Chapter Three: *A tale of sustainable construction technologies and materials. - Digital Timber Construction and Mycelium technology.*

We design, nature builds! Mycelium bricks.

Fungi are nature's primary recyclers. They produce enzymes that aid in the degradation of organic matter, transforming it into minerals. Typically, these life forms grow best in shaded and humid environments. Like an iceberg, the visible portion of a fungus only represents a small fraction of it. Below the surface mushrooms develop long thread-like roots called mycelium. These are extremely thin white filaments that develop in all directions, forming a quickly-growing complex web. When the fungus is implanted in a suitable place, the mycelium behaves like glue, cementing the substrate and transforming it into a solid block. This substrate can be composed of sawdust, ground wood, straw, various agricultural residues, or other similar materials, which might otherwise go to waste. During the curation process, the fungi consumes substantial amounts of CO_2 and encapsulates it within the resulting material. This means that, unlike traditional industrialized materials, mycelium actually absorbs CO_2 from the environment instead of producing it.

Real world applications of Mycelium.

Building with fungus!

The versatility of the material means that it can be molded into any shape imaginable. Researchers from the Netherlands have also developed a technique to 3d print the material into furniture, sculptures and packaging. On top of that, Mycelium has 3 fundamental properties that make it a phenomenal building material: It is highly hydrophobic, fire resistant, and it has shown promising structural capabilities that have been experimented with in various architectural projects around the world, including pavilions and freestanding structures.

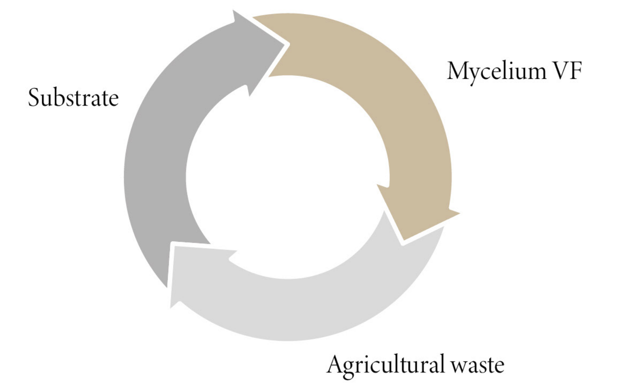
Mycelium bricks production process.

Growing the material instead of manufacturing it!

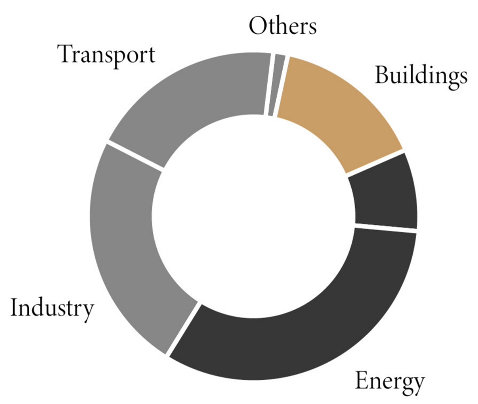
The growing process of Mycelium consists of five steps. The first step is harvesting the mycelium itself. This can be done by simply picking it up in its raw form from its natural environment, or by acquiring it from one of the many companies that today commercialize the material in many forms. After that, the next step is to pour the substrate material into a mold that will guide the growing process of the fungi.

This growing process takes between 5 to 14 days depending on environmental conditions and the size of the bricks themselves. Finally, the resulting product is "cooked" and compressed as to kill the fungi and prevent it from growing any further. The final product has promising structural capabilities that allow it to properly work under compression forces as it has been proven in numerous projects around the world.

The circular economy of the Mycelium core.



