The Living Room

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Knitting as a Strategy to Redefine the Architectural Possibilities of Mycelium Biofabrication in the Built Environment

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1 The Living Room on exhibition in The Farrell Centre, Newcastle, UK. Photo credit: Ben Bridgens.

ABSTRACT

The Living Room is a mycelium-knit biohybrid architecture that consists of an exposed knitted formwork on the interior and a smooth mycelium plaster on the exterior, creating a monolithic 4-m-diameter, freestanding structure. The aim of *The Living Room* is to develop a complex architectural form with doubly-curved surfaces; exploiting the unique properties of a composite system that brings together flexible, shaped, 3D knitted formwork, with *mycocrete*, a bespoke mycelium paste formulated for use with textile scaffolds.

Furthermore, *The Living Room* seeks to demonstrate how bio-textile fabrication can make use of waste materials and by-products from local industries to grow large-scale structures with minimal environmental impact. To achieve these goals, an iterative process was required which integrated physical making at small and large scale, digital modeling, structural analysis, biomaterial experimentation, and knit specification.

The design and fabrication process enabled a conceptual design, developed through physical knit prototyping, to be scaled up via digital modeling, to create a large-scale installation with the flexibility to modify the idealized model geometry on site during fabrication. The process is critically examined, and opportunities to improve the form finding and simulation of the knit formwork canopy are identified as key areas for further development.

INTRODUCTION

Biotechnologies are beginning to offer compelling alternatives to challenge traditional building processes, envisioning a future where growth replaces construction (Dade-Robertson 2020). Alternative practices are undoubtedly required to reduce the carbon impact of the built environment; currently construction is responsible for 11% of global carbon emissions, and an additional 28% of global carbon emissions are generated during building operation (United Nations 2020). The challenge is, therefore, to dramatically reduce the embodied carbon in constituent materials and move towards circular systems, while improving building performances, so that high-energy processes such as heating, cooling, and ventilation can also be reduced.

Mycelium-based composites, composed of mycelium (the root network of fungus) and cellulose-rich substrates, such as sawdust and food waste, are already commercially available for packaging, and insulation (Mogu n.d.; Ecovative n.d.). While most of these composites are formed at standard sizes as panels and blocks, researchers are exploring digital fabrication processes such as 3D printing (Elsacker et al. 2022), 3D knitting (Scott et al. 2021; Yogiaman et al. 2020) and robotic manufacture (Elsacker et al. 2021). The Living Textiles Research Group, based in the Hub for Biotechnology in the Built Environment at Newcastle University, is focused on biohybrid strategies which bring together mycelium with textiles, specifically the application of knitted fabrics as a scaffold for growth, producing permanent knitted formwork to enable the scale-up of mycelium biohybrids for the built environment.

This paper discusses *The Living Room*, a mycelium knit biohybrid architecture that consists of an exposed knitted formwork on the interior and a smooth mycelium plaster on the exterior, creating a freestanding architecture reminiscent of a thin-shell vaulted structure (Figure 1). The aim of *The Living Room* is to develop a complex architectural form with doubly curved surfaces; exploiting the unique properties of a composite system that brings together flexible, shaped, 3D knitted formwork, with *mycocrete*, a bespoke mycelium paste formulated for use with textile scaffolds (Kaiser et al. 2023). Alongside this, the ambition for *The Living Room* is to question material resources; growing the structure using waste and by-products sourced from local industries. To do this, it was necessary to challenge the protocols established in a previous prototype, BioKnit (Agraviador et al. 2022), and to develop new methods to design, test, and fabricate large-scale mycelium textile biohybrids.

This paper describes the iterative design process, analyzing the relationship between physical making and digital modeling as the scale of production increases to achieve the final 4m-diameter, 2m-high prototype. The paper details the specification for the freehand knitted canopy, and the structural modeling required to determine the thickness of mycocrete paste required to achieve structural stability. Findings evaluate the process, and identify challenges and opportunties in the application of knitting as a strategy to redefine the architectural possibilities of mycelium biofabrication for the built environment .

BACKGROUND

Doubly curved surfaces have been developed as knitted components of a series of composite systems using partial knit, or fléchage, to produce internally shaped panels that act as knitted formwork for concrete or resins (Popescu et al. 2021; Liu, Li and Yuan 2020). The advanced programming capabilities of machine knitting have led to specialist research focusing on methods to apply the manufacturing capabilities of Computer Numerical Control (CNC) industrial knitting technologies on an architectural scale (Sabin 2019; Ahlquist 2016; Thomsen et al. 2019; Tamke et al. 2021; Popescu et al. 2021; Underwood and Zilka 2022; Scott et al. 2022). Conversely, there are important precedents such as the immersive installations by Ernesto Neto (Tanya Bonakdar Gallery n.d.) and crochet playgrounds by Toshiko Horiuchi MacAdam (MacAdam 2017) that apply hand process in the construction of large-scale textile structures. Independent of the manufacturing technology, the knitting process remains the same.

