



Insulating Sheathing for Residential Construction

Application Guide for:

ROXUL® COMFORTBOARD™ IS

ROXUL®
The Better Insulation™



Prepared by:

buildingscience**consulting**inc

167 Lexington Court, Unit 5
Waterloo, Ontario
Canada N2J 4R9

Primary Author:

John Straube, Ph.D., P.Eng.

Illustrations by Building Science Corporation of Somerville, MA unless otherwise noted.

DISCLAIMER: Building Science Consulting Inc. and Roxul Inc. have exercised due care to insure that the data and information contained in this document is accurate. However, this document is for **general reference use only**. Specific end use applications vary widely as to design, materials, and environments. Thus, what is appropriate in any specific end use application is a determination that must be made independently by the experienced engineer in their own professional judgment. Building Science Consulting and Roxul fully disclaim any liability for any of the content contained in herein whether such liability be premised on a theory of contract, tort, or otherwise.

Contents

INTRODUCTION: WHAT YOU WILL FIND IN THIS GUIDE	2
BUILDING SCIENCE FOR COMFORTBOARD IS WALLS	4
<i>A functional overview of the building enclosure</i>	4
<i>The “Perfect” Wall</i>	5
Rain Penetration Control	6
<i>Drained Screen Approach</i>	6
<i>Selection of Drainage Plane Material</i>	8
<i>Recommendations for rain penetration control</i>	8
Air Control	11
<i>Basic requirements of Air Barrier Systems</i>	12
Thermal Control	13
<i>Thermal bridging</i>	13
<i>Condensation Control</i>	15
<i>Cladding attachment through Continuous Insulation</i>	17
<i>Recommendations for thermal control by climate zone</i>	19
Vapor Control	21
<i>Inward Vapor Drive</i>	21
<i>Recommendations for vapor control by climate zone</i>	23
MATERIAL PROPERTIES	25
INSTALLATION DETAILS	27
o1. “Thick ci” Cladding Attachment System	28
o2. Foundation-to-Wall Interface	31
o3. Floor Slab-to-Wall Interface	33
o4. Inside Corner – Horizontal Section	35
o5. Outside Corner – Horizontal Section	37
o6. Punched Window Interface – Installation Sequence	39
o7. Wall-to-Balcony Interface	43
o8. Wall-to-Roof Interface	45
REFERENCES AND RESOURCES	47

Introduction: What You Will Find in this Guide

This application guide covers the use of ROXUL COMFORTBOARD™ IS in residential construction for low- and mid-rise buildings in continental North American locations.

The use of Insulating Sheathing (IS)—rigid or semi-rigid insulation board products installed to the exterior of the building structure—is becoming more common in all parts of North America with recent changes to energy efficiency requirements in building codes and standards.

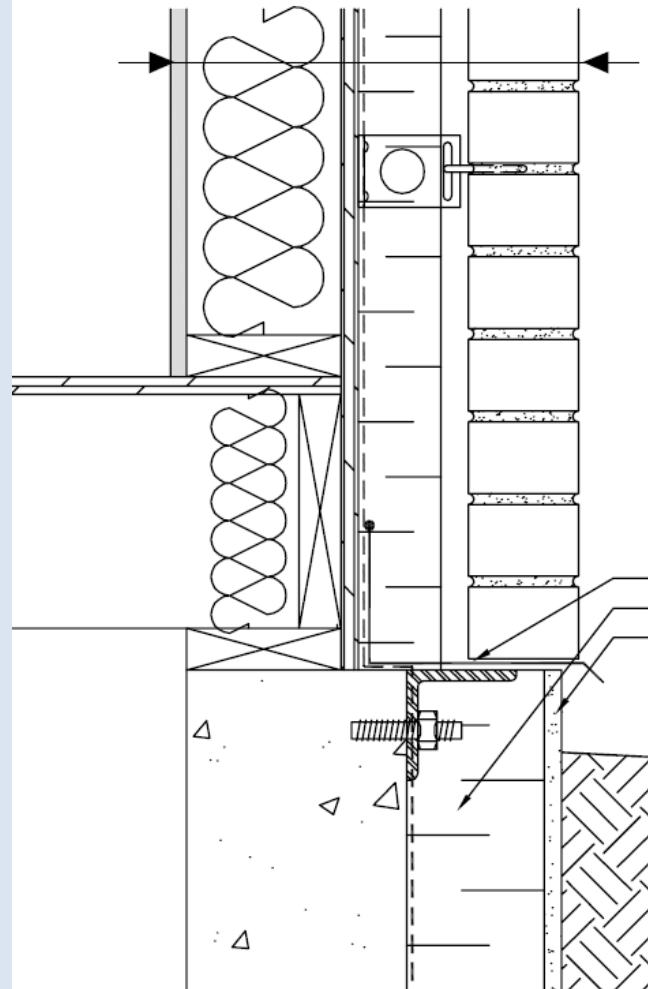
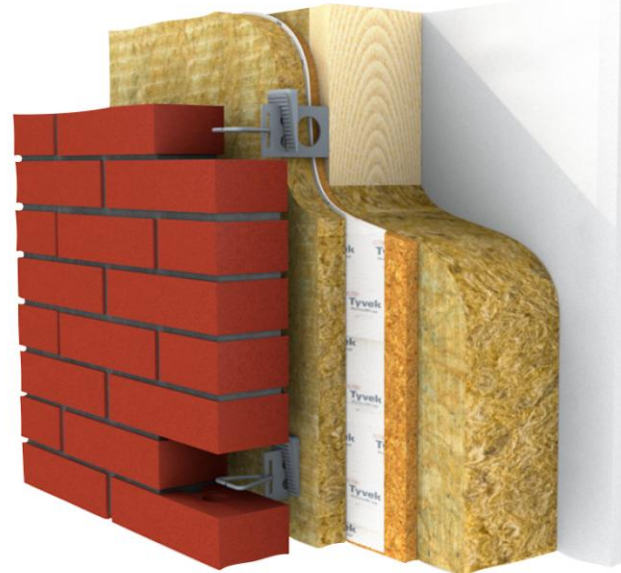
In cold climates the use of exterior insulating sheathing boards has been a method of increasing the thermal performance of the enclosure, as well as a means of reducing the condensation potential with exterior wall assemblies. While insulating sheathing was initially used on cold climates for these reasons, the benefits associated with increased thermal performance make it a viable technology in other climate zones as well.

Modern enclosure design has improved performance of residential wall assemblies in other ways as well by including an air barrier system to control movement of air and a drainage plane to control rain water intrusion. These changes, combined with now widespread use of light claddings (non-self-supporting), has created a number of new challenges, including:

- Detailing drained screen assemblies to manage water intrusion in high exposure areas
- Maintaining continuity of exterior air barrier systems through penetrations and interfaces with other enclosure elements
- Providing continuous thermal insulation and minimizing or eliminating thermal breaks caused by structure and other enclosure penetrations
- Detailing cladding attachment for light- and mid-weight cladding systems

This guide describes the use of ROXUL® COMFORTBOARD™ IS to meet these challenges for residential wall assemblies.

Inside, you will find a building science primer with recommendations by climate zone and a series of best practice enclosure detail drawings.





Here are some examples of buildings addressed by this guide.

Detached House

Single unit, light wood frame construction; up to 3 storey's in height. Typically one or two family dwelling.

This type of building is typically covered by the IRC (International Residential Code) building code in the US; and Part 9 of the NBCC (National Building Code Canada) in Canada.

Row (Town) House

Single unit, light wood frame construction with one or more common party walls up to 3 storey's in height. Typically one or two family dwelling.

This type of building is typically covered by the IRC (International Residential Code) building code in the US; and Part 9 of the NBCC (National Building Code Canada) in Canada.

MURB – Multi-Unit Residential Building

Multi unit residential building of wood frame construction; typically in the townhouse style and/or 3-4 storey's in height. 5-6 storey, wood frame, residential buildings have become more common in parts of North America.

Buildings of this type over 3 storey's in height are covered by the IBC (International Building Code) building code in the US; Buildings over 3 storey's in height, or with a building area over 600m² are covered by Parts 3,4,5 and 6 of the NBCC (National Building Code Canada) in Canada.

Wood-Frame Commercial Building

Low-rise wood frame construction; typically used in low rise commercial and light industrial buildings. Wood-frame commercial buildings of this type are often built using similar techniques to building low-rise wood-frame residential buildings.

Buildings of this type are covered by the IBC (International Building Code) building code in the US. In Canada buildings of this type up to 3 storey's in height and less than 600m² in building area, and belonging to Groups C, D, and E are covered by Part 9 of the NBCC (National Building Code Canada). Low- and Medium- hazard Group F industrial buildings are also covered by Part 9 in Canada.

Building Science for COMFORTBOARD IS Walls

A functional overview of the building enclosure

The building enclosure is defined as the physical component of a building that separates the interior environment from the exterior environment: it is an environmental separator. In general, the physical function of environmental separation can be further grouped into three useful sub-categories as follows:

1. **Support**, i.e., to support, resist, transfer and otherwise accommodate all structural loading imposed by the interior and exterior environments, by the enclosure, and by the building itself. The enclosure, or portions of it, can sometimes be an integral part of the building superstructure either by design or in actual performance.
2. **Control**, i.e., to control, block, regulate and/or moderate all the loadings due to the separation of the interior and exterior environments. This largely means the flow of mass (rain, air, water vapor, pollutants, etc.) and energy (heat, sound, fire, light, etc.).
3. **Finish**, i.e., to finish the surfaces at the interface of the enclosure with the interior and exterior environments. Each of the two interfaces must meet the relevant visual, aesthetic, durability and other performance requirements.

Control and support functions must continue across every penetration, every interface and every assembly. The lack of this continuity is the cause of the vast majority of enclosure performance problems.

For physical performance, the most common required enclosure control functions include resistance to: rain penetration, air flow, heat transfer, condensation, fire & smoke propagation, sound and light transmission (including view, solar heat, and daylight), insect infestation and particulate penetration, and human access. As these functions are required everywhere, continuity of these control functions, especially at penetrations, connections and interfaces between materials, is critical to a successful enclosure.

The most important control function with respect to durability is rain control followed by air control, thermal control, and vapor control. The level of fire and sound control required varies with code requirements and owner requirements. This guide will provide recommendations for residential wall construction with insulating sheathing for rain control, air control, thermal control, and vapor control.

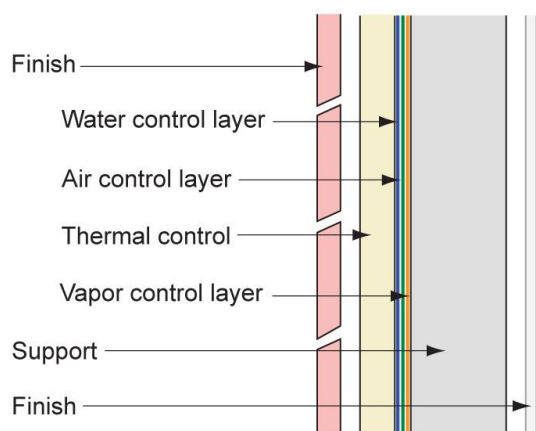


Figure 1: The "perfect" wall

The "Perfect" Wall

The support/control/finish components of a typical enclosure assembly are presented in a conceptually "perfect" sequence in Figure 1.

The concept diagram shows an exterior finish layer (the "cladding") outside of the thermal, air, vapor, and water control layers, which in turn are to the exterior of the building structure and interior finishes.

By locating the heat flow control layer (insulation) on the exterior of the structure and by locating the combined air, water, and vapor control layers between the structure and the insulation, the

structure and control layers are protected from UV exposure, impact, and temperature extremes, thereby increasing the durability of the critical control layers. Such a strategy works well in all climate zones, from Northern heating-dominated climates to hot and humid Southern climates.

Most residential walls include insulation in the structural cavity – which doesn't follow the sequence of layers described above. The typical residential wall is a balance of performance, cost, and constructability issues.

Residential structures typically use a relatively non-conductive structural frame—the structure is wood and wood material based. Cavity fill insulation is also typically less expensive and since the space for insulation is provided by the structural cavity, there is no need for special attachment details. There is a performance compromise with this approach, however, because the insulation within the structural cavity lowers the temperature of the exterior sheathing during wintertime conditions, increasing the risk of condensation. This risk can be managed with the use of insulating sheathing and is described in more detail in the following sections.

