Urban MYCOskin

Project Team: Natalia Beata Piórecka, Rita Morais, Jennifer Levy Girardin

Fungal Architecture

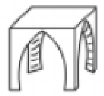
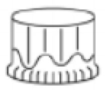
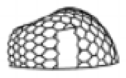
Bio-Integration in Architecture & SOA

The evolution of integrating nature into design and architecture has culminated in Bio-Integrated Design, a holistic approach that incorporates living organisms, organic processes, and materials to achieve harmony with the environment. This method sees nature as a partner in innovation, going beyond traditional Biomimicry.

With the pressing need to combat climate change, biodesign has become pivotal, aiming for environmentally sustainable solutions. This interdisciplinary field fosters collaboration among designers, biologists, engineers, and others. Mycelium-based materials, known for their strength, durability, and eco-friendliness, exemplify this collaborative spirit (Appels, 2020; Appels et al., 2019).

Exploring mycelium's potential in design involves overcoming challenges in scaling and standardization. Yet, there's growing interest in using this material for its low carbon footprint and tuneability (Adamatzky et al., 2023, Yang et al., 2021). Pioneering projects like MycoTree, HiFi Tower, MYCOsella, Monolito Micelio, and BioKnitt showcase the innovative applications of mycelium, employing techniques like 3D printing, weaving, and biowelding.

The goal is to integrate various mycelium fabrication methods, especially 3D printing and fabric forming, to create an innovative biomaterial system. This ambition aims to advance mycelium technology through new design and assembly strategies, as highlighted in the comparative analysis of mycelium projects in the study.

Project / Year of completion	Location	Type	Structure	Fungus	Substrate	Post -treatment	Creators
 HY-FI (2014)	Outside	Brick	Wood, Steel	*Ganoderma lucidum*	Corn stalks	Heat treated	The Living Studio
 SHELL MYCELIUM (2017)	Outside	Panel	Wood, Steel	Information not available	Coir pith	Naturally dried	Studio Beetles 3.3 Yassin Arredia Design
 MYCOTREE (2017)	Inside	Block	Bamboo, Steel	*Pleurotus ostreatus*	Sugar cane, Cassava root	Heat treated	Sustainable Construction KIT Karlsruhe Block Research Group ETH Zürich
 MONOLITO MICELIO (2020)	Outside	Monolith	Wood, Steel	*Ganoderma lucidum*	Hemp	Naturally dried	Georgia Institute of Technology School of Architecture
 GROWING PAVILION (2020)	Outside	Panel	Wood	*Ganoderma lingzhi*	Hemp, Cattail, Mace	Heat treated, Weather resist-ant biocoating	Company New Heroes E. Klarenbeek
 MY-CO SPACE (2021)	Outside	Panel	Wood, Steel	*Fomes fomentarius*	Hemp	Heat treated, Weather resist-ant coating	MY-CO-X Collective

"A review on architecture with fungal biomaterials: the desired and the feasible" (Almpani-Lekk et. al, 2021)

 MYCOskin (2023)	Outside	Panel	Fabrics, Steel Wood PLA	Pleurotus ostreatus/ Ganoderma lucidum	Textile waste/ Hemp	Growing/ Naturally Dried/ Beeswax coated	Bio-ID (Piórecka, Morais, Levy, 2023)

State of Art

Mycelium-based Architecture

Moulding (monolitic in-situ casting ents)


The Hy-fi Tower, The Living, 2014
12 m tall pavilion that used 10,000 mycelium bricks


Mycotree, 2017
Moulded spatial branching structure with load-bearing mycelium components working in compression


MYCOsella, Piórecka 2017
Exploration of structural capacity of mycelium as a chair topology, using resuable moulding fabrication


The Growing Pavilion, Krown Design, 2019
Strcuture combining light, well insulative (termperature and sound) mycelium panels with a variety of organic materials


MycoCreate 2.0, Gürsoy, 2022
Spider-like legs, made using moulded blocks of mycelium for branching structure that supports fungi.

3D Print


Klarenbeek, 2014
3D printed PLA as mo,ld


Blast Studio; The Pulp Faction, Goidea, 2020
3D printed substrate with inoculated mycelium


INSECT Workshops, 2022
3D printed clay with mycelium infill


Levy, Morais, Piórecka, Bio-ID, 2022
Mold as food source
3D printed wood filament

Fabric Forming (non integrated textile)


Caracara Collective, 2017
Mycelium substrate grown inside cotton tubes


Monolito Micelio, MycoMatters Lab, 2018
Wooden internal reinforcing;, mycelilum processed on-site, packed into the plywood and geo-textile formwork;


L'Orso Fungino, MycoMatters Lab, 2021
Upholstered formwork with synthetic geotextile fabric


Tactical Mycelium, MycoMatters Lab, 2021
Mycoarch" composed of active bent PVC and plastic sheeting

Fabric Forming (integrated textile)


Knitted Bio-Material Assembly, 2020
Knitted textile with capability to augment final material composite properties and provide design freedom


BioKnit, HBBE, Newcastle, 2022
Knitted fabric as a scaffold and scaling agent


INSECT Worskhops HBBE, Newcastle, 2022
Crocheted textile elements as scaffold for mycelium composite


MYCOllulose, Piórecka, Bio-ID 2022
Cotton fabric and Bacteria cellulose as sacrifitial mold for mycelium


BioKnit 2 , HBBE, Newcastle, 2023
Knitted fabric as a scaffold and scaling agent

Biowelding


Living Bricks, The Living, 2019
In-situ growth of the material to bond individual units


MycoMatters Lab, 2022
Mycelium panels grown in wooden frames

Weaving


Generated Kagome Morphologies, CITA, 2021
The weave acts as a combined stay-in-place formwork and reinforcement.


House Parts, MycoMatters Lab, 2021
Mycelium panels grown in wooden frames

Bioreceptive and Biorremediating


Paul Stamets, 2005
Burlap sacks filled with wood debris inoculated with Pleurotus ostreatus spawn, that were then layered in the contaminated are


Arup, 2021
mycelium to create sustainable wetlands for healthier waterways


Colmo, Ayres, 2021
3d printing with soil-based material
,mycelium inoculation


Chua, Chevee, Bio-ID, 2021
Layered mycoremediation intervention


MYCOstratum, Piorécka, Bio-ID 2022
Mulit-layered material interactions with the opportunity towards bioremediation

Urban MYCOskin

Culminationating Final Design Project

The Lisbon Urban MYCOskin project at the Tram 28 stop in Praça Martim Moniz showcases circular industrial ecosystem principles and life-cycle thinking, aligning with the New European Bauhaus values. This innovative endeavour uses bioreceptive biomaterials, mycelium composites, for area regeneration and climate change mitigation, enhancing biodiversity. It transforms agricultural and textile waste into valuable resources, in harmony with Lisbon City Council's agenda for environmental regeneration and sustainability.

Additionally, through the use of specific geometrical topologies and by providing space for plant growth, the project counters the urban Heat Island Effect, establishing strategies that include rainwater redirection and shaded areas, improving air circulation and temperature control.

Architecturally, the project emphasises passive cooling systems and green infrastructure, contributing to urban biodiversity and a greener urban fabric. It exemplifies sustainable design by integrating eco-friendly materials in public spaces, improving environmental impact and user experience. The project's circular approach includes repurposing waste and using rainwater harvesting to minimise artificial watering needs.

Introducing Urban MycoSkin, an innovative architectural system that combines mycelium panels and 3D-printed wood filament to create a living and resilient urban space. The existing Tram stop in Lisbon, Portugal, serves as the basis for reconsideration and redesign, aiming to provide human comfort while supporting biodiversity. Mycelium takes centre stage as the primary bio-material for this project. It possesses a unique ability to consume agricultural waste and create panels that are 100% recyclable, with minimal carbon emissions.

Furthermore, this material boasts properties that are advantageous for sustainable urban structures, including insulation and noise absorption. The overall design of the structure promotes shading and rainwater collection, fostering plant growth and biodiversity through a series of mycelium panels that redirect and recollect water, thereby reducing the surrounding temperature. Moreover, the project establishes a circular system where waste streams are upcycled to create architectural materials that can later serve as fertilizers. Over time, the project aims to expand the use of mycelium as an architectural material, enhancing biodiversity and contributing to the creation of a living structure.

Natalia Beata Piórecka, Rita Morais, Jennifer Levy Girardin

Collaborative research

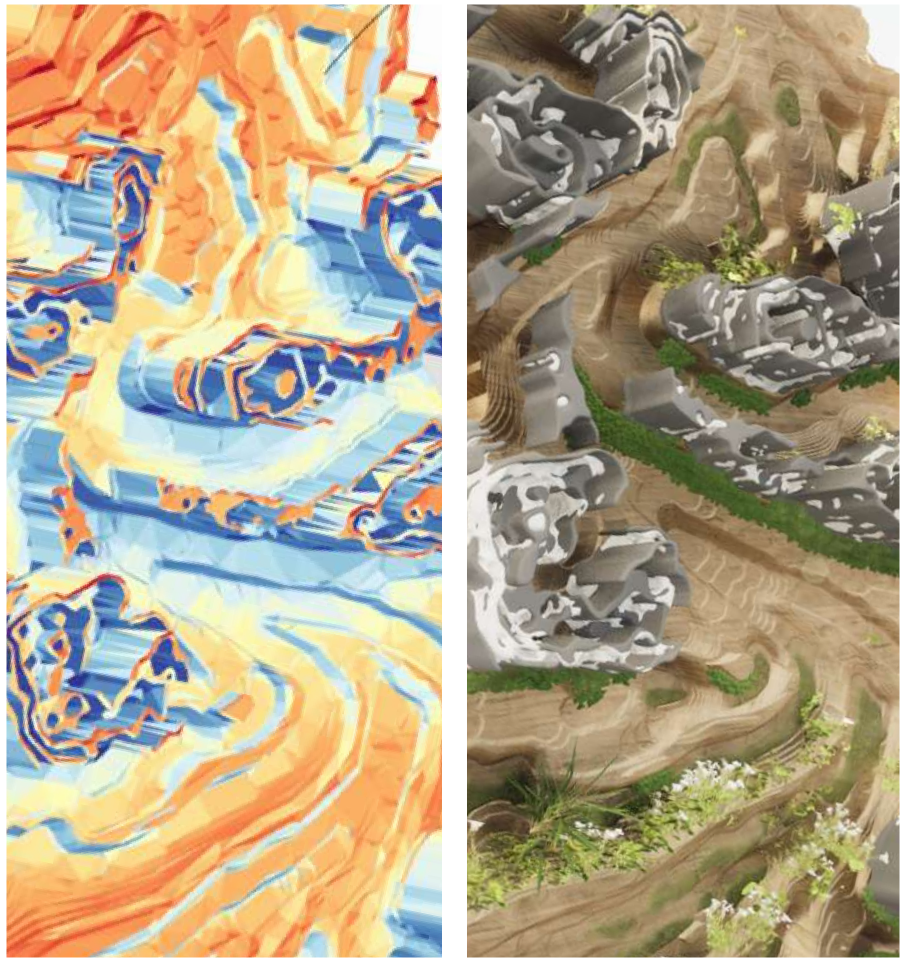
Several projects conducted within the research frame allowed the themes to evolve through a collaborative approach of integrating specialisations of Computational Design, Fabrication and Environmental Studies, tackling the problem from multiple perspective.

Key research agendas include also the development of organically integrated biological material systems and hybrids infused with living organisms. The goal was to create a deeply intertwined strategies and workflows capable of creating opportunities for inviting biological research to fields of design, architecture and built environments. That could revolutionize current notions of conventional materials and assemblies, offering a broad spectrum of possibilities towards new sustainable futures, positive impact on the environment, ability to utilize waste and pollutants, opportunity of achieving bioreceptivity and exploring bioremediation potentials.

Fabrication and Materials

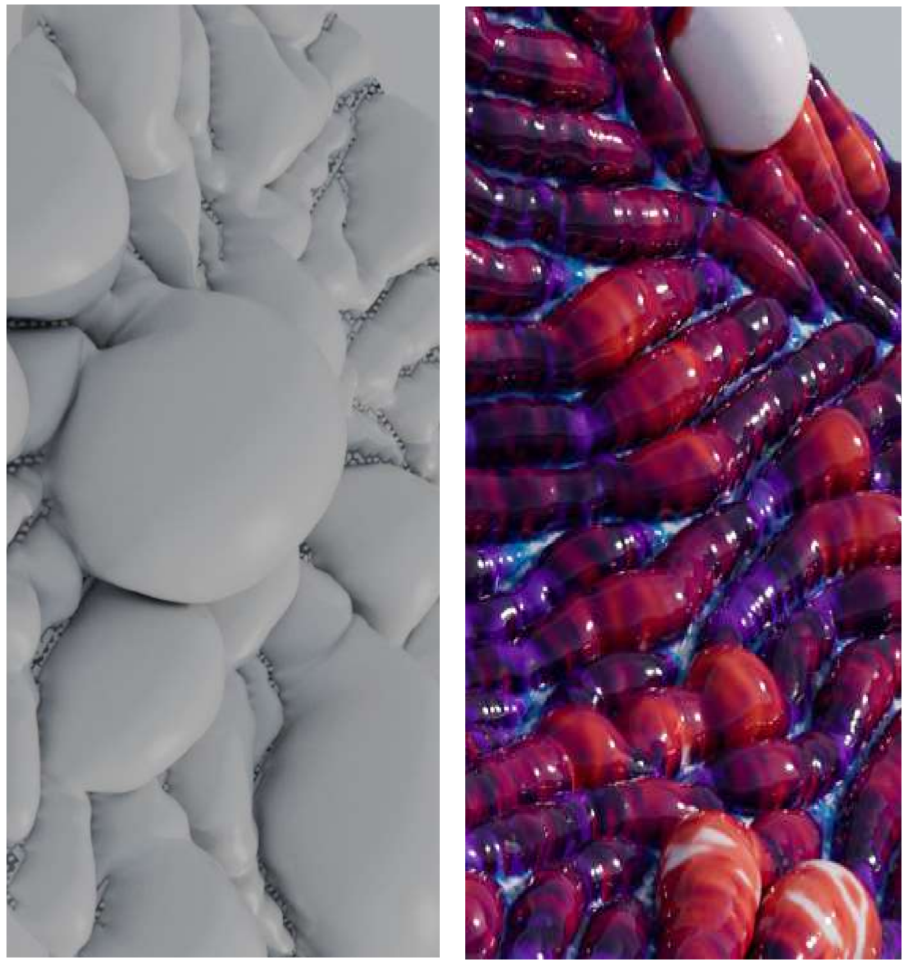
Natalia Piórecka
MYCOstratum: Layered Multi-Material Bioremediation", 2023

Environmentally driven fabrication



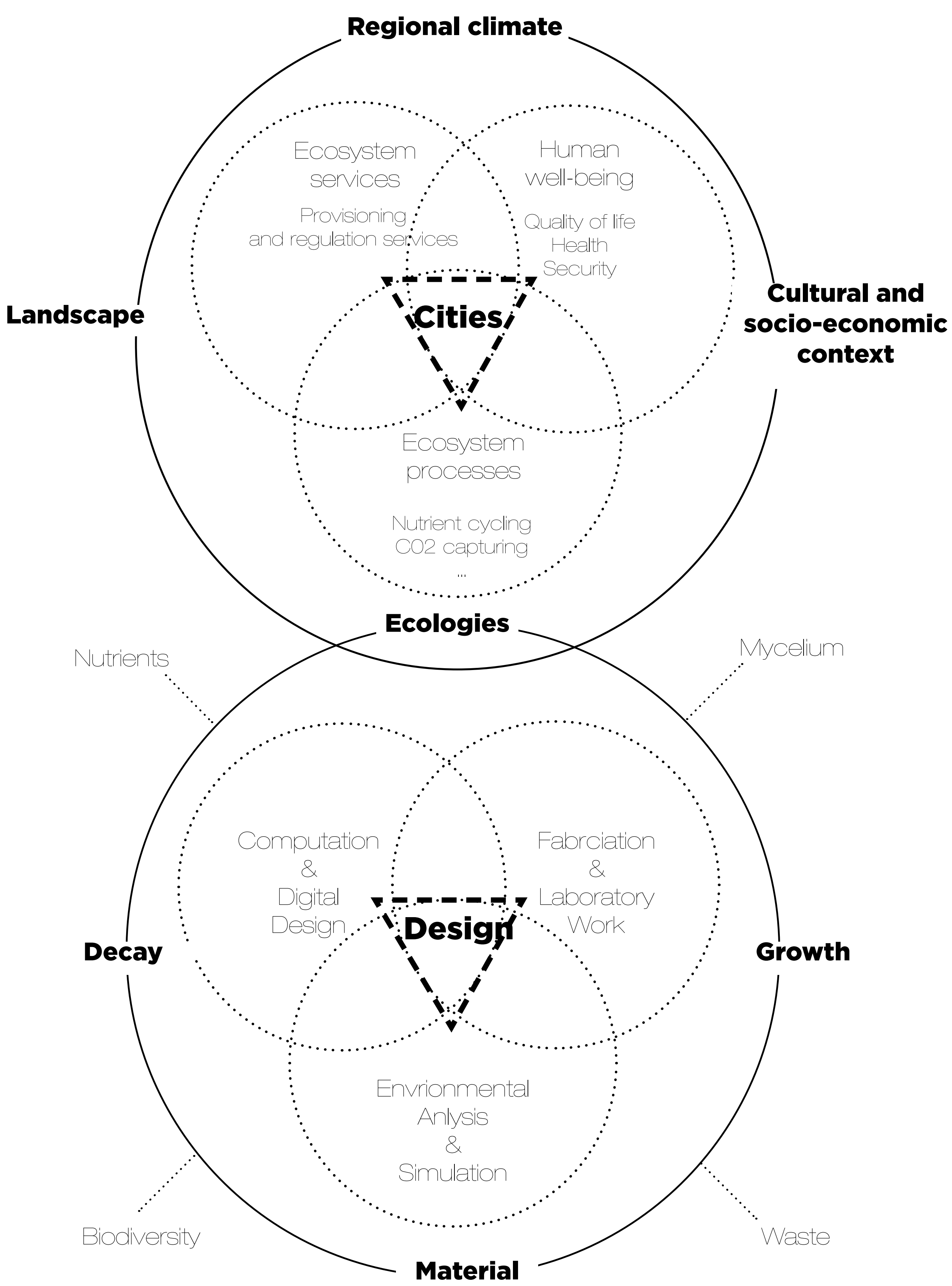
Rita Morais
"Microclimatic pockets", 2023

Computational Design



Jennifer Levy
"Drainage patterns in nature", 2023

Project Contextualization and Strategies



Biomaterial: Mycelium

Natural binder and waste utilization agent, its materiality and abilities are utilized through various fabrication approaches creating an architectural proposal.

