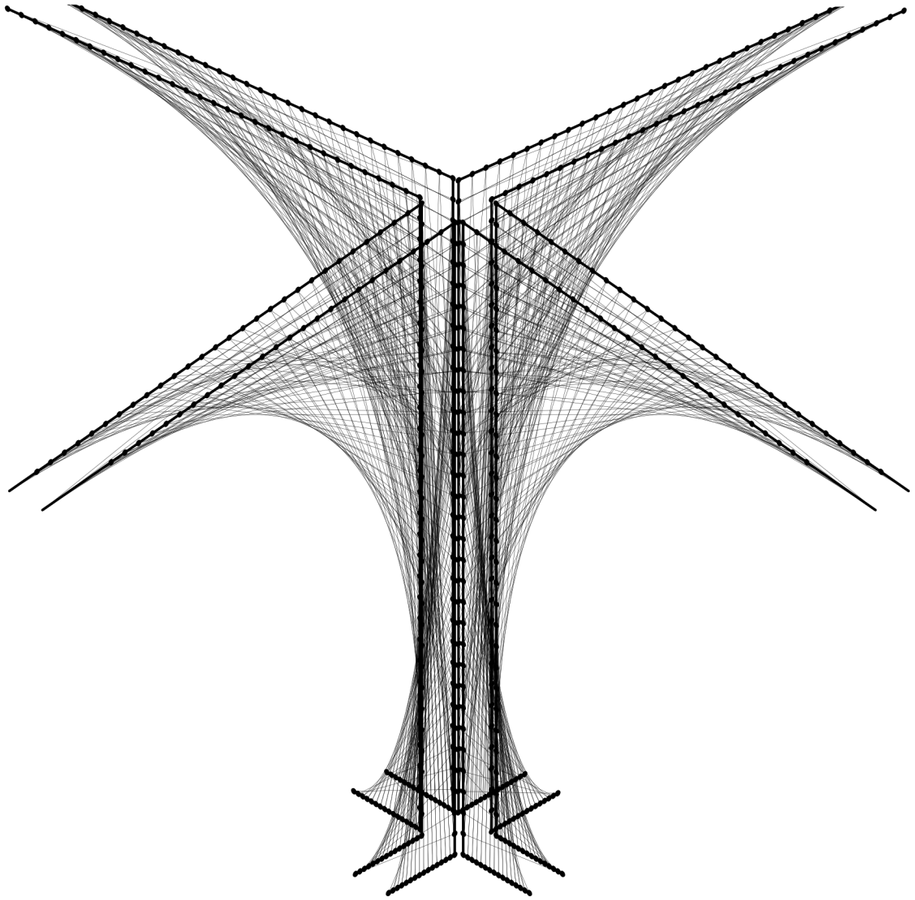


BIOWOUND.

biofiber research laboratory

concrete, steel, brick, and timber ?

challenge in sustainable building materials

A variety of sustainable building materials is needed.

Despite the abundance of sustainable building materials, such as hemp and flax, there is an underutilization in the construction industry.

fig.01: biobased principle

fig.02: various properties

fig.03: expression of form

How can biofibers, such as hemp and flax, be integrated in a sustainable architectural construction?

1. *How can this implementation be achieved while addressing forthcoming challenges related to climate change and rising sea levels in the Hunze River Valley?*
2. *How can this be utilized to enhance awareness and promote education regarding the benefits and applications of biobased materials?*

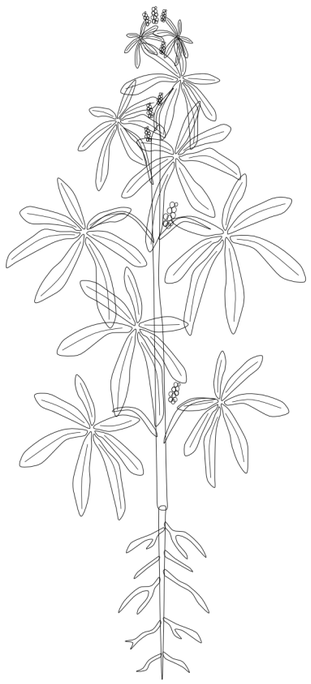


fig.04: cannabis sativa l.

filler material

structural material

fig.05: linum usitatissimum

MATERIAL	youngs modulus (MPa)	compressive strength (MPa)
steel	210 000	350 - 1 000
concrete	20 000	12 - 80
brick	10 000 - 25 000	25 - 60
wood	230 - 20 000	4 - 34
lime hempcrete	**24**	**0.4**

MATERIAL	density (kg/m2)	thermal conductivity (W/M°C)
steel	7 500 - 8 500	52.00
concrete	20 000	1.50
brick	1 300 - 1 700	0.27 - 0.96
wood	350 - 900	0.12 - 0.30
lime hempcrete	**445**	**0.17**

WALL THICKNESS (mm)	120	300	350	400
u-value hempcrete (W/m2K)	**0.54**	**0.20**	**0.17**	**0.15**
u-value concrete (W/m2K)	3.50	1.40	1.20	1.00
u-value timber (W/m2K)	1.20	0.50	0.40	0.35
u-value rockwool (W/m2K)	0.45	0.18	0.15	0.13

fig.06: mechanical properties hempcrete

FIBERS	relative density (G/cm3)	elongation at failure (%)
carbon	1.7-1.9	0.4-1.9
glass	2.5-2.7	1.8-5.4
flax	**1.4-1.5**	**1.2-3.3**
hemp	1.4-1.5	1.0-3.5
jute	1.3-1.49	1.0-1.8
oilbased resin	1.1	7.0-10.0
biobased resin	1.09	5.0

FIBERS	elastic modulus E (Gpa)	tensile strength (Mpa)
carbon	230-250	2000-3000
glass	70-76	2000-3500
flax	**27.6-103**	**343-2000**
hemp	23.5-90	270-900
jute	26-43	320-800
oilbased resin	3-6	60-125
biobased resin	3.2	67.5

FIBERS	energy intensity (MJ/kg)	global warming potential (GWP)
carbon	183-459	16.38
glass	13-51	2.95
flax	**6.5-9.55**	**0.437**
hemp	8.9	0.531
jute	9.6	0.57
oilbased resin	76-80	4.7-8.1
biobased resin	49	4.08

fig.07: mechanical properties flax fibers

01

fig.08. compressed block

cast in form

02

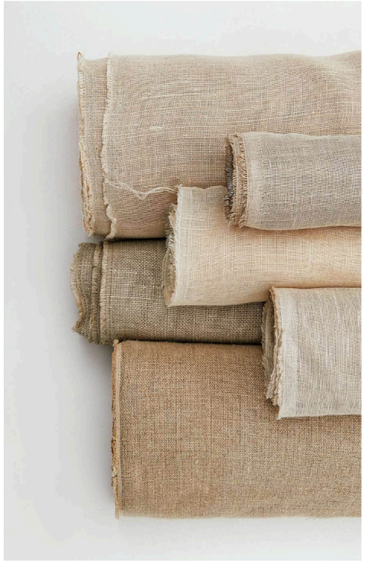


fig.09. Linen / hemp textile

textile / webs

03

fig.10. vacuum pressedfiber sheet

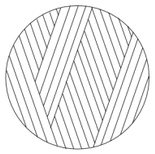
fiber sheet

04

fig.11. coreless filament winding

spun yarn

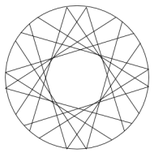
filament winding on mandrel



surface-based

fully covered layers

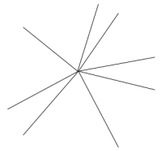
coreless filament winding



surface-based

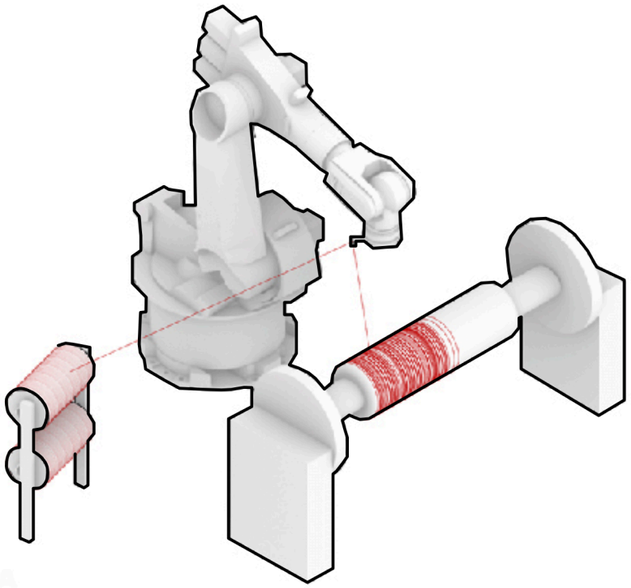
layered fibers

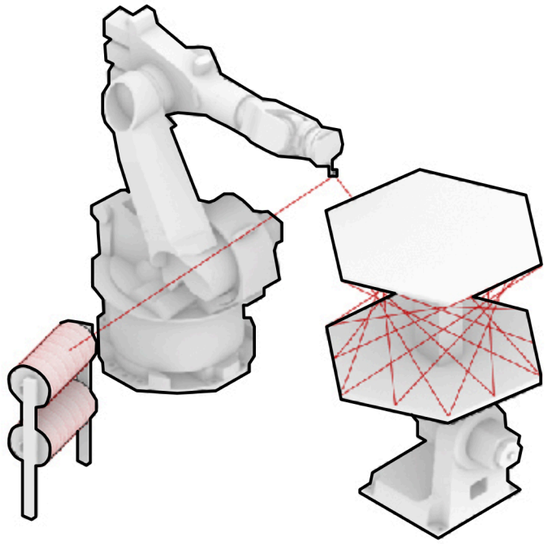
spatial winding



spatial structure

interlocked fibers





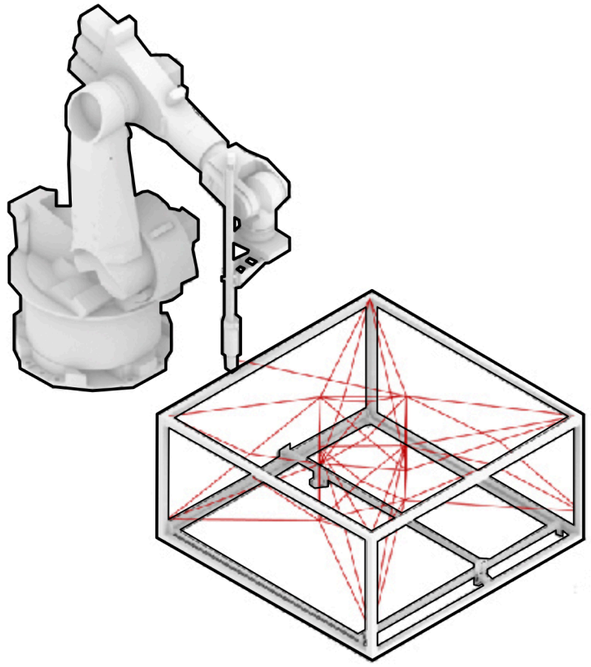
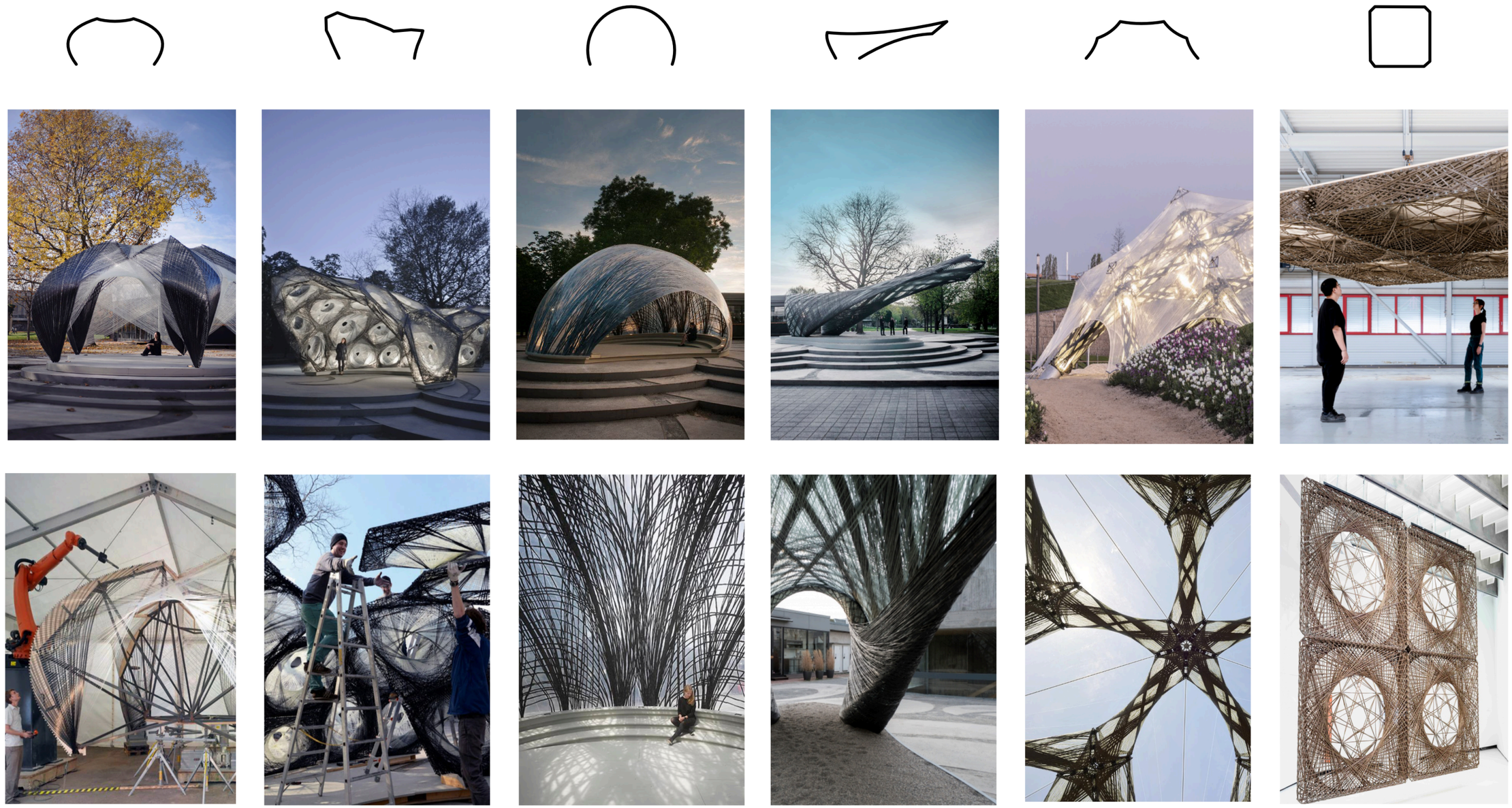
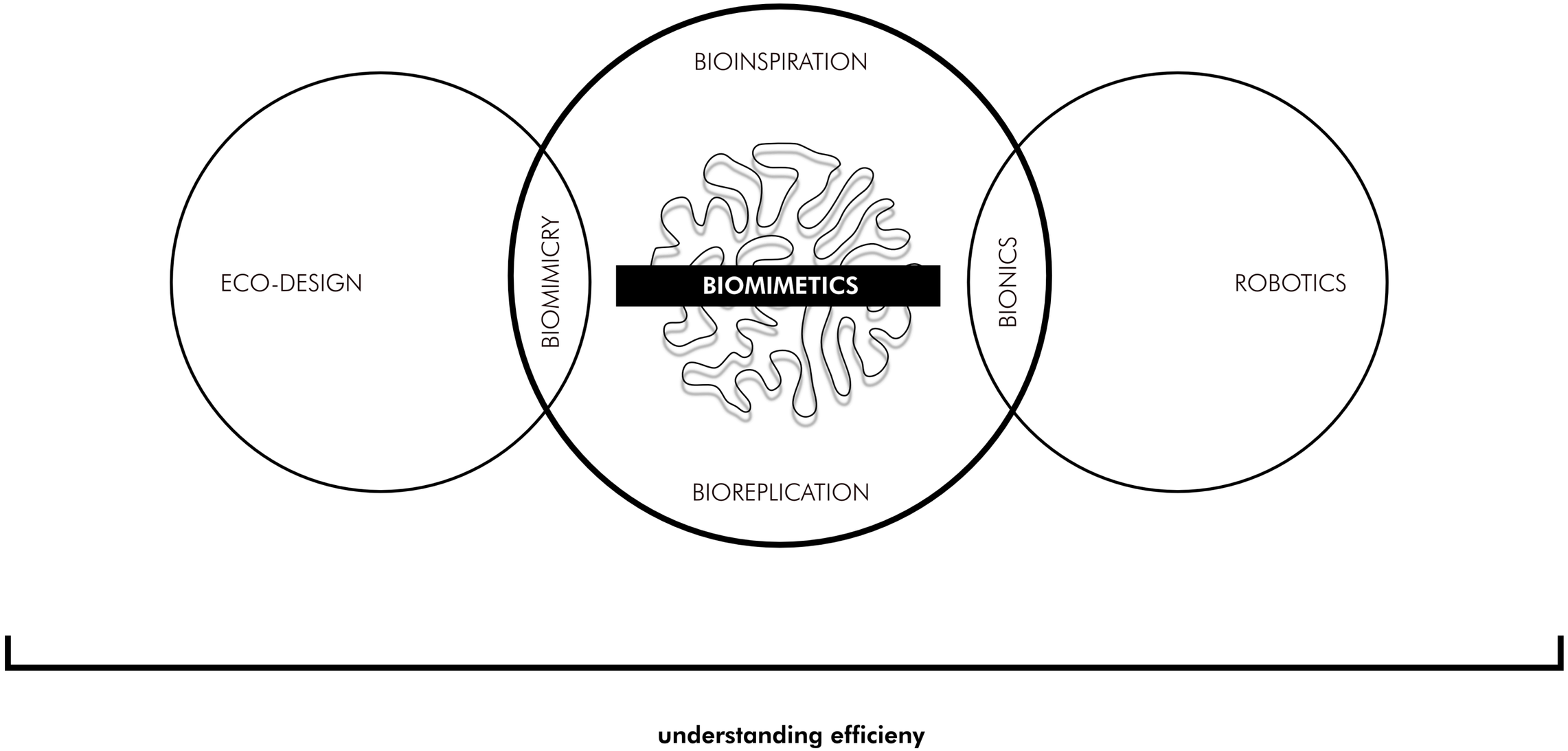


