Living Systems Thinking and Making: 3D Printing with Mycelium and Upcyled Waste Materials

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This research project looks towards new possibilities for designing and making architectural elements and systems with living organisms, upcycled waste, and 3D printing technologies. In line with the 2021 ACSA conference theme, EMPOWER, this research seeks the empowerment of architecture to address our current climate crisis by advancing processes of designing and making architecture with living systems. Through a collaboration with living organisms, advances in symbiotic relationship between humans and non-humans are formed, and new possibilities emerge for architectural design, fabrication, and speculation, that challenge traditional and conventional methods of design and making in a post-human world. The project seeks opportunities for a paradigm shift in architectural design, from 'systems thinking' to 'living systems thinking', offering new possibilities and raising questions regarding approaches to architectural design and fabrication. How can we (humans) empower non-human organisms to collaborate within a design and fabrication process? What are the opportunities for architectural design when we shift from 'systems thinking' to 'living systems thinking'? How can we embed growing, living, 'vibrant matter' [1] in the process of making? How can we advance and improve upon the methods in which we collect and upcycle waste materials that are biodegradable to increase positive impacts on our environment? Can we rethink what we discard, to reduce the use of plastics and other environmentally harmful materials, and advance ecological practices in architecture? The project seeks to address these questions through applied research, and the development of techniques and workflows that demonstrate a method for advancing methods of making. This work and research encompasses a range of topics including computational design, living systems, waste, upcycling, circular economies, bio-design and bio-aesthetics.

DESIGN METHODOLOGY

The Living Systems Thinking and Making project is ongoing research that has been developed over the past two years, and includes a series of multi-scalar mycelium bio-composites, as a means of redefining material, water and energy in the face of changing scales of manufacturing and resource cycles. Our methods build on previous methods of fungal based, bio-based, materials [2] and 3D printed assembles for microbial transformation [3]. This research offers a different focus on bio-techniques for fungal growth in waste substrates in order to advance inoculated mycelium waste based extrusion pastes to 3D print product design objects, furniture, and interior design modular systems. The project includes a series of architectural objects and modular components that are designed and fabricated in a process that integrates upcycled waste materials, 3D printing, and living organisms. The upcycled waste materials include items that are discarded at various scales, from domestic to industrial scales (e.g. coffee grounds, sawdust, cardboard, etc.). By upcycling this waste, these typically discarded items, are provided a second use, as opposed to ending up in a landfill, as well as reducing the embodied energy that is used to transport these items to landfills. The upcycled waste is collected and processed to create new biodegradable waste-based materials. Our team has developed these materials as various extrudable 3D printable pastes that can be inoculated and used as a substrate for growing mycelium, the vegetative part of fungi. (Figure 1). The mycelium is grown on this substrate under specific environmental conditions, forming a dense network of hyphae that serve as a binding material, a natural glue, that strengthens and bonds the upcycled waste materials together. The mycelium hyphae networks grow within and on the paste, solidifying the 3D printed layers into a cohesive whole through bio-welding. Microscopy and computational simulation techniques are used to better understand the behaviors and characteristics of the hyphae networks. (Figures 2 and 3). During the growing period, the mycelium reflects unruly behavior, and leads to new growths, formations, and patterns, as well as haptic qualities, opening up new possibilities for architectural finishes and the expression of bio-aesthetics. The mycelium is grown for approximately 7 days in a sterile environment to avoid contamination, at which point it is removed to stop its growth, followed by a drying and baking process, to remove any additional moisture.

The resulting objects and modular components serve as applied research and a proof-of-concept for a design and fabrication workflow; upcycling waste, 3D printing, and growing mycelium.

Figure 1. Waste material paste substrate with growing mycelium. © bioMATTERS, LLC

