

Illustrated Guide

R22+ Effective Walls

in Residential Construction in British Columbia



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Preface

This guide was funded by BC Housing, the City of Vancouver, and the City of New Westminster, and was prepared by RDH Building Science. Acknowledgment is extended to all those who participated in this project as part of the project team or as external reviewers.



This guide was developed to assist builders and designers to construct walls that achieve R22 or higher thermal performance. The information included in this guide is relevant for low- and mid-rise residential buildings across British Columbia.

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About this Guide

The Illustrated Guide to R22+ Effective Walls in Residential Construction in British Columbia is published by BC Housing. This guide consolidates information on above- and below-grade wall assemblies that are capable of achieving an effective R-value of R-22 or greater. The guide is intended to be an industry, utility, and government resource with respect to meeting this thermal performance level without compromising other aspects of building enclosure performance. These include moisture control, airflow control, and overall durability.

This guide includes information that applies to low-rise detached and semi-detached homes, row-houses/townhomes, and multi-unit residential buildings up to six storeys within British Columbia. It provides general guidance on assembly selection and key considerations but it does not provide extensive information on detailing of the assemblies. The [Additional Resources](#) on page 62 contains a list of other guides with extensive information on the design and construction of high-performance building enclosure assemblies. The guide generally focuses on wood-frame, concrete, and steel-frame walls that use traditional construction methods. Some guidance on other less common wall types is also included.

The 2025 edition includes guidance on the acoustical performance of rainscreen wall assemblies. The guidance is based on findings from a study completed by the BCIT Centre for Architectural Ecology and the National Research Council (NRC) Construction Research Center. Further information as well as measured data of sound transmission loss for selected wall assemblies can be found within the following reports, available from BC Housing and the NRC upon request.

- *Study of Sound Transmission of Wood-frame Split Insulation Wall Assemblies used in BC* (BCIT, 2021)
- *Sound Insulation of Sustainable Building Facades Report No. A1-014306.1* (NRC, 2019)

These reports are referred to in this guide as the BCIT sound isolation study or simply the BCIT study. The acoustic guidance is for information only; consult with a qualified acoustics and noise design specialist for detailed guidance.

This 2025 edition also includes guidance on accounting for and reducing embodied carbon associated with insulated wall assemblies.

Each building project is different, and each presents unique challenges. This guide provides an overview of assemblies that can meet higher thermal performance targets, but the various methods shown will likely need to be modified to accommodate variations. Additionally, alternative wall assemblies exist that are beyond the scope of this guide.

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1 | Wall Assembly Design and Construction

Building Enclosures Overview

The building enclosure is a system of materials, components, and assemblies that physically separate the exterior and interior environments. It comprises various elements which in combination must control water, air, heat, water vapour, fire, smoke, and sound. The enclosure includes roofs, above-grade walls, windows, doors, skylights, below-grade walls, and floors. The enclosure is also an aesthetic element of the building.

Building enclosure assemblies use a series of **control layers**, each intended to serve one or multiple functions within the building enclosure.

For example, an above-grade wood-frame wall has the following elements and controls:

- Exterior cladding that provides both the aesthetic exterior finish as well as the primary water shedding surface.
- A water resistive barrier (WRB) is installed inboard of the cladding as a secondary barrier to moisture to prevent water ingress.
- A drainage gap is installed between the cladding and WRB to allow drainage of water which penetrates past the cladding. This is known as the rainscreen approach.
- Insulation controls the flow of heat through the enclosure which reduces the heating and cooling loads and in turn the energy use of the building.
- The air barrier is installed to control unintended airflow.
- A vapour barrier controls diffusion of water vapour.

Controls can be provided in combination by a single layer within the assembly. For example, the WRB and air barrier may both be provided by the sheathing membrane. The position of these different elements is also fundamental to the performance of the assembly, and appropriate detailing at transitions and penetrations is also important.

This guide focuses on wall assemblies that can achieve an effective R-value of approximately R-22 (RSI-3.85) or more while still meeting the other performance requirements.

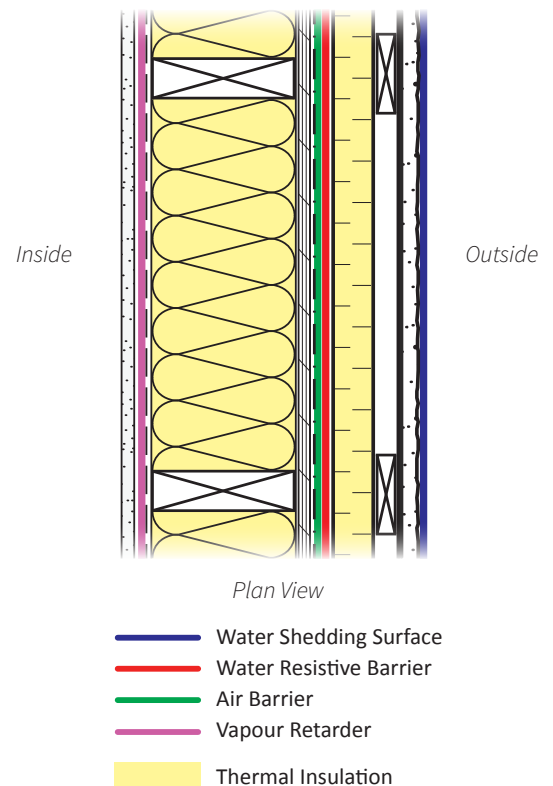


Figure 1-1 Wall assembly control layers

BC Building Code (BCBC) and Vancouver Building By-law (VBBL) Compliance | This guide indicates best practices with respect to air, vapour, and moisture management, rather than strictly minimum requirements of relevant building regulations. This approach is intended to promote the construction of effective and durable assemblies. In some cases the guide identifies materials, assemblies, or practices for which a Registered Professional (B.C. architect or engineer) may be required. Reviewing and complying with relevant building regulations is important for every project.

R-value Calculations

The thermal resistance of building assemblies is commonly indicated using R-value, provided in imperial units of [ft²·°F·hr/Btu], and can also be provided as RSI-value, in metric units of [m²·K/W]. All R-values in this guide are provided in imperial units. The higher the R-value, the better the thermal performance. U-values are another way of describing heat flow through a wall, and are the inverse of R-values. The lower the U-value, the better the thermal performance.

$$\text{RSI } 1.0 \text{ [m}^2\cdot\text{K/W]} = \text{R-5.678 [ft}^2\cdot\text{°F}\cdot\text{hr/Btu]} \quad \text{R} = 1/\text{U}$$

For low-rise residential construction, R-values can be calculated according to Section 9.36. of the British Columbia Building Code (BCBC). This section specifies that R-values are to be calculated using the Isothermal Planes method. The R-value of layers which include multiple components, such as insulated stud walls, are calculated using the Parallel Paths method (i.e., area weighted U-value calculation). An example R-value calculation for a split insulation wood-frame wall assembly is shown below.

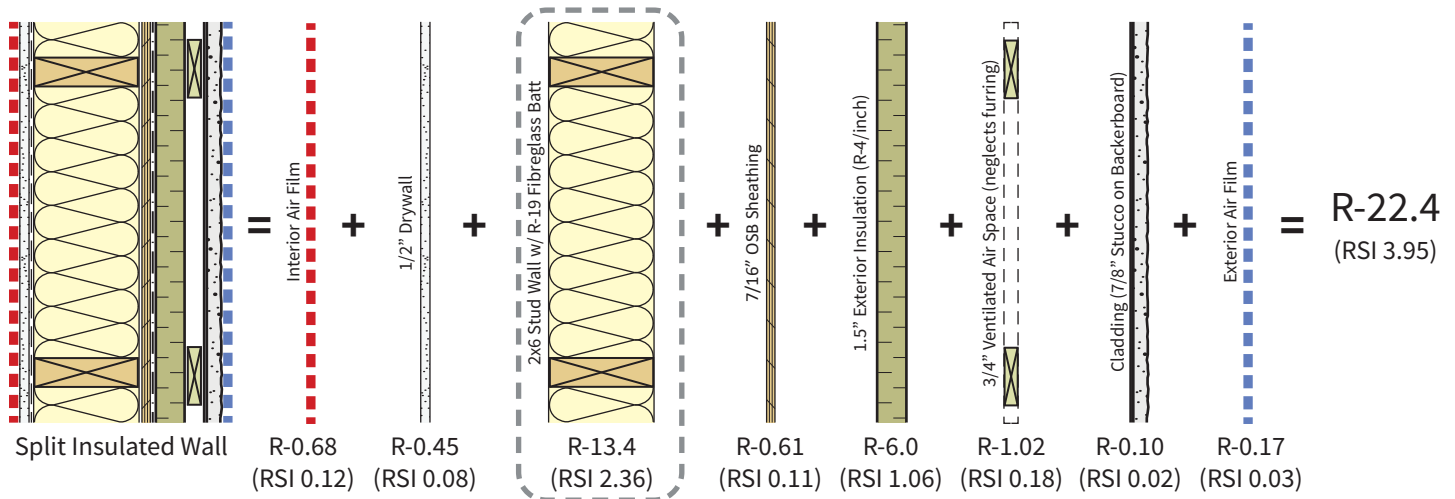


Figure 1-2 Example Isothermal Planes effective R-value calculation based on R-values of each layer

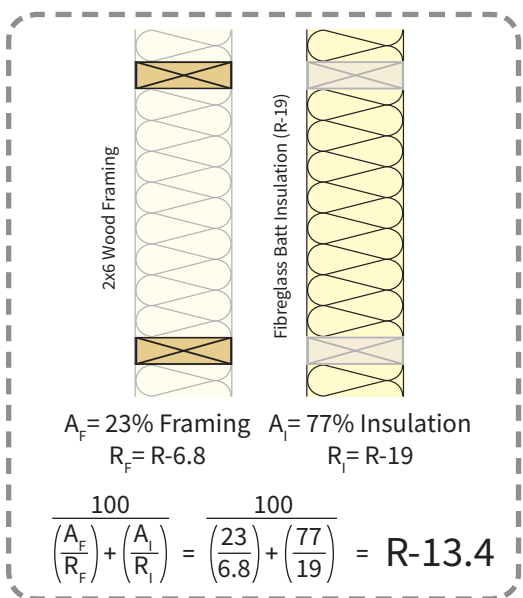


Figure 1-3 Example Parallel Paths effective R-value calculation based on framing factor

Thermal properties of air films and materials are provided in the appendix Section A9.36.2.4. of the BCBC. Framing factors and instructions for how thermal bridges are treated is also included there. A 23% framing factor is used for all calculations in this guide. This matches standard framing practices for 16" wood stud spacing. Part 9 of the BCBC does not require accounting of thermal bridging through the following components:

- Fasteners, brick ties and anchors.
- Pipes, ducts, shelf angles.
- Minor structural members.
- Major penetrations such as balconies, beams, and columns as long as they form less than 2% of the gross wall area.

Accounting for continuous repeating elements which penetrate the insulation is key to accurately calculating the effective R-value.

Wall Assemblies in Non-Part 9 Residential Buildings

Requirements for Calculations

Calculating the thermal performance of wall assemblies in non-Part 9 buildings typically requires more effort compared to Section 9.36. of the BCBC. The heat loss of significant thermal bridges is accounted for by quantifying regular penetrations and transitions with reduced insulation. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 90.1 and the National Energy Code of Canada for Buildings (NECB) provide guidance on accounting for thermal bridging. Appropriate methods include hand calculations, thermal modelling, and even laboratory testing. See also the Standard CSA Z5010 for Thermal Bridging Calculation Methodology and the *Building Envelope Thermal Bridging Guide* (see [Additional Resources](#) on page 62). A registered professional may be required for calculating the effective R-value of wall assemblies in non-Part 9 buildings.

Wood Multi-Unit Residential Buildings up to Six Storeys

The increased height of these buildings requires more structural framing, particularly at the lower floor levels. Stud packs or columns may be utilized to meet seismic and load-bearing requirements. Framing factors can be 30% or higher in some areas. The BCBC and VBBL do not give specific guidance on appropriate framing factors to use for wood-frame wall assemblies in taller multi-unit residential buildings. Accurate framing factors can be determined for each specific building based on the structural drawings.

Thermal Modelling

While hand calculations are appropriate for simple wood-frame and concrete assemblies, computer thermal modelling software such as THERM can be used where two-dimensional heat flow is more complex. Discrete clip systems or complex three-dimensional configurations may require three-dimensional computer thermal modelling software.

Further guidance on effective R-value calculations for wall assemblies and thermal bridges can be found in the *Building Envelope Thermal Bridging Guide* (see [Additional Resources](#) on page 62).

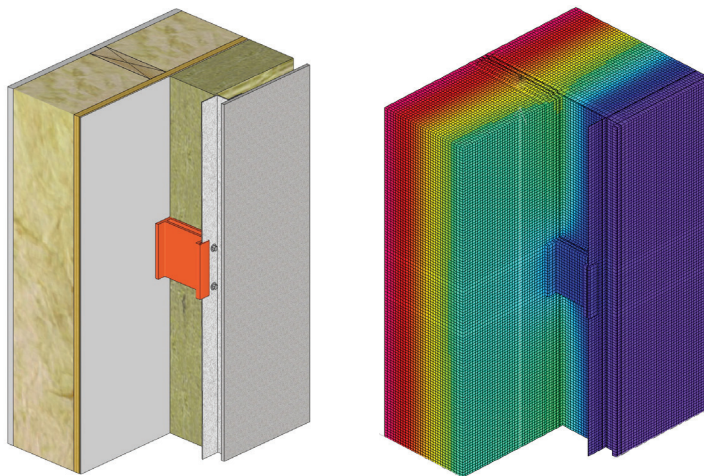


Figure 1-4 Example visual representations of a three-dimensional thermal model showing materials (left) and isothermal characteristics (right).

Material Thermal Properties

Material thermal performance properties are commonly denoted as R-value per inch or RSI per mm thickness. They are also provided as material conductivity units (Btu·in/hr·ft²·°F or W/m·K). Common material thermal properties can be found for various common building and insulation materials in the appendix Section A9.36.2.4 of the BCBC and various tables in ASHRAE 90.1, the NECB, and ASHRAE Handbook – Fundamentals. Newer materials or proprietary systems may use other sources. In general, manufacturers provide the specific thermal performance values for their products based on standardized testing. It is best practice to keep track of the original source for material thermal properties used thermal calculations.

Air Barrier Systems

The air barrier system is used to control unintended airflow into and through the building enclosure. Controlling airflow is important to limit energy use, reduce the potential for condensation, maintain occupant comfort, and manage indoor air quality. Refer to the *Illustrated Guide – Achieving Airtight Buildings* (see [Additional Resources](#) on page 62) for more guidance on designing, building, and testing airtight buildings.

The air barrier must have these four basic characteristics to be effective:

1. All the elements of the air barrier system are adequately **air-impermeable**.
2. The air barrier is **continuous** throughout the building enclosure including at transitions and penetrations.
3. The air barrier as a system is **stiff** and be able to resist wind, stack effect, and mechanical equipment air pressure forces.
4. The air barrier materials are **durable** enough to resist impact, abrasion, UV exposure, moisture, and other degrading forces.

More guidance and details on air barrier systems types can be found in the resources listed in [Additional Resources](#) on page 62.

Exterior Air Barrier Systems

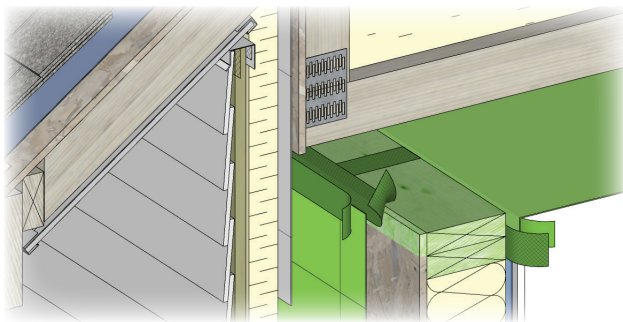
Exterior air barrier approaches in walls use an airtight layer installed over the exterior face of the building structure. The air barrier is made continuous with tapes, membranes, and sealants over joints, transitions and penetrations. A key advantage of exterior approaches is that the continuity of the air barrier is not affected by interior penetrations or disruptions. Exterior air barrier components are often also used as the water resistive barrier. Therefore the effort required to achieve a continuous layer to resist moisture intrusion also contributes to the continuity of the air barrier.

Air Leakage Condensation Risk | An assembly can be at risk of air leakage condensation when the air barrier is located on the exterior (cold) side of the insulation. Therefore, the relative airtightness of the interior (warm) plane of the wall is an important consideration. Interior layers like polyethylene sheet or gypsum wall board can be used to limit the potential for airflow provided they are installed without gaps or voids. This is especially important for deeper wall assemblies with interior insulation.

Some example exterior air barrier systems include:

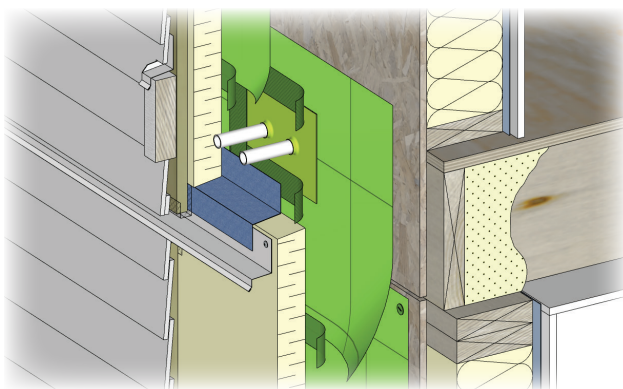
- **Sealed Sheathing:** The joints between sheathing boards are sealed with membrane strips, tape, or sealant so that the sheathing itself provides the air barrier. The sheathing is rigid and fastened to the studs so no additional support is typically required for this system.
- **Sheathing Membrane:** The sheathing membrane, which is usually installed as a water resistive barrier (WRB), can also function as the air barrier. Both mechanically fastened and self-adhered sheet membranes can potentially be used. The laps between sheets, penetrations, and transitions are sealed with adhered laps, tape, and sealant.
- **Liquid-Applied Membrane:** The exterior liquid-applied membrane system relies on the exterior sheathing as the support substrate to achieve a stiff and durable coating.

Placing the air barrier on the exterior typically simplifies and reduces the number of air barrier transitions and penetrations. This results in a more airtight system compared with an interior air barrier approach. However, there are still a variety of key details to carefully consider and design for. Examples of these key details, along with potential methods for maintaining air barrier continuity, are provided in the graphics below. Various other similar important details exist. The details shown use a mechanically-fastened exterior air barrier sheathing membrane, but they can be adapted for other systems.



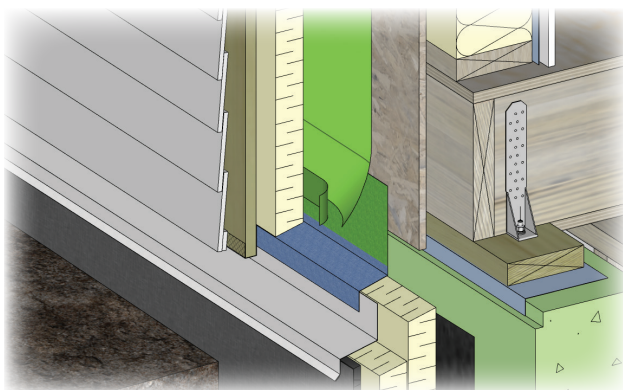
Roof-to-Wall Transitions

This is often one of the most challenging air barrier transition details. The graphic shows a transition from the sheathing membrane over the top plates using specialty tape. The tape must be installed before the roof framing. Tape or sealant is then used to transition from the top plates to the interior ceiling polyethylene sheet.



Circular Penetrations (Conduit, Duct, Wire, etc.)

Circular penetrations are best sealed using an unreinforced EPDM gasket sleeve with an under-sized hole. The EPDM grips and seals around the penetrating element and is sealed to the sheathing membrane with compatible tape or sealant. This approach is typically superior to using strips of tape or direct-applied sealant around the penetration.



Above-Grade to Below-Grade Transitions

The graphic shows a combination of sheathing tape and adhered flashing membrane used to transition from the above-grade sheathing membrane down to the below-grade concrete and waterproofing membrane. It is important to consider the material compatibility of the various components used in multi-step air barrier transitions.

Figure 1-5 Example exterior air barrier transition details

Other Air Barrier Systems

Interior air barrier approaches use an airtight layer applied from the interior. It interfaces with the various interior elements, transitions, and penetrations. Some common interior air barrier systems include:

- **Sealed Polyethylene (or Other Membranes):** The polyethylene sheet installed at the interior of the stud cavity is sealed at all transitions and penetrations with tapes and sealants. The polyethylene sheet is typically clamped between the framing and the interior finish which provides the necessary structural support. A similar approach can also be used with alternative sheet products such as smart vapour retarders or other appropriate airtight membranes.
- **Sealed Sheathing (with Service Cavity):** Sheathing placed at the interior side of the wall can be detailed as airtight by sealing the joints between sheathing boards using membrane, tape, or sealant. As with all interior air barrier approaches, the air barrier transition at the floor line requires careful attention to achieve continuity of the air barrier. The service wall provides a space for electrical and plumbing services without having to penetrate through the interior air barrier.
- **Spray Foam:** Both open cell and closed cell spray polyurethane foams can be used as an air barrier material. They are typically used at penetrations and transitions to accommodate complex geometries. However, these products can also be used within the stud cavities to provide the main component of the air barrier system. Joints, cracks, and gaps that are too small to be effectively sealed with expanding spray foam are sealed with other sealants or adhesives.
- **Airtight Drywall Approach (ADA):** Airtightness of the interior gypsum wall board (i.e., drywall) is provided by sealants and gaskets around the perimeter of each board. Special attention must be paid to ensure continuity at intersections of the exterior walls with partition walls, ceilings, and floors.

Mass Walls

Properly designed and installed concrete or masonry walls may be considered airtight at clear-field wall areas. However, ensuring air barrier continuity at all interfaces with windows and around penetrations requires careful attention. The *Building Envelope Guide for Houses – Part 9 Residential Construction* (see [Additional Resources](#) on page 62) provide information on maintaining the continuity of the air barrier in mass walls.

Mid-Rise Design

The height difference between low-rise and mid-rise buildings introduces the following key design considerations:

- Walls and other above-grade elements are higher and exposed to more wind and rain.
- The enclosure structure often contains more wood to accommodate the structural requirements.
- Wood framing shrinkage will be greater.
- Access for maintenance and renewals will be more difficult.

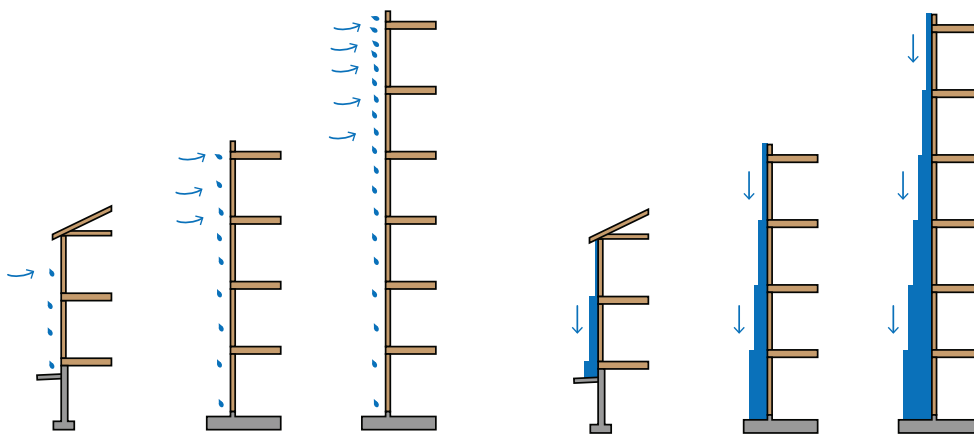


Figure 1-6 Multi-unit residential buildings up to six storeys are exposed to higher wind and rain loads compared to low-rise buildings.

Mid-rise multi-unit residential wood-frame enclosures benefit more from greater durability than those of low-rise buildings due to increased exposure and complexity. The higher wind and rain loads and cumulative rain runoff need to be assessed for the impact on the walls wood structure, cladding attachment, and the water shedding characteristics.

Building Shape and Interfaces

Climate and local topography have a large impact on moisture exposure conditions, but these factors can't easily be changed. Therefore, the most direct way to control exposure to wetting is through building features. Overhang protection with roofs, canopies, and flashing drip edges are effective in limiting runoff on the wall assemblies. In addition, drainage planes behind and around cladding allow water that reaches upper floors to drain out from the wall assembly. Refer to the guides listed in the [Additional Resources](#) on page 62 for further guidance on designing wall assemblies for taller buildings.

Air Barrier Material and Installation

Single-family and smaller Part-9 buildings can typically use residential-grade loose-laid membranes and accessories as the air barrier. However, a more robust range of air barrier products and installation methods are more appropriate for wall assemblies on taller buildings. This is because the higher wind loads and pressures may exert higher forces on the air barrier in these assemblies.

The main concern with installing exterior sheathing membranes on larger buildings is the potential for damage during construction before the cladding is installed. A commercial-grade membrane product, installed in conjunction with strapping or other cladding support system, is an effective way to reduce this risk. Where higher exposure is expected or where strapping will not be in place to secure the membrane, a self-adhered membrane is typically most appropriate.

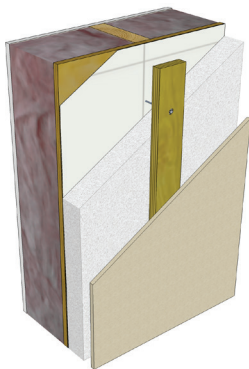
Cladding Attachment Through Exterior Insulation

Chapter 2 outlines typical options for attaching cladding to the wall using long screws through strapping and exterior insulation. The specific guidance provided in the [Reference Fastener Tables](#) on page 33 pertains only to wall assemblies on low-rise buildings less than 3 storeys above-grade. The higher wind loads expected on larger buildings require specific structural analysis for each individual building. See [Additional Resources](#) on page 62 for further guidance on structural calculations for screws through rigid exterior insulation.