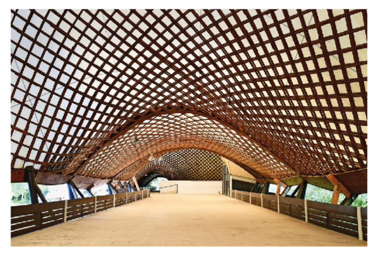
Because the bricks of the vertical farm are produced using agricultural residues-based mycelium, that means that the very crops grown in the core produce the substrate material required to grow more mycelium bricks. After harvesting the crops, the remaining organic waste (roots, leaves and stems) can be used as substrate to further build mycelium based vertical farms, making the entire process a net negative CO_2 endeavor.

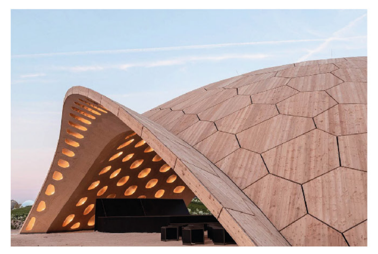


According to the UN Environment Global Status Report, the construction industry alone produces 11% of the global CO_2 emissions every year. If we add it to that produced by building operations, the percentage climbs to 30%. This is the second largest issues addressed by the Hyperbolic Garden.

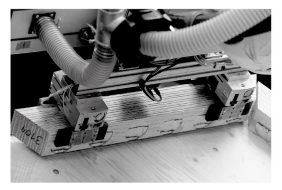
Digital Timber Construction (DTC).

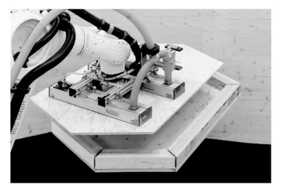
Biomimicry meets robotic construction!

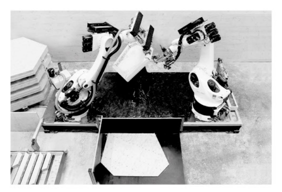




From the 1975 Frei Otto's Multihalle, to the 2019 BUGA Wood Pavilion, Germany has a history of experimentation with timber structures. For the Hyperbolic Garden's timber exo-structure, we took reference from the research conducted by the Institute for Computational Design and Construction (ICD) and the Institute for Building Structures and Structural Design (ITKE) at the University of Stuttgart. As part of their research into biomimicry, they have developed a robotic manufacturing platform for the automated assembly and milling of the BUGA Wood Pavilion's 376 bespoke hollow wood segments. This fabrication process ensures that all segments fit together with sub-millimeter precision like a big, three-dimensional puzzle.





