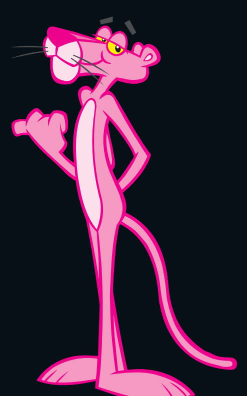
OWENS CORNING®

ResidentialComplete™ Wall Systems
BUILDER'S GUIDE



Building Science Press
30 Forest Street
Somerville, MA 02143
www.buildingscience.com

INTRODUCTION

The focus of this guide is on residential construction using Owens Corning™ products and systems. However, the principles and physics apply to all types of construction and many of examples and details are readily applicable to commercial, institutional construction and special use buildings. In specific cases a design professional should be consulted. The information in this guide is intended to be compliant with the International Residential Code (IRC) most recent edition (2012). In all cases the authority having jurisdiction should be consulted prior to using the information in this guide for code compliance purposes.

This guide addresses one and two story single family detached construction — wood stud, steel stud and concrete masonry units ("CMU").

Owens Corning™ products are highlighted throughout. Substitutions from other manufacturers products are not recommended as specific material and system properties may be significantly different from those of Owens Corning™ products.

The guide is divided into two sections: Part 1 – Principles and Part 2 – Practices. The principles and associated physics form the basis for the specific construction details and methods presented in the second section — the practices part of the guide.

Specific Owens Corning™ product information and web links are contained in the Appendices.

We will continue to update the Builder's Guide to include new Owens Corning™ products and systems, additional building science designs & performance features, sustainability design credits and durability attributes. For a more individualized play review and consultation for qualifying builders, please contact buildingscience@owenscorning.com

CONTENTS

Principles

Practices

PRINCIPLES

CHAPTER 1
THE BUILDING AS A SYSTEM

A building is an environmental separator. It separates the outside from the inside. The separation is often referred to as a building enclosure or a building envelope. The building enclosure or building envelope contains the conditioned space. The conditioned space is conditioned with a heating, ventilating and air conditioning (HVAC) system.

The building enclosure and HVAC system are dependent on one another and the design of one influences the other. In new construction the design of the building enclosure typically governs the design of the HVAC system. The "better" the enclosure, the "better" the HVAC system. "Better" in this case means a more effective, more comfortable, more efficient, smaller, and less expensive HVAC system. Improvements in the building enclosure can be partially offset by reductions in the cost of the HVAC system. Whatever approach is taken durability should be maximized.

In order to function as an environmental separator the following must be met:

- **Control of heat flow**
- **Control of airflow**
- **Control of water vapor flow**
- **Control of rain**
- **Control of ground water**
- Control of light and solar radiation
- **Control of noise and vibrations**
- Control of contaminants, environmental hazards and odors
- Control of insects, rodents and vermin
- **Control of fire**
- **Provide strength and rigidity**
- **Be durable**
- Be aesthetically pleasing
- **Be economical**

The "**bolded**" requirements will be covered in the first section of this guide. Control of heat flow, airflow, water vapor flow, rain and ground water are hygrothermal factors that are key to providing a durable enclosure. The hygrothermal factors are controlled with four principle control layers. Each control layer will be discussed below. Control of noise and vibrations ("acoustics") and control of fire will also be discussed in separate sections that follow.

1.1 CONTROL LAYERS

The building enclosure or building envelope must have four principal control layers as overlays to the structure. They are presented in order of importance and each will be discussed in the order of importance:

- A water control layer
- An air control layer
- A vapor control layer
- A thermal control layer

The best place for the control layers is to locate them on the outside of the structure in order to protect the structure. The optimum configuration is presented in Figure 1.1. However, many configurations are possible and the most common will be presented in this guide.

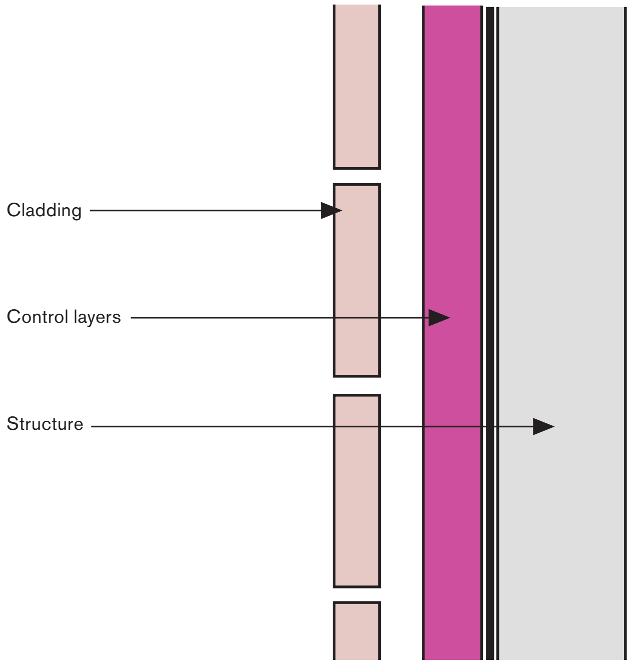


Figure 1.1: The best place for the control layers is to locate them on the outside of the structure.

The most important factor to consider when dealing with control layers is their continuity. Figure 1.2 shows that these control layers need to be continuous around the entire perimeter of the building enclosure.

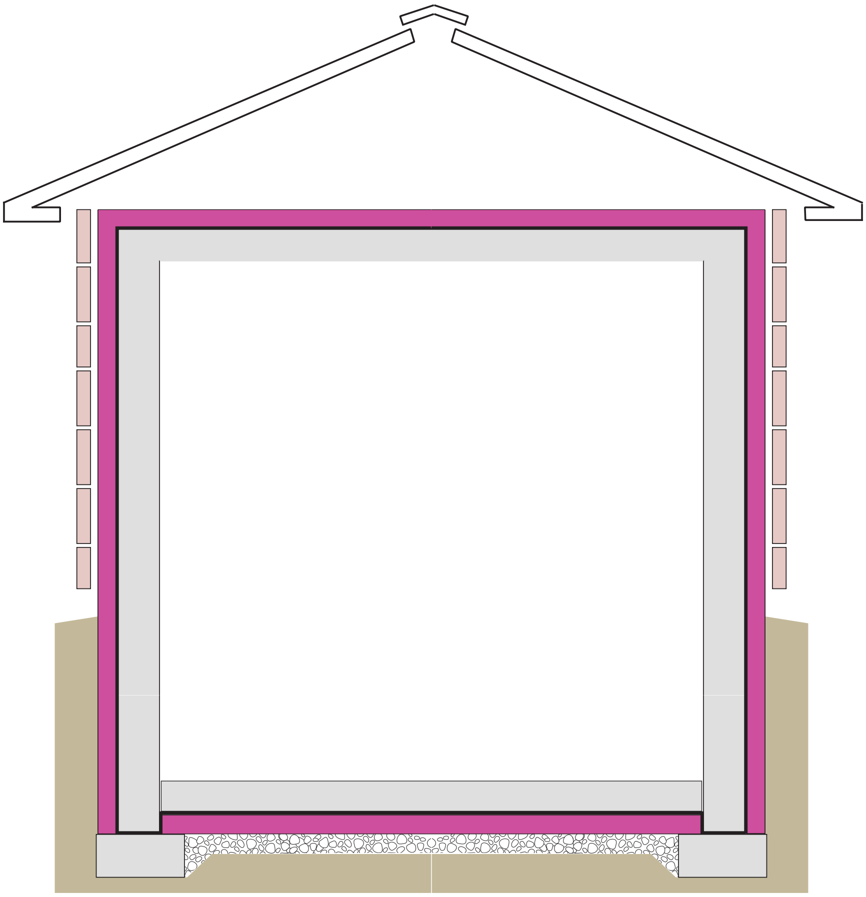


Figure 1.2:
Continuity of control layers. Note that the continuity of the thermal control layer is not possible at the footings for structural reasons.

The most common examples of configurations of control layers are presented in Figure 1.3, Figure 1.4, Figure 1.5, Figure 1.6 and Figure 1.7 for residential wood stud, residential steel stud and residential concrete block (CMU) assemblies.

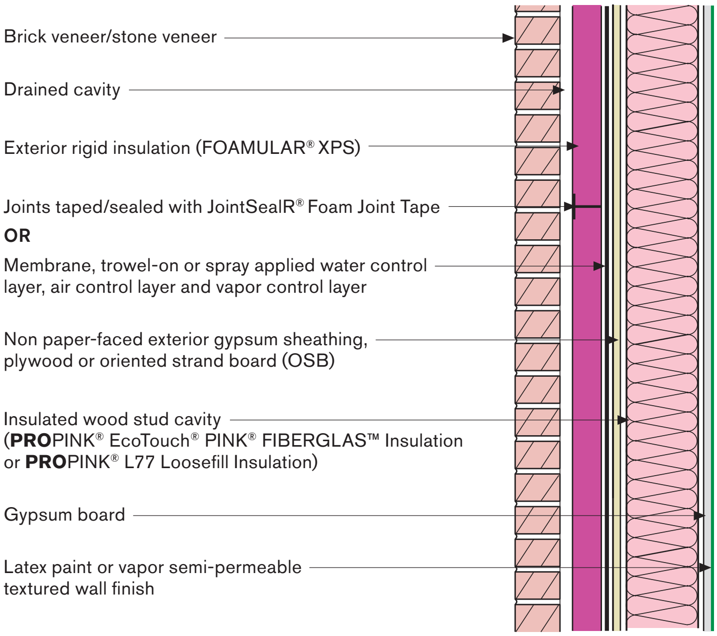


Figure 1.3: Water control layer with a wood stud cavity and brick or stone veneer.

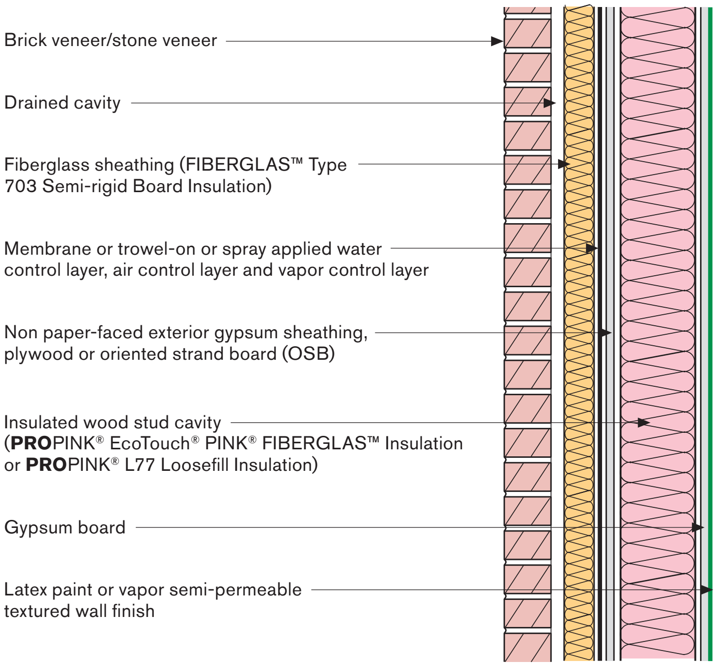


Figure 1.4: Water control layer with a wood stud cavity and brick or stone veneer.

Figure 1.5:
Water control layer with a insulated steel stud cavity and brick or stone veneer.

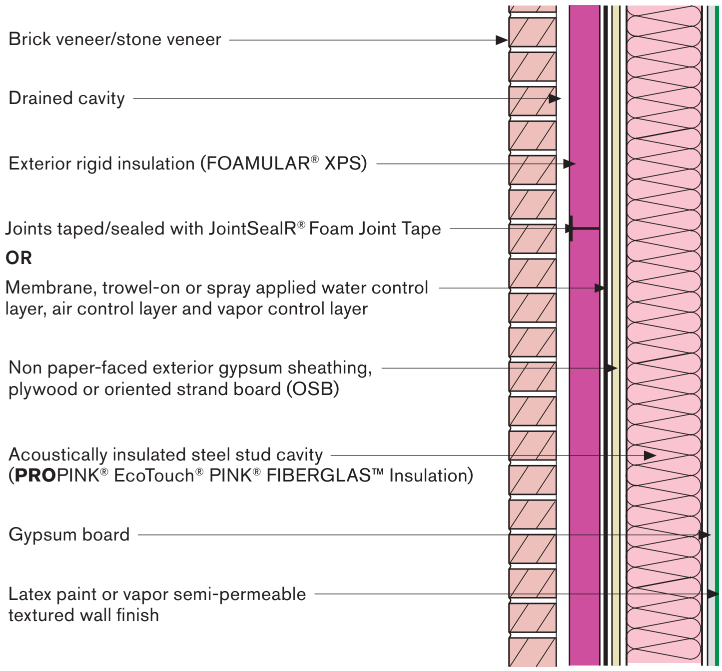
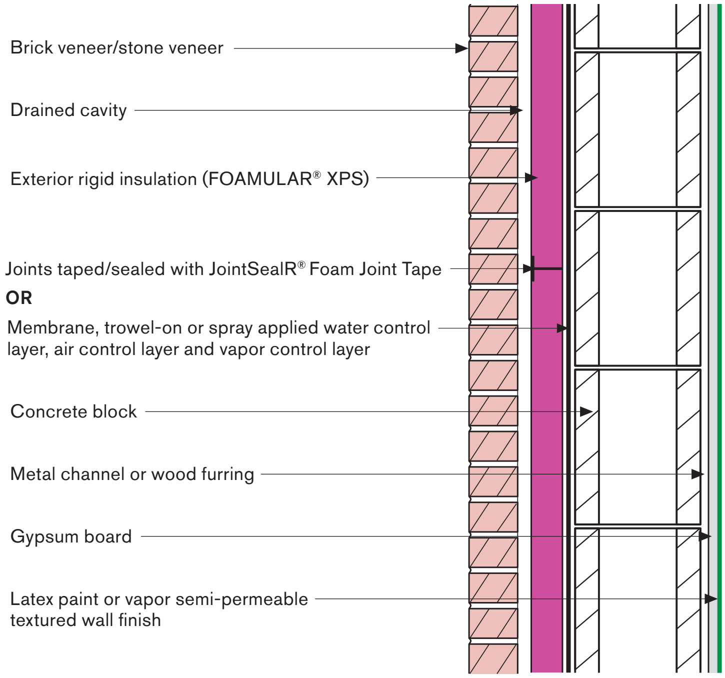


Figure 1.6:
Water control layer with a concrete block wall and brick or stone veneer.



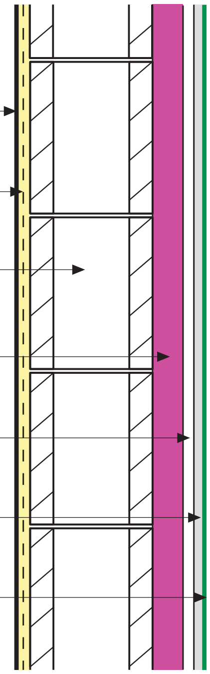


Figure 1.7: Water control layer with a concrete block wall and stucco rendering.

1.2 WATER CONTROL LAYER

Controlling rain and ground water is the single most important factor in the design and construction of durable buildings. Water control layers are used in the design and construction of building enclosures to control rain and ground water.

All exterior claddings pass some rainwater. Siding leaks, brick leaks, stucco leaks and stone leaks. As such, some control of this penetrating rainwater is required. In most walls, this penetrating rainwater is controlled by a water control layer that directs the penetrating water downwards and outwards.

Water control layers are water repellent materials (building paper, housewrap, sheet membranes, and liquid applied coatings) 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 water control layer overlap each other shingle fashion or are sealed so that water drains down and out of the wall. The water control layer is often referred to as the “drainage plane” or “water resistant barrier” or WRB.

The most common water control layer historically is "tar paper" or building paper. More recently, the terms "housewrap" and "building wrap" have been introduced to describe building papers that are not asphalt impregnated felts or coated papers such as polyethylene or polypropylene films. Water control layers can also be created by sealing or layering water resistant sheathings such as a rigid insulation or coated structural sheathings. Finally, fully adhered sheet membranes, or trowel, paint and spray applied coatings applied over structural sheathings such a plywood and OSB can act as water control layers. The recommendations for this guide are based on PINK*WRAP*® Housewrap and FOAMULAR® Extruded Polystyrene (XPS) Insulation with JointSealR® Foam Joint Tape.

Water control layers 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 rigid insulation with taped seams to act as a water control layer and fully adhered sheet membranes and trowel applied coatings are typically impermeable (less than 0.1 perms). There are also spray and trowel and paint applied coatings and some taped rigid insulations that are semi-vapor permeable (1 to 10 perms). Owens Corning™ PINK*WRAP*® Housewrap is rated at 7.7 perms.

1.3 RAIN CONTROL

The fundamental principle of rainwater control is to shed water by layering materials in such a way that water is directed downwards and outwards out of the building. The key to this fundamental principle is drainage.

Gravity is the driving force behind drainage. The "down" direction harnesses the force of gravity and the "out" direction gets the water away from the building enclosure assemblies, openings, components and materials. In general, the sooner water is directed out the better. Sooner, may not always be practical — such as at window openings where draining a window into a drainage space behind a cladding is often more practical than draining them to the exterior face of the cladding.

The most elegant expression of this concept is a flashing (Figure 1.8). Flashings are the most under-rated building enclosure component and arguably the most important. Flashings are integrated with water control layers creating for all practical purposes a flashing for the entire assembly (Figure 1.9).

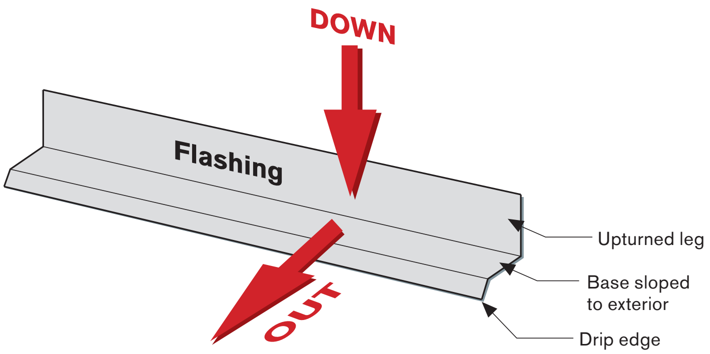


Figure 1.8:
The “down” and “out” approach to flashing.

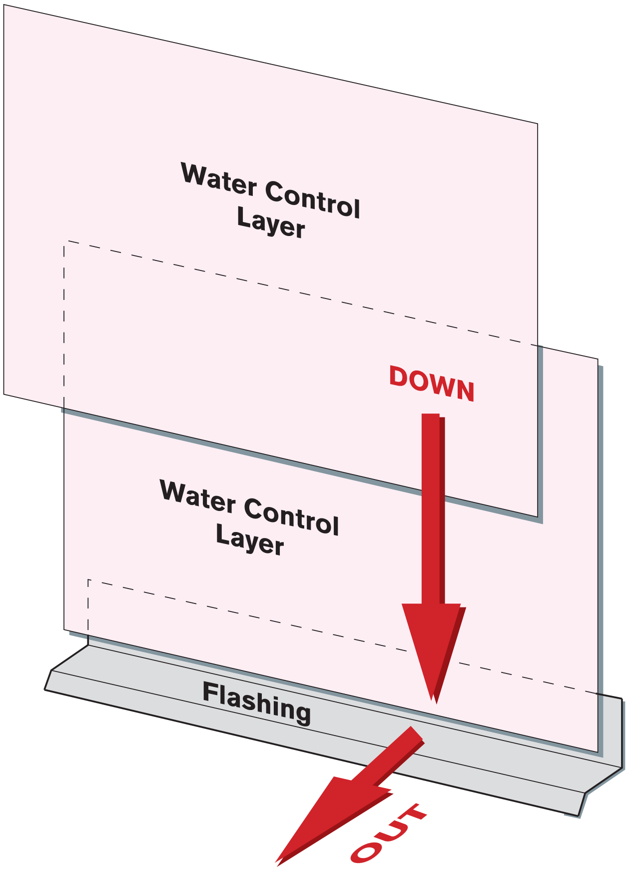


Figure 1.9:
Flashing integrated with water control layer.

A "screen" or "cladding" is installed over the water control layer to provide aesthetics, some limited rain water control and to provide protection from ultra-violet radiation and mechanical damage (Figure 1.10). Drainage occurs between the cladding and the water control layer.

Exterior rigid insulation, FOAMULAR® XPS Insulation, can be made continuous with tapes (JointSealR® Foam Joint Tape) and sealants such that it can act as an effective water control layer (Figure 1.11).

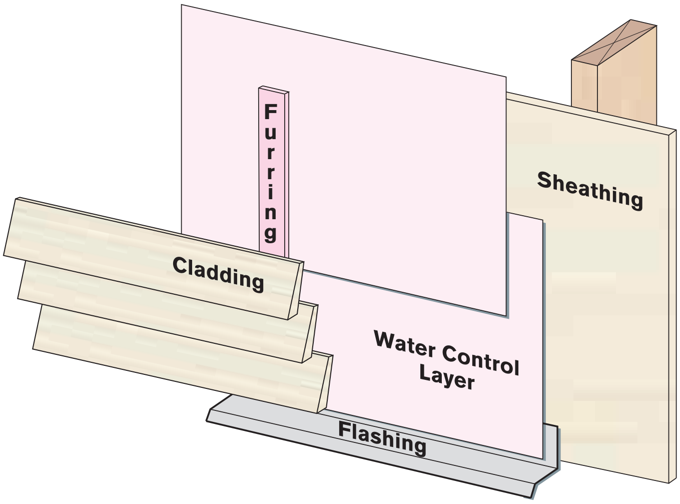


Figure 1.10:
Draining occurs between the cladding and the water control layer.

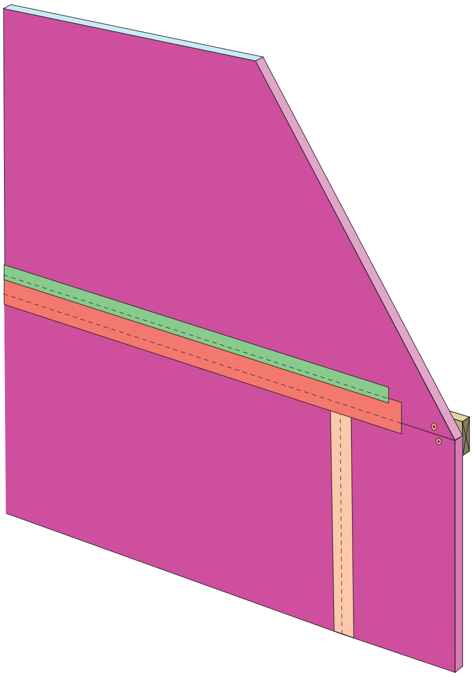


Figure 1.11:
Using tapes and sealants makes rigid insulation a continuous water control layer.

1.4 DRAINAGE AND VENTILATION

In order for drainage to occur, a drainage space must be provided between the cladding and the water control layer. The width of this space varies depending on cladding type and function. This drainage space also provides ventilation and facilitates the redistribution and removal of absorbed water.

Effective drainage of rainwater can occur in drainage spaces as small as 1/16 to 1/8-inch (2 or 3 mm).

Some claddings act as reservoirs — materials that store water. When and if the reservoirs get wet, the stored water can migrate elsewhere and cause problems. The most common reservoir cladding is a brick veneer (although wood siding, fiber cement siding and stone also can be significant reservoir claddings).

"Back ventilating" a reservoir cladding uncouples or disconnects the reservoir cladding from the rest of the wall assembly. The greater the reservoir, the greater the moisture load, and the greater the ventilation required. A reservoir cladding can also be uncoupled by providing a condensing surface such as an impermeable or semi-impermeable insulating sheathing or by using a fully adhered sheet membrane that is also impermeable or semi-impermeable (i.e. also a vapor barrier or retarder).

With wood siding, the drainage space is typically intermittent and depends largely on the profile of the siding. Ideally, wood siding, should be installed over a spacer strip or furring creating a drained (and vented) air space between the drainage plane and wood siding. With vinyl and aluminum siding, the drainage space is more pronounced and furring is not necessary.

With stucco claddings, the drainage space is traditionally provided by using two layers of asphalt impregnated felt paper. The water absorbed by the felt papers from the base coat of stucco causes the papers to swell and expand. When the assembly dries, the papers shrink, wrinkle and de-bond from the stucco rendering providing a tortuous, but reasonably effective drainage space. Today this is viewed as no longer sufficient and a drainage mat is recommended to provide a clear continuous drainage space. This can be accomplished with two layers of PINK*WRAP*® Housewrap with a drainage mat in between.

With brick veneers, the width of the drainage space is based more on tradition than physics. A 1-inch (25 mm) airspace is more-or-less the width of a mason's fingers, hence, the typical requirement for a 1-inch (25 mm) airspace. However, historical experience with stucco and other cladding systems show spaces as small as 1/16-inch (2 mm) drain. However large the space it must be coupled with a functional water control layer.

1.5 DRAIN THE OPENING

Water control layers should be integrated with windows and doors. Actually, they should be integrated with window and door openings as well as the windows and doors themselves.

The seal between a window or door component and the "drainage plane" is rarely perfect — and even if it is perfect at the time of installation it certainly will not be perfect forever.

Furthermore, the window or door component within the opening is rarely perfect — it can and often does leak. This leakage should be managed in the same manner leakage is managed in the plane of the assembly — by drainage to the outside.

Window and door openings should be drained to the exterior using the same principles used in the design and construction of wall assemblies in general.

Pan flashings, membranes lining openings, precast sills with seats extending under window and door units, formable flashings and liquid applied flashings are all methods of providing drained openings.

These techniques allow for sealants to be installed imperfectly or for sealants to age without resulting in catastrophic failure of the assembly. A leak is not truly a leak if it leaks back to the exterior without wetting a water sensitive material.

The two most common methods of integrating windows with the two most common water control layers — housewraps and taped rigid insulation are presented in the series of sequenced images presented in the Appendix where details are provided for the proper flashing and sealing of windows with and without insulating sheathing.

1.6 DRAIN THE BUILDING ENCLOSURE

The water control layer and drainage logic should encompass the entire building enclosure. Deck, balcony and railing connections should be designed and constructed to shed or drain water to the exterior. Roof-wall connections and roof dormer connections should be designed and constructed to shed or drain water to the exterior. Garages, decks, and terraces should be sloped to the exterior and drained. And sites should be graded to shed or drain water away from building perimeters. And finally foundation assemblies should be designed and constructed to drain.

1.7 KEEPING THE GROUNDWATER AND CONTAMINANTS OUT OF FOUNDATIONS

The fundamentals of groundwater control date back to the time of the Romans: drain the site and drain the ground. Today that means collecting the run off from roofs and building surfaces using gutters and draining the water away from foundation perimeters. Roof and façade water should not saturate the ground beside foundations. Grade should slope away from building perimeters and an impermeable layer should cover the ground adjacent to buildings (Figure 1.12).

A free draining layer of backfill material or some other provision for drainage such as a drainage board (INSUL-DRAIN® Extruded Polystyrene (XPS)) or drainage mat should be used to direct penetrating groundwater downward to a perimeter drain. The perimeter drain should be located exterior to the foundation and wrapped completely in a geotextile ("filter fabric"). A crushed stone drainage layer under the basement slab should be connected through the footings to the perimeter drain to provide drainage redundancy and to provide a temporary reservoir for high groundwater loading during downpours if sump pumps fail during electrical outages (if gravity drainage to daylight is not possible).

The basement wall should be damp-proofed and vapor-proofed on the exterior and a capillary break installed over the top of the footing to control "rising damp". Dampproofing and vapor-proofing in these locations is often provided by a fluid applied coating of bitumen. In the past, capillary breaks over footings were not common. They were not needed when basement perimeter walls were uninsulated and unfinished on the interior, because these conditions permitted inward drying of the migrating moisture. For finished basements they are an important control mechanism. Without them, moisture constantly migrates through the foundation, and then into the interior insulation layer.

A capillary break and vapor barrier should also be located under concrete basement floor slabs. Crushed stone or coarse gravel acts as an effective capillary break and sheet polyethylene in direct contract with a concrete floor slab acts as an effective vapor barrier. The concrete slab should be sealed to the perimeter basement wall with sealant (the concrete slab becomes the air control layer or "air barrier" resisting the flow of soil gases such as radon, water vapor and other contaminants).

The crushed stone drainage layer under the basement concrete slab should be vented to the atmosphere to control soil gas (Figure 1.13). Atmospheric air pressure changes are on the order of several hundred Pascal's so that the soil gas vent stack is in essence a "pressure relief vent" or "soil gas bypass" to the atmosphere. Perforated pipe should be attached to the vent stack to extend the pressure field under the slab to the foundation perimeter and to the drainage layer outside the walls. Pipe connections through the footing extend the pressure

field further to the exterior perimeter drain (as well as providing drainage redundancy as previously noted).

The traditional approach to basement water control has been to place the water control layer on the outside and then allow drying to the inside. Drainage, dampproofing or waterproofing and vapor control layers have historically been located on the outside of basement perimeter walls and crushed stone layers and plastic vapor barriers have been located under concrete slabs. The operative principle has been to keep the liquid water out of the structure and locate vapor barriers on the outside — and allow inward drying to the basement space where moisture can be removed by ventilation or dehumidification.

Most interior insulation and finish systems are constructed with moisture sensitive materials (i.e. paper faced gypsum board) and are unable to tolerate even minor groundwater leakage, therefore requiring builders to be "perfect" in controlling groundwater — an impossible requirement. These systems also can prevent inward drying (i.e. when batt or blanket insulation is covered with plastic vapor barriers). This is an issue with moisture of construction, capillary rise and ground water leakage.

Simply leaving off interior vapor barriers or vapor retarders will not avoid problems, because interior water vapor will migrate outward from the basement conditioned space. Then it will condense on the interior surface of the foundation wall providing moisture for mold growth and other problems.

Additionally, most interior insulation systems are not airtight thereby allowing interior air to access the interior surfaces of the perimeter concrete foundation.

The structural elements of below grade walls are cold (concrete is in direct contact with the ground) — especially when insulated on the interior. The main problem with below grade walls comes during the summer when warm moist air comes in contact with basement cold surfaces that are below the dewpoint of the interior air.

Basement walls should be insulated with non-water sensitive insulation such as rigid insulation (FOAMULAR® XPS Insulation) or semi rigid insulation (Owens Corning® Basement Finishing System™) that is designed to prevent interior air from contacting cold basement surfaces — the concrete structural elements.

It is a good idea to construct the foundation wall assembly so that it is able to dry. It can't dry outwards because the ground is wet. It can obviously dry inwards. But there are other possibilities. It can dry upwards and then out above grade.

For inward drying the rigid insulation layer should be vapor permeable (greater than 10 perms) or vapor semi-permeable (between 1 perm and 10 perms) or vapor semi-impermeable (between 0.1 perm and 1 perm). The greater the permeance the greater the inward drying and therefore the lower the risk of moisture accumulation. Additionally, a capillary break should be installed on the top of the footing between the footing and the perimeter foundation wall to control “rising damp”. For interior drying no interior vapor barriers should be installed.

It is typical to use several inches of unfaced extruded polystyrene (FOAMULAR® XPS Insulation) coupled with interior framing insulated with cavity insulation such as fiberglass batts (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) (Figure 1.14). The Owens Corning® Basement Finishing System™ easily meets these permeability requirements as it is a semi rigid fiberglass board with a vapor open finish facing (20 perms) (Figure 1.15).

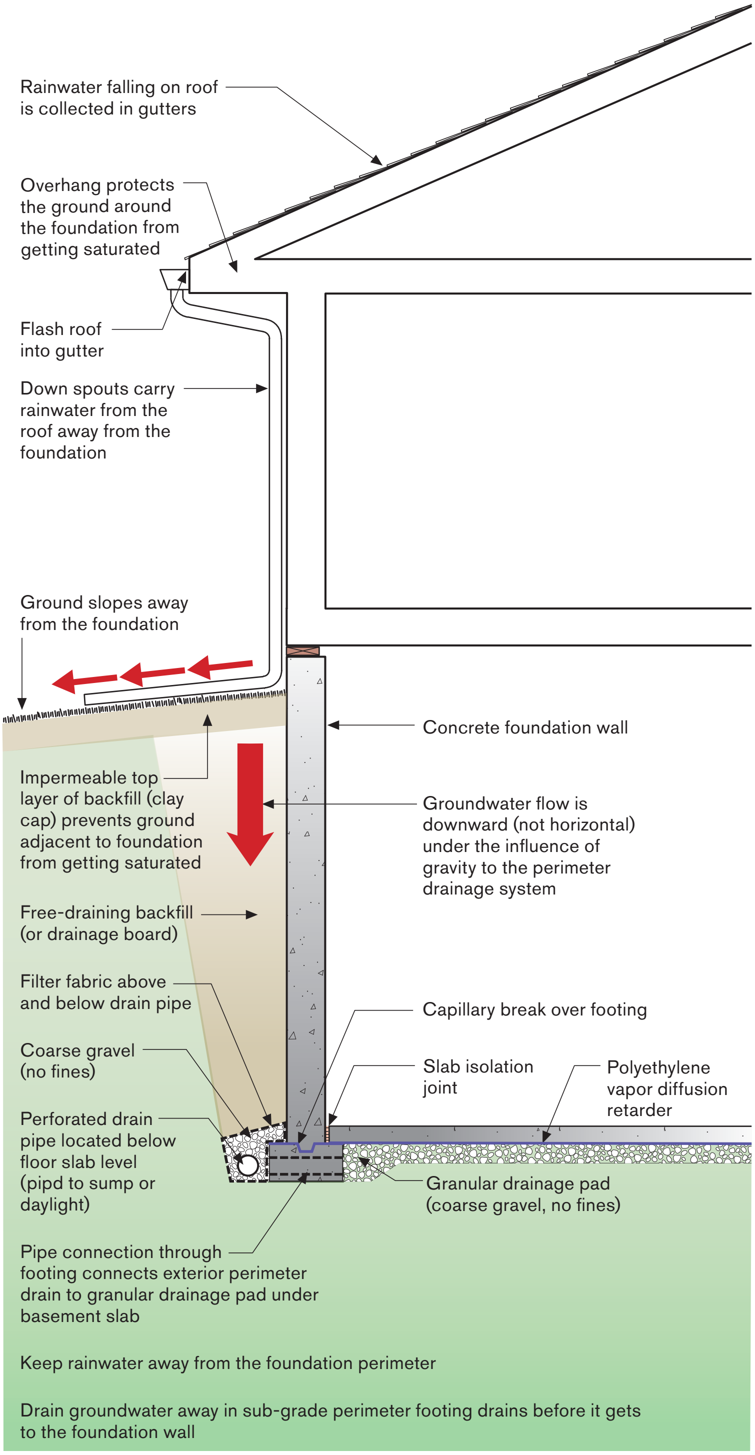


Figure 1.12:
Grade should slope away from building perimeters and an impermeable layer should cover the ground adjacent to buildings.

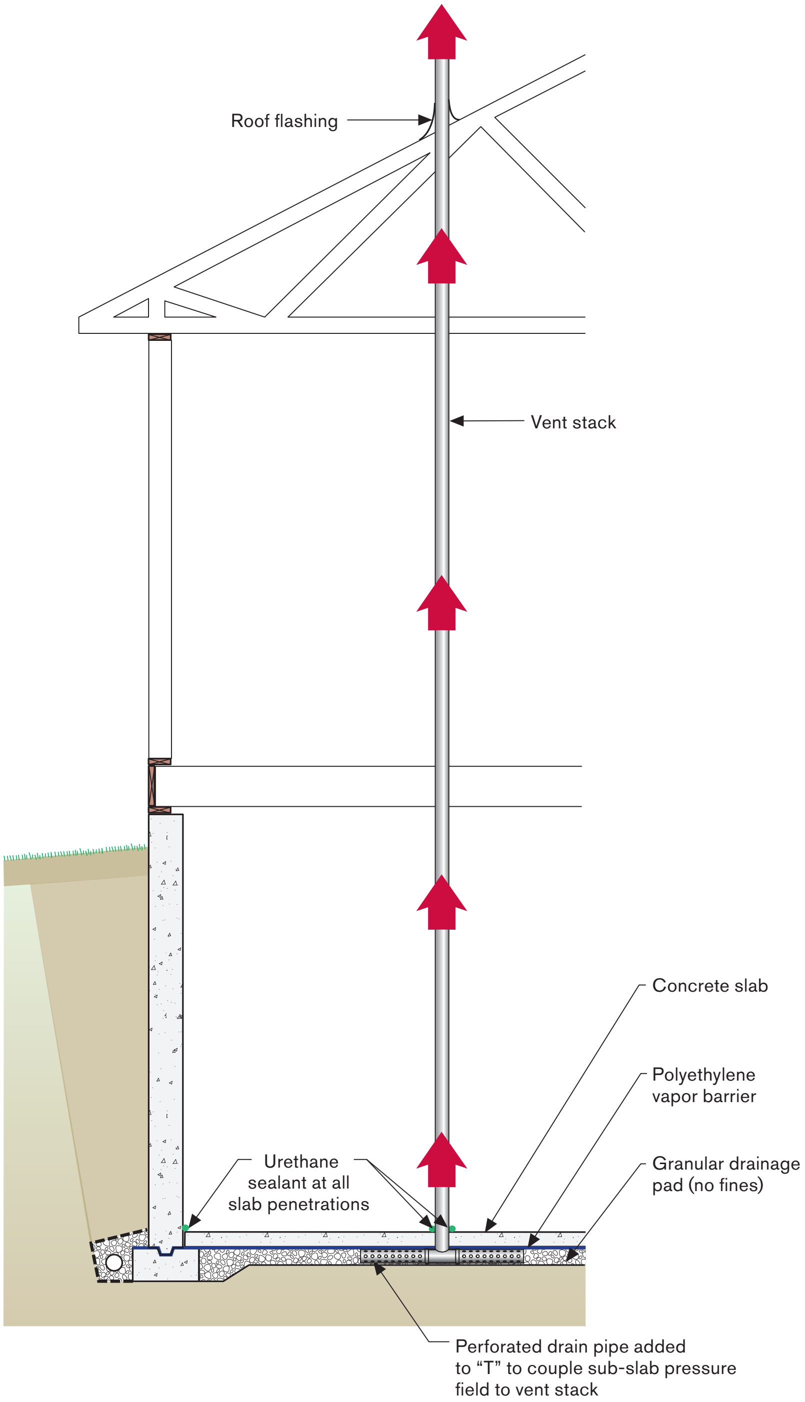


Figure 1.13: Crushed stone drainage under basement concrete slab should be vented to the atmosphere to control soil gas.

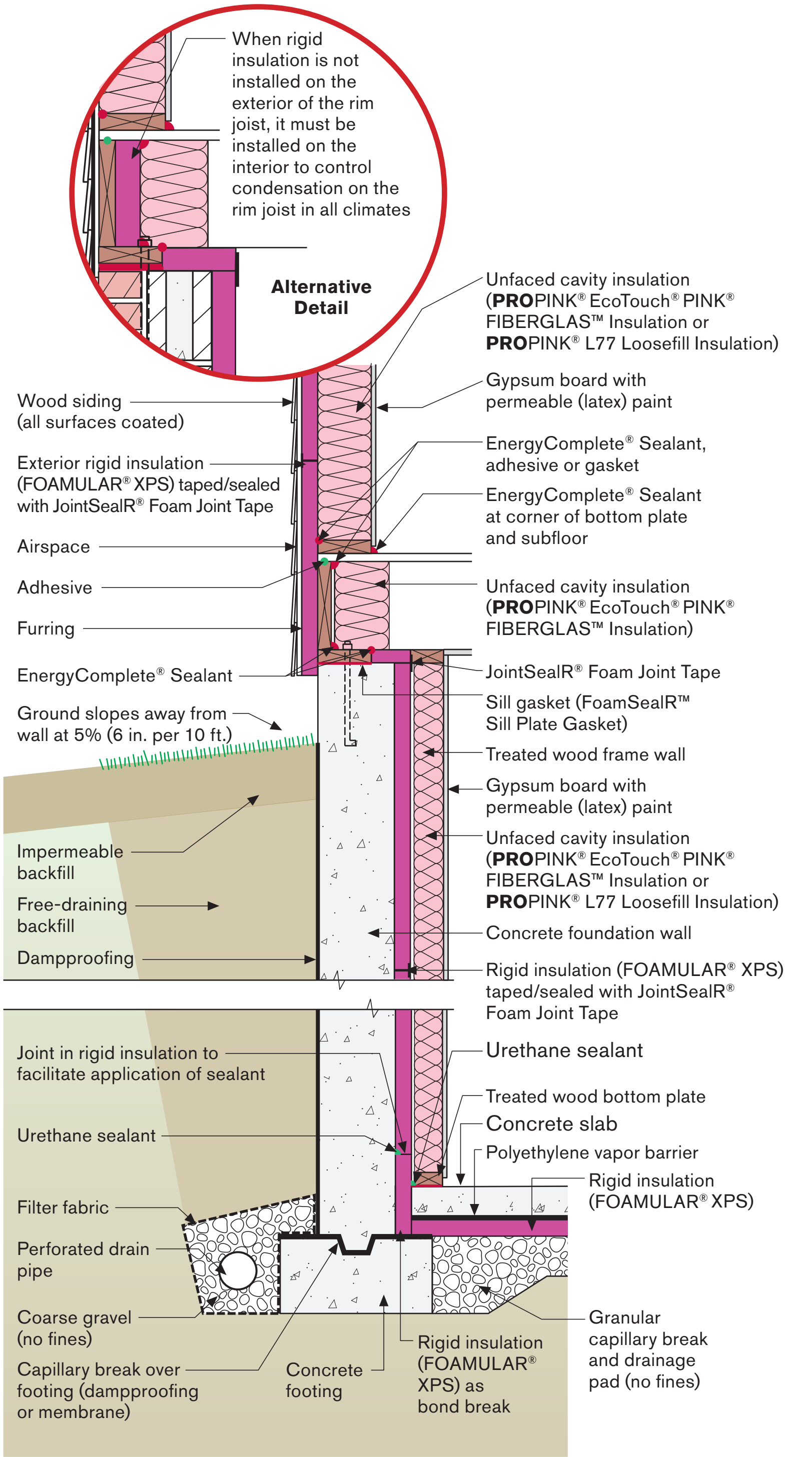


Figure 1.14:
Unfaced extruded polystyrene exterior rigid insulation with fiberglass batts in the wall cavity.

For building science assistance contact
buildingscience@owenscorning.com

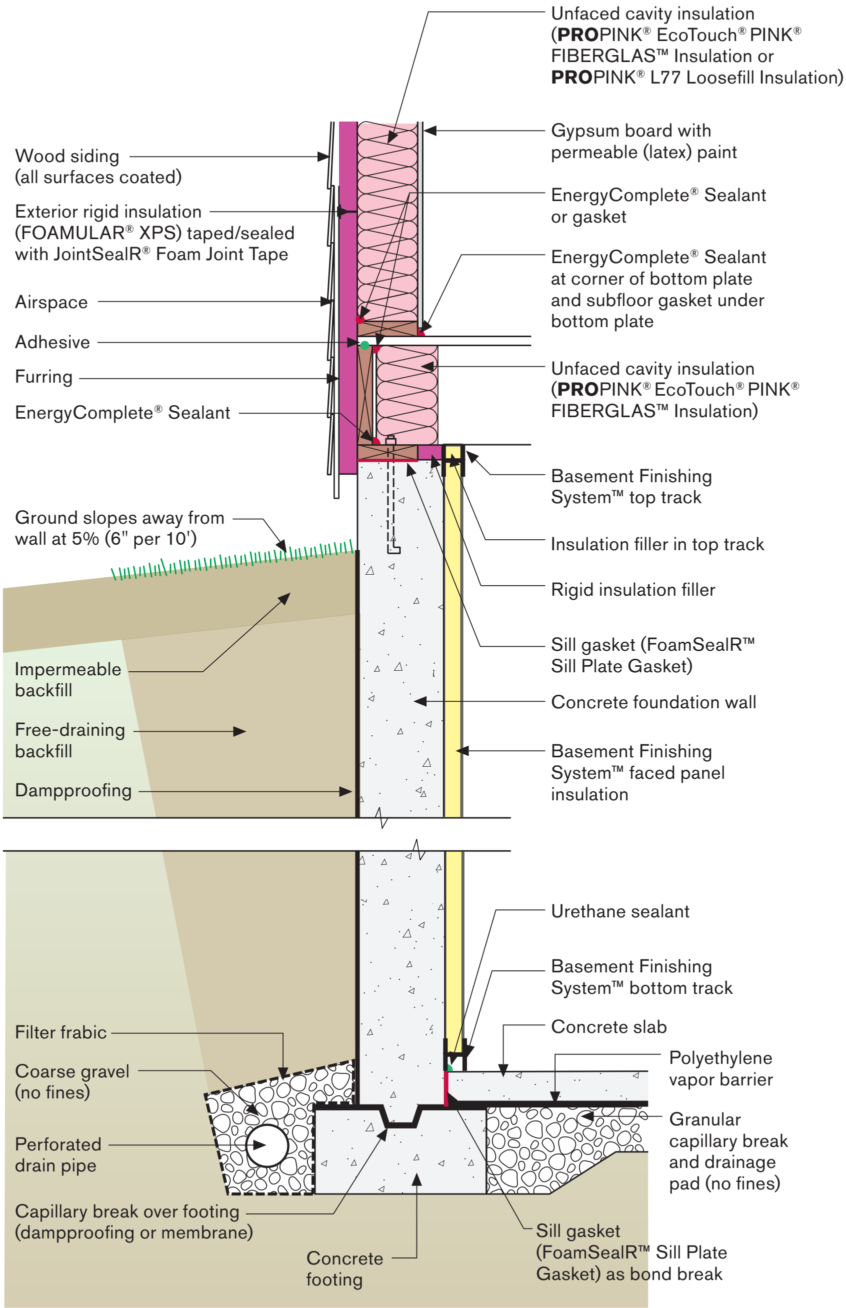


Figure 1.15:
Vapor open basement insulation system.

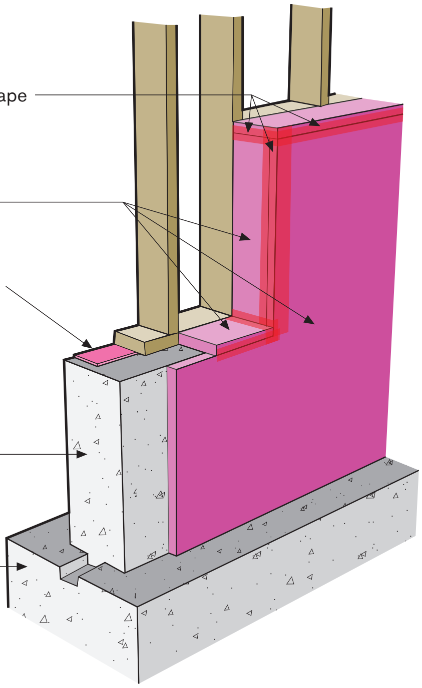


Figure 1.16:
Completely enclose interior concrete to control condensation.

With rigid insulation it is important to completely enclose any interior concrete to control condensation from interior moisture laden air, particularly in the summer (Figure 1.16).

Basement floor slabs are best insulated underneath with rigid insulation (FOAMULAR® XPS Insulation). A sheet polyethylene vapor barrier should be located over the rigid insulation in direct contact with the concrete slab. A sand layer should never be installed between the sheet polyethylene vapor barrier and the concrete slab. Sand layers located between the slab and the vapor barrier can become saturated with water, which are then unable to dry downwards through the vapor barrier. Only drying upward through the slab is possible which typically results in damaged interior floor finishes.

Control of ground water for slab on grade foundations follows the same principle for basement foundations (Figure 1.17).

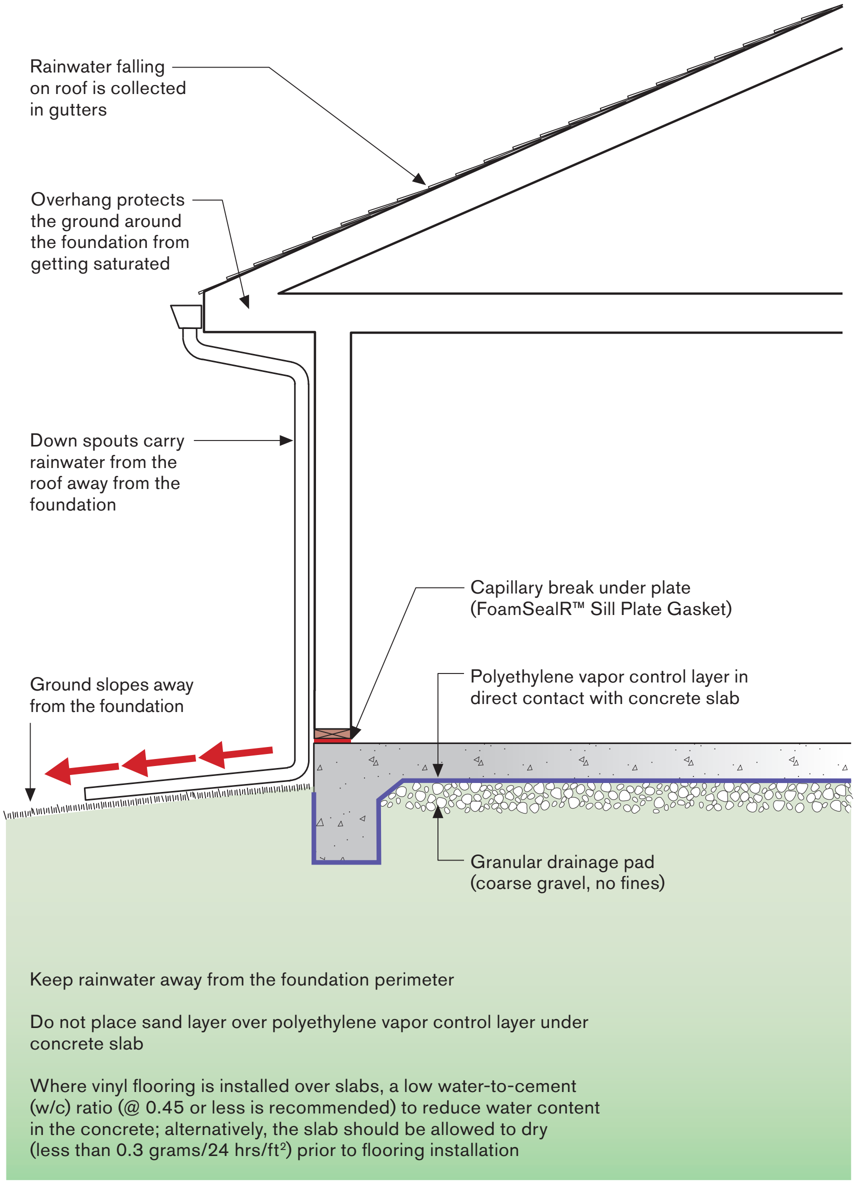


Figure 1.17: Controlling ground water in slab on grade foundation.

1.8 MASS WALLS AND STUCCO ON CONCRETE BLOCK

Some traditional assembles do not rely on drainage for the control of rain water that penetrates claddings. They rely on absorption, storage, redistribution and drying. The most common assembly that relies on this approach is a stucco rendering applied directly to the exterior surface of a concrete block wall (Figure 1.18). These assemblies are common to hot humid climates and have a long distinguished history of successful performance.

Stucco passes very little rain water through its face — but it does pass some rain water nevertheless. This penetrating rain water is stored in a non water sensitive material, in this case concrete block, until it is able to dry either to the exterior or interior or both by the process of vapor diffusion and evaporation. It is common to coat the exterior of the stucco rendering with a vapor permeable layer such as latex paint to further reduce rain water entry. Additionally, the interior of the concrete block is insulated with a non water sensitive rigid insulation which further protects the interior finishes which are often moisture sensitive such as gypsum board and wood trim.

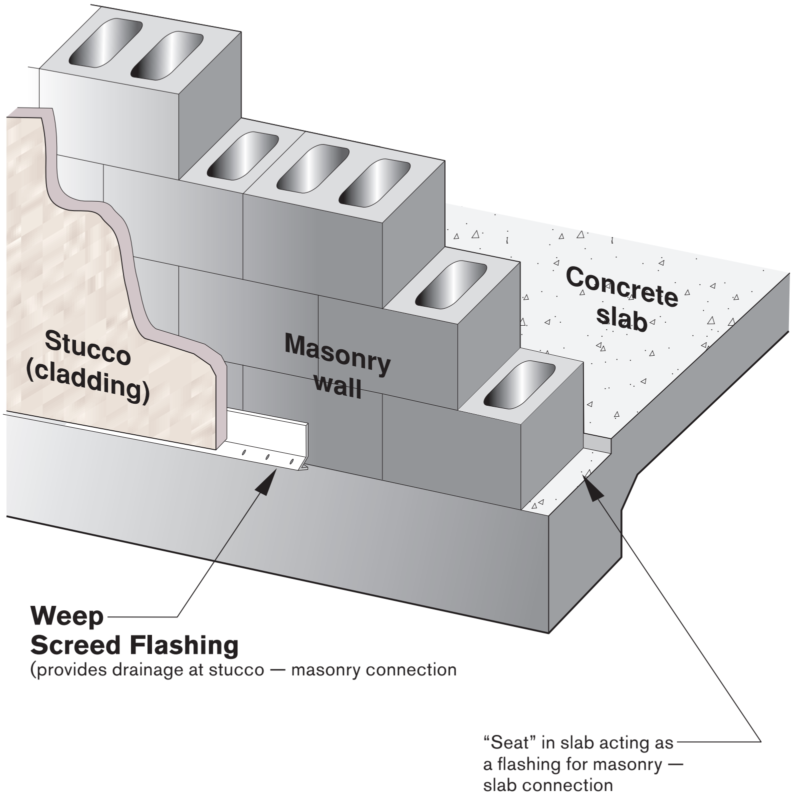


Figure 1.18:
Stucco rendering applied directly to the exterior surface of a concrete block wall.

CHAPTER 2
AIR CONTROL LAYER

Controlling airflow in a building enclosure is important because of its influence on heat and moisture flow. Airflow carries moisture that impacts a material's long-term performance (serviceability) and structural integrity (durability). Airflow also affects building behavior in a fire (spread of smoke and other toxic gases, supply of oxygen), indoor air quality (distribution of pollutants and location of microbial reservoirs) and thermal energy use. One of the key strategies in the control of airflow is the use of air control layers.

Air control layers are systems of materials designed and constructed to control airflow between a conditioned space and an unconditioned space. The air control layer is the primary air enclosure boundary that separates indoor (conditioned) air and outdoor (unconditioned) air. In multi-unit/townhouse/apartment construction the air control layer also separates the conditioned air from any given unit and adjacent units.

In multi-unit/townhouse construction the air control layer is also the smoke barrier in inter-unit separations. The inter-unit separation must also meet the specific fire resistance rating requirement for the given separation.

The air control layer also separates garages from conditioned spaces. In this regard the air control layer is also the "gas barrier" and provides the gas-tight separation between a garage and the remainder of the house or building to control the migration of typical contaminants found in a garage.

Typical configurations of air control layers for typical enclosures are illustrated in Figure 1.19.

2.1 APPROACHES

Air control layers are intended to resist the air pressure differences that act on them. Rigid materials such as gypsum board, exterior sheathing materials like plywood, OSB or FOAMULAR® XPS, and supported flexible barriers such as housewraps are typically effective air control layers if joints and seams are sealed. Fully adhered membrane systems and liquid applied systems supported by exterior sheathing also are effective. Joint sealant systems (EnergyComplete® Sealant) can also act as effective air barrier systems applied internally within cavity systems.

Air control layers keep outside air out of the building enclosure or inside air out of the building enclosure depending on climate or configuration. Sometimes, air control layers do both.

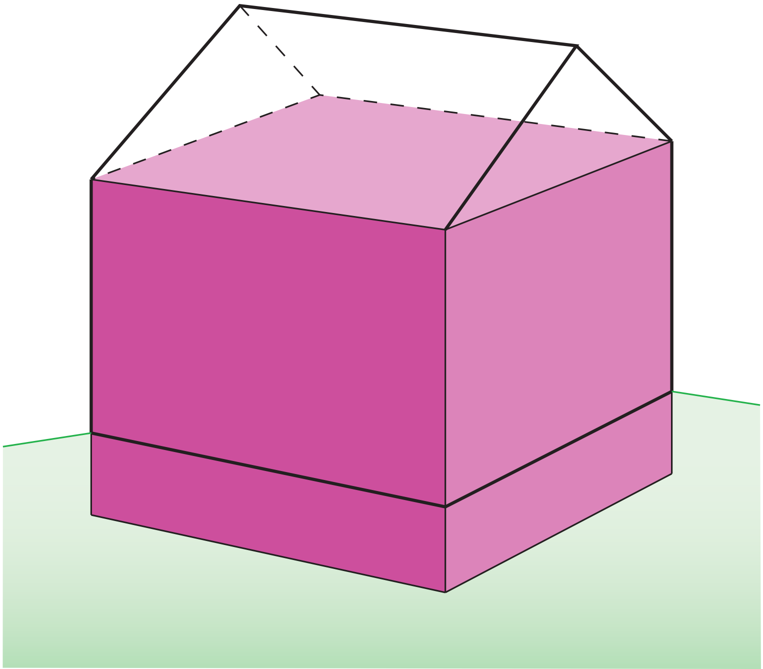
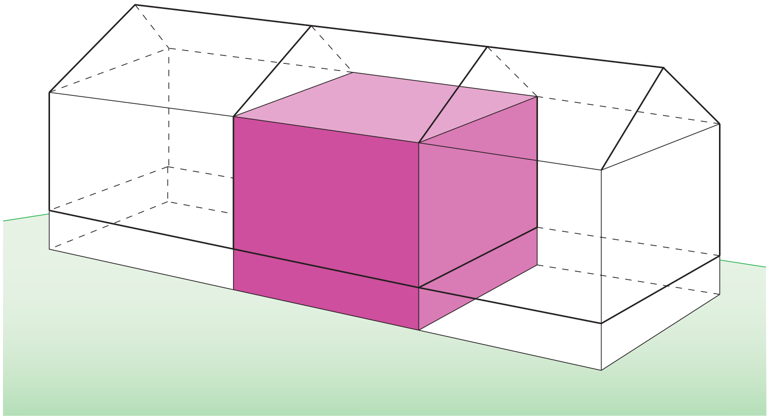


Figure 1.19:
Typical air control layer configurations.



Air control layers can be located anywhere in the building enclosure — at the exterior surface, the interior surface, or at any location in between. In cold climates, interior air control layers control the exfiltration of interior, often moisture-laden air. Whereas exterior air control layers control the infiltration of exterior air and prevent wind-washing through cavity insulation systems.

Air control layers should be:

- Impermeable to air flow
- Continuous over the entire building enclosure or continuous over the enclosure of any given unit
- Able to withstand the forces that may act on them during and after construction
- Durable over the expected lifetime of the building

There are many sealants, caulks and adhesives used in the construction industry. If a sealing application does not have EnergyComplete® Sealant, then choose a high quality urethane sealant, caulk or adhesive that is designated to bond to both surfaces on either side of the gap or crack, and will remain flexible for the desired life of the structure.

