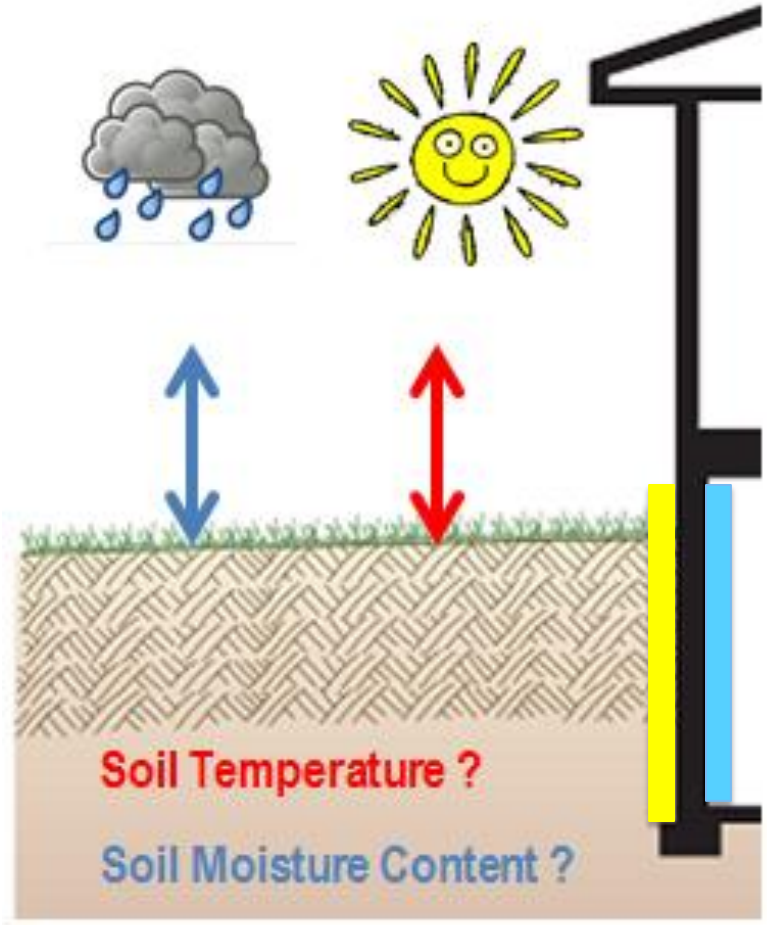
03.05.03.10: WUFI Basement Module

2014 Building Technologies Office Peer Review



DOE Roadmap Goal for Buildings:

50% Energy Savings until 2030
(20% for Building Envelopes)

Durability issues in Walls, Roofs

Now the basement is the “Energy Loss”

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: 10/01/2012

Planned end date: 9/30/2015

Key Milestones

1. Simulated temperature within 1.5 degC
2. Simulated moisture content within 15%

Budget:

Total DOE $ to date: $315K FY14 + $520K FY13

Total future DOE $: $250K (estimated)

Target Market/Audience:

Building Scientists,

Building Envelope Designers,

Architects,

Building Product Manufacturers

Key Partners:

University of Minnesota	Subcontractor
Fraunhofer IBP, Germany	CRADA Partner

Project Goal:

The goal is to create a validated software tool extension for architects and building designers. The tool extension should be able to simulate heat and moisture transfer on below-grade building components to determine energy savings and durability for below-grade materials.

Purpose and Objectives

Problem Statement:
Below-grade materials can accumulate moisture which leads to 40% loss of thermal performance, which has been measured in (Kehrer, Christian 2012). A simulation tool to predict the thermal performance and durability of below-grade materials does not exist, but is needed to identify which kind of below-grade insulation system is energy efficient, durable and cost effective.
The objective is to adapt the existing WUFI source code to make it deployable for below-grade insulation systems. Furthermore validation with measurements should show the application of the new adaptions.

Target Market and Audience:
Building scientists and building envelope designers are the main audience. With this tool they will be able to design a correct below-grade insulation system in terms of energy savings and durability. Data from DOE Energy Data Book result in 0.21 quads which are on risk for regions in the Northeast and Midwest where deep basements are typically used only. Crawl space and slab-on-grade systems can be targeted as well, but are not included in this project at this time.

Purpose and Objectives

Impact of Project:
The impact is to ensure that below-grade insulation system are durable and real energy savings do match theoretically assumed energy savings. The difference is 0.21 quads.

