FABRICATING FOR BIODIVERSITY

Robotic Prototyping of Habitats for Urban Wildlife

Hassell

THE UNIVERSITY OF MELBOURNE

UED LAB

ROB MSD Robotics Lab

We acknowledge and respect the Traditional Custodians of the land upon which we work. We honour their Elders past and present whose knowledge and wisdom has, and will, ensure the continuation of cultures and traditional practices.

CONTENT

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The content of this document was developed through a Hassell-UEDLAB (UoM) academic-industry partnership. The report is written by Alex Felson and Muniroth Lim with support from Richard Mullane. The graphics are from the UEDLAB and Hassell and unless noted, they were generated by Muniroth Lim during her period as a Research Assistant at the UEDLAB working with Alex Felson, Michael Kearney and Ary Hoffmann for one year from August 2023-2024 and subsequently through her role as a Landscape Researcher at Hassell from March--June 2025.

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INTRODUCTION

OVERVIEW

This research brings together industry and academic expertise to creating modular, designed habitats for urban wildlife using robotics and ecological knowledge.

The project is led through a partnership between the University of Melbourne's Urban Ecology and Design Lab and Hassell, alongside the University's Robotics Lab and School of Biosciences.

This applied research initiative aims to design and build artificial habitats that can support, sustain, and maintain viable urban fauna.

Habitat construction focuses on insects, microbial communities, reptiles, amphibians, small mammals and birds.

Our goal is to encourage a more robust and self-sustaining food web by attracting and supporting the insects, microbes, and other organisms that form the essential food sources for higher trophic levels, thereby regenerating viable urban ecosystems and attracting a greater diversity of fauna to targeted sites, and unlocking greater ecological value within every public realm design opportunity.

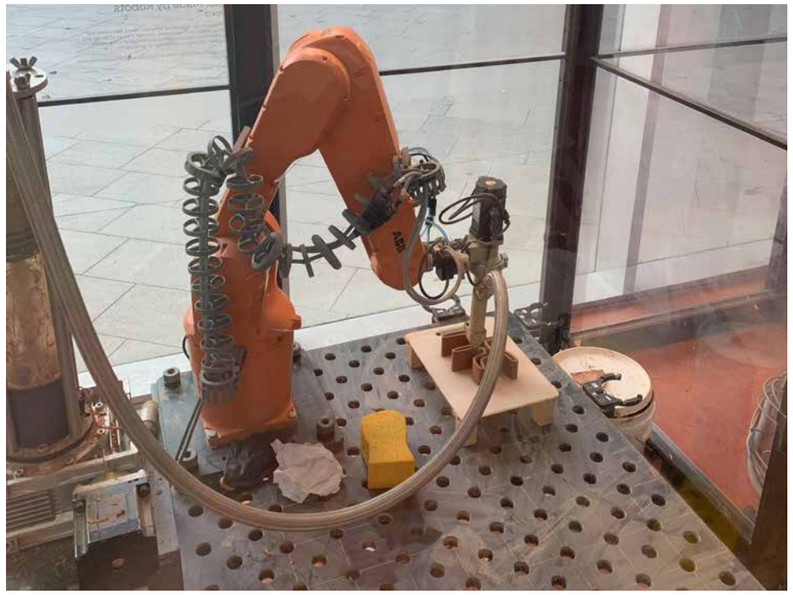
The value of design for small urban fauna as food web catalysts

Insects, microbes, and other small organisms form the foundation of urban food webs, supporting the survival of higher trophic species such as birds, reptiles, and amphibians. Yet, these populations are among the most vulnerable to habitat loss in densely built environments.

Design plays a critical role in reversing this decline. Purposefully designed microhabitats in urban public spaces can create ecological stepping stones that support small fauna, improve biodiversity, and re-establish viable sub-populations that can contribute to larger meta networks of biodiversity. Through careful material selection, form-making, and site-responsive placement, fabricated habitat design can enable conditions where insects and microbial communities can thrive. In doing so, these small species re-initiate predator-prey dynamics in urban systems and can catalyse food webs.

These interventions also serve a cultural and educational role—making the invisible workings of ecosystems visible, and fostering awareness of the overlapping spaces between humans and other urban biodiversity.

Refer to *Wildlife Habitat Design in the Public Realm* for more background information.



Robotics production and manufacturing

The Robotics Lab at the Melbourne School of Design (MSD), University of Melbourne, is an advanced experimental fabrication facility focused on exploring the role of robotics in architecture and construction. Using a project-based research model, the lab investigates how robotic technologies can expand the possibilities of design, material experimentation, and automated fabrication processes.

As part of this urban wildlife habitat project, the Robotics Lab is contributing expertise in custom fabrication and digital design to prototype and construct novel habitat structures. Their involvement supports the development of precision-built, ecologically responsive forms that integrate both biological needs, concerns around vandalism, maintenance, aesthetics and other landscape architecture and urban design considerations. This collaboration enables the team to test how robotics can enhance habitat quality, adaptability, and scalability in urban environments.

Open to University of Melbourne staff and students, the Robotics Lab is increasingly engaging with industry partners. The work on this project reflects a developing role for the Robotics Lab in partnership wit the UEDLAB at MSD to participate in cross-disciplinary innovation and the application of emerging technologies to complex ecological and urban challenges.

PROCESS & STRATEGIES

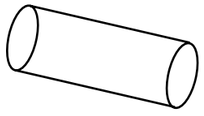
Design process

This project utilises landscape architecture and the design process to explore innovative approaches to artificial habitat construction through a set of modular, ecologically responsive design strategies. Drawing on principles of urban ecology, digital fabrication, and material experimentation, each habitat unit is developed to support a range of ecological functions targeting selected species groups that might exist in urban systems.

Design strategies

1. Targeted species

Designs are informed by ecological consultation to support a range of urban fauna, including native insects (such as pollinators and detritivores), microbial communities, reptiles, amphibians, and small bird species.



2. Physical form

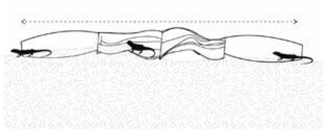
Habitat structures are designed as modular, three-dimensional forms optimized for micro-climatic protection, nesting, and shelter. Their geometries encourage environmental diversity, with features such as cavities, overhangs, openings and textured surfaces to enhance ecological utility.

3. Variation

Multiple design variants have been developed to accommodate different habitat types, each tailored to function in different ways to support species needs. These versions enable testing and evaluation through deployment to understand the species responsiveness to form-function relationships.

4. Ecological processes and functions

Beyond shelter, habitats are designed to contribute to essential ecological processes including breeding, feeding, and thermoregulation. Structural forms aim to support interspecies relationships and contribute to larger food web regeneration goals.

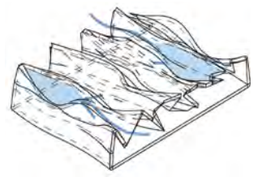


5. Configuration on site

Habitats are installed in clustered or distributed configurations depending on site context. Placement strategies consider solar orientation, hydrology, vegetation, and site accessibility to maximize ecological value and long-term viability.

6. Accumulation of material

Habitat structures incorporate opportunities for visual interpretation and accumulation of material—whether through dynamic placement, exploratory assembly, or visibility into ecological processes—encouraging informal education and engagement with urban biodiversity.



7. Focus on water and clay

Specific habitat elements incorporate water-retaining forms to support moisture-dependent species such as amphibians and burrowing insects. The clay-based substrates help moderate temperature and microclimate within and around the habitat.

8. Aesthetics and interpretation

The functional and performative aspects of the design are further augmented through aesthetics and visualisation. Structures are intended to be visually engaging and provoke curiosity, encouraging interpretation and dialogue around urban biodiversity. The form, material expression, and surface patterning support storytelling and help bridge scientific content with public experience, making ecological processes more visible and legible in the urban landscape.

CLAY HABITAT & 3D PRINTING

What is clay habitat?

Architecture for fauna

- Architecture for fauna = artificial habitat built with clay
- Usng advanced technologies to design and manufacture,
- creating detailed and complex forms
- 3D printing clay aesthetic makes

Values of clay habitat

- Benefits for all in a shared space – fauna, flora and human
- Built with natural material that has thermal enhancement/- regulation property* that is beneficial for ectotherms and species that needs certain amount of temperature to nest or mate
- Improve biodiversity by attracting other fauna and strengthening
- Ecosystem functioning
- Functional art installation in the public realm

Design

Advanced Technologies

- 3D modelling
- 3D clay printing
- Coding script

Art

'Nature's Gallery'

'Living Sculpture'

- 3D clay-printing aesthetic
- Attractive modular arrangements
- Outdoor art installations

Ecology

Biodiversity in the Public Realm

- Providing artificial habitat for urban species and nesting spaces.
- Attracting more diverse fauna to the site via food web* (attract preys to the site because abundance of food source - targeted species we are constructing habitats for)

Why 3D clay printing?

Sustainable material

- Require less energy to produce
- Natural material and abundant
- Harmless to the ecosystem, fauna, flora and humans

Benefits & Advantages

- Require less energy to produce
- Natural material and abundant
- Harmless to the ecosystem, fauna, flora and humans

Ecology / Biodiversity Benefit

- Thermal mass and regulate microclimate of habitat
- Targeted species include bees and garden skinks which are highliy sensitive to temperature and require
- Certain degree of temperature for different activities (basking, foraging, mating, nesting)

Design Benefit

- 3D modelling allow detailed design mimicking nooks and crannies, tight spaces, bent/twisted space preferred by targeted species

Manufacturing Benefit

- Converting the 3D digital design into codes, generating a script with a coding script, can easily print design repetitively
- Production and time efficient

Clay printing aesthetic

- Future-looking, customised and expressive
- Attractive and eye-catching which fits and further emphasize the concept of “Nature’s Gallery” = non-human museum, wild art installation living sculpture

DESIGN PROCESS

DESIGN PROCESS

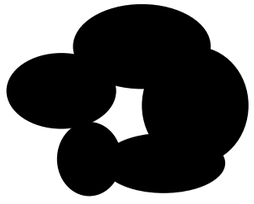
CONCEPT

DESIGN

PRODUCTION

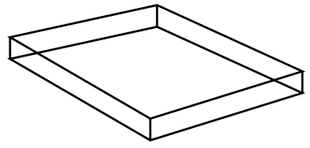
Habitat Form

- Looking at the natural habitat of targeted species and their needs and behaviours.



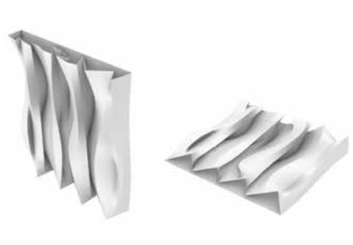
Initial Form

- Breaking the habitat into an initial geometric form as a starting point for clay 3D printing.



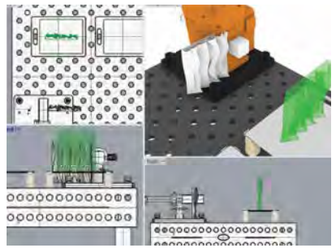
Versions

- Creating different versions of the clay units, exploring density, dimensions, gaps
- Different methods - Grasshopper parametric plug-in, 3D modelling



Printing Script

- Translate 3D form into printing coding script
- Test printings
- Coding script modifications

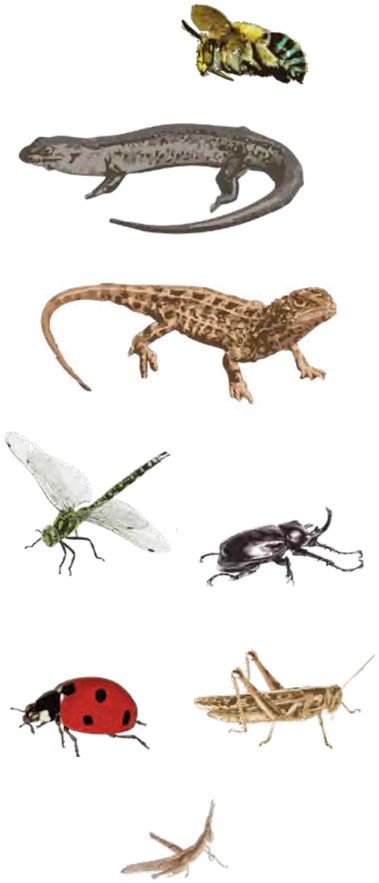


3D Printing

- Clay extrusion, printing robot moving through coding script

SPECIES REQUIREMENTS

Key species



Pollinating insects

- Native solitary bees (blue-banded bees, Sweet bee, etc.)
- **Diet -** Flowering plants, but have a preference of native flowers, water
- **Behaviour -** Forage for nectar from plants, bring back to nest
- **Habitat -** Holes in timber or borrows with depth of at least 100mm
- and diameter of 3mm to 8mm
- **Nesting -** Nest in loose, well drained sandy and clay loam

