CRITICAL MOSS

Hugh Bitzer, Mari Jo, Brian Lawler, Michael Harmon
University of Oregon
Department of Architecture
Eugene, OR 97403

ABSTRACT

Green walls are a proven form of sustainable construction, providing weather protection and creating a beautiful and healthy facade . While green walls typically include a variety of plant species, moss is rarely included. In our case study, we attempted to determine the potential R-value of moss through a variety of tests performed at Hugh's apartment. We hypothesized that a 4" layer of moss on the exterior envelope of a building could contribute an R-value exceeding 3. After collecting in excess of 50 hours of data, we determined the R-value to be 3.56. Using a heat flux transducer and the conventional wood framed wall at Hugh's apartment, our group tested the moss both by itself and as a component of the wall envelope. Performed in an open window, the tests of the moss wall alone yielded the best results (R-value=3.56). While the large R-values recorded for our wall tests seemed to indicate inaccuracy in the measurements, the calibration of the heat flux transducer was likely responsible. A simple comparison using an educated guess of the existing walls R-value helped to confirm that 3.56 was accurate.

INTRODUCTION

In today's world of rising fears over climate change, sustainable building practices are becoming increasingly important. Thus, when it came time to decide upon a case study, our group was eager to explore new methods of green construction. In our initial brainstorming, moss interested us because of its natural abundance and little-known benefits. While green walls are nothing new, moss walls are much rarer. Moss grows quickly and uniformly, and can be very beautiful. In addition, moss's sponginess seemed to suggest it could be beneficial as insulation. The extent of these benefits now became the question. Our group hypothesized that moss could provide an R-value greater than 3.

While moss walls are rare, they do exist. In Paris, there is a museum by Jean Nouvel which includes a green wall featuring moss. Because moss doesn't require soil to grow our wall would be simpler and lighter to construct than typical green walls. A mesh or grate seemed like the best method of containing the moss while still allowing it access to light and water.

Resolved to test our hypothesis, we thus set about deciding on the type of moss to be used. Our initial idea was to find our preferred variety of moss and grow it ourselves. This soon became impractical however, as moss takes several weeks to grow to maturity. We instead resolved to find a desirable patch of moss on campus and use it in our wall. Our search lead us to the cliffs above Franklin Blvd. where it meets I-5. The species of moss at this location was much thicker than other varieties we had seen (4in.+) and thus offered the best hope of insulation. Following a couple trips down Franklin Blvd. that involved scampering over slippery cliffs and hauling back a 20 lb bag of moss, we were ready to begin constructing our wall.

For testing, we used a heat flux transducer which measures heat flow through materials. Heat flux is defined as the rate of heat transfer through a cross section area, and is known as q. This unit, along with temperature (both inside and outside) can be used to calculate an R-value through the equation $Q = U \times A \times \Delta T$.

Our testing location was Hugh's apartment, which features a traditional wood framed wall that receives no direct sunlight. Here, using both the window and the wall, we tested the moss wall both on its own as well as part of the building envelope.

HYPOTHESIS

Question: Will moss be an effective insulator on the exterior envelope of a building?

Hypothesis: A 4" layer of moss placed on the exterior envelope of a building will provide an R-value exceeding 3.

Inquiry Questions:

What types of moss present the most potential benefits as insulators?
Will moss survive on the exterior envelope of a building?

METHODOLOGY

1. A 20” x 30”x 4” wood frame was constructed from 2x4's to hold the moss in place. 1/4” stainless steel mesh was nailed across one side of the frame and a 4” thick layer of moss (from the cliffs bordering Franklin Blvd. near I-5) was laid evenly across it. Chicken wire was then spread across the moss-facing side of the frame (used for its minimal surface area).

Figure 1: Constructing the wall.

2. Using the Campbell Scientific 21x Micrologger, the Heat Flux Transducer was programmed to record heat flux data every minute over a 5mV range. The heat patch was then taped to the interior wall of Hugh's room (located in Emerald Apartments, Eugene) directly opposite the exterior wall (where it receives no direct sunlight).

