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TRILOBITES

What Termites Can Teach Us About Cooling Our Buildings

"We think humans are the best designers, but this is not really true," a researcher said.

By JoAnna Klein

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In the capital of Zimbabwe, a building called Eastgate Centre holds nearly 350,000 square-feet of office space and shops. It uses 90 percent less energy than a similar sized building next door.

What's Eastgate Centre's secret? Termites.

In the 1990s, Mick Pearce, the building's architect, took his inspiration from mounds built by fungus-farming termites he saw on a nature show. The insects created their own air conditioning systems that circulated hot and cool air between the mound and the outside.

As architects and builders seek new and improved ways to cool buildings without using more energy in a warming world, a study of another type of termite mound suggests that Mr. Pearce won't be the last human to take design tips from these cockroach cousins.

"We think humans are the best designers, but this is not really true," said Kamaljit Singh, an engineer at Imperial College London and an author on the study, published Friday in the journal Science Advances. "We can learn from small animals."

newsletter.]

Dr. Singh and his colleagues used high-resolution scanning technology and computer and physical simulations to examine the microscopic structure of the external walls of African termite nests. In slabs that look solid to the naked eye, the team found a network of tiny, interconnected pores. Through principles of basic physics, these pores regulate ventilation, humidity and possibly temperature, within the mound and nest. These natural structures may offer inspiration for engineers and builders, emphasizing how comfort can be achieved through structure alone.

The air conditioning system of the Eastgate Centre in Harare, Zimbabwe, was inspired by termites' nests. David Brazier, via Wikimedia Commons

There are around 2,600 species of termites, and only about two dozen infest and destroy buildings. Many more are highly social builders aiming to protect their queens and ensure the survival of their colonies.

Carbon dioxide must exit so they don't suffocate in their underground nests, and oxygen must enter. The mounds termites build above nests are the lungs

that make this breathing possible.

But there are different types of mounds. Termites that farm fungus build structures with chimneys and openings that work like windows. The structures of non-farming termites, like the ones the researchers collected in Senegal and Guinea, have no apparent openings. To the naked eye, “everything looks blocked,” said Dr. Singh.

But the pores are there, because the mounds are made from stacking pellets of sand mixed with spit and soil. Small spaces form inside these pellets and larger spaces, between them. Previous work with CT scans showed the small pores in the outer walls of these nests.

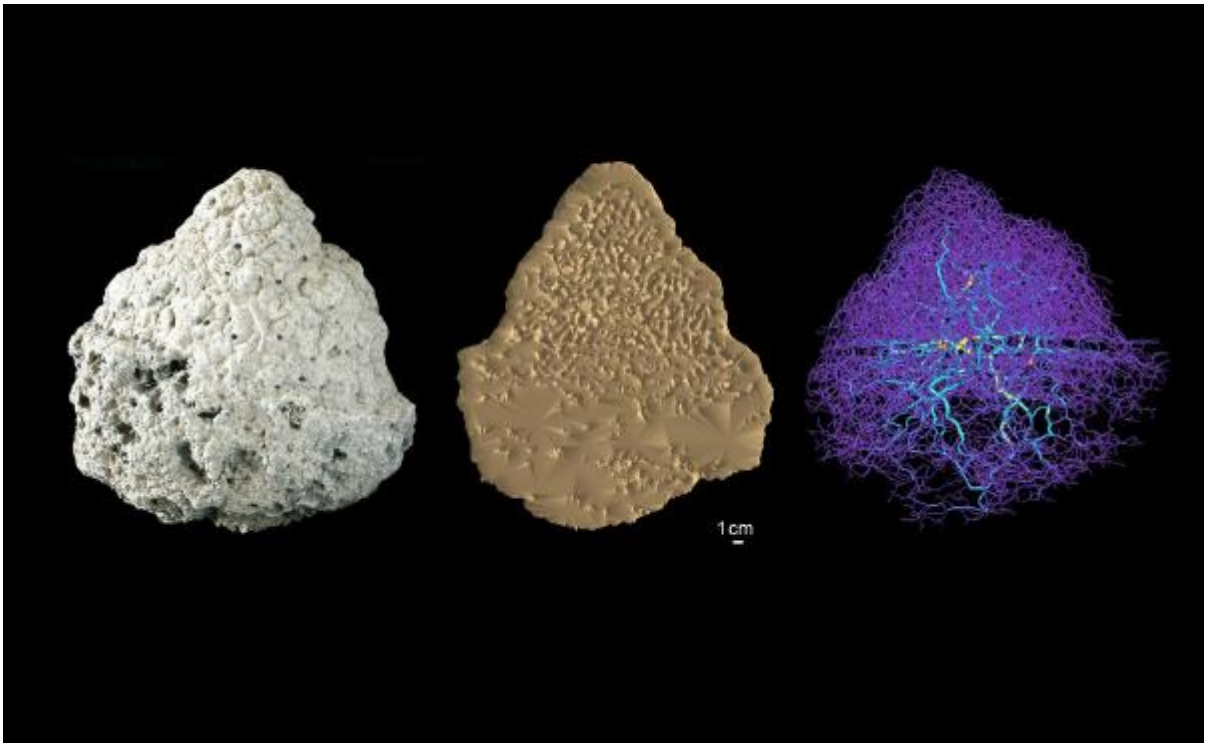
But with micro-CT scanners, the team saw deeper inside, with greater resolution and revealed the connections between smaller pores and biggers ones. That this microstructure was practically the same regardless of whether it was built of sand in dry Senegal or clay in wet Guinea suggested structure, not material, might be the key to ventilation.