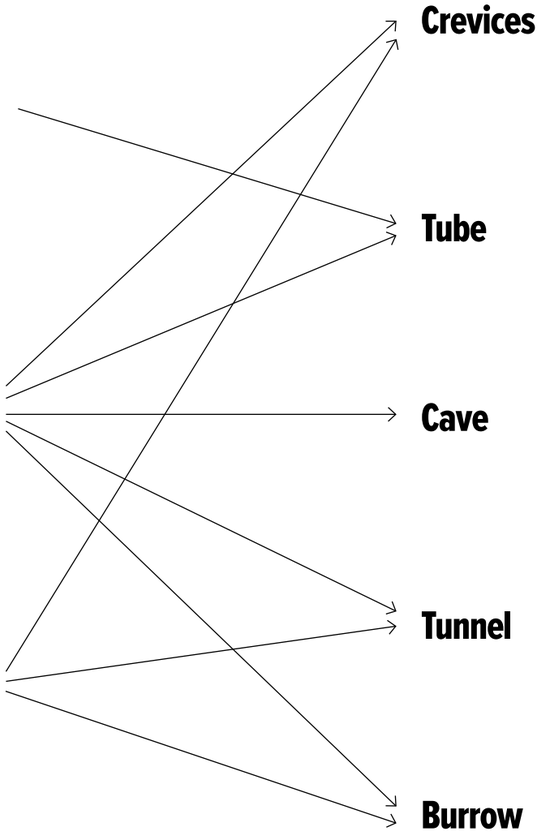
Small garden skinks

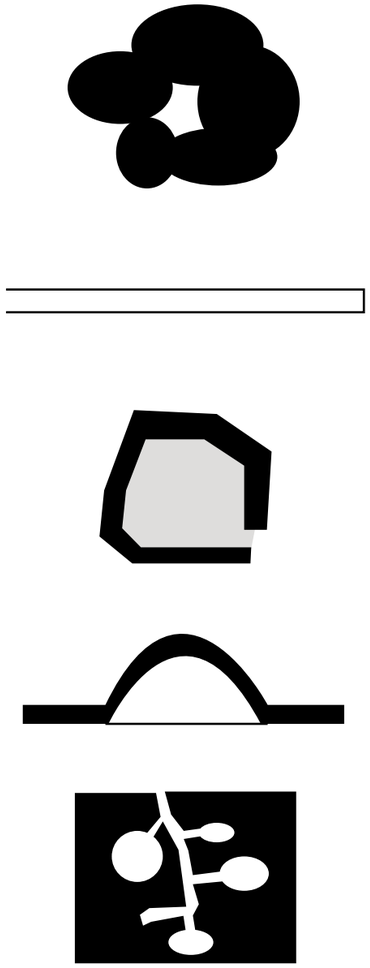
- Harmless small urban reptiles
- **Diet** - Small insects such as crickets, moths, grasshoppers
- **Behaviour -** Basking in the sun, forage in thick and dense vegetation, burrow complex tunnels underground, hiding in rocky outcrops
- **Habitat -** Rocky outcrops, spaces between rock boulders
- **Nesting -** Lay eggs under objects and cover them

Other ground-dwelling invertebrates

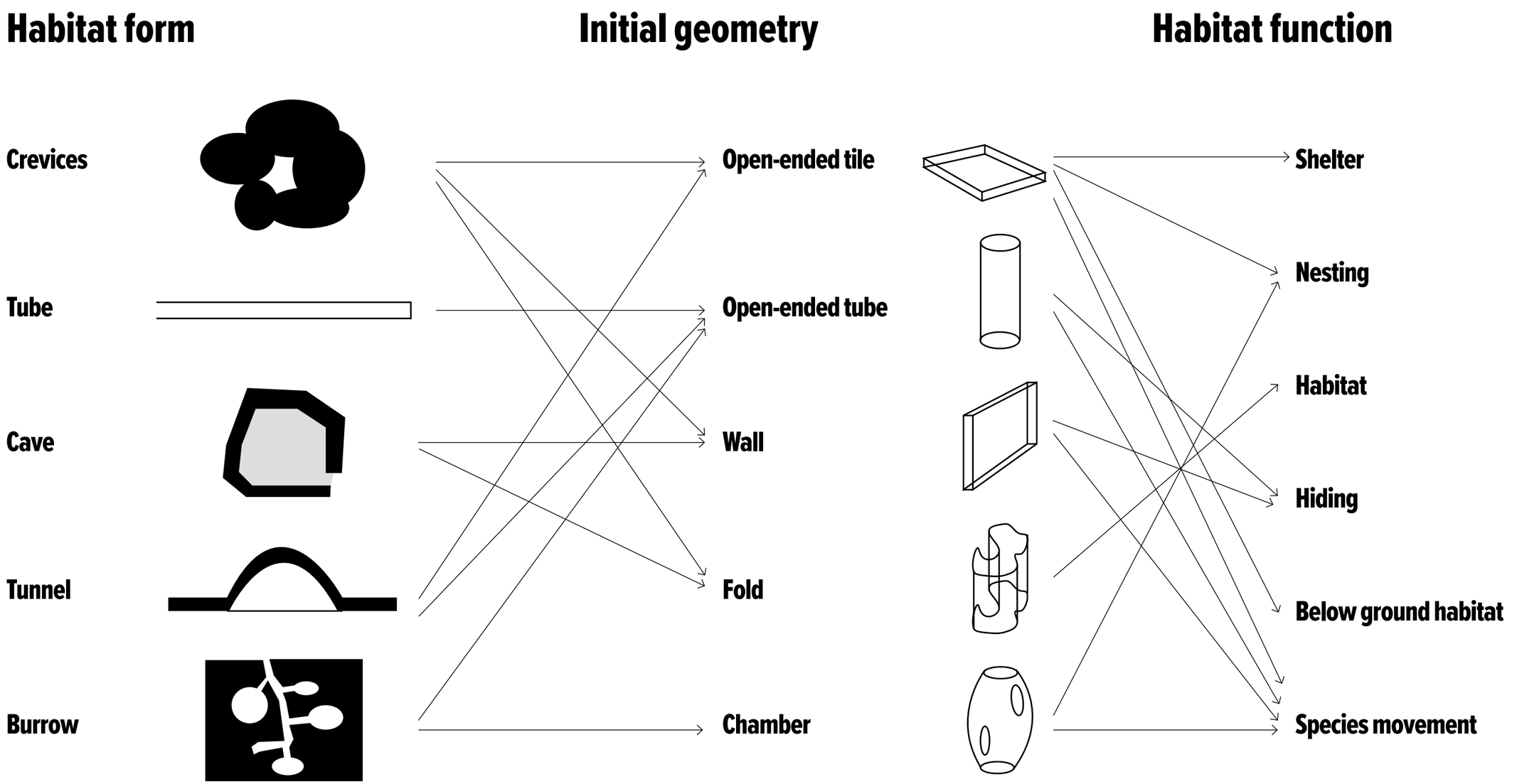
- Including ladybug, crickets, beetles, grasshoppers, etc.
- **Diet -** Plants such shrubs, flowers and native grasses
- **Behaviour -** Burrow, Hiding, foraging on dense ground matter
- **Habitat -** Bare ground with dense and thick vegetation
- **Nesting -** Lay eggs a few cm below ground or on plants

Habitat form





FROM NATURAL TO GEOMETRIC



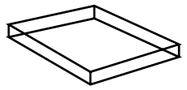
FORM VARIATIONS

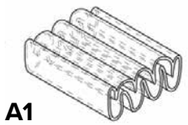
Initial geometry form

Geometry variation

UNIT A
Eco-tile

Open-ended tile




A1


A2


A3


A4

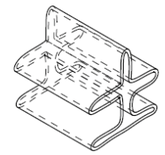
UNIT B
Eco-fold

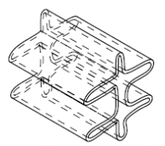
Fold

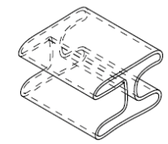

B1.1

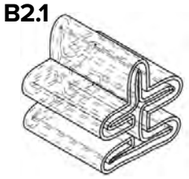

B1.2

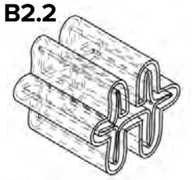

B1.3


B2.1


B2.2


B2.3

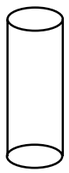

B3.1


B3.2


B3.3

UNIT C
Eco-tube

Open-ended tube

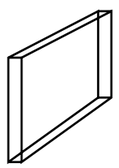


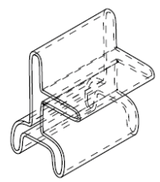

C1

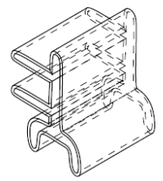

C2

UNIT D
Eco-wall

Wall




D1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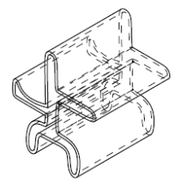
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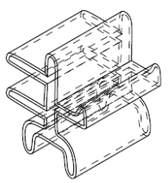
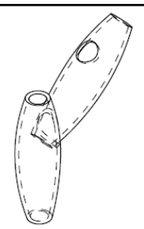
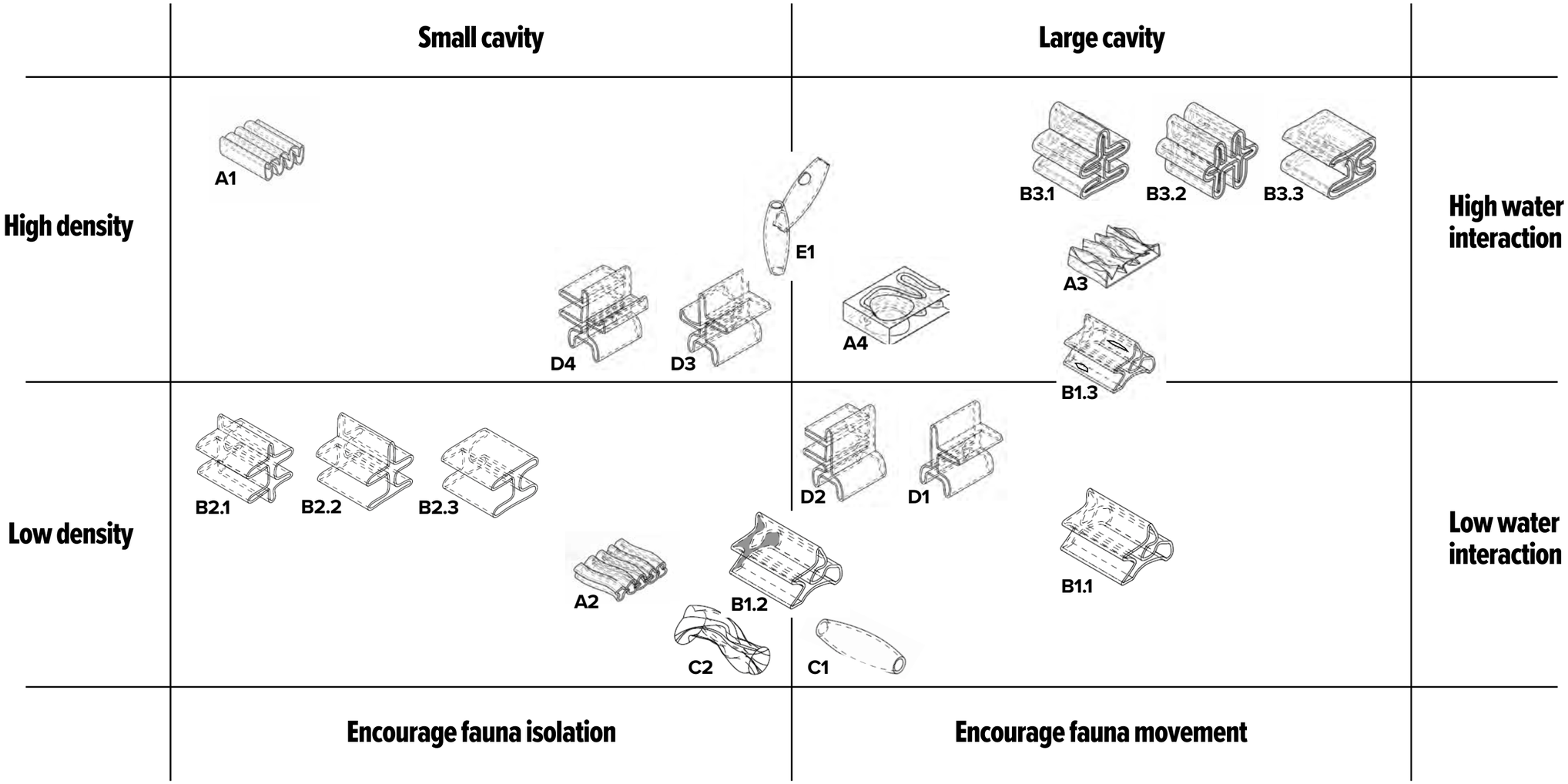