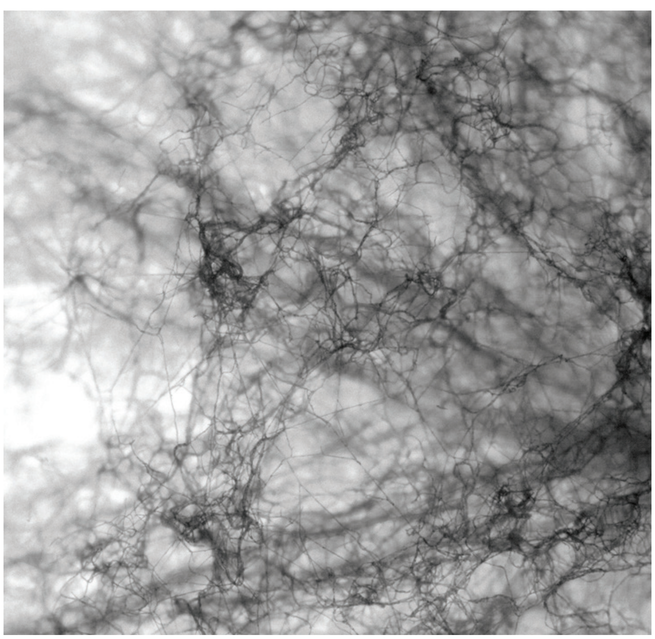

Figure 2. Mycelium hyphae network 10X magnification.
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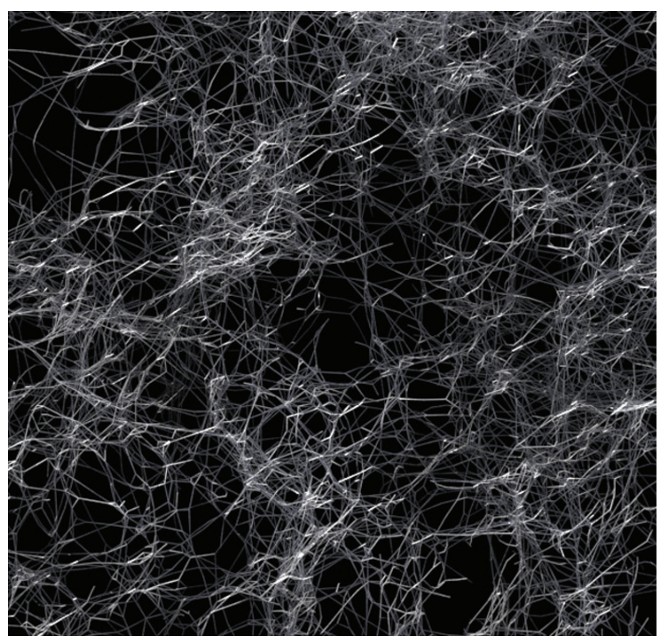

Figure 3. Computational simulation of hypahe network.
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Figure 4. 3D printed mycelium objects. © bioMATTERS, LLC

Figure 5. 3D printing waste material process. © bioMATTERS, LLC

Figure 6. 3D printed waste material component assembly. © bioMATTERS, LLC

Figure 7. D printed waste material component detail. © bioMATTERS, LLC

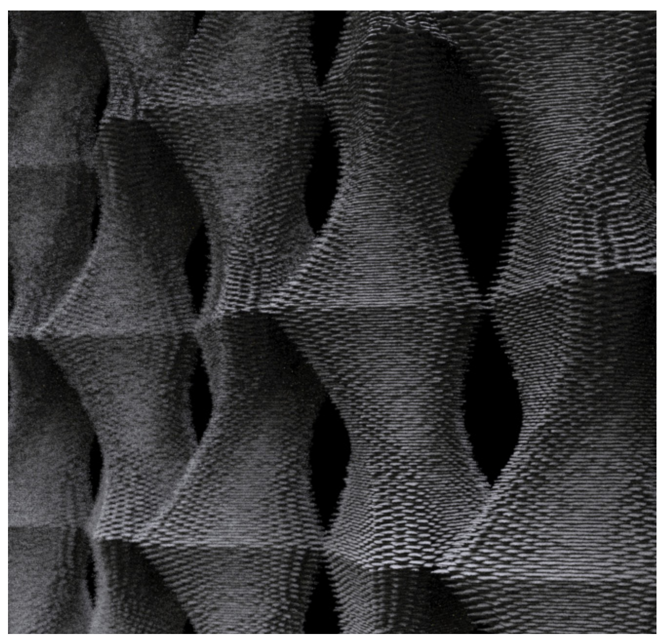

Figure 8. Rendering of 3D printed waste material component assembly. © bioMATTERS, LLC

(Figure 4). These elements, are computational designed and utilize 3D printing techniques to provide opportunities for designing and fabricating complex geometries, surfaces, and forms, that are not possible through other fabrication techniques. (Figure 5). This also eliminates the production of additional material waste from fabrication processes such as casting, which require molds. To shift from an object to an architectural scale, our team is exploring the design and fabrication of components that can be assembled to form larger assemblies. (Figures, 6, 7, and 8). These systems, are intended primarily for interior applications, such as interior screens and performative wall paneling systems. These designed objects serve as a proof-of-concept for 3D printing parts that can be grown with waste materials and natural binders. These elements, while strong and durable, will eventually biodegrade, promoting circular economies and ecological design strategies, as opposed to synthetic, non-biodegradable products and material systems.

CONCLUSION

We believe this research demonstrates new potentials and possibilities for architectures that empower living systems within architectural design and fabrication, promote and advance ecological design, and open up new possibilities for merging computational design workflows with growing living organisms. The project questions cultural attitudes towards debris, by valuing waste contributing to circular material cycles and ecologically positive material processes. It prompts rethinking methods in how individuals, neighborhoods, and cities address waste, and seeks to improve sustainable practices, raise ecological awareness, and promote ecological 'tuning' [4]. The project seeks to address these questions and methods through applied research, and the development of techniques and workflows that demonstrate alternative biologically based methods for designing and making architecture.

ENDNOTES

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