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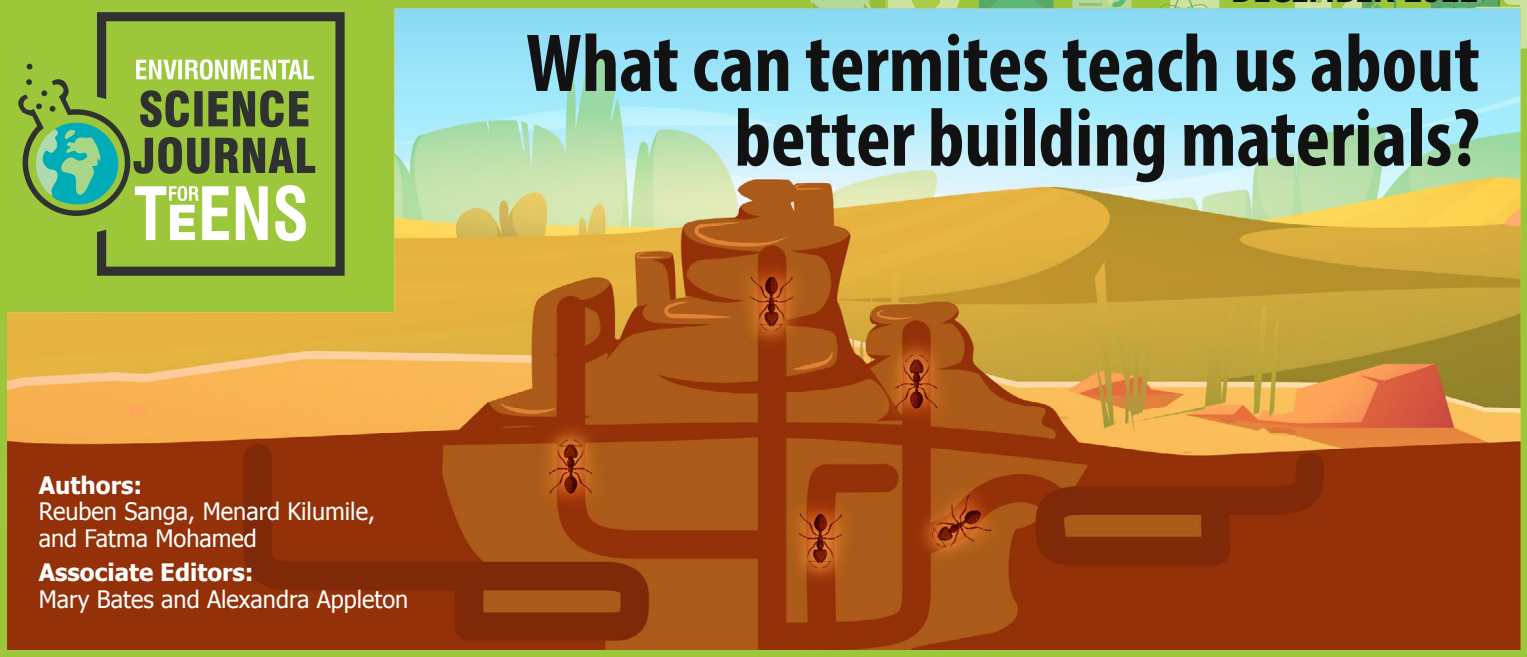
What can termites teach us about better building materials?



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Abstract

UPPER READING LEVEL

There is a global need for more sustainable and environmentally friendly construction materials. The large, stable mounds that termites build for their homes are inspirational! Termite mounds form when the termites mix soil with their saliva. This mixture contains simple sugars that act like glue and give it stability. Cassava is a starchy root vegetable that also contains simple sugars. To mimic termite mounds, we mixed soil with hot paste made from cassava flour. Then, we made bricks containing different amounts of cassava flour paste, from 0% to 6%. We tested the physical properties of these different bricks. Our aim was to see how suitable they would be in building construction. Bricks made with 1.5% cassava flour paste performed best in tests of strength, durability, shrinkage, and water absorption. They were even better than traditional clay bricks with no cassava flour! Our termite mound-inspired bricks provide an inexpensive, accessible, and safe alternative to current building materials.

Introduction

Have you ever wondered how tiny termites build such tall mounds? We thought there might be some engineering wisdom to learn from them. Termites build mounds out of soil that can reach 16 feet (5 meters) high. To make these mounds, termites fill their mouths with soil and mix it with their **saliva**. Termite saliva contains a protein called **cellulase** that breaks down plant material into simple sugars. The mixture of termite saliva and soil acts as cement for the mound. Simple sugars are also found in starchy foods like **cassava**, a root vegetable like a potato. We wanted to see if we could create bricks that mimic termite mounds using cassava flour instead of termite saliva.

Mound-building termites construct large structures to live in.
Photo: Bambiwa, CC BY-SA 4.0

Methods

First, we studied the differences between soil from a termite mound and clay soil from the ground (Figure 1). We collected samples of both types of soil in southern Tanzania, a country in east Africa. We used an **X-ray fluorescence** machine to figure out which chemicals made up the two soils. We also analyzed the physical characteristics of the soils, such as how much water they contained.

Then we were ready to create our own Nature-inspired bricks. We combined cassava flour with hot water to create a thick paste. We mixed ordinary clay soil with the cassava flour paste and poured it into molds so it would dry into brick shapes. We made bricks with different proportions of cassava flour paste. Some bricks contained 0% cassava flour, like traditional clay bricks. Others contained between 1.5% and 6% cassava flour paste and mimicked termite mounds.