D4

UNIT E
Eco-chamber

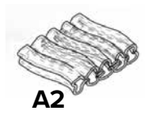
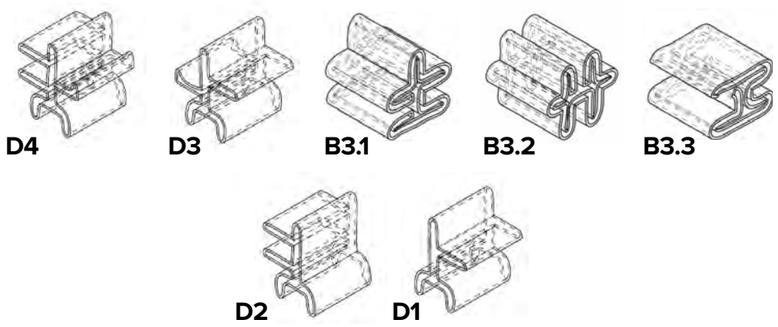
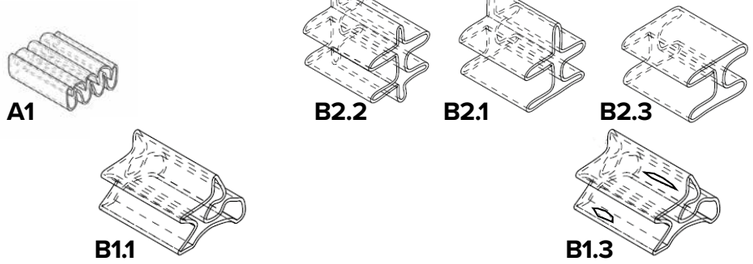
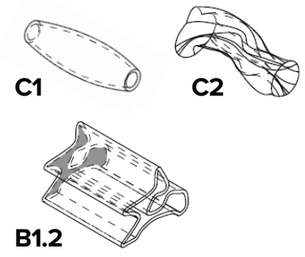
Chamber


E1

CHARACTERISTICS



WATER INTERACTION

	Collect – Short time water retaining – Smaller water quantity	Pool – Longer water retaining
Flow – Allow water to flow at a constant rate – Largest water movement	 A2  A3	 A4  E1
Drip – Medium water movement	 D4 D3 B3.1 B3.2 B3.3 D2 D1	
Seep – Smallest water movement seeping through and near openings	 A1 B2.2 B2.1 B2.3 B1.1 B1.3	 C1 C2 B1.2

WATER INTERACTION

Flow

- Allow water to flow at a constant rate
- Largest water movement

Drip

- Medium water movement

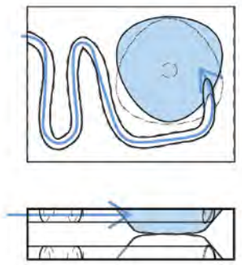
Seep

- Smallest water movement seeping through and near openings

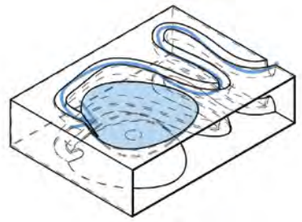
Pool

- Longer water retaining

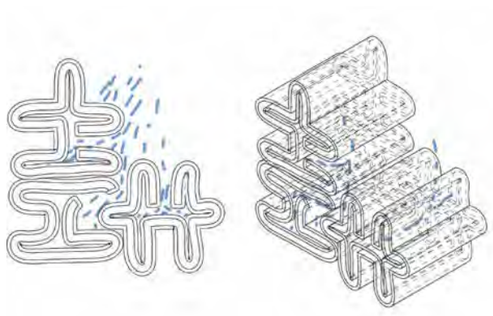
Flow Pool



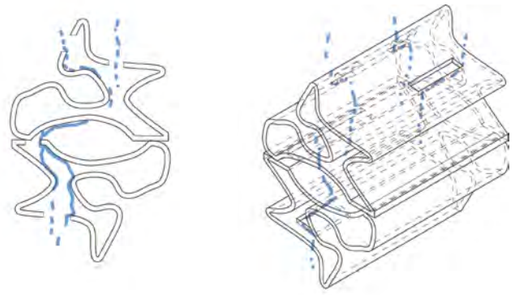
Micro-pool



Creating various mini water typology as resource for targeted fauna species



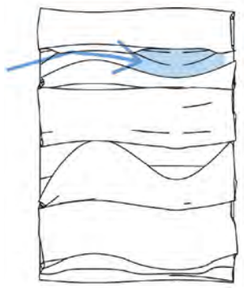
Designed to have openings for fauna movement across the clay pieces, as well as rain water relationship

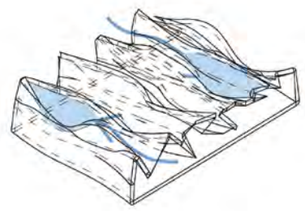


Slits in the clay piece, carved out after printing

Collect

- Short time water retaining
- Smaller water quantity





Uneven surface of the tile would flow and collect pockets of water

PROTOTYPES

UNIT A

Eco-Tile

Function

- Hiding, shelter, nesting

Species

- Native bees and small garden skinks and other ground-dwelling invertebrates

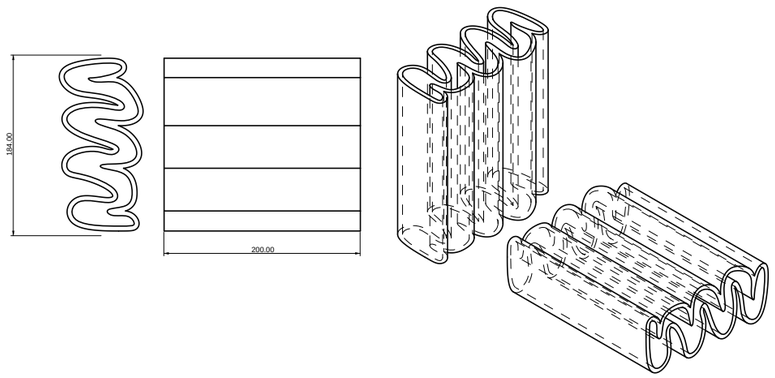
Form benefit

- Compatible with 3D Clay printing process
- Detailed and narrow spaces preferred by targeted species
- Modular arrangement opportunity
- Can be filled with other materials such as rebar or mud

A1

- Wave form tile creates tight twist and turns
- Stable printing structure with straight Z axis

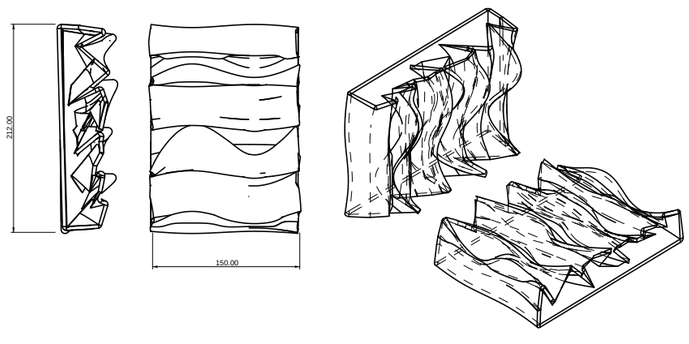
Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets)
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



A2

- Sharp edges tile
- creates nooks and crannies
- Bigger gaps allows collection of water

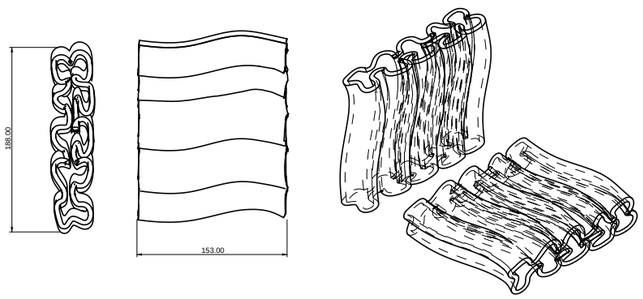
Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets)
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



A3

- Spine bone tile
- Creates separated open gaps / separated lane holes
- Creates separation between each open gaps
- Able to fill different types of mud for a vertical bee hotel

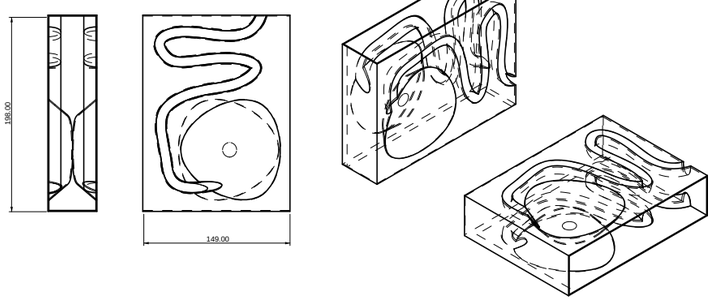
Habitat form	Habitat function	Fauna species
Crevices	Shelter ✓	Pollinators (native bee) ✓
Tube ✓	Nesting ✓	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets)
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource	



A4

- Water pool tile
- For water to ow and pool into a bowl
- Shaped the river and pool on both side for structural support

Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee) ✓
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource ✓	

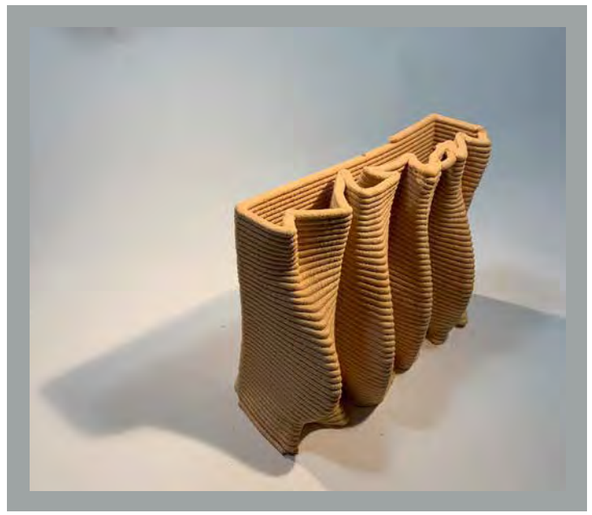


UNIT A

Eco-Tile

A1

A2



A3

A4

UNIT B

Eco-Fold

Function

– Habitat with multi-level

Species

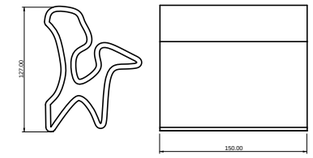
– Small garden skink

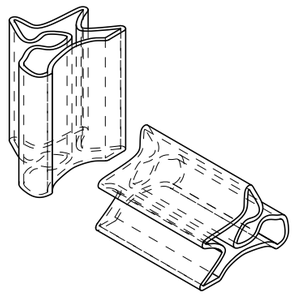
Form benefit

– Compatible with 3D Clay printing process
– Detailed and narrow spaces preferred by targeted species
– Designed to be stacked up with outward nooks and handle to support
– Stacking creates complex passageways targeted fauna can pass through

B1.1

– Open ended folding form.
– Form tried to combine cave, crevices, tunnel and tube.

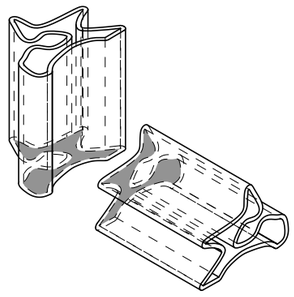




Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	

B1.2

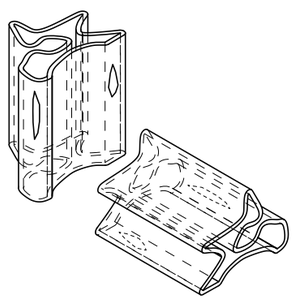
– Capped on 1 side.
– Experiment to see what are the implication if fauna movement is blocked, cannot pass through the other side.



Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource	

B1.3

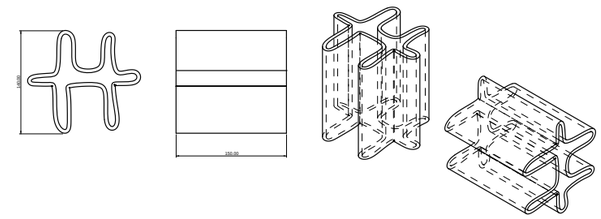
– Opening slits on the form.
– Experiment to see how water would interact with the clay form.
– Water movement exploring is seeping to see if targeted fauna would prefer it more.



Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource ✓	

B2.1

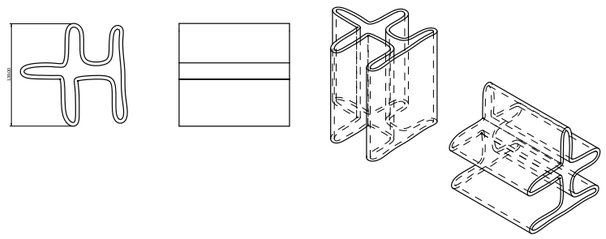
– Clay folded into an H shaped.
– Have 2 sides handles sticking out for stacking and helping with structural support.



Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource	

B2.2

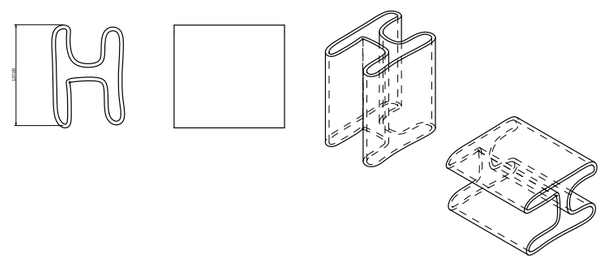
– Have 1 side handles sticking out for structural support.
– The other side has no handle to create a different space type.



Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource	

B2.3

– No handles sticking out.
– Clay form would slide in between the dip area and interlock with each other.



Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement	
	Water resource	

UNIT B

Eco-Fold

Function

– Habitat with multi-level

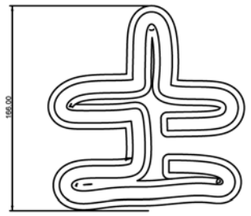
Species

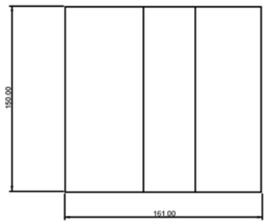
– Small garden skink

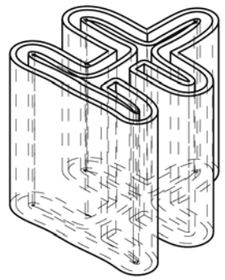
Form benefit

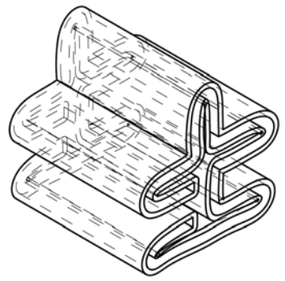
– Double layer/circuit to create a wide gap in the form.
– double clay layer boost microclimate enhancement (warmth storage and cooling).
– Wide gap encourage species. movement within the clay habitat design.
– Allow water to seep in.

B3.1



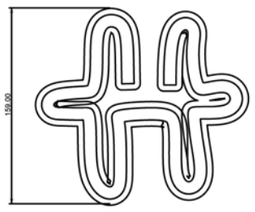


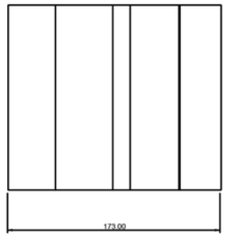


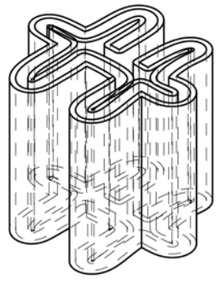


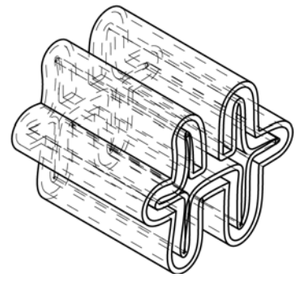
Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource ✓	

B3.2



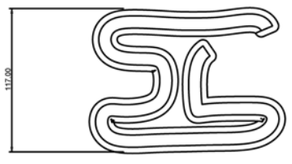


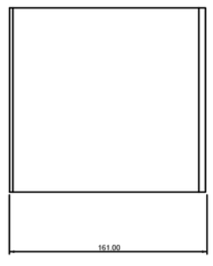


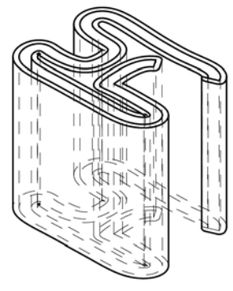


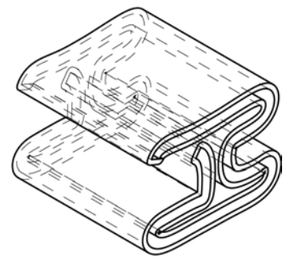
Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource ✓	

B3.3









Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube	Nesting	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource ✓	

UNIT B

Eco-Fold

B1.1

B1.2

B1.3

B2.1

B2.2

B2.3

B3.1

B3.2

B3.3

UNIT C

Eco-Tube

Function

- Tunnel
- Travel

Species

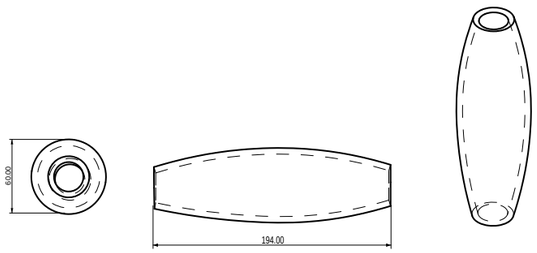
- Small garden skink
- Ground-dwelling invertebrate

Form benefit

- Designed to be re-attached during post-printing
- Wide space and tight spaces in the tunnel
- offers shelter and hiding spots when fauna move from spot A to spot B

C1

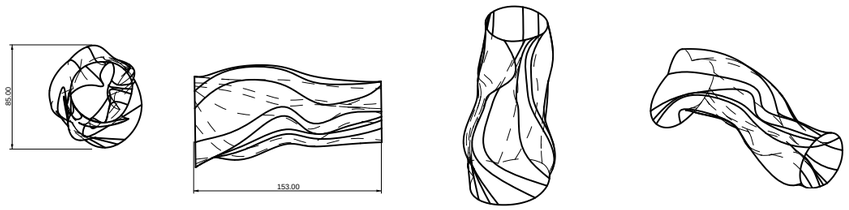
- Enlarged tube shape with small openings.
- Restrict larger animals.



Habitat form	Habitat function	Fauna species
Crevices	Shelter ✔	Pollinators (native bee)
Tube ✔	Nesting	Small garden skink ✔
Cave ✔	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✔
Tunnel	Hiding ✔	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✔
	Species movement ✔	
	Water resource	

C2

- Twisting tube with uneven size openings.
- Larger opening allows tilting of connecting tubes in other directions.
- Would need post-printing assemble of C1 and C2, adding foam or tissue between the two pieces to limit friction.
- Add a tightening joint/component at the connection area as clay shrinks, bent and change shape.



Habitat form	Habitat function	Fauna species
Crevices ✔	Shelter ✔	Pollinators (native bee)
Tube ✔	Nesting	Small garden skink ✔
Cave ✔	Habitat: complex nooks and crannies ✔	Other ground-dwelling invertebrates (beetles, crickets) ✔
Tunnel	Hiding ✔	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✔
	Species movement ✔	
	Water resource	

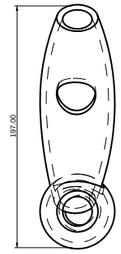
UNIT D

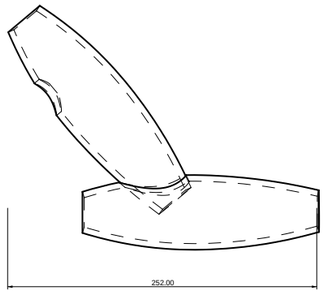
Eco-Chamber

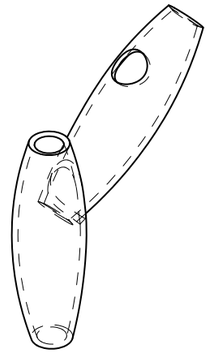
D1

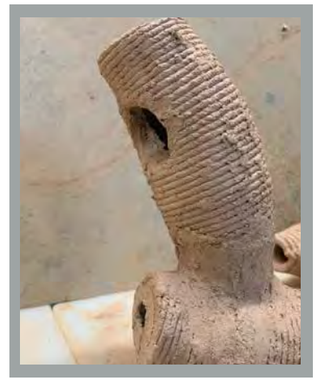
- Same coding script as C2
- Manually carved holes after printing
- Manual reattachment after printing
- Mimicking below ground burrow shape and network

Habitat form	Habitat function	Fauna species
Crevices ✓	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting ✓	Small garden skink ✓
Cave ✓	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Hiding ✓	
Burrow ✓	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	









Function
- Bury
- Nest

Species
- Small garden skink

Form benefit
- Designed to be re-attached during post-printing
- Mimics cacoon shape
- Can create 3 dimensional twisting
- Can be burried for below ground habitat

UNIT E

Eco-Wall

Function
- Corridor

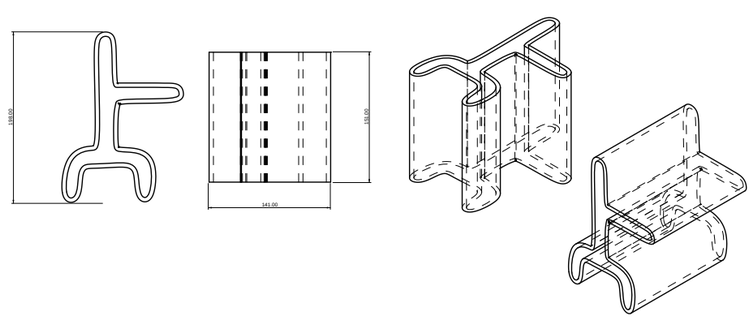
Species
- Small garden skink
- Ground-dwelling invertebrates

Form benefit
- Multifunctional wall with tunnel passage below and perch for structural support or for fauna species resting
- multiple pieces aligning creates a corridor (see configuration)
- allow fauna species to travel form point A to B

E1

- Wall shaped with a handle on 1 side
- The handle creates shades and hiding when combined with the rest of the other form versions
- A tunnel below the wall for fauna movement

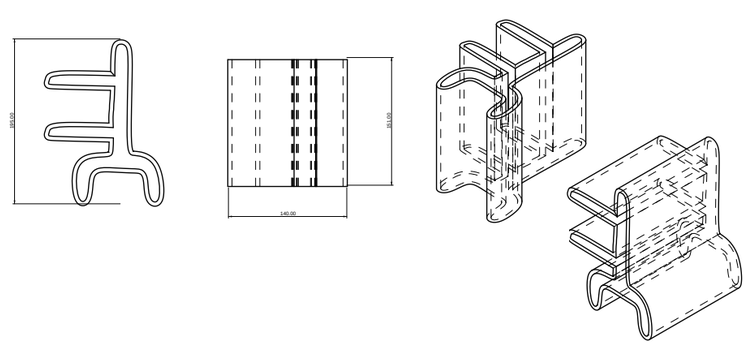
Habitat form	Habitat function	Fauna species
Crevices	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



E2

- Wall shaped with 2 handle on 1 side
- E.1 handle will slide in the gaps between its 2 handles

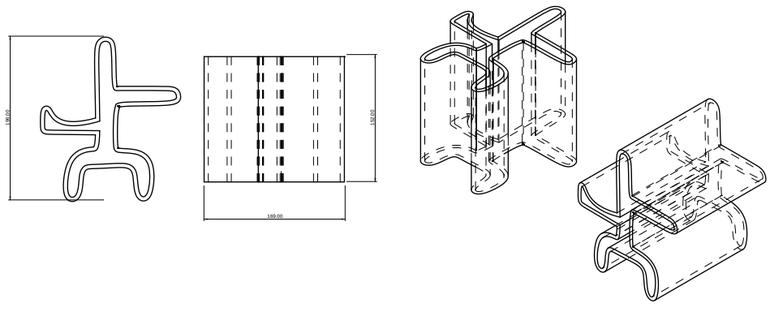
Habitat form	Habitat function	Fauna species
Crevices	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



E3

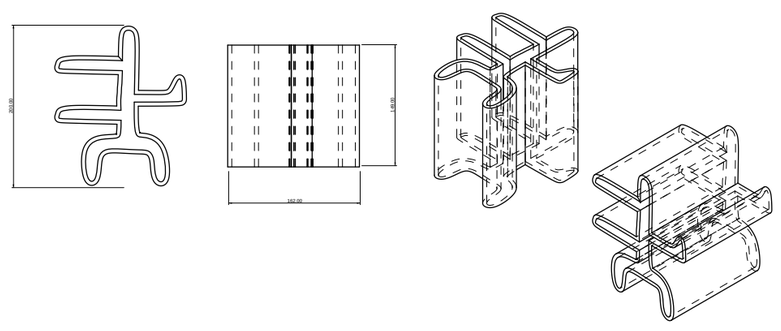
- Wall shaped with a handle on both sides
- Second handle has a dip which can accomodate additional material better such as leaf matter, soil or clay

Habitat form	Habitat function	Fauna species
Crevices	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



E4

Habitat form	Habitat function	Fauna species
Crevices	Shelter ✓	Pollinators (native bee)
Tube ✓	Nesting	Small garden skink ✓
Cave	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Hiding ✓	
Burrow	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Species movement ✓	
	Water resource	



