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Assessing Foundation Insulation Strategies for the 2012 International Energy Conservation Code in Cold Climate New Home Construction

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March 2013

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Unless otherwise noted, all figures were created by NorthernSTAR.

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Definitions

BA	Building America
BAMN	Builders Association of Minnesota
BCAP	Building Codes Assistance Project
ft	Foot
ft^2	Square foot
ICC	International Code Council
IECC	International Energy Conservation Code
in.	Inch
IRC	International Residential Code
MBPA	Minnesota Building Performance Association
NREL	National Renewable Energy Laboratory
WSP	Water separation plane

Executive Summary

Even though the International Energy Conservation Code 2012 (International Code Council 2012) is a model code now available for adoption by individual states, only two cold-climate states have adopted it as their new home energy code. Understanding the resistance to adoption is important in assisting more states to accept the code and engage in deep energy strategies nationwide. This three-part assessment by the NorthernSTAR Building America Partnership was focused on foundation insulation R-values for cold climates and the design, construction, and performance implications. In Section 1, a literature review and attendance at stakeholder meetings held in Minnesota were used to assess general stakeholder interest and concerns about proposed code changes. Section 2 includes drawings of robust foundation insulation systems that were presented at one Minnesota stakeholder meeting to address critical issues and concerns for adopting best practice strategies. In Section 3, a sampling of builders participated in a telephone interview to gain baseline knowledge on insulation systems used to meet the current energy code and how the same builders intend to meet the new proposed code.

In general, most builders expressed interest in being able to deliver greater energy efficiency to their customers. Concerns were voiced, however, about the costs compared to the energy savings, constructability, and durability risk resulting from increased foundation insulation R-values. When solutions for building robust foundation wall systems were presented to stakeholders, they did express interest in learning the details of the strategies. There was, however, continued interest in proof of cost, payback, and hygrothermal performance. Builders who participated in the interview were more confident in being able to meet the new requirements. This might have been a result of these respondents already using more advanced techniques for foundation insulation.

This insight gives Building America an opportunity to engage the industry with existing research and practice measures that can address constructability and durability concerns at the proposed code levels. It also indicates that builders are interested in more specific information on cost, energy savings, and overall hygrothermal performance. Filling these voids could yield the supportive data needed to enhance building industry confidence and engage more states in the adoption of 2012 International Energy Conservation Code for new homes.

Acknowledgments

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The authors also acknowledge Pat Huelman and Tom Schirber, Cold Climate Housing Program, University of Minnesota, for technical guidance, project development, and coordination.

1 Introduction

Changes to the national model energy code for cold and very cold climates are represented in the newly adopted 2012 International Energy Conservation Code (2012 IECC).[1] The new code is inclusive of strategies to meet the U.S. Department of Energy Building America (BA) Program goals for new homes to achieve 30% improvement in energy savings over the 2006 IECC. Communities and states across the United States are in the process of reviewing the code changes and discussing how to integrate the 2012 IECC into their own energy codes. Stakeholder acceptance of the stated benefits is an important tool in creating a smooth transition from the old code to the new code and ensuring compliance that leads to measured energy savings. Although energy efficient, comfortable, safe, healthy, and durable homes are the goal of the BA program, many stakeholders who also desire these outcomes are concerned about potential cost increases and unknown risks that might accompany a change as compared to the known costs and risks of their current building practices.

1.1 2012 International Energy Conservation Code and Impact on Foundation Insulation

A definition of the foundation insulation requirements of 2012 IECC by component can be found in note "c" of the 2012 International Residential Code (IRC) table N1102.1.1 (R402.1.1). For cold-climate zones 5, 6, 7, and 8, the note states the following:

> "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

These changes were designed to achieve 30% increase in energy savings compared to the 2009 IECC—a goal in line with the BA program's desire to achieve 30% energy savings over IECC 2009 while also promoting building durability, indoor air quality, and occupant safety and comfort.

1.2 Insulation Considerations for Basements in Cold Climates

Building foundations are complicated systems that are easily misunderstood and strategies for energy improvement are often oversimplified. In the cold-climate building regions of the United States, it is not uncommon to experience annual frost depths of 3 to 6 ft. Foundation walls typically extend 4 ft or more below grade to protect the foundation from frost heave. As a result, full basements have become a common construction practice. Although it was once typical to find only mechanical equipment, plumbing systems, and stored items located in these spaces, homeowner desire to use a basement as living space creates urgency for reliable information on best practice strategies for foundation insulation systems.

The principal drawback to basement spaces that are surrounded by soil and experience both above grade and below grade conditions is hygrothermal durability. Foundation walls almost

[1] Note that complete citations for all International Code Council (ICC) codes mentioned in this report are given in the References list.

always experience variations in temperature and drying potential from the top (above grade) to the footing (below grade), from season to season, and from wall to wall depending on solar orientation, soil conditions, and design (Huelman et al. 2012). It is common to find full wall, lookout wall, and walkout wall designs in the same basement area. Lack of soil slope, foundation wall waterproofing, capillary breaks, and drainage at the footing create further risk for increased moisture stress resulting from rainwater and groundwater intrusion. Ueno and Lstiburek (2010) note that even though bulk water control adds negligible energy benefit, it should be a base requirement for any high performance house because it is critical for building durability, indoor air quality, pest management, and the creation of acceptable living conditions within or above the foundation space.

Although soil contact prevents the below grade foundation wall from drying to the exterior, interior insulation and the presence of vapor impermeable materials can reduce the opportunity for the foundation wall to dry to the interior. This can create continually wet insulation and building materials. Temperature differences from the top of walls to the bottom can also exacerbate the movement of water vapor toward the sill and rim, especially in hollow core masonry block (Goldberg 1999). This can lead to deterioration and rot of the building structure components, loss of energy efficiency, and decreased comfort, as well as the opportunity for mold growth and resultant poor indoor air quality.