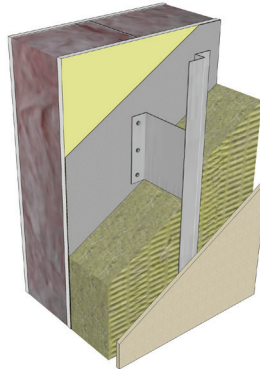
Many proprietary clip and girt systems are available for attaching cladding through exterior insulation. This approach may be more appropriate for mid-rise buildings and where thicker exterior insulation is used. Each manufacturer will have different structural design and attachment guidelines, depending on cladding type, exterior insulation thickness, lateral loads expected, and various other factors. Systems often include a steel, aluminum, or fibreglass clip with an integrated girt or rail system on the exterior face. Brick ties can also be considered a discrete cladding attachment, though these are typical used only to laterally secure the masonry cladding (see [2 | Cladding Support & Fasteners Through Exterior Insulation](#) on page 25).

Each proprietary system will have different thermal performance characteristics and may require thermal modelling to determine the overall thermal performance of the wall assembly. Most clip systems have less than 30% thermal degradation of the exterior insulation. Refer to the manufacturer's literature to find more information about the uses and thermal performance of each clip system.

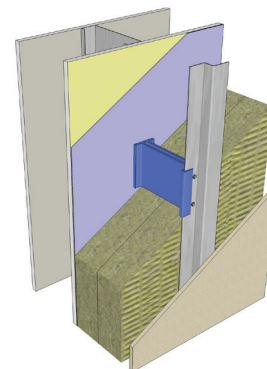
The thermal performance tables in the steel-stud wall assemblies sections ([W-6 | Exterior Insulation](#) on page 45 and [W-7 | Split Insulation](#) on page 47) show R-value ranges for exterior insulation with no thermal degradation down to 30% degradation. This provides data for a range of cladding support systems. This value is then combined with the effective R-value of the overall backup wall assembly including the effect of a concrete floor slab (see [5 | Mid-Rise Concrete Construction](#) on page 49).



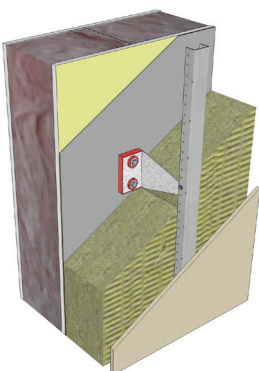
Screws through rigid exterior insulation



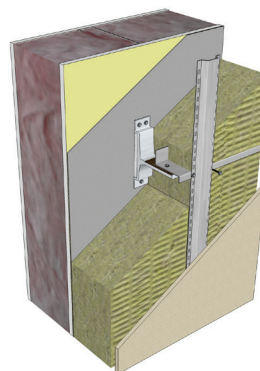
Generic intermittent z-girt clip



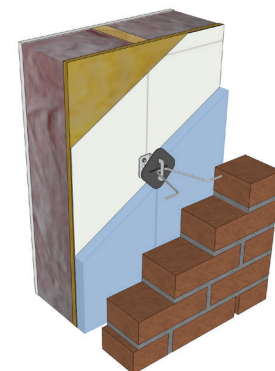
Proprietary fibreglass clip



Proprietary metal clip



Proprietary aluminum clip



Proprietary brick tie

Figure 1-7 Example cladding attachment approaches

Embodied Carbon

Embodied carbon refers to the total greenhouse gases emitted from the extraction, manufacturing, transportation, use, and disposal of building products. Emissions are quantified by their global warming potential (GWP), expressed as carbon dioxide equivalent (kg CO₂e). Emissions are commonly referred to simply as "carbon" or "carbon emissions". Upfront carbon refers to the carbon associated with the early stages of material life cycle including production, transport, and construction emissions.

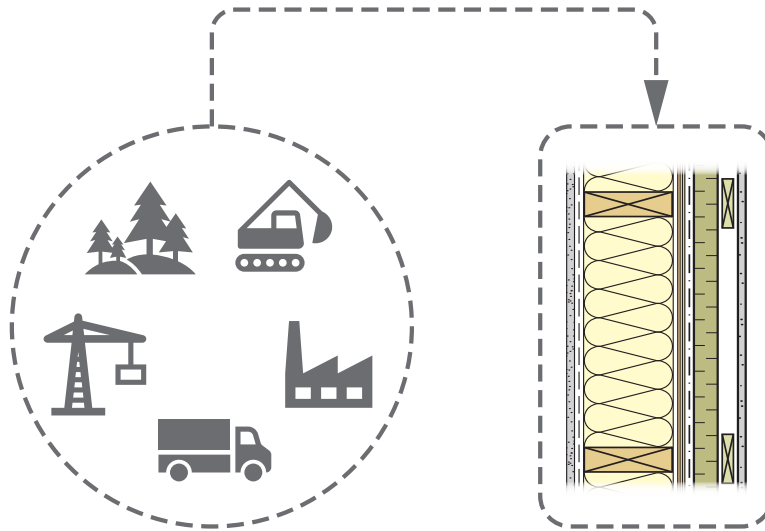


Figure 1-8 Representation of the energy and processes associated with upfront carbon of wall assembly components.

Generally, the less processing involved in manufacturing a material, the lower its embodied carbon. While a product with lower upfront carbon is typically preferred, it is important to manage long-term potential greenhouse gas emissions by using materials that are appropriate for the application. Using an alternative product with lower upfront carbon but shorter lifespan, which requires more frequent replacements, can undermine efforts to reduce embodied carbon overall.

Some materials have very high embodied carbon due to the energy-intensive processes used in their production. Examples include combustion-base operations like cement kilns and blast furnaces. Other materials have a high GWP due to their chemical composition, such as refrigerants used in mechanical systems or as blowing agents in foam insulation. Many of these refrigerants have a GWP thousands of times greater than an equivalent amount of CO₂. However, this is a rapidly evolving landscape with many manufacturers innovating with new, low embodied carbon products including low carbon cements and low GWP refrigerants.

On the other hand, some bio-based building materials are considered a "store" of carbon because they absorb CO₂ from the atmosphere as they grow. Buildings made with carbon-storing materials like wood can keep the CO₂ out of the atmosphere for decades or centuries. Bio-based materials frequently also have lower upfront carbon because they require less processing. In some cases this can mean the materials have very low or even negative embodied carbon.

Embodied carbon has traditionally been a smaller portion of the overall carbon emissions associated with a building's life cycle compared to the operational carbon (i.e., emissions from building energy use throughout its operational life). However, operational carbon of buildings can be significantly reduced through energy efficiency strategies and by using energy sources with lower carbon emissions. In this case, the embodied carbon can become a more significant portion of a building's overall carbon emissions and is therefore worth considering during design work.

Life Cycle Assessment (LCA)

The embodied carbon of building materials can be quantified by conducting a Life Cycle Assessment (LCA). There are several ways LCAs are conducted and some are more useful than others, ranging from “cradle-to-gate” all the way to “cradle-to-cradle” (see right).

Whole-building LCAs use life cycle inventory data to quantify the environmental impact of the building materials. This data is typically obtained through Environmental Product Declarations (EPDs) that are either product-specific from the manufacturer or based on an industry average.

Regulations for Embodied Carbon

Certain jurisdictions may require designers to conduct a building LCA and report embodied carbon for specific building types. Many are moving toward setting limits to reduce embodied carbon. Designers and builders will need to become familiar with the regulations that may impact their process for selecting materials, especially in wall assemblies that constitute a large portion of the building.



Figure 1-9 Building life cycle assessment stages and ranges

How to Reduce Embodied Carbon in Exterior Wall Assemblies

The embodied carbon is an important design category, just like cost and durability. Below are some general considerations for reducing embodied carbon of wall assemblies:

- Limit the use of typically carbon-intensive materials like concrete, aluminum, plastics where possible.
- Use concrete mixes with less Portland cement and that include fly ash and slag.
- Use wood-based carbon-storing materials in the structure and, where feasible, in the insulation and cladding.
- Source local products to reduce carbon emissions associated with transportation of materials.
- Use energy modelling in conjunction with LCA to optimize the amount of insulation being used, carefully balancing the operational and embodied carbon, without over-insulating.

See [Additional Resources](#) on page 62 for further resources on ways to reduce embodied carbon.

The City of Vancouver has updated the Vancouver Building By-law (VBBL) to require embodied carbon calculation, reduction, and reporting for Part 3 buildings. The City of Vancouver has developed Embodied Carbon Guidelines to define the requirements for demonstrating compliance. Refer to vancouver.ca/green-vancouver/zero-emissions-buildings for more information.

Fire Risk

Fire risk is managed by identifying and addressing hazards and implementing controls and mitigating measures through design, construction and operations. The foundation for these is contained within the building and fire codes and local bylaws.

The BC Building Code (BCBC) regulates the design and construction of buildings and BC Fire Code (BCFC) regulates construction fire safety and operation to limit the risk to life and property. The fire-related provisions of these Codes are outlined in this section to identify applicable requirements relating to building fire risks in general and those associated with wall assemblies specifically. It is the responsibility of the building owner to comply with these requirements and the local bylaws. They must also work with registered professionals, designers, and builders to establish compliant design, construction, and operation parameters.

Fire Risk During Construction

Construction of buildings with wall assemblies that achieve R-22+ thermal performance can involve activities and materials that increase the risk of fire. For example, construction activities that involve heat sources or hot work increase the probability of fire occurring, which, combined with increasing quantities of combustible materials like foam insulation on site can lead to severe consequences to life safety and property. These risks are not specific to the design and construction of walls alone, but are addressed through the application of provisions that apply generally to the whole structure, including:

- Control of sources of ignition including smoking, electrical components, heating equipment, engines, hot works, etc.
- Protection of combustible materials from hot work through requirements for separation or noncombustible barriers.
- Active monitoring and follow-up inspections of potential ignition activities.
- Limits on combustible waste and protection of combustible and flammable liquids.

In addition to limiting activities and materials that may increase fire risk, Section 5.6 of the BCFC also requires planning, equipment and facilities to support firefighting and life safety including fire safety planning, firefighting access, fire extinguishers, standpipes, exiting and fire warning systems.

These provisions are intended to provide a minimum level of safety for all construction sites. However, this does not preclude the application of additional safety measures to construction activities. The following additional measures can assist in further limiting the potential for fire initiation, growth and spread.

Preventing Fire Initiation

Enhanced site security measures are used to limit site access to reduce the risk of arson fires. A site-specific enhanced hot work permitting program, implemented by the local authority, facilitates detailed planning to limit the risk of accidental fire initiation from construction hot works like roofing torches. This program may also include monitoring, auditing and specific consequences for non-compliance with the site-specific permit process. Another practical approach to reducing this risk is to use building products that do not require the direct application of heat or flame for installation on site.

Limiting Fire Growth

Limiting the risk of fire growth can include limits on combustible content on site, through either temporary storage strategies that provide adequate spatial separation of combustible materials, or using just-in-time delivery to limit duration of on-site storage. Daily housekeeping to limit the accumulation of combustible waste is also an important aspect of this approach. Furthermore, where the building is intended to have an automatic sprinkler system, it is advisable to stage installation and operation of the system in-step with building construction.

Controlling Fire Spread

Reducing the risk of fire spread to other areas can be accomplished by limiting the exposed combustible construction materials with protective barriers or encapsulation. Barriers required by the BCBC (e.g., exterior cladding and interior finish materials) typically provide this on a storey-by-storey basis. Accelerated completion of fire compartmentalization to limit fire from involving the entire structure is also important. Fire separations including operational fire doors can provide this compartmentalization.

These recommendations are particularly applicable to the construction of walls that may contain combustible insulation or may require weather barriers applied through the application of flame or heat.

Fire Risk of Completed Assemblies

The BCBC limits the type of construction primarily as a function of the building size and the expectation that there is a fire department response to control a fire. The larger and taller the building, the harder it is to control fire spread. The Code addresses this hazard by limiting the use of combustible components. In this respect, there are three types of construction material types: *noncombustible*, *combustible*, and *encapsulated mass timber*. Sprinklers are also an important consideration in limiting the potential growth and spread of fire, and their use can allow some relaxations related to building construction in general.

Encapsulated mass timber construction (EMTC) is a standalone building construction type covered in Subsection 3.1.6. of the BCBC. It has unique design and construction requirements compared to combustible and noncombustible buildings, with some overlap. This section does not include specific reference to fire risk for EMTC. For more information on EMTC buildings refer to the [Additional Resources](#) on page 62.

Combustible Materials in Noncombustible Construction

Buildings that are required to use noncombustible construction are limited in the type, configuration, and quantity of combustible material that can be used. The BCBC provides several exceptions for combustible materials in exterior walls. Two of the most significant exceptions are for cladding (Article 3.1.5.5.) and combustible components (Article 3.1.5.6.).

- Article 3.1.5.5. allows combustible cladding systems on exterior wall assemblies where a building is not more than three storeys in building height or is sprinklered throughout, and the wall assembly satisfies certain performance criteria when subjected to testing in conformance with CAN/ULC-S134, “Fire Test of Exterior Wall Assemblies.”
- Article 3.1.5.6. allows combustible components in exterior wall assemblies based on the same criteria as Article 3.1.5.5., or where the wall assembly is protected by masonry or concrete cladding not less than 25 mm thick. The notes to Article 3.1.5.5. in the BCBC describes a cladding system as “those materials outboard of the sheathing membrane.”

Another significant exception is the use of combustible construction and foamed plastic insulation in exterior wall assemblies based on flame spread rating of the insulation, certain building characteristics, and provision of protective barriers. These are covered in more detail in Article 3.1.5.14. and 3.1.5.15 of the BCBC.

Limits on Combustible Materials in Combustible Construction

On the other hand, buildings that can be constructed of combustible construction still have limits on the type and extent of combustible materials that can be used:

- Articles 3.1.4.2. and 9.10.17.10. of the BCBC requires the protection of foamed plastic insulation to delay the burning of the insulation when exposed to interior fire.
- Article 3.1.4.8. requires residential buildings up to six storeys in building height to use noncombustible or tested fire-retardant-treated wood cladding, with some exceptions, or use exterior wall assemblies that meet certain performance conditions when tested in conformance with CAN/ULC-S134.

Spatial Separation

Spatial separation requirements (Subsection 3.2.3., 9.10.14. and 9.10.15. of the BCBC) are intended to limit the probability that fire will spread from a building to spatially separated neighbouring buildings. Requirements are based on occupancy, sprinklering, the area and configuration (ratio) of exposing building face of fire compartments, and distance to boundaries between buildings. These factors are used to establish the allowable limit for the “percentage of unprotected openings” (e.g., windows and doors), which in turn impacts the construction of the exterior wall. The spatial separation requirements apply to all buildings regardless of the type of construction of the building.

Tables 3.2.3.7. and 9.10.14.5.-A “Minimum Construction Requirements for Exposing Building Faces” address the type of construction of exterior walls and cladding based on proximity of the building to lot boundaries. If a building is required by Subsection 3.2.2. (i.e., based on occupancy) to be of noncombustible construction, the exterior walls and cladding are required to be noncombustible and are not exempted by Table 3.2.3.7. If a building is permitted to be of combustible construction, then the construction of the exterior wall and cladding is permitted to be of combustible material unless the exterior wall (exposed building face) is within proximity to the lot boundaries where Tables 3.2.3.7. and 9.10.14.5.-A require noncombustible construction and cladding. However, an exterior wall required to be of noncombustible construction may still contain combustible components in accordance with the exemptions outlined in Subsection 3.1.5., except for the use of foamed plastic insulation where the permitted percentage of unprotected openings is 10% or less. Note that foamed plastic insulation may also require additional exterior protection for both combustible and non-combustible buildings in accordance with Article 3.2.3.8. Exterior protection of foamed plastic insulation requires concrete, masonry, or noncombustible cladding that passes fire testing (CAN/ULS-S101) as an assembly.

Combustible cladding may be permitted where there are requirements for noncombustible cladding in the following scenarios:

- The exposing building face has a maximum permitted area of unprotected openings of over 25% but not more than 50%.
- The limiting distance is greater than 5 metres.
- The building is sprinklered throughout (including attic and roof spaces).
- Certain cladding specifications are met.
- The entire wall assembly meets certain performance criteria when tested in conformance with CAN/ULC-S134.

Continuity of Fire Separations

Continuity of fire separations is important to limiting fire spread, especially where they abut other fire separations, floors, ceilings or exterior walls. Subsections 3.1.9., 3.1.11., 9.10.9., and 9.10.16 of the BCBC require the provision of fire stopping and blocking to maintain the continuity of fire separations and limit the spread of smoke and fire.

Fire Stopping and Fire Blocking

Fire stopping limits the spread of fire or smoke through service penetrations in fire separations. This is usually achieved with listed fire stopping assemblies or with assemblies that are cast in place and tightly fitted. Fire Blocking is intended to limit the potential for growth and spread of fire in concealed spaces. This is achieved with barriers or limitations on the size of concealed spaces. Fire blocks are required at every floor level, the ceiling level where the ceiling forms part of an assembly required to have a fire-resistance rating, and locations necessary to limit the maximum dimension of a concealed wall space to 20 m horizontally and 3 m vertically. Fire blocks are not required where any of the following conditions can be achieved:

- The wall space is filled with insulation.
- The wall uses noncombustible construction materials and insulation within the wall space.
- The exposed materials within the space including insulation have a flame-spread rating of not more than 25.
- For Part 3 buildings, fire blocks are installed so that the vertical distance between them is not more than 10 m.
- The horizontal dimension of any insulated and concealed air space within the wall is not more than 25 mm.

Acoustical Performance

It is important to understand the characteristics of noise and sound transmission when designing exterior wall assemblies for acoustical performance. An exterior wall assembly design that accounts for sound transmission can provide good sound isolation from the exterior environment. The noise level in a home due to exterior sources depends on:

- The characteristics of the source
- Building enclosure components (including window and wall sections)
- Architectural form
- Room size and layout
- Finishes in which the sound is received

Building Code Sound Transmission Requirements | There are sound transmission requirements for sound isolation between dwelling units and around common spaces in the building, as outlined in BCBC Section 9.11. and Section 5.8. However, there are no sound transmission requirements for exterior walls in current applicable building codes. The information and guidance in this section is intended to help improve the acoustical performance of exterior walls, which improves occupant comfort. See [Additional Resources](#) on page 62 for further information.

This section summarizes sound characteristics, the transmission loss associated with exterior wall assemblies, and specific recommendations for the design and construction of R22+ walls. Refer to [Sound Isolation Performance Considerations for Assemblies in This Guide](#) on page 22 for a summary of how this section relates to the wall assemblies in this guide.

Sound Characteristics and Community Noise

Sound and noise (unwanted sound) are typically measured on a pressure level scale presented as decibels (dB) and/or A-weighted decibels (dBA) using a corrected scale to align with how humans perceive sound. Decibels are presented along a logarithmic scale, meaning that every 10 dB increase is perceived as twice as loud. For reference, a whisper is typically about 20 dBA while traffic noise can be 45 to 85 dBA.

Community noise is considered as all the noise sources in an area. The most significant source is usually traffic noise, though all noise sources contribute to the sound level. How much noise reaches the building is dependent on the distance to the source, nearby surface characteristics, and shielding by barriers or other buildings. Effective noise control is site-specific by considering all local noise sources and site features. Barriers, surface characteristics, site configuration, and building layout can all reduce exposure to noise sources, but the building enclosure is still the last line of defense against outdoor noise transmission.

The indoor noise level, typically taken as a time-averaged noise level, is impacted by the building enclosure's "sound isolation" performance. See [Sound Isolation From Wall Assemblies](#) on page 20 for more information on "sound isolation".

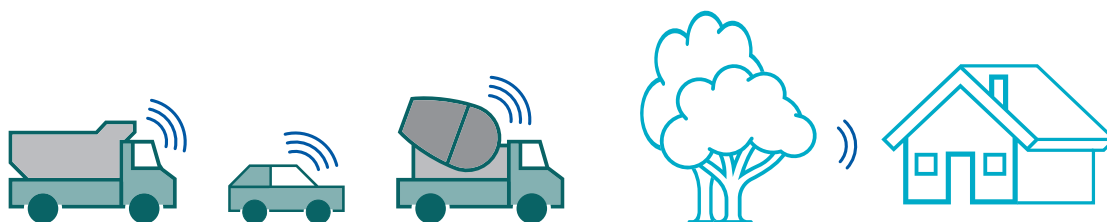
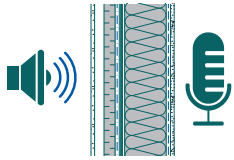


Figure 1-10 Examples of traffic noise, which is usually the most significant source of community noise that transmits into a building.

Sound Isolation From Wall Assemblies

This section provides an introduction to the fundamentals of sound isolation and general guidance on the impact of common material choices and construction techniques for exterior wall assemblies.



Evaluating Sound Isolation

“Sound isolation” is the term used within this guide to indicate sound transmission loss. Sound transmission loss is a measurement of how much the sound/noise level is reduced between the exterior and the interior of a building enclosure. The higher the transmission loss, the better the sound isolation.

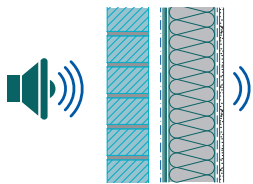
Sound isolation guidance is based on the BCIT sound isolation study (see [About this Guide](#) on page 4) and external reviewer input including acoustic consultants. The BCIT sound isolation study used laboratory testing in accordance with the industry standard ASTM E90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements. The results were used to calculate single number ratings for the Sound Transmission Class (STC), according to ASTM E413 Classification for Rating Sound Insulation, and the Outdoor-Indoor Transmission Class (OITC), according to ASTM E1332 Standard Classification for Rating Outdoor-Indoor Sound Attenuation.

Both STC and OITC provide a standardized measurement of the assembly’s sound isolation performance characteristics taken during testing across a range of frequencies. However, STC quantifies the ability of an assembly to block speech and other similar sounds while OITC provides ratings that align with the ability of an assembly to block lower-frequency outdoor transportation noise. OITC is therefore more appropriate for designing effective sound isolation in exterior building assemblies.

Note that STC and OITC relate to direct transmission loss measurements through an assembly but do not include the flanking paths at adjacent assemblies like floors and roofs. Apparent Sound Transmission Class (ASTC) is the rating system that accounts for the combination of direct and flanking sound transmission. However, ASTC rating measurement approaches set out in the BC Building Code only relate to STC ratings for interior sound isolation between suites and are not appropriate for determining enclosure sound isolation performance for OITC. Consult with a qualified acoustics and noise design specialist for specific guidance on choosing appropriate assemblies based on sound isolation performance.

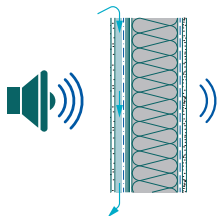
The following headings identify key sound isolation performance factors in exterior wall assemblies.

Cladding

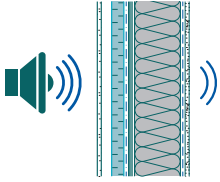


Heavy-weight cladding such as stucco and masonry provide more sound isolation, especially at lower frequencies, when compared to vinyl or fiber cement cladding. The BCIT sound isolation study found the STC/OITC ratings for assemblies with stucco and masonry were 10 to 15 points higher than assemblies with lower mass claddings. Using heavy-weight masonry veneer cladding is typically the most reliable way to increase a wall's OITC rating for lower frequencies.

Rainscreen Cladding Drainage and Ventilation

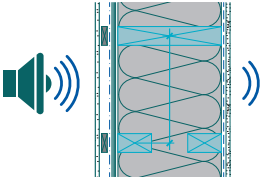


The BCIT study tested wall assemblies with both sealed and fully ventilated rainscreen cavities behind cladding. The BCIT sound isolation study findings are the only published data at the time of this publication that account for wall assemblies with ventilation in rainscreen cavities. The testing indicates that rainscreen ventilation behind the cladding reduces the sound isolation properties of the assembly at higher frequencies, but it does not typically affect the STC/OITC rating.



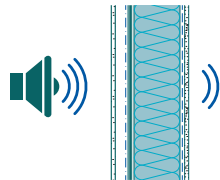
Exterior Insulation

The BCIT study found that 1.5" thick mineral wool board exterior insulation can provide significantly better sound isolation at high frequencies compared to walls with no exterior insulation. However, it provides only moderate overall improvement for lower frequencies associated with STC/OITC ratings.



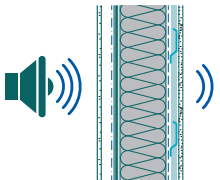
Stud Arrangement and Material

Wall assemblies with single stud wood or heavy gauge (i.e., load bearing) steel stud generally have worse sound isolation characteristics compared to walls with single light gauge steel studs, staggered studs, or double studs. Overall, double stud arrangements, whether wood or steel, provide the best sound isolation.



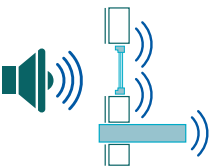
Stud Cavity Insulation

Stud frame cavities are a convenient space for sound absorptive material such as fibrous insulation. Walls with sound absorbing material that fills at least two-thirds of the stud cavity can have an STC/OITC rating increase of 8 to 10 compared to walls without insulation. Batt and blown-in fibrous insulation such as mineral wool, fibreglass, and cellulose are all good sound absorptive materials for interior insulation. Closed-cell spray polyurethane foam and rigid foam board are generally unsuitable as interior insulation intended for sound isolation.



Resilient Channels

The use of resilient channels to attach interior finishes like gypsum board in stud-framed assemblies significantly improves sound isolation performance. Resilient channels act as a sound break by limiting the path for vibration through the stud to the interior finish. Walls with interior resilient channels can have an STC/OITC rating increase of 4 to 9 points, depending on the wall assembly and wall to room area ratio. Exterior resilient channels have not been tested to the same extent. The BCIT study showed that sound isolation at mid and high frequencies is increased when exterior girts are used, but they produce a minimal improvement for lower frequencies associated with STC/OITC ratings.

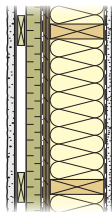


Overall Sound Isolation

The overall sound isolation of the enclosure is dependent on the total composition of the wall assembly, windows, doors, and even service penetrations. A wall assembly with good sound isolation characteristics is only effective if it also uses fenestration products and accessories that also provide good sound isolation. Furthermore, discontinuities in the air barrier can have a significant negative impact on sound isolation performance. Industry testing has shown the component with the weakest sound isolation performance largely limits the overall enclosure sound isolation.