Rainwater collection

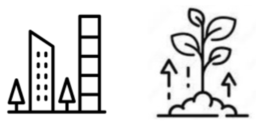
Utilizing the rain water for the plant growth within the structure, limiting the need for artificial watering.

Circularity

Utilization of agricultural and textile waste. Giving another life to out initial our everyday outer skin of cloths.

Urban Heat Island Effect

Create a space that uses passive cooling systems such as shading, green infrastructure and insulation materials to decrease local temperature levels and mitigate the Heat Island Effect in urban areas



Green Urban Fabric

Inviting growth to urban areas through bioreceptive materials. Informed with environmental analysis the aim is to create microenvironments that become habitats not only for human, but for the non-human and encourage biodiversity.

Bioreceptivity

Creating an architectural material system that invites and host growth. Integrating living organisms and natural processes of growth and decay as key parts of the structure.

Climate change and UN Goals

Broader Perspective & Opportunity

Climate change is one of the most pressing challenges that our planet faces. It refers to long-term complex changes in the Earth's climate caused by human activity, including changes of temperature, precipitation or wind patterns (Nations, n.d.). Climate change have an extensive effect on the natural system. With serious consequences for humans, it impacts the environments, leading to flooding, droughts and erosion, affecting water resources or agriculture. It also have an impact on the biodiversity, resulting in high declination of species and habitats loss. Forced for rapid adaptation, many species are led to extinction, what impacts functioning of the ecosystem, directly impacting human societies.

Architecture and construction industry, have substantial impact on the environment and are a significant contributors to climate change and global warming(Impact of Architecture on Climate-Change and Global Warming -, n.d.; Natural-Resource Use and Environmental Impacts | One Planet Network, n.d.; Ways Architecture Can Tackle Global Warming - RTF, n.d.). According to United Nations, buildings are responsible for nearly 40% of global energy use and 33% of greenhouse gas emissions, that includes both their materials, construction and operation (Embodied Carbon - World Green Building Council, n.d.). For this reason, there is necessity for architects to adjust their practices and address the increasing concerns in order to mitigate the impacts of climate change.

"Yet fungi have the potential to play a role in mitigating the effects of climate change. With the use of biotechnology, fungi can help meet the United Nations Sustainable Development Goals, and their properties make them useful organisms in addressing the urgent challenges that humanity faces."

(Baldantoni et al., 2023)

As organisms fungi are very likely to be affected by the changes of the environment, however at the same time they could help to mitigate the effects in the climate change in several ways (Environmentally Conscious Technologies Using Fungi in a Climate-Changing World,) (Ways Architecture Can Tackle Global Warming - RTF, n.d.) (Natural-Resource Use and Environmental Impacts | One Planet Network, n.d.). Mycelium-based materials can be produced in a low cost and energy manner, serving as an environmentally friendly alternative building material. As mentioned before, utilizing waste streams they create a closed loop, sustainable production cycle at the same time having much lower carbon footprint than to traditional building materials as plastics or concrete. Playing an important role in carbon cycle, fungi can help sequester it from the atmosphere. They can break it down and store either in the soil or within their mycelium, meaning that there is a potential to store carbon not only in the soil, but also within the building themselves. Nonetheless, to understand fully the carbon storing potential of mycelium and optimisation of those processes in practice requires further research.

Taking into account the characteristics of fungi, once utilized as material applicable within architecture and built construction, they could substantially contribute to several United Nations' Sustainable Development Goals (SDGs). Namely: Industry, Innovation and Infrastructure; Sustainable Cities and Communities; Climate Action and Life on Land; microarchitecture could address issues related to sustainability and environmental impact, promoting sustainable production, responsible consumption, resource conservation, climate action and also sustainable cities and communities (Baldantoni et al., 2023; Org, n.d.; The 2030 Agenda for Sustainable Development's 17 Sustainable Development Goals (SDGs), n.d.).

Context

Lisbon, Portugal

Portugal is one of the European countries most affected by climate change. Throughout many years Portuguese biggest city, Lisbon, faced increasing threats to climate change. Growing in popularity as tourists destination, stretched urban infrastructure of the city with rapid urbanization. The increasing pressure on natural resources due the urbanization and climate change led to the draughts, seasonal flooding and extreme temperatures. That led to loss of natural habitats and biodiversity and soil erosions.

Urbanization and heavy traffic negatively impact health and life quality in the city, not only with the high levels of air pollution, but also due to the Heat Island Effect (Towards a More Resilient Lisbon UrbaN Green InfraStructure as an Adaptation to Climate Change — English, n.d.) With city retaining more heat than surrounding flora along with rising temperatures, more frequent and intense heat waves had been experienced, increasing risk of wildfires.

To address the impacts of climate change in Lisbon, Lisbon City Council (Município de Lisboa, Portugal) started to adopt Climate Action Plan. It included measures to adapt to the impacts of climate changes, decreasing greenhouse gas emissions, increasing flood resistance, developing zero rainwater green infrastructures, capturing an reusing rainwater providing environmental and social benefits and introduce more green infrastructure, maintaining the quality of ecological base. (Towards a More Resilient Lisbon UrbaN Green InfraStructure as an Adaptation to Climate Change — English, n.d.)

The final design project looked into an public square - Praça Martim Moniz, particularly vulnerable to heat island effect, due to the densely build-up with very little green space. With a cultural and historical significance located in the heart of Lisbon in Portugal, the "regeneration" square, used to be a dangerous, degraded and poor neighbourhood now is known for its diverse community and vibrant street life as a cultural hub. The square being located in a close proximity to many of Lisbon's most popular tourist attractions, is also a transportation hub, with several bus and tram lines passing through the area and therefore resulting reduced air quality.

Recognizing the affected area of the square, Lisbon City Council had implemented several measures to increase amount of vegetation and green space (green roof or walls etc) in the area, improve air quality as well as provide more shade and cooling for residents and visitors, trying to reduce the energy usage of the surrounding buildings. Named after a legendary hero of 12th century's Christian Reconquest of Lisbon, situated in the multicultural neighbourhood of Mouraria square was also facing a number of social issues related to its unsafe and uncharacterised spaces, traffic noise, night usage, insecurities of pedestrian access, parking disorganization, and degradation of the urban fabric itself. Some of these are still valid, despite the recent major renovation, that aimed to reimagine the square, inviting more cultural activity, though events, exhibitions, workshops or concerts.

Picture by Rita Morais

Site

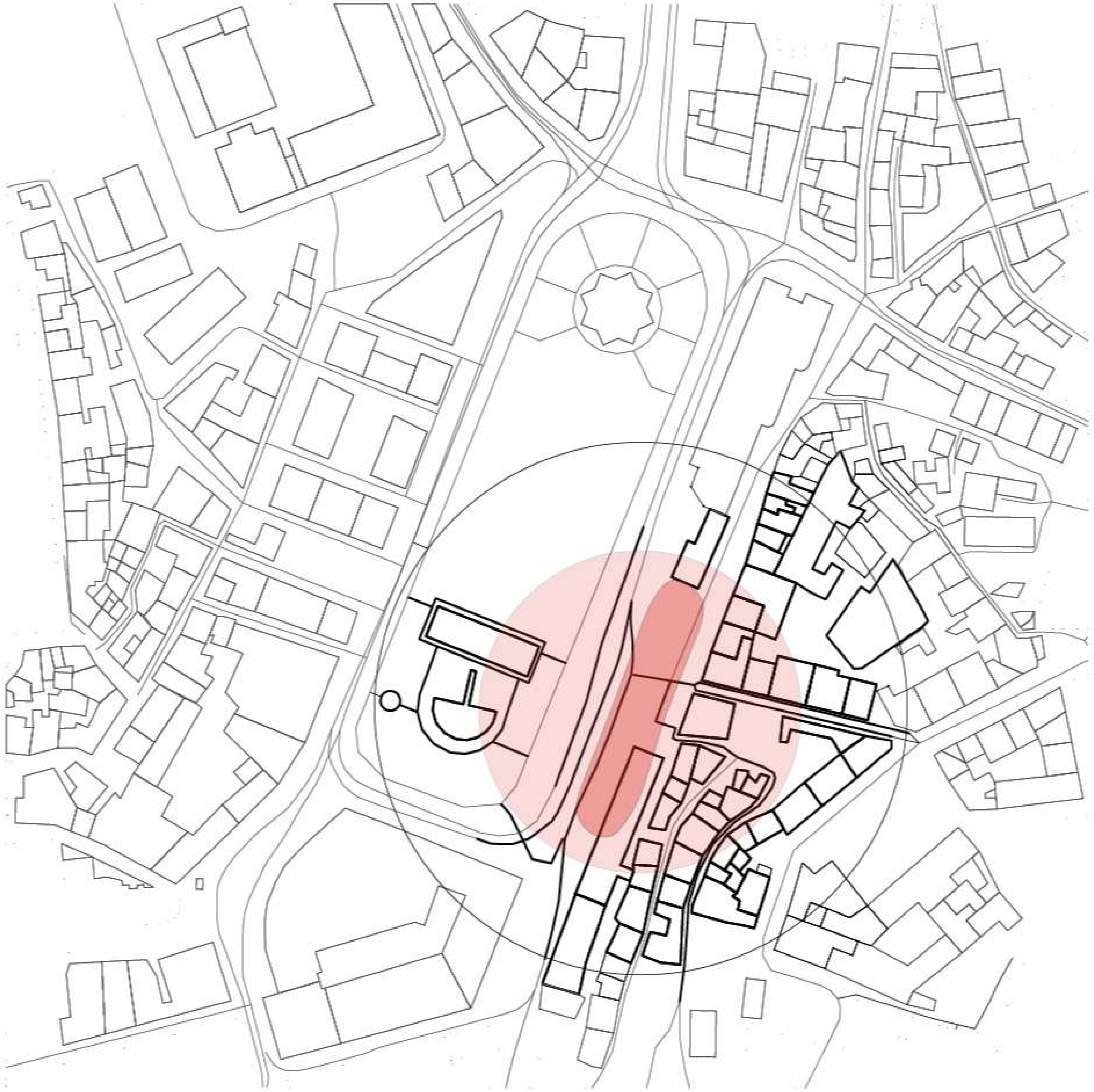
Tram 28 Stop

Considering the extensive area of the square itself, the project shifted its focus to The Tram 28 stop, located on the eastern side of the Praça Martim Moniz. The constrained scale and dedicated functionality of the space, allowed the project to focus on the designing a functional material system, focusing on the interaction between layers, relation with the surrounding environment as well as fabrication and assembly of the parts.

With further development and proceedings of the project the explored design strategies could facilitate more extensive area and complex architectural program implementing developed workflows.

The Tram 28 stop is situated near the intersection of Rua da Palma and Rua dos Cavaleiros and is one of the starting points for the historic tram line no.28 that runs through winding, steep routes of picturesque neighbourhoods of Lisbon. It is famous for its old-fashioned wooden trams, decorated in a vintage style and provide a nostalgic glimpse into Lisbon's past.

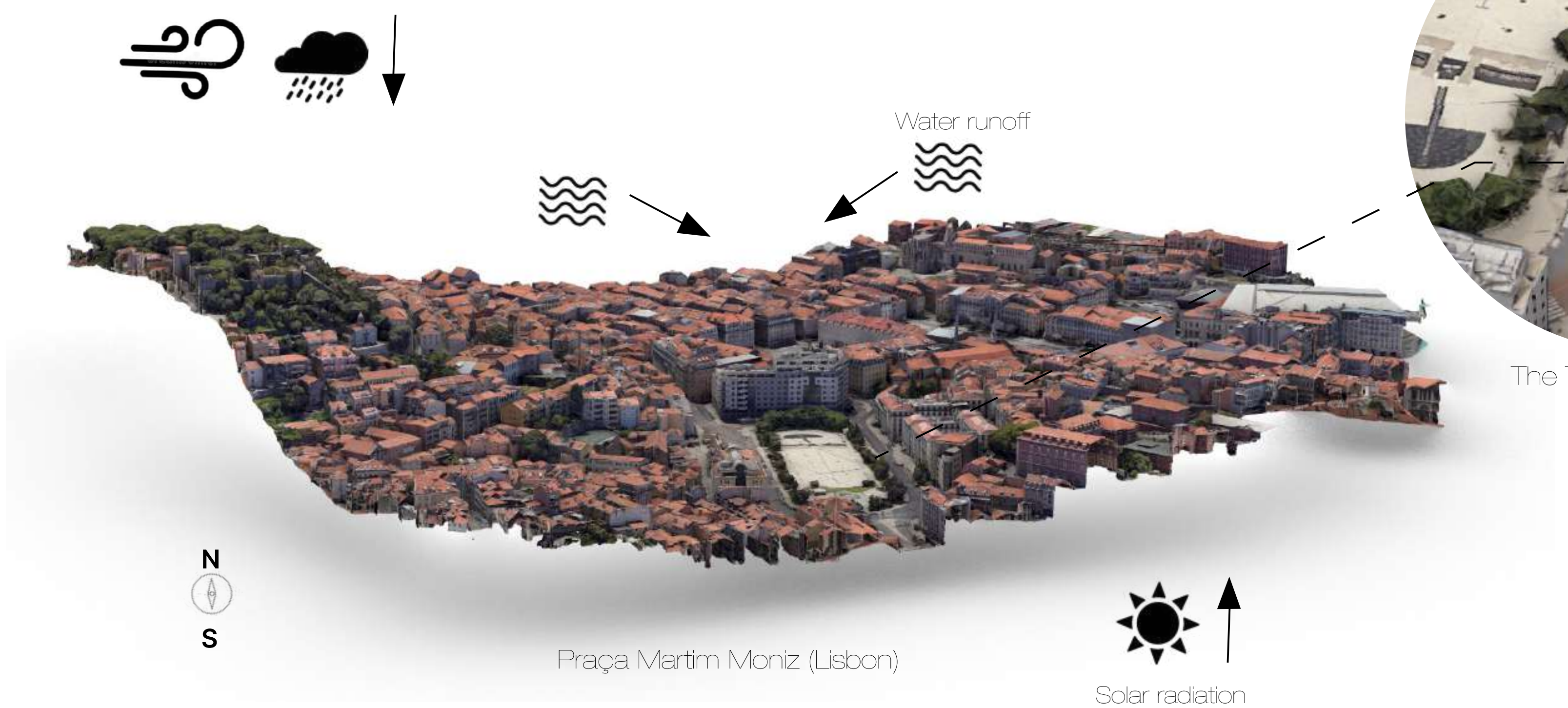
The existing stop is a small, simple shelter structure, designed to protect passengers from the weather while waiting for the tram to arrive. Nonetheless, during peak tourist season or at busy times of day, the stop can become crowded and the featured benches are not sufficient for seating waiting passengers.

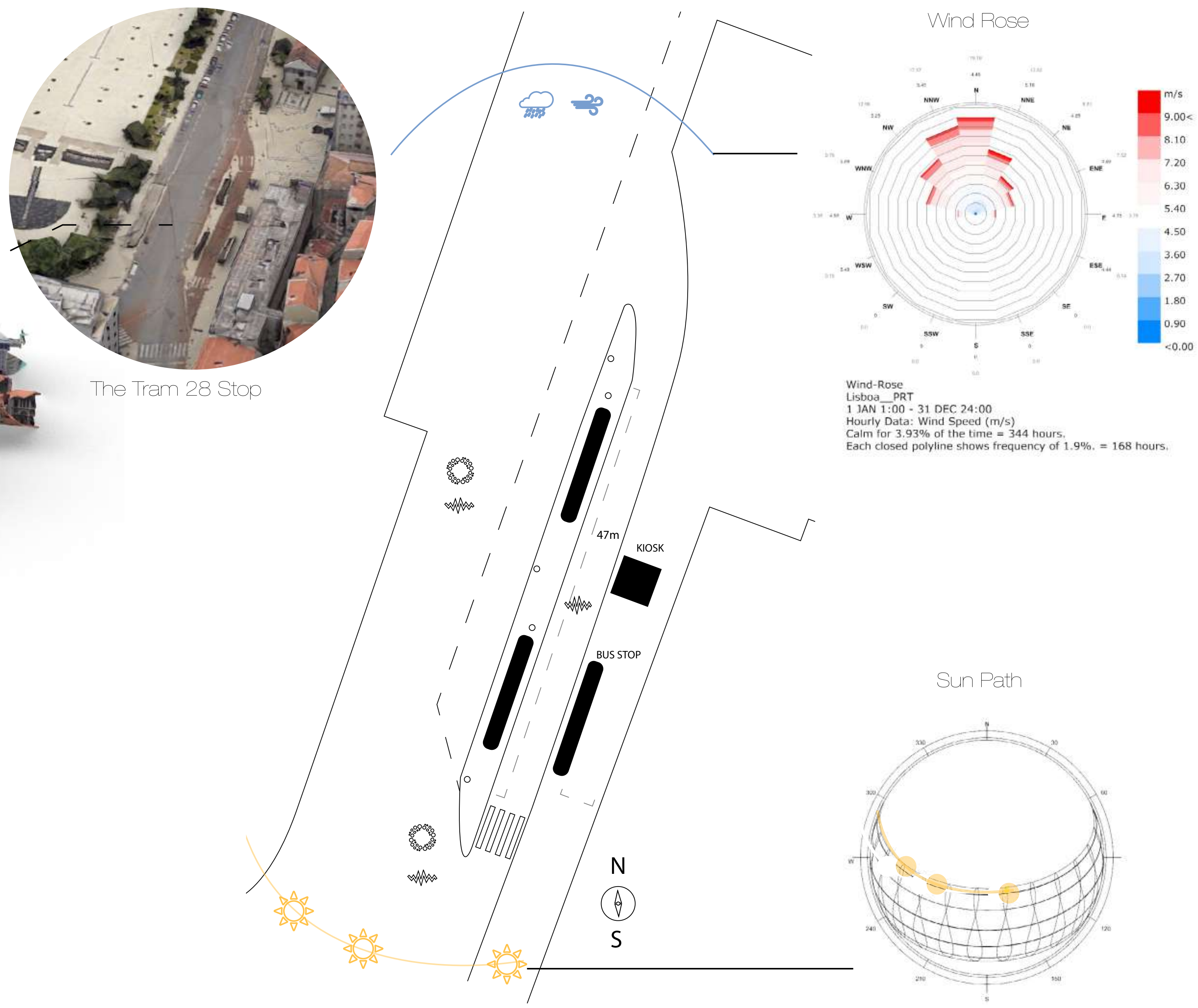


Site - Tram 28 Stop

Pictures by: Rita Morais

Site





Climate challenges

Summer:

- Highly exposed area to solar radiation
- Urban heat Island Effect
- Heat Waves
- Drought periods that affect growth

Winter:

- High humidity levels and cold temperatures negatively affect outdoor confort
- Floofing events due to a lack of permeable areas and location in a valley
- Cold temperatures and high wind speeds can affect growth

Potential Solutions

- Shading areas
- Temperature regulation through thermal mass distribution/geometry
- Green infrastructure for passive cooling and water absorption
- Water deposits

Transit Flow | Covered Areas | Canopy Areas | Envrionemtnal

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Macro scale of the Site

Solar radiation analysis of the site (Ladybug)

The site is under a high variation regarding zousolar exposition between summer and winter.

