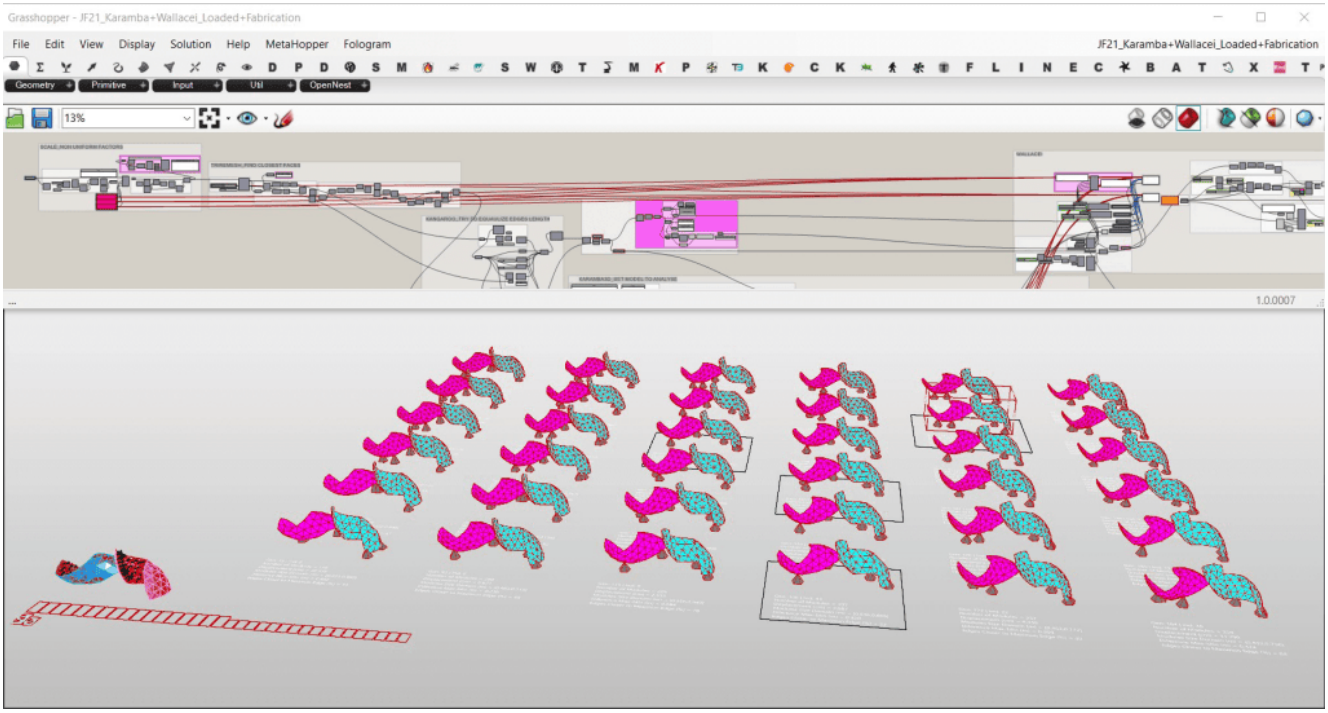
Shellscape Pavilion: Exploring Wood–Bioplastic Composites in Architecture

The Shellscape Pavilion marks the culmination of a two-and-a-half-year PhD research project at the Doctoral Center for Architecture and Design Research at Anhalt University. Conceived as both a material experiment and architectural demonstrator, the pavilion explores the potential of a new composite derived from discarded wood-based products and bioplastics. By transforming these abundant waste streams into building material, the project proposes a viable path toward circular design while showcasing the role of computational workflows and robotic fabrication in experimental architecture.