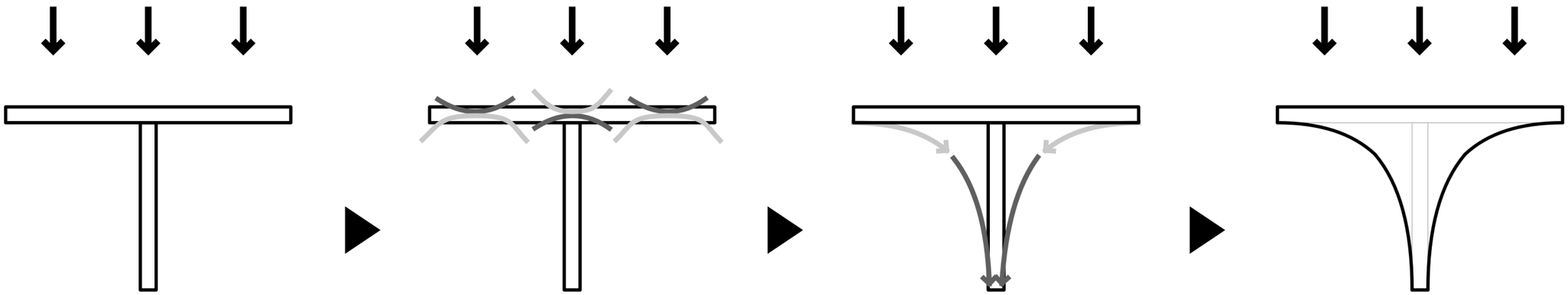
fig.12
research - result



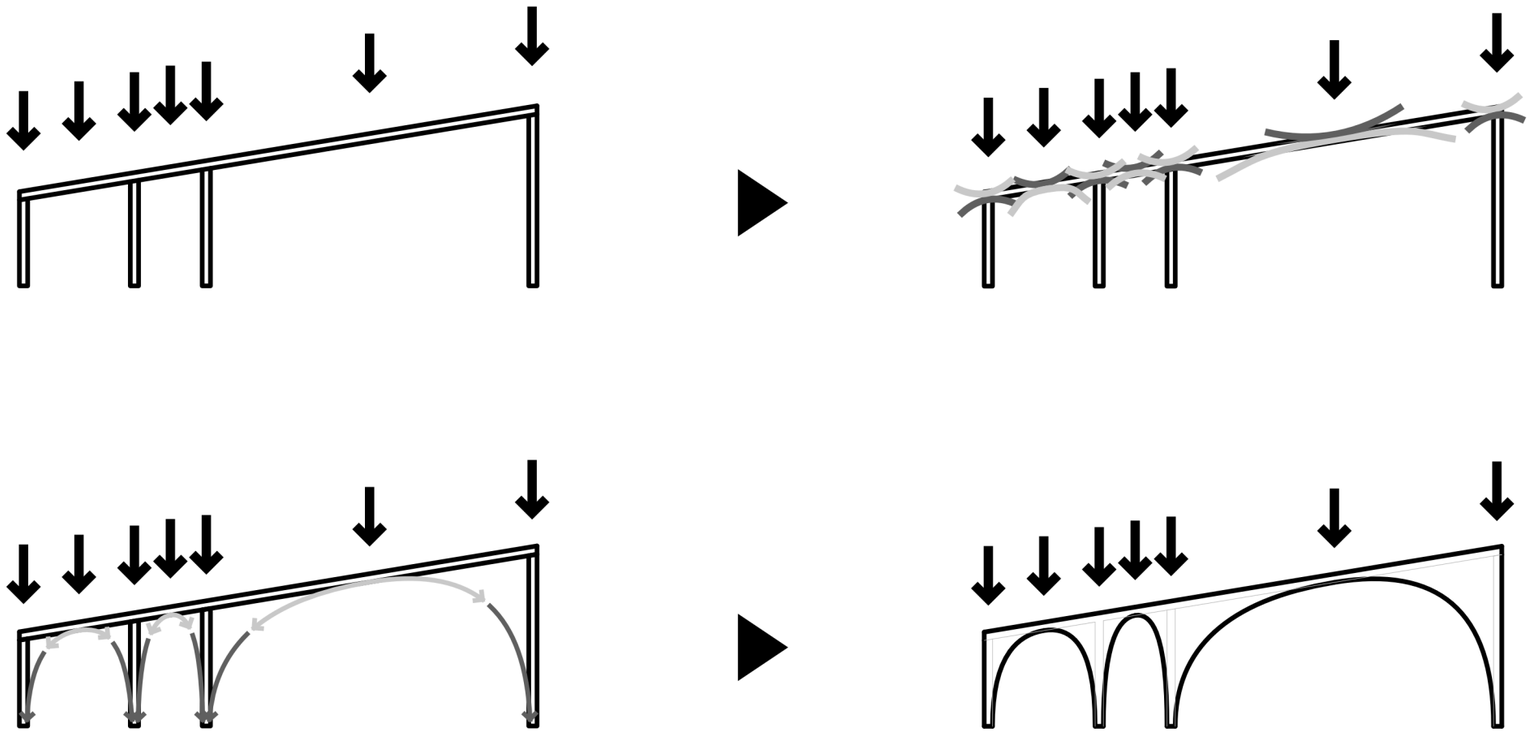
nature inspired design

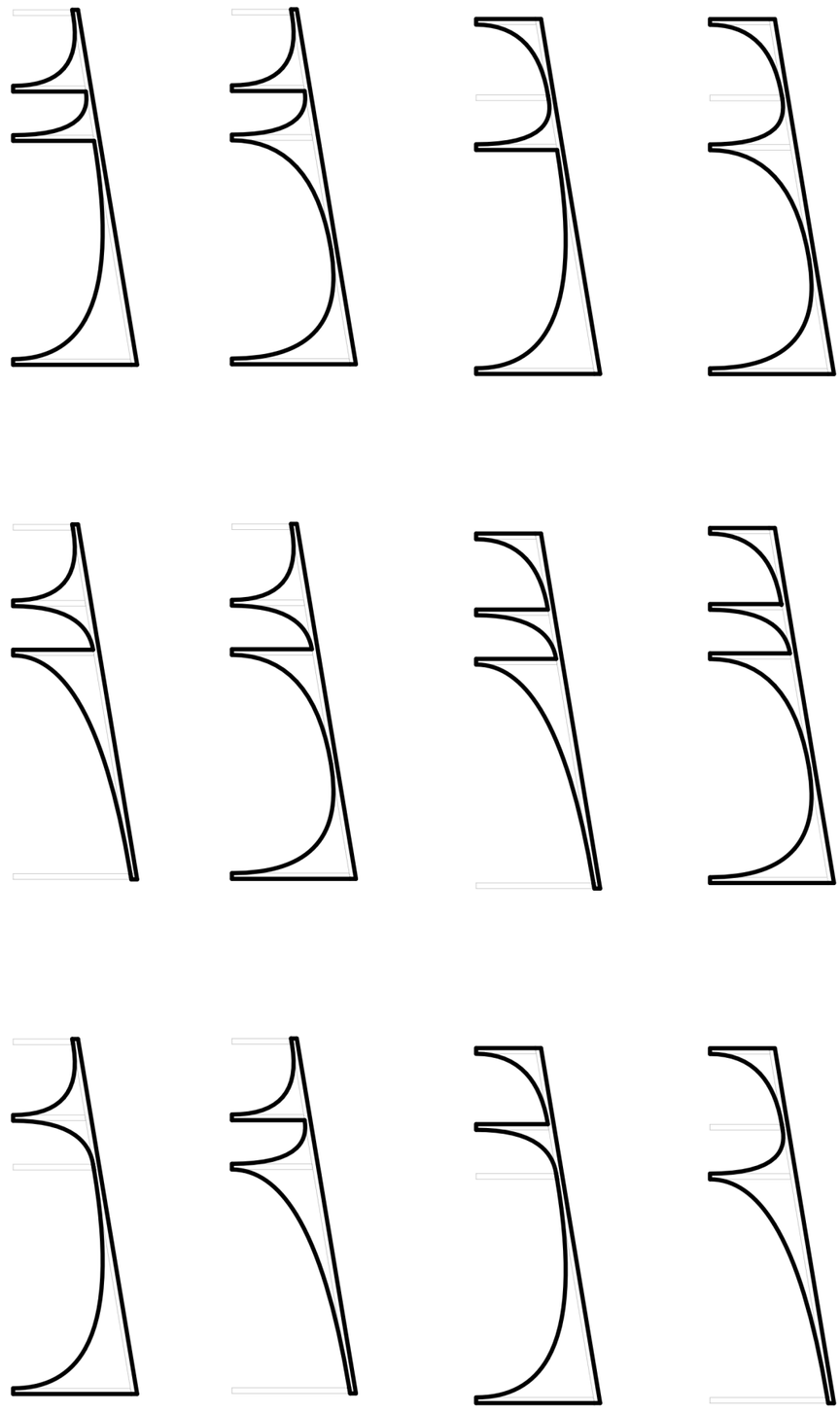
fig.14: demonstration fiber pavillions from ICD University Stuttgart


BIOINSPIRATION
ECO-DESIGN
BIOMIMICRY
BIOMIMETICS
BIONICS
ROBOTICS
BIOREPLICATION
understanding efficieny

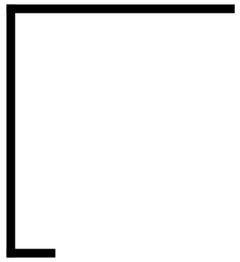


axiom of uniform stress



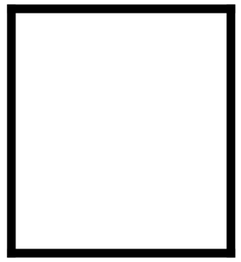


01 the column

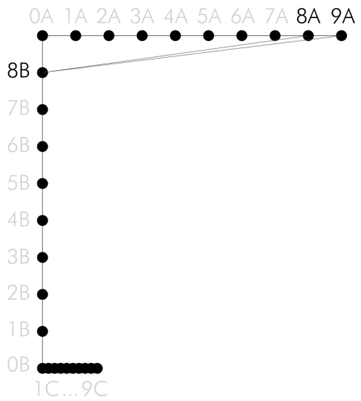


02 the beam

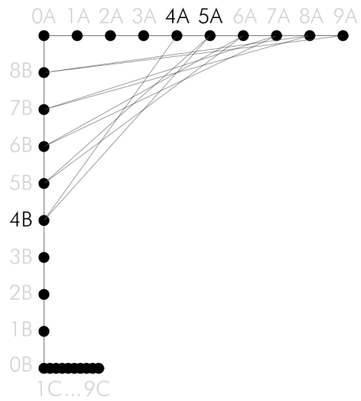
03 the slab



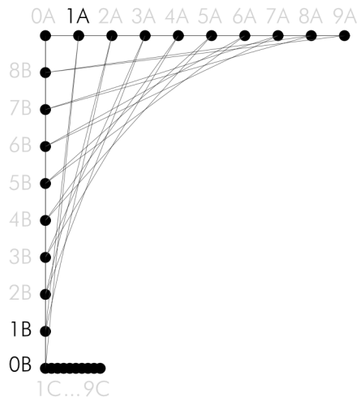
9A → 8B → 8A



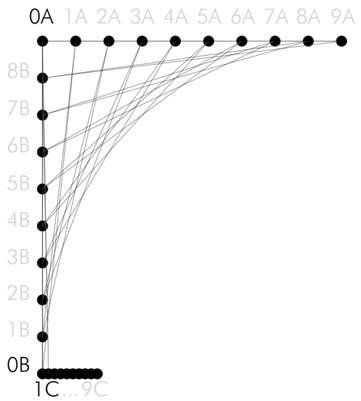
5A → 4B → 4A



1B → 1A → 0B



0B → 0A → 1C



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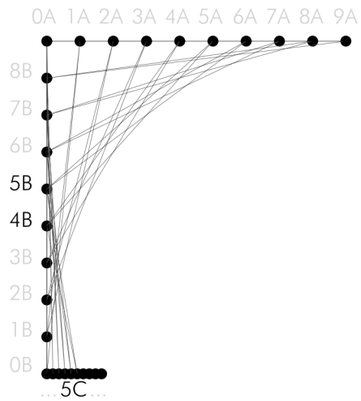
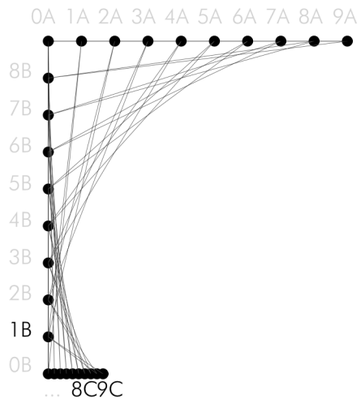
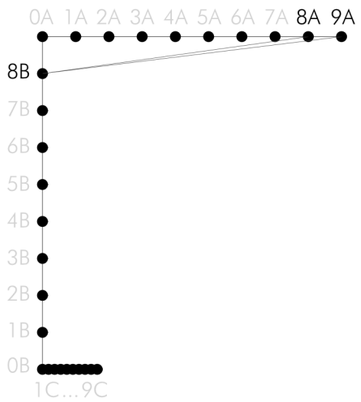


8C → 1B → 9C



01 the column

9A → 8B → 8A



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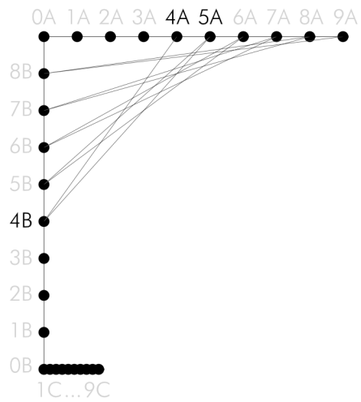

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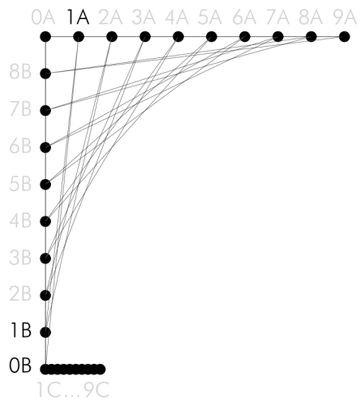

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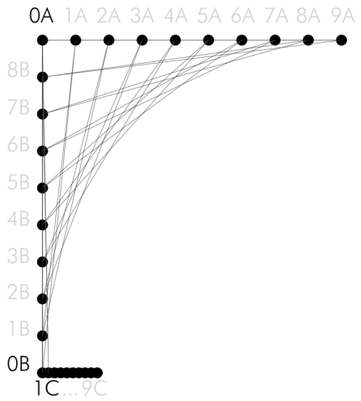

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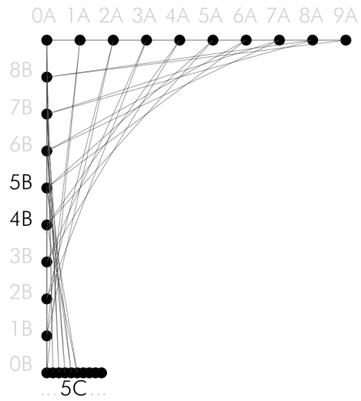
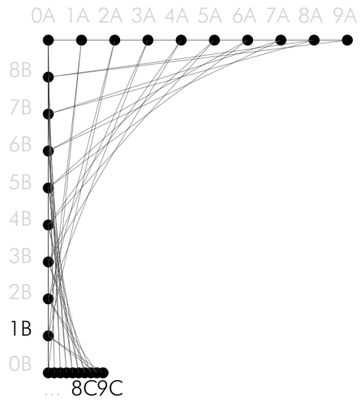
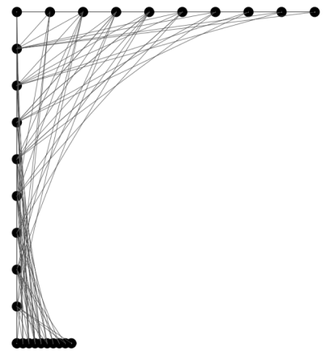
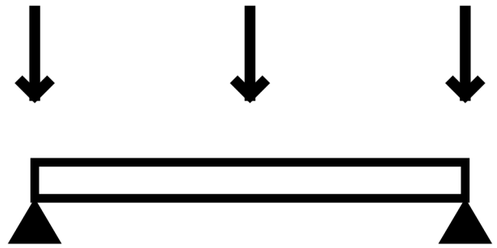