In summer, this area is highly exposed, causing temperature increase and disconfort, and evaporation of water, which can lead to drought.

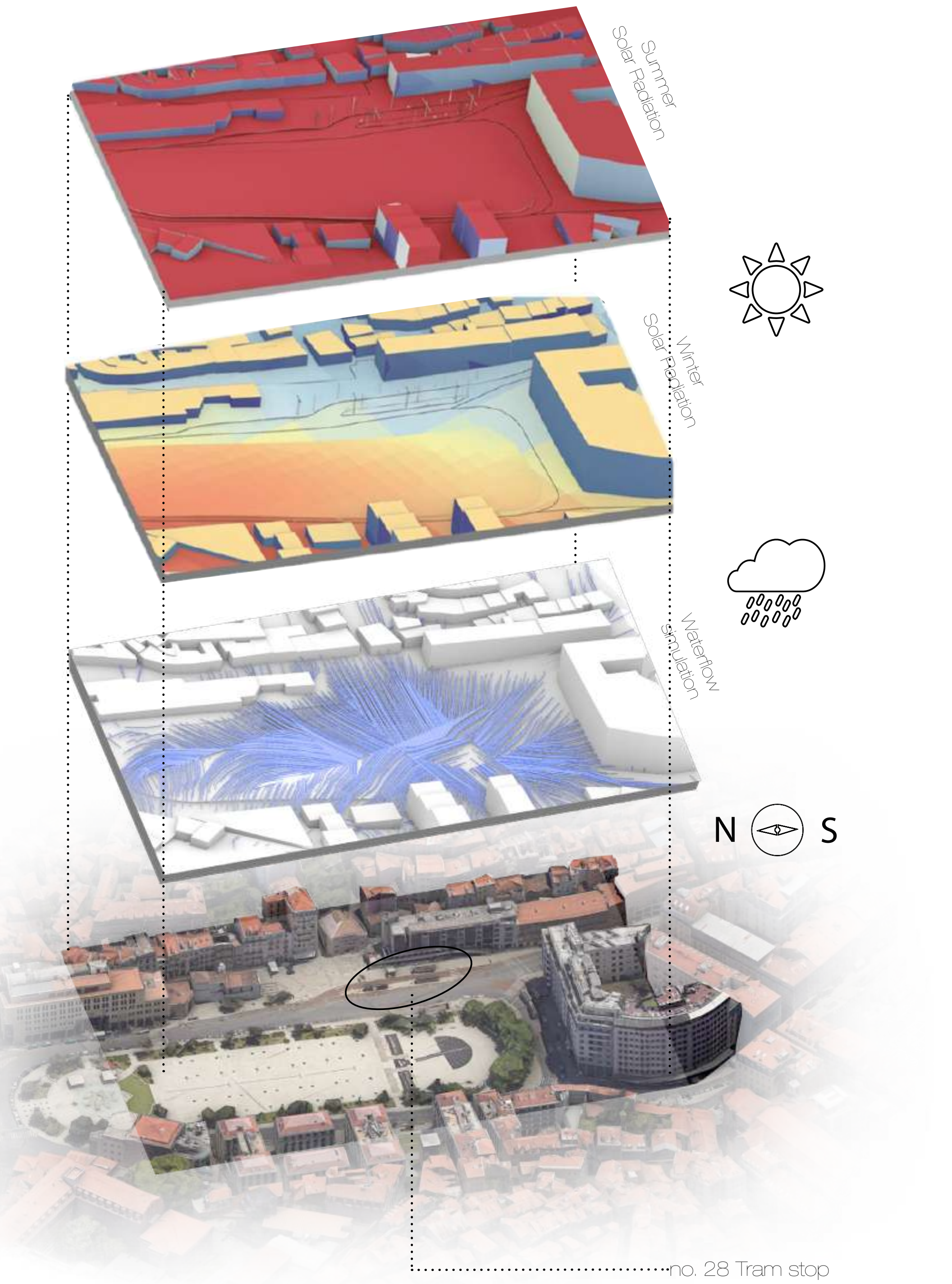
In winter, the area is shaded, contributing to low temperatures and disconfort, specially with wind exposure.

Water flow visualization

Praça Martim Moniz is located in a valley meaning that with heavy rain, specially during winter, water can accumulate in the area causing floodings.

Wind

In this areas the wind comes mostly from the North,.
The fact that the tram stop is located within buildings offers some prtection to the structure.



Materiality of Decay

How decay creates a material

Recent advancements in material science have placed a spotlight on decomposition, particularly for creating innovative biomaterials like mycelium composites. These materials, deriving from the vegetative part of fungus and growing on organic waste, showcase the "materiality of decay." They act as a natural binder through fungal decomposition, offering unique material properties and sustainable production methods.

Mycelium materials are notable for their environmental sustainability and functionality. They're biodegradable, offering an eco-friendly alternative to conventional materials, and can break down various waste types, including agricultural residue, textiles, and plastics. This not only fosters sustainable building materials but also aids in waste management.

Additionally, mycelium materials are highly customizable. They can be tailored to specific needs by altering growth conditions and substrates, resulting in strong, lightweight, and insulative bio-composites suitable for numerous applications.

Beyond environmental benefits, mycelium materials are part of a broader biomaterial system, exhibiting dynamic interactions with other materials and organisms, like mycorrhizal fungi. This opens doors to future regenerative technologies and sustainable, adaptable, and bioactive materials for diverse applications.

Natural Binder

Mycelium waste utilization
and material maker

Substrate & Filling

Hemp blend providing
porosity

Textile Waste
(cotton waste)
maintaining moisture content

Textile Waste
(mix)
unicycled as material

Scaffold/ Sacrificial formwork for growth

Cotton Fabric

95% Cotton
5% Elastane

Synthetic semi-stretch Fabric
85% Polyester
15% Cotton

Synthetic stretch Fabric

86% Nylon
14% Elastane

Frame/ Structural support

Cellulose base PLA
40% Cellulose
60% Plastic

Metal Frame

Stainless Steel to avoid rusting
over the growth period and
moisture exposure

Growth Durability Tests

Livespan of Living Material

The growth durability test assessed the lifespan of living mycelium materials under continuous growth conditions. This experiment examined mycelium-based materials, which are typically created by halting decay at a stage where the mycelium partially decomposes and binds particles without full decay. The test compared substrates at various stages: one with overgrown mycelium for about three weeks, ready for use; another partially decayed after a year of growth; and a fully decayed sample grown for over two years. The fully decayed substrate experienced significant weight and volume loss, turning into a slurry-like fungal biomass rich in organic nutrients, beneficial for soil fertility. Additionally, a glass bowl displayed material changes over approximately a year and a half of continuous mycelium growth.

Three weeks of growth

One year of growth

Over Two years of growth

Exposed material changes of the continuously growing mycelium composite over a year towards full substrate decay

Bioreceptivity Tests

Growth Invitation

In bioreceptivity tests using hemp composite blocks, some with cotton fibers and others encased in fabric, it was found that the fabric-mixed samples (2) showed the best plant growth, particularly for cress and mustard seeds. The original composite samples (1) lost moisture quickly, while the cotton fiber mix (2) was more effective in retaining moisture compared to hard hemp fibers. Samples with fabric casing (3) showed growth, though slower than the mixed fiber samples.

Overall, the addition of fabric helped maintain moisture better than samples without fabric. Natural fabrics like cotton retained more moisture than synthetic fabrics, as observed in the experiment. Future experiments and prototypes will combine the principles of Samples 2 and 3, using fabric forms filled with a mix of original hemp and textile waste to ensure structural integrity.

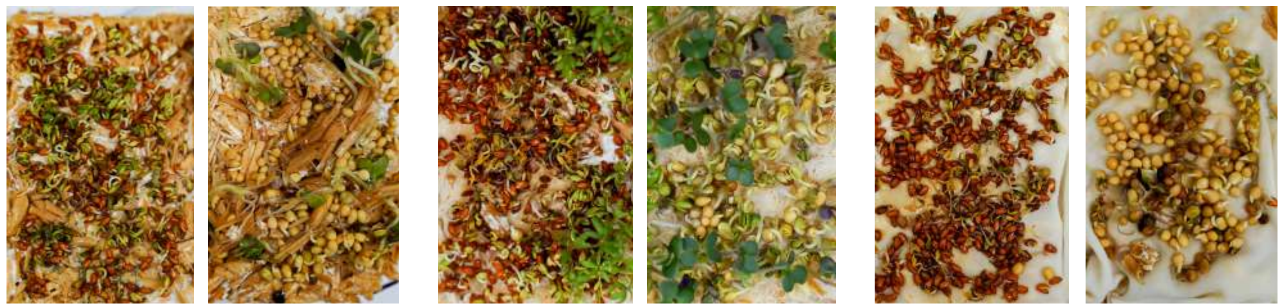
Sample 1
Original Hemp composite

Sample 2
Hemp composite with textile waste

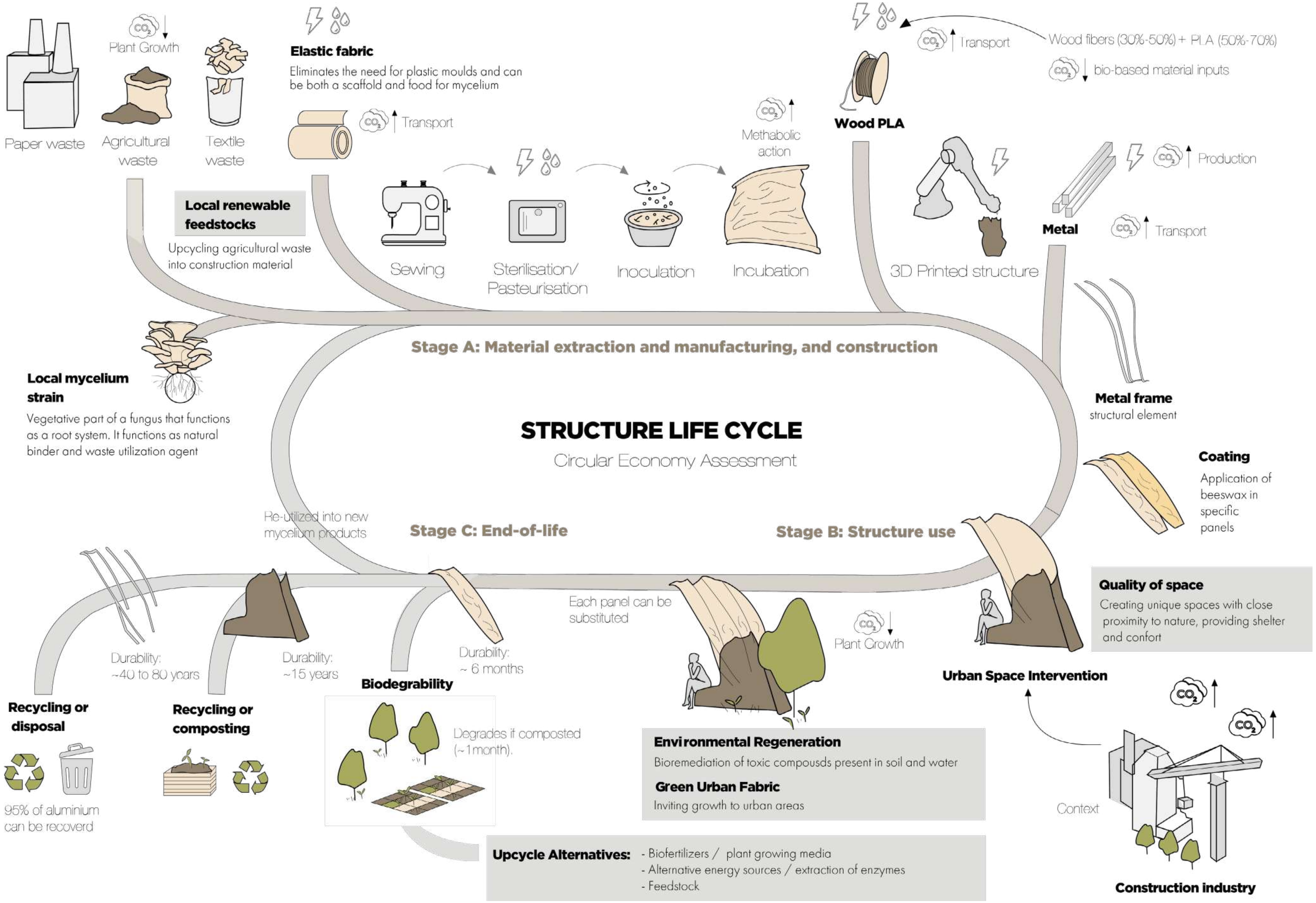
Sample 3
Hemp composite in a textile casing

Week 1 - Germination

Week 2 - Growing chamber



Week 3 - Growth in the Glasshouse Incubator


STRUCTURE LIFE CYCLE
Circular Economy Assessment
Stage A: Material extraction and manufacturing, and construction
Stage B: Structure use
Stage C: End-of-life
Plant Growth
Paper waste
Agricultural waste
Textile waste
Elastic fabric
Eliminates the need for plastic moulds and can be both a scaffold and food for mycelium
Transport
Local renewable feedstocks
Upcycling agricultural waste into construction material
Sewing
Sterilisation/ Pasteurisation
Inoculation
Incubation
Methabolic action
Wood PLA
Transport
Wood fibers (30%-50%) + PLA (50%-70%)
bio-based material inputs
3D Printed structure
Metal
Production
Transport
Local mycelium strain
Vegetative part of a fungus that functions as a root system. It functions as natural binder and waste utilization agent
Metal frame
structural element
Coating
Application of beeswax in specific panels
Re-utilized into new mycelium products
Each panel can be substituted
Plant Growth
Quality of space
Creating unique spaces with close proximity to nature, providing shelter and confort
Urban Space Intervention
Durability: ~40 to 80 years
Durability: ~15 years
Durability: ~ 6 months
Biodegrability
Degrades if composted (~1month).
Recycling or disposal
95% of aluminium can be recoverd
Recycling or composting
Environmental Regeneration
Bioremediation of toxic compousds present in soil and water
Green Urban Fabric
Inviting growth to urban areas
Upcycle Alternatives:
- Biofertilizers / plant growing media
- Alternative energy sources / extraction of enzymes
- Feedstock
Context
Construction industry

Environmental studies
Computational Design
Fabrication and Materials
Global & local Environmentall Design
Computational Design & Simulation
3D Printing & Fabric Forming
Materiality - Mycelium, Soil, Plants
Mycelium Fabric
formes panels
Structural metal Frame
3D printed seating
& semi-structures
integrating layeres
material sytem

Fabrication evolution

Material + Scaffold + Structure

Mycelium composites, known for their promising features, have limitations in lifespan that vary with exposure conditions. Indoors, they can last for years, but outdoors, their durability is influenced by the material formula, environmental conditions, and maintenance. Studies like those on Monolito Micelio have shown that these materials can crack and decay after three months outdoors due to material expansion and contraction (Dessi-Olive, J., 2022).

To address these limitations, strategies like using semi-stretchy fabric as sacrificial mycelium formwork are being explored. Unlike MycoMatters' fabric formwork prototypes (Dessi-Olive, J., 2022), this approach integrates the textile as a structural component.

The Urban MYCOskin project initially used cotton, a biodegradable textile, as a mold for mycelium growth. Cotton decomposes in a few months to a year under normal conditions.

While cotton cultivation has environmental impacts, using it as a mold offers a sustainable alternative to plastic, especially if organic and locally sourced (Rana et al., 2015).

Synthetic textiles like polyester, which decompose much slower, can also be used for upcycling in mycelium projects. Their decomposition rates vary based on environmental factors, but they can last 3-10 years outdoors (Manteco, n.d.; ScienceDirect, n.d.; Xu & Wang, 2012). In mycelium composites, the fabric aids structural integrity while mycelium contributes to fabric decomposition at the end of the hybrid's life.

Overall, the strategy integrates contrasting elements of fabric and mycelium in architectural contexts, maximizing mycelium's potential without relying on it as the main structural component.

