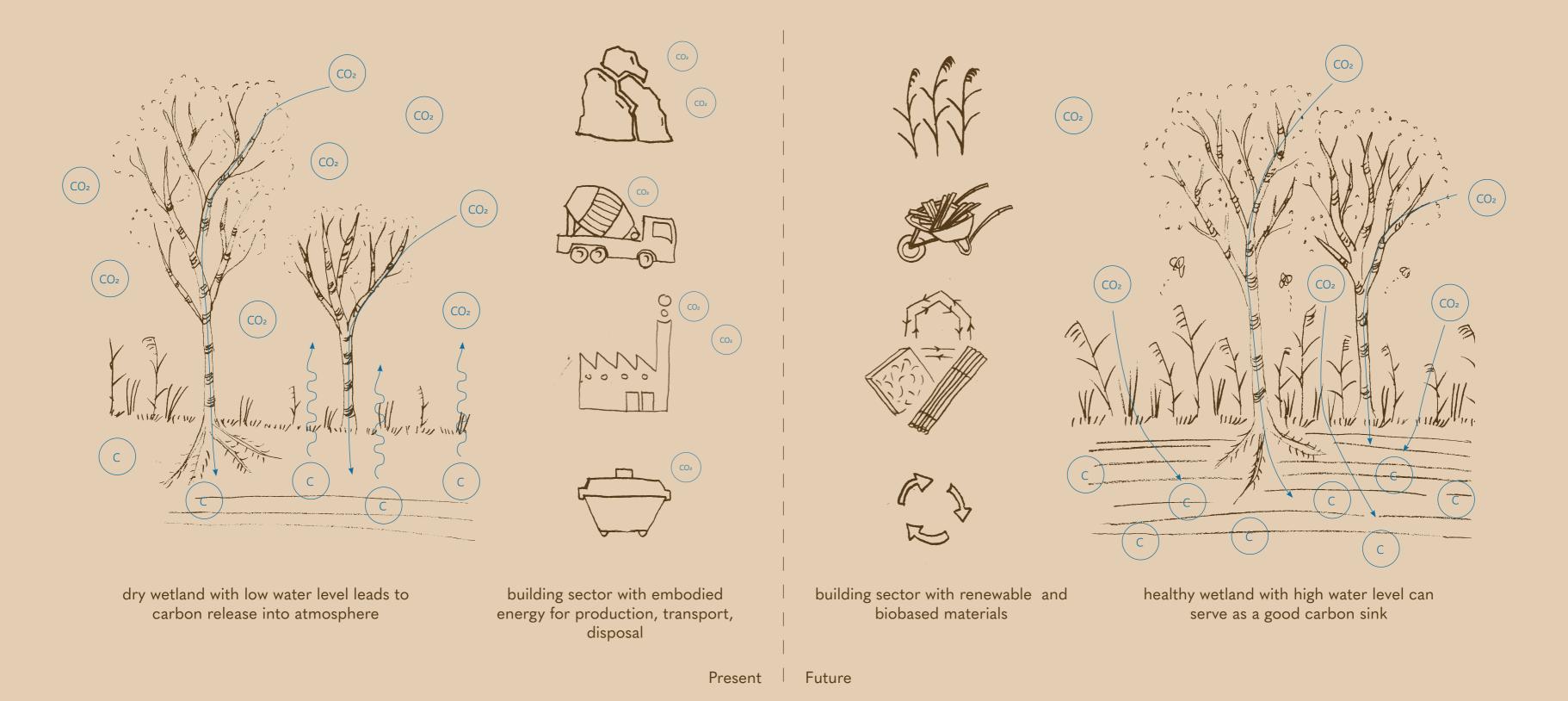
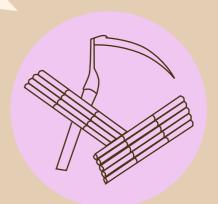


### Environment

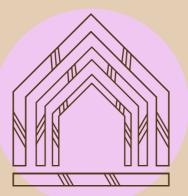


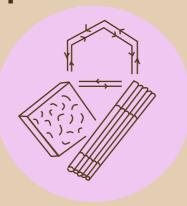


# Need for Reed

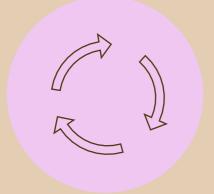


The use of reed as a building material and the benefits of local reed production

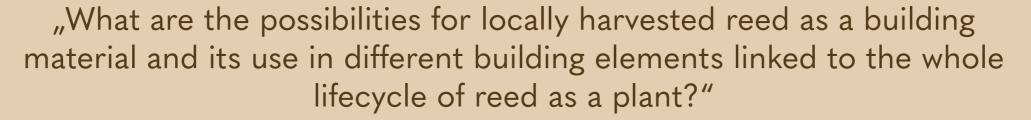


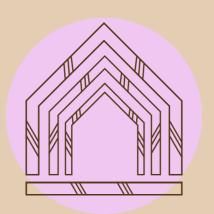


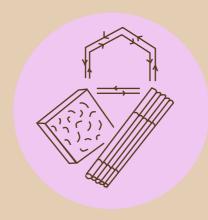


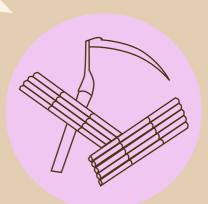


# **Research Question**

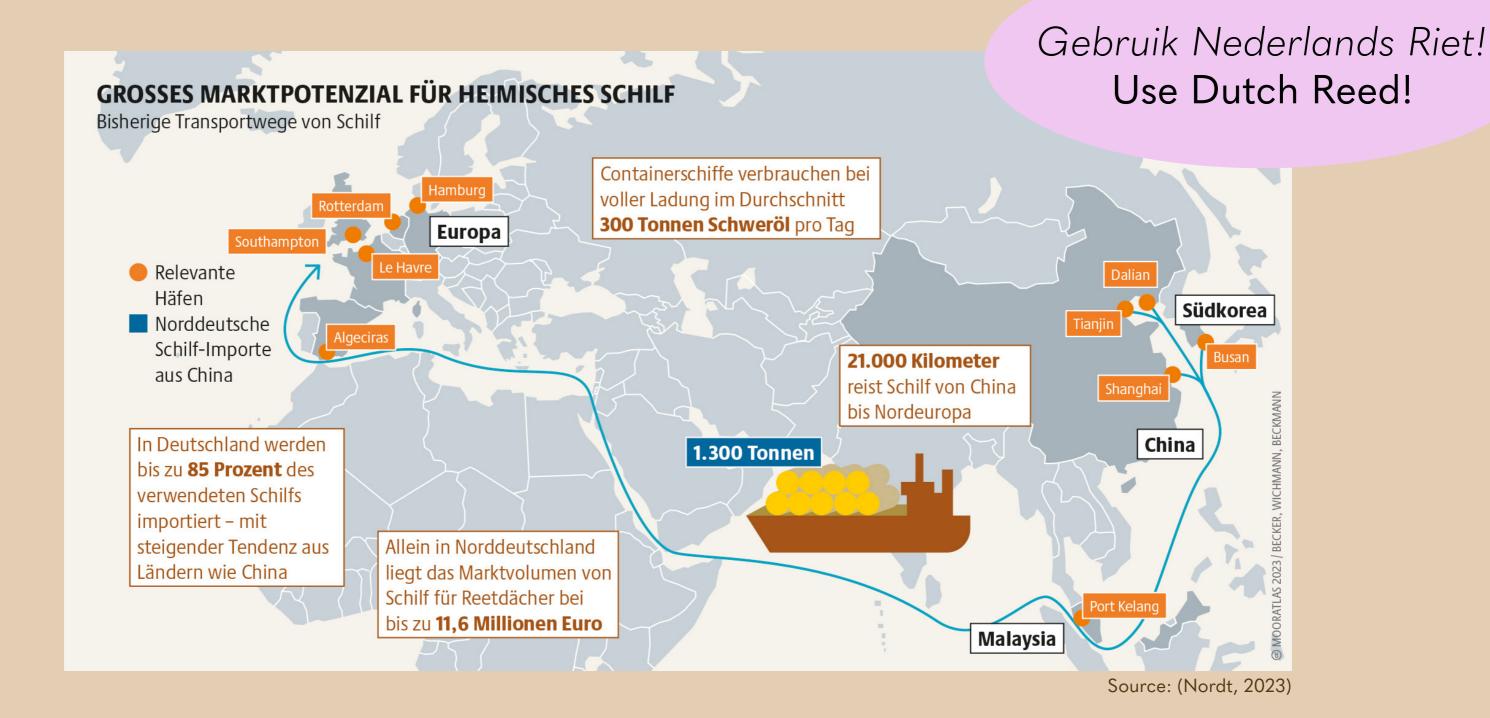




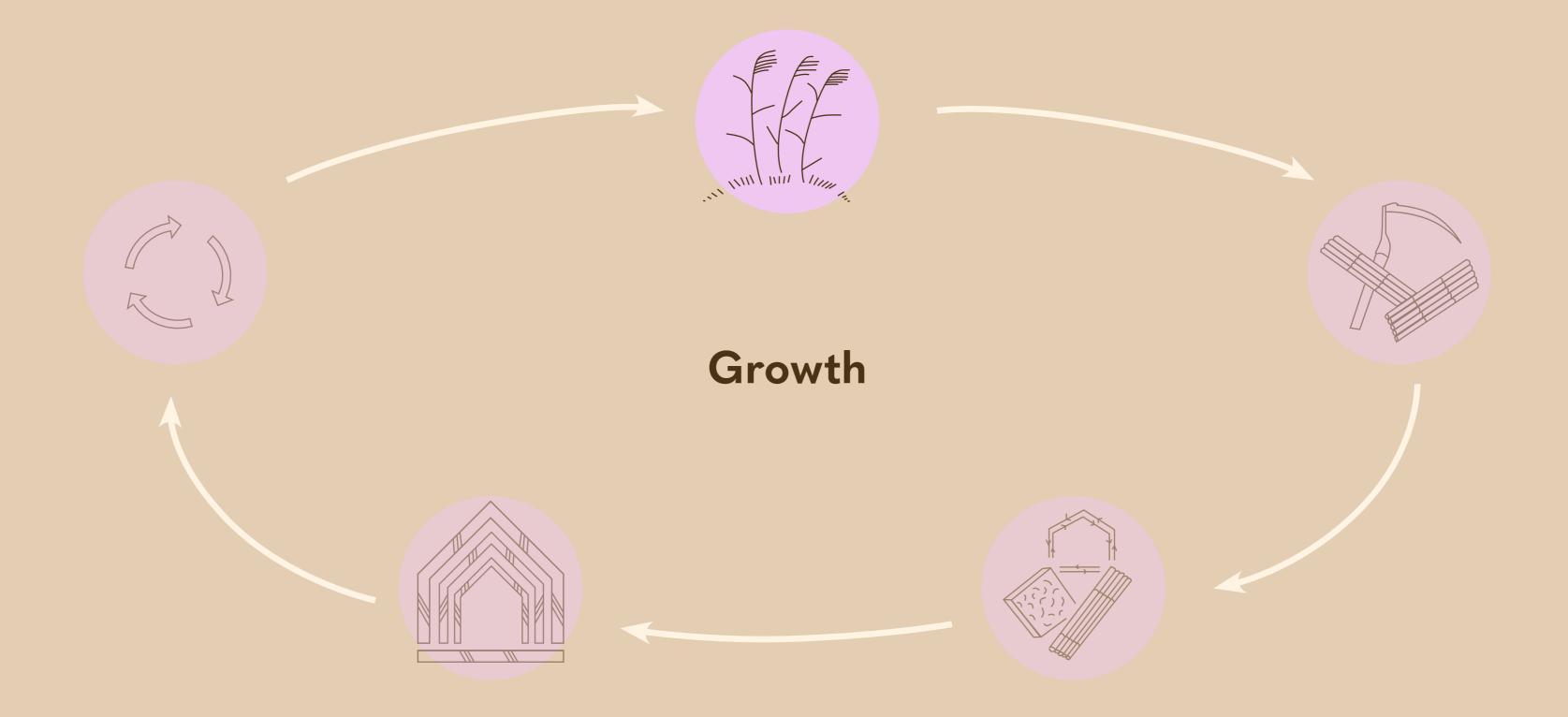




Research Relevance



# Reedsults





# Reed in Winter Reed bundles Reed in Summer



Source: own photography, Haarlem, 21 January 2023

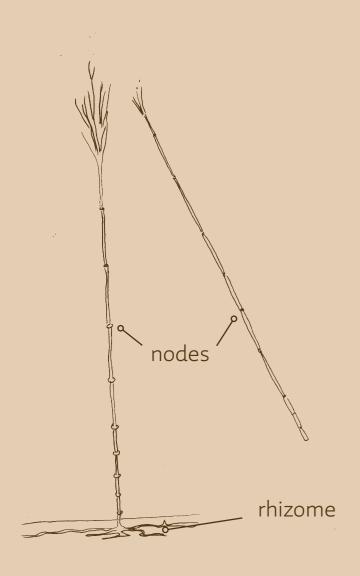
Source: (Riet voor dakbedekking | Rijksdienst voor het Cultureel Erfgoed, no date)

Source: (Common Reed Grass: Finger Lakes PRISM, no date)