UNIT E

Eco-Chamber

E1

E2

E3

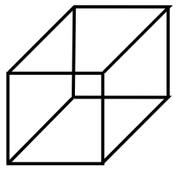
E4

COMBINING FORMS

COMBINATIONS OVERVIEW

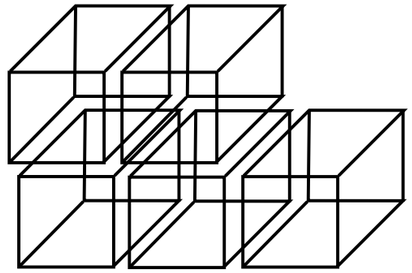
CLAY UNIT

1 printed clay block / piece that will complete a Clay Habitat Design



CLAY HABITAT DESIGN

A combination of clay units arranged and assembled on a site

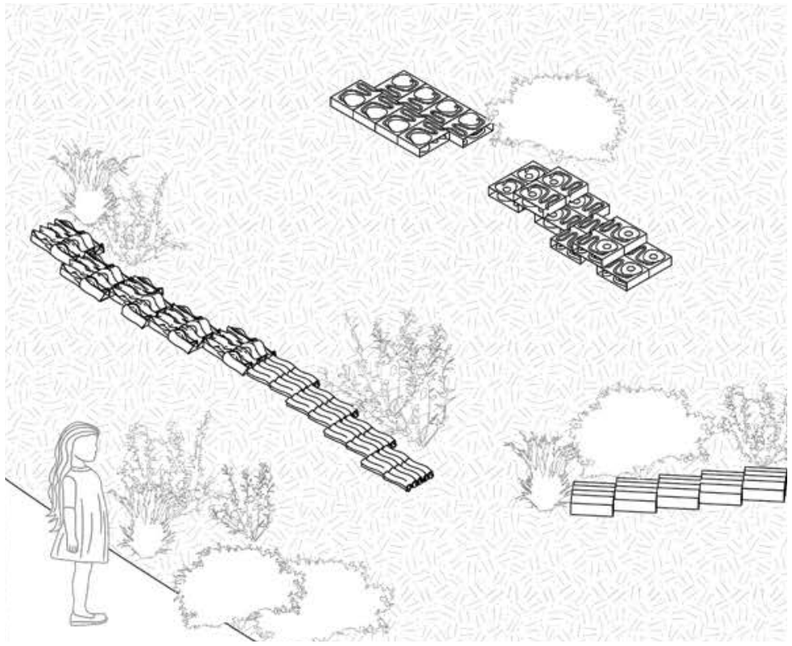


ECOTILES

Clay trail
= Tile + Array

- Function: Hiding, Shelter
- Species: Native bees, Small garden skinks, Round-dwelling invertebrates
- Play action and configuration on site: Array
- Tiles placed on bare to create a clay trail, can create an edge condition with footpath
- Creates an elongated sheltered space for fauna species

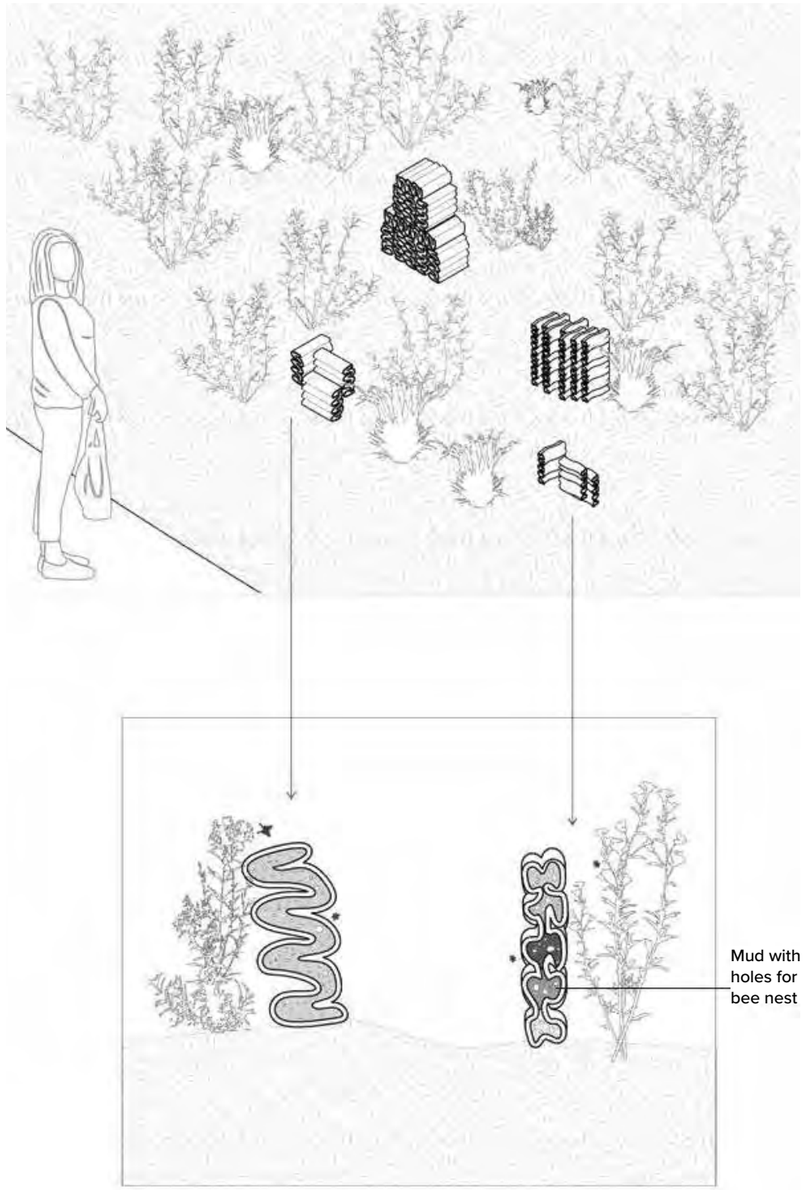
Habitat form	Play action	Habitat function	Fauna species
Crevices ✓	Array ✓	Shelter ✓	Pollinators (native bee)
Tube	Host	Nesting	Small garden skink ✓
Cave	Stack	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Tunnel	Hiding ✓	Other small ground-dwelling species (spiders, slugs) ✓
Burrow	Bury	Below ground habitat	
	Corridor	Species movement	
		Water resource ✓	



Vertical clay nest
= Tile + Host

- Function: nesting
- Species: Native bees
- Play action and configuration on site: Host
- Filling the tile with mud

Habitat form	Play action	Habitat function	Fauna species
Crevices	Array	Shelter ✓	Pollinators (native bee) ✓
Tube ✓	Host ✓	Nesting ✓	Small garden skink
Cave	Stack	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Tunnel	Hiding ✓	Other small ground-dwelling species (spiders, slugs) ✓
Burrow	Bury	Below ground habitat	
	Corridor	Species movement	
		Water resource	



ECOTILES

Clay trial = Tile + Array

– Array of different tiles

Vertical clay nest = Tile + Host

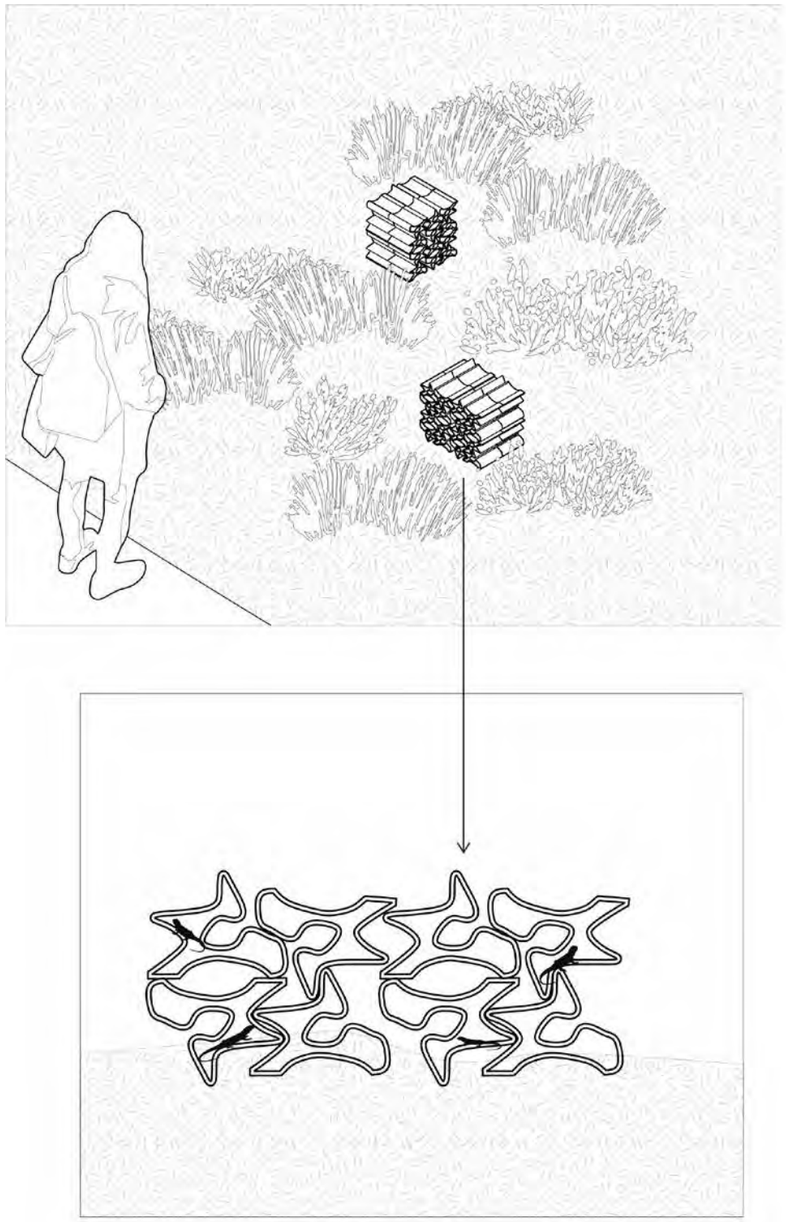
– Clay mud with holes for ground-nesting bee habitat

ECOFOLDS

Clay condo 1 = Fold + Stack

- Function: Habitat with multi-level
- Species: small garden skink
- Play action and configuration: Stack
- Stacking creates complex passageways targeted fauna can pass through

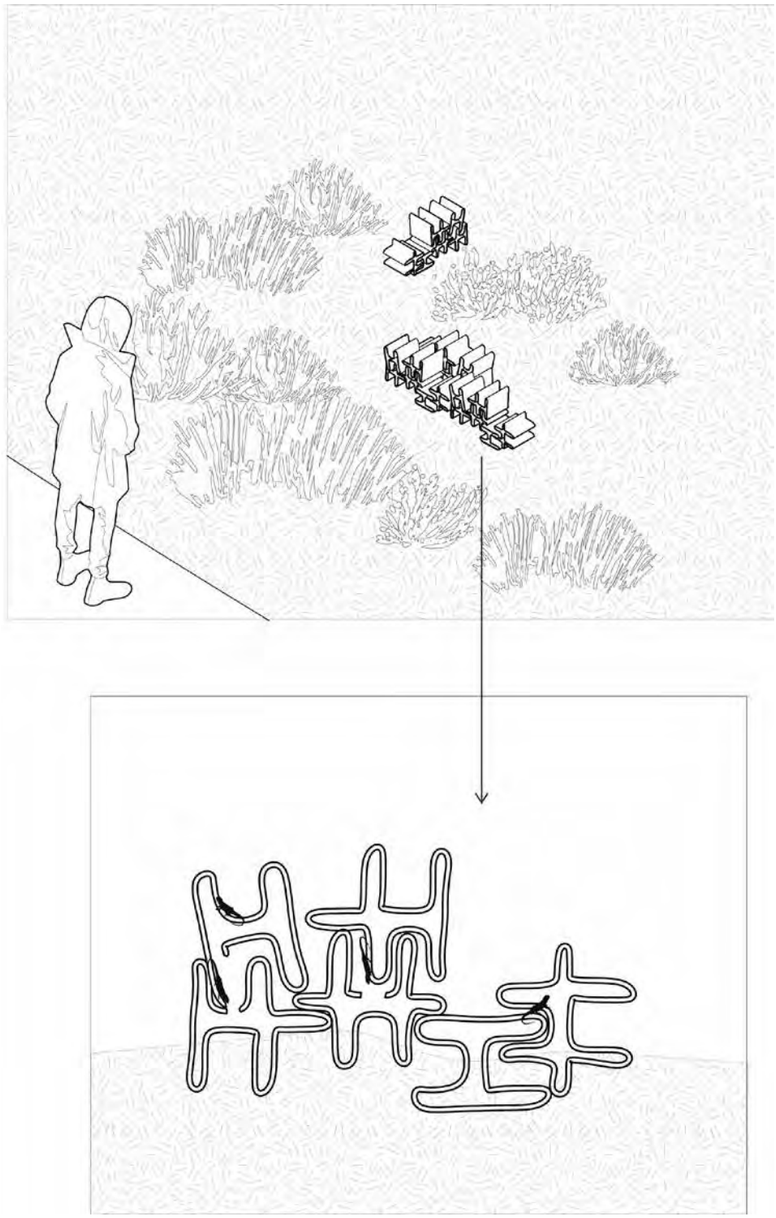
Habitat form	Play action	Habitat function	Fauna species
Crevices ✓	Array	Shelter ✓	Pollinators (native bee)
Tube	Host	Nesting	Small garden skink ✓
Cave ✓	Stack ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets)
Tunnel	Tunnel	Hiding ✓	
Burrow	Bury	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Corridor	Species movement	
		Water resource	



