



COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC

*Promoting and advancing
the development of healthy,
durable and sustainable shelter
for Alaskans and other
circumpolar people.*

Mobile Test Lab Wall Monitoring Study

*Cold Climate Housing Research Center
February 23, 2007*

Project Approach

There are many problems from excessive built-in or stored moisture within a building enclosure include: twisting and warping of framing materials, nail popping, paint peeling, compromised insulation, and over all reduction of thermal performance. To help understand moisture movement, storage and drying in walls, the Mobile Test Lab (MTL) was designed to be moved around the State of Alaska and can be modified to test wall sections, windows, doors, ventilation equipment, and other home systems. For the purposes of this study CCHRC staff used the MTL to test several types of wall systems to asses their performance in cold, wet climates.

The 8' x 8' x 24' Mobile Test Lab (MTL) has nine bays used for comparable testing of different materials and equipment. Each test wall bay is 45 inches wide by 89 inches high. Temperature for the interior of the lab was controlled with electric resistance heaters to achieve 70°F. A heat recovery ventilator was installed and used to ventilate. Relative humidity was not controlled.

All walls had one non-airtight 2" x 4" outlet box installed in the center stud bay 16 inches up from the bottom of the wall. Additionally each wall had a 1/2" hole for the remote sensor cable of the data logger. The initial moisture content for all common framing materials and structural sheathing were 30% and 10% respectively.

Instrumentation

Each of the test walls is outfitted with a series of temperature, relative humidity, and wood moisture content sensors. These sensors were continuously monitored and re-



The mobile test lab on location in Juneau, Alaska



To better understand the temperature gradients and heat flow through the window buck, moisture content pins and a temperature sensor were installed near the exterior surface in all the window bucks.

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corded throughout testing and data was recorded using a data acquisition system. The sensor packages for each wall are similar.

Results

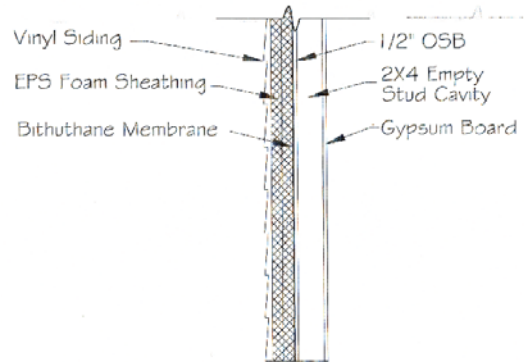
The first wall monitoring study was achieved by increasing the initial moisture content of the building materials to simulate construction in a wet environment. The test wall selection consisted of eight standard construction techniques including siding, sheathing membrane, sheathing, wood studs, insulation and drywall. The ninth test wall used an exterior insulated approach with the insulation, vapor barrier, and air barrier all on the exterior of the sheathing.

Of the nine walls tested, only one showed a drying trend over time – the REMOTE wall system (Residential Exterior Membrane Outside-insulation TEchnique). It offered the most reliable approach to drying of built-in moisture and had the lowest recorded moisture contents in the sheathing, framing and bottom plate at the conclusion of the testing. All other wall configurations increased in moisture content over the duration of the test.

The REMOTE construction sequence begins like any advanced wall framing system wherein the frame is built and sheathed laying on the sub-floor. At this stage an exterior membrane is attached to the outside of the structural sheathing (peel/stick or air/vapor barrier) before standing the wall. Two or three layers of rigid foam are mechanically attached through the sheathing into the studs paying careful attention to offsetting joints in the foam. Any suitable siding can be attached to nailer strips or the foam can be finished with a synthetic stucco system.

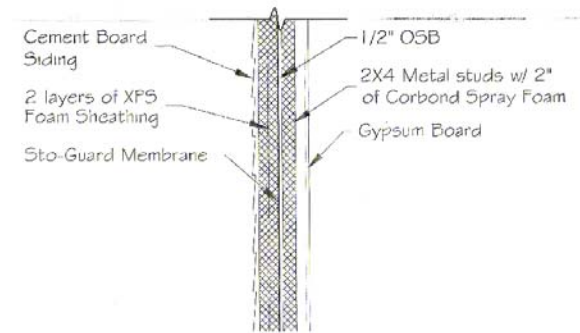
The current (second) study is designed to evaluate different combinations of the REMOTE wall system for both commercial and residential applications. Wall cross-sections and comments are illustrated.

Wall 8 was difficult to evaluate because it was made with insulated concrete forms (ICF). After sixteen months the relative humidity of the concrete was still greater than 85% from the original concrete moisture. This is a potential moisture source for moisture problems in the wall if the wall is not designed to properly deal with sustained elevated internal moisture loads. There were no observed moisture problems for Wall 8 during testing.