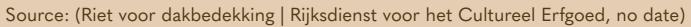




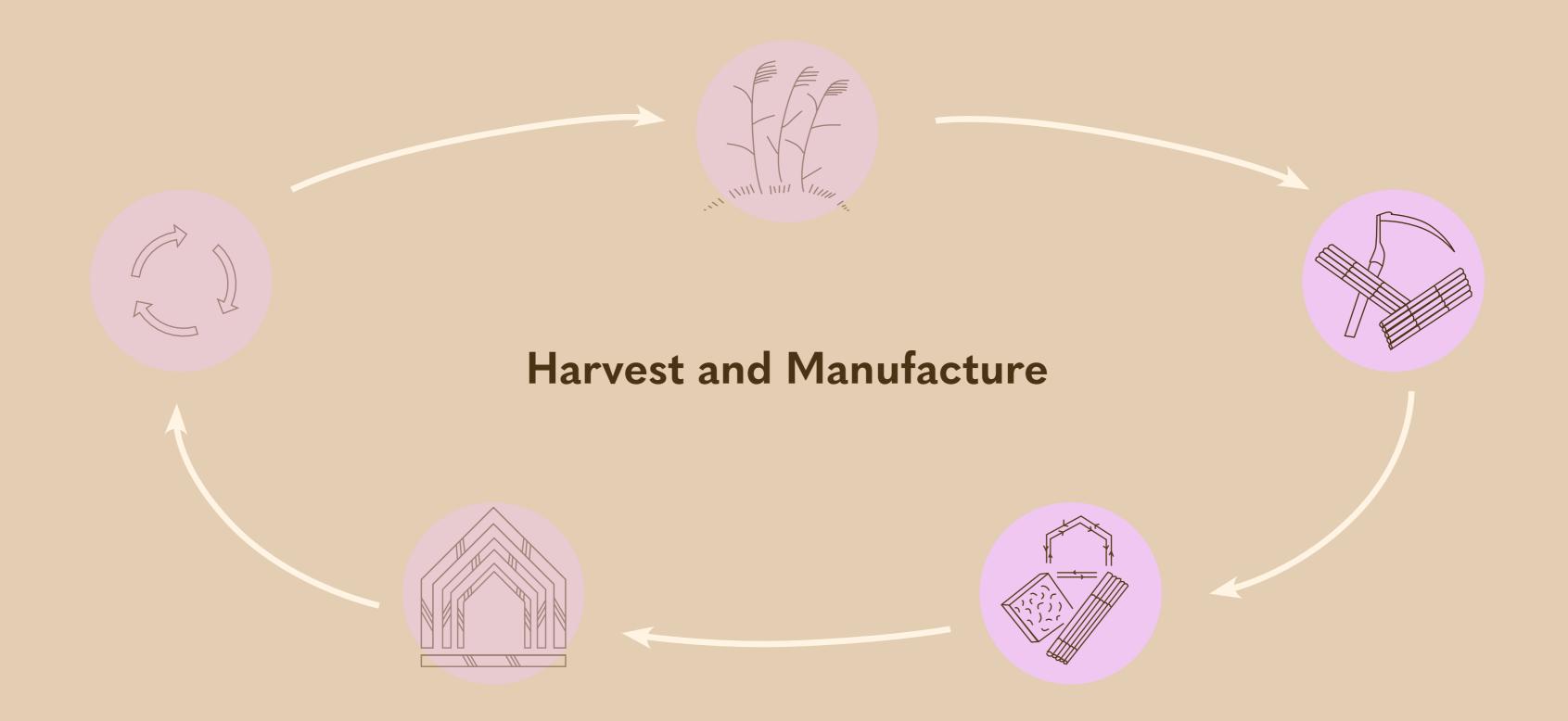
# Reedbed









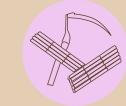


Reedsults Harvest and Manufacture

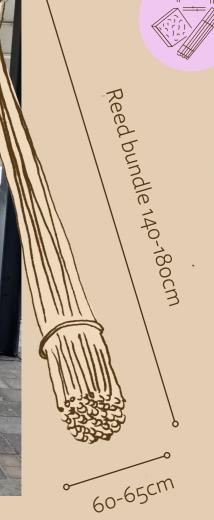




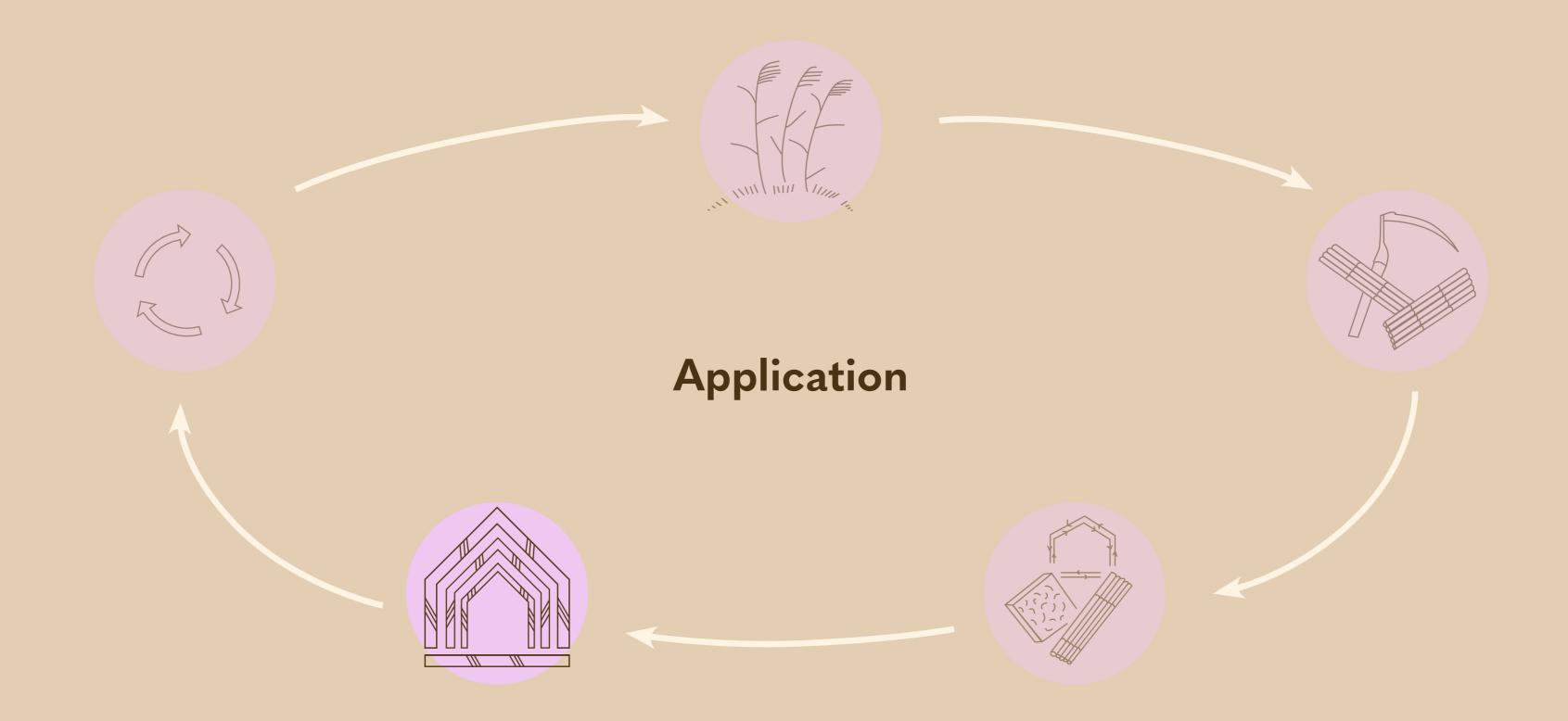












Reedsults



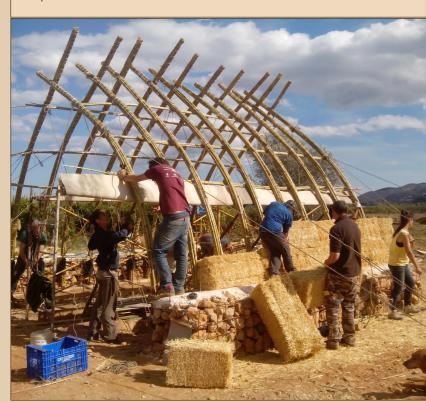
### As Load-Bearing Structure

**Functionality** Flexible and stable, leight weight, buildup easy but connected to manual labour

**Durability** With protective layer or intererior climate it can last centuries

**Circularity** Difficult to replace due to its function but possible to take apart if assembled with strips or rope

**Discussion** Hardly any built examples, to proof capacity more testing and prototyping is necessary. The picture below is from Econstrucció (ES) with Spanish reed.



### **As Partition Wall**

**Functionality** In combination with a timber frame good and flexible in shape

**Durability** If not exposed to changing humidity it can last centuries. Protective layer of plaster beneficial **Circularity** Easily removable

**Discussion** Beneficial light weight dividing wall. Examples already found from Hiss Reet (DE).



#### As Interior Finish

**Functionality** Pleasant climate, good acoustic qualities, normally flammable

**Durability** At walls not resistant to damage and dirt, on ceiling better

**Circularity** Loose material that can be biodegradable and replaced

**Discussion** Reed is a good natural sound absorber due to its hollow stems that need to be placed orthogonally to the incoming sound. An example was found at the Floriade Expo 2023 in Almere (NL).



### As Insulation

Functionality Reed thatch 350 mm ( $\lambda$  = 0.084 W/mK, R = 4.167 m<sup>2</sup>K/W), Reed panel insulation 250mm ( $\lambda$  = 0.065 W/mK, R = 4.0 m<sup>2</sup>K/W) **Durability** If not exposed to changing humidity it can last centuries. Protective layer of plaster beneficial

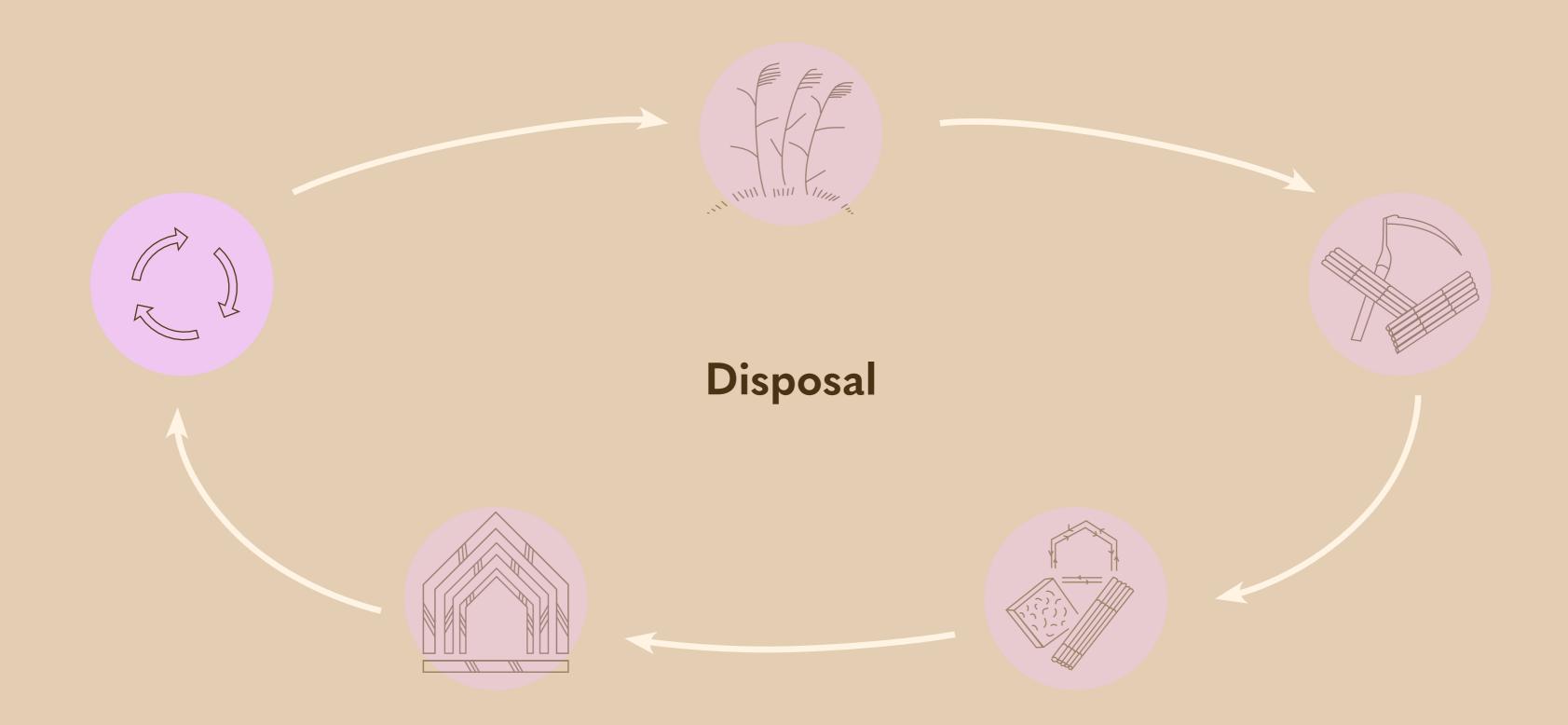
**Circularity** Easily disassembled due to dry connections and ropes/ties/plugs

**Discussion** Thick wall to achieve good insulation factor. Reed thatch can be combined with a thin additional insulation. The picture shows the insulation panels of Leo Bodner (IT).



Sources: 'Aula d'Agricologia, Benidoleig' (2016), 12 March. Available at: https://econstruccio.wordpress.com/portfolio/aula-dagricologia-benidoleig/ (Accessed: 12 May 2023).

Innenausbau. Available at: https://www.hiss-reet.de/baustoffe-aus-schilf/trennwand-system/innenausbau (Accessed: 12 May 2023).

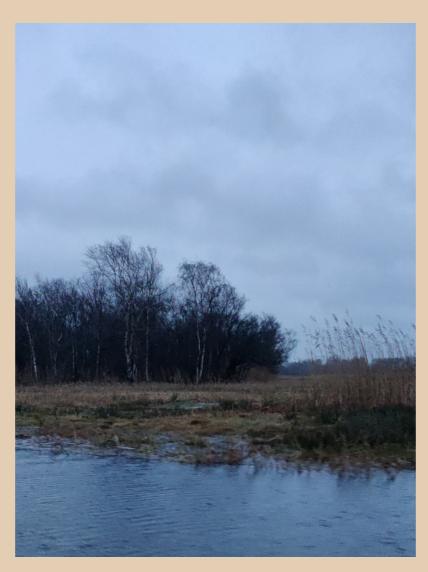




Piling Reed

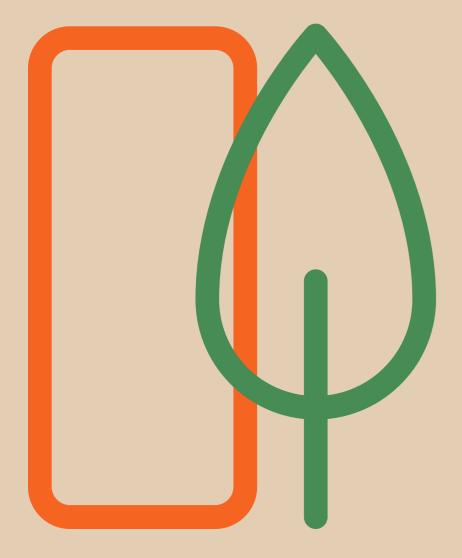


Transport by boat



Biodegradable





# **ECOCITY WORLD SUMMIT 2023**

**CONNECTING COMMUNITIES** 



#### The Present and the Future of Reed

The Netherlands has an extensive history of draining wetlands to create new land for agriculture and settlements. What at that time was considered a harmless creation of new ground led to the disappearance of valuable wetlands. The soggy peat soil can store carbon underground which makes wetlands one of the biggest carbon sinks on earth and an important contributor to the mitigation of climate change. They are also crucial for biodiversity, as habitat for various species and to regulate excessive water. Thanks to the rewetting of the polders in the Netherlands for the creation of healthy wetlands, the potential to grow more wetland crops re-establishes itself, like reed. Currently, the Netherlands imports around 80% of its used reed from abroad. The emissions for such a production chain are enormous and the tradition of local reed harvest gets lost.

Locally grown reed can lead to smaller loops, that can be entirely closed or regrown in just one season. This research explores the circularity of the biobased building material reed with the following

How is locally harvested reed applicable to a design considering the whole lifecycle of reed as a plant and as a building material?



#### Common Reed (Phragmites Australis)

Common reed is a grass-like plan with a height up to 5 m. It grows along river shores, in marshes, and on wetlands all over the world. along river shores, in marshes, and on wetlands all over the world. It can be recognised by its broad leaves and a smooth and hollow stem. The stem is divided with nodes that give it its strength with minium fibre mass. It is waterproof thanks to the woody epidermis as outer layer. As the plant usually grows with its feet in the water, there is no quick mould growth. The roots of the rhizome spread



To understand how reed grows is essential for its further fabrication and application in the built environment. An architect should only consider reed if it grows in the region and value the people that take care of the reedbeds and harvesting. When the layout of a reedbed is provided in a mosaic way with pools and a diverse structure of density for shelter and openness for light birds, fishes, insects, and other species can find a healthy living environment there.



In the Netherlands and other European countries, the harvesting season takes place from December to April, while the actual harvesting only happens a couple days per year due to the dry weather conditions needed. Traditionally, reed is cut manually by sickle or scythe, but nowadays modern reed harvesters are in use. The cutting tractors collect all of it and the selection and cleaning process takes place by hand later. This makes reed cutting still a procedure deeply connected to manual labour. It increases the value of the craftsmanship which is a crucial factor of the application of reed.



#### Manufacture

After the reed has been cut, it gets assembled into bundles. In a storage facility the reed can stay useable for years provided the building has good air circulation. Afterwards the reed can either be used as entire builde for reed thatches, put together for panels or be cut down. To apply the material in its most efficient way the cascading principle is ideal. From the whole stem as reed thatch to the smallest fibres in biobased insulation boards, reed can be used. This research focuses on the raw material.



Repd as a multifunctional building material has a broad variety of application possibilities. The building elements analysed in this research (with a selection presented on this poster) are reed as load-bearing structure, as partition wall, as roof thatching, as foundation, as insulation, interior finish, or bioenergy. The criteria chosen are the functionality, durability, and circularity of reed for each building element. The decision wether the application of reed is feasible and desirable is closely connected to the previously mentioned criteria. In conclusion, the application is possible in many building layers and stores





If the disposal of reed is necessary it can lead to a circular process in nature. Traditionally, left-over reed got spread out in the forest. It would decay and serve as manure for the soil for plants to grow. However, the overregulated process nowadays prevents this. Reed that is not harvested for construction and left behind gets picked up by a heavy vehicle bringing the reed to the nearest compost facility. To use reed as a natural manure for a closed loop of this biobased therial, the processes of the harvesting and the natural circularity of the plant need to find their way back into the regulations of reed cutting.

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#### Acknowledgements

Contact

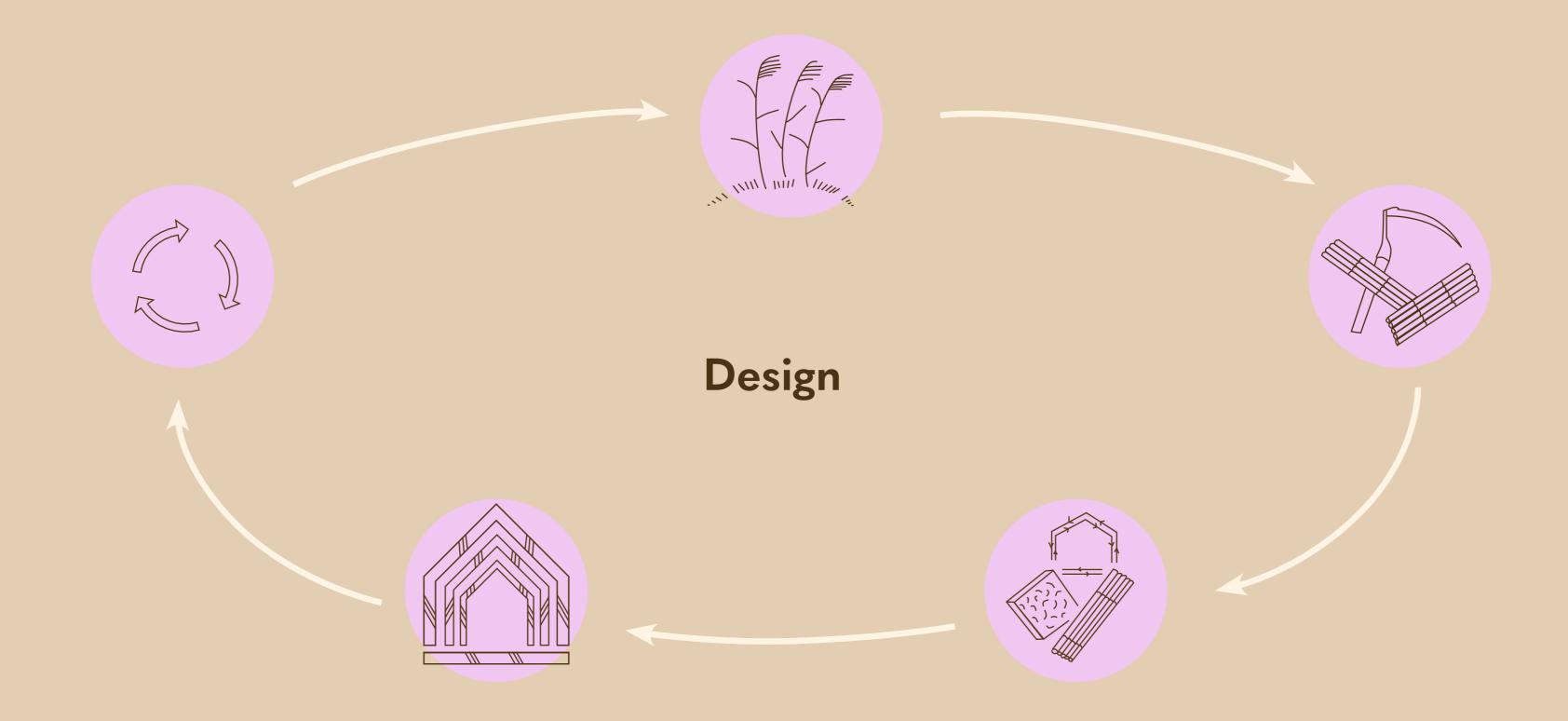
Special thanks to the assistance of my research tutor Dr. ir. Nico Tillie and my friends and family for the love and support during my graduation phase. Thanks to Stylos Fund for the financial support for the trip to London.