Building product manufacturer will be able to develop below-grade insulation systems which ensure the theoretically assumed energy savings.

a. Near-term impact: Envelope designers have a tool to design below-grade insulation system correctly

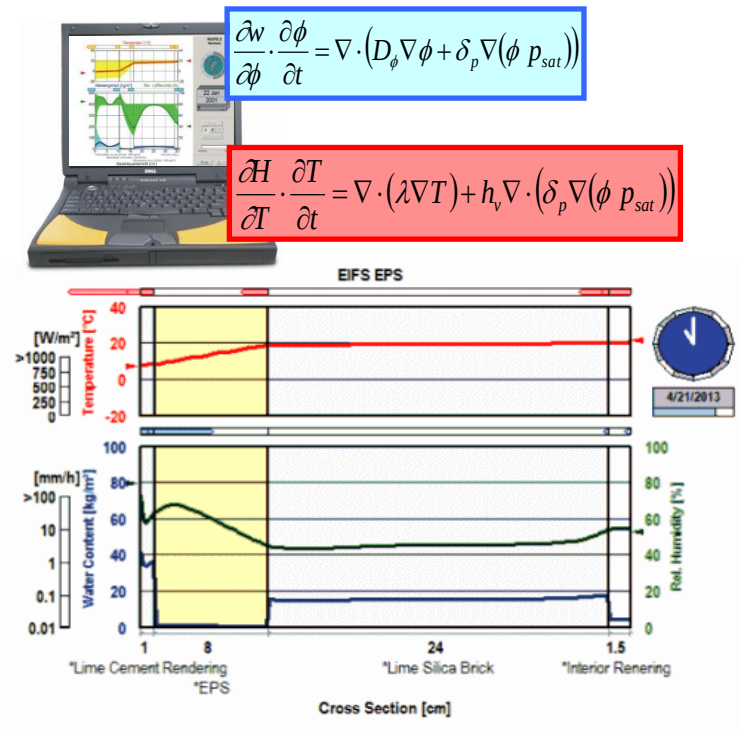
b. Intermediate-term: Building product manufacturer have first prototypes of durable and affordable below-grade insulation systems.

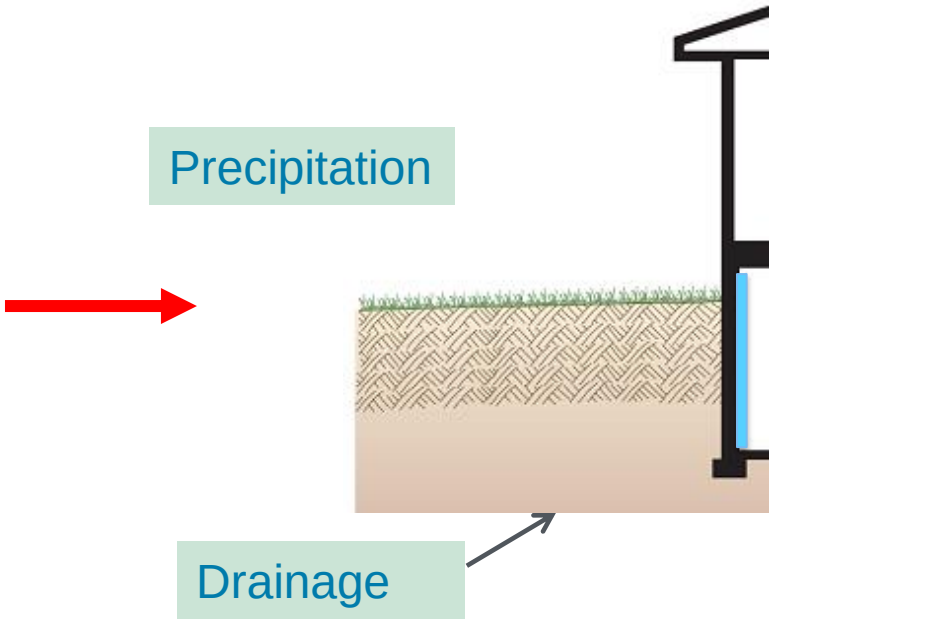
c. Long-term: below-grade insulation system products exist, which ensure theoretically assumed energy savings an durability.