The idea of the perfect wall is intended to guide designers on the proper principles during concept design. The same approach can be extended for other enclosure elements such as roofs and foundations and should be used to ensure continuity of the enclosure control layers when designing details describing the connection between enclosure components such as control joints, window and mechanical penetrations. The details provided in this guide use this approach.

Rain Penetration Control

There are three recognized design strategies to control rain penetration within and through the enclosure: Storage, Drained Screen, or Perfect Barriers.

In a Storage (or Mass) approach, it is assumed that water penetrates the outer surface of the wall and then is eventually removed by drying to the inside or outside. The maximum quantity of rain that can be controlled is limited by the storage capacity available relative to drying conditions. Some examples of mass systems include adobe walls, thatched roofs, solid multi-wythe brick masonry, and single-wythe block masonry that is still employed for some modern buildings.

Drained enclosures assume some rainwater will penetrate the outer surface (hence the cladding “screens” the rain) and therefore the assembly must be designed to remove this water by providing drainage (comprised of a capillary breaking drainage plane, a drainage gap, flashing, and weep hole/drain). Many cladding systems, such as brick veneer and stucco, leak, as do the joints between other cladding types, such as shakes, terra-cotta, small metal panels, or natural stone. For these cladding types drainage is a practical and successful system of rain penetration control.

Perfect Barrier systems stop all water penetration at a single plane. Such perfect control required the advent of modern materials. Because it is difficult to build and maintain a perfect barrier with many materials, it is common to recommend the use of drained walls. However, some systems, usually factory built, provide wall elements that are practical perfect barriers. For example, architectural precast concrete can be considered watertight, as can glazing, and roof membranes. The joints between perfect barrier elements should almost always be drained joints in the form of two-stage sealant joints or similar.

Drained Screen Approach

The drained screen approach is considered to be best practice for rain control for residential buildings using insulating sheathing.

The term “rain screen” is applied to some drained systems, but the term is imprecise, as it means different things to different people. Drained walls may also be vented (a single, or single line of openings in the cladding connected to the exterior), ventilated (at least two openings through the cladding usually distributed between the top and bottom of the cavity), or even pressure-moderated (the air pressure in vented & ventilated walls tends to follow the exterior wind pressure, thereby “moderating the pressure”). Rain screen is applied loosely to all three different types of drained walls.

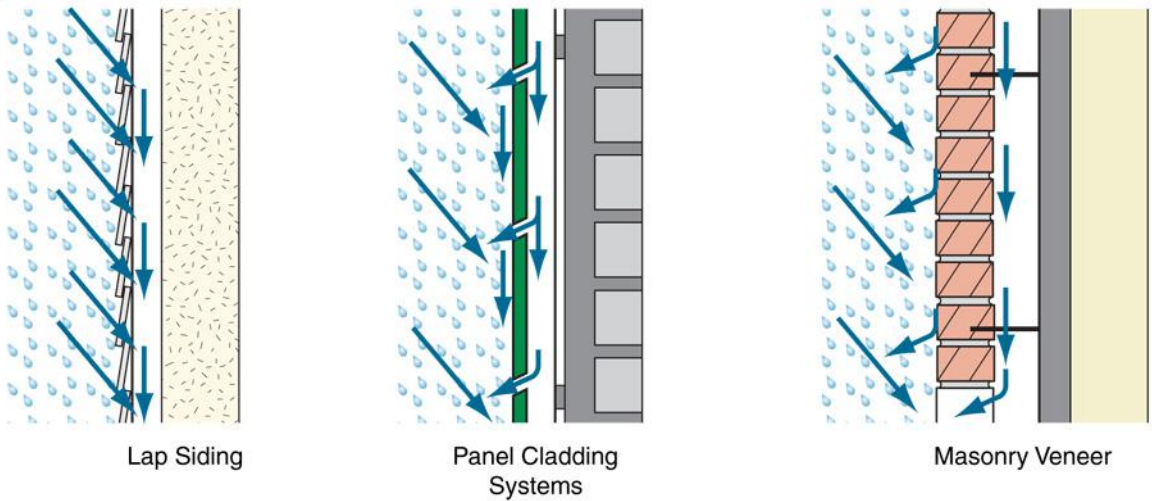


Figure 2: “Screened” and Drained enclosure walls

As drained systems can accommodate a range of claddings and backup systems, this approach to rain control has justifiably received a lot of attention from researchers and practitioners.

Selection of Drainage Plane Material

Drainage planes are water repellent materials (building paper, house wrap, sheet membranes, etc.) that are located behind the cladding and are designed and constructed to drain water that passes through the cladding. They are interconnected with flashings, window and door openings, and other penetrations of the building enclosure to provide drainage of water to the exterior of the building. The materials that form the drainage plane overlap each other shingle fashion or are sealed so that water drains down and out of the wall. The drainage plane is also referred to as the “weather resistive barrier” or WRB. A wall design typically has a single primary drainage plane but may have multiple water-shedding layers as part of a comprehensive water management strategy.

The most common drainage plane is “tar paper” or building paper. More recently, the terms “housewrap” or “building wrap” have been introduced to describe building papers that are not asphalt impregnated felts or coated papers such as polyethylene or polypropylene films. Drainage planes can also be created by sealing or layering water resistant sheathings such as a coated structural sheathing. Finally, fully adhered sheet membranes, or trowel and spray applied coatings can act as drainage planes.

Drainage planes can be vapor permeable or vapor impermeable depending on climate, location within the building enclosure or required control function. Building papers and “housewraps” are typically vapor permeable (more than 10 perms) whereas fully adhered sheet membranes and trowel applied coatings are typically impermeable (less than 0.1 perms). There are a few recently developed spray and trowel applied coatings that are semi-vapor permeable (1 to 10 perms) that are likely to see wider application in the near future.

Recommendations for rain penetration control

The significance of rainwater management cannot be over-emphasized: along with the structural support function it is usually this functional requirement that defines an enclosure design approach.

The climate and the site play a large role in defining the rain exposure that a building is exposed to. The amount of annual rainfall is one factor in gauging the rain exposure for a wall assembly (see Figure 3 below) but this is modified by the coincidence of rainfall with wind events, the orientation of the building, and height of the building. Most parts of the world experience a significant amount of wind-driven rain, and those areas exposed to typhoons can have extreme exposure conditions. While this type of climate demands good rain control strategies for enclosure walls, the rain deposited on walls can be significantly reduced by good design and siting.

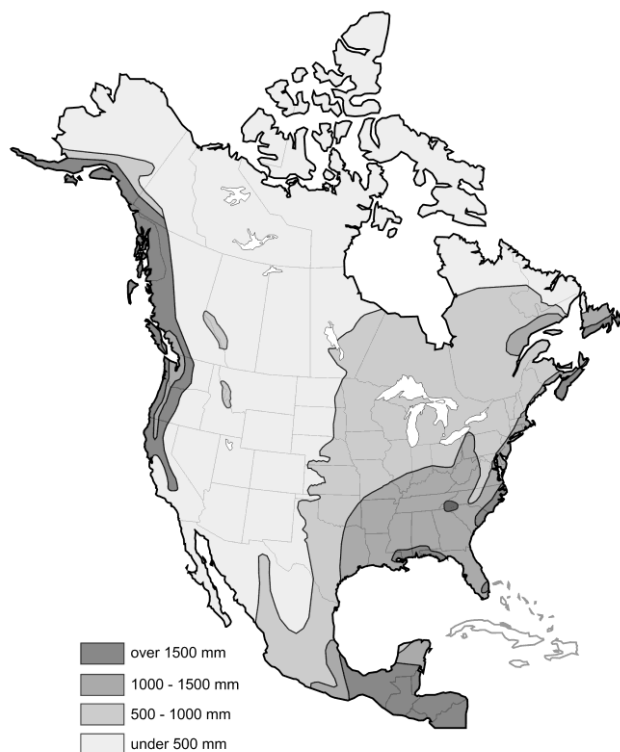


Figure 3: Annual Rainfall Map

(From Building Science Corporation. Based on information from the U.S. Department of Agriculture and Environment Canada)

Drained Screen Wall Recommendations

Screened wall systems are inherently more forgiving than either mass or perfect barrier systems. Properly designed and built screened wall systems will provide economical and durable rain penetration control. Failures in screened systems tend to occur because drainage was not provided (either through a design or construction failure).

The most reliable and widely applicable approach is to follow the mantra:

“Deflection, Drainage/Exclusion/Storage, and Drying”.

Proper siting of the building and the use of sloped hip roofs and generous overhangs deflect driving rain, even for tall buildings. Water on the surface of the wall is shed from and deflected around openings by surface features, drip edges, and protruding flashing. Water is removed from the base of the wall by sloping the grade, and siding is kept at least 8” (200 mm) above grade to protect it from splashes.

Rainwater will penetrate the cladding at joints, laps and penetrations. This water should be removed by drainage through a drainage space and redirected to the exterior by the use of waterproof flashing with all lap joints sealed.

Water will remain within the drainage cavity, will be absorbed into the cladding, and may even penetrate into the structural sheathing or stud space. This water should be removed by drying to the exterior and the interior by allowing diffusion drying and ventilating the space behind the cladding.

Window Installation

Perhaps the most common rainwater control failure occurs at window penetrations. Regardless of which rain penetration control strategy is used, window and door penetrations through a cavity wall should be drained. Sub-sill flashings (see Figure 4) of various types are widely available for this purpose. For drained systems, the flashing can drain into the drainage gap.

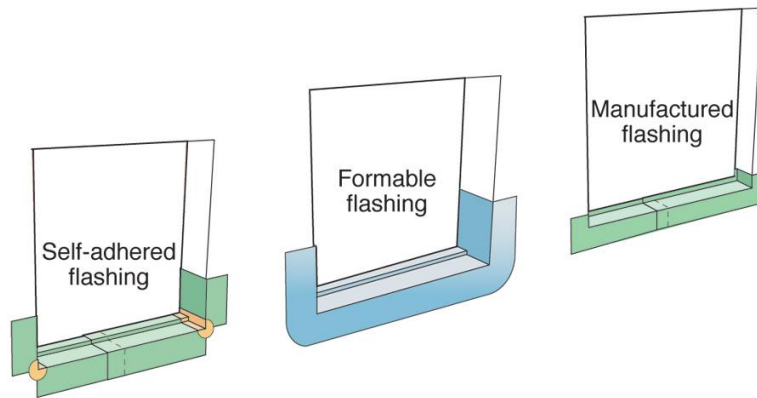


Figure 4: To ensure resistance to rain penetration, sub-sill flashing below all window and door openings is a critical requirement.

Figure 4 shows sub-sill flashing for “punched” (i.e., a window unit within a wall) window openings in a section of wall. Other openings such as large curtain wall sections and patio doors should also be protected with sub-sill flashing. Step-by-step instructions for integration of the window and drainage plane are provided in the details section of this guide.

Air Control

There are three primary classes of reasons why the control of air flow is important to building performance:

1. Moisture control – water vapor in the air can be deposited within the enclosure by condensation and cause serious health, durability, and performance problems.
2. Energy savings – air leaking out of a house must be replaced with outdoor air, which requires energy to condition it. Approximately 30% to 50% of space conditioning energy consumption in many well-insulated houses is due to air leakage through the building enclosure. Air movement within the enclosure, either through low-density insulation or in spaces around insulation can reduce the effectiveness of thermal insulation and thus increase energy transfer across the enclosure.
3. Comfort and health – cold drafts and the excessively dry wintertime air that results from excessive air leakage directly affect human comfort, wind-cooled portions of the interior of the enclosure promote condensation which supports biological growth which in turn affects indoor air quality, airborne sound transmission control requires good airflow control, and odors and gases from outside and adjoining buildings often annoy or cause health problems.

There are other circumstances that require the control of air flow; for example, to control smoke and fire spread through air spaces and building voids and shafts in multi-family residential buildings, but these are situations that deal with extreme events, not typical service.