Numerous approaches can be used to provide air control layers in buildings. Some of the more common are:

- Interior air control layer using gypsum board (Figure 1.20)
- Interior air control layer using a joint sealant system (Figure 1.21)
- Exterior air control layer using taped and sealed rigid insulation (Figure 1.22)
- Exterior air barrier system using a supported and sealed housewrap (Figure 1.23)

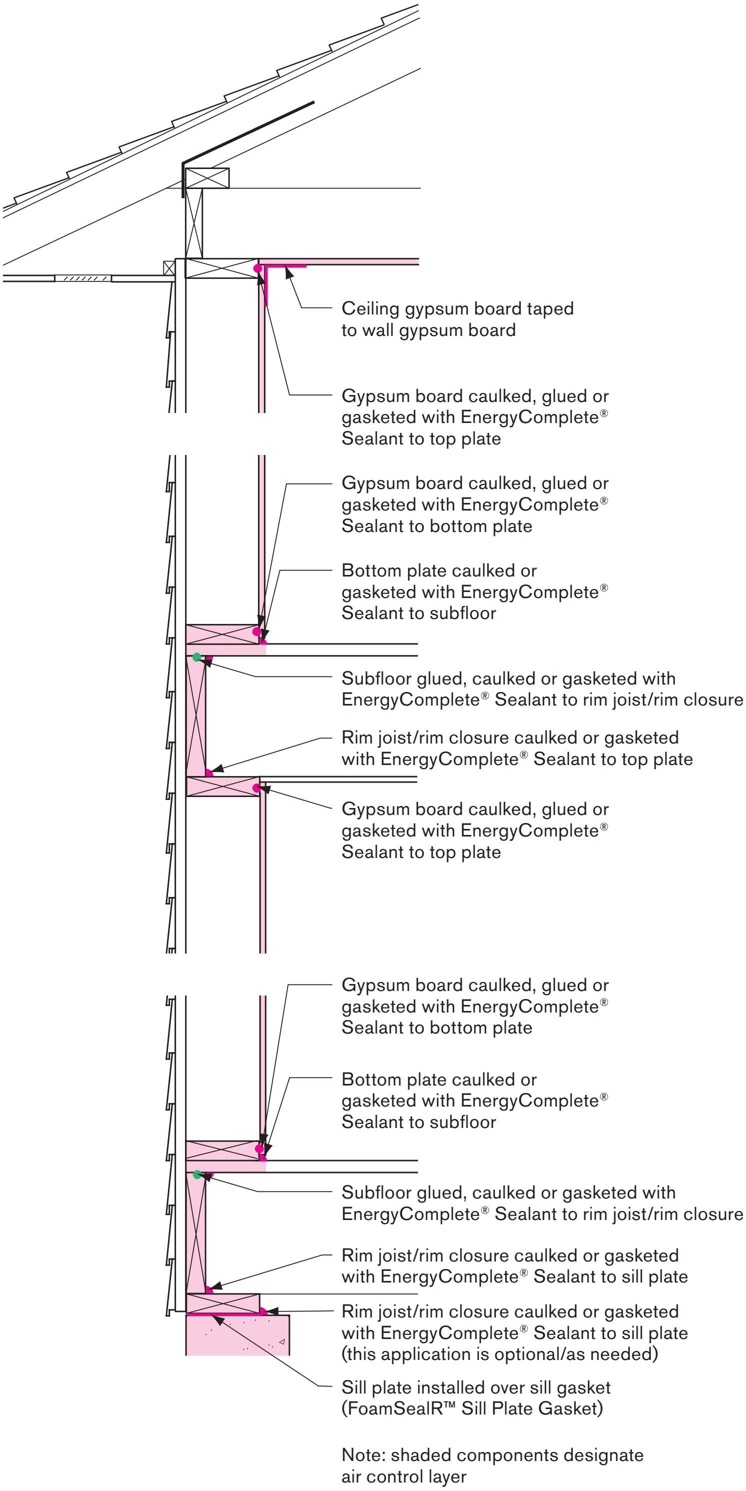
The significant advantage of exterior air control layers is the ease of installation and the lack of detailing issues related to intersecting partition walls and service penetrations.

An additional advantage of exterior air control layers is the control of wind-washing that an exterior air seal provides with insulted cavity frame assemblies.

The significant disadvantage of exterior air control layers is their inability to control the entry of air-transported moisture into insulated cavities from the interior. As a result most exterior air control layers are insulated on their exterior side with rigid or semi-rigid insulations that are not sensitive to wind-washing.

An advantage of interior air control layers over exterior systems is that they control the entry of interior moisture-laden air into insulated assembly cavities during heating periods. The significant disadvantage of interior air control layers is their inability to control wind-washing through cavity insulation and their inability to address the entry of exterior hot-humid air into insulated cavities in hot-humid climates.

Figure 1.20:
Interior air control layer using gypsum board.



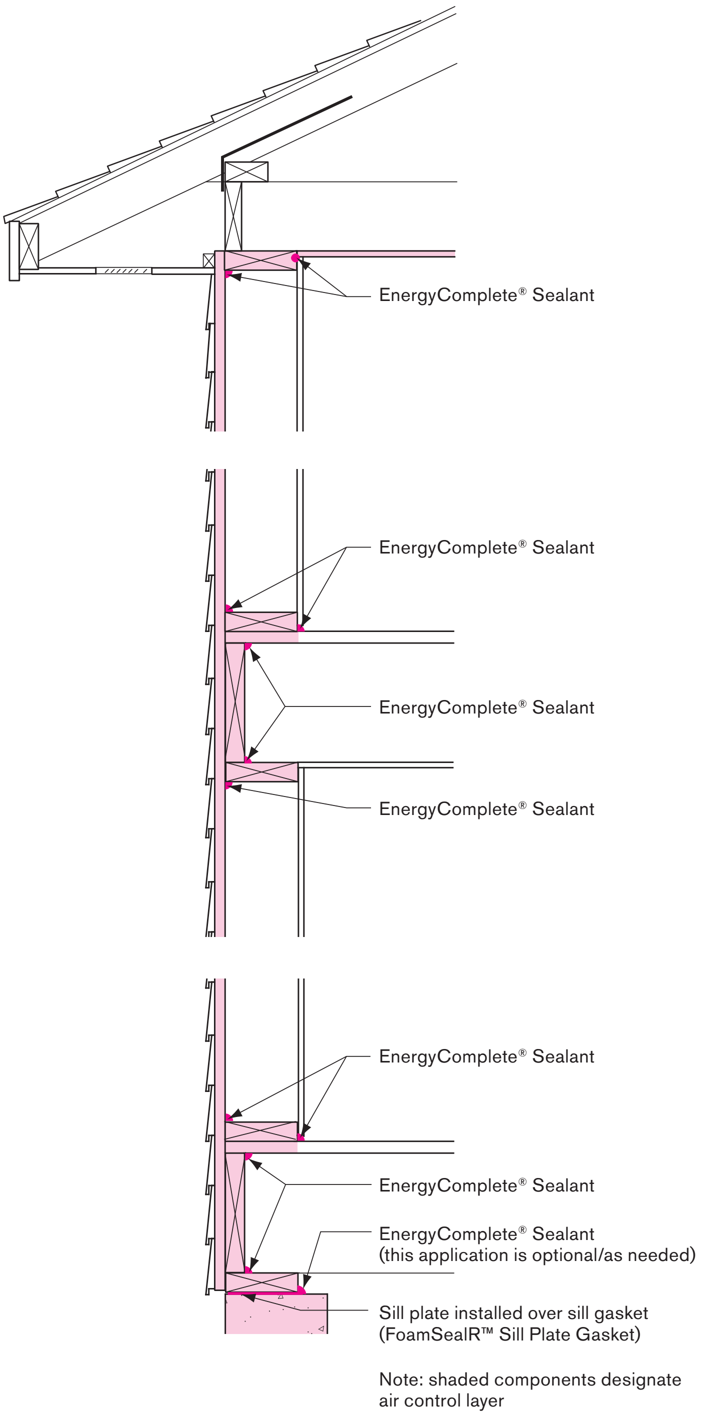


Figure 1.21:
Interior air control layer using a joint sealant system.

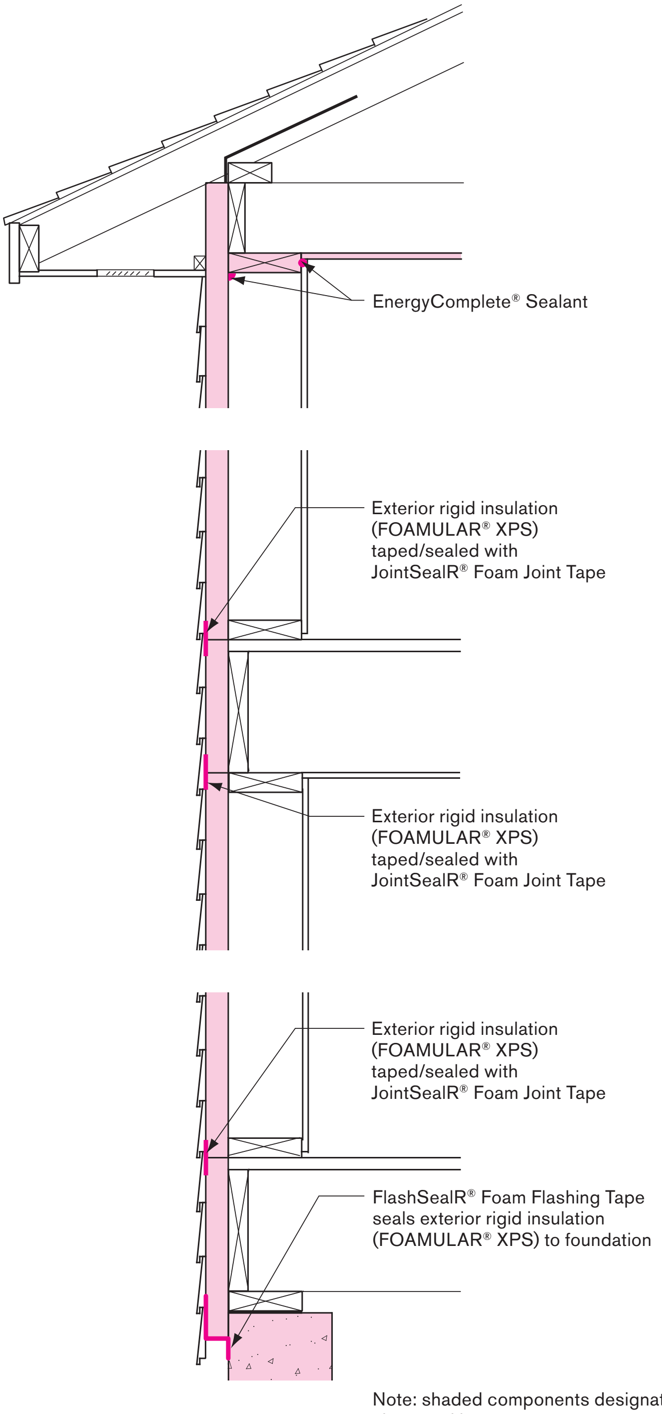


Figure 1.22:
Exterior air control layer using taped and sealed rigid insulation.

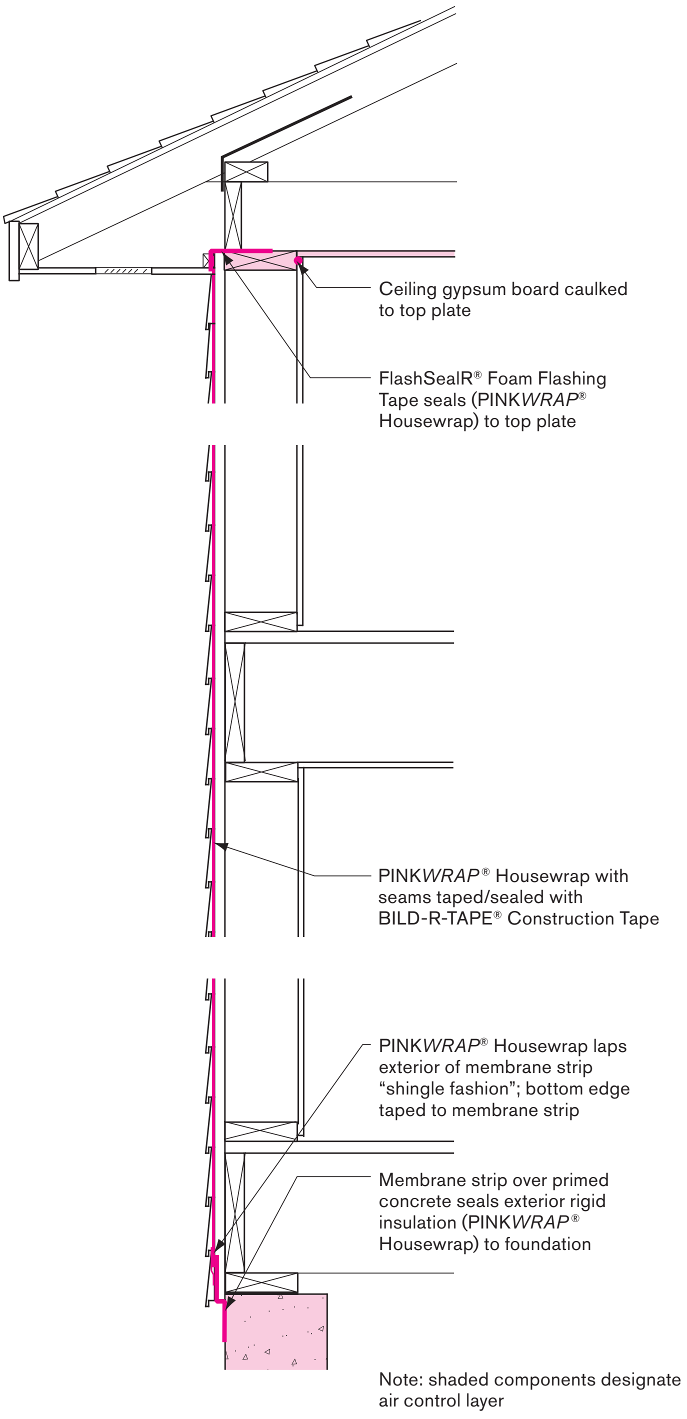


Figure 1.23:
Exterior air barrier system using a supported and sealed housewrap.

Installing both interior and exterior air control layers can address the weakness of each.

Air control layers can also be provided with properties which also class them as vapor barriers. An example of this are self-adhered modified bituminous membranes and sheet polyethylene which can be used as both an air control layer and a vapor control layer.

Keep in mind however, sheet polyethylene on the inside of building assemblies in cold, mixed-humid, marine, hot-dry and hot-humid climates is not generally a good idea; drying of building assemblies in these climates needs to occur to the inside during air conditioning periods.

Note that interior drying is necessary in air conditioned enclosures. In other words, interior vapor barriers such as polyethylene and vinyl wall coverings should never be installed in air conditioned buildings — even ones located in cold climates.

The most common air control layer location and approach is an interior control layer using gypsum board. Where this approach is used window and door openings need to be air sealed from the interior as well as where interior partition walls intersect exterior walls (Figure 1.24). With intersecting interior partition walls both sides of the first stud need to be sealed to the gypsum board as well as the top and bottom of this first stud (Figure 1.25 and Figure 1.26). The tops of interior partition walls also need to be sealed where they intersect insulated ceilings (Figure 1.27).

One way to do this is to install the ceiling gypsum board first. Seal the perimeter of each room to the top plate of both interior and exterior wall framing. Then install the gypsum board on the exterior walls and seal this gypsum board to the first stud of intersecting interior partition walls. Then install gypsum board on the interior partition walls.

Another way to do this is to use a cavity sealant system (EnergyComplete® Sealant) prior to installing any gypsum board. This approach avoids the sequencing issues noted above and considerably speeds up the construction process.

Wherever penetrations exist on the interior of insulated wall and ceiling assemblies such as electrical boxes they should be sealed to interior finishes such as gypsum board with joint compound and sealant or enclosed in airtight enclosures (Figure 1.28 and Figure 1.29).

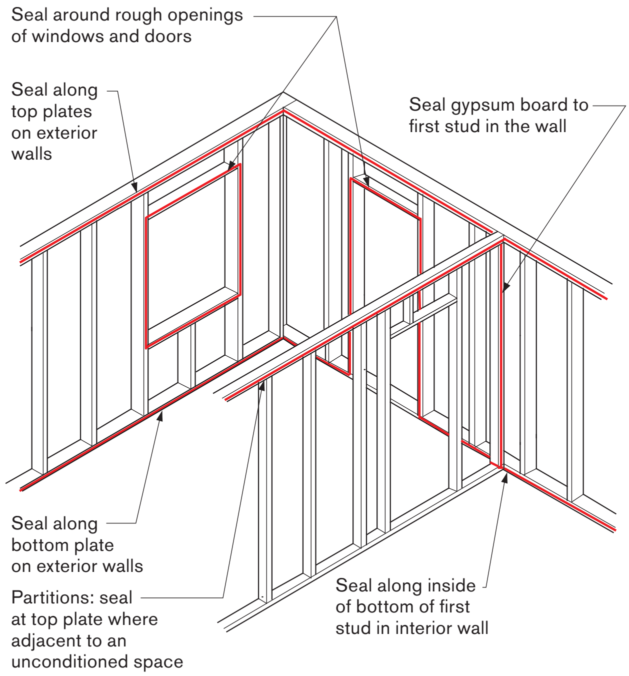


Figure 1.24:
Window and door openings need to be air sealed from the interior.

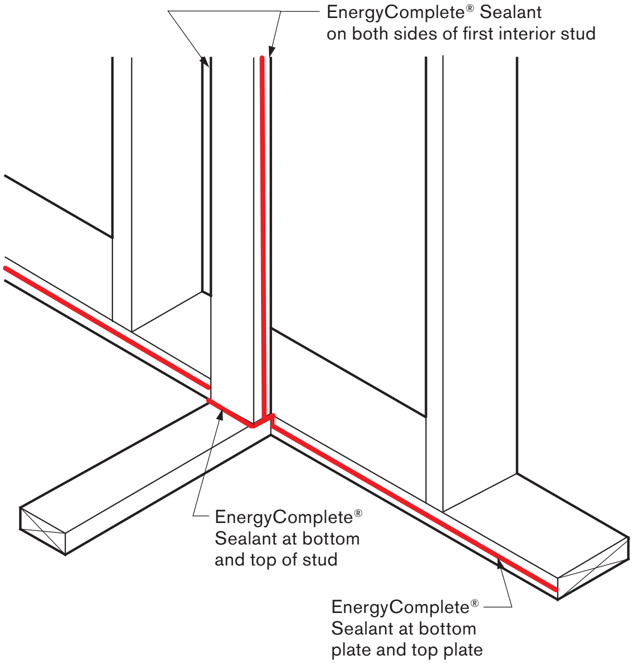


Figure 1.25:
Sealing the bottom of partition walls.

Figure 1.26:
Sealing the top of partition walls.

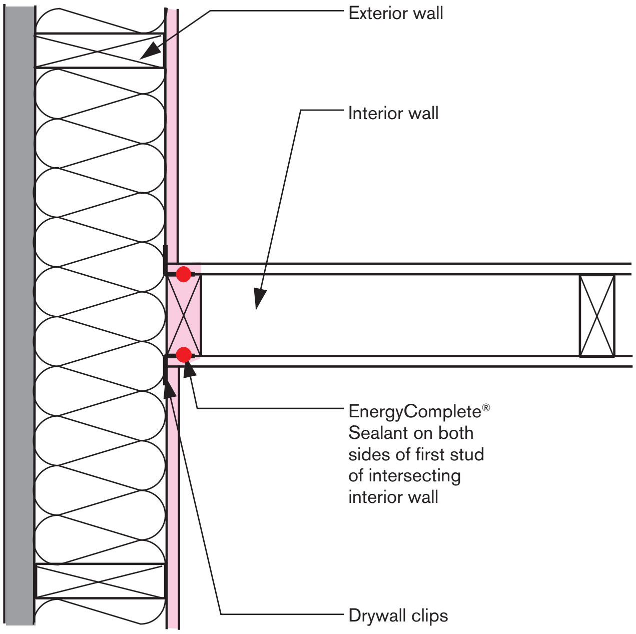
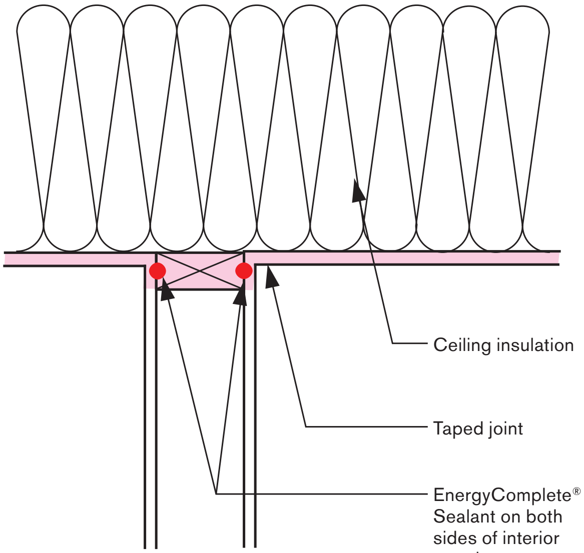


Figure 1.27:
Sealing partition walls where they intersect insulated ceilings.



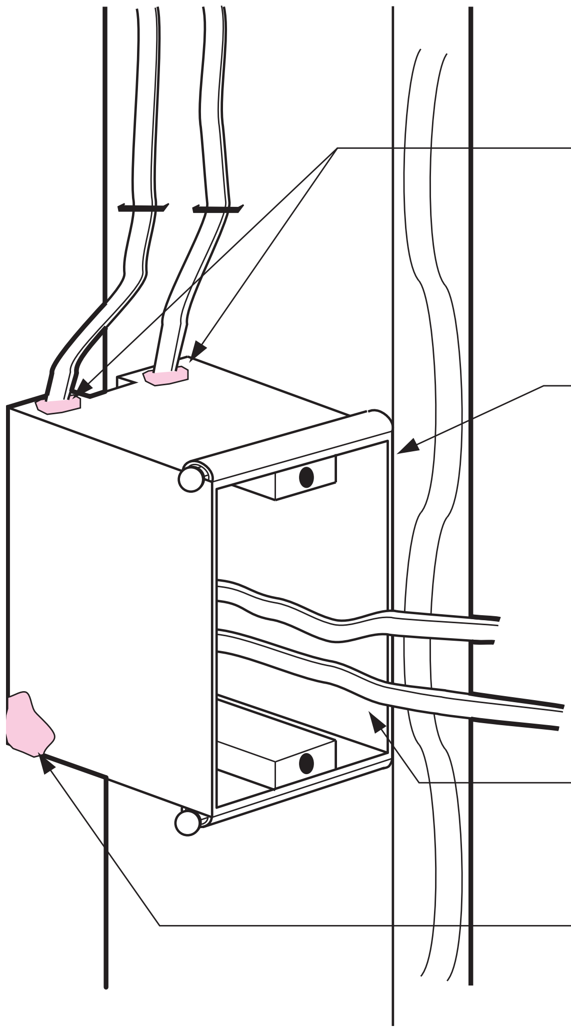


Figure 1.28:
Electrical box sealing

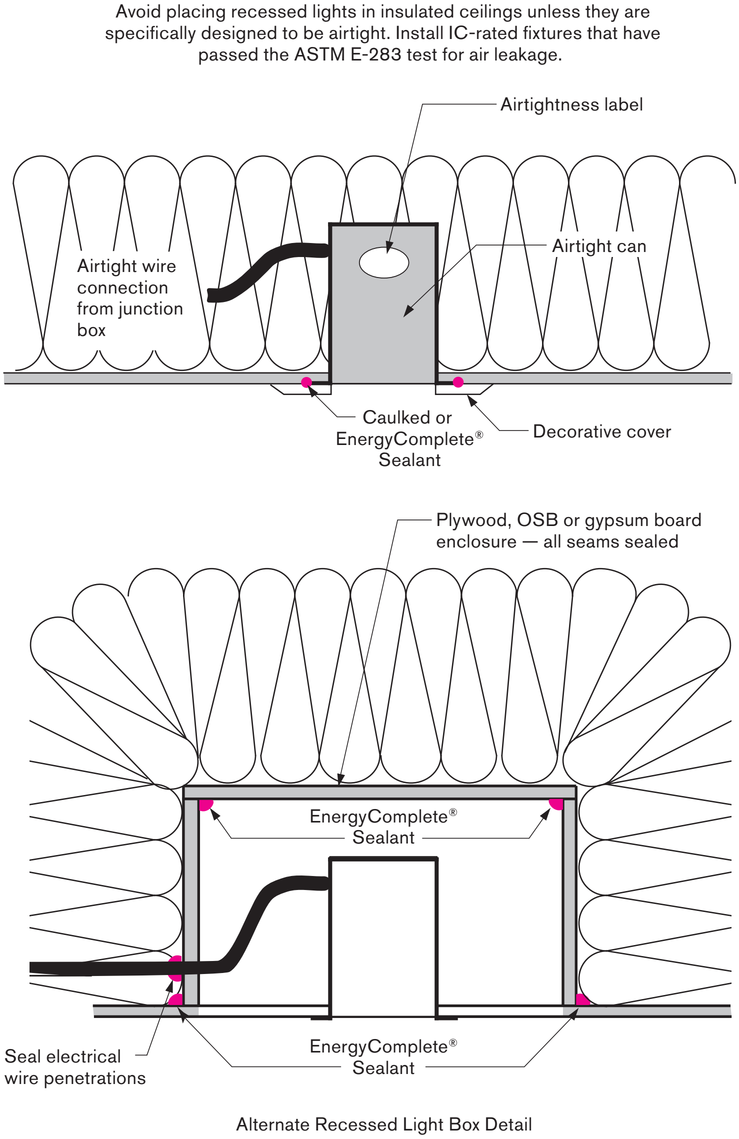


Figure 1.29:
Airtight recessed light box

CHAPTER 3
VAPOR CONTROL LAYER

The function of a vapor control layer is to retard the migration of water vapor. Where it is located in an assembly and its permeability is a function of climate, the characteristics of the materials that comprise the assembly and the interior conditions. Vapor control layers are not typically intended to retard the migration of air. That is the function of air control layers.

Confusion on the issue of vapor control layers and air control layers is common. The confusion arises because air often holds a great deal of moisture in the vapor form. When this air moves from location to location due to an air pressure difference, the vapor moves with it. This is a type of migration of water vapor. In the strictest sense air control layers are also vapor control layers when they control the transport of moisture-laden air.

Incorrect use of vapor control layers can lead to an increase in moisture related problems. Vapor control layers were originally intended to prevent assemblies from getting wet. However, they often prevent assemblies from drying. Vapor control layers installed on the interior of assemblies prevent assemblies from drying inward. This can be a problem in any air-conditioned enclosure. This can also be a problem in any below grade space. Finally this can be a problem where there is also a vapor control layer on the exterior such as impermeable rigid insulation — the “double vapor barrier” problem.

3.1 PRINCIPLES

The fundamental principle of control of water in the vapor form is to keep it out and to let it out if it gets in. It can get complicated because sometimes the best strategies to keep water vapor out also trap water vapor in. This can be a real problem if the assemblies start out wet because of rain or the use of wet materials.

It gets even more complicated because of climate. In general water vapor moves from the warm side of building assemblies to the cold side of building assemblies. This is simple to understand, except we have trouble deciding what side of a wall is the cold or warm side. Logically, this means we need different strategies for different climates. We also have to take into account differences between summer and winter.

Finally, complications arise when materials can store water. A cladding system such as a brick veneer can act as a reservoir after a rainstorm and significantly complicate wall design. Alternatively, wood framing or masonry can act as a hygric buffer absorbing water lessening moisture shocks.

There are three principle control approaches to dealing with water in the vapor form. The first is to let the water vapor pass through the assembly from the inside out and from the outside in. Where a wall assembly is concerned it is a wall that can dry to both sides. We call these types of assemblies "flow-through" assemblies.

The second is to locate a distinctive vapor control layer to retard the flow of water vapor into the wall assembly from either the inside or from the outside. We call these types of assemblies "vapor control layer" assemblies. The most common location for a vapor control layer is on the inside "warm in winter" side of the thermal insulation.

The third is to control the temperature of the surfaces where condensation is likely to occur by raising the surface temperature with insulation. The most common method of doing this is to use rigid insulation on the exterior of assemblies. We call these types of assemblies "control of condensing surface temperature" assemblies.

3.2 FLOW-THROUGH ASSEMBLIES

A wall assembly that is vapor open on both the interior and exterior whose cavity is insulated with a vapor open insulation such as a fiberglass batt or blown netted fiberglass is called a flow-through assembly (Figure 1.30). Plywood and OSB sheathing installed on the exterior are semi vapor permeable — they "breathe". The water control layers (building paper, housewrap

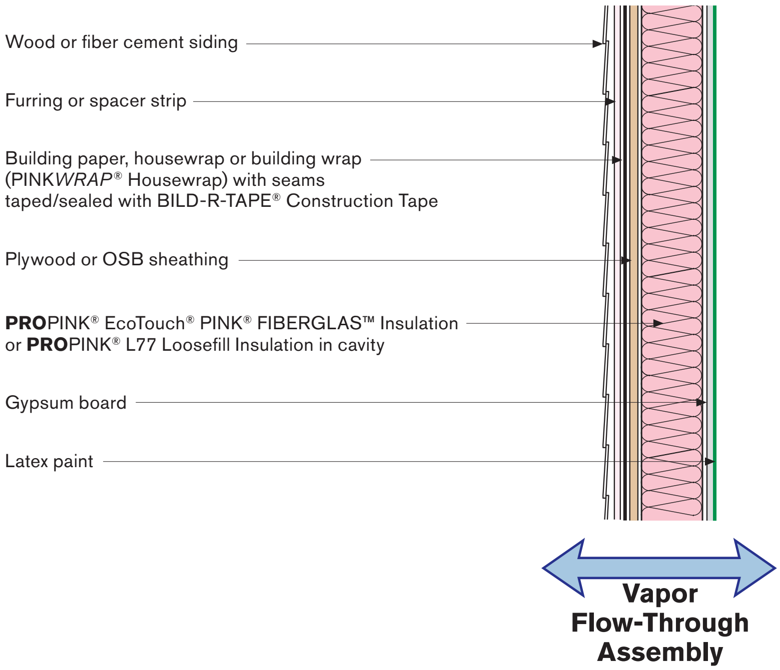


Figure 1.30: Flow-through assembly.

and building wrap) typically installed over plywood and OSB are also semi vapor permeable. Gypsum board installed on the interior painted with latex paint is also semi vapor permeable.

The key to a flow-though assembly is the exterior cladding layer and its attachment. Many exterior claddings can retard the flow of vapor. For example vinyl siding is a vapor barrier. But since vinyl siding is leaky to air at each joint and its profile yields an airspace between it and the water control layer it is said to be "back ventilated". This air circulation behind the vinyl siding prevents the vinyl siding from trapping water vapor allowing the assembly to dry to the exterior.

A brick veneer that is free from mortar droppings with weep openings at the bottom and top is also back ventilated thereby allowing the assembly to dry to the exterior.

Wood siding and fiber cement siding should be installed on furring strips or spacer strips to provide back ventilation creating a flow-through assembly. These furring strips or spacer strips can be as thin as ⅜-inch to provide effective back ventilation.

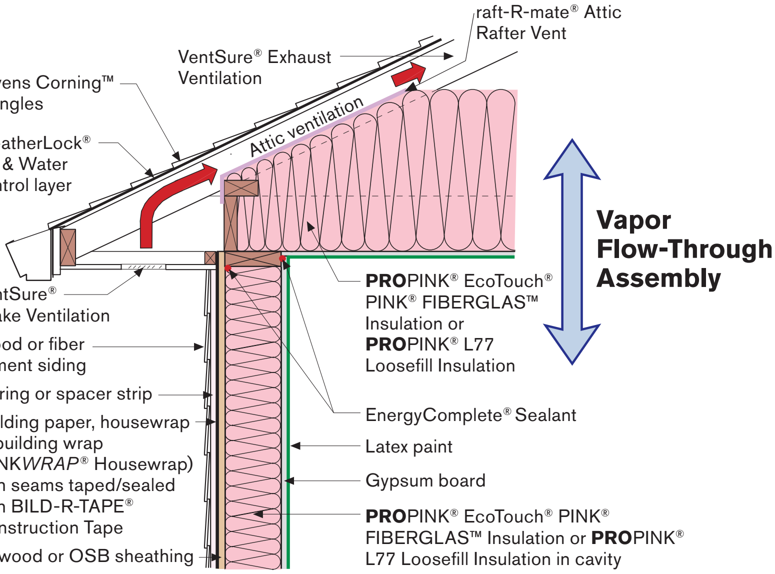


Figure 1.31: Vapor flow-through assembly.

With stucco renderings a continuous air gap should be provided behind the stucco to facilitate back ventilation. This is typically done by providing a drainage mat over the water control layer and then installing a paper backed lath over the drainage mat. Ventilation openings also are provided at the top and bottom of the stucco clad walls.

An attic assembly that is vented and constructed with latex painted ceiling gypsum board and insulated with **PRO**PINK® EcoTouch® PINK® FIBERGLAS™ or **PRO**PINK® L77 Loosefill Insulation or blown fiberglass is also called a flow-through assembly (Figure 1.31).

3.3 LIMITATIONS OF FLOW-THROUGH ASSEMBLIES

Flow-through assemblies perform well in most climates. However, they can be overwhelmed in certain conditions. For example in climates with cold winters where interior moisture levels can get high during the winter months more moisture can enter these assemblies from the interior than can leave these assemblies to the exterior. In such situations it is common to throttle down the vapor flow into the assemblies from the interior by installing a vapor control layer on the interior. The model building codes recognize this and limit flow through assemblies to specific regions. The 2012 IRC limits flow-through assemblies with vented claddings to Climate Zones 1 through 5. A map of the 2012 IRC Climate Zones is presented in Figure 1.32.

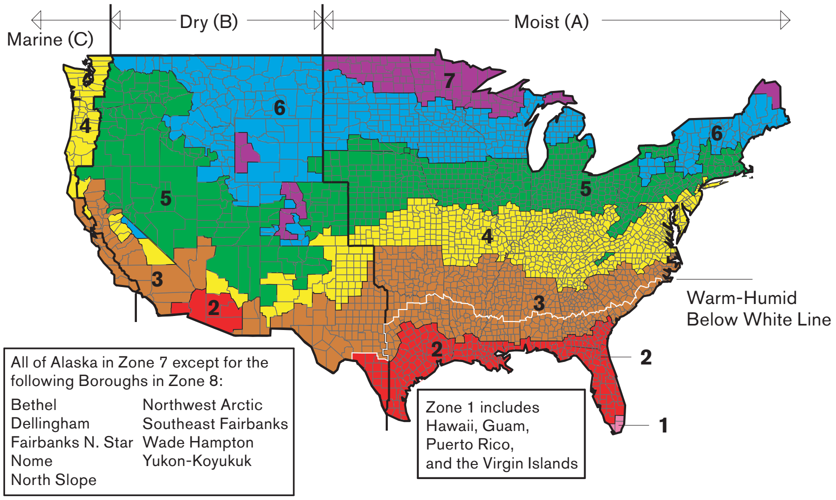


Figure 1.32:
Climate zone map.

Another example where a flow-through assembly can be overwhelmed is where a "reservoir" cladding is located on the exterior of semi vapor permeable water control layers and exterior sheathing such as building paper installed over plywood and OSB sheathing. Consider the case where a brick veneer becomes saturated after a rainstorm. The brick acts as a reservoir storing water. When the sun shines on the rain wetted brick veneer it raises the temperature of the water stored in the brick. This water is now driven out of the brick in both directions (Figure 1.33). The outward drive does not hurt the assembly, but the inward drive can. The water vapor driven inward can pass through the air gap, vapor semi permeable housewrap and vapor semi permeable sheathing into the wall cavity. It is possible to drive sufficient moisture into the assembly to create problems. One effective way of addressing this issue is to have a cavity behind the brick veneer free of mortar droppings that is vented at the top and bottom. The moisture driven inward out of the brick can then be intercepted by a moving stream of ventilation air that dries the assembly to the exterior. Another effective way of addressing this issue is to install a semi vapor impermeable rigid insulation layer behind the brick veneer (FOAMULAR® XPS Insulation) that throttles this inward vapor drive. Note that a drainage gap and a water control layer (FOAMULAR® XPS Insulation with joints sealed with JointSealR® Foam Joint Tape) are still necessary to handle rainwater entry.

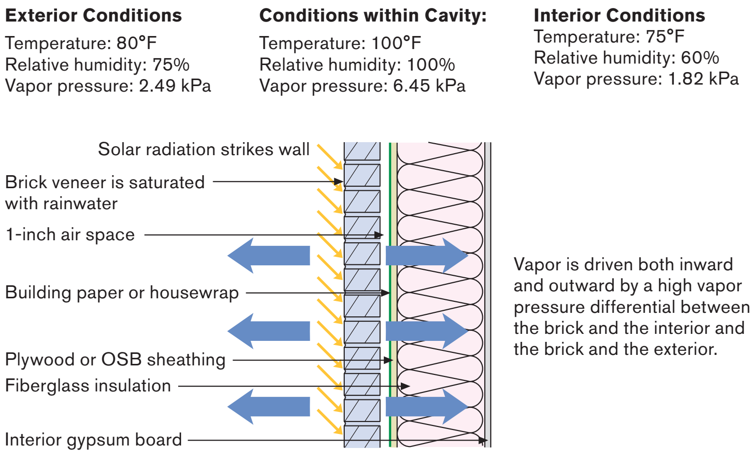


Figure 1.33: Solar driven moisture in brick veneer.

3.4 VAPOR CONTROL LAYER ASSEMBLIES

In more extreme climates such a cold climates where vapor drive from the interior towards the exterior occurs for extended periods of time during the winter months this outward vapor drive can be controlled by installing a vapor control layer on the interior of the insulation (Figure 1.34 and Figure 1.35).

The concern with inwardly located vapor control layers is if they are too impermeable such as sheet polyethylene they can trap moisture in the assembly by preventing inward drying. An effective way to address this issue is to use a material that changes its permeance seasonally and using the typical differences in interior relative humidity between the winter and summer months.

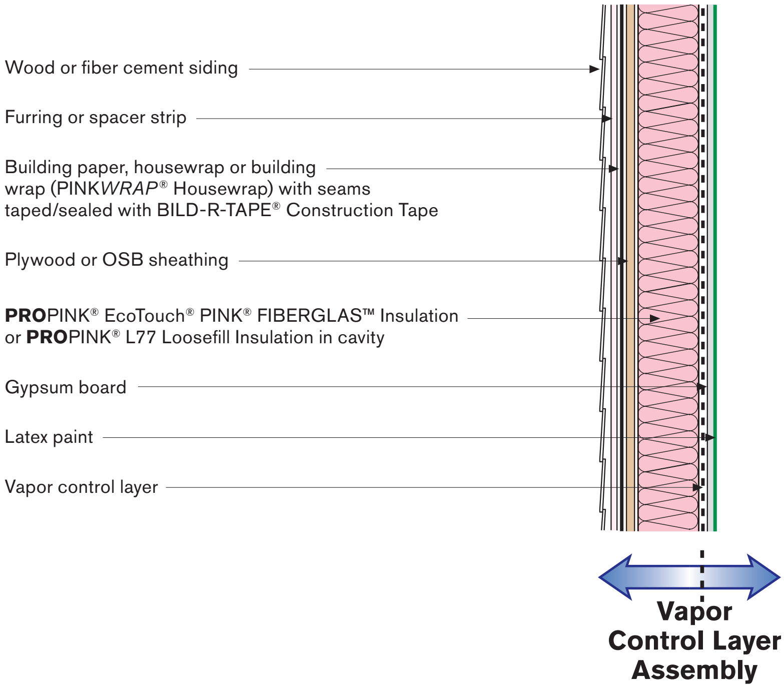


Figure 1.34: Vapor control layer on the interior of the insulation.

For building science assistance contact buildingscience@owenscorning.com

In newly constructed, code compliant North American houses winter interior humidities are typically between 20 percent and 30 percent relative humidity (RH). Summer interior humidities are typically between 50 and 60 percent RH. Note that the comfort range for most people is between 20 percent and 60 percent RH (Figure 1.36).

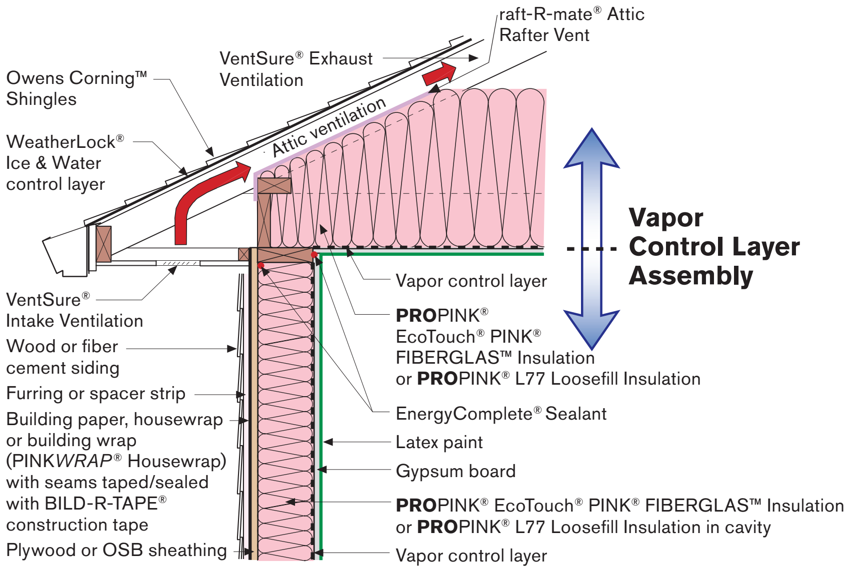


Figure 1.35:
Vapor control layer on the interior of the insulation.

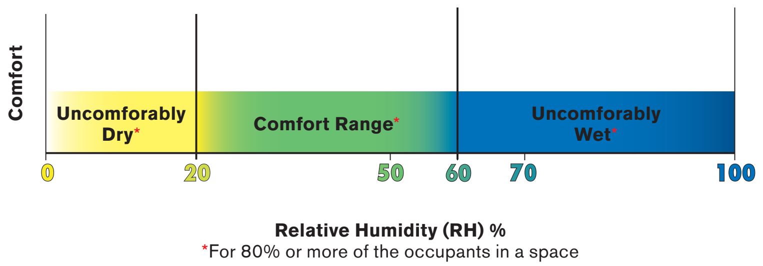


Figure 1.36:
Interior relative humidity and comfort levels.

Asphalt coated kraft paper installed on the interior fiberglass batt cavity insulation (**PRO**PINK® EcoTouch® Kraft-Faced Insulation) changes its water vapor permeance as a function of relative humidity (Figure 1.37). At 25 percent RH it has a permeance of approximately 1 perm. At 60 percent RH it has a permeance of approximately 10 perms. So under typical interior winter conditions the facing is a vapor control layer limiting or throttling the outward vapor drive protecting the assembly. Under typical interior summer conditions the facing is vapor permeable allowing drying to the interior.

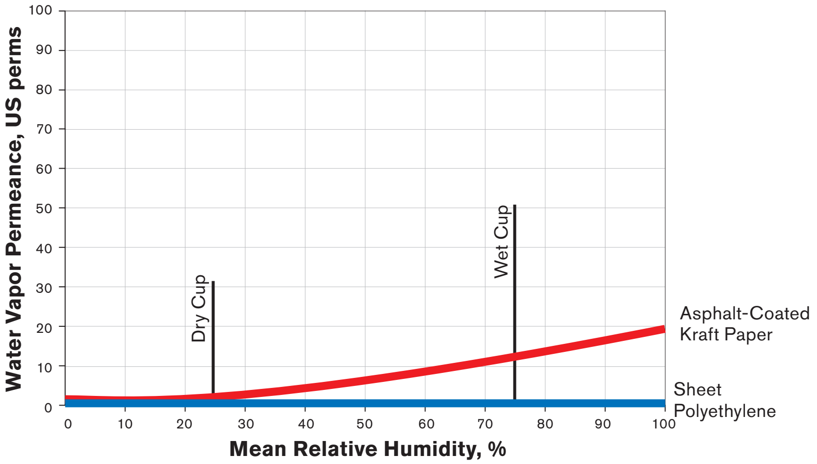


Figure 1.37:
Asphalt coated kraft paper installed on the interior of a cavity filled with fiberglass batt insulation changes its water vapor permeance.

3.5 CONTROL OF CONDENSING SURFACE TEMPERATURE ASSEMBLIES

Vapor drive from the interior to the exterior can also be controlled by installing rigid insulation (FOAMULAR® XPS Insulation) on the exterior of the structural framing. This rigid insulation raises the temperature of the wall cavity surfaces where condensation is likely to occur. We call these types of assemblies "control of condensing surface temperature" assemblies (Figure 1.38).

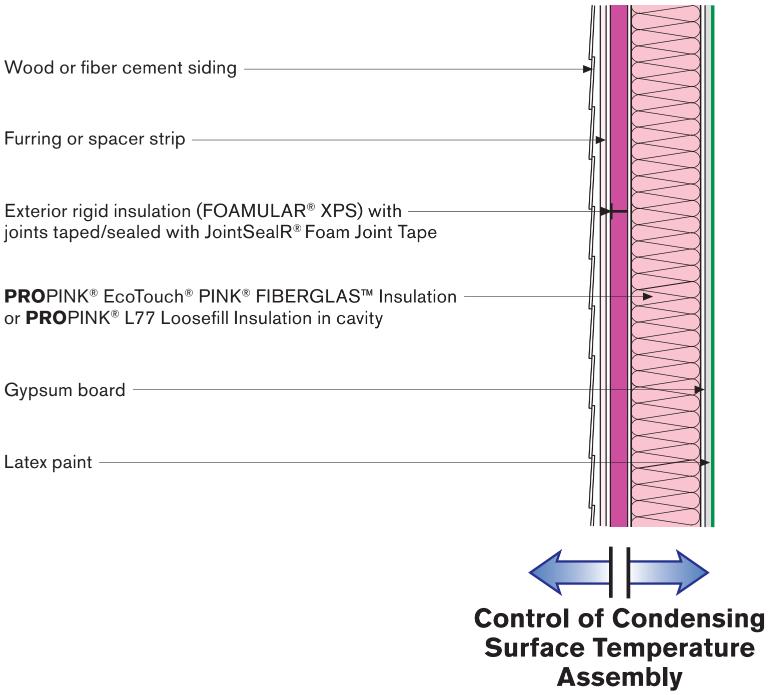


Figure 1.38: Control condensing surface temperature assembly

Figures 1.39 and 1.40 shows how the potential for condensation is reduced for the same wall assembly when rigid insulation is installed on the exterior of the structural framing. By raising the temperature of the condensing surface of interest sufficiently, condensation from interior water vapor migrating into the wall assembly does not occur. This allows assemblies to be constructed in cold climates without interior vapor control layers. The model building codes recognize this and provide guidance on the minimum thermal resistance values of rigid insulation required to control condensation in specific regions.

Figure 1.39:
Potential for condensation for a wall assembly located in Chicago, IL.

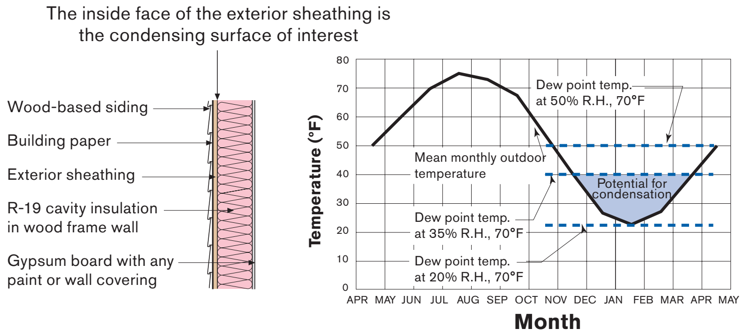


Figure 1.40:
Reduced potential for condensation for a wall assembly located in Chicago, IL

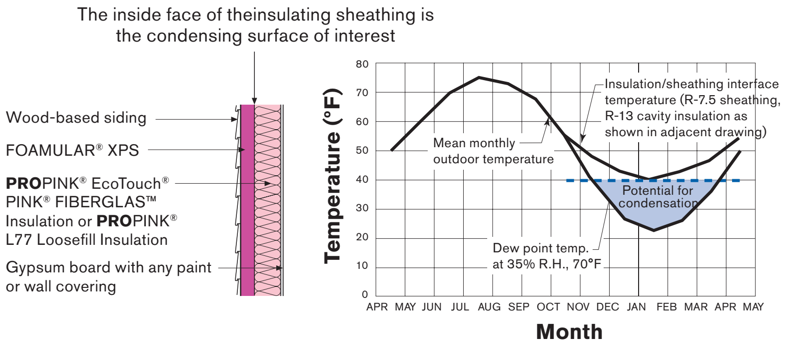


Table 1.1 is information taken from the 2012 IRC and provides guidance for thermal resistance values to control condensation for Climate Zones 5, 6, 7, 8 and 4 marine (4C).

Table 1.1:
Thermal resistance values to control condensation for climate zones 5, 6, 7, 8 and 4 marine from 2012 IRC.

Climate Zone	Framing	Rigid Insulation Minimum R-value
4C	2x4 2x6	2.5 3.75
5	2x4 2x6	5 7.5
6	2x4 2x6	7.5 11.25
7/8	2x4 2x6	10 15

Figure 1.41 illustrates the same principle applied to roofing assemblies. Rigid insulation is installed over the top of the structural roof deck elevating the temperature of the underside of the roof deck to control condensation.

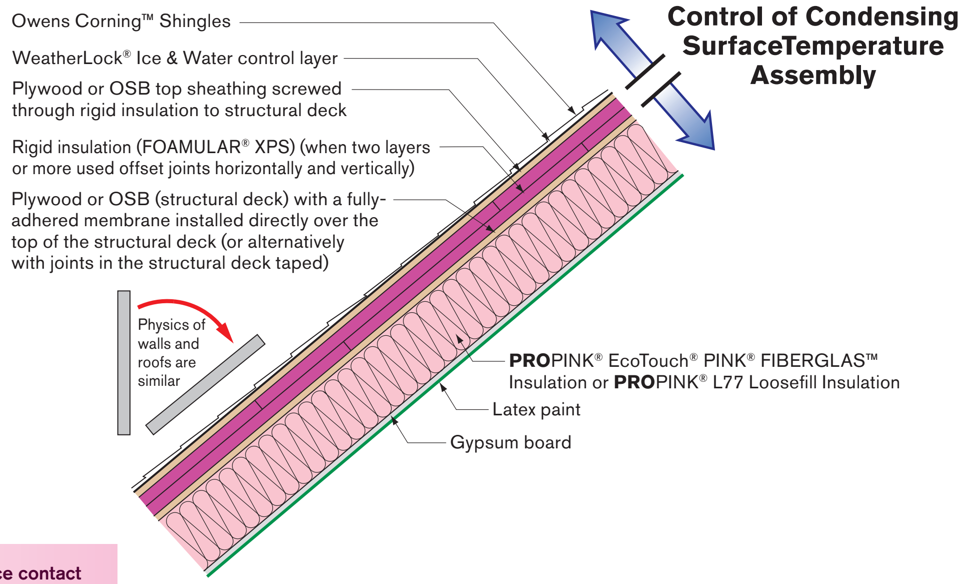


Figure 1.41:
Control condensing surface temperature in a roof assembly.

For building science assistance contact buildingscience@owenscorning.com

Table 1.2 is information taken from the 2012 IRC and provides guidance for thermal resistance values to control condensation in roof/attic assemblies for all Climate Zones.

Table 1.2:
Thermal resistance values to control condensation in roof/attic assemblies for all climate zones from 2012 IRC.

For building science assistance contact buildingscience@owenscorning.com

Climate Zone	Rigid Insulation Minimum R-value	Cavity Insulation Maximum R-value	Minimum Total R-value
1	5	25	30
1, 2 & 3	5	33	38
4A & 4B	15	34	49
4C	10	39	49
5	20	29	49
6	25	24	49
7	30	19	49
8	35	14	49

CHAPTER 4
THERMAL CONTROL LAYER

The function of the thermal control layer is to control the flow of heat from both the inside to the outside and from the outside to the inside. As with the other control layers the most important factor to consider when dealing with the thermal control layer is its continuity.

4.1 THERMAL BRIDGES

Gaps and openings in the thermal control layer are called thermal bridges. Some thermal bridges are not significant, such as wood framing as wood is not highly thermally conductive. However, thermal bridges that occur with highly thermally conductive materials such as concrete and steel can be very significant to the thermal performance of the building and can affect heating and cooling costs, occupant comfort and building durability if condensation occurs on them. Examples of significant thermal bridges are uninsulated exposed concrete foundation slabs, steel beams that penetrate the building enclosure and steel framing in general. Many northern climates jurisdictions require in their codes to include continuous insulation to act as a thermal break over the framing members.

Wood frame building cavities are typically insulated with fiberglass batt or blown fiberglass behind a netting insulation. Wood is not highly thermally conductive and the combination of wood framing and fiberglass cavity insulation is an effective combination. The framing portion of the typical “opaque” portion of the building enclosure when framing on 16-inch centers (not including windows and doors) is approximately 30 percent and the insulated cavity portion of the building enclosure is 70 percent. This is often expressed as a “framing factor” of 30 percent.

With wood frame buildings a framing factor of 30 percent results in a reduction of the effective thermal performance of the cavity insulation by approximately 10 percent. With steel frame buildings a similar framing factor results in a reduction of the effective thermal performance of the cavity insulation by approximately 70 percent due to the high conductivity of steel relative to wood. Hence the practice and need to insulate steel frame buildings on the exterior with continuous rigid insulation.

Framing factors can be reduced to 15 percent or less using efficient framing techniques often called “advanced framing”. These techniques are referenced and accepted by the model building codes and involve “stack framing”, framing on 24-inch centers rather than 16-inch centers, single top plates, two stud corners and elimination of “jack studs” and “cripples”. To provide structural equivalency this is done with 2x6 framing not 2x4 framing.

For fiberglass cavity insulation to be effective it should not have air flowing through it or around it and it should completely fill the cavities. Hence it should be coupled with an air control layer and fitted and cut carefully around electrical wires, service penetrations and boxes and not compressed in a manner that results in voids so that it recovers to full thickness completely (Figure 1.42). Behind electrical boxes, the cavity insulation should be compressed as the density increase that occurs at this location also results in an increased R-value. The insulation must be cut around the box so that the insulation can recover to full thickness at the edges of the box. The other option is to spray loosefill behind a netting. This fiberglass naturally flows behind and around obstructions forming a monolithic insulation pack in the cavity.

Exterior continuous rigid insulation (FOAMULAR® XPS Insulation) can be added to both wood frame buildings and steel frame buildings. As mentioned previously, exterior continuous rigid insulation is essential to steel frame buildings because of the significance of the thermal bridging of the highly conductive steel framing elements.

Concrete masonry block walls — the concrete blocks are often called concrete masonry units or CMU’s — are also highly conductive and are best insulated on the exterior with continuous rigid insulation. It is possible to insulate CMU wall assemblies on the interior with continuous rigid insulation but the thermal bridging of floor systems and floor slabs must be accounted for.

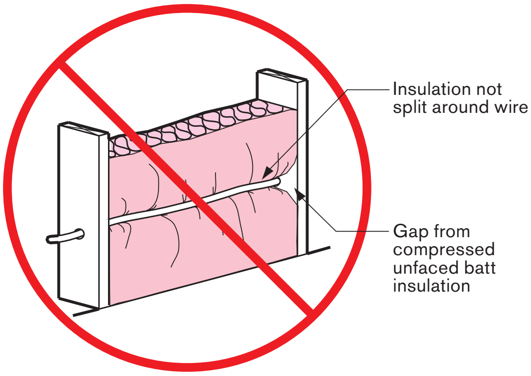
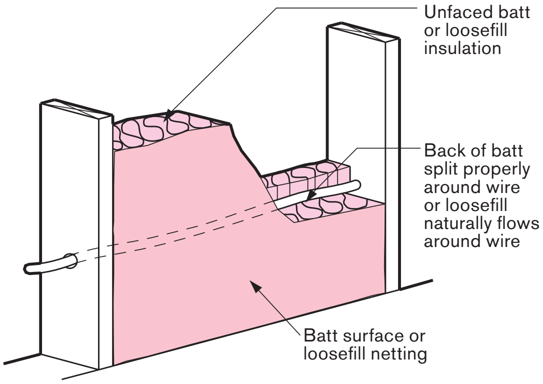
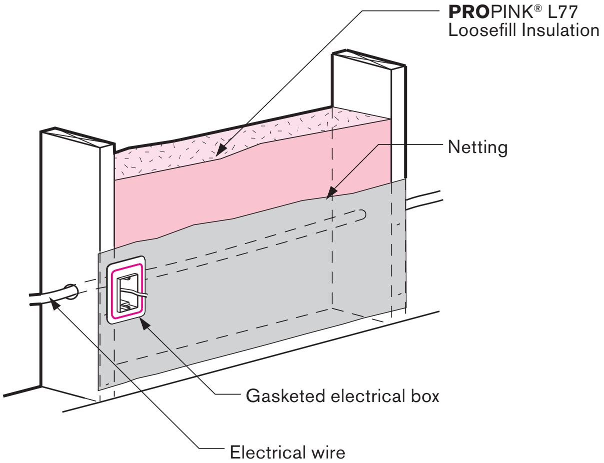


Figure 1.42:
Fiberglass cavity insulation installation.





Grade 1 install training videos available from Owens Corning and other manufacturers

4.2 **CAVITY THERMAL PERFORMANCE**

The space between the thermal bridges or wood framing members in wall and enclosed ceiling/floor assemblies is commonly referred to as a stud cavity, or cavity and it is filled with cavity insulation. This insulation is either in a batt form (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation) or installed as a loosefill (**PRO**PINK® L77 Loosefill Insulation). The level of thermal performance for a cavity is set in the design stage. Once the depth of the cavity has been set, what dimensional or engineered lumber will be used, then the R-value of the cavity is selected.

For batt insulation in say 2x6 construction, the typical batt insulation performance level choices are R-18, R-20, and R-21 in the 5 ½-inch deep cavity. Now converting this to loosefill insulation, the R-value can be set to anywhere in the range from R-22 up to R-25 by introducing different densities of the loosefill. Clearly, in an open attic installation, there is no enclosed cavity and batts can be installed to their unconstrained thickness and even layered to achieve higher insulation levels.

Standard attic insulation products include R-30 and R-38 and can be combined to achieve the higher commonly targeted insulation levels of R-49 and R-60. Again, using loosefill insulation, a continuous range of R-values can be achieved from R-30 up to R-60 and above in increments of R-1 in this unconstrained space.

CHAPTER 5
CONTROL OF NOISE AND VIBRATIONS

There are two ways that sound passes through a building envelope — airborne sound vibrations and structure-borne sound vibrations. Most of the time sound travels through a combination of these two modes of transmission.

Pure airborne sound can be controlled with a continuous air control layer. Pure structure-borne sound vibrations can be controlled with the use of mass and damping. All other sound penetration of the enclosure is a combination of these two modes of sound transmission and can be controlled by a combination of mass, damping, and air flow control.

Sound waves travel through partitions such as exterior walls, windows, and doors. Sound vibrations traveling through solid materials, such as gypsum board, plywood, glass, OSB, studs or joists are called structure-borne vibrations and sound vibrations traveling through air, such as framing cavities, hollow core doors, window assemblies, and unsealed penetrations or gaps are called airborne sound vibrations. Controlling these vibration paths determine how well exterior wall assemblies reduce the transmission of sound (or noise) from one side to the other.

Building enclosures incorporate more than just framing members, insulation, and various types of sheathing. Windows and doors play a critical role in determining the overall noise control performance of any enclosure.

When designing for noise control it is necessary to approach the many noise control paths and design features of the wall as a "system" that interact acoustically with each other. The following noise control elements will be discussed:

- Air Penetrations
- Cavity Insulation
- Breaking Vibration Paths
- Effects of Mass
- Composite Assemblies (Effects from Doors & Windows)

5.1 AIR PENETRATIONS

Air and sound penetration through walls occur as one and the same. If air can penetrate a wall assembly then sound (or noise) will too. It takes very little air leakage to cause significant sound leakage. For example, an opening or crack the total size of only 1/100 of 1% of a total wall's surface area can reduce the sound transmission loss (TL) of a wall from 50 to 40 dB — a significant 10 dB drop in wall or floor sound control performance.

As a result, sealing air gaps and penetrations significantly reduces sound (noise) transmission through partitions such as exterior walls and underscores the importance of the air control layer in controlling sound (noise) transmission. Owens Corning's EnergyComplete® Sealant creates a continuous air barrier system in walls, ceilings and floors.

5.2 CAVITY INSULATION

One of the most effective means to control sound in walls, floors, and ceilings is through the use of fibrous cavity insulation. Air does not have to flow through an assembly to be part of the sound transmission process. Where wall cavities are airtight sound can penetrate the exterior shell into the wall cavity where its energy is converted to structure-borne sound transmission by exciting vibration in the drywall itself. These vibrations in turn excite the interior air creating airborne sound waves again.

Airborne sound vibrations cause air particles to vibrate. Unimpeded, these sound vibrations cause the moving air particles to transfer energy between them, enabling sound to easily travel through air. Air does not need to experience bulk flow to transmit sound through it. When a sound (vibrating air particles) enters a porous material such as fiberglass, the vibrating particles create drag over and around the many fibers to create friction. As a result, sound vibrations are converted to heat and sound energy is dissipated. Two other techniques to break the framing vibrational path at the training members are by applying a thick bead of EnergyComplete® Sealant on all the framing members before applying the drywall and by building a staggered stud or double studded wall.

The key to this process is the total surface area of the fibers which the vibrating air particles must maneuver around. The more fibers and fiber surface area, the more friction and sound attenuation. For sound absorption to occur there must be some level of air movement through the porous material. In this way, the density of fibers (size and qty., not weight) influences the level of sound absorption insulation can provide. Closed cell materials restrict this process.

Combining airtightness with porous framing cavity insulation is an effective noise control strategy.