The use of knit in biotechnology is expanding due to its high biocompatibility with microorganisms, its ability to scale, and the opportunity to produce lightweight structures and complex forms. The use of knitted formwork for mycelium composites has been demonstrated in recent projects (Yogiaman et al. 2020; Scott et al. 2022). BioKnit (Agraviador et al. 2022; Kaiser et al. 2023), achieved curved arches as a result of the transition from a soft material to a rigid form using catenary geometries formed by suspending the prototype during growth.

Biofabrication of Mycelium Composites

To grow a rigid composite material, mycelium spawn (a mixture of growing mycelium and a nutrition source, such as millet or rye) is mixed with bulk substrate material and water. Previous research by our group developed a mycelium paste recipe, mycocrete (Kaiser et al. 2023), specifically adapted for use in textile formwork. This recipe includes paper cellulose products and gelling agents to produce a smooth viscous paste. The mycelium is grown in a controlled environment for 7 to 10 days. During this time, the mycelium colonizes the substrate and binds all the materials together. In previous work, mycelium textile composites have been created by filling tubular knitted formwork (Kaiser et al. 2023); however, for purposes of this research, mycocrete was adapted to use as a mycelium render, plastered onto the surface of the flexible knitted formwork.

DESIGN APPROACH

This paper explores the interaction of digital modeling and physical making for large-scale biofabrication using a knitted canopy to generate the formwork for a mycelium composite. The established design workflow to create knit formwork for doubly curved surfaces is exemplified in the advanced computational design and digital fabrication required for KnitCandela (a thin, sinuous concrete shell built on ultra-lightweight knitted formwork) (Popescu et al. 2021). Here, the precision defined in modeling and simulation requires a combination of external supports, falsework, and internal pneumatics to produce the extraordinary knitted, doubly curved geometries. An alternative approach is proposed in Active-Casting (Yan Ng et al. 2020), where concrete is cast into an extensible knitted formwork. Here, the outcome is an interaction between both the digitally modeled and knitted formwork, and the material behavior of the poured concrete, resulting in “emergent architectural design previously difficult to achieve” (Yan Ng et al. 2020, 547).

The design approach developed in this research combines digital modeling and physical making to address the shape, material, and structural requirements for biofabrication of *The Living Room* (Figure 2). This project is complicated through multiple variables including; the use of unconventional, non-standard materials (wool tops), the application of a freehand knitting process (where stitch length and fabric formation is controlled by hand), and the ambition to biofabricate a freestanding installation with mycelium for public exhibition. As such, the workflow moved between the digital and the physical through iterative cycles of experimentation and analysis.

PHYSICAL MAKING USING GENERATIVE PATTERNS IN KNIT

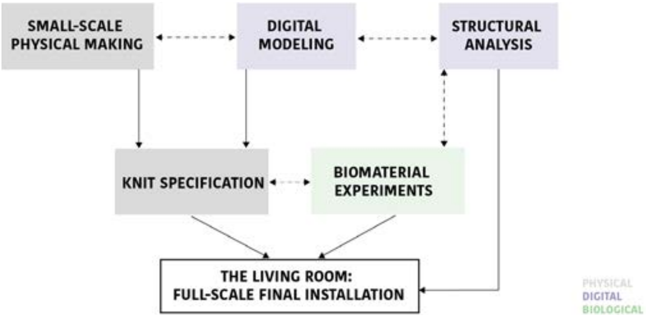
Doubly curved surfaces that become hyperbolic forms (Wertheim 2007) are knitted by increasing the number of stitches by consistent amounts over subsequent courses. These forms can be created from flat or circular knitting techniques. Hand-knit processes are particularly suitable for the development of this kind of complex form because there is flexibility in rates of increasing, achievable without limitations determined by machine control systems. On a small scale knitted models can be self-supporting, generating organic form that is more reminiscent of underwater corals than rectilinear architectural form (Table 1). As a design team, we were keen to understand the scalability of this specific knit geometry using mycelium to produce a self-supporting biohybrid architecture.

Alongside this, our research is focused on the transition to 100% waste material for biofabrication. Thirty-two million *kilograms* of wool is produced each year in the UK (Gosling and Tully 2023, 5) as a by-product of the meat industry. This is a largely wasted resource that is undervalued and underused because it is more difficult to process than wool obtained from sheep bred for their fleece (ibid). The knitted canopy formwork for *The Living Room* is composed of Herdwick wool, a breed native to the hills of Northwest England. The wool was obtained as wool tops - lengths of fibres approximately 25mm diameter - that are scoured and carded, but not twisted into yarns. Wool tops are unsuitable for machine knitting due to the size of this material and the lack of twist (therefore, strength). However, this scale of material is ideal to work manually at a large scale using freehand knitting processes (Figure 3). In addition, initial lab-based experimentation determined that the coarse nature of the wool, and the untwisted bundles of fibers provide an excellent interface for mycelium growth.

A series of initial knitted models were produced that demonstrate how systematic rates of increasing, expressed as a generative pattern, leads to complex three-dimensional forms. By changing the rate and position of increasing, a series of textile forms with hyperbolic geometries can be generated (Wertheim 2007). The initial models are knitted using circular knitting technique, and use only three actions *knit* (K), *increase* (M), and *decrease* (D). Knit continues the knitted fabric around the circumference at a constant rate, *increase* makes a new stitch (by knitting into both the front and back of the stitch) increasing the circumference of the fabric, and *decrease* knits two stitches together, decreasing the circumference of the fabric. Table 1 records the generative pattern required to achieve each form. In this *table, "R"* indicates the course (row) of knitting.