STYLOS I FUND











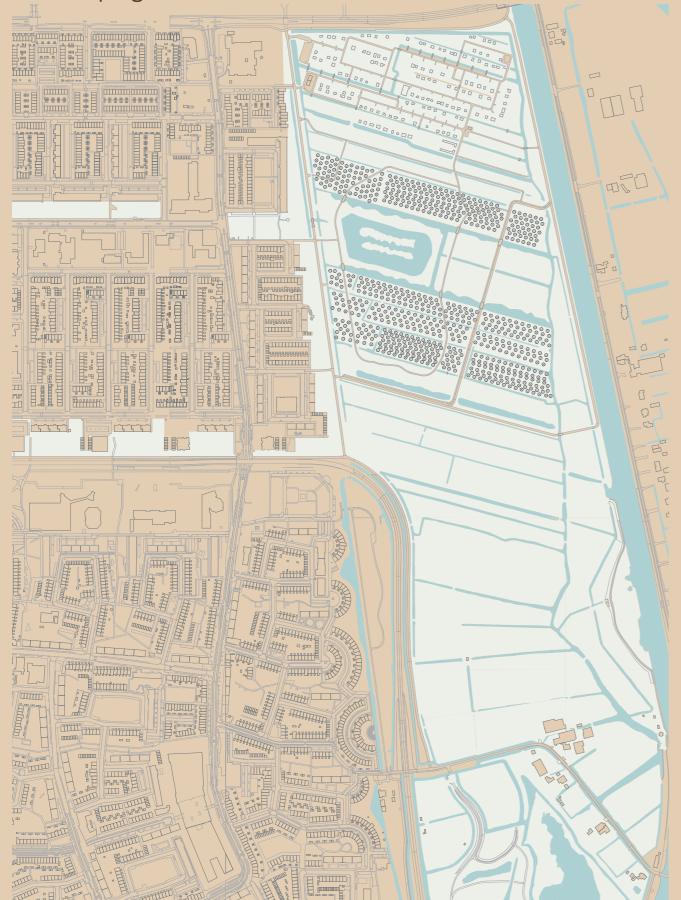


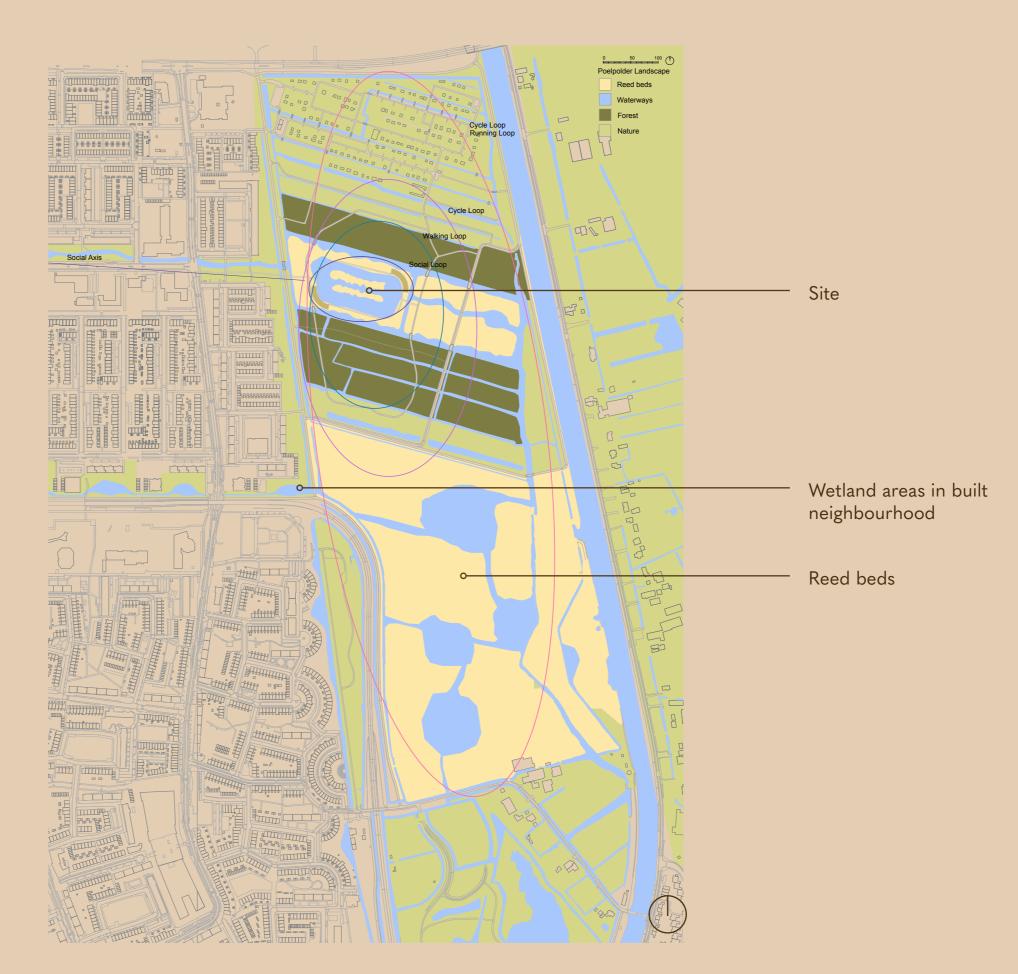
Self-Sufficient

Activities Centre

Biobased Materials

## Landscaping





Reed Harvest The Reed I Need

# **Reference Wouter Slors** Naardermeer

Gebiet

Reed bundles

15 hectare riet

6000-6500

750 hectare natuur

riet pro hectare 400-430

Roofthatch 660m2

9 bundles / m2

6000



# Own Design Poelpolder

Gebiet

natuur

riet

11 hectare 26 hectare **Reed bundles** 

4400-4800

riet pro hectare

400-430

Roofthatch

280m2

9 bundles / m2

2520

Reed construction

785m

0.5 bundles / 1.5m

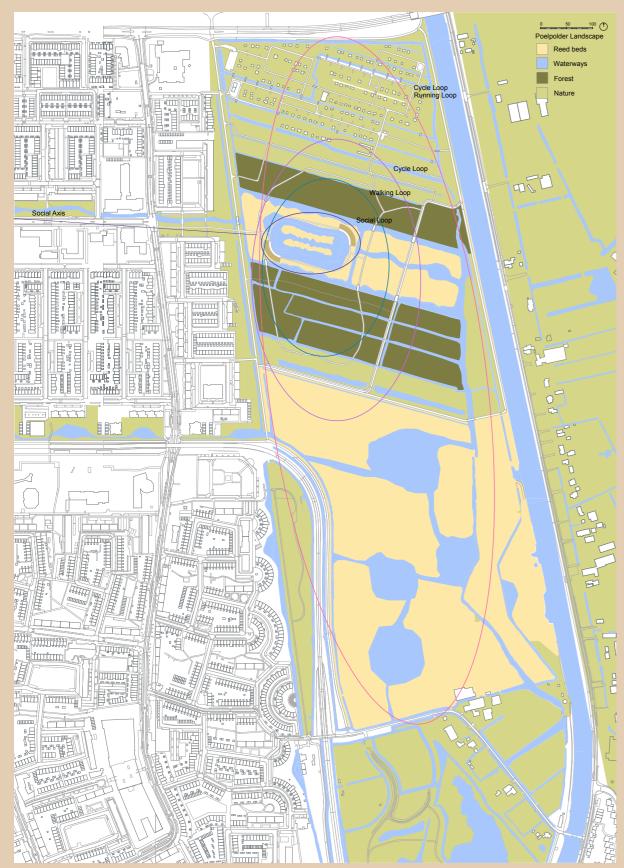
320

Floor insulation 230m2

7 bundles / m2 1610

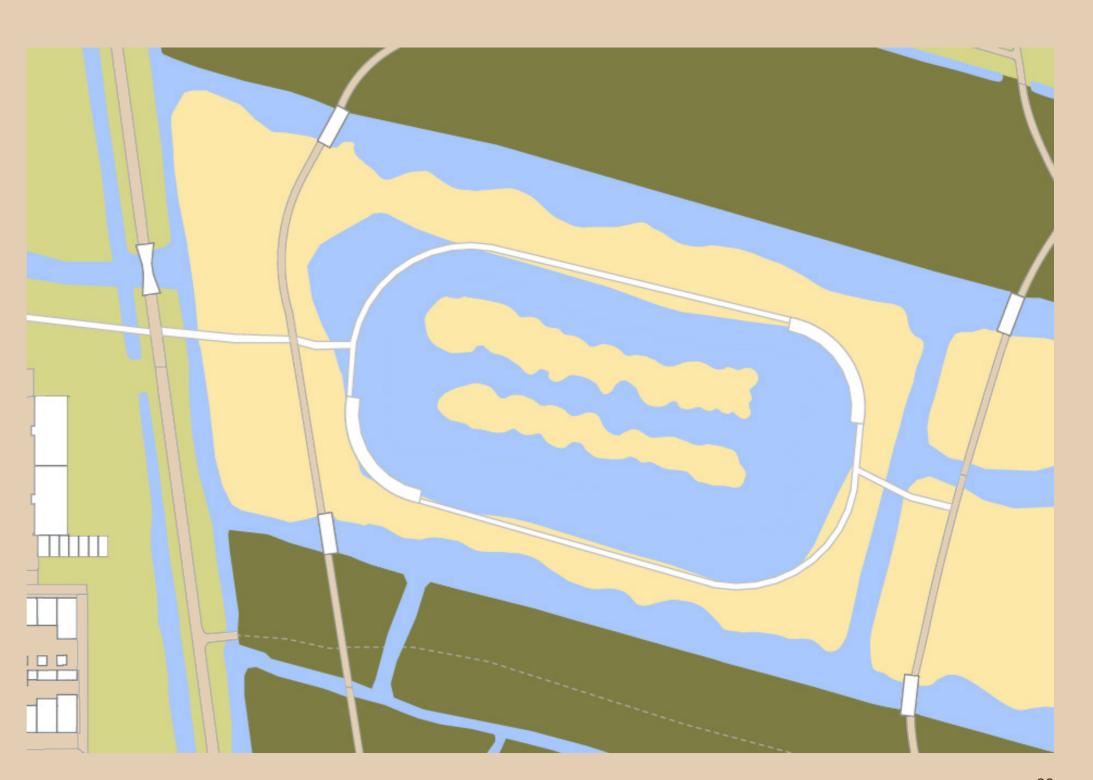
**Total** 4450

# **Building Stages**



# Stage 1

Raising the waterpeil in the polder and building of new walkways, create reed beds in the south.

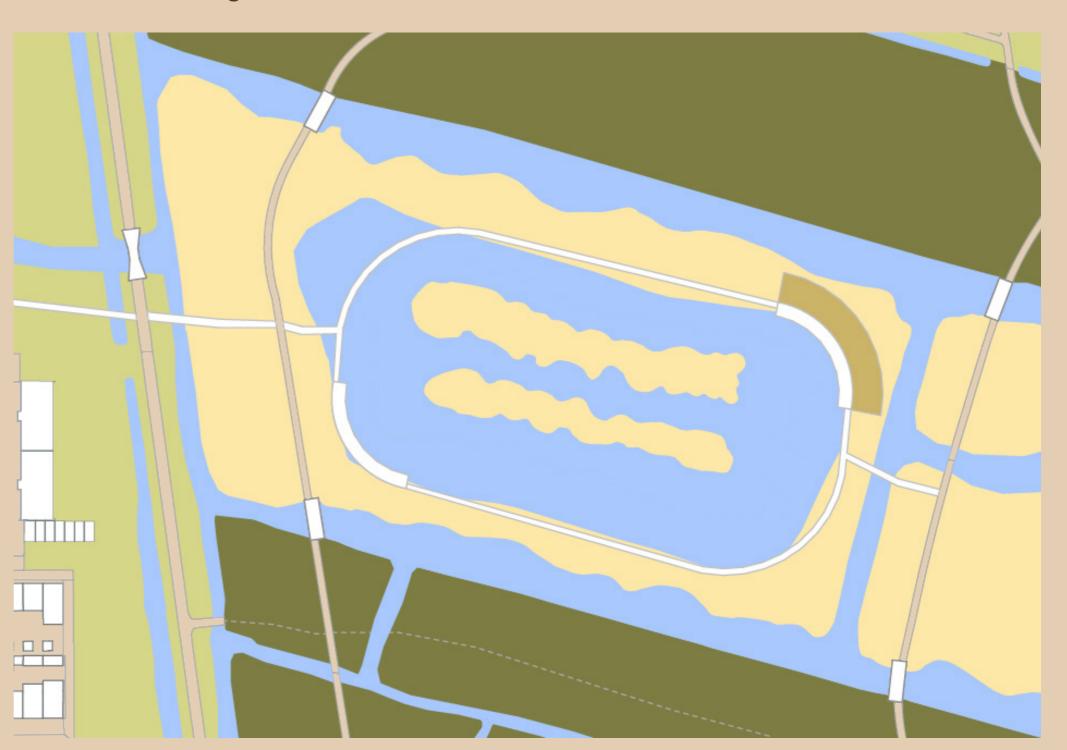


# **Building Stages**



# Stage 2

After first harvesting period of reed the construction of the first intervention can start, enough reed for all of roofing and construction.



