MASTERENTWURF

Digital Upcycling: Wood

PROFESSUR DIGITAL DESIGN AND FABRICATION

LV 1720805, 26.10.2023 - 22.02.2024
T.T. Prof. Moritz Dörstelmann,
Vincent Witt, Erik Zanetti
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 used in buildings. After the building is demolished the materials are 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.

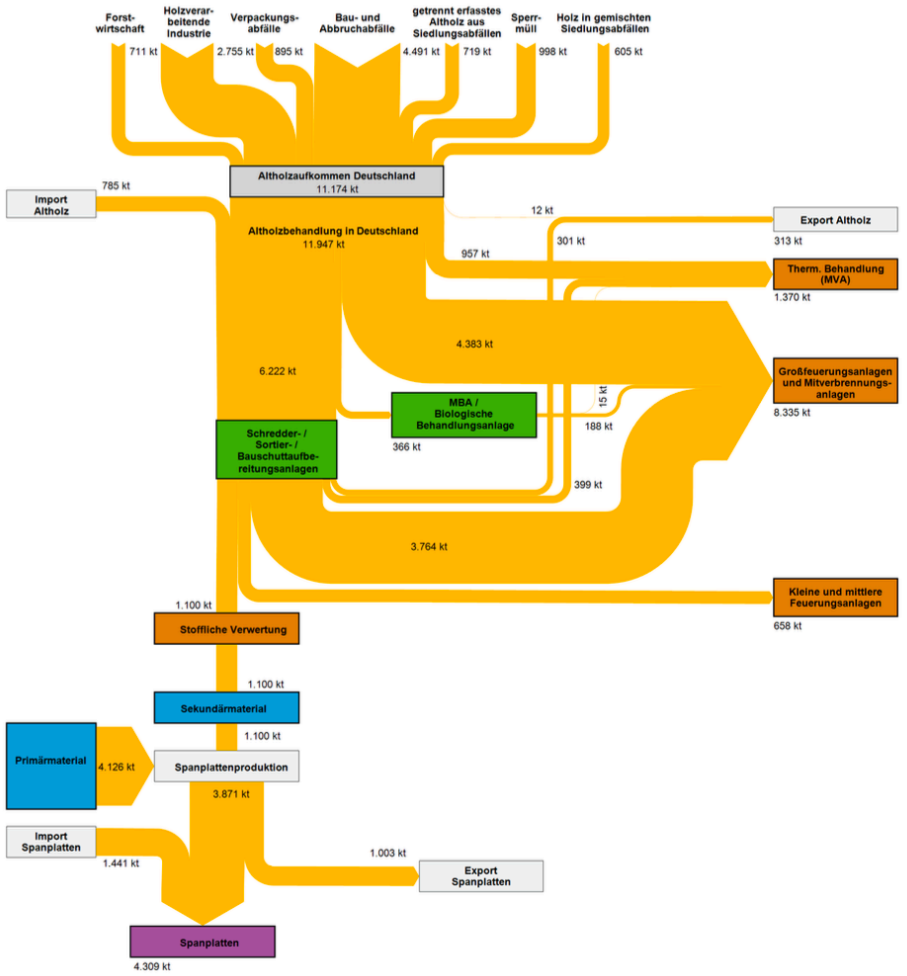
The circular economy, as described by the EllenMacArthur Foundation in 2015, recognises all materials as a circulating resource in the technical or biological metabolism. (https://ellenmacarthurfoundation.org/circular-economy-diagram). From the development of new business and economic models and from 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 Bauen, p. 13)