Of the four foundation wall insulation approaches—exterior, interior, both interior and exterior, and in the middle—the most common insulation approach for new homes has been to insulate on the interior because it is the least expensive. Lstiburek (2006) notes, however, that interior insulation is the most risky insulation system because the foundation wall remains cold as a result of being in contact with below grade soil. It is imperative to keep warm, moist interior air from condensing on the cold wall. To do this, the interior insulation assembly must be built airtight. It must also be built to dry inward (Building Science Corporation 2009) with the insulation layer built vapor-semi-impermeable (greater than 0.1 perm), vapor-semi-permeable (greater than 1.0 perm), or vapor-permeable (greater than 10 perm). As the permeance increases, the inward drying potential rises and the risk of excessive moisture accumulation lowers. Highly permeable interior materials, though, will increase the outward wetting potential during the heating season in cold climates. To achieve the proper permeance, the following insulation products were recommended by Lstiburek: "Up to two inches of unfaced extruded polystyrene (R-10), four inches of unfaced expanded polystyrene (R-15), three inches of closed cell medium density spray polyurethane foam (R-18) and ten inches of open cell low density spray foam (R-35) meet these permeability requirements." The use of vapor-impermeable materials to control air flow adds undue risk because they prevent foundation walls from drying inward.

Contrary to the published information just cited, though, a recent presentation given by Lstiburek and summarized by Holladay (2012) indicates that Lstiburek has reconsidered and suggests that the concrete does not have to dry to the inside.

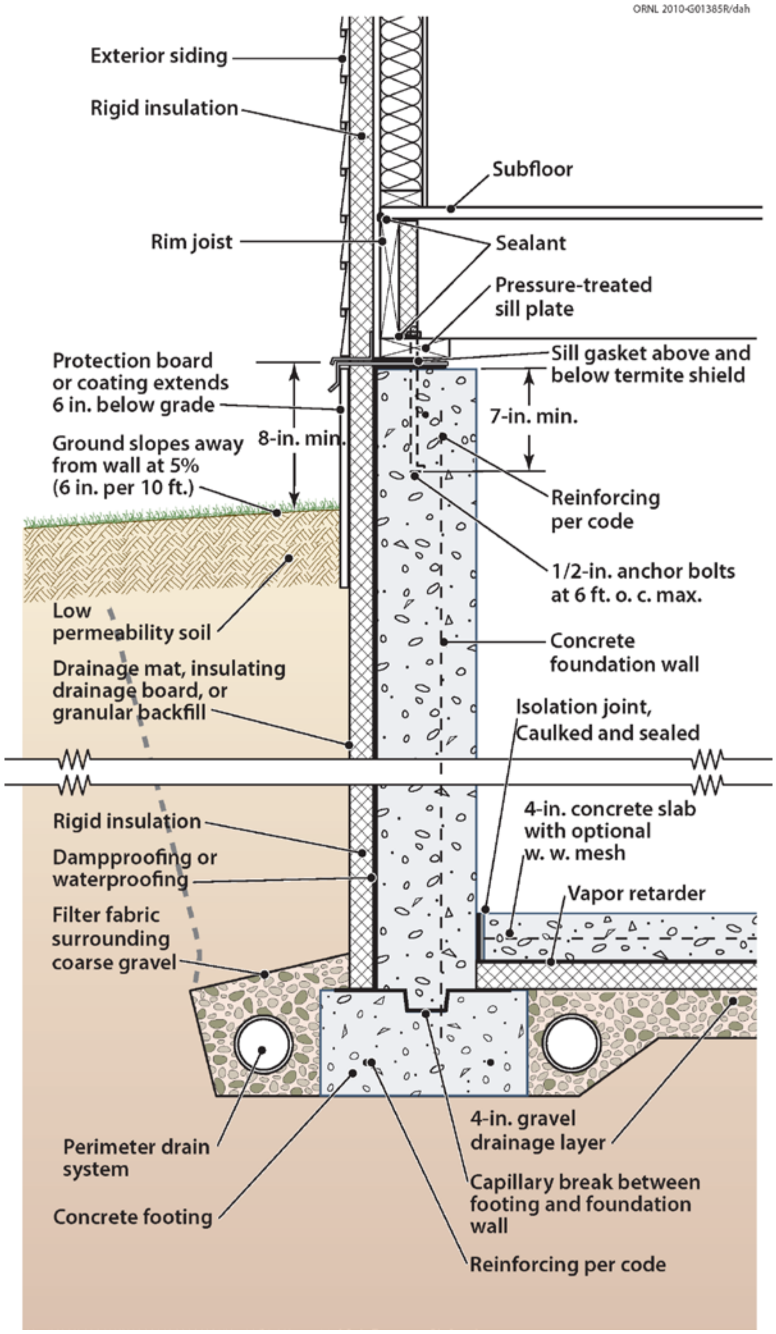
Huelman and coauthors (2012) also note that managing moisture is critical. Any additional moisture from groundwater entry, construction moisture, and capillary rise through the footing could be trapped in the foundation system. This creates opportunities for mold growth, building material degradation, and effective insulation value reduction. If interior insulation is used, the foundation should be very dry and include quality damp/waterproofing. Capillary breaks at critical junctions should be included. Basement dehumidification should be installed. Attention to effective interior air barriers is important.

