

Expert Meeting Report: Foundations Research Results

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NorthernSTAR

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Contents

List of Figures	v
List of Tables	v
Definitions.....	vi
Executive Summary.....	1
1 Background.....	2
2 Meeting Information	3
3 Meeting Objectives and Agenda	4
3.1 Research Questions	4
3.2 Agenda	4
3.3 Presenter Biographies	5
4 Presentation Summaries	6
4.1 Pat Huelman: Foundation Insulation for New and Existing Homes	6
4.2 Louise Goldberg: 30+ Years of Foundations Research at the U of MN.....	7
4.3 Kohta Ueno: Hybrid Foundation Retrofits	10
4.4 Pat Huelman: Presentation of Slides Provided by Philip Fairey of the Florida Solar Energy Center – Flexible Residential Test Facility	13
4.5 Jeff Christian: Foundations Research Ongoing at ORNL.....	13
5 Panel and Group Discussion To Cover Key Questions and Action Items	15
References.....	17

List of Figures

Figure 1. Comparison of thermal integrity factor of control home to a variety of housing styles	8
Figure 2 . Energy performance summary of masonry block test foundations compared to reference poured wall foundation.....	9
Figure 3. BSC-recommended process for insulating wet basements with uneven walls	11
Figure 4. BSC insulation detail for basement that is not typically wet	12

Unless otherwise indicated, all figures were created by NorthernSTAR.

List of Tables

Table 1. Expert Meeting Participants	3
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Definitions

BSC	Building Science Corporation
DOE	U.S. Department of Energy
FTF	Foundation Test Facility
IAQ	Indoor air quality
NREL	National Renewable Energy Laboratory
ORNL	Oak Ridge National Laboratory

Executive Summary

The NorthernSTAR Building America Partnership held an expert meeting on Foundations – Research Results on November 15, 2011 at the University Hotel Minneapolis on the campus of the University of Minnesota in Minneapolis. Featured speakers included Pat Huelman of the University of Minnesota, Louise Goldberg of the University of Minnesota, Kohta Ueno of Building Science Corporation (BSC), and Jeff Christian of Oak Ridge National Laboratory (ORNL). Audience participation was actively encouraged during each presentation to uncover needs and promote dialog among researchers and industry professionals. Key results were:

- Greater understanding of the role of moisture transport through foundation and insulation materials and its potential impact on building durability
- Greater understanding of the role of foundation type in the process of selecting an insulation system for energy performance and building durability
- Need for research to quantify the risks associated with insulation processes to better enable users to weigh costs and benefits against the existing conditions of a home
- Need for improved performance modeling capabilities that address variations in foundation types and soil conditions.

Many laboratories and researchers have been investigating the role of the foundation in building energy and durability for more than 30 years. Yet, the complicated nature of foundation systems, costly financial investment for proper monitoring, and lengthy process for proper research have left many holes in the research and many questions about best practices unanswered. Below-grade heat transfer models are crude and cumbersome, and there are no validated below-grade hygrothermal models.

The growing cultural focus on energy efficiency and homeowner desire to expand living space to the basement create an urgency for good, usable information on best practice strategies for insulation systems, especially for existing homes. Researchers may understand the risks that foundation insulation poses to the home and the occupants, but most contractors and homeowners do not share that understanding. Numerous manufacturers promote their products and systems as energy efficient. They have become the voices of authority with few data to back up their claims and little acceptance of liability for failure.

The next step is to define research projects that address the needs uncovered in the Foundations Expert Meeting.

1 Background

A home's foundation, much like the base of a pyramid, is one of the most important contributors to a home's integrity and longevity. Although much attention has been paid to insulation as a strategy for improving energy efficiency in walls and ceilings, little research has been aggregated on foundation insulation systems and the impact they may have on energy performance and building integrity. The variety of foundation systems in new and existing homes—full walls, lookout walls, walkout walls, crawlspaces, slabs, and combinations—complicate the process of creating one perfect insulation system to meet the needs of every home.

Foundations experience less impact from temperature changes than do above-grade walls; nevertheless, foundation heat loss for new and existing homes can be significant. The surface areas of foundations can be fairly large, and the above-grade part of a foundation can be significant, especially in older homes. Foundation insulation could therefore provide a viable and cost-effective means for achieving significant envelope conservation for new and retrofit applications.

