Porkitecture: The Science of Swine Design

What building materials might help the three little pigs survive the cold?

RESEARCH

Heat and structural stability in buildings: **HEAT (insulation)**

What is heat?
Heat is a form of energy that you experience every day. The more energy the particles have, the faster they move. Hot objects have more thermal energy than cold objects. When matter is heated, the thermal energy in its particles is increased. Heat always flows from warmer objects to cooler objects, never the other way. Most liquids and solids expand when they are heated.

Temperature is the measure of the thermal energy in an object. When you measure the temperature of something cold, the liquid in the thermometer contracts.

The movement of heat from one particle to another is called conduction. Heat that is moving from one place to another, like a conveyor belt, is called convection. Some materials move heat easily, these are called conductors. Insulators reduce the motion of heat.

RESEARCH

Heat and structural stability in buildings: **HEAT (insulation)**

R values of insulation materials:
Cellulose = shredded newspaper is similar to straw (R value per 2.5 cm is 3.3)
Brick = similar to clay (R value per 2.5 cm is 0.2)
Wood = similar to sticks (R value per 2.5 cm is 0.8)
279cm of bricks is the same R value as 15cm of cellulose.

Some of the reasons why you would build with a straw bales or because they have great insulation. This can greatly reduce energy used for heating. They are also good for the environment because they're the part that goes to waste when you are harvesting and making grain. You're basically using a waste product, which reduces things going to the landfill. They also have great fire resistance once plastered, making them safe for use in homes. Straw bale construction use less material than normal home building materials. Lastly, they are better indoor air quality due to non-toxic building material.

Bricks might not have a high r-value for insulation but They have good design flexibility and are Fireproof. They are also long-lasting natural and are good for saving energy. They are a high density building material that means they can absorb heat and store energy which can keep your home cooler or warmer depending on summer or winter.

Wood regulates humidity and can make your home feel cooler. Wood is also a good building material because it combines stability and flexibility. Wood is also a cost effective building material.

RESEARCH

Heat and structural stability in buildings: **HEAT (insulation)**

The sun is one of the most worldwide heaters. It Heats both the Air and the ground and brings warmth to the Earth. For example if the house gets really hot and then quickly gets cold all the heat energy would go into the roof of the wood and would not change forms but would move around it would move from inside the house from outside of the house.
A law of heat is that heat prefers to travel from hot objects to cold objects and hot objects to hot objects so if it's hot inside the house and cold outside the house heat is probably going to move to the outside. If you did this in winter and it was cold outside and hot inside the probable hypothesis would be that the hot air inside would travel to the outside making the inside of the house less hot.
Some people have been able to harness the powers of energy to take cold or hot air from one place and move it to another place. By doing this the refrigerator and heat pump were invented and many other ingenious inventions.

Heat always moves.

Stack effect: Wind enters the building through cracks and openings. Warm air rises, causing cold air to come in through the bottom, causing warm air to leave. There is a pressure difference.

Reverse stack effect: Opposite.

RESEARCH

heat and **structural stability** in buildings.

WIND (damage)

What is a structure?

What makes a structure strong?

Structural stability when air blows into the house.

Some of the other forces that can affect a house include upward forces that can lift up a house, and downward forces that can destroy a house.

Structural instability could look like cracks in the walls and/or cracks in the foundation. They might seem harmless but they can be bad for the foundation and if the issues aren't addressed it co5uld make the house come crashing down.

Uneven floors and walls are also another issue that can be related to houses being structurally unstable. They can indicate shifting or settling of the foundation which can get worse over time and can lead to a lot of damage to the structure.

A sagging roof can also lead to problems with structural supports and weakened stability.

Some weak points: *windows, corners, wall-to-foundation connections, roof-to-wall connections and doors.*

All structural connections in a house should be attached to each other.

VOCABULARY

01 Kinematic Viscosity

02 **Insulation -** Measured in R-value. The higher number, the better the insulation.

03 Fluid Dynamics

04 **Heat Transfer: Conduction -** The movement of heat through solid materials.

05 Thermodynamics

06 **Heat Transfer -** Movement of heat from indoors to outdoors in the winter.

