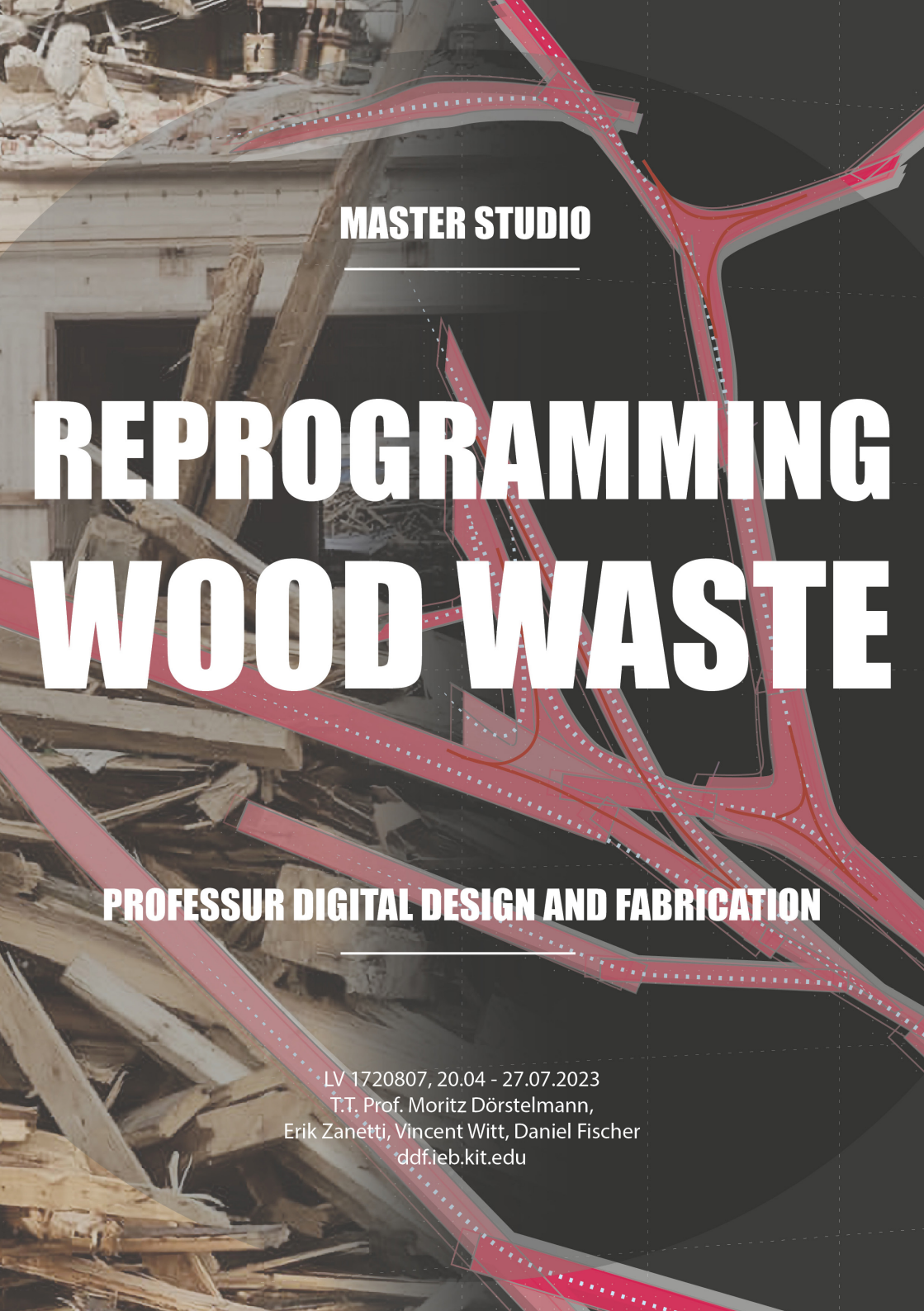


MASTER STUDIO

REPROGRAMMING WOOD WASTE

PROFESSUR DIGITAL DESIGN AND FABRICATION

LV 1720807, 20.04 - 27.07.2023
T.T. Prof. Moritz Dörstelmann,
Erik Zanetti, Vincent Witt, Daniel Fischer
ddf.ieb.kit.edu

CONTENTS

01 INTRODUCTION AND CONTEXT

Construction timber from urban mining, one type of wood waste

The construction industry today is still based on the classic system of the linear economy: raw materials are taken from established natural systems such as forests, mines, quarries

or other extraction sites, processed into building materials and then disposed of.