The STC or Sound Transmission Class of a partition is a single number rating based on laboratory sound transmission loss (TL) measurements. The sound transmission loss of a partition or wall assembly measures the ability of the partition to block or attenuate the transmission of sound passing from one side to the other. The higher the sound transmission loss (measured in decibels, dB, from 125 Hz to 4000 Hz) the more a partition attenuates or reduces the transmission of sound passing through it. The single number STC rating is calculated from the TL data from ASTM Classification E 413. Experimental work has shown a strong relationship between increasing STC and increasing glass fiber insulation R-value in the wall, ceiling, or floor section constructions.

5.3 BREAKING VIBRATION PATHS

Walls and floors also transmit sound when they can transmit vibrations from one face to another through structural elements such as wood framing — studs and floor joists. An effective means of controlling such transmission is to break the vibration path using resilient channels between the gypsum board and the framing elements or to install a sound absorbing mat underlayment between floor finishes and floor sheathing (Owens Corning™ QuietZone® Acoustic Floor Mat).

Another technique is to stagger wood studs or build double walls, reducing sound transmission through them.

5.4 INCREASING MASS

Increasing wall mass is also an effective means of controlling structure borne sound vibrations. A heavier wall requires more energy to set it into vibration. The less a wall vibrates, the less sound passes through it.

Wall mass can be increased by adding an additional layer of gypsum board or by using concrete masonry units (CMUs) for exterior walls or for demising walls in multi-unit/townhouse construction or by adding a layer of gypsum concrete over floor sheathing.

As a general rule, every doubling of the weight of the wall increases sound transmission loss by an additional 5-6 dB. 6 dB is clearly noticeable to the human ear (3 dB is considered barely perceptible). Adding a couple layers of drywall to a partition can often make sense to quickly double the weight of a partition, but only after other measures, such as air sealing, cavity insulation, and vibration breaks, have been taken.

5.5 COMPOSITE ASSEMBLIES (EFFECTS FROM DOORS & WINDOWS)

Enclosure sound control strategies become complicated through the addition of windows and doors. Windows and doors are "designed penetrations". In general, the more energy efficient a window and door, the more effective it is in controlling sound. Double and triple glazed windows that are airtight are extremely effective at controlling sound transmission. Installing them in an airtight manner by connecting them to the assembly air control layer is key to the sound control strategy of the entire enclosure.

CHAPTER 6
CONTROL OF FIRE

A detailed discussion about fire control is beyond the scope of this guide. However, specific information as it relates to wall and roof design and some general principles will be provided.

There are two types of fire issues: fires emanating from the interior of a building and fires emanating from the exterior of a building.

The single most important design consideration for fire safety relating to interior fires is discovery of the fire and getting out of the home quickly and safely. Smoke detectors, carbon monoxide detectors and egress are central to this approach. The model building codes focus on these issues and they will not be discussed further beyond noting that following the model building codes is critical to such fire safety.

Fire safety relating to exterior fires focuses on not spreading fire from the exterior of one structure to another or the spread of fire by vegetation to a building.

6.1 FIRES EMANATING FROM THE INTERIOR

When rigid insulation (FOAMULAR® XPS Insulation) is used in the interior of a building where access is likely and frequent such as in a basement or in a conditioned crawl space, it must be protected from fire. This is typically done with a thermal barrier.

A thermal barrier is intended to protect an element in an assembly in a fire exposure by limiting the temperature rise at the surface of the element being protected to not more than 250 degrees F in a 15-minute time period. The 15-minute period is considered to be sufficient time for occupants to escape from a building.

The IRC recognizes ½-inch gypsum board as an effective thermal barrier as well as 3-inches of fiberglass insulation.

This guide recommends that all rigid insulation used in the interior of a building be protected by either ½-inch gypsum board or a minimum of 3½-inches of fiberglass insulation.

Ignition barriers are different from thermal barriers. Ignition barriers prevent the ignition of the element being protected from a spark, or from direct heat, but does not protect from direct flame. The IRC recognizes 1½-inch mineral fiber or spray on or brush on coatings as effective ignition barriers.

This guide does not recommend the use of ignition barriers as protection for rigid insulation used in the interior of a building.

Where access is not likely or common, such as an attic space that is vented to the exterior which is accessed only to service utilities and is not used for storage, then rigid insulation does not need to be protected from fire. This includes attics that contain HVAC equipment and associated ductwork. Note that this applies only to vented attics.

Where attics are used for storage or that are regularly accessed or are unvented and conditioned, then rigid insulation should be protected from fire with a thermal barrier. Exterior continuous rigid insulation (FOAMULAR® XPS Insulation) is often used as a sheathing at gable ends. In such applications where attics are used for storage and regular access occurs, unfaced fiberglass insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation) or blown-in insulation (**PRO**PINK® L77 Loosefill Insulation) should be used as a thermal barrier (Figure 1.43).

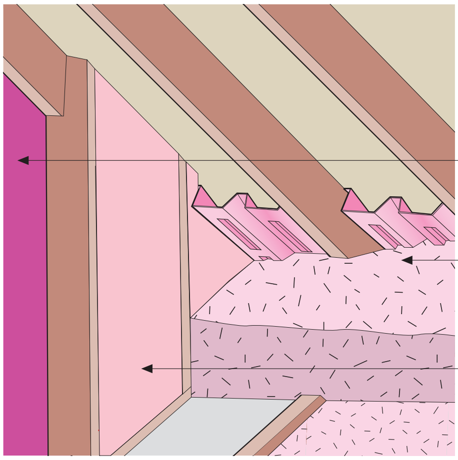


Figure 1.43: Unfaced fiberglass insulation in attics with storage.

Firestopping is used to seal openings and joints in fire-resistance rated wall and floor assemblies to the same degree as the fire-rated wall. In other words the rating of the firestopping material as applied is equal to or greater than the rating of the rated wall or floor assembly itself. In some rated assemblies fiberglass is considered an acceptable firestopping material.

Fireblocking is used to resist the free passage of flames or other products of combustion to other areas through concealed spaces. One of its main purposes is to slow air (oxygen) from feeding a fire. Solid materials such as dimensional wood are considered effective fireblocking material by the IRC as well as appropriate thicknesses of fiberglass insulation that are structurally supported or fixed in place within concealed spaces. EnergyComplete® Sealant is tested and qualified as hosted in UL-ER26533-01 to be a fire blocking material.

Draftstopping is often confused with fireblocking. Draftstopping is used to restrict the movement of air within open spaces of concealed areas. It is often used in open floor truss assemblies to break the open areas down to smaller compartments — typically less than 1,000 square feet. Gypsum board and fiberglass insulation are recognized by the IRC as effective draftstopping materials.

6.2 FIRES EMANATING FROM THE EXTERIOR

Two major concerns exist with fires emanating from the exterior — not spreading fire from the exterior of one structure to another, or the spread of fire by vegetation to a building (“wildfires”).

PRINCIPLES

When there is less than 5 feet between buildings such as is common with zero lot line construction the model codes require that walls be rated from the exterior for fire resistance purposes.

The zoning codes typically allow zero lot line construction. The building codes require specific fire resistance when this occurs.

The most common requirement is a “one hour fire-resistance rating” from the exterior. Ratings are often provided by testing laboratories — the most common being Underwriters Laboratory (UL).

Two specific assemblies using exterior continuous rigid insulation (FOAMULAR® XPS Insulation) have a one hour fire-resistance rating from the exterior. They are both designated as UL — Design No. U364 (Figure 1.44 and Figure 1.45).

The difference between the two wall assemblies is that where a brick veneer cladding is used an exterior rated gypsum sheathing is not required. When vinyl siding, wood or fiber cement siding or stucco are used as cladding materials then an exterior rated gypsum sheathing is required. The exterior rated gypsum sheathing must have joints sealed with joint compound for this rating to be met.

Note that the framing can be either 2x4 or 2x6 framing. However, both framing options must be on 16-inch centers. No rated walls currently exist for 2x6 advanced framing on 24-inch centers. It is not that such walls are unsafe, it is just that no such walls have been formally tested under ANSI/UL 263.

Further note that the rating is limited to walls with 2-inches of exterior continuous rigid insulation (FOAMULAR® XPS Insulation) or less.

With respect to wildfires the issue is burning embers. Roofs are particularly prone to burning ember exposure — both from the perspective of the roof covering and from the perspective of roof venting.

Roof coverings should have an ASTM E 108, Class A fire rating such as TruDefinition® WeatherGuard® HP Shingles.

With wildfires soffit vents are a problem because burning embers get drawn into the soffit vents and roof assemblies catch fire. Roof ventilation is prohibited in many wildfire zones for this reason.

Fortunately, unvented roofs can be constructed if the appropriate thermal and moisture control requirements of the model building codes are followed.

Figure 1.44:
Continuous exterior rigid insulation wall assembly designed to UL-Design No. U-364.

UL Design No. U364

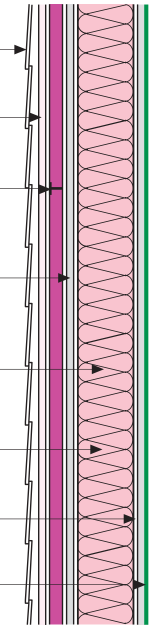
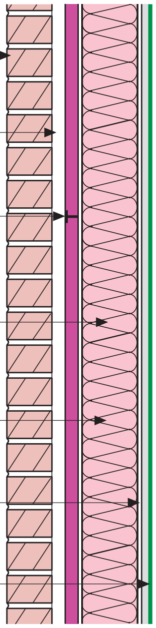


Figure 1.45:
Continuous exterior rigid insulation wall assembly designed to UL-Design No. U-364.

UL Design No. U364



CHAPTER 7

STRENGTH AND RIGIDITY

Walls, roofs and foundations must also provide the necessary strength and rigidity for the building enclosure to address wind, snow and seismic loads. These issues are regional and a detailed discussion of these loads is beyond the scope of this guide. For specific guidance, professionals should be consulted and local codes followed. However, some general points can be made.

Resistance to shear loads due to wind must be provided. Figure 1.46 illustrates some of the basic principles involved. It is clear from Figure 1.46 that walls provide a key function in transferring these loads to the foundation and ultimately to the ground. Similar loads and load paths exist for snow and seismic loads.

One of the most effective ways of providing load resistance to these forces is to provide shear panels at building corners (Figure 1.47). The most common shear panels used are plywood or OSB. Plywood and OSB are often referred to as “structural sheathing”.

In high wind zones, high snow load areas and high seismic risk areas it is often necessary to sheathing the entire building with structural sheathing (Figure 1.48).

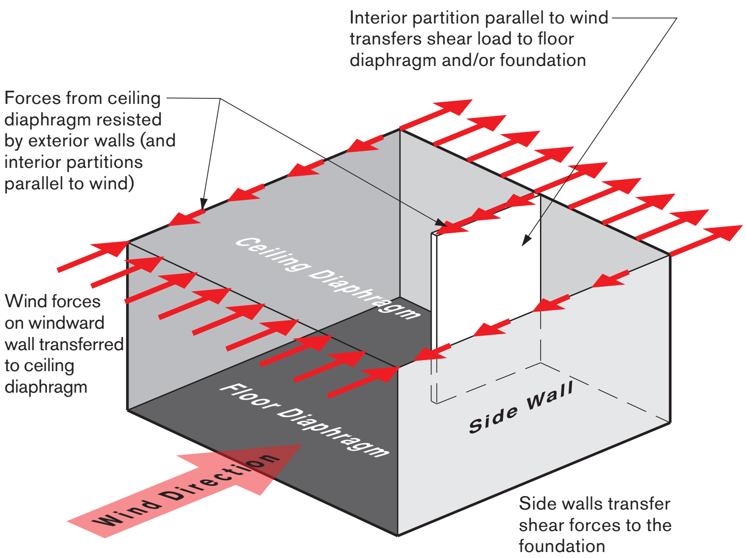


Figure 1.46: Shear loads due to wind.

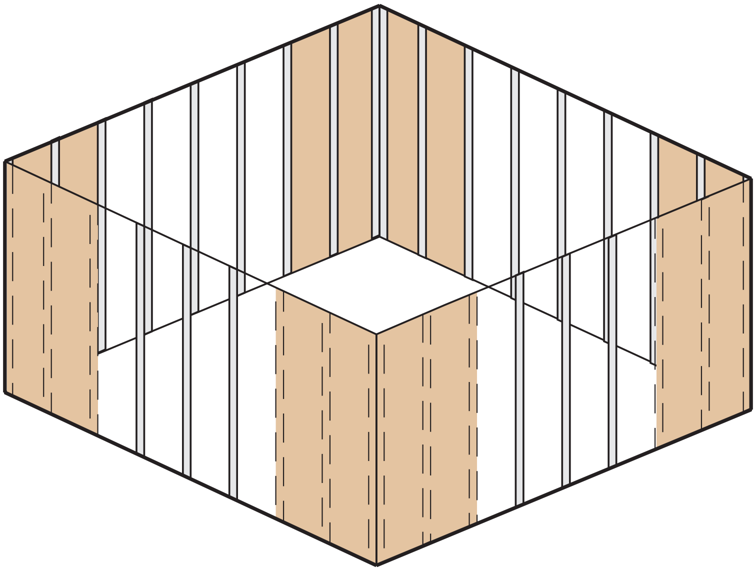


Figure 1.47:
Shear panels at building corners.

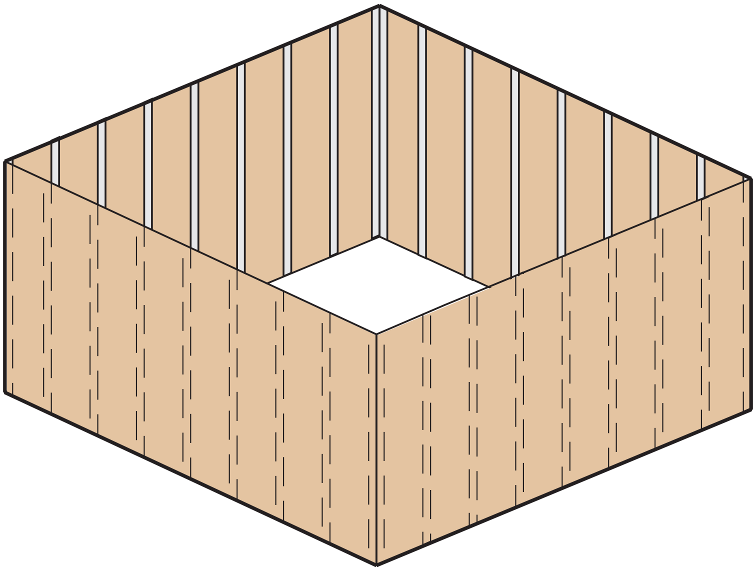


Figure 1.48:
Sheathing the entire building in high wind, snow and seismic areas.

7.1 EXTERIOR RIGID INSULATION

Exterior rigid insulation (FOAMULAR® XPS Insulation) does not provide shear resistance to exterior walls and must be used with structural sheathing. The amount of structural sheathing, type of structural sheathing and connections of the structural sheathing to the structural frame depend on the expected loads. These loads are established by local codes and building practices.

It is common to install exterior rigid insulation (FOAMULAR® XPS Insulation) directly over structural sheathing. Where structural sheathing is used only in corners, the exterior rigid insulation installed over the structural sheathing is integrated with the rigid insulation in the field of the wall by varying its thickness (Figure 1.49).

To align full sheets of exterior rigid insulation with full sheets of structural sheathing a “corner piece” or “filler” of rigid insulation may be necessary (Figure 1.50). Note the additional framing member required in the exterior corner necessary for corner trim attachment.

7.2 CLADDING ATTACHMENT

There are practical and structural limits to the attachment of cladding directly through exterior rigid insulation to the structural frame. Cladding fasteners must be installed directly into framing members. Structural sheathing is not an acceptable base for cladding attachment.

Many cladding manufacturers and suppliers limit the thickness of exterior rigid insulation that their products can be installed over. These limits are typically between 1-inch and 1½-inches for FOAMULAR® XPS Insulation and they vary from manufacturer to manufacturer and between product types. Vinyl siding requirements/limits are typically different than fiber cement siding requirements/limits. Individual manufacturers guidelines should be followed.

When thicker layers of exterior rigid insulation are used, structural furring is used to transfer the wind loads to the structural frame. This furring is typically nominal 1x4 dimensional wood for most wind load areas. Cladding is typically attached to the furring with ring shank nails in place of smooth shank nails due to their greater withdrawal strength (Figure 1.51).

Furring strips should be fastened through the exterior rigid insulation with epoxy coated steel screws. Furring strips do not need to be treated lumber as they easily dry to both sides into the air space they create. Should treated lumber be used for furring then stainless steel screws will be necessary due to the corrosive nature of treated lumber. Spacing of these screws and their gauge is determined by the local wind load and the spacing of the furring strips (16-inch centers vs. 24-inch centers).

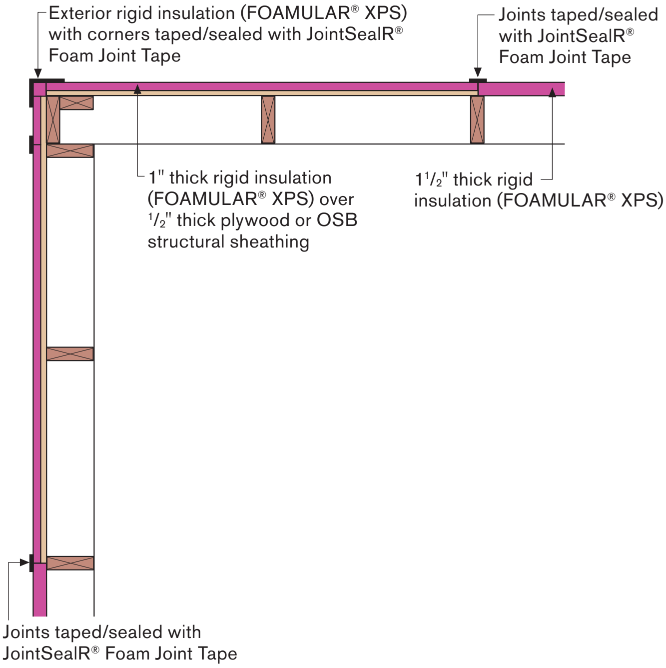


Figure 1.49: Exterior rigid insulation installed over structural sheathing.

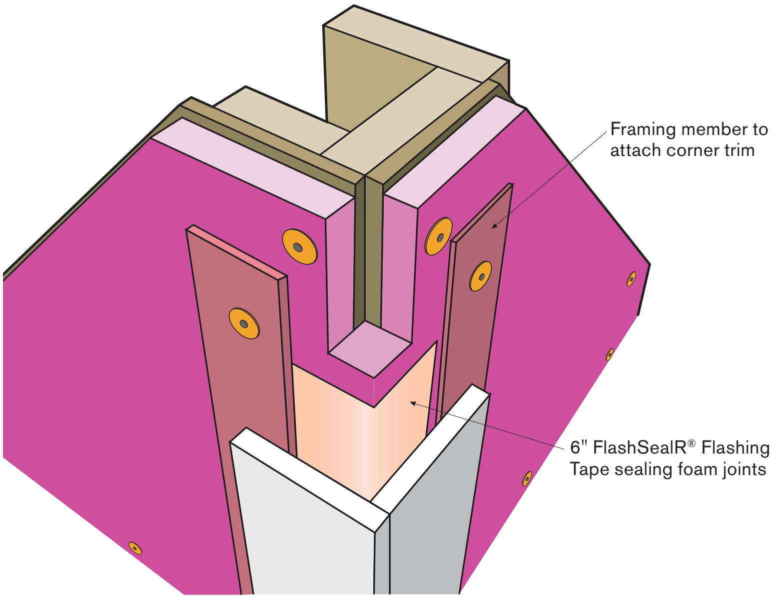


Figure 1.50: Corner piece or filler of exterior rigid insulation.

In higher wind load areas, ¾-inch thick marine grade plywood strips are used in place of 1x4 dimensional wood strips due to their significantly higher nail withdrawal strength. In coastal regions in Florida, 2x4's installed "flat" directly over masonry are often used as a base for cladding attachment as their greater "thickness" allows for long fasteners and high withdrawal strength respectively.

In all cases local codes should be followed and professionals consulted as necessary.

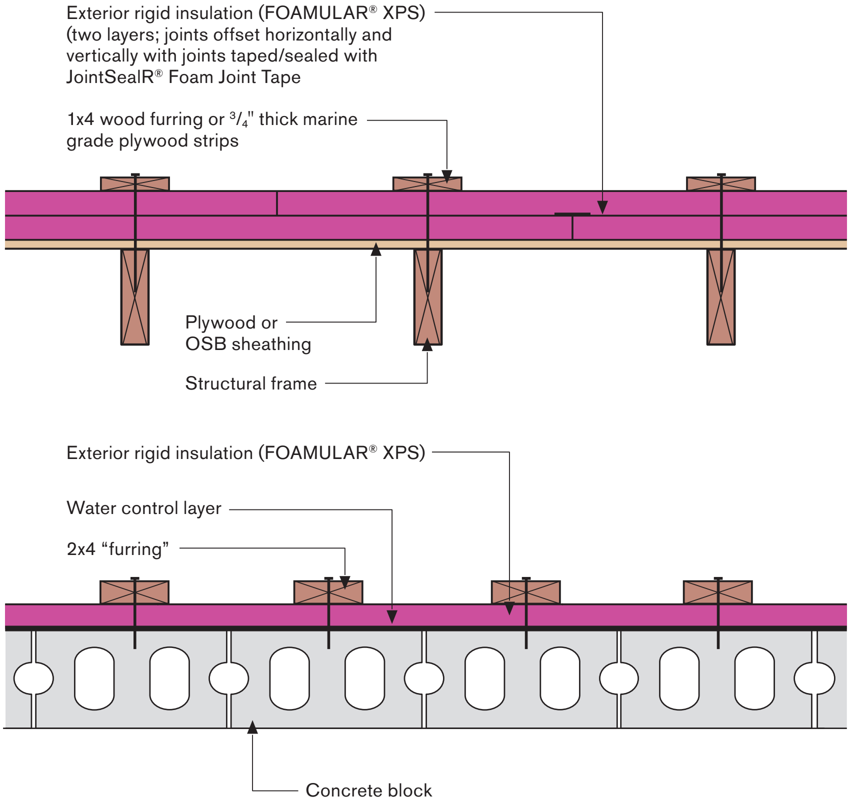


Figure 1.51: Cladding attached to furring.

OWENS CORNING
FOAMULAR
INSULATING SHEATHING
RECUBRIMIENTO AISLANTE
OZONE DEPLETION
ZERO
CERO
NO DAÑA LA CAPA DE OZONO
GREENGUARD

PRACTICES

CHAPTER 8
DESIGNING AND CONSTRUCTING BUILDINGS

Buildings should be suited to their environment. Design and construction should be responsive to wind loads, snow loads and seismic loads. It should also be responsive to soil conditions and frost depth, orientation and solar radiation. Finally, design and construction should consider temperature, humidity, rain and interior conditions.

Building enclosures and mechanical systems should be designed for a specific hygrothermal region (Figure 2.1), rain exposure zone (Figure 2.2) and interior climate in addition to the structural requirements already mentioned.

The interior climate for this guide is assumed to be residential. Interiors are are assumed to be conditioned to 70 degrees F in the winter and 75 degrees F in the summer. Relative humidities are assumed to be limited to 35 percent (no higher) during the coldest month in winter and 65 percent (no higher) in the summer. These conditions also form the basis for the requirements delineated in the model building codes.

High occupant loadings can lead to high interior relative humidities during winter months. High interior relative humidities due to high occupant loading should be controlled by dilution ventilation. The greater the occupant density the greater the dilution ventilation rate required.

This guide does not address high occupant loadings or special use buildings that have high interior levels of moisture such as buildings with spas, indoor swimming pools or buildings that are humidified beyond 35 percent relative humidity during the coldest month in the winter.

The model building codes are also based on the hygrothermal regions noted in Figure 2.1. The model codes further subdivide the regions for energy conservation purposes. Specific “code” climate zones are referenced in 2012 IRC and the 2012 IECC (Figure 2.3). The practices described in this guide are designed to meet the hygrothermal requirements and interior conditions for each IRC and IECC zone noted for each practice.

The model building codes do not currently recognize different rain exposures. However, the wall designs presented in this guide are all designed to work in all rain exposure zones.

Table 2.1 contains the minimum thermal resistance (R-value) requirements specified in the 2009 IECC, 2012 IECC, Federal Tax Credit ATRA 2012, and Owens Corning’s net zero recommendations.

LEGEND

Subarctic/Arctic
A subarctic and arctic climate is defined as a region with approximately 12,600 heating degree days (65°F basis) 1 or greater.

Very Cold
A very cold climate is defined as a region with approximately 9,000 heating degree days (65°F basis) 2 or greater and less than approximately 12,600 heating degree days (65°F basis).

Cold
A cold climate is defined as a region with approximately 5,400 heating degree days (65°F basis) 3 or greater and less than approximately 9,000 heating degree days (65°F basis) 4.

Mixed-Humid
A mixed-humid climate is defined as a region that receives more than 20 inches (50 cm) of annual precipitation, has approximately 5,400 heating degree days (65°F basis) 5 or less, and where the monthly average outdoor temperature drops below 45°F (7°C) during the winter months.

Marine
A marine climate meets all of the following criteria:

- A mean temperature of the coldest month between 27°F (-3°C) and 65°F (18°C)
- A warmest month mean of less than 72°F (22°C)
- At least four months with mean temperatures over 50°F (10°C)

A dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

Hot-Humid
A hot-humid climate is defined as a region that receives more than 20 inches (50 cm) of annual precipitation and where one or both of the following occur:*

- A 67°F (19.5°C) or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- A 73°F (23°C) or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year.

** These last two criteria are identical to those used in the ASHRAE definition of warm-humid climates and are very closely aligned with a region where monthly average outdoor temperature remains above 45°F (7°C) throughout the year.*

Mixed-Dry
A mixed-dry climate is defined as a region that receives less than 20 inches (50 cm) of annual precipitation, has approximately 5,400 heating degree days (65°F basis) or less, and where the average monthly outdoor temperature drops below 45°F (7°C) during the winter months.

Hot-Dry
A hot-dry climate is defined as a region that receives less than 20 inches (50 cm) of annual precipitation and where the monthly average outdoor temperature remains above 45°F (7° C) throughout the year.

1 Celsius: 7,000 heating degree days (18°C basis)
2 Celsius: 5,000 heating degree days (18°C basis)
3 Celsius: 3,000 heating degree days (18°C basis)
4 Celsius: 5,000 heating degree days (18°C basis)
5 Celsius: 3,000 heating degree days (18°C basis)

Figure 2.1: Hygrothermal regions—Based on Herbertson's Thermal Regions, a modified Koppen Classification, the ASHRAE definition of hot-humid climates, the International Energy Conservation Code (IECC) Climate Zones, and average annual precipitation from the U.S. Department of Agriculture and Environment Canada

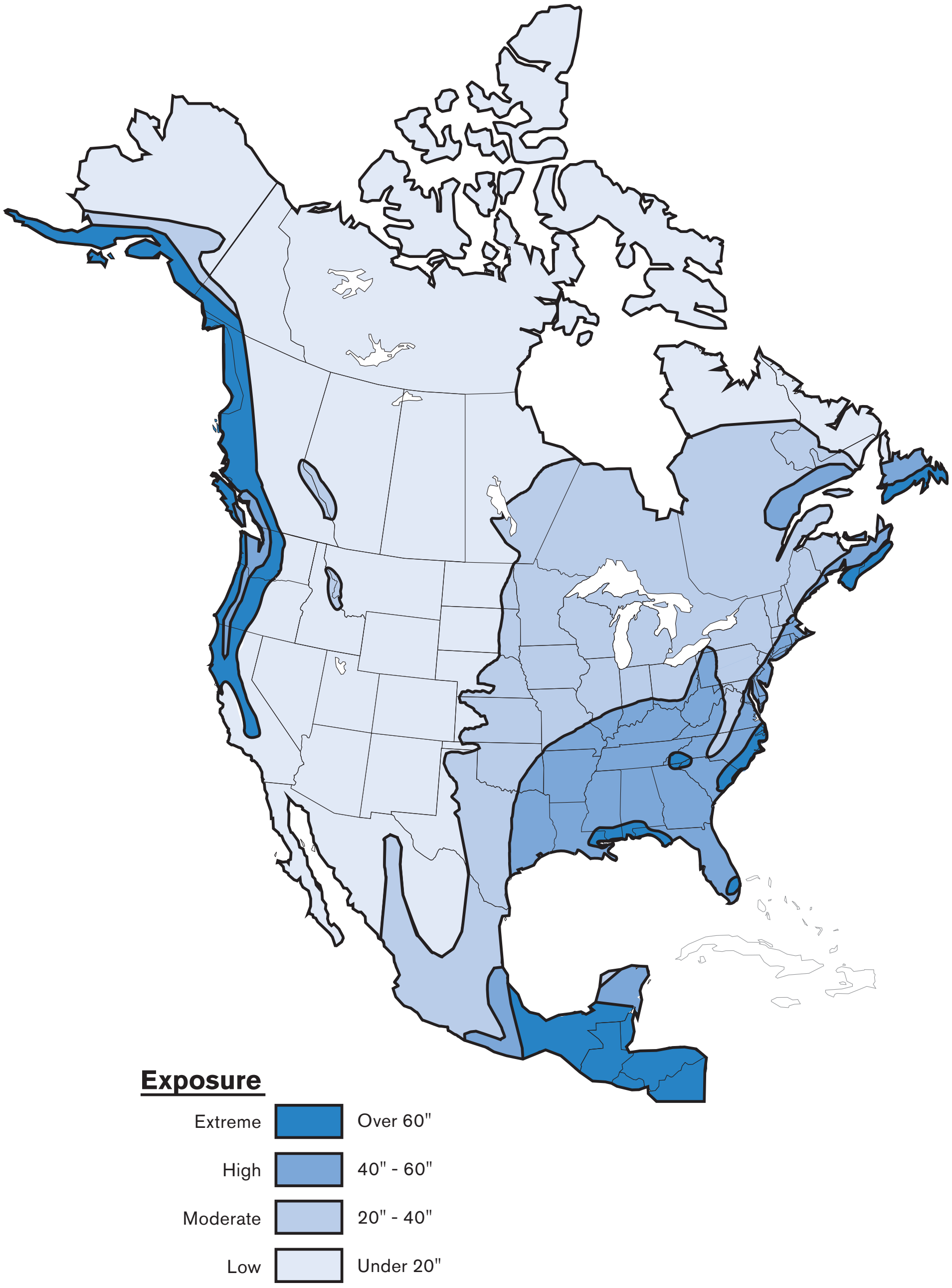


Figure 2.2:
Rain Exposure Zones.

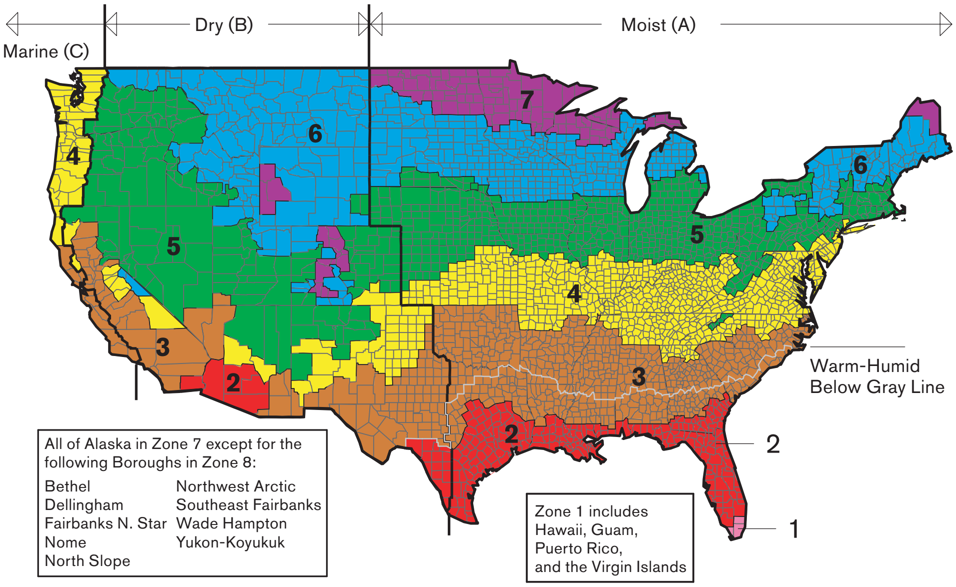


Figure 2.3:
Climate zone map.

Table 2.1:
Climate zones 1A

Component	2009 IECC	2012 IECC	40% <2006 IECC	50% <2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-13	R-13	R-13	R-19	R-19
Wall Insulation Option 2					
Wall Cavity Insulation R-value				R-13	R-13
Wall Continuous Insulation R-value				R-5	R-5
Ceiling Insulation R-value	R-30	R-30	R-30	R-30	R-30
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-13	R-13	R-13	R-13	R-13
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	None	None	None	None	None
Window U-value, SHGC	U=1.20, SHGC=0.30	U=NA, SHGC=0.25	U=NA, SHGC=0.25	U=0.30, SHGC=0.25	U=0.30, SHGC=0.25
House Tightness (ACH50)	7 or Checklist	5 & Checklist	5 & Checklist	5 & Checklist	5 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	No Heat Exchange	No Heat Exchange	No Heat Exchange
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	19	19	19
Appliances	Not Specified	Not Specified	Engery Star	Engery Star	Energy Star
Water Fixtures	Not Specified	Not Specified	Low Flow Fixtures	Low Flow Fixtures	Low Flow Fixtures
Lighting	Not Specified	Not Specified	Fluorescent or LED	Fluorescent or LED	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF	HP 2.0 EF

** Attic/Other. No insulation required in the conditioned space.*

*** SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

Table 2.2: Climate zones 2A and 2B

Component	2009 IECC	2012 IECC	40% <2006 IECC	50% <2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-13	R-13	R-19	R-19	R-19
Wall Insulation Option 2					
Wall Cavity Insulation R-value				R-13	R-13
Wall Continuous Insulation R-value				R-5	R-5
Ceiling Insulation R-value	R-30	R-38	R-38	R-38	R-38
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-13	R-13	R-13	R-13	R-13
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	None	None	None	None	None
Window U-value, SHGC	U=1.20, SHGC=0.30	U=0.40, SHGC=0.25	U=0.40, SHGC=0.25	U=0.30, SHGC=0.25	U=0.30, SHGC=0.25
House Tightness (ACH50)	7 or Checklist	5 & Checklist	5 & Checklist	5 & Checklist	5 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	No Heat Exchange	No Heat Exchange	No Heat Exchange
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	19	19	19
Appliances	Not Specified	Not Specified	Energy Star	Energy Star	Energy Star
Water Fixtures	Not Specified	Not Specified	Low Flow Fixtures	Low Flow Fixtures	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	Fluorescent or LED	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF	HP 2.0 EF

** Attic/Other. No insulation required in the conditioned space.*

*** SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

CHAPTER 9

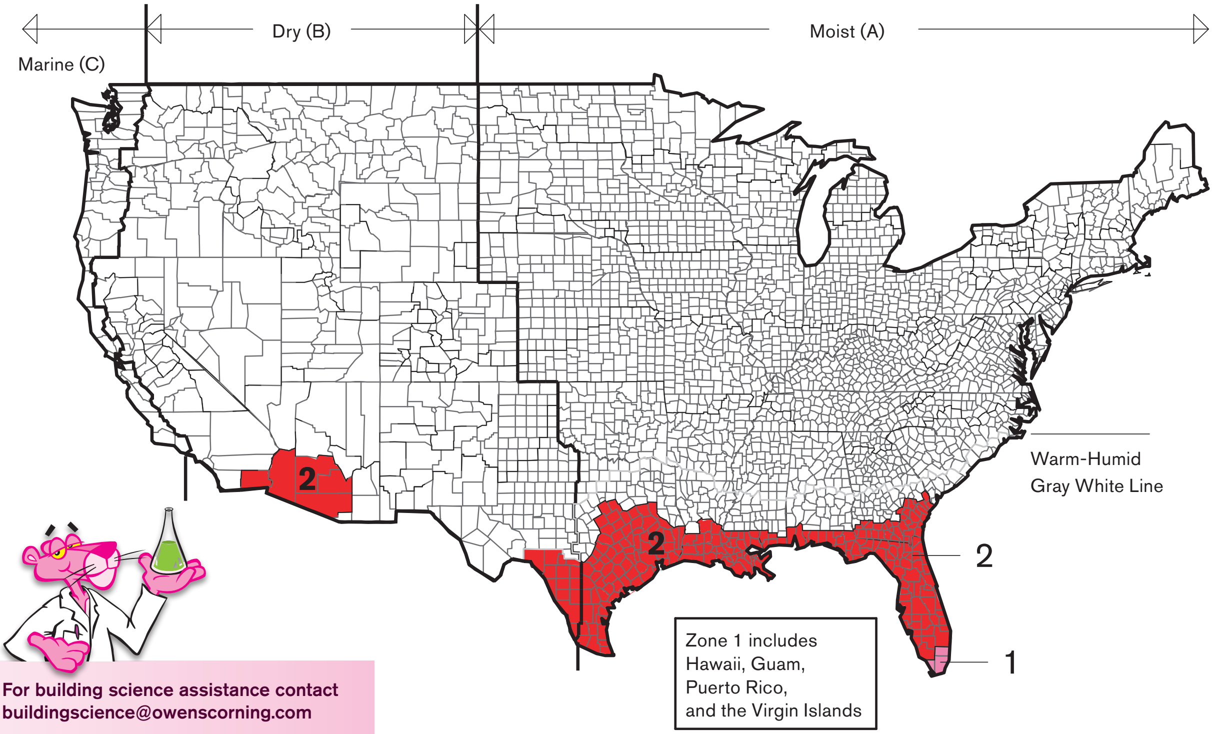
CLIMATE ZONES 1 & 2

The residential buildings constructed in these two zones are principally constructed on slab foundations and crawlspaces due to lack of frost penetration and high ground water.

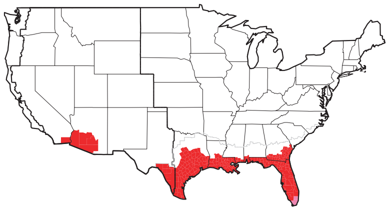
Where slab foundations are used they are typically uninsulated due to the lack of heat loss and heat gain through these assemblies due to the climate and due to concerns about insect migration. Exterior rigid insulation (FOAMULAR® XPS Insulation) in ground contact applications is often avoided for insect control reasons and constructability.

Walls are a combination of wood frame and concrete block — concrete masonry units (CMU). In Florida, CMU construction is common for first floor assemblies and wood frame for second floor assemblies from Orlando south. From Orlando north wood frame predominates as well as throughout the remainder of Climate Zone 2.

Roof construction is predominately vented attics. Some unvented roof assemblies are being constructed due to the increasing demand to locate HVAC systems in the conditioned space, but they are not the norm.



For building science assistance contact
buildingscience@owenscorning.com



9.1 FOUNDATIONS

Figure 2.4 is the recommended foundation detail for CMU construction in South Florida. Note the “seat” in the slab to receive the CMU wall. This seat provides a continuous flashing around the entire perimeter of the building. Also note that the stucco does not extend into the ground. Extending the stucco into the ground is bad practice that results in wicking of moisture into the assembly and provides a pathway for insects. Further note that the under slab polyethylene vapor barrier wraps the grade beam.

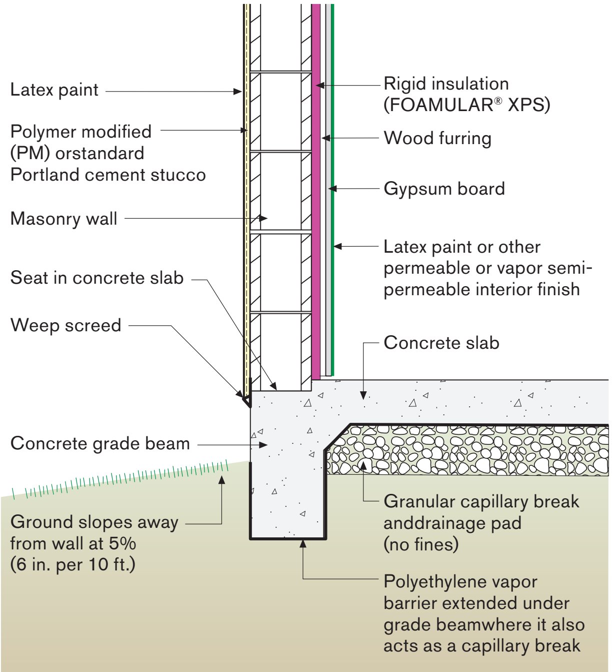


Figure 2.4: Recommended foundation details for CMU construction in South Florida.

Figure 2.5 is the most common foundation detail in Climate Zone 2. It is uninsulated. Note the recommended “seat” in the slab edge and the under slab polyethylene vapor barrier wrapping the grade beam. Further note that the stucco does not extend into the ground.

Figure 2.6 and Figure 2.7 are effective means providing a “dry” slab that is also insulated with rigid insulation (FOAMULAR® XPS Insulation) where the insulation does not act as an insect entry point. A protective membrane strip is used to create a physical barrier to the entry of insects into the building enclosure. Fully-adhered membranes are effective means of insect control. Ground treatment is also recommended. Although the model energy codes do not require under slab insulation it is recommended for comfort reasons and moisture control particularly in the northern parts of Climate Zone 2.

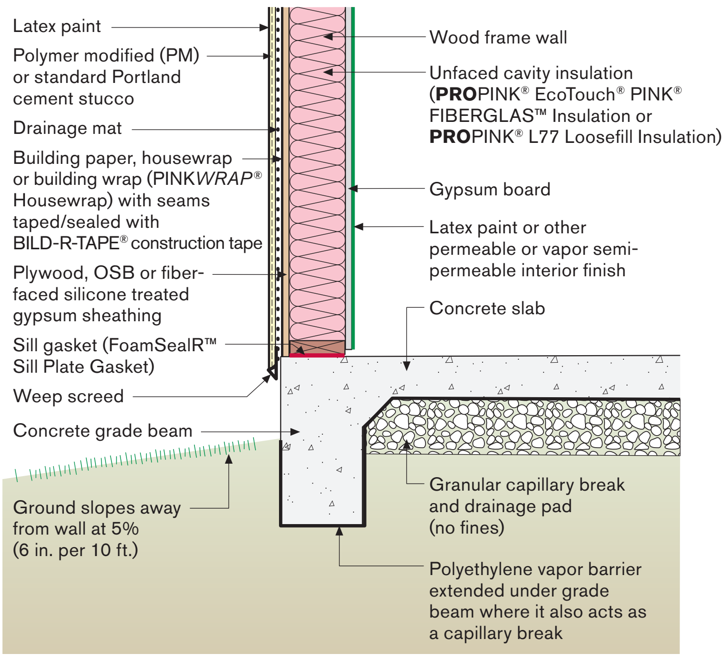


Figure 2.5:
The most common foundation detail in Climate Zone 2.

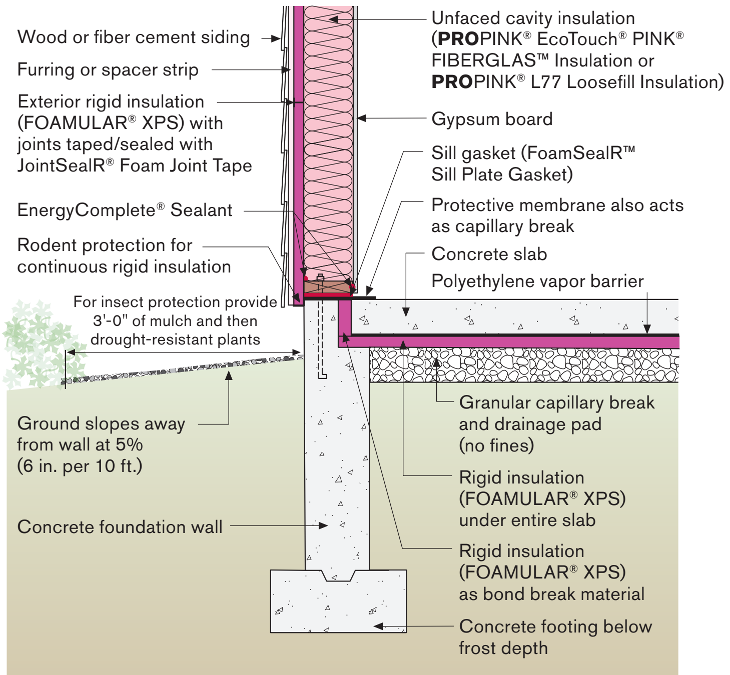
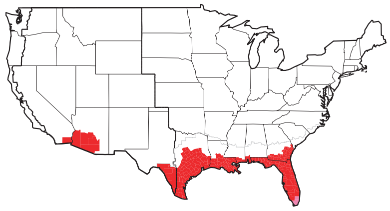


Figure 2.6:
Insulated "dry" slab on grade construction.



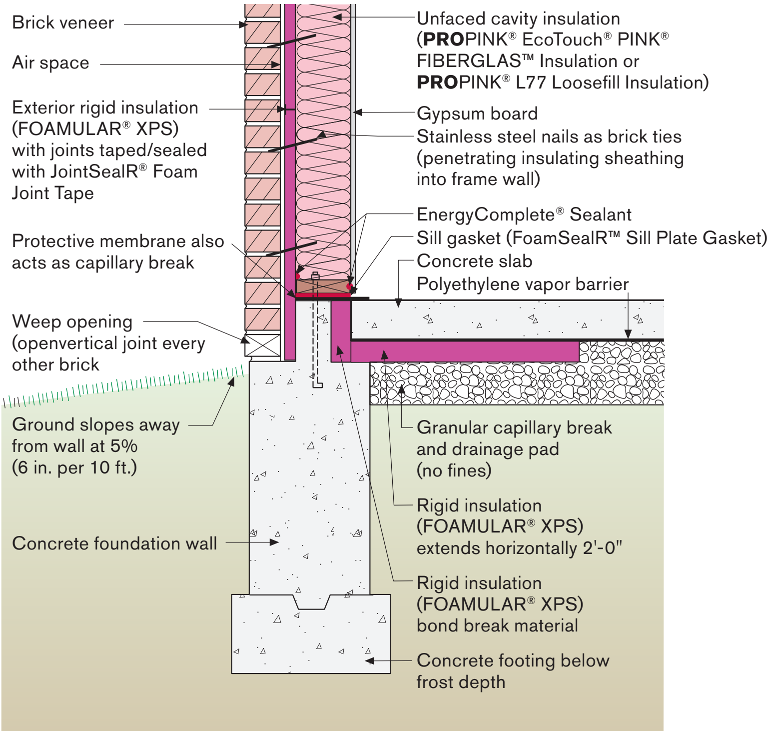
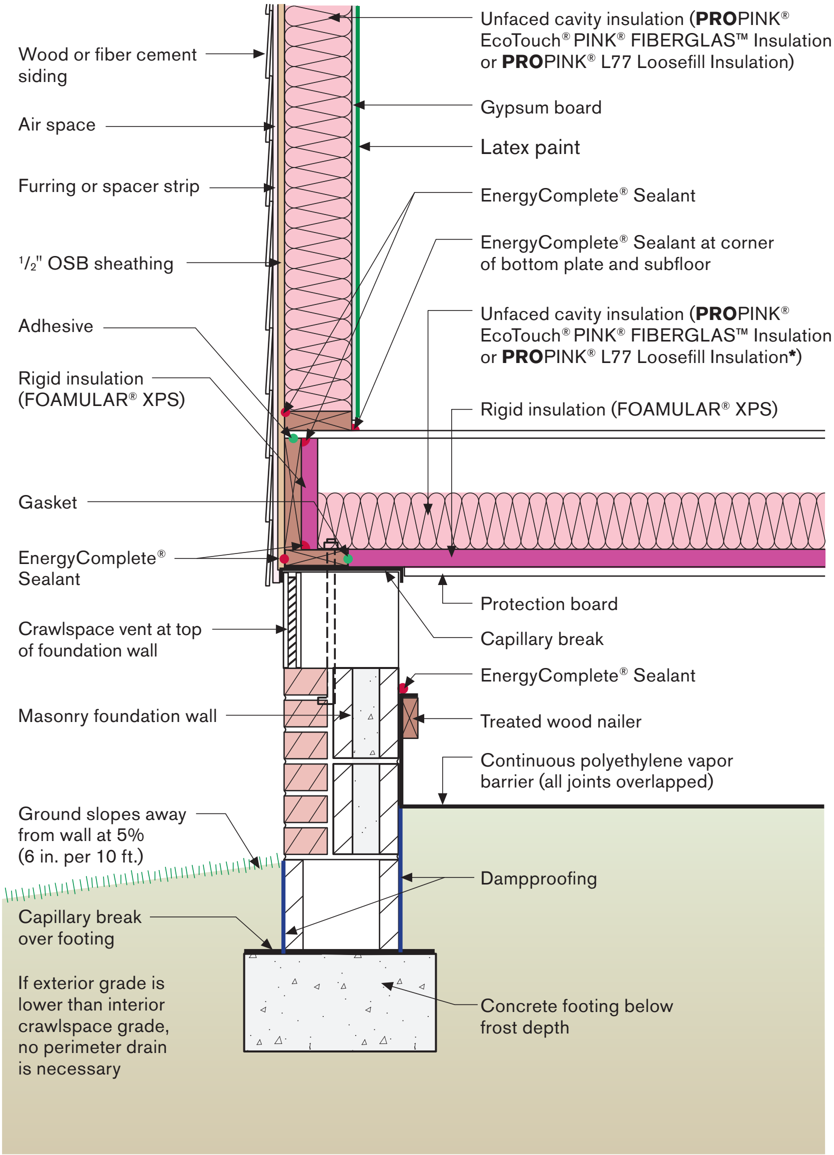


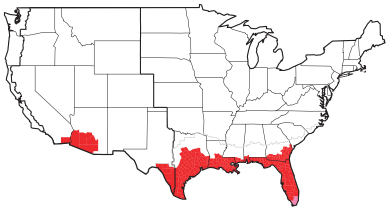
Figure 2.7:
Insulated "dry" slab on grade construction.

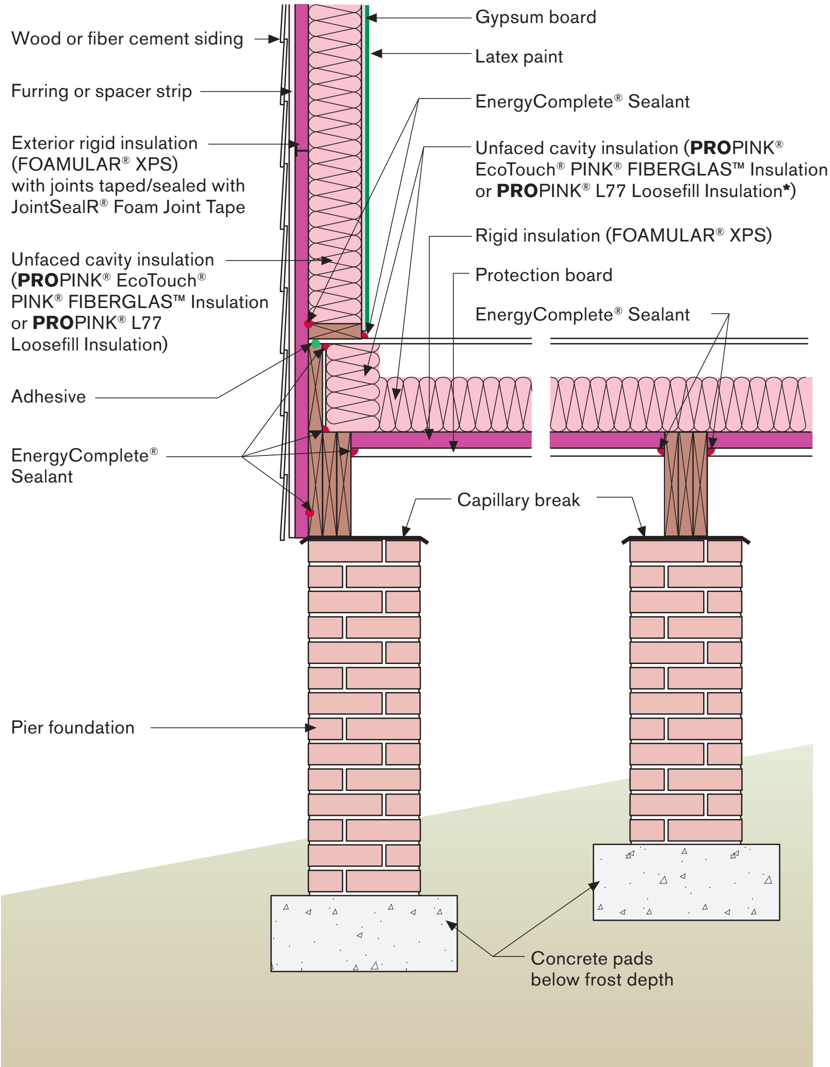
Crawlspaces are common in the Gulf coast regions of Climate Zone 2. They typically are constructed as "vented" crawlspaces and elevated above grade due to high water tables and flooding issues. Figure 2.8 and Figure 2.9 are examples of recommended vented crawlspace construction. Note the continuous rigid insulation (FOAMULAR® XPS Insulation) on the underside of the floor framing. This rigid insulation's primary function is to protect the floor assembly from moisture. The rigid insulation (FOAMULAR® XPS Insulation) should be protected with protection board from fire, insects and vermin. Note that where the floor cavity insulation does not completely fill the space the floor cavity insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) is located in direct contact with the continuous rigid insulation leaving an air space above the cavity insulation. The air space above the insulation results in a more comfortable floor than if the air space is located below the insulation. It is key with this approach to prevent air entry into the perimeter of the floor framing.



*Can only be loosefill if whole cavity is filled

Figure 2.8:
Recommended vented crawlspace construction.





*Can only be loosefill if whole cavity is filled

Figure 2.9: Recommended vented crawlspace construction.

PRACTICES

Unvented crawlspaces should be only considered where flooding is not a concern. Figure 2.10 and Figure 2.11 are recommended approaches to constructing conditioned crawlspaces. Note the protection board on the rigid insulation (FOAMULAR® XPS Insulation) protecting the rigid insulation from fire. Also note the fully-adhered membrane barrier for insect control. In some jurisdictions an inspection strip or gap is required at the top of the crawlspace wall as an insect control mechanism.

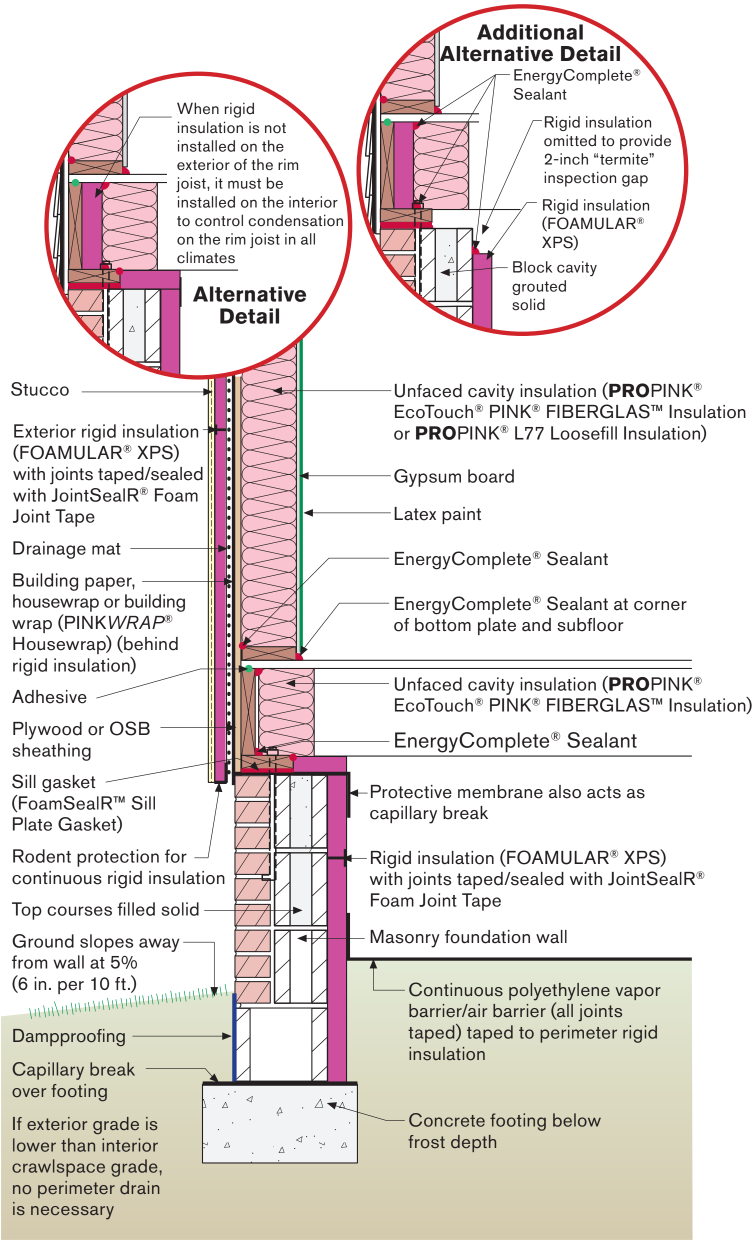


Figure 2.10:
Recommended conditioned crawlspace construction.

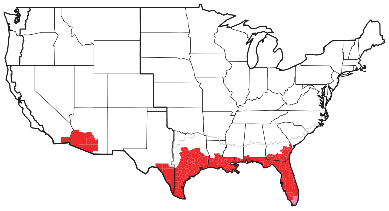
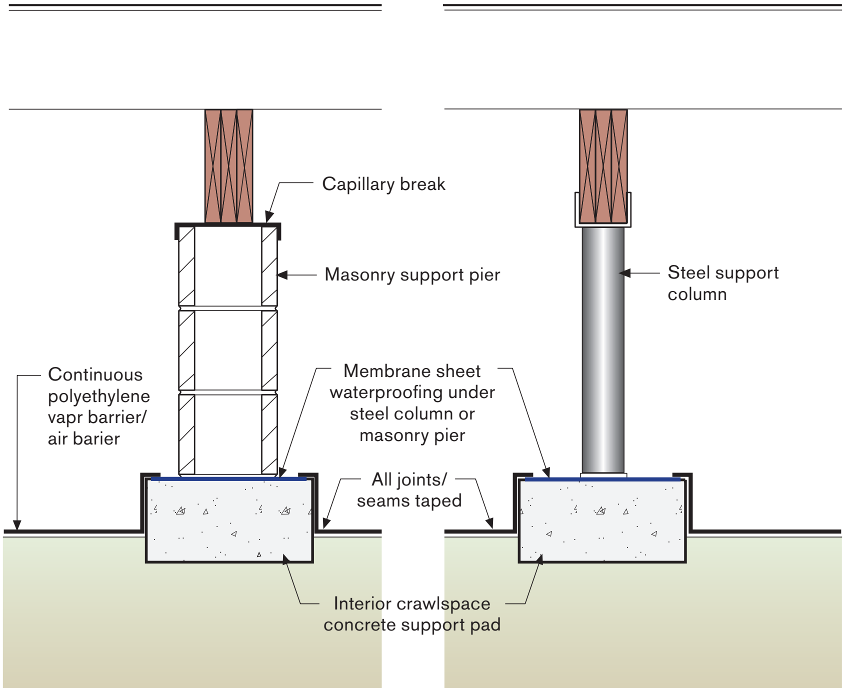


Figure 2.11:
Recommended conditioned crawlspace construction.



9.2 **WALLS**

A common approach to construct wood frame walls in Climate Zone 2 is illustrated in Figure 2.12. The key element of this wall is the gap between the cladding and the rigid insulation (FOAMULAR® XPS Insulation) used to control hydrostatic pressure. The wall cavity insulation is an unfaced fiberglass batt or loosefill (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation).

An equally common approach to construct wood frame walls is illustrated in Figure 2.13. Note the use of plywood or OSB sheathing that is protected by a housewrap (PINK*WRAP*® Housewrap).