The principal drawback to these spaces that are surrounded by soil and experience above-grade conditions is hygrothermal durability. Without a thorough understanding of the underlying moisture transport mechanisms, it is easy to design and deploy foundation insulation systems that can cause significant distress and financial cost for homeowners.

The primary question is whether consensus can be built on the value of foundation insulation as a cost-effective and durable energy conservation measure, especially in cold climates. Additional investigation needs to address potential areas of research that can yield cost-effective returns in increased foundation energy savings and identify systems with full life cycle durability.

2 Meeting Information

The NorthernSTAR Building America Partnership held an Expert Meeting on Foundations – Research Results on November 15, 2011 at the University Hotel Minneapolis on the campus of the University of Minnesota in Minneapolis. There were 29 participants in attendance. Sixteen participants listened via webinar. They were leading researchers, government program managers, and industry experts covering the areas of foundations, insulation, waterproofing, drainage, building enclosures, residential design, engineering, construction, and energy efficiency.

Four presenters provided overviews of technologies and issues associated with new and existing foundations. Lively discussion and participation occurred during each presentation; a wrap-up discussion was held at the end of the session. A list of participants is included in Table 1.

Table 1. Expert Meeting Participants

Name	Organization	Email Address
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* National Renewable Energy Laboratory

3 Meeting Objectives and Agenda

The objective of the half-day meeting was to bring together foundation experts from Building America teams and other related programs and research activities to share information and determine future research issues and needs. Foundation heat loss represents significant opportunities and challenges for new and existing homes. Likewise, foundation insulation will be a critical need in cost-effectively meeting the Building America energy targets. What cannot be ignored, however, is hygrothermal durability and moisture transport systems that may impact the integrity of foundation walls and adjacent building materials, as well as indoor air quality (IAQ). The meeting was designed to be interactive to promote questions and the sharing of experiences to inform the experts from research and industry.

3.1 Research Questions

The NorthernSTAR Partnership raised the following questions as a means to guide the presenters and to stimulate conversation and questions from the attendees:

1. What experimental data are available to characterize the energy performance, hygrothermal behavior, and long-term durability of foundation insulation?
2. What are some of the current challenges for optimizing foundation insulation levels and materials for new and existing homes?
3. Is it possible, or even preferable, to use nonuniform R-values or treatments to optimize below-grade energy performance?
4. How far can existing ground-coupled heat transfer models take us to answer questions 2 and 3?
5. Do we sufficiently understand the tradeoffs, costs, and risks associated with various foundation insulation choices (types, designs, materials, etc.)?
6. What limitations are there with current tools and techniques for the evaluation of hygrothermal transport phenomenology of building foundations?
7. How far can existing hygrothermal models (if any) take us to answer questions 4 and 5?
8. Based on research and field experience, what are current best practices for basements, crawlspaces, and slab-on-grade foundations?

3.2 Agenda

Weather-related travel issues required that the initial agenda be adjusted at the last minute when two speakers were not able to attend. The following agenda represents the speakers who presented during the Expert Meeting:

- | | |
|------|---|
| 8:30 | Welcome and Meeting Introduction – Huelman and Booten |
| 8:45 | Pat Huelman: Foundation Insulation for New and Existing Homes |
| 9:00 | Louise Goldberg: 30+ Years of Foundations Research at the University of Minnesota |
| 9:45 | Kohta Ueno: Hybrid Foundation Retrofits |

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- | | |
|-------|---|
| 10:30 | Break |
| 10:45 | Pat Huelman presentation of slides provided by Philip Fairey of the Florida Solar Energy Center – Flexible Residential Test Facility (presented by Pat Huelman) |
| 11:00 | Jeff Christian: Foundations Research ongoing at ORNL |
| 11:30 | Panel and Group Discussion to Cover Key Questions and Action Items |

3.3 Presenter Biographies

Pat Huelman is an Associate Professor of Residential Energy and Building Systems with the University of Minnesota's Department of Bioproducts and Biosystems Engineering and serves as coordinator of the Cold Climate Housing Program with the University of Minnesota Extension. He is the lead faculty member for the Residential Building Science and Technology undergraduate degree, a principal investigator for hygrothermal testing at the Cloquet Residential Research Facility, and directs the new NorthernSTAR Building America Team. With more than 30 years in the field, Pat has extensive experience and expertise in energy-efficient design, innovative building systems, residential IAQ, mechanical ventilation, and moisture management.