Fugler (2002) reports on the occupant health risks and building durability risks associated with finishing or adding insulation to the interior of a basement with moisture problems. Those risks include toxigenic or pathogenic mold growth potentially harmful to occupants (especially children). Fugler estimates that, in Canada, 20%–50% of basements visited had moisture problems. He advises that the interior basement walls of existing homes should be left unfinished in a cold climate because, among other factors, "there is too much risk in disturbing the moisture and temperature environment that has maintained this foundation for decades." Fugler notes, however, that "if the homeowners are also prepared to add exterior drainage and insulation, interior finishing would pose no problem."

A foundation wall can also be insulated by placing the insulation in the center of the foundation wall. Although this approach is considered ideal, it is also the most expensive and most difficult to construct (Lstiburek 2006).

Lstiburek also notes that exterior insulation and insulation located on both the exterior and the interior constitute an optimal approach for moisture control. The hurdle to using either are the increased costs associated with the need for an additional layer to protect the exterior insulation during backfill and over the life of the home, insect control in termite areas, and heat loss with brick veneers (Lstiburek 2006).

Yet applying insulation to the exterior of the foundation during new home construction and implementing proper groundwater and rainwater management strategies greatly reduce the risks related to water/vapor flow and foundation wall temperature differential. The results of this approach indicate a more comfortable, durable basement environment. Figure 1, created by Oak Ridge National Laboratory, highlights the key elements for exterior insulation and water management on the foundation wall that will help achieve the BA goal of improved energy savings combined with improved building durability, indoor air quality, and occupant safety and comfort.



Note: o.c., on center

Figure 1. Illustration of exterior foundation insulation from the DRAFT Builder's Foundation Handbook created by Oak Ridge National Laboratory for the U.S. Department of Energy

2 Minnesota as a Case Study for Code Change

According to the Building Codes Assistance Project (BCAP 2012a) map of codes per state, the 2012 IECC has been adopted by only one state, Maryland, to date. Although not referenced on the BCAP map, the state of Illinois has also adopted the code (Illinois Department of Commerce and Economic Opportunity 2012). All other states and their various stakeholders have the option to adopt the 2012 IECC as is or use it to help build their own state energy codes.

The NorthernSTAR BA team, led by the University of Minnesota, has the opportunity to observe the conversations happening within the new home building industry about proposed code changes. Minnesota is an important state to study because it has not yet adopted the code but is on track to do so. Adoption, though, has brought about much discussion and resistance by stakeholders in the industry. Understanding how the state proceeds and the industry responds may be helpful in moving other cold-climate states toward adoption of the 2012 IECC and greater reductions in energy use.

Foundation insulation requirements in the 2012 IECC for cold and very cold climates represent a significant departure from existing codes and current practices. In Minnesota, for example, builders currently follow the 2009 Minnesota Energy Code adopted from the 2006 IRC. The current Minnesota Energy Code, which went into effect on June 1, 2009, includes 1322.1102 IRC Section N1102.2.6, Building Thermal Envelope, Foundation wall insulation prescriptive option and N1102.2.6.12 Foundation wall insulation performance option (Minnesota Administrative Rules 2009). These sections include details for basement foundation walls, crawlspace walls, slab on grade, and basement walkout foundation walls with exceptions listed for the southern zone of Minnesota. The following wording is specific to the foundation wall and rim joist area:

> N1102.2.6.4 Foundation wall and rim joist area thermal insulation requirements. The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

The 2012 IECC increases the R-value requirement from R-10 (or R-5 in southern Minnesota with appropriate trade-offs) found in the 2009 Minnesota Energy Code to a minimum of R-15 (continuous)/R-19 (cavity) for the entire state.

With pressure from the Builders Association of Minnesota (BAMN), the state is keenly aware of the need to ensure that the new insulation levels and language will include a solid approach to long-term moisture durability and indoor air quality. The current Minnesota Residential Energy Code incorporates specific performance criteria and prescriptive requirements governing foundation insulation, including the incorporation of a water separation plane (WSP). In general, the code stipulates that the interior side of the WSP must have a stable annual wetting/dry cycle with limited net accumulation of ice or water, prevent conditions for mold growth, and prevent liquid water rundown. The current code proposal developed at the state's request includes a definition and properties for the WSP as follows (Goldberg 2012):

> A single component or system of components creating a plane that effectively resists capillary water flow and water flow caused by hydrostatic pressure and provides a water vapor permeance of 0.1 perms or less to retard vapor flow by diffusion.

BAMN has expressed that an undesired outcome of the code change would be a reduction in the number of builders currently using exterior foundation insulation strategies (BAMN 2012). What is not known is whether builders will change their current building strategies to avoid cost increases or the design details required of thicker exterior insulation. As described in a BA report (Building Industry Research Alliance et al. 2006) "the residential construction industry is highly risk-intolerant and first-cost sensitive. Development of new systems and corresponding changes in design and the relatively low level of R&D investment further complicate construction practices by the housing industry." Today, the challenges remain substantially the same. This could result in a shift in the performance of new homes away from BA program goals described previously.

2.1 Builders Association of Minnesota Energy Code and Housing Summit

On April 3, 2012, BAMN hosted an Energy Code & Housing Summit as an open forum to discuss issues related to the adoption of the 2012 IECC (BAMN 2012). Ed Von Thoma, a member of the NorthernSTAR Building America Partnership Research Team, attended the event and disseminated notes from the presentation (Von Thoma 2012).

The overall concern presented by BAMN is that the R-value increase may pose potential challenges to design and construction as well as create a potential resistance to acceptance by the industry and the home buying markets. The three main issues of concern include durability, constructability, and cost of meeting the 2012 IECC. One of the key issues that surfaced at the BAMN meeting was whether the investment required of the home buyer is justified by the energy conservation methods and resultant energy savings.