3. Two Onset HOBO data loggers were connected to thermistors and programmed to record temperature in degrees F every minute. One HOBO was placed inside next to the HFT, while the other was positioned opposite it on the exterior wall. The thermistors were taped to the wall (to record wall temperature instead of air temp.) and small shading devices were added to eliminate any solar heat gain.

4. Both the Micrologger and the HOBOs were left to record data overnight from 6:00 PM until 12:00 PM the next day. (18 hrs) Data was then downloaded and the exterior HOBO removed.

5. Using nails to support the frame, the moss wall was duct taped flush to Hugh's outside wall opposite the HFT. The exterior HOBO was reattached, this time to the moss wall. Step 4 was then repeated.

6. For the final test, the moss wall was placed within an open 20”x30” window in Hugh's room. Duct tape was used to seal the sides of the window and the HFT and HOBO's were placed opposite each other on the moss wall itself.. Data was recorded for 14 hrs. from 9 PM to 11:00 AM.

Figure 2: Setting up the moss wall.

DATA AND ANALYSIS

To calculate the R-values of the different assemblies, this equation was used:

$$Q = U \times A \times \Delta T$$

Q is the heat flux, and this value was obtained from the Campbell 21x and the heat flux transducer. U is the equivalent to the inverse of the R-value. A is the surface area of where the measurements were taken. ΔT is the change in temperature from interior to exterior, and was obtained from the two HOBO data loggers. To get the R-value, the equation is re-ordered to look like this:

$$R = (A \times \Delta T)/ Q$$

R is equivalent to 1/U.

Fig. 3 shows the graph of the heat flux data for just the wall (red) laid over the graph of the temperature difference data (green), so that the shapes of the curves can be more easily compared. Figs. 4 and 5 show the data in a similar fashion for the moss on wall assembly and the moss in window assembly. In fig. 3, the two graphs have a similar shape, which suggests that the heat flux is directly correlated to the temperature difference. However, in fig. 4 there appears to be no correlation between the two graphs. This could stem from the fact that the moss wall was still at room temperature when it was placed outside, and therefore would have required time to come to equilibrium In fig. 5, there appears to be an inverse correlation between temp. and heat flux. This is difficult to explain, but it does show a correlation. Figs. 6, 7, and 8 show how the calculated R-value fluctuated over time. Because R-values are usually given as constants, we decided to take an average of the R-values for each run, and then compare the three averaged R-values to see what difference the moss made. Fig. 9 shows the average R-values for each test side by side for easy comparison. The grey bar, for the wall by itself, shows an average R-value of approximately 40, which seems rather high for most normal walls. The red bar next to it shows an average R-value of nearly 80 for the wall with the moss on it. This near doubling of the R-value by simply applying moss seems highly unlikely. This inaccuracy could be due to the calibration of the HFT (5mV) which may not have been the best setting for the wall. Large changes in R-value over the testing period may have resulted from some of the circumstances already discussed. Despite the apparent inaccuracies, there does seem to be an improvement in the R-value of the wall when the moss is applied. The average R-value for the moss by itself seems much more likely, at approximately 3.5. The large fluctuations in R-value here could have been due to the wind, which would have had a larger effect on the moss itself, which wasn't windproof. After analyzing all the data, it appears likely that 5mV was a bad setting for testing the wall, but a good one for testing smaller insulators such as moss.

CONCLUSION

The original hypothesis was that the moss would have an R-value of 3 or more. Leading manufacturers of green wall systems claim that their systems provide R-values of 3 also. According to our data, the moss green wall that we constructed had an R-value of 3.5. Although some of the data appears to be inaccurate, the moss did provide insulation, and the apparent R-value equaling that of manufactured green walls indicates that further study could prove fruitful.