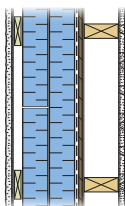
Sound Isolation Performance Considerations for Assemblies in This Guide

This page provides a brief summary of the acoustic considerations for each above-grade wall assembly discussed in this guide, relating to the key differentiators in framing and insulation only. The specific STC/OITC of these assemblies will vary depending on the specific assembly makeup.



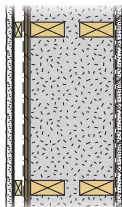
W-1 | Split Insulation (see page 34) and W-3 | Wood Fibre Exterior Insulation (see page 39)

Interior stud cavity fibrous insulation like mineral wool or fibreglass will have the biggest impact on sound isolation performance. The exterior insulation will provide a moderate performance improvement compared to a wall with no exterior insulation. Wider stud spacing will also improve sound isolation performance.



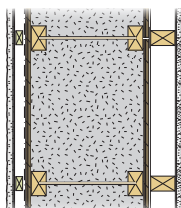
W-2 | Exterior Insulation (see page 37)

The lack of interior stud cavity insulation will significantly reduce the sound isolation performance of this assembly compared to a wall with some interior insulation. Thicker fibrous exterior insulation like semi-rigid mineral wool can provide improvements, while rigid foam board (as shown) will not likely provide sound isolation improvements.



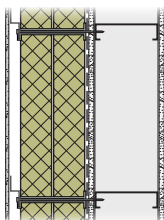
W-4 | Double Stud (see page 41)

Fibrous batt or blown-in insulation in the deep double stud wall cavity will provide a significant sound isolation performance improvement compared to shallower walls with single studs. Staggered studs and increased stud spacing to reduce the framing factor would also increase performance.



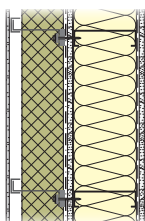
W-5 | Deep Stud with Service Wall (see page 43)

Like W-4, the fibrous batt or blown-in insulation in the deep wall cavity will provide a significant sound isolation performance improvement but to a lesser extent than W-4 due to the deep continuous framing. Insulating the interior service cavity would also increase the performance.



W-6 | Steel Stud Exterior Insulation (see page 45)

Steel stud wall assemblies with lighter gauge steel are better at decoupling materials and isolating vibration, but heavier-gauge load-bearing studs have similar sound isolation performance characteristics as wood studs. Like W-2, the lack of interior stud cavity insulation will significantly reduce the sound isolation performance.



W-7 | Steel Stud Split Insulation (see page 47)

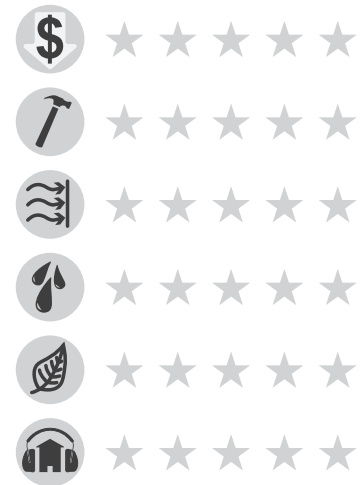
Like W-1 and W-3, interior stud cavity fibrous insulation like mineral wool or fibreglass will have the biggest impact on sound isolation performance. Thicker fibrous exterior insulation like semi-rigid mineral wool can provide moderate performance improvement compared to a wall with no exterior insulation.

Assembly Performance Attributes

Performance Rating

Each assembly type presented in this guide includes an indicator of the relative performance for six different categories. The rating out of five stars can be used to compare assemblies based on cost efficiency, constructability, airtightness, moisture durability, embodied carbon, and acoustics implications. This allows for comparison beyond just thermal performance.

A lower star rating indicates lower performance and a higher star rating indicates higher performance. For example, a wall assembly that is highly airtight and moisture durable would be rated at five stars for these categories. However, if it has a relatively higher cost, is more challenging to construct, and has a high environmental impact, it would be marked at one or two stars in these categories. Note that the wood-frame, concrete, and steel stud wall assemblies are each rated on individual scales.



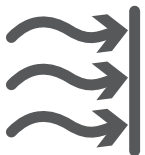
Cost Efficiency

The rating for this category indicates the relative cost efficiency of the assembly in achieving R-22 thermal performance, compared with other assemblies. This rating accounts for the cost of construction materials, labour to install them, and potential maintenance costs associated with the assembly type. In general, assemblies with simpler framing and insulation methods tend to be less expensive than those with complex framing or proprietary insulation methods.



Constructability

Constructability accounts for the relative ease of installation of the various components, potential sequencing challenges, and whether the base construction uses standard materials. Wall assemblies that require specialized framing or insulation are considered less constructible than those with standard framing and insulation. Walls that allow for insulation to be installed without posing potential sequencing issues are also considered more constructible.



Airtightness

This category rates the relative airtightness that can be provided by the assembly when using an exterior air barrier approach (via sheathing membrane) or interior sealed sheathing (when a service wall is provided). It accounts for the potential benefit of exterior insulation in supporting the air barrier, and how easily continuity can be maintained across various interfaces and details.

Traditional interior air barrier approaches are considered the least airtight, and are not included as a standard approach in each of the assemblies presented.



Moisture Durability

This category measures relative moisture durability from exterior sources like rain, and from interior condensation sources such as interior vapour drive or air leakage. The rating accounts for both the moisture exposure the assembly might be subject to due to these sources, and its susceptibility to damage if wetting from these sources does occur. In general, wall assemblies with exterior insulation provide more moisture durability than walls with interior insulation, especially for walls with deep stud cavities.



Embodied Carbon

This indicates the relative complete life cycle environmental impact of each of the wall assemblies. The rating accounts for different parts of the life cycle of the wall assemblies: materials and construction, ease of modification, and end of service life. In general, wall assemblies are considered to be more sustainable if they use more bio-based and low embodied carbon materials, require less material overall, can potentially provide a longer service life, and use materials and components that can be more easily recycled at the end of the service life. The Athena Impact Estimator for Buildings (Athena IE4B v.5.0.0105) life cycle assessment software was used to determine ratings.



Acoustics

This category rates the relative sound isolation performance of the wall assembly based on the insulation and framing arrangement only and all other things equal. Sound isolation rating is affected by the mass of cladding, type of insulation used, and mass of interior finish layers. Doors, windows, penetrations, leaks/holes, use of resilient channels and other factors will also influence performance. Refer to [Acoustical Performance](#) on page 19 for further information on the acoustic considerations for each wall.

The evaluation provided by these metrics is for general guidance purposes based on broad assumptions. Design changes may improve or worsen the performance of any particular assembly in any of the categories identified. The rating for each category is highly dependent on the specific components and materials used. They are not intended as an absolute rating for all assemblies for each wall type.

Assembly Suitability Icons

Each assembly type includes icons indicating the most appropriate uses with respect to building type. The walls are categorized based on durability and constructability of each assembly. The categories are as follows:

- Single-family and duplex homes
- Townhomes and small buildings three storeys or less
- Multi-unit residential buildings up to six storeys

Various walls will be suited to all building types due to their durability and ease of construction. Certain wall types are better suited to single-family and duplex homes which are considered lower risk and are generally simpler to construct.



Single-family/duplex



Three storeys or less



Multi-unit up to six storeys

2 | Cladding Support & Fasteners Through Exterior Insulation

This section provides an overview of the various cladding support systems commonly used with exterior insulation on walls. It includes specific guidance for the design and construction of cladding attachment systems that incorporate screws through strapping and rigid exterior insulation.

Cladding Support Options

Exterior insulation is often needed to achieve R-22 thermal performance. The associated cladding attachment and detailing may be new for some builders. In a conventional wood-frame wall assembly, cladding is attached either directly to the sheathing or over vertical strapping¹ fastened directly to the wall. The addition of exterior insulation increases the distance between the sheathing and the cladding, thus changing the load that must be supported. Selecting a method to support the cladding often depends on the structural loads which must be accommodated. The amount of thermal bridging associated with each method is also an important consideration.

Fasteners Through Insulation: Cladding can be attached and supported by vertical strapping that is fastened with long screws through the exterior insulation and into the framed wall. This is typically the most thermally efficient fastened cladding support option because thermal bridging of the exterior insulation is limited to the fasteners through the insulation. The strapping creates a drainage space, capillary break, and ventilation cavity which is consistent with effective moisture-management techniques. In this arrangement, the rigid exterior insulation and fasteners act in tandem to carry the cladding load. Extruded polystyrene (XPS), expanded polystyrene (EPS), polyisocyanurate (polyiso), and rigid mineral fibre insulations are suitable for this attachment method. Further guidance on structural cladding support using screws through insulation is provided in the following pages.

Proprietary Thermally Efficient Spacers and Clips: Proprietary systems can be used to facilitate easier installation, support heavier claddings, and resist larger wind loads compared to fasteners through insulation. Many systems are available and their performance can vary widely based on thermal efficiency, support of structural loads, and the thickness of exterior insulation that can be accommodated. Clips made from low conductivity materials such as fiberglass and stainless steel can provide excellent thermal efficiency. Carbon steel and aluminum clips typically require specialty thermal breaks and isolation pads to achieve adequate thermal performance.

¹The term “strapping” is used to describe vertical wood furring used to create a capillary break and ventilation space.

Disclaimer & Note on BC Building Code (BCBC) and Vancouver Building By-law (VBBL) Compliance | The structural design guidance is for wood-frame wall assembly types and cladding weights as described in this section. Structural design was completed using standard engineering analysis and testing information from literature available during the development of the original version of this publication. The fastener and strapping requirements tables can be referenced for the design and construction of wood-frame wall assemblies where the cladding is supported on strapping fastened through exterior insulation. For wall assemblies that do not match the types and configurations described in this section, additional resources and references are required. The most up-to-date manufacturer's technical literature for the cladding, insulation, and fastener products used on each specific project determines the suitability of the design. Seek input from the Authority Having Jurisdiction to confirm what information is needed to show compliance with applicable building codes and if a registered professional must be involved. See [Additional Resources](#) on page 62 for further structural design information.

Continuous Framing or Wood Spacers: Continuous wood framing is a way to support cladding without needing clips or long cantilevered screws or the use of rigid exterior insulation. Thermal bridging of the insulation layer through the wood can be significant. See [Continuous Exterior Wood Girts](#) on page 60 for more information on this cladding attachment approach.

Masonry Ties: Masonry ties are used to retain and support brick veneer cladding (in conjunction with the shelf angle) in a similar way to conventional approaches. The ties are either installed on the face of the exterior insulation with longer screws that reach back to the structure or they use extended profiles that extend out through the insulation from the back.

Structural Adhesive: Structural adhesive can be used as part of a proprietary system of materials (EIFS) or prefabricated panel product (SIPS). An advantage of this system is that no structural elements penetrate the insulation so there is essentially no reduction in the insulation effectiveness. Historically, moisture-related issues have been experienced with face-sealed EIFS. However, adequate performance is achievable when installed using rainscreen principles including drainage behind the insulation and good detailing over a robust water resistive barrier. See [Structurally Insulated Panels](#) on page 59 for more information on SIPs.

Structural Fasteners Through Exterior Insulation

The vertical strapping on the exterior face of the exterior insulation is fastened with long structural screws through the insulation and into the wall structure. The cladding is then attached with separate fasteners through the strapping only. This arrangement works as a structural system to resist loads due to the following factors:

- The bending resistance from the structural screw as a moment arm.
- Truss action where the fasteners resist the tension load and the strapping on the insulation layer resist the compression load.
- Friction between the insulation and the strapping and wall created by the force applied by the fasteners, though this is generally not accounted for in the structural design.

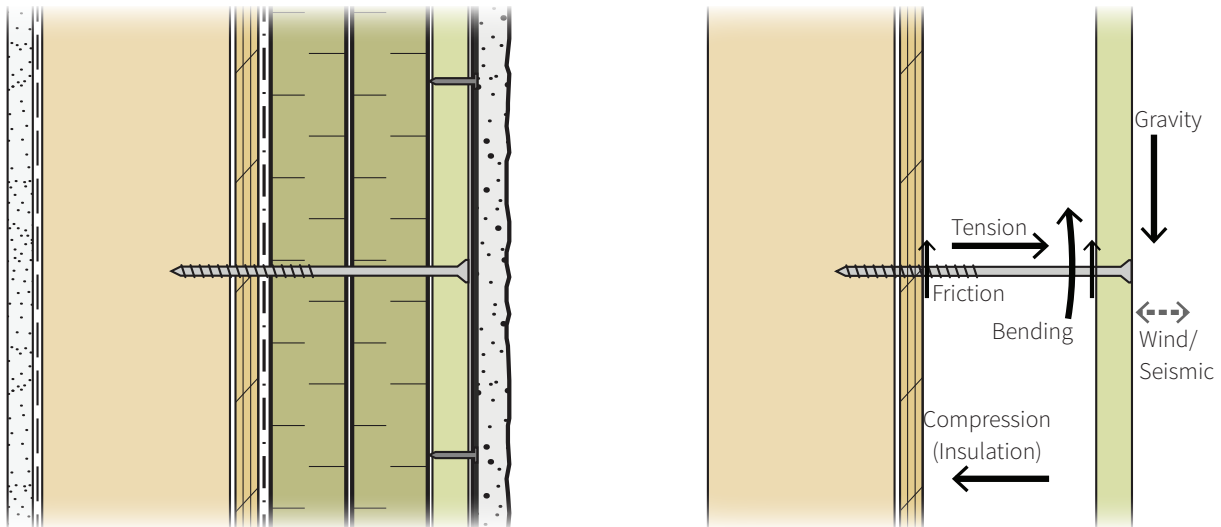


Figure 2-1 Wall exterior insulation service load state (section view)

This cladding attachment system can be used effectively for most conventional cladding types. The screw size and installation will vary depending on the cladding weight and seismic considerations, among other factors. Claddings that weigh over 15 lbs/ft² (73 kg/m²) may not be practicable for this attachment approach.

Consider the following additional parameters in the design and construction of this cladding attachment system:

- The stud spacing and sheathing type and thickness of the wall.
- Exterior insulation type and thickness.
- Cladding support/attachment requirements.

Lower density rigid and semi-rigid mineral fibre insulation (less than 8 lbs/ft³, 126 kg/m³) is not considered rigid enough for this application and would likely compress excessively under the vertical strapping during installation. Therefore, these products are not included in subsequent guidance on this cladding attachment approach. Additionally nails are not considered appropriate for use in this application in most cases.

Cladding Weight

Cladding weight for the purpose of the structural calculations included in this guide are categorized as **Light** (less than 5 lbs/ft², 24kg/m²), **Medium** (5 to less than 10 lbs/ft², 24–49 kg/m²), **Heavy** (10–15 lbs/ft², 49–73 kg/m²), and **Very Heavy** (over 15 lbs/ft², 73 kg/m²) weight cladding. The approximate weight categories for various common cladding types are shown below. Each cladding type will have different weights for different brands and cladding arrangements.

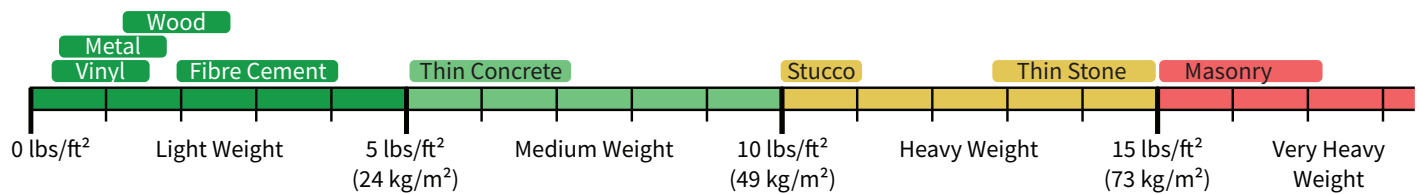


Figure 2-2 Cladding weight of typical cladding products and materials

Strapping

In general, the most appropriate strapping for this application is preservative-treated plywood strips¹. Large screws at close spacing combined with cladding fasteners risk splitting strapping made from solid dimension lumber. Dimension lumber strapping such as nominal 1x3 or 2x4 may be adequate if fasteners use pre-drilled holes. The required strapping thickness and width for structural purposes is a function of the cladding weight and insulation density. Thicker and wider strapping may be necessary with rigid mineral wool products to reduce potential bowing or twisting of the strapping against the more compressible substrate compared to foam board.

¹Borate treatments are often suitable for wood strapping, and are recommended for most applications. Alkaline copper quat (ACQ) and chromated copper arsenate (CCA) may also be suitable treatments, though they can cause fastener metal compatibility issues. See Chapter 7 of the Building Enclosure Design Guide (see [Additional Resources](#) on page 62).

Screws

Stainless steel or galvanized steel screws with a coating rated to 2000-hour salt spray per ASTM B117 provide an appropriate level of corrosion resistance and long-term durability. Additional resistance may be required in highly corrosive environments. The screw material and coating(s) must be compatible with both the strapping material (i.e., wood pressure treatment) and the cladding material¹. This application may require specialty screws designed to accommodate the potentially large torque imparted on the screws as they are installed through thick layers of insulation and into the backup wall. Screws with large heads may require pre-drilled countersunk holes so they can sit flush on the face of the strapping.

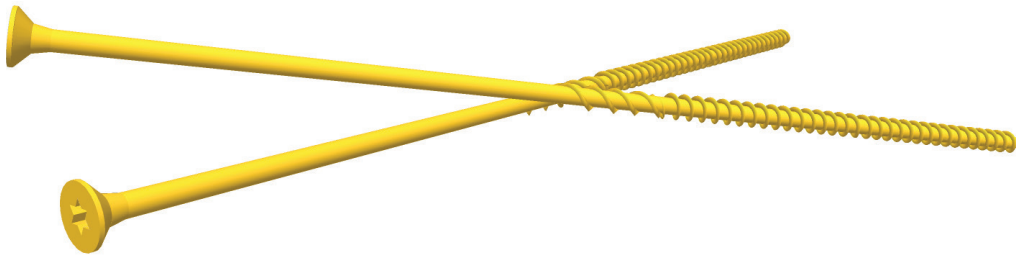


Figure 2-3 Example graphic of coated long screws used for fastening strapping over exterior insulation

Drain Mat

For wall assemblies with light weight cladding and up to a maximum of 2" of exterior insulation, strapping may be replaced with an appropriate drain mat product on the exterior face of the exterior insulation. The drain mat is used to create the drained and vented cavity behind the cladding and support the cladding attachment. The cladding is attached with screw fasteners installed through the drain mat and insulation directly into the backup wall. Note that the cladding type used must be compatible with the larger screw fasteners needed to attach it through the exterior insulation. The drain mat product would have a minimum compression and stiffness strength as required by the cladding manufacturer for an acceptable attachment substrate. Refer to the specific product literature and manufacturer guidance for determining the suitability of drain mat products in this arrangement. Note that a wall assembly with drain mat may still require wood strapping to support cladding and trim around openings and details like windows and through-wall flashings.

Some assemblies in other parts of this guide are shown with a thin drainage layer between the exterior insulation and the wall sheathing membrane. In most cases this layer is expected to have minimal thickness and is not considered to affect the structural requirements of the assembly. The reference fastener tables presented later in this section can apply to assemblies with these components. For assemblies that include an drain mat thicker than 3/8" in this configuration, the same structural requirements would apply as for drain mat used at the exterior face of the exterior insulation as described above.

¹Stainless steel fasteners are most appropriate for ACQ treated wood. Stainless steel or galvanized steel fasteners can be used when using Borate or CCA treated wood. Note that using aluminum-based materials in conjunction with copper-based wood treatments such as ACQ and CCA can lead to corrosion of the aluminum. For further information refer to the *Builder Insight #8 - Compatibility of Fasteners and Connectors with Residential Pressure Treated Wood* (see [Additional Resources](#) on page 62).

Backup Wall and Minimum Fastener Embedment

The stud spacing of the exterior framed wall will govern the horizontal spacing of the strapping and fasteners in most cases. Closer stud and strapping spacing (i.e., maximum 16" o.c.) provides additional support for the cladding, and therefore may allow less frequent vertical screw placement. For wider spaced wood stud framing (i.e., 24" o.c. horizontal spacing) closer vertical spacing may be required (see [Reference Fastener Tables](#) on page 33).

The reference fastener tables included in this section have been developed following the assumption that all screws used to fasten the strapping in place are installed through the wood sheathing and into the wood framing in the backup wall¹. Standard plywood or oriented strand board sheathing is the assumed as sheathing material. Using markers or snap lines on the outside face of the wall sheathing membrane and insulation in line with the stud framing can help indicate where screws are to be fastened into the backup wall. Note that screws that miss the framing aren't considered as part of the structural system. Leaving the missed screws in place (and adding a secondary screw as close as possible into the stud) is an appropriate way to reduce the risk of leakage through open fasteners holes.

The minimum embedment length as given in the reference tables is measured from the outside face of the wood sheathing. The minimum embedment length only accounts for the non-tapered portion of the screw where the screws threads are at the full diameter and excluding the tip. The first 1/4" of the screw tip is typically ignored in determining the appropriate screw length (see Figure 2-7). Contact the screw manufacturer for further information.

Deflection

Testing has shown that some minor deflection of the strapping and cladding may be experienced for wall assemblies with heavy weight claddings. In most cases, the deflection is constrained to less than 1/32", even for typical heavy weight cladding loads. This amount of deflection is similar to the movement a conventional wall assembly would experience due to temperature and moisture variations. Installing claddings like stucco or adhered stone without continuous inside corners and irregular shapes is the most effective way to reduce the risk of cracking from movement or deflection. Crack-prone cladding can be segmented into smaller areas across the face of the wall assembly using crack control joints. Refer to [Additional Resources](#) on page 62 for further structural design and testing information.

¹Note that specific structural design can be completed for an assembly where fasteners are supported only by the sheathing, though this design approach is not included in this guide.

Installation Methods

Insulation Boards

An effective installation approach for exterior insulation boards includes an efficient stacking sequence, offset joints between courses and layers, and as few fasteners as possible. The following instructions and corresponding graphic illustrate this approach.

1. Install the starter course of insulation horizontally using vertical straps fastened at the bottom edge only and held upright spaced off the wall as needed. Offset the insulation boards such that vertical edges are centered between straps. Boards are typically 48" wide so they can usually be secured behind at least three separate straps for strapping spaces 16" on centre.
2. Slot the next course of insulation behind the upright strapping and stack it on the starter course. Add screws along the strapping from the bottom up through the insulation boards as they are installed.
3. Directly stack (as shown) or horizontally offset the insulation boards in a single layer. Offset multiple insulation layers to align vertical joints between adjacent straps for each layer

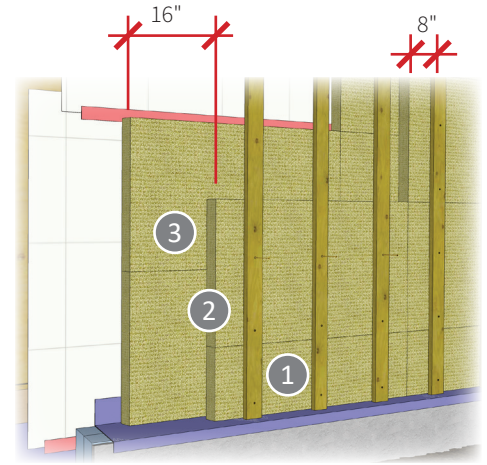


Figure 2-4 Exterior insulation installation

An alternative installation approach is to use fasteners to temporarily pin all insulation boards in place before the strapping is installed. This approach may require screws with large washers to adequately secure heavier insulation. Refer to the insulation manufacturer product data for further guidance on fastener layout and installation requirements.

Optimizing Strapping Layout

In unobstructed “clear-field” wall areas, strapping installation may be relatively straightforward. However, the strapping must still accommodate the openings, penetrations, cladding joints, attachment of flashings and trims, and separations at floor lines.

Optimize strapping layout by using the following techniques:

- Carefully planning the layout to avoid extra strapping pieces, especially around windows and penetrations,
- Reducing the number of insulation pieces by using the largest possible piece.
- Simplifying the trim and flashing arrangement to reduce the need for small insulation blocks.
- Using intermittent blocking to receive closure/return trim and flashing.

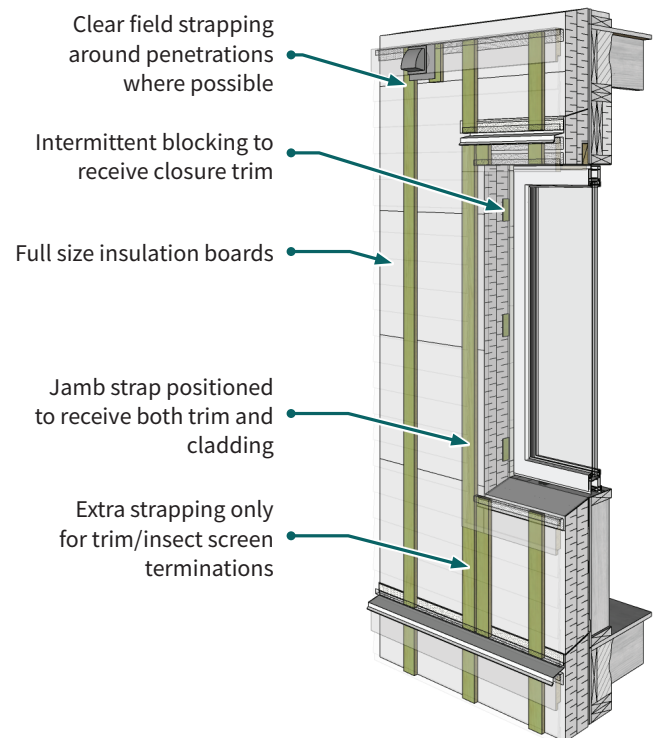


Figure 2-5 Examples of optimized strapping layout

When considering the number of penetrations and estimating the amount of screws needed, remember that while structural requirements can allow large vertical screw spacing (see [Reference Fastener Tables](#) on page 32), this spacing is only available at clear-field wall areas. At windows and doors, strapping pieces are still needed at the perimeter, and fasteners are typically needed at each end of the straps regardless of how short they are. This is also true for wall areas with joints and flashing at floor lines and cladding transitions. A good rule of thumb is to estimate strapping and fastener quantities based on the total wall area including openings, plus 10%.