Carey Becker, of Becker Home Building and Remodeling and a Department of Labor and Industry Residential Energy Code Advisory Committee member, presented a case study evaluating the cost to comply with the 2012 IECC. Becker provided cost data for a home he built in Minneapolis to be marketed to new home buyers. He supplied projected costs for complying with the 2012 IECC and actual costs for complying with the current code. The original home of 540 ft^2 built in 1900 was torn down and a new 1,688- ft^2 home was built to match the look and size of neighboring houses. Becker presented data indicating that meeting the 2012 IECC would increase the home cost by $7,307 with a payback on energy savings of 48.3 years based on REMRate analysis. Of the $7,307 cost, $4,000 was allocated to meeting the R-value for above grade wall insulation, which includes exterior insulation. Less than $1,000 was allocated to meeting the R-value for foundation wall insulation.

Even though the cost of meeting the 2012 IECC for foundation insulation was only $1,000, there was considerable discussion about the foundation wall requirements in the new code. The main resistance and ensuing discussion centered on the code allowance of an insulation assembly consisting of a framed wall with R-19 batt insulation installed on the interior side of the foundation wall. The concern was the potential for moisture to be trapped within the framed wall. The current Minnesota Energy Code has additional requirements for this type of assembly to reduce the potential for moisture problems. BAMN noted, however, that a builder using batt insulation and following the process to reduce moisture risk incurs added expense. The consensus was that BAMN and its stakeholders would prefer to have any language that could create nondurable systems be removed from the code. BAMN also commented that it wished to see a new code that would address the building science of both winter and summer conditions and seasonal impact on drying potential.

In regards to the R-15 requirement, BAMN expressed concern about the impact on design when creating a thicker exterior foundation wall and the concern that a split process of exterior/interior insulation to meet the R-value would reduce drying potential to the inside.

BAMN also contended that the foundation insulation requirement of R-15 continuous insulation does not provide sufficient energy savings for the cost. Association members cited a report from the University of Minnesota conducted in 2005, which determined that, based on thermal requirements, optimal foundation insulation is R-10 (Goldberg and Huelman 2005). An audience member questioned whether this optimal level would also apply to the above grade foundation walls more commonly seen in lookout and walkout foundation configurations. It was not known if any studies have been done for these configurations.

BAMN also noted a conflict in the BCAP (2012b) analysis for new single-family homes in Minnesota and the 2012 IRC Section R702.7.1, where the modeled wall assembly would not be code compliant. Association representatives also contended that BCAP analysis overestimated the energy savings and underestimated the cost of the energy upgrades. BCAP estimates that the proposed code changes would add only $2,682–$3,959 to the cost of a typical home in Minnesota (in comparison to the $7,307 from the BAMN builder study) and produce energy savings of between $848 and $925 per year, shortening the payback to 8 to 14 months (in comparison to the 48.3 years from the BAMN builder study). BAMN has requested details of the modeling assumptions from BCAP in order to study the discrepancies and differences between the BCAP work and the Minneapolis case study findings.

There were numerous audience comments throughout the BAMN presentation. Several builders suggested that different methods could have been used to meet the foundation insulation requirements and yield a significantly lower cost to achieve the code, thus reducing the payback. Some builders also challenged the assumptions used to compute building costs and expressed concerns that numbers were inflated.

Although the BAMN meeting has stimulated industry conversation and further efforts to understand costs, benefits, and risks, a number of media representatives invited to the BAMN meeting presented their view of the outcome with article headlines reading “Local View: If New Building Codes Arrive, Prices Will Rise” (*Duluth Tribune News* 2012); “Builders Balk at Cost of Proposed Code Changes” (Johnson 2012); and “Minnesota Builders Warn Energy-Code Changes Would Raise Prices of Homes” (Dornfield 2012).

2.2 Minnesota Building Performance Association Energy Forum—Spring Edition

On June 12, 2012, the Minnesota Building Performance Association (MBPA) hosted the MBPA Energy Forum—Spring Edition to discuss the 2012 IECC and its impact on the residential building industry. Cindy Ojczyk, NorthernSTAR Building America Partnership Project Team member, attended the forum and disseminated notes from the event (Ojczyk 2012).

The goal of the MBPA meeting was to extend the stakeholder conversation that BAMN began by presenting additional cost estimates, energy savings calculations, and case studies of successful projects that meet the 2012 IECC.

The forum began with a presentation by Isaac Elnecave of the nonprofit Midwest Energy Efficiency Alliance, which represents 13 midwestern states. His presentation highlighted the recent adoption of the 2012 IECC by Illinois, making it the second state to adopt the new energy code. The adoption of the 2012 IECC by Minnesota would be important for influencing the other 11 midwestern states that either have no state energy code or follow codes from 2009 or earlier. Minnesota is also unique to follow because it covers two climate zones and has adapted the energy code in the past to account for temperature differences across the state. Elnecave reiterated that the 2012 IECC does require a blower door test be performed in every new home, and each new home must meet an air leakage rating of less than 3 air changes per hour at 50 Pascals. This requirement for a blower door test is also seen as a hurdle because it adds an additional cost (estimated $150) to the project as well as additional time for scheduling.

Paul Morin of MPBA reviewed data computed by two Minnesota home builders that compared the savings and costs to meet the 2012 IECC in one home with two basement options—a walkout and a full basement. The total cost for the upgrades to meet the 2012 IECC in the home with the walkout option was computed to be $2,122 for an annual energy savings of $280. The total cost for the home with the full basement option was $2,362 with an annual energy savings calculated at $270.