Approach

Approach Method:

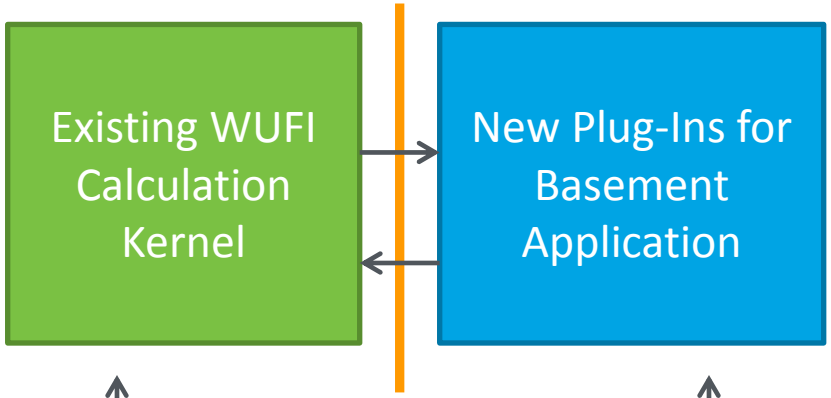
WUFI, developed by Oak Ridge National Laboratory and Fraunhofer IBP, is a widely used heat and moisture transfer simulation program for building envelopes. The approach is to create the necessary changes in the code and validate it against measurements to make it applicable for below-grade insulation systems.





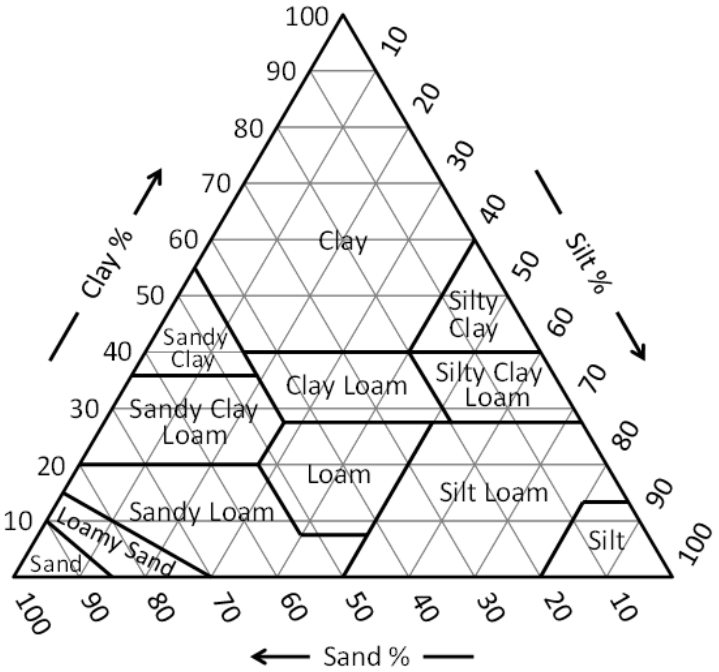
Approach / History

Interface structure in the WUFI code has been accomplished



Interface Implementation by Fraunhofer IBP

Plug-In development by Oak Ridge National Laboratory



(Source: US Department of Agriculture)

Material properties for soils have been translated for the use in building. Rosetta database has been used
http://cals.arizona.edu/research/rosetta/rosetta.html

Approach

Key Issues:

The comparisons between measured and simulated soil temperatures show deviations in the winter time. Many options to find the responsible effects have been investigated with minor success so far. This is our focus at this time and significant for the overall project success.

Distinctive Characteristics:

The complexity of heat and moisture transfer in soils physics requires absolute experts in this field to create a simulation code which addresses soil physics and building science.

Today only about 5 codes exists in the word (2 in North America) which can be used as a basis for this work.

Developers of the WUFI code exist only at Oak Ridge National Laboratory and Fraunhofer IBP, Germany.

This is the first time that this kind of code includes the surrounding soil.

Progress and Accomplishments

Lessons Learned: Coupled heat and moisture transport in soils is complex. The basic difference between measurement and calculation in winter time brings additional challenges.

Accomplishments: The additional software extensions to simulate drainage, rain accumulation and snow cover impact have been completed and work correctly with the existing calculation code. Furthermore one Q3 milestone has been finished.

Market Impact: Final results can be included in the free WUFI download www.WUFI.com/ORNL. We register about 20 downloads a day for years now.

Awards/Recognition: The collaborative developed WUFI software got awarded as being a "2013 TOP-10 Green Building Product".
This is the first time that a software received this award.


CERTIFICATE OF RECOGNITION

BuildingGreen

Publishers of Environmental Building News,™ GreenSpec® and LEEDuser

WUFI software from Fraunhofer IBP and Oak Ridge National Laboratory
has been selected as a
2013 TOP-10 GREEN BUILDING PRODUCT
from the GreenSpec Database

