Lesson Plan Title: Insulate and Waterproof Construction

NATURE Sunday Academy 2017-2018

Project Description:

The "Insulate and Waterproof Construction" activity explores how engineers have improved designs and materials in order to provide comfortable indoor conditions of buildings. Students explore architectural engineering or building sciences, and learn about psychrometry as well as heat and moisture transfer through building envelops. They work in teams to design a roof with exterior walls both in terms of structure and materials to keep an ideal indoor temperature/humidity under different outside conditions. Teams build, test, and evaluate their designed homes. The real-time measurements of the indoor air conditions and the weight of structures will be recorded with a data collection system under a simulated radiation, rainstorm and re-radiation. Students will gain an understanding of what factors affect energy efficiency in homes and how different building envelop designs can affect a home's energy performance.

Project Objectives:

Students should learn or get out of participating in the activity:

1. Architectural Engineering, especially regarding psychrometry and hygrothermal transfer (i.e., heat and moisture) through building envelop, e.g., radiation, conduction, and convection;
2. Engineering design such as water protection and insulation strategies;
3. How to use appropriate tools and techniques to gather, analyze, and interpret data;
4. Teamwork and problem solving.

Session Organization:

11:00-11:30	Cultural connection/brief introduction
11:30-12:00	Activity I
12:00-12:45	Lunch
12:45-1:15	Activity II
1:15-1:50	Activity III
1:50-2:30	Activity IV
2:30-3:00	Wrap up & Discussion

ND State Science Standards:

9-10.1.1. Explain how models can be used to illustrate scientific principles
9-10.1.4. Describe the relationship between form and function (e.g., solids, liquids, gases, cell specialization, simple machines, and plate tectonics)
9-10.2.1. Explain how scientific investigations can result in new ideas
11-12.1.1. Explain how scientists create and use models to address scientific knowledge
11-12.1.2. Identify the structure, organization, and dynamics of components within a system (e.g., cells, tissues, organs, organ systems, reactants and products in chemical equilibrium)
11-12.2.5. Use technology and mathematics to improve investigations and communications

Materials and Equipment:

1. Building materials for each team: components will be manufactured as Lego-kits with standard sizes and materials, e.g., siding, sheathing, air barrier, vapor retarder, structurer elements, sheathing, wood stud,

plastic storage container or planter insert, roof materials, different types of insulation (cotton balls, hay, clay, and shredded paper), cardboard, tape, nuts, non-water proof fabric, fiberglass, and so on.

2. Test beds: temperature sensor, humidity sensor, automatic data logger system, scale, light bulb or heater as a radiation source, a sink or bin, water tube, water sprinkler, and a computer.

Introduction:

How much utilities paid for your home? Why we need to pay (keeps a comfortable indoor condition such temperature and humidity through HVAC system)? What are the facts of building performance in the ND state?

To insulate and waterproof your home is important for a comfortable indoor condition, the energy efficiency, and utility cost.

How to define an ideal or comfortable indoor condition: dry-bulb temperature (e.g., 72 ºF) and humidity ratio (0.009 lb water/lb air)? When the difference between the actual and ideal indoor conditions is big, the building needs more energy to process the air to achieve the ideal condition. How to define the energy unit, BTU (1 British thermal unit: energy needed to raise one ºF for one pound of water)?

Background information on topic and its importance to the real world. How engineers or home builders insulate and waterproof your house to achieve a high-energy efficiency?

Activity I: Build a sample home

Objective: Students are expected to build a sample home using the provided lego-kit materials and tools, and the sample house size is about 3 feet * 3feet * 3 feet.

1) Show students the student reference sheets and design guide.

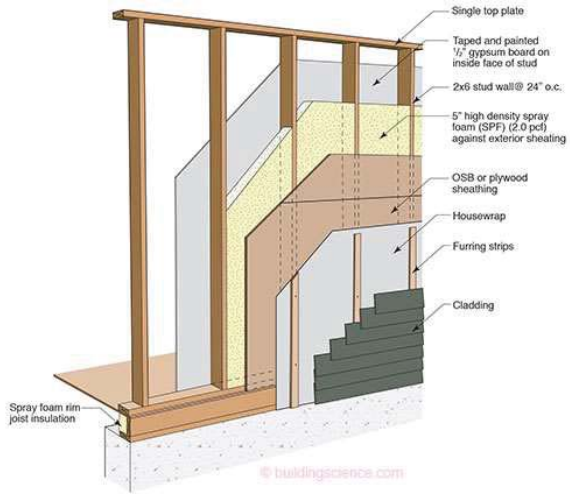
2) Divide the class into up to four teams (4-6 students per team).