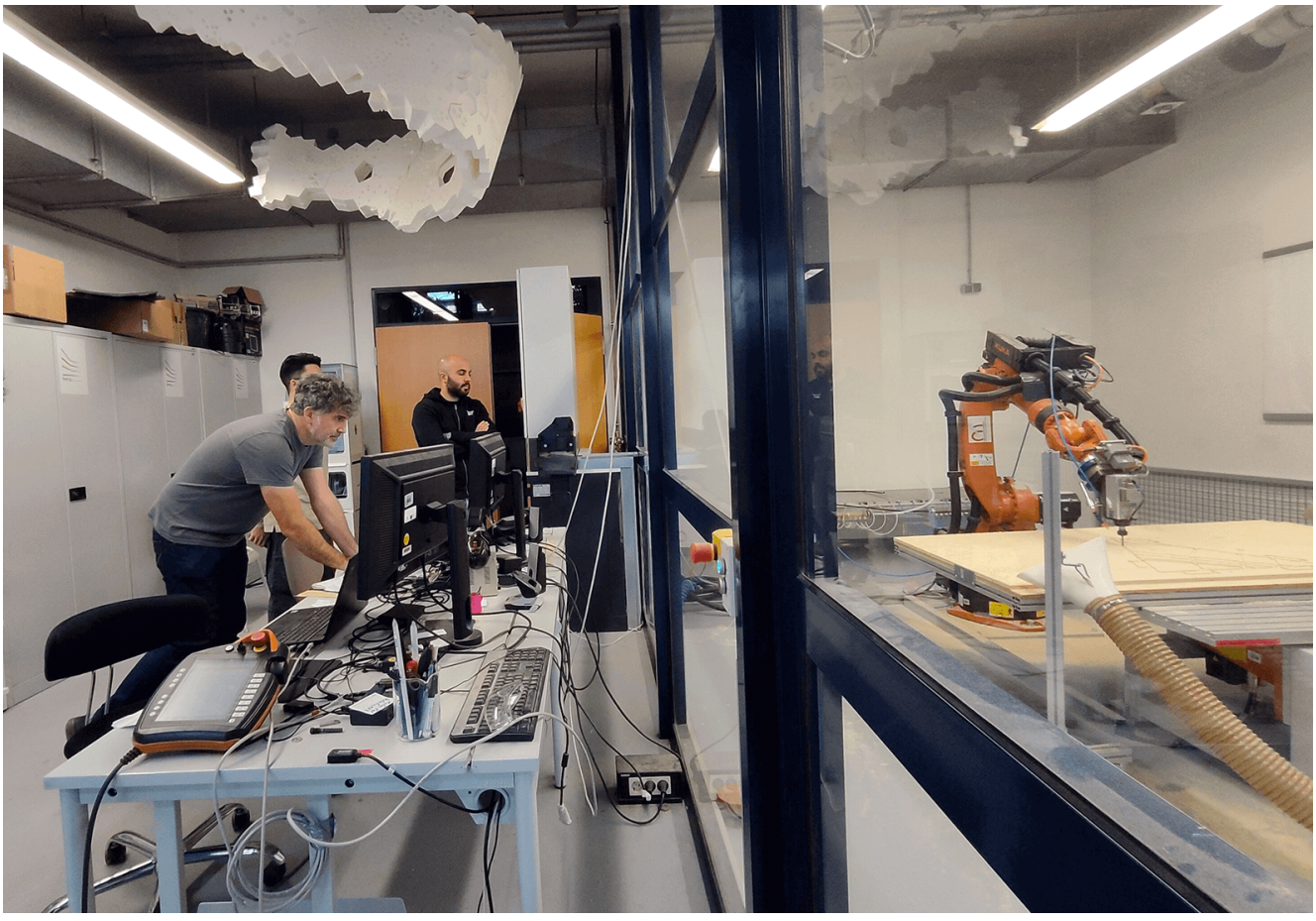


Design optimization in Grasshopper. Parametric workflow integrating Karamba3D and Wallacei to test and refine pavilion geometry according to structural performance and fabrication constraints.

FROM CONCEPT TO DIGITAL WORKFLOW

The design of Shellscape was inspired by the geometry and movement of a turtle’s shell and fins. Parametric explorations in Grasshopper set the foundation, with plugins such as Karamba3D and Wallacei guiding structural optimization. Multiple criteria informed the final form: minimizing displacement, limiting the number of modules within practical dimensions, and maximizing the reactive capacity of the pavilion’s supports.

Triangular modules were ultimately chosen for their fabrication efficiency. Karamba3D was also employed to generate internal reinforcement patterns aligned with principal stress trajectories, giving each module both structural and expressive qualities.