Additionally, one major challenge is learning

2



Material flow for wood waste in Germany

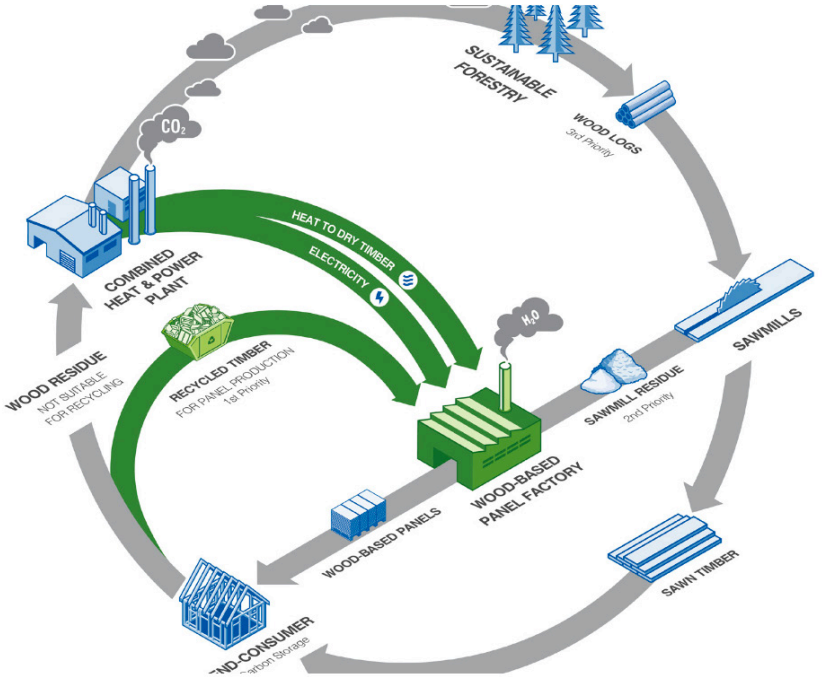
to deal with non-standard materials whose irregular shape derives from their intrinsic natural or man-made variations. The potential is particularly great for bio-based materials and their waste, whose structural properties depend greatly on their fibre orientation and geometry.

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.

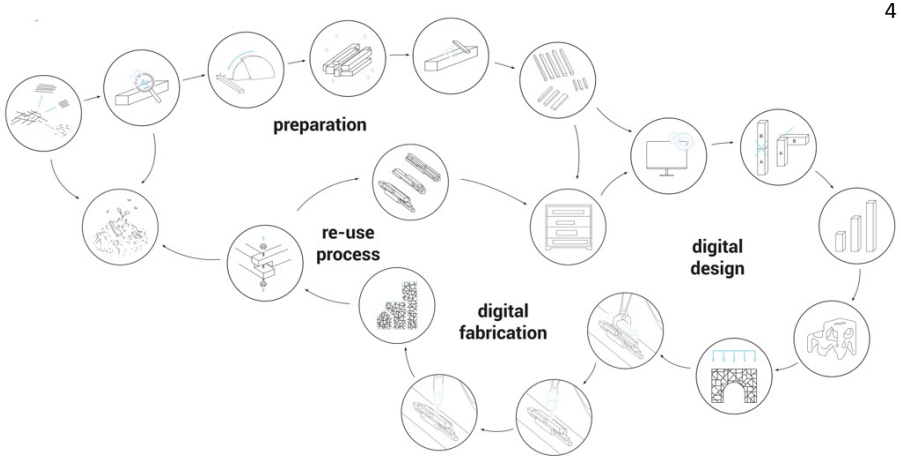
When it comes to timber, the industry currently mainly uses high-quality wood that is in straight parts and reduces the rest into chips or pulp for products that are often not structural or non-recyclable. This results in a loss of value. Instead, leveraging the adaptability of digital and robotic fabrication 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 “Digital Upcycling: Wood”.

