# MYCOstratum: Layered Multi-material Bioremediation

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Integrating principles or architecture and biology this research is being conducted to create a self-sustaining, multi-layered biomaterial system that can potentially remediate degraded or polluted soils using biological organisms such as fungi and plants.

By exploring the interactions present in the Soil Food Web and considering the complementary roles of mycorrhiza and saprophytic fungi, the study seeks to create a free-standing prototype, introducing a material system that can accommodate both types of fungi as well as plants and mosses.

Utilizing the natural life cycles, this study explores the notion of bioremediation, looking into processes of mycoremediation and phytoremeditaion.

**SOIL BIOREMEDIATION**
The project aims to tackle the remediation of soil confirming multiple interfaces between the ground, microbes and plants.

SOIL

**MYCOREMEDIATION**
Mushroom secreting enzymes/ unblocking the nutrients from depleted soils/ decaying the soil contamination

SAPHORITIC & MYCORRHIZAL FUNGI

**PHYTOREMEDIATION**
Plants have the ability to concentrate elements and compounds from the environment and to detoxify various compounds.

PLANT

Fungi hold **soil** in place and reduce erosion

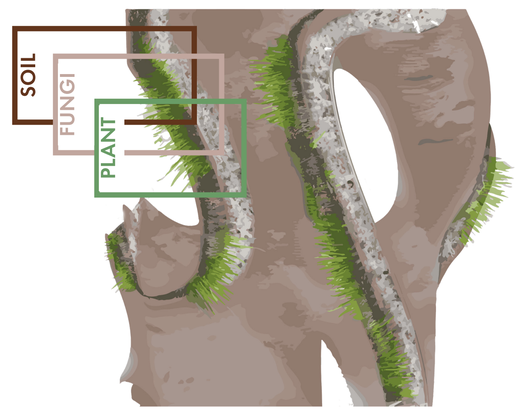
Fungi clean up contaminated soils by breaking down toxins into simpler less harmful compounds
(ie. hydrocarbons and pesticides and heavy metals (Ramachandran, 2019, Kordas, 2022)

Broken down compounds can be further degraded by micro-organisms and **plants**

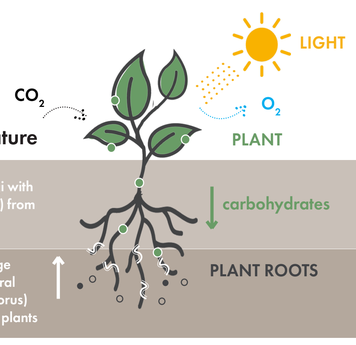
Fungi and **plants** sequester carbon dioxide in the atmosphere, can store it in **soil** and within the composites that they can also create

Fungi fix nitrogen and phosphorus to channel for **plants**, forming symbiotic relationships
(helping roots to reach further, acquire more, in exchange for sugars from plant as food)

Fungi decomposing old **plant** matter recirculate nutrients within **soil** and make them available for other organizms




**Functionality of mycorrhizal and saprophytic fungi in nature**





DEAD ORGANIC MATTER

Plants supply mycorrihizal fungi with carbohydrates (lipids or sugars) from photosynthesis

Saprophytic fungi feed on dead plants and animals remains. By breaking them down with enzymes into soluble compounds.

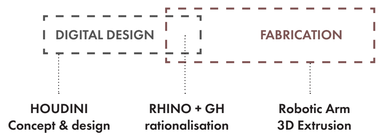
SAPROPHYTIC FUNGI
UPPER SOIL
(sapro = rotten, phyto = plant)

MYCORRHIZAL FUNGI
LOWER SOIL
(myco = fungi + rhizo = root)

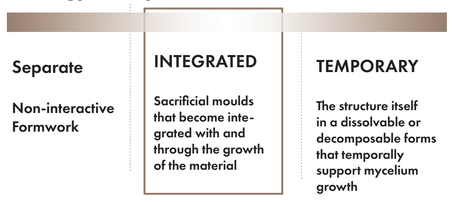
Mycorrhizal fungi with exchange of carbohydrates, absorb mineral nutrients (nitrogen and phosphorus) from soil and transport them to plants

They recycle and realise nutrients from the dead organic matter for other living organisms.