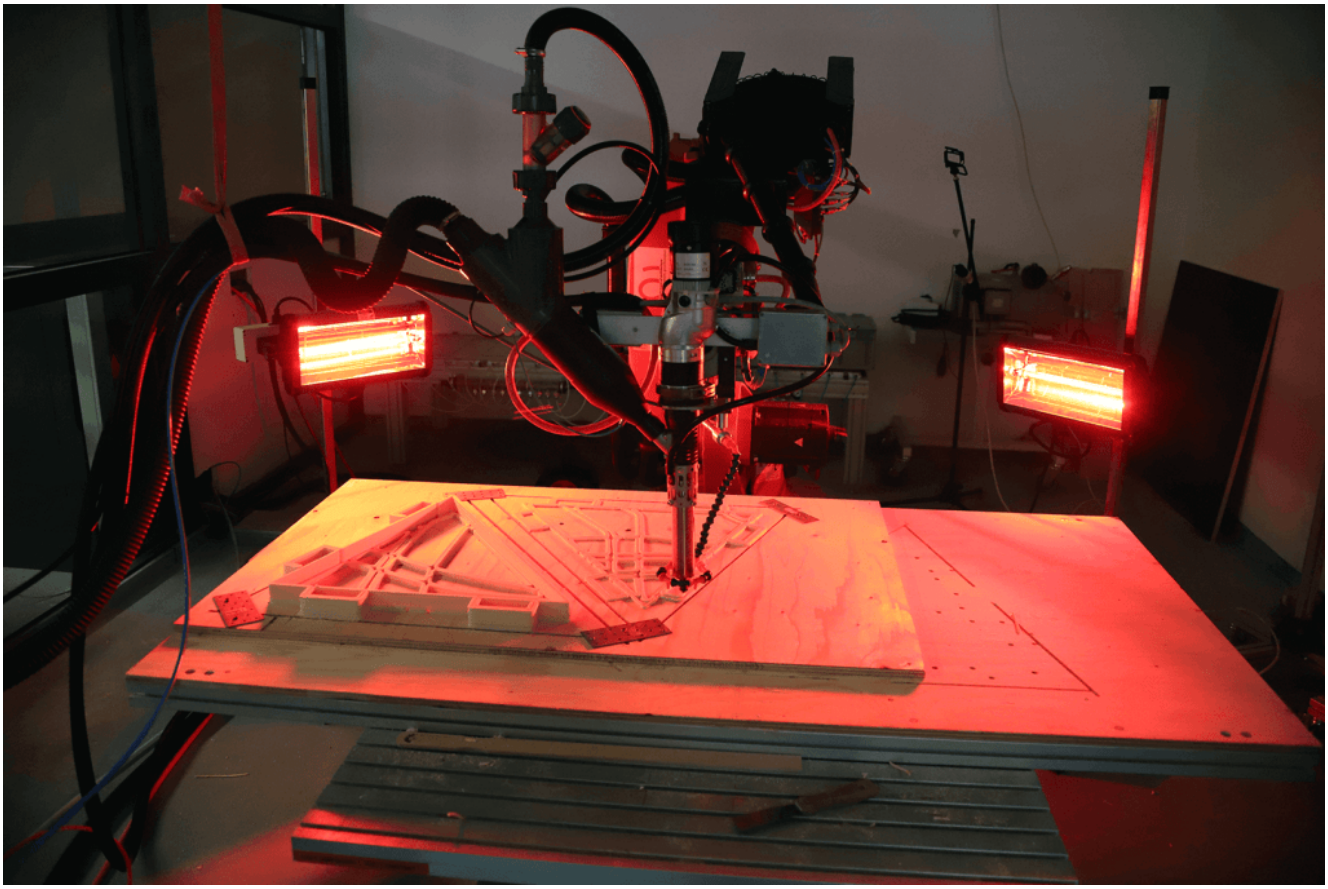
Robotics laboratory in operation. While the KUKA KR 16-2 mills plywood components for the pavilion, the team, including students, prepares the next fabrication program using KUKA|prc in Grasshopper.

ROBOTIC FABRICATION

Realizing the pavilion required a carefully orchestrated robotic workflow carried out in three stages:

- **Milling plywood bases** – The KUKA KR 16-2 robot cut triangular sheets with precision-drilled holes and channels to receive the polymer. Due to production capacity, batches were limited to three modules at a time.
- **Polymer extrusion** – Equipped with an 8 mm nozzle extruder, the robot deposited UPM Formi 3D (a blend of plywood fibers and cellulose) in layers. This process filled the milled cavities, built up internal lattices, and formed side connectors. To ensure proper bonding between layers, extrusion temperatures and robot speeds were carefully calibrated, and heaters were used to stabilize ambient conditions.
- **Surface finishing** – A sanding head was mounted to remove excess material and smooth surfaces, enabling precise module connections.