DIGITAL MODELING

The aim of digital modeling was to explore how to translate the forms generated through patterns of increasing in handknitting into the accurate dimensions necessary to produce the desired knit geometry. The digital model was not required as a visual representation of the architectural form, because the intention was to use the internal



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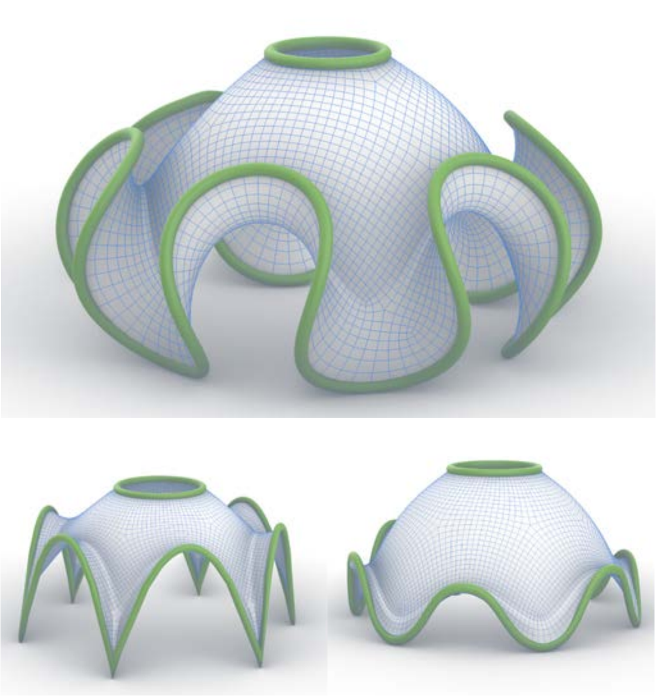

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2 Diagram showing interaction of digital modeling and physical making processes.

3 Freehand knitting process illustrating the scale of knitted stitches created with Herdwick wool tops. Photo credit: Jane Scott.

4 Methods to achieve a domed surface with apertures around the edges and an oculus at the apex. Left: a disjunctive union of a hemisphere with rotational array of bisected hyperboloids. Centre: a hemisphere with Enneper surface with parameters limited to avoid self-intersection. Right: the use of graph mapping to translate the curve of xy function into variable apertures around a hemisphere. Image Credit, Armand

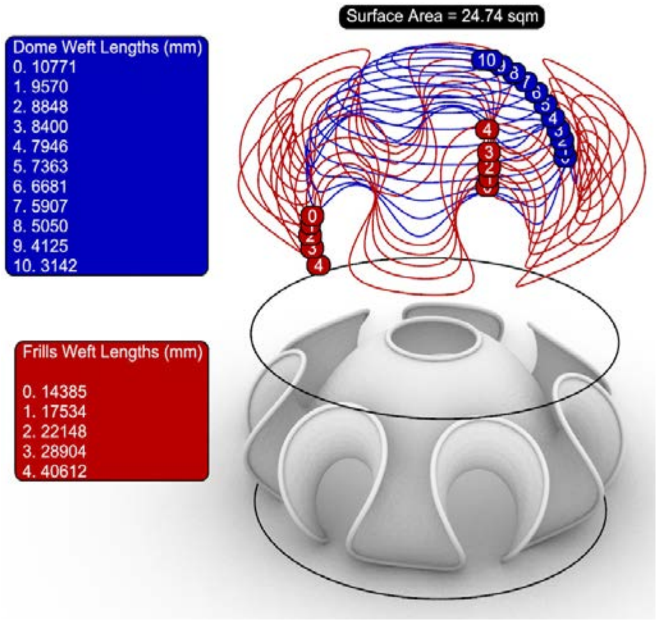
Table 1 Initial hand-knitted models based on generative patterns.

circular hyperbolic	circular hyperbolic	cone	hyperbolic sphere
			
Cast on 20 stitches *R1: K R2: K1, M1 Repeat from *x6 Cast off 337 stitches	Cast on 120 stitches *R1: K R2: K2, D1 Repeat from *x4 **R9: K R10: K2 M1 Repeat from **x4 Cast off 120 stitches	Cast on 60 stitches *R1-5: K R6: K1, D1 Repeat from *x5 Cast off 8 stitches	Cast on 20 stitches *R1: K R2: K1, M1 Repeat from *x4 **R11:K R12:K3 D1 Repeat from **x18 Cast off 20 stitches

structure of the fabric to generate the form, enhanced by external tensioning. The digital model was, however, essential to determine the dimensions and lengths required to create the textile surface by reporting measurements on curved geometries. Rhinoceros 3D modeling software and Grasshopper visual programming software were used to model test geometries by running numerical variables through a script. This application of parametric design was appropriate in ensuring that surface generation was adaptive. Sliders were used to test the impact of different combinations of individual variations on the resultant homogeneous form. These could be manipulated by the team while being able to maintain a structural logic. These sliders were floating-point numbers representing continuous data such as height and diameters of volumes or apertures, or factors related to curvature.