Alex Wilson, Executive Editor

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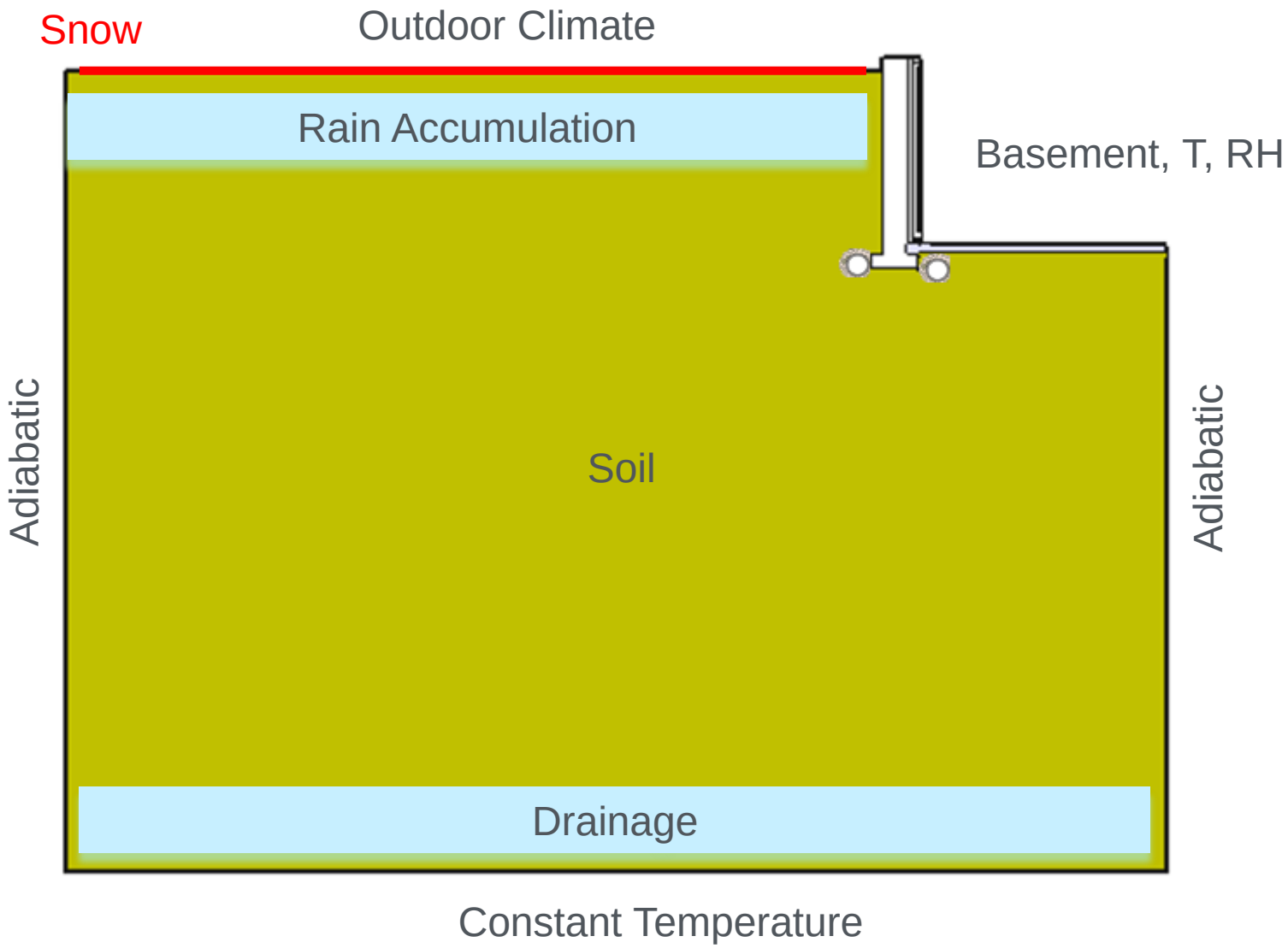
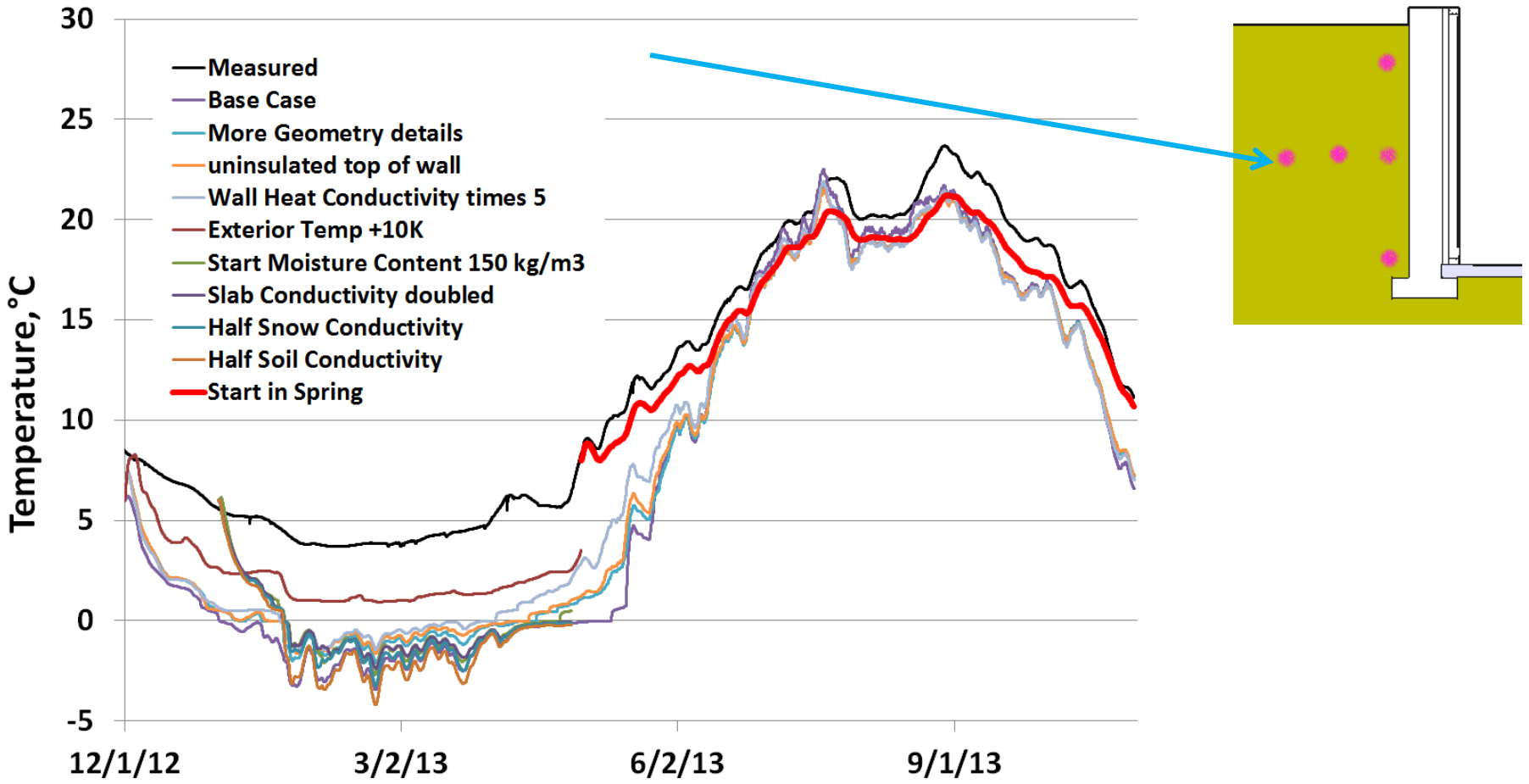
Progress and Accomplishments, Model Validation

