Figure 1: Different scale models made of alginate – from foils, threads, knitted structure to air cushions.
Source: Shape Lab

Milena Stavric

Moving Towards Sustainable Building Materials

The growing negative environmental impact of the construction sector has become a global problem. To achieve the ambitious target of net-zero emissions by 2050, as outlined in the European energy strategy, it is crucial to reevaluate current design concepts, building materials and manufacturing processes. Traditional approaches often rely heavily on resource-intensive materials that contribute to environmental degradation. In order to overcome this problem, we need new approaches to how we think about building. One possible way forward is to shift our focus to more sustainable alternative materials such as composites made from clay, mycelium or alginate. These materials have the potential to pave the way for a greener and healthier built environment.

Since 2020, the Institute of Architecture and Media (IAM) has participated in the SFB project "Advanced computational design" (funded by the Austrian Science Fund, with a project volume of 8 million euros). This project has an interdisciplinary consortium of eight partners from TU Wien and the University of Innsbruck. The project aims to develop advanced design tools and processes through research in the field of digital architecture, integrated building design, computer graphics and virtual reality, discrete and applied geometry and computational mechanics. One of the SFB subprojects, carried out by the IAM's research group Shape Lab, focuses on the integration of cutting-edge digital technologies with sustainable building materials.

MULTI-FUNCTIONALITY VERSUS MULTI-MATERIALITY

Traditional building practices when building a single wall involve using multiple materials for specific purposes, such as support, insulation, vapor barrier and water resistance. However, when it comes to disposing of these walls, separating these materials presents a challenge. To solve this problem, our long-term research goal is to develop modular building components that are tailored to specific needs and fabricated using cutting-edge 3D printing technology. Our long term goal is to create multifunctional wall elements made of clay-mycelium-alginate composite modules, that combine structural support, insulation, vapor control and water resistance into a multi-functional material. By carefully distributing different materials with specific properties, using multi-material 3D printing into a single building block, we aim to replace >

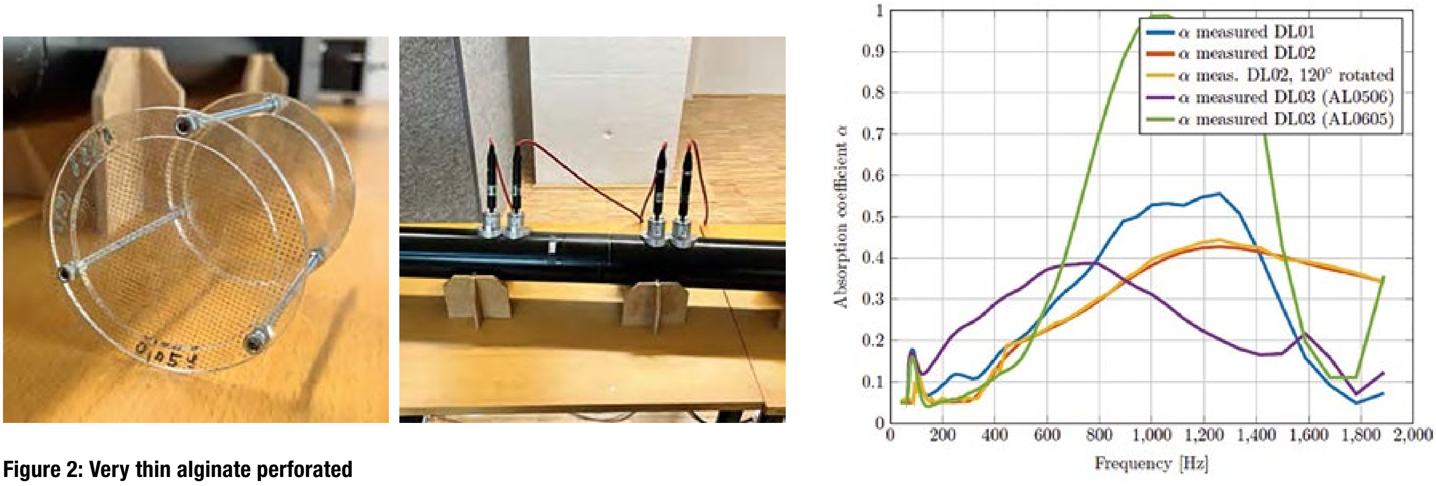


Figure 2: Very thin alginate perforated folie (left), measurements in impedance tube (middle) and results of acoustics measurements with different material compositions and geometries.
Source: Dominik Hemmer

conventional materials with sustainable alternatives, streamline construction processes, optimize material usage and reduce waste, thus improving the overall sustainability of buildings.