Three initial approaches were explored to achieve a domed surface that featured apertures around the edges and an oculus at the apex (Figure 4). The Enneper surface (a self-intersecting surface) was selected; as a minimal surface (Weisstein 2023), it would theoretically encourage the most efficient use of material to bridge between desired sections of geometry, most closely representing the behavior of the knitted fabric.

The script uses the Enneper Surface component of the Lunchbox plugin for Grasshopper (Piker 2017) which constructs a surface based on variables including order, scalar and domain parameters. The order parameter is an integer that defines the number of frills at the edge of a surface. Corresponding to apertures in the final geometry, the team settled on order n=7 to best suit interaction within the exhibition space, given their size. The domain parameter defines how much of the self-intersecting surface is cropped, effectively controlling the intensity of the frill curvature. The team chose an amount that would leave enough material to physically manipulate variation in the openings to enable hierarchy and vistas. The script then superimposes the Enneper surface onto a hemispherical surface with appropriately limited diameter, height, and oculus size parameters, so as not to allow one geometry to subsume the other. The oculus was desired from both design and fabricability needs. The script finally trims away the superfluous geometry underneath before smoothing the remaining joined surfaces to a degree that can make the overall form morph between dome-like to cone-like. With this composite form, further scripting allowed for concentric “latitudinal” lines to be interpolated between the circular oculus to the outer perimeter at a desired spacing (Figure 5). The lengths of these topographical-like contours were critical to inform the knitting pattern, while reporting the total surface area, allowing substrate volumes, weight, and material requirements to be estimated.



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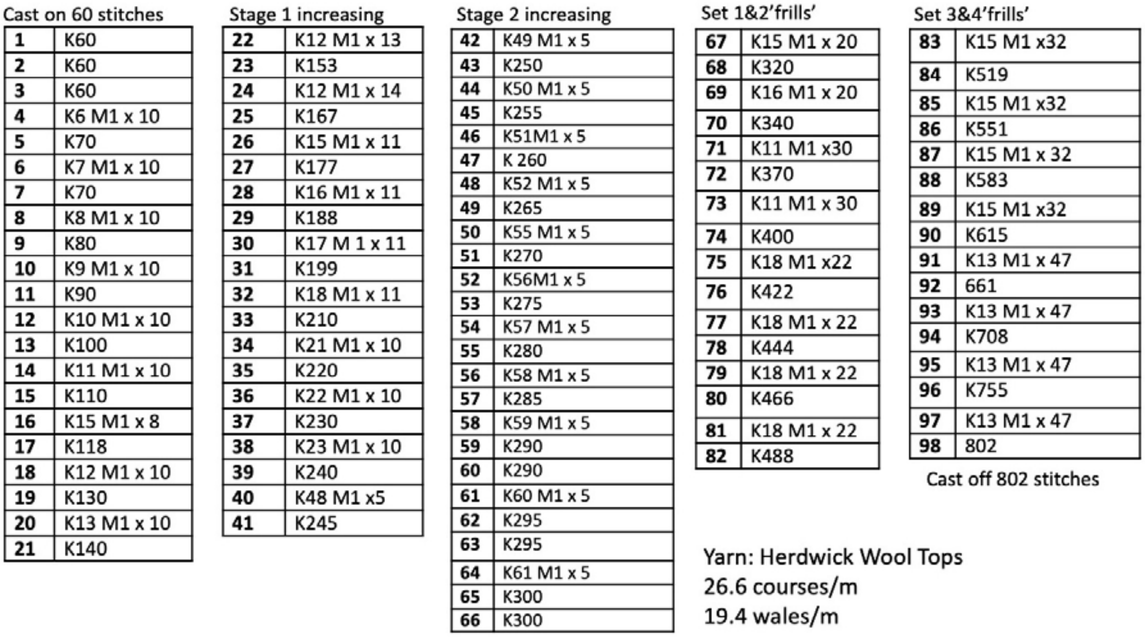
5 The Enneper surface with topographical contours reporting lengths and surface area to directly inform the knitting pattern. Image Credit: Armand Agraviador.

KNIT SPECIFICATION

The knitted formwork canopy was produced using a freehand knitting process to a specification derived from the computational model of the structure. To do this, firstly, the courses (rows) and stitches per meter of fabric were measured from fabric density swatches composed of the exact Herdwick wool tops used for canopy production. The resulting fabric density was 19.4 stitches per meter and 26.6 courses per meter. To determine the required number of stitches in each row, the lengths reported in the computational model were converted into stitches; 60 stitches were cast on to form the initial row. To determine the number of rows knitting, the overall diameter was converted into rows, then divided into 15 equal sections to reflect the computation model. The number of stitches increased over 95 rows to 802 stitches in the final row prior to cast off. The rate of increase was specified for 15 equal sections, and varied dependent upon the amount of extra material that was required to produce the central canopy and the undulating edge ‘frills’. The knitting specification is provided in Figure 6.