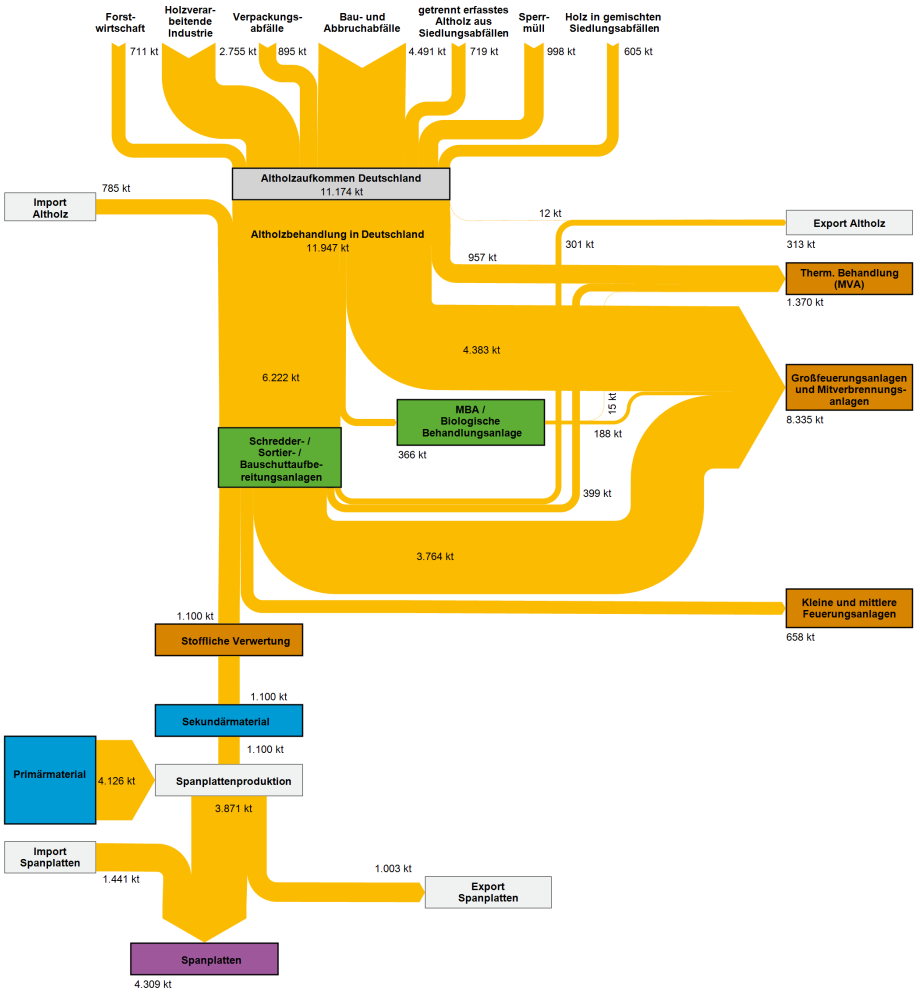
Against the backdrop of a growing world population and increasing scarcity of resources, it is long past time to question the“take-make-dispose” model and recognise materials as a source for continuous future value creation.

The circular economy, as described by the EllenMacArthur Foundation in 2015, recognises all materials as a circulating source in the technical or biological metabolism. (https://

ellenmacarthurfoundation.org/circular-economy-diagram). From the development of new business and economic models and from self-initiated innovation, architects can intervene in the existing system and actively change it.

According to European Union surveys, the construction sector is responsible for 40% of our CO2 and other greenhouse gas emissions, 50% of primary energy consumption, 50% of primary raw material consumption and at least 36% of solid waste generation. This can account as an incredible potential for change. (European Union: LEVEL(S), p. 5)

The key to the circular economy in building construction and reconstruction modelling lies in the issue of material extraction, processing, use, reuse and recycling. Their intrinsic recyclability and cycle-compatible interconnection are to be seen as a prerequisite for their complete value retention. (Hebel and Heisel: Urban Mining und Kreislaufgerechtes



Material flow for wood waste in Germany

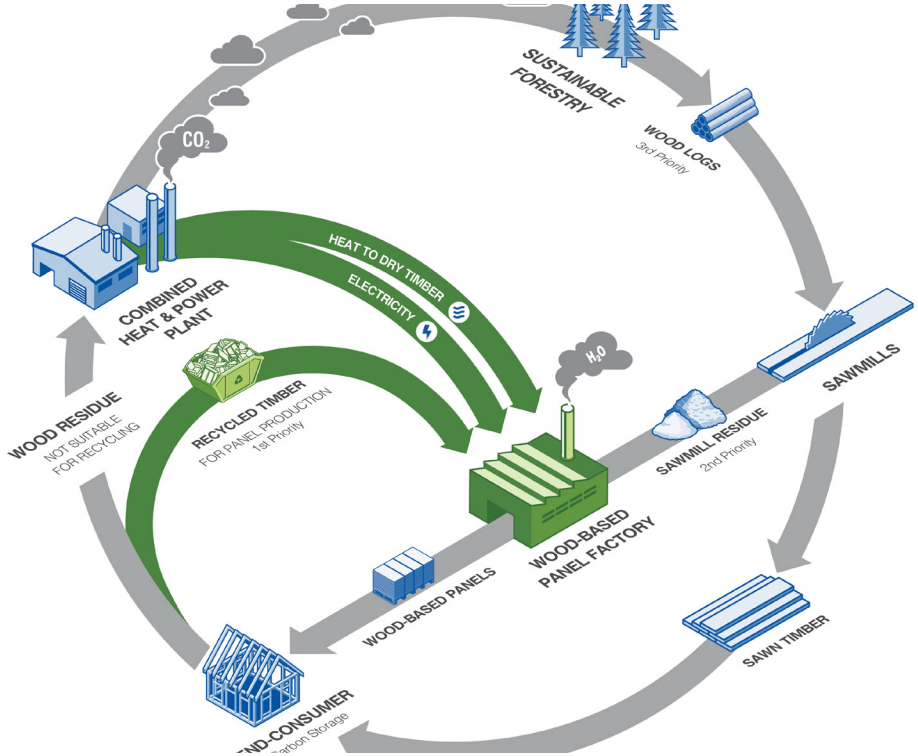
Bauen, p. 13)