Through-Wall Flashing Attachment

The flashing installation approach requires some changes to the typical cladding install sequence. Sheathing membrane on conventional non-exterior insulated walls is typically installed together with the flashing before the bug screen and strapping is added. In exterior insulated walls, it is typically easier to install the flashing in two stages using the combination of metal flashing and a self-adhered membrane.

The membrane provides the necessary transition between the sheathing membrane and the metal flashing at the face of the insulation. This way the metal flashing can be attached either with fasteners directly through the insulation, or onto intermittent wood-blocking. The lapping sequence is simplified and the potential significant thermal bridging of metal through exterior insulation is eliminated. Furthermore, typical off-the-shelf metal flashing profiles can be used instead of custom deep profiles.

Note as shown below, it can be even simpler to install the flashing membrane over the field sheathing membrane instead of trying to align it at laps in the sheathing membrane. This approach reduces laps in the sheathing membrane. Note however there are specific code requirements in Part 9 for how flashings must be installed, so conventional positive lapping is often required.

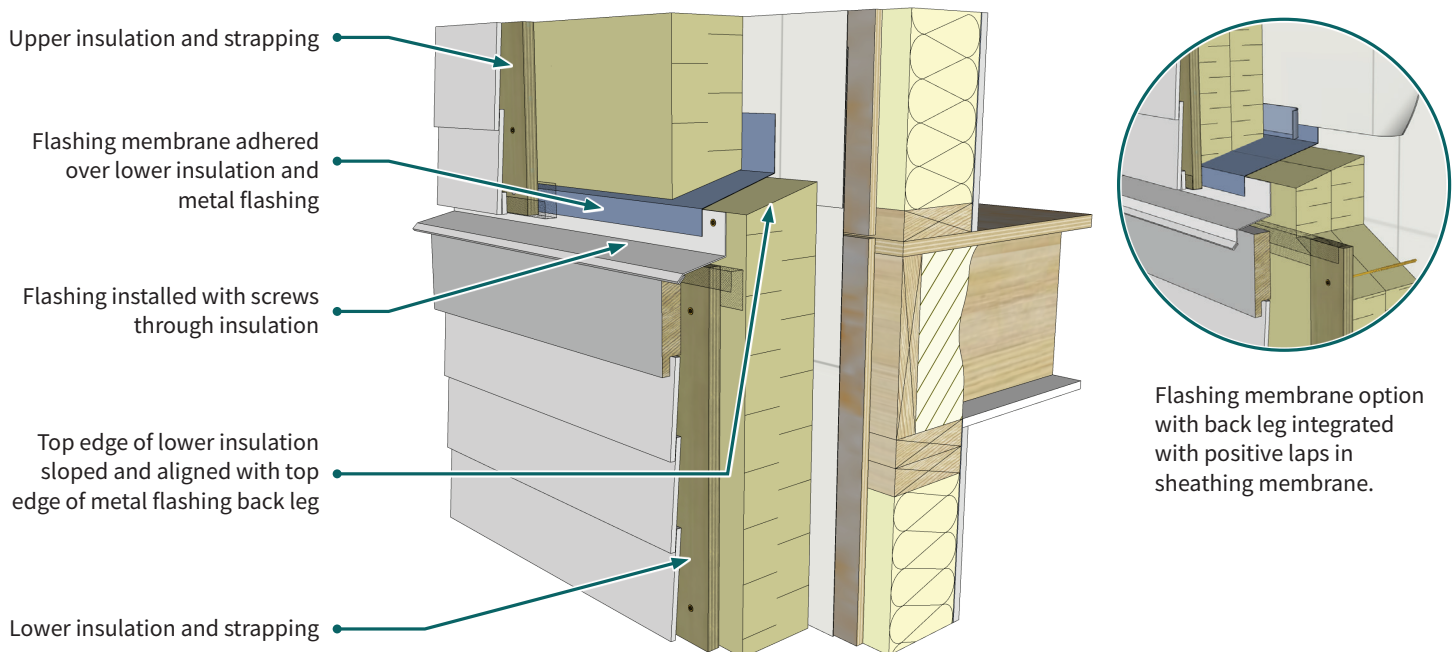


Figure 2-6 Through-wall flashing installation with membrane

Rainscreen Free Area

The BCBC and VBBL require that rainscreen cavities have a minimum free area of 80% (9.27.2.). This means the material used to create the space must not exceed 20% of the cross-sectional area of the drained and vented cavity. This requirement can generally be met with most strapping arrangements, including the strapping widths given in the reference fastener tables at the end of this section. However, narrower strapping or intermittent pieces may be needed at details or terminations to maintain the 80% free area. Drain mat products must also provide a minimum 80% open cavity area. Note the authority having jurisdiction can provide support in confirming that the strapping arrangement is acceptable.

Reference Fastener Tables

The following diagram illustrates various aspects of the fastener and strapping sizing outlined the reference fastener tables on the following page. The tables are categorized by cladding weight and include information for exterior insulation up to 8" thick. See [Additional Resources](#) on page 62 for more guidance on the structural design of cladding support using fasteners through exterior insulation.

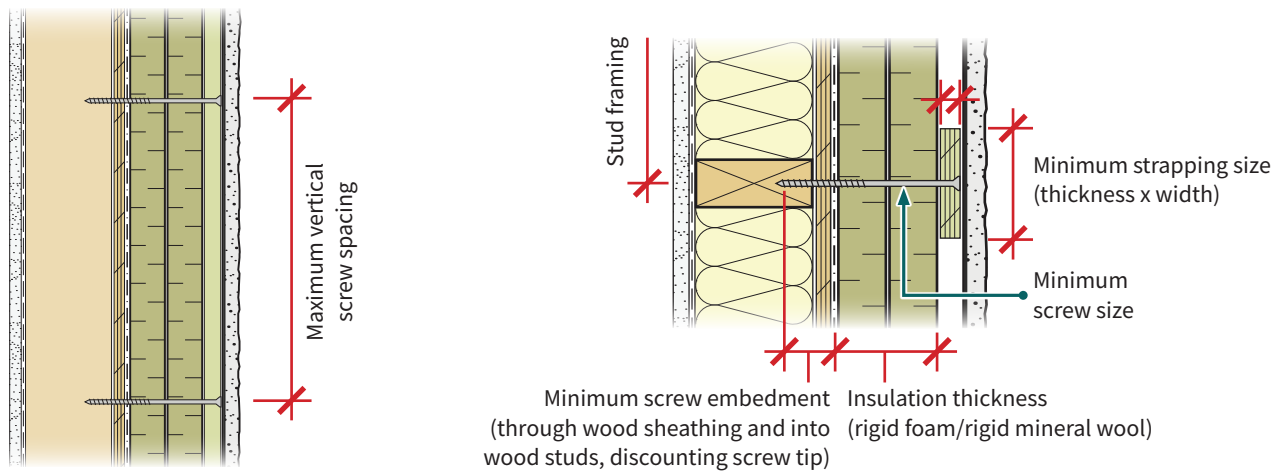
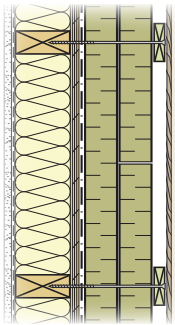


Figure 2-7 Long screw cladding attachment component diagram (section view left and plan view right).

Reference Fastener Tables*

Assumed Structural Properties		
Rigid foam minimum compressive strength	Rigid mineral wool minimum compressive strength	Stainless /galvanized steel screw allowable tensile strength
1440 psf (69 kPa) @10% compression, ASTM C165 testing	439 psf (21 kPa) @ 10% compression, ASTM C165 testing	60,000 psi (414 MPa)

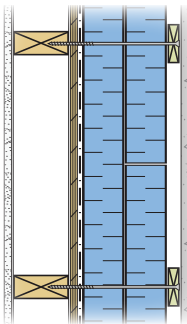
Light Weight Cladding



Fastener/Strapping Installation Requirements - Light Weight Cladding					
Thickness of Exterior Insulation	Maximum Vertical Screw Spacing	Minimum Screw Size	Minimum Screw Embedment	Minimum Strapping Size	
				Rigid Foam	Rigid Mineral Wool
Light Weight Cladding Below 5 lbs/ft² - 16” o.c. Stud Framing					
1” to 2” *	24”	#10	1-1/2”	3/4” × 2-1/2”	3/4” × 2-1/2”
>2” to 8”	16”				
Light Weight Cladding Below 5 lbs/ft² - 24” o.c. Stud Framing					
1” to 2” *	16”	#10	1-1/2”	3/4” × 3-1/2”	3/4” × 3-1/2”
>2” to 8”	12”				

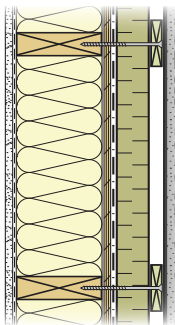
*Wall assemblies with light weight cladding and up to 2" of exterior insulation may use a drain mat rainscreen product in lieu of strapping where appropriate, with fasteners attached directly to the wall framing. Appropriateness of products and fastening configurations in this application to be confirmed with the manufacturer.

Medium Weight Cladding



Fastener/Strapping Installation Requirements - Medium Weight Cladding					
Thickness of Exterior Insulation	Maximum Vertical Screw Spacing	Minimum Screw Size	Minimum Screw Embedment	Minimum Strapping Size	
				Rigid Foam	Rigid Mineral Wool
Medium Weight Cladding Between 5 lbs/ft² and 10 lbs/ft² - 16” o.c. Stud Framing					
1” to 4”	16”	#12	1-1/2”	3/4” x 2-1/2”	3/4” x 3”
>4” to 8”	12”				
Medium Weight Cladding Between 5 lbs/ft² and 10 lbs/ft² - 24” o.c. Stud Framing					
1” to 4”	12”	#12	1-1/2”	3/4” x 3-1/2”	3/4” x 3-1/2”
>4” to 8”	8”				

Heavy Weight Cladding



Fastener/Strapping Installation Requirements - Heavy Weight Cladding					
Thickness of Exterior Insulation	Maximum Vertical Screw Spacing	Minimum Screw Size	Minimum Screw Embedment	Minimum Strapping Size	
				Rigid Foam	Rigid Mineral Wool
Heavy Weight Cladding Between 10 lbs/ft² and 15 lbs/ft² - 16” o.c. Stud Framing					
1" to 2"	16"	#14	1-1/2"	3/4" × 3"	3/4" × 3"
>2" to 8"	12"				
Heavy Weight Cladding Between 10 lbs/ft² and 15 lbs/ft² - 24” o.c. Stud Framing					
1" to 2"	16"	#14	1-1/2"	3/4" × 3-1/2"	3/4" × 3-1/2"
>2" to 4"	12"				
>4" to 8"	6"				

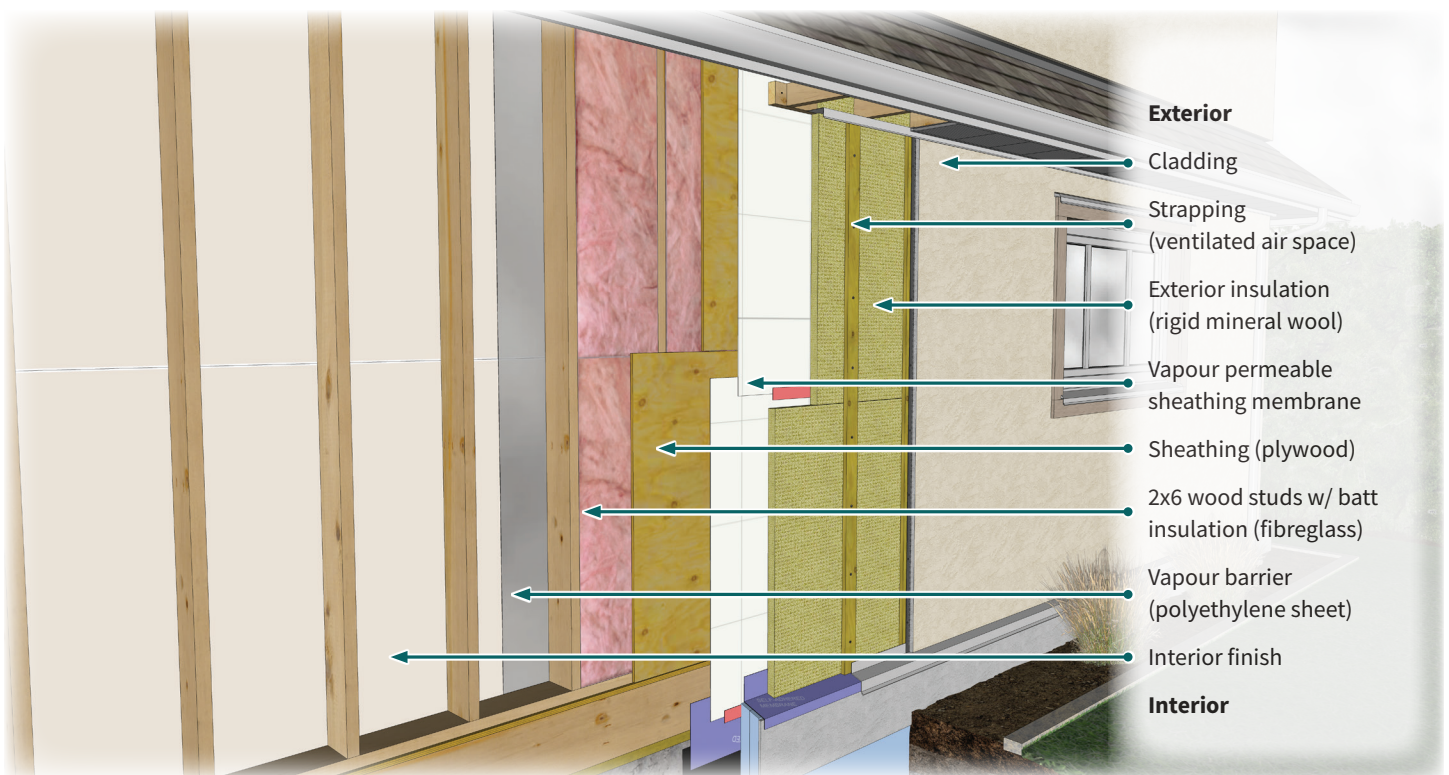
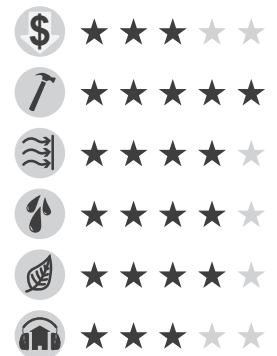
*The information provided in the above tables pertain only to wood-frame wall assemblies on low-rise buildings less than three storeys. The higher wind load expected on larger buildings requires specific structural design. See [Additional Resources](#) on page 62 for further guidance.

3 | Wood-Frame Walls

This section provides guidance on five above-grade wood-frame assemblies that can achieve R-22+ thermal performance.

W-1 | Split Insulation

This above-grade wall assembly consists of rigid or semi-rigid insulation placed on the exterior of a conventional above-grade insulated wood-frame wall assembly. High effective R-values are achieved by using continuous insulation outside of the structural framing combined with a thermally efficient cladding attachment system. See section 2 | [Cladding Support & Fasteners Through Exterior Insulation](#) on page 25 for more information on cladding attachment options. The exterior insulation product must be resistant to moisture because it may be exposed to periodic wetting behind the cladding. Insulation on the exterior side of the stud wall keeps the moisture-sensitive wood sheathing and framing warmer during cold periods. This often reduces the condensation risk and improves the long term durability of the assembly.



Key Considerations

- The method of cladding attachment is important to limit thermal bridging through the exterior insulation while adequately supporting the exterior cladding.
- The vapour permeance of the sheathing membrane and exterior insulation is a key consideration in managing the risk of condensation and the ability of the assembly to dry.

Cladding

Most cladding types can be used with this wall assembly. The cladding attachment strategy depends on the cladding weight and support requirements. In many cases cladding can be attached to vertical wood strapping that is fastened into the backup wall over the rigid exterior insulation. In this arrangement, the rigid exterior insulation and fasteners act together to carry the cladding load (see [2 | Cladding Support & Fasteners Through Exterior Insulation](#) on page 25). Thermally efficient clip or brick tie systems with semi-rigid insulation can also be used.

Water Resistive Barrier

The vapour-permeable sheathing membrane on the exterior face of the wall sheathing functions as the WRB. A variety of products can be used in this application, including mechanically fastened or self-adhered sheet products and liquid-applied materials. The membrane is sufficiently vapour-permeable to reduce the risk of moisture being trapped in the assembly. Taping or sealing joints at the exterior face of low-permeance insulation reduces the risk of water reaching behind the insulation and supports durable water control.

Air Barrier

This assembly can accommodate several air barrier strategies, but the exterior approach using the sheathing membrane is typically the most straightforward. All seams must be taped and sealed to ensure continuity. Structural support for the air barrier is provided by the sheathing and exterior insulation. Other air barrier approaches include sealed sheathing, interior airtight polyethylene, spray foam, and airtight drywall. Maintaining air barrier continuity at transitions and penetrations is critical to performance. See [Air Barrier Systems](#) on page 9 for more information.

Interior Insulation

The stud space can be insulated using a variety of different insulation types, including batt, blown-in fibrous insulation, and spray foam.

Exterior Insulation

Permeable exterior insulation products include mineral wool, fibreglass, and thin expanded polystyrene (EPS). Low-permeance insulation products include extruded polystyrene (XPS), thick expanded polystyrene (EPS), polyisocyanurate (polyiso), and closed-cell spray foam.

These insulation materials can all provide adequate thermal control. However, the permeance of the materials in split insulation assemblies is an important consideration. See [Vapour Barrier and Exterior Insulation Considerations](#) on page 36 for more information.

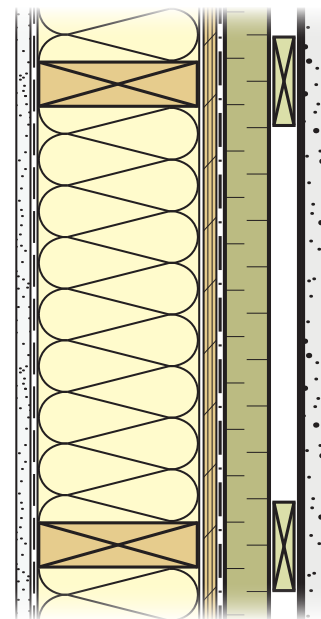


Figure 3-1 W-1 | Split Insulation Wall

Effective Assembly R-value of Split Insulation Wall Assembly [ft²·°F·hr/Btu]				
	2x4 Stud Wall (R-12 Batt)	2x6 Stud Wall (R-19 Batt)		
Thickness of Exterior Insulation	R-value/inch of Exterior Insulation			
	R-4.0	R-5.0	R-4.0	R-5.0
0"	11.3	11.3	16.2	16.2
1/2"	13.4	13.9	18.4	18.9
1"	15.4	16.4	20.4	21.4
1 1/2"	17.4	18.9	22.4	23.9
2"	19.4	21.4	24.4	26.4
2 1/2"	21.4	23.9	26.4	28.9
3"	23.4	26.4	28.4	31.4
3 1/2"	25.4	28.9	30.4	33.9
4"	27.4	31.4	32.4	36.4
4 1/2"	29.4	33.9	34.4	38.9
5"	31.4	36.4	36.4	41.4
5 1/2"	33.4	38.9	38.4	43.9
6"	35.4	41.4	40.4	46.4
A 23% framing factor is assumed which is consistent with standard 16" o.c. stud framing practices. Grey text = less than R-22 effective				

Vapour Barrier and Exterior Insulation Considerations

Exterior insulation helps keep wall sheathing and framing warmer during cold periods, which reduces the potential for condensation. This can make the wall assembly less sensitive to vapour diffusion and air leakage from the interior into and through the wall assembly. However, an interior vapour barrier is still necessary in most cases unless the majority of the insulation is placed on the exterior of the sheathing. A polyethylene sheet is typically used as the interior vapour barrier.

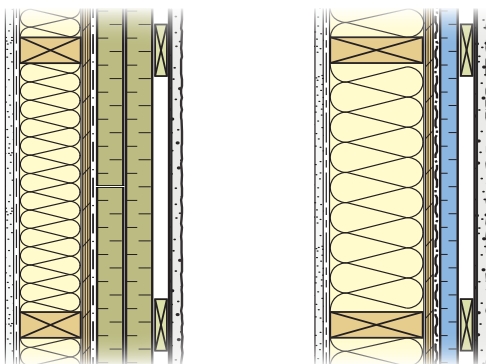
In a split-insulated assembly, low-permeance exterior insulation can increase the risk of moisture in the wall becoming trapped between the interior vapour barrier and the insulation (i.e., two vapour barriers). This can potentially lead to fungal growth and decay. Therefore, when low-permeance exterior insulation is used, the ratio of insulation R-value outboard of the sheathing to that of the interior insulation is a key consideration. The more insulation the better. There are also code requirements that may govern (see below). Keeping the sheathing warmer reduces the condensation risk so the assembly is far less prone to moisture accumulation in the first place.

Additionally, a relatively more permeable interior vapour barrier such as a smart vapour retarder or vapour retarder paint could be used to further reduce the risk of trapped moisture. A thin drainage layer could also be included at the exterior of the sheathing membrane to facilitate drainage of water which may reach behind the insulation.

In general, using vapour permeable exterior insulation results in a lower risk wall assembly compared to an assembly with low-permeance exterior insulation.

Part 9 Code Compliance Paths for Split Insulation Wall Assemblies

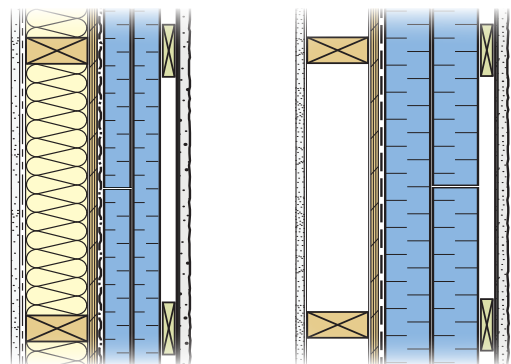
Permeable Exterior Insulation: No Ratio Requirements and Lower Risk



Using permeable exterior insulation ($> 60 \text{ ng}/(\text{s}\cdot\text{m}^2\cdot\text{Pa})$) does not trigger requirements for placement and ratio of low-permeance exterior insulation. Assemblies with permeable exterior insulation comply without having to meet a minimum insulation ratio and are typically lower risk. Note that insulation permeance is a function of both the material type and thickness.

When exterior insulation with permeance near the threshold is used, it is still prudent to follow the design guidance provided for low-permeance insulation (see right).

Low-Permeance Exterior Insulation: Exterior-to-Interior Insulation Ratio Required

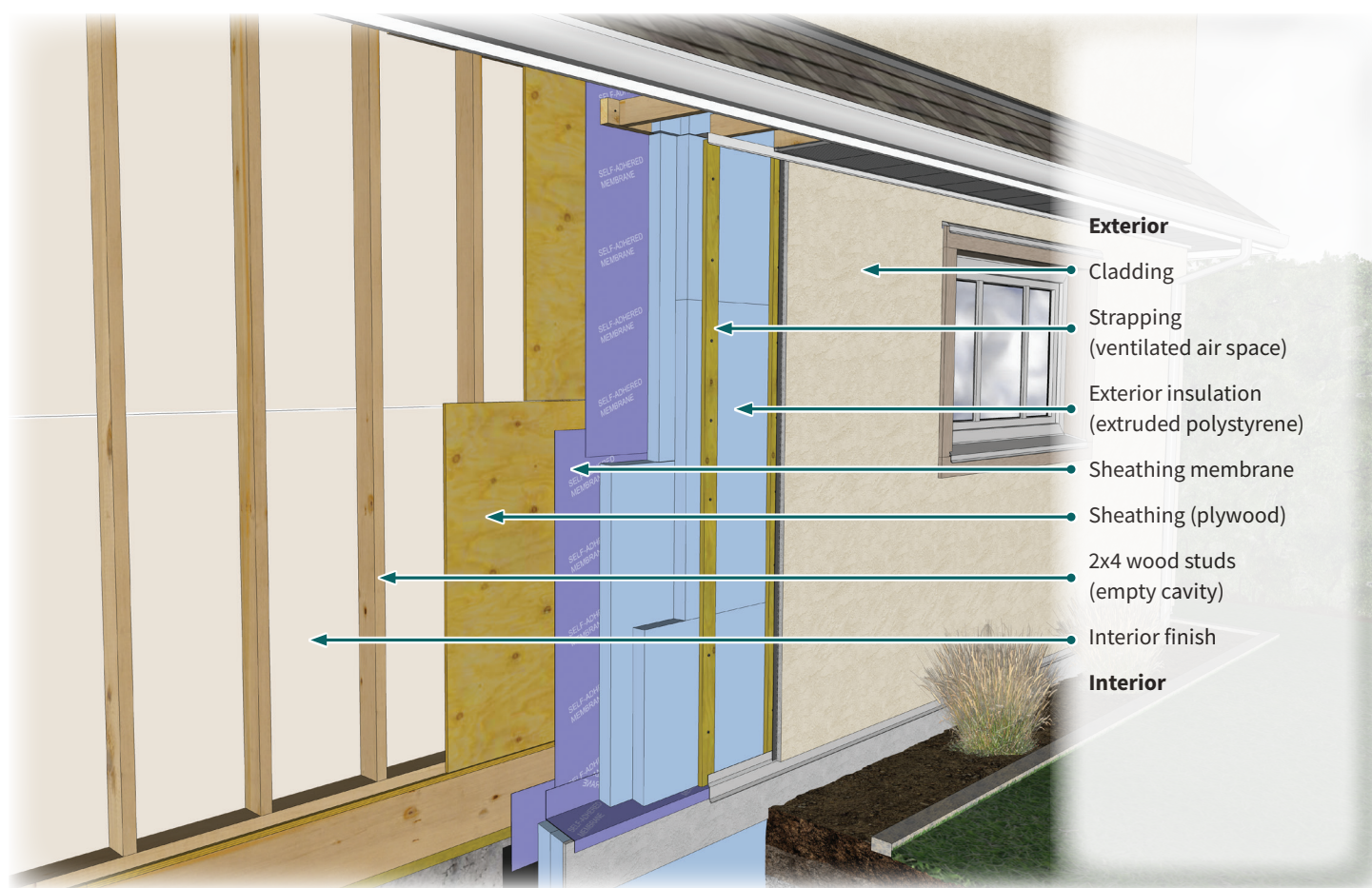
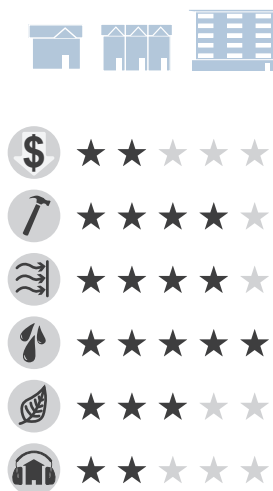


When low-permeance insulation ($\leq 60 \text{ ng}/(\text{s}\cdot\text{m}^2\cdot\text{Pa})$) is used, code requirements can be met by following the insulation ratios in Table 9.25.5.2. These minimum ratios are intended to limit the potential for condensation within the wall assembly. Since outward drying in these assemblies is still limited, it is prudent to consider using a smart vapour retarder and a drainage layer behind the insulation (see above).