3



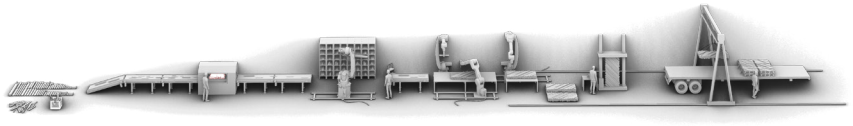
4



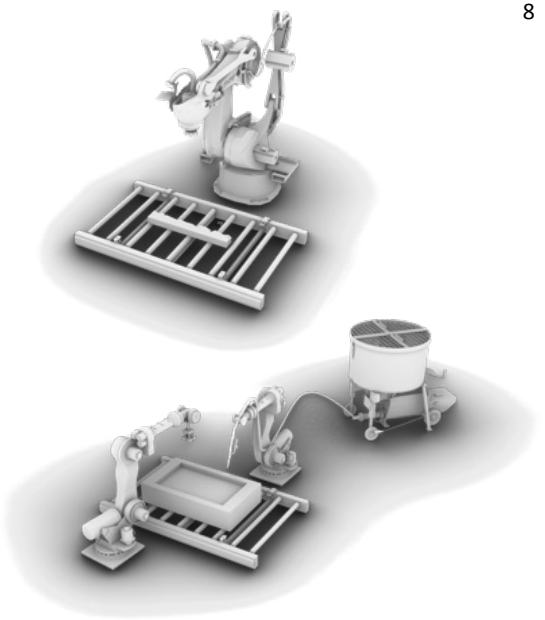
5

6

7



8

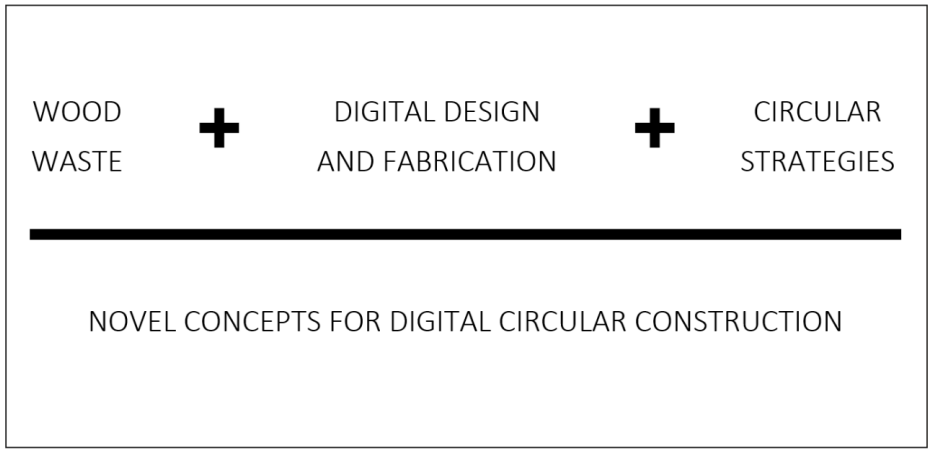


9

10

The studio will build upon the results of the prior studio “Reprogramming Wood Waste”

02 AIM



Overarching goals of ReGrow Design

The studio “Digital Upcycling: Wood” 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.

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.

At the end of the semester all processes will be tested and a prototype of the final design will be built. This is in preparation for a full scale production in the following semester for “dasFest” 2024.

03 METHODS

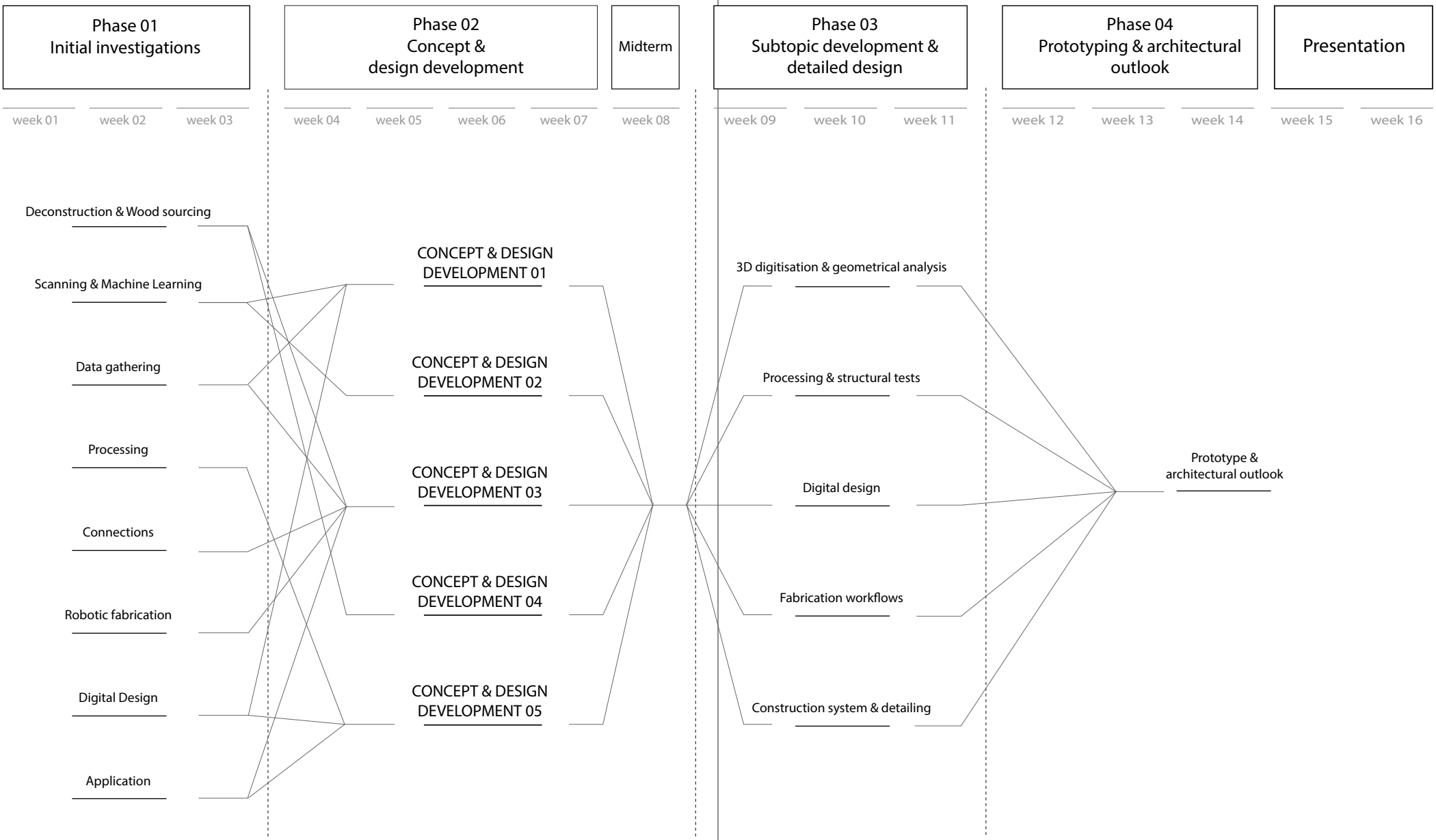
At the intersection of research and teaching, the studio offers students the opportunity to develop their own concepts and inform them through an understanding of material, construction, digital design and digital fabrication processes. The studio uses a series of development phases (see chapter 04), 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. One of the concepts will then be further explored through differnt subtopic developments merging the knowledge developed in the previous phases. A prototype of the final design will be built as a test production run for the following semester.