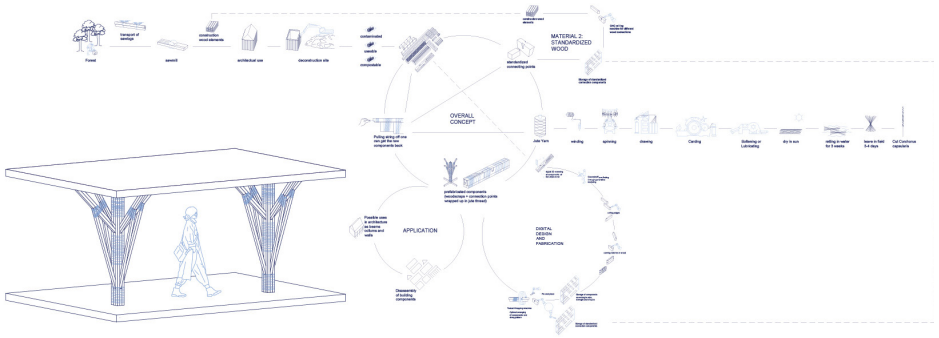
Additionally, one major challenge is learning to deal with non-standard materials whose irregular shape derives from their intrinsic natural or man-made variations. The potential is particularly great for bio-based materials and their waste, whose structural properties depend greatly on their fibre orientation and geometry.

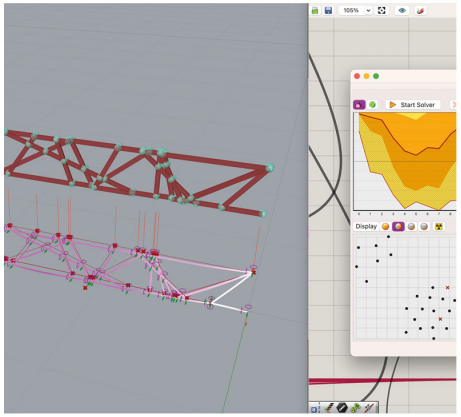
Digital fabrication can have a role in this upcoming transformation of the building industry by enabling custom solutions for novel material processes, providing in this way a plausible support for innovation.

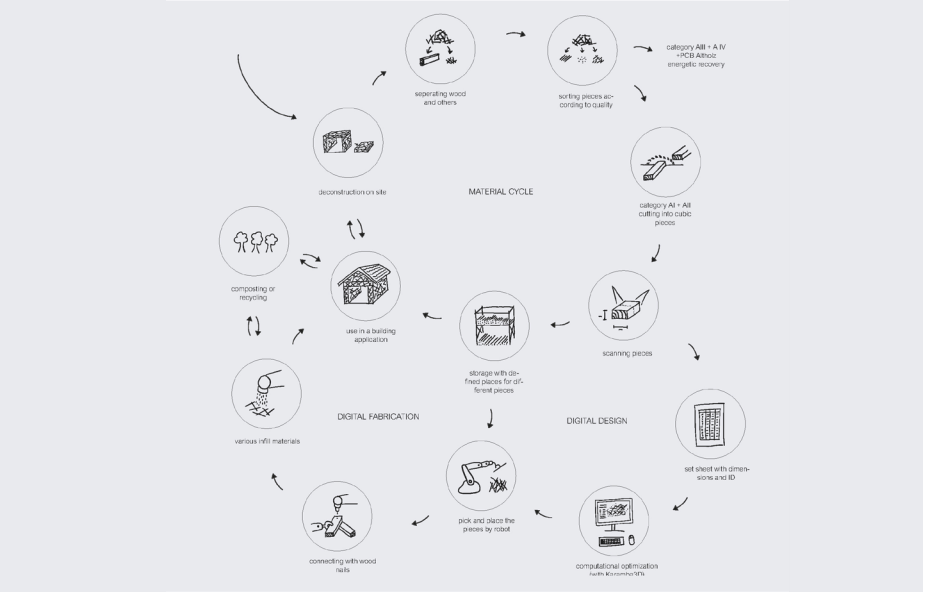
When it comes to timber, the industry currently mainly uses high-quality wood that is in straight parts and reduces the rest into chips or pulps for products that are often not structural or non-recyclable. This results in a loss of value. Instead, leveraging the adaptability of digital and robotic fabrication can create new strategies that emerge from the complexity and irregularity found in waste or reclaimed materials. These strategies should employ digital tools not only as means of control but also as a design methodology and an experimental form-finding process. In this way, the challenge arising from the material can be seen as a potential for experimentation for structural applications and for expanding the design possibilities.

This enormous potential will be explored and investigated in the studio “Reprogramming Wood Waste”.



