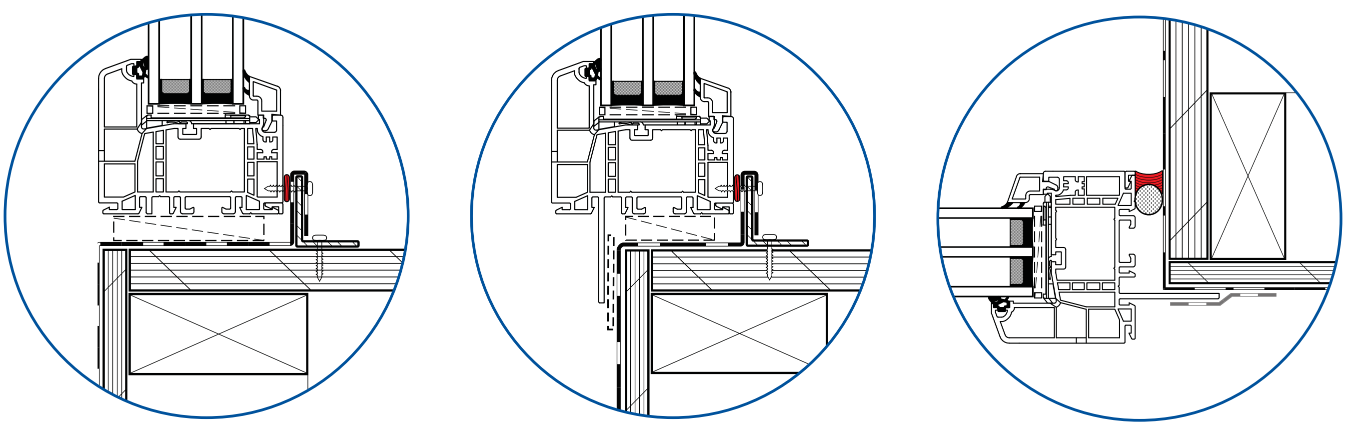
Flange and Non-Flange Windows: Perimeter Seal and Attachment

Seals: The baseline approach for sealing between the window frame and the rough opening at the sill is to use a metal angle or wood block, with the sill membrane wrapped over it so that the back of the window frame can be set into a sealant bead (see Figure 12). The sill angle provides increased moisture penetration resistance as it provides a back dam and elevates the location of the sealant used for the air and water seal above the surface of the sill membrane and away from potential moisture sources. Backer rod and a sealant bead are used at the jamb and head.

Note that per the code-referenced Canadian standard *CSA A440.4-19: Window, Door, and Skylight Installation,* if a sill angle or block is not used, then the sill membrane must be sloped to the exterior. In this case the interior seal at the sill would typically be backer rod and sealant. The baseline sill detailing approach shown throughout this guide series is a metal sill angle.

For any window detailing approach, the air and water seal should transfer between the window and the rough opening membrane at the **interior plane of the frame**, with drainage to the outside provided at the sill membrane. The same sealing approach is used for both flanged and non-flange windows. Sheathing tape at the outside perimeter of the flange is optional at the jamb and head for extra water-shedding protection, but a drainage path must always be maintained past the window sill flange through the use of shims or furring (see Figure 12).

Attachment: Windows can be attached from the interior using clips and the sill angle, or at the exterior with fasteners through the flange. Per *CSA A440.4-19*, the sill membrane must not have penetrations through its horizontal drainage surface.



Sill angle for non-flange window (at sill only)

Sill angle for flanged window

Backer rod and sealant for jamb and head interior seal

Figure 12 Window rough opening air and water sealing options

Window details provided in the Typical Construction Details starting on page 23 are based on best practice for this wall assembly. Refer also to the Canadian Standard *CSA A440.4-19: Window, Door, and Skylight Installation* for code requirements, including sealing and flashing, in Part 9 buildings.

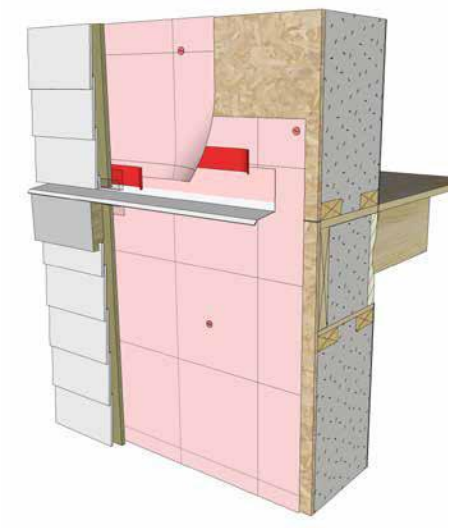


Figure 13 Mechanically fastened sealed sheathing membrane, with all edges of the airtight material sealed and with the back leg of the flashing made part of the air barrier.

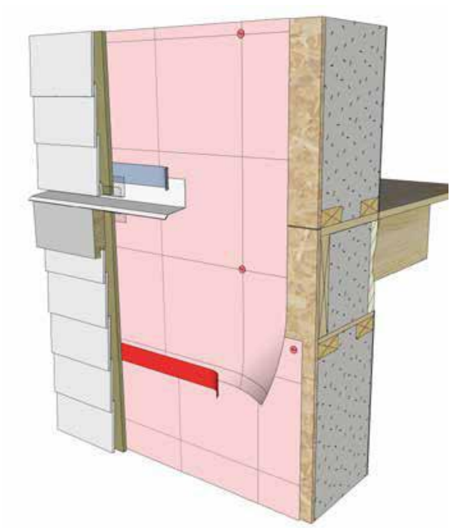


Figure 14 Sealed sheathing membrane without positive lapping of the flashing.

Wall Air Barrier Systems

The wall air barrier system is one of the most important control layers in the assembly. Exterior air barrier approaches generally offer the simplest installation and detailing steps.

Exterior Air Barrier Systems

Mechanically Attached Sheathing Membrane: Mechanically fastened systems use an airtight sheathing membrane, also referred to as house wrap, attached to the exterior sheathing with fasteners and washers. Joints, penetrations, and laps are made airtight using sealant, tape, and self-adhered sheathing membrane strips. Care should be taken to ensure the sheathing membrane is adequately attached to the building during construction and it should be supported by strapping or cladding to avoid damage.

This air barrier approach is the primary air barrier approach shown in the Typical Construction Details starting on page 23.

The sheathing membrane is also usually used as the water-resistive barrier, and must be installed and detailed as such. This dual duty may introduce conflicting details, where lapping requirements hinder the ease of the air barrier detailing. This is most notable at through-wall flashings; if the air barrier membrane must lap over the back leg of the flashing, the flashing back leg must be detailed as part of the air barrier. This is done by sealing the top and sides of the flashing back leg with tape or sealant (see Figure 13). Where positive lapping is not strictly required, the flashing should be installed over the sheathing membrane, with the back leg taped along its top edge, as shown in Figure 14.

Note that specific code requirements may dictate how flashings are installed. Consult with your local authority having jurisdiction to confirm what approaches may be acceptable.

Other Exterior Approaches: The following additional exterior air barrier approaches can also be used with this assembly, and are further discussed in the Assembly #1 guide of this series:

- Vapour-Permeable Self-Adhered Membrane
- Sealed Exterior Sheathing
- Liquid-Applied Membrane

Sealed Interior Polyethylene

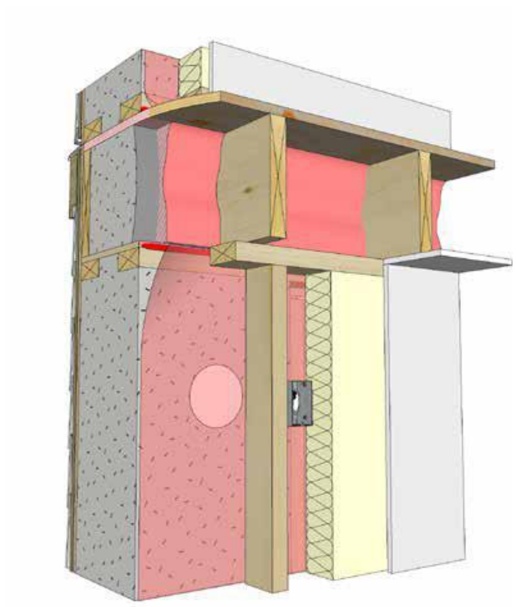


Figure 15 Sealed interior polyethylene approach with all edges of the airtight material taped and sealed.

In this system, polyethylene sheets are sealed to the interior framing to form the interior air barrier. All joints in the polyethylene are also sealed and clamped between the framing and the interior finish (or service cavity framing). Locations where interior finishes are not normally provided require specific measures to ensure the polyethylene is supported.

The various interfaces between the exterior walls and interior elements such as staircases, interior walls, floor framing and service penetrations make the sealed polyethylene approach a difficult air barrier system to implement successfully. Therefore, it is not recommended as the only air barrier system for buildings where high-performance airtightness is required. A service cavity should always be installed to reduce the number of penetrations.

This is the primary air barrier approach used in combination with the exterior air barrier shown in the Typical Construction Details starting on page 23.