Using higher ratios than the code minimums is also an effective way to reduce long term durability risks. Using only exterior insulation further reduces risks (see [W-2 | Exterior Insulation](#) on page 37).

W-2 | Exterior Insulation

This above-grade wall assembly consists of rigid or semi-rigid insulation placed on the exterior of a conventional uninsulated wood-frame wall assembly. High effective R-values are achieved by using continuous insulation outside of the structural framing combined with a thermally efficient cladding attachment system. See section 2 | [Cladding Support & Fasteners Through Exterior Insulation](#) on page 25 for more information on cladding attachment options. The exterior insulation product must be resistant to moisture because it may be exposed to periodic wetting behind the cladding. In cold climates, insulation on the exterior side of the stud wall keeps the moisture-sensitive wood sheathing and framing warmer during cold periods. This often reduces the condensation risk and improves the long-term durability of the assembly.



Key Considerations

- The method of cladding attachment is important to limit thermal bridging through the exterior insulation while adequately supporting the exterior cladding.
- Since the insulation is located entirely outside the framed wall, an interior vapour barrier is typically not needed.
- Low-permeance sheathing membrane can be used to provide both liquid water and vapour control (i.e., water resistive barrier and vapour barrier).

Cladding

Most cladding types can be used with this wall assembly. The cladding attachment strategy depends on cladding weight and support requirements. In many cases, cladding can be attached to vertical wood strapping fastened with screws through the exterior insulation and into the backup wall. In this arrangement, the rigid insulation and fasteners act together to carry the cladding load (see 2 | [Cladding Support & Fasteners Through Exterior Insulation](#) on page 25). Thermally efficient cladding supports and brick ties can also be used, allowing for the use of semi-rigid exterior insulation products.

Water Resistive Barrier

A low-permeance sheathing membrane installed on the exterior face of the wall sheathing provides the WRB in this assembly. Self-adhered sheet products are typically used for this application, and some liquid-applied products are also appropriate. If a permeable WRB is used, taping joints and/or installing a drainage mat reduces the risk of water reaching behind the insulation and supports durable water control.

Air Barrier

This assembly can accommodate several air barrier strategies, but the exterior approach using the sheathing membrane is typically the most straightforward. Structural support for the air barrier is provided by the sheathing and exterior insulation. Maintaining air barrier continuity at transitions and penetrations is critical to performance. See [Air Barrier Systems](#) on page 9 for more information.

Exterior Insulation Types

Permeable exterior insulation products include mineral wool, fibreglass, and thin expanded polystyrene (EPS). Low-permeance insulation products include extruded polystyrene (XPS), thick expanded polystyrene (EPS), polyisocyanurate (polyiso), and closed-cell spray foam.

Vapour Barrier

Exterior insulation in this assembly increases the temperature of the wood sheathing and significantly reduces the risk of condensation. The low-permeance sheathing membrane serves as the vapour barrier and limits inward vapour drive from incidental water between the insulation and the membrane. An interior vapour barrier is not needed.

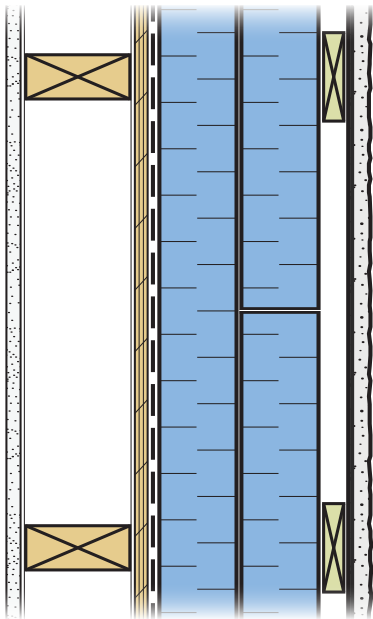


Figure 3-2 W-2 | Exterior Insulation Wall

Effective Assembly R-value for 2x4 or 2x6 Exterior Insulation Stud Wall (No Batt) [ft ² ·°F·hr/Btu]		
Thickness of Exterior Insulation	R-value/inch of Exterior Insulation	
	R-4.0	R-5.0
3 1/2"	18.0	21.5
4"	20.0	24.0
4 1/2"	22.0	26.5
5"	24.0	29.0
5 1/2"	26.0	31.5
6"	28.0	34.0
6 1/2"	30.0	36.5
7"	32.0	39.0
Grey text = less than R-22 effective		

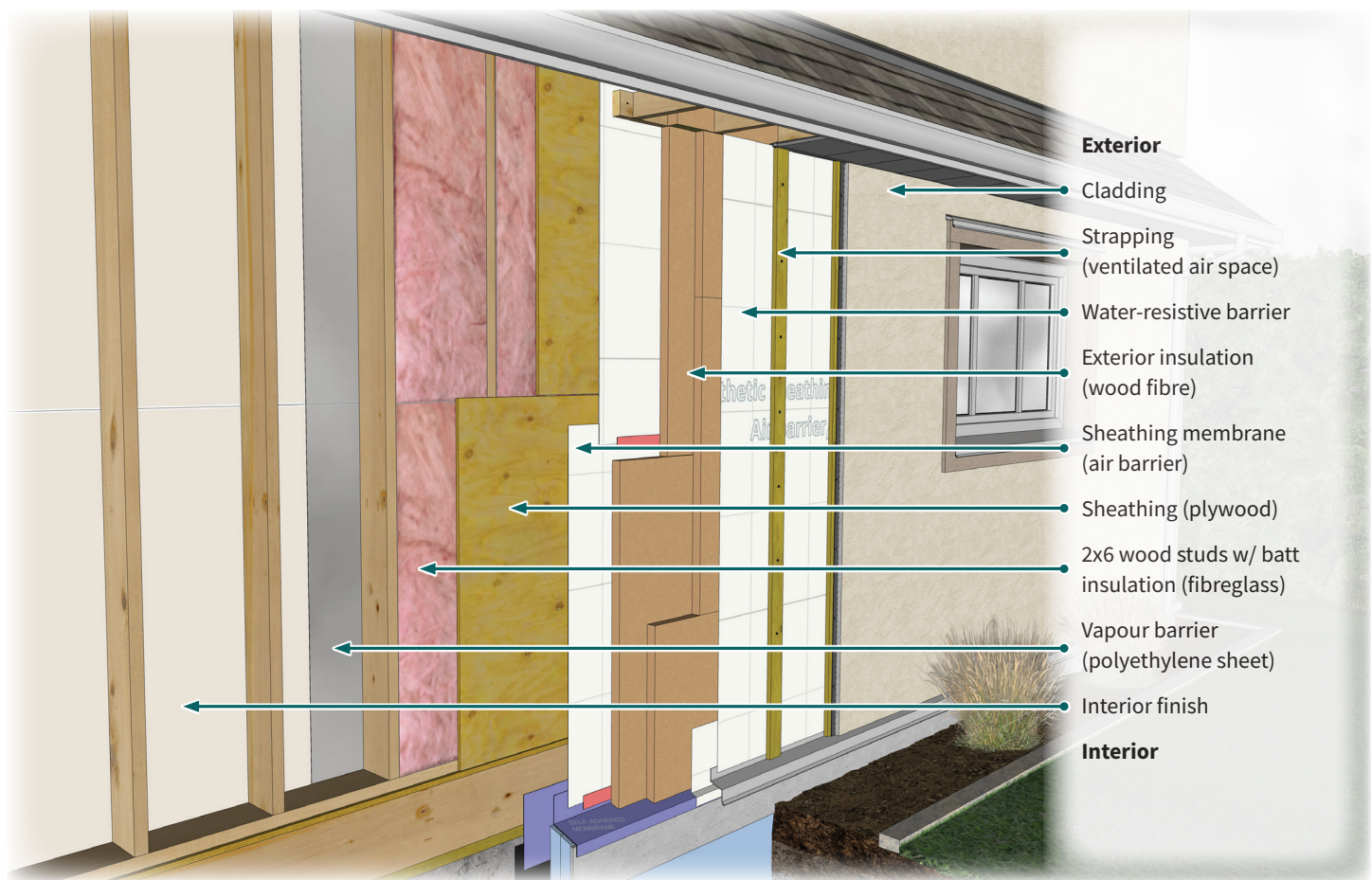
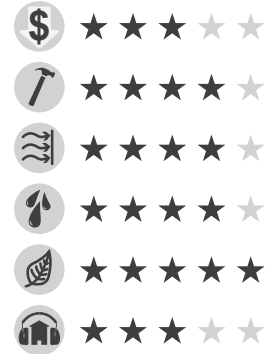
Low-Permeance Materials On Wet Wood-Frame Walls | Trapped construction moisture may be a concern when low-permeance materials are installed at the exterior face of wood assemblies. Stud packs, rim joists, and window headers can contain thick wood elements that restrict inward drying, increasing the risk of moisture accumulation. Confirm that wood is dry before installing low-permeance membranes or insulation products. Permeable exterior materials may be more appropriate in situations where drying is a concern.

W-3 | Wood Fibre Exterior Insulation



This above-grade wall assembly consists of wood fibre insulation placed on the exterior of a conventional insulated wood-frame wall assembly. High effective R-values are achieved using continuous insulation outside of the structural framing, low-conductivity cladding attachments, and insulation within the stud space. Cladding is typically supported by vertical strapping fastened with screws through the wood fibre insulation and into the backup wall.

Wood fibre insulation is moisture-sensitive and must be protected by a water-resistive barrier (WRB) installed behind the insulation. This product is considered exterior insulation because it is installed outside the wood framing and sheathing. Insulation on the exterior side of the wall keeps the moisture-sensitive wood sheathing and framing warmer during cold periods. This often reduces the condensation risk and improves the long-term durability of the assembly.



Key Considerations

- The method of cladding attachment is important to limit thermal bridging through the exterior insulation while adequately supporting the exterior cladding.
- The vapour permeance of the sheathing membrane and exterior insulation is a key consideration in managing the risk of condensation and the ability of the assembly to dry.
- Wood fibre insulation is sensitive to moisture and requires a protective water-resistive barrier (WRB).

Cladding

Most cladding types can be used with this wall assembly. The cladding attachment strategy depends on cladding weight and support requirements. In many cases, cladding can be attached to vertical plywood strapping fastened through the exterior insulation and into the backup wall. In this arrangement, the rigid insulation and fasteners act together to carry the cladding load (see 2 | [Cladding Support & Fasteners Through Exterior Insulation](#) on page 25). Thermally efficient cladding support brackets can also be used with this assembly.

Water Resistive Barrier

A vapour-permeable sheathing membrane is installed on the exterior face of the wood fibre insulation to protect it from moisture accumulation and deterioration. The membrane is located between the strapping and the insulation. Available products include mechanically fastened and self-adhered sheet membranes. The WRB must be vapour-permeable to support outward drying of the assembly. Some wood fibre products include proprietary additives and may be marketed as moisture-tolerant or water-resistive. For this guide, wood fibre insulation is considered moisture-sensitive and requires exterior moisture protection.

Air Barrier

This assembly accommodates several air barrier strategies. The most straightforward approach is a sealed sheathing membrane applied directly to the exterior face of the sheathing. If the sheathing membrane functions as the air barrier, all seams must be taped and sealed to maintain continuity. Structural support is provided by the sheathing and exterior insulation on either side of the membrane.

Interior Insulation Types

The stud space can be insulated using a variety of different insulation types, including batt, blown-in fibrous insulation, and spray foam.

Exterior Insulation Types

This assembly can use various types of wood fibre insulation, including semi-rigid and rigid products. R-values vary by product and are measured as R-value per inch of continuous insulation.

Vapour Barrier

Exterior insulation helps keep the wood sheathing warm and reduces the risk of condensation. An interior vapour barrier is still used unless most of the total R-value is located outside the sheathing. Polyethylene sheet products are typically used as the interior vapour barrier in this type of assembly.

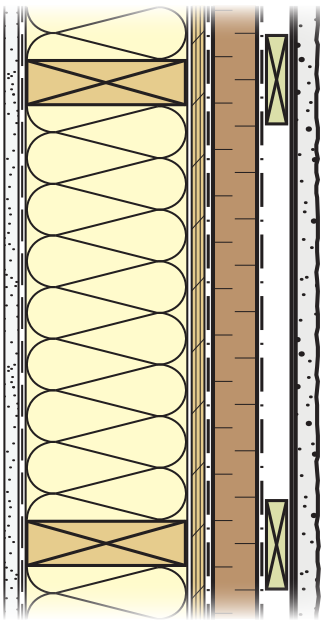


Figure 3-3 W-3 | Wood Fibre Split Insulation Wall

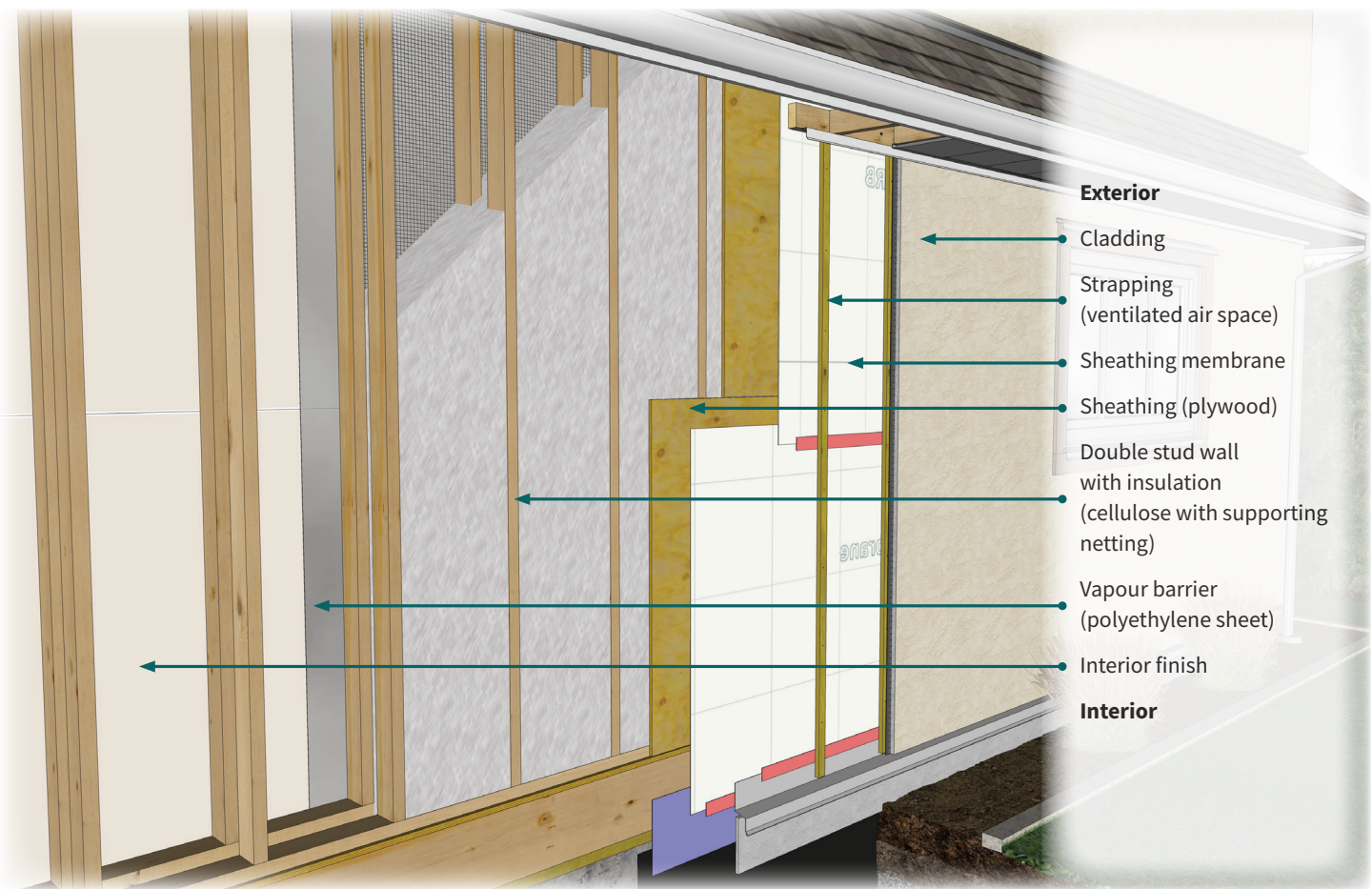
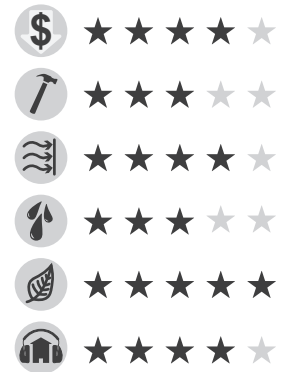
Effective Assembly R-value of Split Insulation Wall Assembly [ft²·°F·hr/Btu]				
	2x4 Stud Wall (R-12 Batt)		2x6 Stud Wall (R-19 Batt)	
Thickness of Exterior Insulation	R-value/inch of Exterior Insulation			
	R-3.0	R-4.0	R-3.0	R-4.0
1"	14.3	15.3	19.2	20.2
1 1/2"	15.8	17.3	20.7	22.2
2"	17.3	19.3	22.2	24.2
2 1/2"	18.8	21.3	23.7	26.2
3"	20.3	23.3	25.2	28.2
3 1/2"	21.8	25.3	26.7	30.2
4"	23.3	27.3	28.2	32.2
4 1/2"	24.8	29.3	29.7	34.2
5"	26.3	31.3	31.2	36.2
5 1/2"	27.8	33.3	32.7	38.2
6"	29.3	35.3	34.2	40.2
A 23% framing factor is assumed which is consistent with standard 16" o.c. stud framing practices. Grey text = less than R-22 effective				

Moisture Sensitive Materials Outside Wood-frame Walls | Wood fibre insulation is considered moisture sensitive unless long-term moisture exposure performance has been demonstrated and robust manufacturer warranties are available.

W-4 | Double Stud



This above-grade wall assembly consists of a deeper stud cavity created by adding an interior framed wall to a conventional wood-frame wall assembly. High effective R-values are achieved by filling the full wall cavity with batt insulation, blown-in fibrous insulation, spray foam insulation, or a combination thereof. No exterior insulation is included in this assembly, so cladding can be attached directly to the wall using vertical strapping and standard rainscreen detailing. In cold climates, placing insulation entirely on the interior side of the sheathing increases the risk of condensation on the exterior sheathing. Maintaining air barrier continuity and installing an interior vapour barrier are both critical to the performance of this assembly. High-quality insulation installation is also important to limit internal airflow and reduce moisture durability risk.



Key Considerations

- High-quality insulation installation is critical to limiting airflow within the deep wall cavity. Uncontrolled airflow can reduce thermal performance and increase the risk of moisture accumulation inside the assembly.
- Air barrier continuity and an interior vapour barrier are both essential to the performance of this assembly. The lower sheathing temperature due to more interior R-value increases the risk of condensation compared to standard wall construction.

Cladding

Most cladding types can be used with this wall assembly. Cladding is fastened directly to the wall using vertical strapping and standard rainscreen detailing. The cladding controls most bulk water. Any water that passes through must drain out through the cavity created by the vertical strapping. The rainscreen space also promotes drying of the wall assembly and reduces the risk of water being trapped behind low-permeance cladding such as vinyl, fibre cement, or stucco.

Water Resistive Barrier

A vapour-permeable sheathing membrane is installed on the exterior face of the sheathing, behind the vertical strapping. Mechanically fastened, self-adhered, and some liquid-applied products are suitable for this application.

Air Barrier

This assembly supports several air barrier approaches. The exterior sheathing membrane is often the most straightforward option. When the membrane forms the air barrier, all seams must be taped and sealed to ensure continuity. Structural support is provided by strapping and sheathing or by adhesion to the sheathing surface. A sealed sheathing approach can also be used, where taped joints maintain continuity.

Given the depth of insulation, a secondary interior air barrier layer is recommended. This can include a polyethylene sheet or airtight drywall to limit interior air movement into the wall cavity. Maintaining air barrier continuity at transitions and penetrations is critical to performance. See [Air Barrier Systems](#) on page 9 for more information.

Insulation Types

The stud space can be insulated using batt, blown-in fibrous insulation, or open-cell spray foam. Batt products include mineral wool or fibreglass. Blown-in options include cellulose or fibreglass. Higher density blown products with binders help prevent settlement in deeper wall cavities. Flash-and-fill combinations using closed-cell spray foam and fibrous fill can also improve airtightness and limit internal airflow.

Vapour Barrier

This assembly places all the insulation on the interior side of moisture-sensitive framing and sheathing. That increases the risk of condensation and moisture accumulation at cold surfaces. A vapour barrier is installed on the interior face of the innermost stud wall to control outward vapour flow. Polyethylene sheet products are typically used for this purpose in double-stud assemblies. Plywood or OSB sheathing can serve this function if the dry cup permeance is 60 ng/(s·m²·Pa) or less.

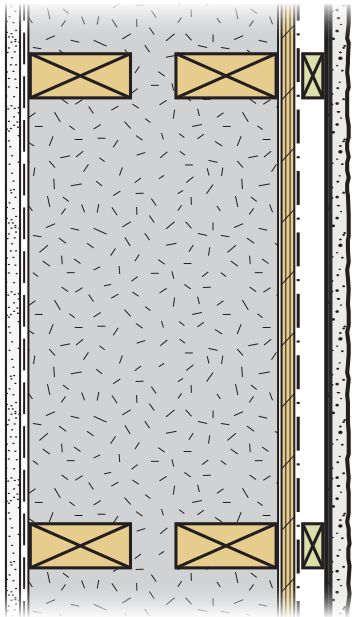


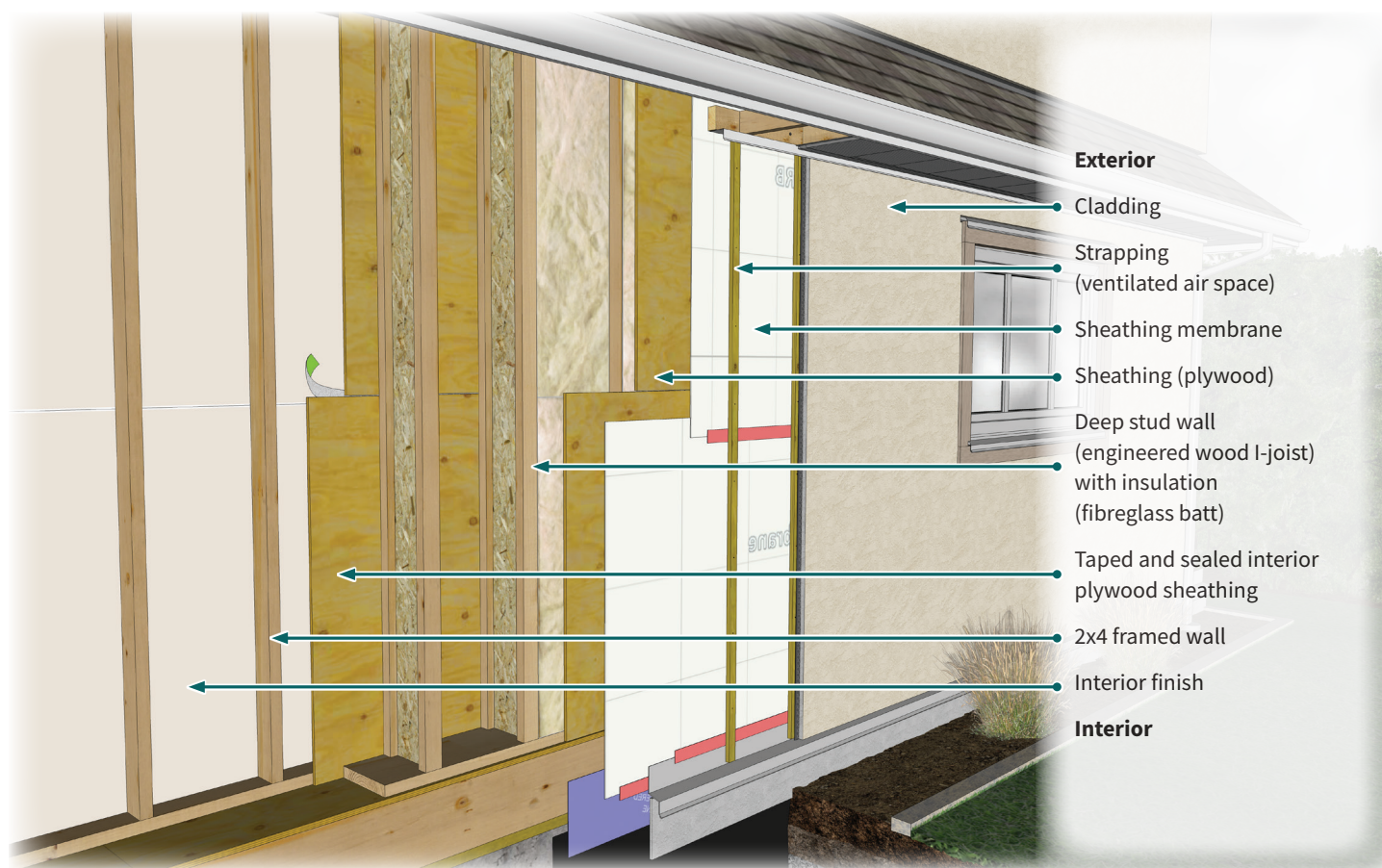
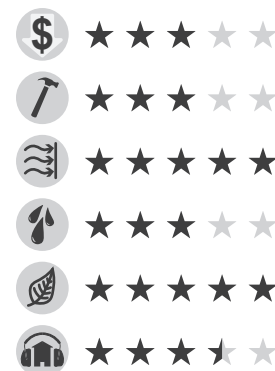
Figure 3-4 W-4 | Double Stud Wall

Effective Assembly R-value for Double 2x4 Stud Wall* [ft²·°F·hr/Btu]			
Thickness of Gap Between Stud Walls	R-value/inch of Insulation		
	R-3.4	R-4.0	R-5.0
0"	19.7	21.2	23.3
1/4"	20.5	22.2	24.5
1/2"	21.4	23.2	25.8
1"	23.1	25.2	28.3
1 1/2"	24.8	27.2	30.8
2"	26.5	29.2	33.3
2 1/2"	28.2	31.2	35.8
3"	29.9	33.2	38.3
3 1/2"	31.6	35.2	40.8
4"	33.3	37.2	43.3
4 1/2"	35.0	39.2	45.8
5"	36.7	41.2	48.3
Assumes interior stud wall has the same 23% framing factor as the exterior stud wall, though it may require less framing Grey text = less than R-22 effective			

W-5 | Deep Stud With Service Wall



This above-grade wall assembly includes a deeper stud cavity formed using either deep studs (2x10 or 2x12), engineered wood I-joists, or similar framing components. A 2x4 interior service wall is typically added to allow electrical, plumbing, and HVAC services to run without penetrating the interior air barrier. High effective R-values are achieved by filling the full wall cavity with batt insulation, blown-in fibrous insulation, or spray foam. The service wall can also be insulated. Exterior insulation is often not included in this assembly. Cladding can be attached directly to the wall using vertical strapping and standard rainscreen detailing. In cold climates, placing insulation entirely on the interior side of the sheathing increases the risk of condensation on the exterior sheathing. Maintaining air barrier continuity and installing an interior vapour barrier are both critical to the performance of this assembly. High-quality insulation installation is also important to limit internal airflow and reduce moisture durability risk.