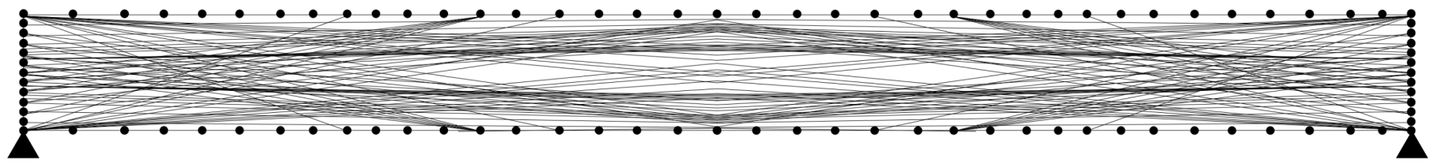
8C → 1B → 9C

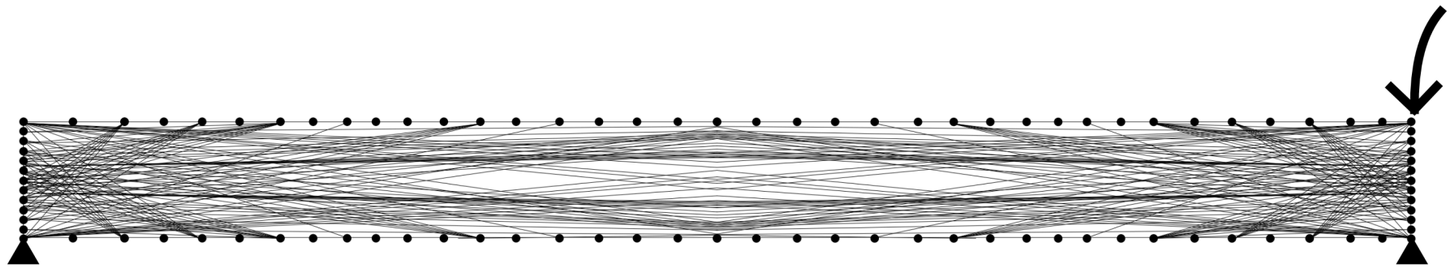


reinforcements

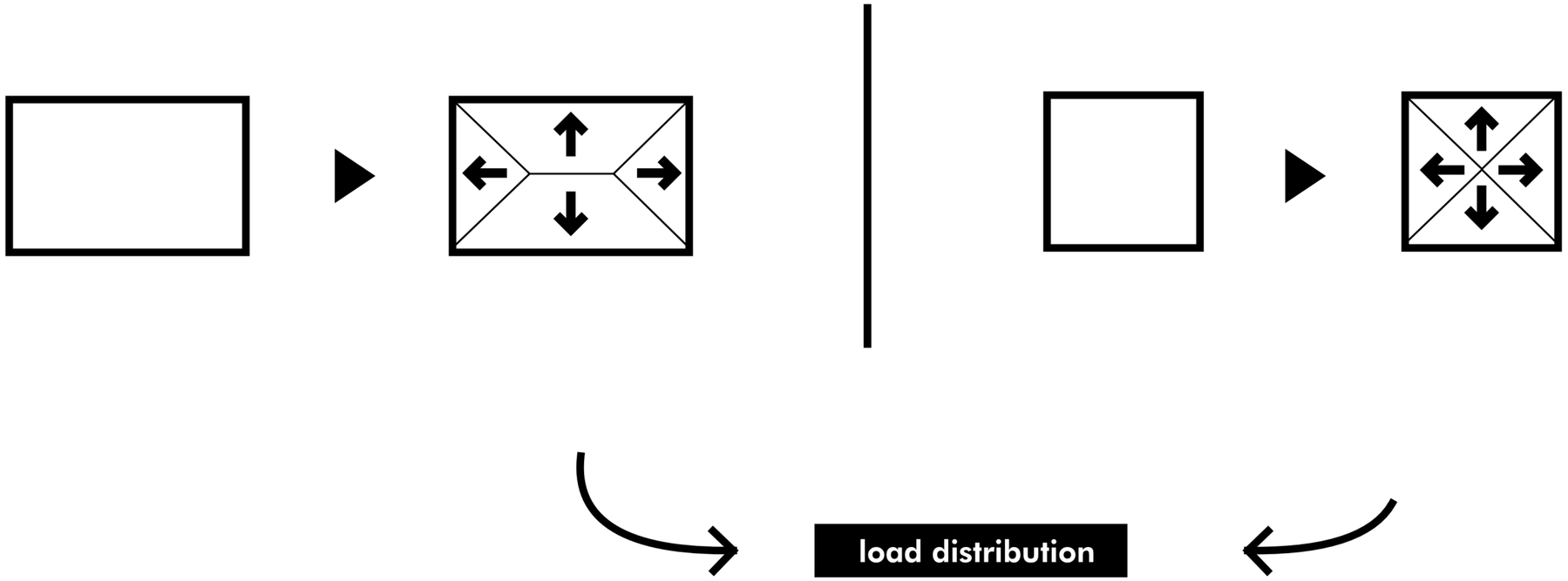








reinforcements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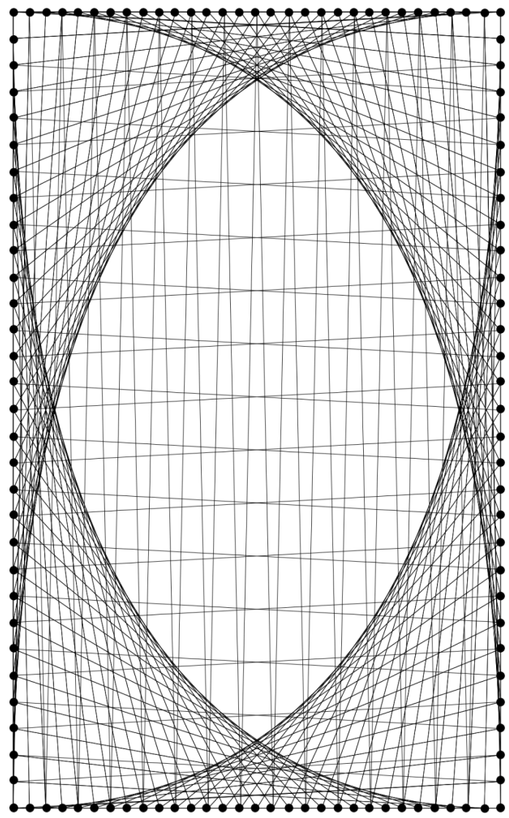
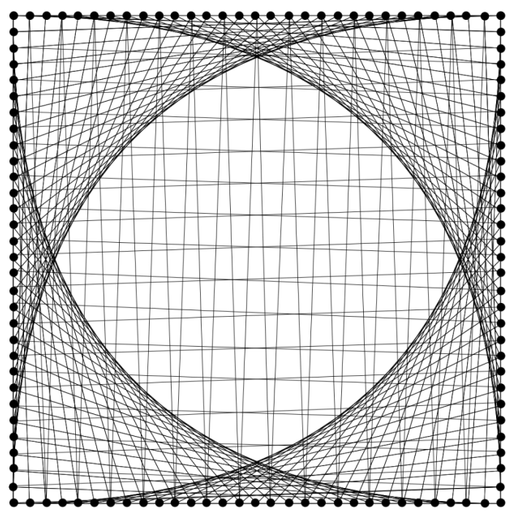
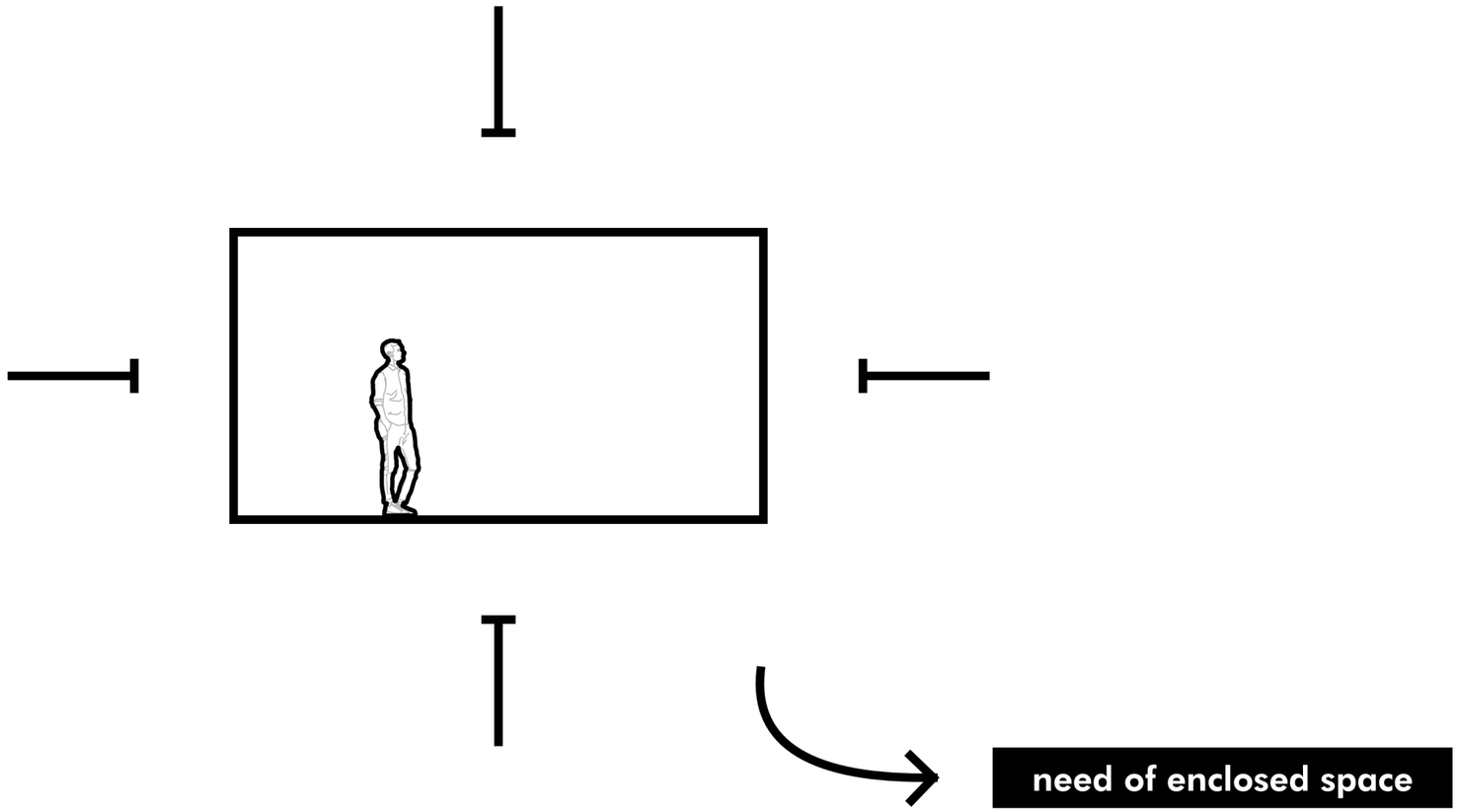





need of enclosed space

filler material

fig.04: cannabis sativa l.