Sealed Interior Sheathing

This approach uses an interior layer of sheathing as the primary interior air barrier element. The sheathing joints are sealed with tape or membrane strips, and the perimeter is set onto gaskets or sealant on the wall framing. Penetrations through the air barrier can be limited by using a service wall framed inside the sheathing, where electrical and plumbing services can be run.

Airtight Drywall

In the airtight drywall approach, the interior gypsum board and framing members provide the interior air barrier. Continuity between different materials is created with sealants or gaskets. Special attention is required to seal penetrations in the gypsum board at electrical fixtures and other services, as well as the intersection of partition walls with exterior walls and the ceiling.

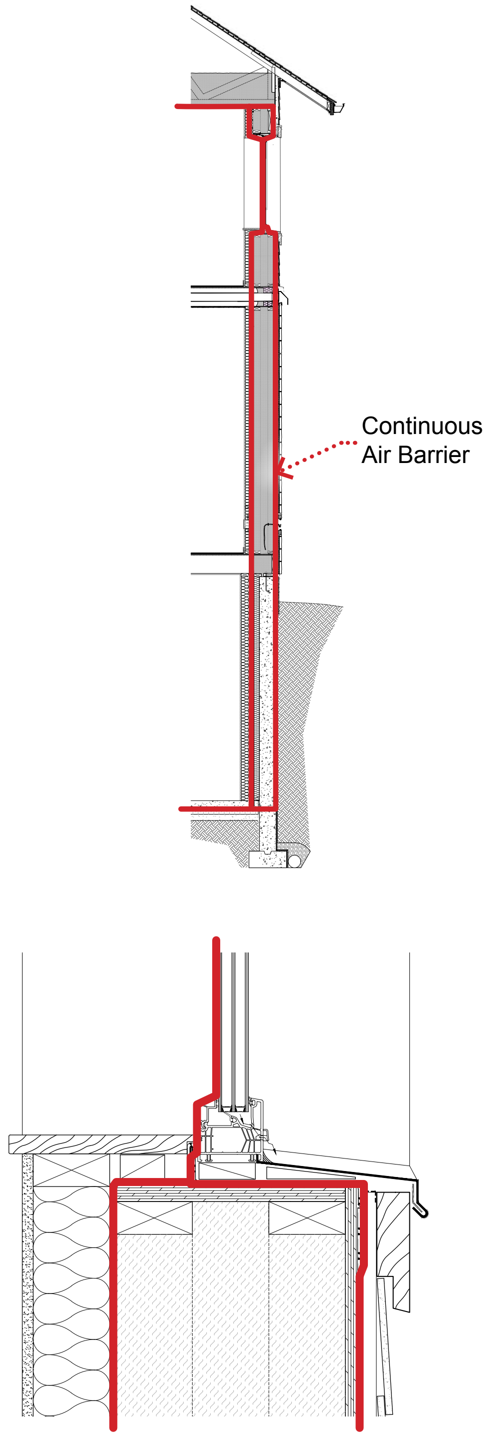


Figure 16 Example air barrier lines of continuity across the entire building enclosure and including all transition details.

Air Barrier Detailing

The most important aspect of designing an airtight enclosure is detailing the interfaces and penetrations, because this is where discontinuities are most likely to occur. While the individual air barrier materials and components provide control of air movement for each individual assembly, how and where each assembly intersects and the continuity of the air barrier across these joints should be the focus of the detailing work. Whether at the base of wall, windows, service penetrations, roof-to-wall interface, or countless other detail locations, the details should provide a clear indication of the air barrier continuity across the building enclosure.

A best practice design technique for ensuring continuity of the air barrier is to draw a continuous line around the building enclosure. This can help to identify the air barrier on building plans, sections, and details. The line should continue around the entire enclosure and connect back to itself with no discontinuities. It should be possible to trace the air barrier without, as it were, lifting one's pen off the paper. The same concept applies to individual detail drawings as well. A detail should be prepared for all air barrier interface locations, clearly showing how continuity is maintained. Reviewing these transitions early on and collaborating with the affected trades will allow locations with constructability or sequencing issues to be identified and help determine if a revised detail is necessary.

Assemblies with interior air barriers in particular must account for all the potential interruptions and interfaces at the interior face of the building. Details for these locations should include all necessary components and products, and basic installation measures, to provide a continuous air barrier across all elements of the assembly. See Typical Construction Details starting on page 23.

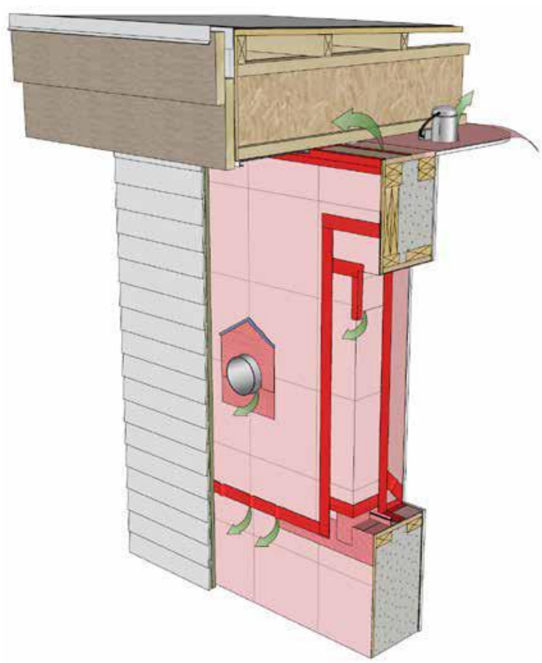


Figure 17 Common wall and ceiling air barrier deficiencies

Figure 18 Example airtightness sign to use on site for notifying all staff and trades

Common Air Barrier Deficiencies & Challenges

Common deficiencies and challenging areas can occur at all areas of the air barrier system. The integrity of the air barrier relies upon the quality and completeness of the installation work. Some common air barrier deficiencies and likely deficiency locations include:

- Structural and service penetrations
- Wrinkled/fishmouth/incomplete membrane laps
- Roof-to-wall and other interfaces with various transition materials
- Roof/ceiling penetrations
- Window membrane and perimeter sealing
- Above-grade to below-grade transitions
- Complex building forms and enclosure shapes such as fin walls and projections
- Late installation of service penetrations such that proper detailing can't be completed

These deficiencies can be avoided by using comprehensive detailing at the design stage, and employing proper quality control and assurance measures during construction.

On-site quality control of air barrier installation is a complex process. It is fundamentally important to achieving an airtight building and requires substantial oversight. The builder is ultimately responsible for ensuring all aspects of the system are installed and complete.

A successful approach to mitigate this risk is to designate an “air boss”, who is a member of the construction team responsible specifically for the air barrier. This person should be appropriately trained on and knowledgeable of air barrier strategies in general and the specific air barrier systems being used on the project. For more information on successful implementation of a high-performance air barrier system, refer to the *Illustrated Guide - Achieving Airtight Buildings* published by BC Housing.

Typical Construction Details

The example details shown in the following pages are intended to establish a common level of detailing for the LEEP NZE Wall Assembly #4. Each guide in this series contains a similar set of details for their respective assembly.

Using These Details

Builders are invited to replicate or modify these details, within the guidelines provided, to achieve the desired performance outcome. This may include Net Zero Energy (NZE) or other high-performance standards for light wood-framed construction.

We recognize that there are a multitude of high-performance wall assemblies. However, in regional LEEP initiatives, builder groups repeatedly asked to focus on these walls. LEEP worked with building science experts to evaluate these generic wall assemblies based on climate conditions, construction practices and local building codes. This guide series provides information, criteria and data that will help builders determine which of these generic types of high-performance wall assemblies are best suited to their needs.

The construction details illustrate transition strategies for air barrier, water-resistive barrier, and insulation continuity. The annotations and legend in each sample detail contains red “AB” and "AB/WRB" icons to indicate the various air barrier and, where applicable, water-resistive barrier components present. Note that these images are provided to illustrate improved best practices. To use these details in your project, modifications may be needed, including:

- Creating additional details as required to address all elements of the specific project,
- Selecting specific exterior cladding types and finishing systems in response to design requirements, including the related water management and fastening details,
- Coordinating the wall assembly into the full scope of project specific systems and components such as: structural system, water management, mechanical and electrical systems, fire and life safety considerations, and
- Producing specifications, certification or inspection as required by authorities having jurisdiction.

Any modifications or additional details developed need to be carried out by those that have the experience and competency to do so. Minimum professional requirements vary by Province. To reduce the risk of post-installation deficiencies such as water penetration and mold, builders are encouraged to have details developed or reviewed by a building science engineer or architect.

Inexperienced crews should practice assembly installation and detailing work by building full-scale on-site mockups that can also be used for instruction and quality control (see also the Builder Checklist for Net Zero Wall Construction on page 35).

Each unique project will require the development of specific details and construction documents to address the varied conditions found in each building and the local construction trade's capacity. In addition, each builder must provide quality control and assume liability for the work they complete. Reliable technical information and training is critical to your success. We recommend that builders take advantage of technical guides and training opportunities offered by credible sources and share this training with everyone on your crew. Work with your local Home Builders Association (HBA) to find more information and to build local capacity.