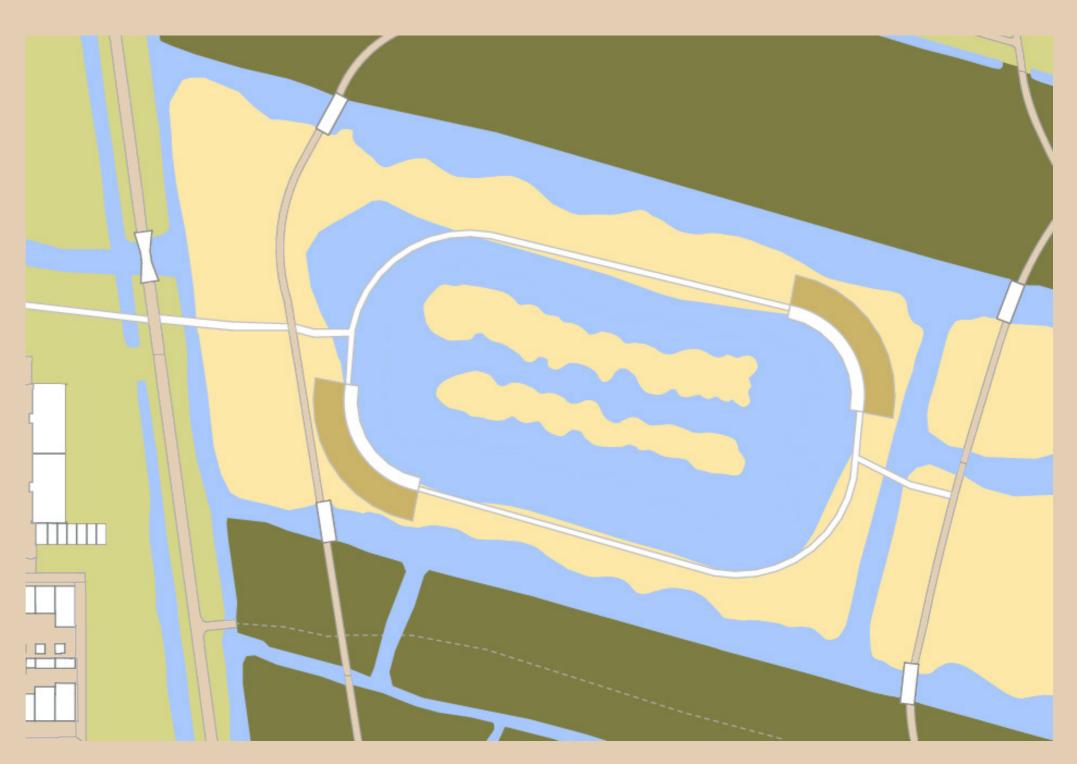


# **Building Stages**

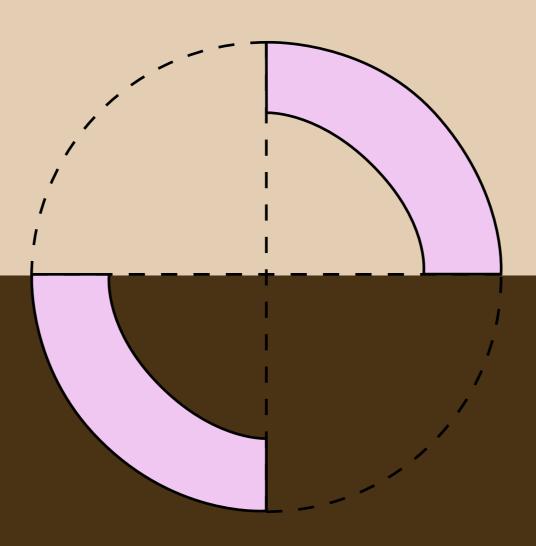


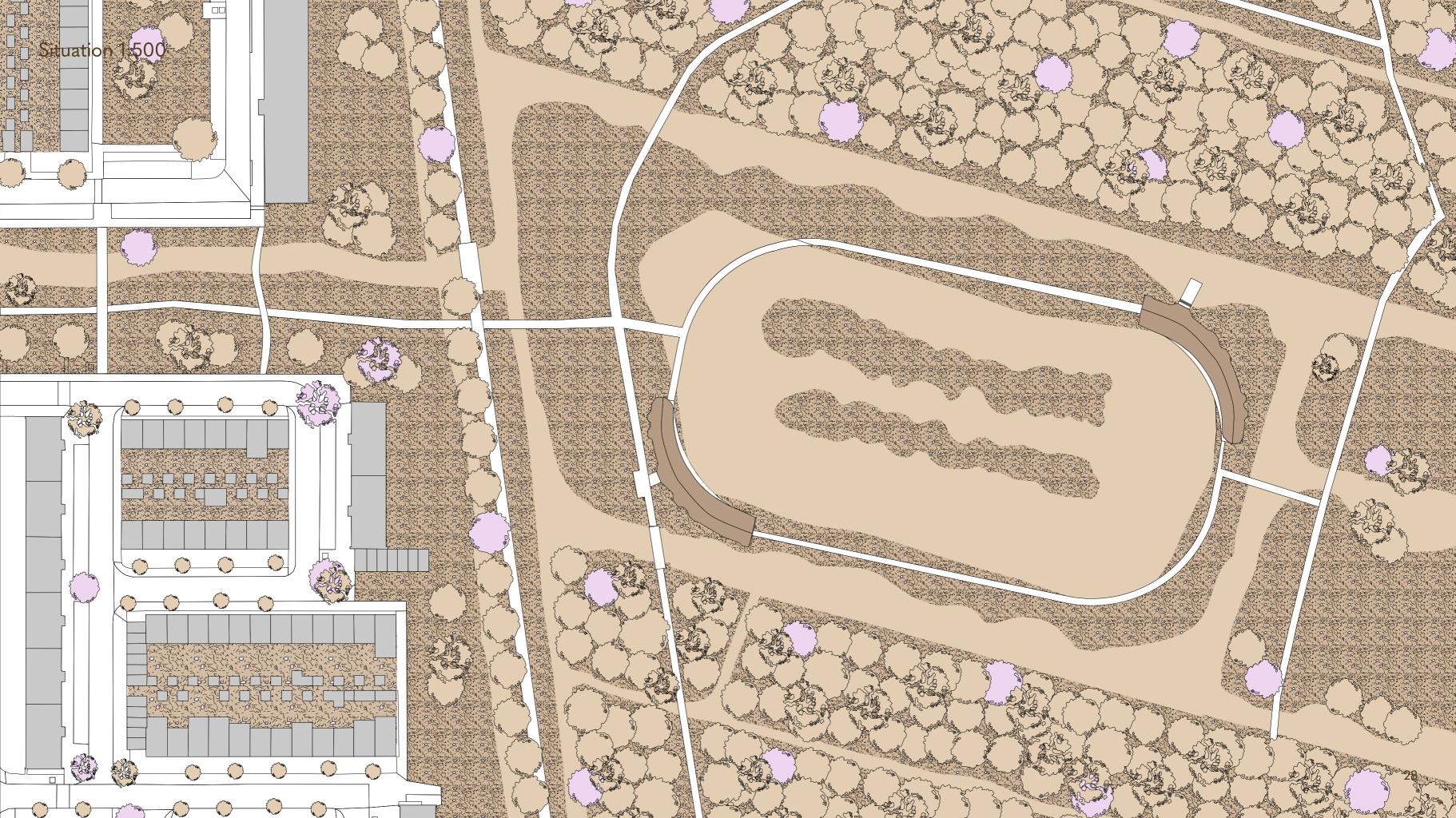
Stage 3

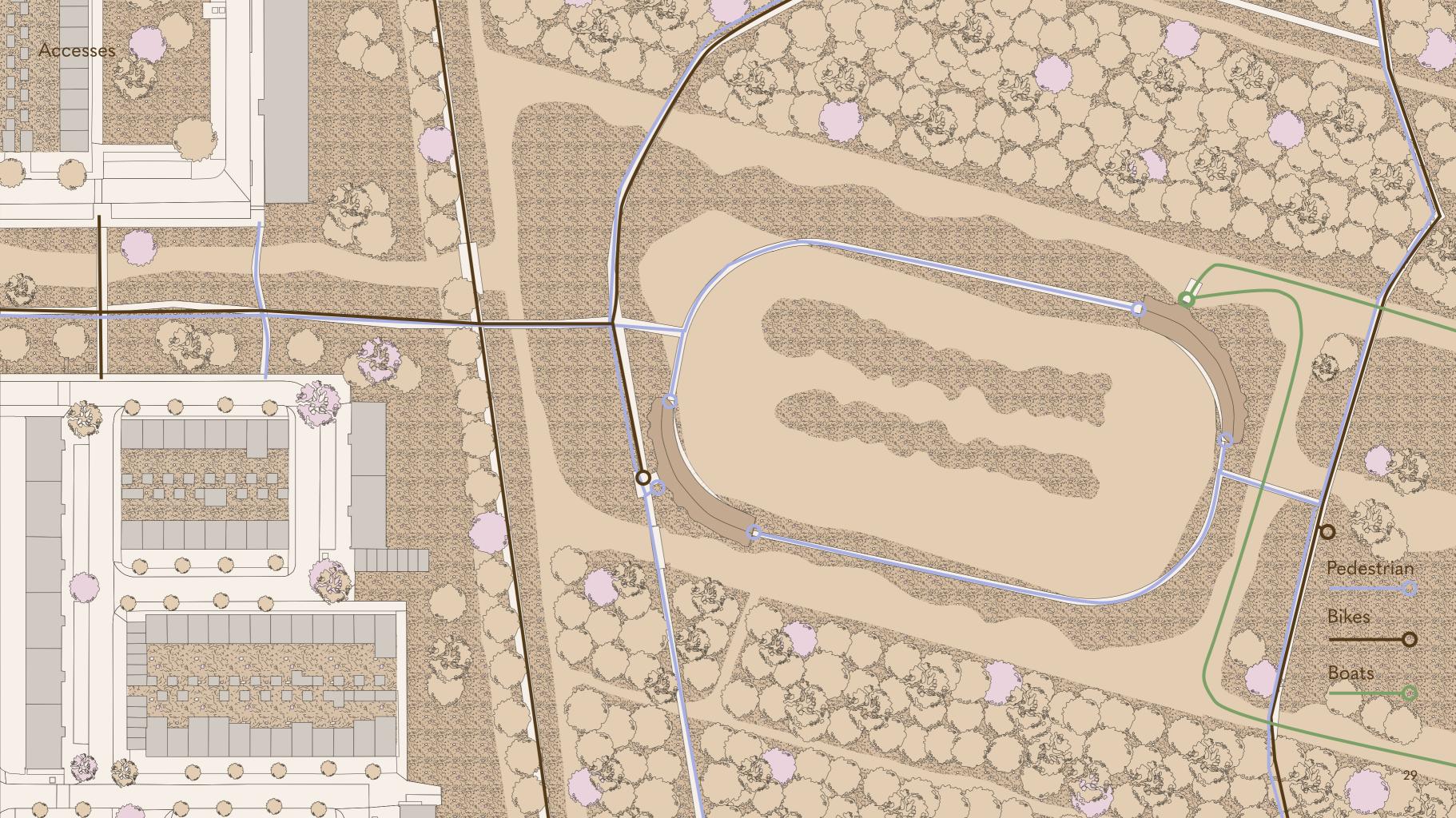
The next harvesting season a year later offers new material to build the second building.









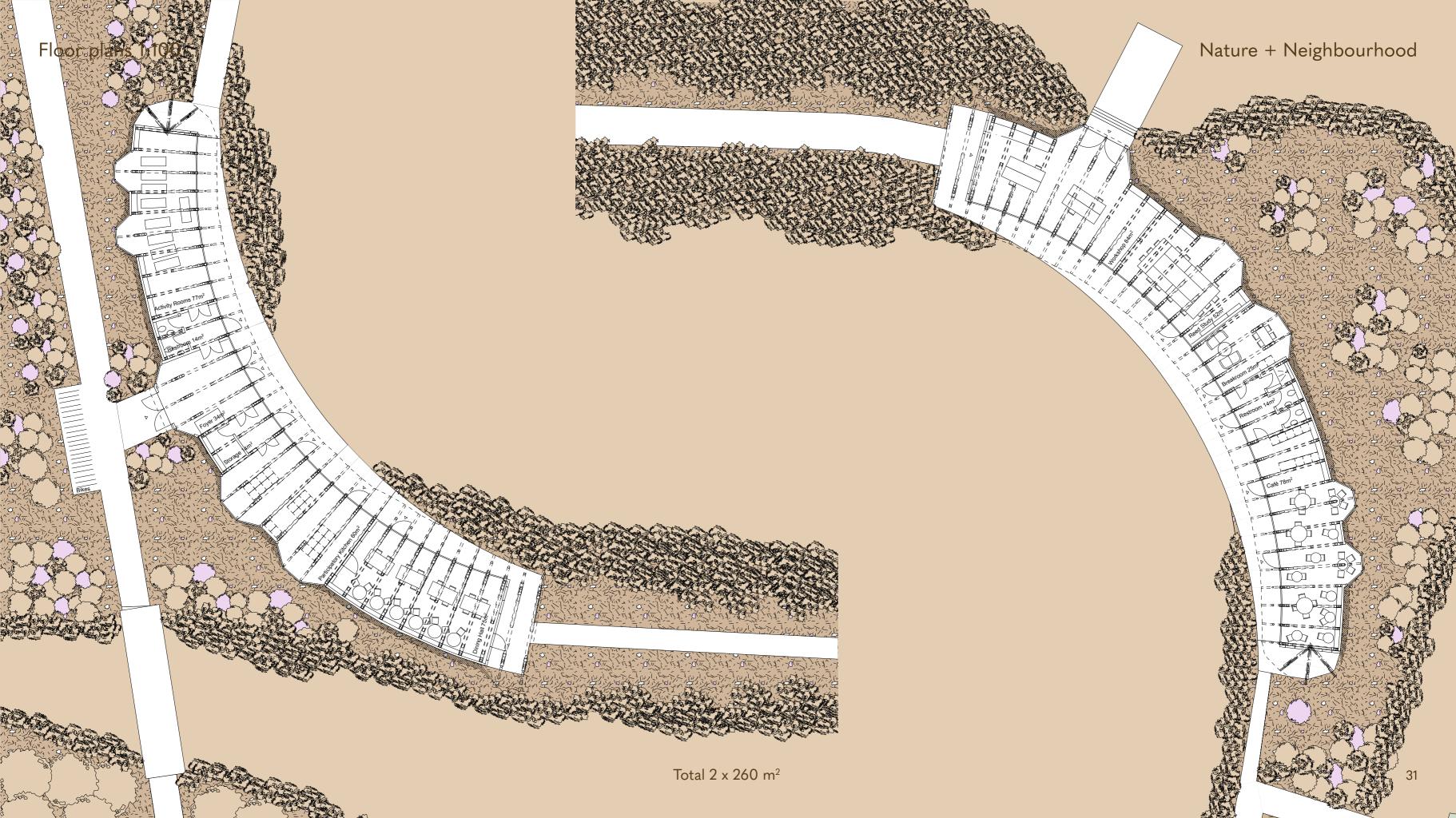


# Nature Pavilion

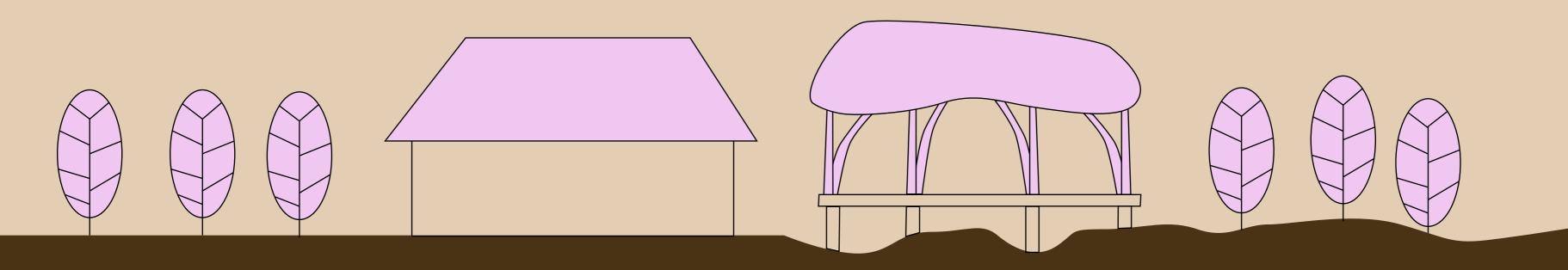
- Reed workshop
- Reed study
- Cafe

# **Activites Pavilion**

- Participatory Kitchen
- Dining room
- Activity Rooms



# **Tradition**



# Toolbox

| Application                | Functionality  | Durability   | Circularity  | Application in Design  |
|----------------------------|--|--|--|--|
| Criteria  Building Element | + Meets requirements +/- Under circumstances - Does not meet requirements                                  | + Long-lasting<br>+/- Under<br>circumstances<br>- Needs replacement<br>often                                 | + Easily removable<br>and biodegradable<br>+/- With effort<br>- Not easily replaced        | + Definitely<br>+/- Depending on<br>biobased alternatives<br>- No use                          |
| Load-bearing<br>structure  | +/- Flexible and stable for its light weight. Cannot carry much just stacked but in bales similar to straw | +/- If assembled correctly and covered with a protective layer of plaster it lasts for centuries.            | -<br>Difficult to replace<br>due to its function as<br>load-bearing                        | -<br>Hardly any built<br>examples found,<br>only with testing<br>and prototyping<br>applicable |
| Non load-bearing<br>Wall   | +/- For a dividing wall in combination with other materials possible (such as timber frames)               | + If not exposed to changing humidity in the interior it lasts long. Protective layer of plaster adds to it. | +<br>Easily removable<br>if damaged or<br>disassembled.                                    | +<br>Very beneficial<br>lightweight dividing<br>wall. Examples by<br>Hiss Reet.                |
| Roof Thatching             | +<br>Good insulation,<br>water repellent   | +/-<br>Dependent on angle<br>of roof, maintenance<br>necessary   | +<br>Easily removable<br>because other layer<br>of building an not<br>covered with plaster | +/- Application is commonly known with lots of built examples. Not suitable for PV             |
| Foundation                 | +/-<br>In combination with<br>biomass it can be<br>used on wetlands  | -<br>A new layer of reed<br>needs to be added<br>because it quickly<br>biodegrades                           | +<br>Easily biodegradable  | Replacement of foundation necessary every couple of months results in high maintenance         |
| Insulation                 | + Thermal conductivity of around 0.05 W/mK comparable to other insulation materials                        | + If not exposed to changing humiditiy it lasts long with a protective layer of plaster.                     | +/-<br>Easily disassembled<br>but dependent<br>on other building<br>elements               | + Good in combination with a loadbearing timber construction as filling element.               |
| Exterior Finish            | +/-<br>Meets requirements<br>the same as roof  | -<br>Needs protecting<br>roof otherwise mould<br>growth is fast  | +<br>Easily removable<br>because other<br>building layer                                   | +/-<br>More resistant<br>facades give building<br>a longer lifepan                             |
| Interior Finish            | +<br>Pleasant climate,<br>good acoustic<br>qualities, normally<br>flammable                                | +/-<br>At walls not resistant<br>to damage and dirt,<br>on ceiling more<br>beneficial                        | + Loose material that<br>can be biodegradable<br>and replaced                              | +<br>Good natural sound<br>absorber results in<br>a comfortable inner<br>atmosphere            |

# Traditional Roofthatch



# Innovative Roofthatch



# Bamboo structure

# Spanish Reed Structure



Material Tests

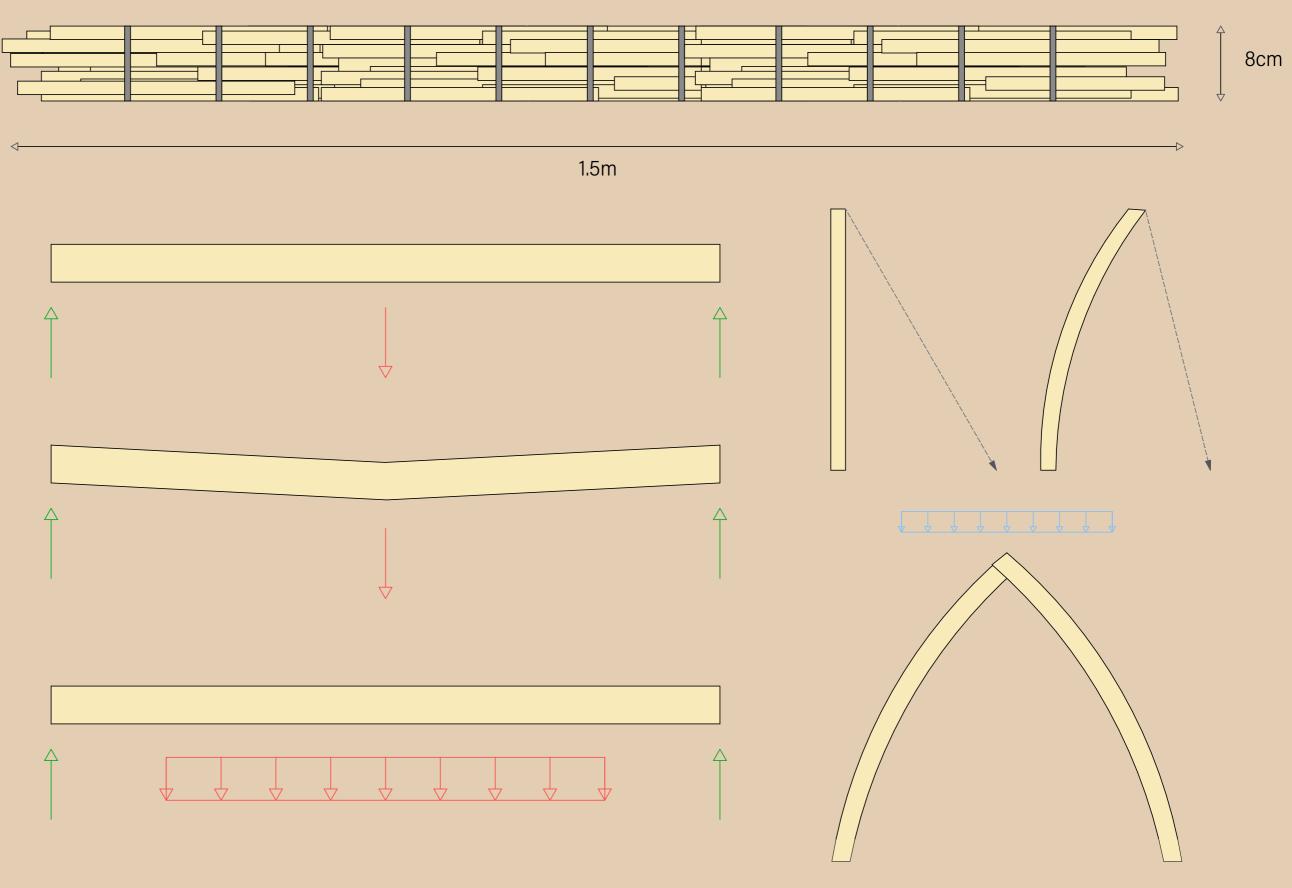
Tradition + Innovation

### Reed Beam

Diameter: 80 mm Length: 1500 mm Weight 1400 g Max load: 5000 g

Material: 1/2 reed bundle

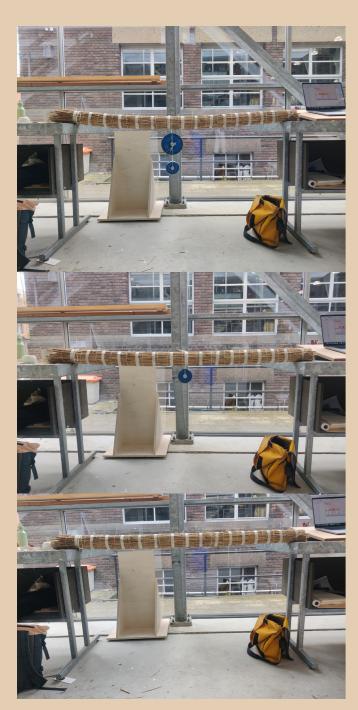


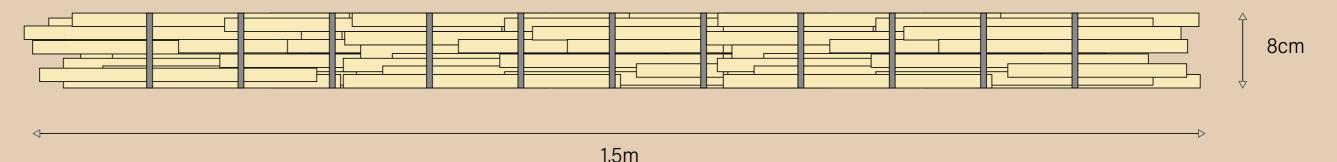


### **Reed Beam**

Diameter: 80 mm Length: 1500 mm Weight 1400 g Max load: 5000 g

Material: 1/2 reed bundle





# Assembly

#### **Duration**

2 hours

#### Material

Robe, tongs, cylinder, reed bundle

### Method

cylinder gets filled with small reed stems and then always pushed further and filled with more reed to have the beam equally dense everywhere