Key Considerations

- High-quality insulation installation is essential to limiting airflow within the deep wall cavity. Uncontrolled airflow can reduce thermal performance and increase the risk of moisture accumulation within the assembly.
- Continuous air barrier detailing and an interior vapour barrier are critical to the assembly's performance. The lower exterior sheathing temperature increases the risk of condensation compared to standard wall construction.

Cladding

Most cladding types can be used with this wall assembly. Cladding is fastened directly to the wall using vertical strapping and standard rainscreen detailing. The cladding controls most bulk water. Any water that passes through must drain out through the cavity created by the vertical strapping. The rainscreen space also promotes drying of the wall assembly and reduces the risk of water being trapped behind low-permeance cladding such as vinyl, fibre cement, or stucco.

Water Resistive Barrier

A vapour-permeable sheathing membrane is installed on the exterior face of the sheathing, behind the vertical strapping. Mechanically fastened, self-adhered, and some liquid-applied products are suitable for this application.

Air Barrier

The interior sheathing between the service wall and deep stud wall is detailed as the primary air barrier for this assembly. This interior air barrier limits airflow into the insulated cavity from the conditioned space. A secondary exterior air barrier can also be used to reduce wind penetration and improve overall airtightness. Options include a vapour-permeable self-adhered membrane or sealed exterior sheathing. The floor line transition requires careful detailing to maintain continuity of the interior air barrier.

Insulation Types

The stud space can be insulated using batt, blown-in fibrous insulation, or open-cell spray foam. Batt products include mineral wool or fibreglass. Blown-in options include cellulose or fibreglass. Higher density blown products with binders help prevent settlement in deeper wall cavities. Flash-and-fill combinations using closed-cell spray foam and fibrous fill can also improve airtightness and limit internal airflow.

Note that 2x8 framed wall assemblies can only achieve R-22 thermal performance with optimized framing layout and high R-value insulation.

Vapour Barrier

This assembly places all the insulation on the interior side of moisture-sensitive framing and sheathing. That increases the risk of condensation and moisture accumulation at cold surfaces. A vapour barrier is installed on the interior face of the innermost stud wall to control outward vapour flow. Polyethylene sheet products are typically used. Plywood or OSB sheathing can also serve this function.

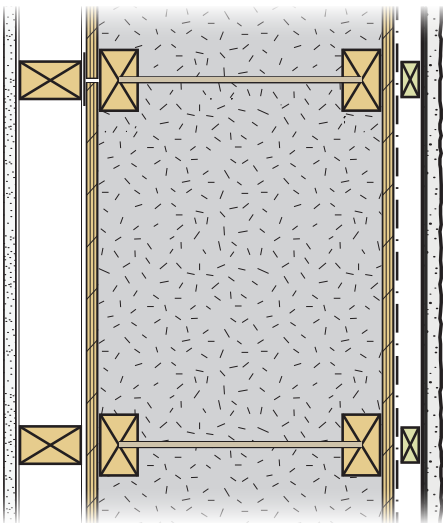


Figure 3-5 W-5 | Deep Stud Wall with Service Wall

Effective Assembly R-value for Deep Stud Walls [ft ² ·°F·hr/Btu]						
	Uninsulated Service Wall				Insulated (R-12) 2x4 Service Wall	
Thickness of Wall Framing	R-value/inch of Insulation					
	R-3.4	R-4.0	R-5.0	R-3.4	R-4.0	R-5.0
2x6	17.7	18.9	20.5	25.2	26.3	28.0
2x8	21.9	23.5	25.6	29.4	31.0	33.1
2x10	26.7	28.7	31.5	34.2	36.2	39.0
2x12	31.6	34.0	37.3	39.0	41.5	44.8
9.5" I-joist	28.4	31.2	35.5	35.9	38.7	43.0
11-7/8" I-joist	35.4	39.2	44.9	42.9	46.7	52.3
14" I-joist	41.7	46.3	53.3	49.1	53.8	60.7
16" I-Joist	47.6	53.0	61.1	55.0	60.5	68.6
A 23% framing factor is assumed which is consistent with standard 16" o.c. stud framing practices. Reduced framing factors may be possible. Grey text = less than R-22 effective						

4 | Steel Stud Walls

This section provides guidance on two above-grade steel stud wall assemblies that can achieve R-22 or greater effective thermal performance. Steel stud framing is significantly less thermally efficient than wood framing due to the high conductivity of metal studs. Steel framing conducts heat through insulation placed within the stud space, causing significant thermal bridging and reduced thermal performance. Concrete or other materials that penetrate insulation layers will also result in thermal bridging (see 5 | Mid-Rise Concrete Construction on page 49. The parallel paths method cannot accurately calculate the effective R-value of steel stud walls due to complex heat flow pathways. The R-values presented are based on three-dimensional thermal modelling that accounts for the effects of structural thermal bridging and cladding attachment clip systems.

W-6 | Exterior Insulation

This above-grade wall assembly consists of rigid or semi-rigid insulation installed on the exterior of a conventional uninsulated steel stud wall. High effective R-values are achieved by placing continuous insulation outside the structural framing and any concrete elements, combined with thermally efficient cladding attachment systems. The exterior insulation must be moisture-resistant, as it may be exposed to periodic wetting behind the cladding. In cold climates, insulation on the exterior side of the stud wall keeps the steel framing and sheathing warmer during cold periods. This often reduces the condensation risk and improves the long-term durability of the assembly.

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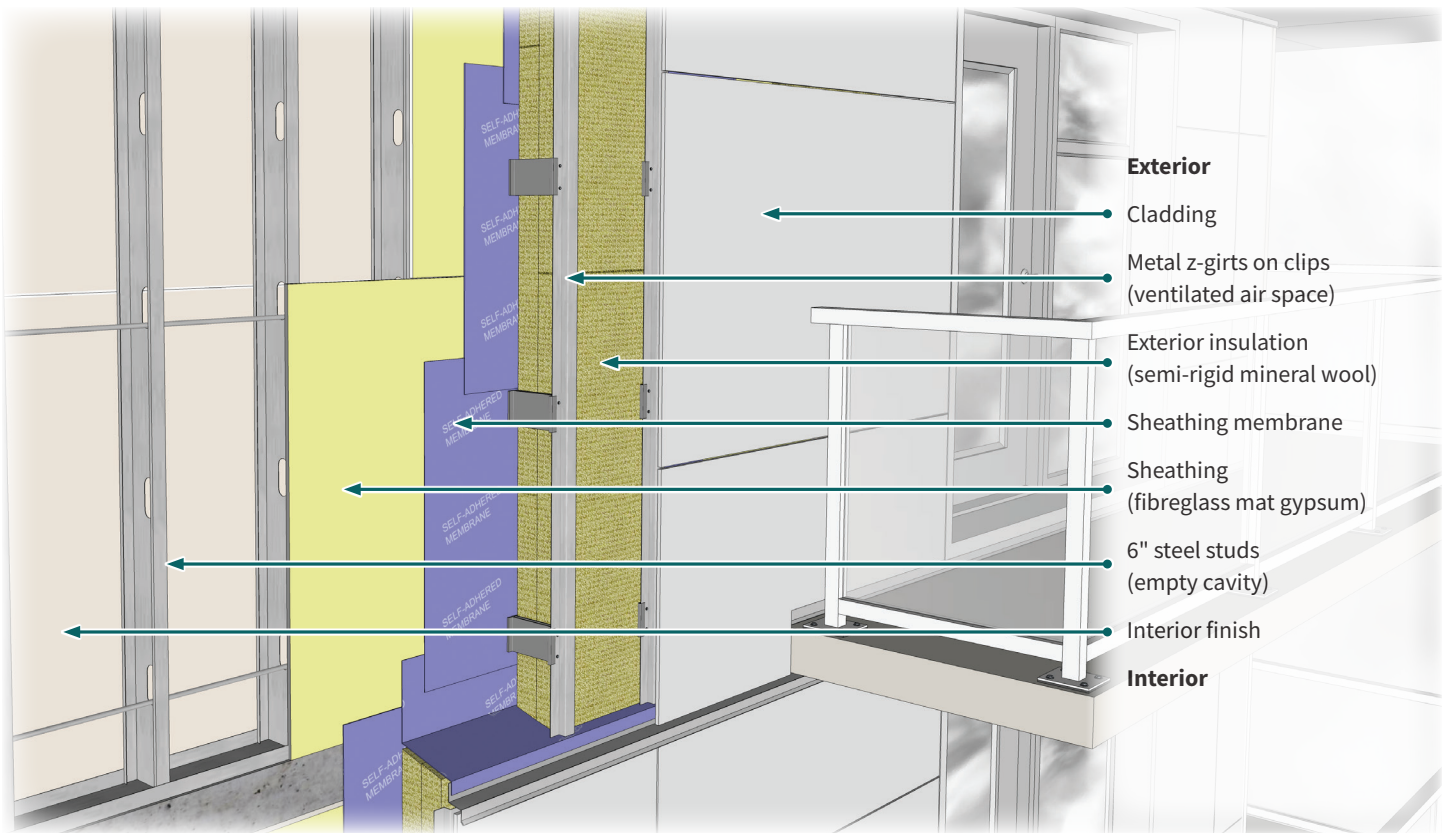
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Key Considerations

- Cladding attachment strategy is important for reducing thermal bridging while providing adequate support for the exterior cladding.
- Thermally efficient cladding attachment systems such as fiberglass or stainless steel help reduce the thermal bridging through the exterior insulation.
- Concrete elements extending beyond the plane of the insulation significantly reduce the thermal performance of the assembly.
- Installing continuous exterior insulation over all structural components helps reduce or eliminate this type of thermal bridging.
- A low-permeance sheathing membrane can serve as both the water-resistive barrier and the vapour barrier in this assembly.

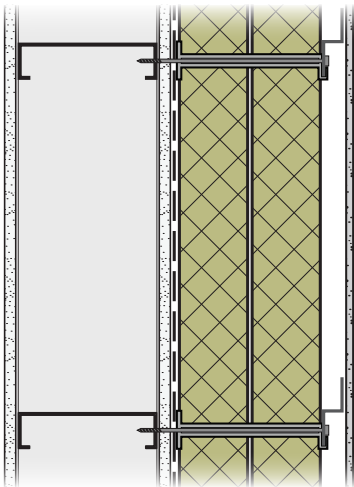


Figure 4-1 W-6 | Exterior Insulation Steel Stud Wall

Cladding

Most cladding types can be used with this wall assembly, although fire protection requirements may limit certain materials or configurations. The cladding attachment strategy depends on cladding weight and support requirements. Thermally efficient cladding supports and brick ties are compatible with this assembly and allow the use of semi-rigid exterior insulation products.

Water Resistive Barrier

A low-permeance sheathing membrane installed on the exterior face of the wall sheathing provides the WRB in this assembly. Self-adhered sheet products are typically used for this application, and some liquid-applied products are also appropriate.

Air Barrier

This assembly can accommodate several air barrier strategies, but the exterior approach using the sheathing membrane is typically the most straightforward. Structural support for the air barrier is provided by the sheathing and exterior insulation. Maintaining air barrier continuity at transitions and penetrations is critical to performance. See [Air Barrier Systems](#) on page 9 for more information.

Exterior Insulation Types

Various types of exterior insulation can be used in this assembly, including permeable options such as semi-rigid or rigid mineral wool. See [Fire Risk](#) on page 16 for guidance on the use of combustible insulation types in above-grade wall assemblies.

Vapour Barrier

Exterior insulation in this assembly increases the temperature of the wood sheathing and significantly reduces the risk of condensation. The low-permeance sheathing membrane serves as the vapour barrier and limits inward vapour drive from incidental water between the insulation and the membrane. An interior vapour barrier is not needed.

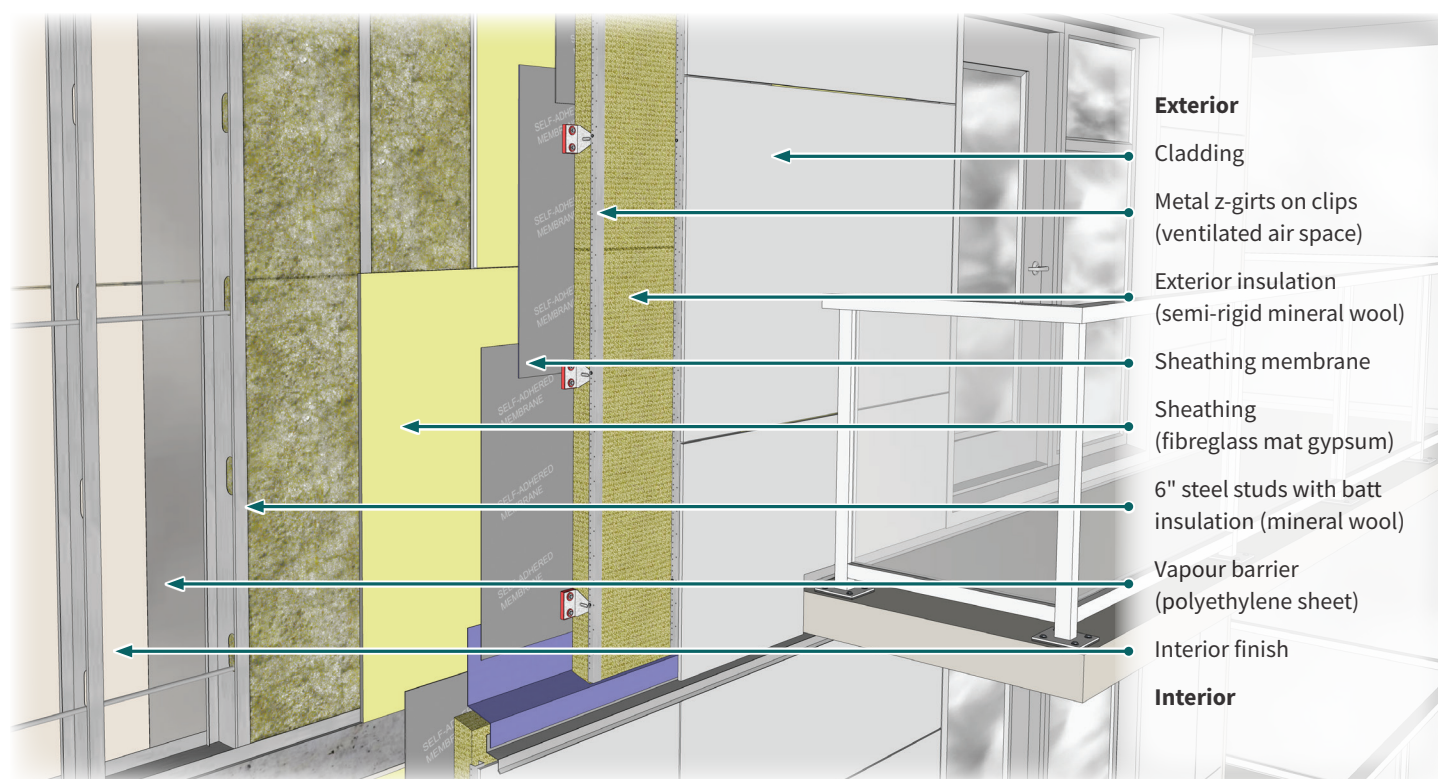
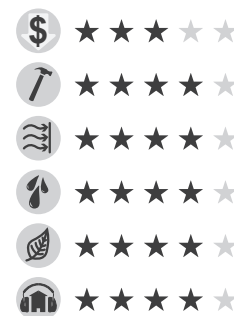
Effective Assembly R-value for 6" Exterior Insulated Steel Stud Wall (No Batt) [ft²·°F·hr/Btu]								
Full-Height Backup Wall Effective R-value (includes slab): R-3.5								
+ Exterior Insulation Thickness	R-value/inch of Exterior Insulation							
	R-4.0				R-5.0			
	Percentage Effectiveness of Exterior Insulation							
	70%	80%	90%	100%	70%	80%	90%	100%
3"	8.4	9.6	10.8	12	10.5	12	13.5	15
4"	11.2	12.8	14.4	16	14	16	18	20
5"	14	16	18	20	17.5	20	22.5	25
6"	16.8	19.2	21.6	24	21	24	27	30
7"	19.6	22.4	25.2	28	24.5	28	31.5	35
8"	22.4	25.6	28.8	32	28	32	36	40
Grey text = results in less than R-22 effective when added to backup wall R-value								

W-7 | Split Insulation



This above-grade wall assembly consists of rigid or semi-rigid insulation installed on the exterior of an insulated steel stud wall. High effective R-values are achieved by combining continuous exterior insulation with thermally efficient cladding attachments and insulation within the stud space. Steel framing and exposed concrete slab edges cause significant thermal bridging that reduces overall performance, so most insulation must be placed on the exterior. Split insulation wall assemblies with less than 4 inches of exterior insulation typically do not achieve R-22 effective thermal performance. See 5 | [Mid-Rise Concrete Construction](#) on page 49 for more information.

Cladding is supported using thermally efficient attachment systems compatible with rigid or semi-rigid insulation. The exterior insulation must be moisture-resistant, as it will be exposed to periodic wetting behind the cladding. In cold climates, insulation on the exterior side of the stud wall keeps the steel framing and sheathing warmer during cold periods. This often reduces the condensation risk and improves the long-term durability of the assembly.



Key Considerations

- The vapour permeance of the sheathing membrane and exterior insulation is a key consideration in managing the risk of condensation and the ability of the assembly to dry.
- Thermally efficient cladding attachment systems such as fibreglass or stainless steel help reduce the thermal bridging through the exterior insulation.
- Concrete elements extending beyond the plane of insulation significantly reduce the thermal performance of the assembly.

Cladding

Most cladding types can be used with this wall assembly, although fire protection requirements may limit certain materials or configurations. The cladding attachment strategy depends on cladding weight and support requirements. Thermally efficient cladding supports and brick ties are compatible with this assembly and allow the use of semi-rigid exterior insulation products.

Water Resistive Barrier

The vapour-permeable sheathing membrane on the exterior face of the wall sheathing functions as the WRB. A variety of products can be used in this application, including mechanically fastened or self-adhered sheet products and liquid-applied materials. The membrane is sufficiently vapour-permeable to reduce the risk of moisture being trapped in the assembly. Taping or sealing joints at the exterior face of low-permeance insulation reduces the risk of water reaching behind the insulation and supports durable water control.

Air Barrier

This assembly can accommodate several air barrier strategies, but the exterior approach using the sheathing membrane is typically the most straightforward. Structural support for the air barrier is provided by the sheathing and exterior insulation. Maintaining air barrier continuity at transitions and penetrations is critical to performance. See [Air Barrier Systems](#) on page 9 for more information.

Exterior Insulation Types

Various types of exterior insulation can be used in this assembly, including permeable options such as semi-rigid or rigid mineral wool. See [Fire Risk](#) on page 16 for guidance on the use of combustible insulation types in above-grade wall assemblies.

Vapour Barrier

Exterior insulation helps keep the sheathing warm and reduces the risk of condensation. An interior vapour barrier is still used unless most of the total R-value is located outside the sheathing. Polyethylene sheet products are typically used as the interior vapour barrier in this type of assembly.

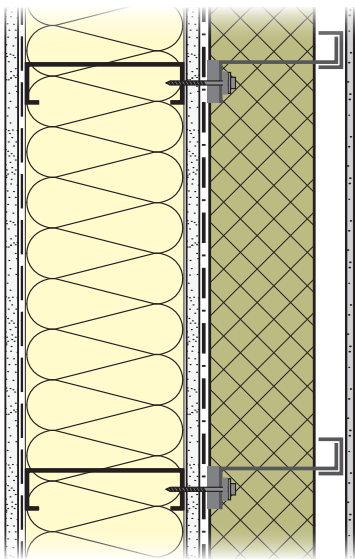


Figure 4-2 W-7 | Split Insulation Steel Stud Wall

Effective Assembly R-value for 6" Split Insulated Steel Stud Wall (R-20 Batt) [ft²·°F·hr/Btu]								
Full-Height Backup Wall Effective R-value (includes slab): R-8.3								
+ Exterior Insulation Thickness	R-value/inch of Exterior Insulation							
	R-4.0				R-5.0			
	Percentage Effectiveness of Exterior Insulation							
	70%	80%	90%	100%	70%	80%	90%	100%
3"	8.4	9.6	10.8	12	10.5	12	13.5	15
4"	11.2	12.8	14.4	16	14	16	18	20
5"	14	16	18	20	17.5	20	22.5	25
6"	16.8	19.2	21.6	24	21	24	27	30
7"	19.6	22.4	25.2	28	24.5	28	31.5	35
8"	22.4	25.6	28.8	32	28	32	36	40
Grey text = results in less than R-22 effective when added to backup wall R-value								

5 | Mid-Rise Concrete Construction

This section provides guidance on concrete wall enclosure assemblies and other above-grade elements that interface with walls.

Above-Grade Concrete Wall Assemblies

Mass walls can be insulated on the exterior, interior, or on both sides (in the case of Insulating Concrete Forms). Exterior insulation concrete walls are more appropriate for above-grade assemblies both in terms of moisture durability and thermal continuity. The method of cladding attachment through exterior insulation is important to limit thermal bridging through the exterior insulation. Thermally efficient cladding supports and brick ties can be used with this assembly. If interior insulation is used, continuous rigid foam board or spray foam is needed to limit thermal bridging.

See also Insulating Concrete Forms in [9 | Other R-22+ Walls](#) on page 59.

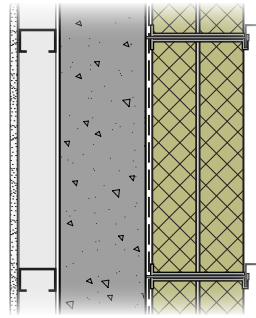


Figure 5-1 Exterior insulation above-grade concrete wall

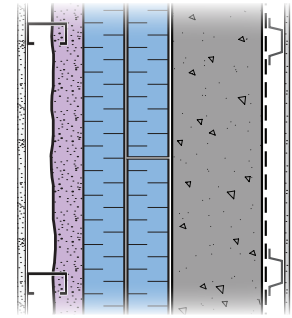


Figure 5-2 Interior insulation above-grade concrete wall

Concrete Slab Edges

Concrete floor slabs that extend beyond the plane of the wall insulation are a major thermal bridge. These interfaces are often overlooked. Interior wall insulation is typically fully interrupted by the slab edge, so it can be difficult to achieve thermal continuity here. A specialty slab edge thermal break may be necessary (see next page). On the other hand, exterior insulation of any depth can be extended over the face of the slab to limit heat loss here. The thicker the exterior insulation, the better. If there is limited depth to the exterior insulation then the wall structure can be set out from the face of the slab edge to make room for more slab edge insulation. Uncontrolled slab edge thermal bridging will dramatically impact the thermal performance of the wall.

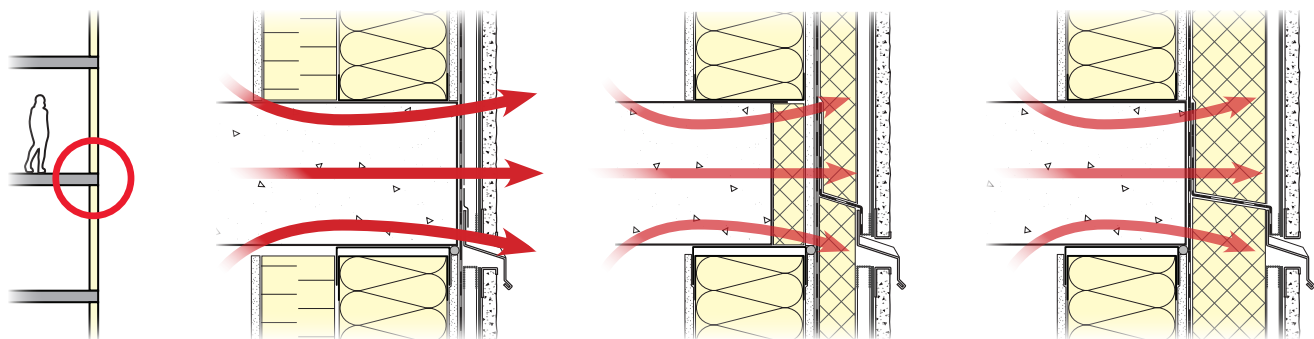


Figure 5-3 Concrete slab edges that extend beyond the plane of the insulation can result in significantly more thermal bridging compared to slab edges covered with insulation.