3) Explain that they need to develop a building envelop system that can maintain the original indoor air conditions as possible after the water (about 1 liter) is poured on the walls through sprinklers and the a heater is placed nearby the house for 5-10 minutes.

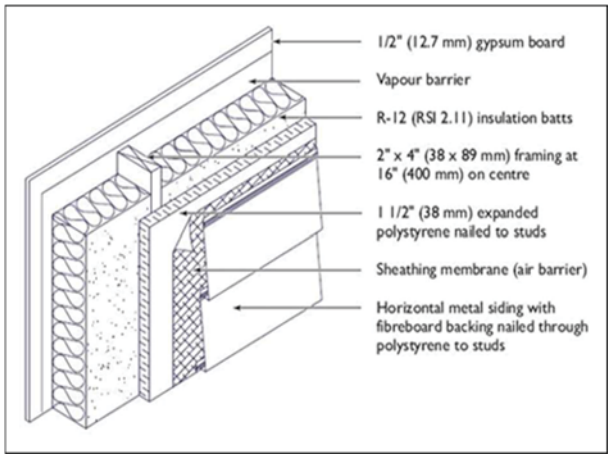
4) Introduce the lesson, ask students to consider the different designs strategies and materials used in the walls and roof they see in your community. Discuss how wall layers, material types, and roof are selected for a better building performance, for example, a flat roof is not a good choice for an area that received a great deal of snow as the weight of snow is more likely to collapse the roof structure.

5) Teams consider their challenge, develop a drawn plan, then present their designs to the class. A hole should be placed on the roof so that the house's indoor measurements will be taken to a computer for presentation and analysis.

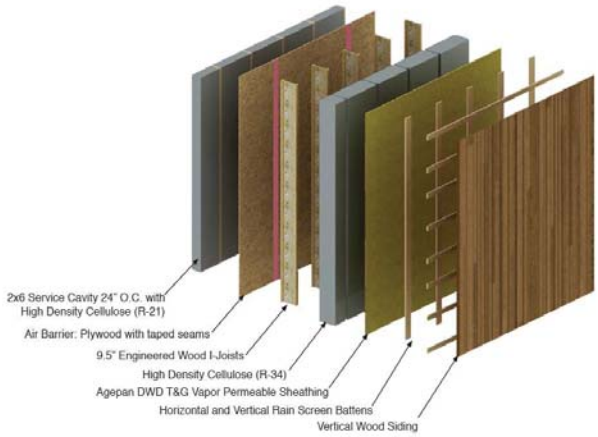
Wall construction types: (up to the available building materials from *Lowe's* store and the budget)



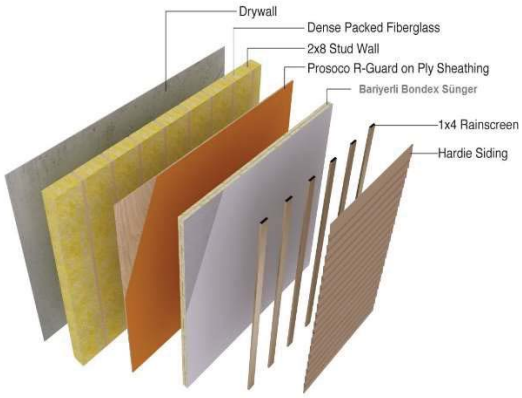
Wall Type 1



Wall Type 2.



Wall Type 3



Wall Type 4

Tools:

Sealant;
Sealant gun;
Ruler;
Hammer;
Nails.

Activity II: Test the sample home under a simulated radiation source nearby the home

Objective: Students are expected to observe the change of air temperature and humidity inside the sample and the weight change of the sample home; to draw the profiles of the three variables over time; and to understand the phenomena mechanism.