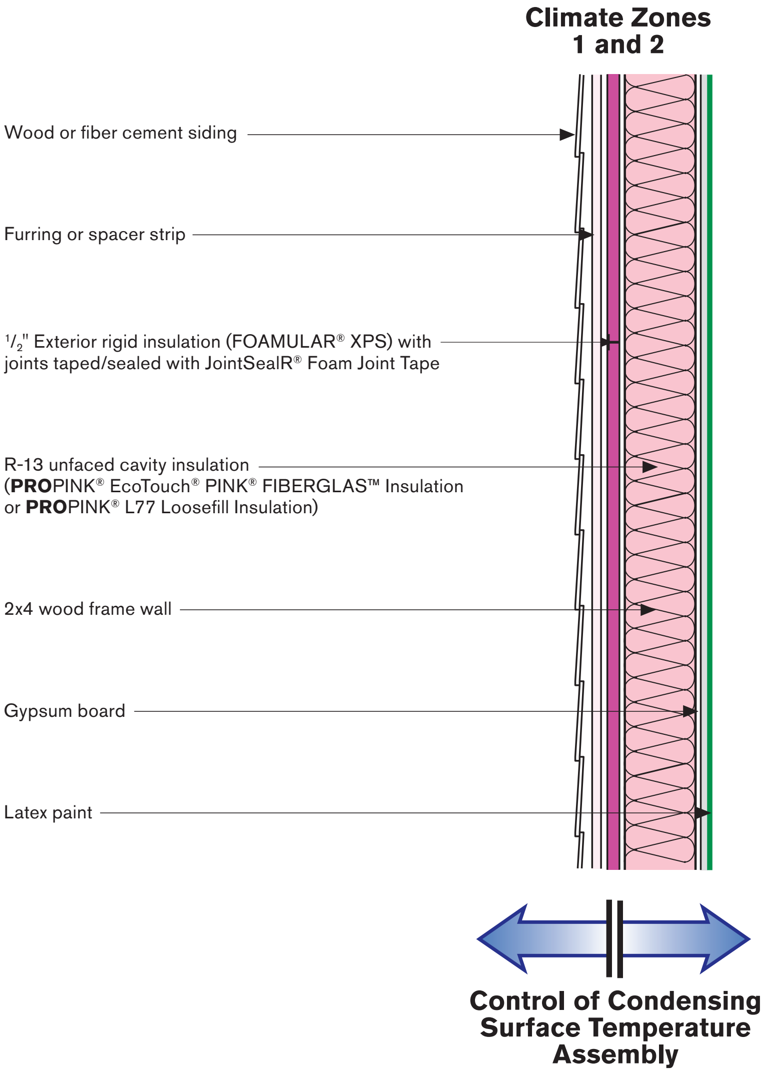


Figure 2.12: Common wood frame wall construction in Climate Zone 2.

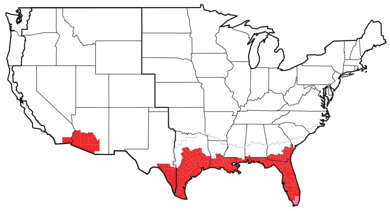


Figure 2.14 is an approach to construct externally insulated CMU walls. Note the use of 2x4 furring. The 2x4 furring is necessary to provide sufficient withdrawal strength for cladding attachment in high wind zones. The advantage of exterior rigid insulation (FOAMULAR® XPS Insulation) is that it provides an effective thermal break where slab inter-floors are used.

Figure 2.15 illustrates the more common approach to construct CMU walls.

Figure 2.16 illustrates a method of attachment for cladding systems on CMU walls in high wind zones. Again, note the use of the 2x4 furring.

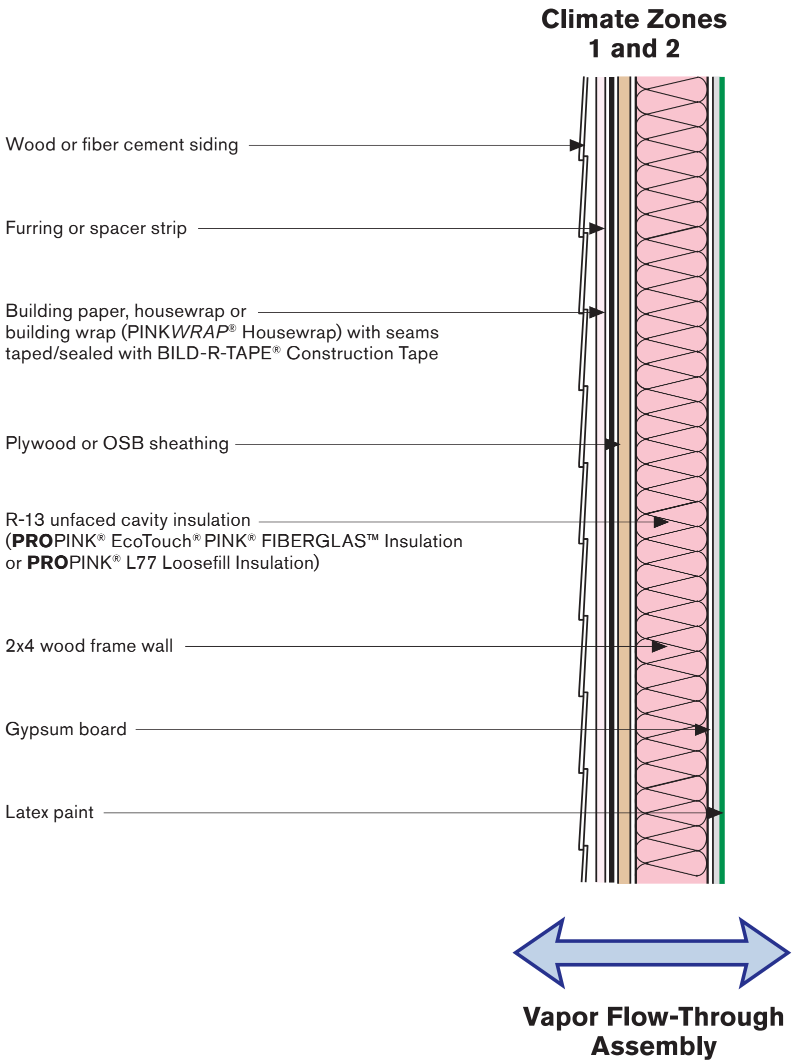


Figure 2.13: Common wood frame wall construction in Climate Zone 2.

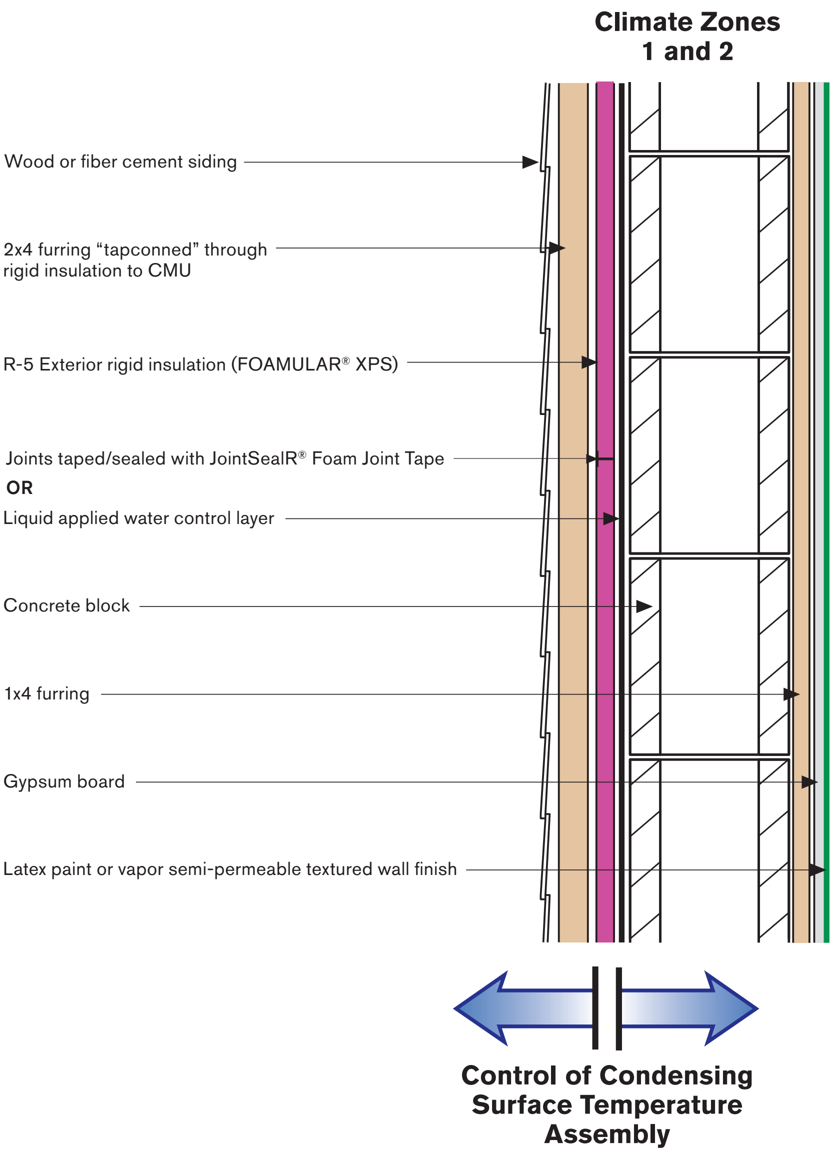
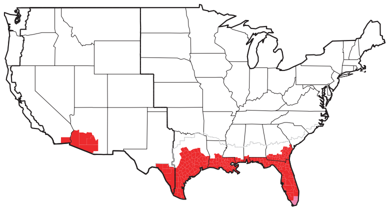


Figure 2.14: Externally insulated CMU wall construction.



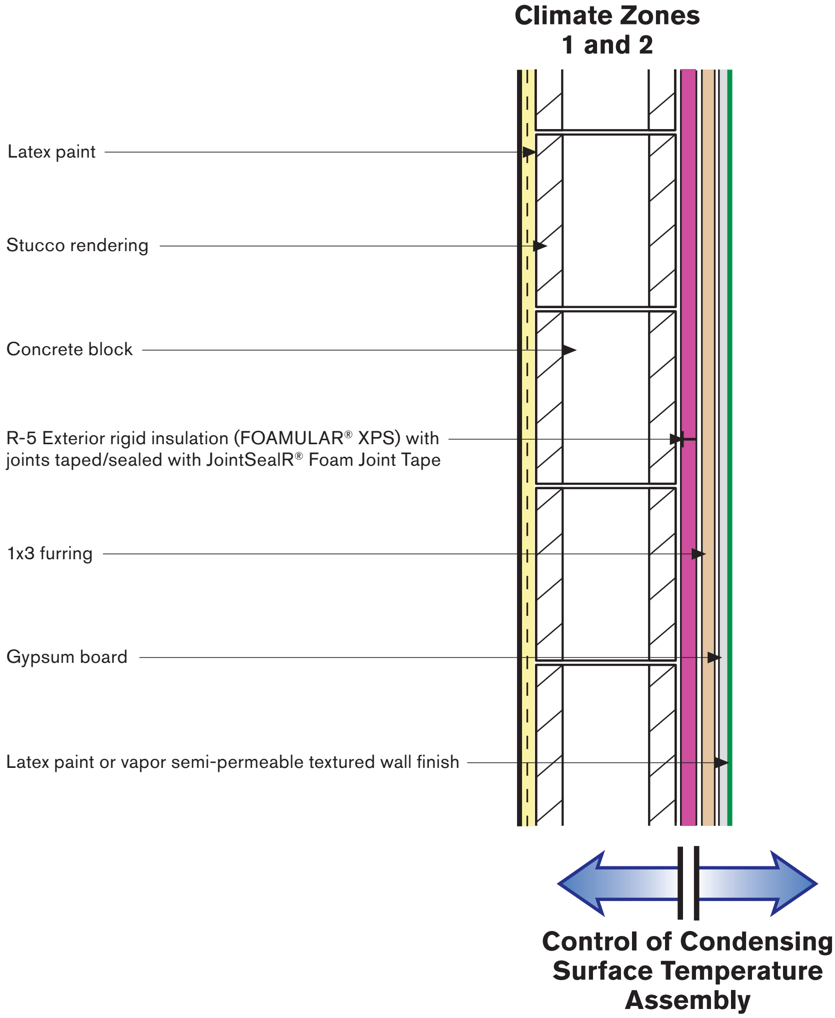


Figure 2.15: Common CMU wall construction.

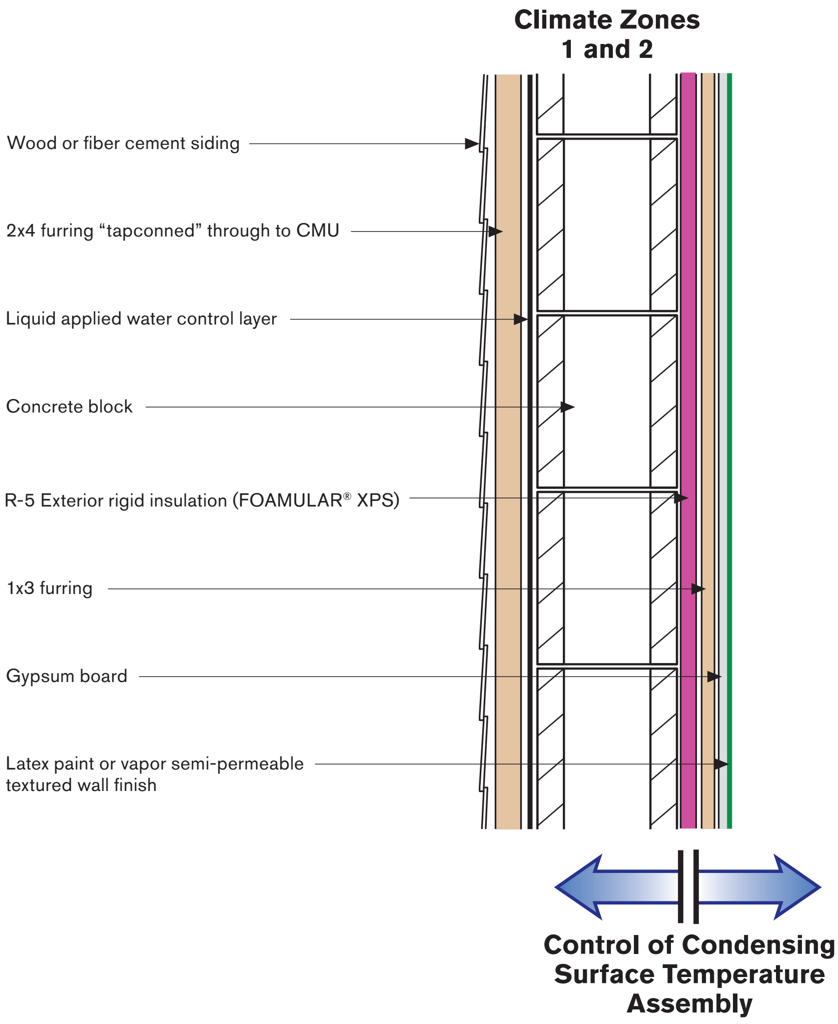
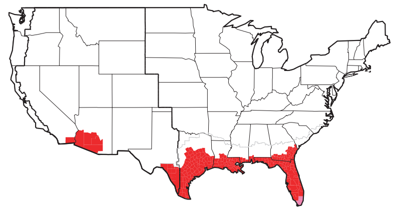


Figure 2.16: Attaching cladding to CMU walls in high wind zones.



9.3 ROOFS

The most common approach to roof construction in Climate Zone 1 and Climate Zone 2 is a vented attic. Figure 2.17 and Figure 2.18 illustrate recommended approaches to constructing vented attics. Note the use of a “kraft”-faced fiberglass batt insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) in Figure 2.18. The kraft facing is a vapor retarder not a vapor barrier and can be used throughout Climate Zone 1 and Climate Zone 2. The kraft facing is not required for vapor control in these climate zones but is often used for ease of installation.

A tile roof version of a vented attic is presented in Figure 2.19. This detail shows a fully-adhered membrane under the tile.

Unvented roofing assemblies are illustrated in Figure 2.20, Figure 2.21 and Figure 2.22. The amount of rigid insulation (FOAMULAR® XPS Insulation) in each of these assemblies is specified by the IRC to control condensation.

Figure 2.23 is an unvented attic approach that can only be used in hot dry climates (Climate Zone 2B). Note that the roofing tiles provide a vented space allowing the roof sheathing to dry into. However, this drying is only possible if the roofing membrane is vapor open (Class III vapor retarder).

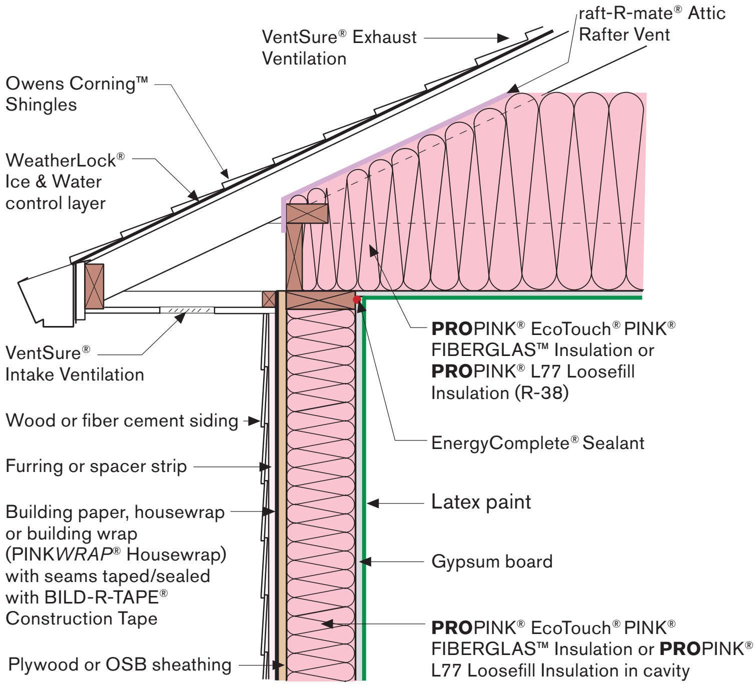


Figure 2.17: Recommended vented attic construction in Climate Zones 1 and 2.

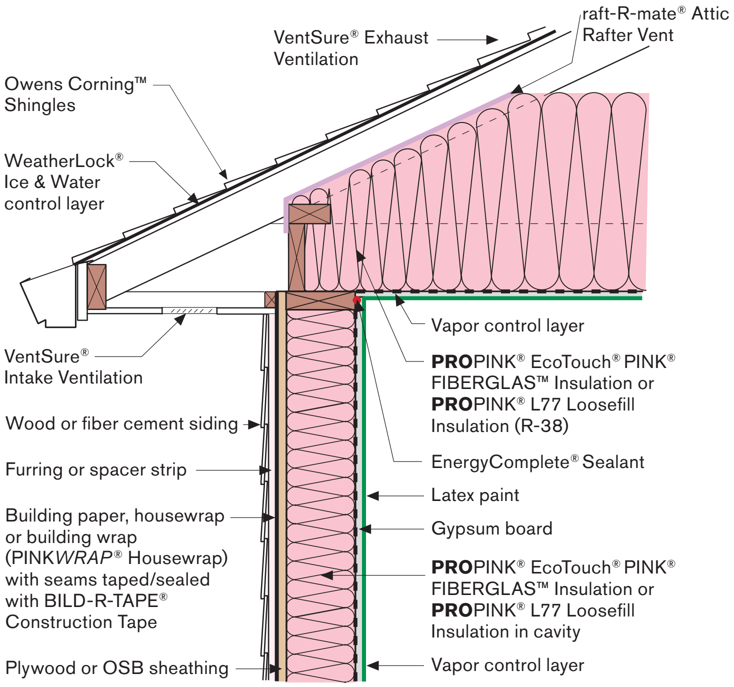


Figure 2.18: Recommended vented attic construction in Climate Zones 1 and 2.

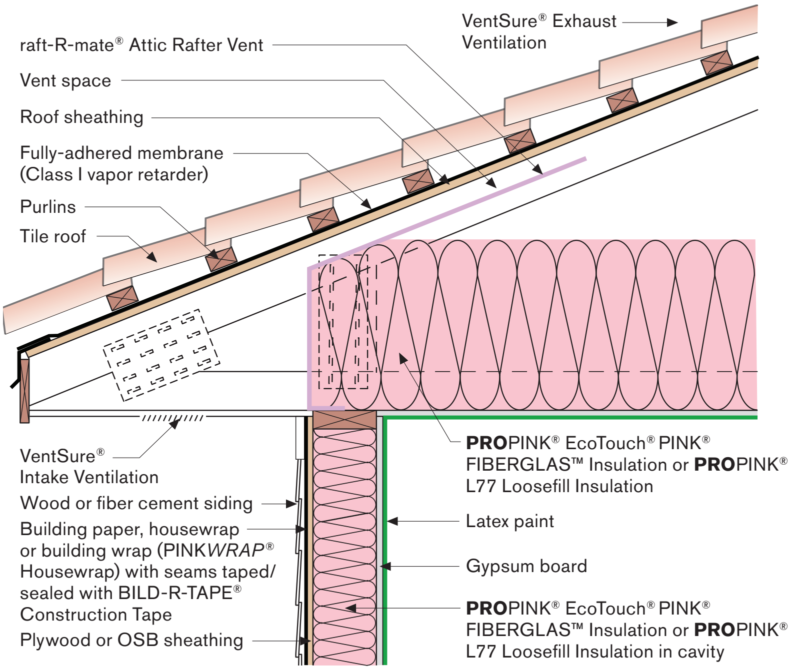
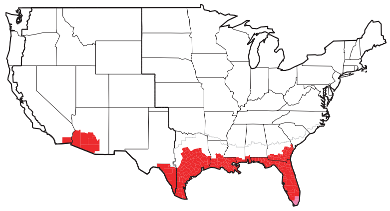


Figure 2.19: Vented attic with a tiled roof.



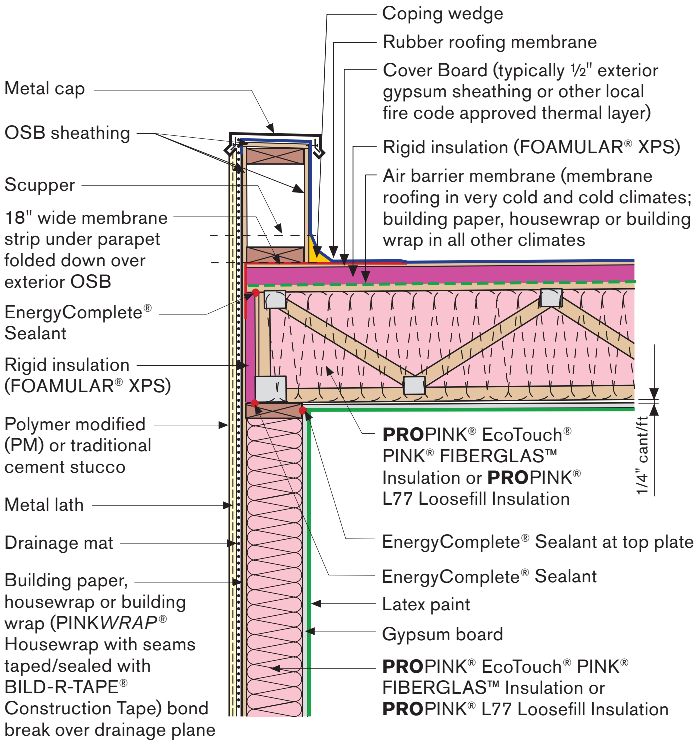


Figure 2.20:
Unvented roofing assembly.

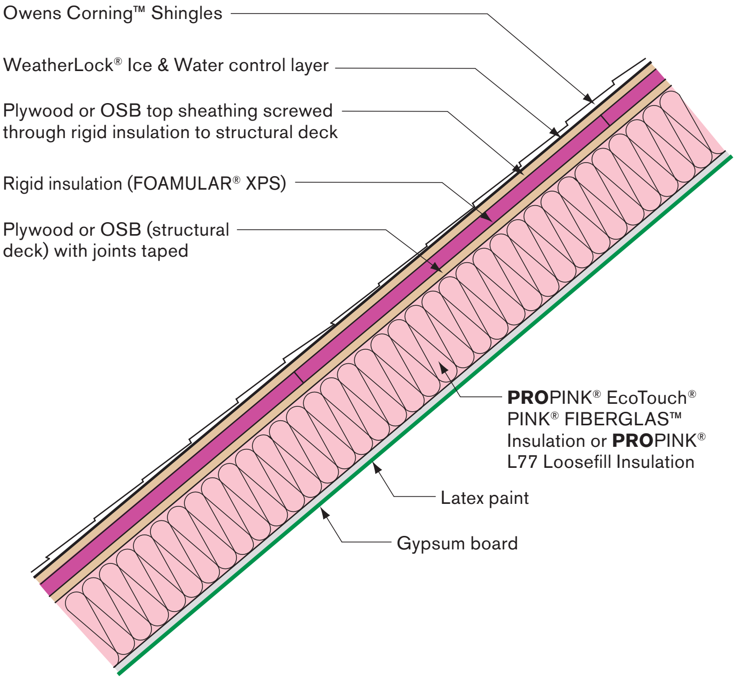


Figure 2.21:
Unvented roofing assembly.

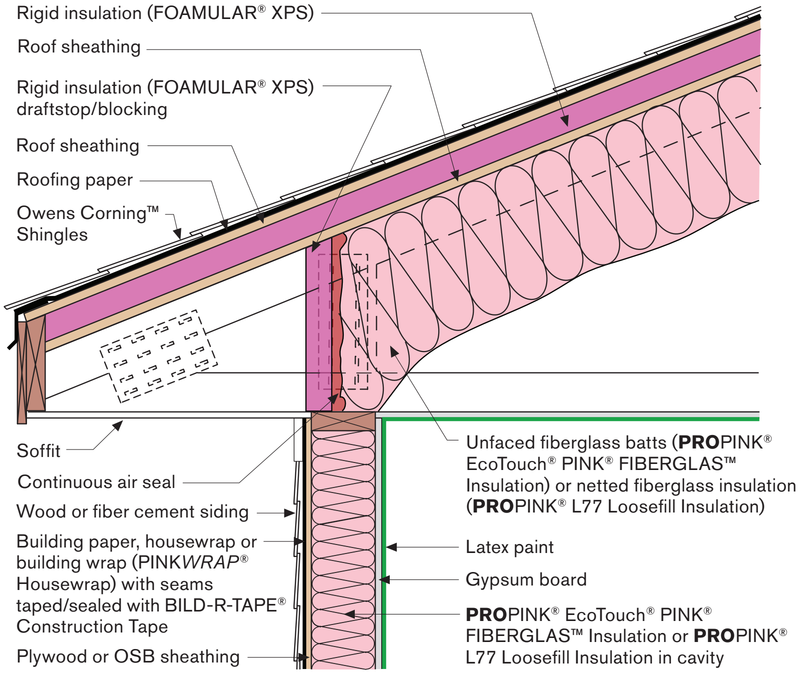


Figure 2.22: Unvented roofing assembly.

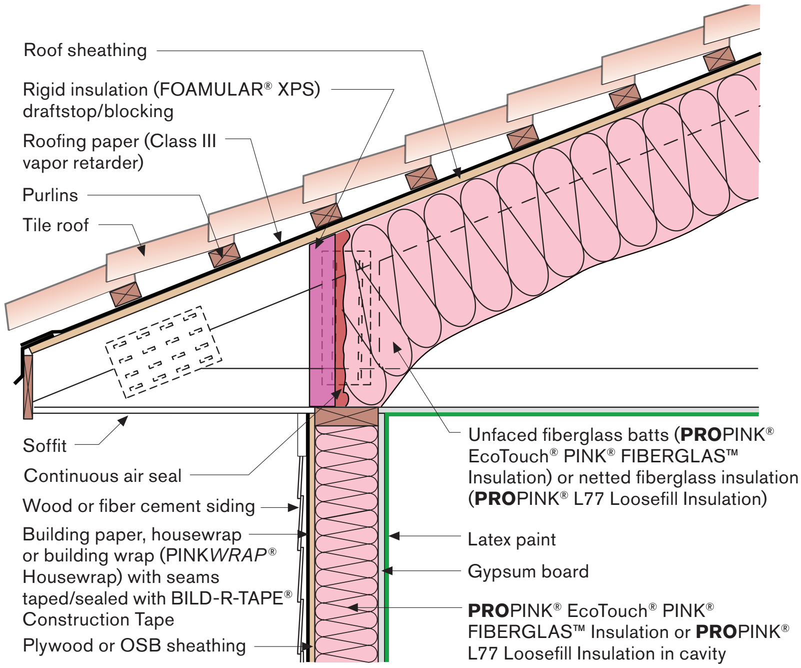
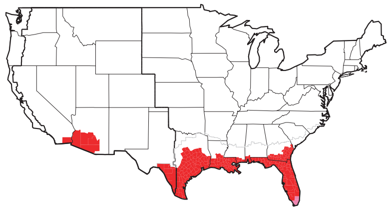


Figure 2.23: Unvented attic detail for Climate Zone 2B only.



9.4 CASE STUDIES

Three complete sections are presented as typical for Houston (Figure 2.24), Orlando (Figure 2.25) and Tucson (Figure 2.26) that meet or exceed the 2012 IECC as well as meet the requirements for environmental separation. See tables 2.1 and 2.2 for specific insulation levels to achieve overall desired performance in other cities in these climate zones.

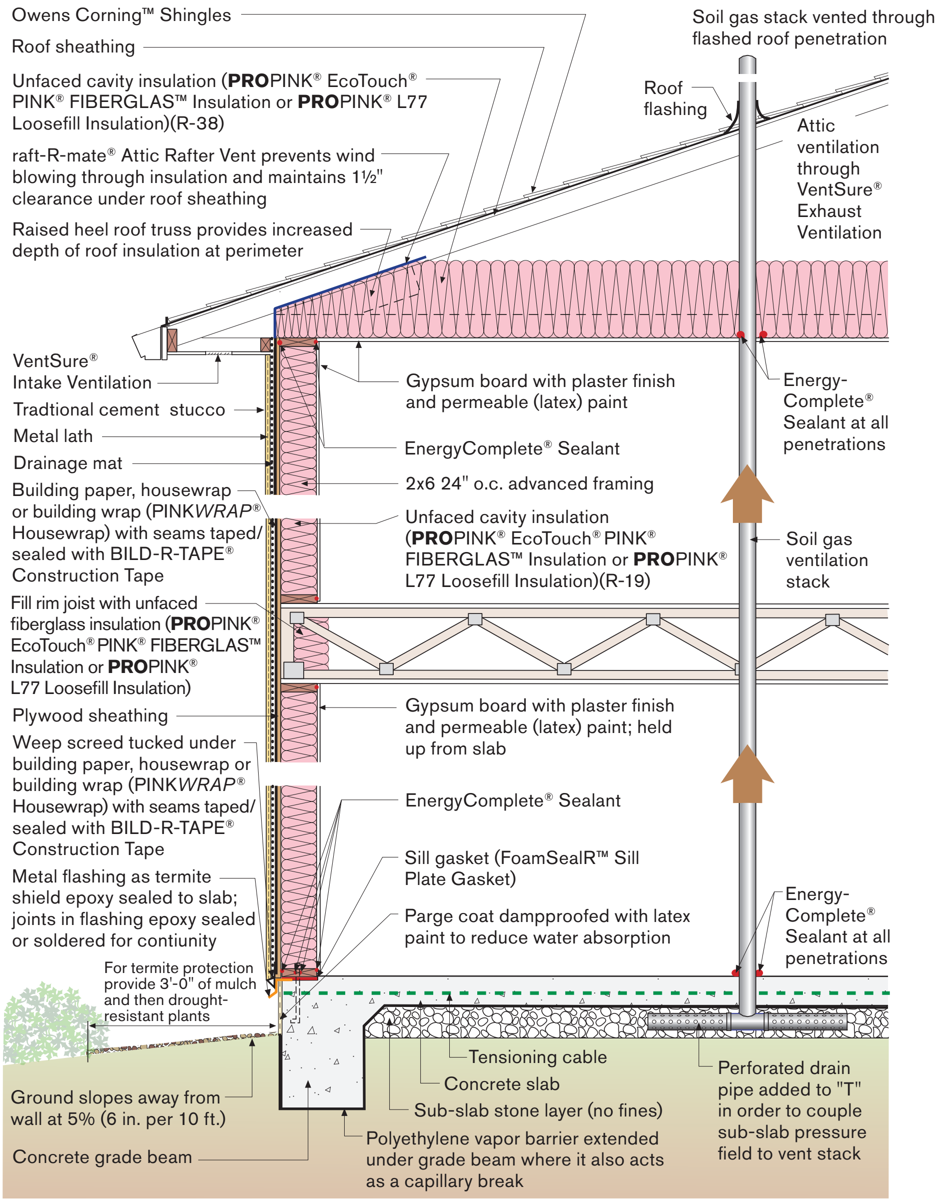


Figure 2.24: Houston case study profile.

PRACTICES

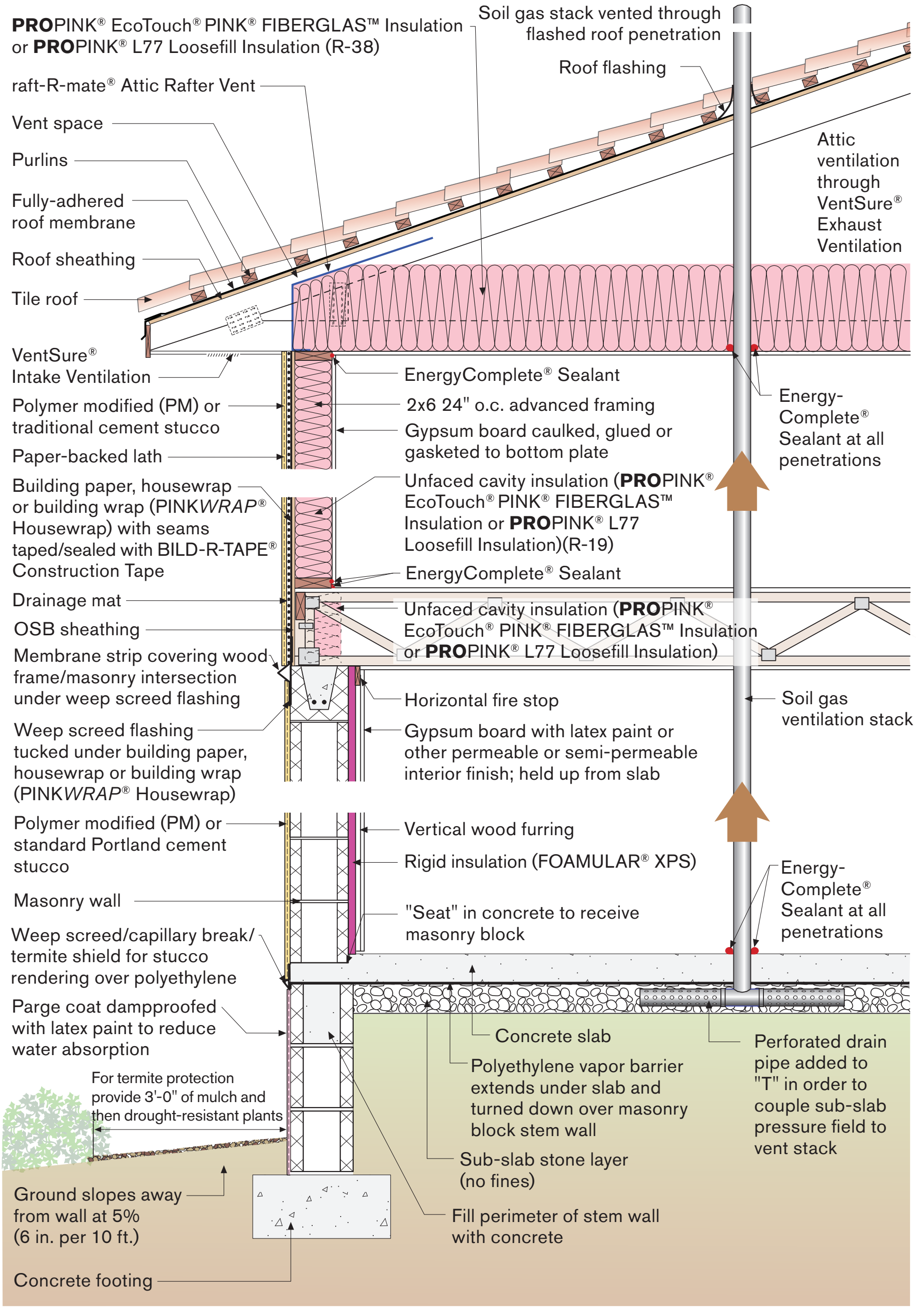


Figure 2.25: Orlando case study profile.

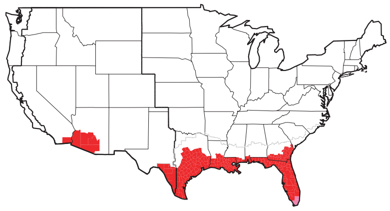
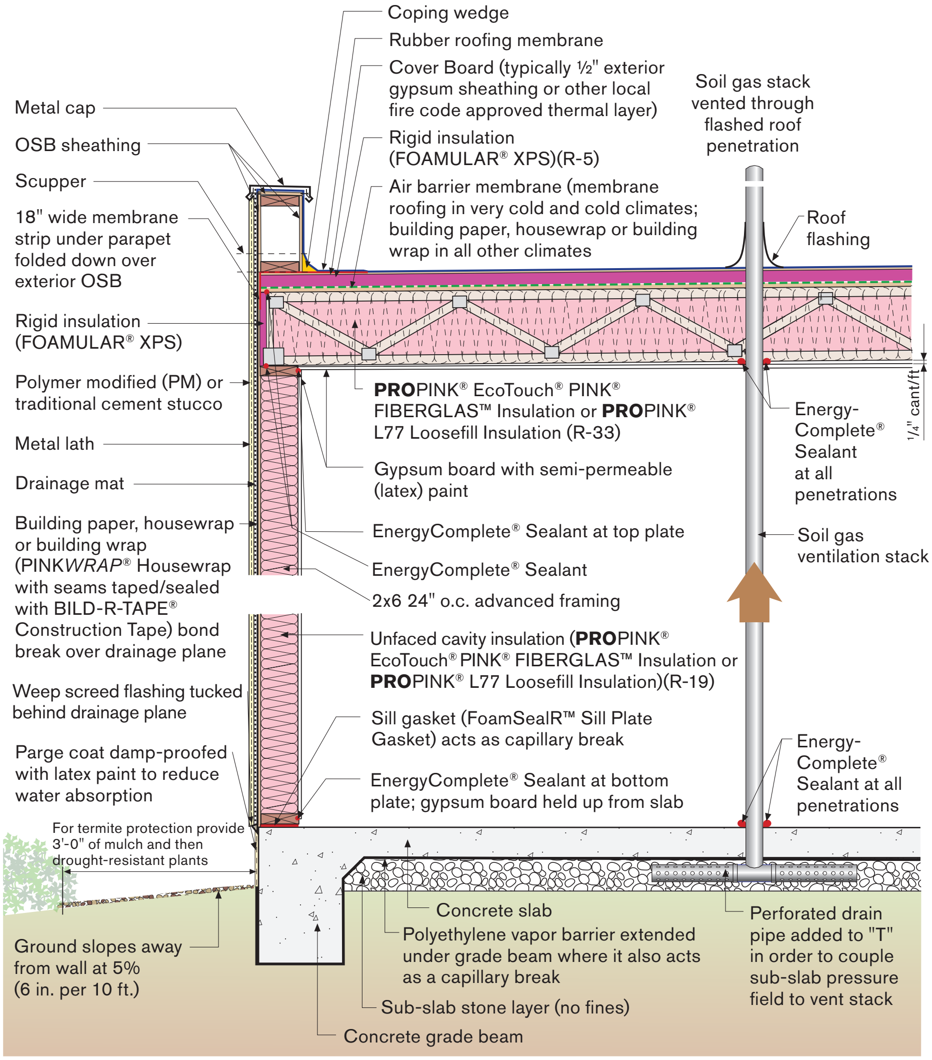


Figure 2.26: Tucson case study profile.



CHAPTER 10

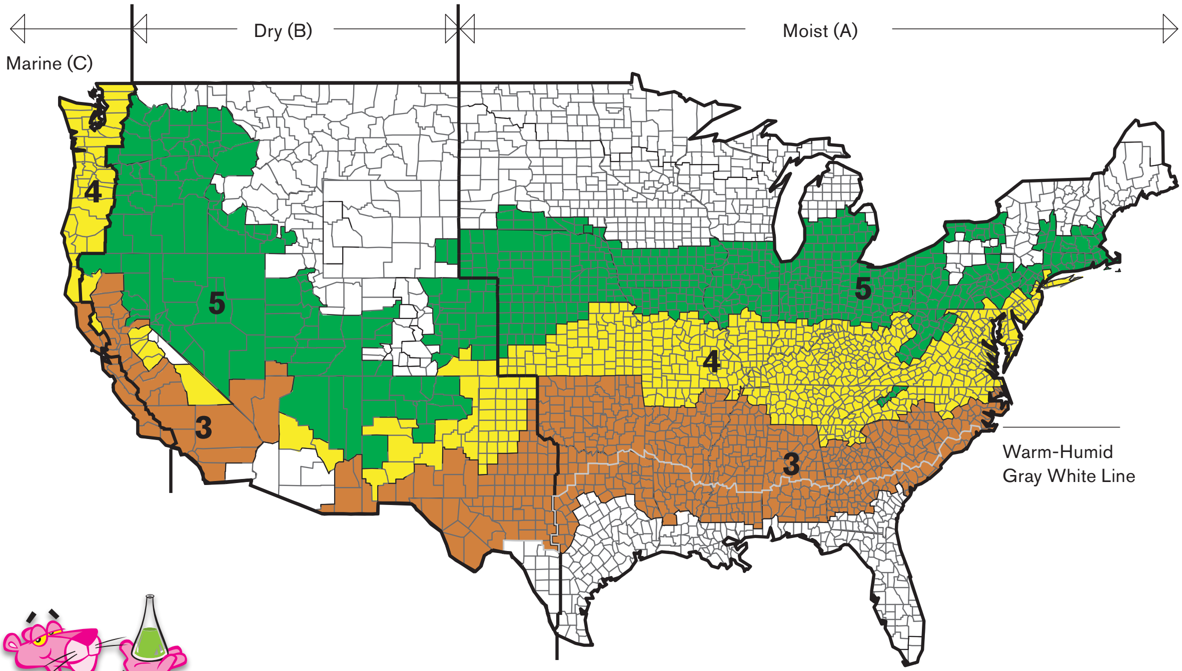
CLIMATE ZONES 3, 4 & 5

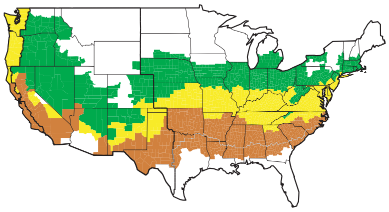
The residential buildings constructed in these two zones are constructed on each of the three typical foundation types: slab foundations, crawlspaces and basements.

Where slab foundations are used they are insulated as are basement foundations. Exterior rigid insulation (FOAMULAR® XPS Insulation) is often avoided for insect control reasons and constructability.

Walls are typically wood frame — with both 2x4 and 2x6 framing.

Roof construction is predominately vented attics. Some unvented roof assemblies are being constructed, but they are not the norm.





10.1 FOUNDATIONS

Figure 2.27 is an effective means providing a “dry” slab that is also insulated with rigid insulation (FOAMULAR® XPS Insulation) where the insulation does not act as an insect entry point. A protective membrane strip is used to create a physical barrier to the entry of insects into the building enclosure. Fully-adhered membranes are effective means of insect control. Ground treatment is also recommended.

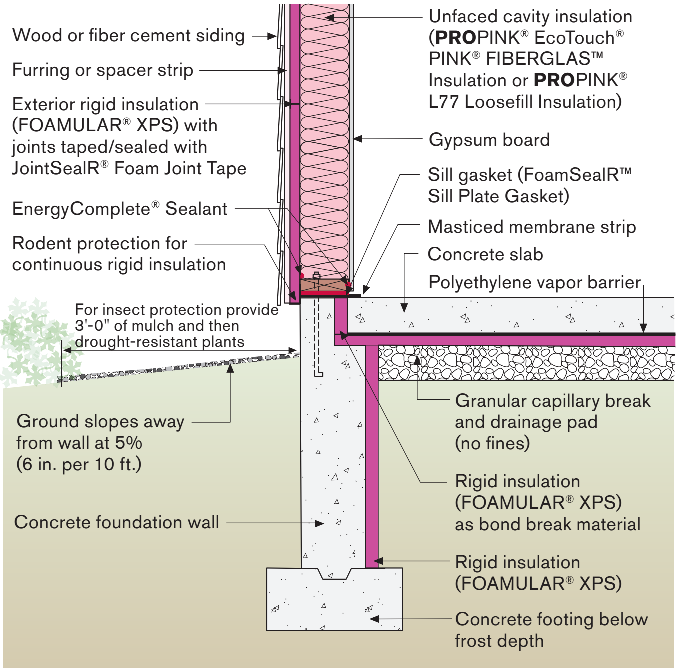


Figure 2.27: Insulated “dry” slab on grade construction.

Crawlspaces are typically constructed as “vented” crawlspaces. Figure 2.28 is an example of recommended vented crawlspace construction. Note the continuous rigid insulation (FOAMULAR® XPS Insulation) on the underside of the floor framing. This rigid insulation’s primary function is to protect the floor assembly from moisture. The rigid insulation should be protected with protection board from fire, insects and vermin. Note that the floor cavity insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) is located in direct contact with the continuous rigid insulation leaving and air space above the cavity insulation. The air space results in a more comfortable floor. It is key with this approach to prevent air entry into the perimeter of the floor framing.

Unvented crawlspaces should be only considered where flooding is not a concern. Figure 2.29 and Figure 2.30 are recommended approaches to constructing conditioned crawlspaces. Note the protection board on the rigid insulation (FOAMULAR® XPS Insulation)

PRACTICES

Table 2.3: Climate zones 3A, 3B and 3C

Component	2009 IECC	2012 IECC	40% <2006 IECC	50% <2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-13	R-20	R-20	R-20	R-21
Wall Insulation Option 2					
Wall Cavity Insulation R-value		R-13	R-13	R-13	R-13
Wall Continuous Insulation R-value		R-5	R-5	R-5	R-7.5
Ceiling Insulation R-value	R-30	R-38	R-38	R-38	R-38
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	R-13 inside	R-13 inside	R-13 inside	R-13 inside	R-13 inside
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-19	R-19	R-19	R-19	R-19
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	None	None	None	None	None
Window U-value, SHGC	U=0.50, SHGC=0.30	U=0.35, SHGC=0.25	U=0.30, SHGC=0.25	U=0.30, SHGC=0.25	U=0.30, SHGC=0.25
House Tightness (ACH50)	7 or Checklist	3 & Checklist	3 & Checklist	2 & Checklist	2 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	No Heat Exchange	No Heat Exchange	HRV >60% SRE
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	AFUE 90	AFUE 90	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	17	18	18
Appliances	Not Specified	Not Specified	Energy Star	Energy Star	Energy Star
Water Fixtures	Not Specified	Not Specified	Low Flow Fixtures	Low Flow Fixtures	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	>=80% Energy Star	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF	HP 2.0 EF

** Attic/Other. No insulation required in the conditioned space.*

*** SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

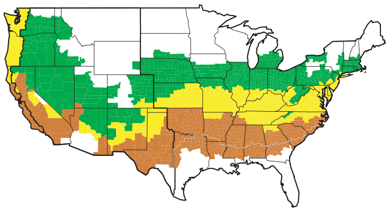


Table 2.4: Climate zones 4A and 4B

Component	2009 IECC	2012 IECC	40% <2006 IECC	50% <2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-13	R-20	R-20	R-21	R-21
Wall Insulation Option 2					
Wall Cavity Insulation R-value		R-13	R-13	R-13	R-13
Wall Continuous Insulation R-value		R-5	R-5	R-7.5	R-7.5
Ceiling Insulation R-value	R-30	R-49	R-49	R-49	R-60
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	R-13 inside	R-13 inside	R-13 inside	R-13 inside	R-21 inside
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-19	R-19	R-19	R-19	R-25
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft
Window U-value, SHGC	U=0.35, SHGC=NA	U=0.35, SHGC=0.40	U=0.30, SHGC=0.40	U=0.30, SHGC=0.40	U=0.30, SHGC=0.40
House Tightness (ACH50)	7 or Checklist	3 & Checklist	3 & Checklist	2 & Checklist	1 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	No Heat Exchange	HRV>60% SRE	HRV>60 SRE w/bypass
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	90 AFUE	90 AFUE	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	15	15	18
Appliances	Not Specified	Not Specified	Not Specified	Energy Star	Energy Star
Water Fixtures	Not Specified	Not Specified	Not Specified	Low Flow Fixtures	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	>=80% Energy Star	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF	HP 2.0 EF

* *Attic/Other. No insulation required in the conditioned space.*

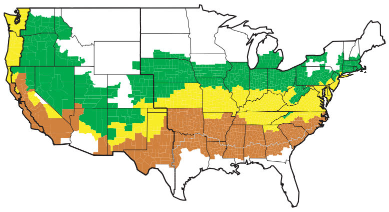
** *SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

Table 2.5: Climate zones 4C, 5A and 5B

Component	2009 IECC	2012 IECC	40% <2006 IECC	50% <2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-20	R-20	R-20	R-21	R-30 Double Wall
Wall Insulation Option 2					
Wall Cavity Insulation R-value	R-13	R-13	R-13	R-13	R-19
Wall Continuous Insulation R-value	R-5	R-5	R-5	R-7.5	R-10
Ceiling Insulation R-value	R-38	R-49	R-49	R-49	R-60
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	R-13 inside	R-19 inside	R-19 inside	R-19 inside	R-21 inside
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-30	R-30	R-30	R-30	R-30
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft	R-10, 2 ft
Window U-value, SHGC	U=0.35, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.20, SHGC=0.40
House Tightness (ACH50)	7 or Checklist	3 & Checklist	2 & Checklist	1 & Checklist	0.6 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	No Heat Exchange	HRV>60% SRE	HRV>60 SRE w/bypass
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	90 HSPF	0.90 HSPF	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	18
Appliances	Not Specified	Not Specified	Not Specified	Energy Star	Energy Star
Water Fixtures	Not Specified	Not Specified	Not Specified	Low Flow Fixtures	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	>=80% Energy Star	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF

* *Attic/Other. No insulation required in the conditioned space.*

** *SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*



protecting the rigid insulation from fire. Also note the fully-adhered membrane barrier for insect control.

Basement foundations are principally insulated from the interior due to constructability issues, thermal bridging issues with brick veneer construction, insect control and vermin issues and cost issues.

Figure 2.31 and Figure 2.32 are two means of constructing insulated basements. Note with Figure 2.32 it is recommended that a dehumidifier be installed and used in the basement space during the summer months.

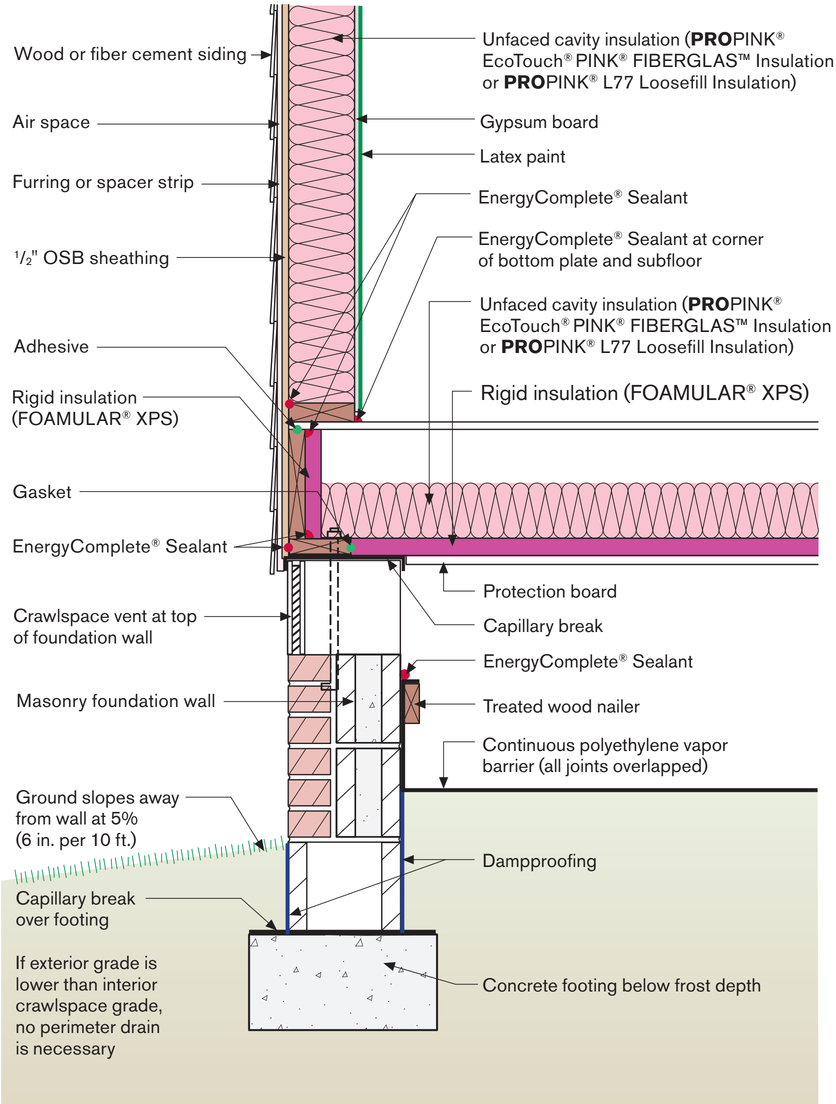


Figure 2.28: Recommended vented crawlspace construction.

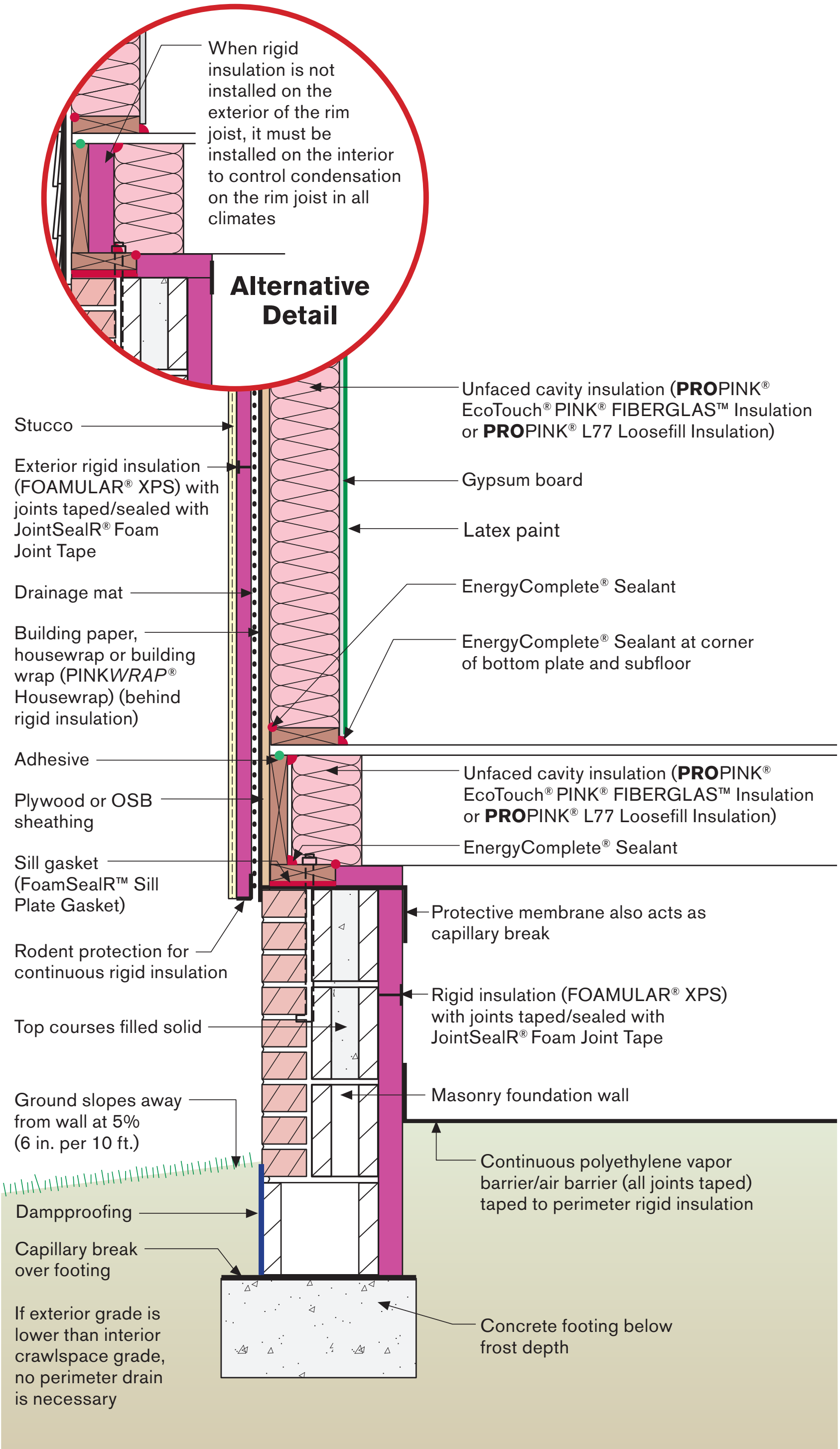


Figure 2.29:
Recommended conditioned crawlspace construction.

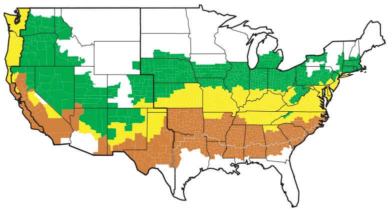
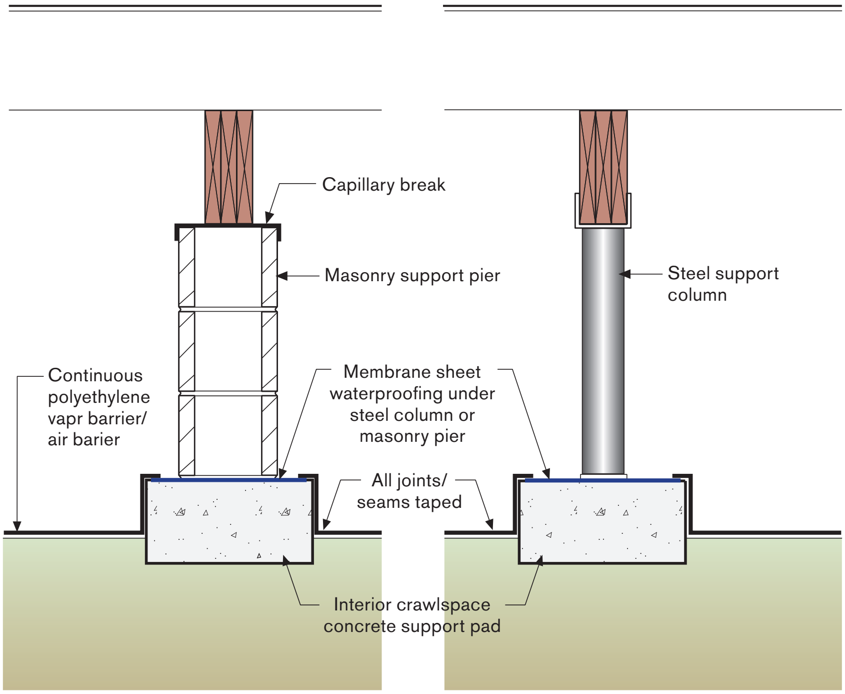


Figure 2.30:
Recommended conditioned crawlspace construction.