Clay condo 2 = Fold + Stack

- Function: Habitat with multi-level
- Species: small garden skink
- Play action and configuration: Stack
- Stacking creates complex passageways targeted fauna can pass through

Habitat form	Play action	Habitat function	Fauna species
Crevices ✓	Array	Shelter ✓	Pollinators (native bee)
Tube	Host	Nesting	Small garden skink ✓
Cave ✓	Stack ✓	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Tunnel	Hiding ✓	
Burrow	Bury	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Corridor	Species movement ✓	
		Water resource ✓	



ECOFOLDS

Clay condo 1 = Fold + Stack

– Combining B.1 and B.2

– Assembling with maximum structural support for unit B.1

Clay condo 2 = Fold + Stack

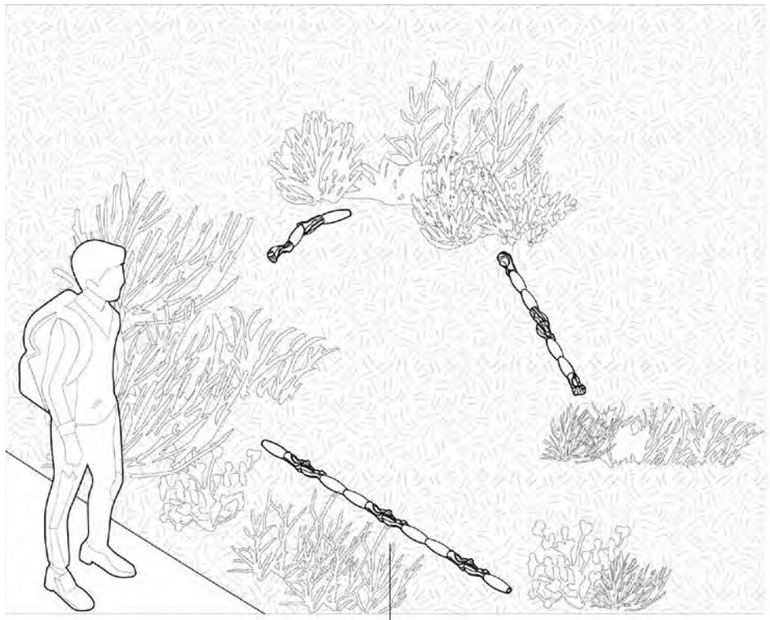
– Double lining folding block creates more opening spaces, as well as, opportunity to add materials in between (mud, heating wires)

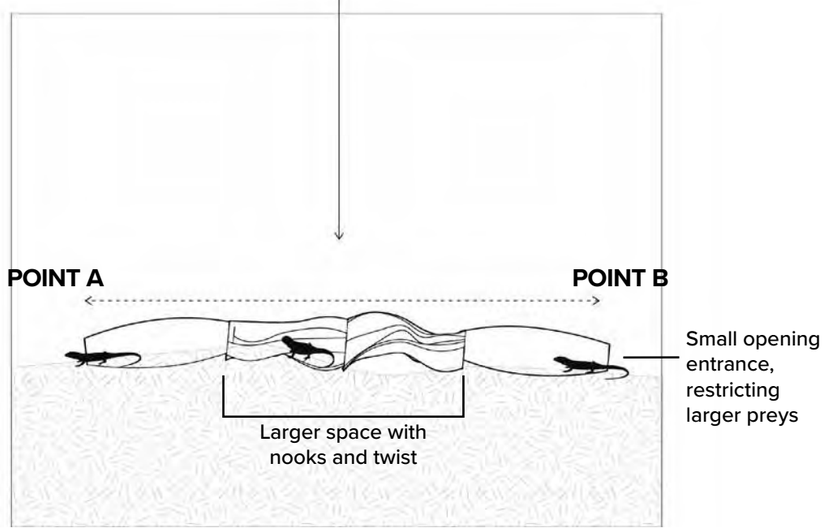
ECOTUBES / CHAMBER

Clay tunnel = tube + tunnel

- Function: tunnel, travel
- Species: small garden skink,
- ground-dwelling invertebrate
- Play action and configuration: Tunnel
- Offers shelter and hiding spots when fauna move from spot A to spot B

Habitat form	Play action	Habitat function	Fauna species
Crevices ✓	Array	Shelter ✓	Pollinators (native bee)
Tube ✓	Host	Nesting	Small garden skink ✓
Cave	Stack	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Tunnel ✓	Hiding ✓	
Burrow	Bury	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Corridor	Species movement ✓	
		Water resource	

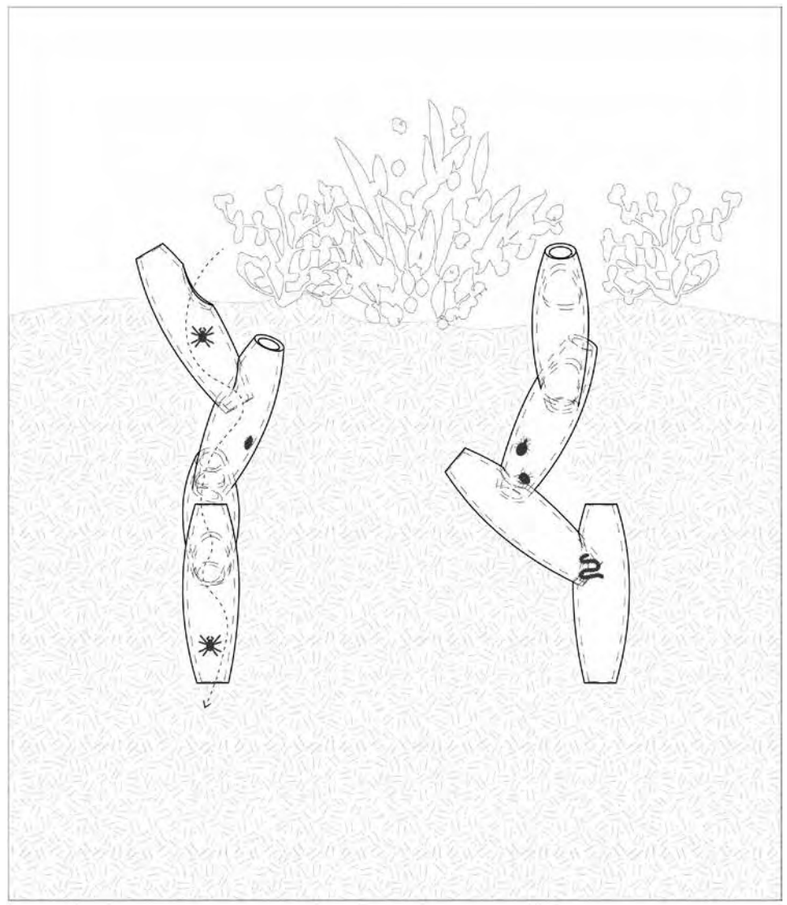




Underground clay chandelier = chamber + bury

- Function: Bury, nest
- Species: small garden skink,
- Play action and configuration: Bury
- Burried for below ground habitat
- 3 dimensional twists mimicking burrows

Habitat form	Play action	Habitat function	Fauna species
Crevices	Array	Shelter ✓	Pollinators (native bee)
Tube	Host	Nesting ✓	Small garden skink ✓
Cave	Stack	Habitat: complex nooks and crannies	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel	Tunnel ✓	Hiding ✓	
Burrow ✓	Bury ✓	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Corridor	Species movement ✓	
		Water resource	



ECOTUBES / CHAMBER

Clay tunnel = tube + tunnel

Photo shows an example of how C1 and C2 can be reattached.

Underground clay chandelier = chamber + bury

Photo shows drying process of unit D configuration.

CLAY CORRIDOR

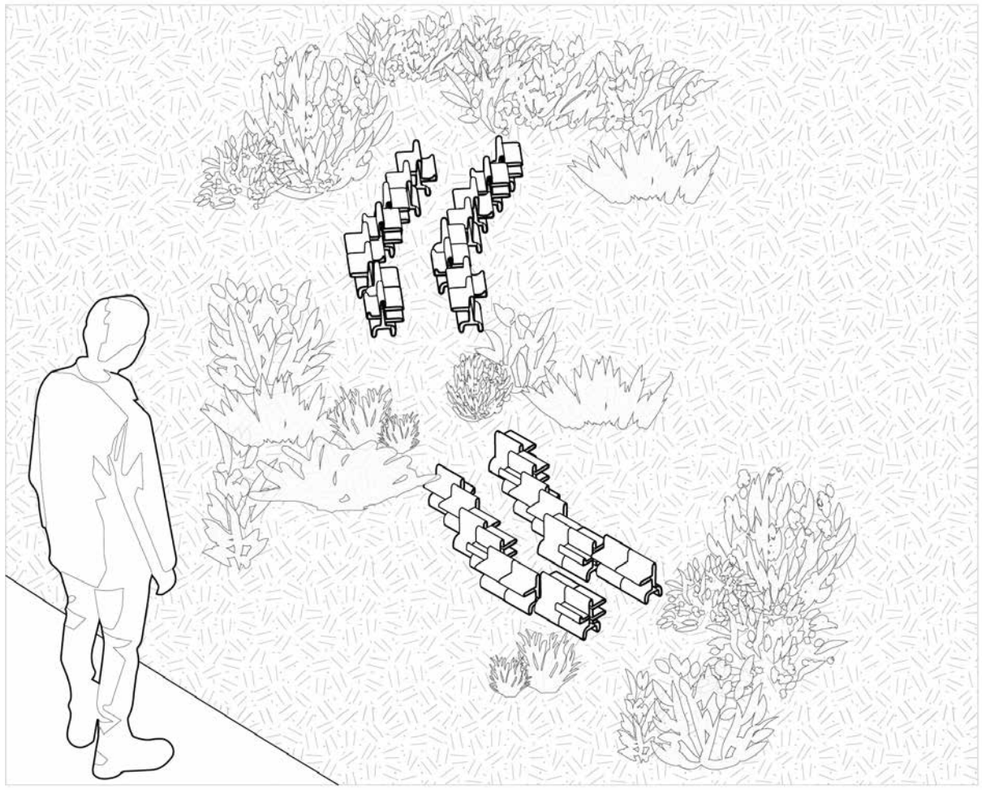
= wall + corridor

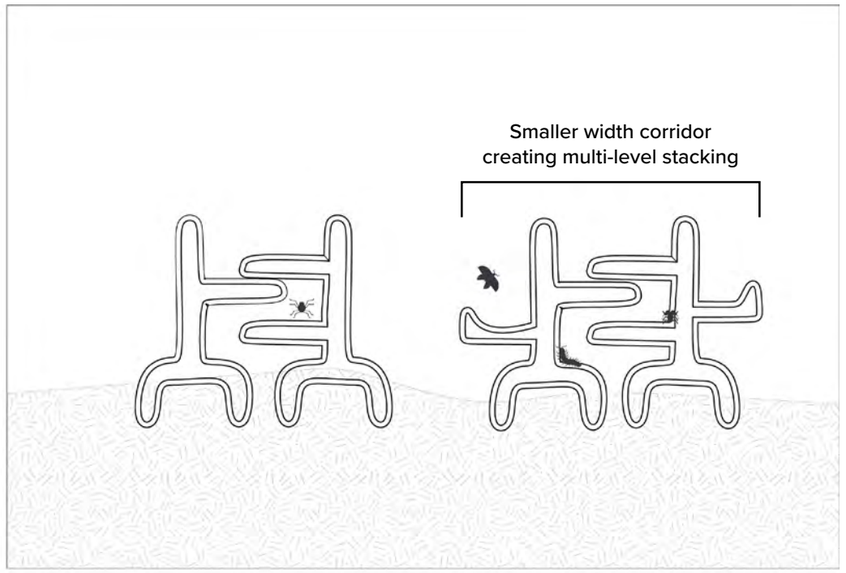
Function: Corridor

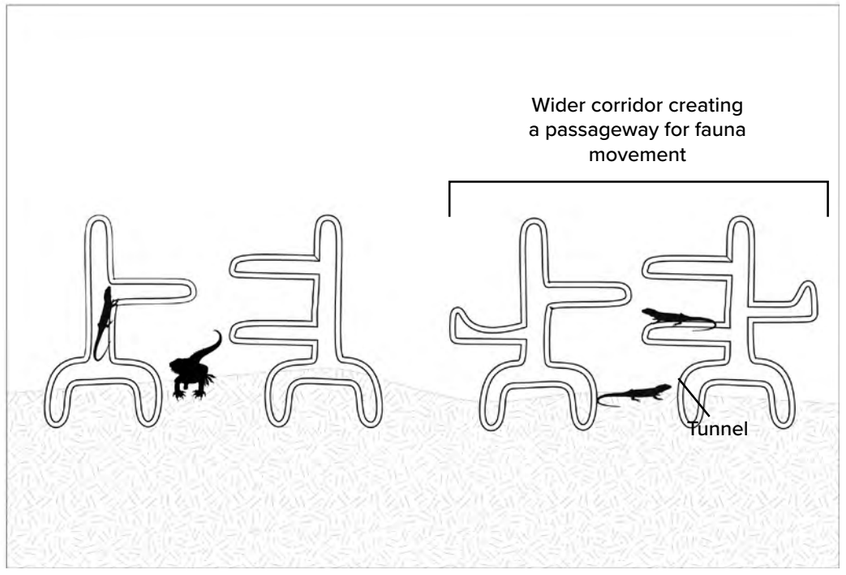
Species: small garden skink, ground-dwelling invertebrates