When the team mimicked strong winds in simulations, structures without the larger pores couldn’t breathe as well and accumulated more carbon dioxide. The researchers also drenched mound walls in water to mimic heavy rain. The big-pore-small-pore structure dried out faster.

Scott Turner, a physiologist who was not involved in the study said Dr. Singh’s research revealed how these pores help manage gas flow and drainage.

“If you look at the physics of gas exchange in the lung, it’s very much the same way as the termite mound is organized,” said Dr. Turner.

Stirring from wind, much like a muscle contraction, allows gases to mix and reach important places like a termite nest or human blood. “If you think about what the mound is,” he said, “it’s literally an organ in physiology that’s constructed out of dirt by a bunch of little termites.”



Three views of a termites' nest, including from left, a photo of the nest, a tomography of the the nest's interior and the networks of galleries and paths in it.
G. Theraulaz, CRCA, CBI, CNRS, Toulouse

The team also thinks the pores may help regulate temperature. But Dr. Turner says in other nests soil does this; more research is needed.

It's also unclear how the termites work together to build these structures. They could coordinate actions through synergy, a kind of indirect communication system where the termites respond to chemical traces left behind by others, said Guy Theraulaz, a French biologist who also worked on the study. It's believed that a pheromone, or chemical signal in the spit on the pellets tells the blind termites when to build.

"They don't have to really think," he said. They follow rules that result from evolutionary forces and function kind of like an artificial intelligence program.

Thinking or not, "I personally wish that more people could be like termites and be comfortable with natural ventilation," said Maki San Miguel Paulson, an architect who consults on building envelopes — the outer layers that keep air sealed inside buildings. Termites, she said, "don't want an airtight environment. They want the air to flow through their building."

Builders typically focus on mechanical ventilation — fans, heating and cooling — that uses fuel and is easier to control. Eco-friendly buildings are typically smaller scale, because human comfort is difficult to achieve in systems dependent on varying climates. “Wouldn’t it be nice if people could do a building that does both?” she said.

Dr. Singh and his colleagues hope future studies of nests from other termite species will reveal general design principles that can be scaled up for humans. And as Eastgate Centre shows, buildings inspired by termites don’t have to look like termites built them.

“There is a danger to see beautiful forms and shapes in nature and simply copy them,” said Mr. Pearce. “We’re not copying forms. We’re copying the process that made the form.”

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