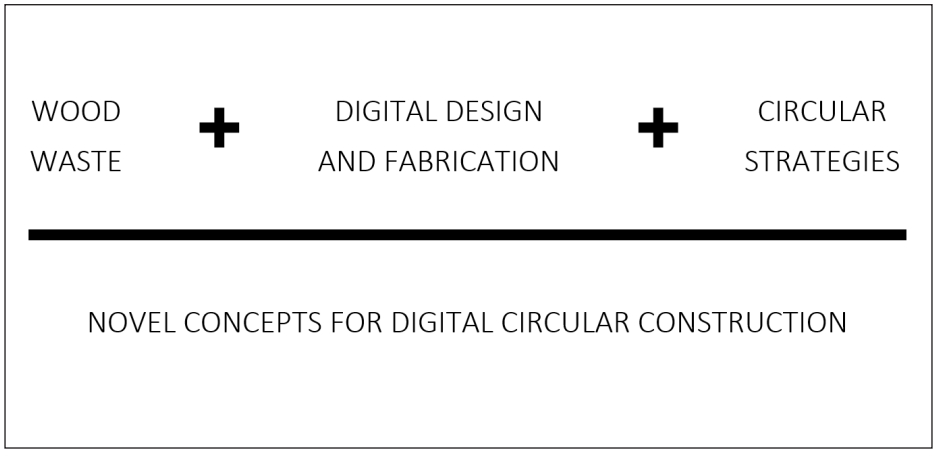






The studio will build upon the results of the seminar “MatchMaking”- developed in collaboration with the Professur Nachhaltiges Bauen

02 AIM



Overarching goal of Reprogramming Wood Waste

The studio “Reprogramming Wood Waste” aims at developing circular construction solutions that are sustainable, circular and locally sourced for waste and reclaimed timber. It aims to do so by capitalising on the adaptability of computational tools and digital fabrication processes.The objective is to enhance their circular potential through novel processing concepts, resulting in a proof of concept for an envisioned construction method and architectural application. In particular, the focus will be on hybrid or composite materialities that can respond to different architectural or construction parameters.

The studio will develop architectural and construction applications through the basic design of a case-study building based on the innovative construction system. The design of this experimental structure is based on an integrated concept that considers design, digital fabrication, assembly and reconfiguration, as well as disassembly and recycling. Fragments of this will then be developed through full-scale proof-of-concept prototypes, supporting the material, process and concept. These will showcase the tailored architectural solution resulting from research-based exploratory prototypes, in which material behaviour, manufacturing, aesthetics, structural capabilities as well as technical solutions are explored.

The final prototypes will be displayed at the end of the semester, showcasing a range of applications and concepts for implementing circular digital construction for wood waste.

03 METHODS

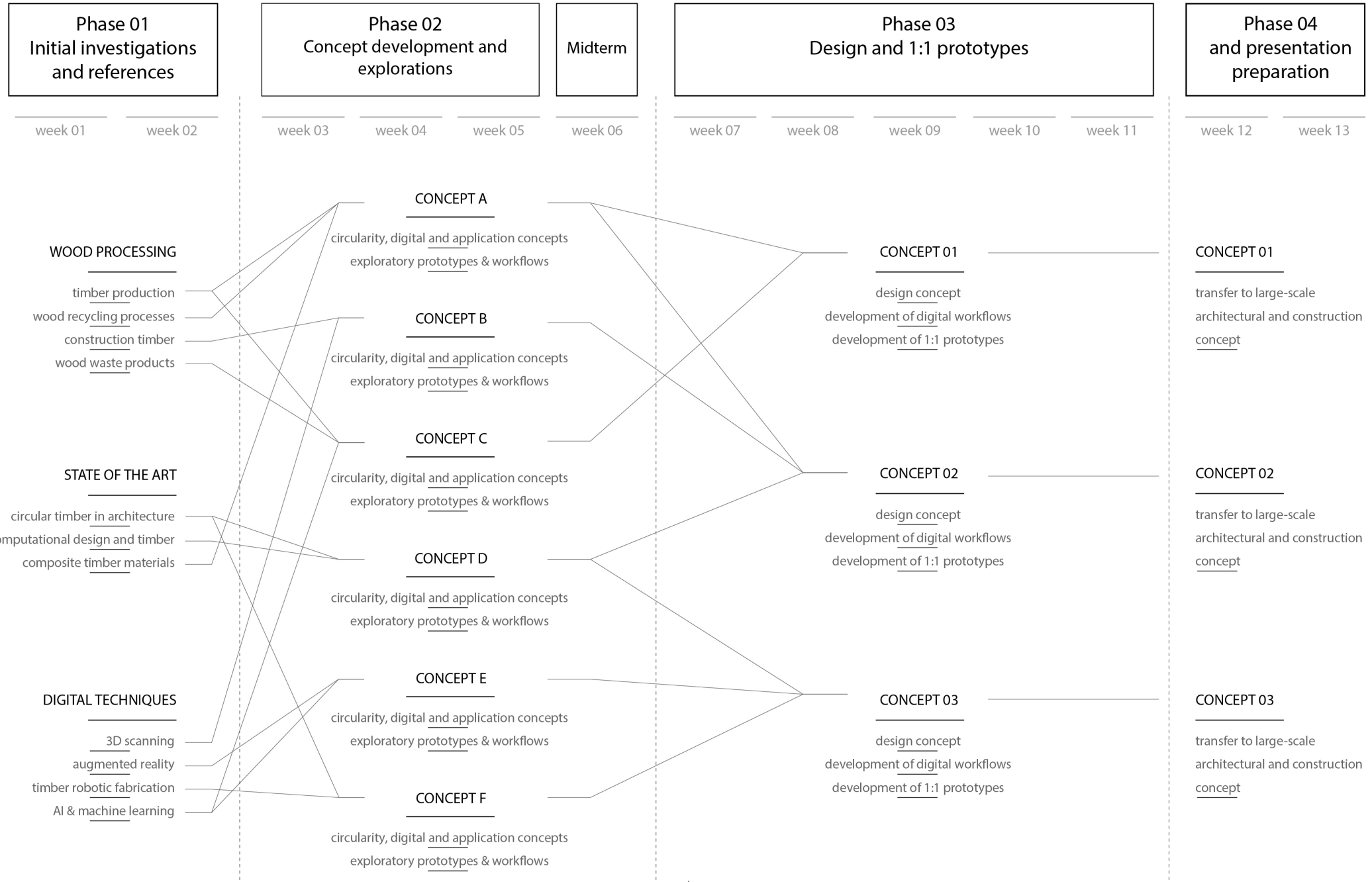
At the intersection of research and teaching, the studio offers students the opportunity to develop their own concepts and inform them through an understanding of material, construction, digital design and digital fabrication processes. The studio uses a series of development phases (see chapter 04), meant to guide the students through the implementation of the studio methodology, starting from individual initial investigations on selected topics to introduce the students to the topic. Subsequently, students will merge into groups and develop a series of potential concepts, related applications and explorative prototypes or workflows. The architectural potential of these concepts is then explored by groups through design iterations for experimental structures and 1:1 prototypes, merging the knowledge developed in the previous phases.