## Digital Design to Fabrication




## Strategy for mycelium formwork & fabrication

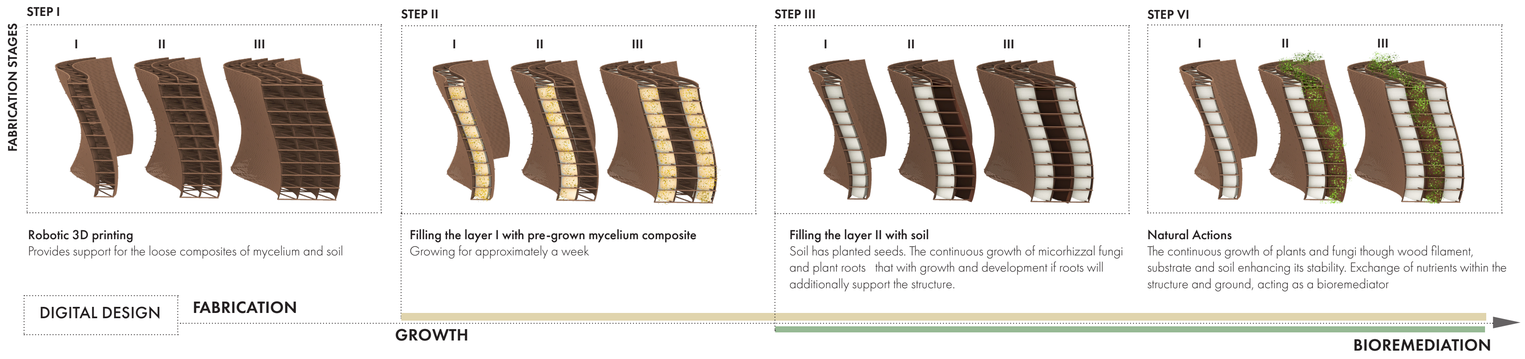



## Toolpath generation method

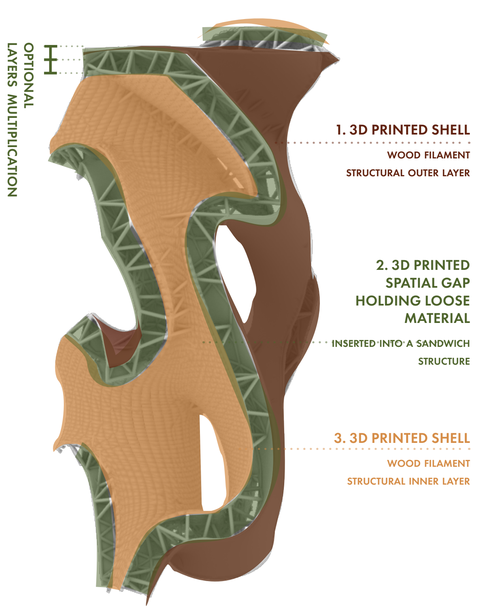
| GEOMETRY | OFFSET | CONTOUR | VERTICAL DENSITY | HORIZONTAL DENSITY | WEAVING | OPTIMISATION |
|---|---|---|---|---|---|---|
| Creating desired surface (also mesh) | Offset of the surface to generate shell | create the contour of the geometry to the desired layer height | group together the number of layers for each set between the bridges | divide the curves achieving points where the bridges will be created | weave the points and combine them with polylines, then weave the contours | Optimising the curve order for the robotic printing |