For more guidance and example detailing for net zero energy wall assemblies, refer to the following additional resources:

- BC Energy Step Code Builder Guide, BC Housing
- Building Enclosure Design Guide, BC Housing
- Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings, FP Innovations, BC Housing, and the Canadian Wood Council
- Illustrated Guide–R22+ Effective Walls in Wood Frame Construction in British Columbia, BC Housing

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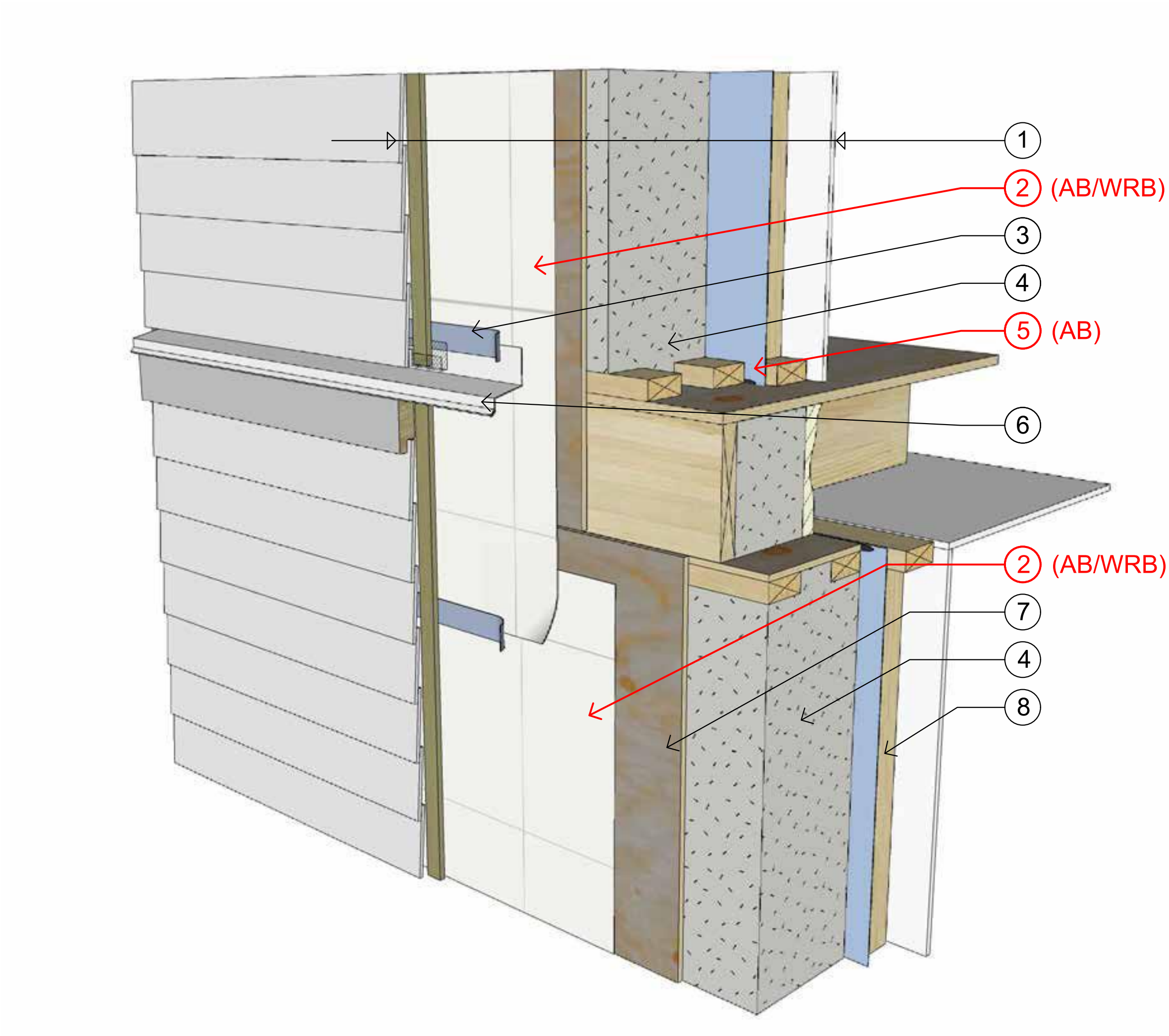


LEGEND

1. Wall assembly, refer to double stud wall details
2. VP sheathing membrane (AB/WRB)
3. Tape seal
4. 2x4 wood framing filled with blown-in insulation
5. Polyethylene sheet membrane (AB)
6. Pre-finished metal flashing
7. Sheathing
8. 2x4 wood framing service cavity with batt insulation

NOTE

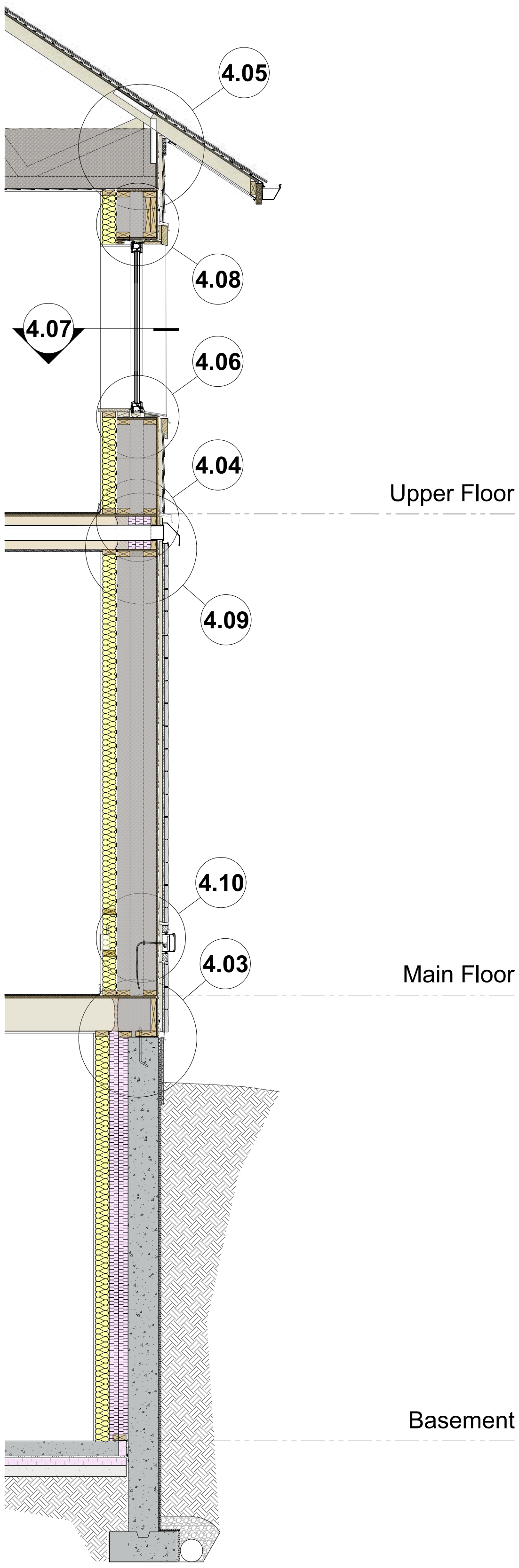
Refer to Appendix A for recommended products

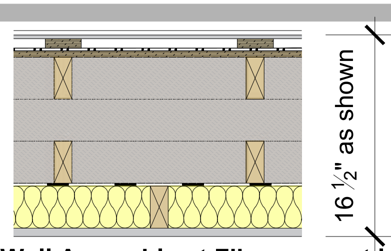
ABBREVIATIONS

AB → Air Barrier
WRB → Water Resistive Barrier
VB → Vapour Barrier
VP → Vapour Permeable
XPS → Extruded Polystyrene

WALL SECTION OVERVIEW & MATERIALS | D4.01

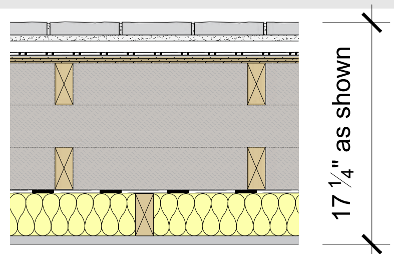
Assembly #4 | Double Stud Wall with Interior Service Wall





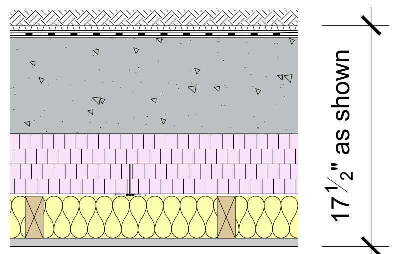
Wall Assembly at Fibre cement lap siding

- Fibre cement lap siding ($\frac{3}{8}$")
- Pressure treated wood strapping/air cavity ($\frac{3}{4}$")
- VP sheathing membrane (AB/WRB)
- Sheathing ($\frac{1}{2}$")
- 2x4 wood framing filled with blown-in insulation (3 $\frac{1}{2}$")
- 3 1/2" gap filled with blown-in insulation (3 $\frac{1}{2}$")
- 2x4 wood framing filled with blown-in insulation (3 $\frac{1}{2}$")
- Polyethylene sheet membrane (AB)
- 2x4 wood framing service cavity with batt insulation (3 $\frac{1}{2}$")
- Interior gypsum wall board ($\frac{1}{2}$")