Louise Goldberg obtained B.Sc, M.Sc, and Ph.D degrees, all in Mechanical Engineering from the University of the Witwatersrand in South Africa. Currently she holds a part-time appointment at the University of Minnesota in the Department of Bioproducts and Biosystems Engineering as a senior research associate and director of the Energy Systems Design Program. She is also the principal of Lofrango Engineering, an engineering and applied physics intellectual property development enterprise. During her tenure at the University, Louise has been a principal or co-principal investigator on 29 funded research projects and published over 30 refereed research papers and articles as well as numerous other articles and reports. She has amassed more than 30 years of experience in the field of building physics.

Kohta Ueno (M.A.Sc.) is a senior associate of BSC. His responsibilities include project management; liaison work with builders and industry clients; heating, ventilation, and air conditioning design; energy analysis of house designs; computer modeling; field testing and verification; and forensic field investigations. He has been with BSC since 1998, and completed his Master's degree with the Building Engineering Group under John Straube at the University of Waterloo in 2007.

Jeff Christian is a researcher at ORNL. Jeff's research spans deep residential retrofits; low-energy residential and commercial buildings; advanced appliances; moisture control in buildings, roofs, walls, and foundation; cooling, heating, and solar power integrated systems; and whole-building design and performance. Since 2002, he has focused much of his research effort on building systems integration.

4 Presentation Summaries

Four presentations were given by industry experts describing current foundation issues, research, products, and tools for new construction and existing homes. Active discussion was encouraged throughout each presentation to uncover questions and concerns experienced by the attendees. Comments and questions posed by the attendees as well as presenter responses are inserted in the summaries in italics to help the reader understand the dynamic exchange of information.

4.1 Pat Huelman: Foundation Insulation for New and Existing Homes

Mr. Huelman opened the complex foundation discussion by framing the opportunities and obstacles to foundation insulation. Data show that there are many uninsulated foundations in cold climates. Data also show that many homeowners are seeking ways to insulate basements to transform them into living spaces or to insulate crawlspaces and slabs to make the rest of the home more energy efficient and comfortable. Many homes were built at a time when foundation insulation was not included as part of the construction package. Data also show that in certain cold climates new homes are still being built without foundation insulation.

Although foundations experience less impact from temperature changes than do above-grade walls, foundation heat loss can still be significant for new and existing homes: The surface areas can be fairly large, and the above-grade part of a foundation can be significant, especially in older homes. The large stock of uninsulated foundations provides great opportunities to improve total energy efficiency and comfort in the U.S. housing stock and provide job opportunities for professionals.

Given all the reasons why it is important to improve energy efficiency and comfort, there are many obstacles to insulating foundations in existing homes:

- Lack of waterproofing, capillary breaks, and drainage at the footing provides opportunities for water intrusion and its potential negative impact on insulating value, building material durability, and IAQ.
- Current foundation modeling programs are limited and do not consider hygrothermal impact, temperature variation, or foundation type. Applying one modeling technique to predict performance is difficult, because foundation walls almost 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 and design:
 - The above-grade part of a foundation can be extremely cold in winter.
 - The bottom part of the foundation wall can be below the dew point in summer.
 - There are many different types of foundations—slabs, crawlspaces, full-foundation walls, walk-out walls, sloped walls, garden/look-out walls.
- Because foundations are connected with the ground, they must dry inward. Interior insulation systems, however, can limit inward drying potential of bulk water and vapor, resulting in wet or damp foundation walls and insulation.

- Exterior insulation is preferred over interior insulation because of its superior drying potential; however, there are reasons why it is not widely used on existing homes:
 - A buried foundation is extremely difficult to insulate because of backfill, landscaping, and utility connections to the home.
 - Interior insulation systems are widely available and promoted in the marketplace making it easy for contractors and homeowners to understand what they are buying even if few or no data are available to verify manufacturers' claims.
- Although researchers understand the risks of interior foundation insulation, the lack of data and proof make it difficult to quantify those risks for homeowners or contractors.

To advance the understanding of foundation insulation systems and of user motivation for selecting a foundation insulation system, and to improve the capability of performance modeling programs, the NorthernSTAR Building America Partnership will conduct three related research projects:

- Investigate the impact of the new 2012 International Energy Conservation Code changes for basement insulation on cold climate builders. Will an increase to an R-value of R-15/R-19 result in builders—who are currently using exterior insulation systems—returning to interior insulation systems that are easier to install and less expensive than their exterior counterparts?
- Conduct insulation testing at four insulation levels in three climate zones to expand current below-grade heat transfer modeling capabilities to include limited hygrothermal evaluation.
- Conduct a research review on products and methods used in other industries for their potential use in the residential building industry to improve the efficiency and cost of installing exterior insulation on existing homes.