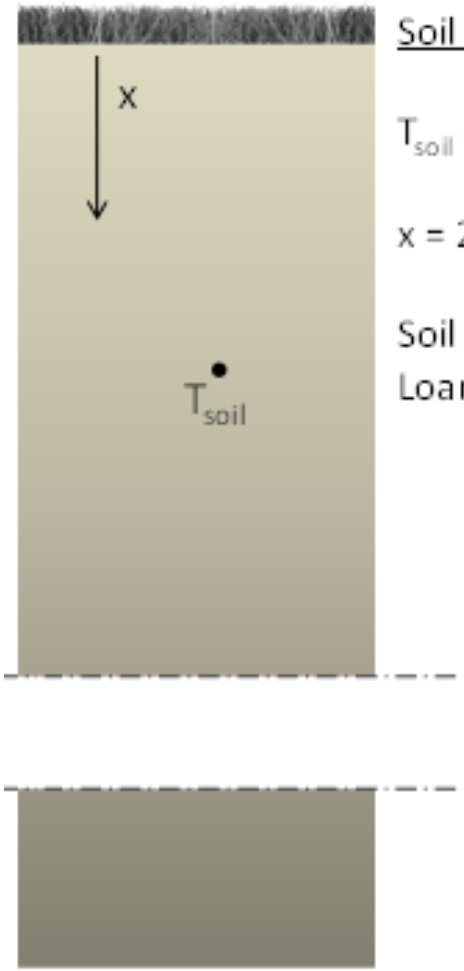


Validation Results with Minnesota Data



Some effects in the winter-time data or simulation are presently not consistent. Summer time agreement is good.