The primary plane of air flow control in a wall is generally called the air barrier. Because such a plane is in practice comprised of elements and joints, the term air barrier system (ABS) is preferred. In framed, low-rise residential buildings, the primary air barrier system is often located on the interior of the exterior wall, comprised of either an inner layer of drywall (sealed around the perimeter and at all penetrations) or sealed polyethylene. However, an exterior air barrier system is preferred because fewer penetrations need to be accommodated and it is more easily inspected. An exterior ABS can be constructed using outer layers of sheathing (such as gypsum, waferboard, and fiberboard) with tapes or sealed housewrap. Unsealed housewrap or building paper provides additional resistance to out-of-plane air flow through the enclosure assembly. In many modern building assemblies, exterior sheathing is designed and detailed to be part of an outboard air barrier system and additional layers providing resistance to air flow are provided to the interior. Note that the plane of airtightness labeled by the designer (and all building sections should indicate what is intended to be the air barrier) or builder as the air barrier system may not in fact act as the ABS if that plane is not made continuous through all construction details.

Basic requirements of Air Barrier Systems

Typically, several different materials, joints and assemblies are combined to provide an uninterrupted plane of primary airflow control. Regardless of how air control is achieved, the following five requirements must be met by the air barrier system (ABS):

1. **Continuity.** This is the most important and most difficult requirement. Enclosures are 3-D systems! ABS continuity must be ensured through doors, windows, penetrations, around corners, at floor lines, soffits, etc.
2. **Strength.** If the ABS is, as designed, much less air permeable than the remainder of the enclosure assembly, then it must also be designed to transfer the full design wind load (e.g., the 1-in-30 year gust) to the structural system. Fastenings can often be critical, especially for flexible non-adhered membrane systems.
3. **Durability.** The ABS must continue to perform for its service life. Therefore, the ease of repair and replacement, the imposed stresses and material resistance to movement, fatigue, temperature, etc. are all considerations.
4. **Stiffness.** The stiffness of the ABS (including fastening methods) must reduce or eliminate deflections to control air movement into the enclosure by pumping (movement of the air barrier pulls and pushes air into and out of enclosure cavities). The ABS must also be stiff enough that deformations do not change the air permeance (e.g., by stretching holes around fasteners) and/or distribute loads through unintentional load paths.
5. **Impermeability.** Naturally, the ABS must be impermeable to air. Typical recommended air permeability values are less than about $1.3 \times 10^{-6} \text{ m}^3/\text{m}^2/\text{Pa}$. However air barrier materials are commonly defined as materials which pass less than $Q < 0.02 \text{ lps/m}^2 @ 75 \text{ Pa}$. Although this is an easy property to measure it is not as important as might be thought. In practice, the ability to achieve other requirements (especially continuity) are more important to performance, and the air “permeance” of joints, cracks, and penetrations outweighs the air permeance of the solid materials that make up most of the area of the ABS. Hence, a component should have an air leakage rate of less than $Q < 0.2 \text{ lps/m}^2 @ 75 \text{ Pa}$, and the whole building system should leak less than $Q < 2.0 \text{ lps/m}^2 @ 75 \text{ Pa}$.

Joints, penetrations, and transitions are the critical link in achieving airtightness. At penetrations and transitions, details must show how an uninterrupted, strong and airtight plane continues from the wall element to other components of the enclosure such as windows, roof and foundation assemblies, while accommodating dimensional construction tolerances and in-service movements.

Thermal Control

As society demands that residential buildings consume less energy and generate less pollution, minimizing the flow of heat through the enclosure has become an increasingly important function for the enclosure to perform. The control of heat flow is also important for the control of interior surface temperatures, and hence ensuring human comfort and avoiding cold weather condensation. Controlling the temperature of various elements and layers within an enclosure assembly can be used to avoid condensation or enhance drying, both of which influence durability.

R-value is commonly used to measure the thermal control of insulation products. However, this metric does not account for the impacts of thermal bridging, air leakage, installation quality, or thermal mass. It is this multitude of factors that working together delivers good thermal control.

Thermal bridging

Heat flow is often greater at corners, window frames, intersections between different assemblies, etc. When heat flows at a much higher rate through one part of an assembly than another, the term thermal bridge is used to reflect the fact that the heat has bypassed the thermal insulation.

Thermal bridges become important when:

- they cause cold spots within an assembly that might cause performance (e.g., surface condensation), durability or comfort problems
- they are either large enough or intense enough (highly conductive) that they affect the total heat loss through the enclosure

Thermal bridging can severely compromise thermal control and comfort in some building types. Heat flow through steel stud walls is dominated by heat flow through the metal components (see Figure 5).

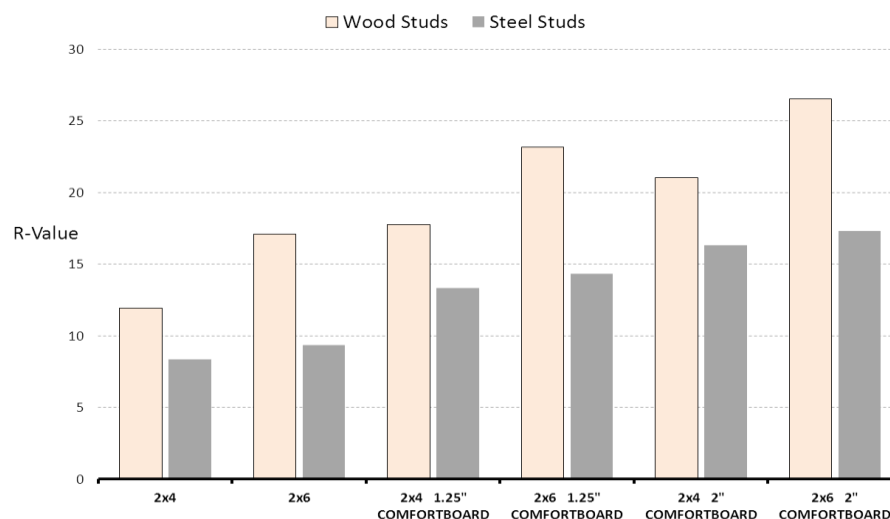


Figure 5: Best case R-values for walls with no extra framing for windows, floors or partitions.

Failure to break these thermal bridges can reduce the R-value of the insulating components by 50 to 80%.

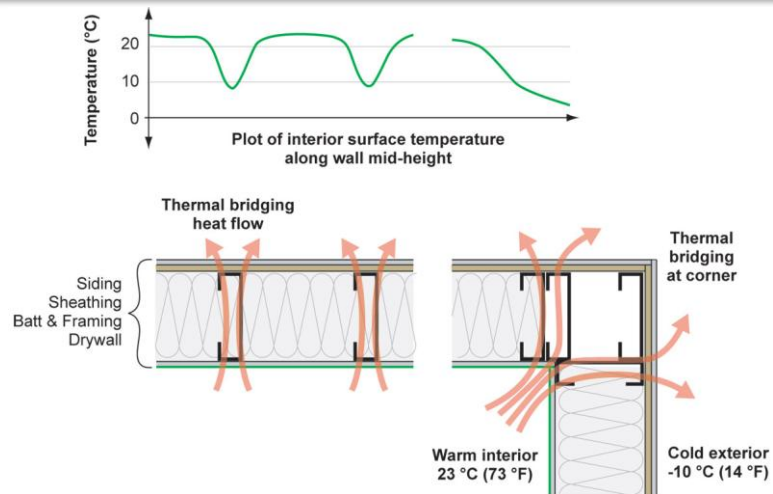


Figure 6: Thermal bridging can cause local temperature depressions during cold weather, resulting in condensation, mold growth, and staining.

For these reasons, continuous exterior insulation is recommended in all residential buildings.

Condensation Control

Air leaking outward through the enclosure wall in cold weather will contact the back of the sheathing in framed walls and can form condensation. This condensation can accumulate as frost in cold weather, and subsequently cause “leaks” when the frost thaws and liquid water drains down, or cause rot if the moisture does not dry quickly upon the return of warmer and sunnier weather.

In walls with sufficient exterior insulation, the temperature at the back of the sheathing will be above the dewpoint temperature of the interior air: therefore condensation due to air leakage cannot occur within the stud space. If an assembly is shown by calculation to be safe against air leakage condensation (using the ratio of exterior-to-interior insulation method described below – Table 1), then diffusion condensation cannot occur, even if absolutely no vapor resistance is provided inside of the sheathing (i.e., no vapor barrier or other control layer), and even if the sheathing is a vapor barrier (such as foil-faced insulations).

The interior conditions within a building during cold weather are critical variables in understanding the risk of condensation, and must be known if predictions and calculations are to be made. Interior temperatures are often in the 70 °F / 21 °C range, but relative humidity levels, and thus air moisture content, can vary significantly. In most office, school, and retail occupancies, ventilation rates are high enough that the RH during winter months is in the range of 25 to 35%. In some residential occupancy, the interior moisture generation is higher and exterior air ventilation rate lower than commercial occupancies, and hence the RH will often be higher. In special occupancies, such as swimming pools, both the interior temperature and relative humidity levels will be higher (78°F/25 °C and 60%RH), resulting in very high absolute humidity levels.

The moisture content of the exterior air always drops at very cold conditions as the maximum air moisture content drops. As outdoor conditions become colder, the interior RH drops because interior moisture is diluted by increasingly dry exterior air. This effect provides some protection against condensation, as the coldest week of the year is likely to coincide with some of the lowest interior humidity levels.

The interior moisture content is usually defined by a combination of temperature and relative humidity. More direct metrics are absolute humidity or humidity ratio, usually expressed in grams of water per kg of dry air (or grains of water per pound of dry air). However, practically speaking, the most useful measure is the dewpoint temperature of the interior air.

Table 1 provides the level of insulation (sheathing plus airspace and cladding) that should be provided outside of a stud space filled with air permeable insulation (i.e., batt or blown fibrous insulation) to prevent cold-weather exfiltration condensation. It can be seen that mild temperatures and dry interior air require little exterior insulation to control condensation, whereas a museum maintained at 50% in Fairbanks, Alaska or Yellowknife, Northwest Territories should have essentially all of the insulation on the exterior.

Table 1: Ratio of exterior-interior insulation to control air leakage condensation

Indoor		RH	20	25	30	35	40	50	60
Dew point		°C	-3.0	0.0	2.5	4.7	6.6	9.9	12.7
		°F	26.6	32.0	36.6	40.5	44.0	49.9	54.8
T _{outdoor}	°C	°F							
	0	32	0.00	0.00	0.12	0.23	0.32	0.47	0.60
	-5	23	0.08	0.19	0.29	0.37	0.45	0.57	0.68
	-10	14	0.23	0.32	0.40	0.48	0.54	0.64	0.73
	-15	5	0.33	0.42	0.49	0.55	0.60	0.69	0.77
	-20	-4	0.41	0.49	0.55	0.60	0.65	0.73	0.80
	-25	-13	0.48	0.54	0.60	0.65	0.69	0.76	0.82
	-30	-22	0.53	0.59	0.64	0.68	0.72	0.78	0.84
	-35	-31	0.57	0.63	0.67	0.71	0.74	0.80	0.85
-40	-40	0.61	0.66	0.70	0.73	0.76	0.82	0.86	

If the sheathing layers are very vapor permeable (e.g., ROXUL COMFORTBOARD IS over fiberboard or gypsum sheathing, and housewrap) then very little insulation value is required outboard of the stud bay. However, while these permeable layers can essentially eliminate vapor diffusion condensation risks with lower exterior sheathing R-values, the risk of air leakage condensation does not drop as much: air leakage may still deliver more water vapor to the back of the sheathing than can be removed by diffusion through the sheathing, and hence condensation could still occur and accumulate.

For important projects or situations in which the design team has little historical experience, investigation using widely available computer models such as WUFI Pro would be prudent if the necessary time and skills are available.

Cladding attachment through Continuous Insulation

Cladding attachment is a common question when assemblies with exterior continuous insulation ("ci") are proposed. Although solutions for semi-rigid stonewool insulation boards are not currently widely used in all parts of North America, they are simple, straightforward, and time tested in Europe and other parts of the world. Two methods of cladding attachment are considered here:

- a **"Thin ci" approach** for ROXUL COMFORTBOARD IS thicknesses of 1.5" (38 mm) and less, where light-weight cladding systems are attached directly to the wall structure through the insulation, and
- a **"Thick ci" approach** for ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm), where light-weight or mid-weight cladding systems are attached to furring that is itself fastened to the structure through one or more layers of insulation

1.5" represents a practical limitation to the **"Thin ci"** approach because this is the maximum thickness that commonly available fasteners can span to reach the wall structure. In addition, insulating sheathing of all types has long been used by the industry at thicknesses of up to 1.5" or 38 mm and hence there is experience with its installation and detailing.