Pat Huelman, team lead for the NorthernSTAR Building America Partnership, presented four drawings of foundation insulation systems that represent robust methods that would meet the 2012 IECC and potentially comply with the foundation performance criteria in the 2009 Minnesota Energy Code. These four drawings were based on best practice building science information from research conducted at the University of Minnesota as well as best practice measures promoted by BA. The goal of the presentation was to address the durability concerns expressed at the BAMN meeting by offering best practice solutions to increasing R-value while attending to building durability, air quality, insulation quality and performance, and constructability. The four solutions also represent the four foundation wall insulation approaches – exterior, interior, both interior and exterior, and in the middle - while indicating the best methodology to reduce risk.

These four solutions, however, do not represent all of the possible foundation wall insulation strategies that could be conceived based on the code. Because the energy code does not include or exclude specific materials or dictate where insulation must be placed on the foundation wall, many more solutions exist to meet the R-value requirements of the code. Yet not all systems are equally robust and will not equally minimize building durability risk while maximizing energy performance. And given that the moisture performance requirements for the proposed Minnesota code were still under development, only the most robust systems were presented to the MBPA audience.

Huelman also mentioned that Louise Goldberg, a NorthernSTAR Co-principal investigator with the University of Minnesota, is under contract with the Minnesota Department of Labor and Industry and the State of Minnesota to conduct a "due diligence" review of the proposed code language. Goldberg's task is to evaluate the entire range of foundation insulation materials and strategies to ensure compliance with the original performance criteria set out in the 2009 Minnesota Energy Code.

Figure 2 shows the first solution presented by Huelman. It is a foundation wall with insulation in the center, which is considered ideal, but most difficult to construct. Achieving the required R-value for the 2012 IECC is a matter of increasing the thickness of the insulation. Because the concrete on the exterior foundation serves as the protective barrier to the insulation, no further protection is needed. The additional elements that make this strategy robust—waterproofing, perimeter drainage systems, capillary break, slab drainage, air sealing, vapor and moisture management, sloped grade, and flashing—maximize building durability.

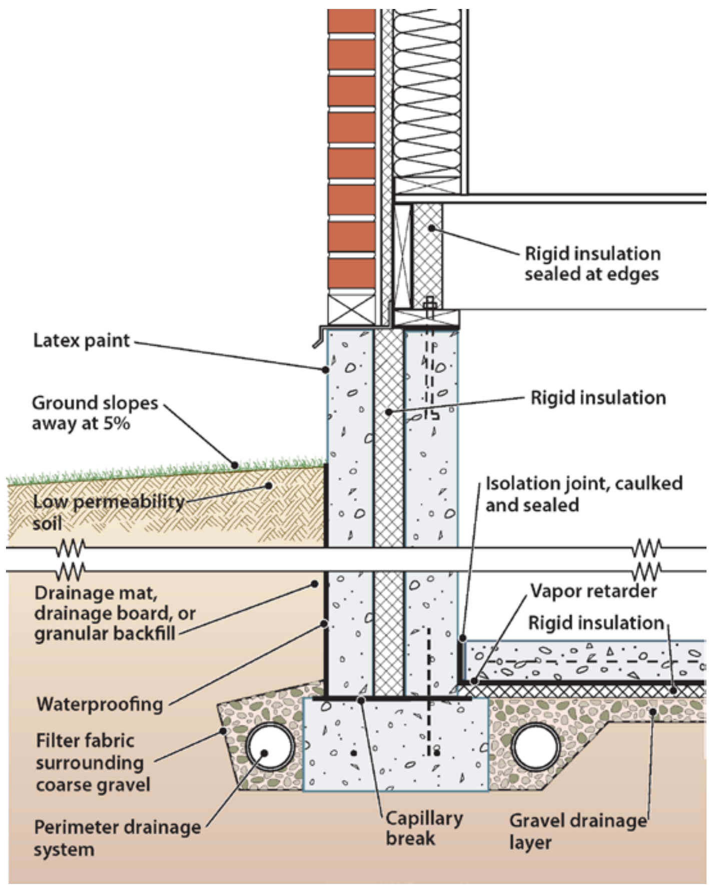


Figure 2. Cast-in-place concrete foundation wall with integral rigid insulation

Figure 3 is a foundation wall with insulation on the exterior. Huelman stated that it is considered one of the most universal systems because it can work for both cast-in-place concrete and concrete masonry foundation walls. Achieving the required R-value for the 2012 IECC is a matter of increasing the thickness of the insulation. The exposed insulation on the exterior foundation requires a protective board or coating to maintain the integrity of the exterior insulation. The additional elements that make this strategy robust—waterproofing, perimeter drainage systems, capillary break, slab drainage, air sealing, vapor and moisture management, sloped grade, and flashing—maximize building durability. The details for aligning above and below grade insulation, which address the constructability concerns expressed by the builders in the BAMN meeting, are also given in Figure 3.