Fabrication References

Funriture 3D pritnigng

3D Printed Chair series (Private commision) by Philipp Aduatz

Mawj by Nagami + MEAN

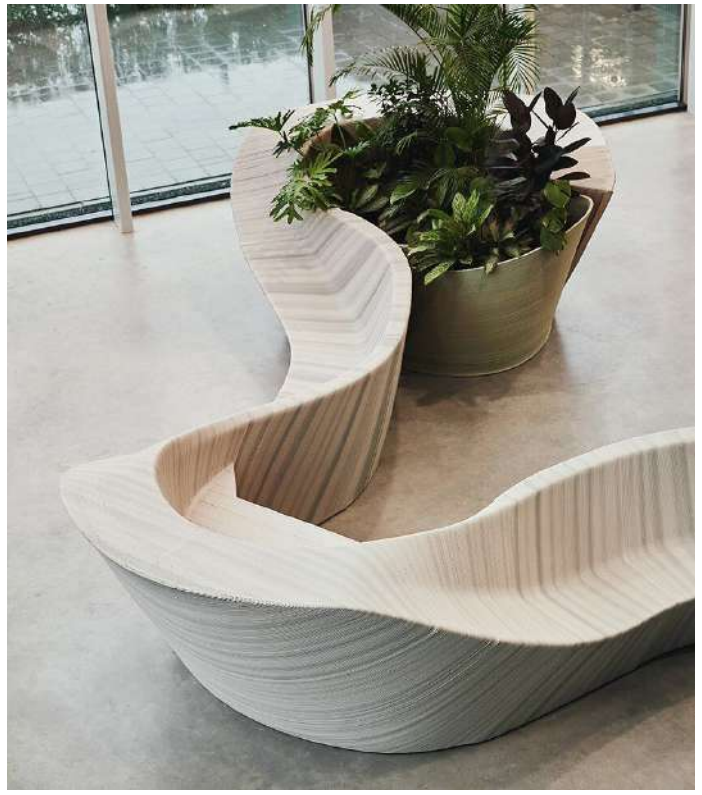
Ermis Chair by New Raw

Rise and Low – both by Zaha Hadid Architects

Reform Lounge Chair by Reform Design Lab

Print Your City! Recycled Public Furniture by The New Raw

Second Nature Series by New Raw for Blue Cycle



Swinging multi-purpose furniture by The New Raw

Sofa So Good Lounger by Janne Kyttanen

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Fabric forming with Mycelium


The Mycelium Monolith: A bioPavilion- MycoMatters Lab, 2018


MYCO-Knit CompoSITe - HBBE, 2022


Bio-Knitt, HBBE, 2022


I.N.S.E.C.T. Summercap -INterSpecies Exploration by biodigital Craft and manufacturing Technologies - Ilgun, et all. 2022


Knited Bio-Material Assembly, Yogiaman et al, 2020


MYCOllulose - Piórecka, 2022


Strategies for growing large -Scale Mycelium Structures, MycoMatters Lab, 2022

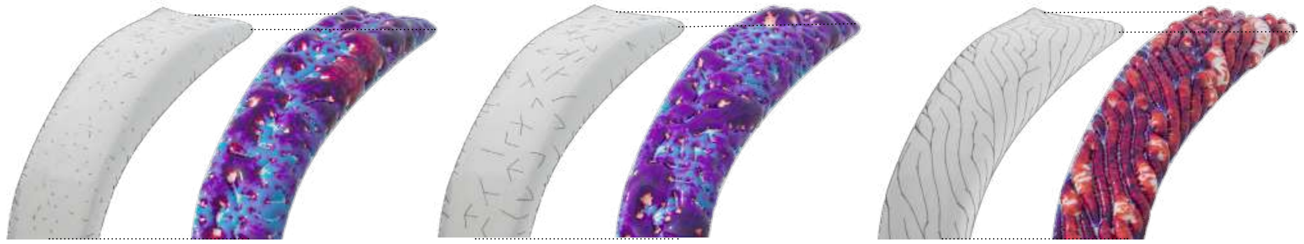

Bio Knitt 2.0 - HBBE, 2023

Framed Prototype

Frame and Fabric surface

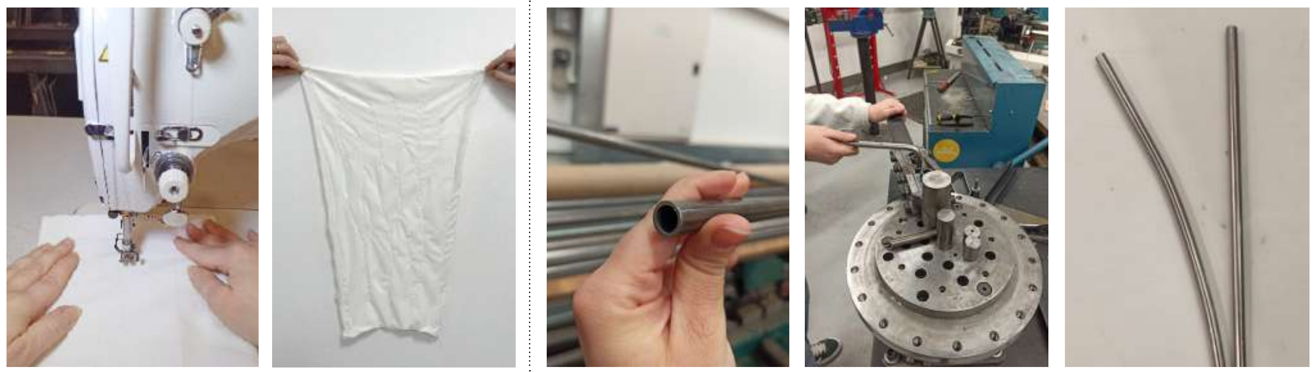
In developing a framed prototype, a new iteration of the panel was created, focusing on scaling up size and increasing the size of openings for easier filling with a substrate blend of hemp fibers and textile mix. The hard hemp fibers maintained porosity, while the textiles added other properties. This design incorporated results from a computational simulation that investigated different pattern creation strategies, concluding that short continuous line seams were optimal for achieving the panel's desired inflation.

Seams Inflation Panel Analysis



Pinned Points   Short Line Seams   Elongated Continuous Line Seams

Panel Fabrication steps



Seams - Sewing   Scaffold - Metal Frame bending

Assembling   Panel filling with mycelium substrate   Growth and drying

Curvature Created witrh the Frame and flexibity of the panel

Material quality through Fabrication

Soft velvet like texture on the surface
Detail of the sewing seems visible
Texture of the filling substrate reflected on the surface

Porosity and smoothness
High resolution of forms
Woody smell and feel

Natalia Beata Piórecka, Rita Morais, Jennifer Levy Girardin

Patterns of Infill

Exploring Pneumatic Forms

This research, inspired by previous studies, focused on exploring fabric formwork strategies within a digital environment using pneumatic structure simulations. Pneumatic structures are lightweight membranes filled with air, relying on internal pressure to maintain shape and counteract external forces (Pneumatic Structure | Dlubal Software, n.d.).

The project aimed to replicate the appearance and behavior of textile-filled mycelium geometries using pneumatic membranes. The goal was to understand how surface patterns impact the structures and influence water flow on the panels. Challenges arose in ensuring the mycelium substrate filled all areas of the fabric, unlike more fluid materials like concrete or plaster.

To overcome these challenges, inflation stress colours were used to identify areas that would fill more easily or pose difficulties.

Houdini software simulated air pressure on the panels, with color variations indicating areas of higher tension.In pneumatic structures, air pressure causes a specific curvature in the membrane, creating stress proportional to this curvature (Pneumatic Structures and Internal Pressure | WinTess Software, n.d.). For this study, a vellum solver adjusted the stiffness to a pressure of 6x100 with a rest length scale of 1, representing the original distance between points in the geometry (Animate Vellum Rest Length Scale | Forums | SideFX, n.d.).

The colour scale, ranging from white (0 value) to light blue, dark purple, magenta, and back to white, was used to represent maximum stress levels, aiding in understanding how different areas of the structure would react to internal pressure.

Pattern Forming

Shortest Path Logic

The following patterns were modeled and simulated using a shortest path pattern logic, simulating long elongated curved lines. These were based on the previous experiments were long lines proved to be the most efficient at redirecting water.

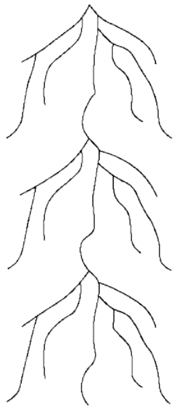
The colors represent the stretch stress that the fabric is being submitted to. How "stretchy" the different simulations are indicate how easy the panels could be filled (since if the pattern lines are very close one to another, filling these was harder).

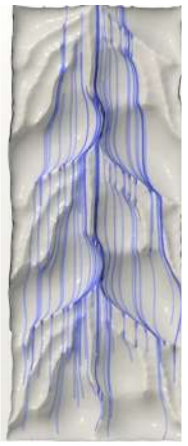
Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 900

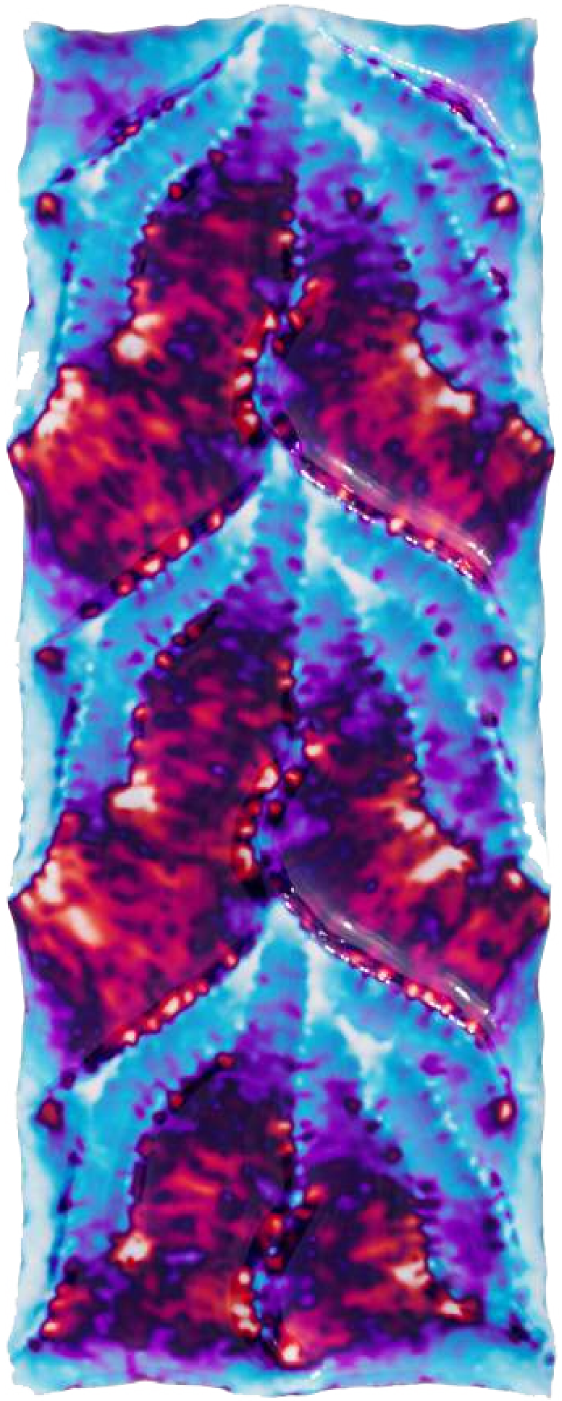
Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 950

Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 1000

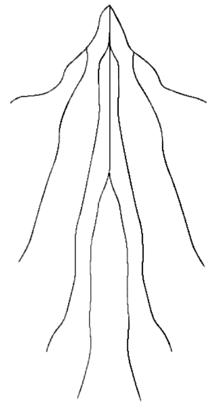
Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 850



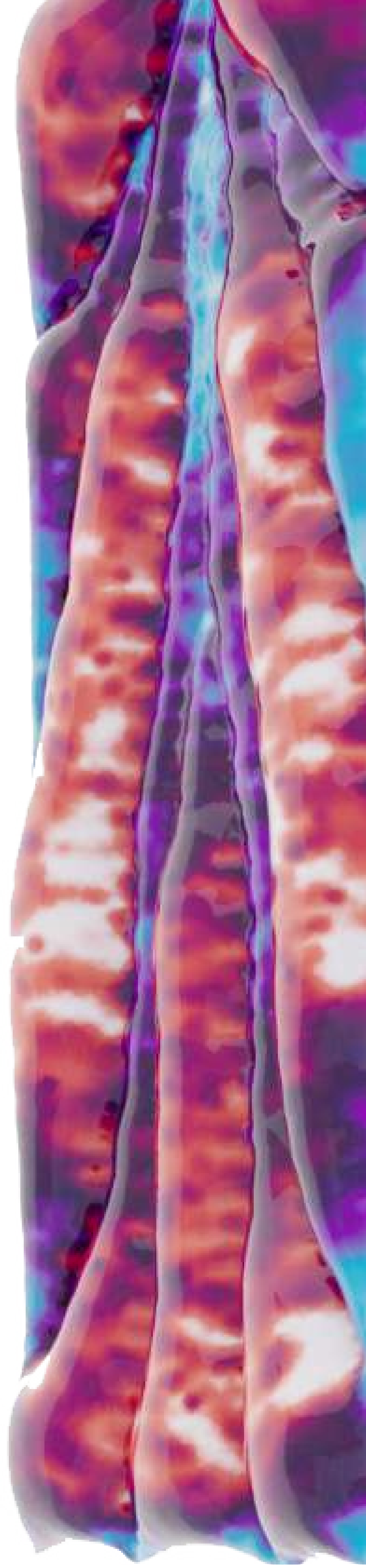




Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 1000



Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 1080

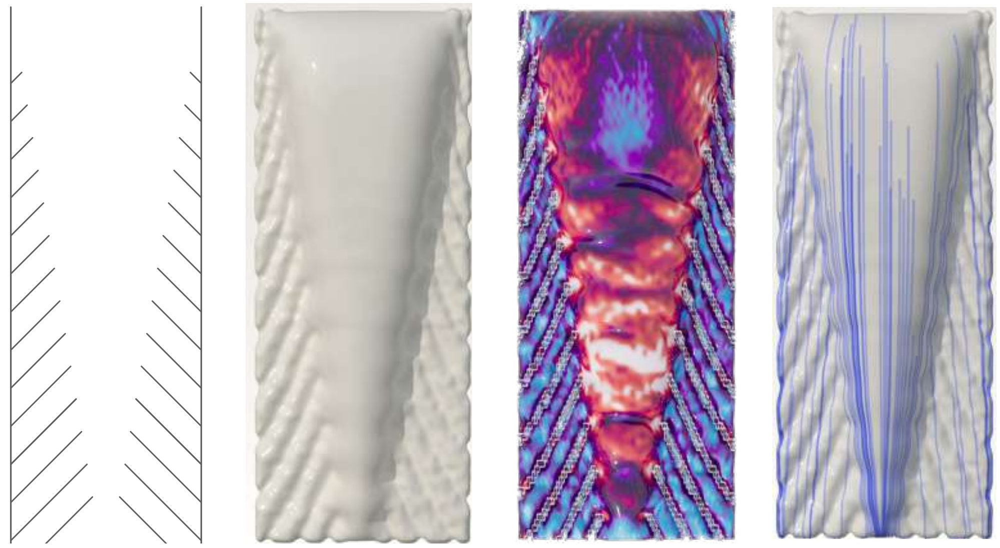


Pattern Forming

Controlled Line Drawing Logic

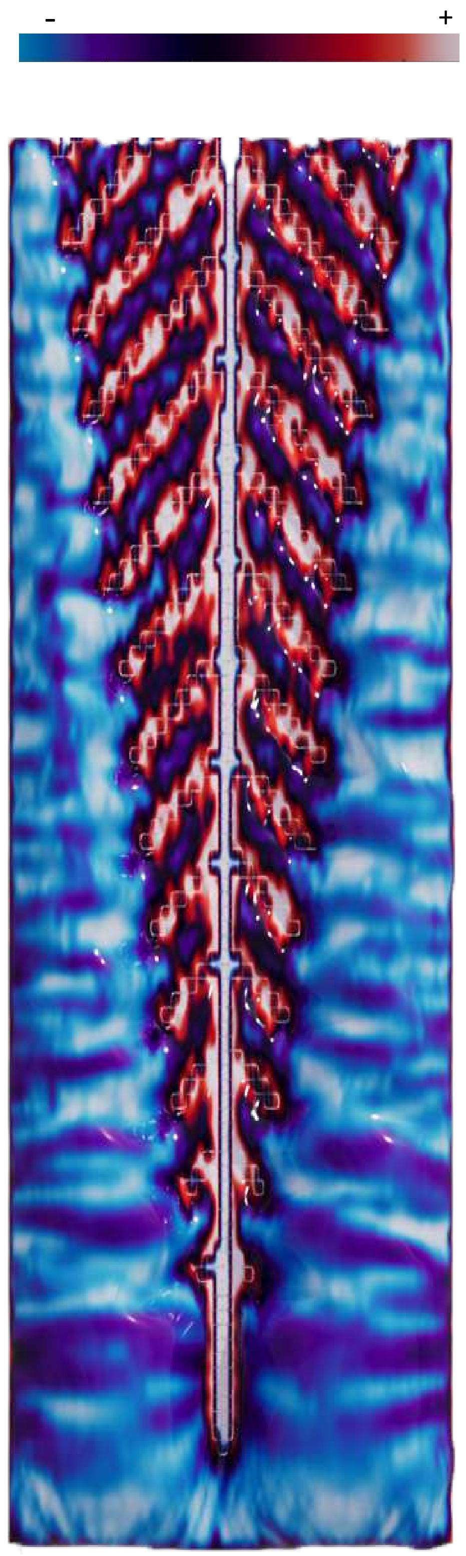
The following patterns were modeled and simulated using a series of different line drawings, based on water flows and analysis from previous design experiments. As stated before, the patterns with the long lines proved to be the most efficient at redirecting water.

In this case, the stretch colors helped indicate how easy or difficult the filling may be, once it would be fabricated on a large scale.