The generative knitting pattern for the canopy is very different to a program developed for CNC knitting. In the Shima Seiki Apex system (a system equipped with various pattern production tools for planning and creating original



Cast on 60 stitches

1	K60
2	K60
3	K60
4	K6 M1 x 10
5	K70
6	K7 M1 x 10
7	K70
8	K8 M1 x 10
9	K80
10	K9 M1 x 10
11	K90
12	K10 M1 x 10
13	K100
14	K11 M1 x 10
15	K110
16	K15 M1 x 8
17	K118
18	K12 M1 x 10
19	K130
20	K13 M1 x 10
21	K140

Stage 1 increasing

22	K12 M1 x 13
23	K153
24	K12 M1 x 14
25	K167
26	K15 M1 x 11
27	K177
28	K16 M1 x 11
29	K188
30	K17 M 1 x 11
31	K199
32	K18 M1 x 11
33	K210
34	K21 M1 x 10
35	K220
36	K22 M1 x 10
37	K230
38	K23 M1 x 10
39	K240
40	K48 M1 x5
41	K245

Stage 2 increasing

42	K49 M1 x 5
43	K250
44	K50 M1 x 5
45	K255
46	K51M1 x 5
47	K 260
48	K52 M1 x 5
49	K265
50	K55 M1 x 5
51	K270
52	K56M1 x 5
53	K275
54	K57 M1 x 5
55	K280
56	K58 M1 x 5
57	K285
58	K59 M1 x 5
59	K290
60	K290
61	K60 M1 x 5
62	K295
63	K295
64	K61 M1 x 5
65	K300
66	K300

Set 1&2'frills'

67	K15 M1 x 20
68	K320
69	K16 M1 x 20
70	K340
71	K11 M1 x30
72	K370
73	K11 M1 x 30
74	K400
75	K18 M1 x22
76	K422
77	K18 M1 x 22
78	K444
79	K18 M1 x 22
80	K466
81	K18 M1 x 22
82	K488

Set 3&4'frills'

83	K15 M1 x32
84	K519
85	K15 M1 x32
86	K551
87	K15 M1 x 32
88	K583
89	K15 M1 x32
90	K615
91	K13 M1 x 47
92	661
93	K13 M1 x 47
94	K708
95	K13 M1 x 47
96	K755
97	K13 M1 x 47
98	802

Cast off 802 stitches

Yarn: Herdwick Wool Tops
26.6 courses/m
19.4 wales/m

6

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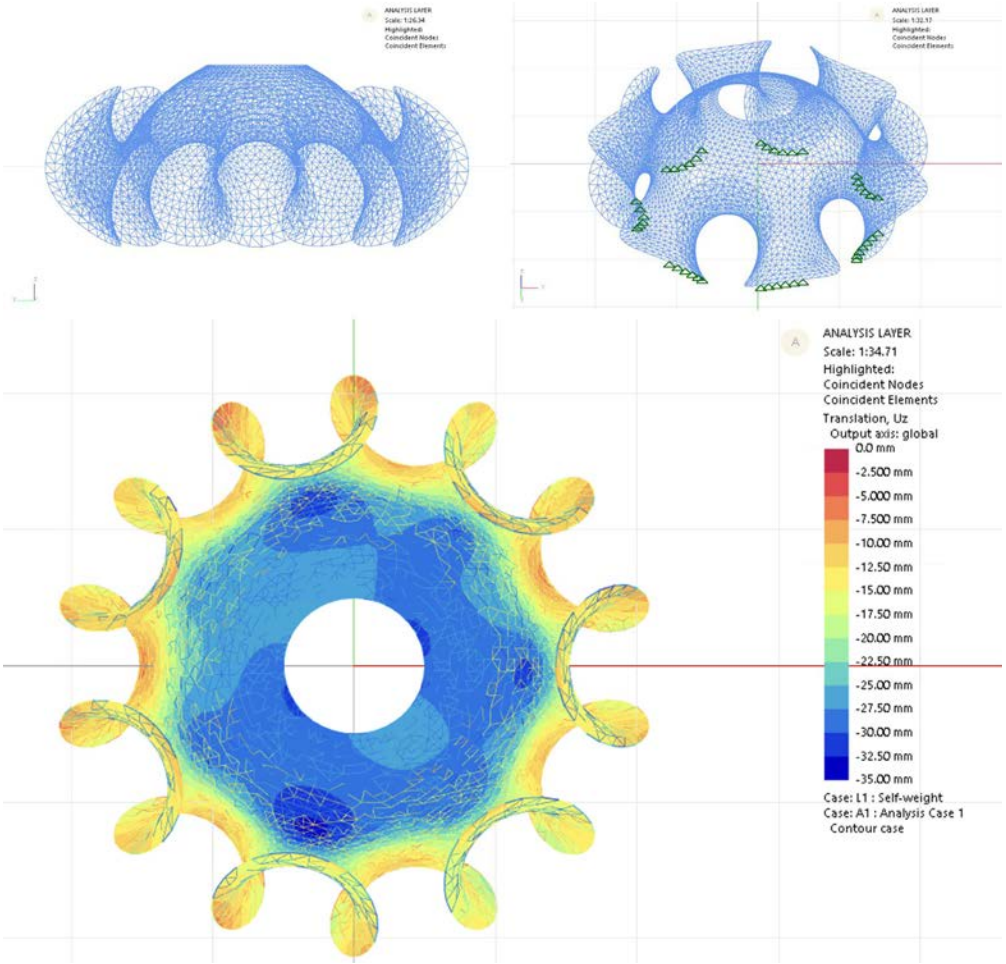
6 Specification for freehand knitted canopy formwork extracted from computational model. Image Credit: Jane Scott.