Students participated throughout, operating the robotic lab, programming toolpaths in KUKA|prc, and performing quality checks on fabricated modules.



Polymer extrusion. The robot deposits UPM Formi 3D into the milled plywood channels, while heaters maintain optimal room temperature to help ensure strong bonding between printed layers.

OVERCOMING MATERIAL CHALLENGES

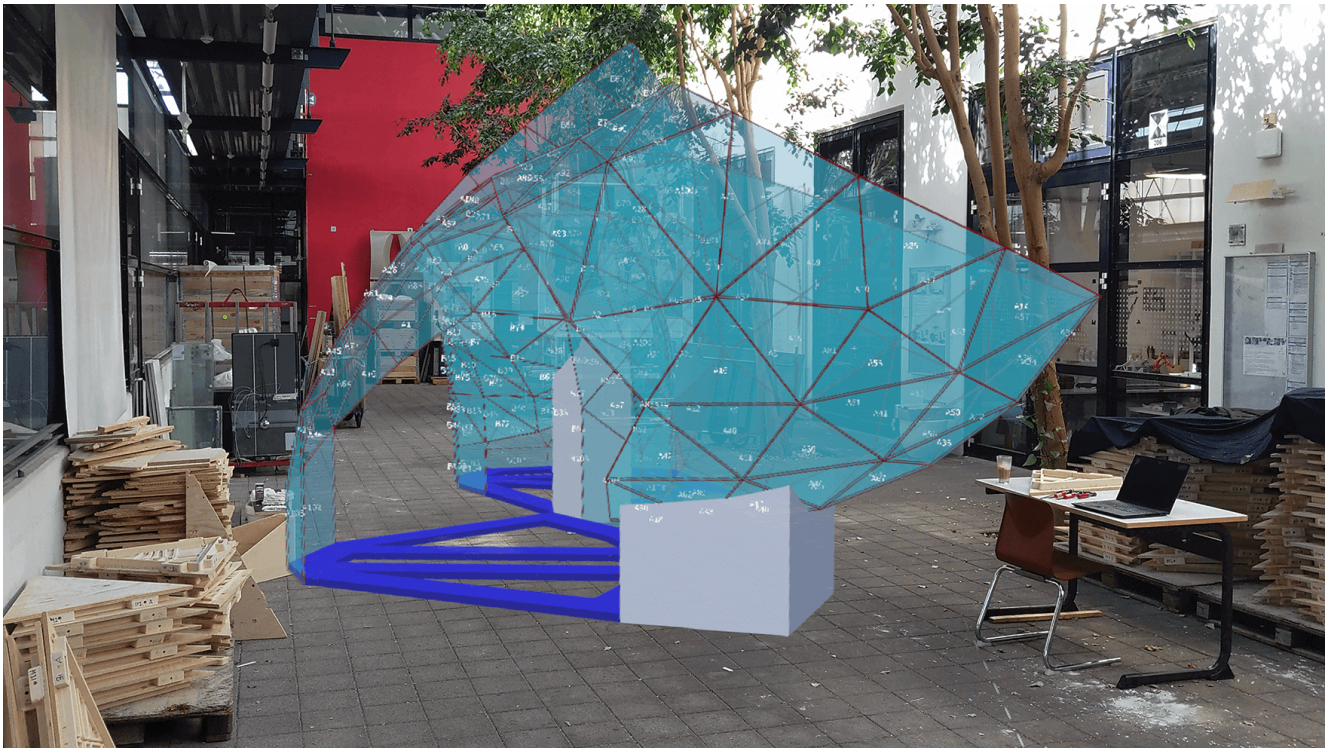
One of the greatest technical hurdles was preventing interlayer fractures caused by premature cooling of printed layers. Early failures prompted adjustments to extrusion parameters, the installation of radiators, and the optimization of toolpaths. Damaged modules were either reprinted or reinforced with metal pins, ensuring reliable durability during assembly.



Module quality inspection. Students examine and measure finished composite modules to verify dimensional accuracy and connection details before pavilion assembly.