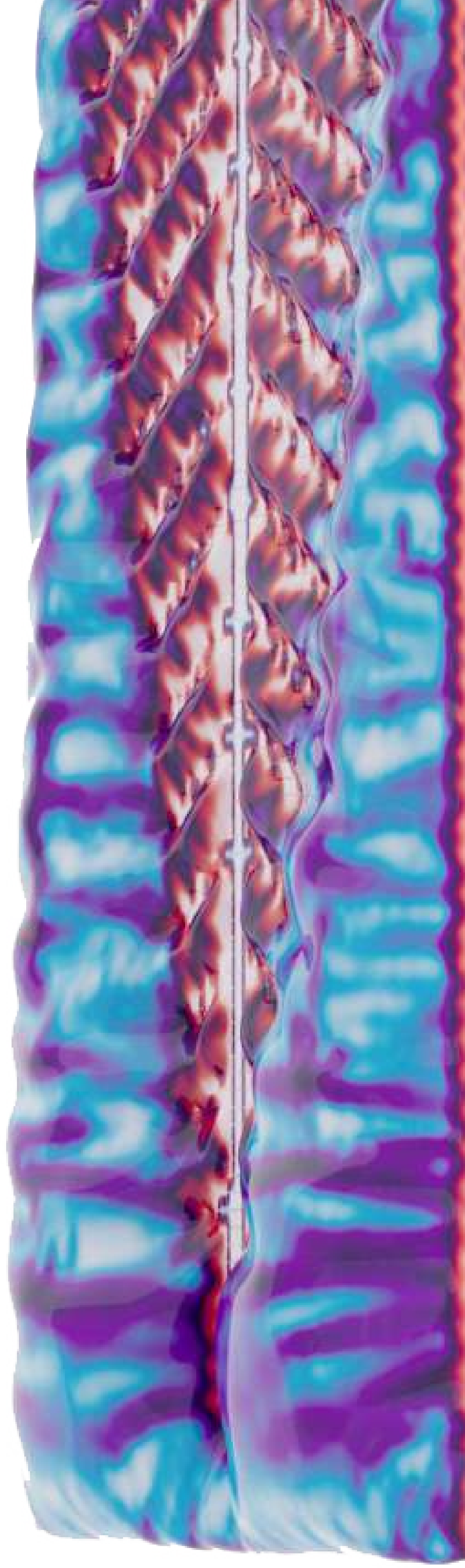


Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 800

Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 950

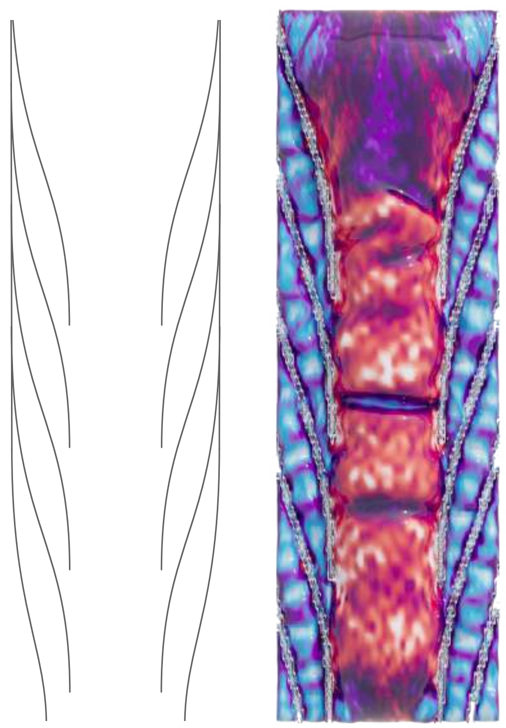


Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 1000

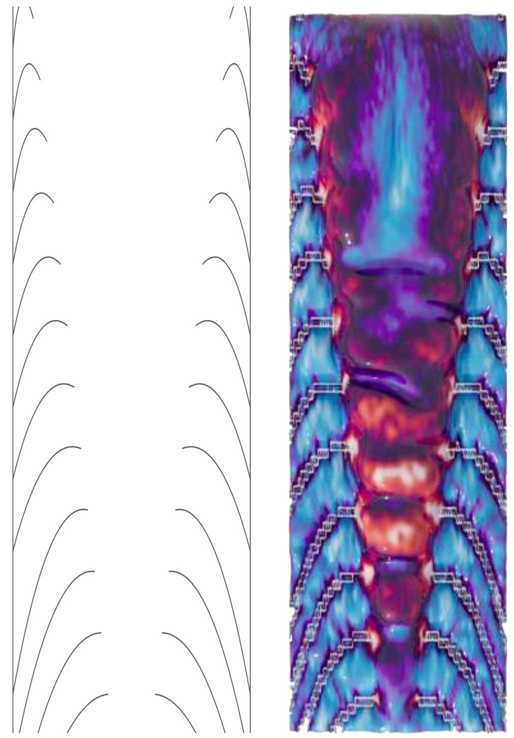


Panel Selection

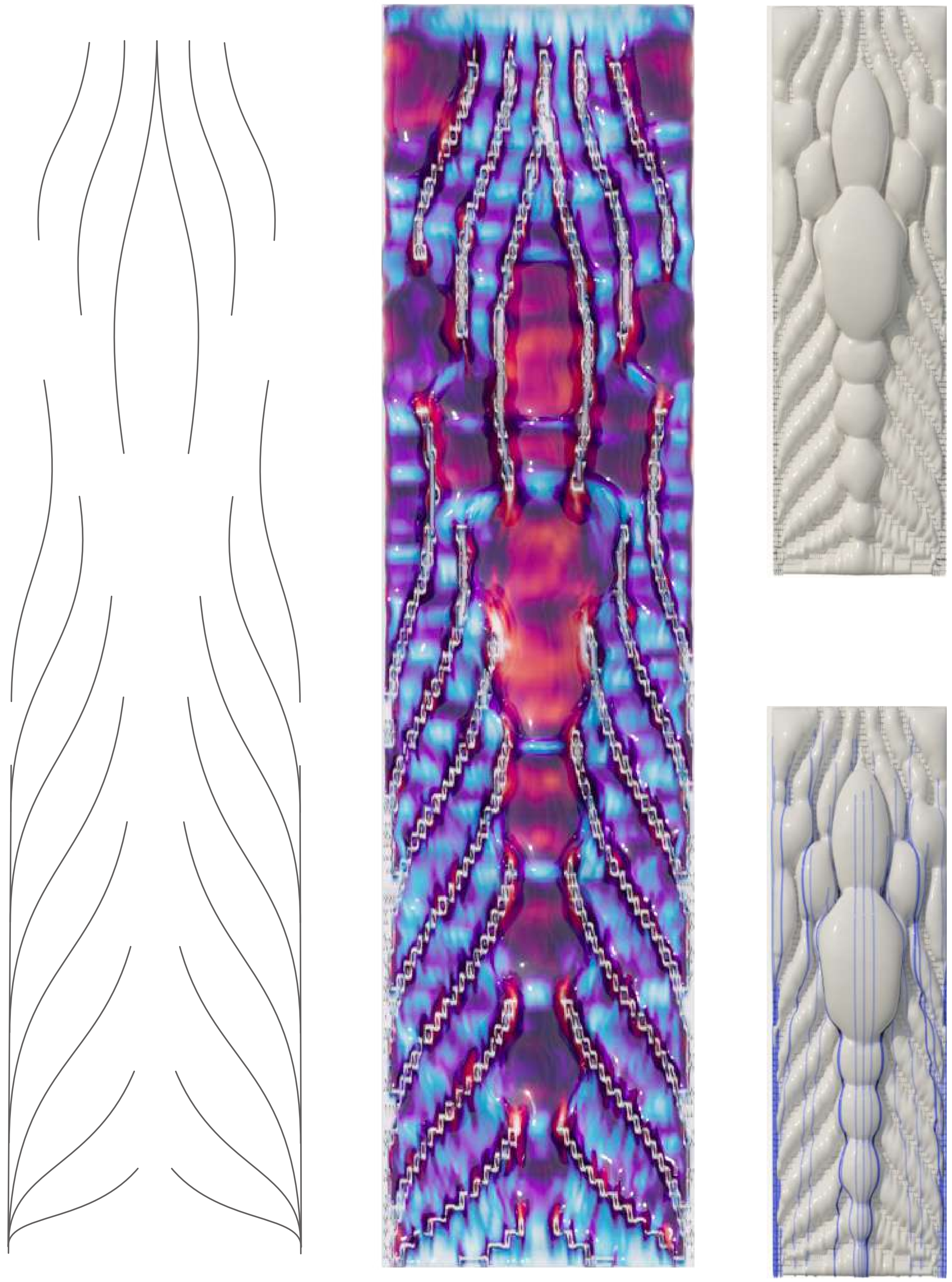
Of all of the modelled and tested panels, the following panel was chosen for several reasons. The elongated lines drawing towards the sides created ridges redirecting water to either side of the panel. The inflation colours also indicate that the centre of the panel is more inflated than the sides, furthermore aiding the redirection of the water to the sides. The line patterns on the inflated form-work panel create a design which on one hand captures water to enhance biodiversity and on the other hand, creates an aesthetic geometry that is open for further design explorations.



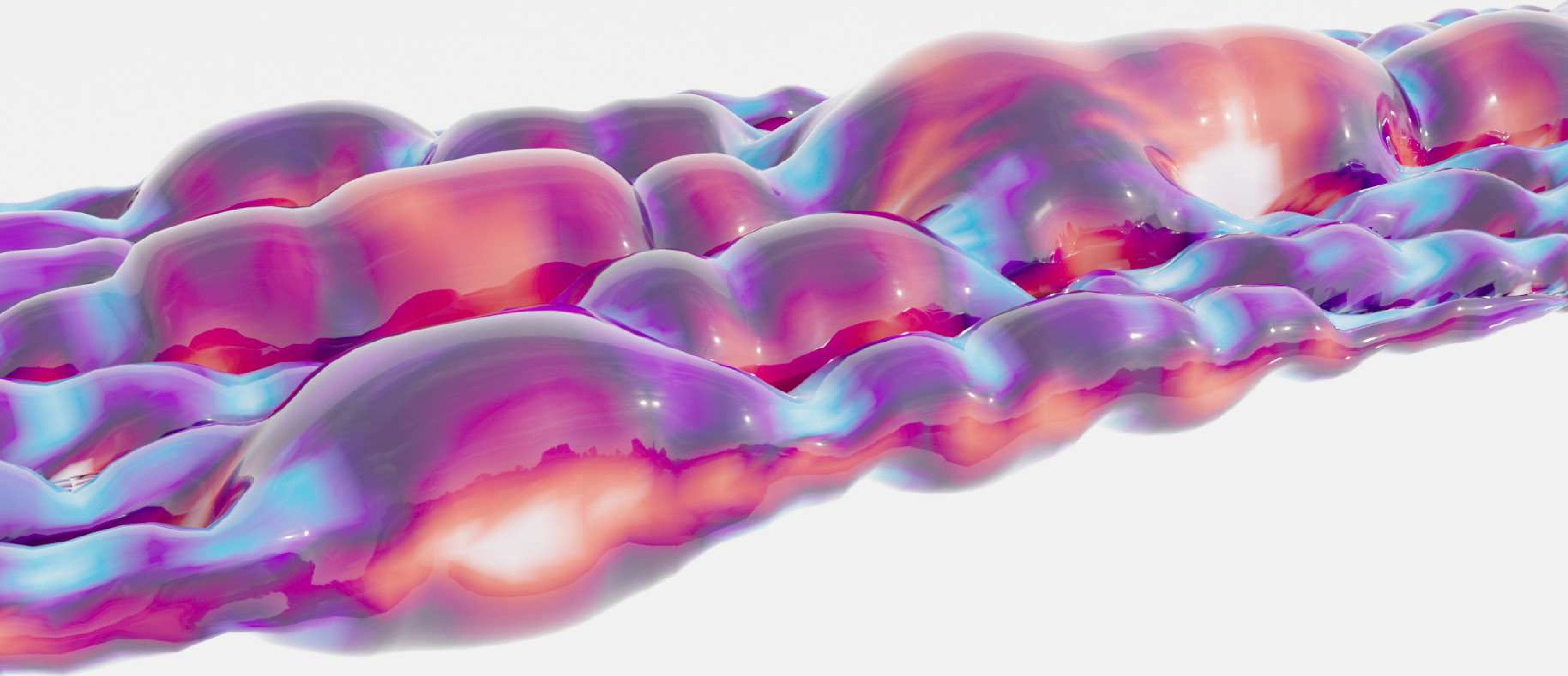
Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 850



Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 870



Stiffness (P) : 6
Rest Length Scale: 1
Maximum Stretch Stress: 1100



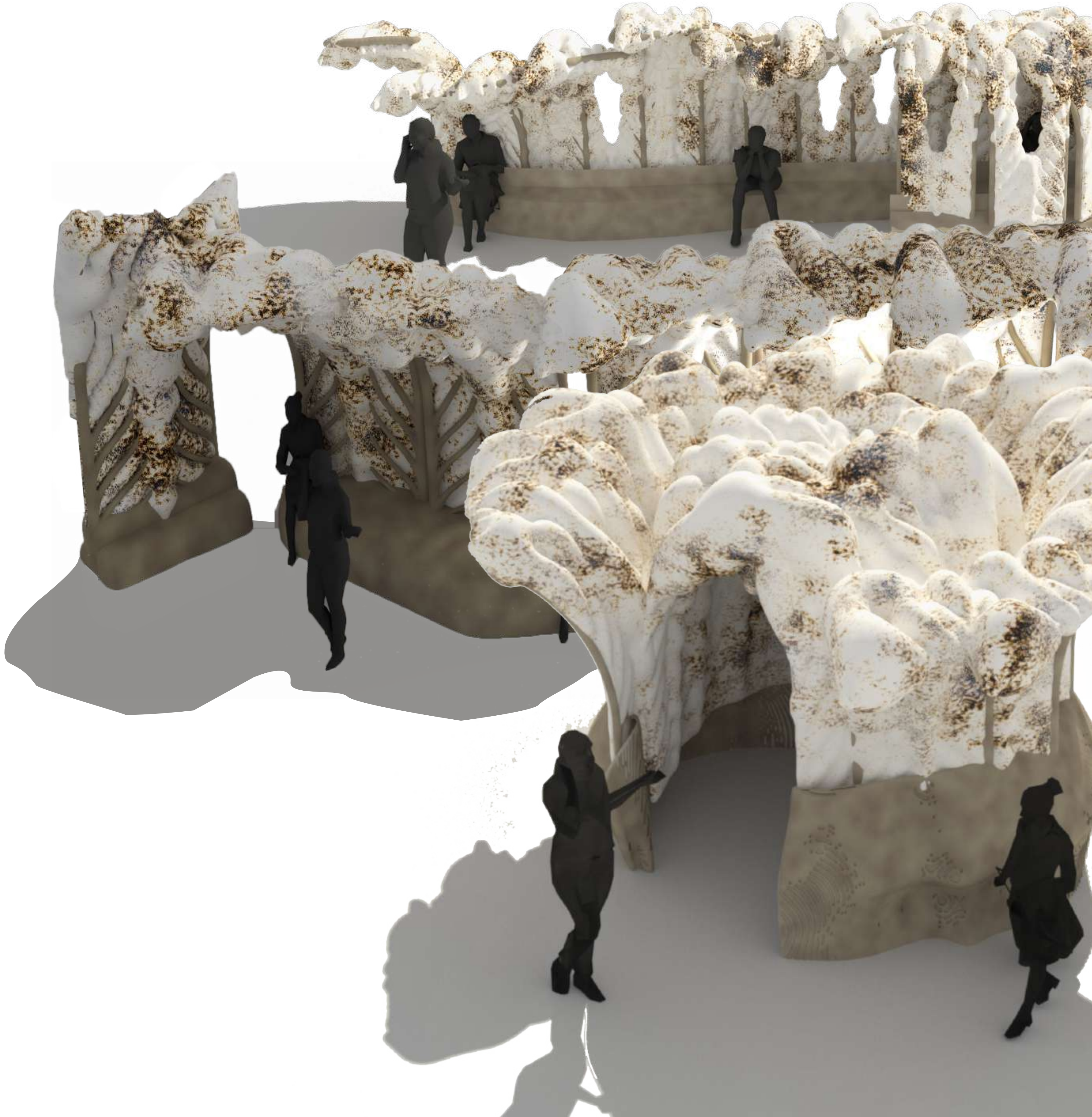
Topologies evolution

Application in context

The topologies previously explored were applied as urban interventions, demonstrating the versatility of the architectural system. Sections were manipulated, arrayed, and scaled to create structures ranging from open spaces to enclosed kiosks and continuous walls. A blend of open and enclosed walls was also conceptualized for a bus stop iteration. These applications illustrated the system's adaptability in various urban settings, highlighting its potential for diverse spatial interventions.