07 Wind Speed

08 **R value** - R-value is a wall's capacity to resist heat loss or its thermal resistance.

09 Uplift Forces

10 **Thermal Boundary (Building Envelope is the shell of a house)**

HYPOTHESIS

If three houses are built from bricks, sticks and straw, then bricks will help pigs survive **wind** best because it is the strongest material.

If three houses are built from bricks, sticks and straw, then Straw will help pigs survive **Heat** best because it insulates best.

MATERIALS

Clay bricks
Silicone
Straw
Wood
Hot glue
Yarn
Thermometer x2
Leaf blower

Heat Test - Procedure

20.32 long by 10.16 wide by 12.7 high

Step 1

Construct houses

- Take clay (bricks) and sculpt into box shape roughly 20cm long by 10cm wide by 10cm high not including top and bottom.
- Take hay bales and stack the straw and string it together into the same shape as above.
- Finally take wood and make four pieces of wood and use gorilla wood glue to secure them together.
- For the tops and bottoms use two pieces of wood 20cm by 10cm per house.
- Drill small hole into each roof for thermometer. .
- Use silicone to seal the cracks.

Step 2

Put thermometer in one house using the drilled hole. Measure initial temperature.

Step 3

Please outside in cold air. Record air temperature. Measure internal temperature of each structure every ten minutes for 30 minutes.

Record the temperature changes on piece of piece of paper.

Step 4

Repeat steps 2 and 3 with the other structures. Repeat steps 2 and 3 multiple times to collect data.

Wind Test - Procedure

Step 1

Use houses from heat test to test structural stability.

Step 2

Use leaf blower to simulate high winds. (The wolf.)

Step 3

Place each house on wood siding to prepare for the wind test.

Step 4

Place wind (leaf blower) in front of each house. Blow on each house starting 1.5 meters away. Record damage or movement.

Step 5

Blow on each house from 0.9m away and record damage or movement.

Step 6

Blow on each house from 0.3m away from houses and record damage or movement.

1st try at building a brick house had no structural stability due to materials used.

BRICK

2nd try at building a brick house was a better representation of bricks stability.

STICKS/WOOD

Wood was used to create the “stick” structure.

STRAW

Mini hay bales were constructed from real straw.

These hay bales were tied together.