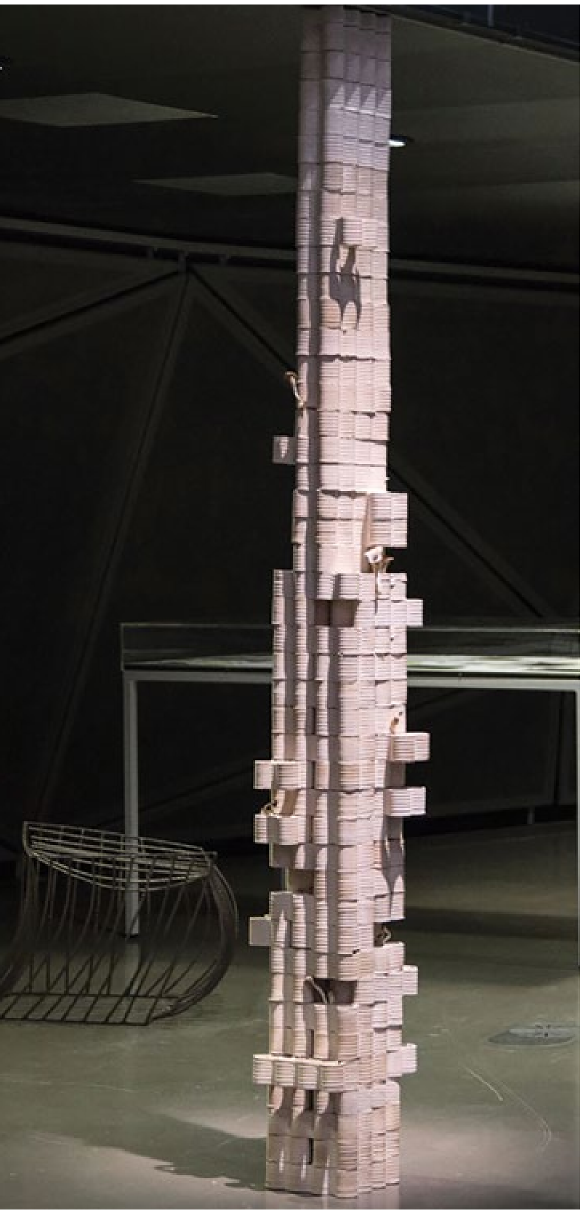
UNVEILING THE POTENTIAL OF ALGINATE COMPOSITES

In our first experiments with alginate composites, we added various natural additives. Chitosan, for instance, increased rigidity, while glycerin improved elasticity. We explored a wide range of geometries, from linear elements to complex membranes and shells. The encouraging results of our approach were evident in these initial models (Figure 1). Furthermore, we began to investigate exciting new possibilities, including scalability and integration of inorganic materials such as clay and perlite.

These initial experiments fostered valuable collaborations. In collaboration with Karin-Stana Kleinschek (Institute of Chemistry and Technology of Biobased Systems) and Jamila Ballint (Institute of Signal Processing and Speech Communication), we developed a thin, perforated alginate film as a potential alternative to plastic-based acoustic solutions (Figure 2).

Building on this success, we are currently developing a second exciting application: alginate-perlite composites (Figure 3, left). This lightweight material is characterized by a highly porous structure that results in exceptional thermal performance. It has the potential to replace standard insulation materials, such as extruded polystyrene (XPS) boards, and makes construction more environmentally friendly.

Figure 3: Alginate composite with a porous structure offers an alternative to the standard thermal insulation structure (left), the elastic alginate-clay material (center) and alginate-fiber composite (right)
Source: Shape Lab



As alginate's inherent binding properties hold promise, we are also exploring its potential for the production of thin, elastic composites by combining it with clay or natural fibers. The first material experiments show encouraging signs of flexibility and water resistance (Figure 3, center and right). Our research with alginate composites is ongoing. We are constantly seeking new ways to leverage this sustainable material for a greener future in construction.

FROM CLAY TO THE COMPOSITE "MYCERA"

Prior to reinforced concrete, clay was a dominant building material in the form of bricks, roof tiles and decorative facade elements. With our research we aim to revisit clay as traditional material and combine it with mycelium (the vegetative part of fungi) and 3D fabrication process. Through this exploration, we have developed a material called MyCera. This composite material uses the mycelium to reinforce unfired clay structures as it grows throughout the material. In fired clay applications, the mycelium biodegrades, leaving behind a unique microporous structure that cannot be achieved with conventional methods. Motivated by the results of MyCera and our collaboration with the Institute of Applied Geosciences (Dorothee Hippler) and the Faculty of Agriculture's Department for Industrial Microbiology at the University of Belgrade (Anita Klaus), we've opened a new avenue of research. This exciting path will lead to a future project exploring porous, mycelium-based clay composites and scaling our processes to achieve architectural building scale.

MyCera also has also caught the attention of the design world (Figure 4). Since 2022, it has been part of the prestigious LINZ Ars Electronica's permanent material collection exhibition. Additionally, Material District, a platform for the promotion of sustainable materials, has included MyCera in its collection since 2023 and presents it at various exhibitions worldwide. Some of the materials and prototypes from this research can be seen in the Basic Research exhibition at the Museum of Perception (MUWA) in Graz until May 15, 2024.

Figure 4: above: MyCera at the Material District 2023 (Ultrechtt, Netherlands, 2023). After printing, the structure was inoculated with mycelium and the elements were connected by the expansion of the hyphal network until they fully dried out under atmospheric conditions. The mycelium fibers transmit forces between adjacent elements by penetrating the inner structures of the elements; below: a MyCera column at the exhibition in Kunsthaus Graz, Steiermark Schau (Graz, Austria, 2021).
Source: Shape Lab

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holds the position of associate professor in architectural geometry and digital design at the Faculty of Architecture's Institute of Architecture and Media. Since 2020, she has served as the principal investigator (PI) in the SFB project "Advanced computational design" (2020-2028). This project is dedicated to the seamless integration of cutting-edge digital technologies with sustainable new building materials, fostering innovation in architectural design and construction.

Source: Privat

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