## Minimal Surface Structure Layering

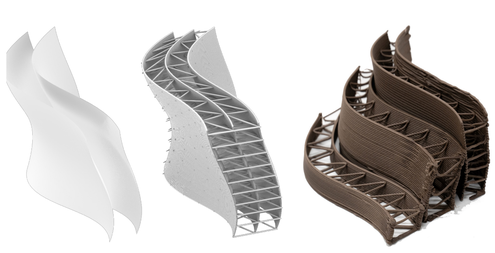

## Layered Fabrication Strategy



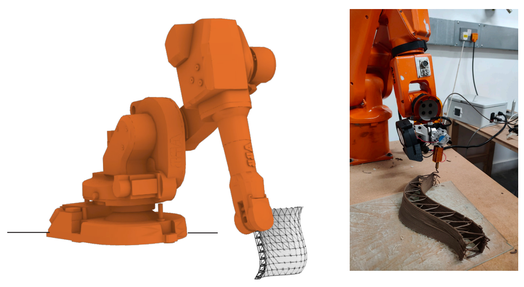

## Overall structure



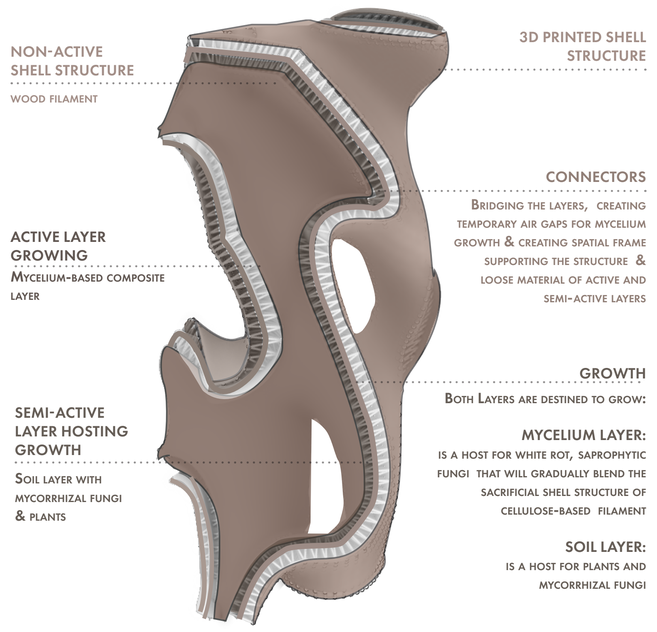

## Detailed Fabricated Section of the original Structure



## Robotic Fabrication



## Structure Functionalities




## Horizontal and vertical Assemblies

## Infill and Growth Progression of assembled layers

To achieve this, the project focuses on developing fabrication strategies for material layering, exploring means of hosting material substrates, encouraging growth and nutrient exchange.

The prototype system is composed of layers of soil and natural fibre waste that serve as hosts for both fungi types and plant growth. Using robotic extrusion 3D printing, a double layer shell with a cellulose-based filament is printed. Walls are connected with 3D bridging system, creating a scaffold. The ability to control the density of the bridged structure allows to lock in place a variety of loose particles of both soil and cellulose fibres within the layer, as substrates for the growth. The continuous growth of plant roots and mycelium networks within the structure is an inseparable part of the fabrication strategy that enhances structure stability and together with bridged 3D print strengthens the locking particles.

Once up-scaled and placed on site, this innovative approach to bioremediation the structure could have a substantial potential for rehabilitating vulnerable grounds.

Introducing growth, decay, and nutrient exchange as natural means for land rehabilitation, the research sought specific characteristics and functionalities of the living organisms and materials involved.

The overall study highlights the importance of considering the relationships between architecture, biology, and the natural world when addressing environmental challenges.

## Organisms functionality the design

**MOSS**
Carbon dioxide absorbers
Moisture keeper

**STRUCTURAL SUPPORT/FRAME**
Cellulose-based filament or paste
Host for mycelium and loose materials
Robotic extrusion

**MYCORRHIZAL FUNGI**
(myco = fungi + rhizo = root)
Mycoremediator
Symbiosis with plant roots

**PLANTS**
Phytoremediator
Roots and microbiom

**SAPROPHYTIC FUNGI**
(sapro = rotten, phyto = plant)
Mycoremediator
Decomposing dead matter

**SOIL**
Remediated matter
Depleted or contaminated soil