For light-weight cladding systems, such as vinyl siding, wood siding, and fiber cement siding or panels, on low rise buildings that are not in a high wind design area, the **"Thin ci"** cladding attachment approach is appropriate. This approach takes advantage of the compressive strength of the insulation to support the cladding (see Figure 7 below).

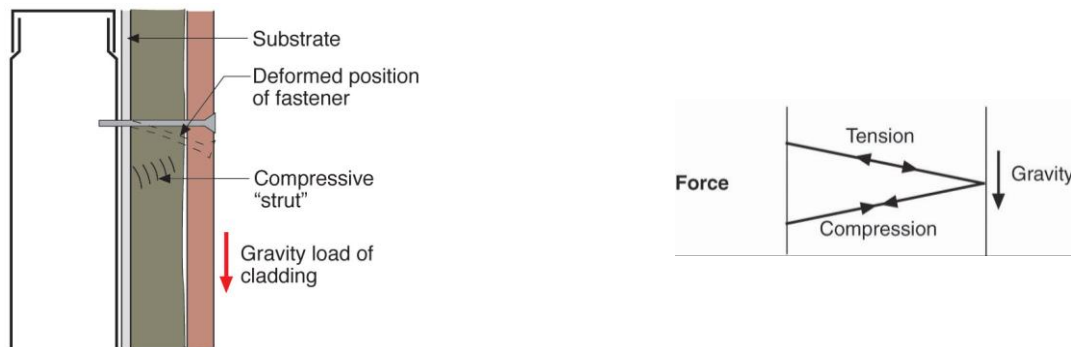


Figure 7: A "strut-and-tie" model can be used to explain the remarkable strength and stiffness that is achieved through the use of standard furring strips screw fastened through insulating sheathing. This low-cost and high-performance approach can be used to support gravity loads for most lightweight claddings.

For ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm), light-weight and mid-weight (stucco, manufactured stone veneer) cladding, systems must be attached using the **"Thick ci"** approach. This approach requires that furring or "strapping" first be attached through the insulation, often with long fasteners, directly to the wall structure. The cladding is then attached to the furring (see Figure 8 below).

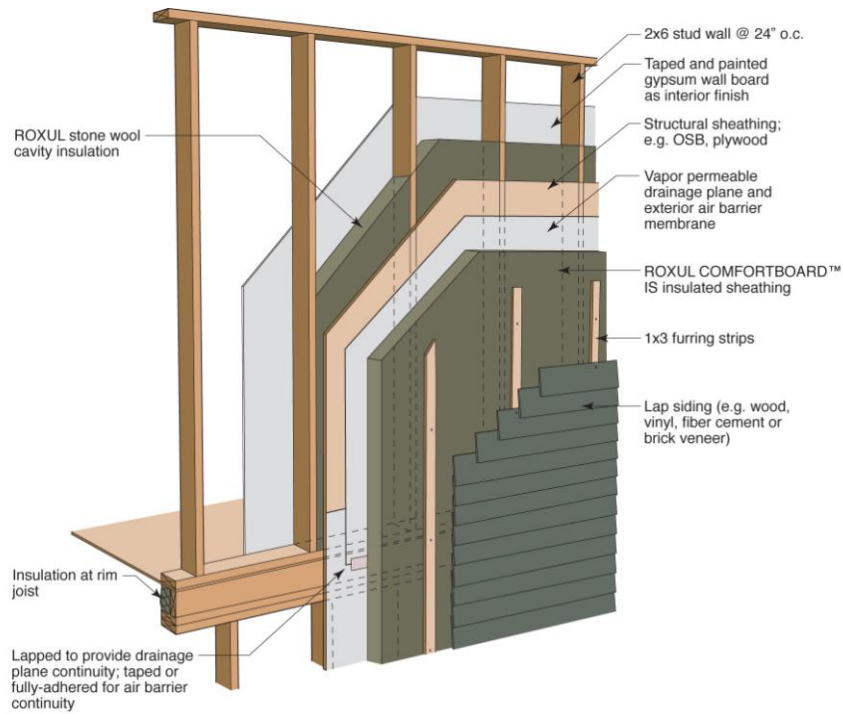


Figure 8: Example of “Thick ci” cladding attachment approach

More information on the “**Thick ci**” approach can be found in the details section of this application guide.

For larger buildings and heavier cladding systems, the required structural connections often need a different design approach to accommodate a continuous insulation with minimal thermal bridging. Traditionally, relieving or shelf angles are used to collect the gravity load of heavy masonry veneers every one or two floors. For heavy-weight cladding attachment systems, please see the application guide for ROXUL® CAVITYROCK® insulation.

Recommendations for thermal control by climate zone

Figure 9: North American Climate Zone Map
(based on ASHRAE Standard 90.1-2007)



Zone 1	1A - Very Hot-Humid with $5000 < \text{CDD}_{10^{\circ}\text{C}} < \text{CDD}_{50^{\circ}\text{F}}$ 1B - Dry with $5000 < \text{CDD}_{10^{\circ}\text{C}} < \text{CDD}_{50^{\circ}\text{F}}$
Zone 2	2A - Hot-Humid with $3500 < \text{CDD}_{10^{\circ}\text{C}} \leq 5000$ ($6300 < \text{CDD}_{50^{\circ}\text{F}} \leq 9000$) 2B - Dry with $3500 < \text{CDD}_{10^{\circ}\text{C}} \leq 5000$ ($6300 < \text{CDD}_{50^{\circ}\text{F}} \leq 9000$)
Zone 3	3A - Warm-Humid with $2500 < \text{CDD}_{10^{\circ}\text{C}} < 3500$ ($4500 < \text{CDD}_{50^{\circ}\text{F}} \leq 6300$) 3B - Dry with $2500 < \text{CDD}_{10^{\circ}\text{C}} < 3500$ ($4500 < \text{CDD}_{50^{\circ}\text{F}} \leq 6300$) 3C - Warm-Marine with $\text{CDD}_{10^{\circ}\text{C}} \leq 2500$ AND $\text{HDD}_{18^{\circ}\text{C}} \leq 2000$ ($\text{CDD}_{50^{\circ}\text{F}} \leq 4500$ AND $\text{HDD}_{65^{\circ}\text{F}} \leq 3600$)
Zone 4	4A - Mixed-Humid with $\text{CDD}_{10^{\circ}\text{C}} \leq 2500$ AND $\text{HDD}_{18^{\circ}\text{C}} \leq 3000$ ($\text{CDD}_{50^{\circ}\text{F}} \leq 4500$ AND $3600 < \text{HDD}_{65^{\circ}\text{F}} \leq 5400$) 4B - Dry with $\text{CDD}_{10^{\circ}\text{C}} \leq 2500$ AND $\text{HDD}_{18^{\circ}\text{C}} \leq 3000$ ($\text{CDD}_{50^{\circ}\text{F}} \leq 4500$ AND $3600 < \text{HDD}_{65^{\circ}\text{F}} \leq 5400$) 4C - Mixed-Marine with $2000 < \text{HDD}_{18^{\circ}\text{C}} \leq 3000$ ($3600 < \text{HDD}_{65^{\circ}\text{F}} \leq 5400$)
Zone 5	5A - Cool-Humid with $3000 < \text{HDD}_{18^{\circ}\text{C}} \leq 4000$ ($5400 < \text{HDD}_{65^{\circ}\text{F}} \leq 7200$) 5B - Dry with $3000 < \text{HDD}_{18^{\circ}\text{C}} \leq 4000$ ($5400 < \text{HDD}_{65^{\circ}\text{F}} \leq 7200$) 5C - Marine with $3000 < \text{HDD}_{18^{\circ}\text{C}} \leq 4000$ ($5400 < \text{HDD}_{65^{\circ}\text{F}} \leq 7200$)
Zone 6	6A - Cold-Humid with $4000 < \text{HDD}_{18^{\circ}\text{C}} \leq 5000$ ($7200 < \text{HDD}_{65^{\circ}\text{F}} \leq 9000$) 6B - Dry with $4000 < \text{HDD}_{18^{\circ}\text{C}} \leq 5000$ ($7200 < \text{HDD}_{65^{\circ}\text{F}} \leq 9000$)
Zone 7	Very Cold with $5000 < \text{HDD}_{18^{\circ}\text{C}} \leq 7000$ ($9000 < \text{HDD}_{65^{\circ}\text{F}} \leq 12600$)
Zone 8	Subarctic with $7000 < \text{HDD}_{18^{\circ}\text{C}}$ ($12600 < \text{HDD}_{65^{\circ}\text{F}}$)

HDD = Heating Degree Days
CDD = Cooling Degree days

Starting with the climate zone in which the project is located (Figure 9 above); use Table 2 below to find the recommended total R-value of the wall assembly. Recommendations for other enclosure elements are also provided.

Table 2: R-value Recommendations by Climate Zone for each enclosure element

Climate Zone	Wall	Vented Attic	Compact Roof	Basement Wall	Exposed floor	Slab edge ¹	Windows (U/SHGC)	Sub-slab ²
1	10	40	35	5	10	none	yes	none
2	15	50	40	10	20	5	0.35/<0.25	none
3	20	50	45	10	20	7.5	0.30/<0.3	5
4	25	60	45	15	30	7.5	0.30/<0.35	7.5
5	30	65	50	15	30	10	0.24/<0.50	7.5
6	35	75	60	20	40	10	0.18/--	10
7	40	90	65	25	45	15	0.15/--	15
8	50	100	75	35	50	20	0.15/--	20

Table 3: ROXUL COMFORTBOARD IS Thickness to Reach Recommended R-value for Various Wall Assemblies

Nominal R-value	Wall Assemblies with ROXUL® COMFORTBOARD™ IS Thickness		
	2x6 wood frame with R-22 COMFORTBATT	2x4 wood frame with R14 COMFORTBATT	Load bearing clay masonry or CMU
10	-	-	3"
15	-	1"	4" (2+2)
20	-	1.5"	5" (2+3)
25	1"	3"	7" (3+4)*
30	2"	4" (2+2)	8" (4+4)*
35	4" (2+2)	6" (3+3)	9" (6+3)*
40	5" (2+3)	7" (4+3)*	10" (6+4)*
50	7" (4+3)*	9" (6+3)*	12" (6+6)*

* Values in parentheses give the thicknesses of each layer of insulating sheathing required to make up the total thickness. For example, (6+6) would be two layers of 6" thick insulating sheathing to make a total of 12". Standard available thicknesses may vary – please consult www.ROXUL.com or contact sales for details.

CMU = Concrete Masonry Unit

Vapor Control

Although most condensation problems occur because of air leakage, vapor diffusion can also occasionally cause damaging amounts of wetting. However, vapor diffusion is also an important drying mechanism, which may be an important part of a wall assembly design.

Vapor diffusion is the movement of water vapor molecules through the microscopic open pore structure of porous materials (glass, solid plastics, and metals are not porous, wood, gypsum, and concrete are). Vapor diffusion always moves from more to less vapor concentration, but practically this tends to mean from the warm side to the cold side of an enclosure or material layer. As the process is relatively slow, it usually requires weeks or months to move significant quantities of water vapor. Vapor permeance is used to describe the ease of vapor diffusion through a layer of material. A Building Science Digest entitled BSD-106: Understanding Vapor Barriers is available at buildingscience.com for more specific guidance on this topic.

The need for a vapor control layer, and which class, depends strongly on the enclosure design, the air permeance of the insulation layers, the interior conditions, and the exterior climate. The exterior climate is divided into zones from 1 to 8 based on heating degree days (HDD) and cooling degree days (CDD) (see Figure 9 above). The zones are further sub-divided into different exterior humidity levels, indicated by appending the letters A to C (e.g., zone 6C).

The class of vapor control required can be prescribed for many common wall or roof assemblies for interior conditions of normal residential, school, retail, and office occupancy. This means indoor temperatures of around 72 °F (21°C) and indoor winter time relative humidity of less than 40% (less than 35% in zones 7 and 8). Special analysis and unique enclosure details may be required for buildings with higher interior relative humidities.