AUGMENTED REALITY ASSEMBLY

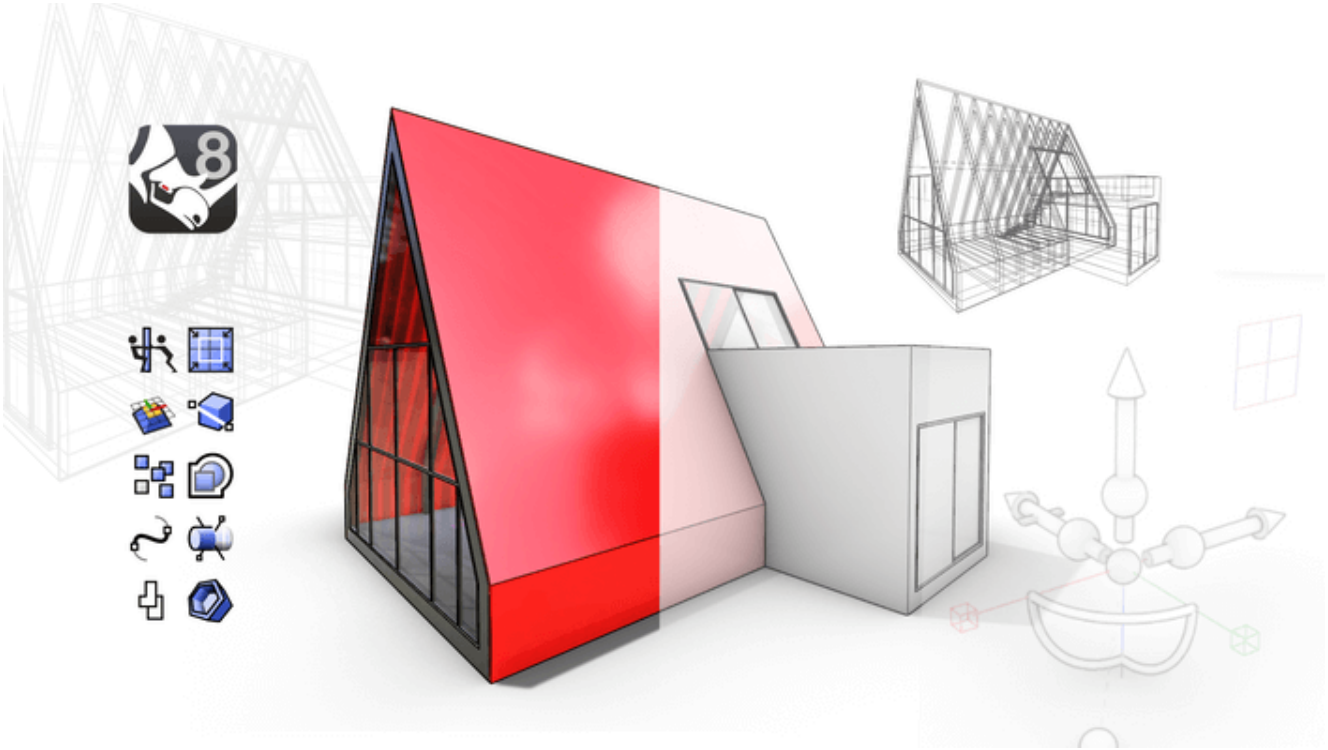
The pavilion’s assembly process was guided by HoloLens 2 and Fologram, which projected the digital model directly onto the physical site. This allowed the team to visualize the position of each module in real time and verify alignment during construction. The Shellscape team used temporary props to secure modules as the structure took shape.



Augmented reality assembly planning. The pavilion’s digital model is overlaid onto the physical site using Hololens 2 and Fologram, allowing the team to visualize module positions and assembly sequence before construction begins.

A CIRCULAR ARCHITECTURAL PROTOTYPE

The completed pavilion features a flowing, double-curved form, where smooth plywood surfaces contrast with the exposed polymer lattice. Light filtering through the interlocking modules generates a striking interior atmosphere, while close inspection reveals stress-informed reinforcement patterns running across the composite.



See Also

INTRODUCTION TO RHINO 8

More than an academic prototype, Shellscape stands as a **full-scale demonstration of sustainable design and fabrication systems**. By uniting computational design, robotic manufacturing, and mixed-reality construction, it offers a tangible model for how research-driven methods can advance lightweight, circular, and materially inventive architecture.



Early stage of pavilion assembly. The initial structural foundation and composite modules are positioned on-site according to the predefined assembly sequence, which was developed using augmented reality planning.



Shellscape stands as a full-scale demonstration of sustainable design and fabrication systems.

CREDITS

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