PENNSYLVANIA HOUSING RESEARCH CENTER

DURABILITY EVALUATION OF INSULATED RIM JOISTS

June 2016 | Emma Dickson, Christopher Hine, and Brian Wolfgang

INTRODUCTION

Throughout the building enclosure there are various assemblies that are deemed critical to the long-term energy efficiency and durability of a building. When best practices are followed, these critical areas contribute to a sustainable enclosure. When one or more components are incorrectly designed or installed, moisture accumulation, rot, or mold growth may arise.

Rim joists (also referred to as rim boards, band joists, or band boards: see Figure 1) are a critical portion of the building enclosure, especially at the first framed floor level when left exposed to an unfinished basement or crawlspace. U.S. Census data suggests that more than 50% of existing and new homes are set on full/partial basements or crawlspaces in cold climates. The prominence of this assembly and the opportunities for retrofit of the insulation provides ample potential to improve the contribution of this assembly to the overall building enclosure performance.

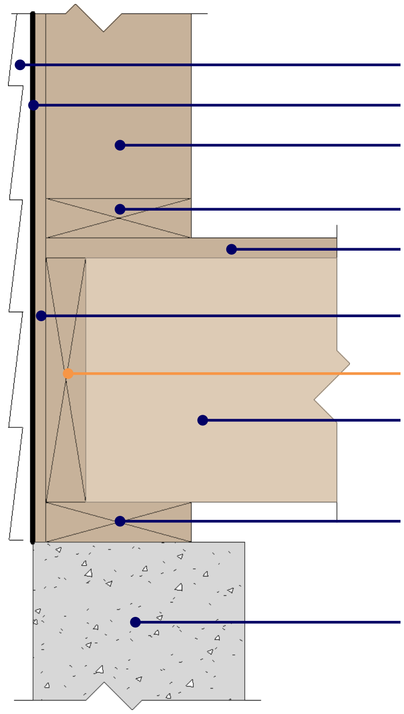

Figure 1: Uninsulated rim joist assembly

ENCLOSURE DESIGN STRATEGIES

There are two main building enclosure design strategies that relate to rim joists. Assemblies should be designed to:

1. Prevent condensation, and
2. Maximize drying potential.

CONDENSATION PREVENTION

One of the most critical functions of the building enclosure is to manage moisture in various forms. It must be assumed that enclosure assemblies will get wet at some point in the life of a building. Typically walls become wet through water vapor condensation within walls and bulk moisture intrusion at penetrations. The primary method of drying, however, is through vapor diffusion.

What makes the rim joist assembly so critical is its susceptibility to condensation. First floor framing that is exposed to unfinished basements or crawlspaces below typically allows humid air to come in contact with the interior surface of rim joists. During winter, this surface is cold, usually below the dew point of the interior environment. When interior water vapor is carried through convection and comes in contact with this surface, condensation can occur. Condensation can lead to degradation of the rim joist material or can lead to mold growth.

The best strategy for preventing condensation is to limit the ability of interior humid air from coming in contact with this condensation plane or to warm the surface to a temperature above the dew point. The specification and placement of insulation is typically the best way to accomplish this goal of lowering the risk of condensation formation.

This brief will describe four different rim joist insulation assemblies and their ability to prevent condensation from occurring on the interior face of the rim joist. Also, the impact of insulation selection on the drying potential of the overall assembly will be discussed.

MAXIMIZING DRYING POTENTIAL

The design strategy that addresses drying potential for insulated rim joists is more dependent on material selection, specifically insulation type. All materials and layers in enclosure assemblies have specific material properties relating to structural capacity, density, etc. The crucial material property for maximizing drying potential is vapor permeability.

As mentioned previously, typically walls become wet through water vapor condensation within walls and bulk moisture intrusion at penetrations. The primary method of drying, however, is through vapor diffusion. Vapor diffusion is the movement of water vapor through materials in an enclosure assembly. Materials with a higher vapor permeability allow diffusion at a faster rate, while materials with a lower vapor permeability allow diffusion at a slower rate.