Validation Results with European Data

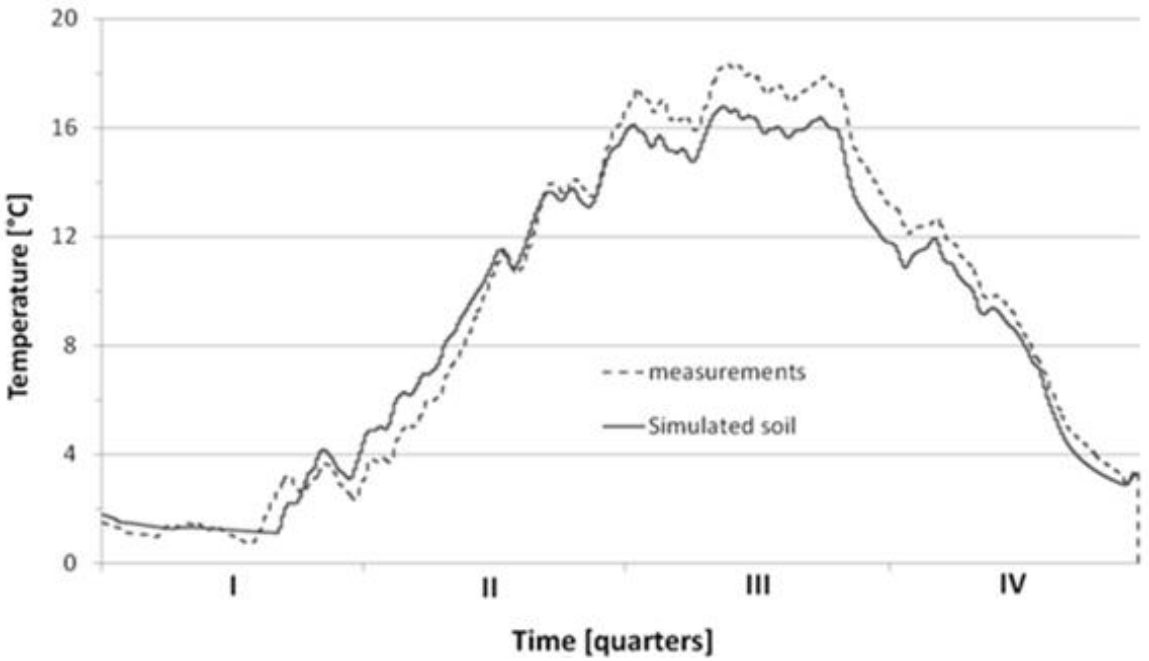


Soil Model

T_{soil} = 1 m dept

x = 20 m

Soil type:
Loamy sand



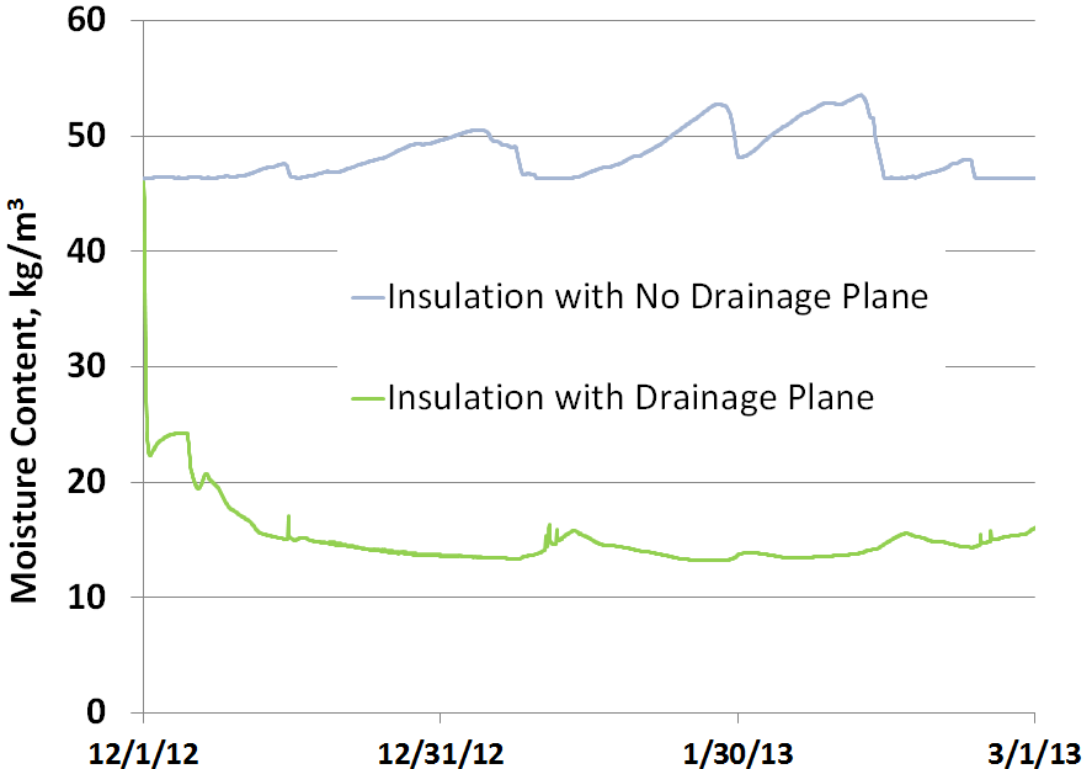
Another comparison with European measurement data and known weather conditions shows a pretty good validation result all over the year.