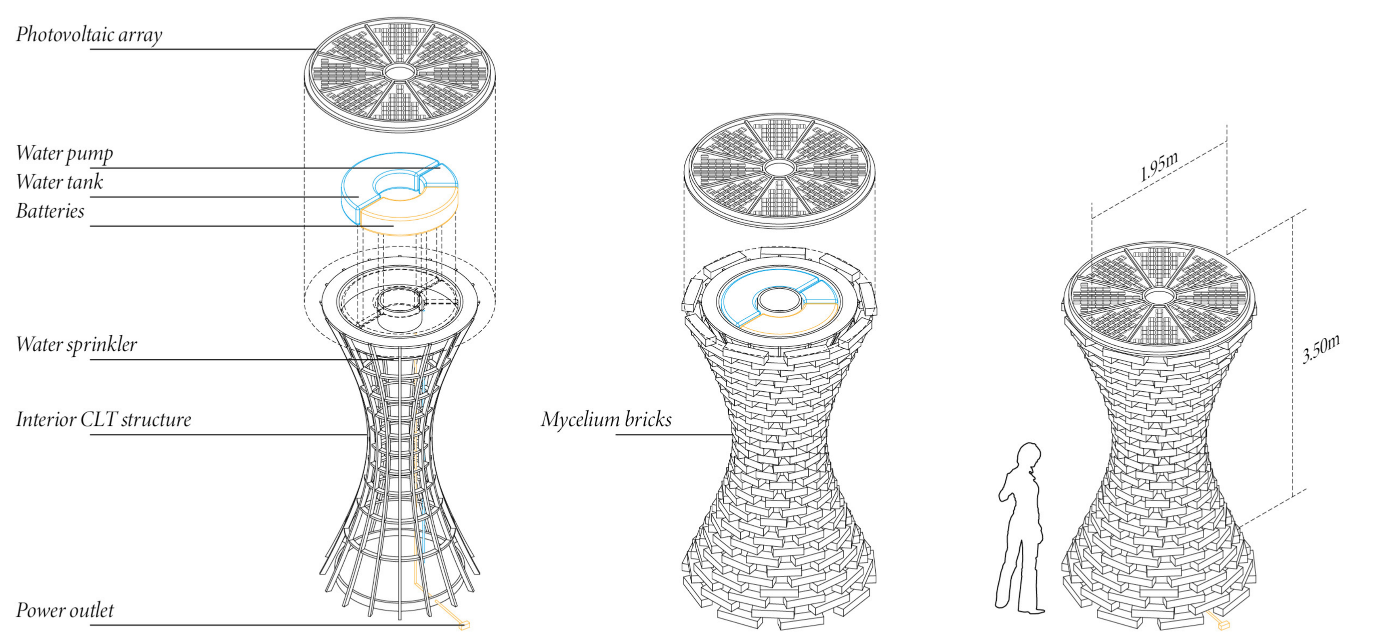


The pavilion builds on the biomimetic principle of using "less material" by having "more form". In order to minimize material consumption and weight, each wood segment is built up from two thin plates that plank a ring of edge-beams on top and bottom, forming large scale hollow wooden cases with polygonal forms.

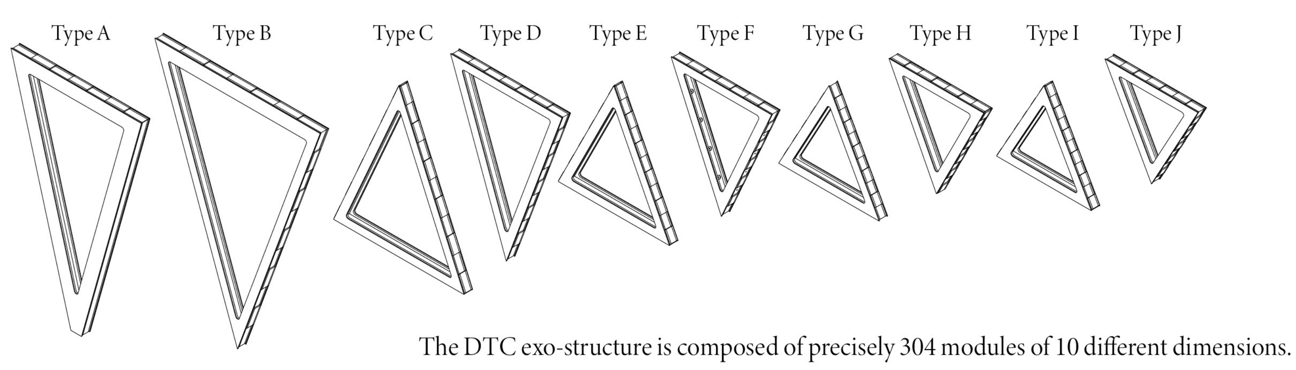
A note on scalability:

Because the design of the hyperbolic garden is entirely modular, the concept can easily be scaled to adapt to both urban and domestic settings. We have designed a prototype for domestic use built on the same principles of its urban-scale counterpart. A cross laminated timber (CLT) inner structure is wrapped by mycelium bricks that provide the growing canvas for the vertical farming crops. A photovoltaic array on top of the structure harvests enough energy to run the water pump that keeps the crops irrigated and light the hosting home.

The structural components can be standardized and the bricks can be grown domestically by the users themselves, thus reducing costs and incentivizing the widespread adoption of vertical farming.