Table 4: Vapor control layer classification; tested by ASTM E96 dry-cup (Method A)

Class	Permeance		Description
	US perms (gr/hr·ft ² ·inHg)	SI perms (ng/s·m ² ·Pa)	
I	Less than 0.1	Less than 6	Impermeable
II	0.1 to 1.0	6 to 60	Semi-impermeable
III	1 to 10	60 to 600	Semi-permeable
none	Over 10	Over 600	Permeable

Inward Vapor Drive

Inward vapor drive in building enclosures occurs when the cladding absorbs and stores rain water (masonry, stucco, etc.), is heated by the exterior environment and solar radiation. This combination of water and heat energy in the cladding results in an elevated vapor pressure and the moisture is driven into the enclosure. Inward vapor drive is a design concern for buildings in Climate Zones 1 to 4 and for some enclosures with absorptive claddings in other climate zones.

The amount of vapor diffusion is dependent on the vapor pressure gradient, that is, the difference in vapor pressures between two points in the assembly, and the vapor permeance of the building materials.

The most common moisture-related durability issue caused by inward moisture drives is moisture accumulation inside the gypsum wall board as a result of a low permeance coating such as vinyl wall paper, or on the back of low permeance materials installed on the interior of the gypsum wall board such as mirrors, cabinetry, whiteboards, etc. This often results in the formation of mold either on the drywall or the back of the wall covering, and in worst cases, the disintegration of the gypsum wall board.

ROXUL COMFORTBOARD IS is vapor open, so the driven water vapor will pass directly through the insulation. To address moisture related concerns from inward driven moisture in wall assemblies with continuous exterior ROXUL COMFORTBOARD IS, we recommend that the air/water barrier on the exterior of the sheathing have a maximum vapor permeance of 6.5 perms ($376 \text{ ng/Pa} \cdot \text{s} \cdot \text{m}^2$), and that the interior wall covering be latex paint. All low permeance wall coverings such as cabinetry, mirrors etc, should be installed on strapping to allow air flow between the gypsum and the covering. These recommendations are based on BSC's field investigation experience, and hygrothermal simulations and analysis of wall assemblies constructed with continuous exterior ROXUL COMFORTBOARD IS in climate zones 1-4. For more information about this topic, please see "Hygrothermal Simulations and Analysis of Solar-Driven Inward Water Vapor", which is available from ROXUL Technical Services

Recommendations for vapor control by climate zone

Different types of assemblies have different vapor control requirements. Although the requirements can be developed through rational engineering analysis, a simplified summary of recommendations, many from the US ICC (International Code Council) “I” codes, is presented below for the “normal” occupancies described above. Houses with indoor relative humidity levels of over 40%RH when the outdoor temperature is below 20°F (-7°C) for prolonged periods of time require special analysis and often unique enclosure details to prevent moisture problems.

Vapor control recommendations are divided into two categories:

- Assemblies with all or most (more than 75% of the total) of the insulation value located outboard of the structure (framing or solid)
- Framed assemblies with some insulation value outside of the framing or structure

These recommendations apply only to the wall assemblies addressed in this guide. Recommendations for walls in each category are provided below.

Assemblies with all or most (more than 75% of the total) of the insulation value located outboard of the structure (framing or solid)

This is the simplest and most robust wall to design with respect to vapor control. Such walls should ideally have all moisture sensitive components and materials located on the inside of the insulation. In this location, a Class I or II layer on the inside of all or most of the insulation value is acceptable and recommended if all outboard components are moisture tolerant. A Class III layer on the interface of a high permance (more than 10 perms) insulation layer outboard of a moisture-sensitive structure should only be used if warm weather and inward vapor drive condensation are not an issue or are controlled by interior drying, ventilation of the cladding, or other means.

Condensation during warm (humid) weather and condensation caused by vapor driven inward from wetted cladding heated by the sun will occur on the exterior of the vapor control layer: hence it is best detailed as a drainage plane water control layer.

Framed assemblies with some insulation value outside of the framing or structure.

It is desirable to design for drying, especially in warmer climate zones (4 and 5 especially). The use of insulation on the exterior of the sheathing increases its temperature in cold weather, thereby relaxing the need to control cold-weather vapor diffusion. Exterior insulation made of stonewool fibers is highly vapor permeable and when combined with vapor permeable sheathing and membrane layers, enclosures will behave differently than less permeable sheathings/membranes: less R-value of such products are needed to perform well than the rules in this category.

A Class III vapor retarder can be used instead of a Class I or Class II in zones 4c, 5, 6, 7, or 8 where any of the criteria for the specific zone from the list below is met. These criteria may depend upon the climate zone and the ratio of the insulation value in the stud space to insulation value installed outboard of the sheathing.

The insulation value in the stud space is often a function of whether 3.5”, 5.5”, 6” or 8” framing is filled with insulation. Batt products well supported on the open side DO NOT need to fill the whole stud space, and thereby reduce the required insulation value of the exterior continuous insulation layer. Cavity insulations need to be in tight contact on five surfaces: the sixth surface can be open to the interior.

A Class III vapor control layer may be used instead of a Class I or II layer on the interior of framed walls in zone 4c and higher, if any of the following criteria are met:

Zone 4c (e.g., Vancouver, Seattle or Portland)

- Sheathing-to-cavity R-value ratio of >0.20
- Insulated sheathing with an R-value ≥ 2.5 on a 2x4 framed wall
- Insulated sheathing with an R-value ≥ 3.75 on a 2x6 framed wall.

Zone 5 (e.g. Chicago, Windsor, Boston)

- Sheathing-to-cavity R-value ratio of >0.35
- Insulated sheathing with an R-value ≥ 5 (e.g., 1.25" ROXUL COMFORTBOARD IS) on a 2x4 framed wall
- Insulated sheathing with an R-value ≥ 7.5 (e.g., 2" ROXUL COMFORTBOARD IS) on a 2x6 framed wall.

Zone 6 (e.g., Toronto, Ottawa, Helena, Montreal, Halifax, Minneapolis)

- Sheathing-to-cavity R-value ratio of >0.50
- Insulated sheathing with an R-value ≥ 7.5 (e.g., 2" ROXUL COMFORTBOARD IS) on a 2x4 framed wall
- Insulated sheathing with an R-value ≥ 11.25 (e.g., 3" ROXUL COMFORTBOARD IS) on a 2x6 framed wall.

Zones 7 and 8 (e.g. Calgary, Edmonton, Whitehorse, Anchorage, Fairbanks)

- Sheathing-to-cavity R-value ratio of >0.70
- Insulated sheathing with an R-value ≥ 10 (e.g., 2.5" ROXUL COMFORTBOARD IS) on a 2x4 framed wall
- Insulated sheathing with an R-value ≥ 15 (e.g., 3.75" ROXUL COMFORTBOARD IS) on a 2x6 framed wall.

Material Properties

The following tables summarize the relevant material properties for the ROXUL® COMFORTBOARD™ IS insulated sheathing product mentioned in this guide.

ROXUL COMFORTBOARD IS Material Properties Table	
Thermal Resistance	RSI value 0.72 m ² K/W per 25.4 mm @ 24°C
	R-value 4.0 hr · ft ² · F/Btu per inch @ 75°F
	Cold Weather
	RSI value 0.78 m ² K/W per 25.4 mm @ -4°C
	R-value 4.4 hr · ft ² · F/Btu per inch @ 25°F
	Hot Weather
	RSI value 0.70 m ² K/W per 25.4 mm @ 37.8°C
	R-value 4.0 hr · ft ² · F/Btu per inch @ 100°F
Density	128 kg/m ³ (8.0 lb/ft ³)
Compressive Strength	745 psf (35.5 kPa) resistance at 10% compression 1270 psf (61 kPa) resistance at 20% compression
Vapor Permeance	1768 ng Pa · s · m ² (31 perms)
Water Absorption	0.7% by vol
Moisture Sorption	0.05% by weight

About Stone Wool

ROXUL stone-wool insulation is a rock-based mineral fiber insulation comprised of Basalt rock and Recycled Slag. Basalt is a volcanic rock which is abundant in the earth, and slag is a by-product of the steel and copper industry. The minerals are melted and spin into fibers.

Thermal Insulation

Stone wool is an **excellent insulator** and a vital component in an energy efficient building. In fact insulation saves 12 times as much energy per pound in it is first year in place as the energy used to product it. www.naima.org/pages/benefits/environ/effic.html

Sound Absorption

The non-directional fiber orientation of ROXUL stone wool helps the absorption of acoustic waves and **can reduce the intensity and propagation of noise.**

Fire Resistant

Stone wool can withstand temperatures up to 2150°F (1177°C). Consequently is **does not contribute either to the development and spread of fire or the release of toxic gases.**

Water Repellent

Stone wool is water repellent yet vapor permeable. This means the insulation cannot absorb water so the **R-value is not affected.** Additionally it is completely resistant to rot, mildew, mold and bacterial growth, contributing to a safer indoor environment.

Dimensional Stability

Stone wool **retains its characteristics unaltered over time.** It undergoes only minimal changes in size or performance due to the changing conditions of temperature and humidity.

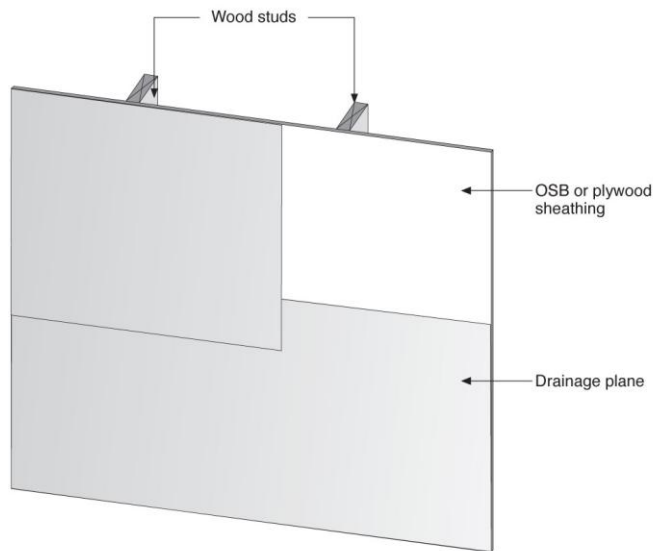
Installation Details

The following drawings illustrate common construction details for residential wall assemblies using the products and building science information provided in this guide. The drawings are not project-specific and, of course, are meant to be modified by the project architect to include selected cladding, structural, and other construction materials. Each drawing, however, clearly labels assembly elements by function and a narrative description of each detail is included.

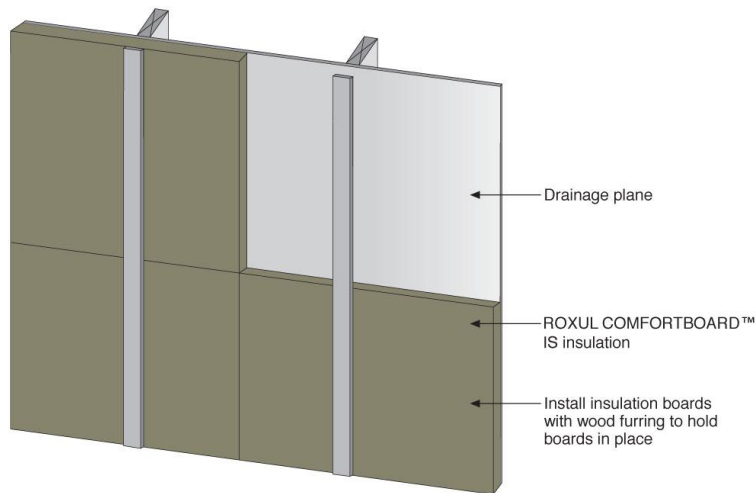
The following details are included in this guide:

01. “Thick ci” Cladding Attachment System
02. Foundation-to-Wall Interface
03. Floor Slab-to-Wall Interface
04. Inside Corner – Horizontal Section
05. Outside Corner – Horizontal Section
06. Punched Window Interface – Installation Sequence
07. Wall-to-Balcony Interface
08. Wall-to-Roof Interface

01. “Thick ci” Cladding Attachment System



Step 1: Install Drainage Plane Material over the Structural Sheathing

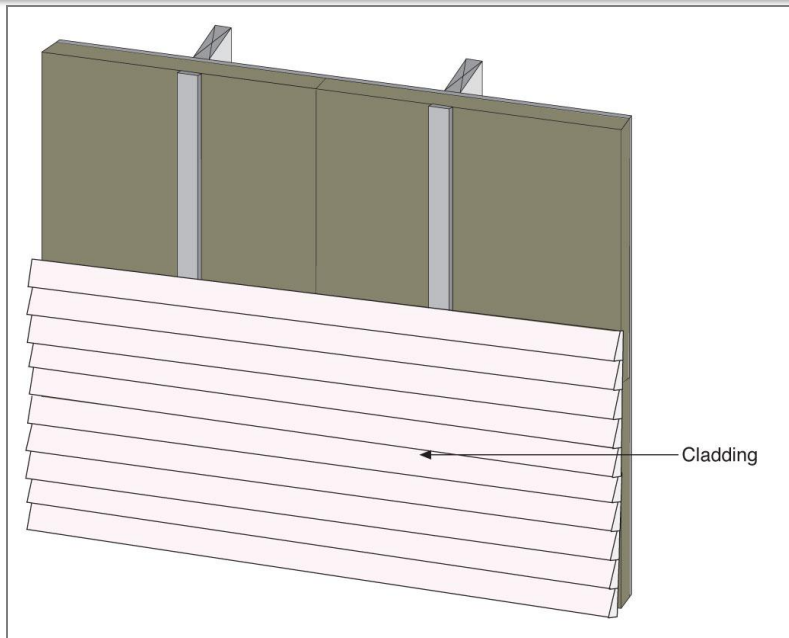


Step 2: Install ROXUL COMFORTBOARD IS and Furring (i.e., strapping)

Board edges should be butted tightly together. Multi-layers should have joints staggered. (no joint sealing is required)

NOTE – if strapping is installed immediately ROXUL COMFORTBOARD IS boards can be temporarily attached to wall. If the insulation is to be left exposed before strapping is installed it needs to be securely mechanically fastened to the building.