Concrete Balconies

Concrete balcony slabs that extend beyond the plane of the wall insulation can lead to significant thermal bridging. This is the case regardless of the above-grade wall type and even where exterior insulation is used. If the insulation does not cover or at least wrap a large portion of the concrete elements then concentrated heat loss will occur. This thermal bridging can account for 50% or more of the overall heat loss through the assembly. Proprietary slab edge thermal breaks can work well to significantly reduce the heat loss. A visual comparison of heat loss is shown in Figure 5-4 and Figure 5-5 to the right.

Concrete Podium Slabs

Concrete podium structures are another major thermal bridge at the transition to the above-grade wall. Just like with slab edges and balconies, exterior insulation and thermal breaks are effective tools to limit heat loss here. Extending insulation on the underside and top side of the podium slab at least 24" beyond the face of the wall insulation is another way to reduce heat loss.

Thermal Break Products

Concrete thermal break products are used to reduce heat loss through otherwise continuous concrete elements while still providing the structural support needed. These products are most commonly used at slab edges and balconies to create a separation between interior and exterior concrete elements. They are cast into the slab and use lower conductivity materials including high-strength foam and stainless steel reinforcing that interlock with adjacent concrete and reinforcing. They provide insulation for the concrete without significantly affecting the shape or performance of the concrete elements.

Alternatively, manufactured balcony attachment products that use thermally efficient materials attached at the outside face of the enclosure can also be used to limit thermal bridging through the concrete. Concrete thermal breaks and manufactured balcony products are especially helpful when standard insulation approaches cannot be used to cover concrete, or where balconies extend through wall insulation.

Note that thermal break products for structural steel penetrations are also available and provide similar benefits as concrete thermal breaks.

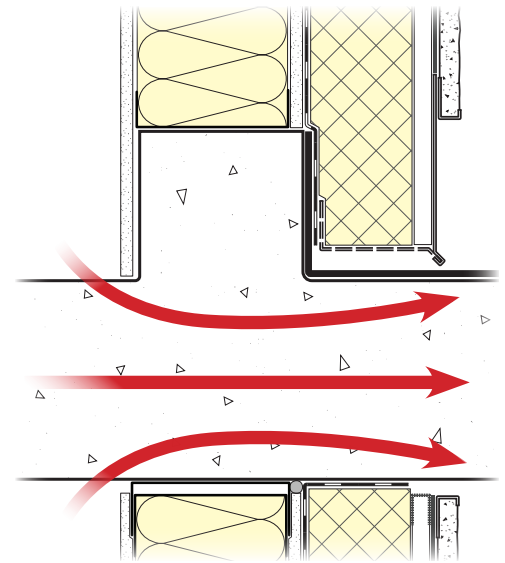


Figure 5-4 Balconies that penetrate the insulation can cause significant thermal bridging.

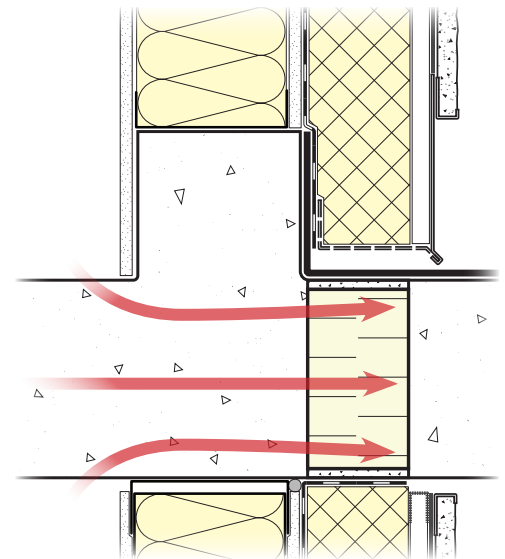


Figure 5-5 Concrete slab thermal breaks allow for continuous concrete elements without significant thermal bridging.

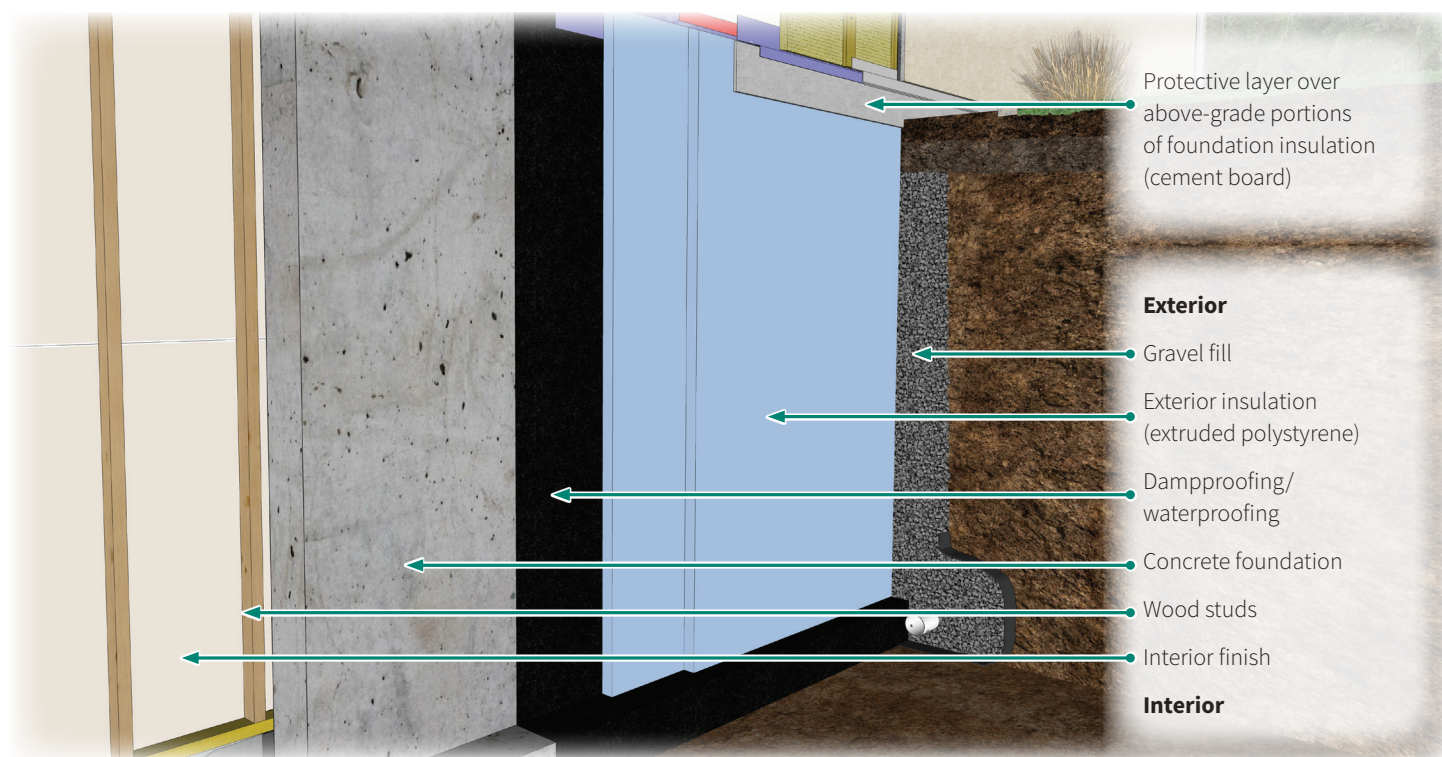
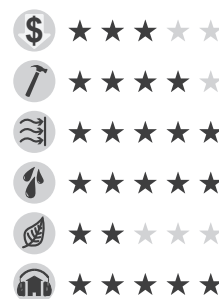
6 | Below-Grade Walls

Below-grade concrete walls form an important part of the thermal enclosure of buildings. This section provides information about two different methods for insulating these walls.

WBG-1 | Exterior Insulation



This below-grade wall assembly consists of rigid insulation placed on the exterior of the concrete foundation wall. An interior service wall is typically constructed to provide room for electrical and plumbing services. High effective R-values are achieved by using continuous insulation outside of the concrete structure. The insulation product used in this arrangement must be highly moisture tolerant and suitable for below-grade applications. In cold climates, insulation on the exterior side of the concrete wall keeps it warmer during cold periods. This often reduces the risk of condensation and damage to moisture sensitive interior wall components and finishes. Exterior insulation improves the long-term durability of the assembly. A drainage layer is provided at the exterior face of the insulation to reduce the amount of moisture that reaches the water control layer on the concrete.



Key Considerations

- Effective below-grade foundation drainage is a key aspect of long-term performance of this wall assembly.
- Continuity of the water resistive barrier, air barrier, vapour barrier, and insulation at the below-grade to above-grade wall transition is important to the overall performance.
- The exterior face of foundation walls can be difficult and expensive to access post-construction. Therefore, it is prudent to design these assemblies conservatively with respect to water penetration.

Drainage

Adequate control of surface water and groundwater is essential for maintaining the long-term water penetration resistance of this assembly. Water is directed away from the wall primarily by an impermeable surface layer at grade, such as a clay cap, sloped away from the building. Porous materials, such as gravel fill or drain mat, direct water that reaches the wall down to the foundation drainage system. If drainage is not possible, such as in areas with a high water table and hydrostatic pressure against the wall, then robust waterproofing is the primary water control layer.

Water Control - No Hydrostatic Pressure (Dampproofing)

An impermeable surface at grade combined with drainage material and exterior insulation forms an effective water control system that limits water reaching the concrete surface. A dampproofing product such as an asphalt-based emulsion or a self-adhered membrane is typically sufficient to resist any water that does reach the concrete. Proper joint and crack control detailing further reduces the risk of water penetration.

Water Control - Hydrostatic Pressure

Robust roofing-grade waterproofing is necessary if the below-grade wall is permanently submerged below the water table.

Air Barrier

The concrete wall is the most airtight element in this assembly and is usually the most straightforward to make the air control layer. It is made continuous with adjacent building enclosure assemblies such as the concrete floor and the above-grade walls using tape, membrane, and sealant.

Insulation

Various types of insulation can be used including extruded polystyrene, high density expanded polystyrene and rigid mineral wool. It is important that the insulation product is extremely moisture tolerant as it can potentially be exposed to significant wetting in this below-grade application.

Vapour Barrier

The concrete foundation wall and water control membrane provide the vapour control in this assembly.

Other Considerations

Untreated wood framing members can experience moisture damage if they are in direct contact with below-grade concrete. A gap or capillary break helps reduce the risk of damage here. Preservative-treated wood framing can also be used.

If insulation is used in the interior wall assembly then insulation ratio requirements would be triggered and an interior vapour barrier would be needed.

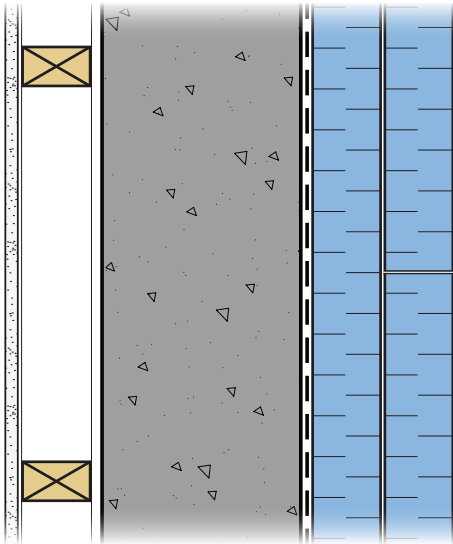


Figure 6-1 WBG-1 | Exterior Insulation Below-Grade Concrete Wall

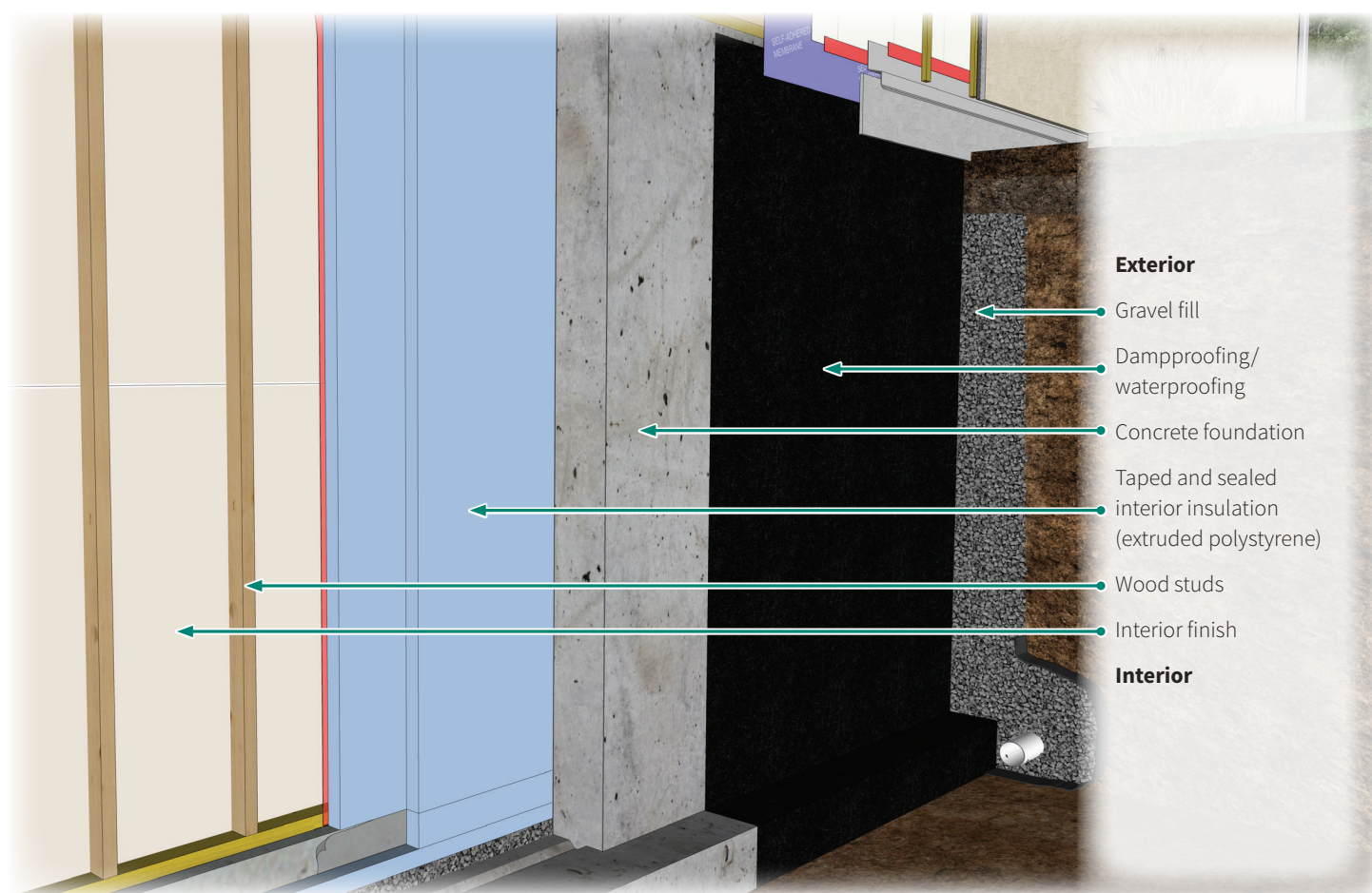
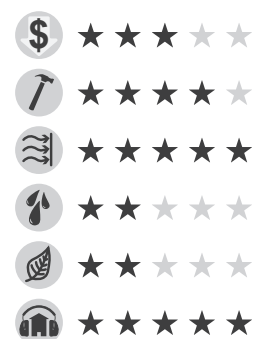
Effective Assembly R-value of Exterior Insulated Below-Grade Wall [ft ² ·°F·hr/Btu]		
Thickness of Exterior Insulation	R-value/inch of Exterior Insulation	
	R-4.0	R-5.0
3 1/2"	16.6	20.1
4"	18.6	22.6
4 1/2"	20.6	25.1
5"	22.6	27.6
5 1/2"	24.6	30.1
6"	26.6	32.6
6 1/2"	28.6	35.1
7"	30.6	37.6
7 1/2"	32.6	40.1
8"	34.6	42.6
Grey text = less than R-22 effective		

WBG-2 | Interior Insulation



This below-grade wall assembly consists of low-permeance moisture tolerant insulation placed in a continuous layer on the interior of the concrete foundation wall. High effective R-values are achieved by using continuous insulation placed between the concrete foundation wall and the interior service wall. Insulation on the interior of the concrete foundation wall results in cooler concrete and this can lead to an increased risk of condensation and associated damage. A robust interior air barrier combined with interior humidity control through adequate ventilation is key to reducing this risk.

Below-grade walls with only interior fibrous batt insulation in a wood-framed wall and with polyethylene sheet pose an unacceptable risk of long-term moisture damage. A continuous layer of airtight low-permeance insulation directly against the concrete is an effective way to address this risk.



Key Considerations

- Effective below-grade foundation drainage is a key aspect of long-term performance of this wall assembly.
- Continuity of the water resistive barrier, air barrier, vapour barrier, and insulation at the below-grade to above-grade wall transition is important to the overall performance.
- The exterior face of foundation walls can be difficult and expensive to access post-construction. Therefore, it is prudent to design these assemblies conservatively with respect to water penetration.

Drainage

Adequate control of surface water and groundwater is essential for maintaining the long-term water penetration resistance of this assembly. Water is directed away from the wall primarily by an impermeable surface layer at grade, such as a clay cap, sloped away from the building. Porous materials, such as gravel fill or drain mat, direct water that reaches the wall down to the foundation drainage system. If drainage is not possible, such as in areas with a high water table and hydrostatic pressure against the wall, then robust waterproofing is the primary water control layer.

Water Control - No Hydrostatic Pressure (Dampproofing)

An impermeable surface at grade combined with drainage material forms an effective water control system that limits water reaching the concrete surface. A dampproofing product such as an asphalt-based emulsion or a self-adhered membrane is typically sufficient to resist any water that does reach the concrete. Proper joint and crack control detailing further reduces the risk of water penetration.

Water Control - Hydrostatic Pressure

Robust roofing-grade waterproofing is necessary if the below-grade wall is permanently submerged below the water table.

Air Barrier

The concrete wall is the most airtight element in this assembly and is usually the most straightforward element to make continuous with adjacent assemblies. However, it is also important that an interior air barrier be maintained to limit condensation risk. Without it there is the potential for relatively warm moist interior air to flow past the insulation and condense on the cool concrete. This interior air barrier can be achieved by sealing the joints between insulation boards or by using spray foam products.

Insulation

Extruded polystyrene (XPS) and closed-cell spray polyurethane foam insulation are typically most appropriate for this application. They are both insensitive to potential moisture within the concrete and they are low-permeance.

Vapour Barrier

The low-permeance foam insulation (i.e., XPS or closed-cell spray foam) provides the vapour barrier in this assembly. No additional vapour barrier is needed on the interior of the wood stud wall unless it is insulated.

Other Considerations

It is possible to use only strapping fastened through the insulation if an interior service cavity is not needed. An interior finish is required to provide fire protection for the foam plastic insulation.

If insulation is used in the interior stud wall assembly then insulation ratio requirements would be triggered and an interior vapour barrier would be needed.

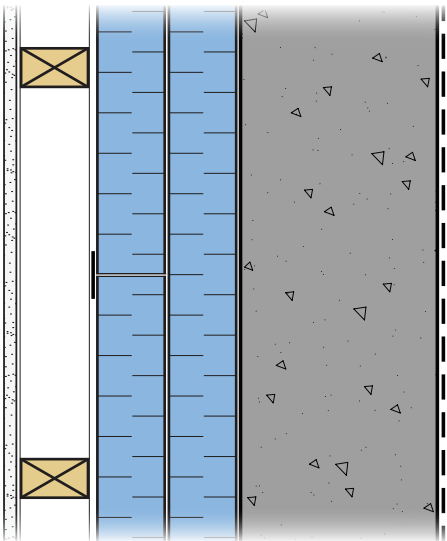


Figure 6-2 WBG-2 | Interior Insulation Below-Grade Concrete Wall

Effective Assembly R-value of Exterior Insulated Below-Grade Wall [ft ² ·°F·hr/Btu]		
Thickness of Interior Insulation	R-value/inch of Exterior Insulation	
	R-5.0	R-6.0
3 1/2"	20.1	23.6
4"	22.6	26.6
4 1/2"	25.1	29.6
5"	27.6	32.6
5 1/2"	30.1	35.6
6"	32.6	38.6
6 1/2"	35.1	41.6
7"	37.6	44.6
7 1/2"	40.1	47.6
8"	42.6	50.6
Grey text = less than R-22 effective		

7 | Walls Less Than R-22 Effective

Wood Stud Walls

Assemblies that will not meet the R-22 effective with standard construction methods and insulation types are outlined below.

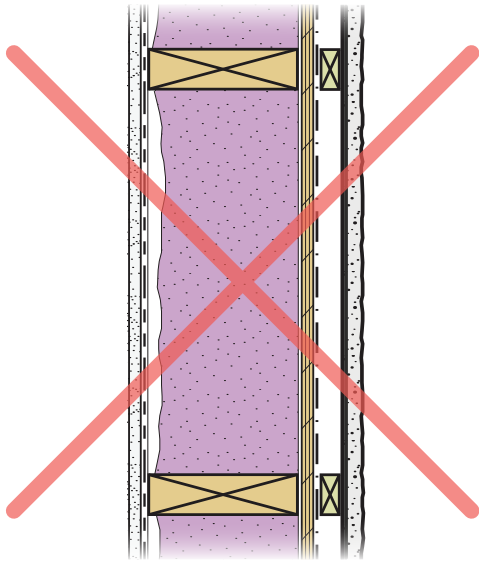


Figure 7-1 2x6 stud walls with insulation only in the stud cavity (regardless of the insulation type)

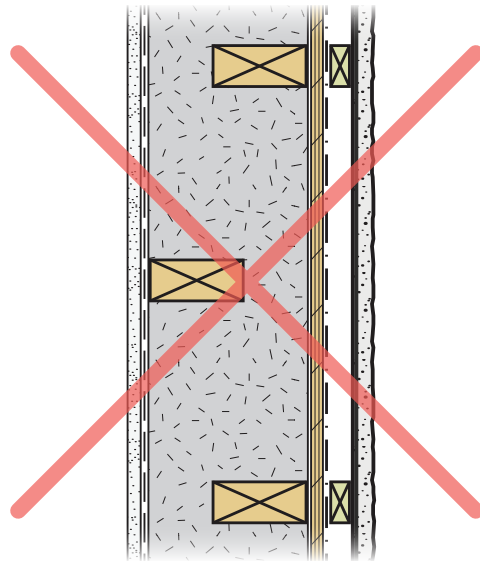


Figure 7-2 2x4 double stud wall on 2x6 plates with staggered overlapping studs or without a gap between the two stud walls

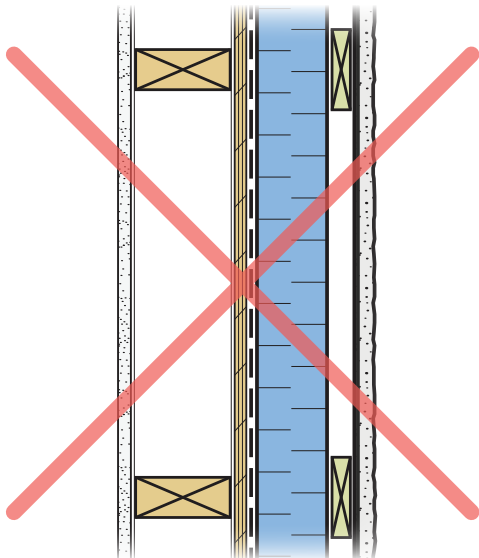


Figure 7-3 Exterior insulation stud wall with 3" or less of Insulation (regardless of the insulation type)

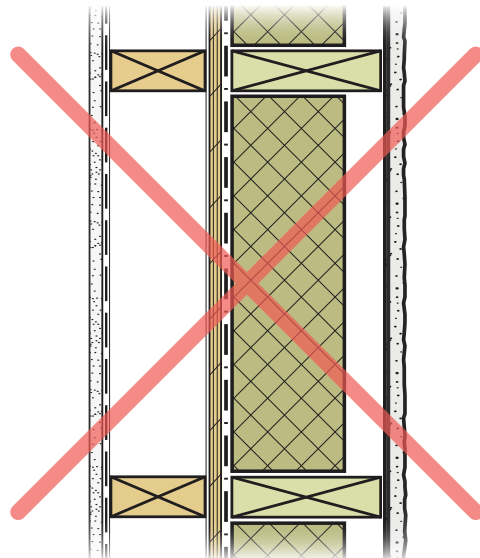


Figure 7-4 Exterior insulation wall with continuous framing and 4" or less of insulation (regardless of the insulation type)

Steel Stud and Concrete Walls

Assemblies that will not meet the R-22 effective requirement using standard construction methods and insulation types are outlined below.