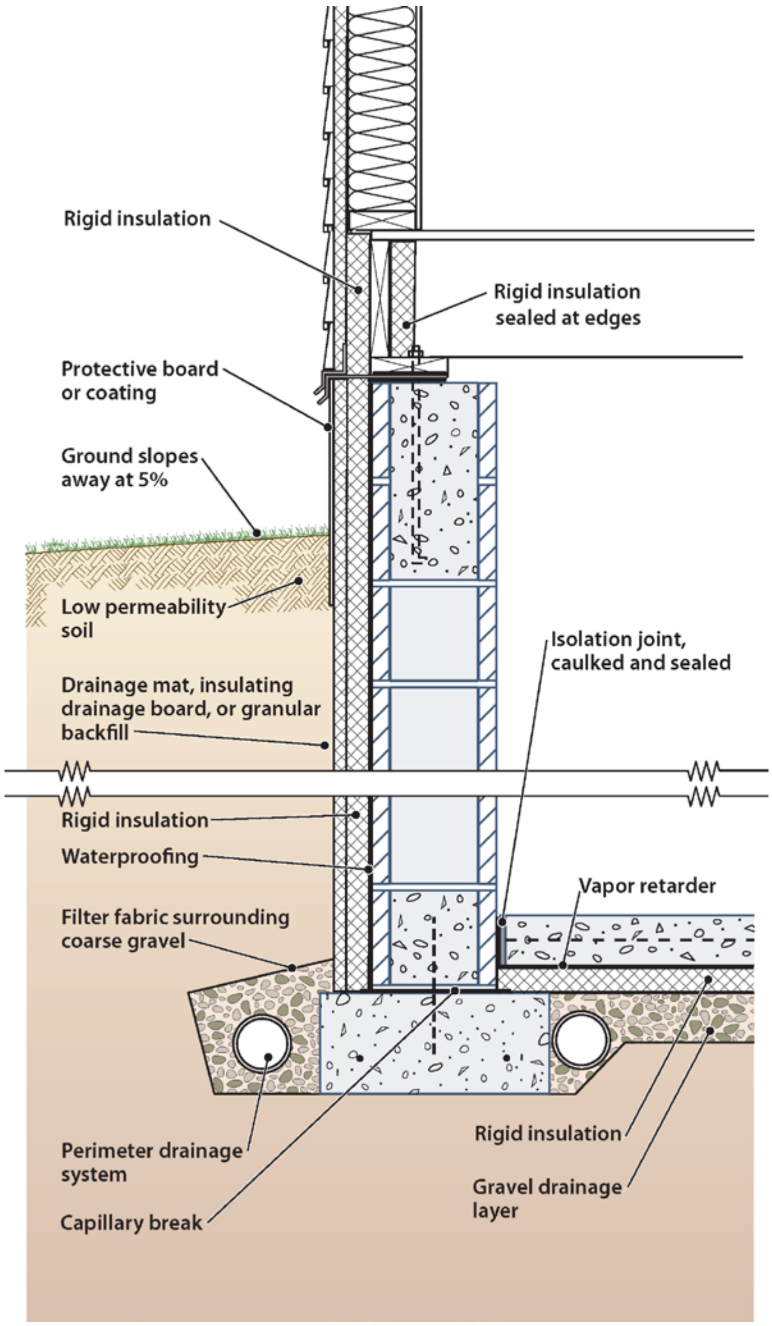


Figure 3. Concrete masonry foundation wall with exterior rigid/semi-rigid insulation

Huelman noted that a foundation wall with insulation on the exterior and interior has been made possible and easier to attain using insulated concrete forms where the structural concrete is poured in between the insulation as shown in Figure 4. A protective board or coating is needed to maintain the integrity of the exterior insulation and a thermal barrier is usually required on the interior for fire safety. The additional elements that make this strategy robust—waterproofing, perimeter drainage systems, capillary break, slab drainage, air sealing, vapor and moisture management, sloped grade, interior finishes, and flashing—maximize building durability. The details for aligning above and below grade insulation are also shown in Figure 4.