Wall Assembly at Thin Stone Veneer

- Thin stone veneer assembly c/w stucco base coat, wire lath and backer board (1 $\frac{1}{2}$")
- Pressure treated wood strapping/air cavity ($\frac{3}{4}$")
- VP sheathing membrane (AB/WRB)
- Sheathing ($\frac{1}{2}$")
- 2x4 wood framing filled with blown-in insulation (3 $\frac{1}{2}$")
- 3 1/2" gap filled with blown-in insulation (3 $\frac{1}{2}$")
- 2x4 wood framing filled with blown-in insulation (3 $\frac{1}{2}$")
- Polyethylene sheet membrane (AB)
- 2x4 wood framing service cavity with batt insulation (3 $\frac{1}{2}$")
- Interior gypsum wall board ($\frac{1}{2}$")

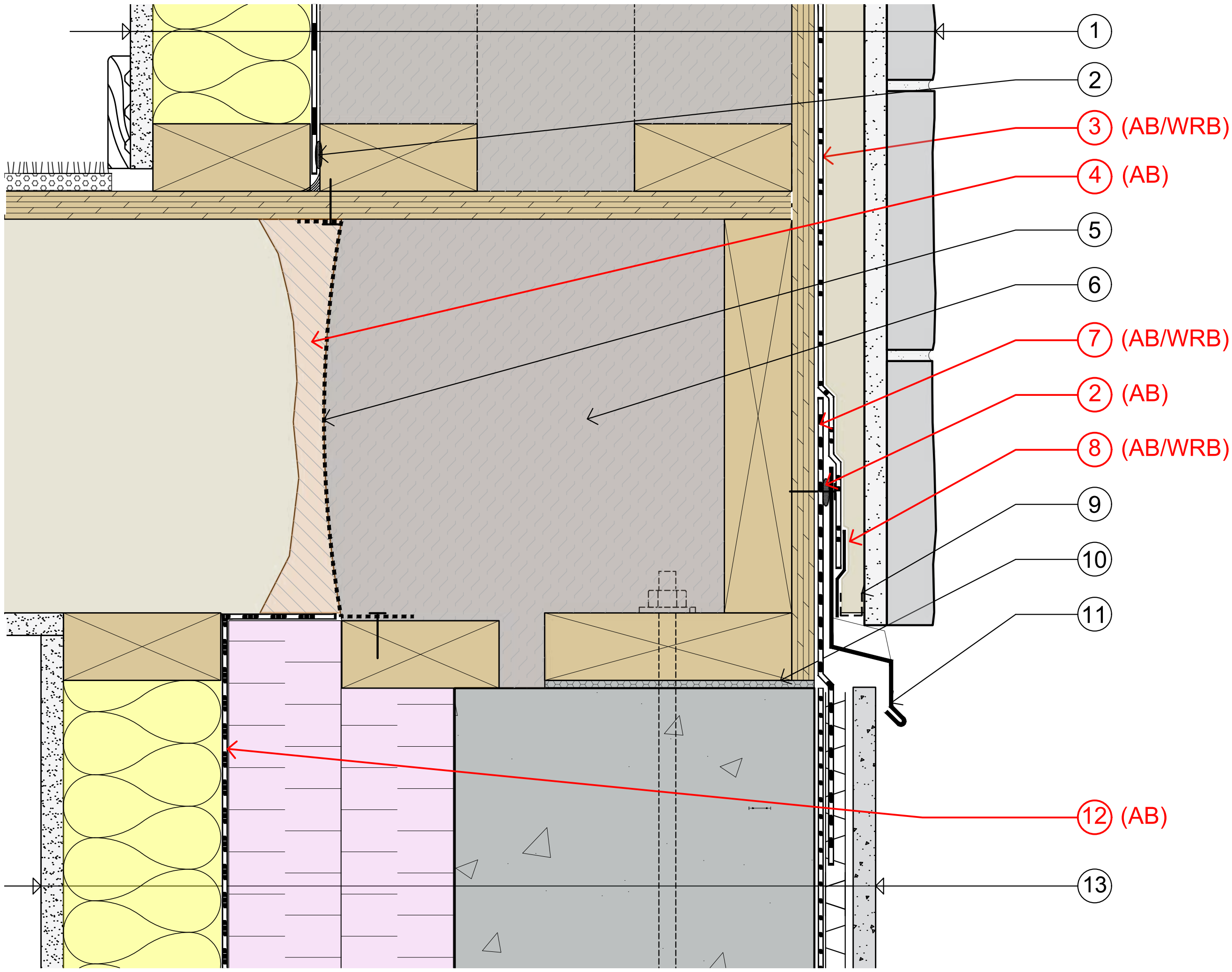


Foundation Wall below Grade

- Concrete board (above grade)
- Exterior grade or soil (below grade)
- Plastic drain mat w/ integrated filter fabric (below grade) ($\frac{1}{2}$")
- Below grade waterproofing membrane (AB/WRB)
- Concrete foundation wall (8")
- XPS insulation board sealed at all joints and perimeter with continuous tape and spray foam (5") (AB)
- 2x4 wood framing service cavity with batt insulation (3 $\frac{1}{2}$")
- Interior gypsum wall board ($\frac{1}{2}$")

WALL SECTION AND ASSEMBLIES | D4.02

Assembly #4 | Double Stud Wall with Interior Service Wall

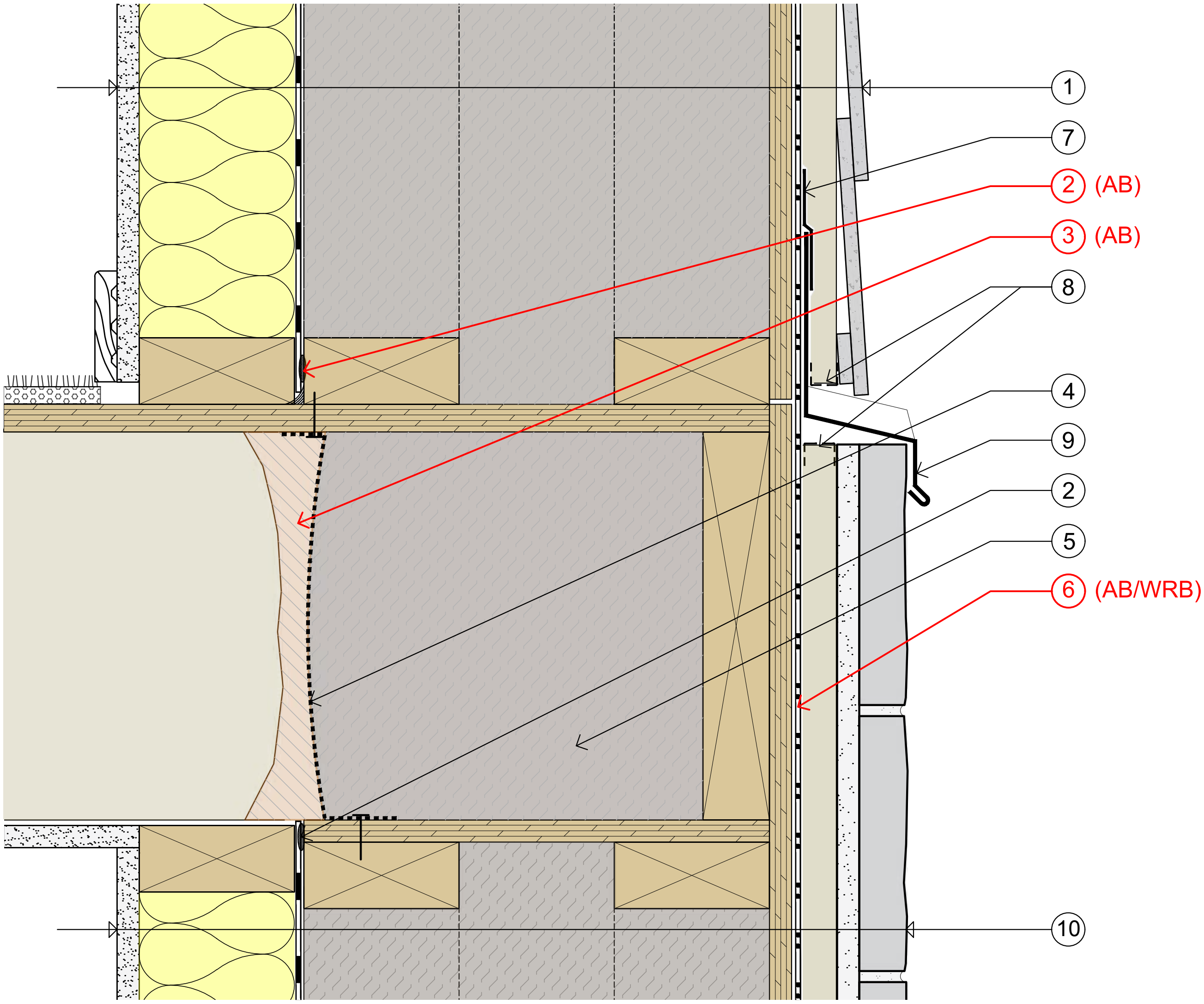


LEGEND

1. Wall assembly
   - Thin stone veneer assembly c/w stucco base coat, wire lath and backer board
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. Continuous sealant
3. VP sheathing membrane (AB/WRB)
4. Continuous polyurethane spray foam insulation (AB)
5. Cellulose insulation retention mesh stapled around joist space
6. Cellulose insulation
7. Self adhesive membrane (AB/WRB)
8. Tape seal (AB/WRB)
9. Insect screen
10. Foam gasket
11. Pre-finished metal flashing
12. Foam tape (AB)
13. Wall assembly
    - Concrete cement board above grade
    - Plastic drain mat with integrated filter fabric
    - Below grade waterproofing membrane (AB/WRB)
    - Concrete foundation wall
    - XPS insulation board sealed at all joints and perimeter with continuous tape and spray foam (AB)
    - 2x4 wood framing service cavity with batt insulation
    - Interior gypsum wall board