Comment: Cable and utility companies use methods that do not require the use of backhoes. Has this been explored?

Response: It is one area we will review once research begins.

Mr. Huelman concluded by posing the following statement: “To meet the Building America goals of “do no harm” and to cost-effectively achieve improved energy efficiency and durability, the question that remains to be answered is: What is the risk of uncontrolled dampness and mold growth behind interior insulation systems? If interior insulation systems meet the goal for cost-effective installation, what is their impact on materials, building performance, energy efficiency, and IAQ?”

4.2 Louise Goldberg: 30+ Years of Foundations Research at the U of MN

Dr. Goldberg had the arduous task of summarizing more than 30 years of foundations research in a 45-minute presentation. The University of Minnesota began its tenure in foundations research in 1981 to help the Minnesota Housing Finance Agency evaluate the energy performance of occupied earth-sheltered homes, which the industry was promoting as highly energy efficient.

The control house was constructed of an above-grade “super-insulated” R-19 wall, crawlspace, and passive solar Trombe wall. Its energy performance was compared to five earth sheltered homes and other residential housing styles. Figure 2 provides the results of the study.

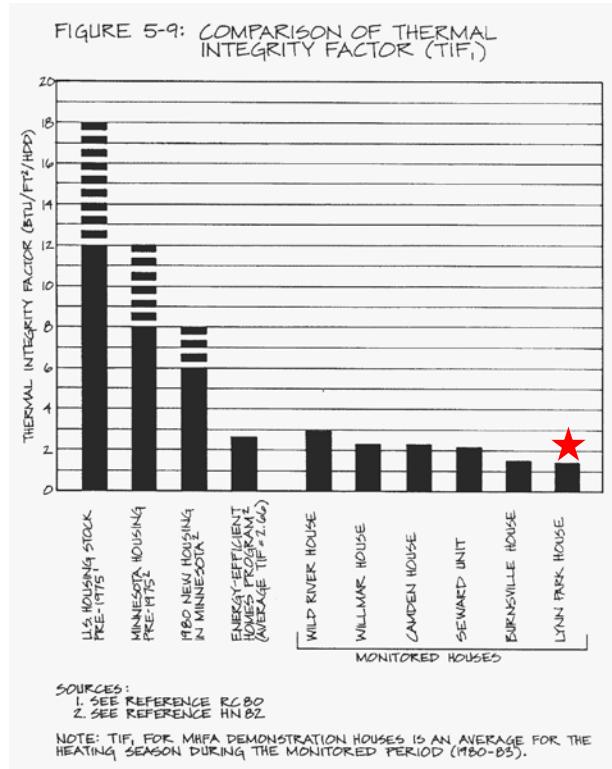
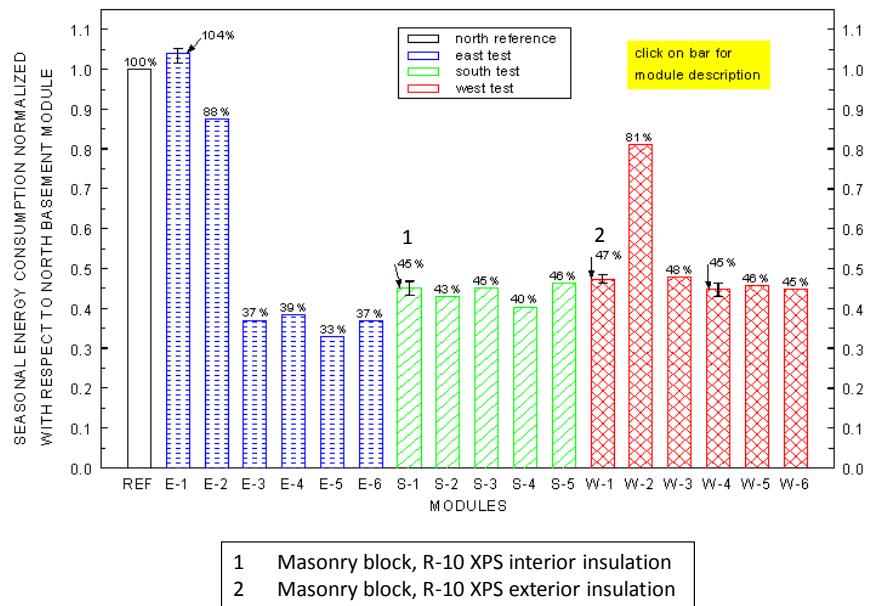


Figure 1. Comparison of thermal integrity factor of control home to a variety of housing styles

The R-19 super-insulated control home (red star) outperformed a variety of home styles, including the earth-sheltered homes and those in an energy-efficient homes program. The results did not favor the widely held theory that earth-sheltered homes were the most energy-efficient building strategy.