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

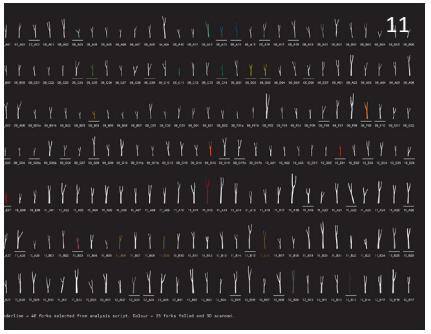
Winter Semester 2023-2024



DEVELOPMENT PHASE 01:
Initial investigations and references

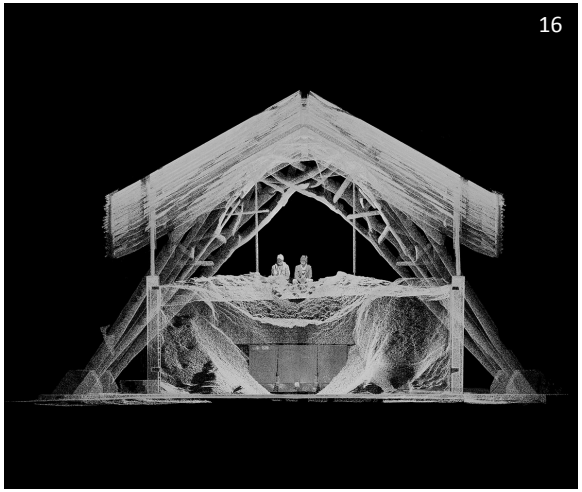
The initial development phase will encompass a comprehensive exploration of indepth topics, including material sourcing, processing methods, robotic manufacturing, digital design, and practical application. This will serve to create a varied repertoire on which to base and position the upcoming concept and design developments. To familiarise students with the underlying themes of the studio, this first phase will be complemented by introductory lectures on computational design methodologies and digital fabrication as well as on the research carried out in the previous semester.