BASE OF WALL AT FOUNDATION | D4.03

Assembly #4 | Double Stud Wall with Interior Service Wall

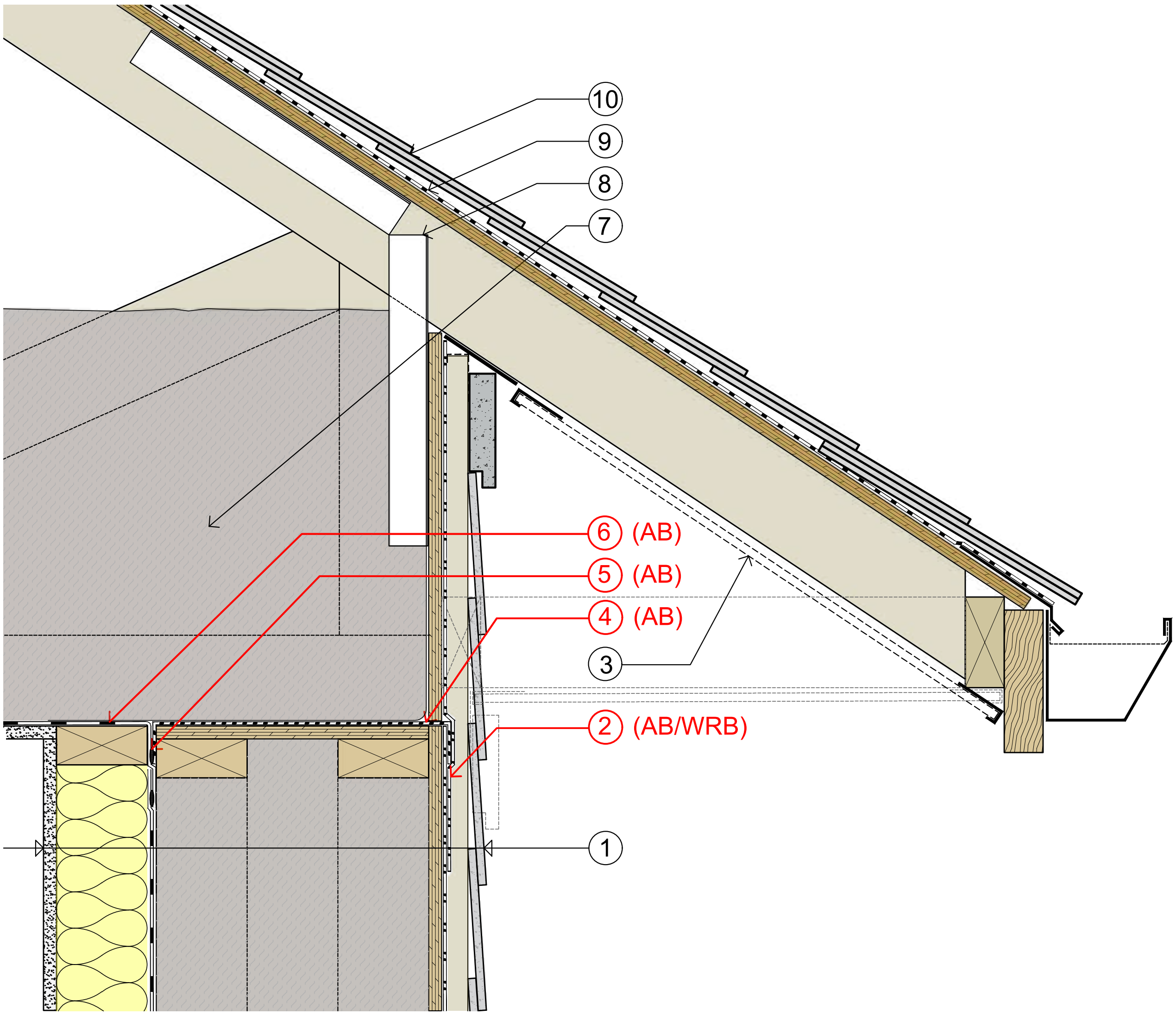


LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. Continuous sealant (AB)
3. Continuous polyurethane spray foam insulation (AB)
4. Cellulose insulation retention mesh stapled around joist space
5. Cellulose insulation
6. VP sheathing membrane (AB/WRB)
7. Tape seal
8. Insect screen
9. Pre-finished metal flashing
10. Wall assembly
    - Thin stone veneer assembly c/w stucco base coat, wire lath and backer board
    - Pressure treated wood strapping/air cavity
    - VP sheathing membrane (AB/WRB)
    - Sheathing
    - 2x4 wood framing filled with blown-in insulation
    - 3 1/2" gap filled with blown-in insulation
    - 2x4 wood framing filled with blown-in insulation
    - Polyethylene sheet membrane (AB)
    - 2x4 wood framing service cavity with batt insulation
    - Interior gypsum wall board

CLADDING TRANSITION AT FLOOR LINE | D4.04

Assembly #4 | Double Stud Wall with Interior Service Wall

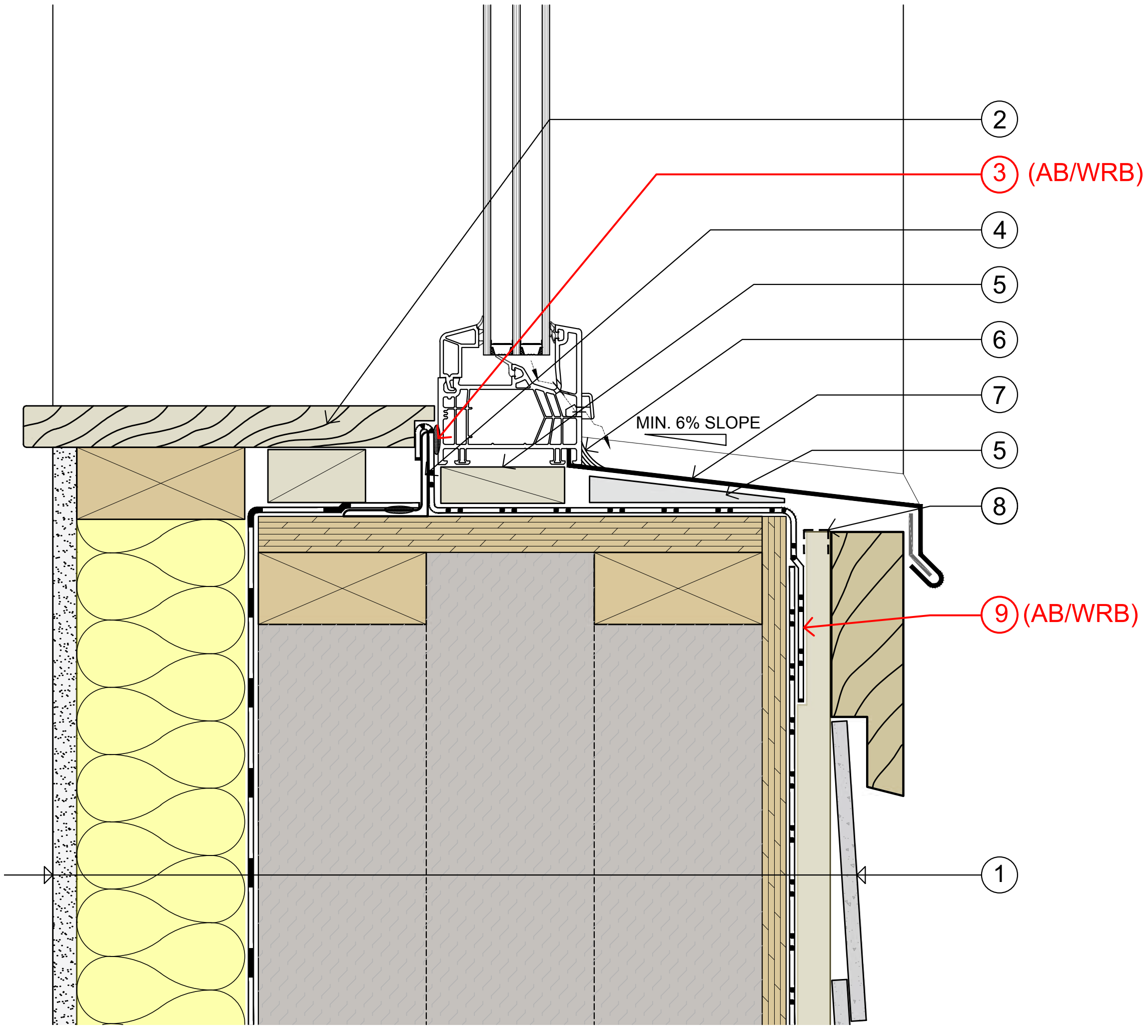


LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. VP sheathing membrane (AB/WRB)
3. Perforated soffit panel
4. Continuous self adhesive membrane over all top plates (AB)
5. Continuous sealant at ceiling poly (AB)
6. Ceiling poly (AB)
7. Cellulose insulation
8. Vent & insulation stop
9. Roof underlayment including eave protection
10. Roofing shingles