In 1987 the Foundation Test Facility (FTF) was built by the University in Rosemount, Minnesota, as a project for the U.S. Department of Energy (DOE). It was originally intended to be used for four years but continued operating for 18 years. There were six total modules on site—four foundation modules, a slab-on-grade module, and a frost-protected shallow foundation module. The original goals were to demonstrate, through rigorous experimentation, that foundation insulation could save energy, and to provide data to calibrate energy simulation programs. Although the data were never used for energy simulation programs, Figure 3 provides data on energy performance that were collected over 10 years.



Energy performance summary, 1988-1999

Figure 2. Energy performance summary of masonry block test foundations compared to reference poured wall foundation

The reference module was a poured concrete foundation with no insulation or waterproofing. The test modules were foundations made of masonry block. Wall E-1 is an uninsulated, open-core block wall that is demonstrating energy consumption greater than the uninsulated reference poured concrete wall. The research found that open cores create convective loops because of the temperature differential at the top of the foundation wall versus the bottom. Wall E-2, however, is an uninsulated block wall where the cores have been filled with a lightweight aggregate to prevent convective loops. The results show a 16% energy performance improvement when the cores are filled but the block remains uninsulated. This result provides an opportunity to explore the potential for energy improvement in hollow core block walls by filling the cores without the expense of insulation.

Dr. Goldberg demonstrated that insulation strategies are complex and depend on the type of foundation wall and position of the insulation. Although the walls represented by the green and red bars indicate that adding insulation either on the exterior or interior helps improve energy performance compared to the reference wall, hollow core walls create convective loops that pose a durability risk at the rim joist brought on by moisture transport from the convective loops. The value of exterior insulation installed over hollow core masonry blocks is that exterior insulation reduces the temperature differential in the block and thus reduces convective loops, moisture

transport, and durability risk. Because most of the existing housing stock is constructed with hollow core masonry block, the balance of energy performance, insulation position, and moisture transport must be considered.

The complexity of foundation insulation is further increased when the issue of moisture transport through insulation is considered. The test modules showed that varying degrees of condensate were removed from the wall/insulation configurations over 10 years of collecting data. Condensate collected from the insulation actually increased in some as the insulation aged.

Additional testing done at the FTF for product manufacturing clients revealed that condensate quantities and wetting/drying potential were also impacted by the vapor retarder and the solar orientation of the wall, which further complicated performance modeling.

In 1997, while the FTF was still operating, the University built the Cloquet Residential Research Facility to focus research on the impact of foundation insulation systems on the rim joist. The most important point made by Dr. Goldberg from the research is that hollow core concrete masonry blocks enhance vapor transport to the rim and care must be taken to reduce convective loops and water/vapor intrusion.

Dr. Goldberg's work has been used to develop the whole-building energy simulation Shen/DOE 2.1 algorithm for energy calculations that were used for the 1988 Foundations Handbook. She also used her research to create BUFETS revision A, BUFETS revision B/EnergyPlus integration algorithm revision A, the Minnesota Quantification Tool (unified solution of ground and building temperature fields), and 2011: BUFETS revision B/EnergyPlus integration algorithm revision B.

Her work was instrumental in the development of the Foundations Rule in 2009 Minnesota Energy code. In the rule, a performance option for insulation could be followed by a professional using the four criteria provided with great confidence in a successful outcome. The four criteria are:

- The use of a continuous water separation plane between the interior and exterior based on the properties of the materials and construction methodology of the foundation
- A certification by a licensed engineer that the design meets the code requirements
- Proper installation that maintains the integrity of the water separation plane
- A foundation air barrier.

The greatest research need posed by Dr. Goldberg is the development of a quantitative foundation simulation tool that will help a professional design the water separation plane as required by the code and to provide adequate documentation for certification by an engineer. An energy simulation program is also needed that couples ground and building temperature fields along with energy transport in the soil and building envelope components.