cast in form

fig.08. compressed block

+

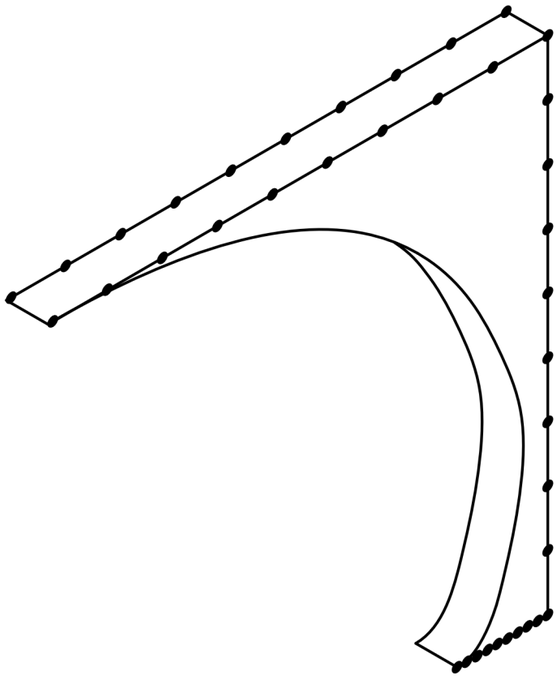
spun yarn

fig.11. coreless filament winding

structural material

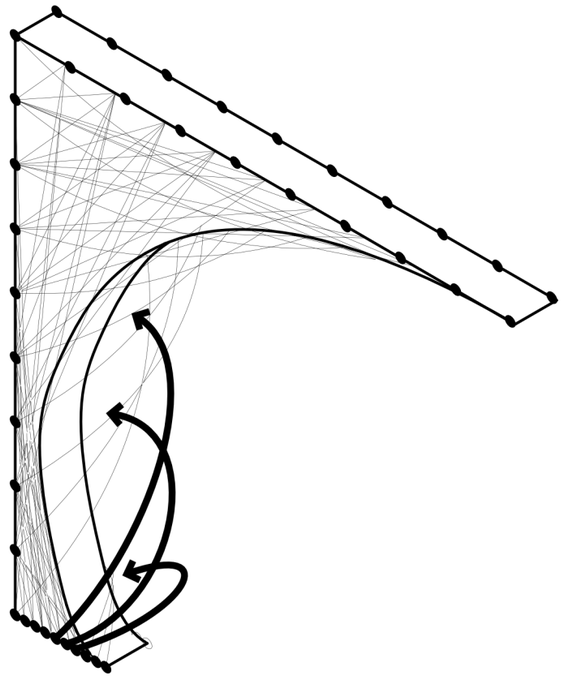
fig.05: linum usitatissimum

01

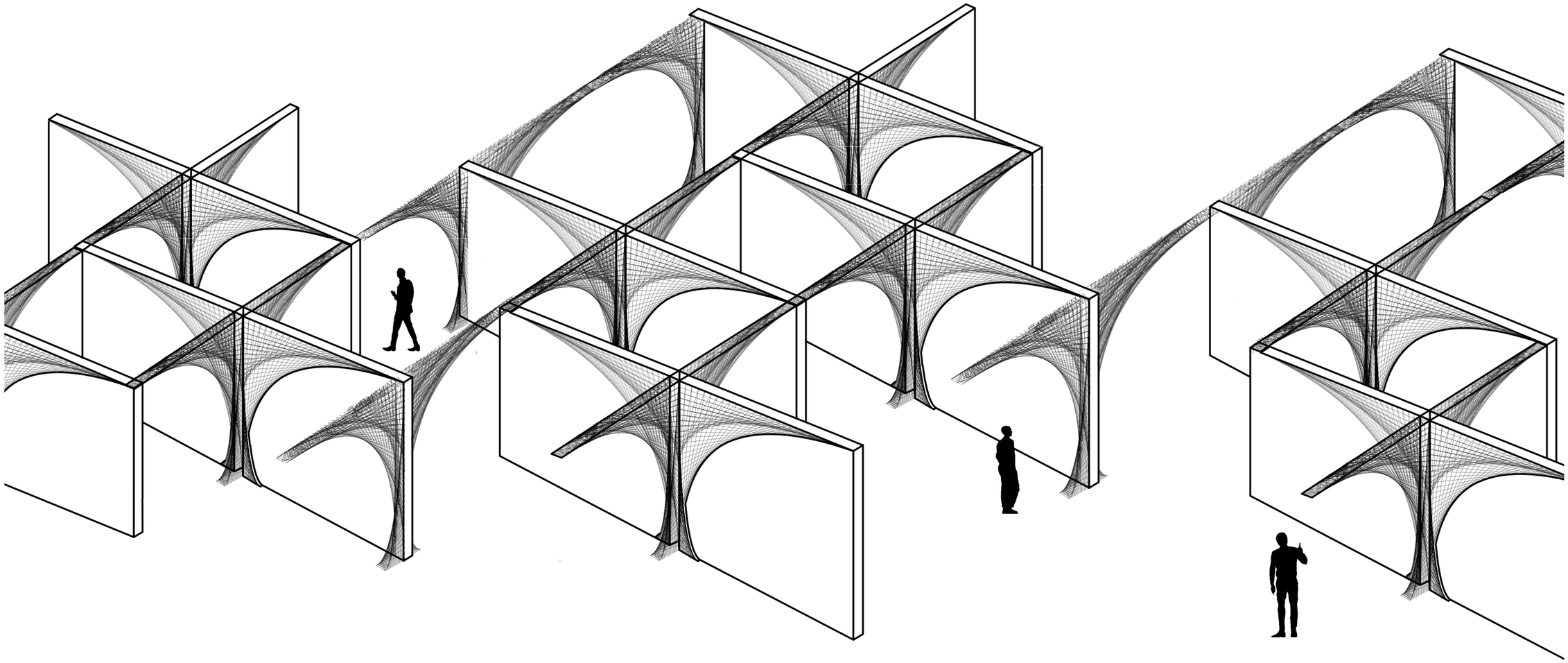


cast hempcrete core

02



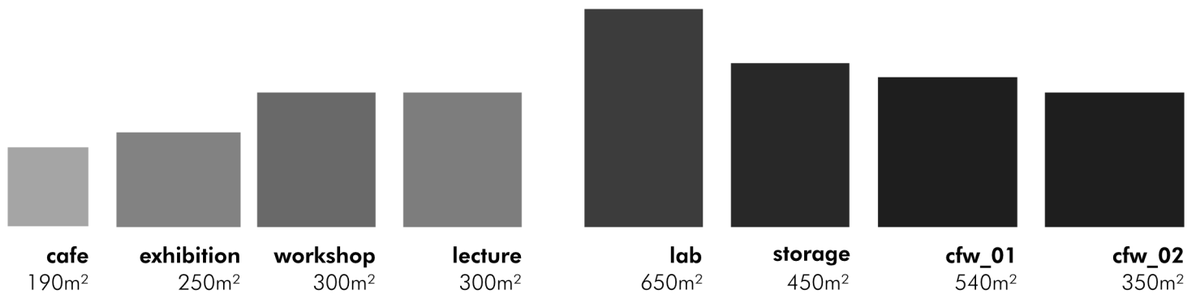
wind flax fibers around core



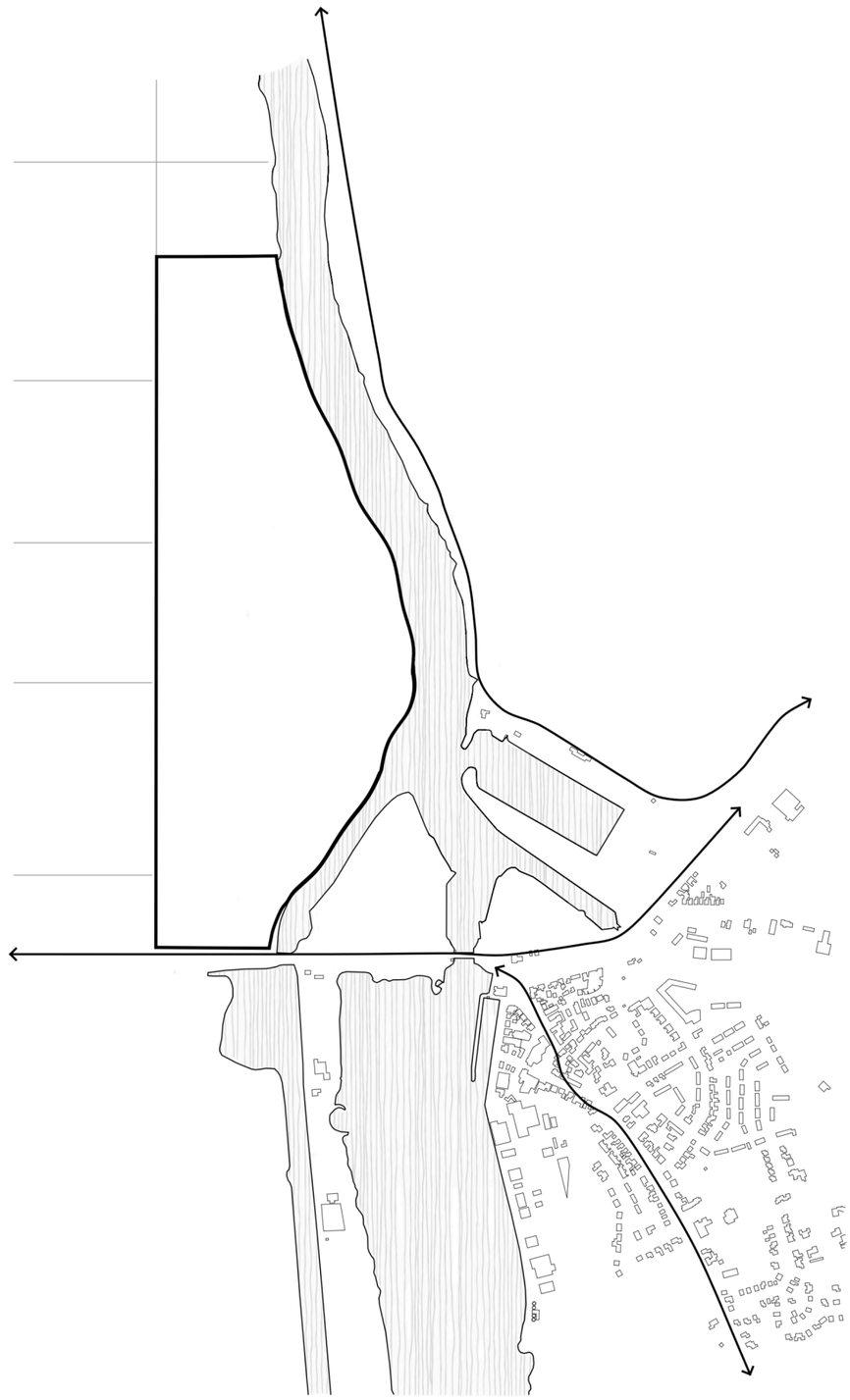
design assignment

The goal is to design a **Biofiber Research Laboratory** constructed using bio fibers and filament winding, with the aim of fostering innovation, education, and public engagement. This multidimensional facility should integrate research and educational facilities. The objective is to create a dynamic environment that not only facilitates research in biofiber technology but also opens its doors to the public, in order to increase awareness and understanding of biobased materials.

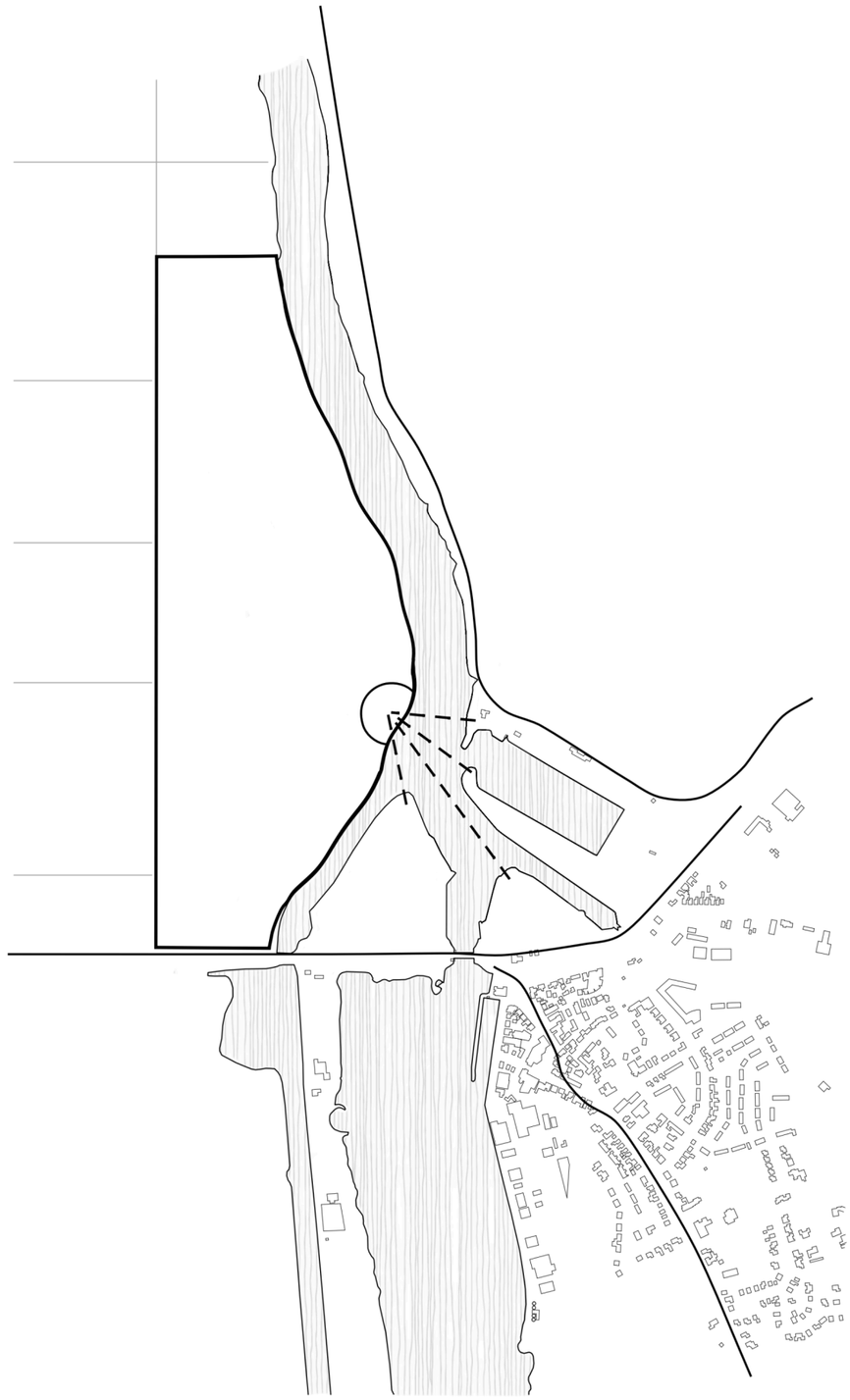
location: *zoutkamp, groningen, netherlands 53°20'22.5"N 6°17'17.0"E*
year: *2124*
materiality: *flax and hemp fibers*
target-group: *from general public to architects, to constructors, to investors, …*