The assumption that enclosure assemblies will get wet over time is again critical to understanding this design strategy. For rim joists, one can assume that the rim joist itself will get wet, whether through condensation from the interior or bulk moisture from the exterior due to a flashing error or significant driving rain. Once the rim joist is wet, is it able to adequately dry to the interior, exterior, or both? Drying will depend on the layers installed on both sides of the joist. The materials making up both exterior sheathing and rim joists (wood or engineered wood) have a fairly low vapor permeability, but this process does not focus on vapor travelling through the joists but rather the joist drying out. Therefore, the type of insulation installed and its vapor permeability will be a deciding factor in the drying potential of the assembly.

The material in the assembly with the lowest vapor permeability is sometimes referred to as the throttle. For example, if the throttle is to the interior side of the rim joist, the assembly will have a greater potential to dry to the outside.

The following scenarios are simplified to focus on insulation type and placement. The impact of exterior cladding is not taken into account. Each scenario is described both visually and through the listing of vapor permeability values of each assembly material in adjacent tables. Note that these vapor permeability values are approximate values for comparison only.

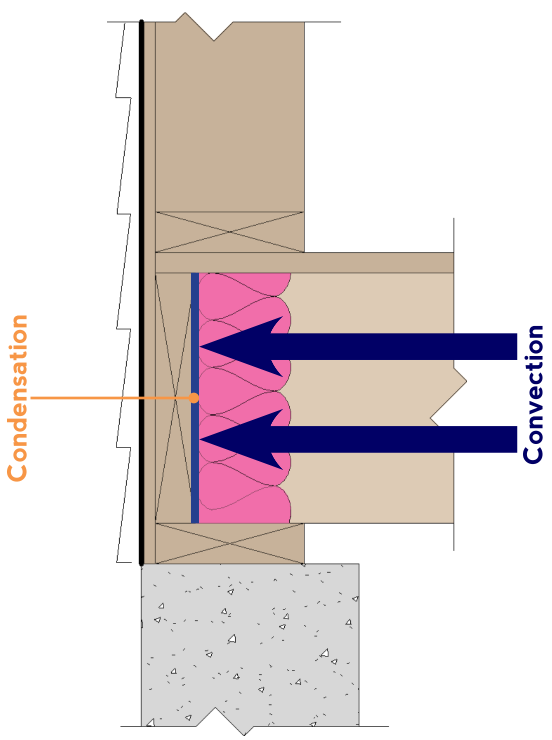

Figure 2: Rim joist assembly w/fiberglass insulation
Fiberglass insulation provides thermal resistance to the assembly but does not prevent vapor through convection from condensing on the interior surface of the rim joist.

RIM JOIST WITH FIBERGLASS BATT

When rim joists are insulated with fiberglass batts, air with a high relative humidity can come in contact with the cooler rim joist by means of convection since fiberglass batt insulation is air permeable. If this happens during the winter months, condensation and frost can occur on the inside face of the rim joist material. While this scenario allows for drying to both the inside and outside due to the high air and vapor permeability of the fiberglass insulation, the risk of condensation typically outweighs this drying potential. Figure 2 shows this assembly and identifies the plane where condensation is a risk in winter. Table 1 lists approximate vapor permeability values for each material.

Table 1: Rim joist w/batt assembly materials

Layers (Outside - Inside)	Vapor Permeability (perm)
Water-Resistive Barrier	5.0 - 50
Exterior Sheathing	2.8 - 5.9
Rim Joist	1.4 - 5.0
Fiberglass Batt Insulation	118

RIM JOIST WITH INTERIOR FOAM

While air- and vapor-permeable insulation allows drying to the inside, the application of a low air-permeable insulation on the interior reduces the risk of interior condensation in winter. This insulation, whether spray polyurethane foam or foam board, raises the temperature of the interior face of the assembly to a level higher than the dew point, thus lowering the risk of condensation. With this scenario the vapor permeability throttle will be the foam insulation (see Table 2); therefore, the highest drying potential will be to the exterior as shown in Figure 3. This figure shows the assumption that even though condensation risk is low, the rim joist itself could still become wet due to bulk moisture intrusion.