14


11


15


12

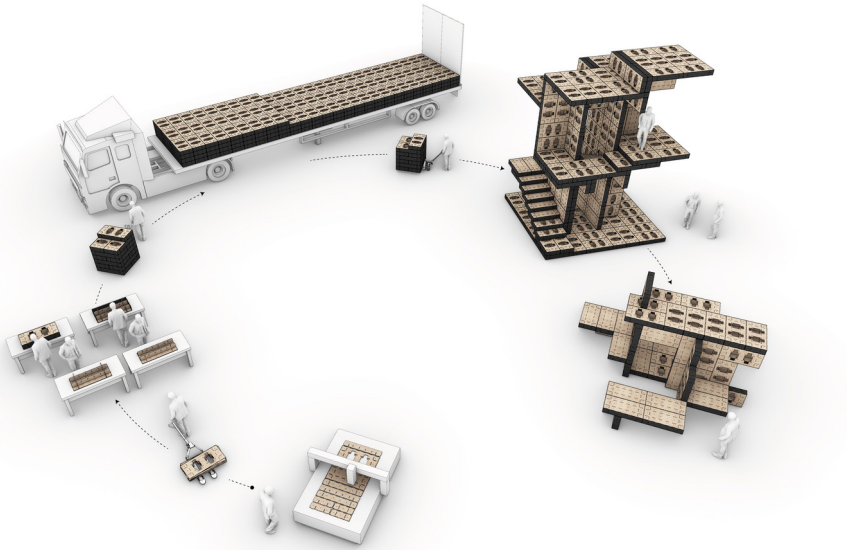

16


13

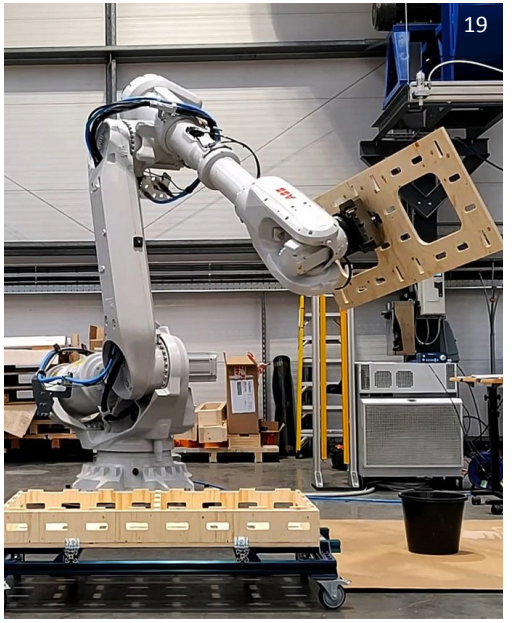
DEVELOPMENT PHASE 02:
Concept and design development

Buidling on the initial investigations the studio will develop different architectural designs and construction applications taking different variables. Through the basic design of a case-study building or research demonstrator based on the innovative construction system the process undestandig will be enhanced. 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.

17

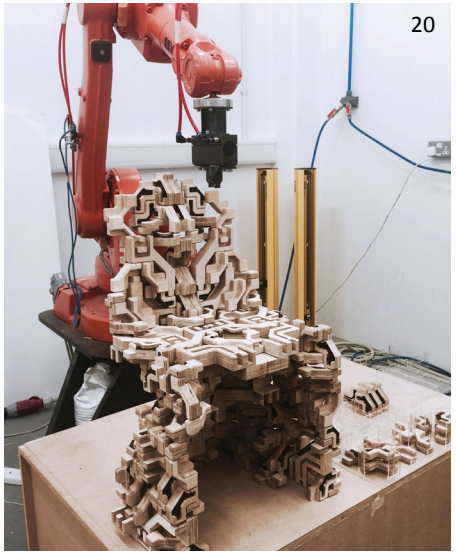


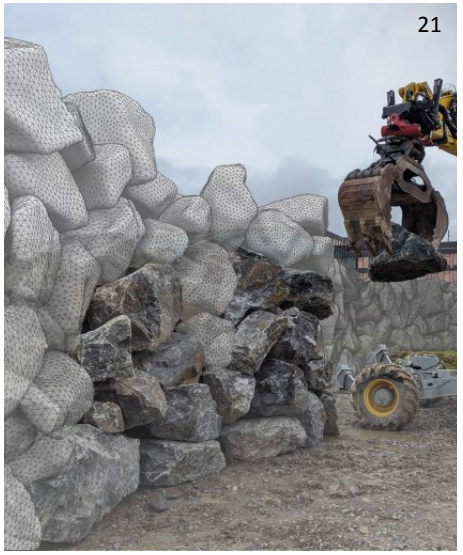

18

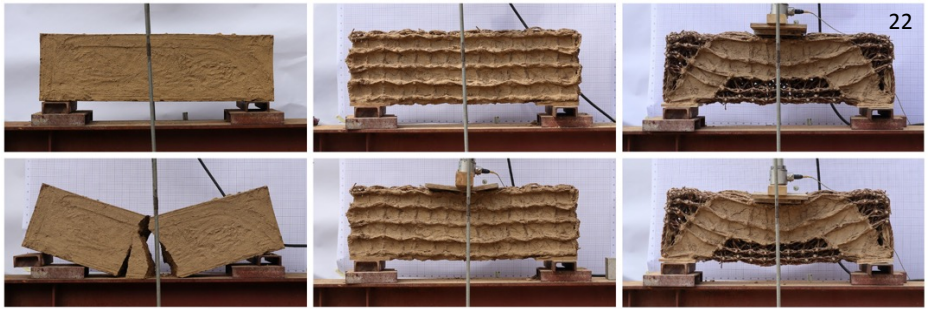

19

DEVELOPMENT PHASE 03:
Suptopic development and detailed design

In the third studio phase, students will build on the developed concepts and explore expert subtopics of the selected concept to be further developed. These expert topics cover the whole production chain from material gathering to sorting and assesing to robotic construction and are tailord to a fullscale integration into the building design and system. This development will be carried out through project-related diagrams or comparable representations explaining the overall research as well as the topics of circularity, process application and ingetragion in digital fabrication technology. In addition, the developed concepts are to be tested using initial prototypes and/or explorative prototypes and workflows.