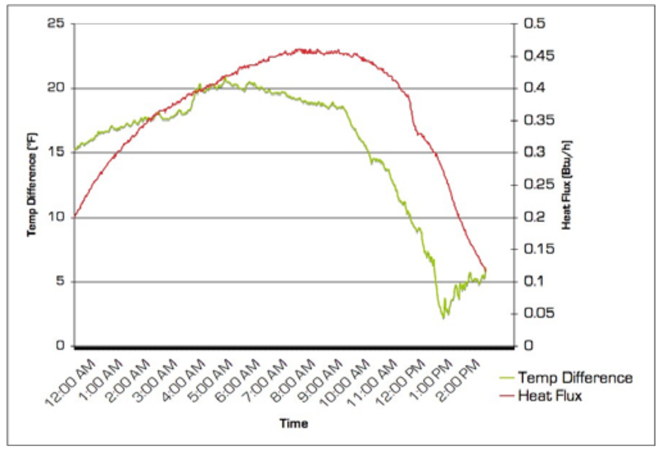

Fig. 3: Graph of heat flux of just the wall (red) and temperature difference (green) measured over time

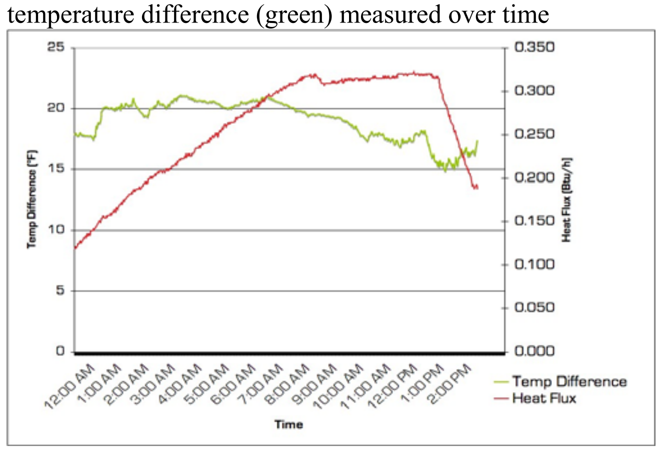

Fig. 4: Graph of heat flux for the moss attached to the wall (red) and temperature difference (green) measured over time.

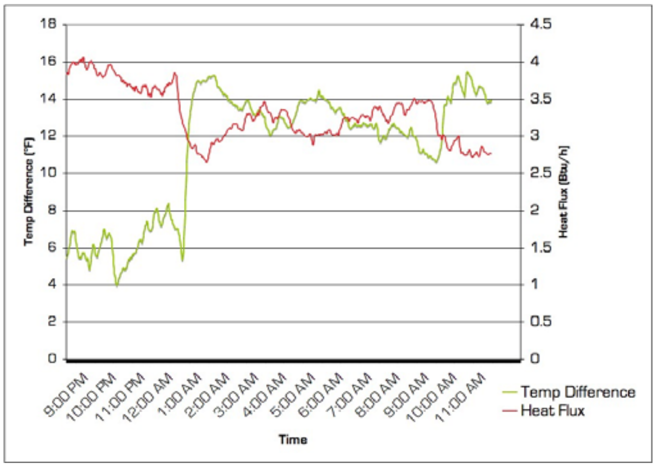

Fig. 5: Graph of heat flux for the moss installed in the window (red) and the temperature difference (green) over time

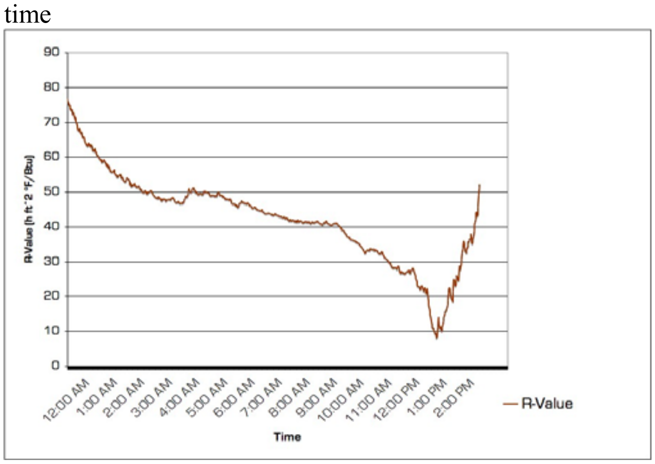

Fig. 6: Graph of calculated R-value of the wall over time.