When the bricks were dry, we tested them as building materials.

- We measured their **compressive strength** by applying force to the top and bottom of the brick until it fractured.
- We measured if the bricks cracked as they shrank while drying.
- We put the bricks into a machine that shook them with sand particles to determine their durability.
- We worked out how much unwanted moisture from the environment the bricks absorbed.

a)

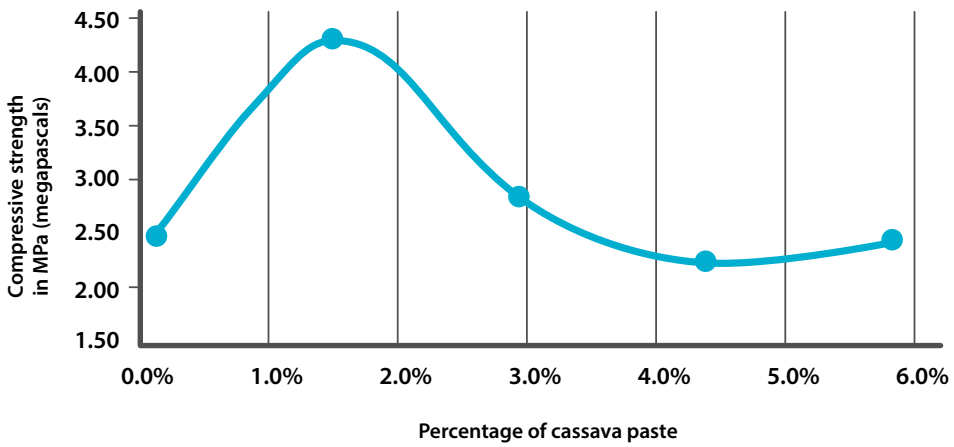
b)

Figure 1:
Soil samples from
a) a termite mound
b) nearby clay soil

Results

The chemical tests showed that the termite mound sample and the clay soil sample contained similar chemicals. The physical tests showed some differences between the two samples. For example, the termite mound sample contained less moisture than the nearby clay soil sample.

The compressive strength of traditional sun-dried clay bricks is 1.5 – 2.5 **megapascals**. Bricks dried locally in special ovens are stronger. They have a compressive strength of around 3.5 megapascals. The compressive strength of termite-inspired bricks containing 1.5% cassava flour paste was 4.28 megapascals. This is quite a lot higher than clay bricks (Figure 2). The compressive strength decreased a little in the bricks with more cassava paste. Bricks made from 1.5% cassava paste also had low shrinkage rates. The bricks containing 1.5% and 6% cassava paste performed best in tests of durability and water absorption.



What kind of brick had the highest compressive strength?

Figure 2:
Compressive strength of bricks containing different amounts of cassava paste.

Discussion

Our results show that bricks made from cassava paste have the potential to perform well as building materials. The bricks containing 1.5% cassava paste had the highest strength of all materials tested. These bricks also performed well in tests of shrinkage, durability, and water absorption. Increasing the percentage of cassava paste beyond 1.5% did not result in stronger bricks. This may be because greater amounts of cassava paste produce more gas. This causes the bricks to swell and crack, weakening the compressive strength.

Conclusion

Producing building materials and constructing buildings often has a negative environmental impact. We need to find alternative materials that are environmentally friendly. They also need to be easily available from local sources. Scientists and engineers are looking to solutions in Nature for inspiration. Why not head to the bug house at your local zoo or sit down with an animal encyclopedia to check out the fascinating behavior of different insects. Who knows – in the future, you might live in a house inspired by one of them!

The process of creating traditional burnt clay bricks is energy inefficient. It also harms the environment and people's health. Our experiments show that termite mounds can inspire better building materials. Alternative clay bricks made with cassava paste are structurally strong. They are better for the environment and human health, too. Looking for solutions in Nature may help us create better buildings in the future.

Glossary of Key Terms

Cassava – a starchy root vegetable that people eat throughout the tropics. We mixed flour made from cassava with hot water to create a thick paste.

Cellulase – a protein that breaks down plant material into simple sugars. Termite saliva contains cellulase to help them digest their plant diet.

Compressive strength – the ability of a material to withstand the pressure of a force that pushes or compresses it. High compressive strength is a good characteristic of construction materials.

Megapascal – a unit to measure pressure. Bricks made with hot cassava paste had a compressive strength of over 4 megapascals, making them stronger than traditional clay bricks.

Saliva – clear liquid made by glands in the mouth. Saliva plays a role in digestion by helping break down food as you chew.

X-ray fluorescence – an experimental technique that uses the interaction of X-rays with a material to determine the chemicals that make up that material. Researchers used X-ray fluorescence to figure out the combination of chemicals in different soil samples.

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Check your understanding

1. If you were given the choice between traditional clay bricks and bricks containing different amounts of cassava paste, which kind would you choose to use in constructing a building? Why?

2. Why is it good for bricks used in building construction to have a high compressive strength?

3. What kind of tests would you perform on a brick to determine if it would make a good building material?

4. We looked to Nature for inspiration. Can you think of another example when Nature inspired human researchers or designers?

5. In small groups, research the challenges of using different environmentally-friendly materials and sustainable sources of energy in construction. Design your own building, labeling it clearly and explaining the choices you have made.

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