#### Reflection

Easy and light material to handle, no machine necessary and quite fast, could be optimised by machine

### Reasoning

Good method to use smaller reed stems that are sorted out from the roof thatch. Stems of all sizes are used

### **Features**

#### Weakness

- Material reed itself is not stable enough, dependent on how it is tied together. Tape makes reed more stiff than robe.
- Good straps are essential to the success of the beam
- Linear load is better than a single load

### **Flexibility**

- Well bendable also during assembly
- -> opportunity for arches

### **Diagonally**

Not suitable for diagonal beam with single load, bends easily

### **Elasticity**

Beam can be easily straightened again, has tension on it

# Steps for Design

#### **Reed Arches**

Use material in an arch form that gives the material a certain tension and stability

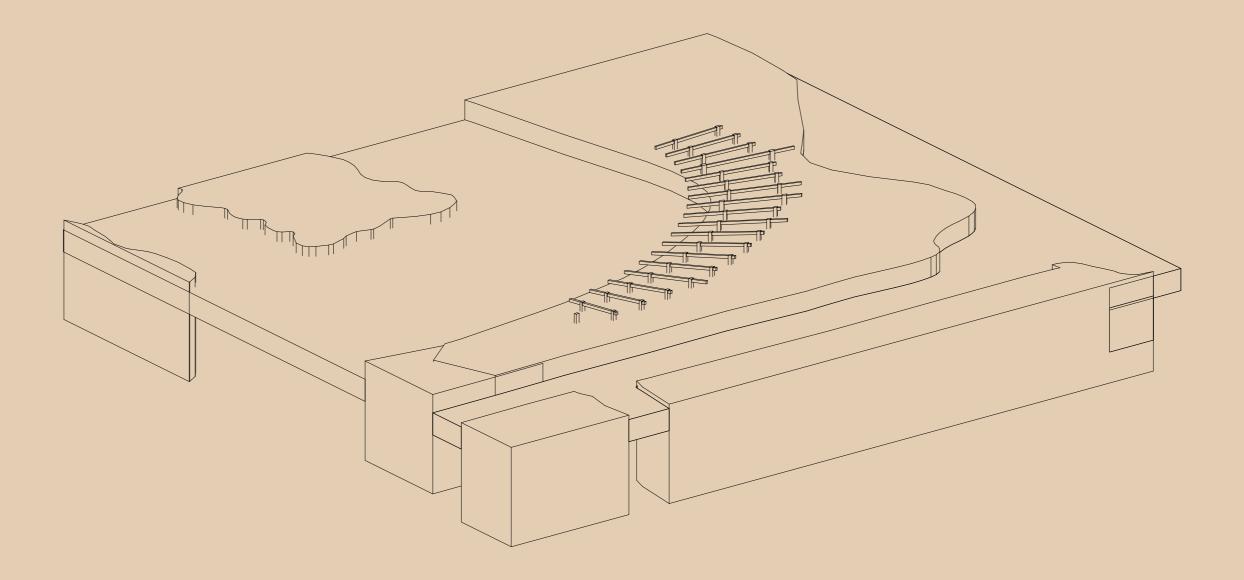
An arch is less vulnerable to loads than a straight or a diagonal beam

### Straps

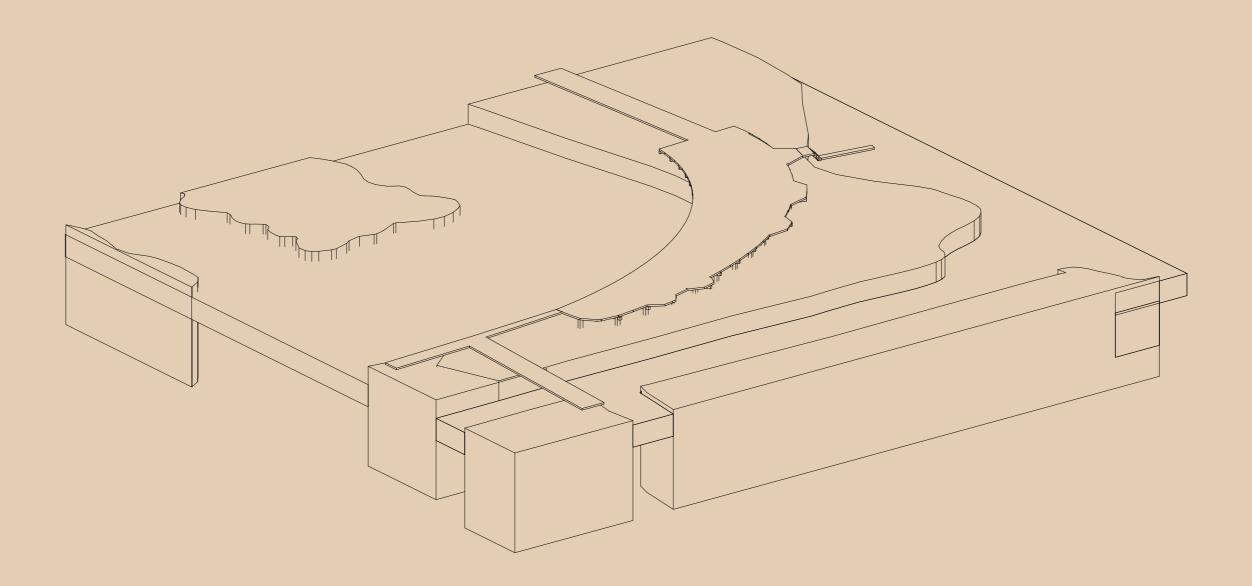
The success of the arch is dependent on its straps, it needs to be well tied together

#### **Attachment**

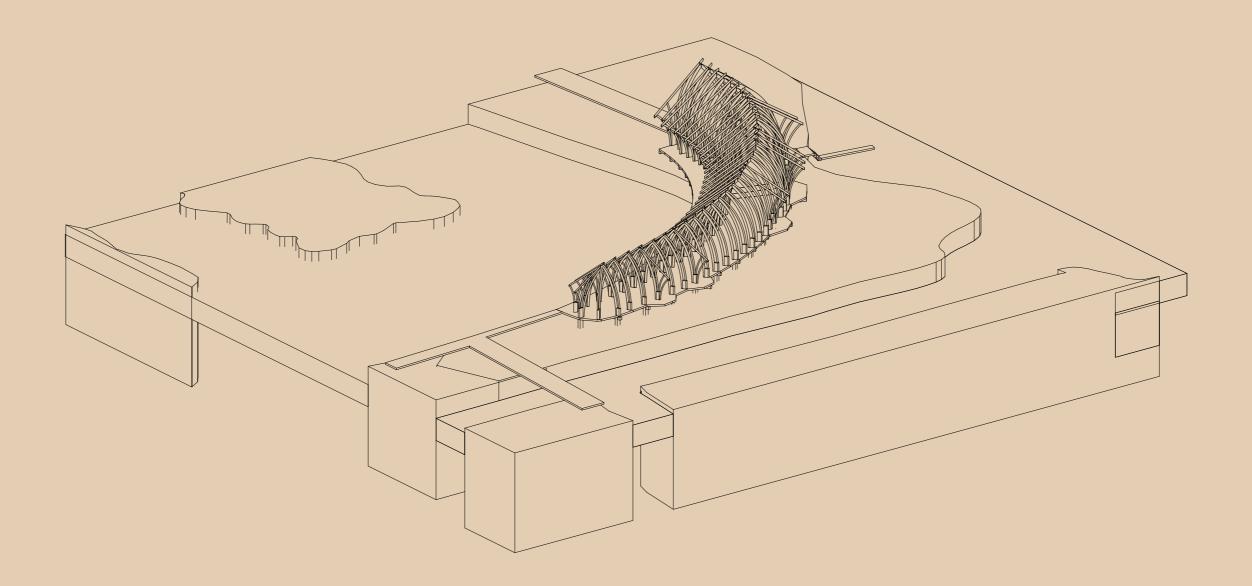
How to attach the arch to other building elements is crucial to direct the load of the roof into the foundation Step 1 - Foundation Tradition + Innovation



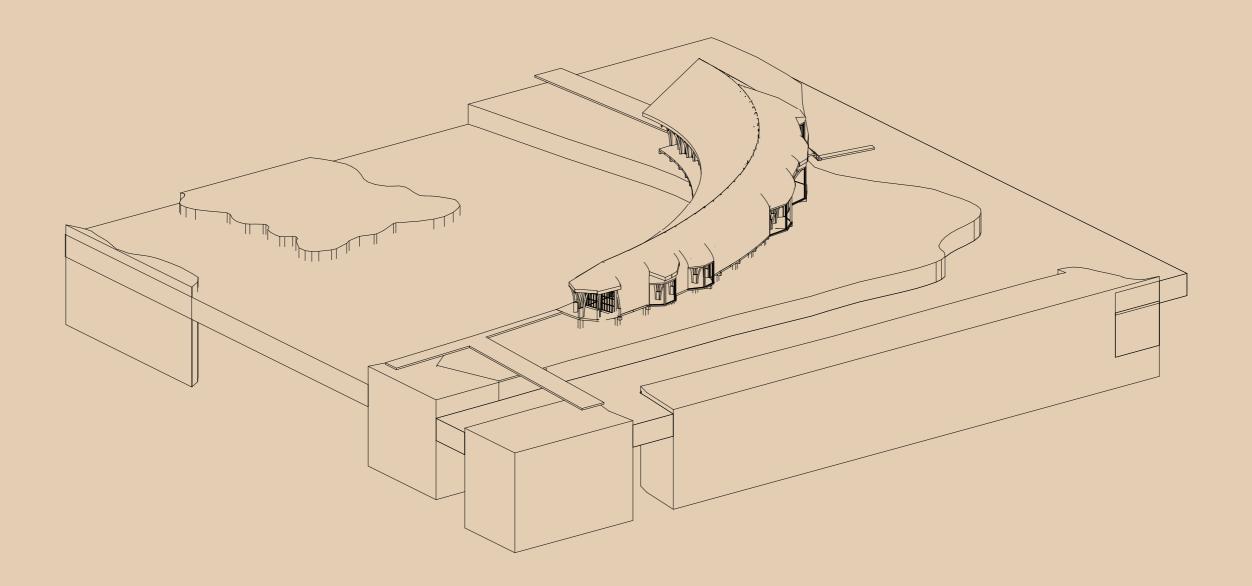
Step 2 - Floors Tradition + Innovation



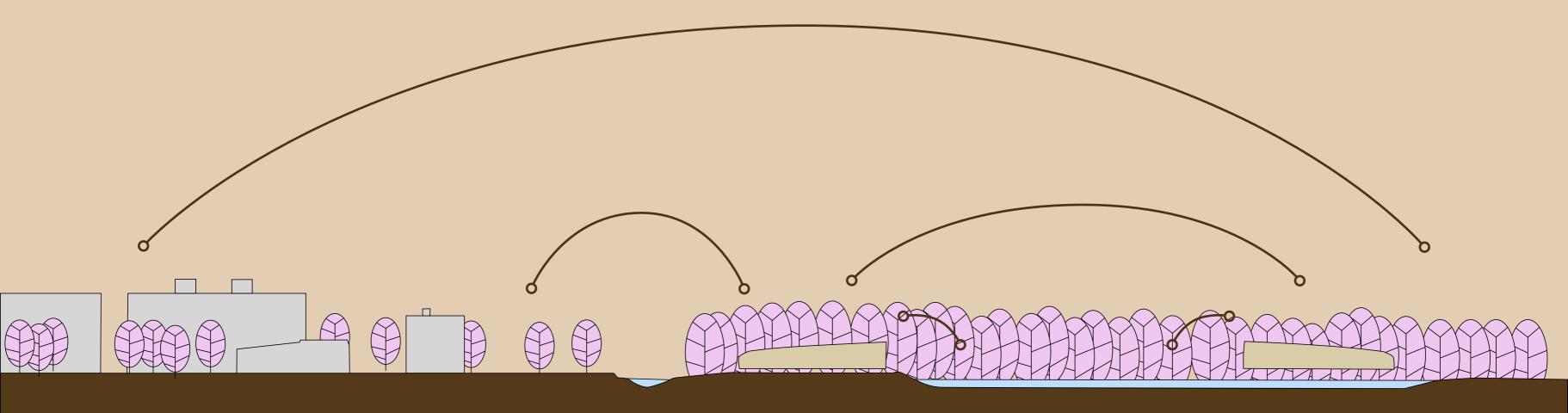
Step 3 - Reed Arches Tradition + Innovation