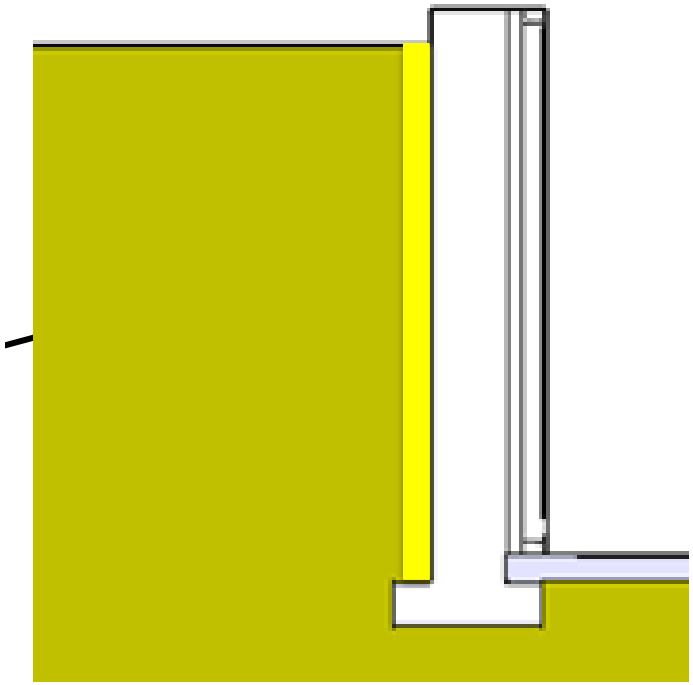
Progress and Accomplishments

Effect of Drainage Planes, Q3 Milestone:

Drainage planes help at the right place to keep the below-grade materials dry and durable. So far manufacturers do not recommend them in combination with insulation below-grade.

This effect can be simulated with the new developed Plug-In.





Project Integration and Collaboration

Project Integration: We are in contact with many building product manufacturers especially drainage plane manufacturers. At this time they do not combine thermal insulation with drainage planes for below-grade application and need the outcome of this basic research. They will be involved more at a later time at this project.

Partners, Subcontractors, and Collaborators:

responsible for setup and evaluation of soil measurement data

Responsible for interface development in the WUFI code

Communications: Conference Building XII, 2013
Building America Expert Meeting, 2013

Next Steps and Future Plans

Next Steps and Future Plans:

Measurement data for the second winter are expected soon. This data may identify sources of the discrepancies, e.g., soil compaction effects are expected.

Collaboration partner University of Minnesota conducts heat and moisture analysis at this time as well to supply us with additional input to identify those undiscovered effects.

Measurements are planned at ORNL together with industry partners to gather data for the drainage performance of drainage planes under real conditions.

References

Publications:

Hughes P., Desjarlais, A., Kehrer M., Hun, D. (2013) "*Advances in Understanding Durability of the Building Envelope: ORNL Research*", Energy Design Update Vol. 33, No. 11 November 2013.

Kehrer M., Pallin, S. (2013); *Hygrothermal Material Properties for Soils in Building Science*; Journal of National Institute of Building Science, Oct. 2013 Issue Vol.1, No.3, Washington, DC.

Kehrer M., Pallin, S. (2013); *Hygrothermal Material Properties for Soils in Building Science*; Proceedings of Conference on Thermal Performance of the Exterior Envelopes of Whole Buildings XII, 2013, Clearwater, FL.

Kehrer, M. Christian, J. (2012); Measurement of Exterior Foundation Insulation to Assess Durability in Energy-Saving Performance. ORNL Report ORNL/TM-2012/159.

Presentations:

Hygrothermal Material Properties for Soils in Building Science; Buildings XII, Thermal Performance of the Exterior Envelopes (Clearwater, FL; 12/4/2013).