1) The radiation source is simulated by a heater placed nearby the sample house;
2) A test team will measure the original psychrometric reading and the house total weight during the Activity II (i.e., from the sample's STATE 1 to STATE 2).

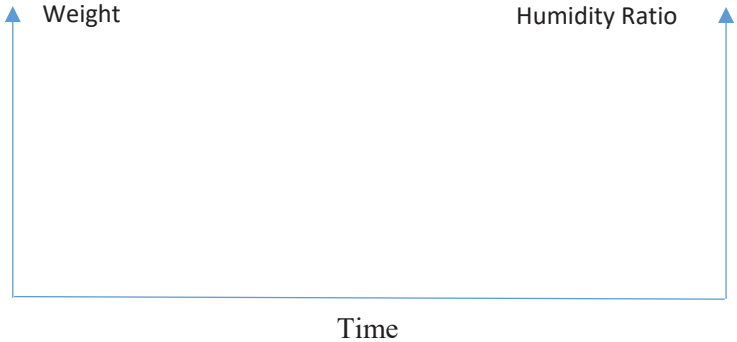
Test tool:

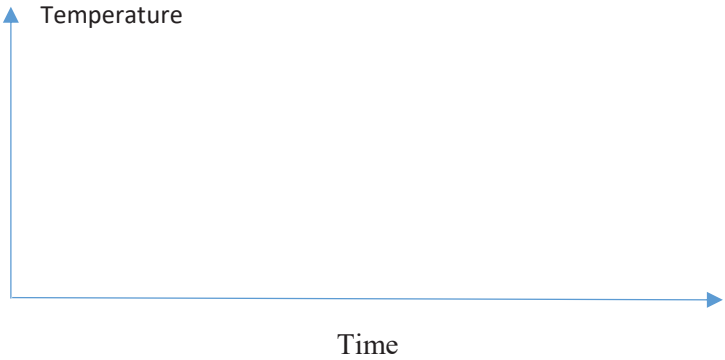
Heater, Data logger, computer

Scale;

Temperature and humidity sensor

Profiles: Draw two profiles from STATE 1 (before the activity II test) to STATE 2 (after the activity II test) using excel. One profile is time vs. weigh and humidity; the other time vs. temperature.





Questions:

How do Weight and humidity ratio change (i.e., bulk water stored in the sample and vapor water inside the sample)?

How does the temperature change (i.e., the heat transfer to the indoor air)?

Why?

Activity III: Test the sample home under a simulated rainstorm on the home

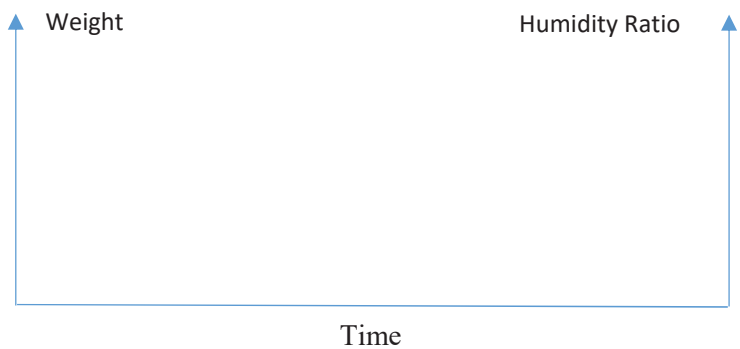
Objective: Students are expected to observe the change of air temperature and humidity inside the sample and the weight change of the sample home; identify how much bulk water leakage is stored in the house and how the temperature and humidity change inside the house after the test scenarios; and to understand the phenomena mechanism.