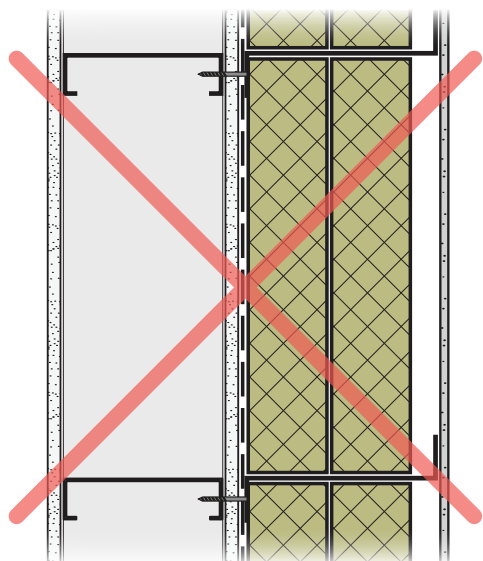


Figure 7-5 Exterior insulation steel stud wall with continuous metal Z-girts and 6" or less of exterior insulation (regardless of the insulation type)

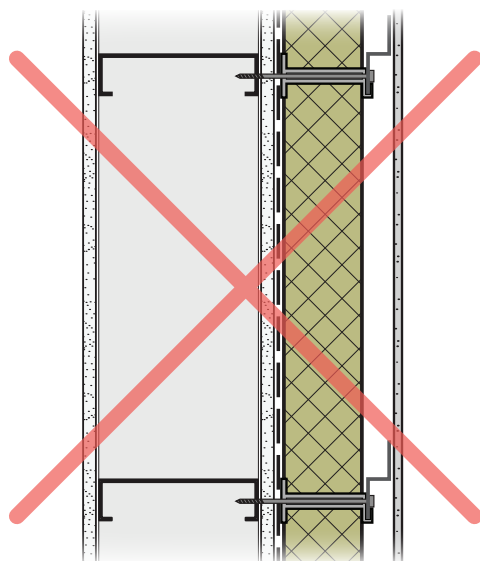


Figure 7-6 Exterior insulation steel stud wall with 3" or less of insulation (regardless of the insulation type)

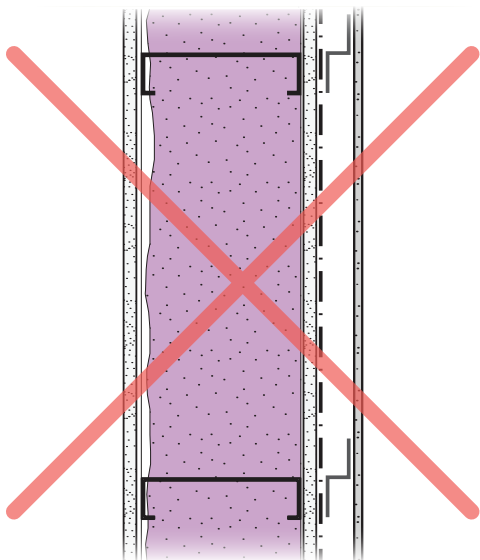


Figure 7-7 6" steel stud walls with insulation only in the stud cavity (regardless of the insulation type)

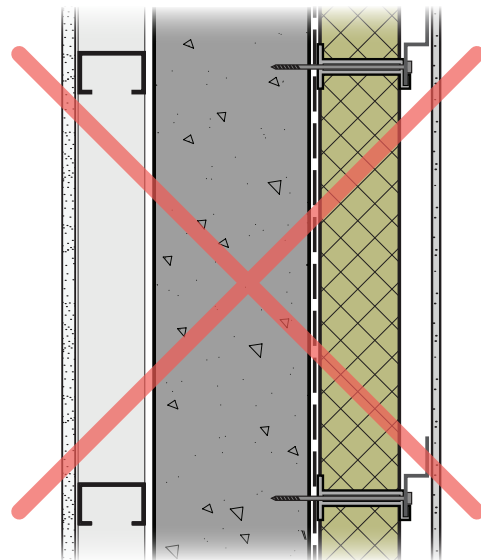
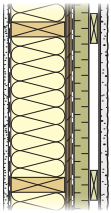
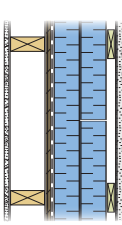
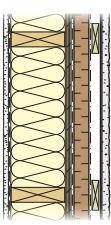
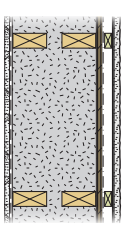
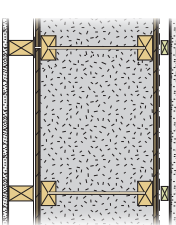
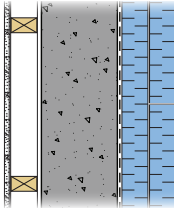
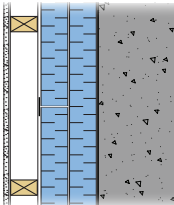
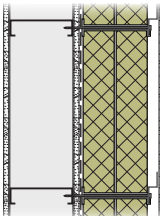
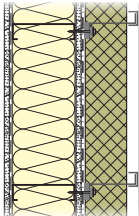
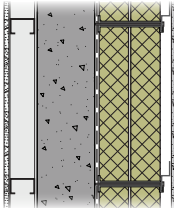
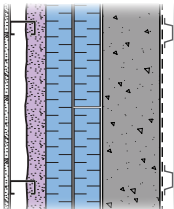


Figure 7-8 Concrete wall with 3" or less of insulation (regardless of the insulation type or placement)

8 | Summary of Wall Assemblies

This section provides a summary of the minimum insulation levels required for each assembly to achieve R-22 effective as well as key considerations for design and construction. The effective R-values of specific assemblies will vary slightly depending on the layers used, but the values provided are intended to be conservative.

Wood Frame	Minimum Insulation Levels to Achieve R-22 Effective	Key Considerations
W-1 Split Insulation 	2x4 Studs (R-12 Batt) + 3" R-4/inch or 2 1/2" R-5/inch Ext. Ins. 2x6 Studs (R-19 Batt) + 1 1/2" of R-4/inch or R-5/inch Ext. Ins. 2x6 Studs (R-22 Batt) + 1" of R-5/inch Ext. Ins. 2x6 Studs (R-24 Batt) + 1" of R-4/inch Ext. Ins.	Vapour permeable sheathing membrane and exterior insulation reduce the risk of moisture being trapped in the assembly. High insulation ratio reduces the risk of condensation on the interior side of the sheathing.
W-2 Exterior Insulation 	2x4 or 2x6 Studs (empty) + 5" R-4/inch or 4" R-5/inch	Limit thermal bridging through the exterior insulation by using efficient cladding attachment systems. Drain mat behind the exterior insulation reduces the risk of liquid water being held against the sheathing membrane.
W-3 Wood fibre 	2x4 Studs (R-12 Batt) + 4" R-3/inch or 3" R-4/inch Ext. Ins. 2x6 Studs (R-19 Batt) + 2" of R-3/inch or 1 1/2" R-4/inch Ext. Ins.	Wood fibre insulation is sensitive to moisture and typically requires a protective water-resistive barrier (WRB).
W-4 Double Stud 	2x4 Double Stud Wall with No Gap and R-5/inch Insulation 2x4 Double Stud Wall with 1/2" Gap and R-4/inch Insulation 2x4 Double Stud Wall with 1" Gap and R-3.4/inch Insulation	Well-consolidated insulation and continuity of the air barrier are fundamental to the performance of this assembly. The lower sheathing temperature due to more interior R-value increases the risk of condensation.
W-5 Deep Stud 	2x8 Stud Wall with R-4 or R-5/inch Insulation 2x10 Stud Wall with R-3.4/inch Insulation 9.5" Engineered Wood I-Joist with R-3.4/inch Insulation	Well-consolidated insulation and continuity of the air barrier are fundamental to the performance of this assembly. The lower sheathing temperature due to more interior R-value increases the risk of condensation.

Below-Grade		Minimum Insulation Levels to Achieve R-22 Effective	Key Considerations
WBG-1 Exterior Insulation		5" R-4/inch Insulation or 4" R-5/inch Exterior Insulation	Effective below-grade foundation drainage is key to long-term performance. Use robust products and detailing because the exterior of foundation walls can be difficult and expensive to access for repairs.
		4" R-5/inch Insulation or 3 1/2" R-6/inch Interior Insulation or 2 1/2" R-5/inch + 2x4 Studs (R-12 Batt)	Effective below-grade foundation drainage is key to long-term performance. Continuity of all controls layers is important. Interior airtightness is need to reduce the risk of condensation on the concrete.
Steel Stud			
W-6 Exterior Insulation		Empty Studs + 6" of R-4/inch or 5" R-5/inch Ext. Ins.	Thermally efficient cladding attachment systems such as fibreglass or stainless steel help reduce the thermal bridging through the exterior insulation. A low-permeance sheathing membrane can serve as both the water-resistive barrier and the vapour barrier in this assembly.
		3.625" Studs (R-12 Batt) + 5" R-4/inch or R-5/inch Ext. Ins. 6" Studs (R-20 Batt) + 4" of R-4/inch or R-5/inch Ext. Ins.	Vapour permeable sheathing membrane and exterior insulation reduce the risk of moisture being trapped in the assembly. High insulation ratio reduces the risk of condensation on the interior side of the sheathing.
Above-Grade Concrete			
Exterior Insulation		6" R-4/inch Insulation or 5" R-5/inch Exterior Insulation	Limit thermal bridging through the exterior insulation by using efficient cladding attachment methods. Exterior insulation over all concrete elements can help reduce thermal bridging.
		4" R-5/inch Insulation or 3 1/2" R-6/inch Interior Insulation	Continuity of insulation is difficult to maintain at concrete floor slabs. Thermal break products can help reduce thermal bridging.

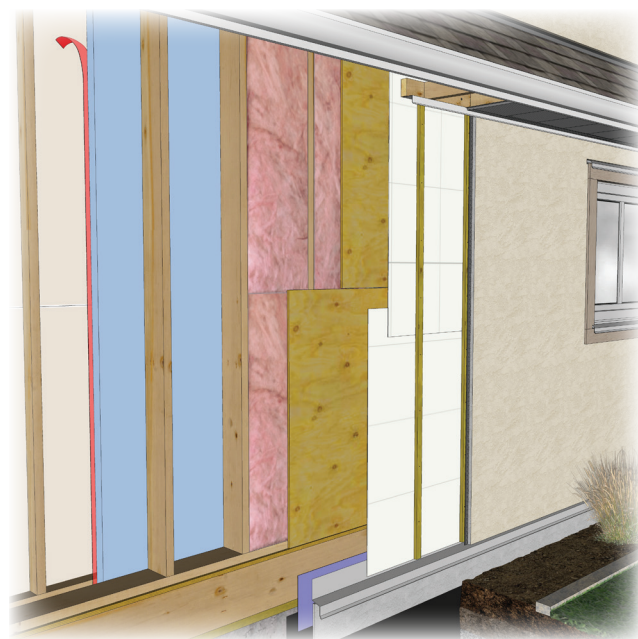
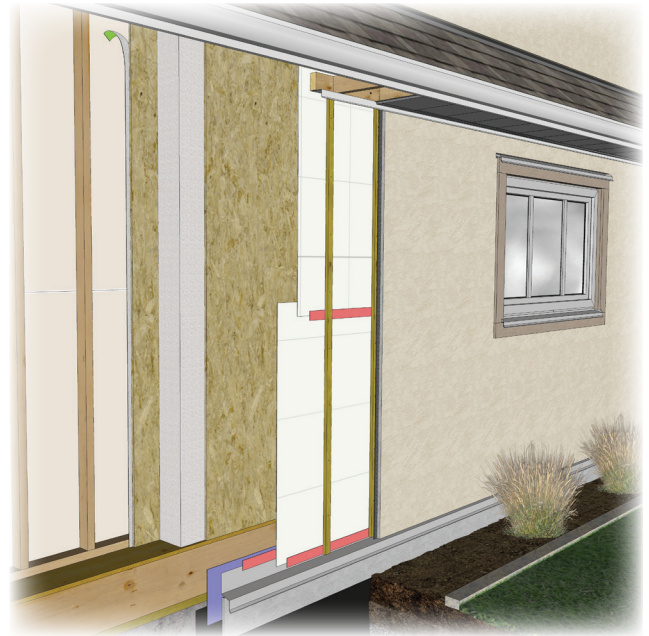
9 | Other R-22+ Walls

This section provides a brief overview of other wall assemblies that could potentially be used to achieve the R-22 effective.

Structurally Insulated Panels

Manufactured structurally insulated panels (SIPs) consist of continuous EPS foam insulation fully adhered between two layers of OSB sheathing. The panels are assembled together on site to form the wall structure and thermal insulation. Typically 5 1/2" of insulation would be required in this assembly to achieve R-22 or greater.

Air barrier continuity of joints between panels can be challenging. Construction tolerances and panel sequencing must be a key focus. Manufacturers will typically provide the relevant details and products specific to their system. Sealing panel joints on the interior and exterior side and filling gaps between panels are key ways to achieve air control. A sheathing membrane is typically installed on the exterior of this assembly to provide the water resistive barrier and a secondary air barrier. An interior service wall is typically used to reduce the penetrations through the SIP.

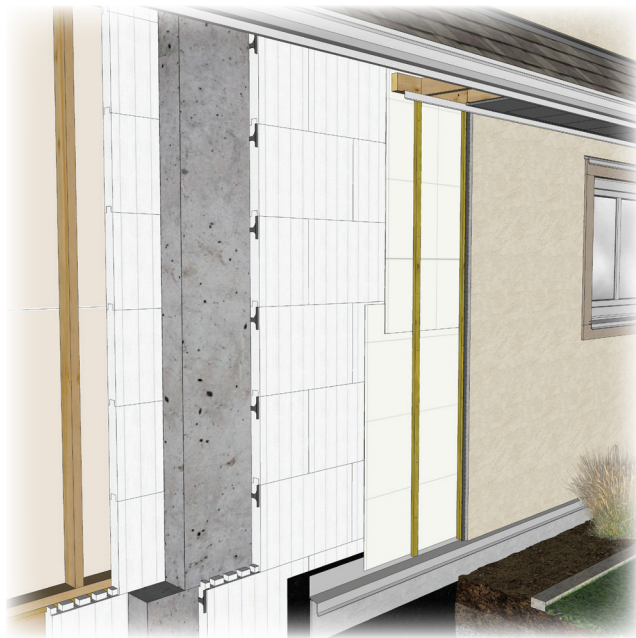
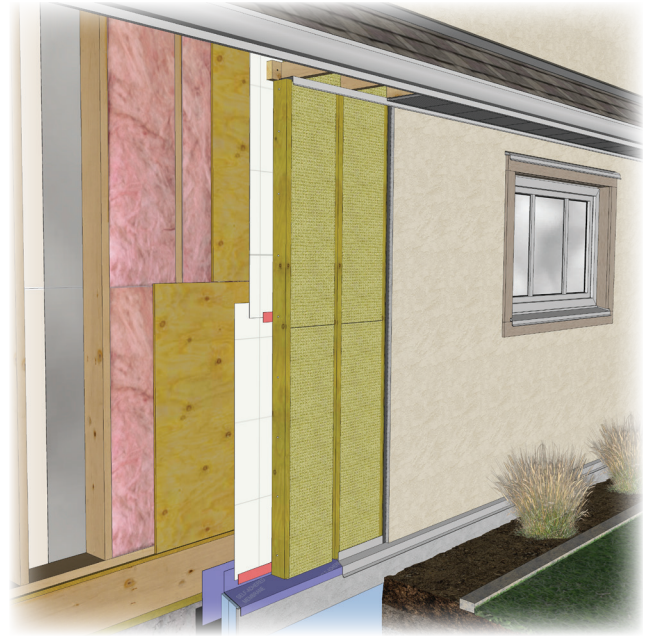


Interior Insulation Above-Grade Wall

This above-grade wall assembly consists of rigid low-permeance insulation boards (typically XPS or EPS) installed on the interior of the insulated stud wall. Like the exterior insulation strategy, this wall uses continuous insulation to efficiently achieve higher R-values. However, like the deeper interior insulated walls, there is a higher risk of condensation on the exterior sheathing. This can be managed by sealing the rigid insulation to provide the interior air barrier. Achieving airtightness can be challenging, as discussed in [Air Barrier Systems](#) on page 9. Interior gypsum wall board can be installed on vertical strapping or a service wall to provide an interior finish as well as fire protection.

Continuous Exterior Wood Girts

This above-grade assembly consists semi-rigid insulation between exterior wood girts on the exterior of a conventional insulated wood-frame wall assembly. The girts provide the cladding support and space for the rainscreen. The continuous wood members that penetrate the exterior insulation reduce the wall R-value similar thermal bridging through stud walls. Therefore additional insulation thickness is typically required to achieve the same thermal performance as continuous insulation. Key considerations for this assembly are similar to those for the W-1 split insulation and W-2 exterior insulation above-grade assemblies.

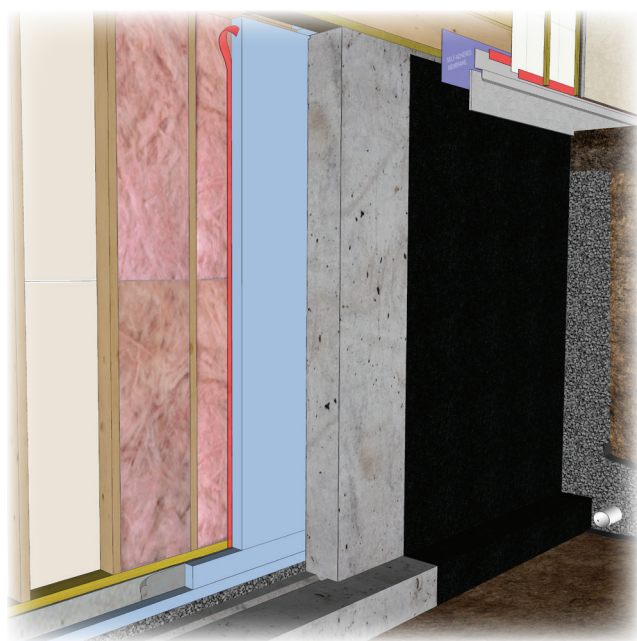
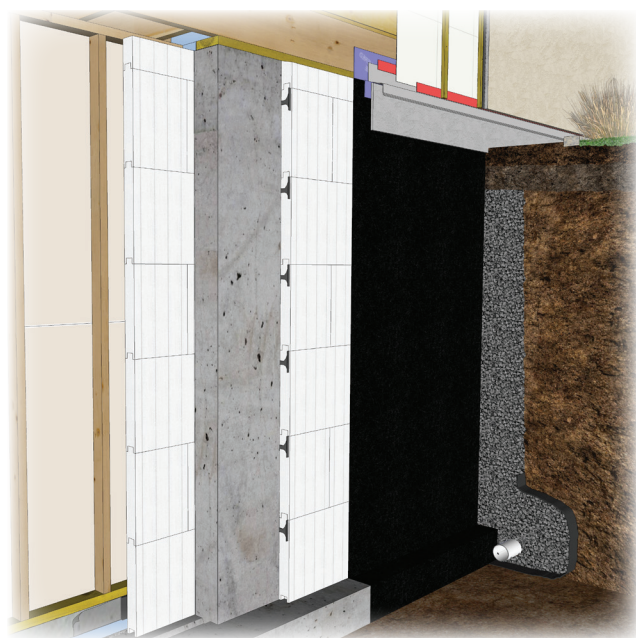


Insulating Concrete Forms (Above-Grade)

Insulating Concrete Forms (ICFs) are manufactured interlocking formwork modules made of rigid EPS insulation. The ICF modules are used as permanent concrete forms and provide thermal insulation. High effective R-values of the assembly are achieved by the combination of the interior and exterior form layers. Typically at least 5" total insulation thickness is needed to achieve R-22 effective. Interior finishes can be installed either directly onto the foam using built-in flanges in the ICF or with an interior stud wall. The concrete is typically the most airtight element in this assembly but it can be hard to access for tie-ins. Careful sequencing is needed to achieve continuity across elements. A dedicated air barrier membrane can also be used. In most cases a dedicated WRB membrane is also needed.

Insulating Concrete Forms (Below-Grade)

This common wall assembly consists of ICF modules used as the permanent concrete formwork and the thermal insulation. High effective R-values of the assembly are achieved by the combination of the interior and exterior form layer. Typically at least 5" total insulation thickness is needed to achieve R-22 effective. Below-grade dampproofing or waterproofing is still needed to control exterior water since the modules are not water tight. It is important to use membrane products that are specifically formulated to adhered to EPS to avoid the risk of delamination and damage. The concrete is typically the most airtight element in this assembly but it can be hard to access for tie-ins. Careful sequencing is needed to achieve continuity across elements. A dedicated air barrier membrane can also be used. Interior finishes can be installed either directly onto the foam using built-in flanges in the ICF or with an interior stud wall.



Interior Rigid Insulation and Batt

This is a variant of the WBG-2 interior insulation below-grade wall. It still uses continuous air-impermeable, moisture tolerant, low-permeance insulation on the interior of the concrete foundation wall. The difference is that this wall also includes batt insulation in the 2x4 interior stud cavity. Insulation in the stud cavity provides additional R-value and can reduce the amount of continuous insulation required. The rigid insulation is still used as the primary air barrier in this assembly, but an interior vapour barrier on the stud wall is still required. Using a smart vapour retarder or vapour barrier paint can help reduce the risk of moisture being trapped in the assembly. At least 2" of continuous rigid foam board or spray foam insulation is required to achieve R-22 and limit the potential for condensation within the wall assembly.

Additional Resources

This guide provides an overview of different assemblies which can potentially be used to meet an R-22 performance requirement. Other resources are also available which provide more detailed information regarding building enclosure systems and design.

Design Guides

- Illustrated Guide—Energy Efficiency Requirements for Houses in British Columbia | BC Housing
(Available at bchousing.org)
- Illustrated Guide—Achieving Airtight Buildings | BC Housing
(Available at bchousing.org)
- Illustrated Guide—Insulated Wood-Frame Vaulted & Flat Roofs for Residential Construction in British Columbia
(Available at bchousing.org)
- Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings | FPInnovations, BC Housing, and the Canadian Wood Council.
(Available at fpinnovations.ca)
- Building Envelope Guide for Houses - Part 9 Residential Construction | BC Housing
(Available at bchousing.org)
- Building Enclosure Design Guide - Wood-Frame Multi-Unit Residential Buildings | BC Housing
(Available at bchousing.org)
- Canadian Home Builder's Association Builders' Manual | Canadian Home Builders' Association
(Available at chba.ca/buildermanual.aspx)
- Canadian Wood-Frame House Construction | Canada Mortgage and Housing Corporation (CMHC)
(Available at cmhc-schl.gc.ca)
- Residential Construction Performance Guide | BC Housing
(Available at bchousing.org)
- Builder's Guide to Cold Climates | Building Science Corporation
(Available at buildingscience.com)
- Pathways to High-Performance Housing in British Columbia | FPInnovations
(Available at fpinnovations.ca)
- LEED v4 and Low Carbon Building Materials – 2017 | BC Ministry of the Environment and Climate Change Strategy
(Available at gov.bc.ca)
- Making Embodied Carbon Mainstream – May 2021 | Pacific Institute for Climate Solutions
(Available at pics.uvic.ca)
- Joint Professional Practice Guidelines - Encapsulated Mass Timber Construction up to 12 Storeys | Architectural institute of BC (AIBC) and Engineers and Geoscientists BC (EGBC) (Available at egbc.ca)

Structural Design Guides and References

- Guide to Attaching Sheathing, Furring and/or Cladding through Continuous Foam Insulation to Wood Framing, Steel Framing, Concrete and CMU Substrates with TRUFAST SIP TP, SIP LD and Tru-Grip Fasteners | NTA Inc.
(Available at trufast.com)
- External Insulation of Masonry Walls and Wood Framed Walls | The National Renewable Energy Laboratory
(U.S. Department of Energy) (Available at ntis.gov)
- Rockwool - ComfortBoard (IS) Deflection Testing | Building Science Corporation
(Available at rockwool.com)
- Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing | Foam Sheathing Coalition
(Available at hunterpanels.com)

Technical Information

- Study of Moisture-Related Durability of Walls with Exterior Insulation in the Pacific Northwest | Building Science Corporation.
(Available at buildingsciencelabs.com)
- Wall Thermal Design Calculator | Canadian Wood Council
(Available at cwc.ca)
- Building Envelope Thermal Bridging Guide | BC Hydro and BC Housing
(Available at bchydro.com and bchousing.org)
- ASHRAE Handbook of Fundamentals | American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
(Available at ashrae.org)
- Builder Insight 08 - Compatibility of Fasteners and Connectors with Residential Pressure Treated Wood | BC Housing
(Available at bchousing.org)
- Sound Insulation of Sustainable Building Facades Report No. A1-014306.1 | National Research Council of Canada
(Available upon request from NRC)
- Road and Rail Noise: Effects on Housing | Canadian Mortgage and Housing Corporation
(Available at publications.gc.ca)
- Burden of disease from environmental noise: quantification of healthy life years lost in Europe | World Health Organization
(Available at who.int)
- Sound Transmission of Wood-frame Wall Assemblies | BC Housing
(Available upon request from BC Housing)
- Building Smart with Sound Principles and Noise Control in Homes | BC Housing Learning on Demand
(Available at learningondemand.bchousing.org)
- Achieving Real Net-Zero Emission Homes: Embodied carbon scenario analysis of the upper tiers of performance in the 2020 Canadian National Building Code – 2021 | Natural Resources Canada & Builders for Climate Action
(Available at buildersforclimateaction.org)
- Embodied Carbon: A Primer for Buildings in Canada – 2021 | Canada Green Building Council
(Available at cagbc.org)

Embodied Carbon Tools

- LCA Data & Software, Impact Estimator, EcoCalculator and EPD & EBD Services | Athena Sustainable Materials Institute (Available at athenasmi.org)
- Tally 2024 | Tally Whole Building Life Cycle Assessment (Available at choosetally.com)
- Resources | Carbon Leadership Forum (Available at clfbritishcolumbia.com)
- Zero Carbon Building Standards | Canada Green Building Council (Available at cagbc.org)

Acoustical Performance of Enclosure Assemblies

- Study of Sound Transmission of Wood-frame Split Insulation Wall Assemblies Used in BC (BCIT, 2021) (available upon request)
- Sound Insulation of Sustainable Building Facades Report No. A1-014306.1 (NRC, 2019) (available upon request)

Building Codes & Standards

- Vancouver Building By-law (VBBL) 2019 | King's Printer for British Columbia (Available at bccodes.ca)
- British Columbia Building Code (BCBC) 2024 | King's Printer for British Columbia (Available at bccodes.ca)
- British Columbia Fire Code (BCFC) 2024 | King's Printer for British Columbia (Available at bccodes.ca)
- ASHRAE Standard 90.1 | American Society of Heating, Refrigerating, and Air-Conditioning Engineers (Available at ashrae.org)
- National Energy Code of Canada for Buildings | National Research Council Canada (Available at nrc-cnrc.gc.ca)
- Energy Modelling Guidelines | City of Vancouver (Available at vancouver.ca)
- Zero Carbon Building Design Standard | Canada Green Building Council (Available at cagbc.org)

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.



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