20


21

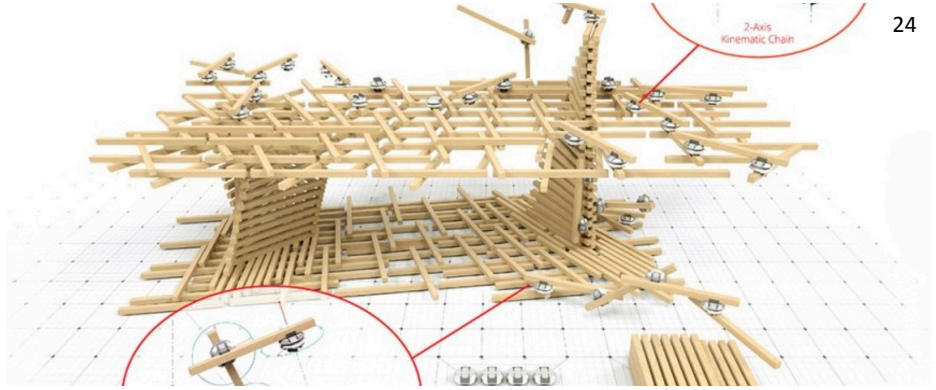

22


23

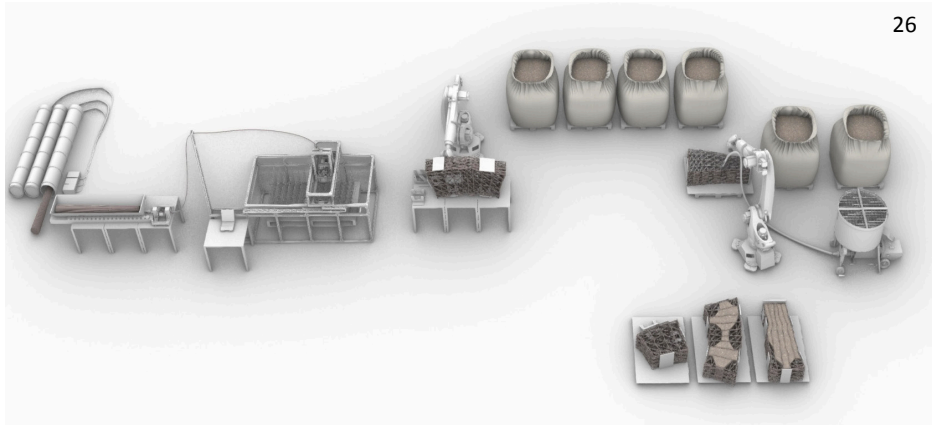
DEVELOPMENT PHASE 04:
Prototyping and architectural outlook

In this phase, all the designs developed will feed into a final concept from which parts of the design will be developed into a full scale prototype. Validated through test production, the 1:1 scale prototype will serve as a proof of concept for the production of a demonstrator in the following semester for dasFest 2024. As a result of the development of the mockup, the prototype demonstrates the design, material and fabrication aspects of the project and validate its architectural potential. Students will continue to speculate on the underlying architectural design repertoire that emerges from the proposed construction concept as a way of reflecting on the implications of the novel construction system along the continuous line of investigation developed so far.

25



24



26


27


28


29


31


30


32

05 DELIVERABLES

DELIVERABLES FOR FINAL PRESENTATION

Group presentation divided into smaller groups for subtopics

- Storyline of the project, from concept to global and detailed construction system (e.g. concept diagrams, circularity diagram, micro climate adaptation diagram, local energy diagram)

- Presentation of the different subtopics, such as structural logic, material logic and different application strategies (e.g. slideshows showing step-by-step development, diagrams)

- Architectural and construction parameters

- Architectural and construction scenarios, showing the vision for future potential applications (e.g. diagrams, visualitions or rendering)

DELIVERABLES PER DEVELOPMENT PHASE

Development phase 01:

- Presentation on the results of the investigations (depending on the topic; e.g. data for waste wood stream and sourcing data, existing software and solutions for scanning, slides presenting advantages and current obstacles for the implementation of waste wood into processes in construction, current or historical architectural and construction application)

Development phase 02:

- Proposals for construction system design integrating concepts for components, structural logic and optimisation, material logic and optimisation, (e.g. concept diagrams, circularity diagram, construction system detail proposals, visualisations for design, application and overall construction scenarios)

- Architectural and construction parameters (diagram and digital design workflows)

Development phase 03:

- Indepth development of subtopics, (e.g. digital design, fabrication workflows etc.)