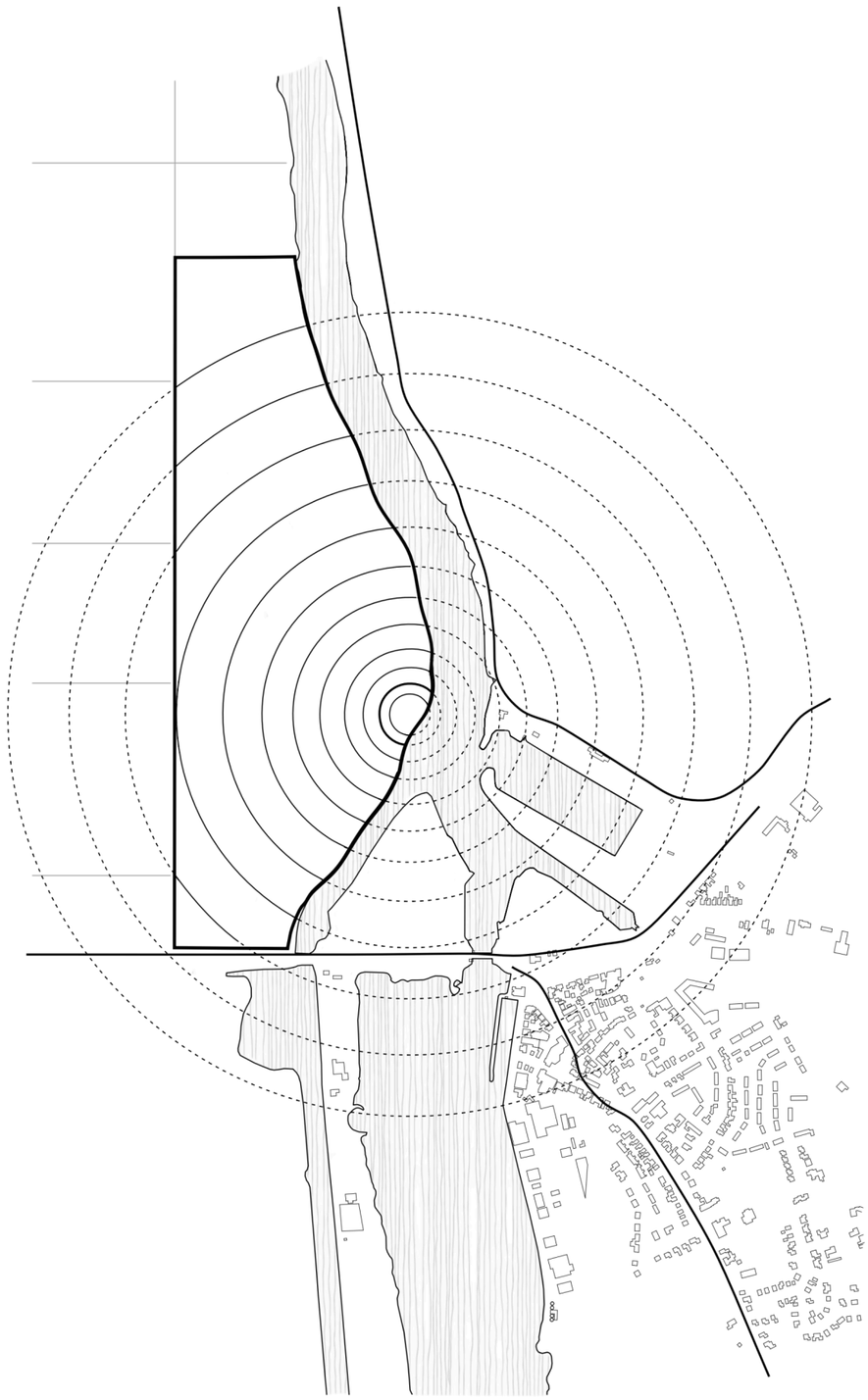
2124

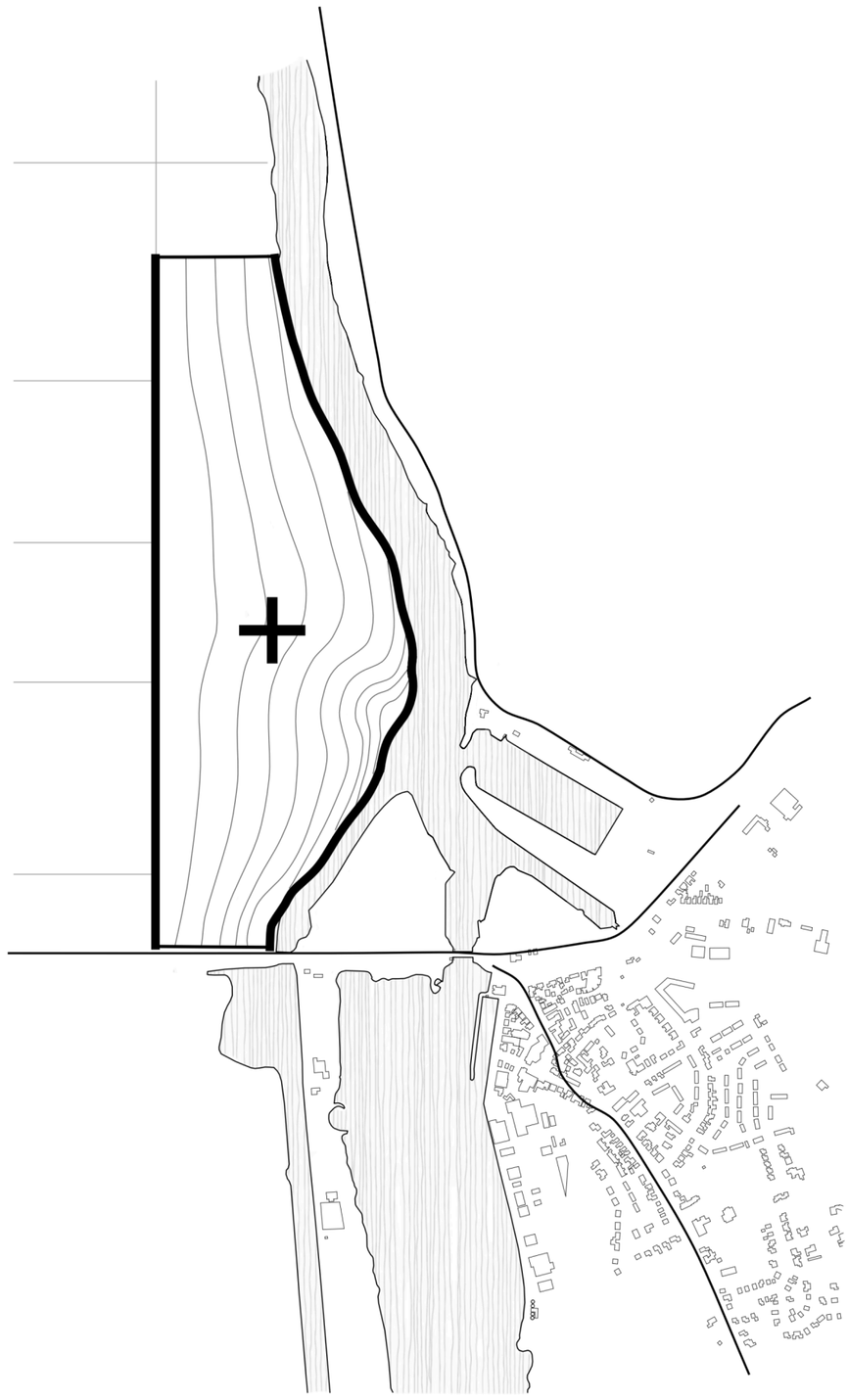


design - site analysis

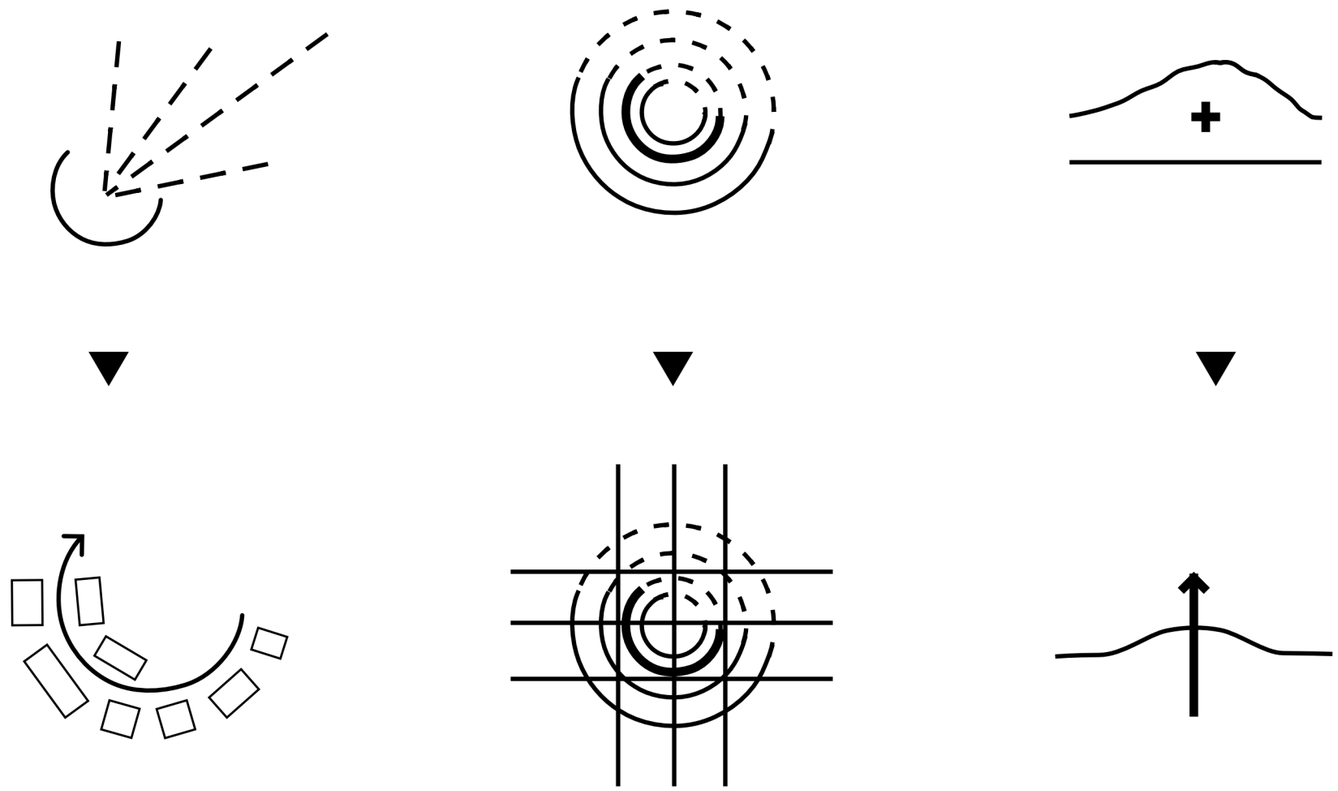


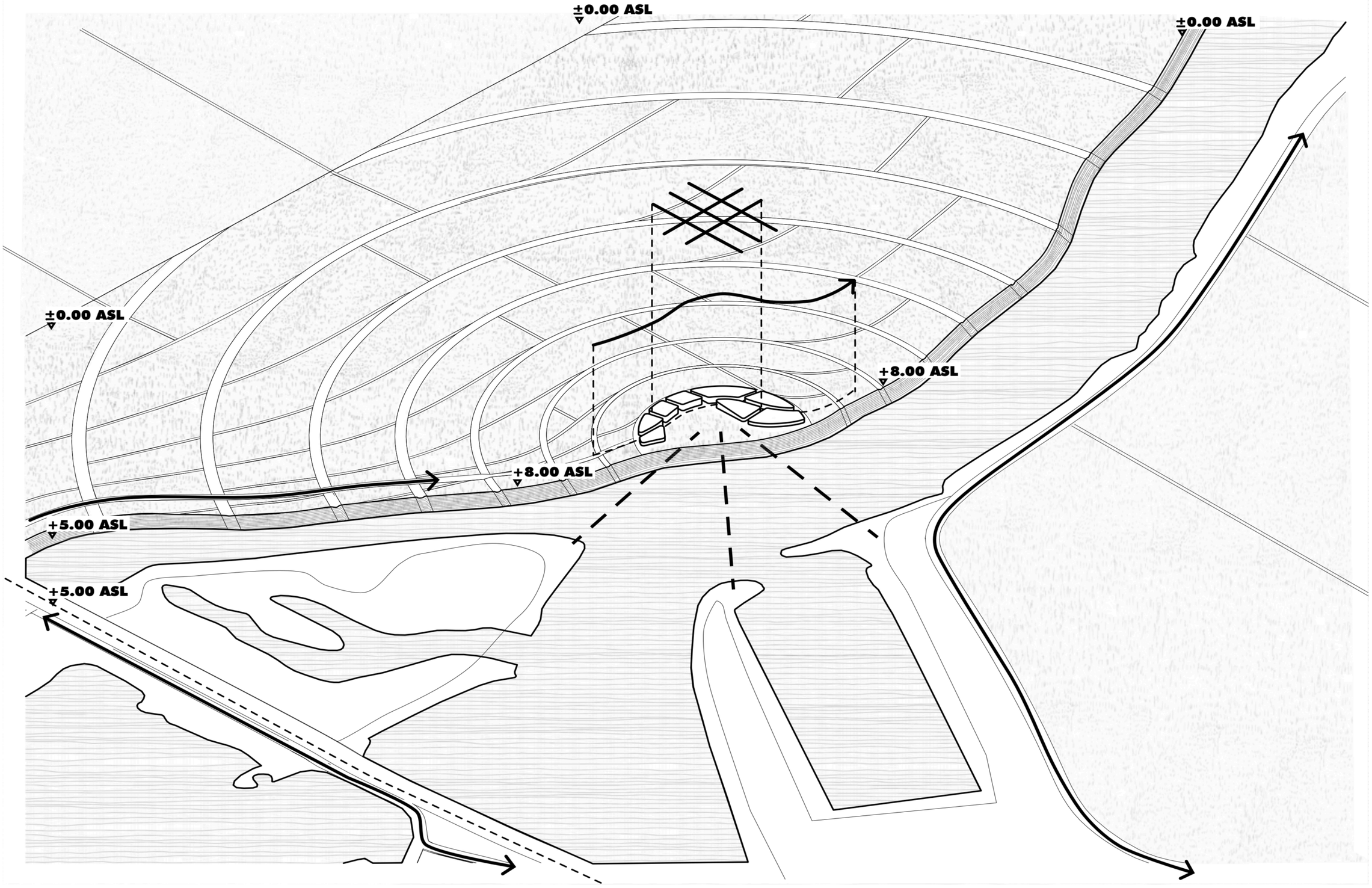
design - site analysis - placement



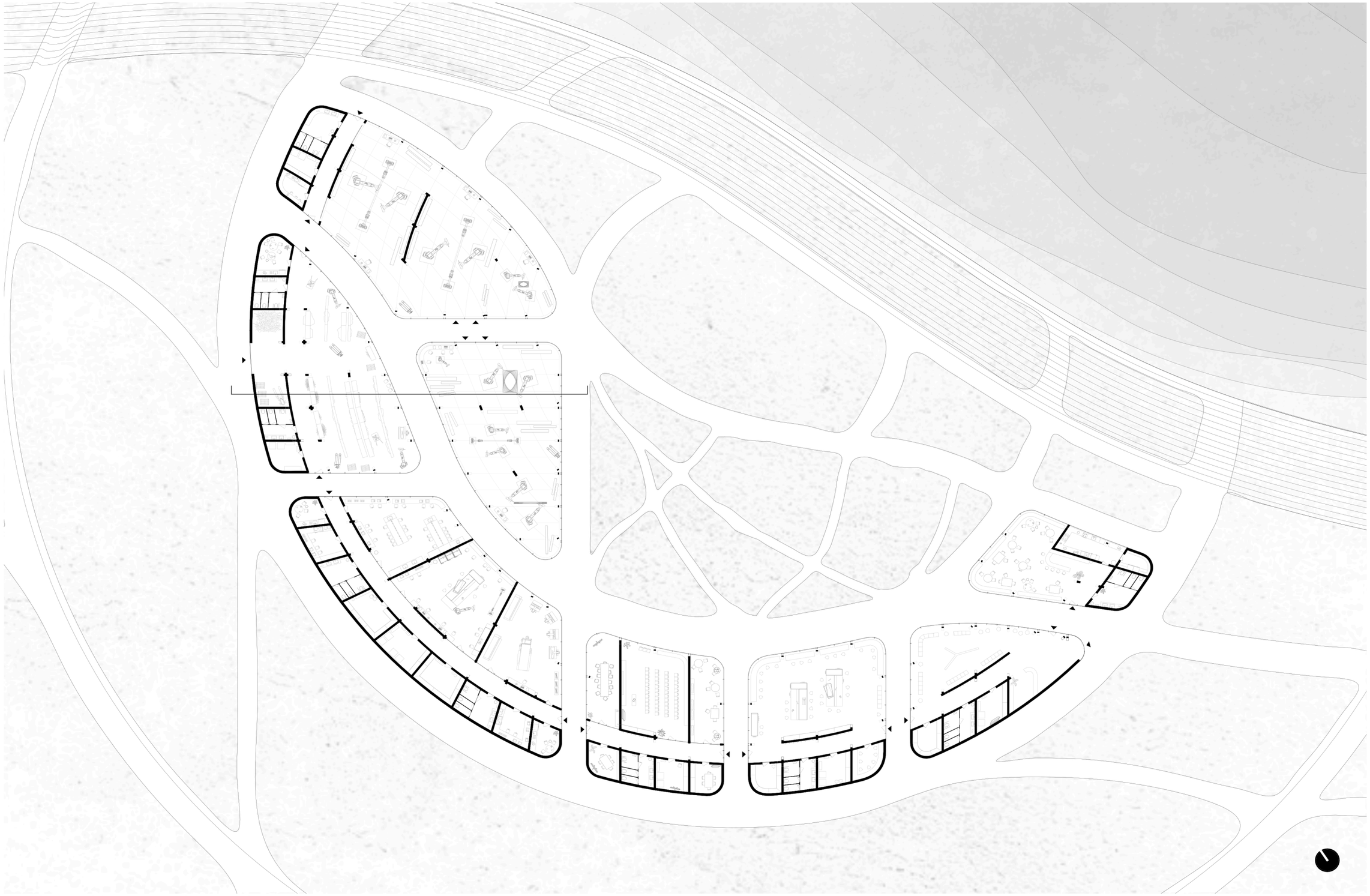


design - site analysis - influence

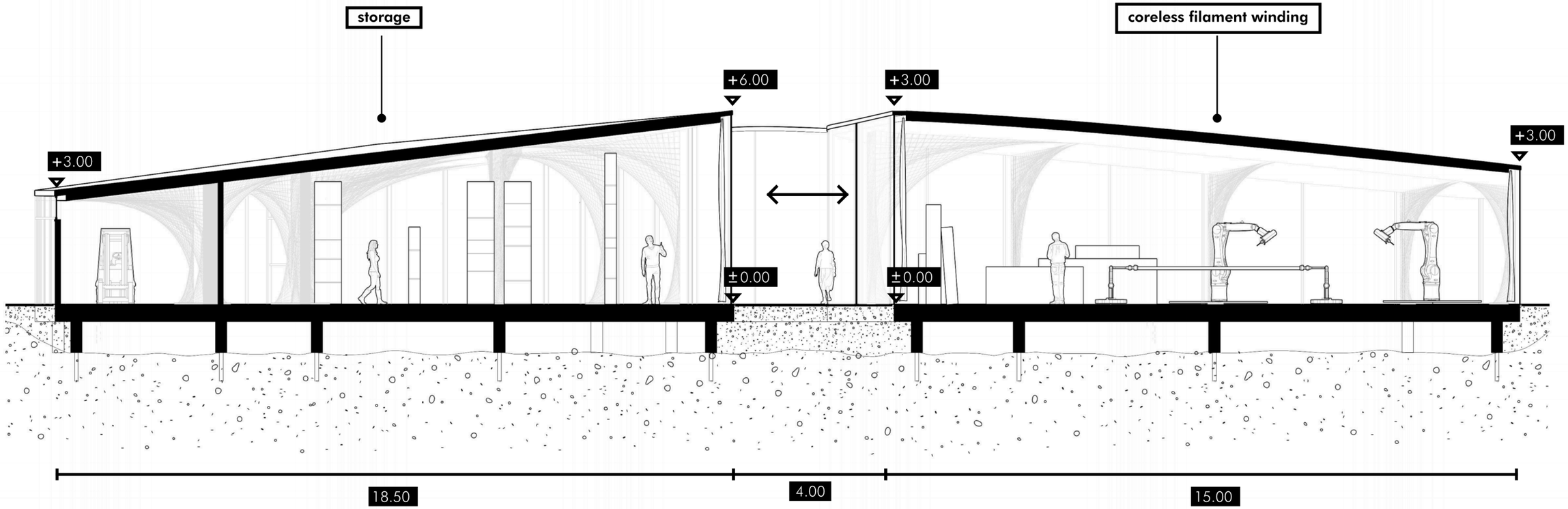




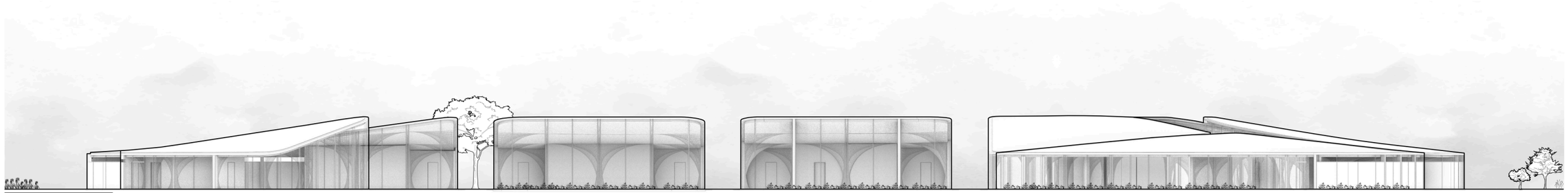
design - axonometric overview



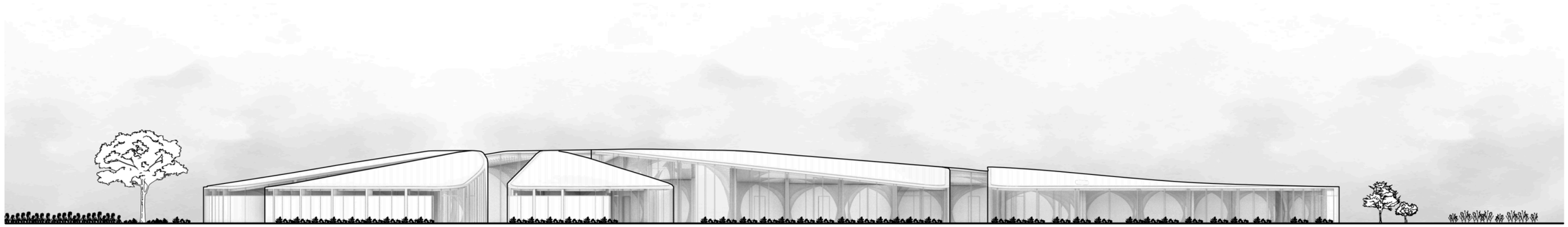
01_cafe 02_exhibition 03_workshop 04_lecture
05_lab 06_storage 07_cfw01 08_cfw02
floorplan


storage
coreless filament winding
+6.00
+3.00
+3.00
+3.00
±0.00
±0.00
18.50
4.00
15.00