4.3 Kohta Ueno: Hybrid Foundation Retrofits

Mr. Ueno presented the research that the BSC has been doing on hybrid foundations as a Building America partner. BSC's main focus was on uneven wall foundations, such as old rubble

stone foundations, and assemblies for bulk water control. Knowing that interior insulation solutions are the most desired option by homeowners (because they are less costly and less invasive than exterior insulation retrofits or complete foundation wall replacement), BSC focused on interior insulation solutions for wet foundations in cold climates.

Like Mr. Huelman, Mr. Ueno presented the obstacles one faces when dealing with foundations: wintertime moisture condensation, condensation at the bottom of the wall, lack of drying of the assembly, and liquid water through the wall. In some rare instances, extreme cold and saturated soils can result in frost heave.

The BSC approach to dealing with insulation and wet basements begins with placing a membrane capillary break between the foundation and the sill beam whenever possible. Although this may require that the house be raised off the foundation 1 in. to create the gap, BSC has had great success with the method to decouple opportunities for water to wick up the foundation wall and cause rot in the beam. The same membrane is brought down the interior of the foundation and water is directed to an interior perimeter drain. Spray foam insulation is applied over the membrane. The details are presented in Figure 4.

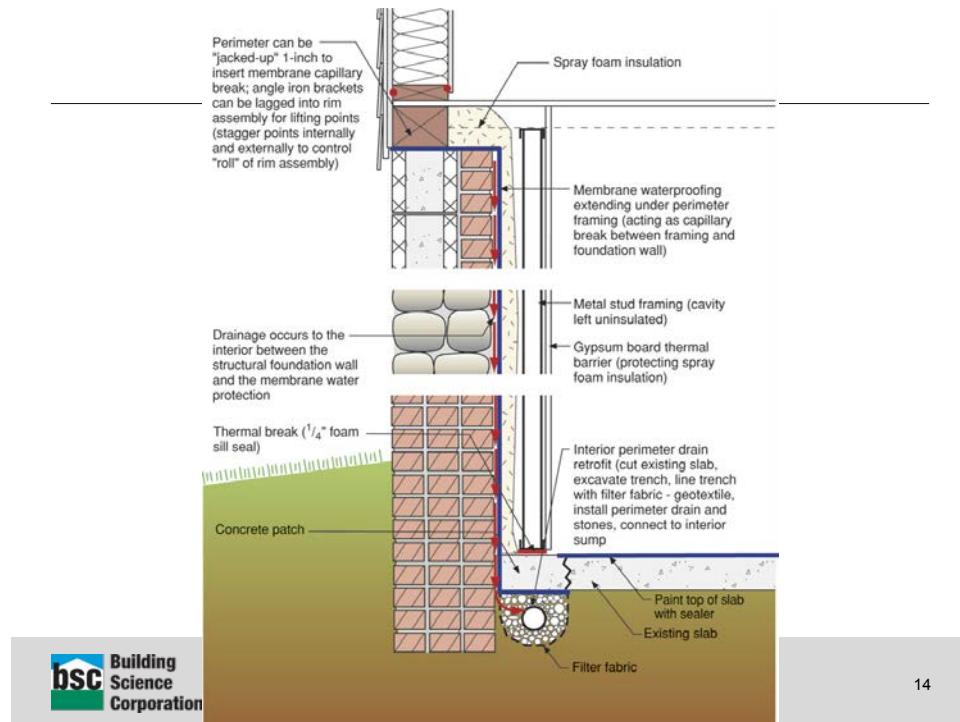


Figure 3. BSC-recommended process for insulating wet basements with uneven walls

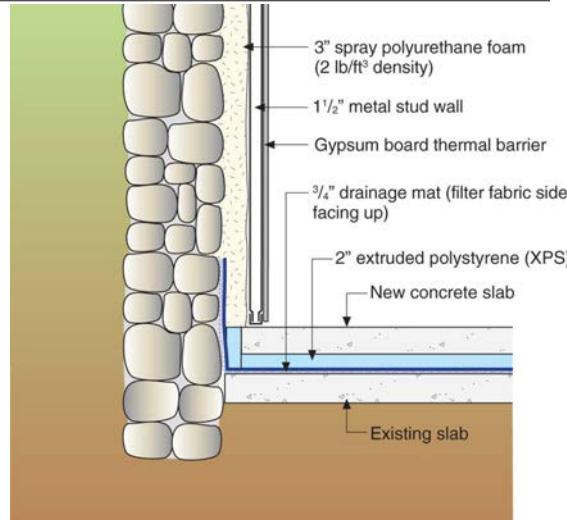
Question: Does the membrane act as a vapor barrier and reduce the potential of inward drying?