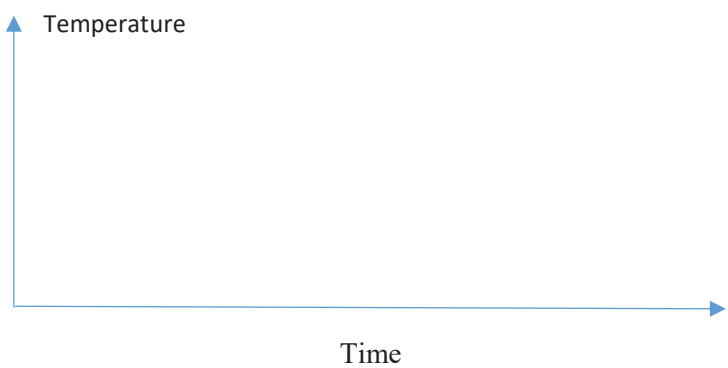
1) The rainstorm is simulated by water sprinkled from a set of water sprinklers placed nearby the sample house;
2) A test team will measure the original psychrometric reading and the house total weight during the Activity III (i.e., from the sample's STATE 3 to STATE 4).

Test tool:

A set of water sprinklers, Data logger, computer, Scale, Temperature and humidity sensor

Profiles: Draw two profiles from STATE 3 (before the activity III test) to STATE 4 (after the activity III test) using excel. One profile is time vs. weigh and humidity; the other time vs. temperature.





Questions:

How do Weight and humidity ratio change (i.e., bulk water stored in the sample and vapor water inside the sample)?

How does the temperature change (i.e., the heat transfer to the indoor air)?
Why?

Activity IV: Test the sample home under a simulated re-radiation source nearby the home

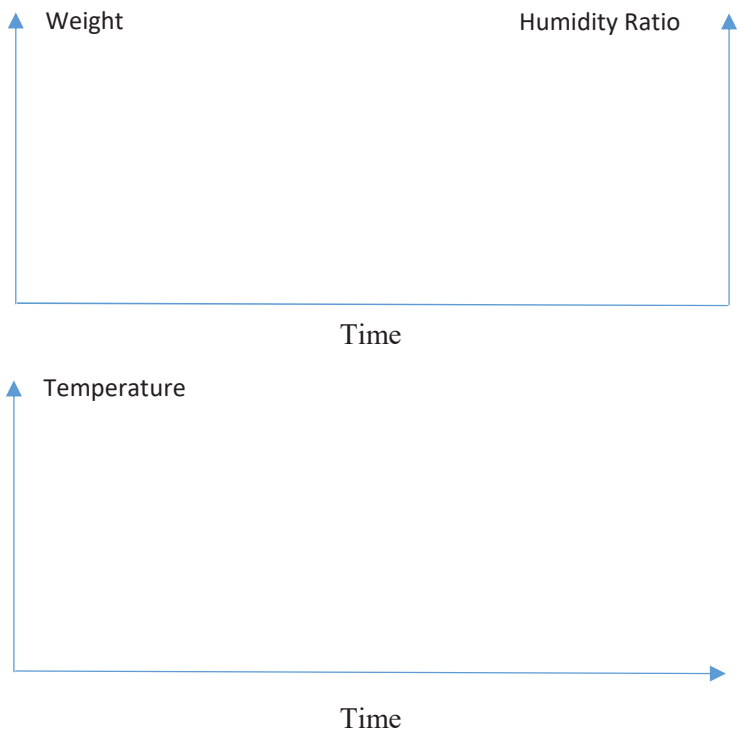
Objective: Students are expected to observe the change of air temperature and humidity inside the sample and the weight change of the sample home after the home stores water leakage from activity III; to compare the phenomena with the phenomena from the original test activity II.

1) The radiation source is re-simulated by a heater placed nearby the sample house;
2) A test team will measure the original psychrometric reading and the house total weight during the Activity IV (i.e., from the sample's STATE 5 to STATE 6).

Test tool:

Heater, data logger, computer, scale, temperature and humidity sensor.

Profiles: Draw two profiles from STATE 5 (before the activity IV test) to STATE 6 (after the activity IV test) using excel. One profile is time vs. weigh and humidity; the other time vs. temperature.



Questions:

How do Weight and humidity ratio change (i.e., bulk water stored in the sample and vapor water inside the sample)?

How does the temperature change (i.e., the heat transfer to the indoor air)?

What is the profile difference between this activity and the original test activity II?

Why?

Wrap-Up & Discussion:

1. How were the concepts of STEM used in today's activity?
2. What was the most successful idea you used in the activity?

3. What did you try in the activity that did not work?
4. Why do think it did not work?