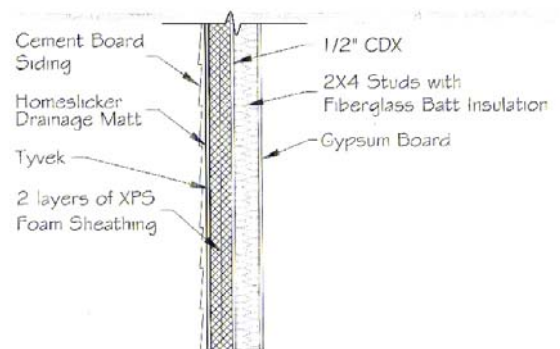
WALL 2
SC: 3/4" = 1'

Walls 1-6, with no insulation in the cavity space dried the most quickly, avoiding any serious moisture related risks.



WALL 7
SC: 3/4" = 1'

Wall 7, insulated with spray foam in the stud space also dried very slowly, and held water between the spray foam insulation and the sheathing. This resulted in the highest risk to moisture damage of the test walls.



WALL 9
SC: 3/4" = 1'

Wall 9, insulated with batt insulation, dried slower than Walls 1-6. The lower sheathing temperature in combination with vapor open insulation could be a risk for moisture damage. This was shown by the measured elevated moisture content levels of the sheathing.

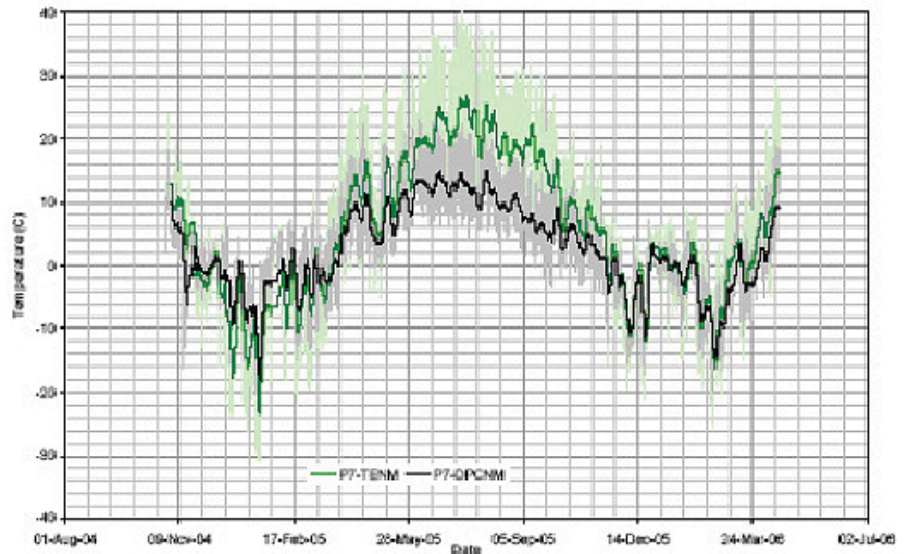
Condensation Analysis

Another common method to evaluate wall performance during full scale wall testing is to determine the number of hours of possible condensation on either the sheathing or drywall/poly. This is done by calculating the dew point temperature in the cavity space from the relative humidity and temperature sensor and comparing it to the surface temperatures of both the sheathing and the drywall for every hour of the year. In most common wall assemblies, condensation may occur on the interior surface of the sheathing in the winter, or the exterior surface of the drywall/poly in the summer.

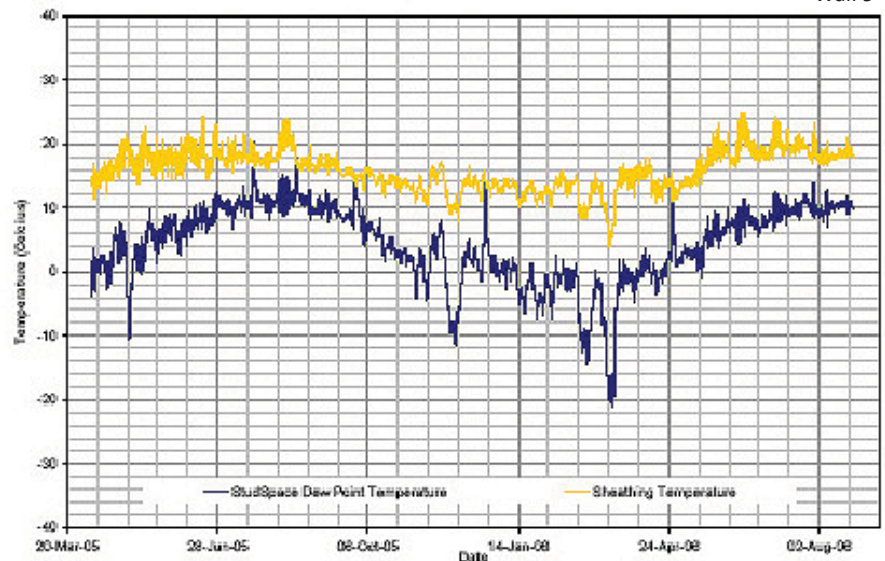
During a recent full scale wall test in climate zone 6, a similar wall was tested, constructed with fiber cement plank, Tyvek®, sheathing, 5.5" batt, and drywall. This wall had over 1000 hours of winter condensation in one year. Condensation is shown in the graph (above right) every time that the green line (sheathing temperature) falls below the black line (dew point temperature in the studs pace).