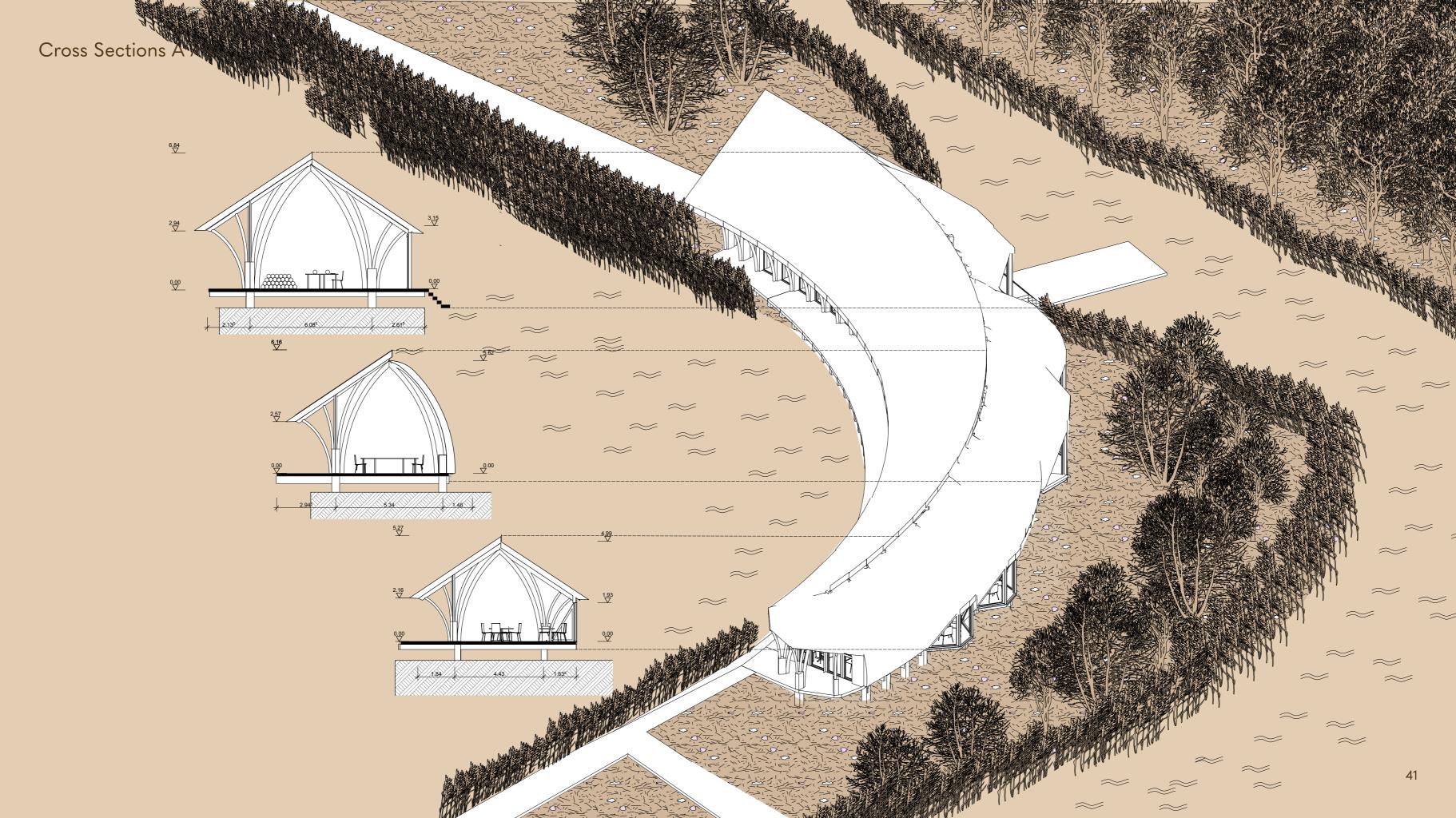


Step 4 - Roof Tradition + Innovation

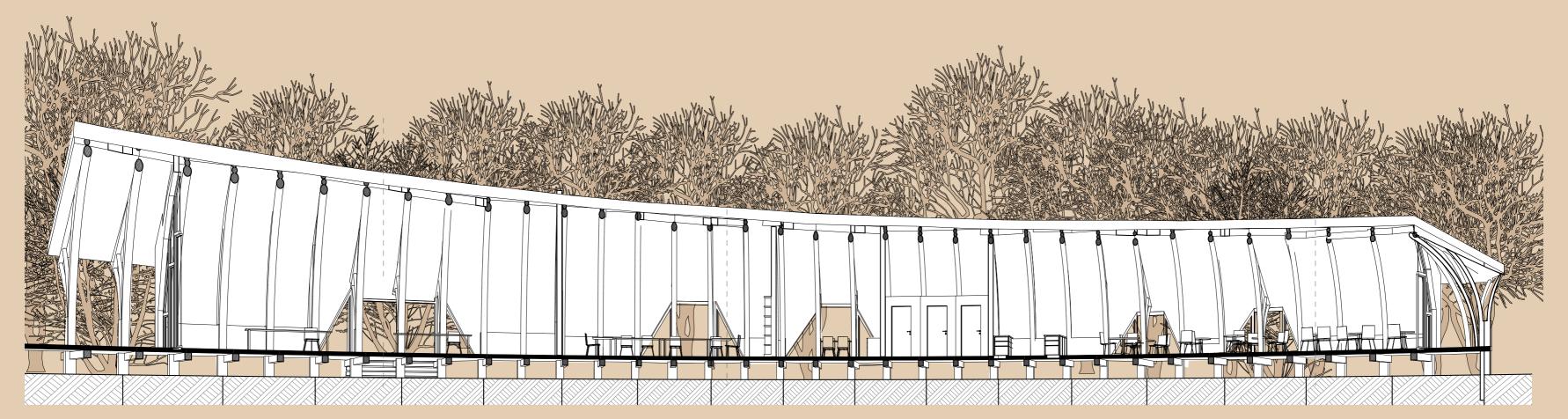


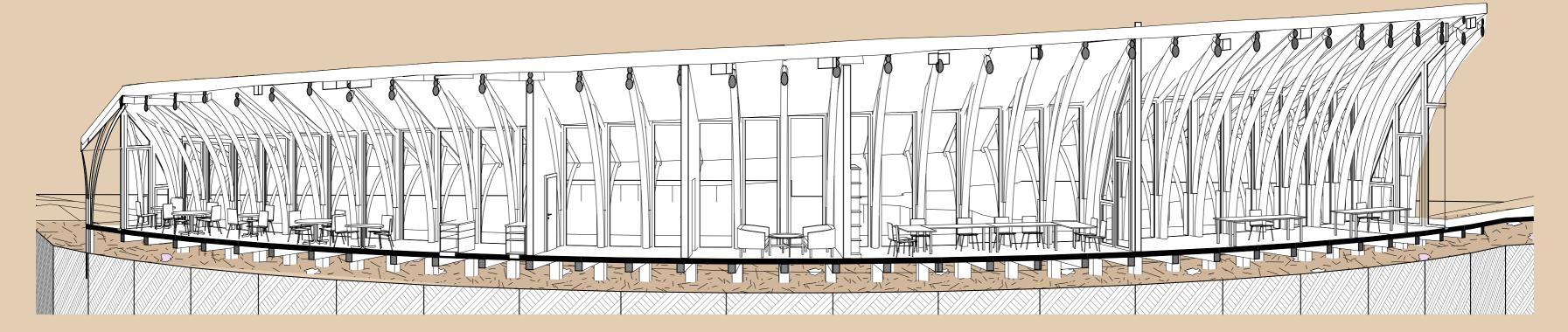
### Nature



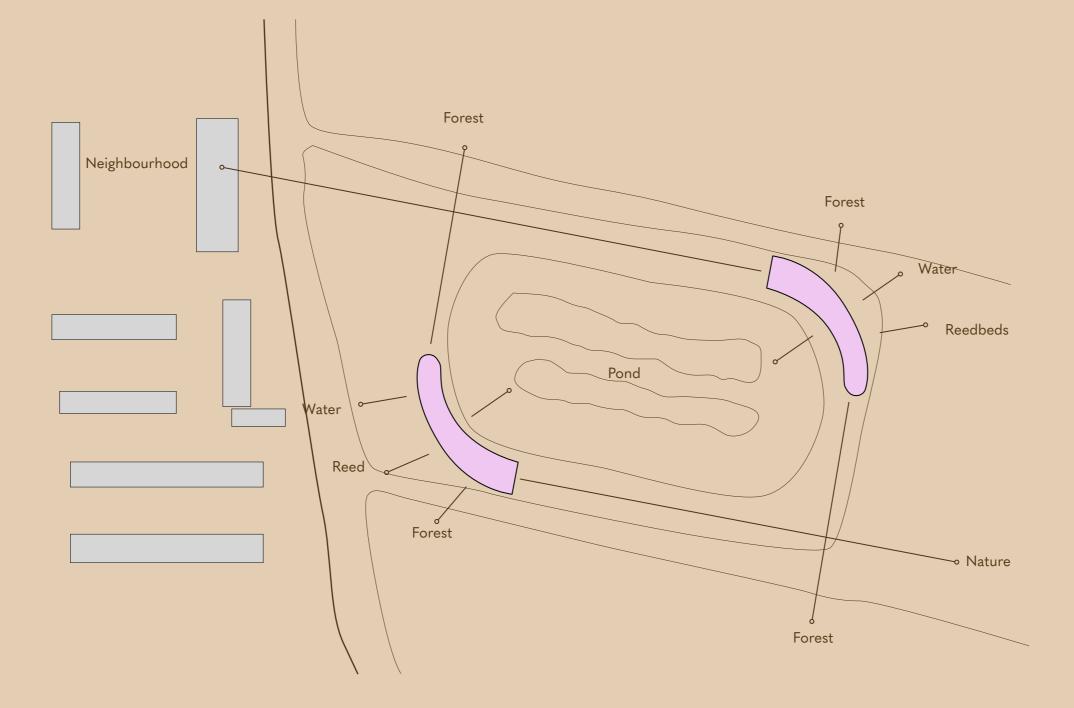


Longitudinal Sections Nature Pavilion Nature + Neighbourhood

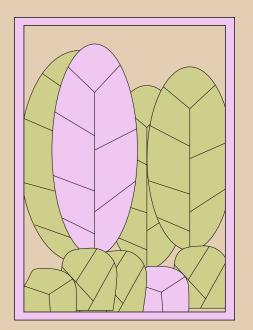


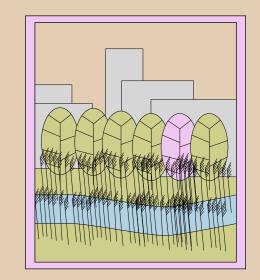


## View diagram

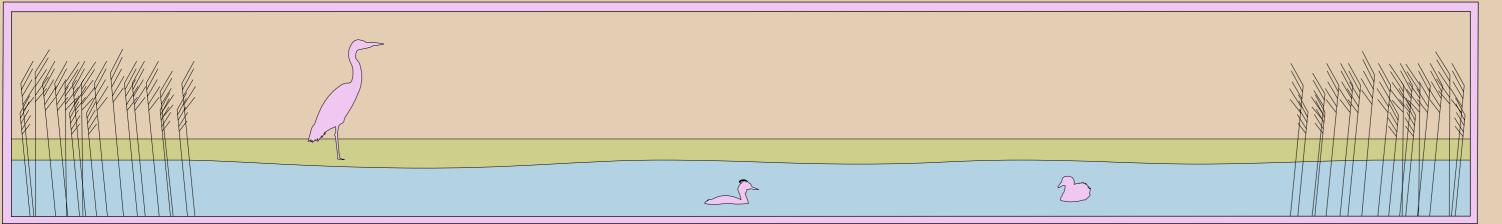


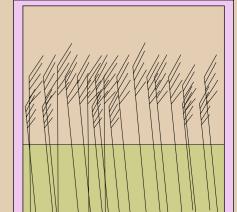
#### Selective







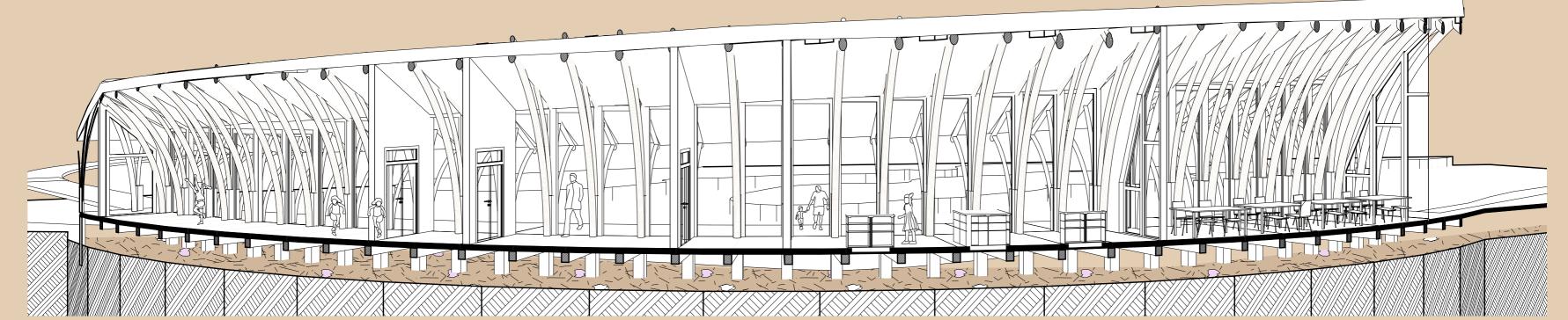




Longitudinal Sections Activities Pavilion

Nature + Neighbourhood

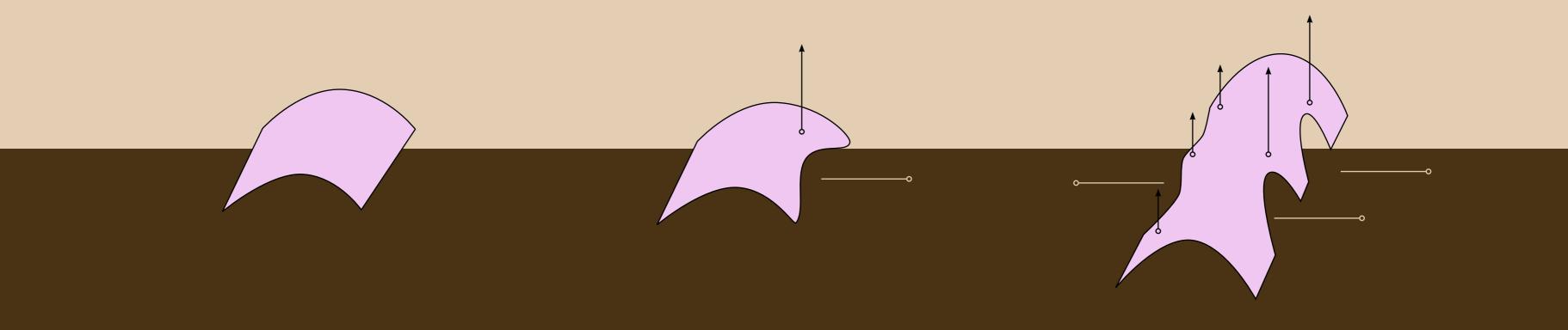