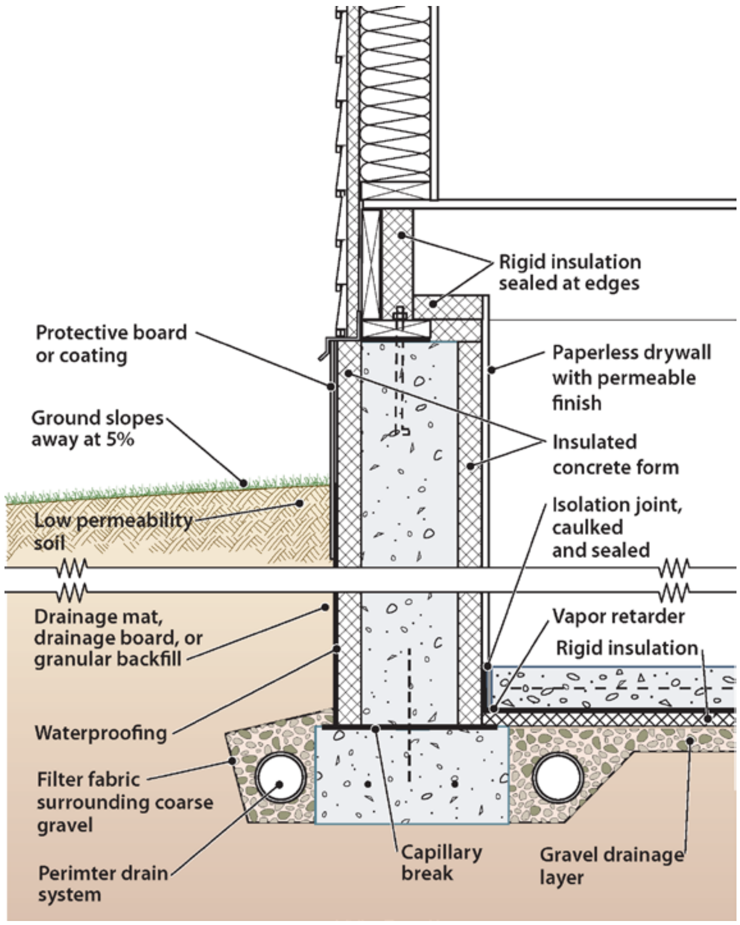


Figure 4. Cast-in-place concrete foundation wall with insulated concrete forms

A robust foundation wall system with insulation on the interior can be achieved by following very specific air sealing and moisture management details to reduce the risk of moisture migration that can result in building rot, loss of integrity, or mold growth. Huelman presented Figure 5 to show how a cast-in-place concrete foundation is used to minimize bulk water movement through the walls. Exterior and interior waterproofing, perimeter drainage systems, capillary break, slab drainage, air sealing, vapor and moisture management, sloped grade, interior finishes, and flashing maximize building durability by attending to bulk water and vapor management. Closed cell spray foam insulation applied along the full height of the wall and the rim maximizes R-value and air sealing opportunities. A hollow-framed wall allows for air flow behind the paperless drywall to enable any drying to the interior. In some cases, the foam thickness may need to exceed the R-15 thermal requirement to successfully meet the vapor permeability requirements in the Minnesota code.

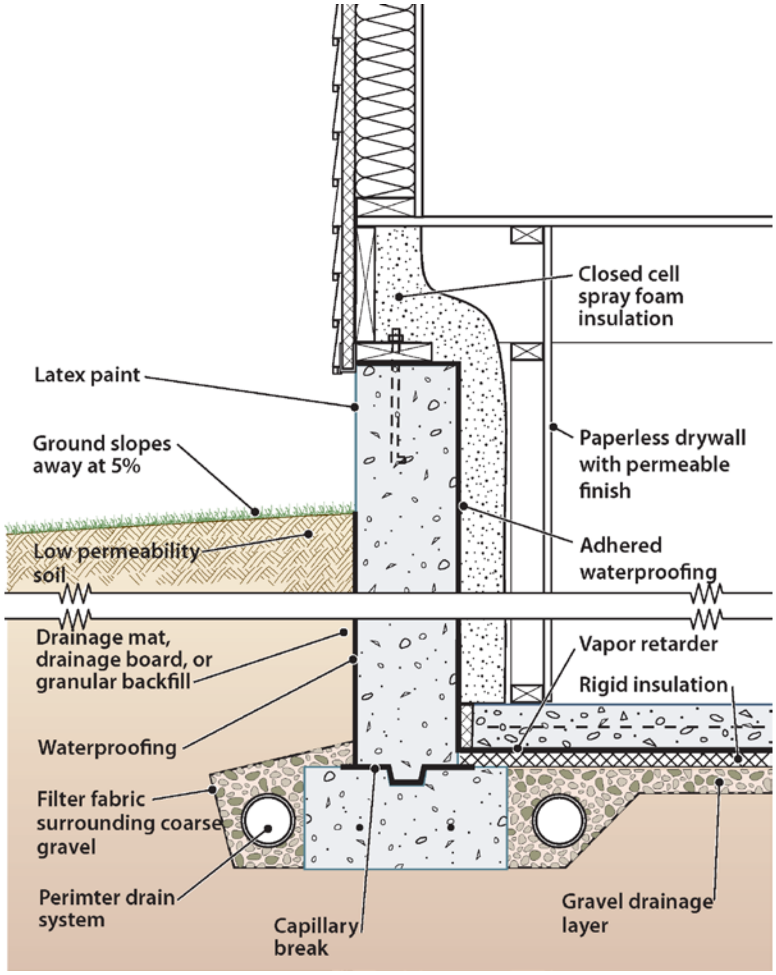


Figure 5. Cast-in-place concrete foundation wall interior closed cell spray foam insulation

At the end of the MBPA program, time was allocated to address questions from the audience. One audience member was interested in seeing cost data for building a home with the four robust foundation insulation strategies presented by Huelman. Several additional audience members requested access to the foundation insulation strategy drawings. There was a question about design details when using exterior foundation insulation and the transition where above grade materials meet below grade materials. Huelman referred back to the slides showing exterior insulation to point out the details. Another question centered on insulation grade requirements in the code. Elnecave answered that although the code does not require insulation installation to meet a certain grade, how well or how poorly insulation is installed could affect the final blower door test and might have an impact on occupant comfort, putting a builder at risk for a callback. When asked why batt insulation is still allowed in the code, the audience was reminded that the energy code does not and cannot recommend or exclude specific products. It only makes provisions for R-value.

3 Baseline Foundation Insulation Strategies of New Home Builders in Minnesota

The BAMN discussion on the risk of using batt insulation to meet the code highlights the shifting stakeholder attitudes about insulation. There is a greater understanding that energy efficiency and building durability are affected by factors beyond the R-value of the insulation. Efforts by the building science community to communicate the benefits of exterior foundation insulation have resulted in more cold-climate builders adopting an exterior approach. There is a risk, however, that the builders using exterior insulation strategies will return to interior foundation strategies if they feel that material costs or design challenges will become greater as the R-value increases. There is also a risk that perceived cost increases and difficulty of design integration will keep other builders from moving to exterior insulation practices.

The NorthernSTAR Building America Partnership team was interested in gauging the attitudes of new home builders in Minnesota on the proposed code changes. Specifically, the team was interested in knowing how the 2012 IECC foundation changes for cold and very cold climates would affect decisions of residential builders with respect to foundation insulation type and insulation location. Market-ready solutions improve efficiency only when they are adopted by the industry and accepted by consumers. The builder questionnaire given in Table 1 was intended to promote conversation and identify issues related to the residential construction industry's willingness to embrace advances in construction processes and practices.

NorthernSTAR industry partners selected 18 contractors to participate in a telephone questionnaire. These 18 were predominantly high-end custom builders already following above-code building practices. Ten builders were able to give answers, and Table 1 presents the results.