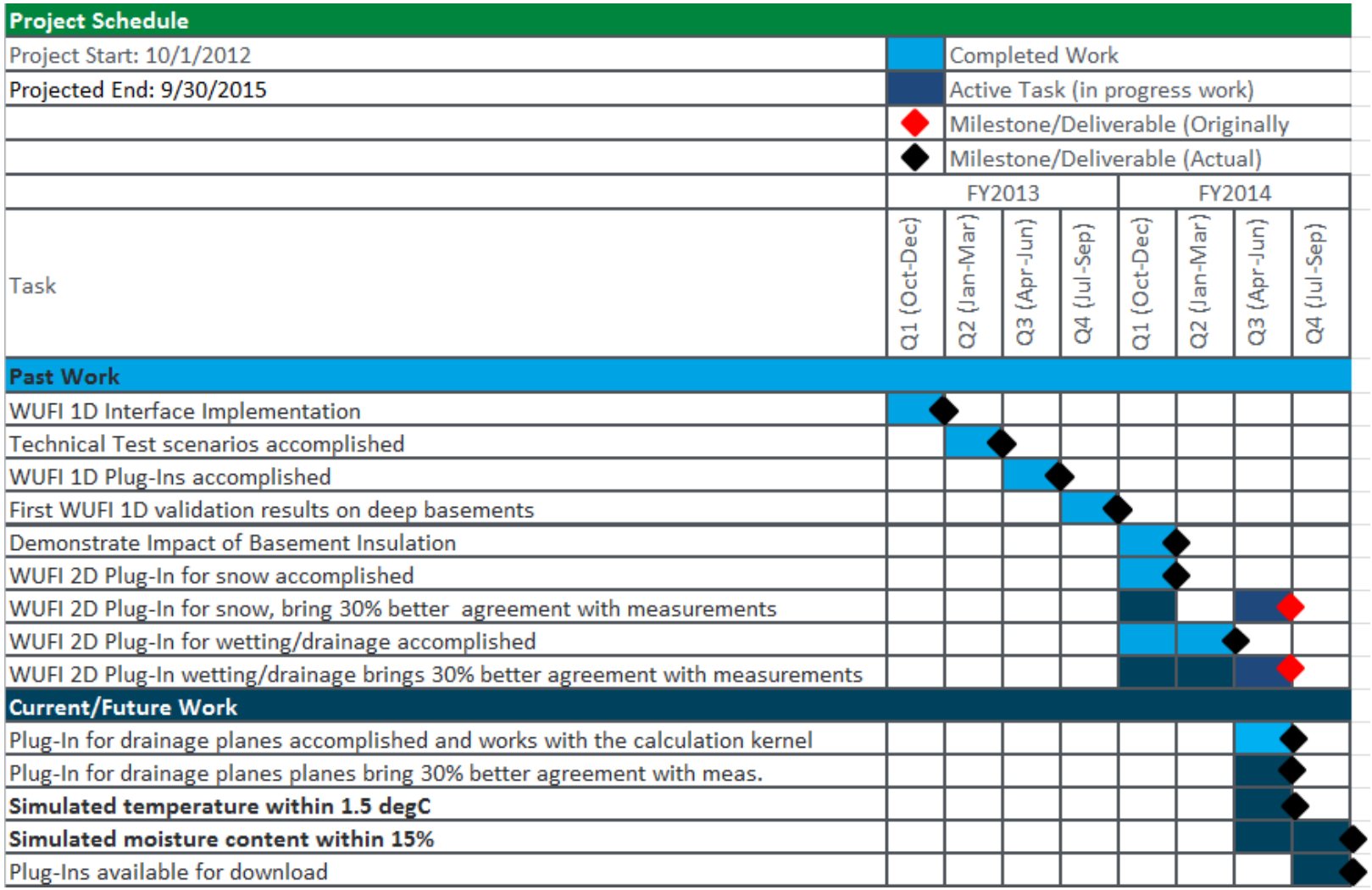
Foundation Research at the Oak Ridge National Laboratory; NorthernStar Building America Foundation Expert meeting (Minneapolis, MN; 3/21/2013)

Project Budget

Project Budget: The project budget is part of the core funding for ORNL's Building Envelope Group. It has historically been used to create the successful WUFI code.
Variances: A Q3 Milestone has been accomplished now as the completion of the slipped milestone needs more time. We wait on updated measurement data
Cost to Date: $315K FY14 + $520k FY13
Additional Funding: $250K

Budget History					
10/1/2012– FY2013 (past)		FY2014 (current)		FY2015 – 9/30/2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$520K	$50K	$315K	$20K	$250K	$50K

Project Plan and Schedule



The slipped Q1 and Q2 milestone are results of the differences measurement/calculation. Go/No-Go decision points are bold.