Play action and configurations:

- Multiple pieces aligning creates a corridor (see configuration)
- Allow fauna species to travel form point A to B







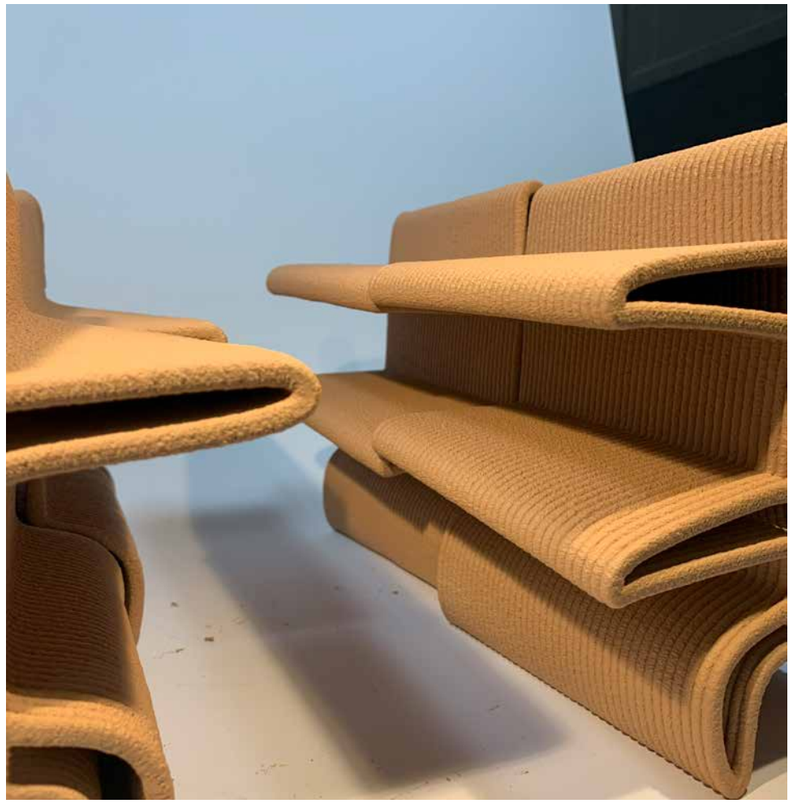
Habitat form	Play action	Habitat function	Fauna species
Crevices ✓	Array	Shelter ✓	Pollinators (native bee)
Tube	Host	Nesting	Small garden skink ✓
Cave	Stack	Habitat: complex nooks and crannies ✓	Other ground-dwelling invertebrates (beetles, crickets) ✓
Tunnel ✓	Tunnel ✓	Hiding ✓	
Burrow	Bury	Below ground habitat	Other small ground-dwelling species (spiders, slugs) ✓
	Corridor ✓	Species movement ✓	
		Water resource	