Response: Yes, the membrane acts as a vapor barrier, but here the bigger issue is insulating in a wet environment.

The approach to insulation in a wet basement needs to be made on a case-by-case basis, based on how wet and how often the basement is wet: there are cases where the full drainage layer behind the spray foam might not be necessary. This usually occurs when the basement is not historically wet (just occasionally wet). In this situation, a “minimal” drainage system can be implemented: a drainage mat connected to a sump can be placed over the existing slab and partially up the uneven wall, and a new insulated slab is installed over the existing slab. Bulk water can drain from the foundation wall, into the drainage mat, and then the sump. When insulation is sprayed onto the foundation wall, the insulation on the wall connects to the slab insulation to create a continuous thermal layer. See Figure 5 for more detail:

Partial Drainage Detail

- Insulated slab on top of existing slab
- No membrane up wall surface
- Wet vs. dry basement?
- Light gauge steel framing interior wall



Hybrid Foundation Retrofits

22

Figure 4. BSC insulation detail for basement that is not typically wet

Insulation strategies for uneven foundation walls are further complicated during deep energy retrofits when the above-grade walls are insulated on the exterior and the foundation is insulated on the interior. This leaves the sill beam in a vulnerable position sandwiched between two insulation layers that will prevent drying to either side. If a capillary break is used between the foundation and the sill, bulk water impact is significantly reduced, which reduces the risk of rot. BSC has often replaced the insulation at this junction with a hybrid solution of rock wool at the sill to promote drying to the interior.

Question: What to do with beams embedded in masonry pockets?

Response: It is a topic that we are currently researching. I have written a paper for BEST3, involving simulations of beams embedded in masonry after insulation. However, the simulations

are thoroughly inconclusive—doing field experiments would be more valuable, and we hope that there will be funding for this research.

4.4 Pat Huelman: Presentation of Slides Provided by Philip Fairey of the Florida Solar Energy Center – Flexible Residential Test Facility

Mr. Huelman presented on behalf of Mr. Fairey, who was not able to attend the Foundations Expert Meeting. Mr. Huelman provided a brief synopsis of the work being done by the Building America partner, Florida Solar Energy Center, which recently opened a new testing laboratory of two identical homes to answer issues related to slab-on-grade construction, climate impact, cooling interaction, and the coupling of the slab and ground as well as slab, ground, and interior flooring finish. The Florida Solar Energy Center has taken care to build instrumentation and temperature sensors in the below-grade surface. Moisture probes will also provide greater perspective on soil domain, help validate models, and provide inputs to current models. The goal of the research is to expand the Building America database on foundation performance.

4.5 Jeff Christian: Foundations Research Ongoing at ORNL

Mr. Christian opened his presentation by reviewing of a variety of case studies that demonstrate the focused effort at ORNL to understand foundation systems. The first involved three visually identical slab-on-grade robo (test) houses built with different energy strategies. House 1 (the base house) had R-5 horizontal slab perimeter insulation on all foundation walls except the interface with the attached garage. The retrofit house, sometimes called the CC2, had horizontal R-5 all the way around including the interface with the garage wall. The International Energy Conservation Code 2015 compliant home had R-10 vertical insulation all the way around the perimeter including the interface wall with the garage. (All these systems are inside the foundation wall.) The retrofit/CC2 house achieved 40% energy savings over the base home. Most significant to the findings are the incentives a homeowner could acquire from utility companies for reaching energy goals. In the retrofit house, the incentive could be as much as \$4,000.

The robo houses were built with sensors buried in the walls to capture material properties and explore thermal properties as moisture content changes. The goal of the robo houses is to model the wall-insulation-soil system with maximum possible independence of soils water content. The results of the ongoing robo study are available on the [ORNL website](#). Data are constantly updated to correspond to retrofit changes that are performed on the houses over the years of study.

A second case study highlighted the effort of a homeowner who had a goal of achieving zero energy. The home was outfitted with an 8.5 kWp PV system plus extreme retrofit measures. The full basement was uninsulated, yet the homeowner understood this to be an important area for energy improvement. The homeowner insulated from the exterior by digging 2 ft below grade and wrapping continuous insulation around the foundation as well as over the tops and sides of the concrete steps and landing tied to the home. The retrofit strategies resulted in a reduction in air changes per hour of more than 50%.