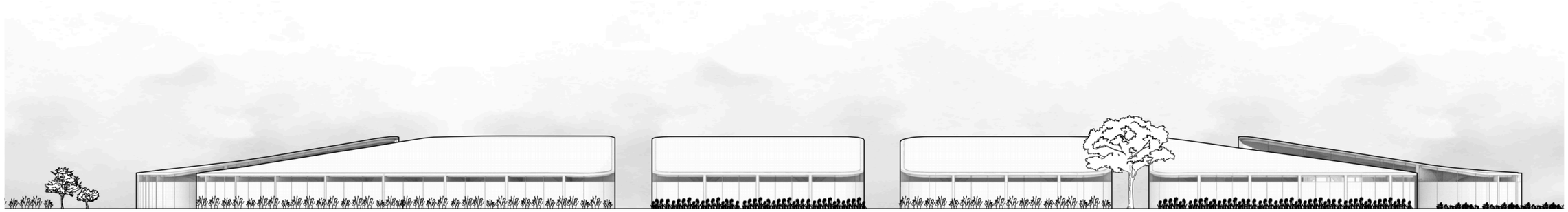
section A-A



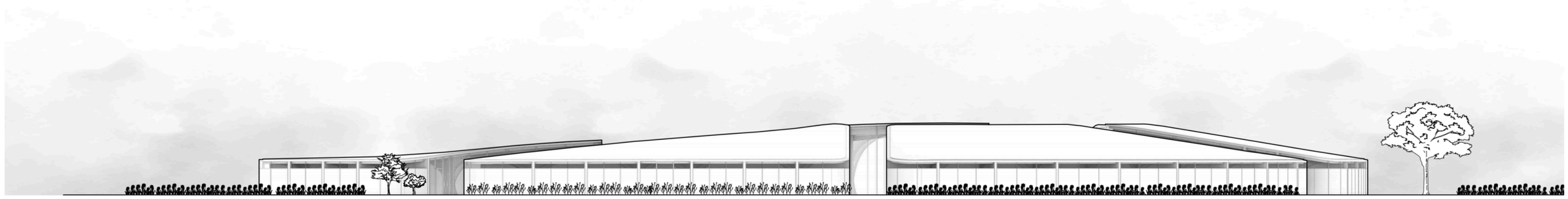
elevation north



elevation east

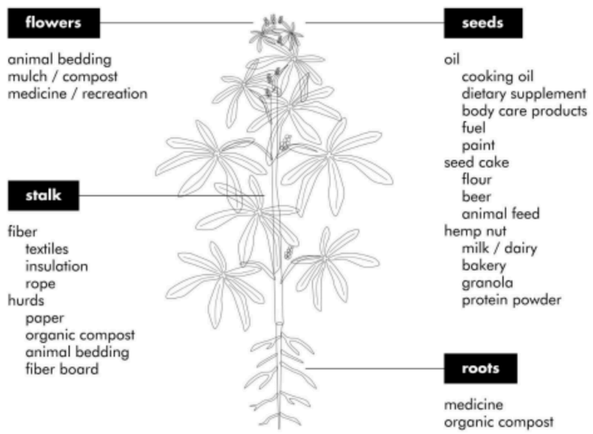


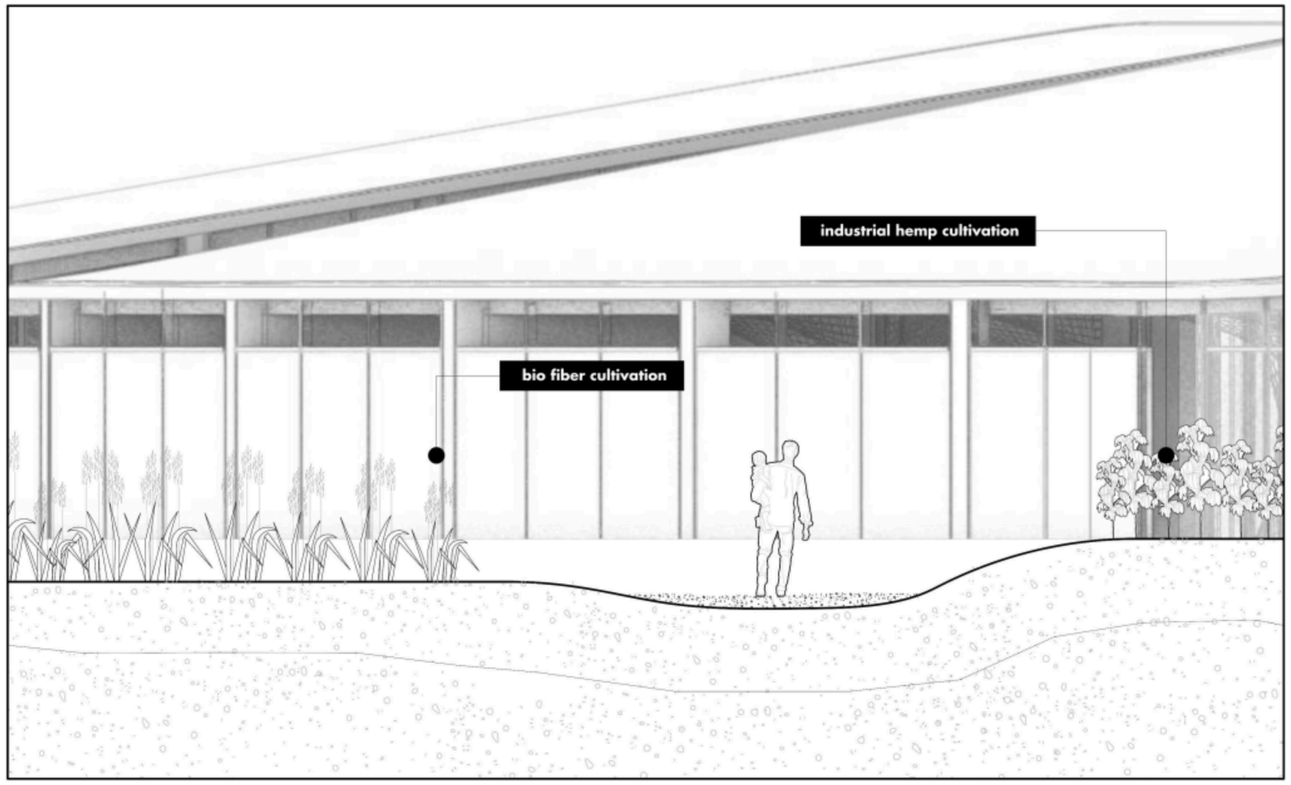
elevation south

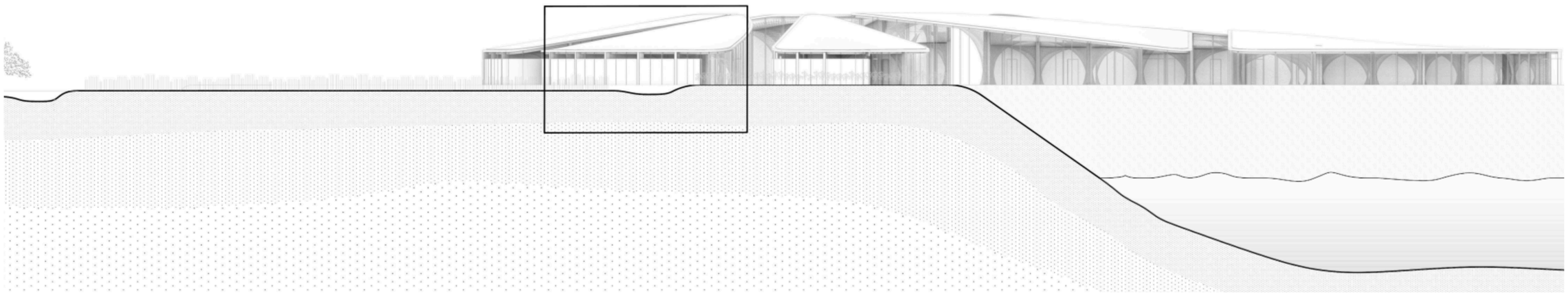


elevation west

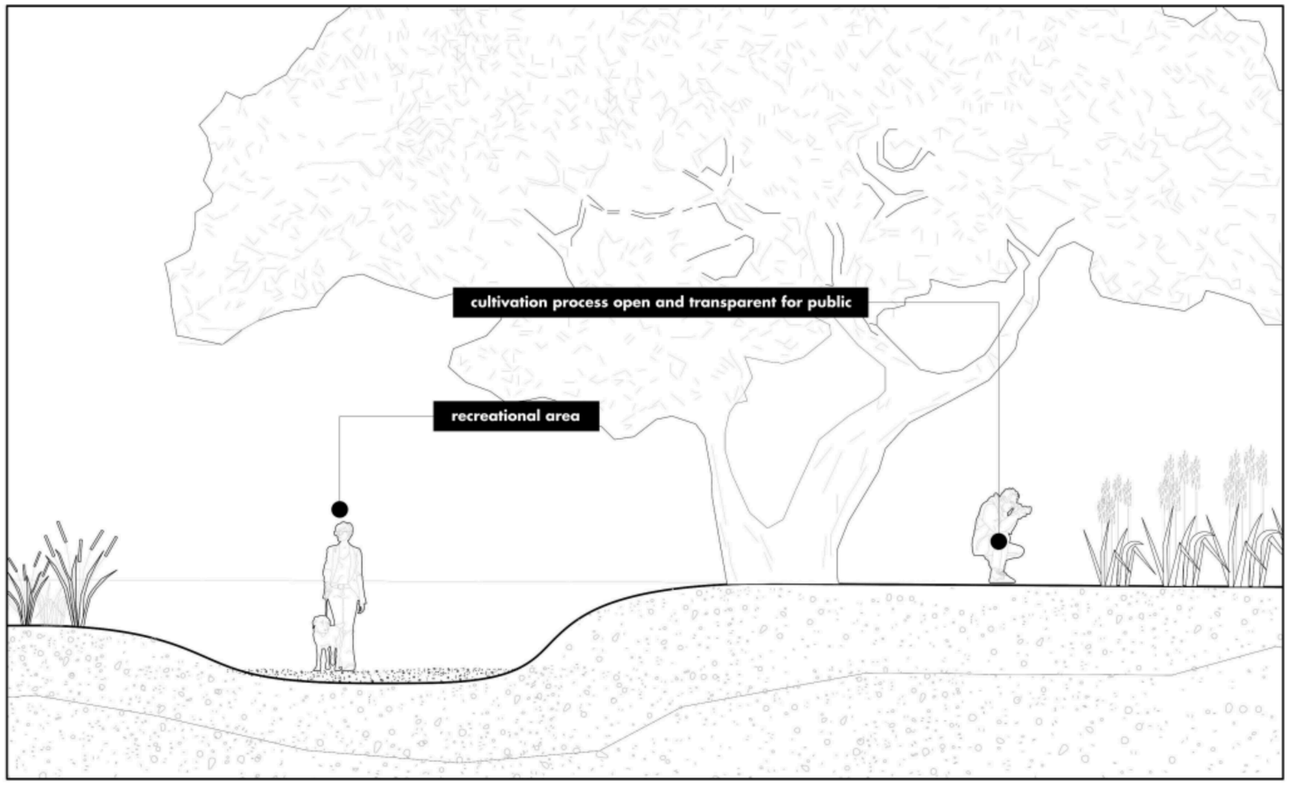
1:200

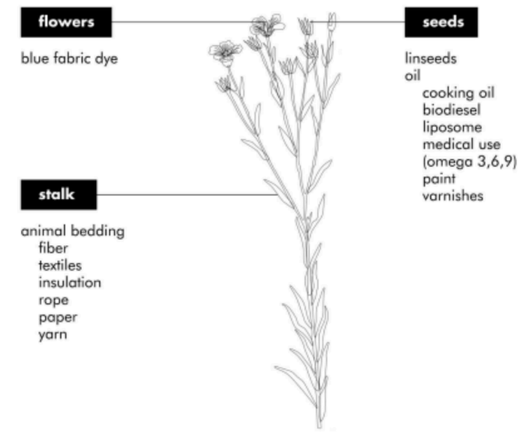


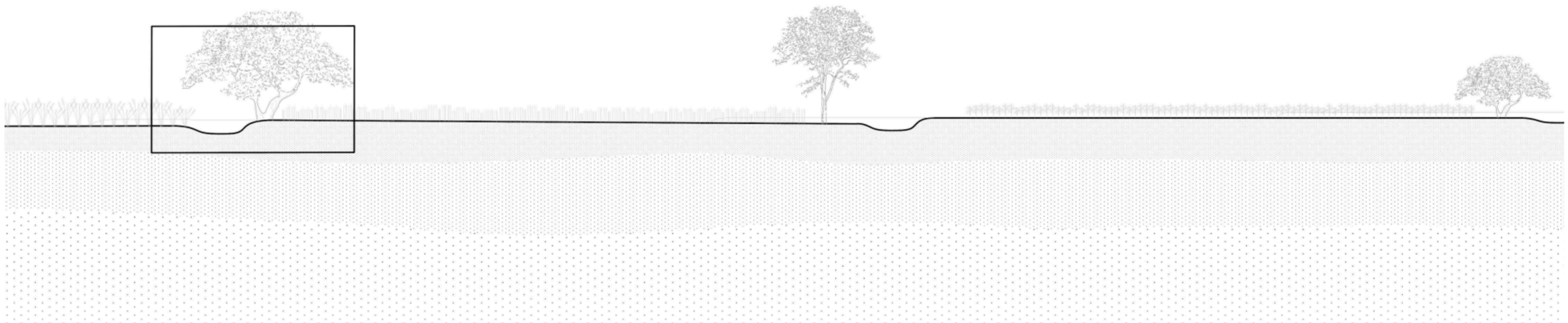




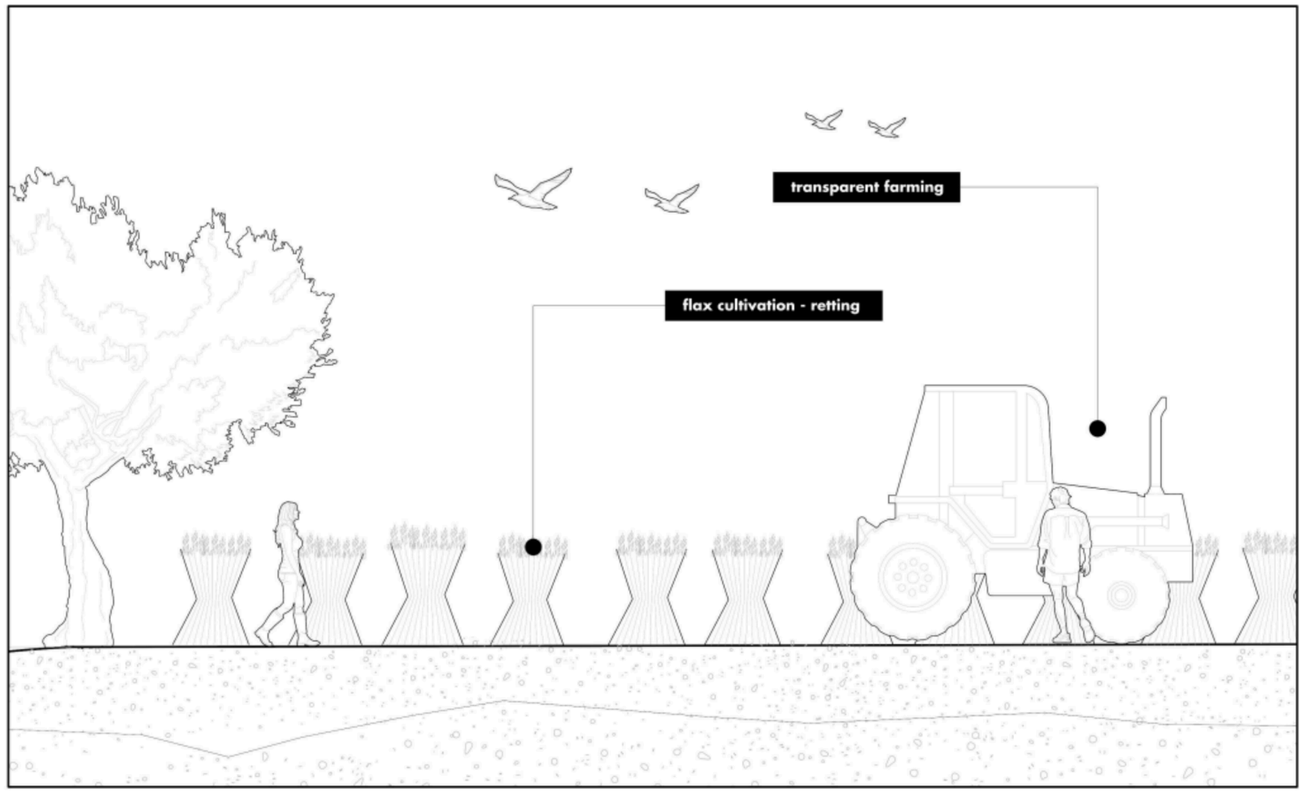
design - landscape section - cultivation of biofibers