TIMELINE

November 24
First tests
Exterior Temperate -3

November 25
Second Tests
Exterior Temperate -7

November 26
Third Tests
Exterior Temperate -3

December 1
Fourth Tests
Exterior Temperature
Exterior Temperate +2

December 10
Fifth Tests
Exterior Temperate +2

December 17
Sixth Tests
Exterior Temperate -12

Data Collection and
Data Visualization

Analysis and
Presentation

VARIABLES

CONTROL

Exterior Temperature

Location

Size of house

Thickness of building materials

Wind speed

MANIPULATED

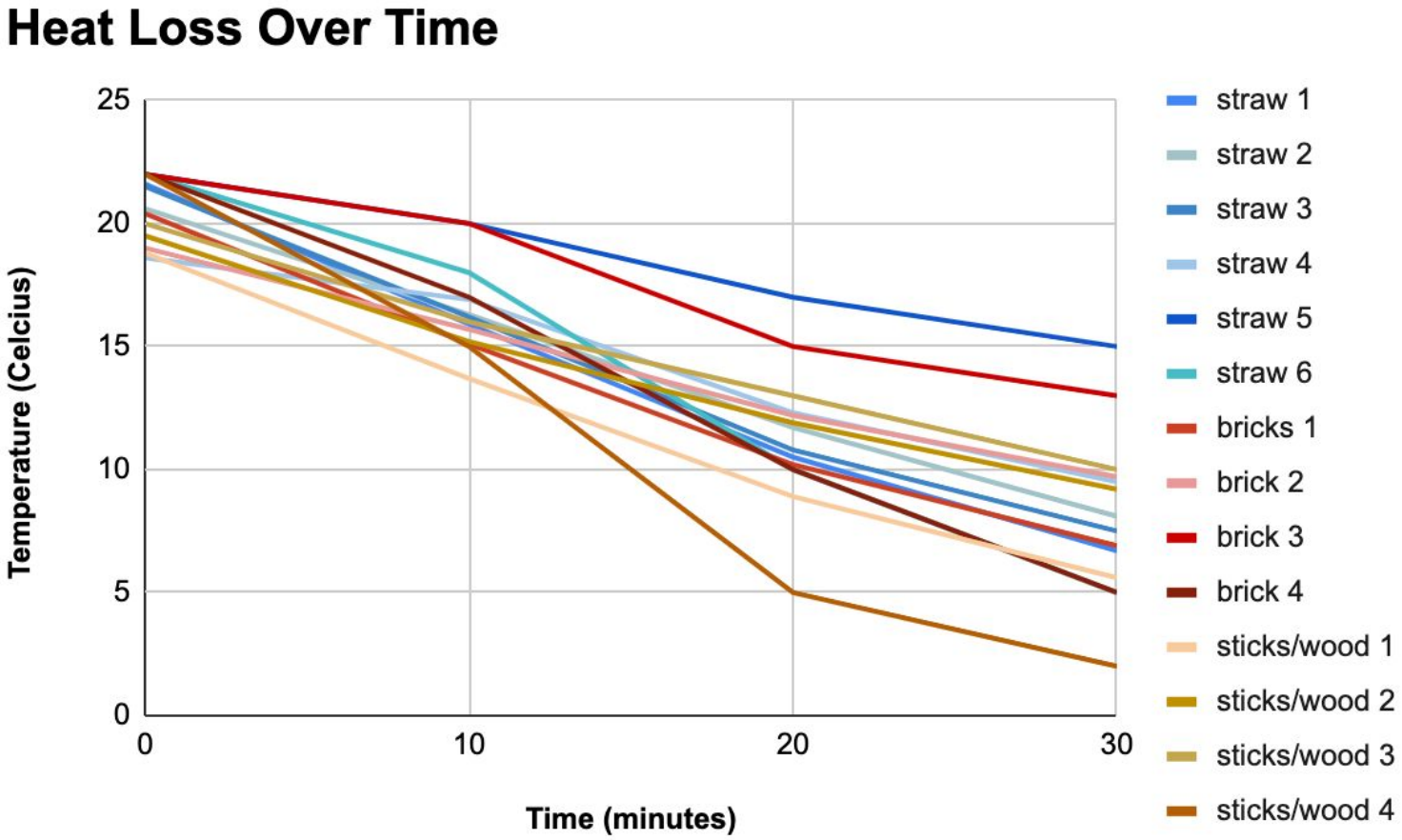
Building materials

RESPONDING

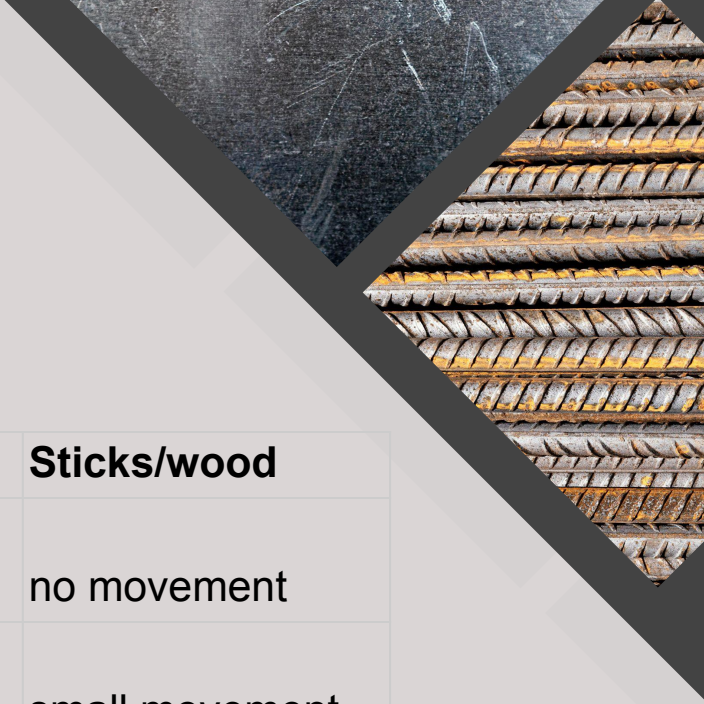
Damage and Movement (wind test)