7 Knitted canopy formwork tensioned into position within a scaffold frame. Photo credit: Ben Bridgens.

print designs) for example, the position and function of every stitch is specified within a knitting surface. However, using a generative pattern based on conventions familiar to hand knitting, the individual stitches are not recorded; instead the rate of increase is specified for each row/course of knitting based on the previous row. This approach is extremely valuable when working by hand because only the rate of increase needs to be considered during the knitting process. As long as the beginning and end of the row is known, the position of additional stitches can be placed systematically around the circumference during knitting. This technique enabled over 25m^2 of knitted canopy formwork required for *The Living Room* to be produced by hand (Figure 7).

STRUCTURAL ANALYSIS

In addition to providing the dimensions for the knit specification, the Enneper surface model was also used as the basis for a structural model to confirm that the free-standing canopy would be able to support its own weight, and to determine the required thickness of mycelium paste in different areas of the structure. The Enneper surface model was imported into Oasys GSA structural analysis software (Oasys GSA n.d.) as a mesh of 3-noded triangular elements. As the materials have relatively low stiffness for a structure of this scale, a static P-delta analysis was used which takes into account any changes in geometric stiffness under loading. Mechanical properties (Young's modulus and failure stress) of the hardened mycelium



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8 Structural analysis: triangular mesh imported from Rhino to GSA (top left), support locations denoted by green triangles (top right), vertical displacements under self-weight with 30mm mycelium composite (bottom). Image Credit Ben Bridgens.

9 *The Living Room* tensioned within a scaffold frame during application of mycelium paste; the indicated thicknesses were informed by structural analysis. Photo credit: Ben Bridgens.

10 Preparation of the adapted mycocrete paste using paper sludge, a by-product from the papermaking industry in the North of England, and waste sawdust from a local sawmill.

11 Biomaterial experiments: A thin layer of paste on knitted wool (left); a thicker layer of paste (middle); sections through both samples (right). Photo credit: Dilan Ozkan.

12 Extension of knitted wool when supporting weight of wet mycelium paste. Photo credit: Dilan Ozkan.

composite were determined through physical testing of material samples in tension, compression, and bending (Kaiser et al. 2023). Allowable tensile and compressive stresses in the material were limited to 50% of failure stress to provide a safety factor of "2". The density of the knit and the hardened mycelium composite were measured and applied as uniform vertical loading on the canopy. As *The Living Room* will be exhibited indoors, no wind or other loading were required. Initially, mycelium composite thicknesses of 20mm, 25mm, and 30mm were applied throughout the structure, and displacements were checked (Figure 8). Twenty-millimeter- and 25-mm-thick mycelium resulted in excessive vertical displacements (90mm and 50mm at the oculus). Thirty-millimeter-thick mycelium resulted in 35mm vertical displacement at the oculus, which was felt to be reasonable given, the scale of the structure. Stresses were then checked and were found to be generally an order of magnitude lower than the allowable material stresses, with the exception of the contact points where the structure meets the ground, and some areas around the ‘frills’. It was, therefore, decided that the mycelium composite thickness should be increased to 40mm around the supports and ‘saddles’ which support the frills, and reduced to 20mm in the upper part of the structure carrying the least load, resulting in very low stresses (Figure 9).

BIOMATERIAL EXPERIMENTS

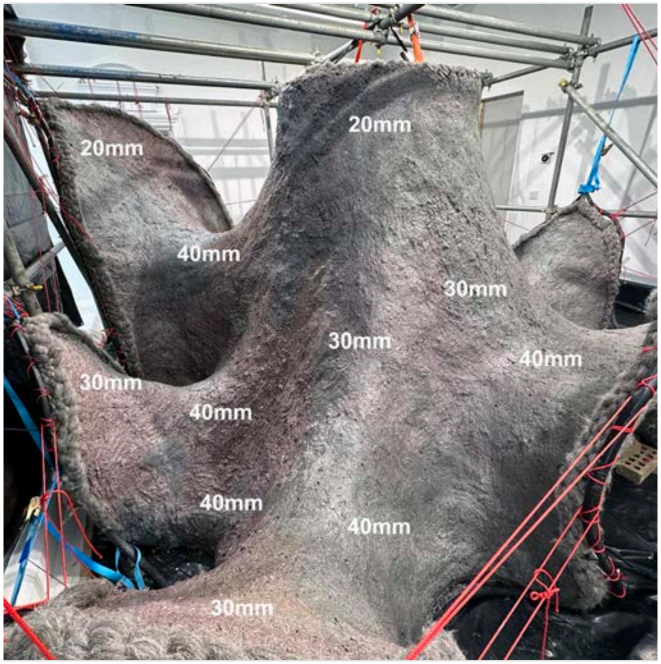
A series of biomaterial experiments were carried out to develop a mycelium composite paste which: (i) used local waste materials as substrate, (ii) could be ‘plastered’ on to the knitted formwork to form a continuous layer, (iii) would grow rapidly and, therefore, minimize contamination from other micro-organisms in a non-sterile environment, and (iv) would bond to the knitted wool to create a high strength composite material.