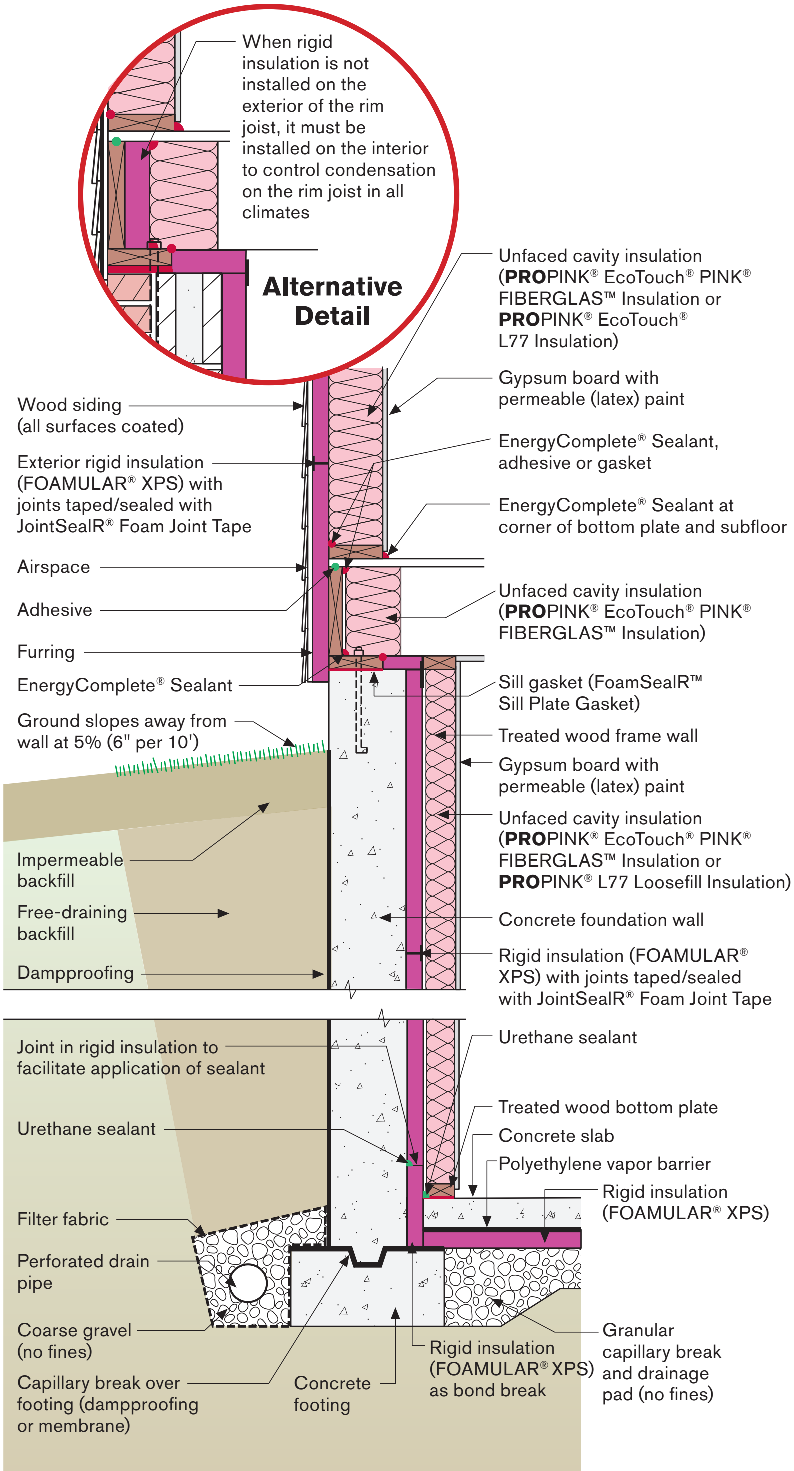
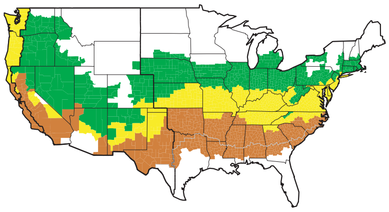


Figure 2.31:
Insulated basement construction.



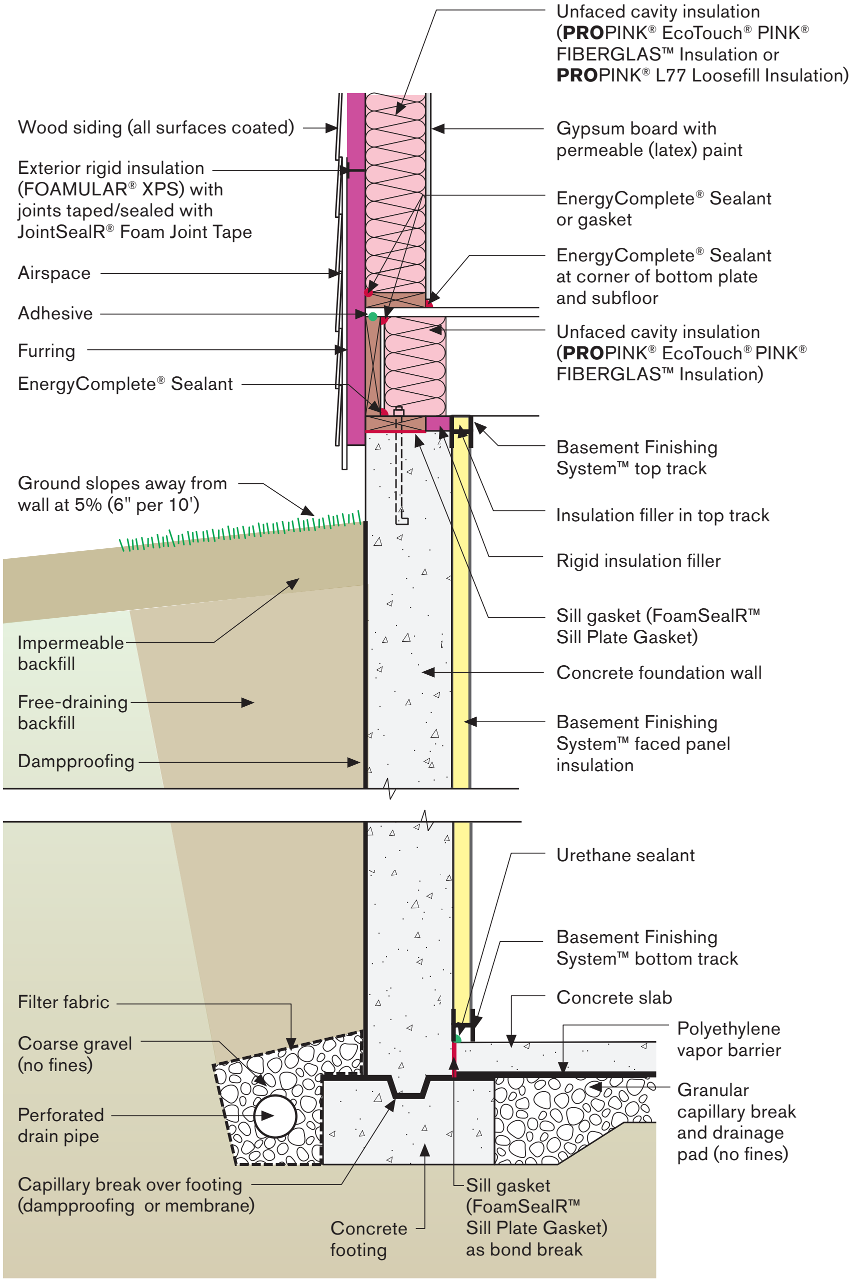


Figure 2.32:
Insulated basement construction.

10.2 WALLS

A common approach to construct wood frame walls in Climate Zones 3,4 and 5 is illustrated in Figure 2.33. Note the use of plywood or OSB sheathing that is protected by a housewrap (PINK*WRAP*® Housewrap). The key element of this wall is the gap between the cladding and the housewrap (PINK*WRAP*® Housewrap) used to control hydrostatic pressure. The wall cavity insulation is an unfaced fiberglass batt (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation). Figure 2.34 is identical to Figure 2.33 except for the use of kraft-faced fiberglass batt insulation. Both unfaced and kraft-faced batt insulation perform successfully in these climate zones.

An equally common approach to construct wood frame walls is illustrated in Figure 2.35 and Figure 2.36. In both of these wall assemblies taped and sealed with JointSealR® Foam Joint Tape®, rigid insulation (FOAMULAR® XPS Insulation) is used to provide water control. Again note the gap between the cladding and the sheathing to control hydrostatic pressure.

Figure 2.37 and Figure 2.38 show walls completely sheathed with plywood or OSB and then in turn externally insulated with continuous rigid insulation. Note the use of a housewrap (PINK*WRAP*® Housewrap) between the continuous rigid insulation (FOAMULAR® XPS Insulation) and the plywood or OSB sheathing.

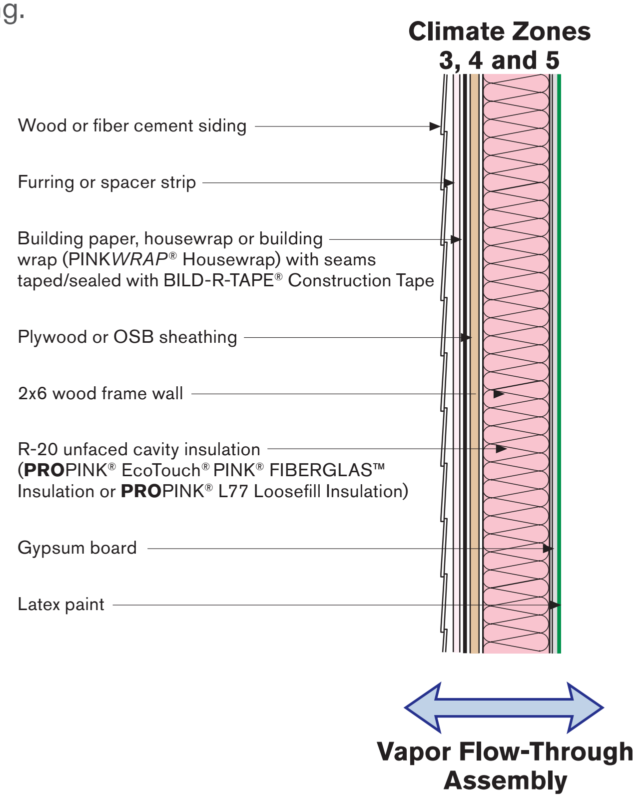
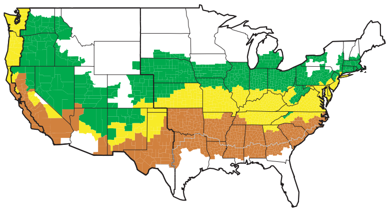


Figure 2.33: Common wood frame wall construction in Climate Zones 3, 4 and 5.



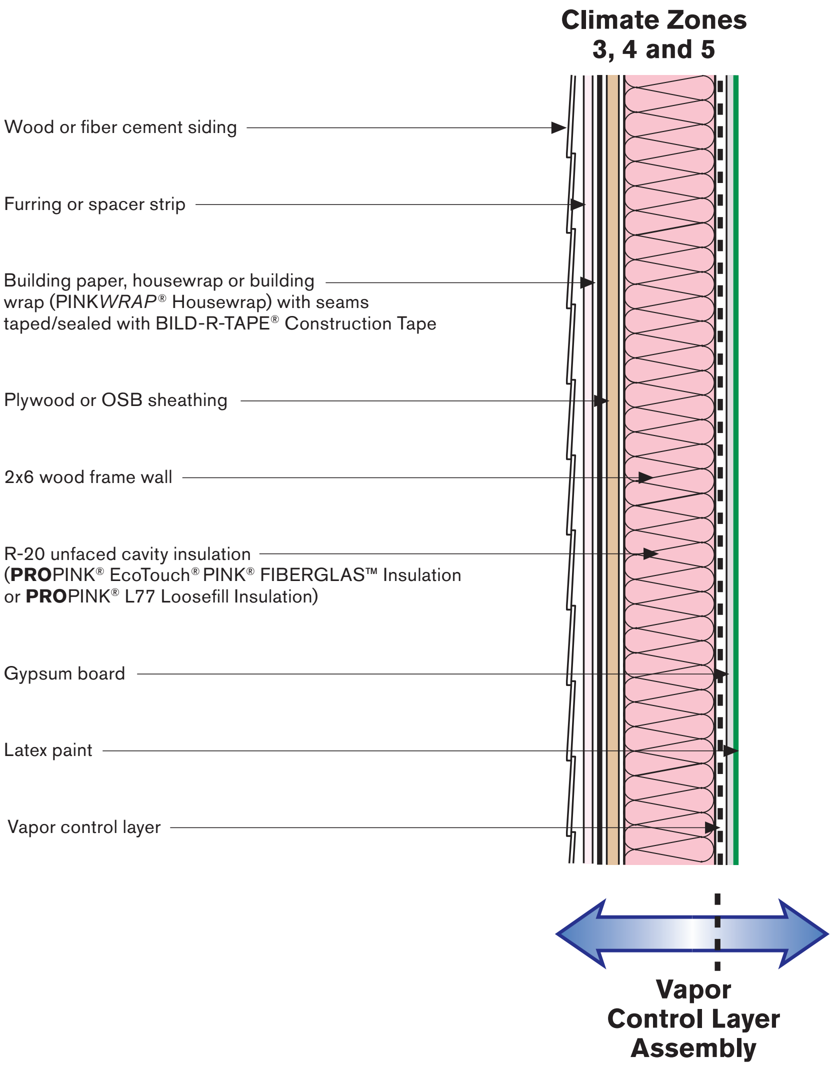


Figure 2.34:
Common wood frame wall construction in Climate Zones 3, 4 and 5.

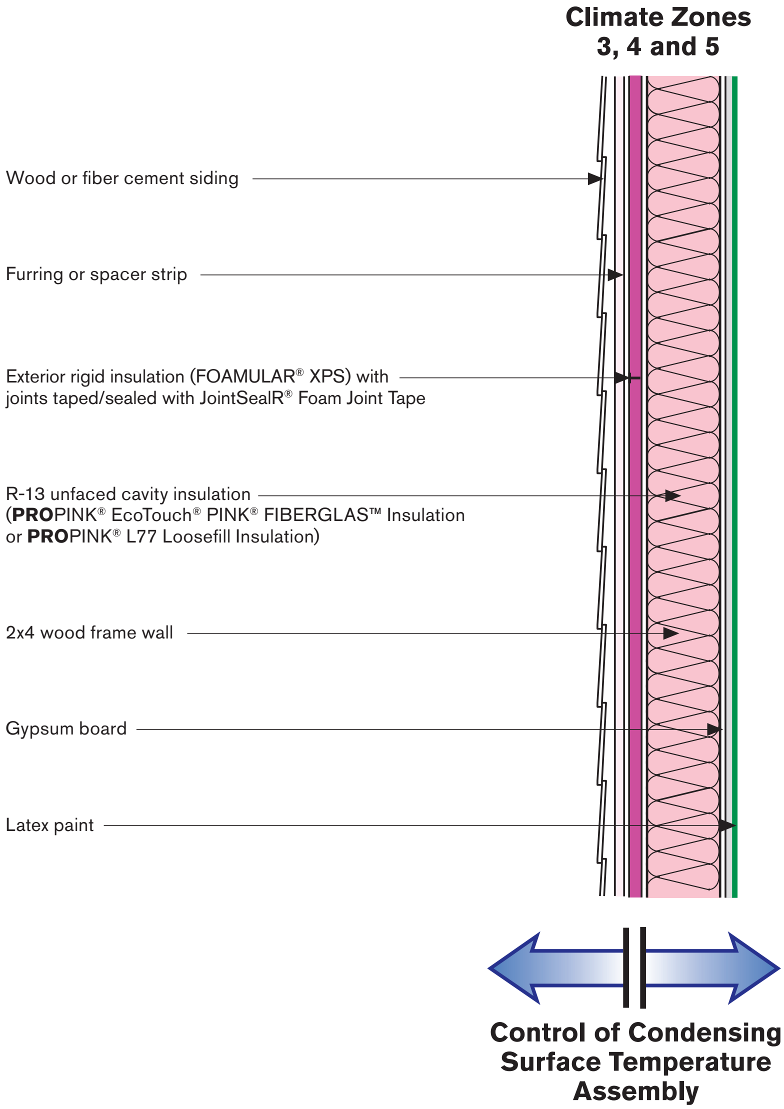


Figure 2.35:
Common wood frame wall construction in Climate Zones 3, 4 and 5.

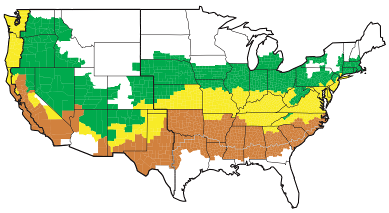
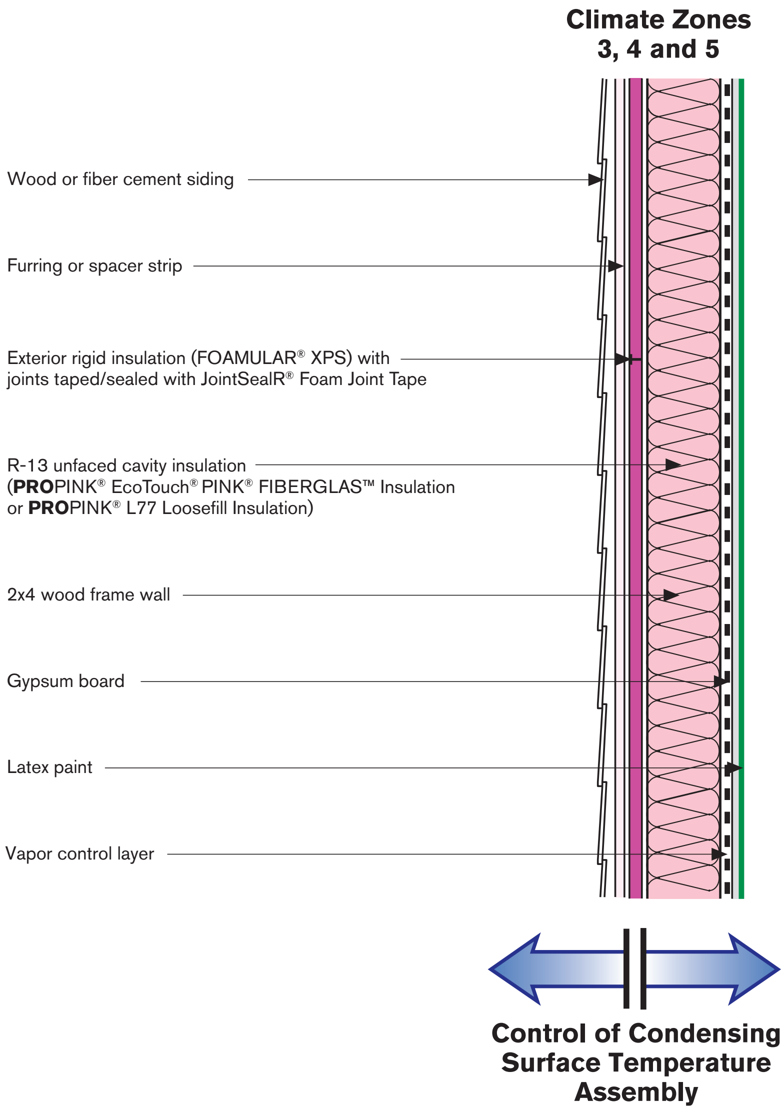


Figure 2.36: Common wood frame wall construction in Climate Zones 3, 4 and 5.



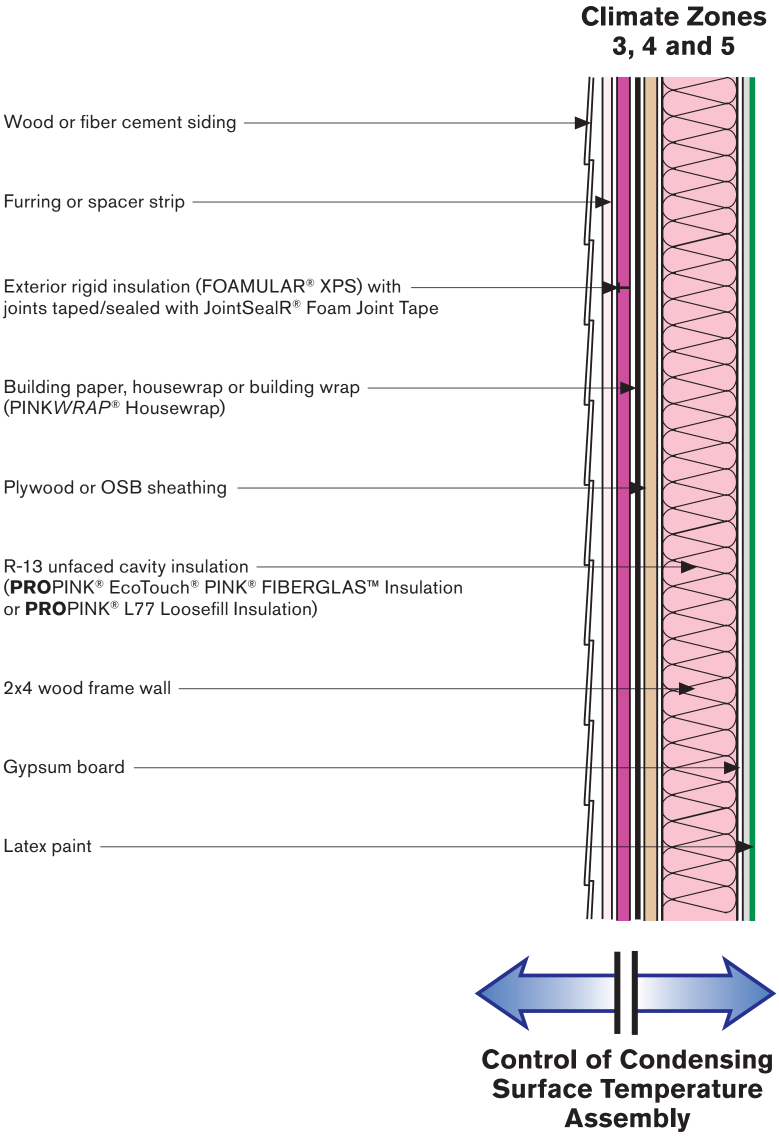
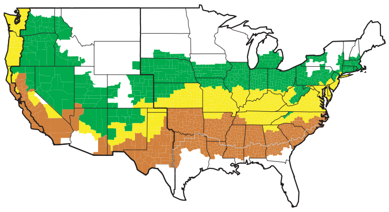


Figure 2.37: Externally insulated wood frame wall construction in Climate Zones 3, 4 and 5.



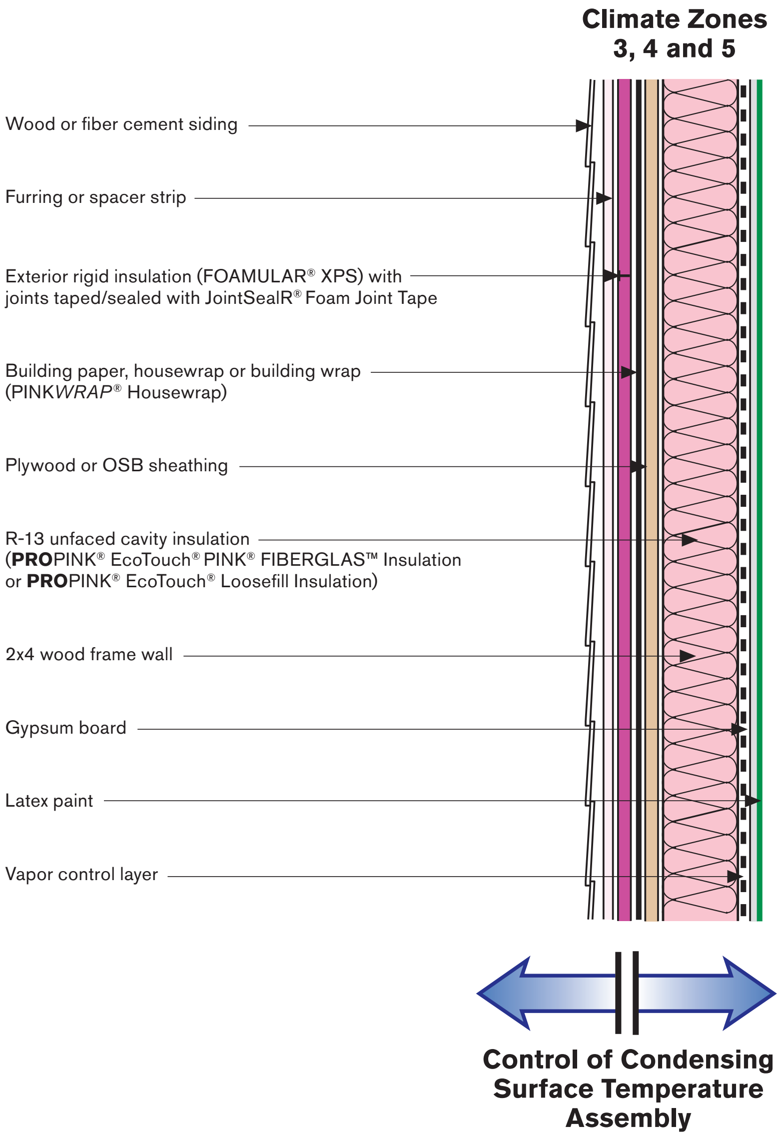


Figure 2.38:
Externally insulated wood frame wall construction in Climate Zones 3, 4 and 5.

10.3 ROOFS

The most common approach to roof construction in these climate zones is a vented attic. Figure 2.39 and Figure 2.40 illustrate recommended approaches to constructing vented attics. Note the use of a "kraft"-faced fiberglass batt insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation) or blown-in insulation (**PRO**PINK® L77 Loosefill Insulation) in Figure 2.40. The kraft facing is a vapor retarder not a vapor barrier and can be used throughout Climate Zone 3, Climate Zone 4 and Climate Zone 5. The kraft facing is not required for vapor control in these climate zones but is often used for ease of installation.

Unvented roofing assemblies are illustrated in Figure 2.41 and Figure 2.42. The amount of rigid insulation (FOAMULAR® XPS Insulation) in each of these assemblies is specified by the IRC to control condensation.

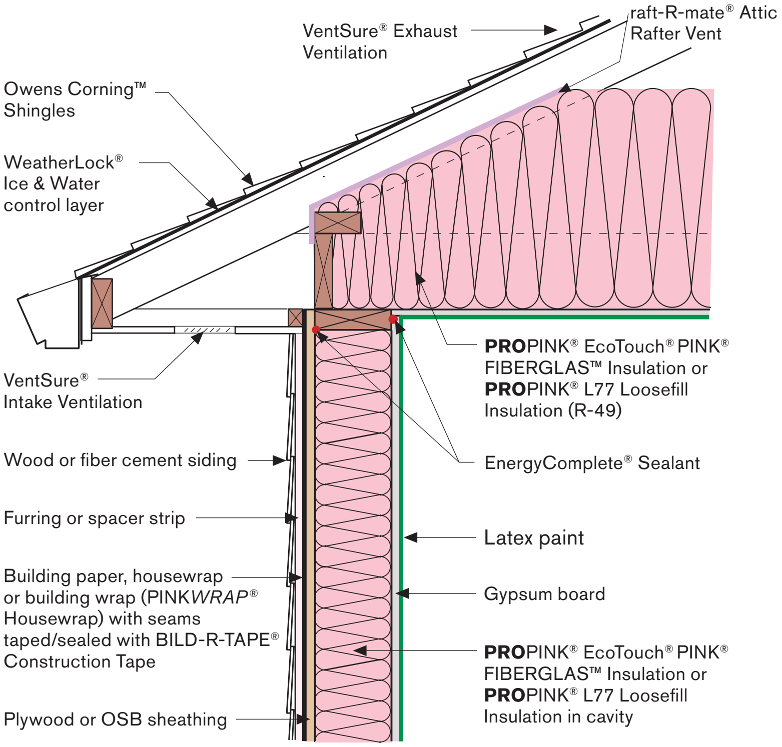
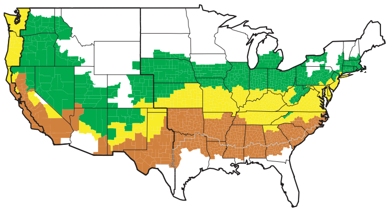


Figure 2.39: Recommended vented attic construction in Climate Zones 3, 4 and 5.



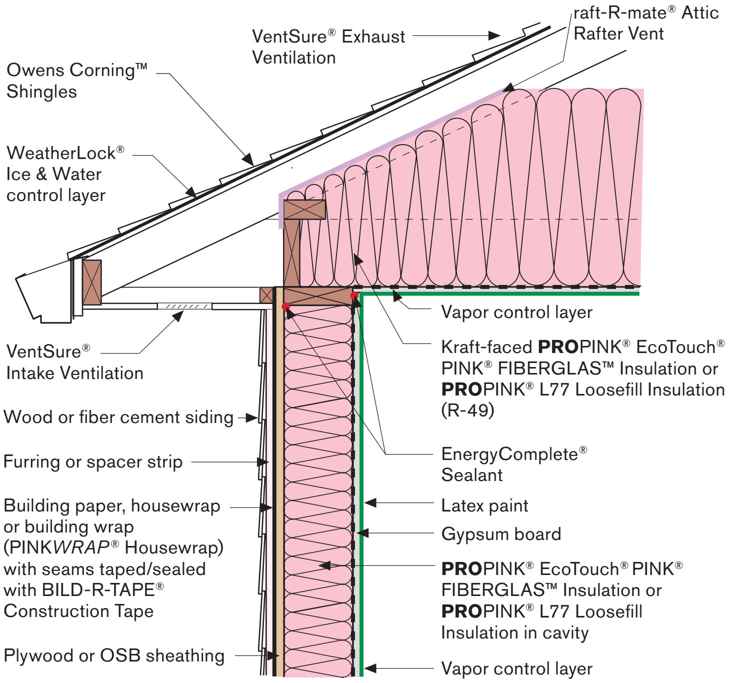


Figure 2.40:
Recommended vented attic construction in Climate Zones 3, 4 and 5.

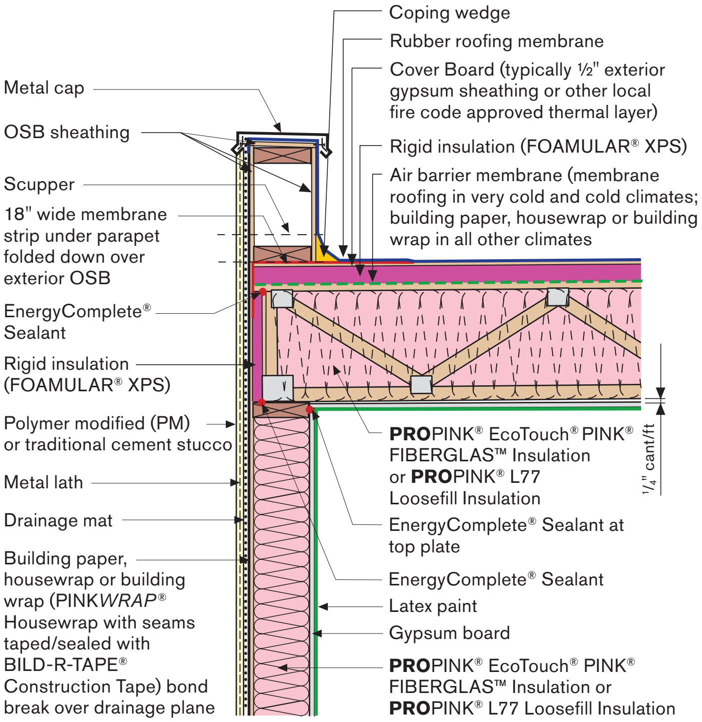


Figure 2.41:
Unvented attic details in Climate Zones 3, 4 and 5.

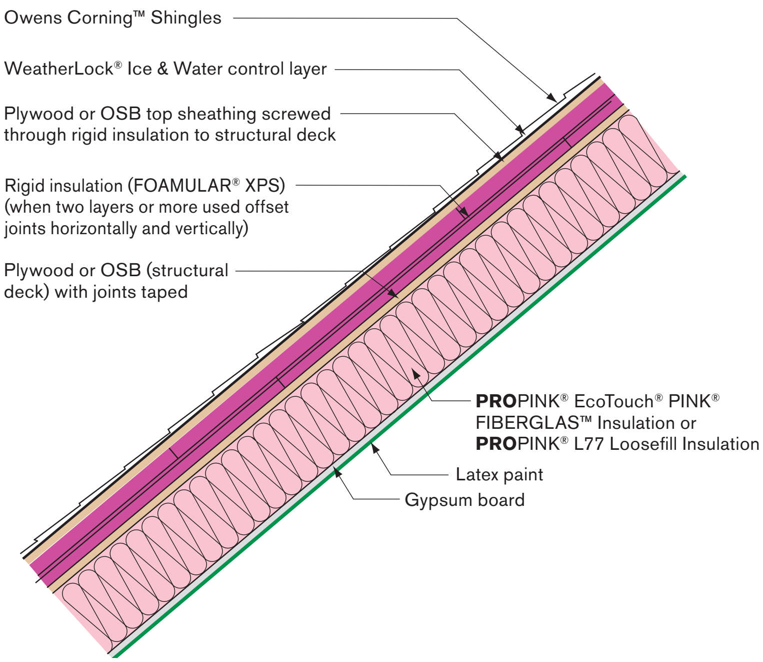
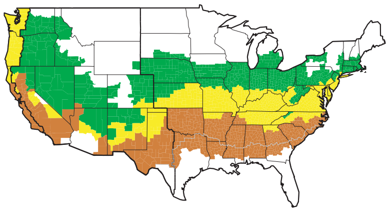


Figure 2.42:
Unvented attic details in Climate Zones 3, 4 and 5.



10.4 CASE STUDIES

Two complete sections are presented as typical for Louisville (Figure 2.43) and Chicago (Figure 2.44) that meet or exceed the 2012 IECC as well as meet the requirements for environmental separation. See tables 2.3, 2.4 and 2.5 for specific insulation levels to achieve overall desired performance in other cities in these climate zones.

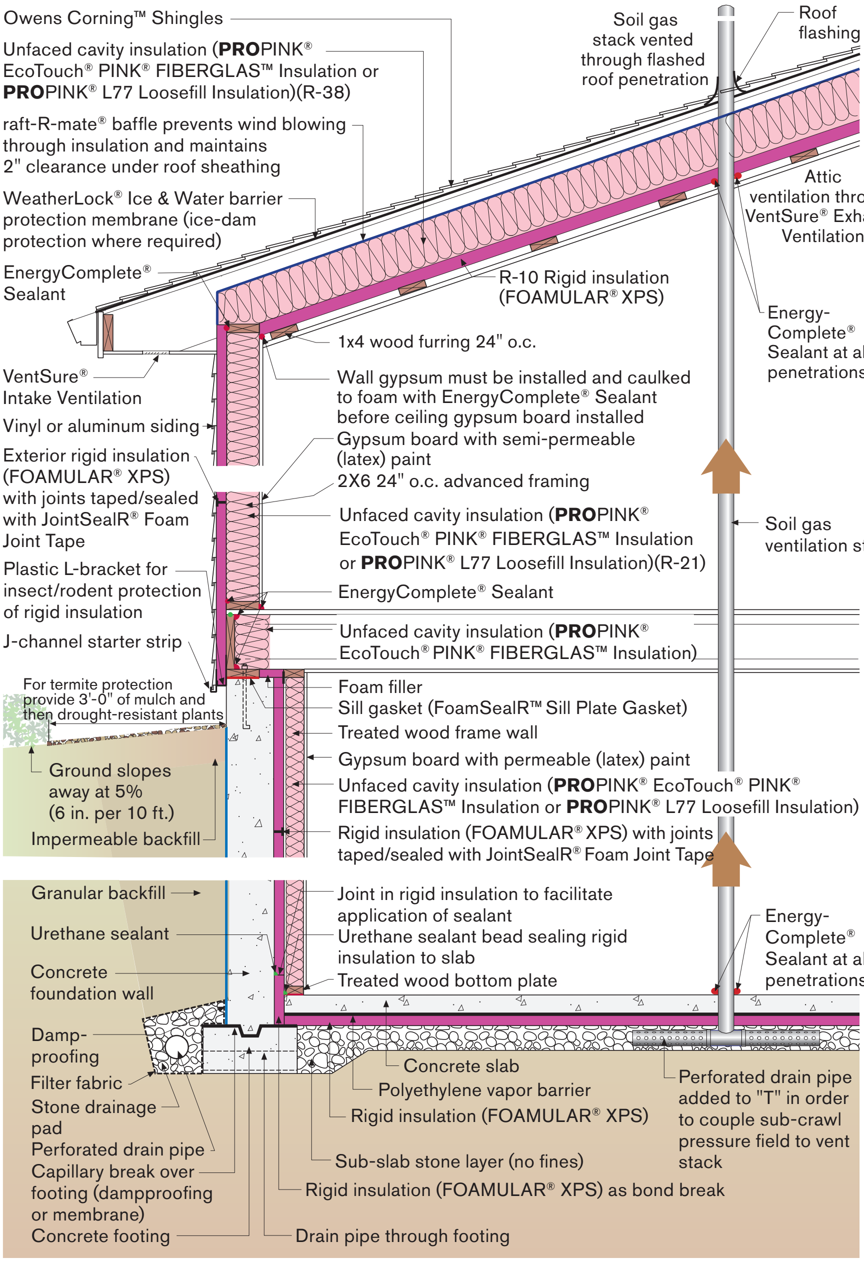


Figure 2.43: Louisville case study profile.

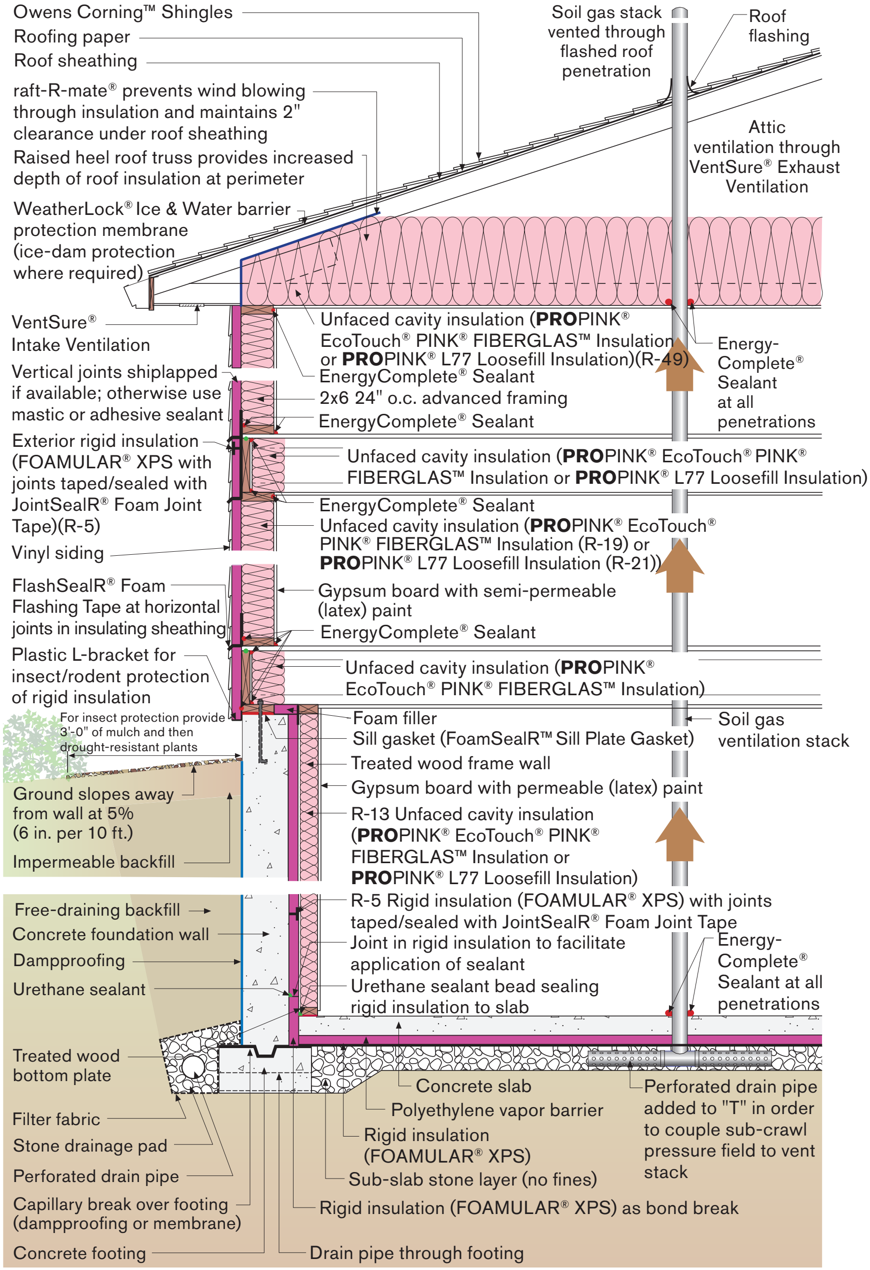
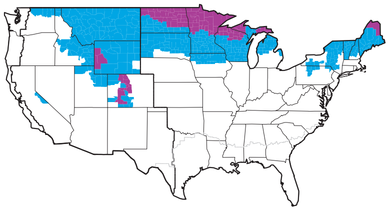


Figure 2.44: Chicago case study profile.



CHAPTER 11

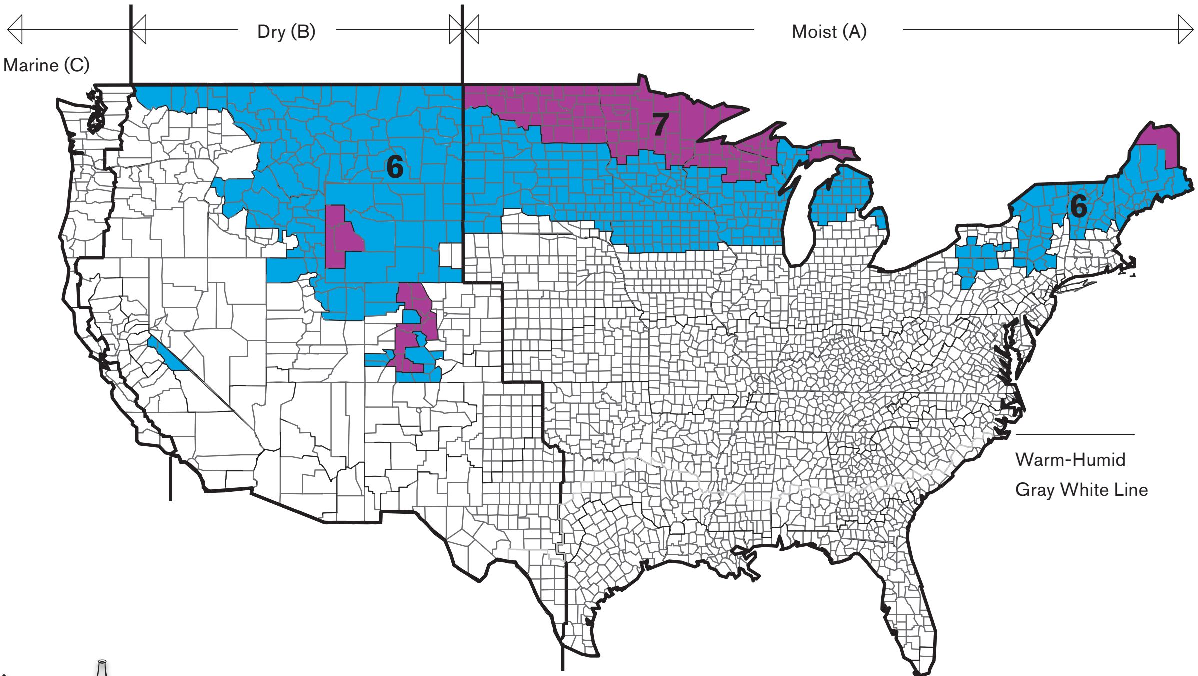
CLIMATE ZONES 6, 7 & 8

The residential buildings constructed in these three zones are constructed on each of the three typical foundation types: slab foundations, crawlspaces and basements.

Where slab foundations are used they are insulated as are basement foundations. Exterior rigid insulation (FOAMULAR® XPS Insulation) is often avoided for insect control reasons and constructability.

Walls are typically wood frame — predominately 2x6 framing.

Roof construction is predominately vented attics. Some unvented roof assemblies are being constructed, but they are not common.



All of Alaska in Zone 7 except for the following Boroughs in Zone 8:

Bethel	Northwest Arctic
Dellingham	Southeast Fairbanks
Fairbanks N. Star	Wade Hampton
Nome	Yukon-Koyukuk
North Slope	

For building science assistance contact
buildingscience@owenscorning.com

11.1 FOUNDATIONS

Figure 2.45 is an effective means providing a "dry" slab that is also insulated with rigid insulation (FOAMULAR® XPS Insulation) where the insulation does not act as an insect entry point. A protective membrane strip is used to create a physical barrier to the entry of insects into the building enclosure. Fully-adhered membranes are effective means of insect control. Ground treatment is also recommended.

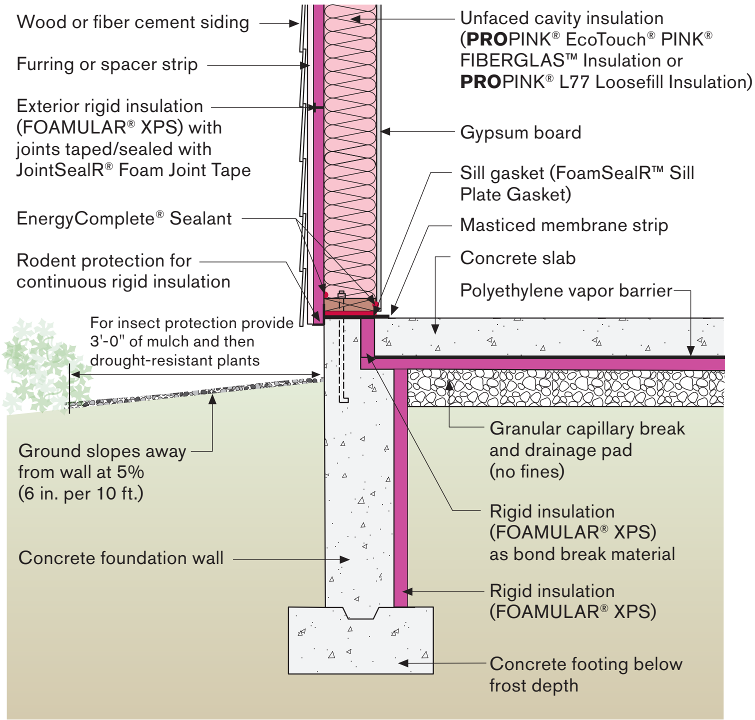
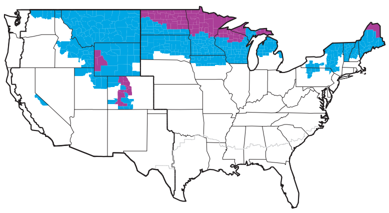


Figure 2.45: Insulated "dry" slab on grade construction.

Crawlspaces typically are constructed as "vented" crawlspaces. Figure 2.46 is an example of recommended vented crawlspace construction. Note the continuous rigid insulation (FOAMULAR® XPS Insulation) on the underside of the floor framing. This rigid insulation's primary function is to protect the floor assembly from moisture. The rigid insulation should be protected with protection board from fire, insects and vermin. Note that the floor cavity insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) is located in direct contact with the continuous rigid insulation leaving an air space above the cavity insulation. The air space results in a more comfortable floor. It is key with this approach to prevent air entry into the perimeter of the floor framing. This is the preferred method of construction when protection of the permafrost layer is necessary in Alaska.



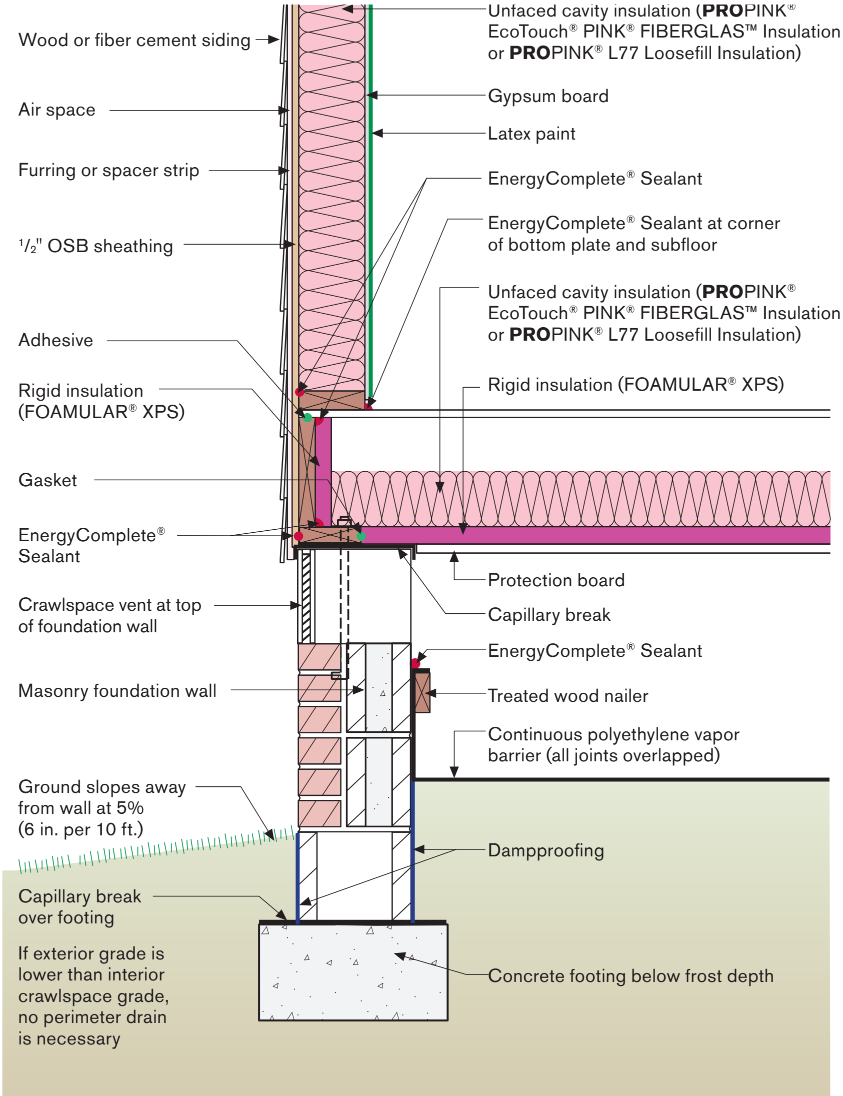


Figure 2.46: Recommended vented crawlspace construction.

Unvented crawlspaces should only be considered where flooding is not a concern. Figure 2.47 and Figure 2.48 are recommended approaches to constructing conditioned crawlspaces. Note that protection board on the rigid insulation (FOAMULAR® XPS Insulation) protecting the rigid insulation from fire is required if crawlspace is used for storage or for more than access for servicing equipment. Also note the fully-adhered membrane barrier for insect control.

Basement foundations are principally insulated from the interior due to constructability issues, thermal bridging issues with brick veneer construction, insect control and vermin issues and cost issues.

PRACTICES

Table 2.6: Climate zone 6A and 6B

Component	2009 IECC	2012 IECC	40%<2006 IECC	50%<2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-19 Inside	R-20	R-20	R-20	R-40 double wall
Wall Continuous Insulation R-value		R-5	R-5	R-5	
Wall Insulation Option 2					
Wall Cavity Insulation R-value	R-13	R-13	R-13	R-13	R-19
Wall Continuous Insulation R-value	R-5	R-10	R-10	R-10	R-20
Ceiling Insulation R-value	R-49	R-49	R-49	R-49	R-60
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	R-19 Inside	R-19 Inside	R-19 Inside	R-19 Inside	R-21 Inside
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-30	R-30	R-30	R-30	R-30
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft
Window U-value, SHGC	U=0.35, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.18, SHGC=0.40
House Tightness (ACH50)	7 or Checklist	3 & Checklist	2 & Checklist	1 & Checklist	0.6 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	HRV>60% SRE	HRV>60% SRE	HRV> 60% SRE w/bypass
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	90 AFUE	0.90 AFUE	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	18
Appliances	Not Specified	Not Specified	Not Specified	Not Specified	Energy Star
Water Fixtures	Not Specified	Not Specified	Not Specified	Not Specified	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	>=80% Energy Star	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF

** Attic/Other. No insulation required in the conditioned space.*

*** SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

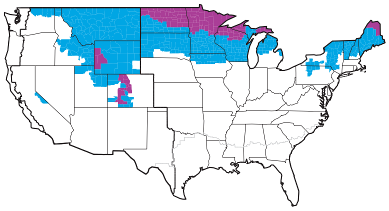


Table 2.7:
Climate zones
7 and 8

Component	2009 IECC	2012 IECC	40%<2006 IECC	50%<2006 IECC	Net Zero
Wall Insulation Option 1					
Wall Cavity Insulation R-value	R-21	R-20	R-20	R-20	R-40 Double Wall
Wall Continuous Insulation R-value		R-5	$-5	R-5	
Wall Insulation Option 2					
Wall Cavity Insulation R-value	R-13	R-13	R-13	R-13	R-19
Wall Continuous Insulation R-value	R-5	R-10	R-10	R-10	R-20
Ceiling Insulation R-value	R-49	R-49	R-49	R-49	R-60
Conditioned Basement or Crawl Space					
Basement Ceiling Insulation	None	None	None	None	None
Under Slab Insulation	None	None	None	None	None
Basement Wall	R-19 Inside	R-19 Inside	R-19 Inside	R-19 Inside	R-21 Inside
Unconditioned Basement or Crawl Space					
Basement Ceiling Insulation	R-38	R-38	R-38	R-38	R-38
Under Slab Insulation	None	None	None	None	None
Basement Wall	None	None	None	None	None
Slab					
Under Slab Insulation Level	None	None	None	None	None
Slab Edge Insulation Level	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft	R-10, 4 ft
Window U-value, SHGC	U=0.35, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.32, SHGC=NA	U=0.18, SHGC=0.40
House Tightness (ACH50)	7 or Checklist	3 & Checklist	2 & Checklist	1 & Checklist	0.6 & Checklist
Ventilation	No Heat Exchange	No Heat Exchange	HRV>60% SRE	HRV>60% SRE	HRV>60 SRE w/bypass
Duct Location	Not Specified	Not Specified	Conditioned Space	Conditioned Space	Conditioned Space
Duct Insulation	R-8/R-6*	R-8/R-6*	R-4	R-4	R-4
Heater Type	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Typically Gas Furnace	Air Source HP
Heater Efficiency	Minimum Allowed	Minimum Allowed	90 AFUE	0.90 AFUE	10 HSPF
AC Efficiency (SEER)**	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	18
Appliances	Not Specified	Not Specified	Not Specified	Not Specified	Energy Star
Water Fixtures	Not Specified	Not Specified	Not Specified	Not Specified	Low Flow Fixtures
Lighting	Not Specified	Not Specified	>=80% Energy Star	>=80% Energy Star	Fluorescent or LED
Hot Water Heating	Minimum Allowed	Minimum Allowed	Minimum Allowed	Minimum Allowed	HP 2.0 EF

* *Attic/Other. No insulation required in the conditioned space.*

** *SEER 13 except Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Arizona, California, Nevada, and New Mexico require SEER 14 after January 1, 2015.*

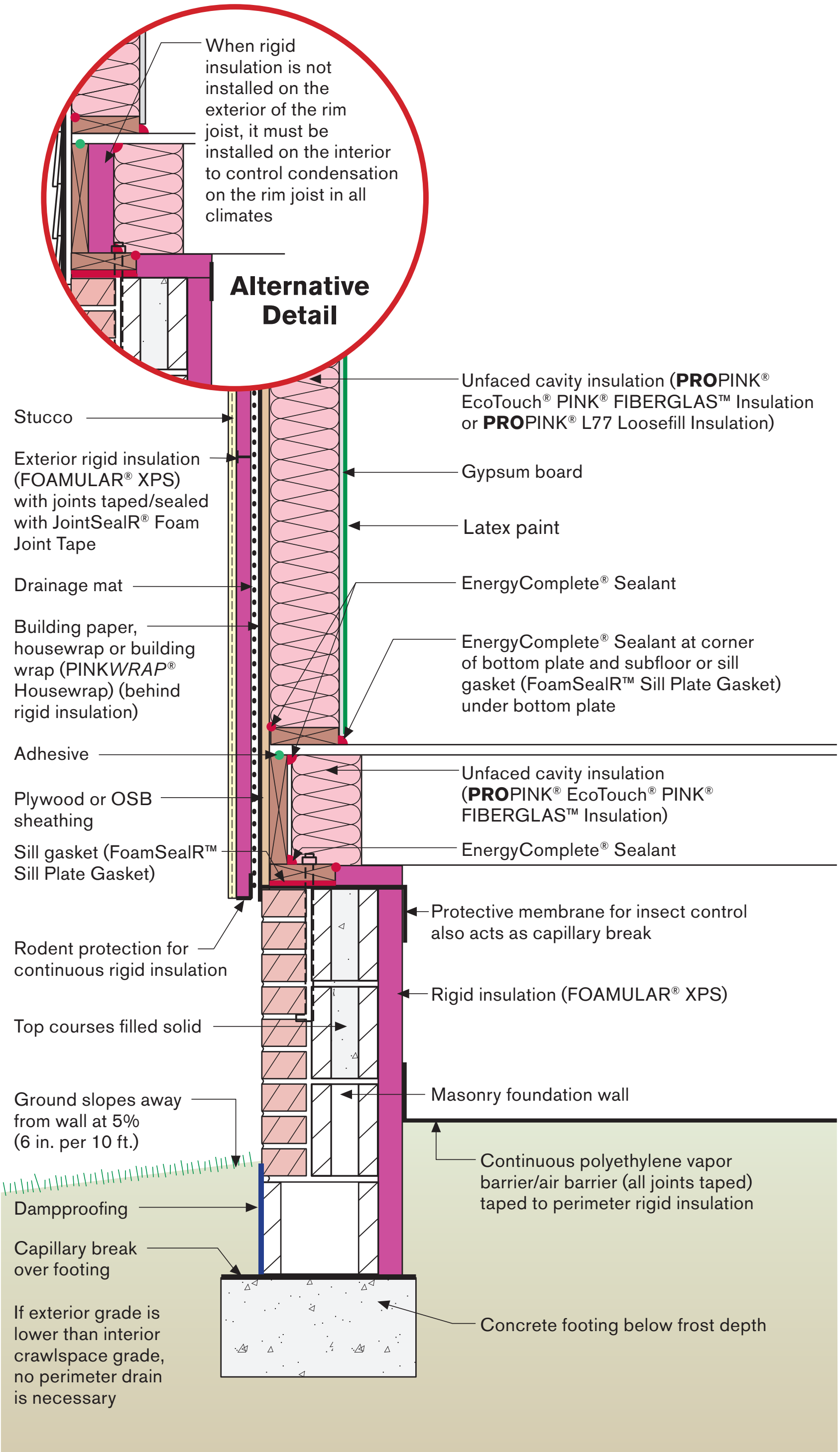
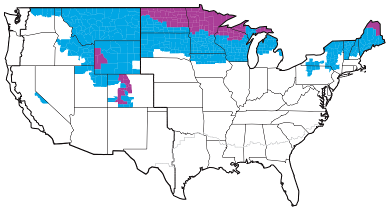


Figure 2.47: Unvented crawlspace construction.



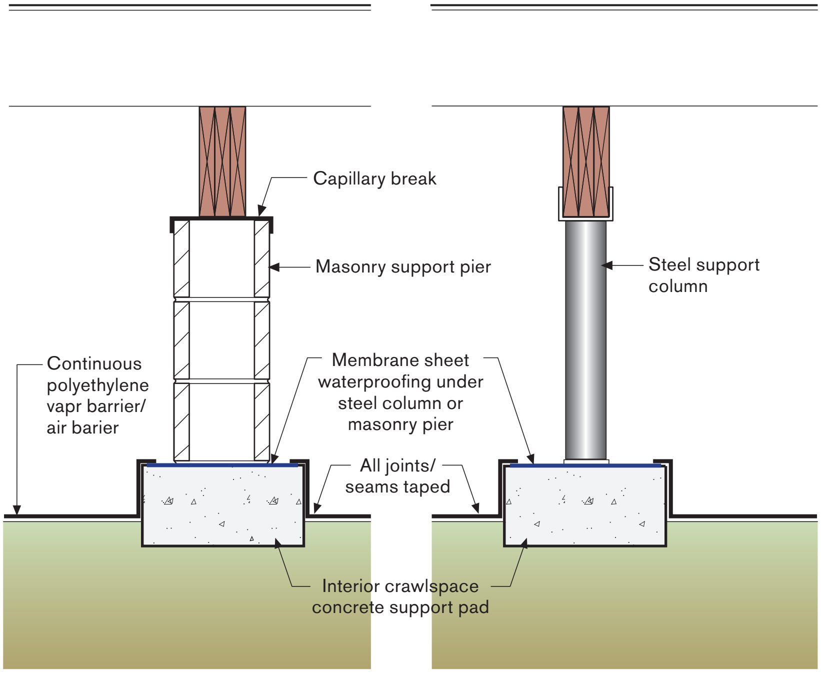


Figure 2.48: Unvented crawlspace construction.

Figure 2.49 and Figure 2.50 are two means of constructing insulated basements. Note with Figure 2.50 it is recommended that a dehumidifier be installed and used in the basement space during the summer months.