Table 2: Rim joist w/interior foam assembly materials

Layers (Outside - Inside)	Vapor Permeability (perm)
Water-Resistive Barrier	5.0 - 50
Exterior Sheathing	2.8 - 5.9
Rim Joist	1.4 - 5.0
Closed-Cell Spray Foam Insulation	0.1 - 1.0

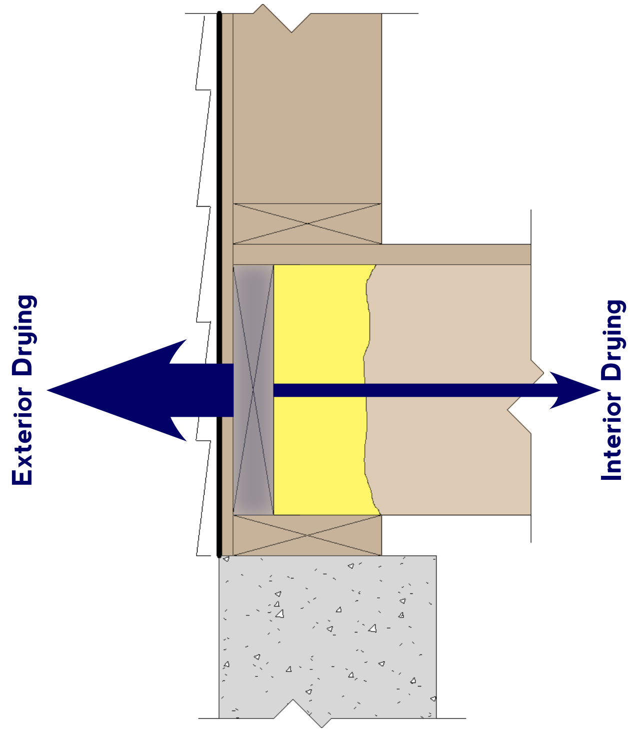

Figure 3: Rim joist w/interior foam insulation
An air-impermeable insulation such as foam reduces the likelihood of humid air coming in contact with a cool surface while, in this instance, still allowing drying to the exterior.

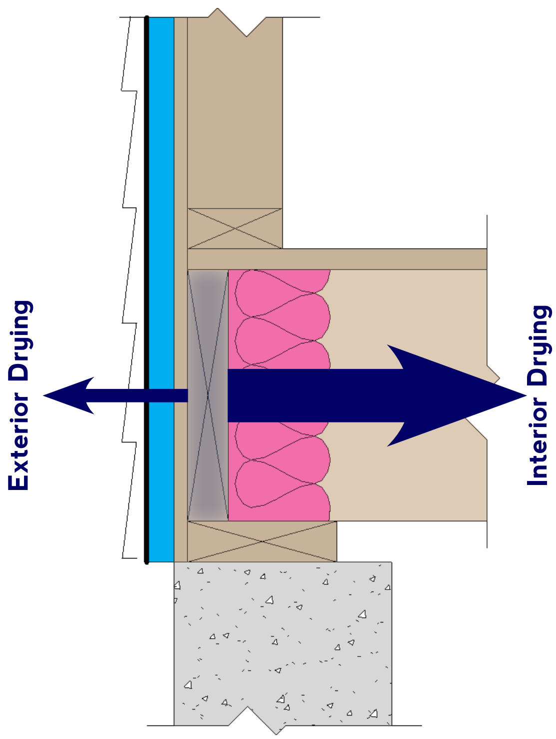

Figure 4: Rim joist w/exterior foam insulation
Exterior foam insulation raises the temperature of the inside face of the rim joist to reduce the likelihood of condensation while still allowing drying to the interior.