The starting point for these experiments was the mycelium paste recipe developed for the BioKnit prototype (Kaiser et al. 2023), which was adapted by replacing substrate materials such as paper powder and sawdust with locally sourced waste materials, and developing a paste consistency which could be applied as a continuous layer over the textile surface (Figure 10). The new recipe was tested in a series of experiments to study possible sources of contamination and sterilization procedures (including sterilizing the knitted wool with ethanol prior to application). This was done in order to determine optimal conditions for mycelium growth (a balance of oxygen, nutrients, moisture, material thickness, and temperature), and to study the interaction of the mycelium with the knitted wool formwork (Figure 11 and 12). Mechanical testing was carried out on material samples to determine the strength and stiffness, which informed the structural analysis.The outcomes from these experiments informed the large-scale biofabrication of *The Living Room*, which required approximately 560kg of mycelium composite paste.

DISCUSSION

Initial exploration of form through physical making in knit was vital to ensure that the structural concept was driven by the ability of knit to generate complex, organic 3D forms from simple knit specifications. However, the route to scale up these concepts to architectural scale, while enabling the form to be creatively manipulated during the final installation was challenging, and required a novel physico-digital workflow.

Parametric modeling of mathematically defined forms in Rhino enabled the conceptual form to be captured digitally, providing dimensions for the full-scale knit canopy and providing the mesh for structural analysis. The generative knitting pattern - specifying the rate of increase for each row rather than the position and function of individual stitches - was critical to simplify the freehand knitting process in order to produce over 25m² of internally shaped fabric by hand.The exceptional flexibility and extensibility of knit meant that the final form was not fixed at this stage, as it would be with conventional construction materials. This approach worked well: as the knit canopy was tensioned into position within a scaffold frame, the team were able to manipulate the form and create a large opening on one side to form an entrance for adults, while providing a series of smaller 'frills' of varying sizes for children to crawl through (Figure 13 and 14). While it was understood that the structural analysis was not fully representative of the final structural form, it was invaluable in providing guidance on mycelium paste thickness – crucially enabling the team to understand the considerable quantities of materials that were required (approximately 560kg of wet paste). The very low material stresses (typically an order of magnitude lower than the allowable material stress) gave the team confidence that even with significant changes to the structural form in the final installation, the material



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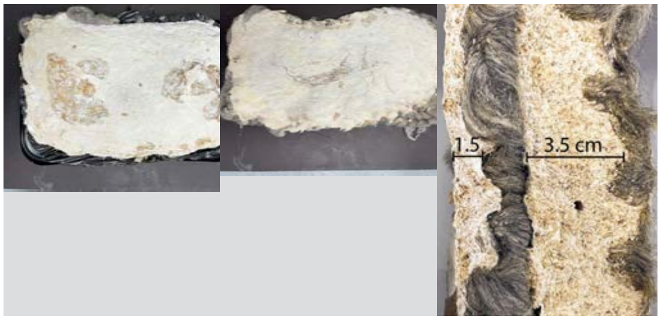

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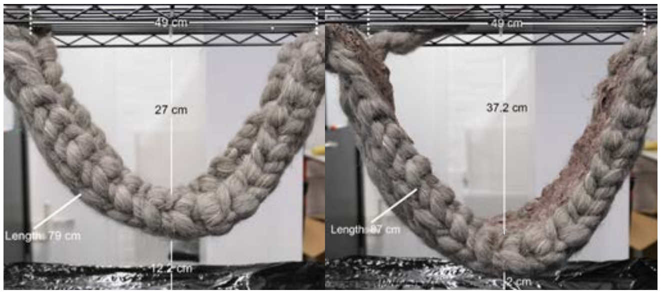

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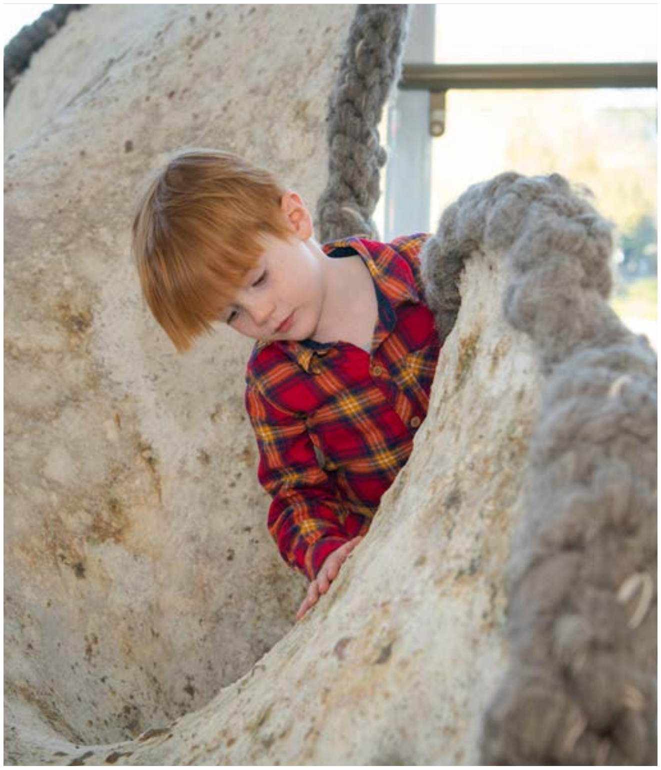
would have sufficient strength to create a self-supporting structure.