A series of skill-building tutorials at the beginning of the semester introduces students to selected topics, processes and workflows in computational design and digital fabrication.

No prior knowledge is required to take the studio.

04 DEVELOPMENT PHASES

Summer Semester 2023



DEVELOPMENT PHASE 01:

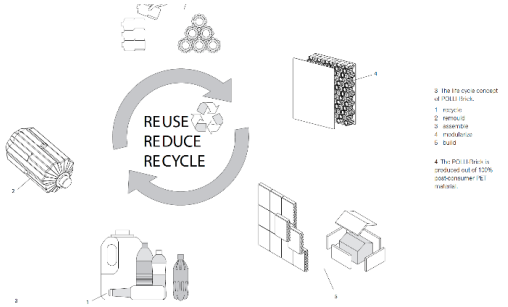
Iniital investigations and references

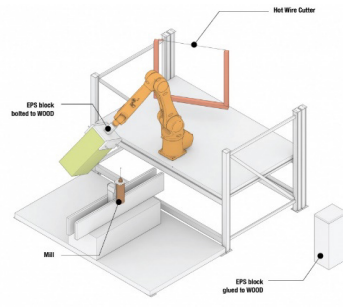
The first development phase consists of a range of investigations on the state of art, including materials, digital fabrication techniques and architectural references. This will serve to create a varied repertoire on which to base and position the upcoming research. These investigations will be guided through a series of specific research questions. To familiarise students with the underlying themes of the studio, this first phase will be complemented by introductory lectures on computational and digital fabrication thinking as well as on the research carried out in the previous semester. These will be combined with first introductory tutorials on computational software during the studio times.

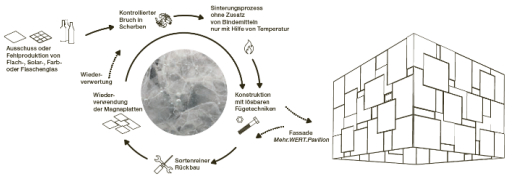
DEVELOPMENT PHASE 02:

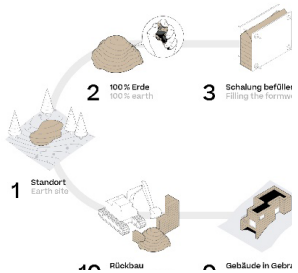
Concept development and explorations

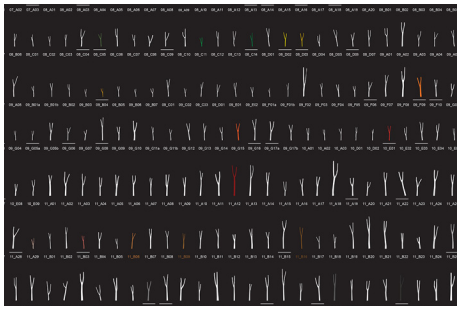
In the second studio phase, students will develop a series of potential concepts for novel circular construction systems that combine materiality with computational workflows and digital fabrication techniques. This development will be carried out through project-related diagrams or comparable representations explaining the overall concept as well as the topics of circularity, process application and digital fabrication technology. In addition, the developed concepts are to be tested using initial prototypes and/or explorative prototypes and workflows.

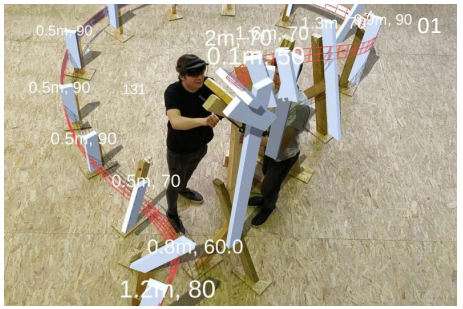












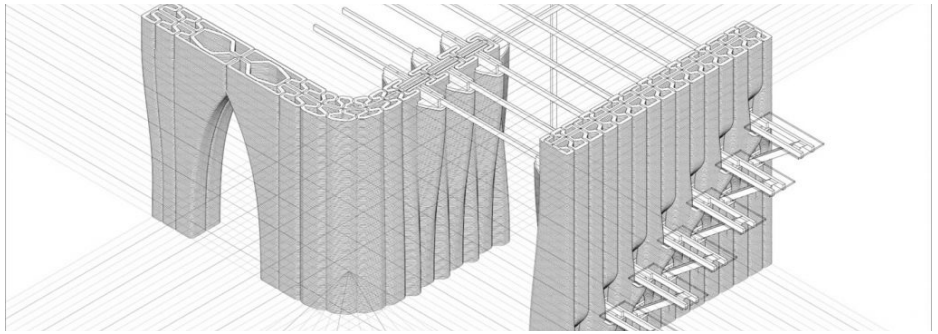
DEVELOPMENT PHASE 03:

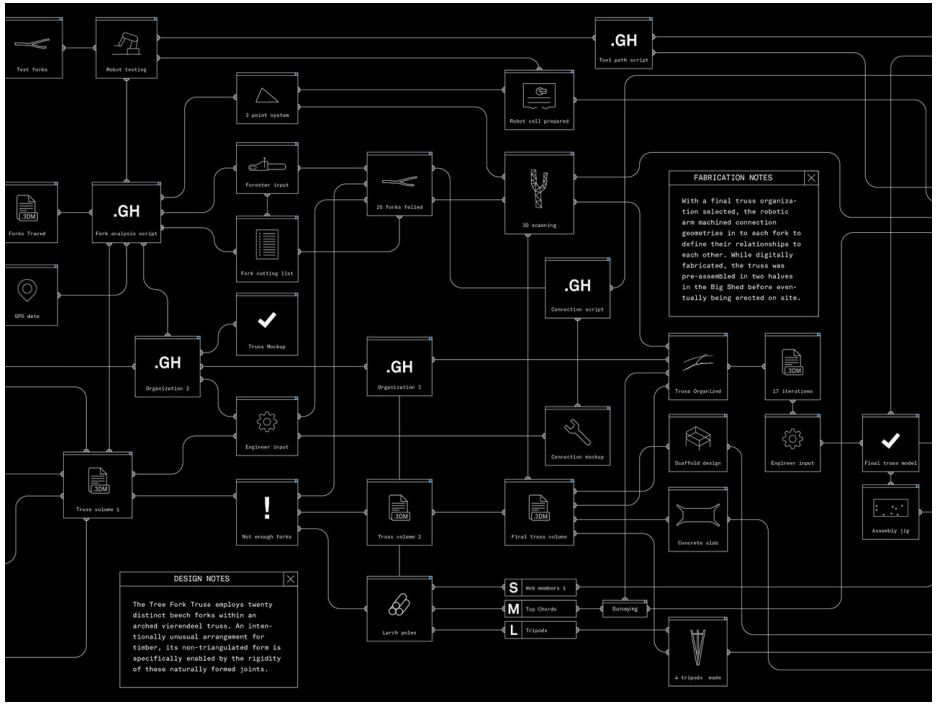
Design and 1:1 prototypes

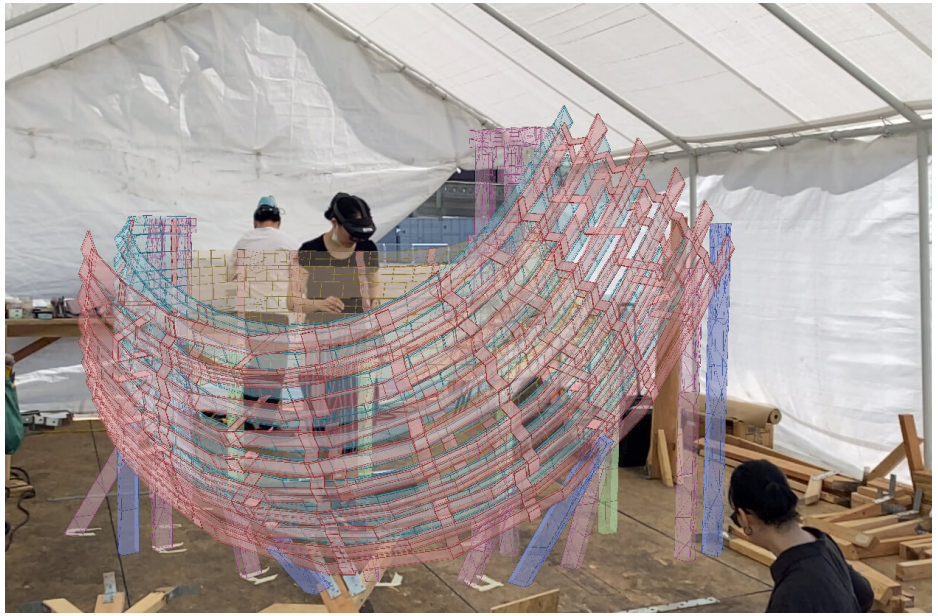
The studio will develop architectural and construction applications through the basic design of a case-study building or research demonstrator based on the innovative construction system. The design of this experimental structure is based on an integrated concept that considers design, digital fabrication, assembly and reconfiguration, as well as disassembly and recycling.