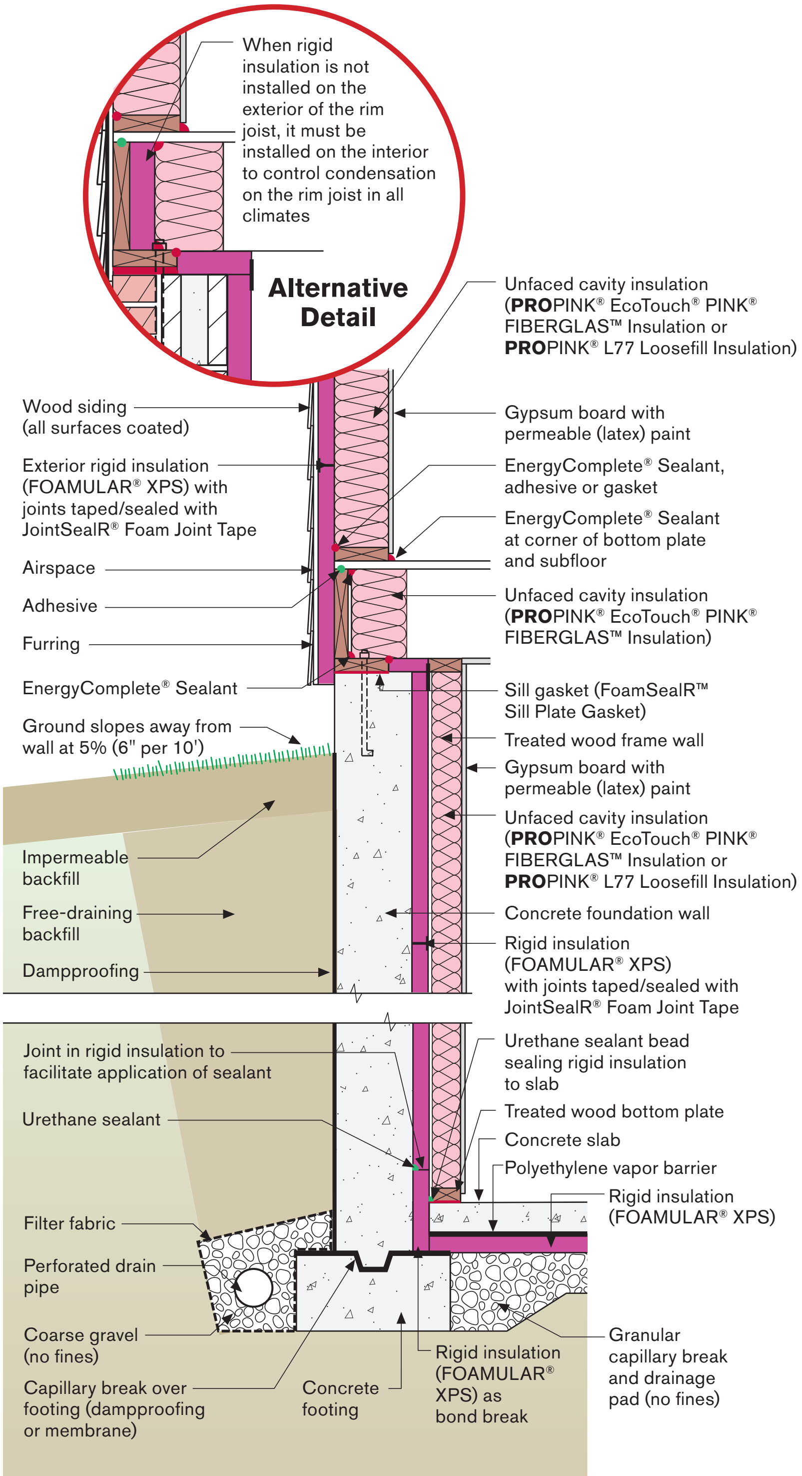
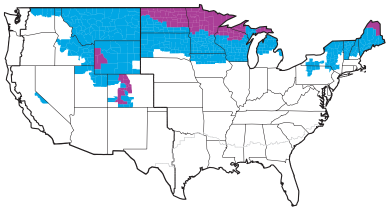


Figure 2.49: Insulated basement construction.



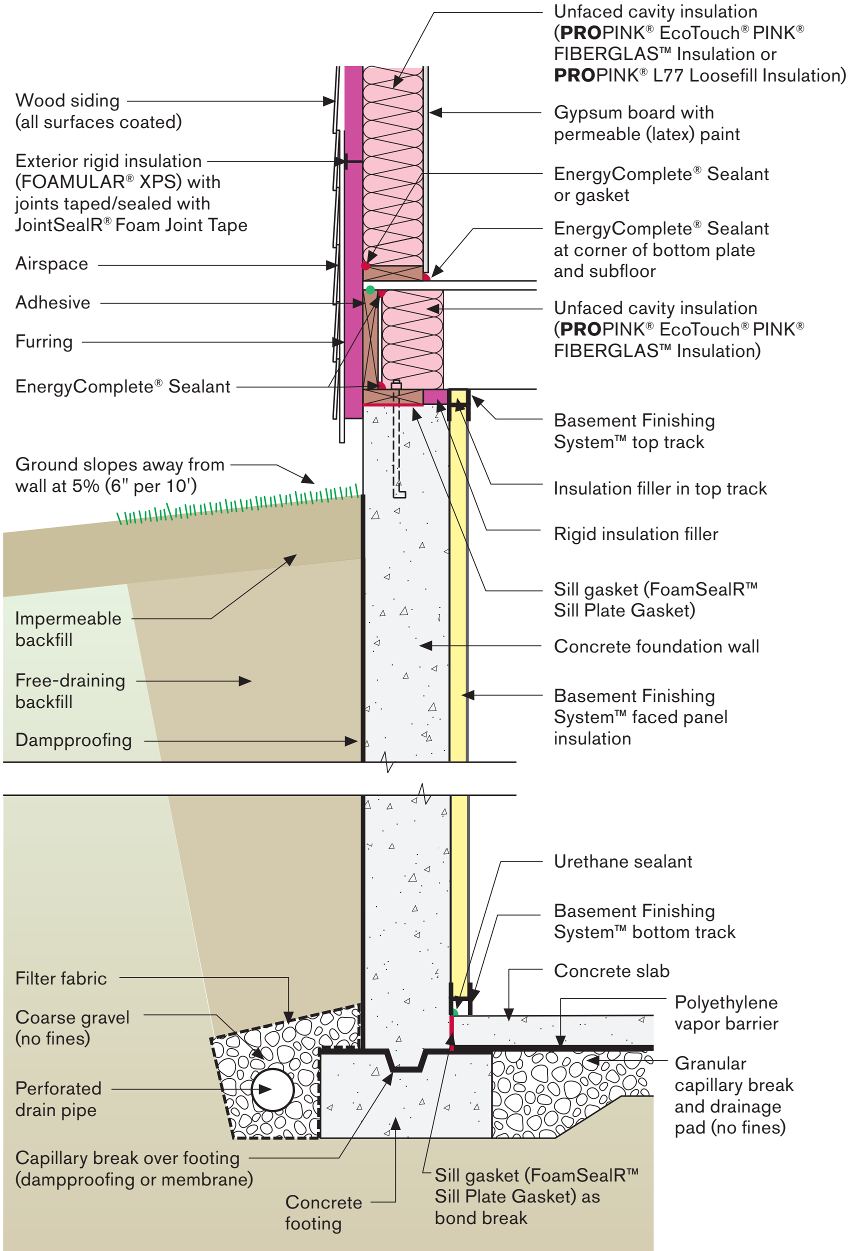


Figure 2.50: Insulated basement construction.

PRACTICES

11.2 WALLS

A common approach to construct wood frame walls in Climate Zone 6, 7 and 8 is illustrated in Figure 2.51. Note the use of plywood or OSB sheathing that is protected by a housewrap (PINK*WRAP*® Housewrap) under the continuous rigid insulation (FOAMULAR® XPS Insulation). One of key elements of this wall is the gap between the cladding and the housewrap used to control hydrostatic pressure. The wall cavity insulation is a kraft-faced fiberglass batt (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation). The kraft-facing is necessary for moisture control in these climate zones. Note the 2x6 framing.

If 2x4 framing is used and the thickness of the continuous insulation (FOAMULAR® XPS Insulation) increased then an unfaced fiberglass batt (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) can be used (Figure 2.52). If 2x6 framing is used the thickness of the continuous rigid insulation needs to be increased further still (Figure 2.53). Note the use of a housewrap (PINK*WRAP*® Housewrap) between the continuous rigid insulation and the plywood or OSB sheathing.

Plywood and OSB sheathing can be omitted in regions where wind loads are low. Figure 2.54 and Figure 2.55 are analogous to Figure 2.52 and Figure 2.53 but without the structural sheathing. In both of these wall assemblies taped and sealed with JointSealR®, rigid insulation (FOAMULAR® XPS Insulation) is used to provide water control. Again note the gap between the cladding and the sheathing to control hydrostatic pressure.

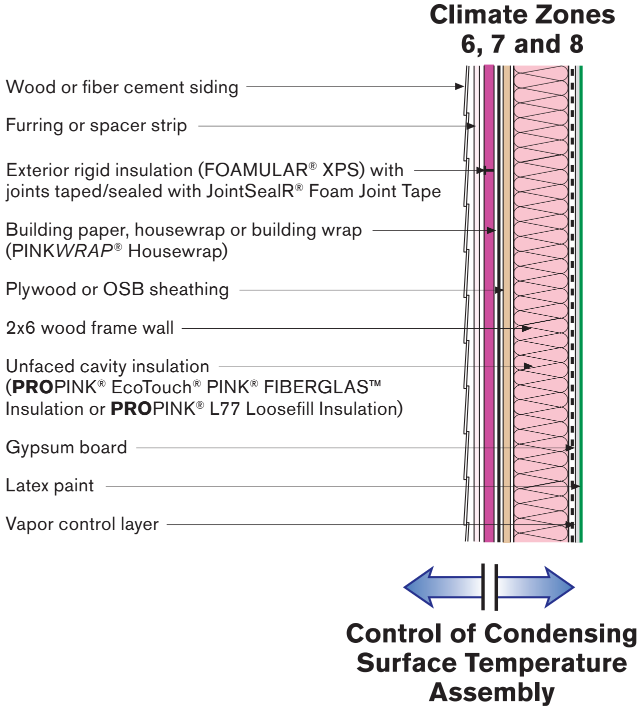
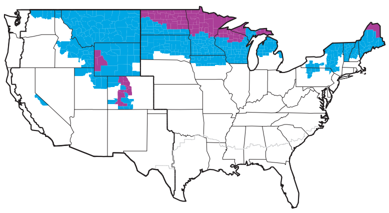


Figure 2.51: Common wood frame wall construction in Climate Zones 6, 7 and 8.



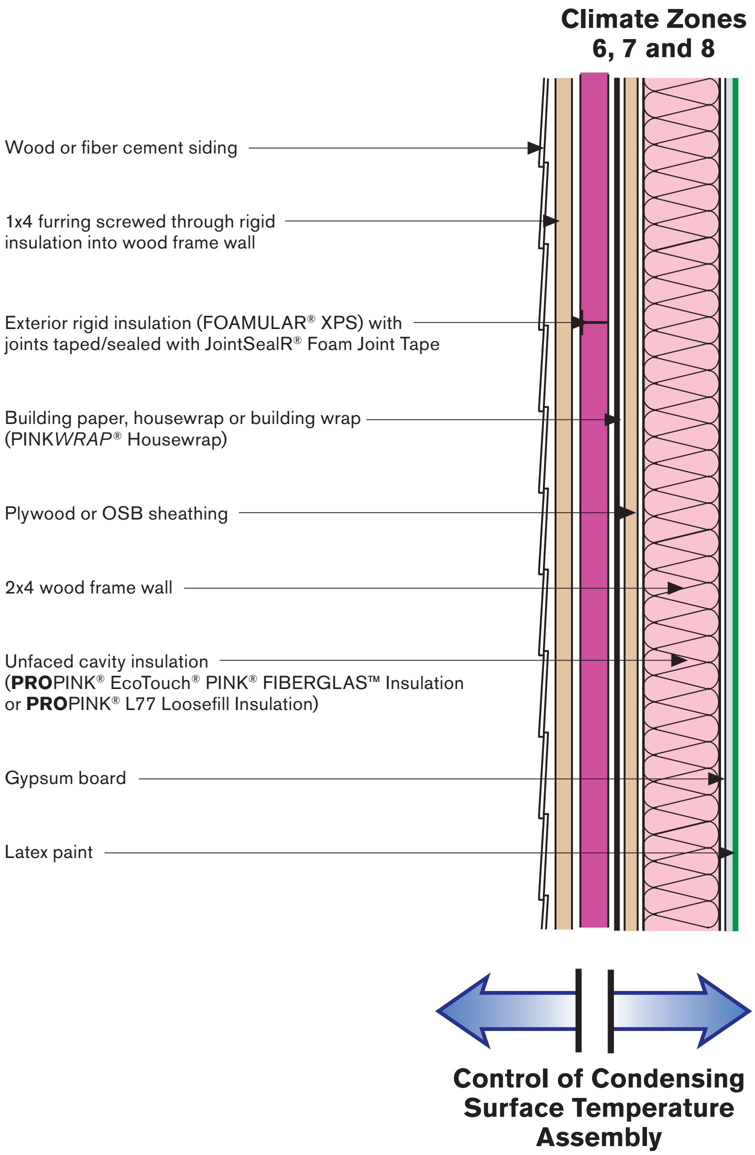


Figure 2.52: Common 2x4 wood frame wall construction in Climate Zones 6, 7 and 8.

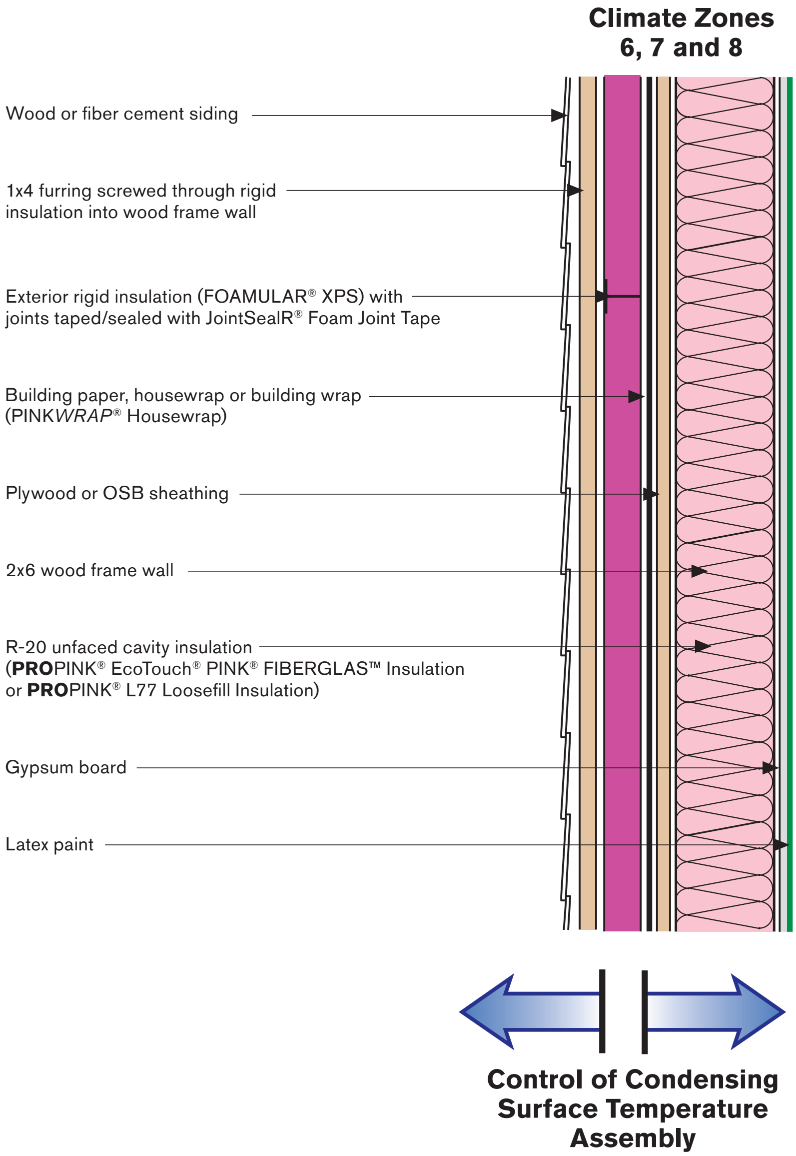
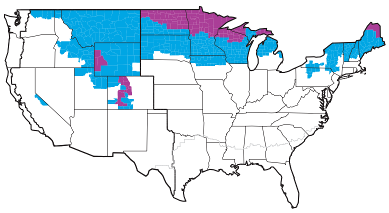


Figure 2.53:
Common 2x6 wood frame wall construction in Climate Zones 6, 7 and 8.



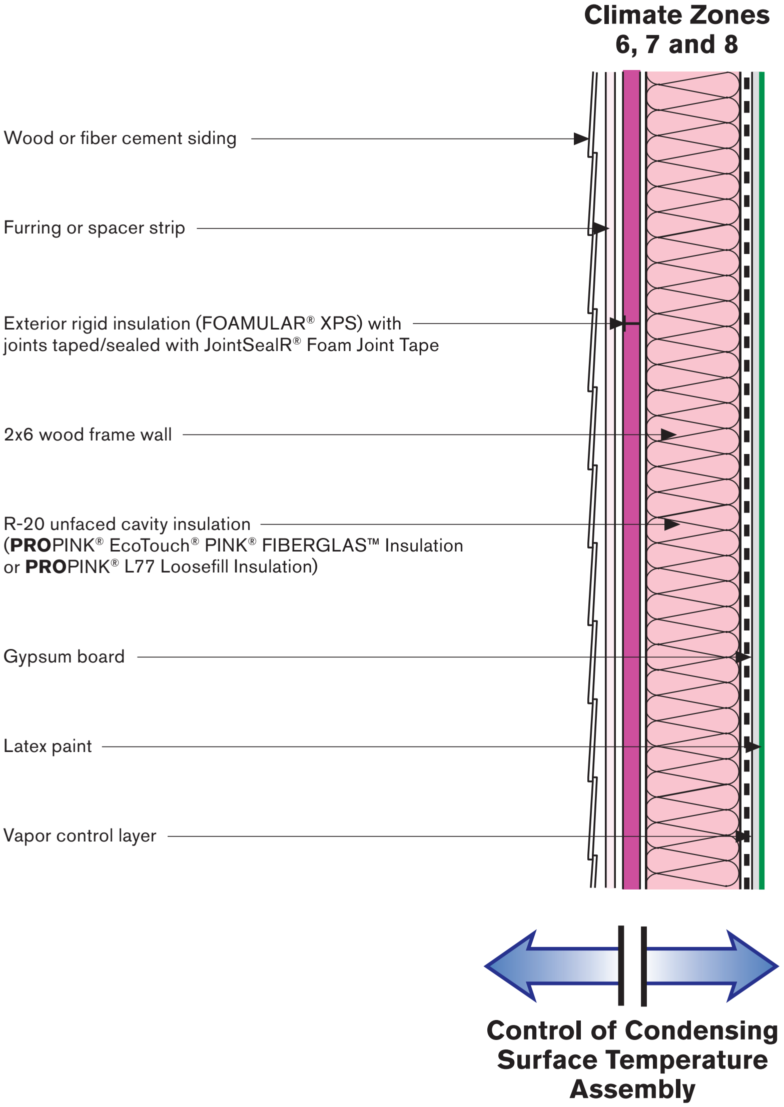


Figure 2.54:
Low wind load 2x6 wood frame wall construction in Climate Zones 6, 7 and 8.

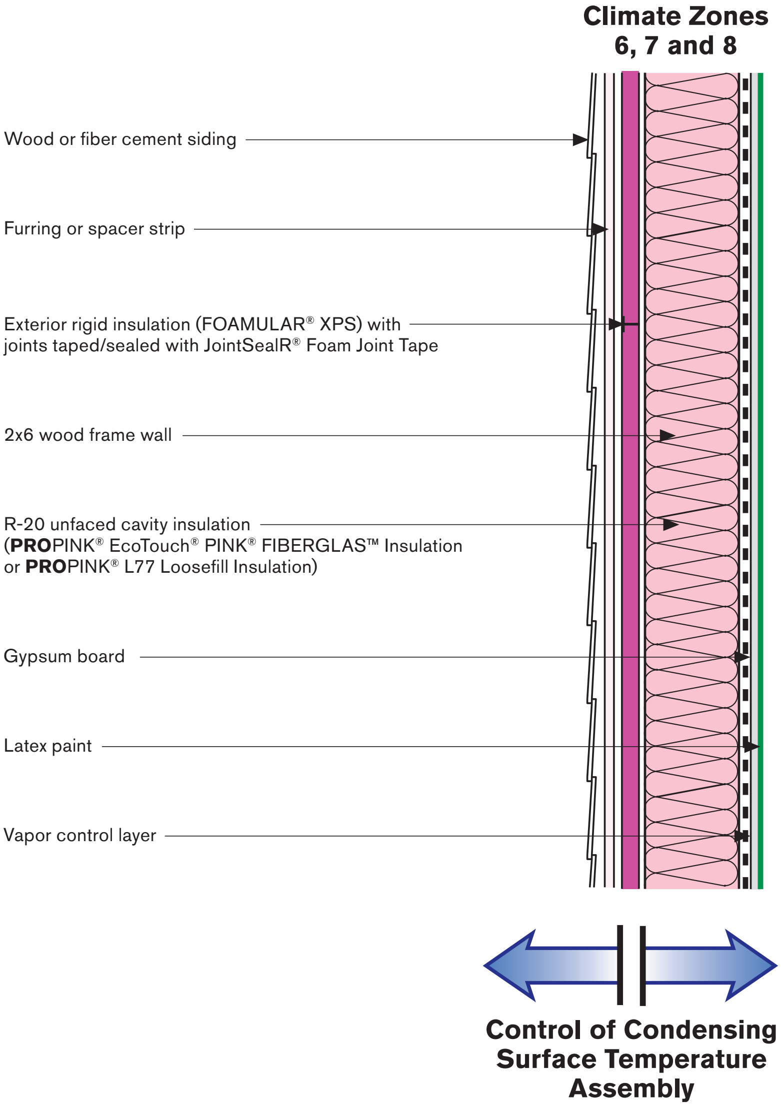


Figure 2.55:
Low wind load 2x4 wood frame wall construction in Climate Zones 6, 7 and 8.

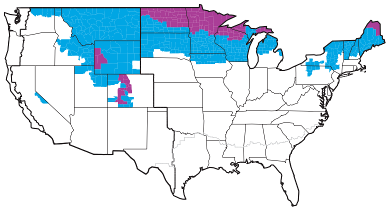


Figure 2.56 and Figure 2.57 show walls completely sheathed with plywood or OSB and then in turn externally insulated with continuous rigid insulation (FOAMULAR® XPS Insulation).

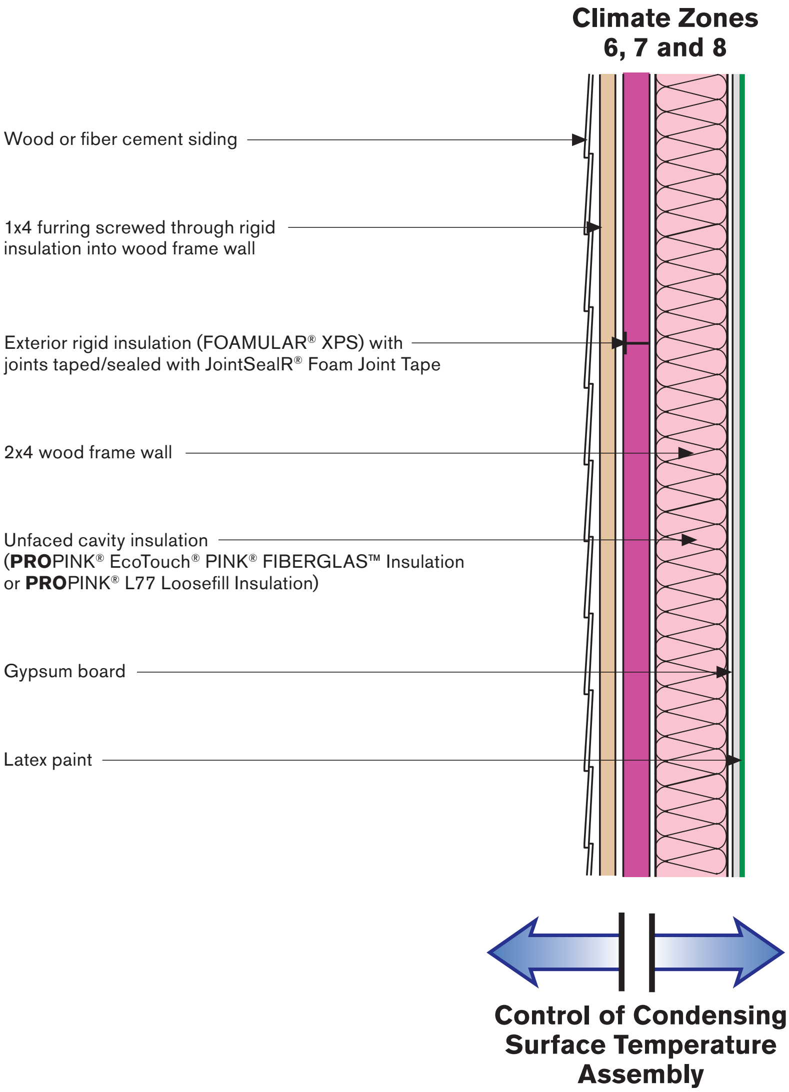


Figure 2.56:
Externally insulated wood frame wall construction in Climate Zones 6, 7 and 8.

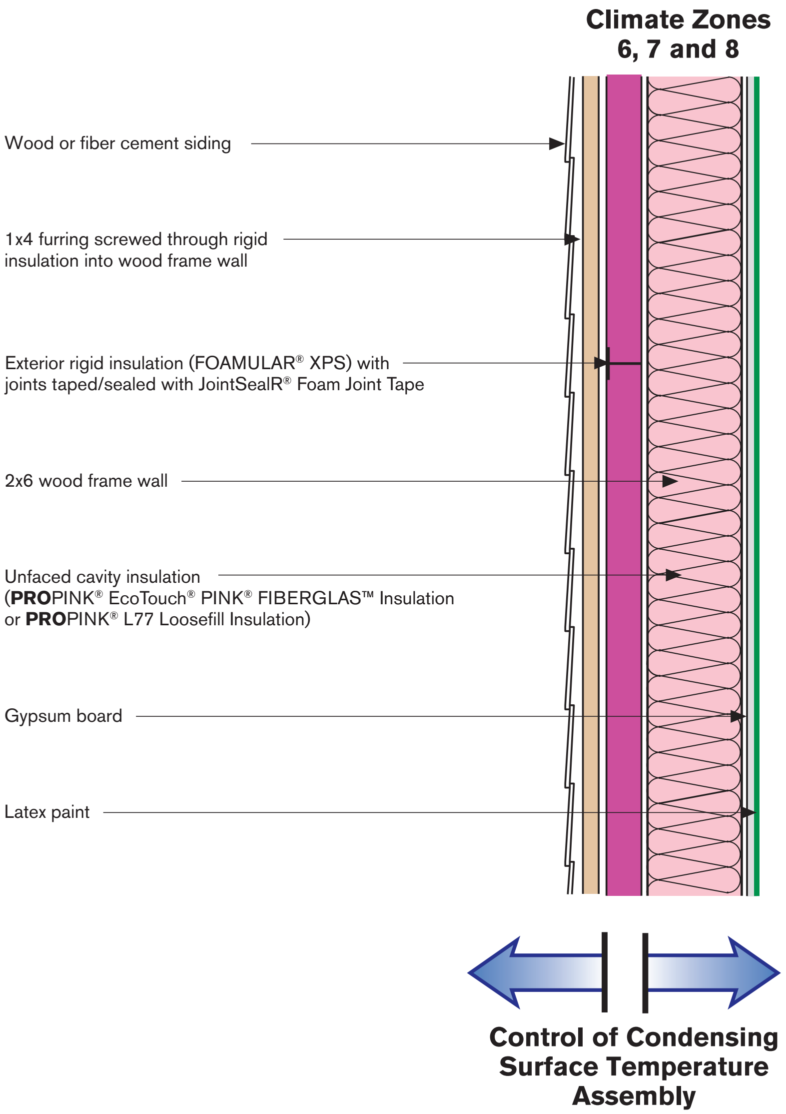
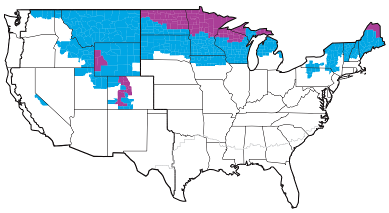


Figure 2.57: Externally insulated wood frame wall construction in Climate Zones 6, 7 and 8.



11.3 **ROOFS**

One of the most common approach to roof construction in these climate zones is a vented attic. Figure 2.58 illustrates recommended approaches to constructing vented attics. Note the use of a "kraft"-faced fiberglass batt insulation (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation or **PRO**PINK® L77 Loosefill Insulation) in Figure 2.58. The kraft facing is a vapor retarder. The kraft facing is required for vapor control in these climate zones. Note that the vapor control layer can also be a polyethylene sheet metal.

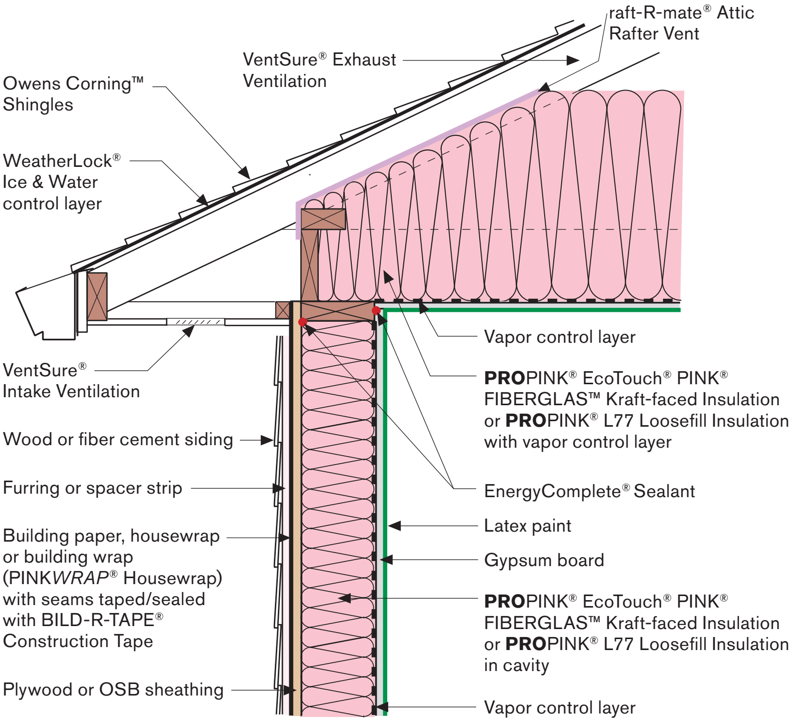


Figure 2.58:
Recommended vented attic construction in Climate Zones 6, 7 and 8.

Unvented roofing assemblies are illustrated in Figure 2.59 and Figure 2.60. The amount of rigid insulation (FOAMULAR® XPS Insulation) in each of these assemblies is specified by the IRC to control condensation.

Unvented roofs constructed where the ground snow load is greater than 50 lb/ft^2 need a vented over roof to control ice damming as illustrated in Figure 2.61.

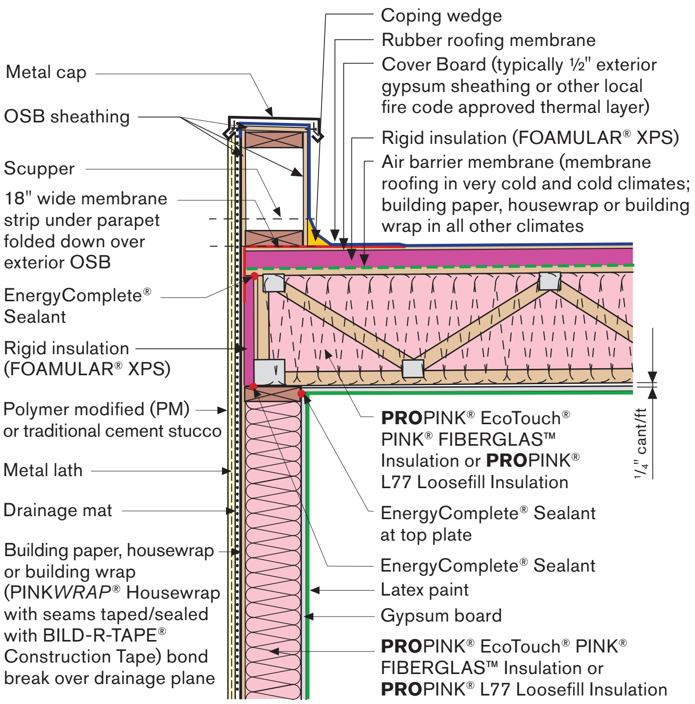


Figure 2.59: Unvented attic details in Climate Zones 6, 7 and 8.

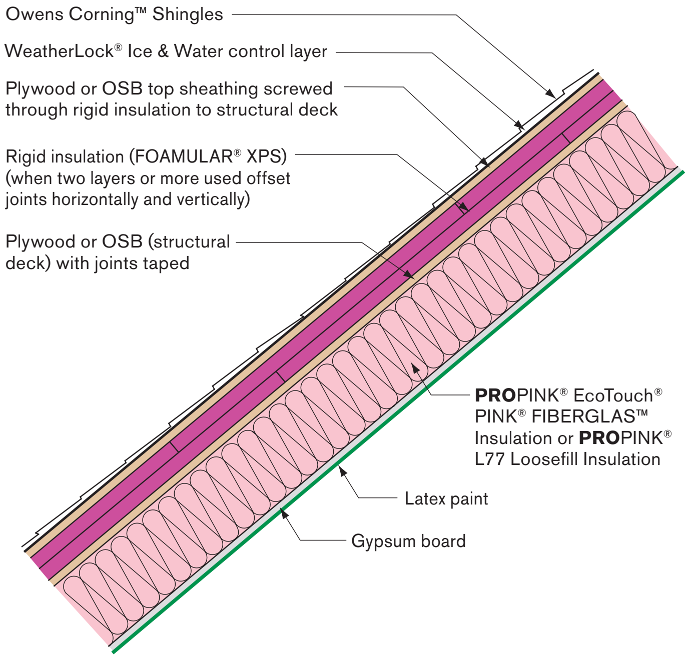
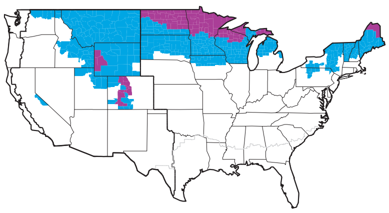


Figure 2.60: Unvented attic details in Climate Zones 6, 7 and 8.



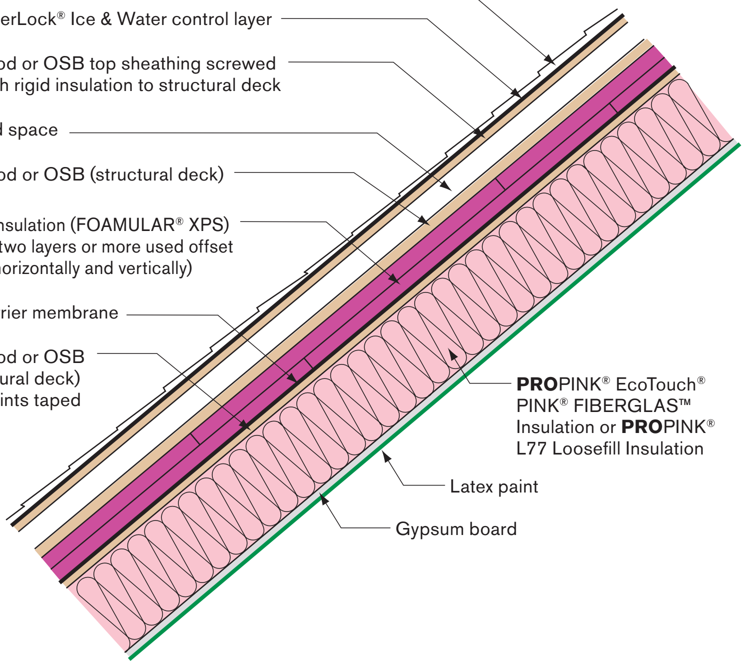


Figure 2.61: Controlling ice damming in Climate Zones 6, 7 and 8.

11.4 CASE STUDIES

One complete section is presented as typical for Minneapolis (Figure 2.62) that meets or exceeds the 2012 IECC as well as meets the requirements for environmental separation. See tables 2.6 and 2.7 for specific insulation levels to achieve overall desired performance in other cities in these climate zones.

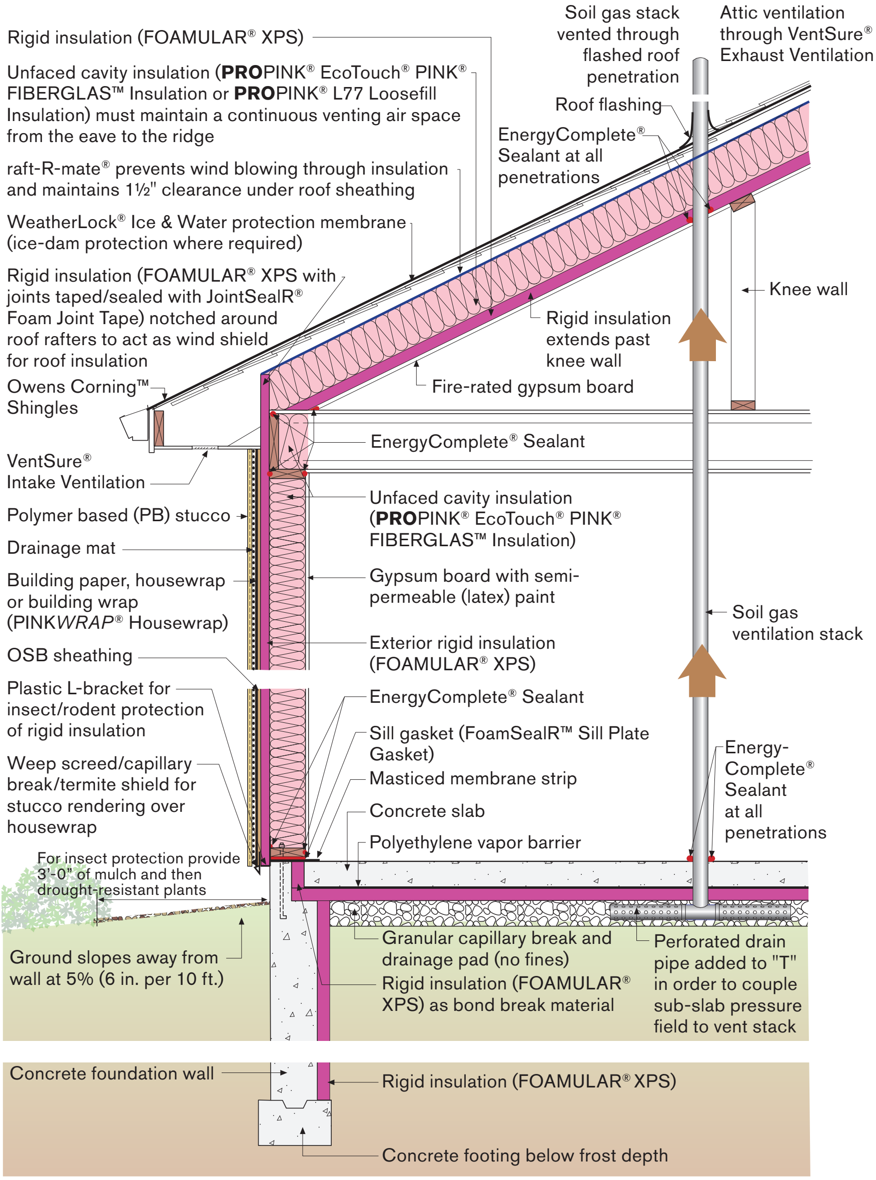
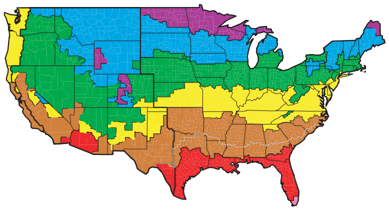


Figure 2.62: Minneapolis case study profile.

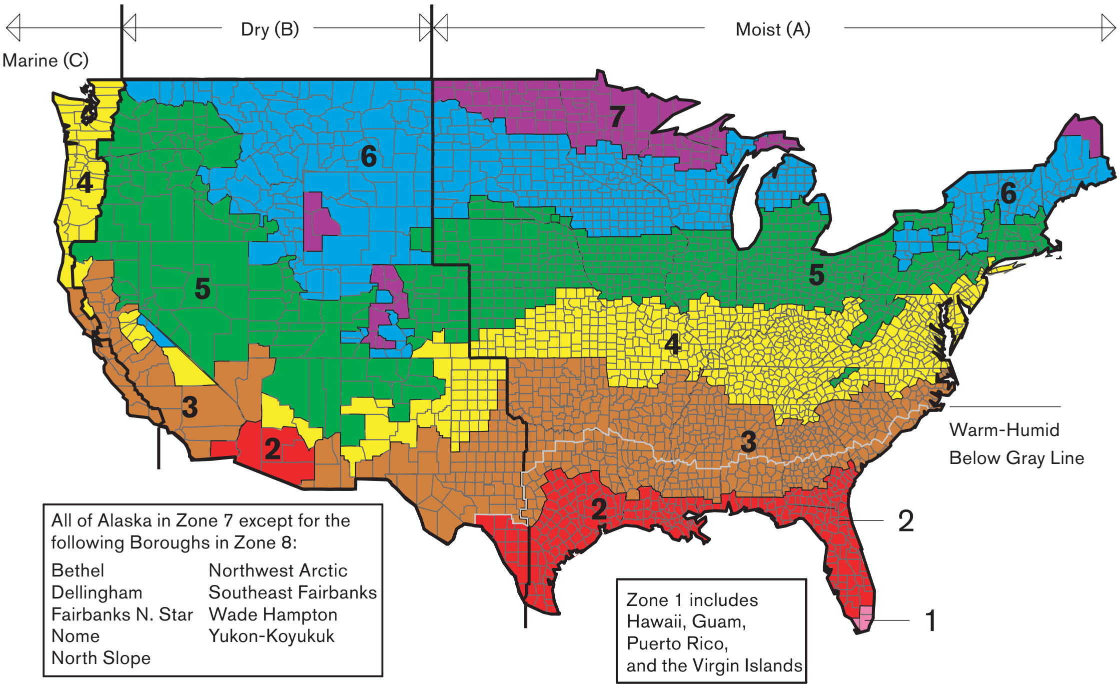


CHAPTER 12
NET ZERO

Net zero houses are defined here as houses that when renewable energy systems such as photovoltaic (PV) are added to them the amount of total energy consumed by the house will equal the total energy produced by the PV system added to the house. So for the purposes of this guide the houses are "net zero ready". They will only be net zero after the PV is added. For the typical home with a floor area of approximately 2,500 ft^2 a PV system with a capacity of 5 to 7.5 KW will be necessary to achieve net zero.

To achieve net zero an ultra efficient building enclosure must be constructed. Additionally all lighting, heating and cooling systems, ventilation systems, domestic hot water systems and appliances must also be ultra efficient.

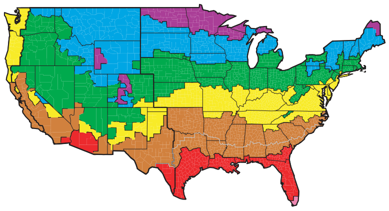
Lighting should all be compact florescent or light-emitting diode (LED). Heating systems should be sealed combustion 95 percent efficient gas or heat pumps with scroll compressors and desuperheaters. Ventilation systems should be fully ducted and balanced heat recovery ventilators (HRVs) or energy recovery ventilators (ERVs). Hot water heating should be coupled to heat pumps or via instantaneous condensing gas. Appliances should be selected from the 10 percent of the Energy Star appliance tables.



PRACTICES

The general net zero performance metrics are available in the following tables:

Two building enclosure designs for net zero will be presented — one for Climate Zone 3 and one for Climate Zone 5.



12.1 FOUNDATIONS

For slab foundations located in Climate Zone 3 R-5 rigid insulation (FOAMULAR® XPS Insulation) should be installed under the slab and to the inside of the stem wall (Figure 2.63).

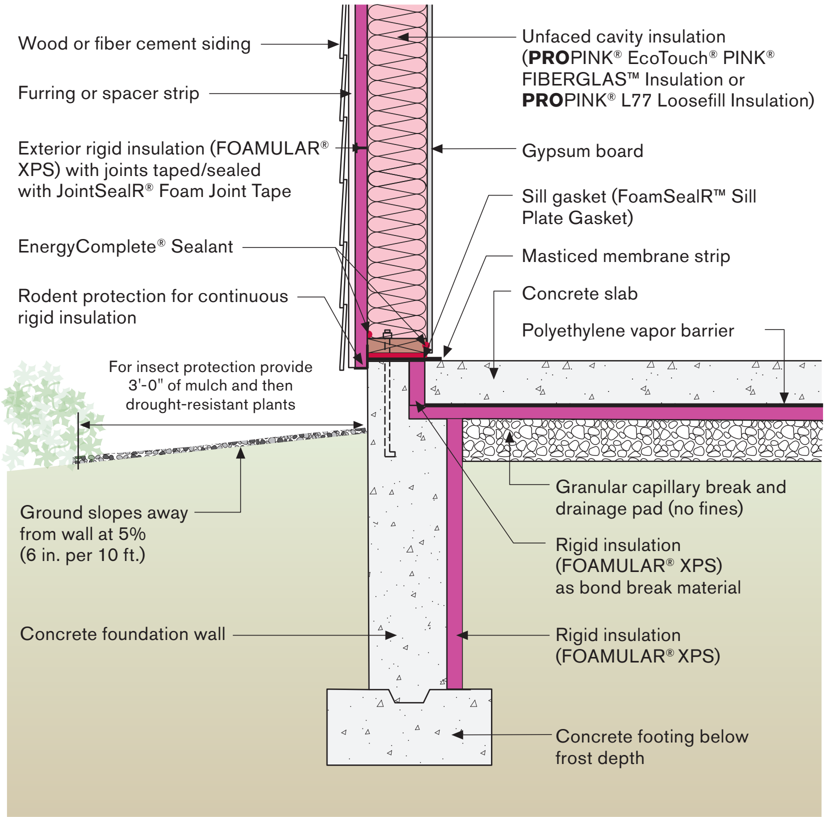


Figure 2.63: Insulated slab on grade construction.

For basement foundations located in Climate Zone 5 R-10 rigid insulation (FOAMULAR® XPS Insulation) should be installed under the slab. For basement walls R-10 rigid insulation (FOAMULAR® XPS Insulation) should also be installed on the interior of exterior foundation walls and then covered with a 2x4 frame wall that is insulated with an unfaced fiberglass batt (**PRO**PINK® EcoTouch® PINK® FIBERGLAS™ Insulation) or blown-in insulation (**PRO**PINK® L77 Loosefill Insulation) (Figure 2.64).

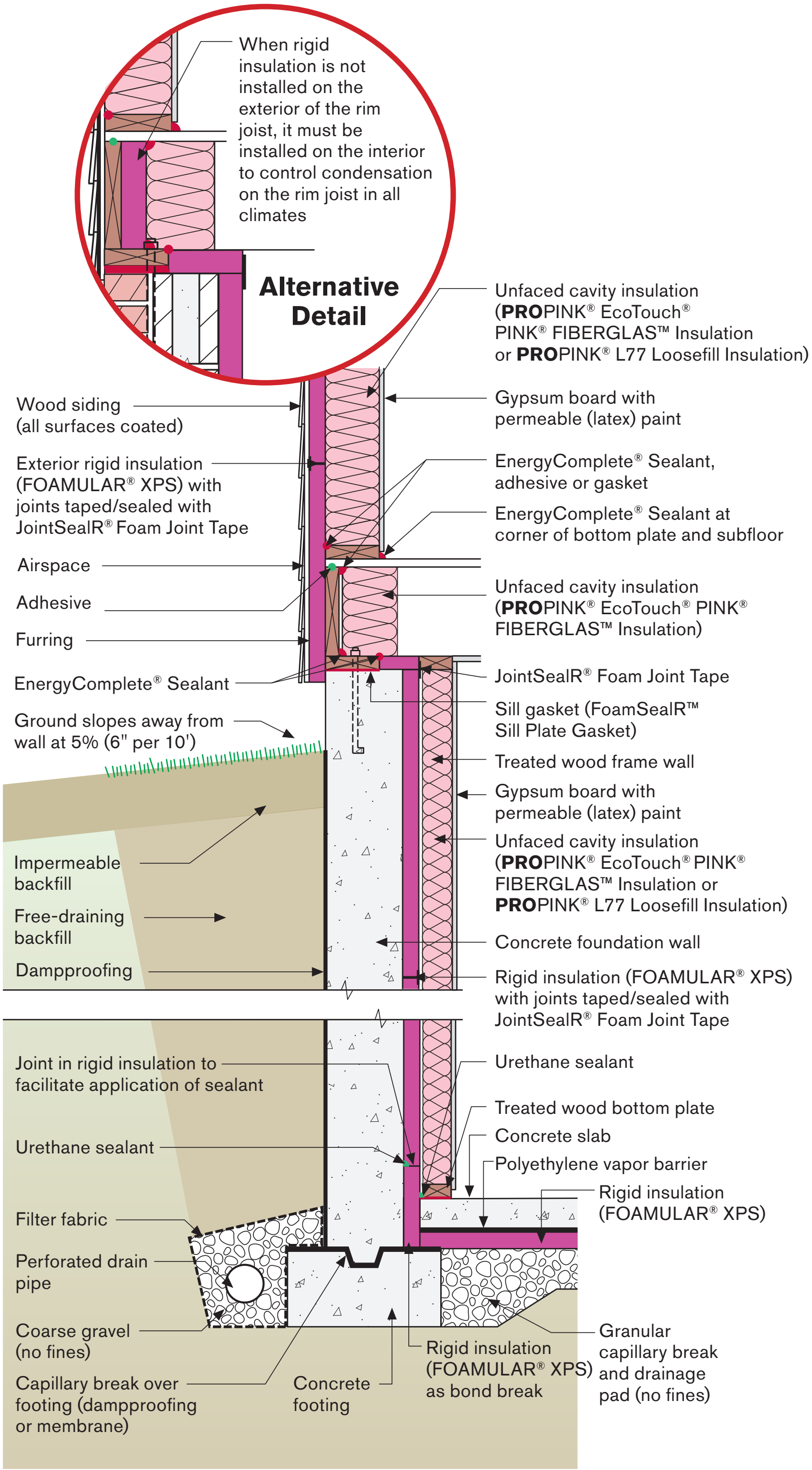
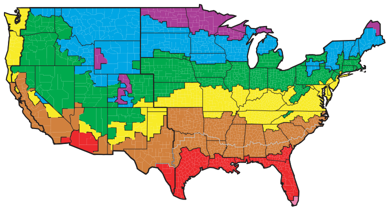


Figure 2.64:
Insulated basement construction.



12.2 WALLS

Two basic wall types are common for net zero buildings — continuous exterior insulation or double wall construction.

The continuous exterior insulation wall type is further broken down into two approaches — a fully structurally sheathed wall with a fully-adhered membrane covered with continuous rigid insulation (FOAMULAR® XPS Insulation) (Figure 2.65) or a wall with two or more layers of rigid insulation (FOAMULAR® XPS Insulation) without the structural sheathing and fully-adhered membrane (Figure 2.66).

The advantage of the wall with the fully-adhered membrane is that ultra low levels of air leakage can be reliably achieved — less than 0.5 ach@50 Pa.

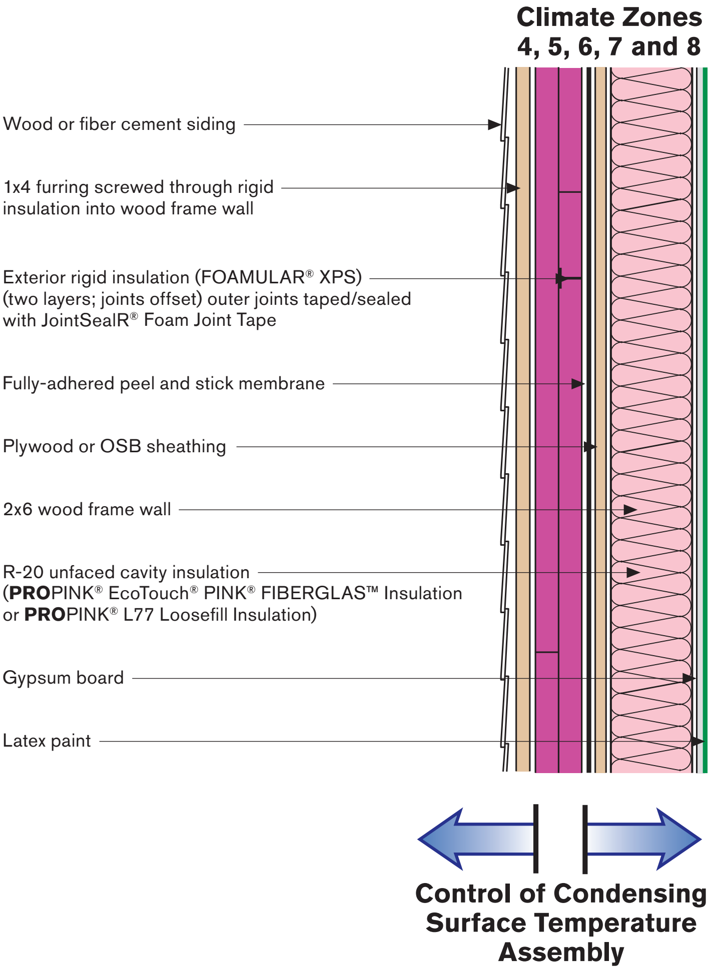


Figure 2.65: Exterior insulation on a wood frame wall.

PRACTICES

The advantage of the wall without the fully-adhered membrane is lower cost — but attention to airtightness needs to be fastidious.

One of the most challenging details for walls with thick layers of continuous exterior rigid insulation is the window to wall interface. Two standard approaches are presented in the appendix Figure A.1a through Figure A.3t and Figure A.4i through Figure A.4w.

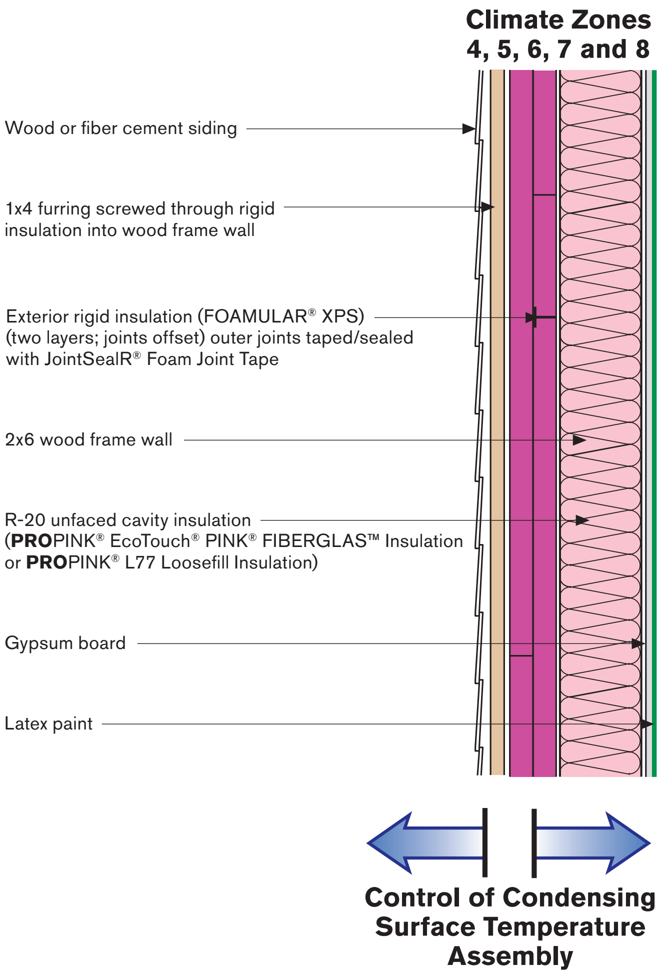


Figure 2.66: Exterior insulation on a wood frame wall.

Double wall construction avoids the use of rigid insulating sheathing. Ultra low levels of air leakage are achieved with a fully-adhered membrane on the exterior sheathing of the interior wall (Figure 2.67). In these types of assemblies the interior frame wall is typically the load bearing wall.

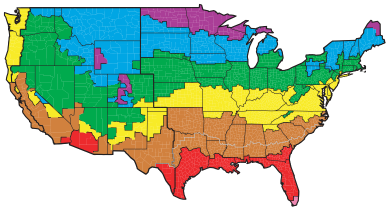
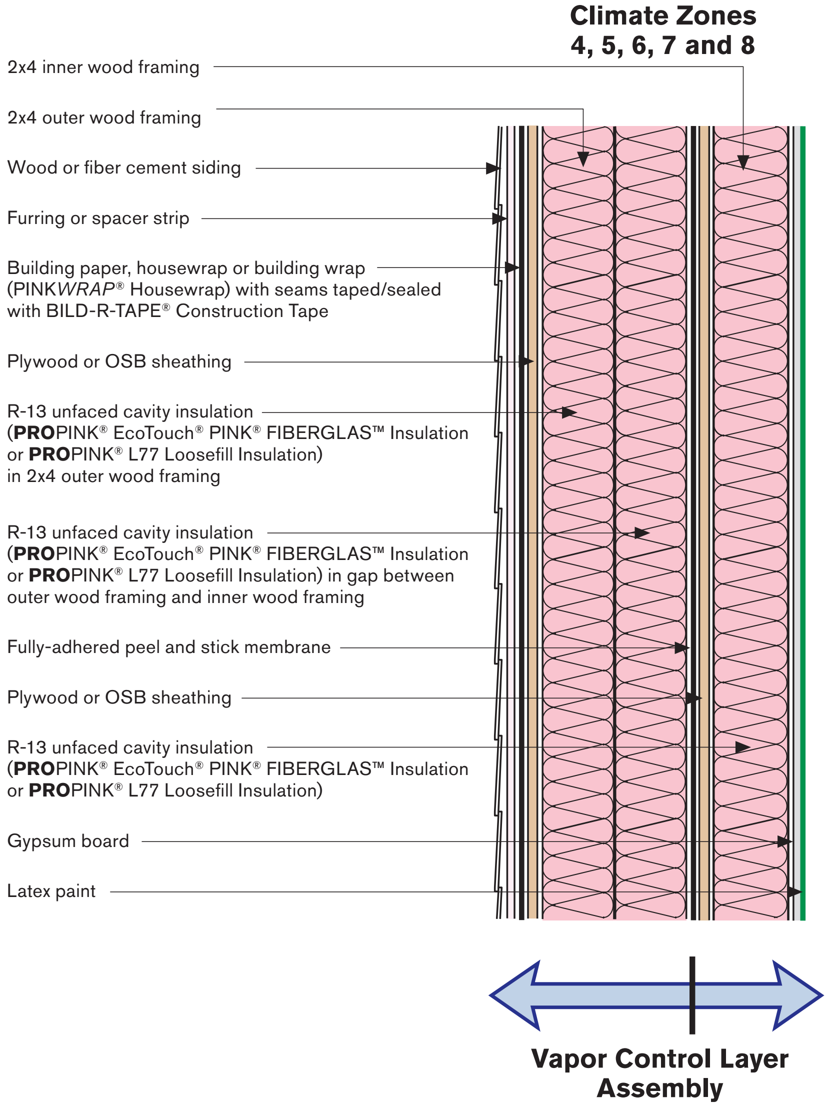


Figure 2.67:
Double wall construction.



12.3 ROOFS

Both vented and unvented roofs are common for net zero energy buildings (Figure 2.70 and Figure 2.71). Note that in high snow load areas vented over roofs should be installed over unvented roof assemblies to control ice damming.

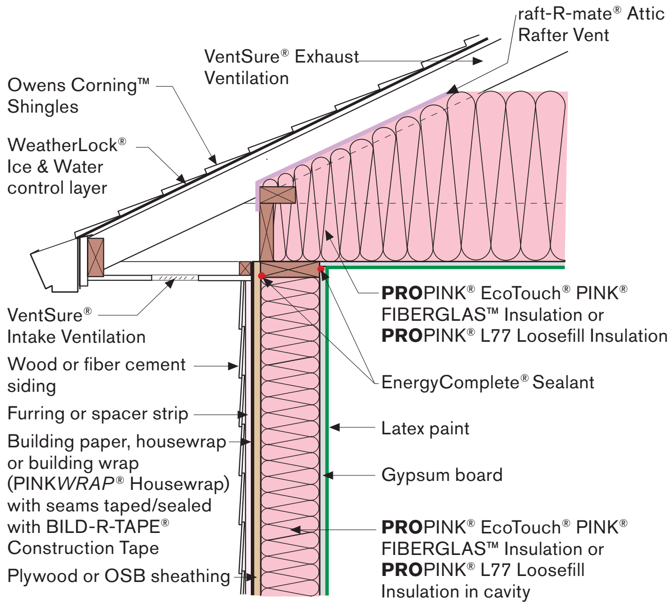


Figure 2.68: Recommended net zero energy building vented attic construction.