The answers indicate a movement away from fiberglass batt insulation to continuous foam board products installed on the interior, exterior, or a combination of interior and exterior. No builders reported that they would change the location of their insulation as a result of the increased R-value requirement. All builders reported being satisfied with their current foundation insulation strategy and said they would prefer to continue using it. It should be noted, though, that several of these current practices meet the prescriptive language in the current 2009 Minnesota code, but they may not meet the moisture performance criteria in the current or proposed code language.

Only two builders were concerned with design details that might arise when exterior foundation insulation is increased to meet code. These builders, however, would still prefer to apply insulation on the exterior instead of the interior.

The concerns about code changes were consistent with those raised at the BAMN meeting. The builders that responded to the questionnaire were concerned that other builders in the state could continue to use batt insulation and experience moisture and durability issues as a result. It is important to note that the sample size of 10 builders is small compared to the number of licensed builders in the state.

Table 1. Builder Responses to Proposed Foundation Insulation Code Change Questions

Builder	What is your current foundation insulation and waterproofing strategy?	If code changes require continuous R-15 (interior, middle, or exterior) or R-19 cavity, what would be your likely insulation approach?	Why?	Are you in agreement with this possible code change? If not, what are your concerns about it?
A	Thermax R-10	Continuous interior	Like the performance and installation of interior insulation	Going backward with cavity insulation, potential moisture issues
B	Thermax	Continuous interior	Doesn't like fiberglass	Condensation on the poly
C	Thermax	Continuous interior	Too hard to manage backfill on exterior	Durability/moisture if using batts
D	Warm and dry basement	Continuous exterior	Prefer to insulate at exterior	Prefer to insulate at exterior
E	Warm-n-Dri R-10, with 2-in. foam on interior	Will use current system - interior	Warm and dry basement	None
F	Warm and dry basement	Continuous exterior	Easier to install on exterior	Moisture issues with cavity insulation
G	R-10 rigid foam exterior	Continuous exterior	Prefer to insulate at exterior	Detailing where foundation insulation meets exterior wall
H	10 R-value exterior continuous and 10 R-value interior rigid foam board	Continue with current practice, if this doesn't meet code will consider insulating concrete forms	Provides value to clients	None
I	5 R-value exterior continuous rigid foam	Continuous exterior	Prefer to insulate at exterior	Detailing where foundation insulation meets exterior wall
J	Exterior liquid applied membrane, capillary break at footing, exterior drain tile, exterior rigid insulation R-10	Exterior	Cost and performance is optimal	No. Changes are intended to achieve a particular result and the results desired are not completely related to the code change. There are other factors that are more complex related to foundations and insulation that require a more comprehensive approach to each situation. Testing and verification are needed.

4 Conclusions and Further Work

As the BA program targets greater energy efficiency levels in homes, builders are interested in being able to deliver greater energy efficiency to their customers. Yet adoption of the 2012 IECC—designed to deliver the increase energy efficiency in homes—has met resistance in cold-climate states: only two states have embraced the new code. The conversations being held by stakeholders in Minnesota indicate that builders have a variety of concerns about adopting the new code. In regards to foundation insulation, cost versus energy savings, constructability, and durability are the top three issues.

The durability concerns indicate a misunderstanding about the role of energy code. Stakeholder resistance to code change has centered on batt insulation and potential moisture issues. Builders are unaware that code cannot mandate or exclude products, nor does it address all building science strategies to ensure a safe, durable building. The stakeholder meetings indicate that there is a general lack of awareness about resources available to help builders and design professionals integrate code mandates with strategies to ensure building durability. This gives the BA program an opportunity to promote its existing best practices and measure guidelines for durable foundation wall systems. The survey of builders also shows that once a builder moves to a higher level of performance, they grasp an understanding of the benefits that makes reverting to previous strategies undesirable.

Code recommendations need to be framed in the context of the building culture and climate. Many cold-climate homes, especially those in the Midwest, are not just full-depth foundation wall systems. Some have lookout walls, walkout walls, and combinations. It is not known how the presence of two or more wall types affects effective R-value, hygrothermal performance, and durability. Although exterior insulation strategies could effectively address concerns, moving builders toward adopting them might require proof of effectiveness and detailed information on how to construct exterior insulation in a low-risk, cost-effective manner.

Builders are also seeking strategies to protect foundation walls from both summer and winter conditions. Exterior insulation strategies may be the recommended strategy from a building science perspective, but builders are looking for proof that the process will be effective and deliver the energy savings for the added costs. The BA program could help alleviate constructability concerns by making available detailed foundation insulation drawings that would help builders understand how to address design impacts of thicker wall insulations under varying insulation strategies.

The greatest concerns for adoption of the code, as voiced by stakeholders, center on proof of actual energy performance, costs, and payback. Minnesota stakeholders are seeking to understand the value of embracing proven cost-effective advances in product and process technologies before they sell this value to home buyers. The current energy code is based on R-10 (or R-5 with trade-offs in southern Minnesota) foundation insulation and builders are seeking data to prove that increasing to R-15 will provide cost-effective energy performance. The BAMN case study produced different cost/payback data than the BCAP and MBPA case studies, further enhancing the confusion in the industry.

BA has many opportunities to help builders over the hurdles of understanding durability, constructability, and cost versus energy performance for foundation insulation in regards to the 2012 IECC. BA data and expertise can help offset the negative media reports that surfaced after the industry summits. Disseminating supportive data and detailed drawings will help to build industry and consumer confidence and engage more states in the adoption of the 2012 IECC for new homes.

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