Developed Section

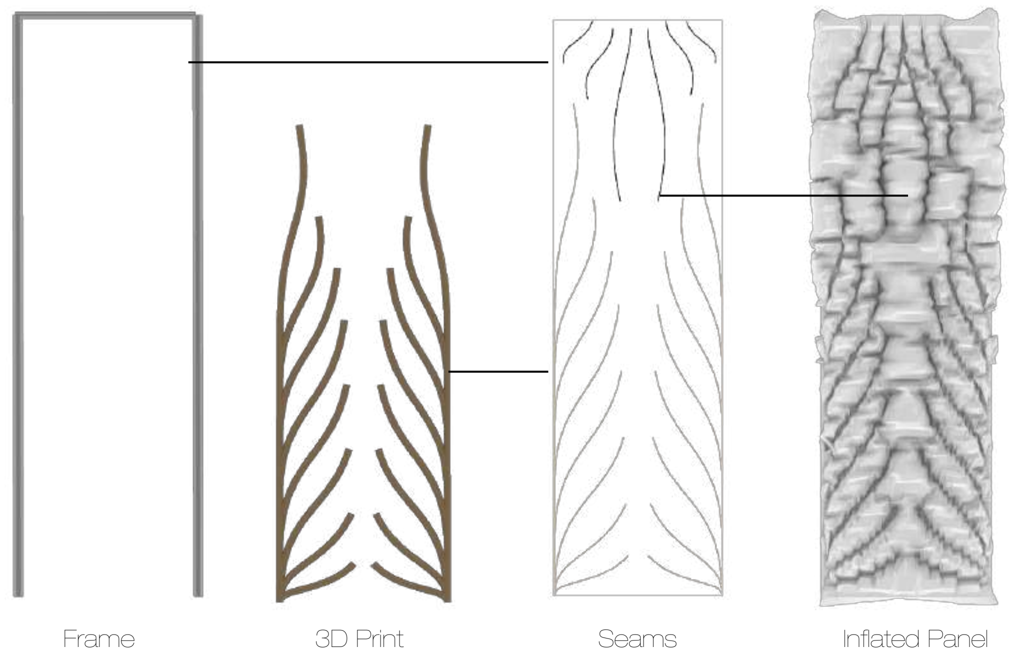
Kiosk

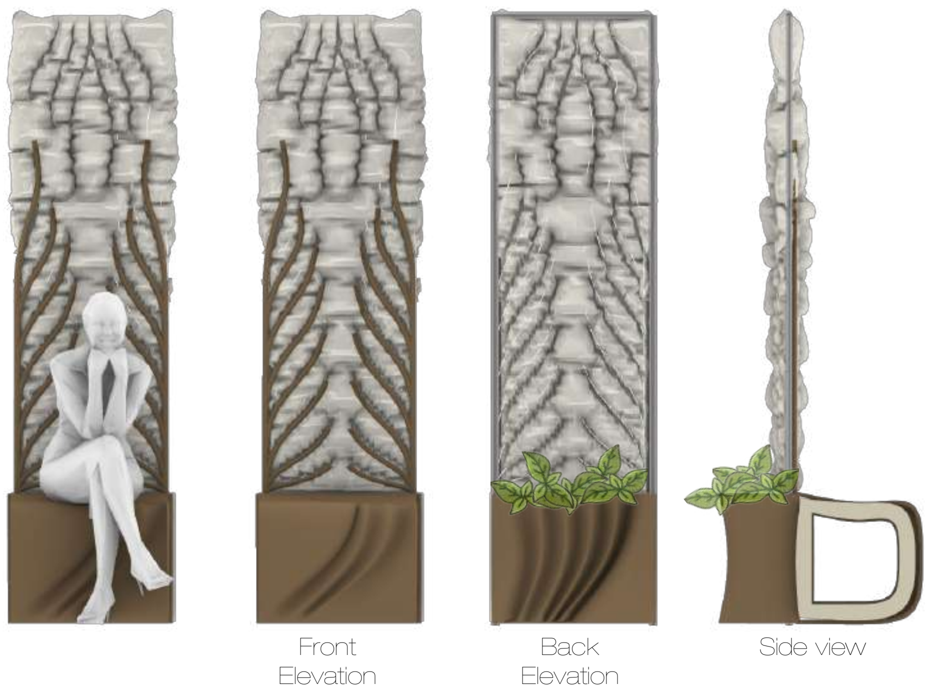


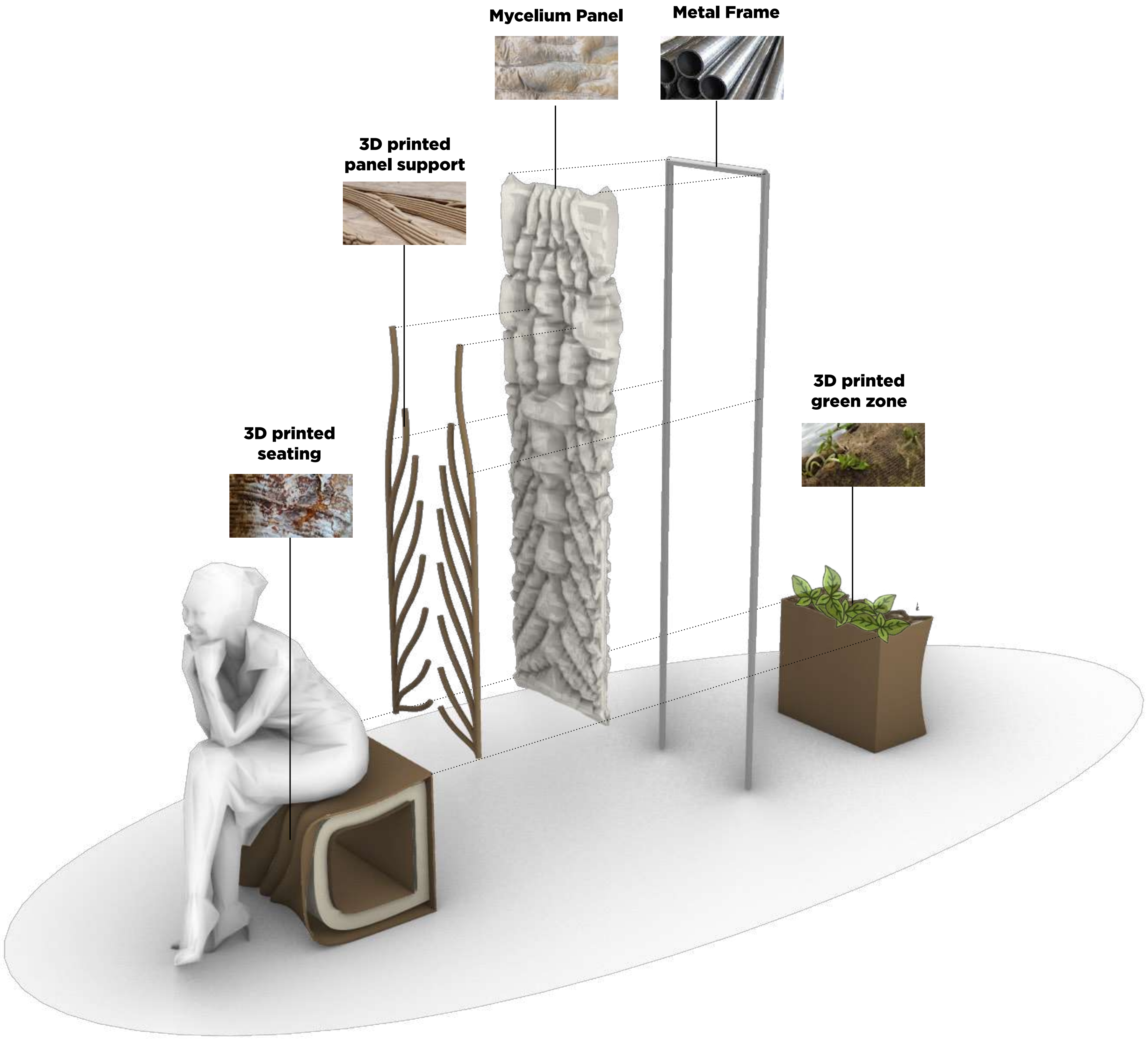
Bus stop

Digital Fabrication Assembly

Digital Fabrication

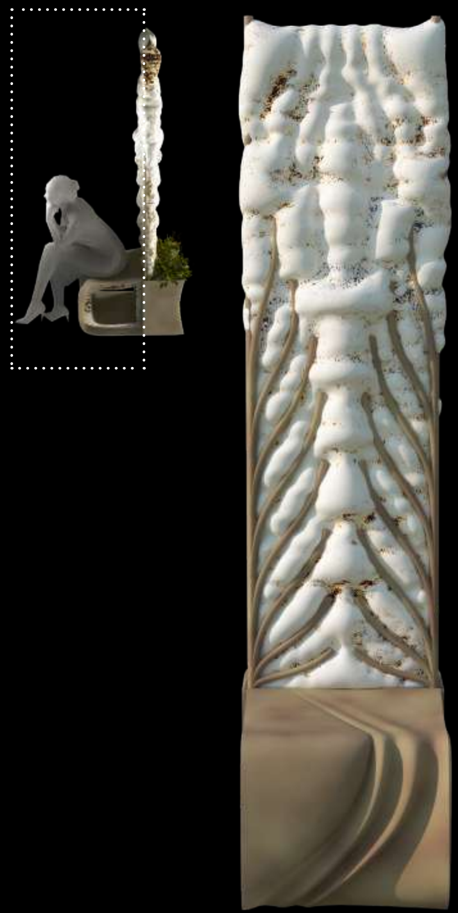






Digital Design of the Final Prototype

Front Elevation
Seating



Back Elevation
Green Zone

Final Panel Prototype

Panel


Digital Panel Design


Robotically 3D printing referencing semi-support structure


Adjusting the shape according to the print reference

Panel Sewing


Distributing fixtures for frame assembly


Applyig fasteners

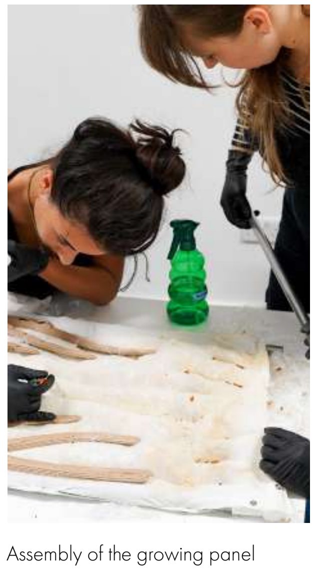

Preparing the material

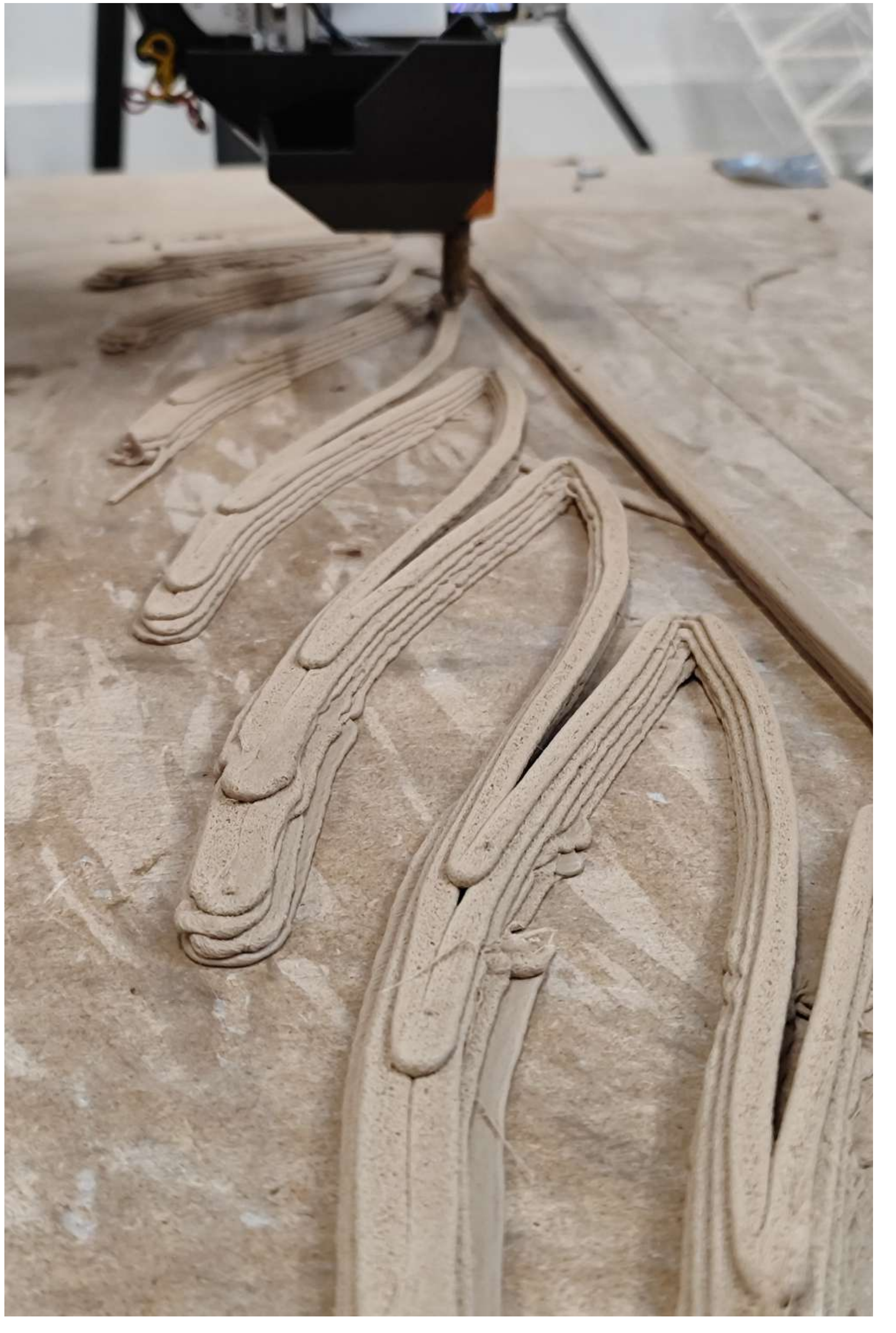

Mixing the waste textile and material


Filling the fabric

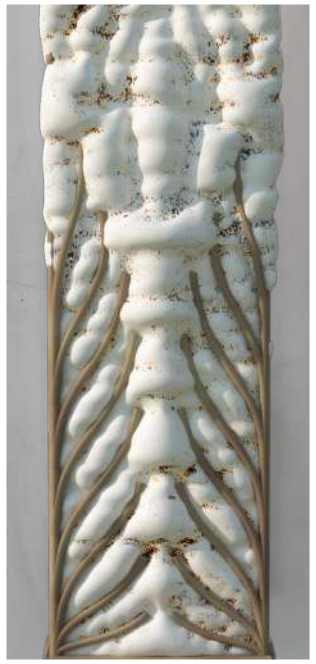

Further Filling and 3D print assembly


Growth of the panel


Assembly of the growing panel



Prototype Mycelium Infill Progression


Digital Model of the Prototype


Sewn Fabric


Sewn Fabric


Filling Stage 1


Filling Stage 2


Filling Stage 4


Attachment of the 3D print

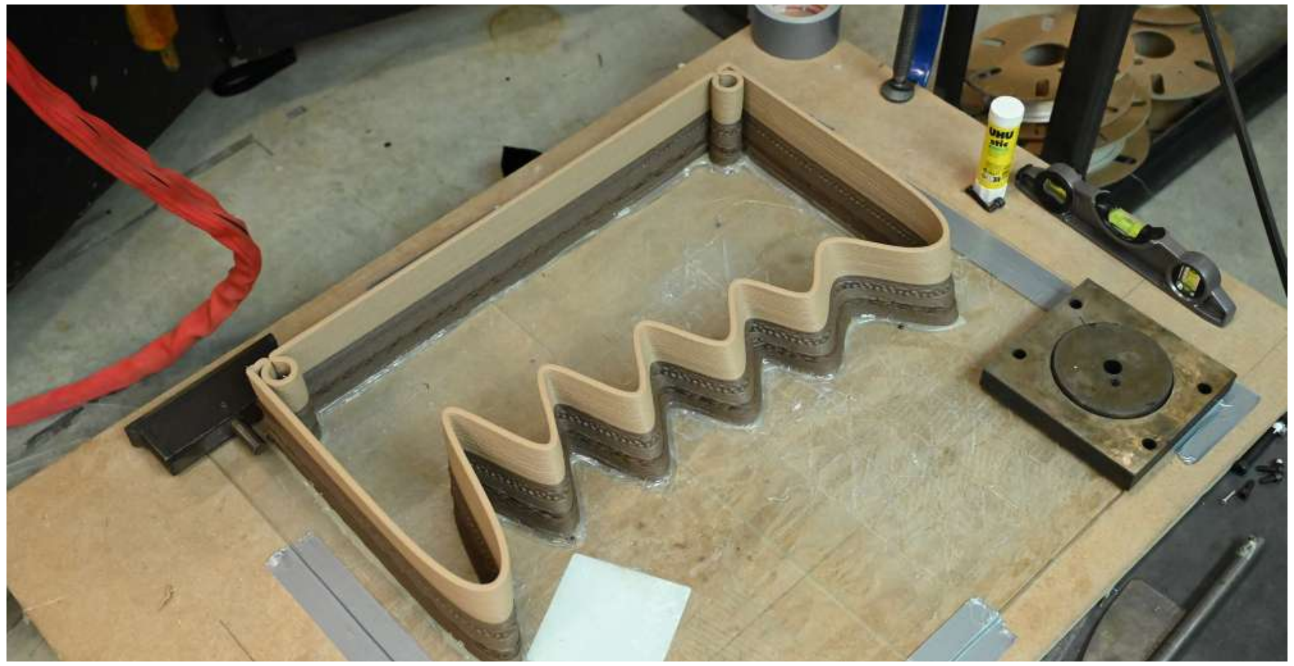

Securing and placing in the incubator

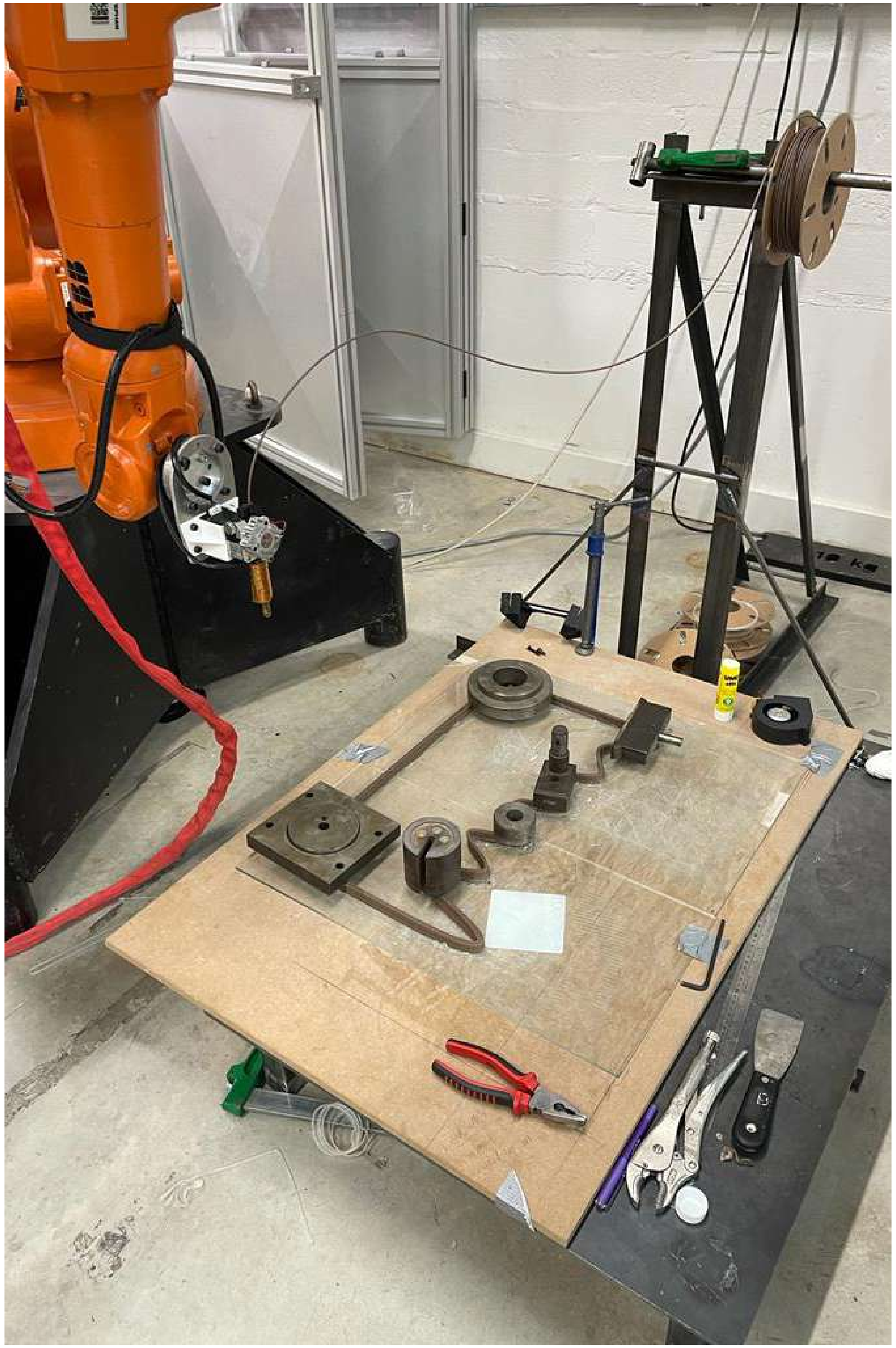

Grown Panel

3D Printed Base

Geometrical Bespokenes

he foundation was 3D printed over the course of three days, during which we tested various kinds of wood PLA. The original base had a size of 40x20x30 cm, then proportionately it got was scaled to 55x27x41cm. Since it was printed by a robot and was relatively sizable, precautions were taken to ensure its stability and prevent lifting at the edges. Holes were incorporated into the print as holder and fixings for the metal tubes to slot in place.





Final Prorotype Assembly

Covered structural metal frame

The covered structural metal frame serves the purpose of providing the necessary structural support for the prototype. Designed to integrate seamlessly with the proximity of growing living organisms, it utilizes stainless steel and is strategically hidden from view. Its primary function is to act as a scaffold, hosting material panes that facilitate plant growth and redirect water.

Fabric Formed Panel filled with inoculated with Mycelium substrate (mix of waste textiles and hemp shives)

The fabric-filled mycelium panels are intentionally designed to be seamlessly integrated with the printing process as they grow over time. This integration involves utilizing a filament infused with cellulose fibres. The purpose of this design is to support the panels' future curvature, particularly as the natural processes of infill deterioration and fabric weathering begin to influence the overall integrity of the panels over time. By considering these factors, the design ensures that the panels maintain their structural stability throughout their lifespan.