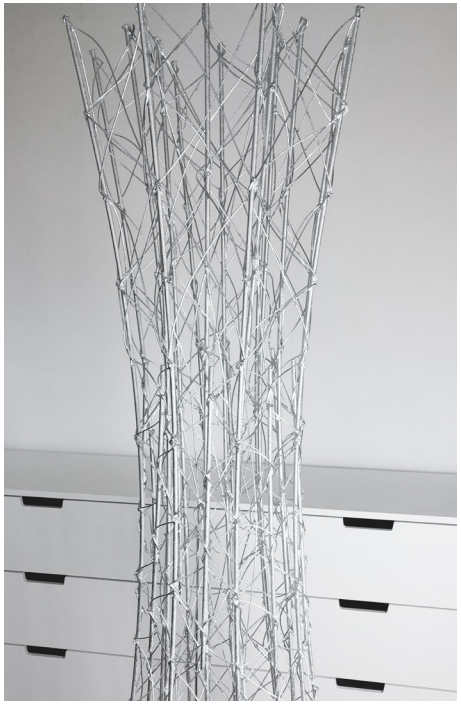
The design development will be bottom-up and will emerge from the materiality, processing concept and envisioned digital workflow.

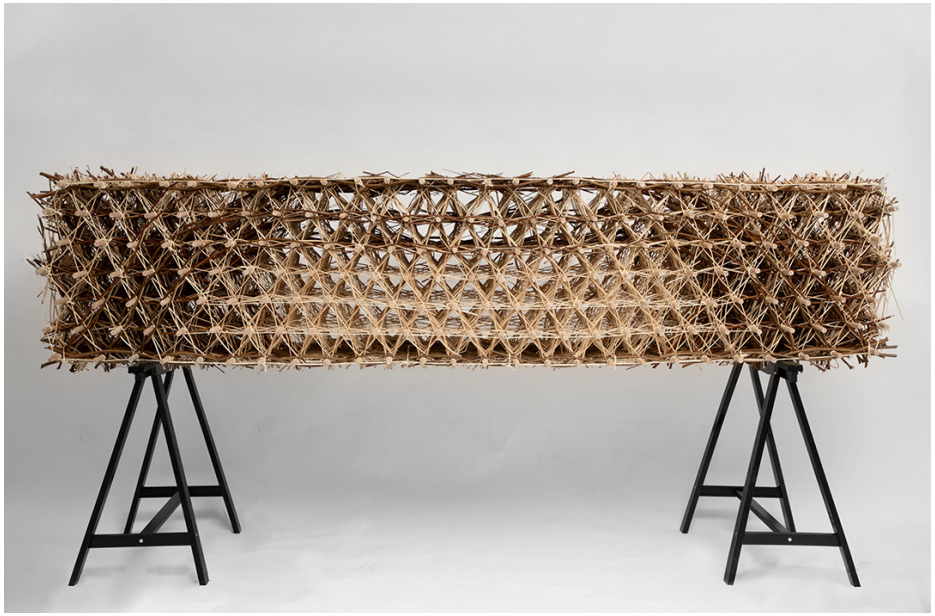
Fragments of the design will then be developed through full-scale prototypes. The 1:1 scale prototype, minimum 1x1 metres, will serve as a proof-of-concept model that results from the evolution of the exploratory prototypes and demonstrates the design, material and fabrication aspects of the project and validates their architectural potential.




Test forks
Robot testing
.GH
Tool path script
3 point system
Robot cell prepared
Forwoter input
25 forks felled
3D scanning
Forks Traced
.GH
Fork analysis script
Fork cutting list
GPS data
Truss Mockup
.GH
Connection script
.GH
Organization 2
.GH
Organization 3
Truss Organized
17 iterations
Engineer input
Connection mockup
Scaffold design
Engineer input
Final truss model
Truss volume 1
Not enough forks
Truss volume 2
Final truss volume
Concrete slab
Assembly jig
FABRICATION NOTES
With a final truss organization selected, the robotic arm machined connection geometries in to each fork to define their relationships to each other. While digitally fabricated, the truss was pre-assembled in two halves in the Big Shed before eventually being erected on site.
DESIGN NOTES
The Tree Fork Truss employs twenty distinct beech forks within an arched vierendeel truss. An intentionally unusual arrangement for timber, its non-triangulated form is specifically enabled by the rigidity of these naturally formed joints.
Larch poles
S Web members 1
M Top Chords
L Tripods
Surveying
4 tripods made