Development phase 04:

- Presentation of the final overall design, developed in details regarding the different subtopics, such as digital design, material logic and different functional integration strategies (e.g. rendering for design, diagrams, detailed 3d model and detail drawings)

- Building component(s) and implemented workflow from digital design to digital fabrication

06 SCHEDULE

Studio dates:
Thursdays, 10.00 am – 5.30 pm

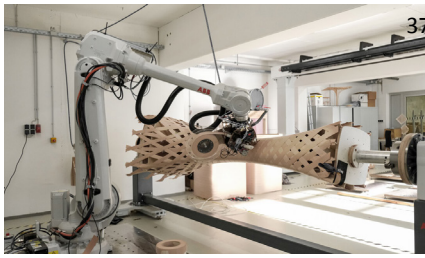
Studio room:
20.40 1.OG R 133
&
DDF FABRICATION LAB
DDF Fabrication Lab - Karlspark
Technologiezentrum, Siemensalee,
Karlsruhe

Month	KW	Week	Nr.	Day	Studio dates	Description	Studio phases
Oktober	42	16.10-22.10	-	Mon.	**16.10**	Vorstellung Entwursthemen	
	43	23.10-29.10	1	Th.	26.10	10:00 - 12:00 Intro to the course 13.00 - 17.00: Introduction Rhino & Grasshopper	
November	44	30.10-05.11	2	Th.	02.11	Desk crits 13.00 - 17.00: Introduction to Digital Design Workflows	**PHASE 01: Initial investigations**
	45	06.11-12.11	3	Th.	09.11	Presentation Phase 01 & Intro Phase 02 Introduction to structural analsysis and optimisations with grasshopper	
			-	Fr.+Sa.	10+11.11	Exkursion	
	46	13.11-19.11	4	Th.	16.11	Desk crits Introduction to 3d scanning & Augmented Reality and Robotic fabrication	
	47	20.11-26.11	5	Th.	**23.11.**	Desk crits	**PHASE 02: Concept & design development**
	48	27.11-03.12	6	Th.	30.11	Desk crits	
December	49	04.12-10.12	7	Th.	07.12	Desk crits	
	50	11.12-17.12	8	Th.	16.12	Midterm & into Phase 03	
	51	18.12-24.12	9	Th.	21.12	Desk crits	
	52	25.12-31.12	-	Th.	28.12	Holidays	
January	1	01.01-07.01	-	Th.	04.01	Holidays	**PHASE 03: Subtopic development & detailed design**
	2	08.01-14.01	10	Th.	11.01	Desk crits	
	3	15.01-21.01	11	Th.	18.01	Midterm 2 & into Phase 04	
	4	22.01-28.01	12	Th.	25.01	Desk crits	
February	5	29.01-04.02	13	Th.	01.02	Desk crits	**PHASE 04: Prototyping & architectural outlook**
	6	05.02-11.02	14	Th.	08.02	Desk crits	
	7	05.02-11.02	15	Th.	15.02	Desk crits	**Presentation Preparation**
	8	19.02-25.02	-	Th.	22.02	Final presentation	

07 EXCURSION

Excursion to Kassel and Berlin:
10.11- 11.11

UNIKASSEL VERSITÄT
ARCHITEKTUR
STADTPLANUNG
LANDSCHAFTSPLANUNG


37

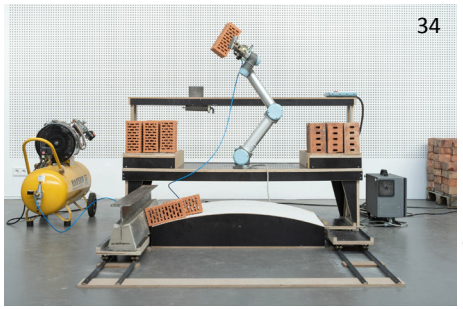
38

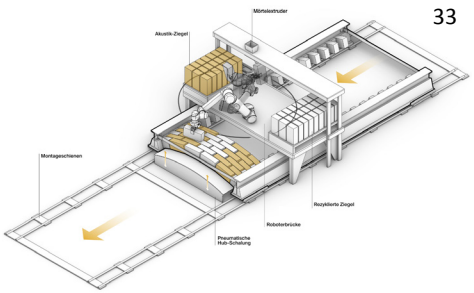
Natural
Building Lab


36


35

Universität der Künste Berlin


34



33

08 REFERENCES

Images

1 https://www.fornnax.com/images/fornnax/woodwaste.jpg

2 https://www.umweltbundesamt.de/sites/default/files/medien/1/bilder/altholz_2015_inkl._im-_und_export_uba-farben.png