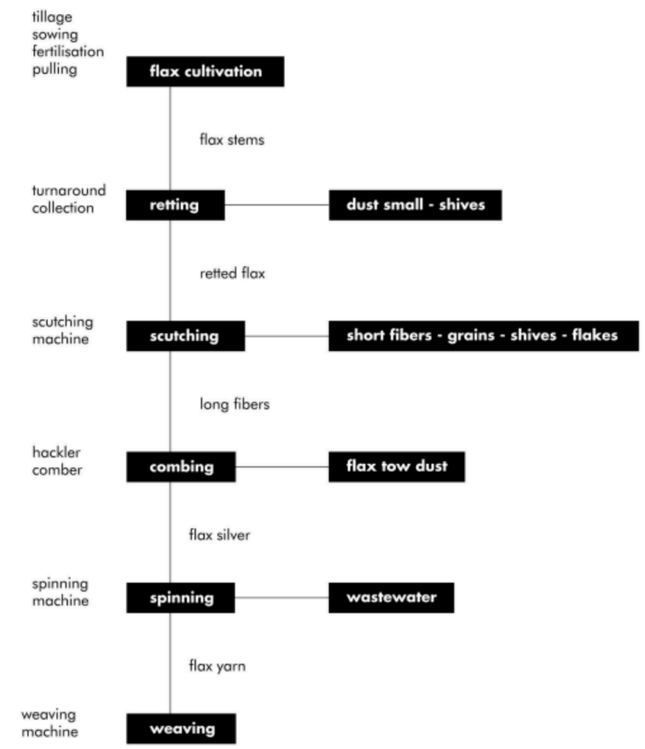


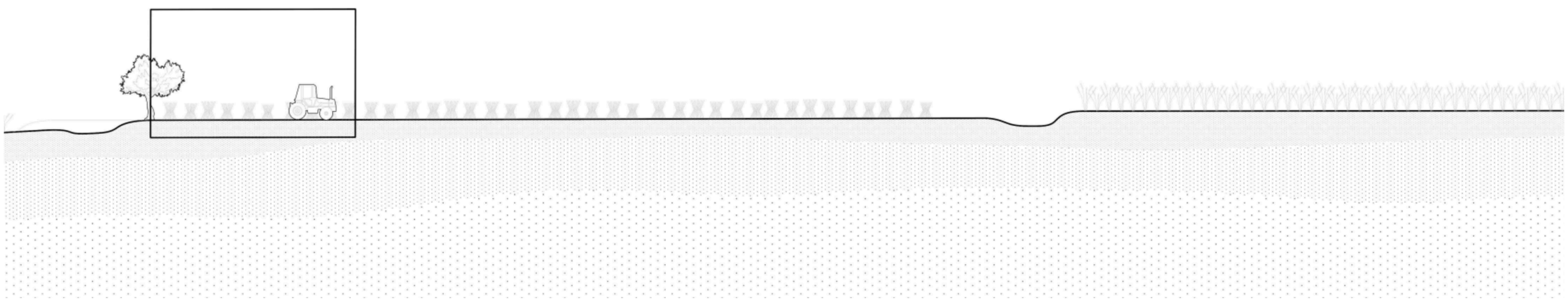


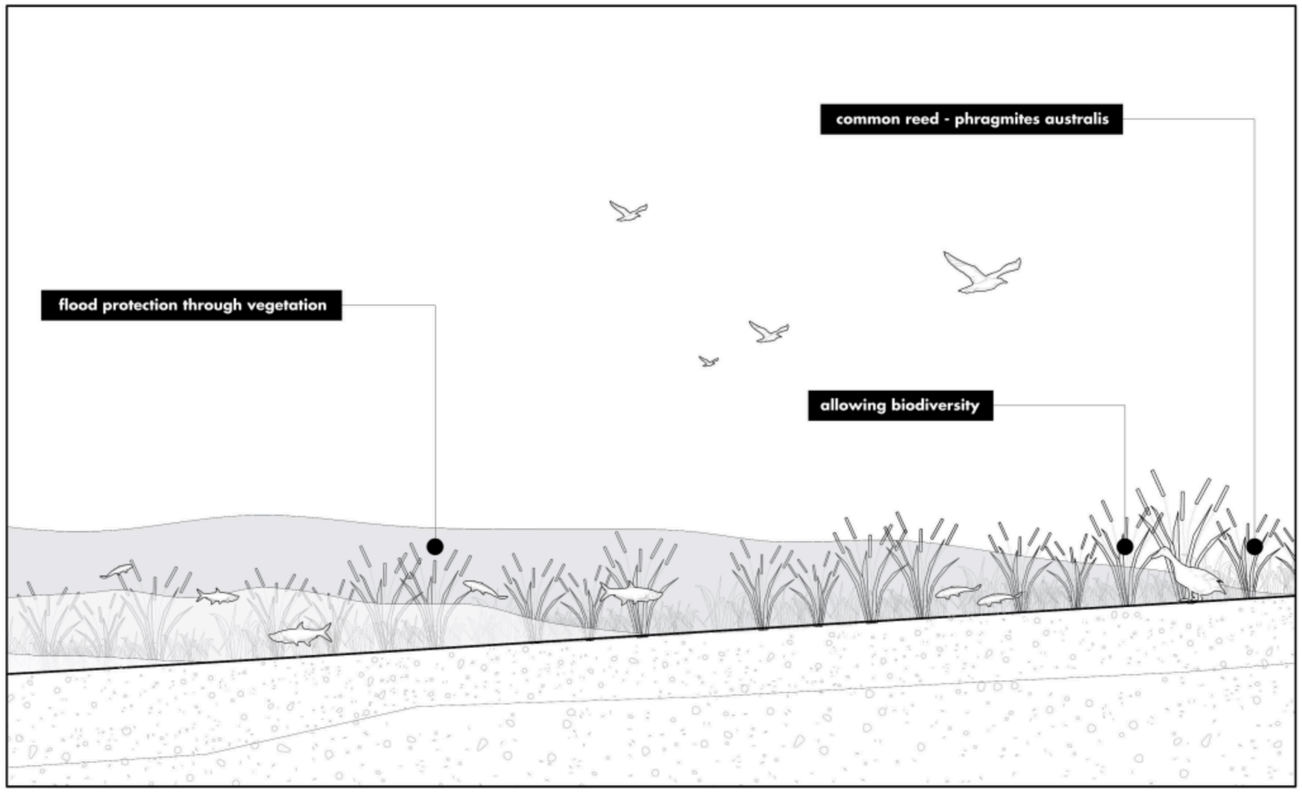


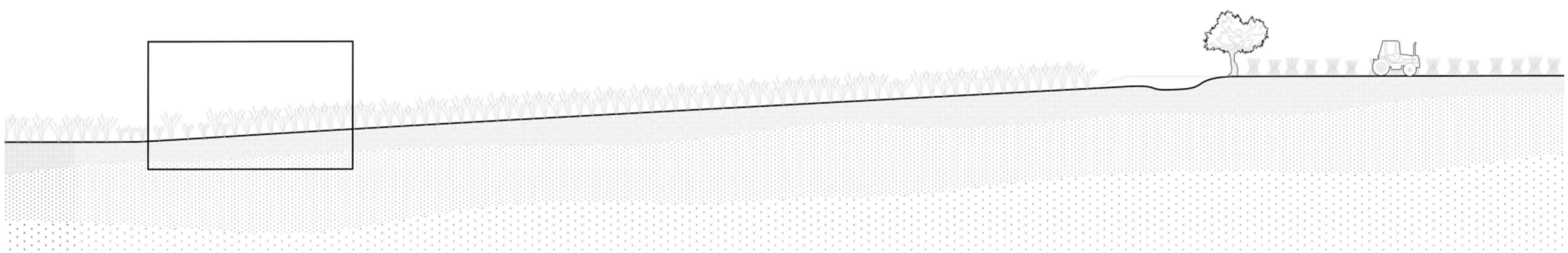
design - landscape section - recreational areas


transparent farming
flax cultivation - retting

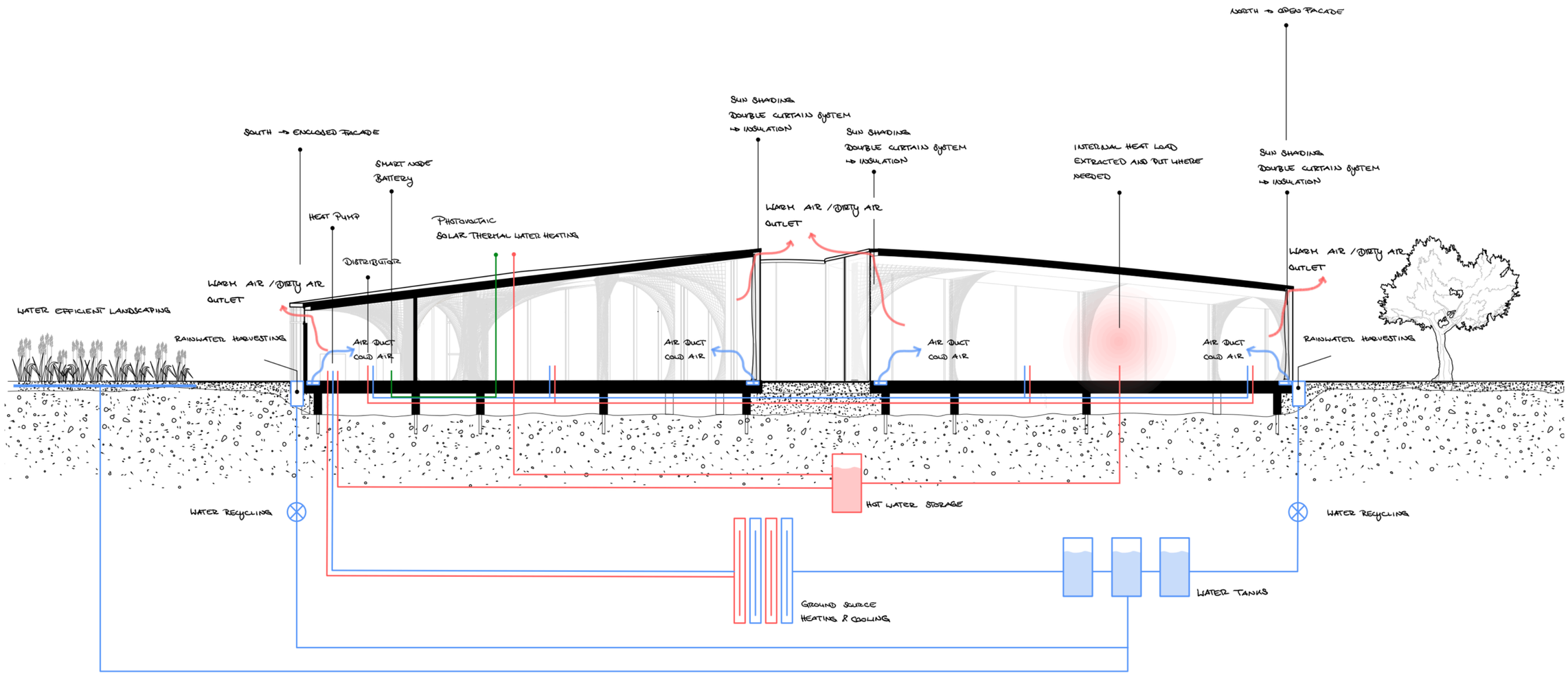

tillage
sowing
fertilisation
pulling
flax cultivation
flax stems
turnaround
collection
retting
dust small - shives
retted flax
scutching
machine
scutching
short fibers - grains - shives - flakes
long fibers
hackler
comber
combing
flax tow dust
flax silver
spinning
machine
spinning
wastewater
flax yarn
weaving
machine
weaving

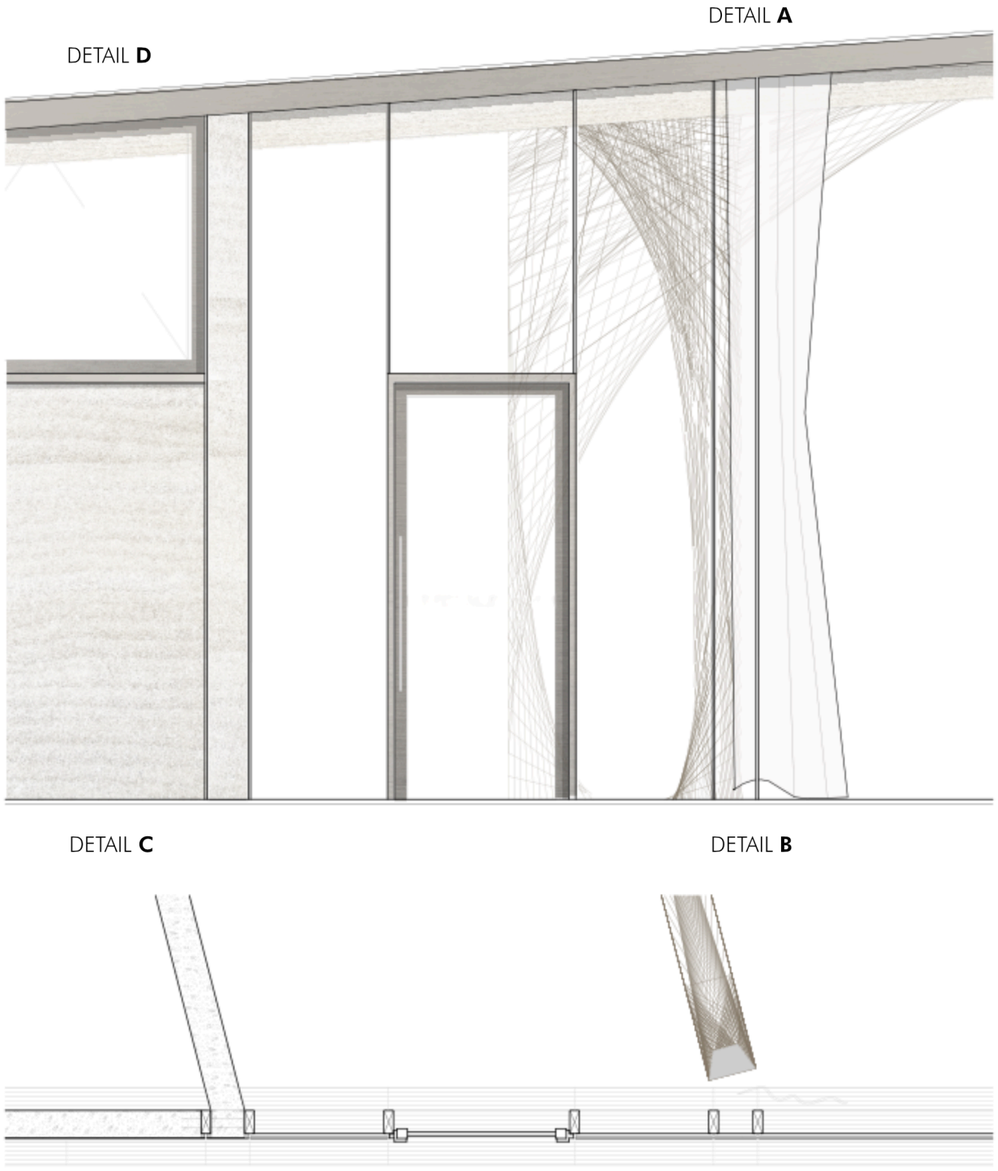


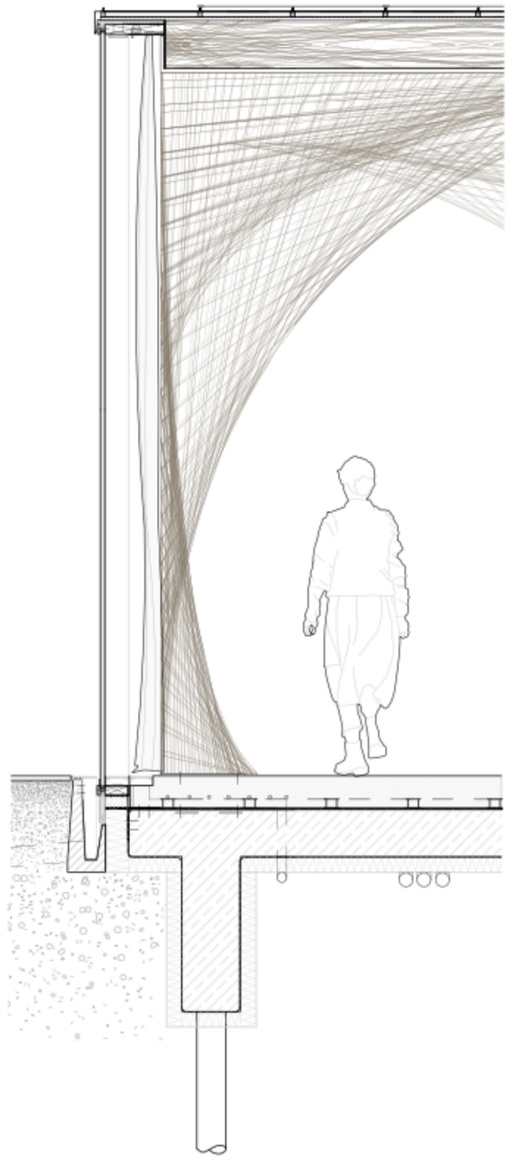




design - landscape section -flood protection


NORTH → OPEN FACADE
SUN SHADING
DOUBLE CURTAIN SYSTEM
→ INSULATION
SUN SHADING
DOUBLE CURTAIN SYSTEM
→ INSULATION
INTERNAL HEAT LOAD
EXTRACTED AND PUT WHERE
NEEDED
SUN SHADING
DOUBLE CURTAIN SYSTEM
→ INSULATION
SOUTH → ENCLOSED FACADE
SMART NODE
BATTERY
HEAT PUMP
PHOTOVOLTAIC
SOLAR THERMAL WATER HEATING
DISTRIBUTOR
WARM AIR / DIRTY AIR
OUTLET
WARM AIR / DIRTY AIR
OUTLET
WARM AIR / DIRTY AIR
OUTLET
WATER EFFICIENT LANDSCAPING
RAINWATER HARVESTING
AIR DUCT
COLD AIR
AIR DUCT
COLD AIR
AIR DUCT
COLD AIR
AIR DUCT
COLD AIR
RAINWATER HARVESTING
HOT WATER STORAGE
WATER RECYCLING
WATER RECYCLING
GROUND SOURCE
HEATING & COOLING
WATER TANKS