Refer to separate ROXUL fastener guidelines for detailed information



Step 3: Install Cladding Material

Install cladding to furring as per cladding manufacturer's instructions.

ROXUL® Building Science Notes

01. GENERAL

- a. Detail is applicable to light-weight cladding systems including vinyl siding, wood siding, and fiber cement siding or panels with ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm). For heavy-weight cladding systems, see ROXUL CAVITYROCK™ Application Guide. Detail is applicable for ROXUL COMFORTBOARD IS thicknesses less than 1.5" (38 mm), with the exception that "perfect barrier" type cladding can be directly attached to framing through insulation as per cladding manufacturer's instructions.

02. STRUCTURE

- a. A wood frame is illustrated in this detail. Alternates for the infill wall structure include light gage metal stud with exterior gypsum board sheathing and a CMU structural wall.

03. RAIN WATER CONTROL LAYER

- a. A drained-screen approach to rain water control (as illustrated) is recommended.
- b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
- c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable "peel and stick" self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see section 06 below)

04. AIR CONTROL LAYER

- a. The drainage plane may be detailed as the primary air control layer if made continuous.
- b. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
- c. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.

05. THERMAL CONTROL LAYER

- a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
- b. The amount of insulation recommended varies by climate region (see Table 2)

06. VAPOR CONTROL LAYER

- a. The assembly as illustrated is a "vapor open" assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.

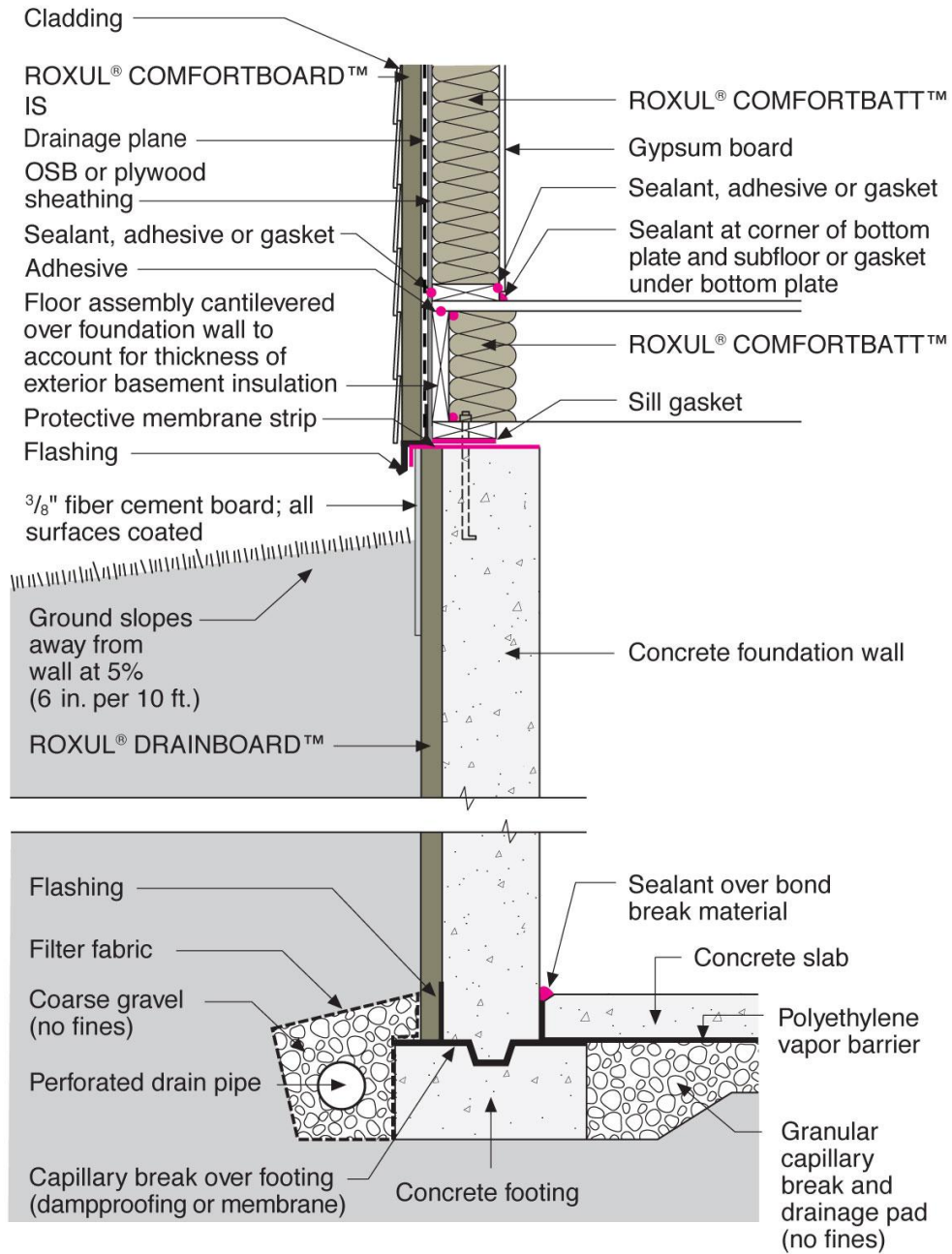
07. EXTERIOR CLADDING

- a. A drained and back-ventilated wood or fiber cement siding is illustrated.
- b. Increasing the air-gap reduces the amount of solar driven inward vapor drive
- c. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer's notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels

08. QUALITY CONTROL CONSIDERATIONS

- a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in "shingle" fashion.
- b. Ensure a tight fit where the exterior insulation boards are fit together. At mechanical and structural penetrations, an opening in the ROXUL COMFORTBOARD IS layer may be cut slightly undersized to ensure a tight fit.

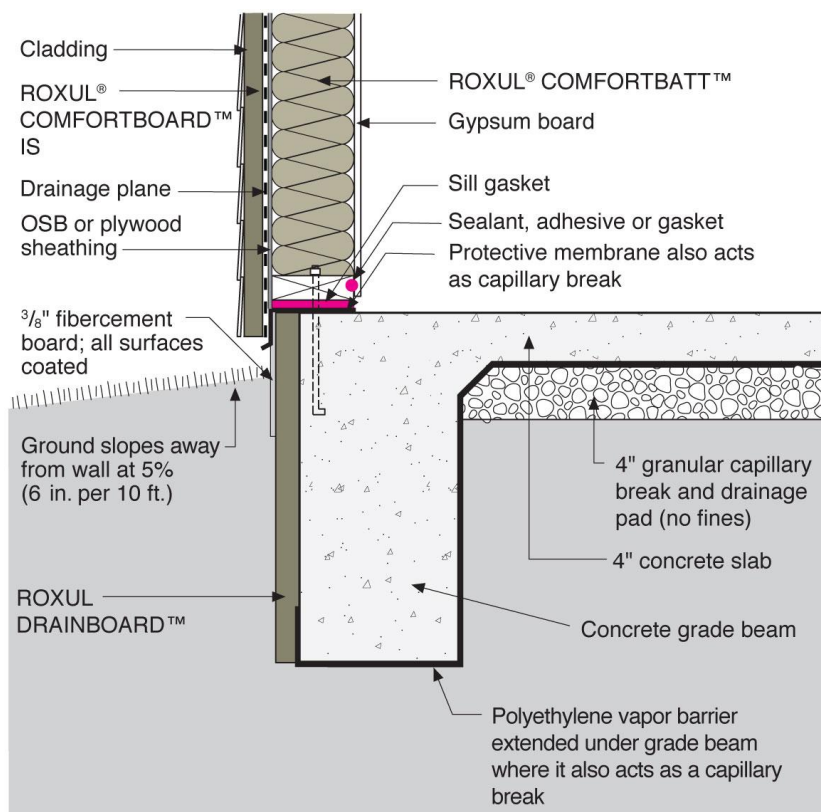
02. Foundation-to-Wall Interface



ROXUL® Building Science Notes

01. GENERAL
 - a. Detail is applicable to grade-level wall-to-basement or crawlspace stem wall interface.
02. STRUCTURE
 - a. A site-cast concrete foundation wall and floor slab is pictured. A CMU foundation wall is an alternate.
03. RAIN WATER CONTROL LAYER
 - a. A drained-screen approach to rain water control (as illustrated) is recommended.
 - b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
 - c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable "peel and stick" self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section 06 below)
04. AIR CONTROL LAYER
 - a. The drainage plane may be detailed as the primary air control layer if made continuous.
 - b. Other air barrier system components include the concrete structure, sealant at the rim joist and other framing connections, and the sill gasket.
 - c. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
 - d. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
05. THERMAL CONTROL LAYER
 - a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
 - c. An adequate thickness of insulating sheathing must be provided outside of the rim joist to prevent air leakage condensation from occurring in this location (see Table 1).
06. VAPOR CONTROL LAYER
 - a. The assembly as illustrated is a "vapor open" assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
07. EXTERIOR CLADDING
 - a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer's notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
08. QUALITY CONTROL CONSIDERATIONS
 - a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in "shingle" fashion.
 - b. Ensure a tight fit where the exterior insulation transitions from below- to above-grade wall.
 - c. Ensure that the finished grade is sloped away from the building.