These results can be compared to a similar wall construction in the CCHRC/UAS test trailer. Wall 9 is constructed with fiber cement plank, drainage matt, Tyvek®, EPS, sheathing, 3.5" batt insulation, and drywall. With the addition of the exterior insulation, the number of condensation hours was decreased to zero because the temperature of the sheathing was increased during the winter months. The graph for CCHRC/UAS Wall 9 is shown to the right. The temperature of the interior surface of the sheathing does not drop below the dew point temperature once during the year of monitoring. All of the CCHRC test walls were analyzed for condensation potential and it was found that none of the test walls had any hours of condensation throughout the period of the testing.

Most moisture problems that occur in the building enclosure are caused by detail de-



Wall 9



Simulated water leak

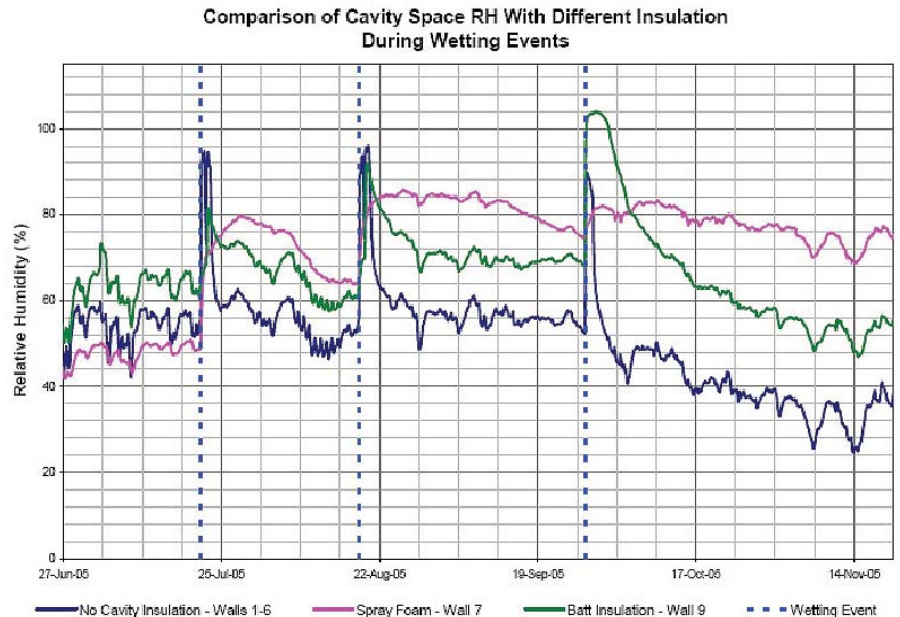




sign and construction deficiencies allowing water into the wall. To simulate a leak, the wetting apparatuses (photograph page 3) were used to inject a known amount of water on three separate occasions.

A wetting event in the cavity space should cause an increase in the moisture content of the sheathing and the relative humidity in the stud space. This added moisture will only become a problem if the moisture content stays elevated and does not dry in a timely manner.

The graph at right shows that all of the relative humidity's are approximately the same previous to the wetting events (the dotted lines). Following the first wetting, the relative humidity rises, although Walls 1-6 and Wall 9 return to normal after about one month. After the second wetting, Walls 7 and 9 do not decrease in relative humidity until after the end of the analysis time period.



Conclusions

This research project generated the following conclusions:

- All of the test walls can perform well in a climate similar to Juneau's. This was shown by the absence of moisture problems, caused by the local climate.
- The external wetting apparatus showed no response in any of the monitoring sensors, and was difficult to use, because of the positioning of the tube, and the lack of drainage space in some of the test walls.
- Wetting of the stud space (by 100 mL doses of water) increased the relative humidity, and in some cases, the moisture content to risky, or dangerous moisture levels inside some the test walls.
- Examining the test walls for condensation potential in the cavity space showed that none of the wall systems had sheathing temperatures or drywall temperatures that fell below the dew point temperature of the cavity space. This lack of condensation potential is directly linked to the use of exterior insulation.
- The relative humidity in the drainage gap of vinyl walls coincided closely with the relative humidity of the exterior environment, while the relative humidity in the drainage gap of the fiber cement walls, was buffered by the storage capacity of the cladding.