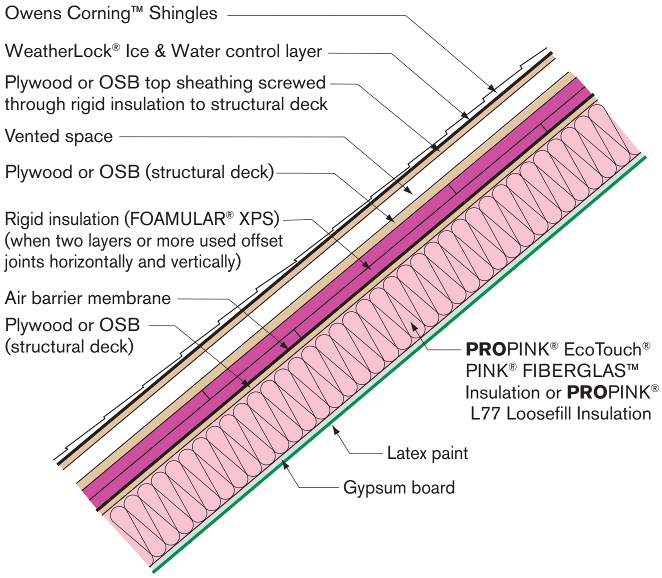
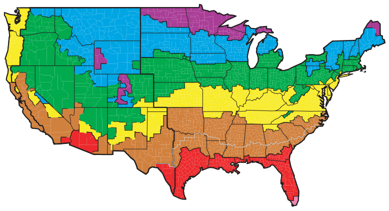


Figure 2.69: Recommended net zero energy building unvented attic construction.



12.4 CASE STUDIES

Two complete sections are presented as typical for Atlanta (Figure 2.72) and Boston (Figure 2.73) that meet the requirements for environmental separation net zero buildings in Climate Zone 3 and Climate Zone 5 respectively.

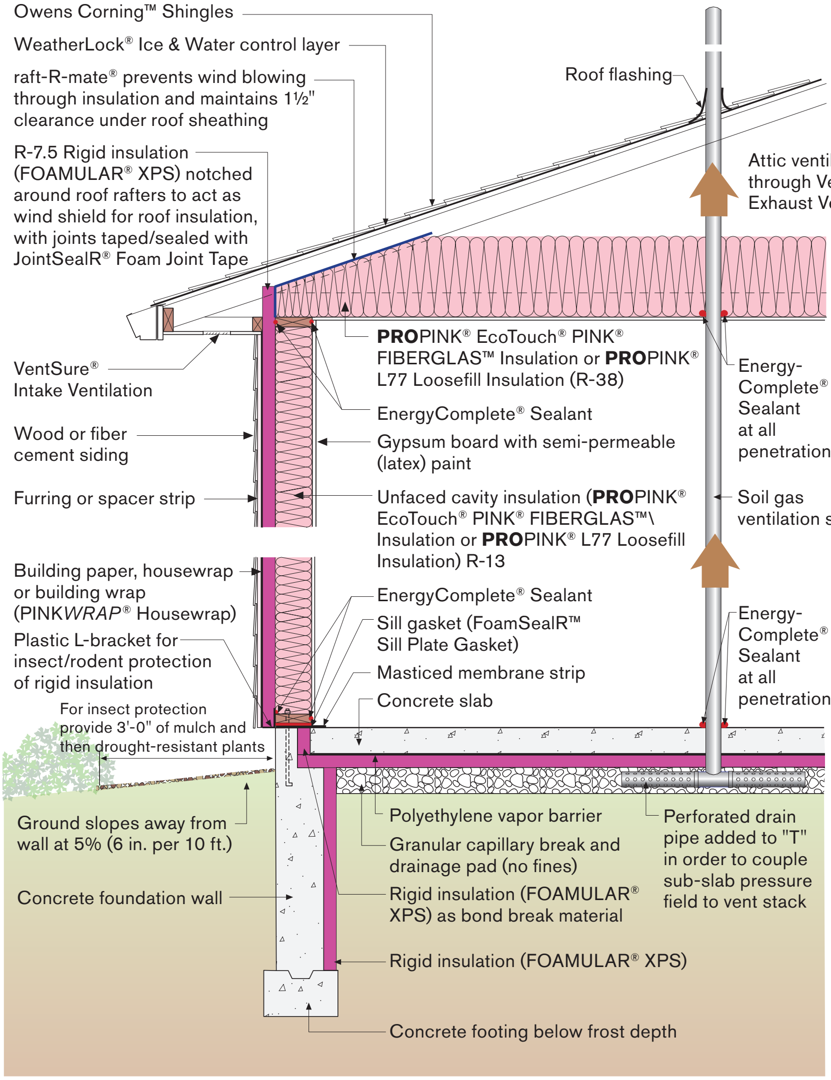


Figure 2.70: Atlanta Climate Zone 3 case study profile.

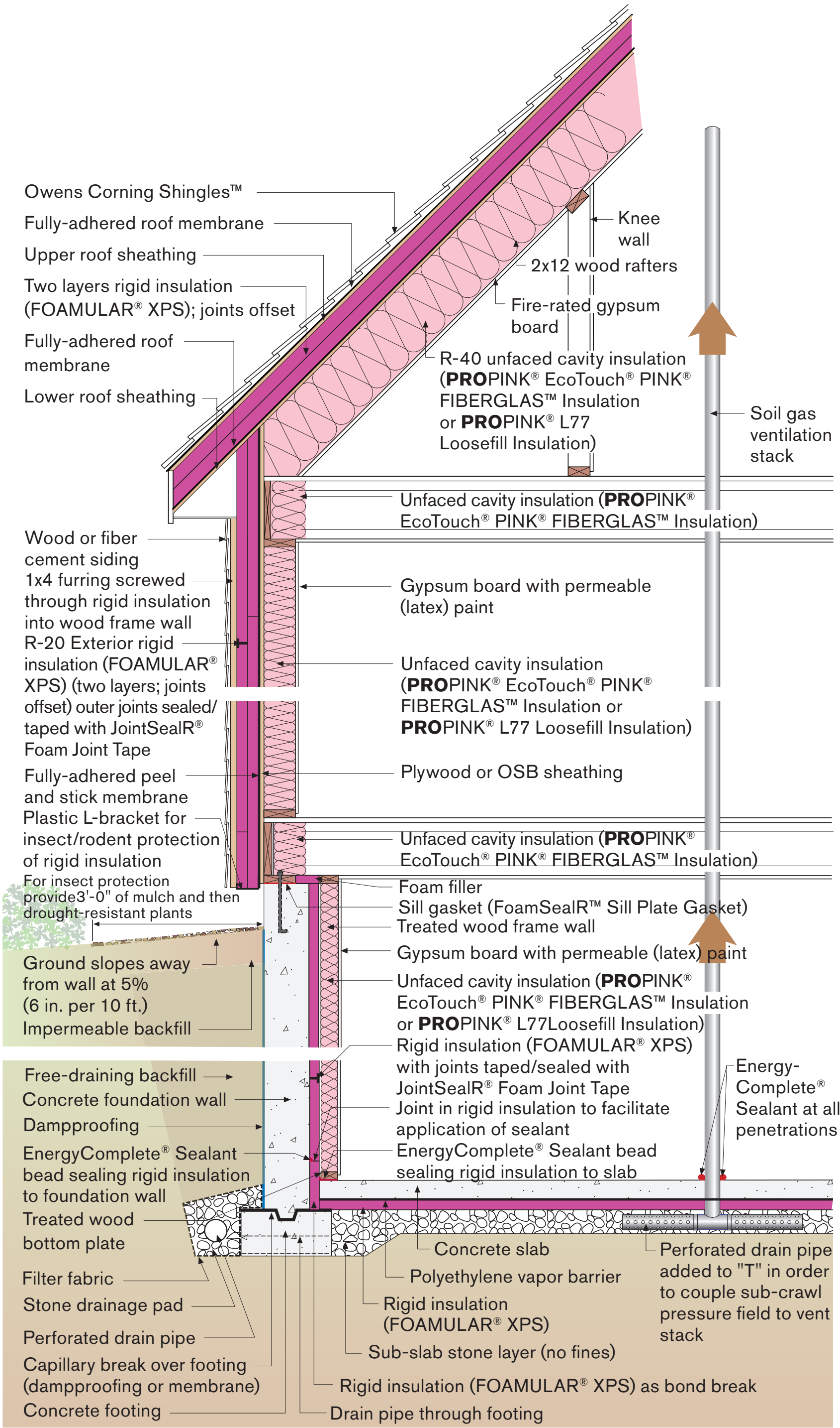


Figure 2.71:
Boston Climate Zone 5 case study profile.

APPENDIX

APPENDIX A

This appendix contains four series of window flashing detail. The first series is the proper flashing procedure for an OSB sheathed wall and window opening with PINK*WRAP*® Housewrap, BILD-R-TAPE® Construction Tape, and FlashSealR® Foam Flashing Tape as the water resistive barrier (WRB). The second series is the proper flashing procedure for a wall sheathed with FOAMULAR® XPS Insulation and FlashSealR® Foam Flashing Tape as the WRB. The third series is the proper flashing procedure for a wall sheathed by OSB and FOAMULAR® XPS Insulation, JointSealR® Foam Joint Tape and FlashSealR® Foam Flashing Tape as the WRB, along with furring strips to back ventilate the siding. The fourth series is the proper flashing for a walled sheathed by OSB and FOAMULAR® XPS Insulation, a properly installed layer of building paper, FlashSealR® Foam Flashing Tape and JointSealR® Foam Joint Tape as the WRB.

APPENDIX

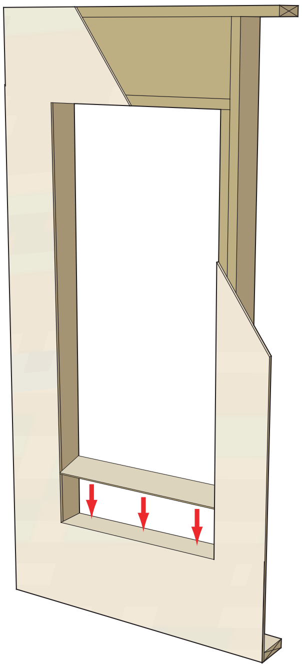


Figure A.1a:
Wood frame wall with OSB sheathing; install beveled sill backdam.

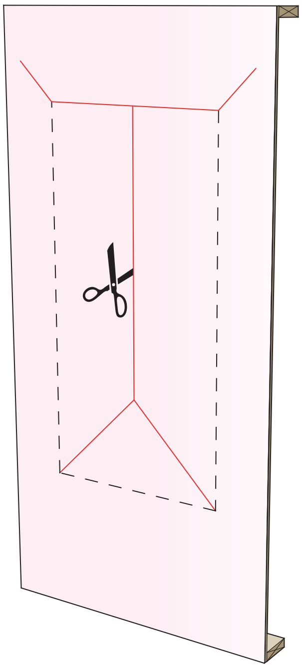


Figure A.1b:
Modified "I" cut in housewrap (PINK*WRAP*® Housewrap).

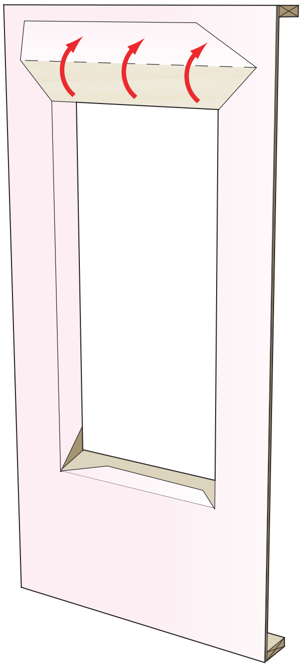


Figure A.1c:
Housewrap (PINK*WRAP*® Housewrap) folded in.

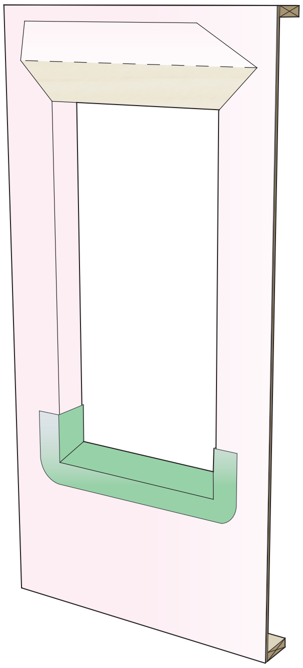


Figure A.1d:
Install sill flashing.

Figure A.1e:
Install adhesive at head and jambs; install window plumb, level and square per manufacturer's instructions.

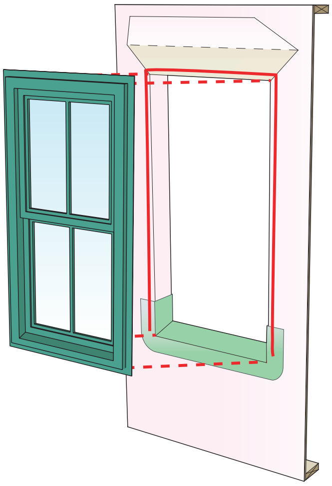


Figure A.1f:
Install jamb flashing.

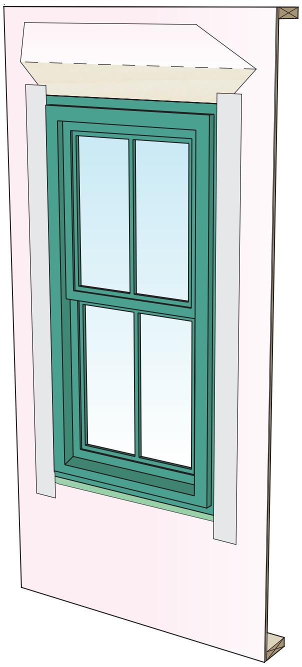


Figure A.1g:
Install head flashing.

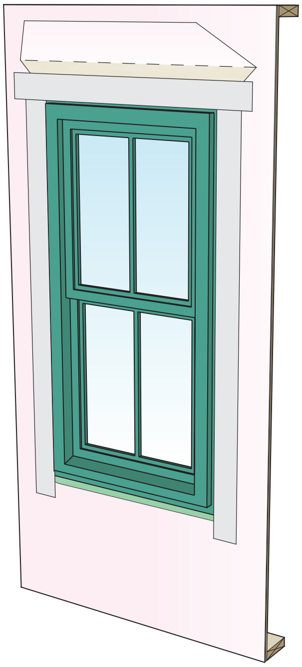
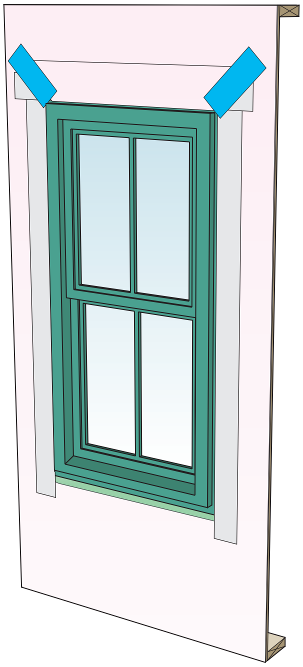


Figure A.1h:
Fold housewrap (PINK*WRAP*® Housewrap) down at head; apply corner patches at head.



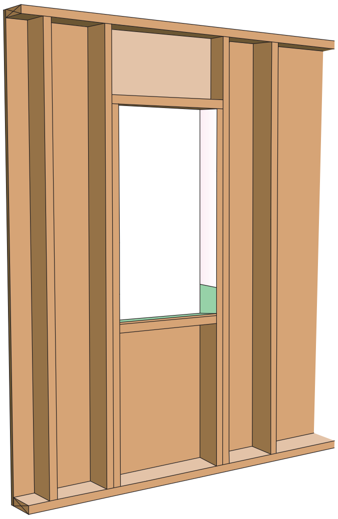


Figure A.1i:
Interior view of bevelled sill and sill flashing.

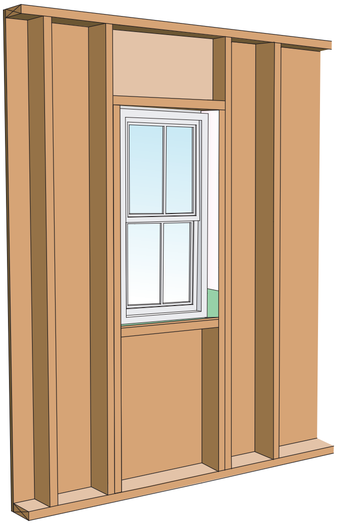


Figure A.1j:
Interior view of window installed.

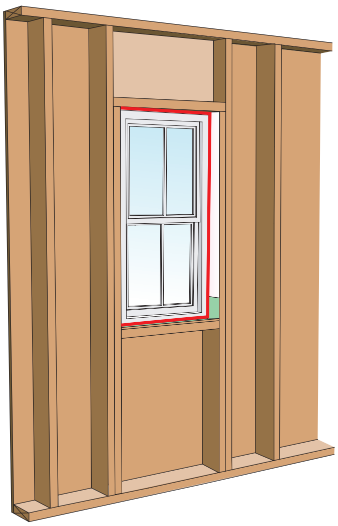


Figure A.1k:
Air seal window around entire perimeter from interior with non-expanding foam.

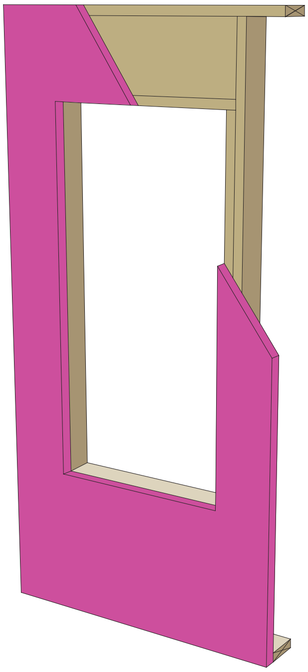


Figure A.2a:
Insulating sheathing (FOAMULAR® XPS Insulation) on wood frame wall.

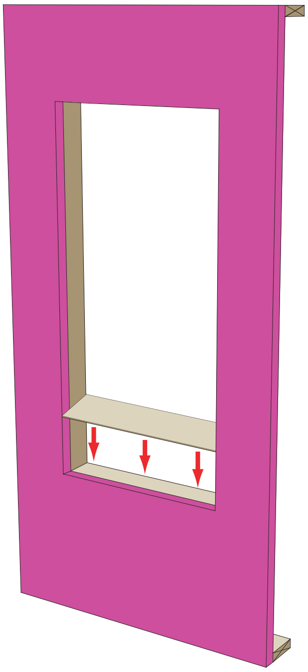


Figure A.2b:
Install bevelled sill as backdam.

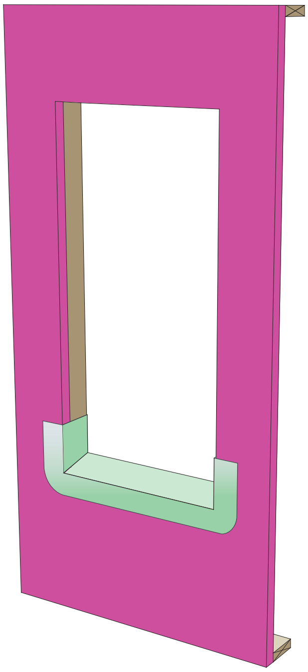


Figure A.2c:
Apply sill flashing.

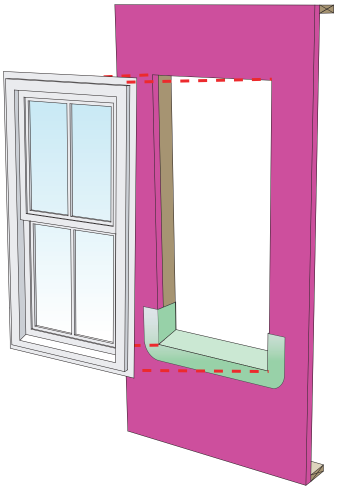


Figure A.2d:
Install window plumb, level and square per manufacturer's instructions.

APPENDIX

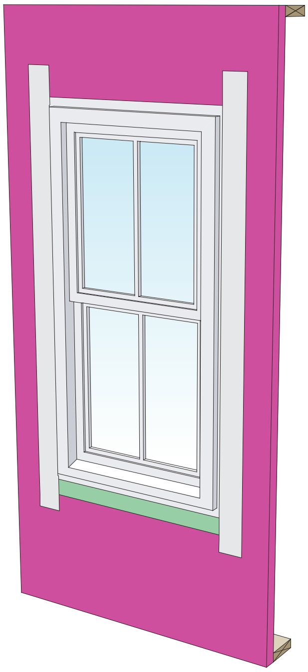


Figure A.2e:
Apply self-adhered jamb flashing.

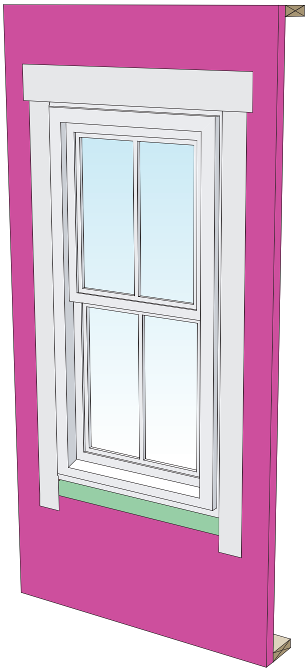


Figure A.2f:
Install drip cap (if applicable); install self-adhered head flashing.

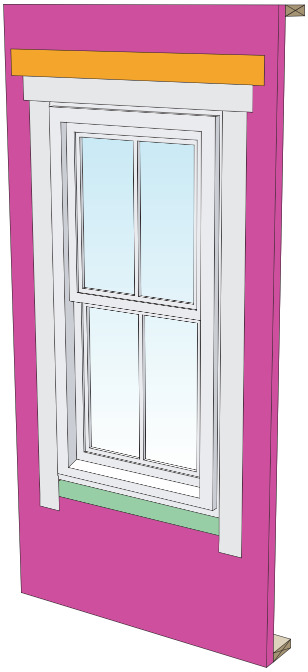


Figure A.2g:
Tape (FlashSealR® Foam Flashing Tape) top edge of head flashing.

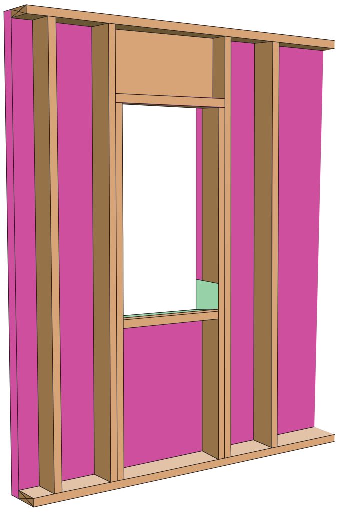


Figure A.2h:
Interior view of bevelled sill backdam and sill flashing.

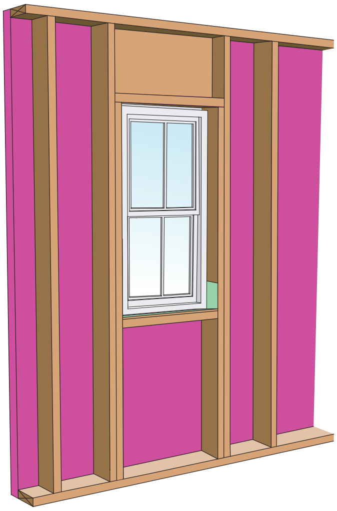


Figure A.2i:
Interior view of window installed.

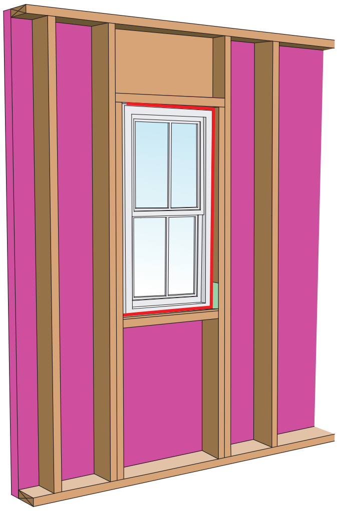


Figure A.2j:
Air seal window around entire perimeter from interior with non-expanding foam.

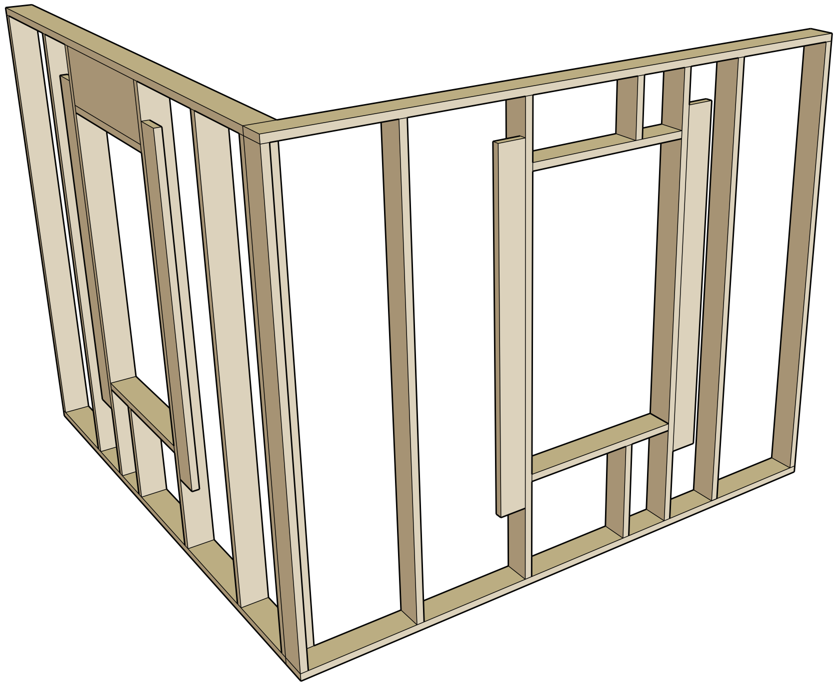


Figure A.3a:
Wood frame wall.

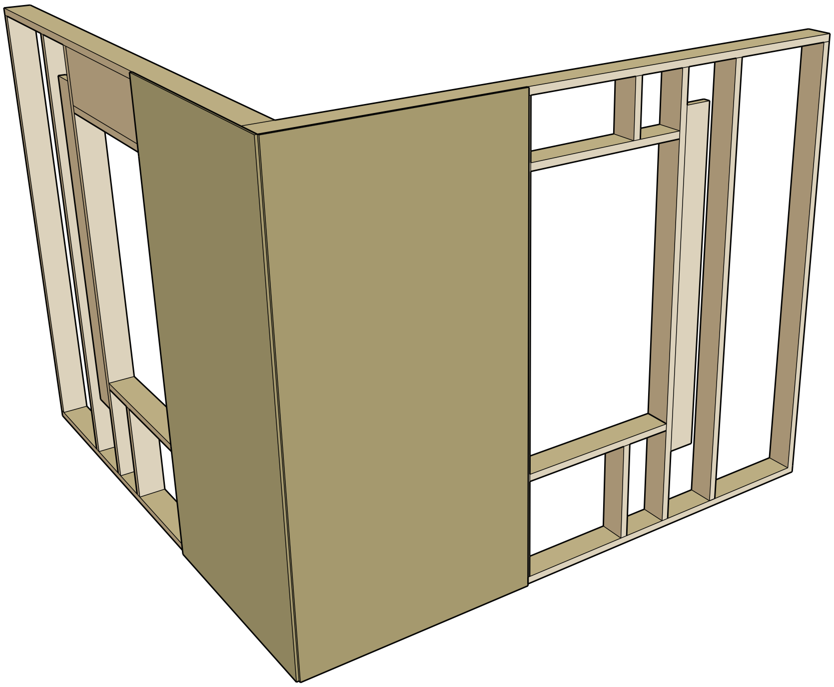


Figure A.3b:
Install OSB sheathing at corners.

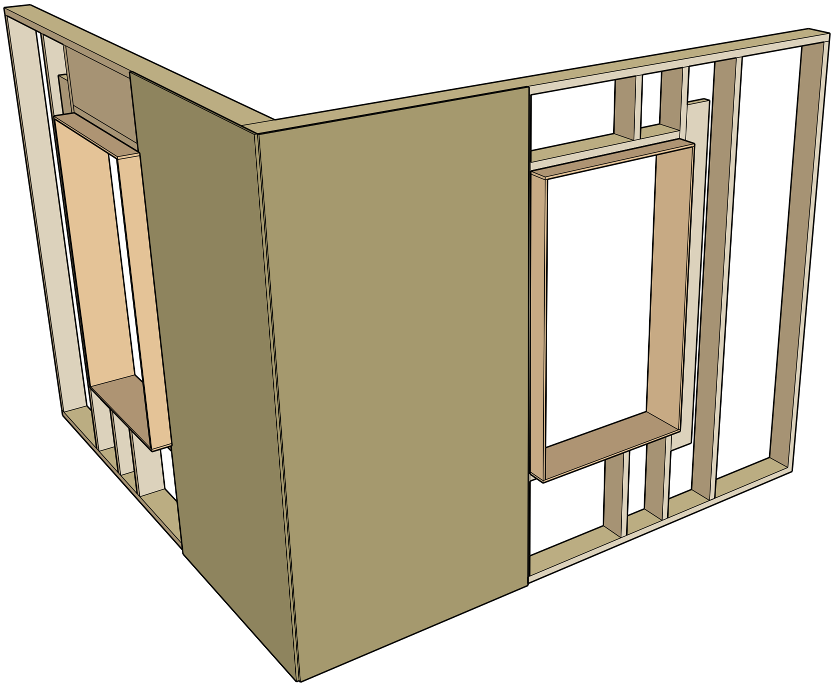


Figure A.3c:
Install plywood window extension box.

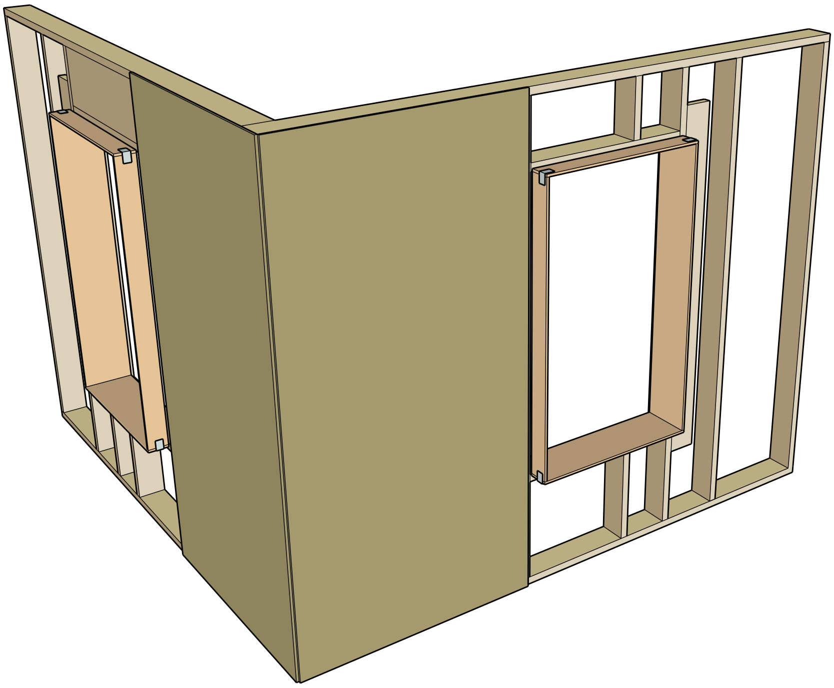


Figure A.3d:
Install reinforcing clips at corners of plywood extension box.

APPENDIX

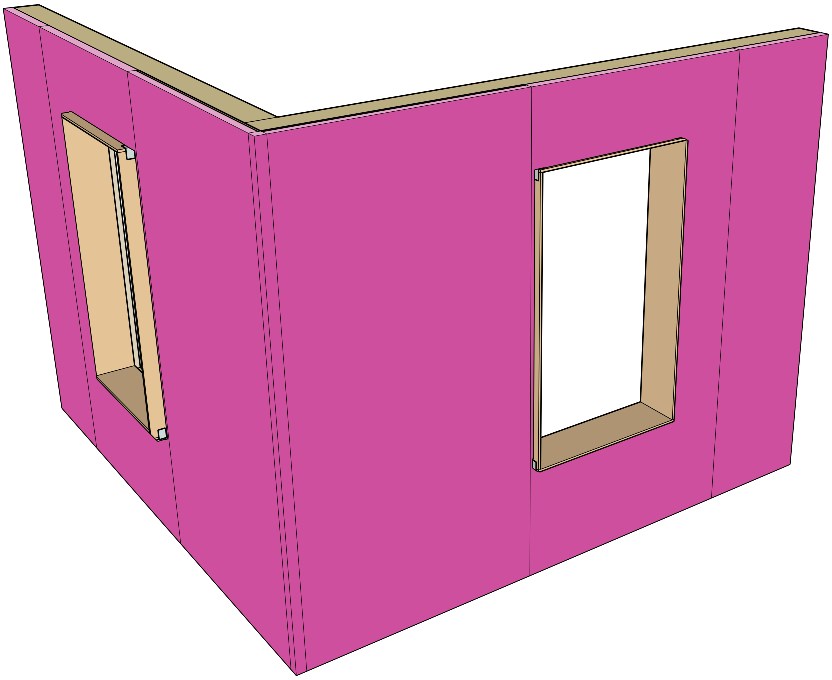


Figure A.3e:
Install one layer of insulating sheathing (FOAMULAR® XPS Insulation).

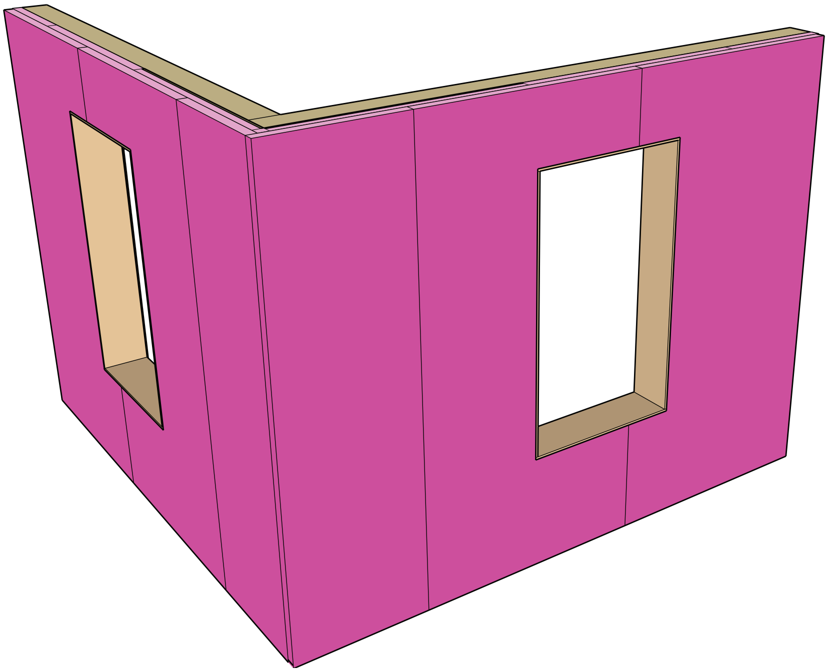


Figure A.3f:
Install second layer of insulating sheathing (FOAMULAR® XPS Insulation); joints offset horizontally and vertically.

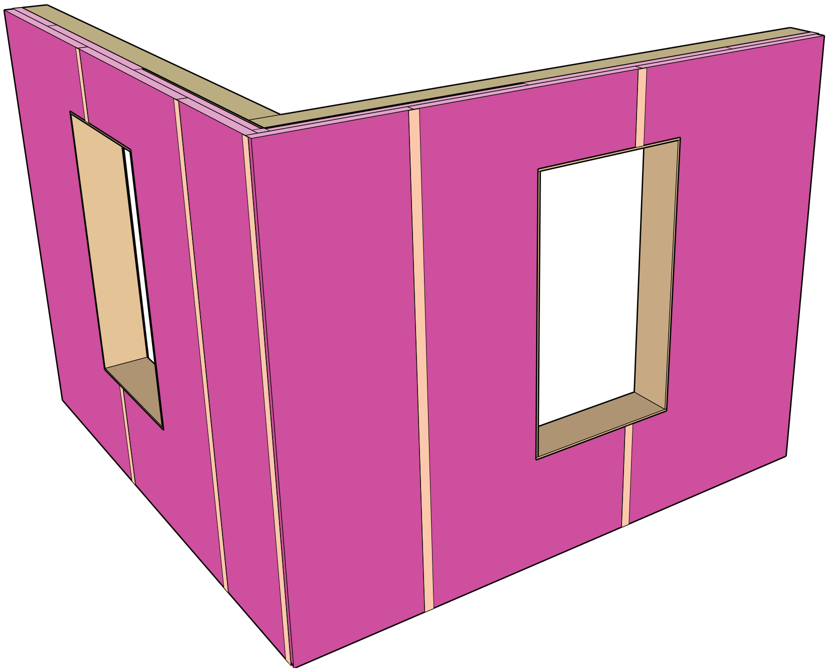


Figure A.3g:
Tape (JointSealR®
Foam Joint Tape)
seams of insulating
sheathing.

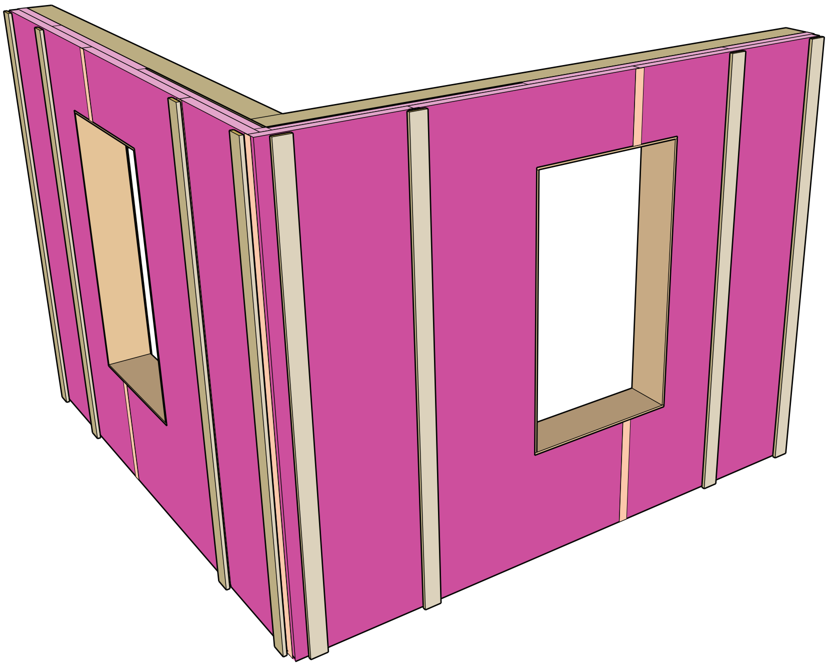


Figure A.3h:
Install furring strips.

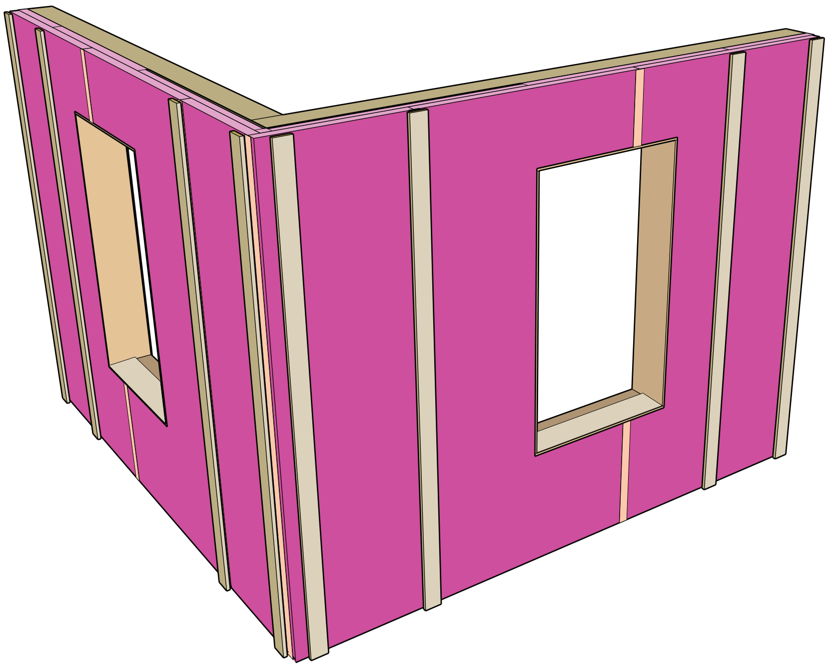


Figure A.3i:
Install bevelled sill as backdam.

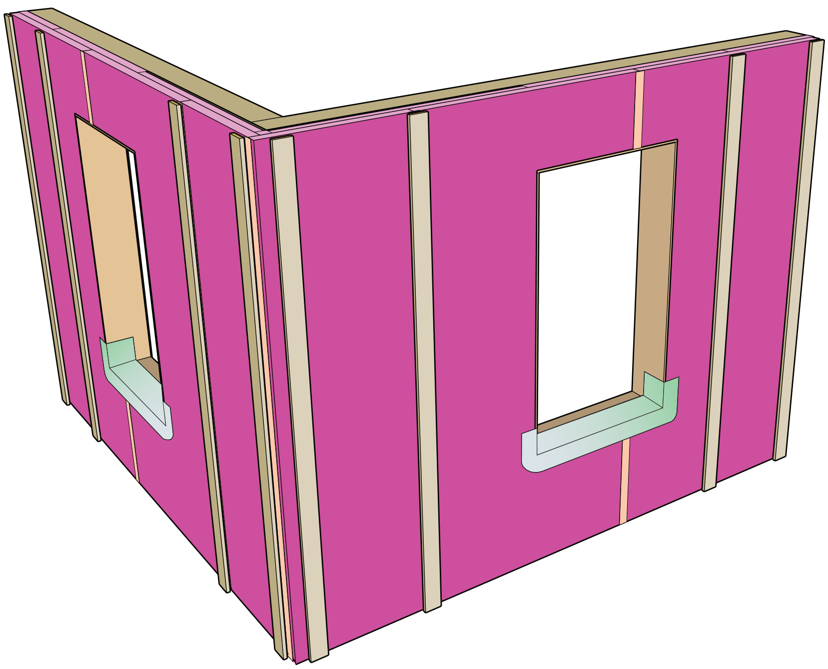


Figure A.3j:
Install sill flashing.

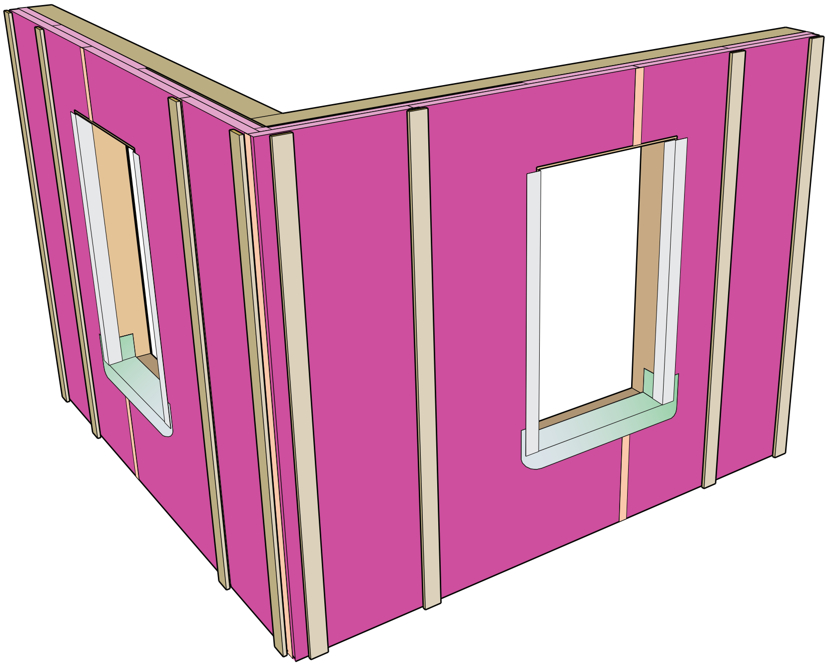


Figure A.3k:
Install jamb flashing.

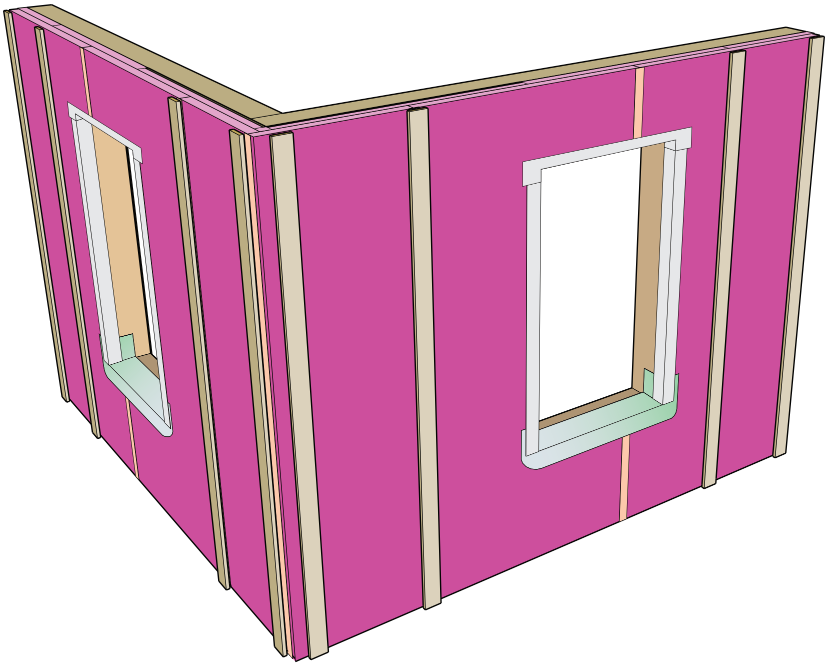


Figure A.3l:
Install head flashing.

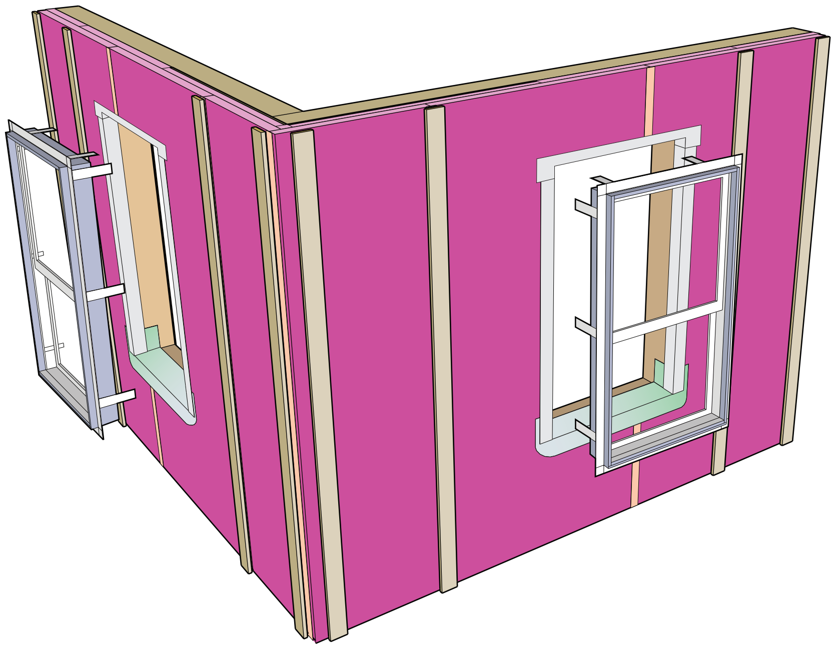


Figure A.3m:
Install windows plumb, level and square per manufacturer's instructions.

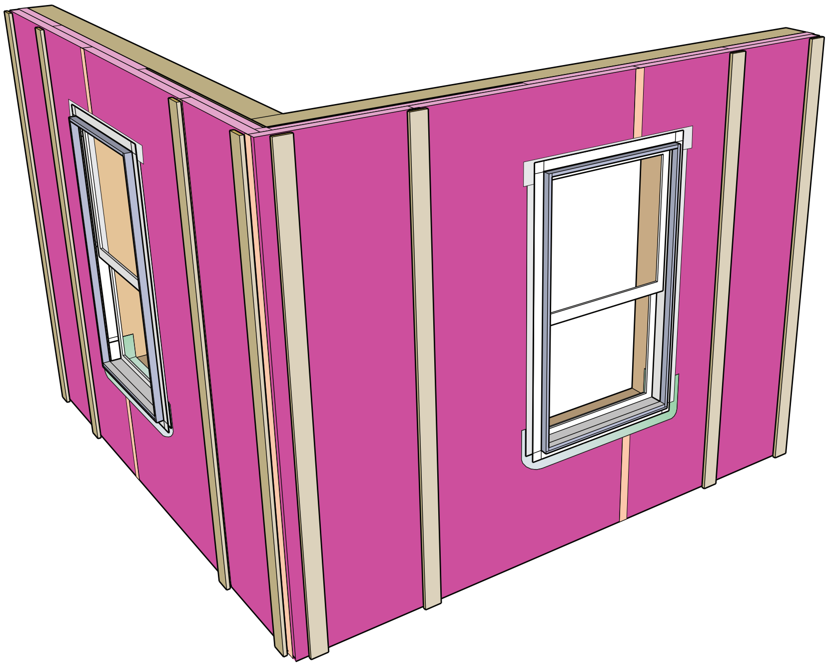


Figure A.3n:
Windows installed.

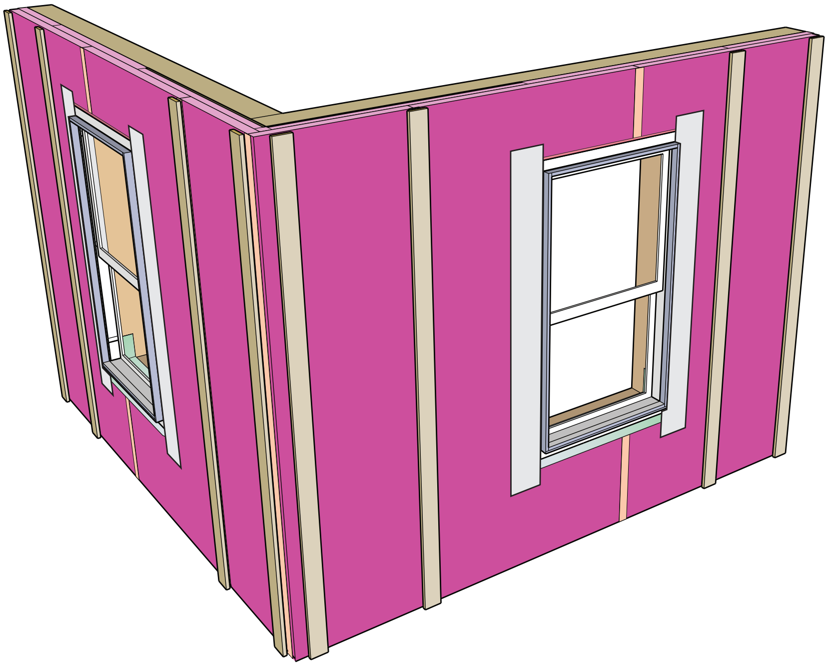


Figure A.3o:
Install jamb flashing.

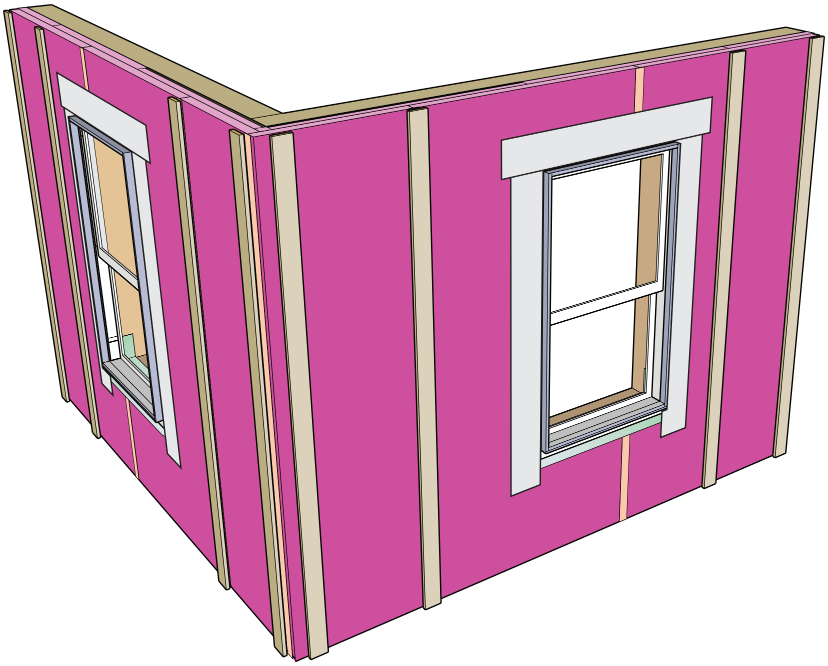


Figure A.3p:
Install head flashing.

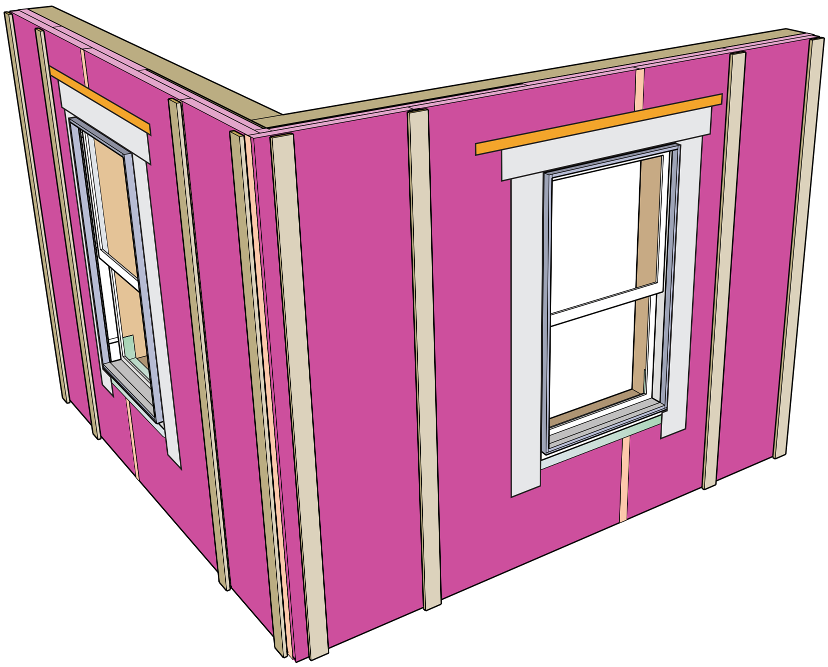


Figure A.3q:
Tape (FlashSealR® Foam Flashing Tape) top edge of head flashing.

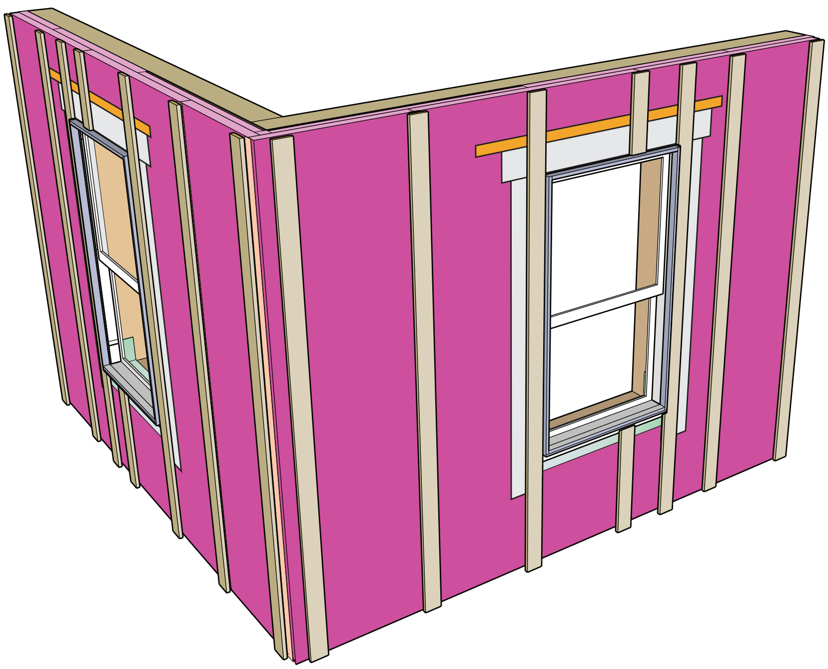


Figure A.3r:
Install additional furring around windows.

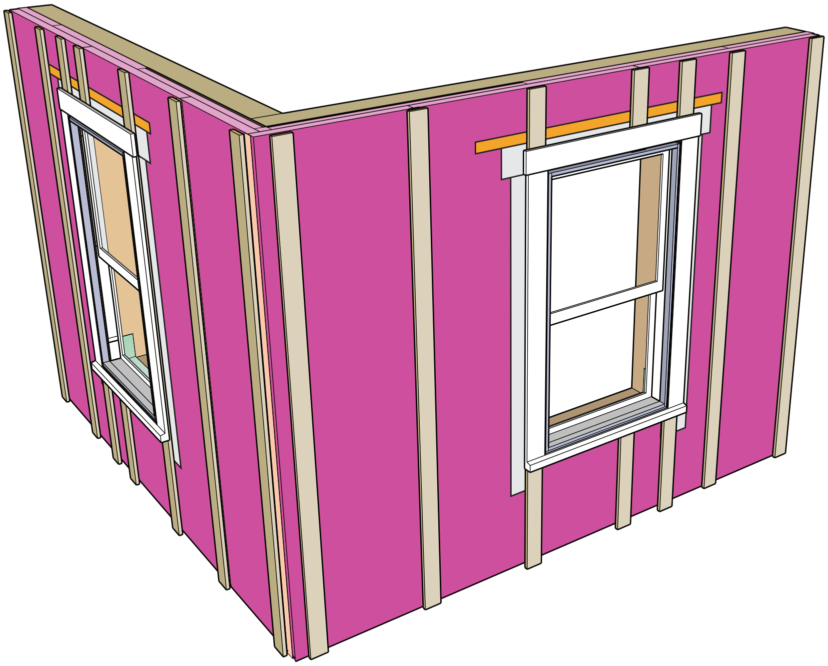


Figure A.3s:
Install trim.

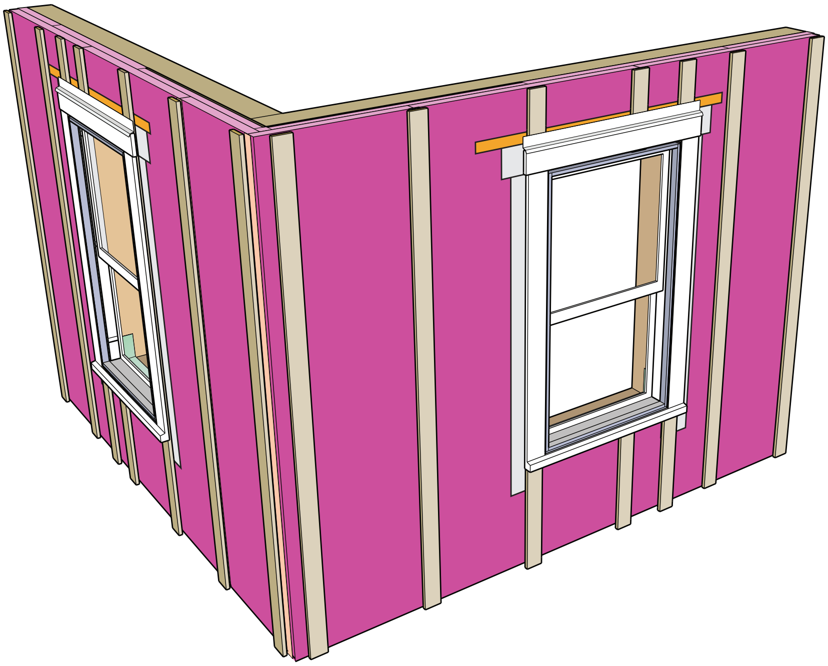


Figure A.3t:
Install cap flashing.