CLAY CORRIDOR

= wall + corridor

Tight width corridor

Medium width corridor

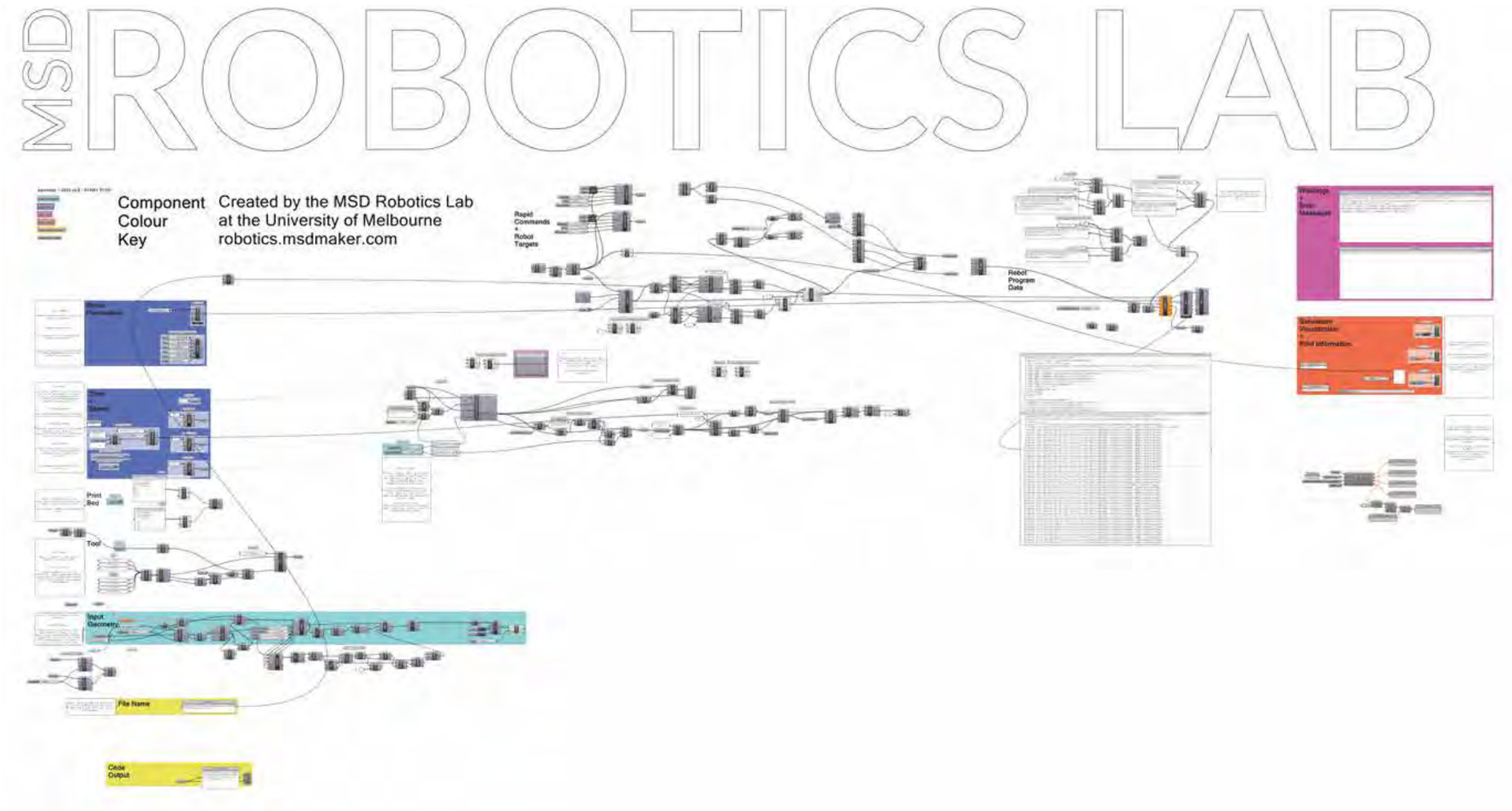


Wide corridor

PRODUCTION

PRINTING AND PRODUCTION

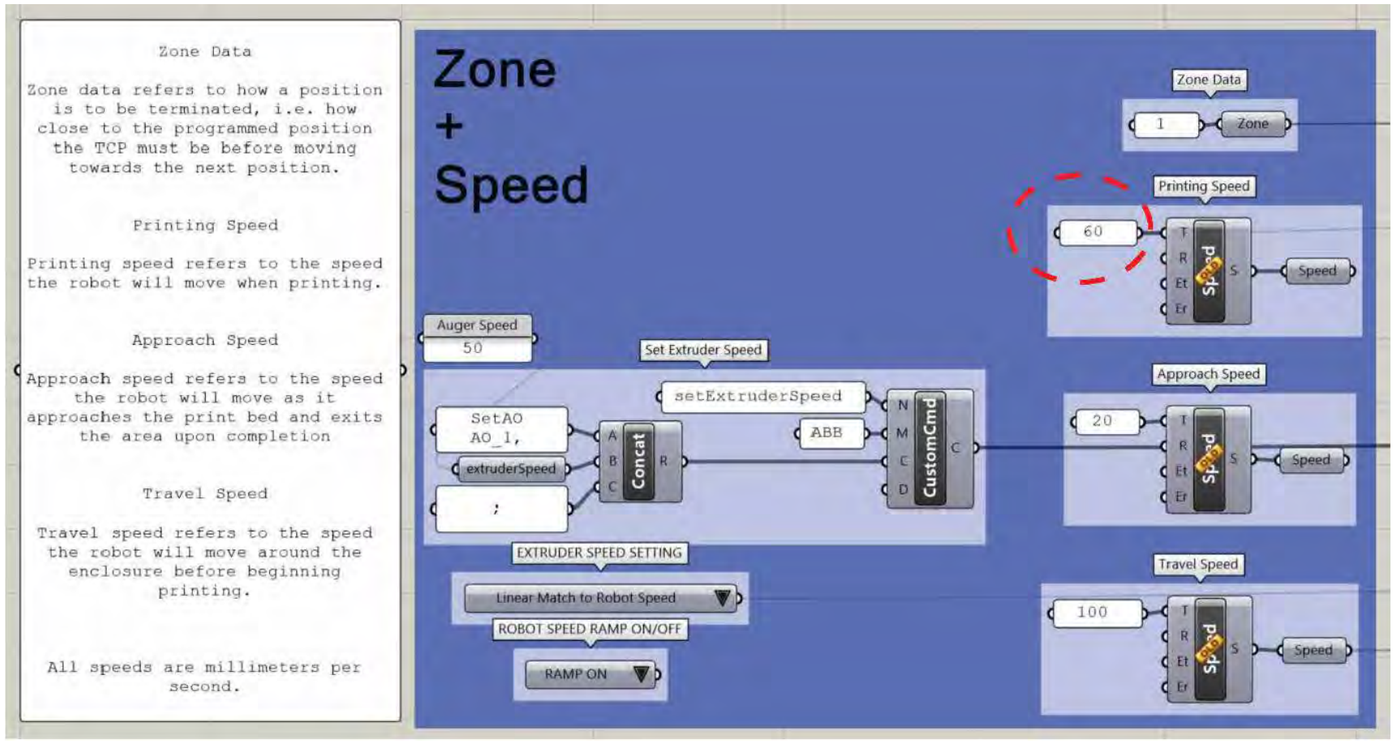
Printing settings

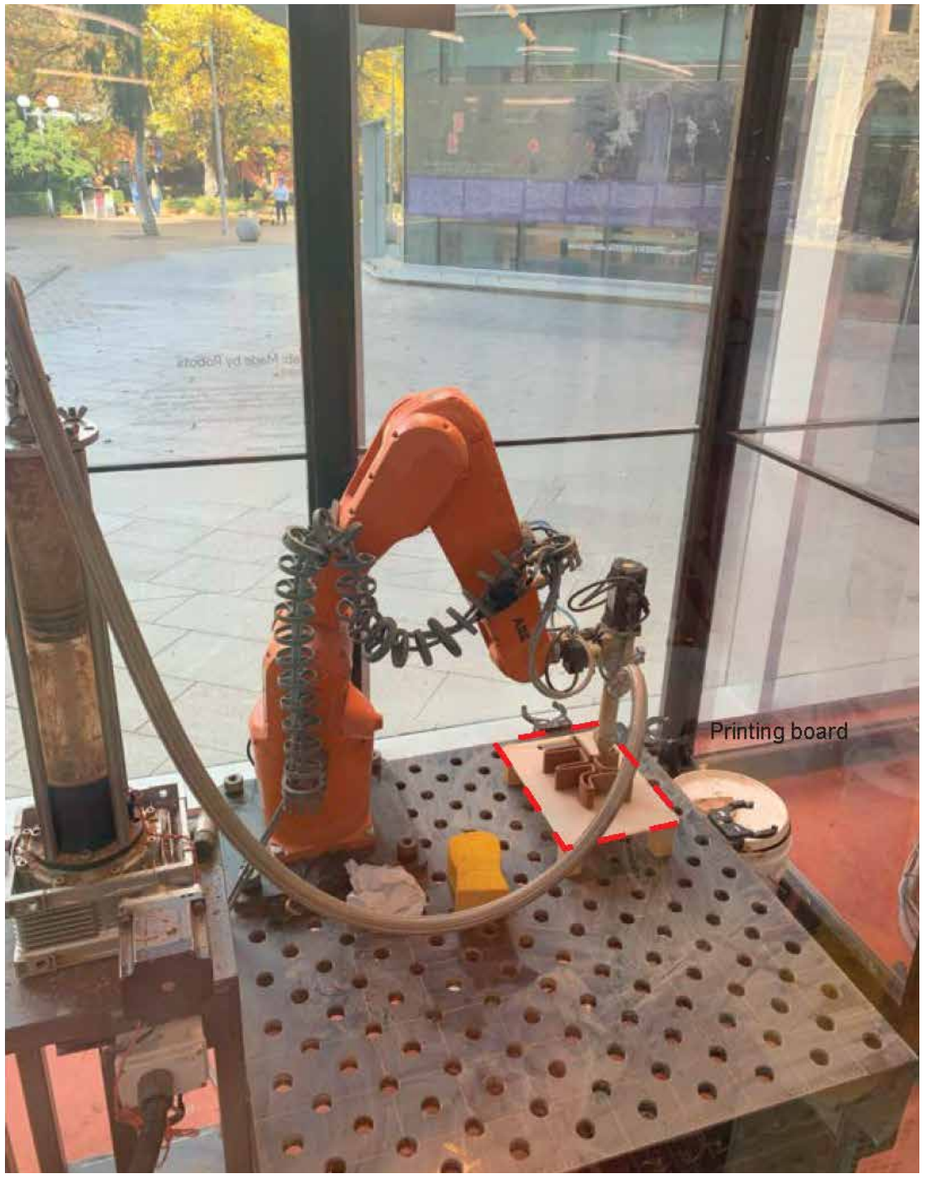


MSD Robotics Lab Grasshopper script for generating 3D clay printing script

PRINTING AND PRODUCTION

Printing settings





3D clay printing parameter setting used:

- Nozzle size 5mm
- Printing bed bound max 200 (L) x 200 (W) x 200 (H)
- Printing speed from 40 to 60
  Auger speed 50 (pushing clay out)
- Printing from bottom to top on Z axis

PRINTING AND PRODUCTION

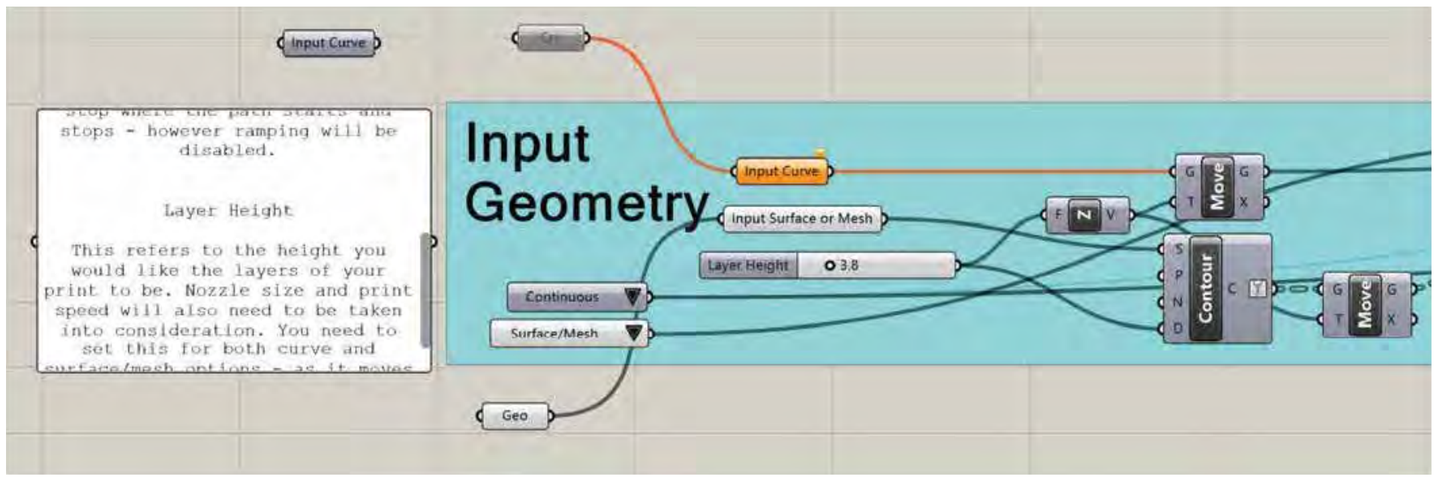
Printing settings

Surface to curve to script

Curve to printing curve to script

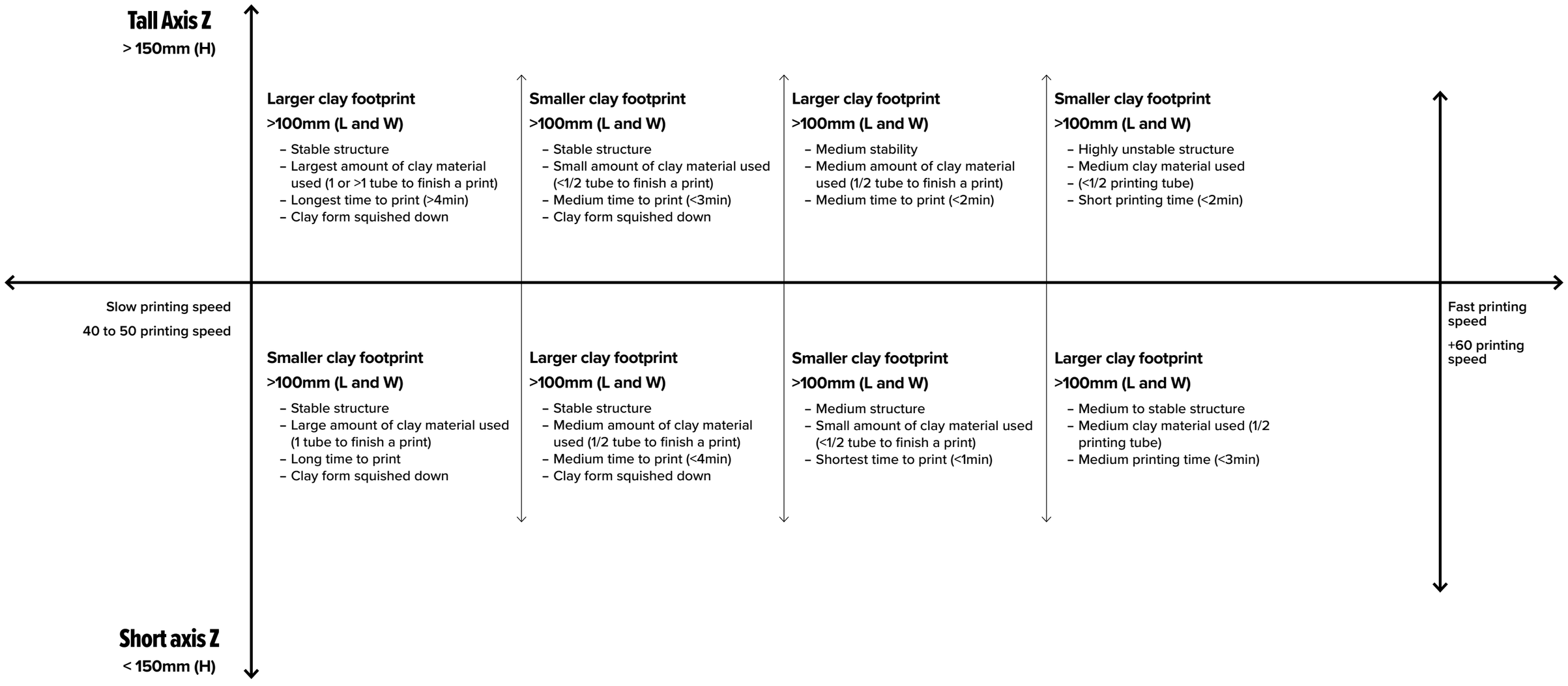
3D clay printing parameter setting used:

- Continuous extrusion of clay from start to end of printing script
- Clay layer for 5mm is around 3.8mm
- Surface to curve to script setting
- Curve to script setting



PRINT SETTINGS

- Twisted form is not taken into consideration yet, more than 30 degree bent could lead to the wet clay to collapse on its own weight during printing
- Shakiness from the robotic movement could also cause the board to move and collapse the clay structure while printing smaller form



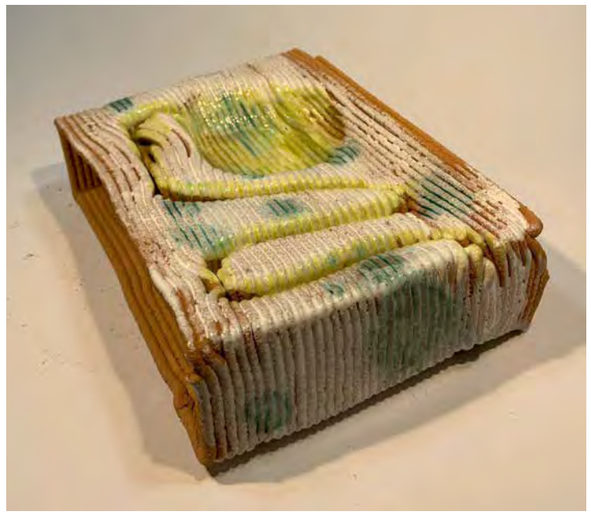
GLAZING

Glazing techniques

- Paintbrush (large or small strocks)
- Dipping
- Splashing
- Dripping

Goal

- To attract attention: use contrasting colours and highlight form by glazing curved edges.
- To blend with vegetation or surrounding: use similar tone to surrounding landscape (green, yellow, brown, blue tone).



Before glazed firing

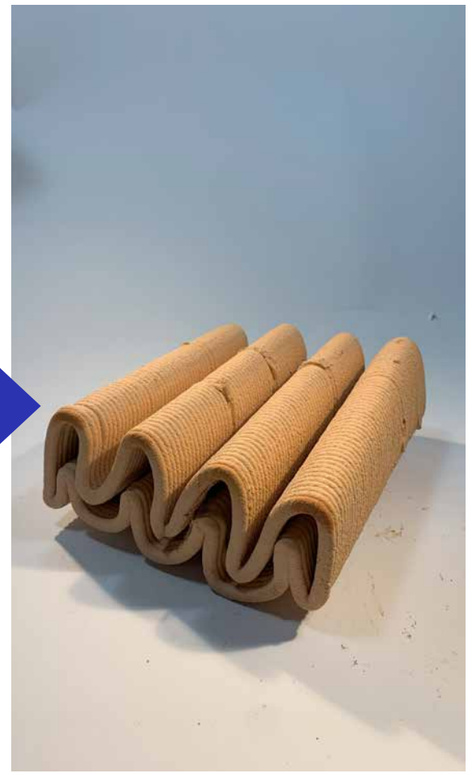
After glazed firing

POST-PRODUCTION

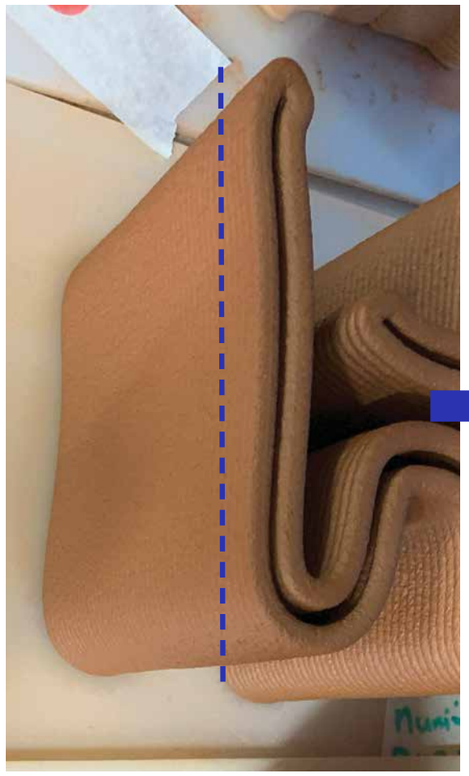
Considerations

- Tilting / bending
- Cracking
- Shrinking

Gaps after printing



Gaps shrinking during drying



Straight extrusion right after printing

Bent surface while drying

Fixing cracks during drying

Hassell

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