Building America Case Study

# Cold Climate Foundation Wall Hygrothermal Research Facility

Cloquet, Minnesota

## PROJECT INFORMATION

**Project Name:** Cold Climate Foundation Insulation Testing

**Location:** Cloquet Residential Research Facility, Cloquet, MN

**Partners:** Northern*STAR* Building America Partnership

**Research Specialty:** Building Envelope and Wall Systems

**Application:** Retrofit or New; Single and Multifamily

**Facility Size and Date:** Built 1997

- 120-ft × 20-ft, 10-ft × 20-ft bump out
- 12 bays main level
- Full basement, with multiple foundation types

**Applicable Climate Zones:** Cold and Very Cold, 6 and 7

The University of Minnesota's Cloquet Residential Research Facility (CRRF) in northern Minnesota features more than 2,500 ft$^2$ of below-grade space for building systems foundation hygrothermal research. Here, the U.S. Department of Energy's team, Northern*STAR* Building America Partnership, researches ways to improve the energy efficiency of the building envelope, including wall assemblies, basements, roofs, insulation, and air leakage.

The CRRF was designed as a full-scale test bed to evaluate long-term, cold climate building performance. Half the basement walls are constructed of concrete block and half are constructed of cast-in-place concrete. Located in climate zone 7, the center is oriented on an east-west axis so roofs and test walls face north and south. In addition to envelope-related studies, researchers at the center have developed innovative thermal and moisture instrumentation and capabilities for measuring real-time basement indoor air temperature and relative humidity (RH).

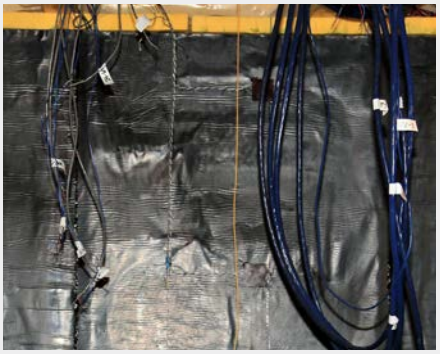
## Current Capabilities and Focus

The instrumentation system is designed for measuring heat and moisture ground coupling processes and retrofit test approaches. It includes sensors that measure RH, air and surface temperature, heat flux, masonry block face shell, and soil moisture content data on four separate wall systems. Researchers use different soil types (loam, sand, and silty-sand backfills) to investigate the influence of soil properties on the hygrothermal performance of these foundation insulation systems. Currently, more than 680 channels are active in the laboratory, collecting data continuously every 12 minutes; however, the laboratory has the capability of running more than 1,400 channels.

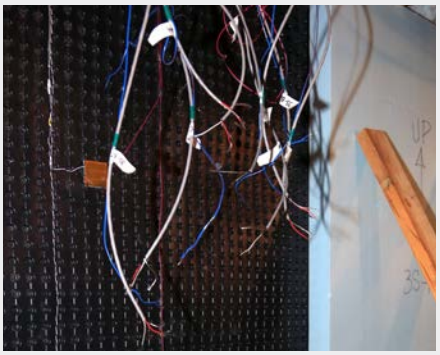
The team is measuring all these data continuously over the course of a year for several types of foundation retrofit insulation systems, including:

- Interior, full-height rigid insulation
- Exterior, half-height rigid insulation
- Adhered (rubberized asphalt and polyethylene laminate) water separation planes (WSPs)
- Non-adhered, mechanically attached (dimpled high-density polyethylene sheet) WSPs.

## Existing Wall System Configurations



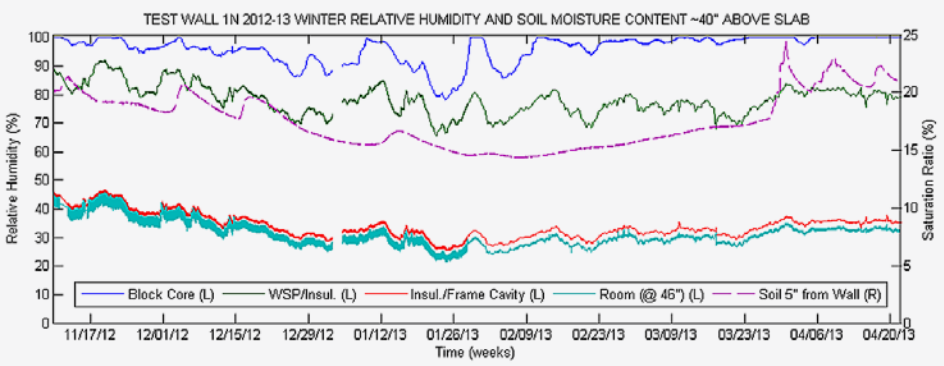
Adhered WSP with instrumentation.



Non-adhered WSP and rigid insulation with instrumentation.

Rigid insulation with unfilled wood stud wall with instrumentation.

Image credit: All images were created by the Northern*STAR* team.




Example data from the CRRF showing the RH and soil moisture content profile for a north wall with an adhered WSP with loam backfill.

## Experimental Opportunities

Comprehensive hygrothermal performance testing will help the project team to:

- Generate heat flux comparisons and in-situ sorption non-isotherms for masonry block foundation walls.
- Investigate insulation for home retrofits and waterproofing strategies for basement build-outs.
- Show the strength of vapor coupling between the masonry block wall cores and the rim assembly.
- Show whether a foundation wall retrofitted with an interior non-adhered WSP remains perpetually wet after a cooling season of bulk water leakage through the wall.
- Provide a side-by-side comparison of interior and exterior insulation strategies.
- Examine retrofit strategies for rim joist cavities.
- Provide experimental data for validating earth contact thermal and hygrothermal simulation programs.

## Looking Ahead

The CRRF is versatile enough for very specific projects and large enough to simultaneously run multiple projects. It has a complete set of sensors to measure hygrothermal and energy transport performance of building envelopes, including temperature, RH, heat flux, in-situ R-value, differential and absolute pressure, moisture content, electrical energy, and humidifier water consumption. It includes an extensible real-time control system that can be configured for multiple loops simultaneously, including air handlers, humidifiers/dehumidifiers, air conditioners, wall wetting systems and proportional-integral differential controllers for hot boxes/plates.

In summary, the data acquisition and control system is flexible and extensible enough to accommodate any type of sensor at any scan and any type of control system. The project team will continue to focus on hygrothermal research for building foundations.

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