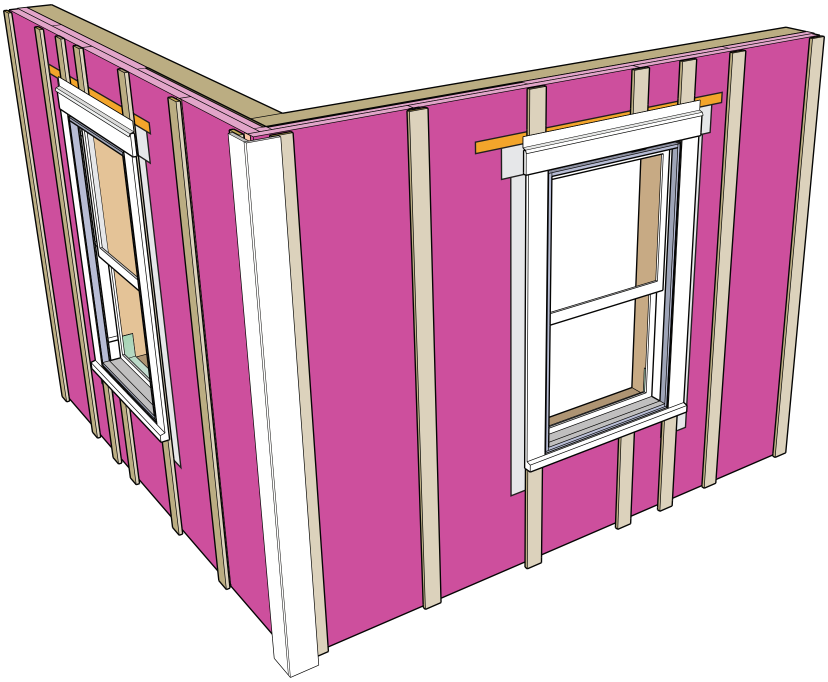


Figure A.3u:
Install corner trim.

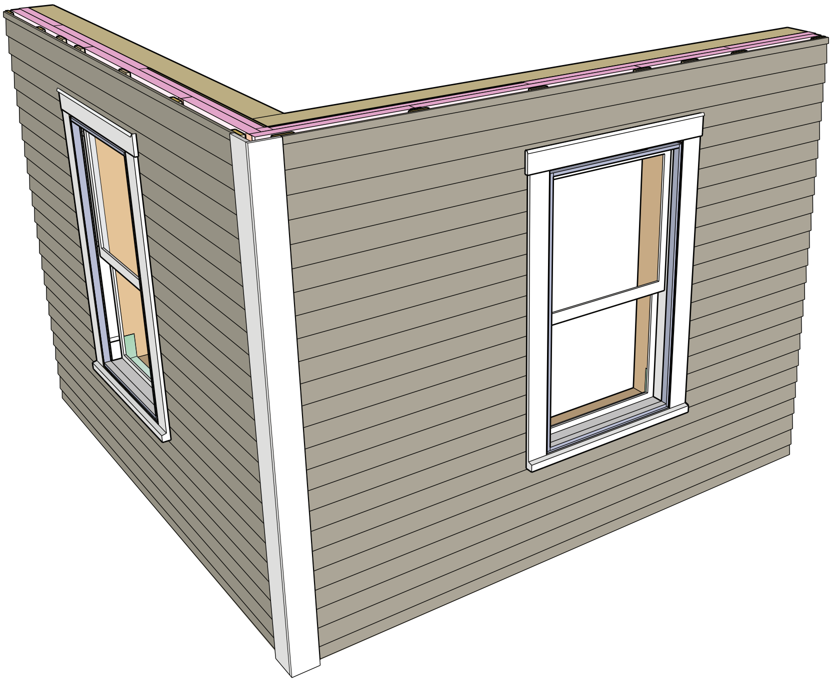


Figure A.3v:
Install siding.

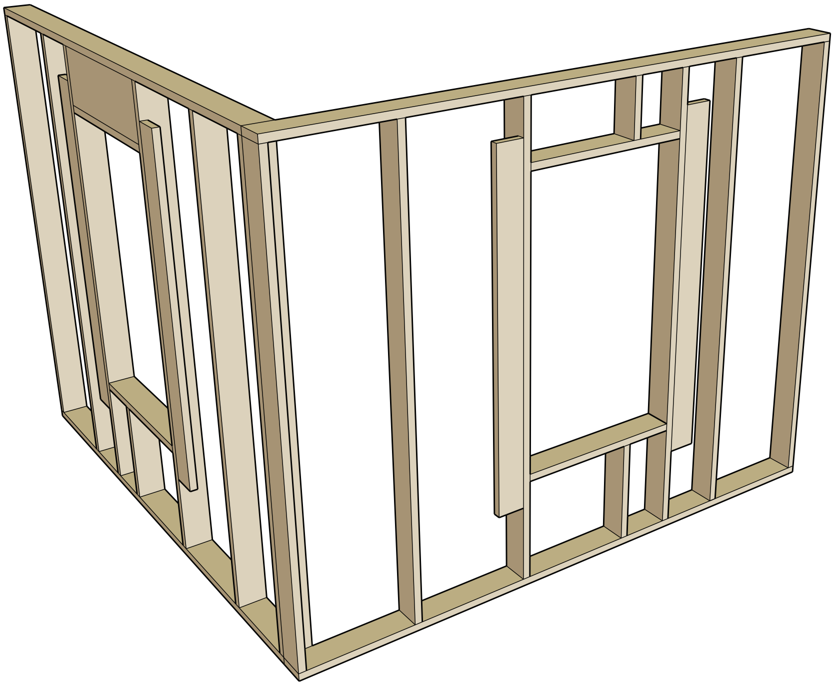


Figure A.4a:
Wood frame wall.

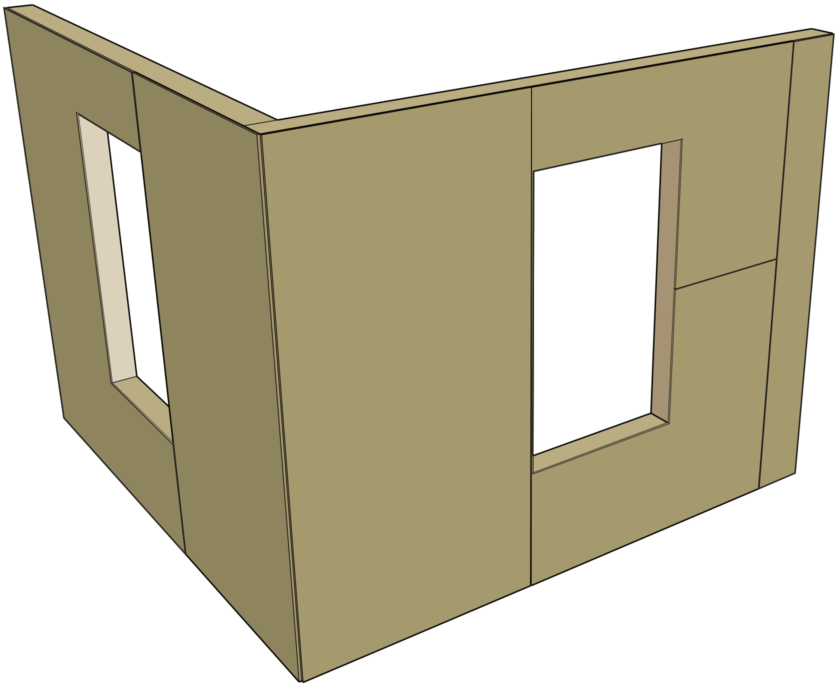


Figure A.4b:
Install OSB sheathing.

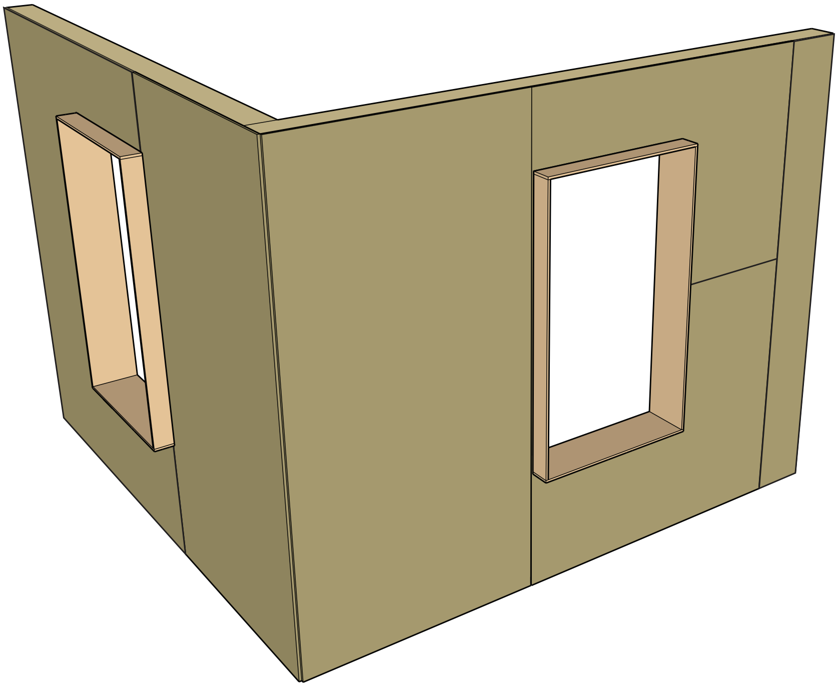


Figure A.4c:
Install plywood window extension box.

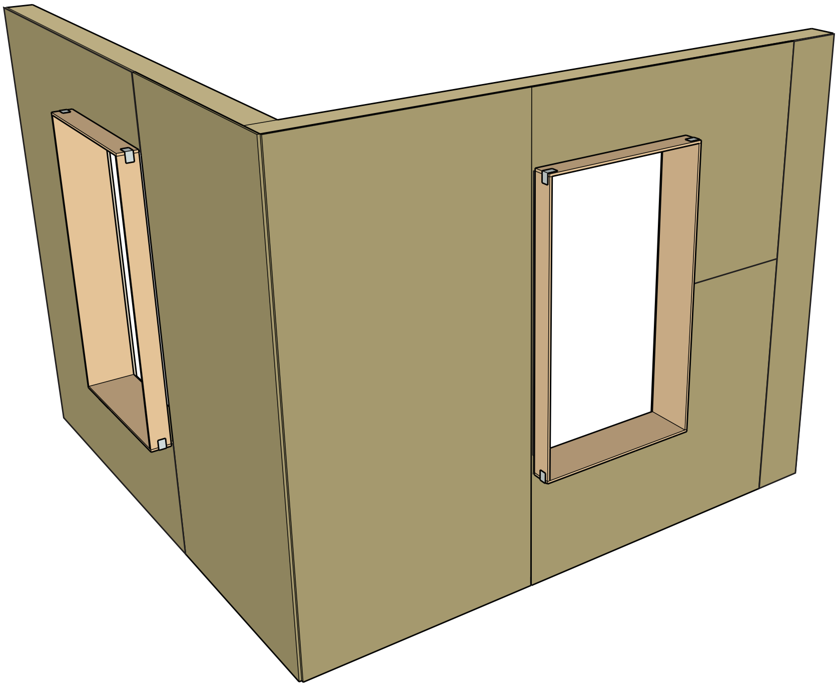


Figure A.4d:
Install reinforcing clips on corners of plywood extension box.

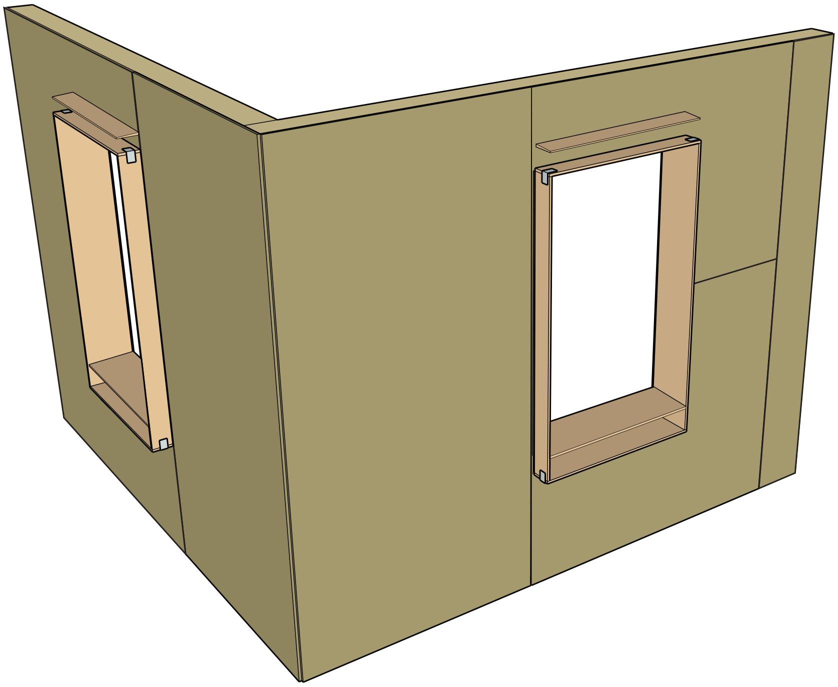


Figure A.4e:
Install sloping head piece.

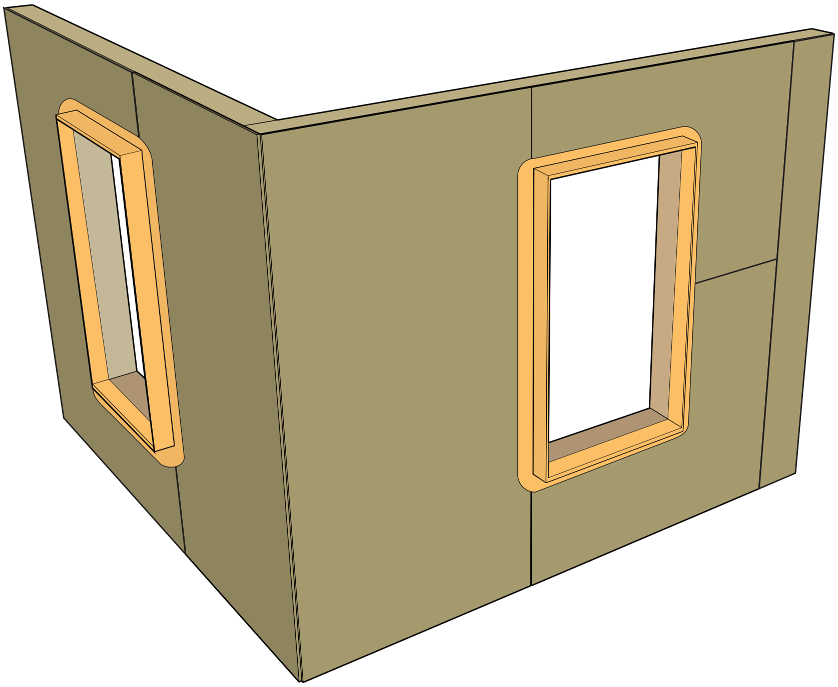


Figure A.4f:
Install liquid applied flashing.

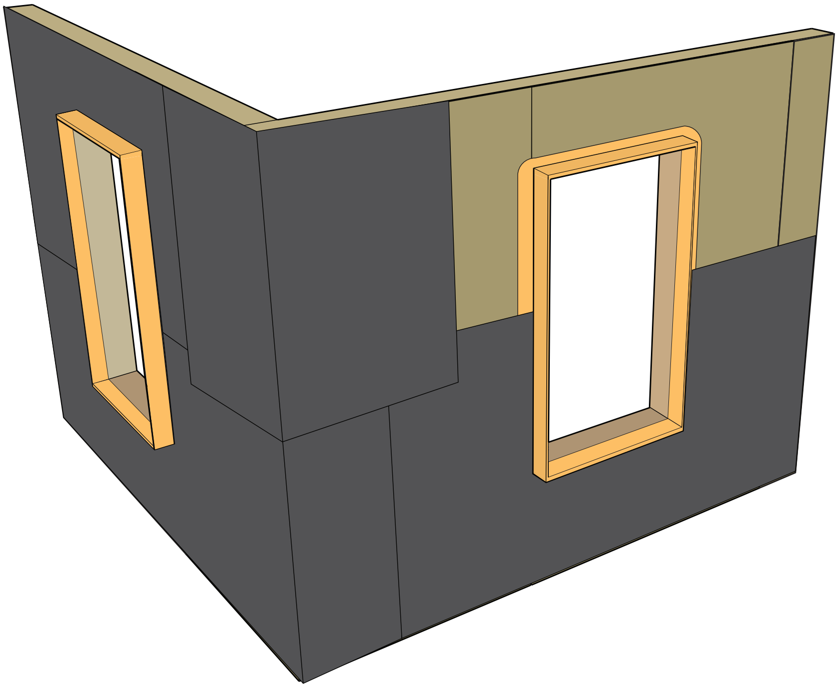


Figure A.4g:
Install building paper shingle-fashion.

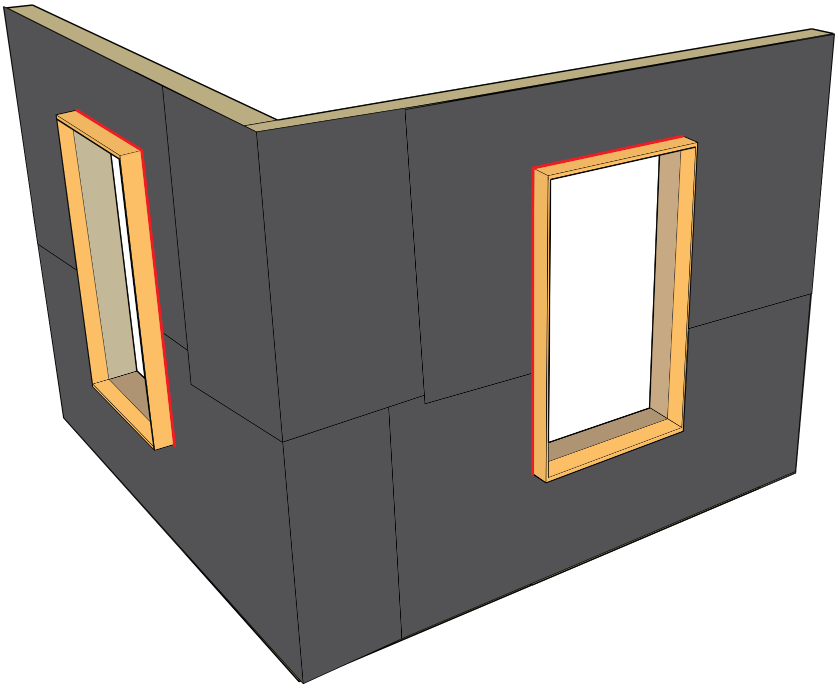


Figure A.4h:
Install sealant around perimeter of window extension box.

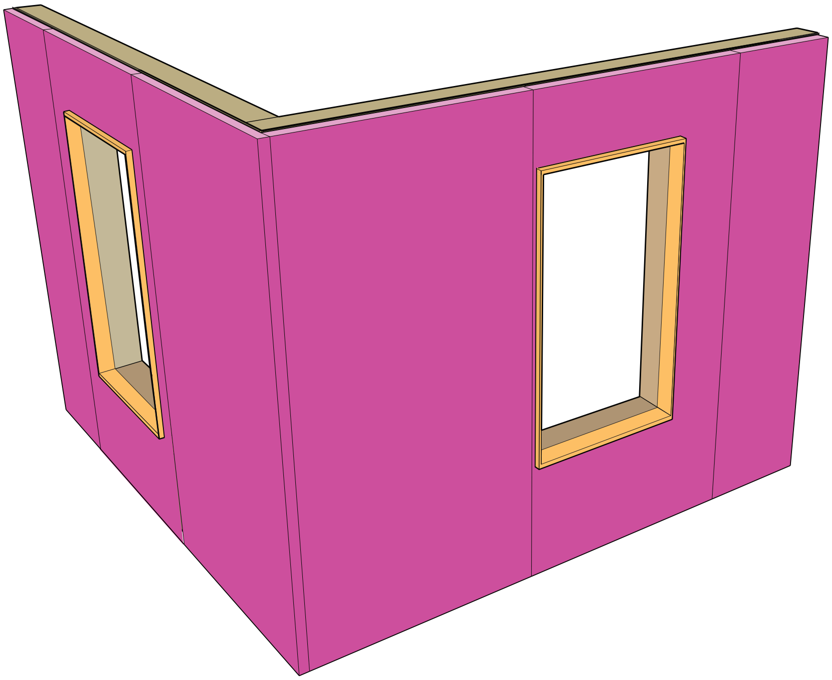


Figure A.4i:
Install one layer of insulating sheathing (FOAMULAR® XPS Insulation).

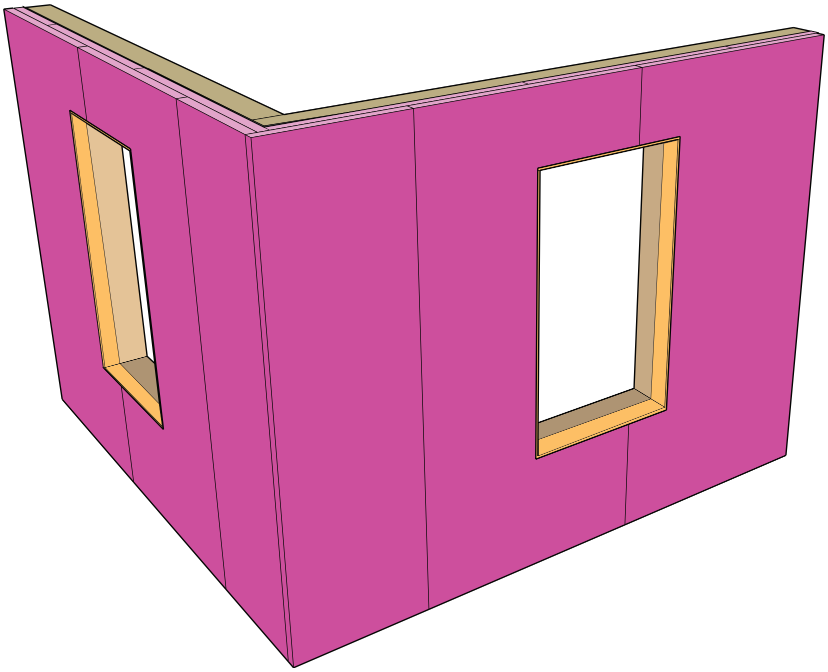


Figure A.4j:
Install second layer of insulating sheathing (FOAMULAR® XPS Insulation).

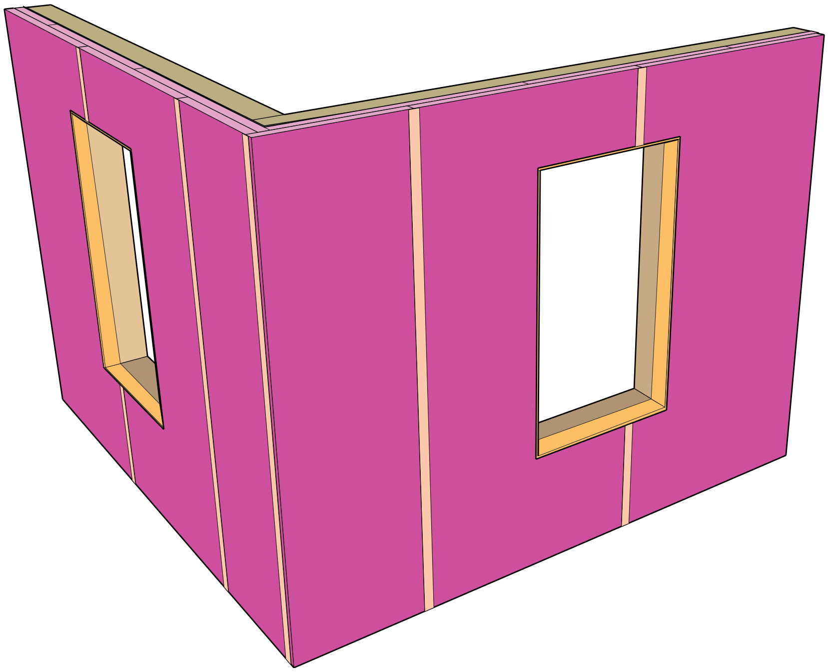


Figure A.4k:
Tape (JointSealR® Foam Joint Tape) seams in insulating sheathing.

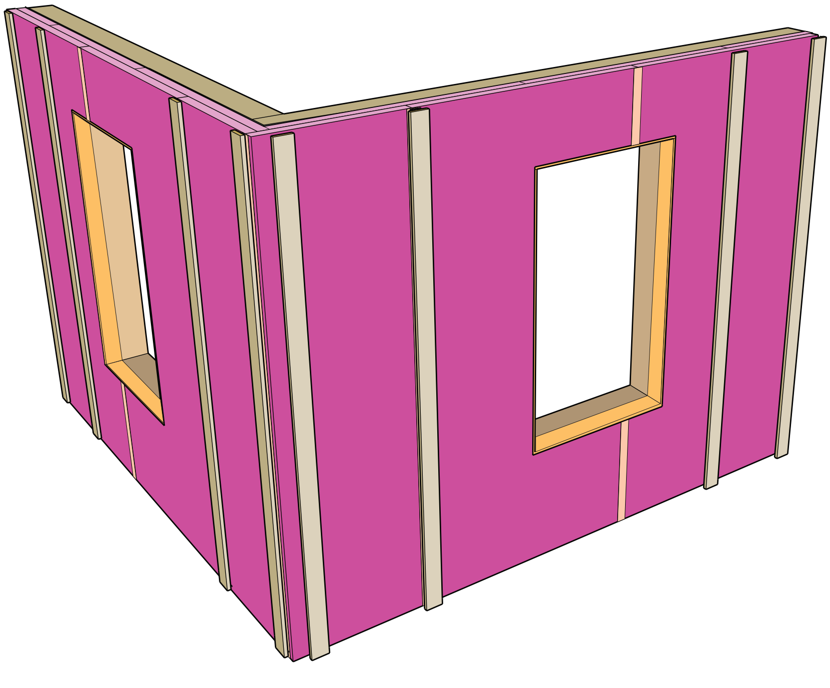


Figure A.4l:
Install furring strips.

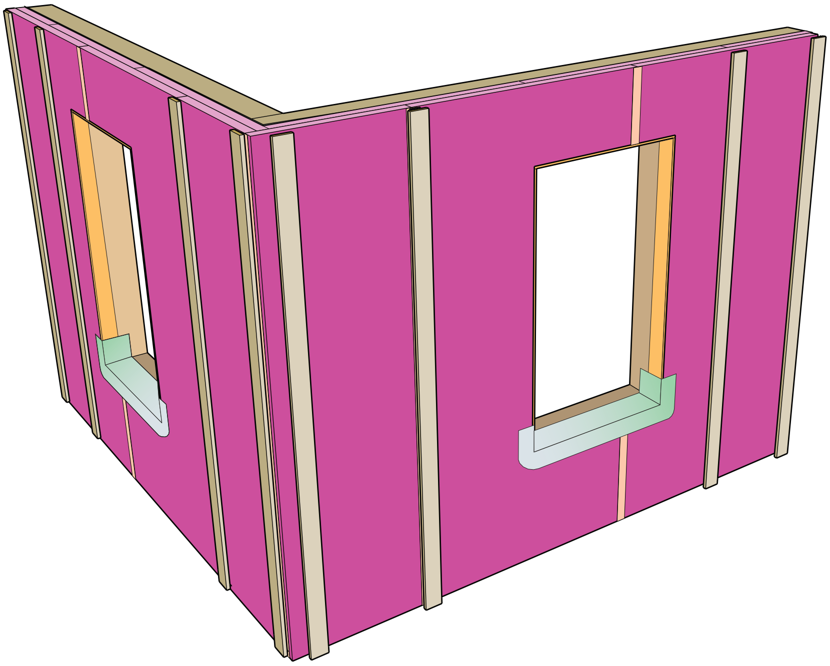


Figure A.4m:
Install sill flashing.

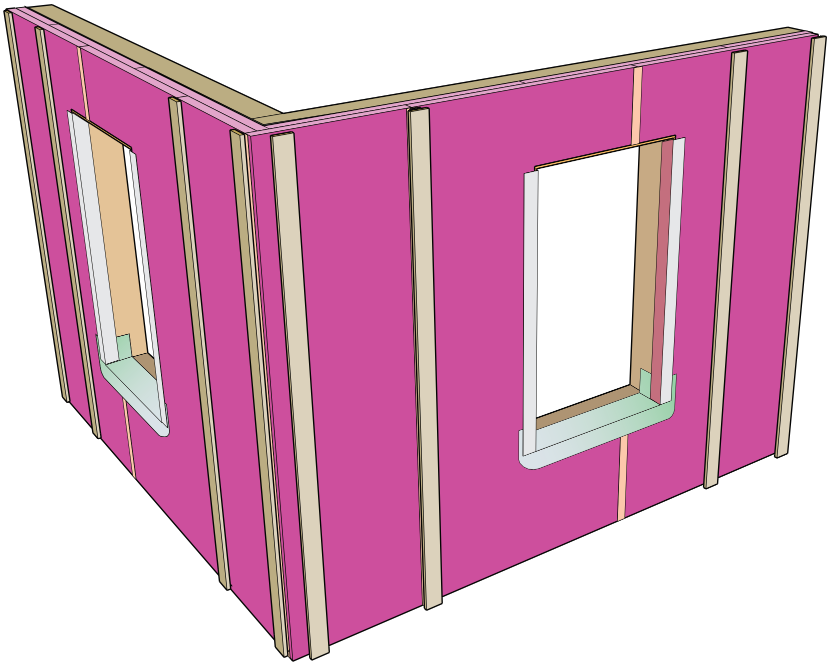


Figure A.4n:
Install jamb flashing.

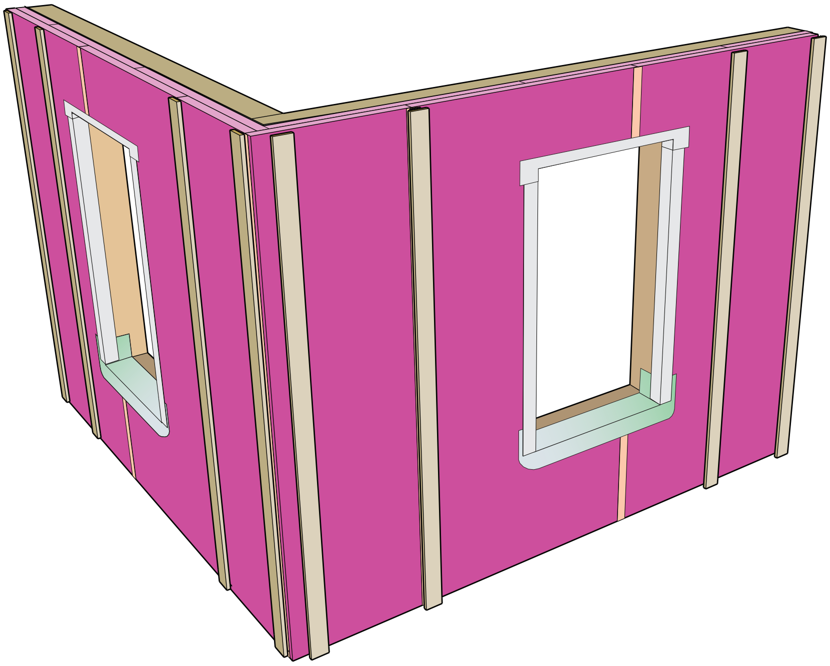


Figure A.4o:
Install head flashing.

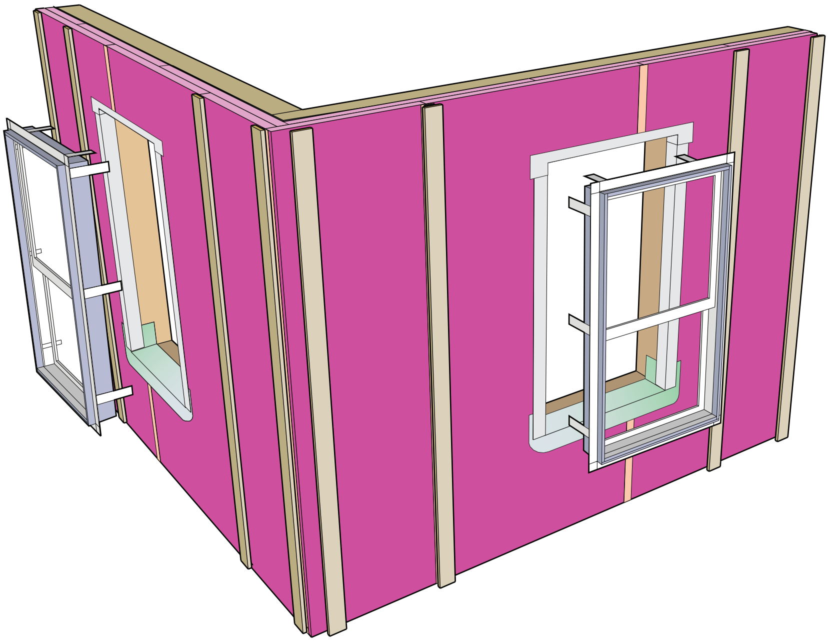


Figure A.4p:
Install window plumb, level and square per manufacturer's instructions.

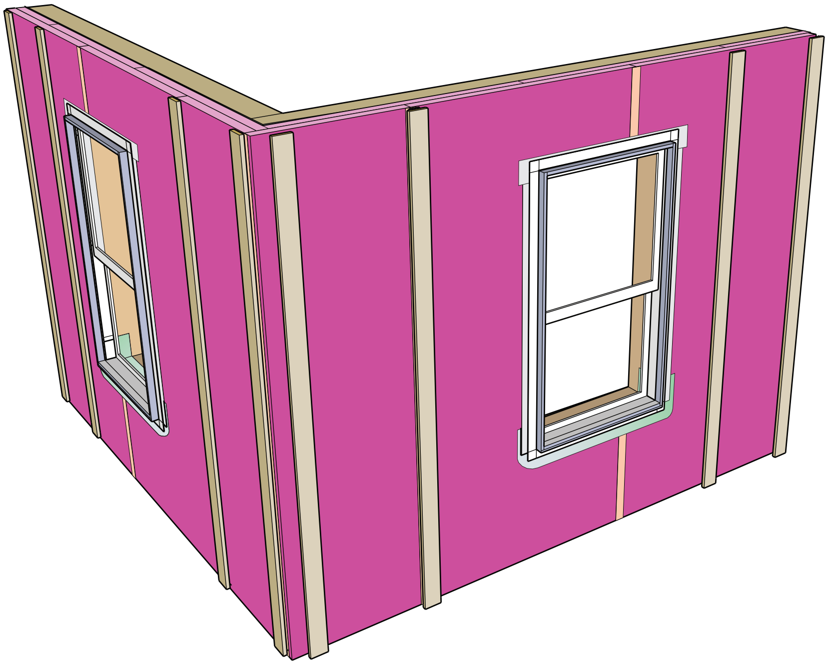


Figure A.4q:
Window installed.

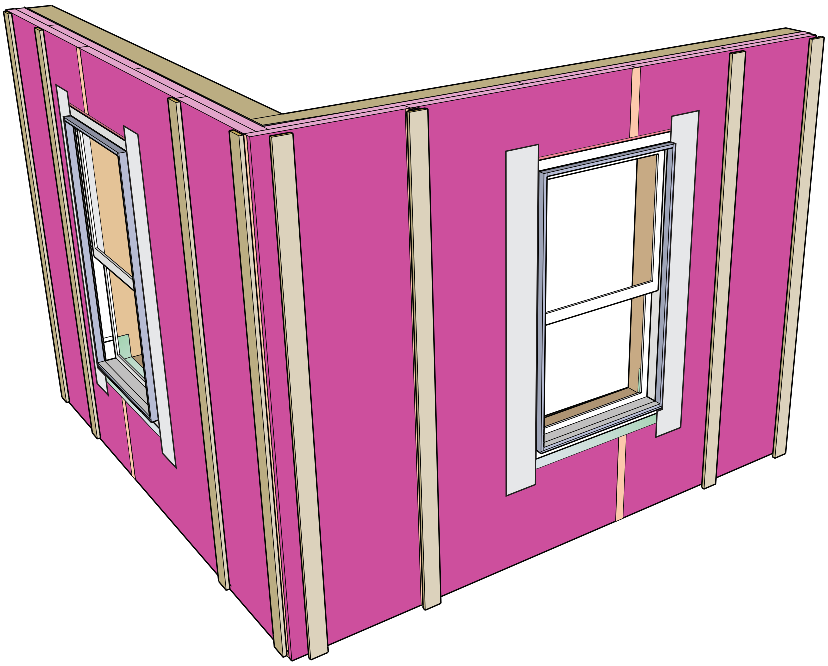


Figure A.4r:
Install jamb flashing.

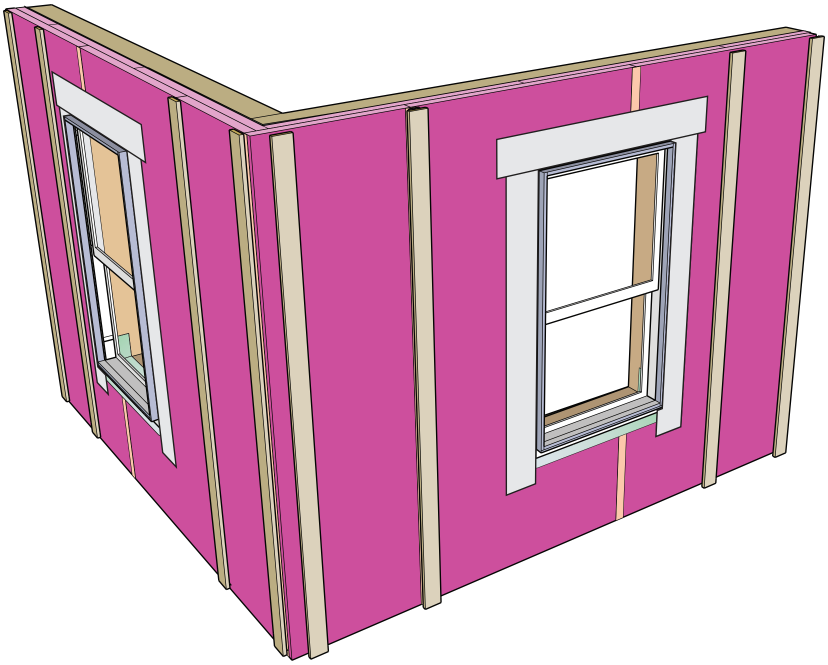


Figure A.4s:
Install head flashing.

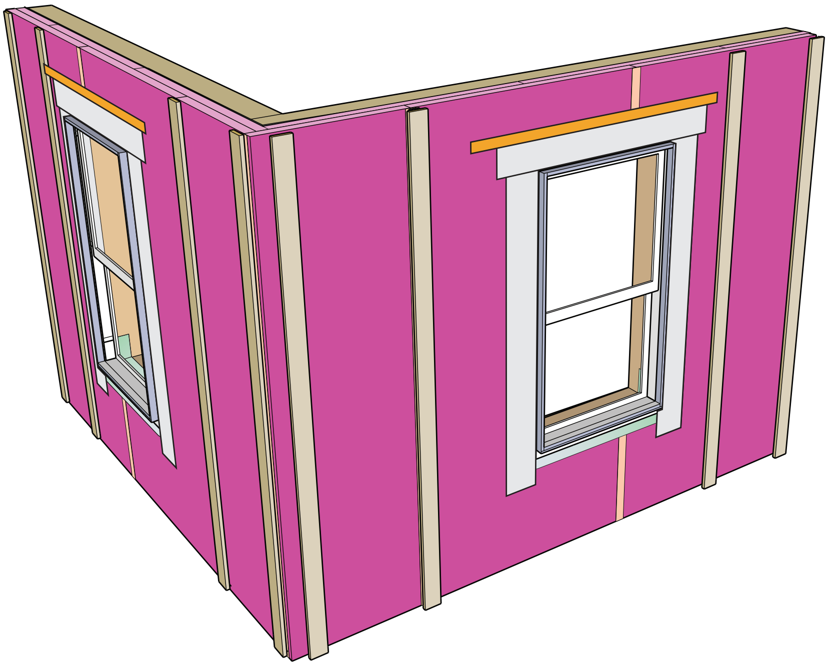


Figure A.4t:
Tape (FlashSealR®
Foam Flashing Tape)
top edge of head
flashing.

Figure A.4u:
Install additional furring around windows.

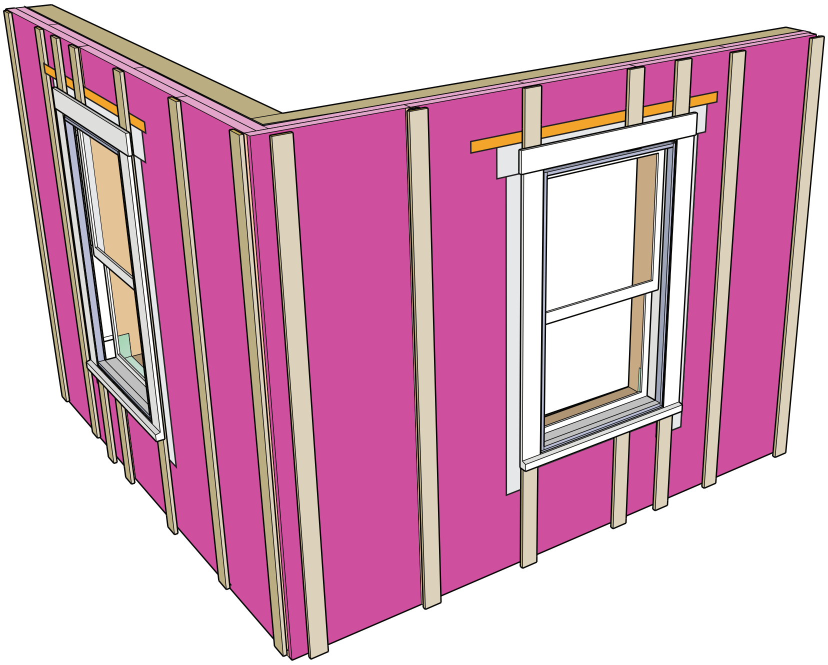


Figure A.4v:
Install trim.

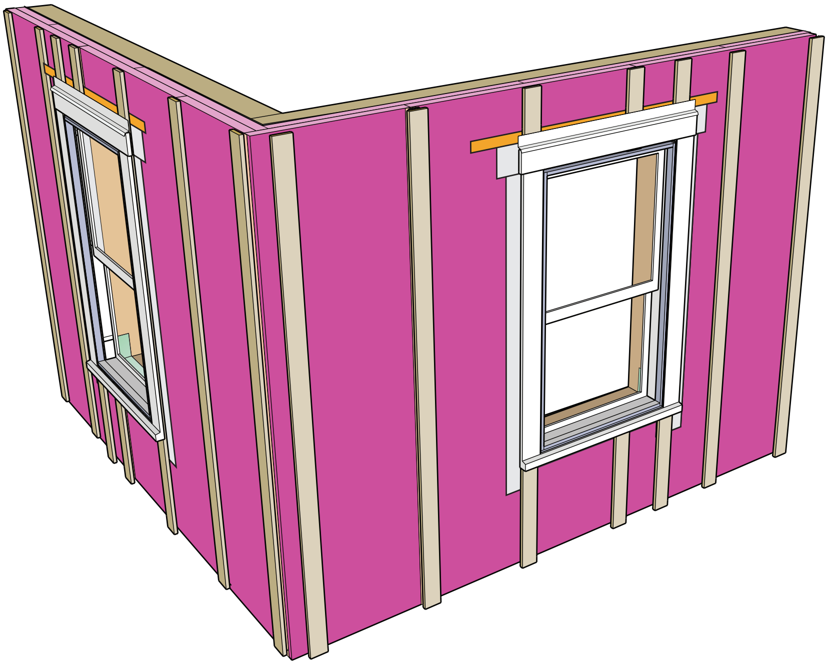


Figure A.4w:
Install cap flashing.

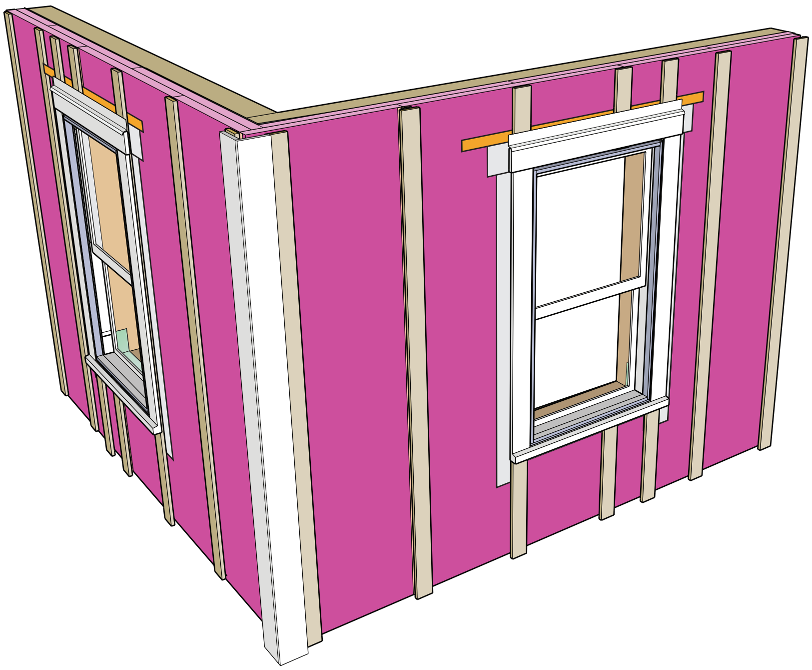


Figure A.4x:
Install corner trim.

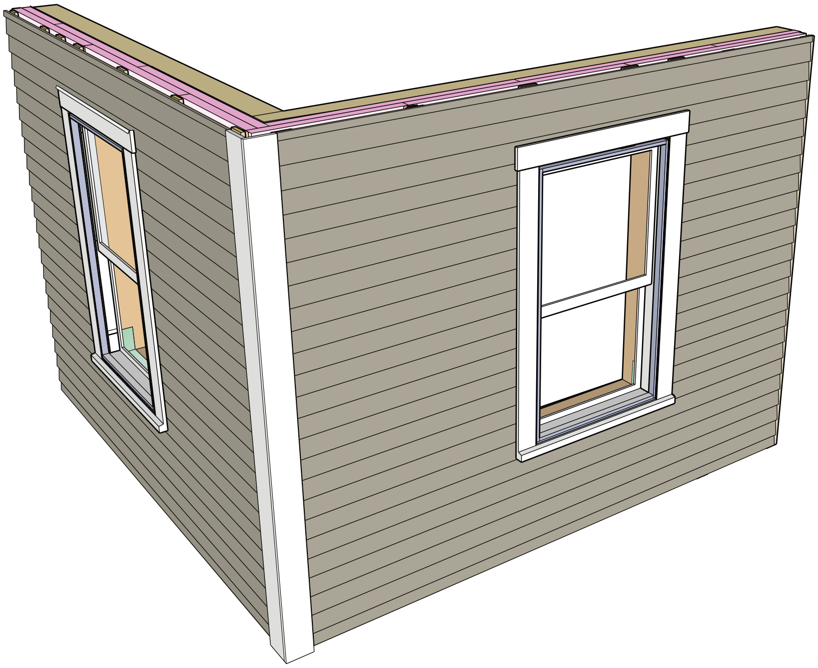


Figure A.4y:
Install siding.

INSTALLATION INSTRUCTIONS — RCWS

FOAMSEALR™
(OC 23514-D)

1. Smooth top surface of foundation wall to have minimal variation.
2. Unroll FoamSealR™ sill plate gasket on top surface of foundation wall or fasten to bottom of sill plate on tilt-up wall sections with ridged side toward roughest surface.
3. Overlap all end and perpendicular joints.
4. Pierce FoamSealR™ sill plate gasket at anchor bolt locations.
5. Set and anchor sill plate to foundation wall.

FOAMULAR®
(ESR-1061)

1. FOAMULAR® insulation boards measuring 2 ft by 8 ft ($^{3}/_{5}$ m by 2 $^{2}/_{5}$ m) or 4 ft by 8 ft (1 $^{1}/_{5}$ m by 2 $^{2}/_{5}$ m) should be installed horizontally or vertically with long joints and end joints in contact with one another.
2. When installed directly on framing members, the insulation boards measuring 2 ft by 8 ft (0.6 m by 2.4 m) must be installed horizontally and framing members are spaced a maximum of 16-inches on center.
    a. For wood framing, the insulation boards are attached using $^{3}/_{8}$-inch-diameter-head (9 ½ mm) galvanized nails, 1-inch-crown (25 $^{2}/_{5}$ mm) galvanized staples, 6d ring-shank nails with 1-inch (25 $^{2}/_{5}$ mm) plastic washers or equivalent fasteners long enough to penetrate framing a minimum of $^{3}/_{4}$-inch (19 mm), or through the sheathing, whichever is less.
    b. For steel framing, the insulation boards are attached using No. 6, Type S drywall screws, with 1-inch (25 $^{2}/_{5}$ mm) plastic washers, long enough to penetrate the framing a minimum of ¾-inch (19 mm).
3. Fasteners must not be over-driven. Fasteners must be spaced a minimum of 12-inches on center around the perimeter and 16-inches on center in the field.

JOINTSEALR®
(OC 10015678-C)

1. Remove release liner backing material and center the adhesive tape over the joint to be sealed.
2. Continue to remove the liner and press the tape firmly in place over the joint. Lap intersections or joined tapes a minimum of 3 ½-inches.
3. Using a J-Roller or laminate roller, roll the tape firmly in place to ensure intimate contact between tape and substrate and to eliminate trapping air between the tape and substrate.
4. To obtain best adhesion, JointSealR® Foam Joint Tape should be installed when outdoor temperatures are

above 0 degrees F and below 120 degrees F. The surface of the FOAMULAR® insulation to which JointSealR® Foam Joint Tape is applied must be smooth, clean, dry, and free of contaminants.

FLASHSEALR®
(Draft of OC 10017505)

1. Substrate surfaces should be smooth, clean, dry, and free of contaminates. Remove any contaminants or loose debris from the substrate surface prior to application. For optimal adhesion to foam substrates, FlashSealR® should be installed at the same time the foam sheathing is installed.
2. Cut the FlashSealR® Foam Flashing Tape into the required lengths. Generally, the required length is the length of the side of the window or door to be sealed plus two times the width of the tape being used.
3. Install FlashSealR® Foam Flashing Tape first along the bottom edge of the opening, then along the sides, and then finish along the top edge.
4. Peel back a small portion of the smaller release paper sheet. Start away from the window/door opening, a distance equal to the width of the tape. Center the tape over the joint.
5. Press the exposed adhesive portion of the tape firmly into place against the window or door jamb. Continue the installation by removing the release liner while applying firm pressure to the flashing tape surface as it comes into contact with the jamb surface. Continue until the end of the tape is reached.
6. Starting at a corner, peel back a portion of the larger section of release liner. Press the exposed adhesive portion of the tape firmly into place against the substrate. Continue the installation by removing the release liner while applying firm pressure to the flashing tape surface as it comes into contact with the foam sheathing. Continue until the end of the tape is reached.
7. Using a roller (rubber, wood or steel "J" roller) apply sufficient pressure along the entire tape surface to ensure intimate contact between tape and substrate and to eliminate any air trapped beneath the tape.
8. Always overlap a distance equal to the width of the tape. All horizontal overlaps should be in a lapped, or shingled application, so that any liquid water traveling down the housewrap or sheathing is continuously directed to the outside of the wall assembly.

PINK*WRAP*®
(Adapted from ESR-2801)

1. PINK*WRAP*® water-resistive barriers are installed after wall framing is completed and before windows and doors are installed.
2. Place the end of the roll a minimum of 6-inches (152 mm) from the starting corner and fasten to the sheathing with corrosion-resistant nails, of sufficient length to penetrate the wood sheathing/studs by ¾-inches, having minimum 1-inch-diameter (25 $^2/_5$ mm) plastic washer heads or cap heads, spaced at a maximum of 16-inches (406 mm) on center, or corrosion-resistant staples, of sufficient length to penetrate the wood sheathing/studs by ¾-inches, with minimum 1-inch (25 $^2/_5$ mm) crowns, spaced a maximum of 12-inches (305 mm) on center.
3. Unroll around the building and fasten with nails spaced at a maximum of 16-inches (406 mm) on center or staples spaced a maximum of 12-inches (305 mm) on center.

4. The printed side of the wrap is installed facing the outside. A minimum of 6-inches (102 mm) of overlap must be provided for vertical seams and 2-inches (52 mm) for horizontal seams, except where the published installation instructions specify a greater overlap.

ENERGY COMPLETE® SEALANT

(Installed Prior to Cavity Insulation) — (Dave Wolf)

The EnergyComplete® Sealant is a two-part, high performance latex-based foam used to seal cracks and penetrations through a building envelope and from floor to floor in a building. These two components are to be used in the EnergyComplete® Machine, which has been specifically designed for this foam. The foam is applied, by a certified contractor, in a bead format, expands to roughly 5 times its original volume, and is durable enough to follow with the installation of insulation in 20 minutes after application (depending on temperature and relative humidity). The unique flexible nature of the foam allows it to: (1) maintain its seal, despite seasonal expansion and contraction of the joints in the house, and (2) function as a gasket when applied between materials, such as the drywall and framing.

All large openings in the building enclosure need to be blocked (e.g., chases, floor joist cavities that cross the building enclosure, etc.). Beyond that, no other extraordinary preparation is required that wouldn't otherwise be done prior to installing insulation.

The EnergyComplete® Sealant does not require the installer to wear a chemical mask, and it is not necessary for other trades to leave the area during the application. When installing the product, the installer will only need to use chemical gloves, goggles or a face shield, a long sleeved shirt, and a dust mask, if the installation site is dusty.

How to find a Certified Installer — EnergyComplete® Sealant is applied by certified insulation contractors, which can be found at www.ocenergycomplete.com/locator.

CAVITY INSULATION — BATTS

(NAIMA BI402, OC 10017858)

Faced Insulation

There are three commonly accepted methods of installing faced insulation in wood framing members: pressure fit, face and inset.

When the cavity contains obstructions such as electrical boxes, wiring or plumbing, the blanket/batt insulation will require some field fabrication. For electrical boxes a piece will need to be cut out. The piece should be slightly smaller than the dimensions of the box

so the insulation fits snugly around the box but without bulging or buckling. The piece can be inserted behind the box to fill in the gap between the box and the finish material on the backside of the cavity, or the gap can be filled in with a foam sealant. The gap should never be left unfilled, nor should the insulation batt simply be tucked in behind or around the box without cutting the piece out. Failure to do so will result in voids around the box. For wiring or plumbing that runs through the cavity, vertically or horizontally, the blanket insulation must be either split or slit so that it fits around the obstruction and still fills the cavity. Placing the entire batt on one side of the obstruction or the other (all in front or all behind) will result in a void along the entire length of the obstruction and reduce the thermal performance of the insulation. Wherever batts or rolls of any type are too short to fill a stud cavity, a piece should be cut to size to fill the gap. When insulation is too long, it should be cut to fit properly, not doubled over or forced to fit.

Pressure Fit or Friction Fit — No Stapling

1. Gently place the insulation into the cavity space between framing. Make sure the insulation facing is flush with the face of the stud. The insulation must fit snugly at the sides and ends.
2. It is important that the insulation completely fill the cavity. In walls that are higher than 8 ft, use minimal stapling to hold insulation in place until drywall is installed.

Face Stapling

1. Place the insulation between framing members and check to be sure it fits the cavity at both ends.
2. With facing material flush with the face of the framing, the flanges will overlap the framing. Staple the flanges to the face of the framing, using enough staples to hold the insulation firmly in place and avoid gaps and fishmouths. The flange of the faced insulation placed in the next cavity will overlap the previously stapled flange.
3. When more than one batt is used in a single cavity, pieces must be snugly butted without gap between them.

Inset Stapling

1. Gently press the insulation at the sides into the framing cavity, usually about ¾-inch, until the outside edge of the flange is flush with the face of the framing. Don't inset the tabs any further than necessary for stapling.
2. When inset stapling insulation between inclined or vertical framing members, as in cathedral ceilings or walls, start stapling at the top and work down.
3. Use enough staples to hold the insulation firmly in place and avoid gaps and "fishmouths" between flanges and framing, approximately every 16-inches.

Note: When insulating sidewalls, place the insulation in the cavity and check to be sure it completely fills the cavity, top to bottom. When insulating ceilings, be sure that each batt is butted closely to the next one before fastening.

APPENDIX

Unfaced Insulation

To install unfaced insulation, gently place the insulation into the cavity space between framing members. It is important that insulation be correctly sized for the cavity and fit snugly at the sides and ends. No fastening is required if the insulation material is held in place on all four sides and fills the wall cavity. The insulation in knee walls should be held in place to prevent the insulation from falling out of the wall cavity over time.

CAVITY INSULATION — LOOSEFILL

(Adapted from OC 10012454Z)

The process of blowing insulation into walls is best accomplished when broken down into two steps:

- Installing fabric
- Installing Insulation.

Installing Fabric

1. Use a polypropylene non-woven fabric for this application.
2. Choose a wall section. Unroll the fabric along the wall section. Pick up the folded edge of the fabric and staple about half way up the first stud in the wall. Take the roll end of the fabric and staple half way up the last section of the wall. Use a razor knife to cut the fabric to length down the last stud. Wear safety glasses with side shields while stapling. Stapling can cause injury. Follow all stapling device safety requirements.
3. Place an appropriately rated stepladder at one end of the wall. Standing on the ladder, reach down and lift the outer flap of the fabric and staple to the top plate of the wall. Staple along the top plate of the wall over to the other end. Staples should be placed no more than 1-inch apart
4. Move to the center of the wall and staple down the stud about half way. Moving away from the center, staple down adjoining studs half way down. As you move out from the center, pull the fabric outward to remove wrinkles.
5. Move to lower portion of the wall and staple the rest of the way down the studs pulling the fabric as needed to remove wrinkles.
6. Staple around all windows and doors. Staple bottom plate last.
7. Move to the next wall section.
8. If the wall section is taller than 9 ft you will need to make up the distance with additional fabric. The additional fabric will need to overlap the previously installed sheet by at least 6-inches. The overlap can be taped to prevent wool from escaping.

Installing Insulation

1. With the fabric in place, choose a stud cavity to start with. Cut two x patterns into the fabric, one 30-inches from the bottom and the other 24-inches from the top, large enough to accommodate the hose diameter. Insert the hose into the bottom cut and begin filling. When the loosefill stops flowing aim the hose down then up to compact the wall cavity. When there is no additional flow, move to the top opening and repeat. To get higher densities it may be necessary to cut three x patterns in the fabric. Fill each one starting at the bottom and moving up. When the wall is full, turn off the machine and remove the hose.

2. Inspect the cavity for unfilled areas. These areas can be seen as lighter colored areas behind the fabric. Insert the hose in this area and fill until the cavity is of uniform color and shape before moving to the next cavity.

3. For cavities that are 2-inches and smaller in width, cut away the fabric and fill with batt material.

4. After all cavities are filled cut fabric away from doors, windows and electrical boxes. Inspect studs for any protruding staples and hammer in if necessary. Use a broom to smooth out any bumps in the fabric. Sweep up any residual insulation from the floor.

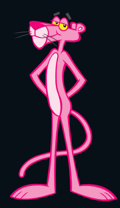
FOR MORE INFORMATION ON THE OWENS CORNING FAMILY OF BUILDING PRODUCTS, CONTACT YOUR OWENS CORNING DEALER, CALL 1-800-GET-PINK® OR ACCESS OUR WEB SITES: WWW.FOAMULAR.COM, WWW.OCBUILDINGSPEC.COM OR WWW.OWENSCORNINGCOMMERCIAL.COM.

Disclaimer of Liability

Technical information contained herein is furnished without charge or obligation and is given and accepted at recipient's sole risk. Because conditions of use may vary and are beyond our control, Owens Corning makes no representation about, and is not responsible or liable for the accuracy or reliability of data associated with particular uses of any product described herein. Nothing contained in this bulletin shall be considered a recommendation.

cornerstone partner AIA

OWENS CORNING FOAM INSULATION, LLC
ONE OWENS CORNING PARKWAY
TOLEDO, OHIO, USA 43659
1-800-GET-PINK®
www.owenscorning.com



Pub. No. 10018868. Printed in the U.S.A. December 2013.