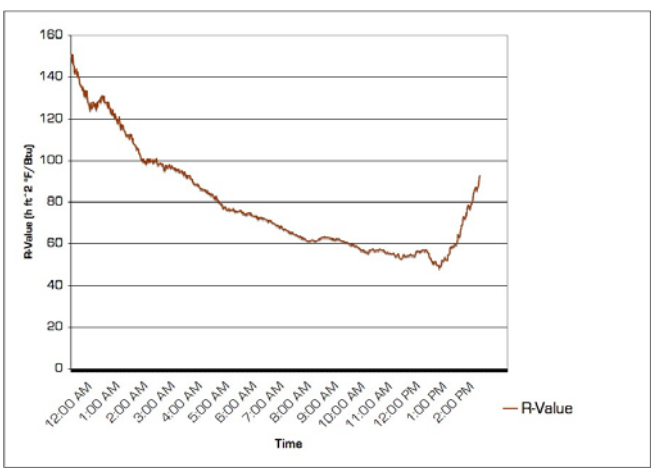

Fig. 7: Graph of calculated R-value of the moss attached to the wall over time.

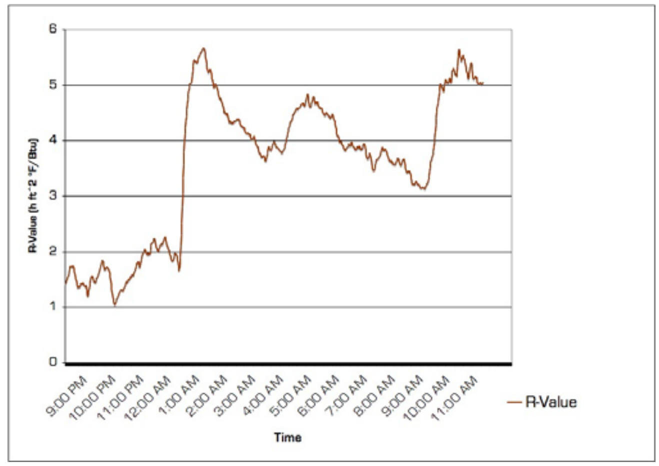

Fig. 8: Graph of calculated R-value of the moss installed in the window over time.

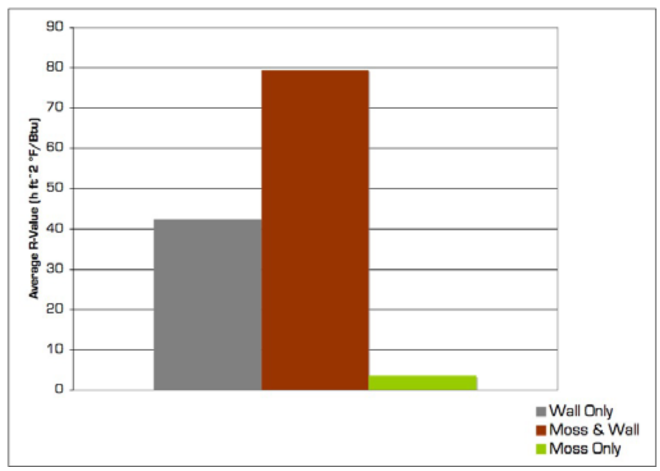

Fig. 9: Graph showing the average R-values for the wall only (gray), moss and the wall (red) and the moss only (green).

DESIGN LESSONS LEARNED

Moss is a plant that is very low cost and low maintenance. In addition, it provides insulation. These two factors make moss an attractive option for green walls. However, moss has trouble growing in direct sunlight, which makes it less ideal for use in areas where green walls are used to shade the building. However, considering this fact along with the fact that most mosses keeps their color year-round, moss becomes an attractive option for wet, northern climes.

Figure 10: Brian and Mari, oblivious to what's outside.

REFERENCES

Kwok, Alison. Stein, Ben et. al. *Mechanical and Electrical Equipment for Buildings*. John Wiley and Sons Inc: Hoboken, New Jersey. 2006.

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