Robotically 3D printing panel supports semi-support (vertiacal layer-by-layer printing)

designed to be integrated with the panel over the growth time utilizing a fillament with cellulose fibres; it is supporting panels future curvature, especially once the processes of deterioration of the infill and then fabrics will influence the panels integrity with the progression of time and weathering

Robotically 3D printing base as semi-support structure (horizontal layer-by-layer printing)

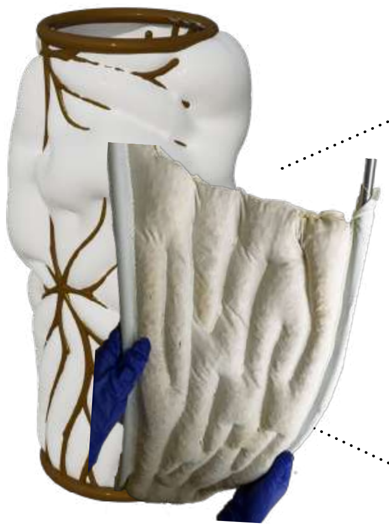
it is designed to host plant growth with redirected waters; ideally it would have additional layer inside to host mycelium composite, it will also layerd for introduce layering of various composts and aggregates accommodating growth; it will also accomodate drainage as important element of plant health and well-being. In future iterations the process would evolve to non planar printing

Final Design & Analysis

Small Scale to Macro Scale

The project was conceived in a bottom-to-top logic, where an initial exploration into a small-scale component was developed. This then scaled into a column structure to then a wall system, to finally an enclosed space.

Mircro
Small Scale
Initial Component



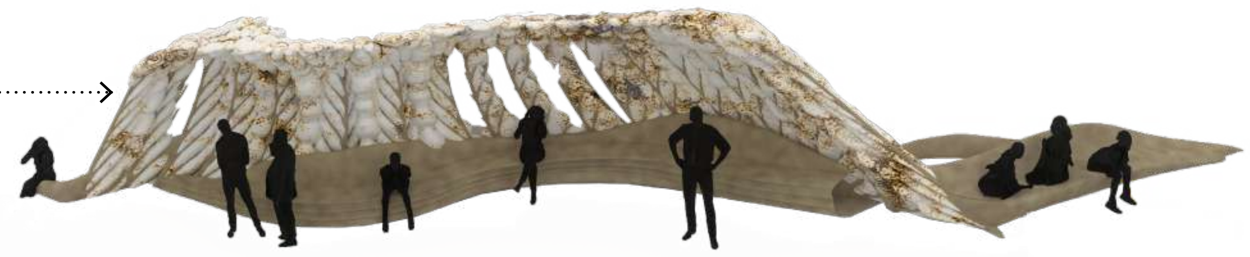
Initial fabrication scaffold that evolved into the following designs.

Messo I
Medium Scale
Column - Section Element

Messo II
Medium Scale II
Wall System

Macro II
Large Scale Structure - Vision
Architectural Space - Vision

Macro I
Large Scale - Bus Stop
Architectural Space - Design Proposal



Design Strategies

Environmental

- Channel, redirect and recollect water
- Tackle the "Heat Island" problem
- Increase Biodiversity by the use of bio-materials and recollection of water around the structure
- Different areas increasing Shade

Design

- Improve overall experience of the space
- Upgrade the seating space and circulation
- Merge function and bio-materials to create a pleasing aesthetic
- Pattern on Mycelium panels feed function and design

Material

- Use of Constructive Mycelium Panels
- Utilizing stainless steel as a structural material and scaffold, holding the Mycelium panels in place
- Textiles that will encase, hold and bind together the Mycelium
- Wood with multiple functions such as water retention, outdoor furniture, and promoting biodiversity.

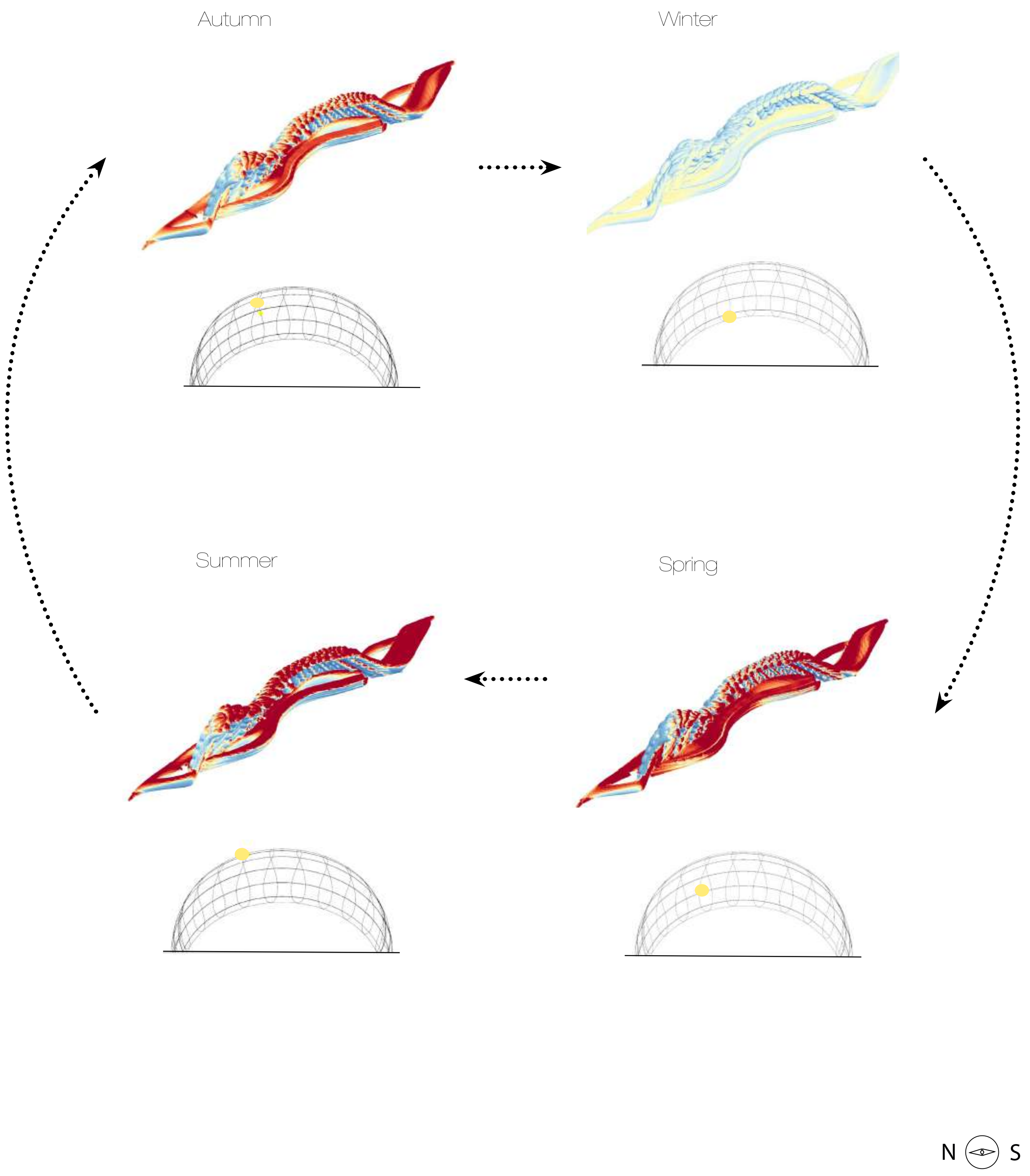
Geometry

- Textile filled mycelium panels
- Curvature encreasing shade and water recollection
- Sinuous shape follow function of the structure
- Patterns on Mycelium panels create novel "inflated" geometries

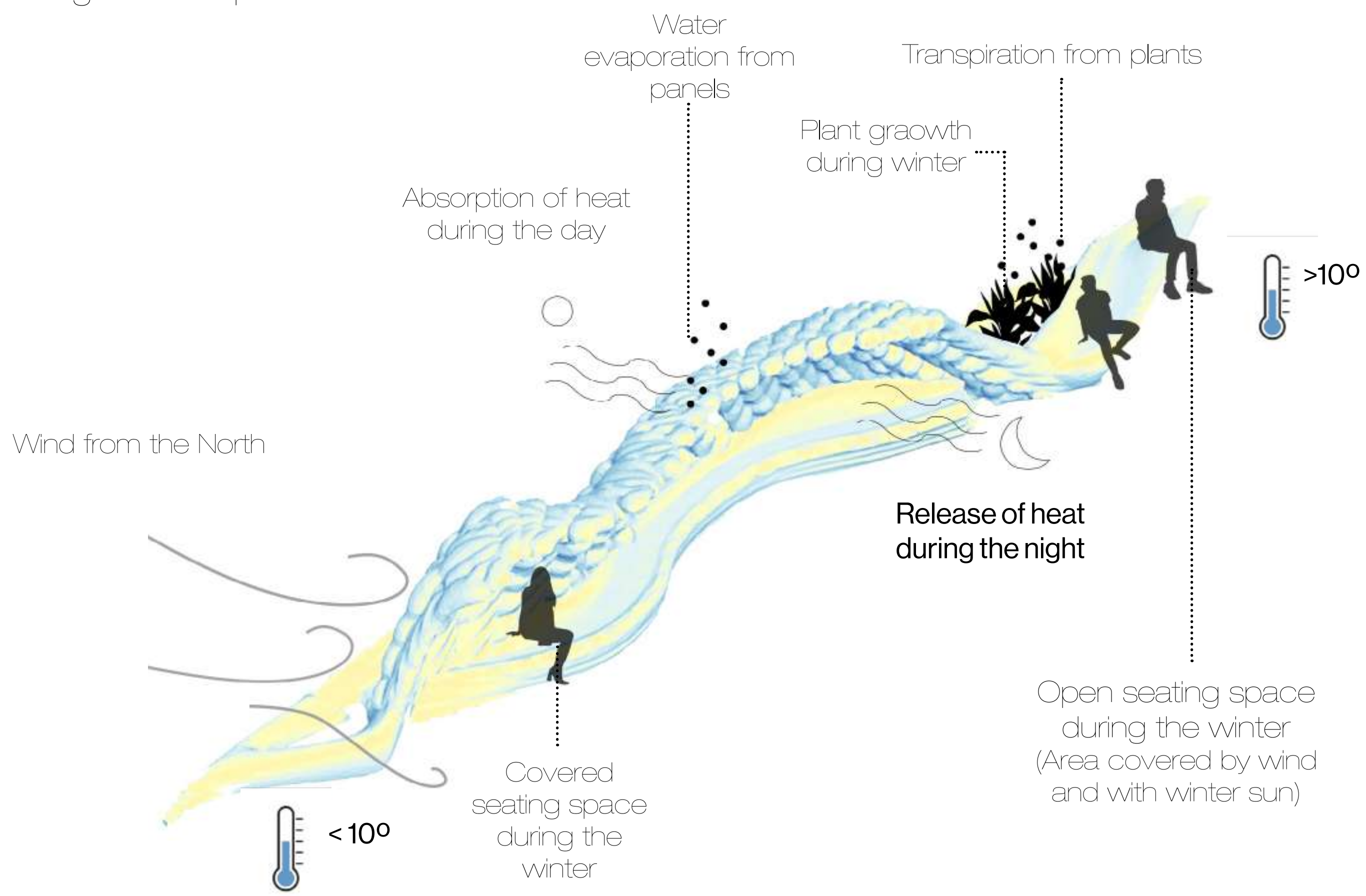
Environmental Analysis

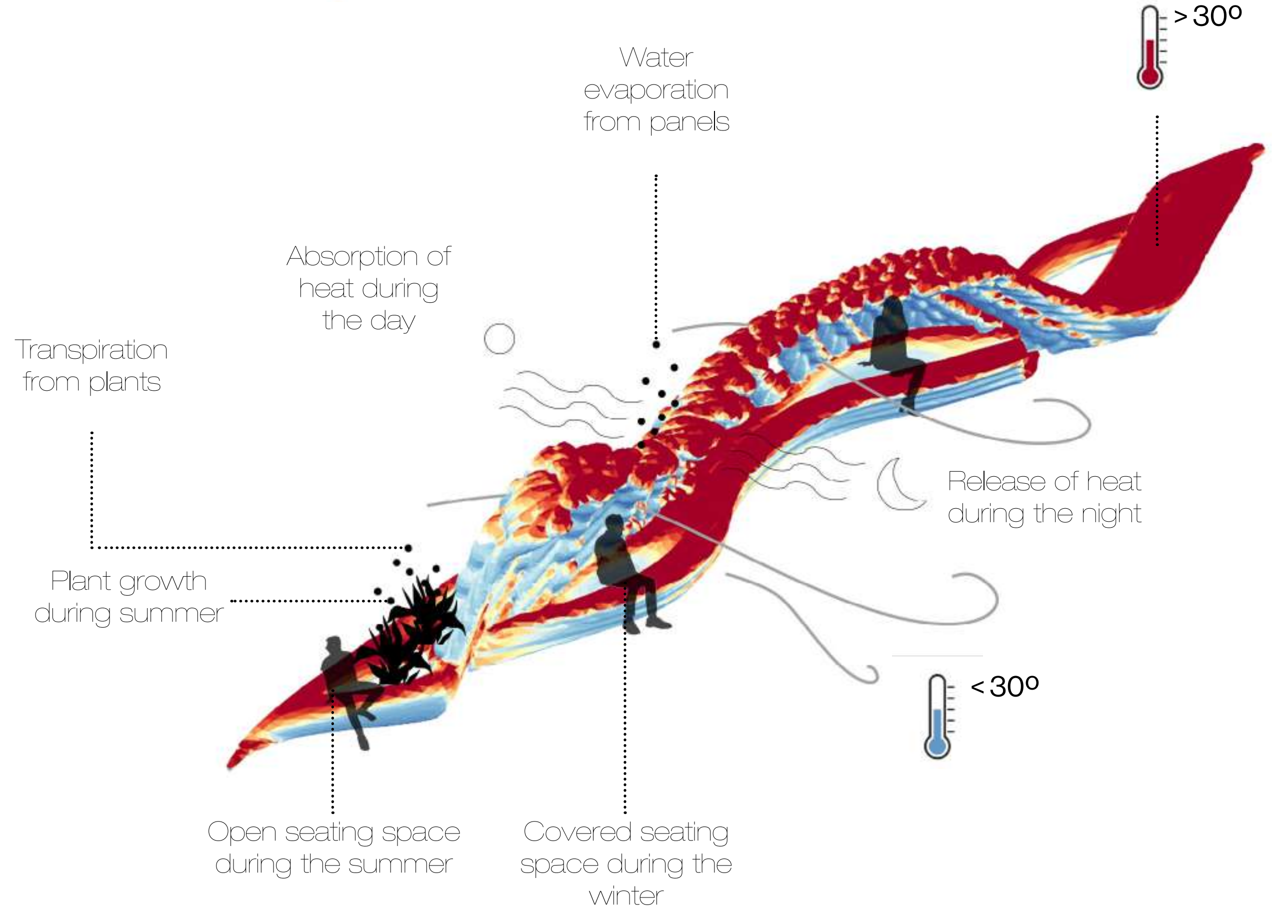
Solar radiation and temperature

Seasonal variation



Usage of the space



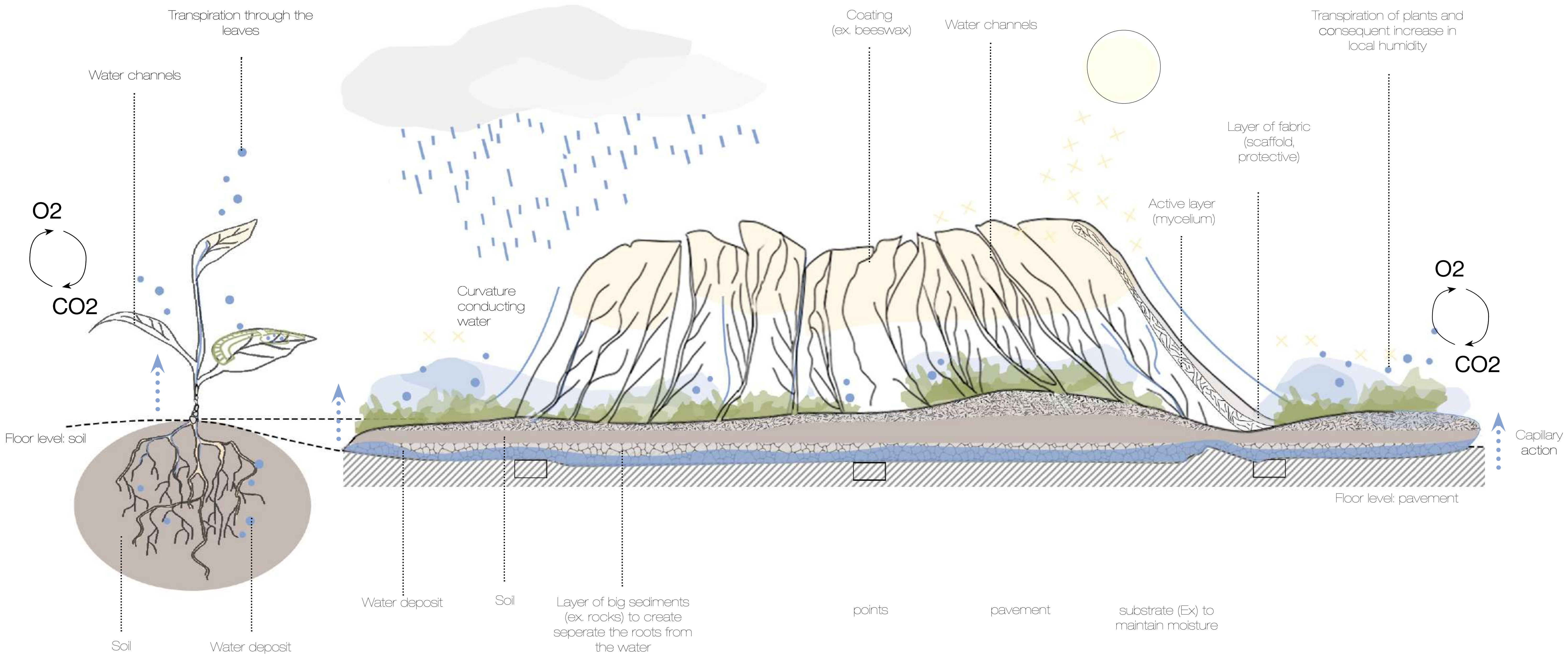


Water systems

Buildings fucntioning a plants. I

Plants have developed various mechanisms to regulate water within their systems. They use curvature to position their leaves or stems in a way that directs water towards the roots. Transpiration, the process of water evaporating from the leaf surface, helps regulate the plant's temperature. Ridges on leaves can guide water droplets to form continuous streams, while internal channels like xylem and phloem transport water and nutrients throughout the plant's tissues. Capillary action enables water to move upward against gravity, ensuring uniform hydration. Water stored in the soil serves as a reservoir for periods of limited rainfall, ensuring water availability.