3 https://www.kronospan-worldwide.com/interface/images/uploads/content/circular-economy-with-texts.png

4 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

5 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

6 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

7 KIT DDF Students: Christian Hoffmann, Johannes Hoer, Lara Marquardt, Valerie Michels

8 KIT DDF Students: Christian Hoffmann, Johannes Hoer, Lara Marquardt, Valerie Michels

9 KIT DDF Students: Christian Hoffmann, Johannes Hoer, Lara Marquardt, Valerie Michels

10 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

11 https://designandmake.aaschool.ac.uk//assets/project/wood-chip-barn/07_WCB_ZacharyMollica.jpg

12 https://karamba3d.com/101/wp-content/uploads/2023/02/bg-20230103-022535674-ios-edit-cropped.jpg

13 https://designandmake.aaschool.ac.uk//assets/project/wood-chip-barn/cover.jpg

14 https://thetyee.ca//News/2018/12/10/PHOTO1-Empty-stripped-home.JPG

15 https://images.adsttc.com/media/images/5cc6/5f2d/284d/d11a/2b00/0357/slideshow/022_People_s_Pavillion_-_Eindhoven.jpg?1556504335

16 https://designandmake.aaschool.ac.uk//assets/project/wood-chip-barn/02_WCB_ZacharyMollica.jpg

17 https://images.adsttc.com/media/images/5fde/05d5/63c0/1798/5900/07c1/slideshow/BlockTypeA_05_Process_Diagram.jpg?1608385967

18 https://arqa.com/wp-content/uploads/2022/09/house-block_photo-2.jpg

19 https://www.yankodesign.com/images/design_news/2021/12/351099/03_microhomes_auar_roboticdwelling.jpg

20 https://parametric-architecture.com/wp-content/uploads/2020/01/Bartlett-RC4-INT-3-scaled.jpg

21 https://media.springernature.com/lw685/springer-static/image/art%3A10.1007%2Fs41693-020-00037-6/MediaObjects/41693_2020_37_Fig11_HTML.jpg

22 KIT DDF

23 KIT DDF

24 https://www.icd.uni-stuttgart.de/img/wp-content/gallery/itech_msc_2018_dist_timber/MSc_Dist_Timn-10.jpg?__scale=w:686,h:515,cx:67,cy:0,cw:1065,ch:800

25 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

26 KIT DDF

27 https://www.buildingcentre.co.uk/media/w1440/featured/semblr-promo-image-(c)-Ivo-Tedbury.jpg

28 KIT DDF Students: Michael Hosch, Michelle Montnacher, Elisa Muhr, Saskia Nehr, Otto von Zastrow-Marcks

29 KIT DDF Students: Thibaud Lhoest, Deniz Okurogullari, Clement Potier, Yannick Scherle, Paula Seifert

30 KIT DDF Students: Christian Hoffmann, Johannes Hoer, Lara Marquardt, Valerie Michels

31 KIT DDF Students: Students: Aurelie Pha, Loana Köhler, Tobias Mäckle, Lin Chang, Nicola Gil Arango

32 KIT DDF Students: Helena Krapp, Julia Bakucz, Jonathan Fryns, Yasmin Zeitouni, Ismael Acuna

33 https://www.baunetz-campus.de/img/2/9/8/4/6/8/2/Minimal_Mineral_Baunetz_Campus_2023__002_-abe2070586469cba.jpeg

34 https://www.baunetz-campus.de/img/2/9/8/4/6/8/2/3632_aziz_alexander_brechenmacher__gengnagel_loutfi_Fig_04-07f298c9b3ecac4d.jpeg

35 https://www.nbl.berlin/wp-content/uploads/2020/10/Collagen-Axo-A3_Seite_1-810x540.jpg

36 https://www.nbl.berlin/wp-content/uploads/2018/07/ansicht.jpg

37 https://www.ingenieurbau-online.de/fileadmin/_processed_/1/0/csm_forschungsdemonstrator-presse_7eb69d47a1.jpg

38 https://www.uni-kassel.de/fb06/index.php?eID=dumpFile&t=p&p=38481&token=3d748b98cbba241cc7a942d72d23f1f6417d57b2