Question: Did the homeowner have any modeling tools to direct the decision to wrap the porch as part of the home?

Answer: He did not have any modeling tools and did not want to disrupt the front steps and rebar connection to the home. He used the guide of “continuous insulation” to inform his decisions

A third case study involves an occupied home with a higher than average envelope leakage. Although many energy strategies were implemented, the homeowner did not opt for insulating the heated basement. Testing will be conducted for a two-year period. Heat loss will be measured in the uninsulated basement for one year and one year with the foundation insulated.

Another case study featured a two-story retrofit with flash and batt insulation above grade and triple-pane windows. ORNL was interested in exploring the thermal and moisture transport properties of different insulations on the brick foundation of an occupied home. The owners approved the unconventional use of mixed insulation materials in the basement and allowed closed cell foam to be applied to one part of the brick foundation, open cell on another part, and nothing on a third wall. The owners are also open to ORNL experimenting with hydraulic vacuum excavation around the exterior of the foundation to apply exterior insulation. Test results so far have indicated that the home is 71% more airtight than when the project began. The home will continue to undergo monitoring.

Question: Improved airtight measurement came from a flash and batt home?

Answer: Yes. Many other energy strategies that contributed to improvement included foaming the attic ceiling, rim joists between above grade floors and rim joists in basement, addressing air gaps between wood to wood connections

Question: What about air barriers in the basement?

Answer: The rim in the basement has been foamed, but no air barrier on basement walls. It still achieved improved airtightness.

Mr. Christian also presented a one-year comparative study of vented versus sealed/unvented crawlspaces of two identical robo houses. As expected, the vented crawlspace grows mold during the cooling season, and the results indicate that in mixed humid climates crawlspace walls should be sealed and insulated.

5 Panel and Group Discussion To Cover Key Questions and Action Items

Comment: BSC strategies look very expensive.

Ueno: Foams are expensive materials but the expense is weighed against the goals of dealing with wet basements that owners seek to insulate.

Comment: In some cases it may be less expensive to raise a home off its foundation to create new walls and slab than to try and deal with existing conditions. It provides homeowners with higher basement ceilings and allows best practices used in new construction rather than trying to overcome existing problems.

Huelman: There are three solutions to energy improvement for the foundation: (1) relatively robust exterior insulation; (2) do nothing; and (3) potentially inexpensive and risky interior options for which we do not have performance data. These are the reasons why we are here—to figure out how to make this clear, safe, and effective to the consumer.

Christian: We have to get a risk analysis.

Question: Is there a consensus on using vapor permeable insulation?

Ueno: BSC is OK using permeable and impermeable. The bigger concern is that any air space behind insulation is sealed off.

Goldberg: We need to include the water separation plane as part of the insulation system.

Huelman: We need to consider the moisture content in the foundation wall and its impact on the moisture content of the rim. To understand the risk, we need better data on vertical coupling.

Christian: Guidance on foundation insulation and research for below grade need to be regionalized.

Huelman: What is the role, if any, of sub-slab depressurization on drying potential?

Ueno: Pulling air out will dry the slab, but air comes from somewhere. Is that an energy penalty?

Comment: A basement will dry in winter due to dry air under the slab, but depressurization in summer does not work to dry the basement, as the air being pulled carries moisture.

Question: If we foam rim joists for energy, are we causing more harm? How do we know what makes sense in regards to durability and affordability?

Huelman: Building America research needs to create processes for decision making to balance energy improvement, energy penalty, and risk.

Comment: Retailers take no responsibility for home improvement materials and systems and remodelers do not know or understand the risks of using these materials and systems.

Comment: Should research be done to determine the risks? Who should or should not be doing installation in the field?

Goldberg: The four-step process in the code is designed to limit design and installation to those who can design as prescribed in the performance pathway. That way the engineer takes on liability by certifying design.

Comment: An engineer signoff is not a solution in the contractor world. But can the goal of research be to make a blanket statement that homes of a certain era are too risky to insulate and should not be done?

Christian: Perhaps we need to develop a weighted probability system of questions and answers that a user can input to determine best strategies for the situation.

Booten: If you had to recommend something for Building America for next year, what would you recommend?

Christian: Put aside new construction and focus on retrofit. Build a 5-minute app that helps users weigh the risks.

Ueno: Expand research to advance modeling and field studies to look at risk factors in greater detail.

Goldberg: Identify risks and inexpensive solutions.

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