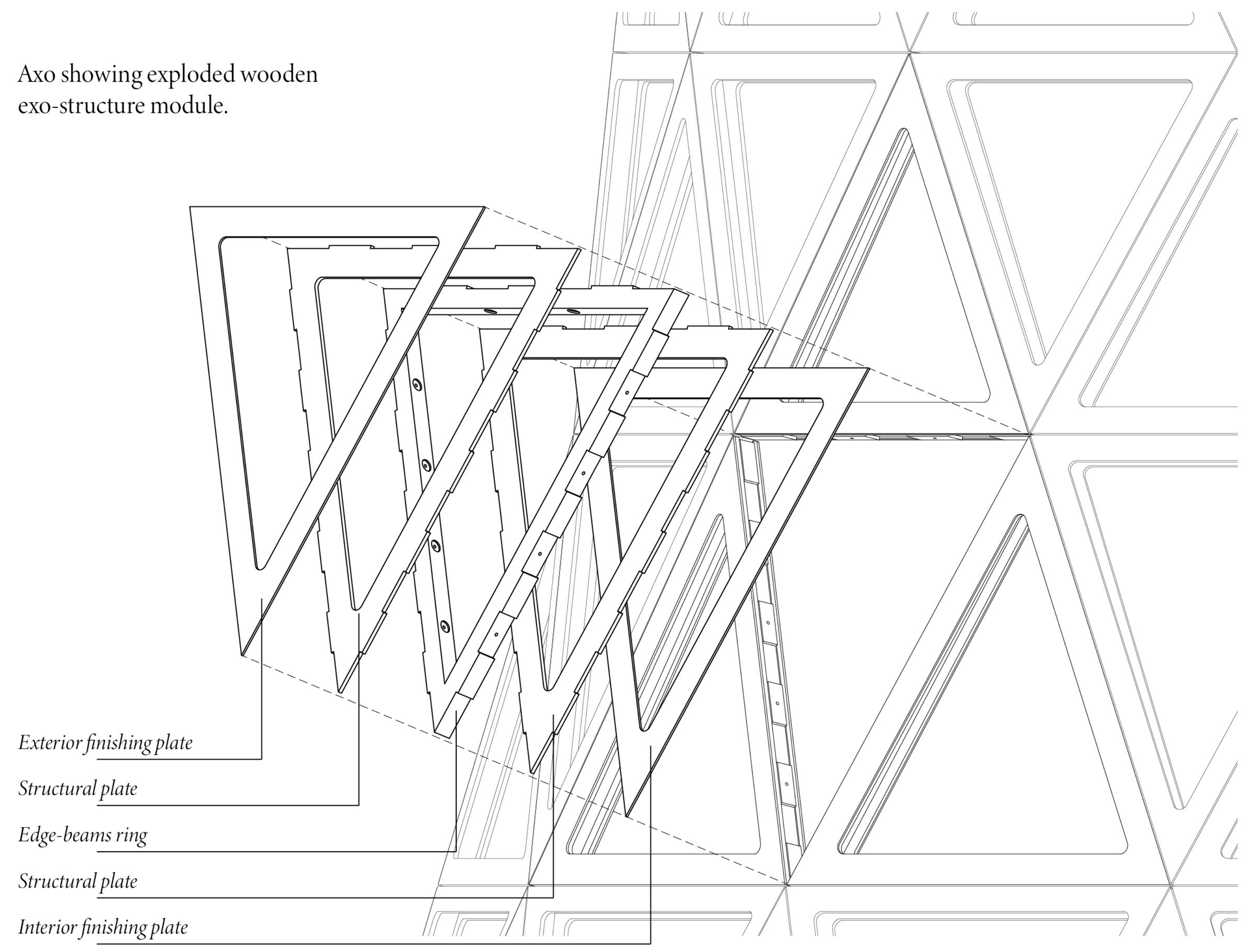


Biomimicry applied to the Hyperbolic Garden timber exo-structure.



The DTC exo-structure is composed of precisely 304 modules of 10 different dimensions.

Axo showing exploded wooden exo-structure module.



Partial elevation with sectioned DTC structure showing the CLT ramp spiraling around the mycelium core.