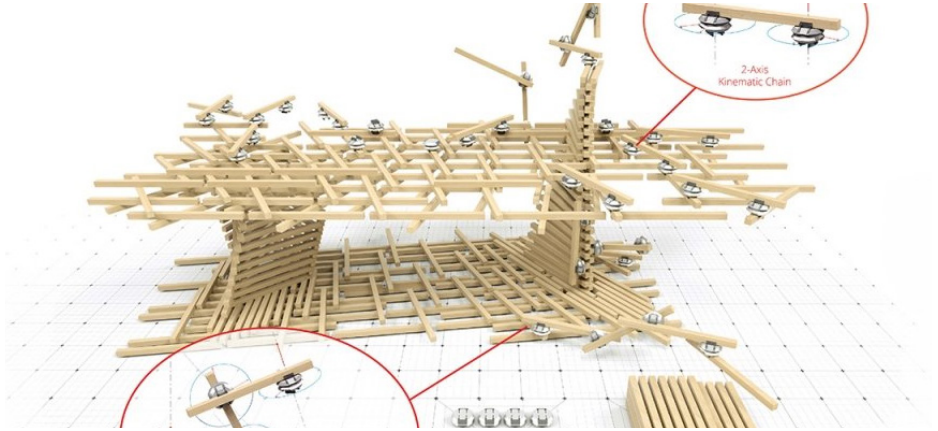


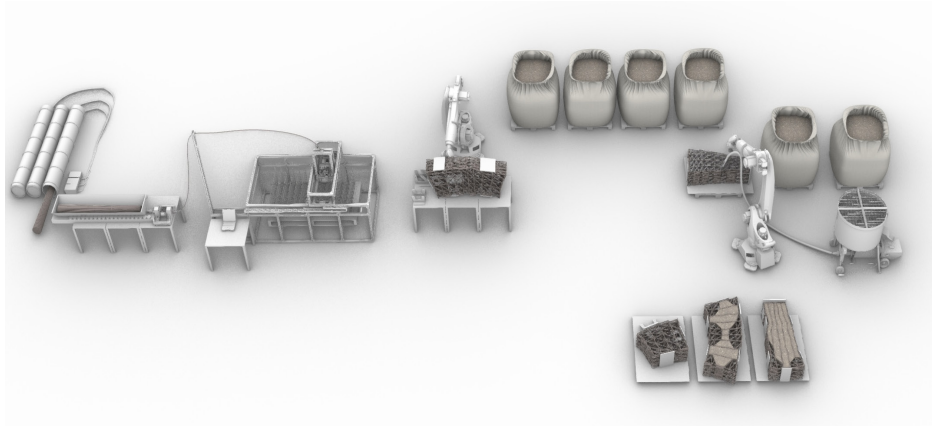


DEVELOPMENT PHASE 04:

Trasnfer to large-scale architectural and construction concepts

In this phase, students will speculate on the underlying architectural design repertoire emerging from the proposed construction concepts as a way to reflect on the impact of the novel construction system along the continuous line of investigation developed thus far.





05 DELIVERABLES

DELIVERABLES FOR FINAL PRESENTATION - 03.08.2023

Group presentation – max. 20 minutes

- Storyline of each project, from research to design

- Concept diagrams

- 1:1 prototype, exploratory prototypes and workflows

- Design from global scale to details - including architectural and construction parameters (such as structural logic and material logic)

- Large-scale architectural and construction concept

BOOKLET - 20.08.2023

Individual and group hand-in - Documentation of the progress at the different phases based on template by DDF

DELIVERABLES PER DEVELOPMENT PHASE

TBC

06 SCHEDULE

Studio dates:
Thursdays, 10.00 am – 5.30 pm

Studio room:
1.OG R 133 &
DDF Fabrication Lab - Karlspark
Technologiezentrum, Siemensalee, Karlsruhe

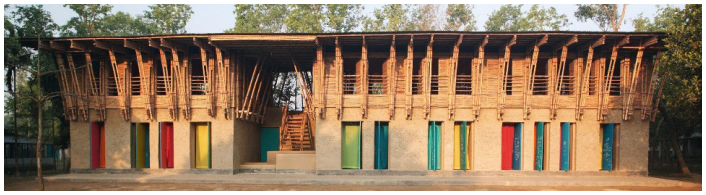
Month	KW	Week	Nr.	Day	Studio dates	Description	Studio phases
April	15		-	Tu.	11.04	Vorstellung Entwursthemen	
	15		-	Fr.	18.04	Meeting about excursion (TBC per email)	
	16		1	Th.	20.04	10:00 - 12:00 Intro to the course 13.00 - 17.00: Introduction Rhino and Grasshopper	
					21.04-22.04	Excursion	**PHASE 01: Investigations, references and introductions**
	17		2	Th.	27.04	Desk crits Introduction to rhino and grasshopper strategies for concept development	
May	18		3	Th.	04.05	Presentation Phase 01 Introduction to structural analsysis and optimisations with grasshopper	
	19		4	Th.	11.05	Desk crits	
	20		X	Th.	18.05	Holiday	**PHASE 02: Concept development and exploratory prototyping/workflows**
	21		5	Th.	25.05	Desk crits Introduction to 3d scanning & Augmented Reality	
June	22		X	Th.	01.06	Seminarwoche	
	23		X	Th.	08.06	Holiday	
	24		6	Th.	15.06	Midterm	
	25		7		22.06	Desk crits	
	26		8		29.06	Desk crits	
July	27		9		06.07	Desk crits	**PHASE 03: Design and 1:1 prototype development**
	28		10		13.07	Desk crits	
	29		11		20.07	Desk crits	
	30	13.02 - 17.02	12	-	27.07	Desk crits	**PHASE 04 & Presentation preparation**
August	31	20.02 - 24.02	13	-	03.08	Final presentation	

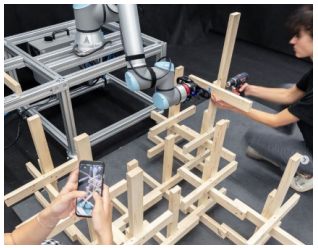
07 EXCURSION

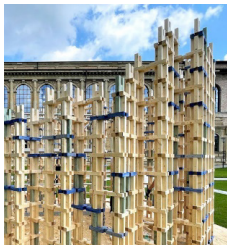
21.04 - Munich
22.04- Buga 2023 Mannheim

(more information will be communicated on a meeting on the 18.04)

BAU
Weltleitmesse für Architektur, Materialien, Systeme
17.–22. April 2023 | Trade Fair Center Messe München







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08 REFERENCES

Images