WALL & ROOF INTERFACE | D4.05

Assembly #4 | Double Stud Wall with Interior Service Wall

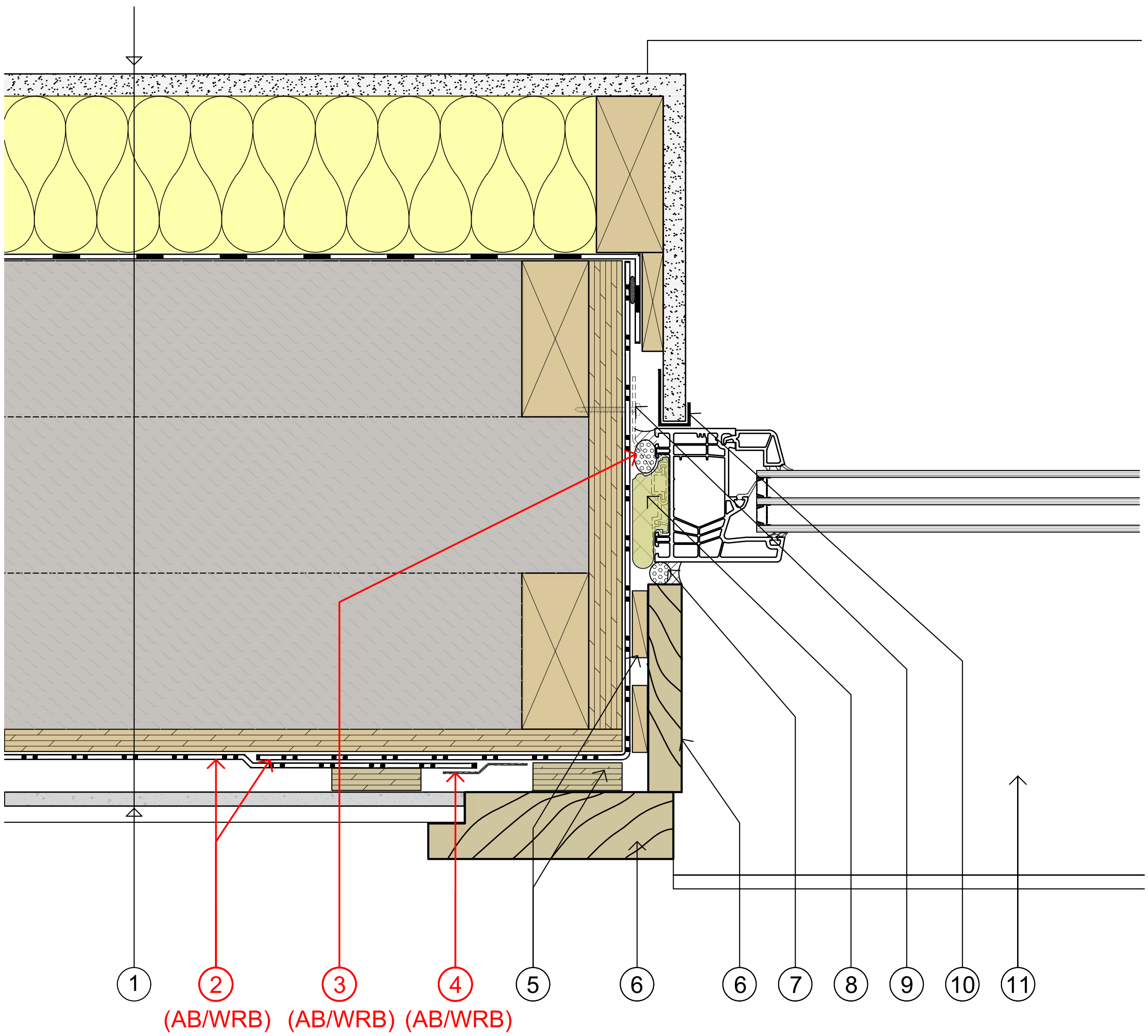


LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. Interior window sill
3. Continuous sealant (AB)
4. Continuous angle
5. Intermittent shims adhered with sealant
6. Continuous sealant
7. Pre-finished metal flashing c/w fastening cleat
8. Insect screen
9. Self adhesive membrane (AB/WRB)

WINDOW SILL | D4.06

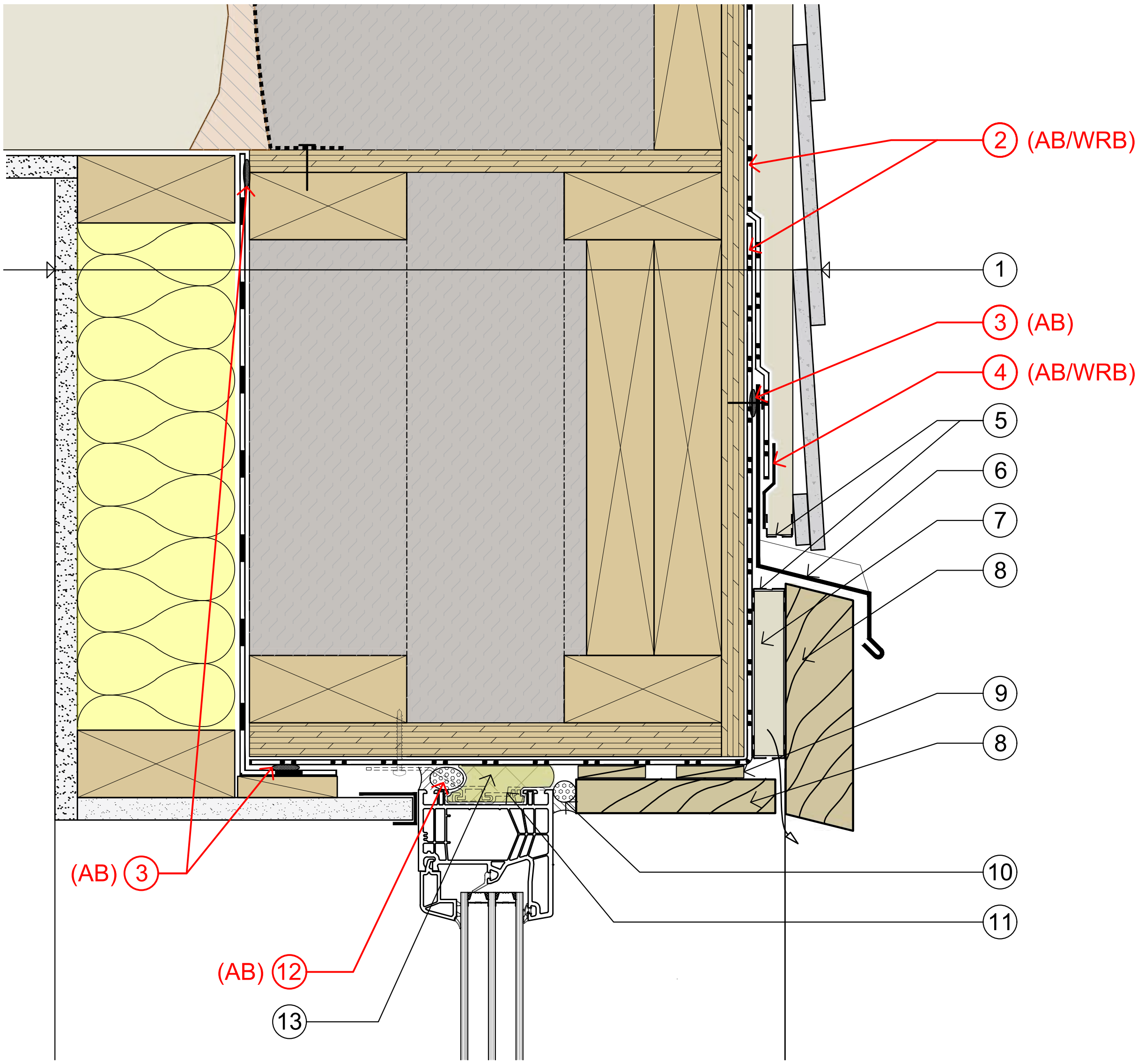
Assembly #4 | Double Stud Wall with Interior Service Wall



LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. VP sheathing membrane (AB/WRB)
3. Backer rod and sealant (AB/WRB)
4. Tape seal (AB/WRB)
5. Pressure treated strapping
6. Exterior trim
7. Backer rod & sealant
8. Insulation
9. Intermittent fastening clip & fastener
10. J Trim
11. Pre-finished metal flashing