03. Floor Slab-to-Wall Interface

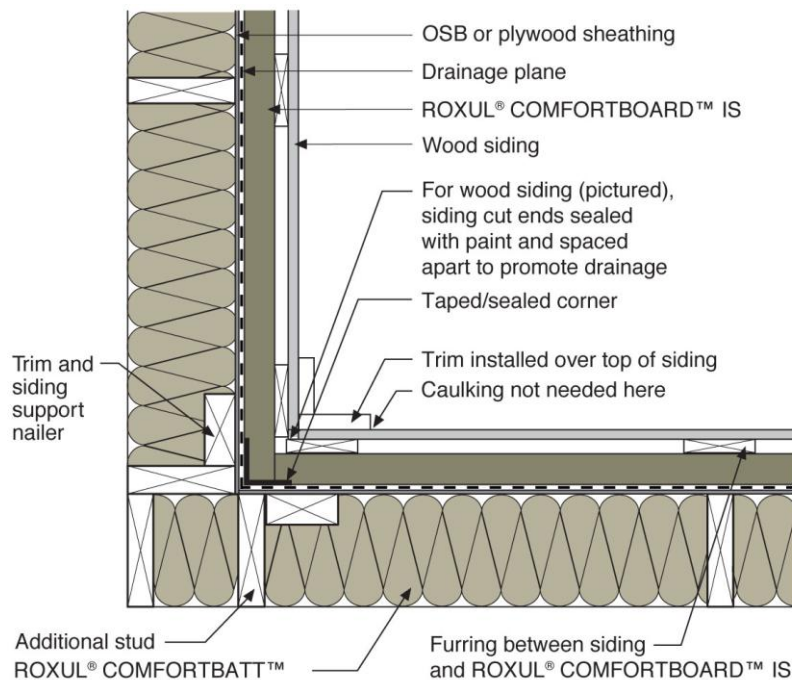


ROXUL® Building Science Notes

01. GENERAL
 - a. Detail is applicable to grade-level wall to stem wall or slab-on-grade interface.
02. STRUCTURE
 - a. A site-cast concrete foundation wall and floor slab is pictured. A CMU foundation wall is an alternate.
03. RAIN WATER CONTROL LAYER
 - a. A drained-screen approach to rain water control (as illustrated) is recommended.
 - b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
 - c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable "peel and stick" self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section 06 below)

- o4. **AIR CONTROL LAYER**
 - a. The drainage plane may be detailed as the primary air control layer if made continuous.
 - b. Other air barrier system components include the concrete structure, sealant at the rim joist and other framing connections, and the sill gasket.
 - c. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
 - d. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
- o5. **THERMAL CONTROL LAYER**
 - a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
- o6. **VAPOR CONTROL LAYER**
 - a. The assembly as illustrated is a “vapor open” assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
- o7. **EXTERIOR CLADDING**
 - a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer’s notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
- o8. **QUALITY CONTROL CONSIDERATIONS**
 - a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in “shingle” fashion.
 - b. Ensure a tight fit where the exterior insulation transitions from below- to above-grade wall.
 - c. Ensure that the finished grade is sloped away from the building.

04. Inside Corner – Horizontal Section



ROXUL® Building Science Notes

01. GENERAL

- a. Detail is applicable to above-grade walls with light-weight cladding systems (see 07.b below) over ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm) for low and mid-rise construction.

02. STRUCTURE

- a. A wood frame is illustrated in this detail. Alternates for the infill wall structure include light gage metal stud with exterior gypsum board sheathing and a CMU structural wall.

03. RAIN WATER CONTROL LAYER

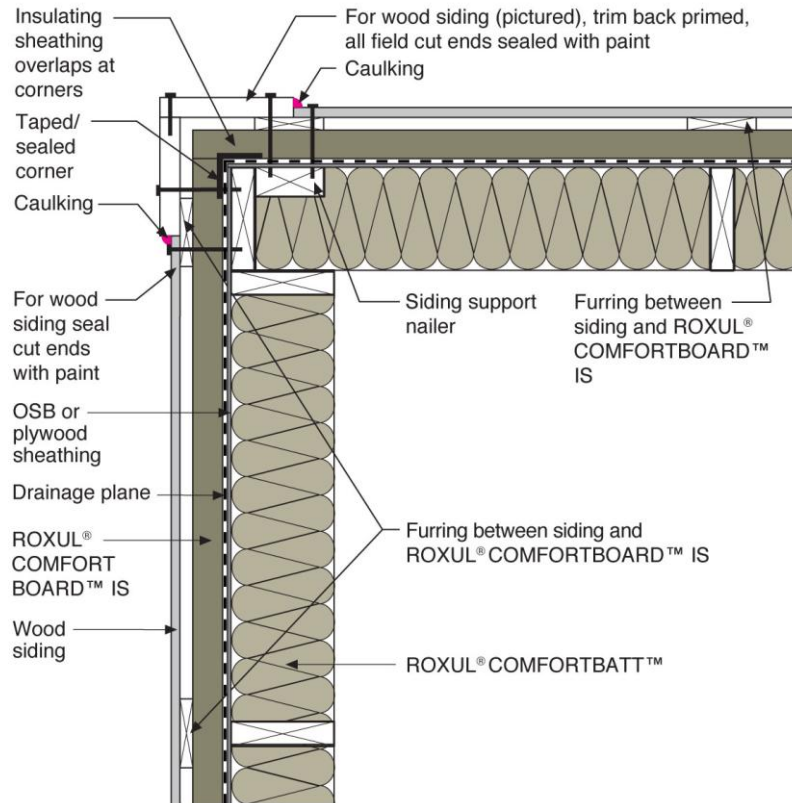
- a. A drained-screen approach to rain water control (as illustrated) is recommended.
- b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
- c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable "peel and stick" self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section 06 below)

04. AIR CONTROL LAYER

- a. The drainage plane may be detailed as the primary air control layer if made continuous.
- b. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall

- approach requires all penetrations of the gypsum board to be carefully sealed.
- c. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
- o5. **THERMAL CONTROL LAYER**
- a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
- o6. **VAPOR CONTROL LAYER**
- a. The assembly as illustrated is a “vapor open” assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
- o7. **EXTERIOR CLADDING**
- a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer’s notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
- o8. **QUALITY CONTROL CONSIDERATIONS**
- a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in “shingle” fashion.
 - b. Ensure a tight fit where the exterior insulation boards are fit together. At mechanical and structural penetrations, an opening in the ROXUL COMFORTBOARD IS layer may be cut slightly undersized to ensure a tight fit.

05. Outside Corner – Horizontal Section



ROXUL® Building Science Notes

01. GENERAL

- a. Detail is applicable to above-grade walls with light-weight cladding systems (see 07.b below) over ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm) for low and mid-rise construction.

02. STRUCTURE

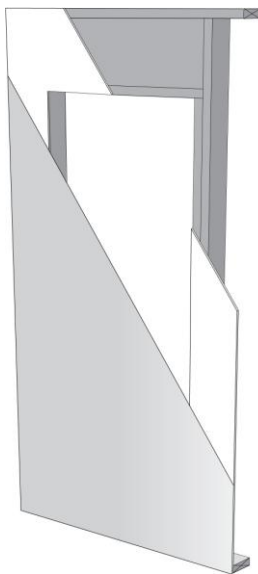
- a. A wood frame is illustrated in this detail. Alternates for the infill wall structure include light gage metal stud with exterior gypsum board sheathing and a CMU structural wall.

03. RAIN WATER CONTROL LAYER

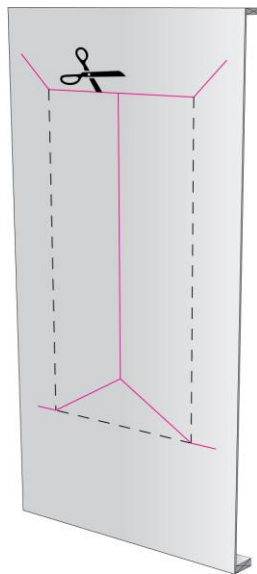
- a. A drained-screen approach to rain water control (as illustrated) is recommended.
- b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
- c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane

- iv. vapor permeable “peel and stick” self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section o6 below)
- o4. **AIR CONTROL LAYER**
 - a. The drainage plane may be detailed as the primary air control layer if made continuous.
 - b. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
 - c. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
- o5. **THERMAL CONTROL LAYER**
 - a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
- o6. **VAPOR CONTROL LAYER**
 - a. The assembly as illustrated is a “vapor open” assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
- o7. **EXTERIOR CLADDING**
 - a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer’s notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
- o8. **QUALITY CONTROL CONSIDERATIONS**
 - a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in “shingle” fashion.
 - b. Ensure a tight fit where the exterior insulation boards are fit together. At mechanical and structural penetrations, an opening in the ROXUL COMFORTBOARD IS layer may be cut slightly undersized to ensure a tight fit.

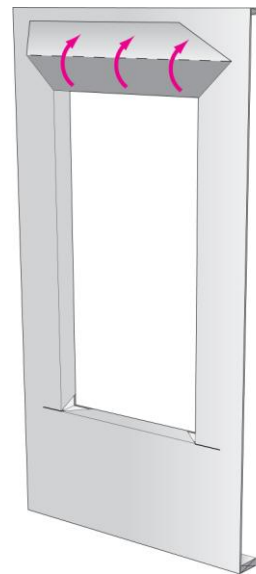
06. Punched Window Interface – Installation Sequence



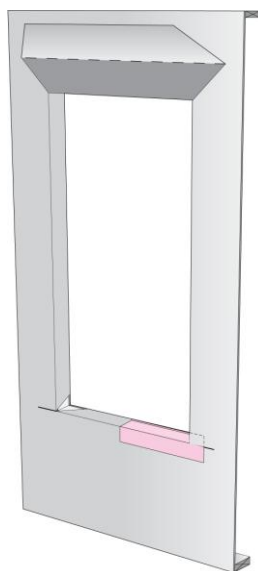
Step 1: Wood frame wall sheathed with OSB or plywood with housewrap as drainage plane.



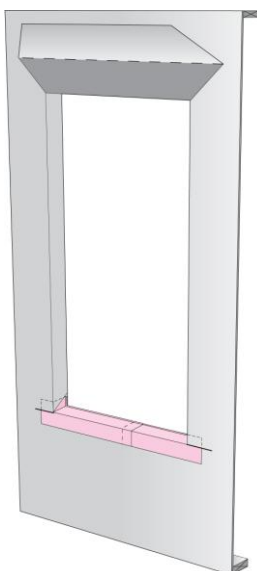
Step 2: Modified "I" cut in housewrap over framed opening (dashed line above)



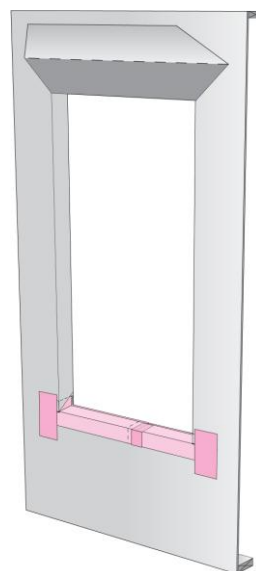
Step 3: Housewrap folded in at jambs and sill and secured tightly. Head flap folded outward; or, tuck head flap under



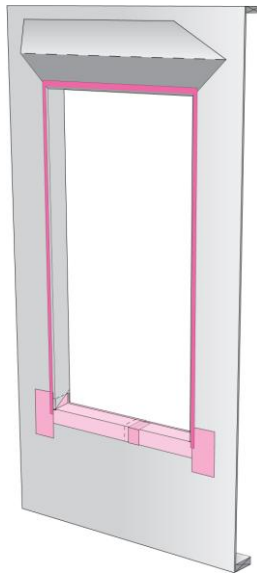
Step 4: Install first piece of sill pan into horizontal slit in housewrap. Pan must fit tightly. Fasten at vertical face of pan only.



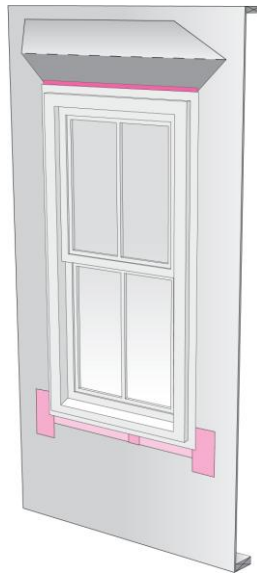
Step 5: Slip second piece of sill pan into horizontal slit in housewrap; pan must fit tightly. Fasten only at exterior vertical face. Ensure a minimum 3" overlap at sill



Step 6: Tape or flash sill pan at jambs and sill joint



Step 7: Back-caulk window. Apply sealant at jambs and head; do not apply to sill to allow for drainage. Or, caulk can be applied to window nailing flange prior to installation.



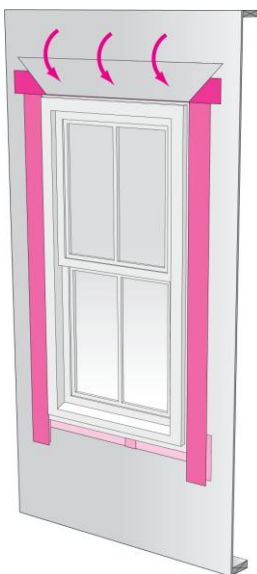
Step 8: Install window plumb, level and square per manufacturer's instructions.



Step 9: Install jamb flashing; extend minimum 1" above head nailing flange and a minimum 3" below sill nailing flange.



Step 10: Install head flashing; extend minimum 2" past edge of jamb flashing



Step 11: Fold housewrap down at head. Ensure head flap has not been damaged during the installation process.