The Enneper surface model generated in Rhino was based on a dome with 'frills' around the edge. The form of the central dome could not be achieved in the final installation without internal support, and options were considered for rigid or inflated falsework, but it was felt that this would be wasteful and would eliminate one of the benefits of permanent textile formwork (i.e. zero waste during installation). This resulted in a disconnect between the digital model and the full-scale physical installation; however, this reflects the approach described by Yan Ng et al. (2020) as 'emergent', where form is generated through the interaction between different material behaviors. In future, this could be supported by using a form-finding simulation which incorporates the mechanical properties of the knit, to provide a realistic, draped geometry. This form of simulation would also have benefits in simulating the installation, including tensioning strategies and assessing the impact of stretch in the knitted textile during application of the mycelium paste.

CONCLUSIONS

The Living Room looks beyond current industrial technologies to explore new approaches to making that position knitting as a key biofabrication strategy for applying biotechnologies in the built environment. By taking the knitting technique off machine, the freedom to work with radical patterns of stitches and multiple scales of increasing to generate 3D form at any size specification, is proposed. Computational modeling of an Enneper surface provided the dimensions required to produce knit specifications adapted for the large scale, unconventional yarns used for this form of knitting. In addition, the physical components of knitted canopy formwork and mycopaste render came together in digital space through structural analysis. This was done in order to determine material quantities required to achieve stability for the proposed doubly curved, organic geometry.

There are several key areas anticipated for future research. From a design perspective, integrating iterative cycles of simulation and testing, particularly focusing on the interaction of the material properties, both in small-scale lab tests and through large-scale prototyping, is critical, as our research group moves towards the ambition of working exclusively with waste materials for biofabrication. Secondly, from a fabrication perspective, the freehand knitting technique suggests that different manufacturing approaches for knitting at scale are required in order to move away from fixed needle beds and



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13 *The Living Room* on display as part of the More With Less Exhibition at The Farrell Centre, Newcastle. Image credit The Farrell Centre / Simon Veit-Wilson.

14 *The Living Room* from the inside view. Image credit The Farrell Centre / Simon Veit-Wilson.

to look towards robotic fabrication. New ways to automate production while retaining freedom in fabric formation are currently under review within The Living Textiles Research Group.

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IMAGE CREDITS

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Dr. Jane Scott leads The Living Textiles Research Group in the Hub for Biotechnology in the Built Environment at Newcastle University. Her interdisciplinary research is located at the interface of programmable materials, knitted fabric design, architecture, and biology. Her research positions textiles as a critical biofabrication strategy in the development of biohybrid materials and composites for architecture. Through large-scale prototyping, her group has established the protocols for textile/mycelium architecture, and this work has been exhibited in major venues, including The Farrell Centre, Newcastle, and the Design Museum London. Jane was a member of the Board of Directors of ACADIA (2017-2021) and conference co-chair for ACADIA 2021 Realignments Toward Critical Computation.

Ben Bridgens is Professor of Regenerative Architecture in the School of Architecture, Planning and Landscape at Newcastle University, and a founding member of the Hub for Biotechnology in the Built Environment (HBBE, www.bbe.ac.uk). Ben works at the interface of engineering, architecture, and design, critically examining 'sustainable' technologies, and exploring the potential for combining traditional construction practices with biotechnology and natural systems to go beyond sustainability and create a regenerative built environment.

Romy Kaiser is a bio-designer and researcher focusing on biomaterials, textile thinking, and fibre-based biofabrication methods. Currently, she holds a PhD position at the Hub for Biotechnology in the Built Environment, Newcastle (UK), working at the intersection between biology, textiles, and architecture as part of the Living Textiles Group. Romy's research project 'Knit- Mycelium Hybrids' is investigating the scaffolding potential of knitted textiles for mycelium growth contributing to the field of biofabrication. The possibilities of using textiles as a tool for scaling up 'Biological Engineered Living Materials' (Bio-ELMs) in the Built Environment are researched.

Dilan Ozkan is an architect and researcher focusing on working with non-linear materials. Dilan completed an architectural design Master's at the Pratt Institute in New York, and currently, she is a PhD student and Research Assistant in the Hub for Biotechnology in the Built Environment at Newcastle University, UK. Within her research, she is developing a design framework and biodigital fabrication method to guide the growth of living materials. During her PhD, she formed a study group called Mycology for Architecture to collaborate with other disciplines and share knowledge about fungi.

Armand Agraviador is an independent researcher. His research investigates the architectural potential of integrating these novel biomaterial technologies into the built environment. He has worked in several architectural practices across a range of project scales from furniture to master plans. During his time in industry, he spezialised in building information modeling and computational design, and has utilized his skills to incorporate biological concepts to structure and facade. He has worked on several large-scale infrastructure projects, including an airport and rail terminus, but has had particular enjoyment in working with heritage buildings and distilleries.