The purpose of the diagram is to demonstrate how these natural mechanisms can be applied to the proposed structure.



Water systems

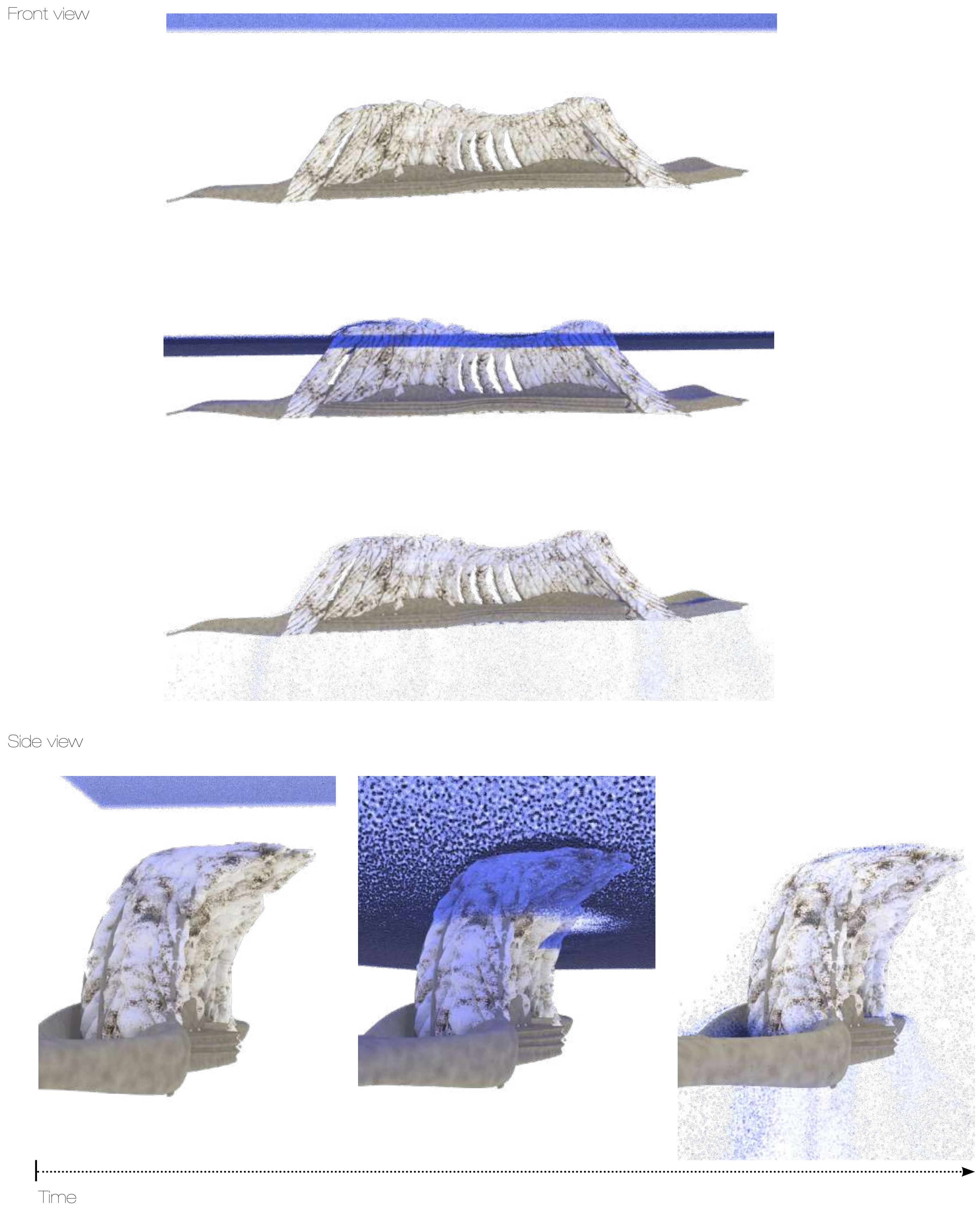
Buildings fucntioning a plants. II

This structure takes inspiration from the water management mechanisms observed in plants to establish its own water system. Similar to leaves, the panels of the structure are designed with curvature and channels created by inflated fabric to direct the flow of water towards the soil.

To address water scarcity during periods of low rainfall, a water reservoir is integrated at the base of the structure. Furthermore, the use of porous materials like fabric, wood, and mycelium substrate facilitates capillary action, enabling water to be distributed to the surface layers. By supporting plant growth within the structure, the processes of transpiration and passive cooling are introduced.

Water flow simulation

Rain water simulation



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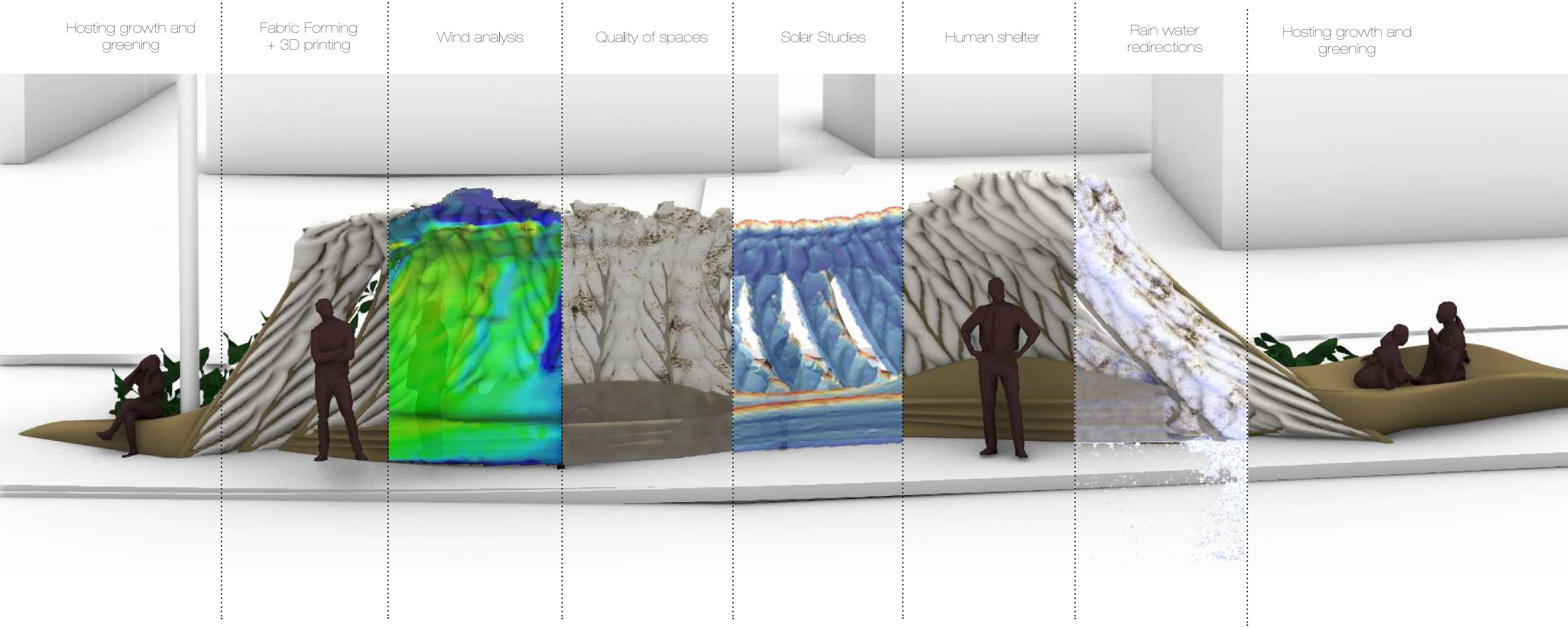
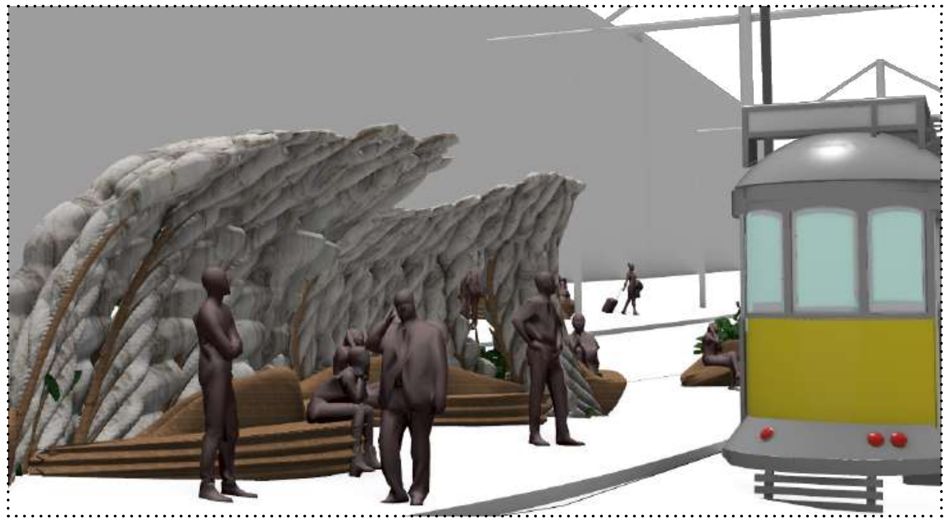
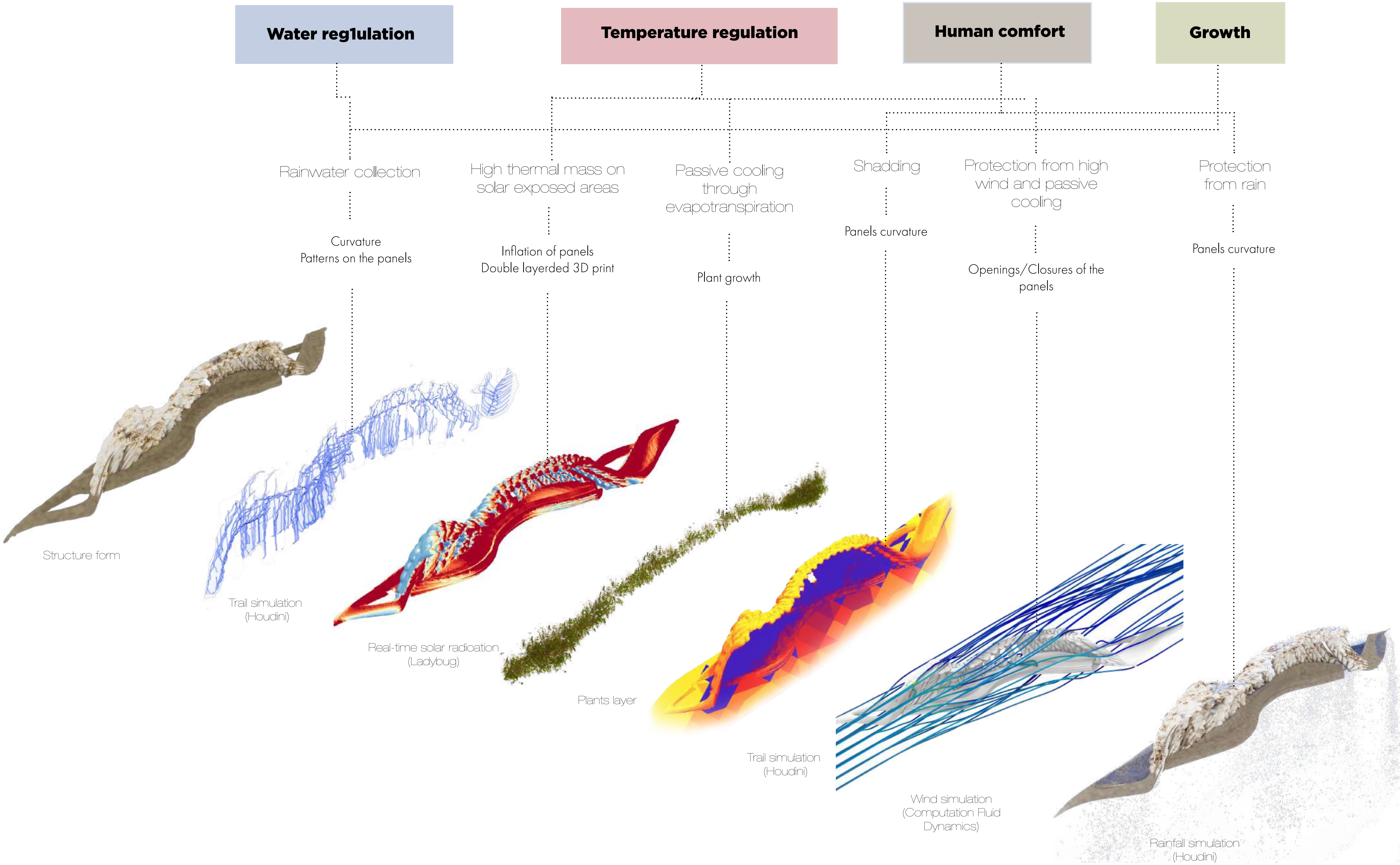
Integration of design elements into the final bus stop design



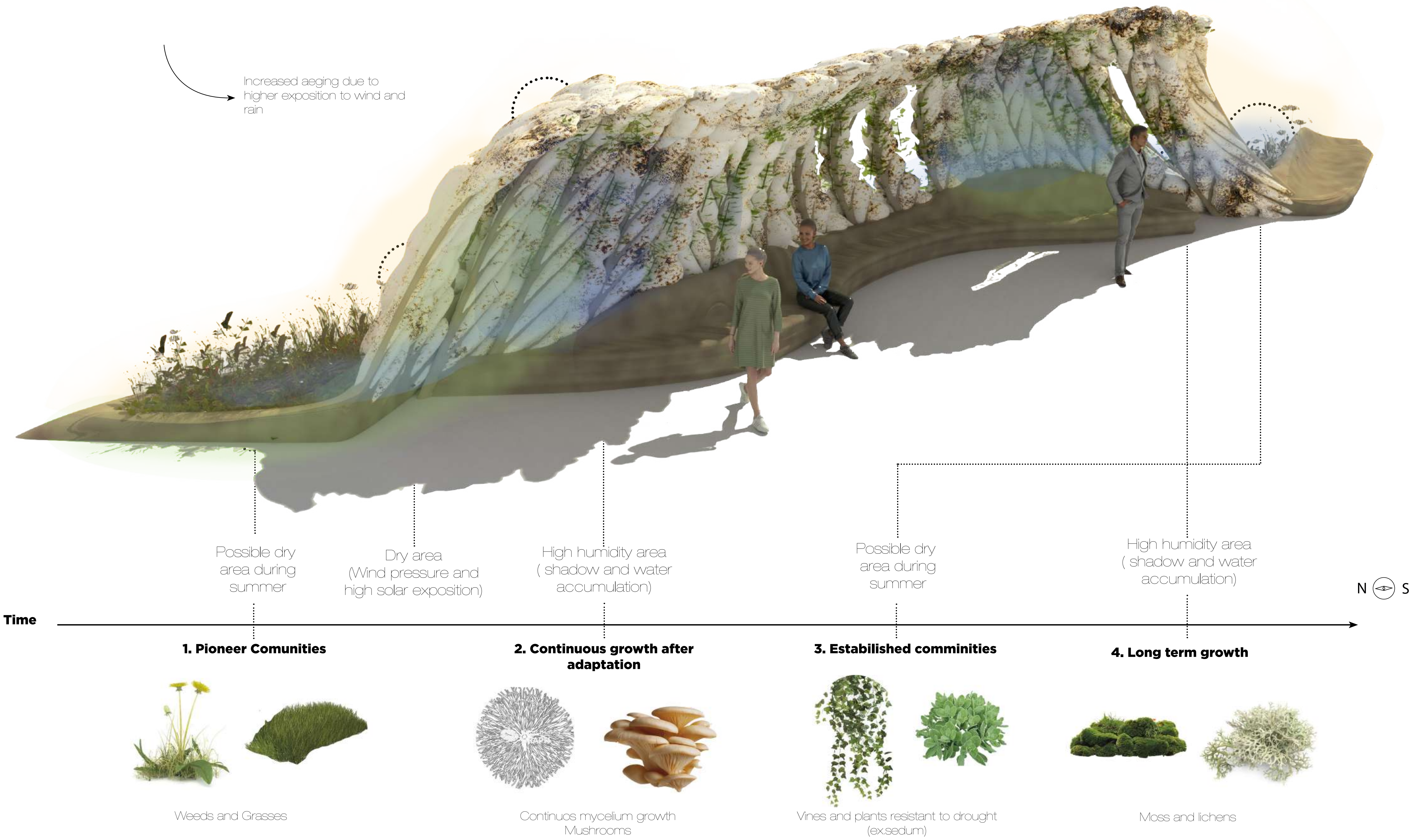
Final Bus stop Formation



Bioclimatic Strategies



Microclimates




SALÃO LISBOA

Architectural Vision

Stimulating the Curiosity of Mycelium

Functionality and visual appeal are both crucial in architectural design, with the former ensuring practicality and the latter creating an engaging experience. The project aimed to blend these aspects, crafting spaces that are efficient, resilient, and aesthetically pleasing.

The perception of mycelium, often explored in art and architecture, is evolving from negative to appreciative, recognizing its material and intrinsic values (Sydor et al., 2022). However, public unfamiliarity with biomaterials and concepts like living structures necessitates an emphasis on aesthetic appeal. Integrating familiar forms reduces the unfamiliarity associated with living materials, making the design more relatable and bridging the gap between nature and built environments. This approach enhances the visual and artistic qualities of the Urban MYCOskin project.

Moreover, the project transforms Praça Martim Moniz in Lisbon into a lively, inviting area. Incorporating green spaces, shade, and noise reduction creates a comfortable environment for the community, addressing climate change and the need for adaptable spaces. It also attracts tourists, boosting the local economy and the site's appeal.

The design values mycelium's aesthetic qualities, including its forms, material interactions, colors, textures, and proportions. With living organisms present, the space offers a multi-sensory experience, engaging sight, smell, sound, and touch (Spencer, 2020). The aim was to craft captivating spaces that enrich the emotional and sensory experiences of users.

This section presents visuals illustrating the evolution of the biohybrid material system, from a bus stop design in Lisbon to a broader vision of intricate spaces, showcasing the potential of the materials and strategies.

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