## Lifting the Reed Blanket

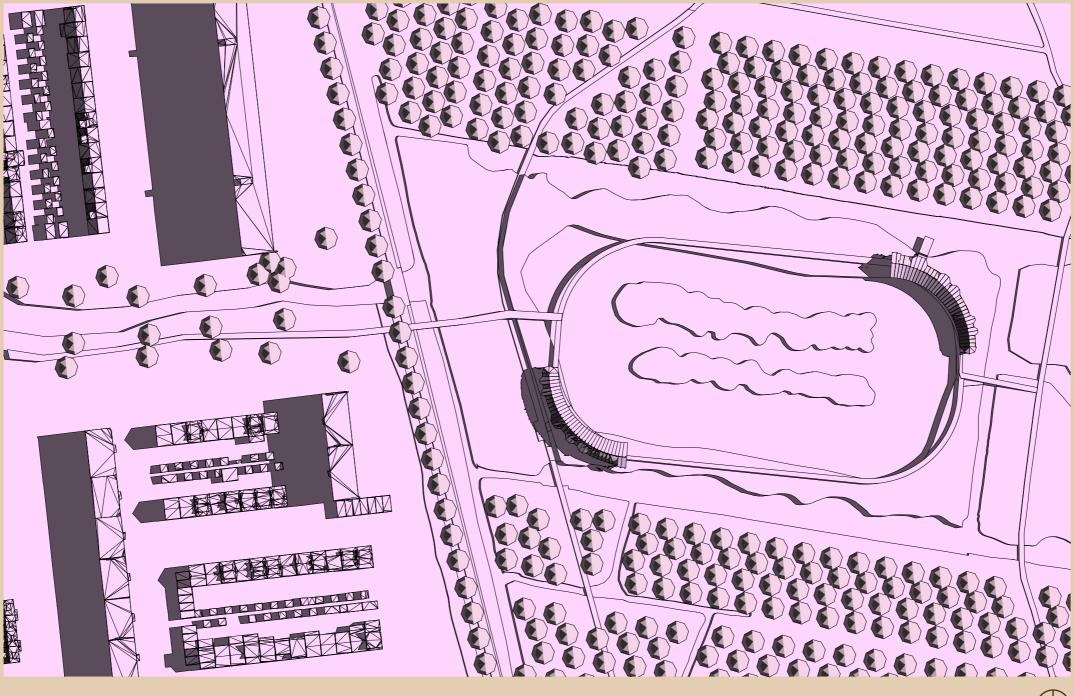


Elevations Reed blanket



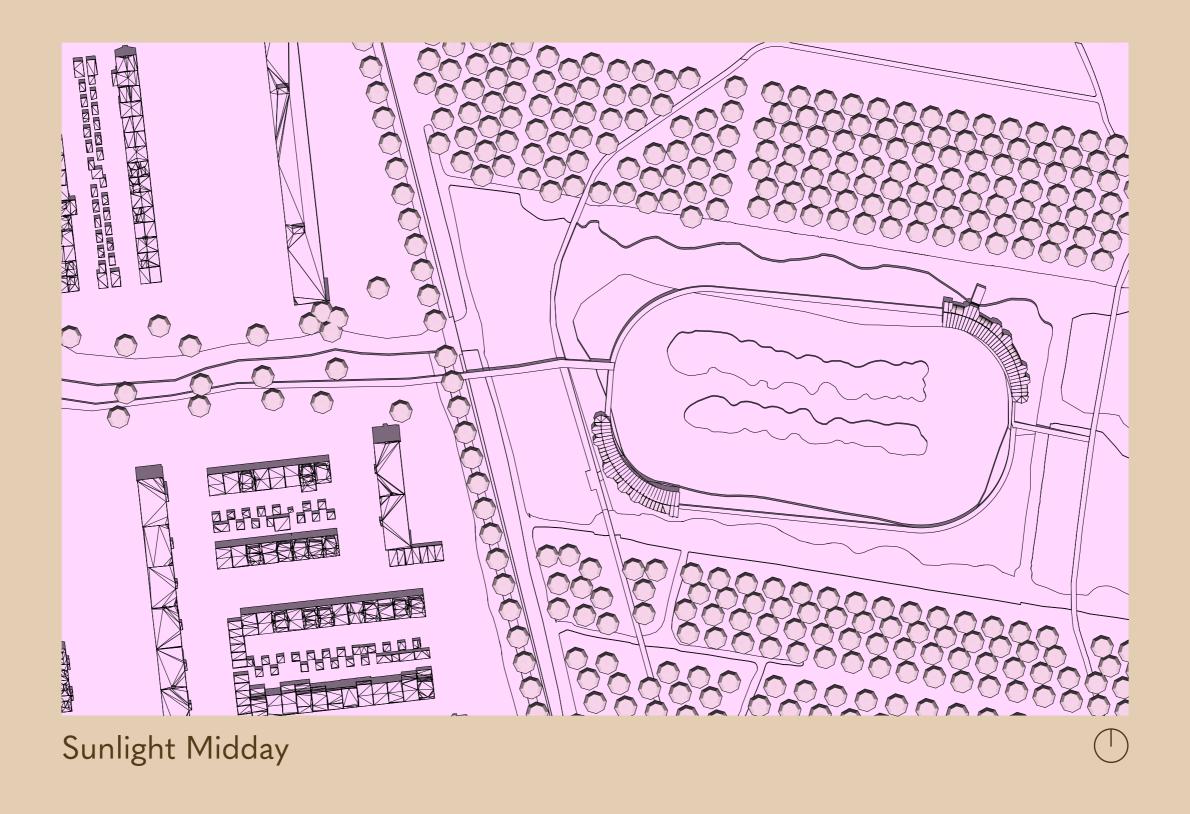


Orientation Reed blanket

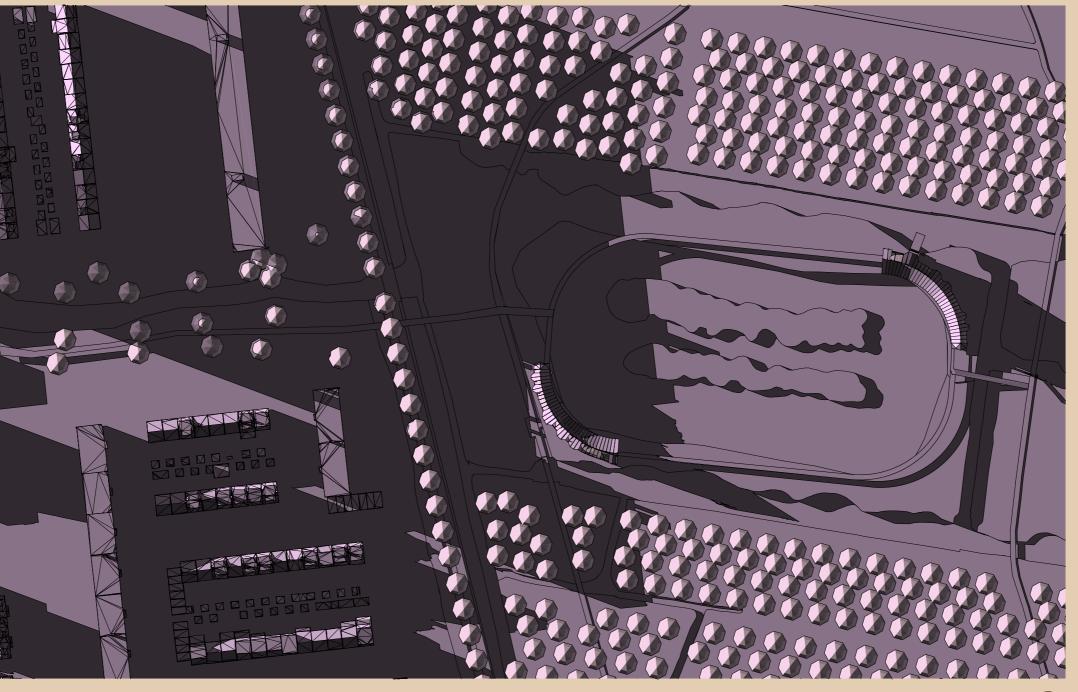


Sunlight Morning

Orientation Reed blanket



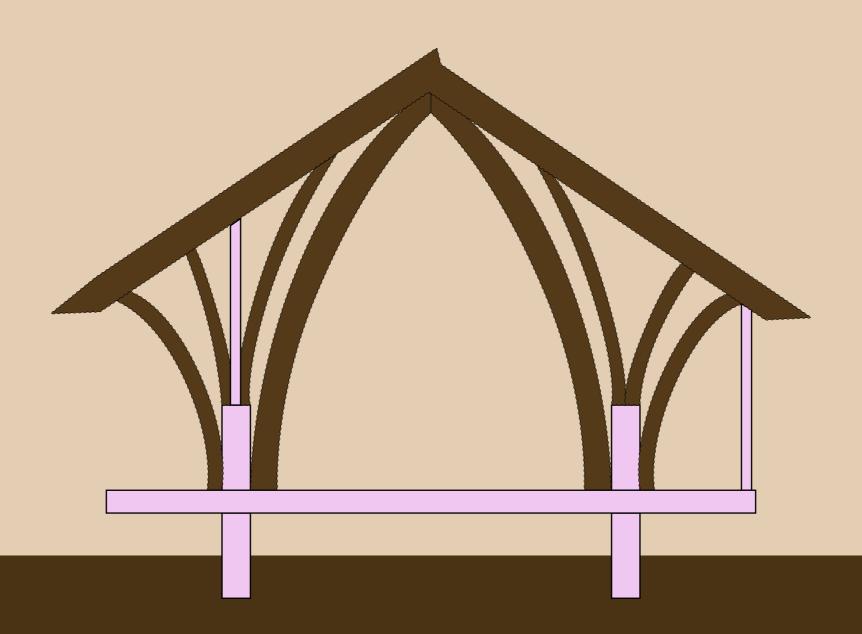
Orientation Reed blanket



Sunlight Evening

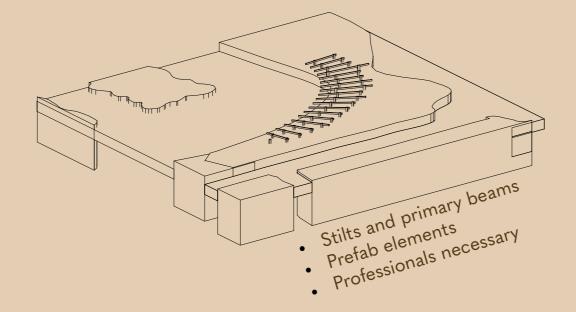


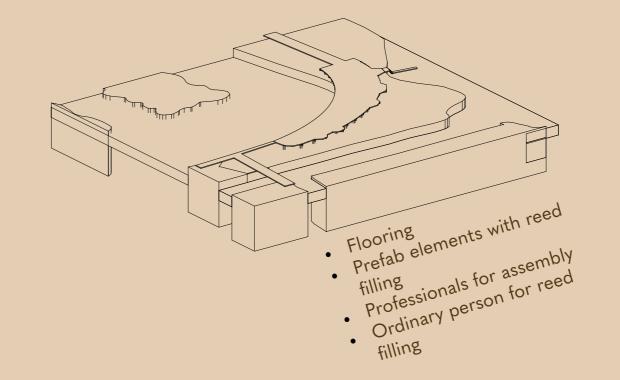
The Flexible



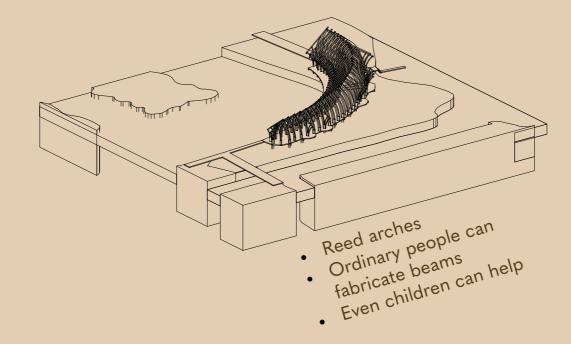
Building Stages Hybrid Building

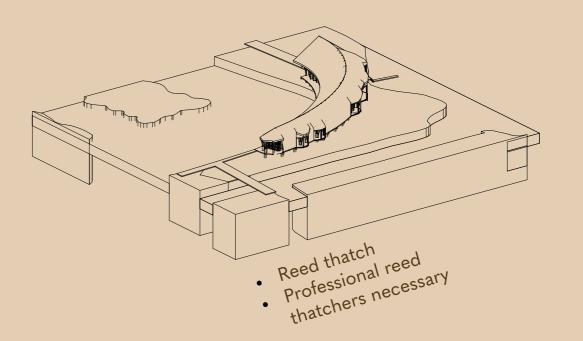
The Non-Flexible

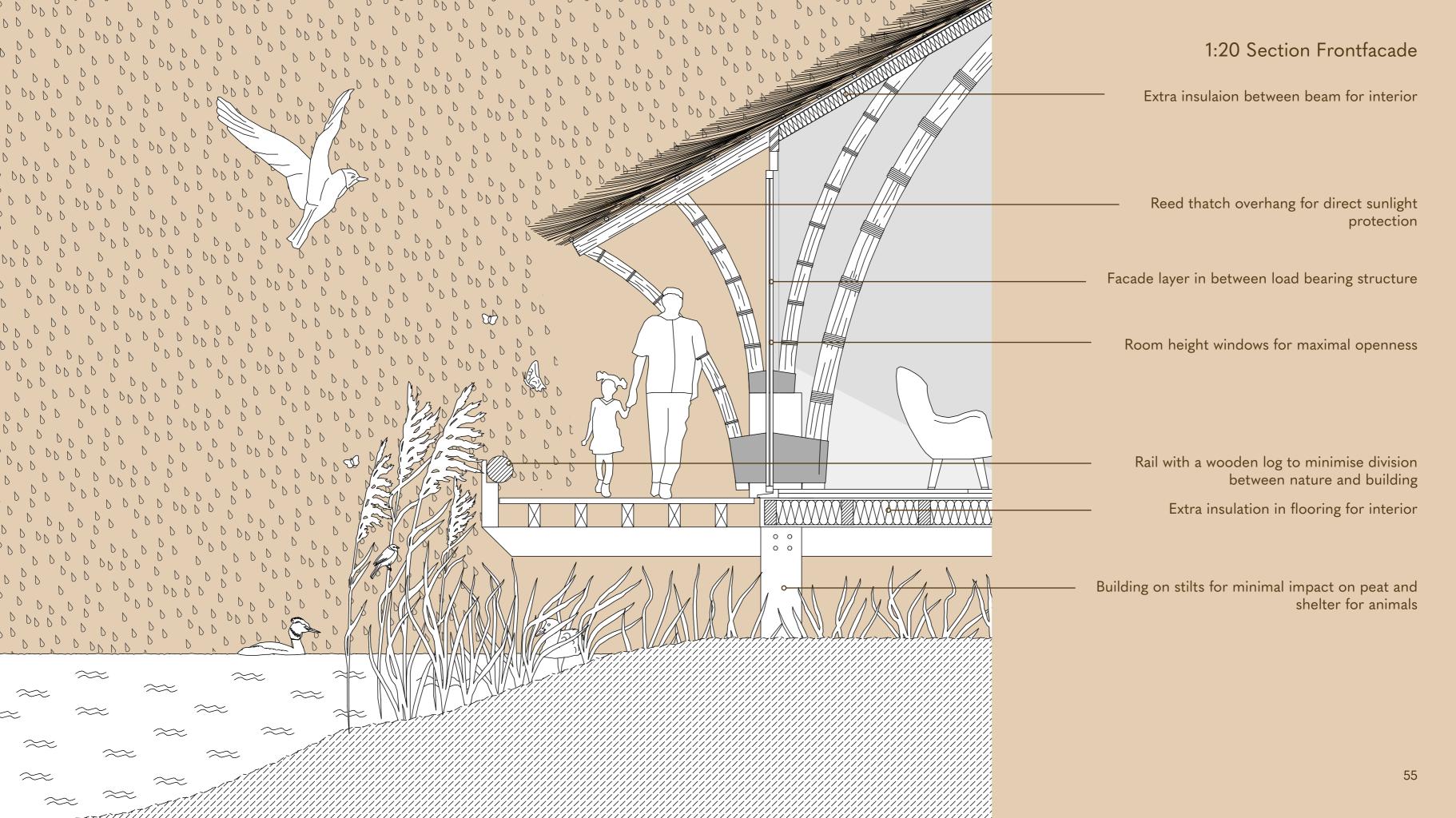




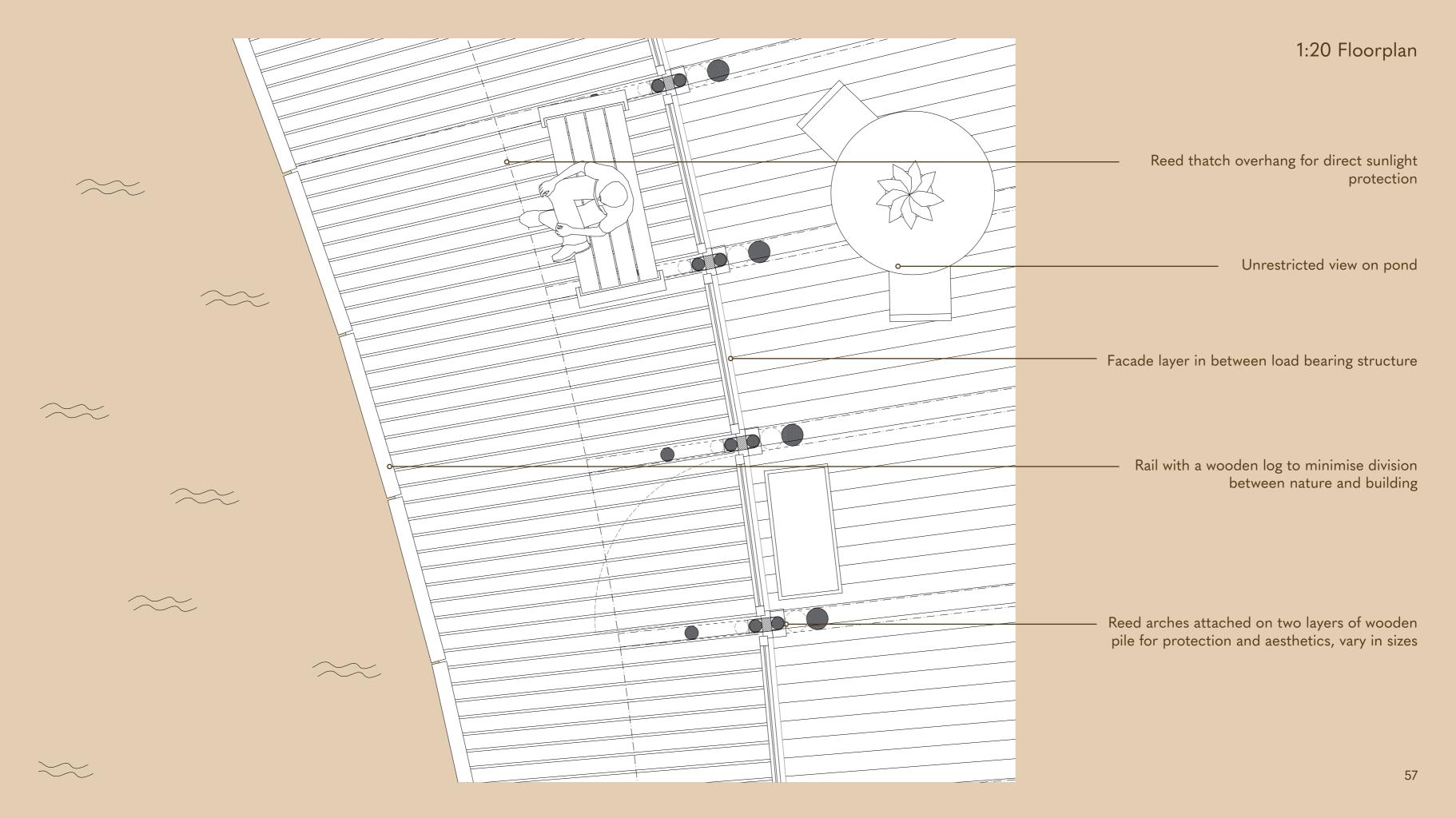