WINDOW JAMB | D4.07

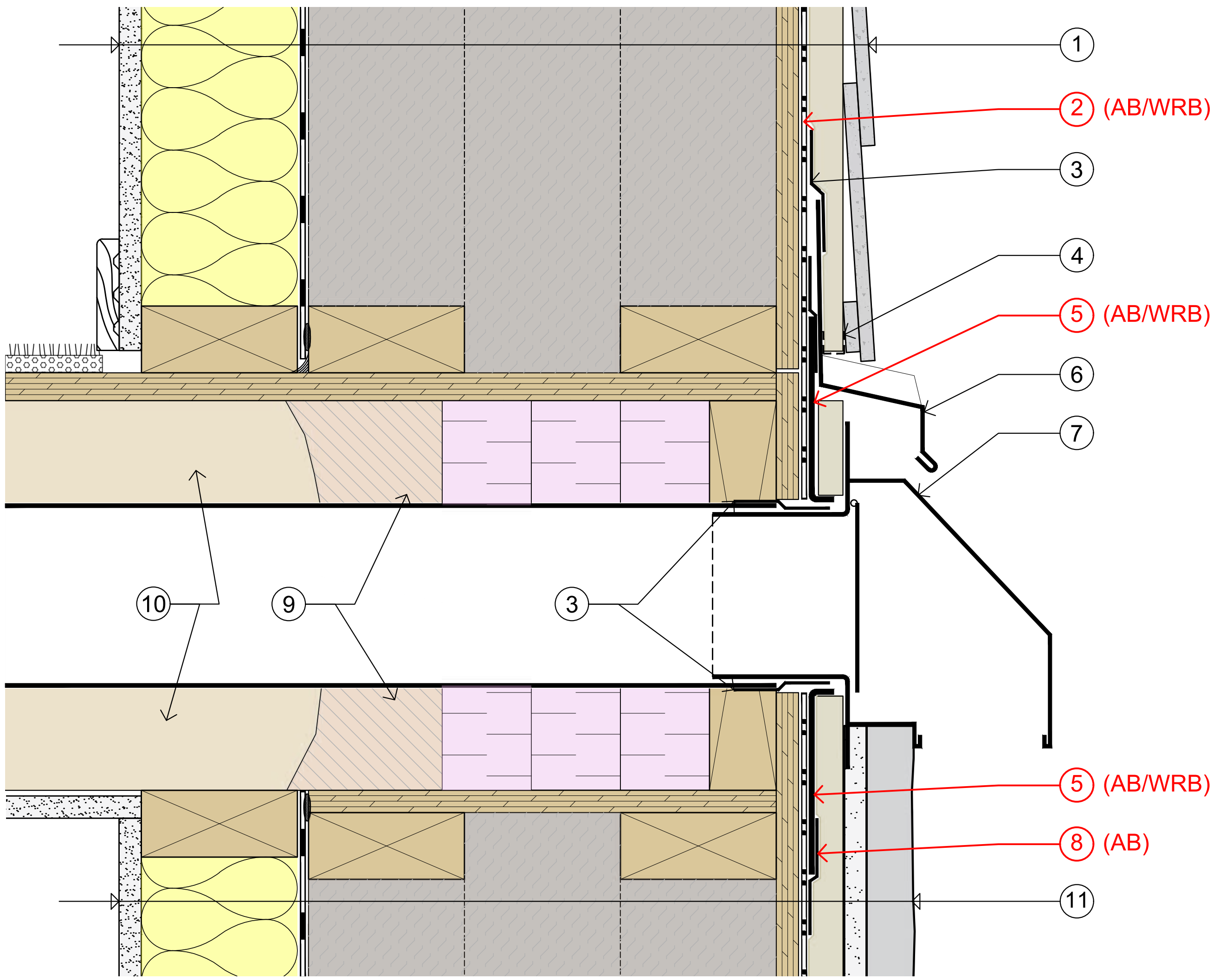


LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. VP sheathing membrane (AB/WRB)
3. Sealant (AB)
4. Tape seal (AB/WRB)
5. Insect screen
6. Pre-finished metal flashing
7. Intermittent pressure treated strapping
8. Exterior trim
9. Intermittent pressure shims to suit
10. Backer rod & sealant
11. Intermittent fastening clip & fastener
12. Backer rod & sealant (AB)
13. Insulation

WINDOW HEAD | D4.08

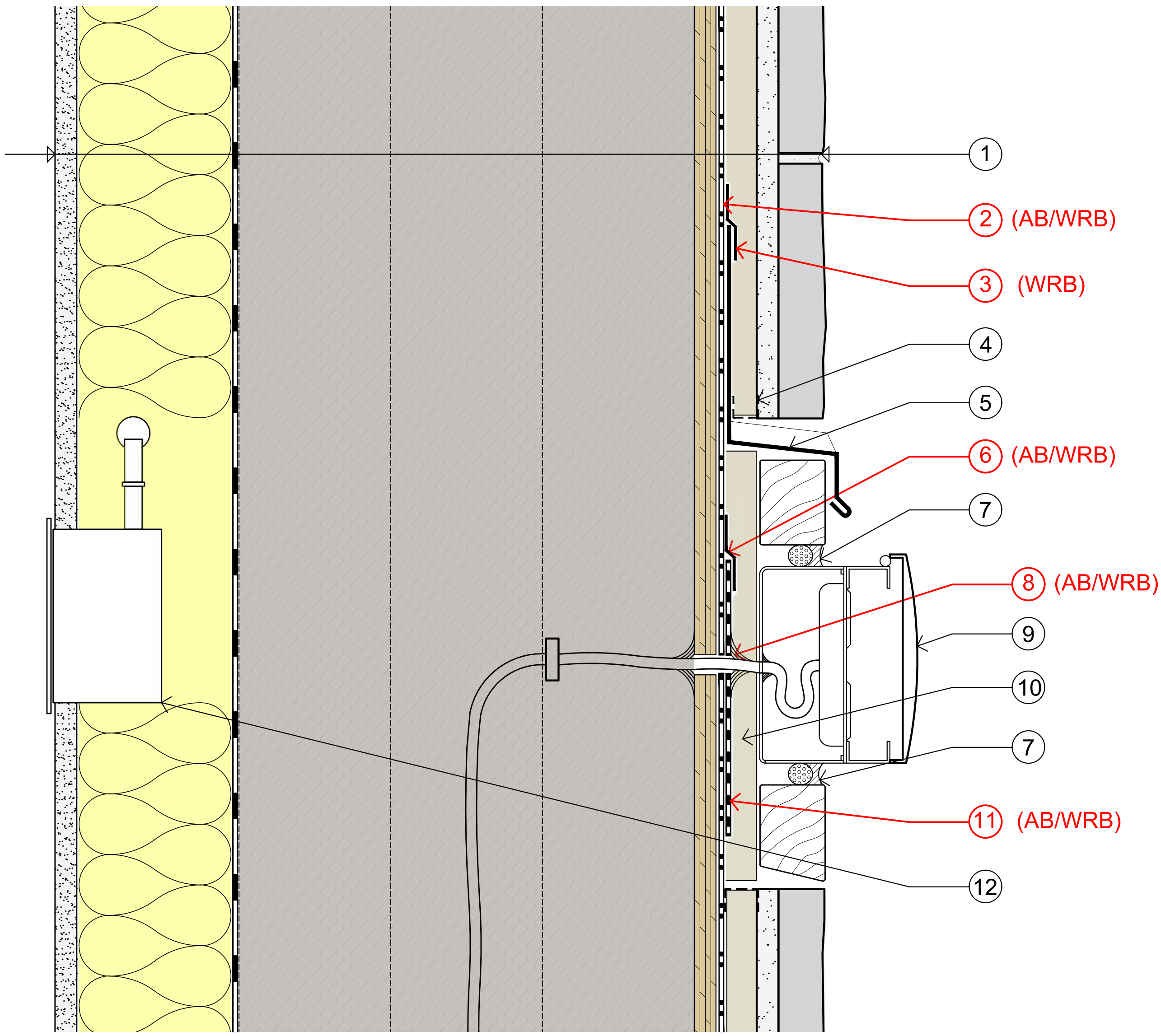
Assembly #4 | Double Stud Wall with Interior Service Wall



LEGEND

1. Wall assembly
   - Fibre cement lap siding
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. VP sheathing membrane (AB/WRB)
3. Tape seal
4. Insect screen
5. EPDM patch with under-sized hole for gripping to duct perimeter (AB/WRB)
6. Pre-finished metal flashing
7. Pre-finished metal vent hood with flange
8. Tape seal (AB)
9. Continuous polyurethane spray foam insulation to at framing interfaces (AB)
10. Duct insulation
11. Wall assembly
    - Thin stone veneer assembly c/w stucco base coat, wire lath and backer board
    - Pressure treated wood strapping/air cavity
    - VP sheathing membrane (AB/WRB)
    - Sheathing
    - 2x4 wood framing filled with blown-in insulation
    - 3 1/2" gap filled with blown-in insulation
    - 2x4 wood framing filled with blown-in insulation
    - Polyethylene sheet membrane (AB)
    - 2x4 wood framing service cavity with batt insulation
    - Interior gypsum wall board

WALL PENETRATION AT DUCT - SECTION | D4.09



LEGEND

1. Wall assembly
   - Thin stone veneer assembly c/w stucco base coat, wire lath and backer board
   - Pressure treated wood strapping/air cavity
   - VP sheathing membrane (AB/WRB)
   - Sheathing
   - 2x4 wood framing filled with blown-in insulation
   - 3 1/2" gap filled with blown-in insulation
   - 2x4 wood framing filled with blown-in insulation
   - Polyethylene sheet membrane (AB)
   - 2x4 wood framing service cavity with batt insulation
   - Interior gypsum wall board
2. VP sheathing membrane (AB/WRB)
3. Tape seal (WRB)
4. Insect screen
5. Pre-finished metal flashing c/w jamb closures
6. Tape seal (AB/WRB)
7. Backer rod & sealant at all sides
8. Bare cable sealed all around (AB/WRB)
9. Exterior grade electrical outlet
10. Pressure treated plywood strapping to suit
11. Self adhesive membrane (AB/WRB)
12. Electrical box with wiring contained in service cavity

WALL PENETRATION AT RECEPTACLE - SECTION | D4.10

Builder Checklist for Net Zero Wall Construction

Use the following builder checklist as a reference during the planning and construction phases.