RIM JOIST WITH EXTERIOR FOAM AND INTERIOR FIBERGLASS BATTS

Incorporating both rigid foam insulation on the exterior and fiberglass insulation on the interior side of the assembly can increase the energy efficiency of the enclosure. The application of foam to the outside keeps the rim joist warmer in wintertime conditions, which reduces the risk of condensation on the inside. However, the installation of the exterior foam must be free from defects to reduce the amount of bulk water entering the assembly. The throttle in this scenario is the exterior foam; therefore, the maximum drying potential will be to the inside, as shown in Figure 4 and Table 3.

Table 3: Rim joist w/exterior foam assembly materials

Layers (Outside - Inside)	Vapor Permeability (perm)
XPS Rigid Foam Insulation	1.0
Water-Resistive Barrier	5.0 - 50
Exterior Sheathing	2.8 - 5.9
Rim Joist	1.4 - 5.0
Fiberglass Batt Insulation	118

RIM JOIST WITH INTERIOR AND EXTERIOR FOAM

While installing foam on the interior and exterior of the rim joist assembly has the potential to reduce thermal bridging through the framed walls and condensation through convection from the interior, the drying potential from the middle of the assembly is dramatically reduced. The throttle in this scenario is the foam insulation at both the inside and outside locations (see Figure 5 and Table 4). If this assembly were to be exposed to moisture, the drying cycle time would be increased. Over time this could lead to the assembly accumulating moisture due to the lack of drying to either side.

Table 4: Rim joist w/interior foam assembly materials

Layers (Outside - Inside)	Vapor Permeability (perm)
XPS Rigid Foam Insulation	1.0
Water-Resistive Barrier	5.0 - 50
Exterior Sheathing	2.8 - 5.9
Rim Joist	1.4 - 5.0
Closed-Cell Spray Foam Insulation	0.1 - 1.0

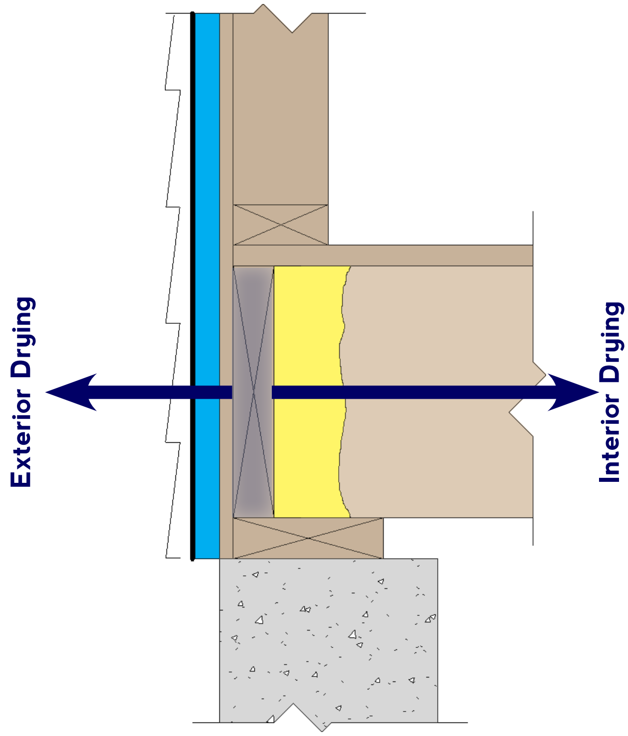

Figure 5: Rim joist w/interior and exterior foam
Interior and exterior foam may be desirable from an energy efficiency perspective and to control condensation, but it can reduce the drying potential should the assembly become wet.

CONCLUSIONS

It is clear that adding insulation to rim joist assemblies is beneficial to reducing heat loss in winter. However, it is critical that the selection of an insulation product take into account its interaction with moisture present in the assembly. Proper design of the building enclosure takes into account risk when comparing different options, but does not guarantee success or failure of the system. As with any building enclosure assembly, the key to long-term durability is proper assembly design and construction given the site conditions, cost constraints, and specific building configuration.

REFERENCES

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2013). *2013 ASHRAE Handbook: Fundamentals*, Atlanta, GA.