The Flexible







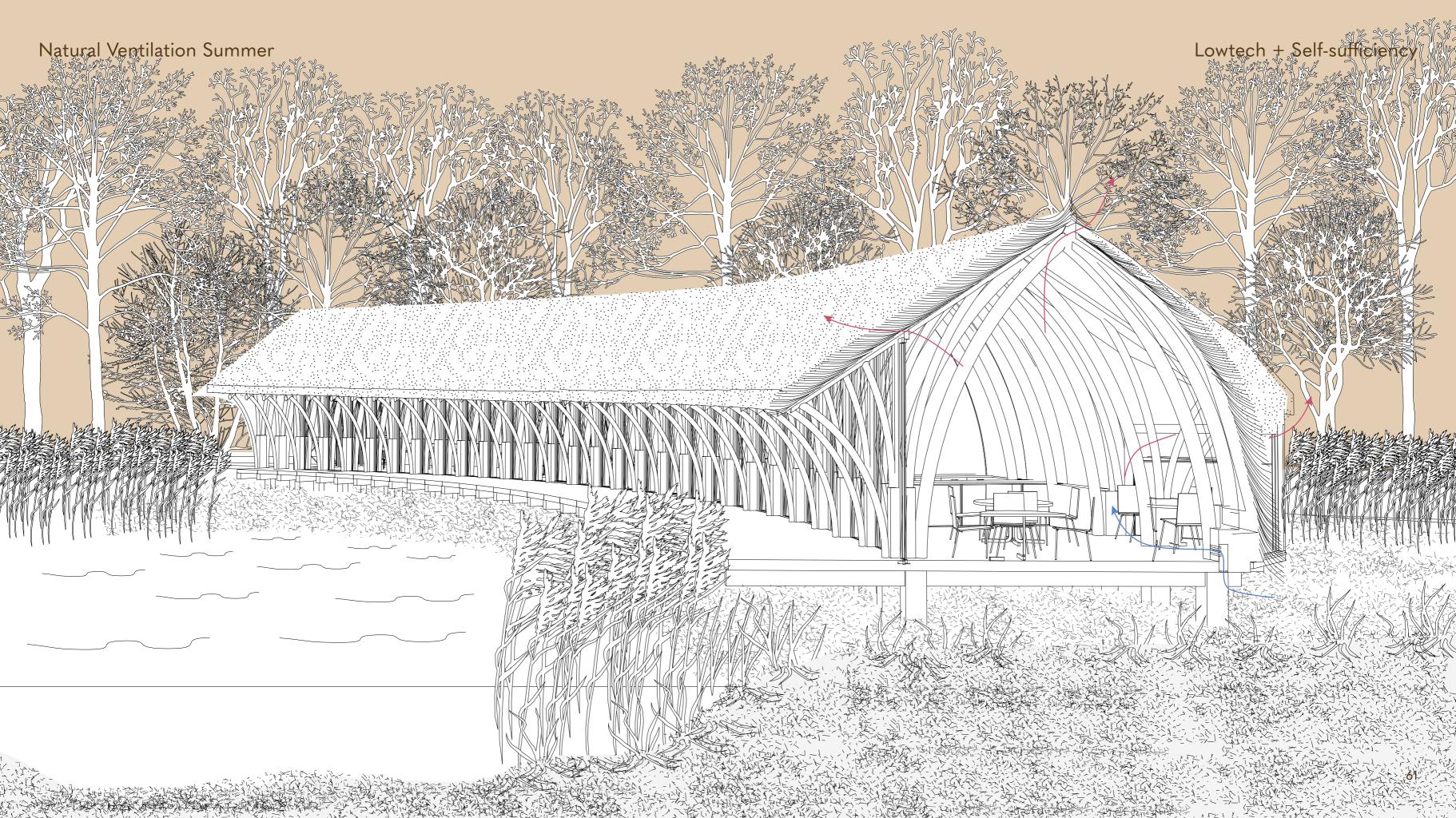


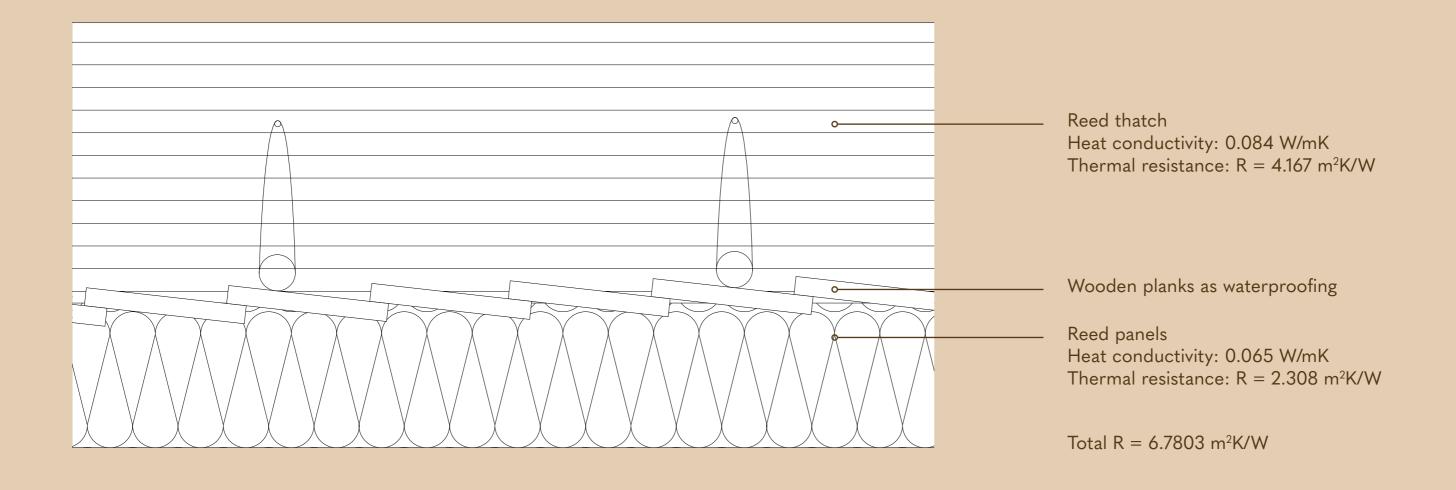


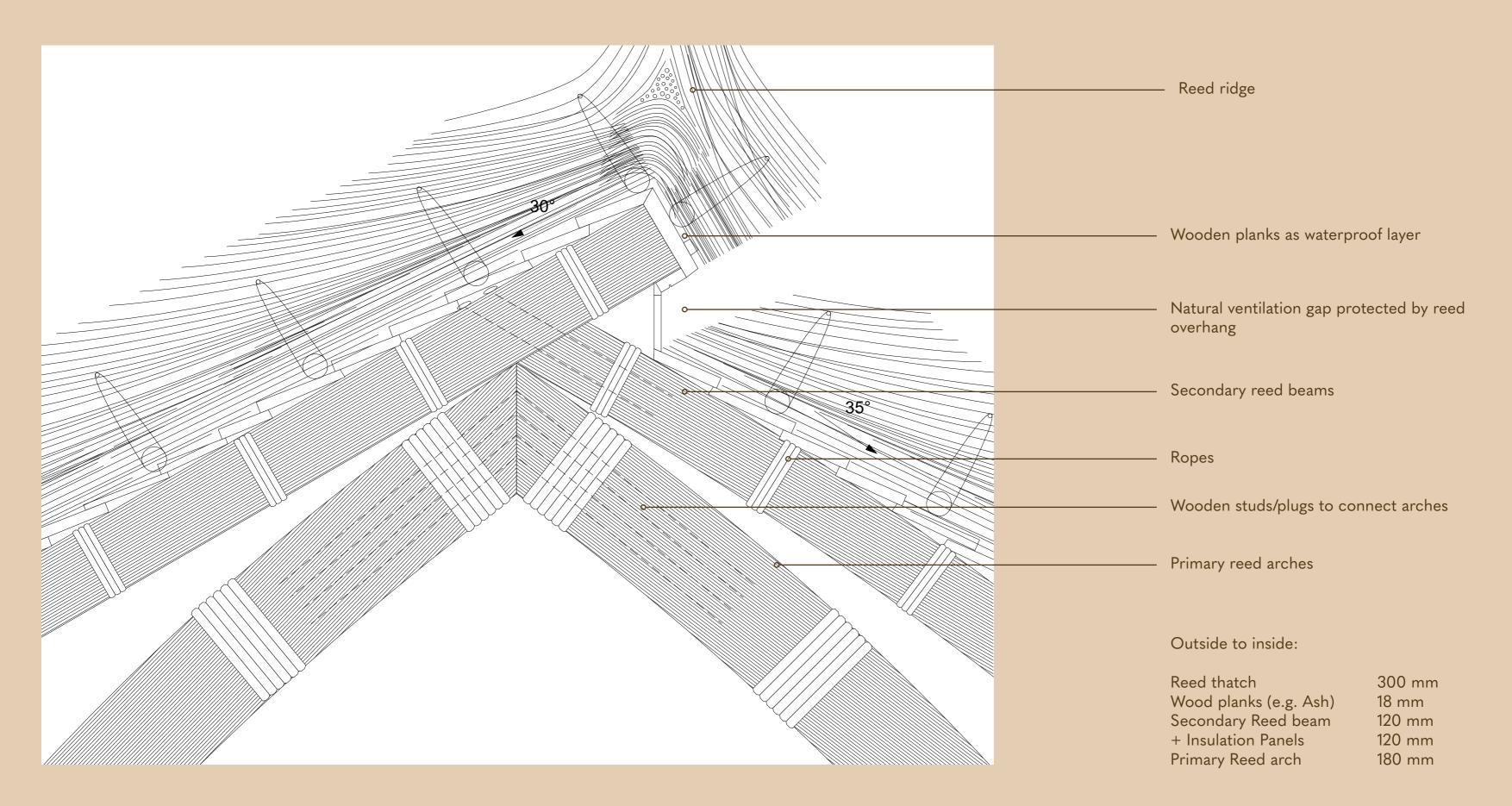
# 1:20 Section Backfacade Lighting around the arches Multifunctional stud for arch support, ducts, wires, electricity, table PV panels in glas of window

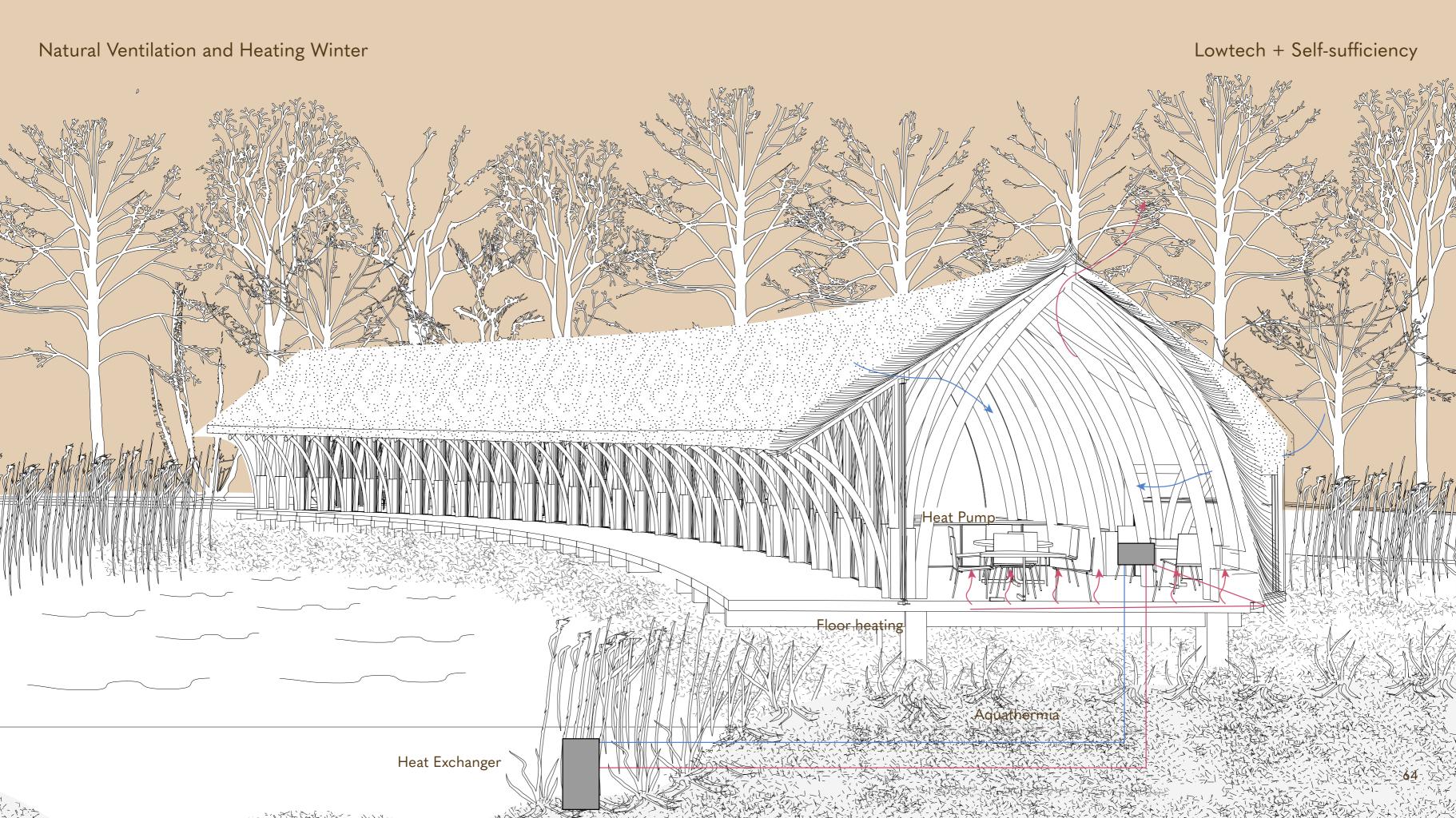




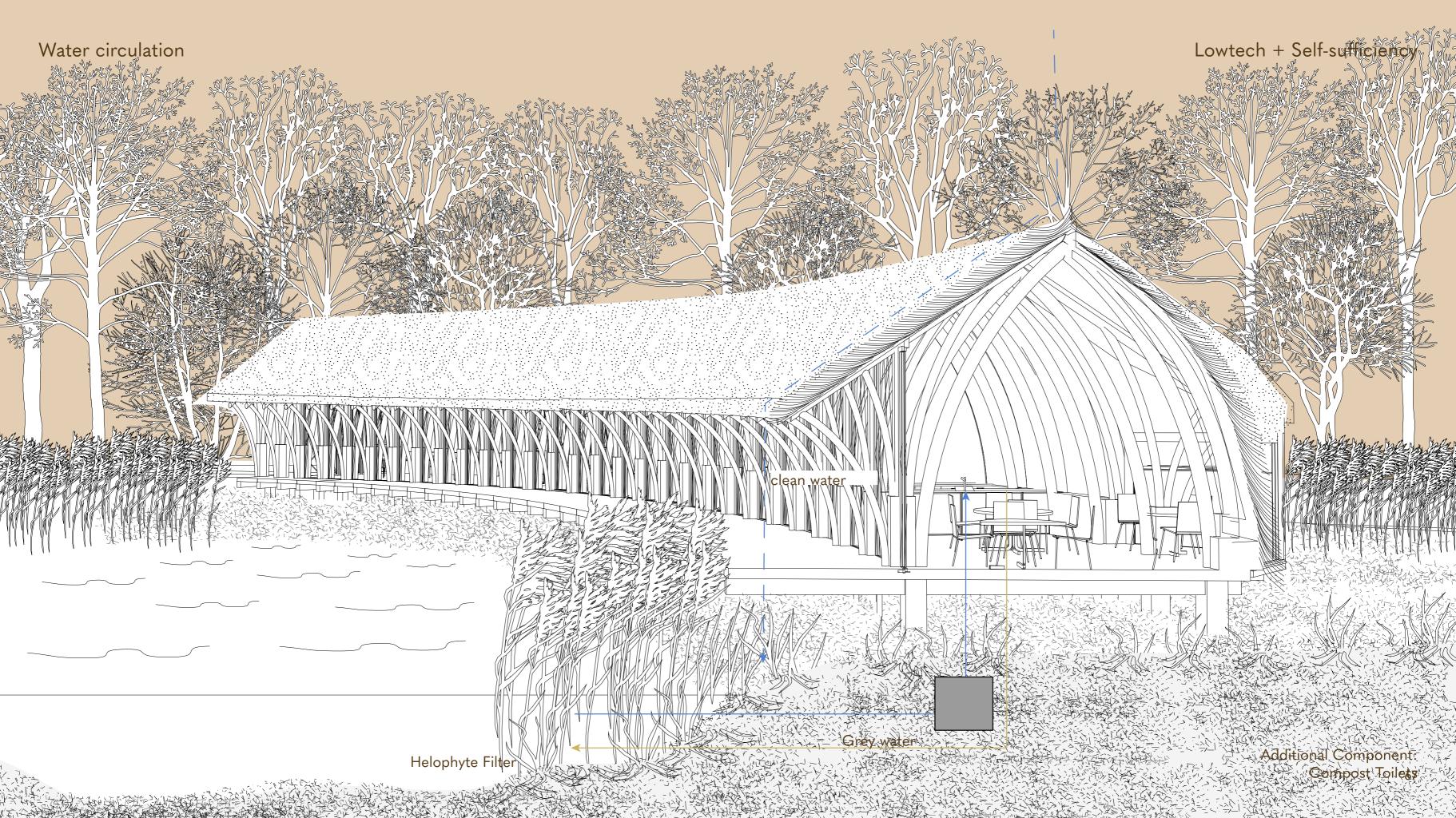




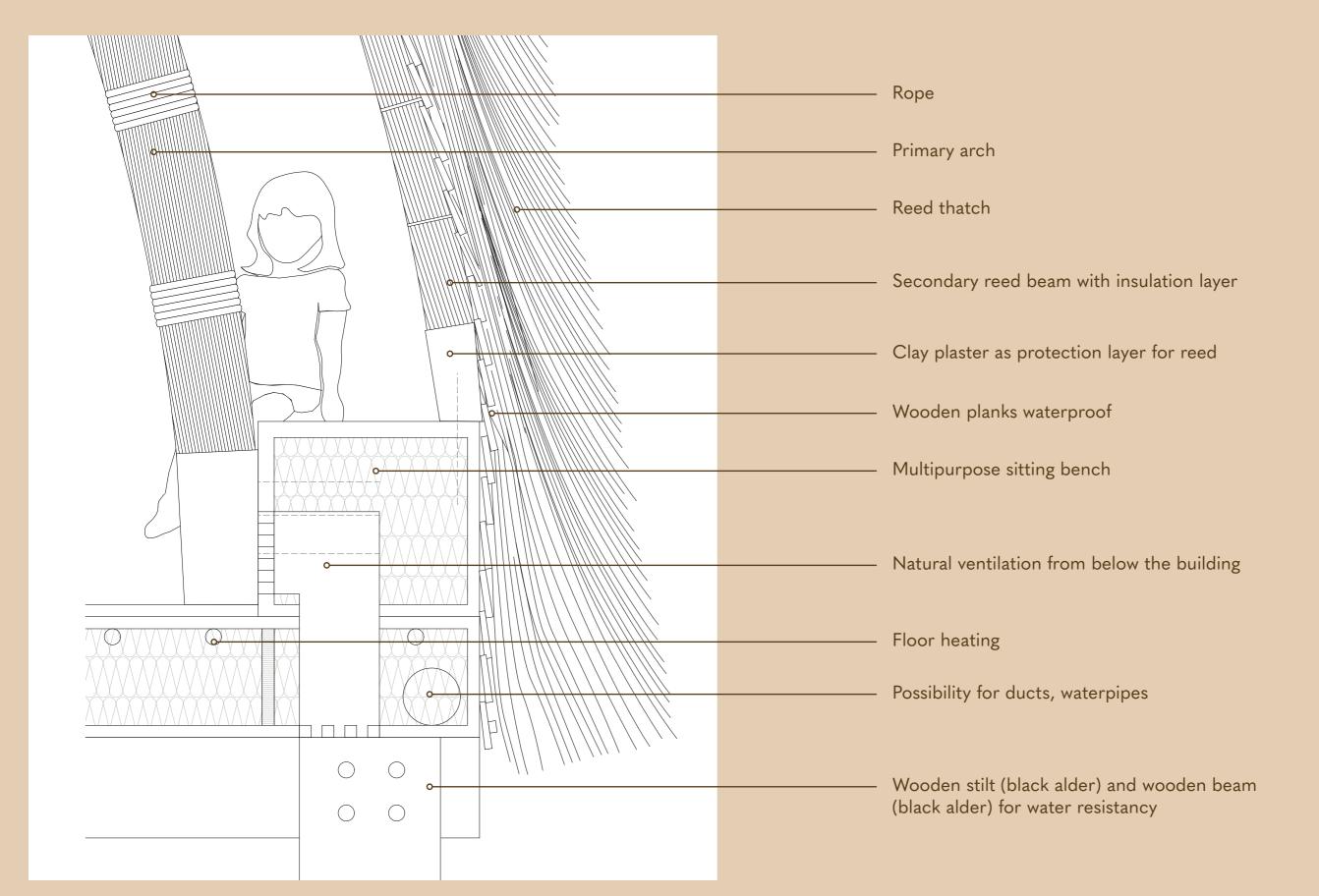








Detail 1:10 Bench Lowtech + Self-sufficiency





Reed



Common Ash



Clay Plaster



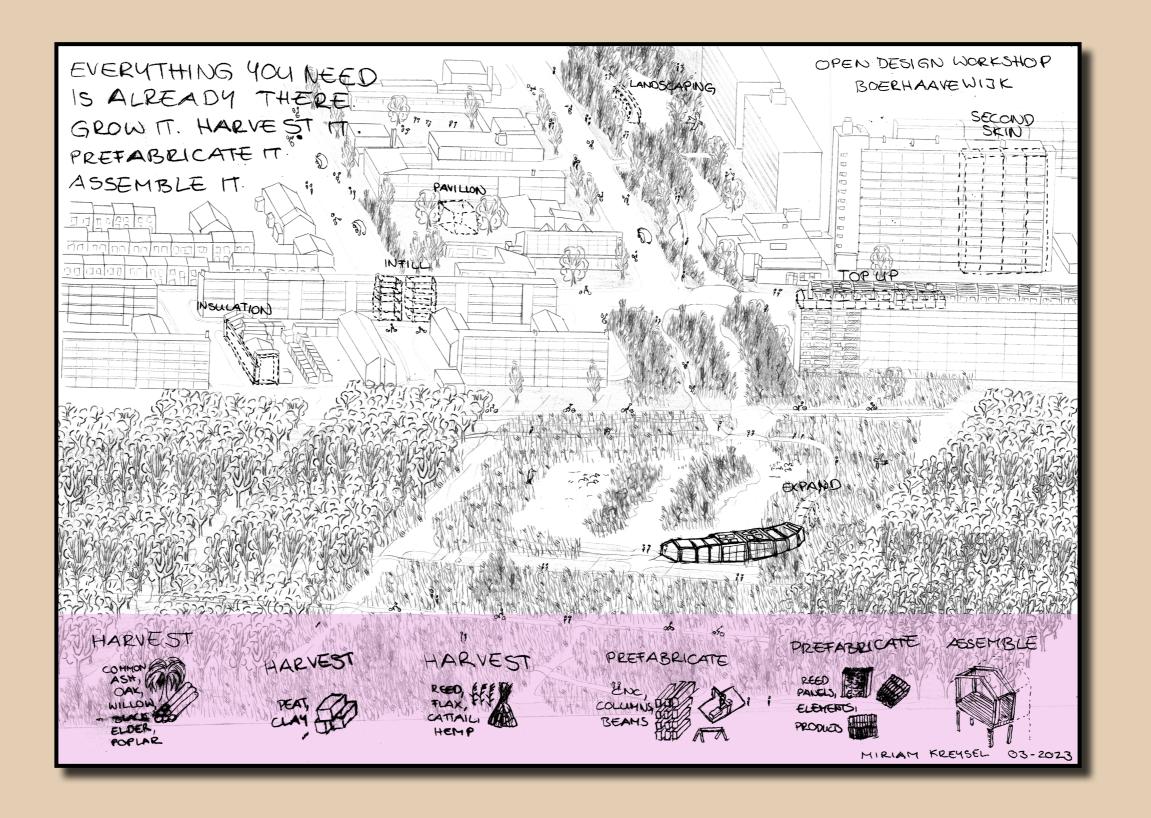
Hemp Rope



Black Alder







Retrofitting Boerhaavewijk

Urban Section in the Future