Temperature Change over Time

DATA


Heat Loss Over Time
Temperature (Celcius)
25
20
15
10
5
0
0
10
20
30
Time (minutes)
straw 1
straw 2
straw 3
straw 4
straw 5
straw 6
bricks 1
brick 2
brick 3
brick 4
sticks/wood 1
sticks/wood 2
sticks/wood 3
sticks/wood 4

DATA



Location of Wind Source	Straw	Bricks	Sticks/wood
1.5 meters away from structure	no movement	no movement	no movement
0.9 meters away from structure	significant movement (1.8 meters)	no movement	small movement (0.5 meters)
0.3 meters away from structure	significant movement (2.4 meters)	small movement (0.3 meters)	significant movement (1.7 meters)

ANALYSIS OF RESULTS

The least heat loss occurred with straw (in test 5) and then the second least occurred with brick (in test 3). In straw test 5, there was only 7 degrees of temperature loss. Whereas in Brick test 3, there was 9 degrees of temperature loss.

The most heat loss occurred with sticks/wood in test 4. This test resulted in 20 degrees of heat loss in only 30 minutes.

Based on the r value of the building materials used (brick, wood, straw), it would make sense that straw would be a good insulator of heat. Straw has an r value of 3.3 which is much higher than the r value of brick and wood. However, in the tests, the data doesn’t align with the prediction of the r values.

The materials functioned similarly, even though straw did have a slight advantage over the brick and wood.

The information tells us that the most sturdy structure during high winds would be the brick, followed by the wood and then straw structures. Brick moved the least even when the wind was 0.3 meters away. None of the structures had much lasting damage, although the straw structure did flip over in the wind.

CONCLUSION

In conclusion, after several tests, straw was the best for maintaining heat and brick was the best for stability. If the pigs were consulting about housing materials, brick would offer the safest option and still maintain some warmth in cold temperatures. In this sense, the pigs that used brick in the children’s story were saved from the big bad wolf and this representation was accurate using data to prove it.

The data supports the hypothesis that brick and straw have different strengths but are both good building materials. If the pigs knew more about straw bale construction, they would be a very good option for safe, warm and sturdy housing.

REAL WORLD APPLICATION

Severe winds often destroy houses. Research, says that storms find the weak points in houses. Research helps so you can make your house as safe as possible from windstorms, damage and temperature changes.

Piggies would be safest in high winds in a brick building. The brick building was the heaviest, weighing it down and keeping it on the ground. It also is the sturdiest and strongest building material. If you are choosing a building to live in, or to shelter in during high winds, a brick building would be a good choice.

Piggies would stay warmest, longest, in a straw building. This is because straw is made of a lot of little holes which come together to form one material. Therefore, it insulates well. A strawbale house would be a very good choice to keep warm in a cold climate.

Other building materials, like foam, cellulose and harder packed straw would likely be even better for insulation.

There are also other ways to protect against winds like preventing updraft with good windows, no holes and fewer doors. In high winds such as tornadoes no building materials are perfect so people should go underground. Steel concrete and different building techniques can help buildings survive tornadoes and earthquakes better.

This relates to the real world because people want to be warm and safe at home, work and school.

Next Steps

Replace wooden roofs with accurate roofing materials.

Metal
Wood
Insulation
Tiles

Test more variety of building materials

Steel
Concrete

Change straw bale construction and use plaster

Pack strawbales tighter.
Plaster strawbales.

Test under stronger wind conditions

Use stronger winds to see how the houses hold up.

Add small holes to simulate doors and windows to test updraft effect.

Test under hail conditions

Simulate hail to protect the piggies.

Test under hot conditions

Reserse test

How long the building stay cool in hot conditions?

Sources of Error

Exterior Temperate

This was dependent on weather conditions.

Roof Material

All roofs used wood as a controlled variety but this could impact insulation values.

Starting Temperature

The temperate inside was variable between 19 and 21 degrees.

Thermometer Accuracy

Two thermometers were used to improve accuracy, but a more accurate and sophisticated thermometer would improve data.

Gaps in Buildings

Building materials were simple. Silicone might have left gaps for air and heat to transfer.

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