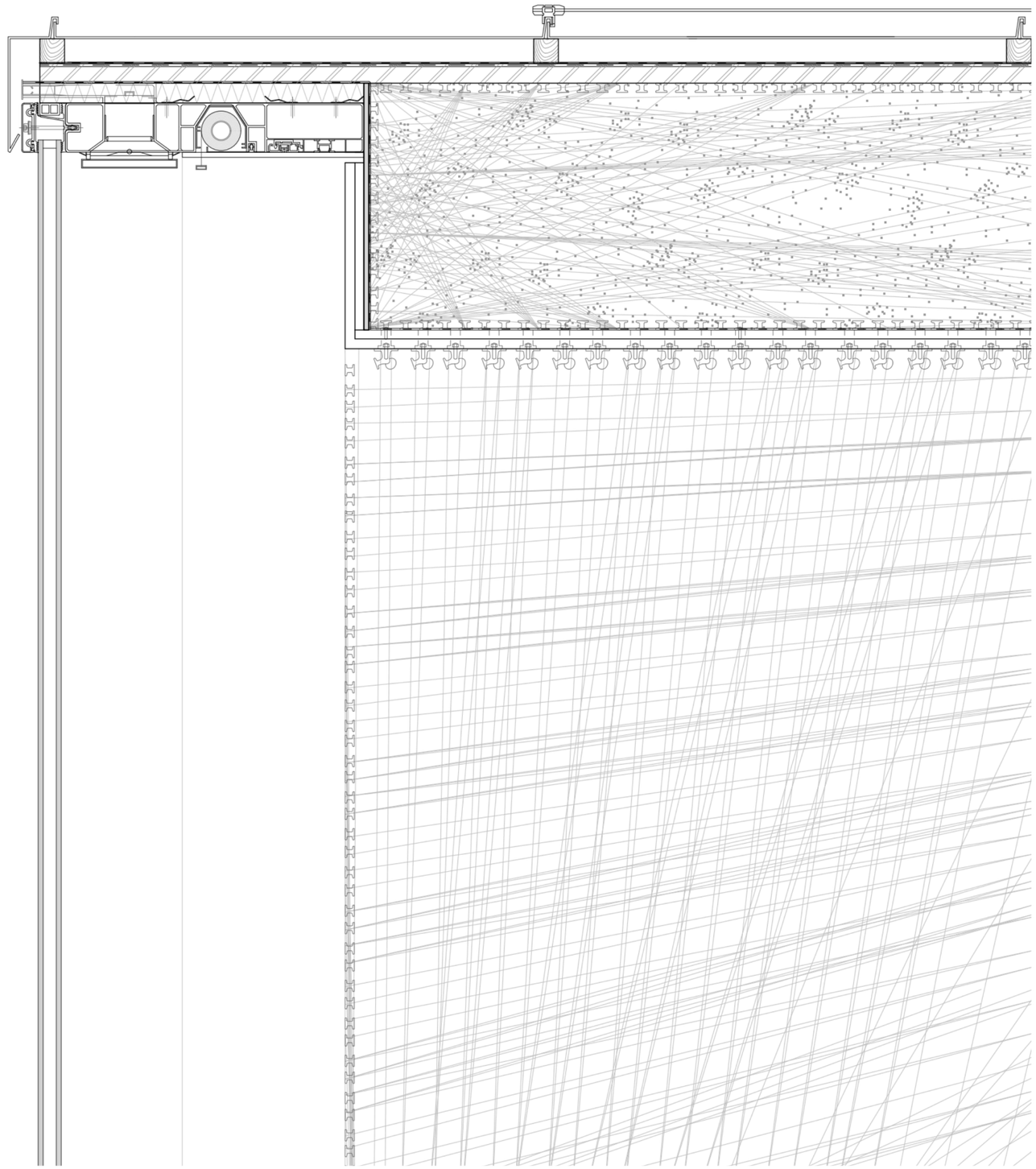




design - facade section

CURTAIN WALL UNIT

Exhaust air
Sunshading
Curtain rail
Light fixture



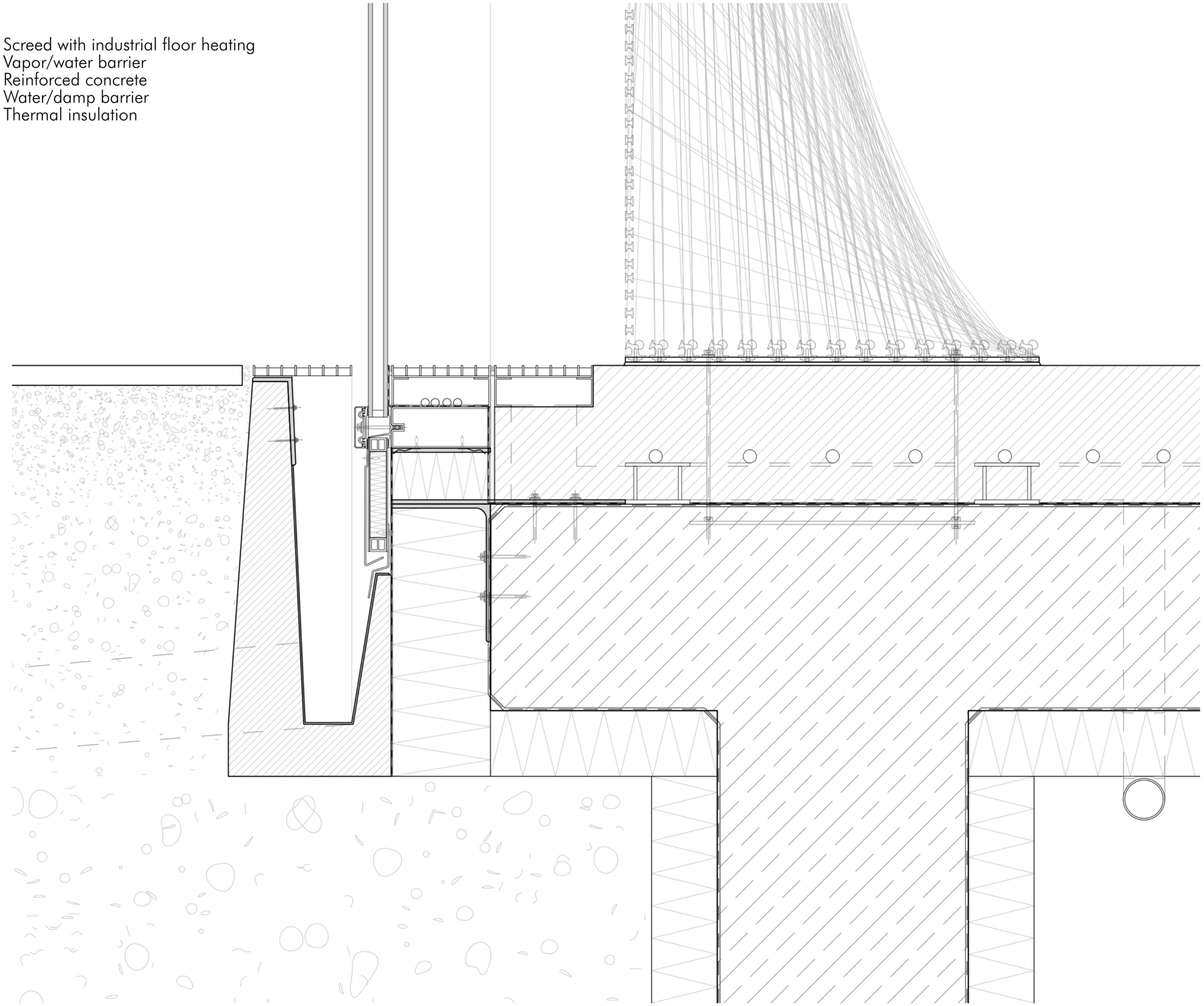
Solar panels

5mm	Fiber board roof cladding
30mm	Timber batten
1.2mm	thermal/damp barrier
30mm	OSB board
250mm	Flax wound and hemp compound insulation and structure
12mm	Plaster board
12mm	Plaster

DETAIL ROOF A

DETAIL FLOOR B

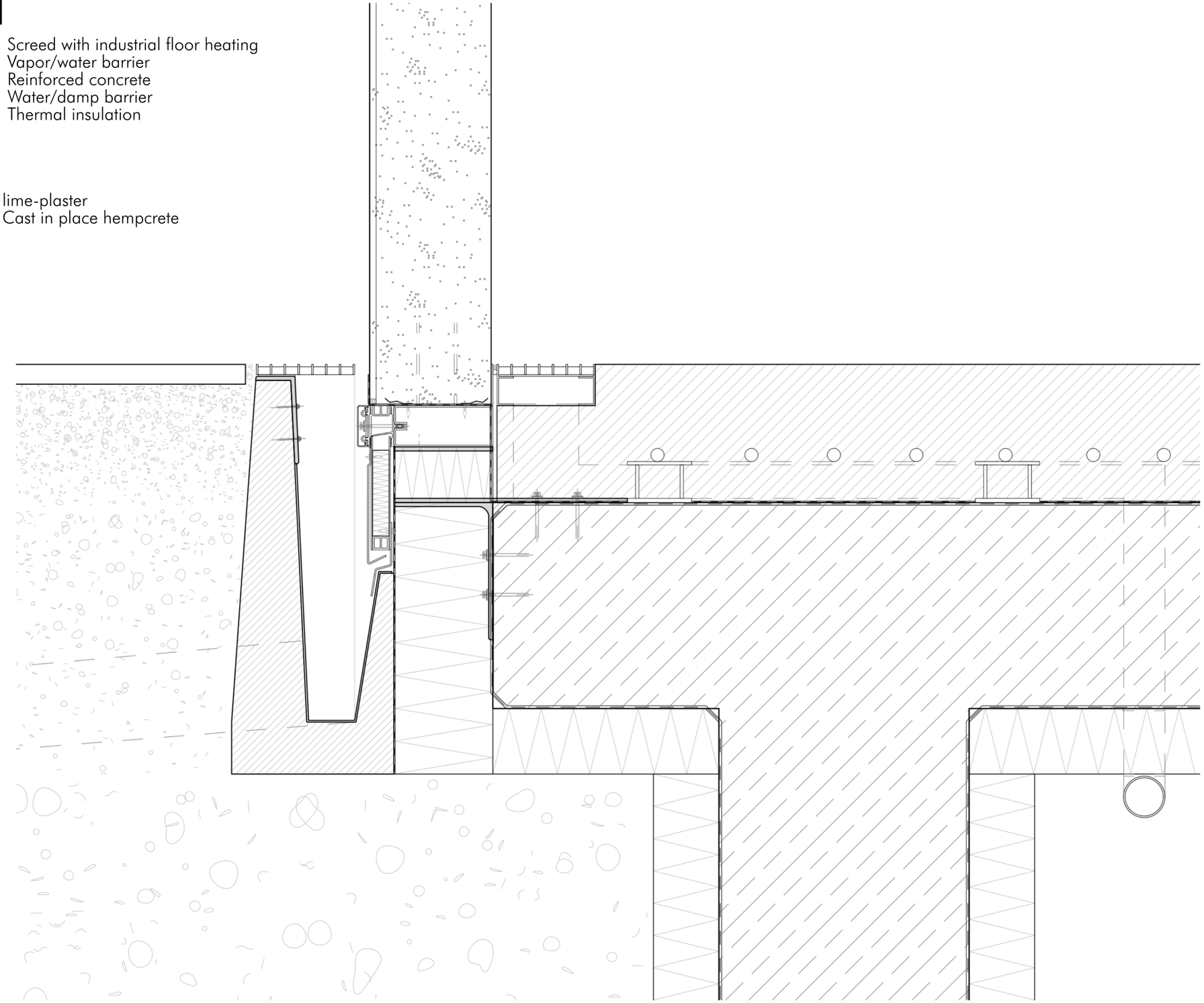
170mm	Screed with industrial floor heating
1.2mm	Vapor/water barrier
250mm	Reinforced concrete
2.4mm	Water/damp barrier
80mm	Thermal insulation



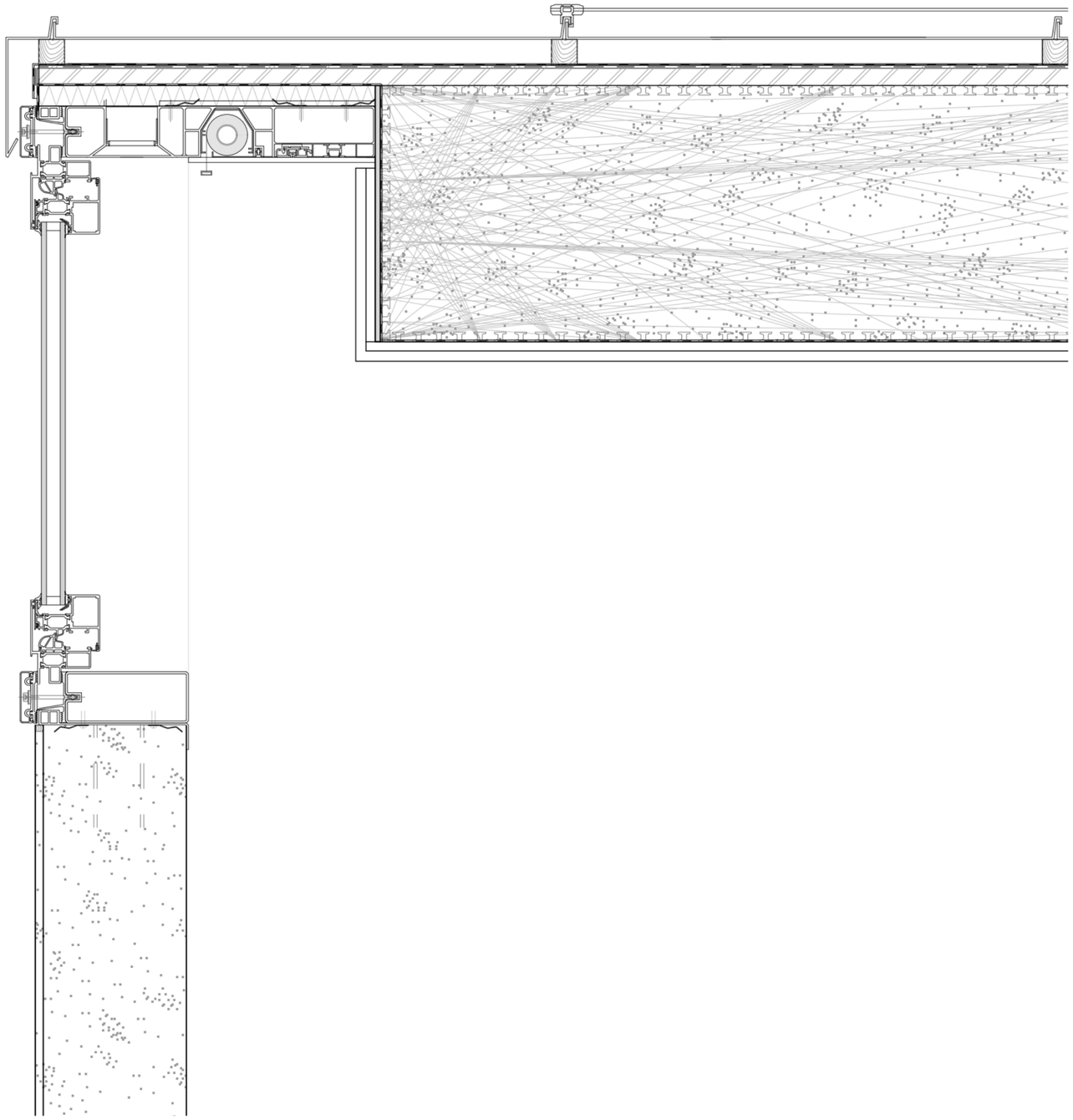
DETAIL FLOOR C

170mm	Screed with industrial floor heating
1.2mm	Vapor/water barrier
250mm	Reinforced concrete
2.4mm	Water/damp barrier
80mm	Thermal insulation

1.2mm	lime-plaster
150mm	Cast in place hempcrete



CURTAIN WALL UNIT
Exhaust air
Sunshading
Curtain rail
Light fixture



1.2mm	lime-plaster
150mm	Cast in place hempcrete
	Solar panels
5mm	Fiber board roof cladding
30mm	Timber batten
1.2mm	thermal/damp barrier
30mm	OSB board
250mm	Flax wound and hemp compound insulation and structure
12mm	Plaster board
12mm	Plaster

DETAIL ROOF D

fig.01: biobased principle
Hemp-Fiber Grow Mats - Lee Valley Tools. (n.d.). https://www.leevalley.com/en-ca/shop/garden/planting/propagation/seed-starting/111130-hemp-fiber-grow-mats?item=XB849

fig.02: various properties
A FLAX PROJECT by Christien Meindertsma. (n.d.).http://www.flaxproject.com/

fig.03: expression of form
Staugaitis, L. (2019, January 11). Quirky interventions by Octavi Serra question the rules of public spaces. Colossal. https://www.thisiscolossal.com/2019/01/quirky-interventions-by-octavi-serra/

fig.04:cannabis sativa l.
Roos, D. (n.d.). Industrial hemp is North Carolina's newest crop! NC State Extension. https://growingsmallfarms.ces.ncsu.edu/2017/08/industrial-hemp-is-north-carolinas-newest-crop/

fig.05: linum usitatissimum
Focal.(n.d.). https://www.innovationintextiles.com/new-flax-fibre-cones-for-speakers-diaphragm/

fig.06: mechanical properties hempcrete
Heider Vanessa. (2023).

fig.07: mechanical properties flax fibers
Heider Vanessa. (2023).

fig.08: compressed in block
Construction, B. (2023, March 1). Flax: A fibre of the future for construction? Bouygues Construction's Blog. https://www.bouygues-construction.com/blog/en/lin-fibre-construction/

fig.09: textiles/webs
Bernáth, I. (2023, September 27). These are the interior design trends of 2021. Evert Groot Interieurstoffen. https://evertgroot.nl/en/these-are-the-interior-design-trends-of-2021

fig.10: fiber sheet
FIBRO_SKIN. (2022, June 29). IAAC Blog.https://www.iaacblog.com/programs/fibro_skin/

fig.11: spun yarn
ICD/ITKE University of Stuttgart (n.d.).Universität Stuttgart. https://www.icd.uni-stuttgart.de/projects/livMatS-Pavilion/

fig.12: filament winding methods
Duque Estrada, R., Kannenberg, F., Wagner, H. J., Yablonina, M., & Menges, A. (2020).Spatial winding: cooperative heterogeneous multi-robot system for fibrous structures. Construction Robotics, 4, 205-215.

fig.13: coreless filament winding princpile
Heider Vanessa. (2023).

fig.14: demonstration fiber pavillions from ICD University Stuttgart
ICD/ITKE University of Stuttgart (n.d.).Universität Stuttgart. https://www.icd.uni-stuttgart.de/projects/livMatS-Pavilion/