☑	Pre-Design	Summary
☐	An Integrated Design Process (IDP) will benefit a project of any size. **IDP is a collaborative, team approach** to building design and construction. Gather your team and discuss options **before the design is completed**. Identify cross-over efficiencies and optimize for specific project goals. Put more effort up-front, by comparing options and using tools to measure and predict performance. IDP pays-off with better results, less risk, and predictable cost-to-benefit outcomes.	TEAMWORK & TOOLS
☐	**Discovery Meeting:** Invite key stakeholders to **define project goals**. Discuss labeling programs or incentives. Assess existing conditions and identify challenges and limitations. Identify priorities: must-have, wish-list and deal-breakers. Include: Owner, Builder, Designer, Energy Advisor, others as needed.	DEFINE GOALS
☐	**Target Building Performance:** Review code requirements and voluntary labelling programs. Select project goals for overall building performance (min. requirements or % better than code min. reference house) This will identify the **target range for the R-value of wall assemblies**. Record the project goals, refer back to them often and share them with everyone who joins the team.	SET PERFORMANCE TARGETS
☑	**Design Development**	
☐	Work with a **Licensed Designer or Technologist** to coordinate aesthetics, functional requirements and building systems. Prepare a draft design proposal that addresses all project goals.	DRAFT
☐	**Engage an Energy Advisor (EA) during schematic design**. Energy modeling will calculate the overall energy performance of your building compared to a generic 'typical' code minimum reference house. This becomes your 'benchmark' or baseline. Your Energy Advisor will confirm specific requirements or minimum standards for individual assembly or unit types. (Reference house is NBC 9.36 code minimum).	MEASURE
☐	**Select NZE Wall Assembly use criteria** starting with local climate zone and building code requirements. Consider other factors such as trade capacity, skills and experience, material cost and environmental impact. **Calculate effective R-values**: include insulation, cladding and framing variations, fasteners, and all other components. (Ask your EA or Designer about online calculators).	SELECT AND CALCULATE
☐	**Minimize Building Energy Loads**: Less energy required = less cost for Net Zero & more resilience. An 'Enclosure-First' approach uses high-performance walls to minimize the loss of expensive heated or cooled air. Coordinate all assembly types to create a continuous enclosure: foundation, walls, roofs, floors, doors, windows. Use details that show air-tightness strategies at difficult transition points. Use 'Passive Design' to your advantage: Consider the energy implications of building form, size, site orientation, solar heat gain, window to wall ratios, natural convection, exterior shading and cooling from vegetation and trees. These factors play a huge role in heating and cooling loads.	MINIMIZE ENERGY LOADS
☐	**Charrette**: Schedule this meeting well in advance. Ask all participants to prepare ahead. Hold a group, round-table discussion where all team-members, trades and consultants review draft plans, share ideas, compare options and optimize for the best outcome. Record important points and use this working session to make final decisions. Revise all drawing sets and complete the design proposal to clearly communicates these decisions.	OPTIMIZE AND FINALIZE

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✔	Construction Documents - Review	Summary
☐	Wall Assembly Technical Review	REVIEW
	a. Integrate the selected wall assembly (building enclosure) into the structural system (load bearing components) of your building. These are separate systems but may be integrated in some locations. Confirm that each system and all components, framing and connections meet code requirements. Provide details for each critical and atypical condition.	ENCLOSURE & STRUCTURE
	b. WRB: Check that water management system allows water to shed off sloped surfaces and escape all cavities and has overlapped and properly layered 'water-resistive barriers' and/or rainscreen systems.	WATER
	c. AB: Confirm 'continuous air barrier' across all transitions and between assembly and unit types. Check permeability based on wall assembly, particularly if air barrier is separate from the vapour control layer. Note this in your specifications and on your drawings. Confirm the correct and consistent use of flashing and sealants.	AIR
	d. VB: Confirm that there is only one vapour barrier in each assembly. Show this in wall sections. Check permeability based on wall assembly and climate zone. Note this in specifications and on your drawings.	VAPOUR
	e. Check condensation risk based on wall assembly materials, permeability, inboard to outboard insulation ratios and wall thickness. Confirm based on local climate and building code requirements. (See wall guides.)	CONDENSATION
	f. Reduce embodied carbon when selecting materials and look for 'low carbon' options. (Try online calculators like LEEP's MCE2). Consider life cycle and end-of-life cost. Ask questions about material source, manufacturing and transportation. Download and read EPDs (Environmental Product Declarations).	CARBON
☐	**Compliance and Verification**: Confirm compliance with local by-laws and construction regulations. Check for additional requirements beyond provincial code. Obtain required stamps, certification and additional documents required by voluntary labeling or incentive programs.	CHECK COMPLIANCE
☐	**Coordinate Building Systems**: Mechanical, electrical, and plumbing systems must be designed and sized correctly. Beware of rule-of-thumb solutions in high-performance, air-tight buildings. Consider both up-front cost and life-cycle costs. Peak energy loads determine equipment size and capacity so work to reduce loads first. Energy and heat recovery systems can also pay back by reducing waste and long-term cost.	COORDINATE MECHANICAL ELECTRICAL & PLUMBING
☐	**Construction Permit Application**: Confirm submission requirements and fees. Speak with the municipal plans examiner, review construction documents, wall assembly details, compliance package and discuss any deficiencies. Provide supporting information as requested.	APPLY

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✓	Skills & Management	Summary
☐	**Pre-construction Team Meeting**: Clarify timeline and milestones. Review wall details and performance goals with the design and construction team (i.e., designer, EA, engineers, site supervisor, foundation co., framers, roofers, mason, all trades). Confirm start dates, sequencing, staging, lead-times. Always include contingency.	PLAN
☐	**Equip your crew for success**: Every crew member and all trades must clearly understand the project goals, the relevant construction documents and what you expect from them. Discuss any changes to typical practices and provide information when needed. Post details on the job site or give out copies to take home. Ask your crew to watch 'LEEP NZE Walls' construction training videos on the NRCan YouTube Channel. Ask questions and discuss.	EQUIP & TEACH
☐	**Build a wall mock-up and test new assemblies and details**: Explain quality control expectations. Trial and discuss transition points, rim joist, wall-to-roof, doors & windows, wall thickness, cladding attachment, outboard insulation, continuous air barrier strategies, vapour barrier, and integration of water management and structural systems. Photograph mock-ups and details showing success and failure for future reference.	TEST & LEARN
☐	**Schedule air-tightness testing** (blower-door test) and designate an on-site 'Air Boss' to inform all trades and catch air-sealing errors. Request pre & post-drywall testing to provide preliminary feedback and allow time to seal leaks and gaps before the final test to verify performance.	ENFORCE & VERIFY

Notes and References:

- The Canadian Association of Consulting Energy Advisors can direct you to a qualified Energy Advisor in your area.
- HVAC Designers of Canada can help you find a qualified HVAC Designer in your area. Email: info@hvacdc.ca
- The Canadian Homebuilders Association (CHBA) and LEEP offer information and training opportunities. Ask your local home builders association to **request training or continuing-ed sessions** on Integrated Design (IDP), Costing, Carbon, wall systems, HVAC, more.
- Watch NRCan LEEP **videos**. Go to the NaturalResourcesCa YouTube Channel. Search YouTube for “LEEP NZE Walls” or “Guides sur les murs nets zero”. NRCan LEEP also offers videos and apps on HVAC design, Heat Pumps, and more.
- LEEP offers online **guides, calculators, tools, and apps**: *LEEP NZE Wall Guide Series*, *Material Carbon Emissions Estimator* (MCE2), *Cost-Benefit Analysis Tool* (CBAT), HVAC guides, PV guides. Other industry tools calculate effective R-value or Solar Heat Gain conditions.
- 'Performance Path' energy modeling often reveals cost and time-saving options. In addition, it provides verification of building performance to demonstrate **code compliance**. 'Prescriptive Path' compliance remains an option in most areas. Minimum performance requirements are determined by current Provincial building codes, energy codes, plus city or local regulations. Regional codes may reference the NBC but include variations. *EnerGuide* compares to 'typical' NBC 9.36 code minimum.
- **Labeling programs** like *CHBA Net Zero Homes Program*, *LEED for Homes*, and *Passive House* share many objectives but vary in scope. Each program uses different metrics. Consult their websites for details or ask an EA, Architect, or Licensed Technologist to help.

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Developed by Natural Resources Canada's Local Energy Efficiency Partnerships (LEEP) team

LEEP Technology Guides and Tools available online. Search "NRCan LEEP".

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