Step 12: Apply corner patches at head; extend minimum 1" beyond cut in housewrap. Air seal window around entire perimeter on the interior with sealant or non-expanding foam.



Step 13: Install ROXUL COMFORTBOARD IS insulation.



Step 14: Install furring over ROXUL COMFORTBOARD IS insulation.



Step 15: Outward leg of cap flashing extends past face of trim (to be added in Step 19).



Step 16: Adhesive membrane strip extends past cap flashing.



Step 17: Sheathing tape applied over adhesive membrane strip to secure top edge.



Step 18: Install next course of ROXUL COMFORTBOARD IS and furring. Drainage gap created by furring. Do not fasten furring through head cap flashing.

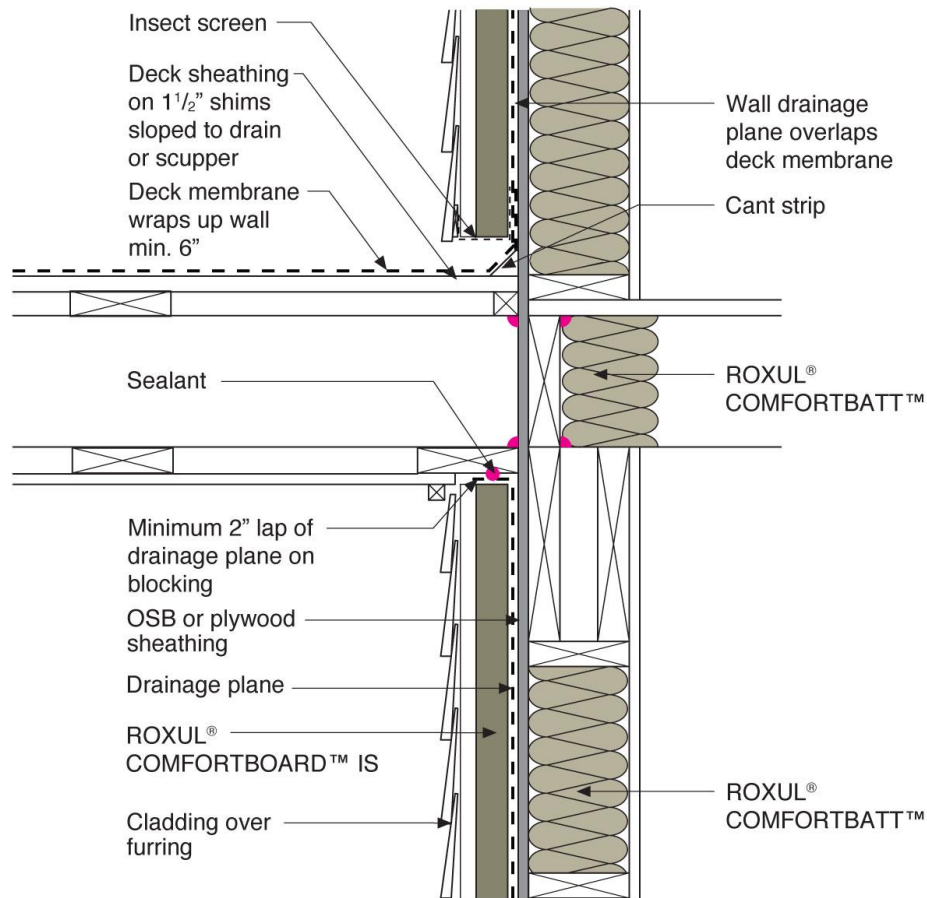


Step 19: Trim installed at head and jambs; sloped cap flashing (shown) installed over lower trim at head of window.



Step 20: Install vinyl, wood, or fiber cement siding.

07. Wall-to-Balcony Interface



ROXUL® Building Science Notes

01. GENERAL

- a. Detail is applicable to above-grade walls with light-weight cladding systems (see 07.b below) over ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm) for low and mid-rise construction.

02. STRUCTURE

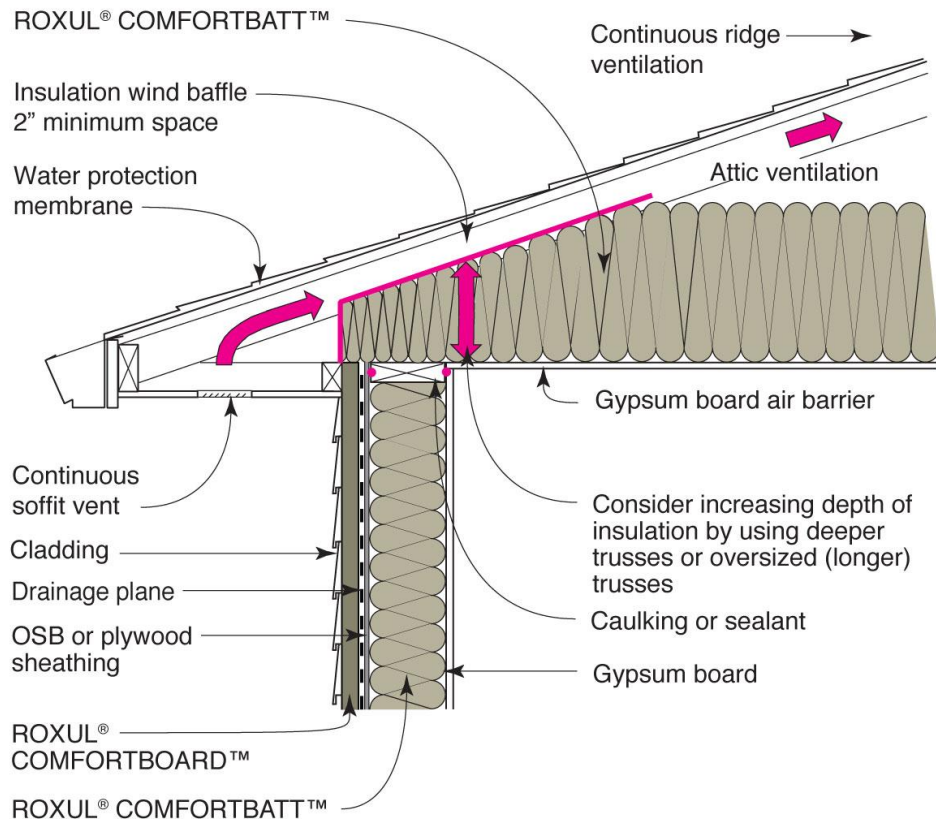
- a. A wood frame is illustrated in this detail. Alternates for the infill wall structure include light gage metal stud with exterior gypsum board sheathing and a CMU structural wall.

03. RAIN WATER CONTROL LAYER

- a. A drained-screen approach to rain water control (as illustrated) is recommended.
- b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
- c. Material options for the drainage plane shown in the wall assembly above include:

- i. non-perforated housewrap or building wrap
 - ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable “peel and stick” self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section 06 below)
- 04. AIR CONTROL LAYER
 - a. The drainage plane may be detailed as the primary air control layer if made continuous.
 - b. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
 - c. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
- 05. THERMAL CONTROL LAYER
 - a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
 - c. An adequate thickness of insulating sheathing must be provided outside of the rim joist to prevent air leakage condensation from occurring in this location (see Table 1).
- 06. VAPOR CONTROL LAYER
 - a. The assembly as illustrated is a “vapor open” assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
- 07. EXTERIOR CLADDING
 - a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer’s notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
- 08. QUALITY CONTROL CONSIDERATIONS
 - a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in “shingle” fashion.
 - b. Ensure a tight fit where the exterior insulation boards are fit together. At mechanical and structural penetrations, an opening in the ROXUL COMFORTBOARD IS layer may be cut slightly undersized to ensure a tight fit.

08. Wall-to-Roof Interface



ROXUL® Building Science Notes

01. GENERAL

- a. Detail is applicable to above-grade walls with light-weight cladding systems (see 07.b below) over ROXUL COMFORTBOARD IS thicknesses greater than 1.5" (38 mm) for low and mid-rise construction. A vented attic roof construction is illustrated.

02. STRUCTURE

- a. A wood frame is illustrated in this detail. Alternates for the infill wall structure include light gage metal stud with exterior gypsum board sheathing and a CMU structural wall.

03. RAIN WATER CONTROL LAYER

- a. A drained-screen approach to rain water control (as illustrated) is recommended.
- b. The drainage plane material is the primary rain water control layer in the wall assembly. Water penetrating the exterior cladding must be directed to the exterior by this layer.
- c. Material options for the drainage plane shown in the wall assembly above include:
 - i. non-perforated housewrap or building wrap

- ii. building paper
 - iii. vapor permeable liquid or fluid applied membrane
 - iv. vapor permeable “peel and stick” self-adhered membrane
 - v. vapor impermeable membranes may be used depending on vapor control design (see Section o6 below)
- o4. AIR CONTROL LAYER
 - a. The drainage plane may be detailed as the primary air control layer if made continuous.
 - b. If an air permeable cavity insulation is selected an airtight drywall approach should be used. An airtight drywall approach requires all penetrations of the gypsum board to be carefully sealed.
 - c. Multiple planes of airtightness are recommended where practical to control convection within the enclosure cavity.
- o5. THERMAL CONTROL LAYER
 - a. ROXUL COMFORTBOARD IS insulation is the primary thermal control layer.
 - b. The amount of insulation recommended varies by climate region (see Table 2)
- o6. VAPOR CONTROL LAYER
 - a. The assembly as illustrated is a “vapor open” assembly, meaning that there is a single line of vapor control and that drying can occur towards the interior or towards the exterior from this line. Selection of vapor-open interior finishes should be considered. If vapor impermeable finishes are used, analysis should be conducted to assess drying potential.
- o7. EXTERIOR CLADDING
 - a. A drained and back-ventilated wood or fiber cement siding is illustrated.
 - b. Material options for the exterior cladding include:
 - i. Vinyl siding (see manufacturer’s notes for installation on furring)
 - ii. Wood siding
 - iii. Fiber cement siding or panels
- o8. QUALITY CONTROL CONSIDERATIONS
 - a. Inspect the lapping of drainage plane pieces to ensure that pieces are installed in “shingle” fashion.
 - b. Ensure a tight fit where the exterior insulation boards are fit together. At mechanical and structural penetrations, an opening in the ROXUL COMFORTBOARD IS layer may be cut slightly undersized to ensure a tight fit.

References and Resources

For more information on ROXUL COMFORTBOARD IS, please visit:

<http://www.roxul.com/products/residential/roxul+comfortboard+is>

For more information on the design of wall assemblies with insulating sheathing for residential construction:

- Building Science Insight 001: The Perfect Wall
- Building Science Insight 005: A Bridge Too Far
- Building Science Digest 011: Thermal Control in Buildings
- Building Science Digest 013: Rain Control in Buildings
- Building Science Digest 163: Controlling Cold-Weather Condensation Using Insulation

For general building science information:

- buildingscience.com



ROXUL INC. is the North American Operations of ROCKWOOL INTERNATIONAL A/S. In July of 2013, ROXUL INC. and ROCKWOOL: INTERNATIONAL A/S celebrated 25 years of success in North America.

ROXUL INC. is the leading North American manufacturer of stone wool insulation products for the North American market. It has two strategically placed manufacturing facilities, one in Milton (East) and the other in Grand Forks, British Columbia (West). Both factories use world-class technology to produce residential products, as well as a wide array of industrial, commercial, and marine stone wool insulation products.

ROXUL INC. demonstrates their commitment to the environment both by producing eco-friendly insulation products and by using green manufacturing processes. They constantly strive to reduce their consumption of raw materials and conserve energy in manufacturing their products. In fact, their manufacturing facilities have comprehensive environmental management systems including advanced recycling technologies at both plants. ROXUL INC is also active in several green organizations working towards sustainable development and a greener, healthier planet.

For more information about ROXUL INC. and our products, please visit www.roxul.com

ROXUL[®]
The Better Insulation[™]

USA

ROXUL INC.
420 Bronte St. S. Suite 105
Milton, Ontario L9T 0H9
Phone: (905) 864-8369
Fax: (905) 864-3140

Canada

ROXUL INC.
420 Bronte St. S. Suite 105
Milton, Ontario L9T 0H9
Phone: (905) 864-8369
Fax: (905) 864-3140

Revised Apr-11-2014

Supersedes Jan-22-2014