How to Print a House:

Extension Altes Hallenbad Heidelberg

Project MA / WS 2024-2025

Professorship Digital Fabrication
Prof. Dr. Kathrin Dörfler / Iuliia Larikova, M.A.

Chair of Building Technology and Climate Responsive Design
Prof. Thomas Auer / Dr. Sandra Persiani/ David Briels, M.Sc.

Introduction

Additive Manufacturing (AM), or 3D Printing, offers a variety of technological perspectives that will influence all aspects of building construction in the future: materiality, structure, detailing, thermal envelope, building climate. Among many aspects, AM allows to completely redesign building elements, embedding new material solutions with advanced functionality.

The design task of the studio project is to design a mixed-use residential building for flexible use in a vacant lot next to the famous Altes Hallenbad in central Heidelberg, combining passive design strategies with the specific Additive Manufacturing Technology - Selective Paste Intrusion (SPI). By understanding the SPI technology features, such as resolution and granularity, mechanical properties, building physics usability, geometric freedoms, as well as process constraints, we will explore and creatively investigate its possibilities to use these properties as a design driver for designing a sustainable, and resource efficient building. These features can range from energy-efficient elements, such as optimised thermal insulation, to intelligent systems that enhance occupant comfort and sustainability.

In a first phase, students will focus on a given research topic, working in groups of three people. The aim is to allow the students to deepen one given aspect which will be of relevance in the design task. In a second phase, as the students are mixed into new groups of 3 integrating different knowledge from the previous phase, the teams are to develop design concepts integrating architectural design, climate strategies and SPI technology into one concept - by focusing on SPI-only or SPI-timber hybrid constructions. The third design phase further deepens on the development of the design principles, the construction principles of prefabricated SPI building blocks or hybrid SPI-timber elements and the overall design of the building. The design proposal should be developed that find a balance between durability, material justice, resource conservation, and flexible, spatial playability, and that take up the need for sustainability in various facets.

Project MA / WS 2024-2025 / Technical University of Munich

Teaching

Professorship of Digital Fabrication

Prof. Dr. Kathrin Dörfler, Iuliia Larikova, M.A.

Chair of Building Technology and Climate Responsive Design

Prof. Thomas Auer, Dr. Sandra Persiani, David Briels, M.Sc.

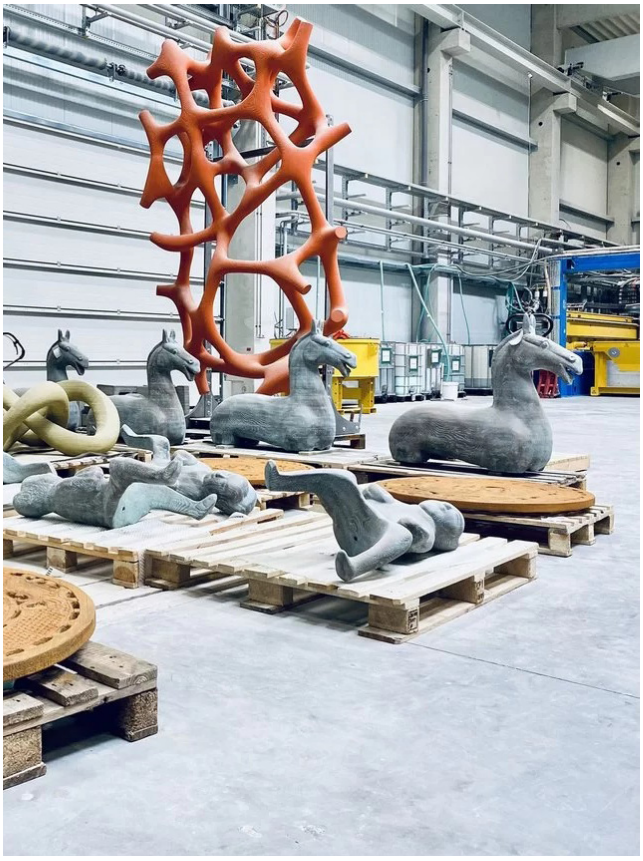
In collaboration with **SSV Architekten** and **Addditive Tectonics**

Schedule

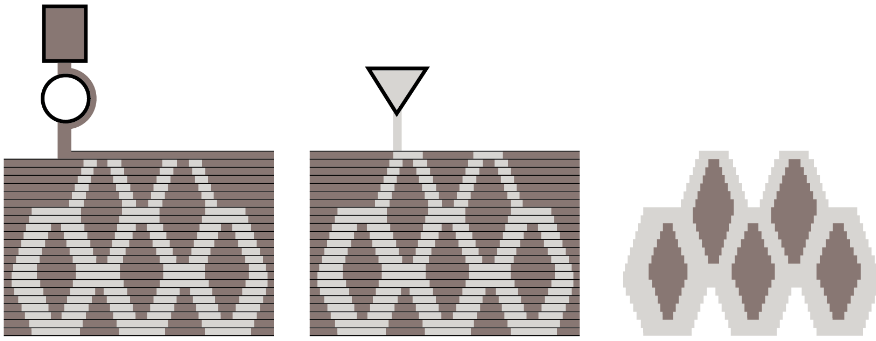
Tuesdays / 10:00 - 13:00 / Room will be announced

Date	Program	Room	Presentation
16/10	**Kick-off**	5146 / 0501	
22/10	Lectures Input		
24/10-25/10	Exursion Heidelberg + Additive Tectonics		
29/10	**Research presentation**		*Tasks 1 & 2*
05/11	Desk crit		
12/11	**1. Midterm presentation**	5146 / 0501	*Task 3*
19/11	Desk crit		
26/11	Desk crit		
03/12	Desk crit		
10/12	Desk crit		
17/12	**2. Midterm presentation**	5146 / 0501	*Task 4*
07/01	Desk crit		
14/01	Desk crit		
21/01	Desk crit		
28/01	Desk crit		
04/02	**Final presentation**	5146 / 0501	*Task 5*

Altes Hallenbad © KRAUSGRUPPE



Additive Tectonics © Hochschule für Technik Stuttgart



*SPI method utilised for closed-cell geometries with trapped lightweight aggregates:
a) deposition of aggregate layer; b) selective binding with a cement-paste, c) excavated component.
© Krakovská et al. 2024*

SPI Method

The SPI method involves spreading loose aggregates in layers within a particle bed, which are then selectively bound using a binder, in this case, cement paste. The surrounding unbound aggregates thereby act as a support structure for the fabricated unreinforced concrete component, enabling the creation of intricate, high-resolution, free-form geometries. Following the printing process, the component is left for curing within the particle bed and can subsequently be excavated. The proposed design strategy of large-scale and lightweight components utilizes the SPI method while expanding its intended application through the use of lightweight aggregates, particle trapping, and functional grading. *Krakovská et al. 2024*

Kurt Wohlgemuth, inventor of the SPI printhead, excavating the produced segments.

Semester structure

The semester is organized around five tasks completed in groups of three students.

Task 1 / Research / 29.10
A4 research report
Presentation
We will begin with a research task that focuses on different aspects of the research context. This includes current construction practices, the potential role of regenerative materials, as well as computational tools and digital fabrication. Each group will be assigned a specific topic, along with relevant literature to read. Use the provided literature as a foundation to delve deeper into your own investigations. Along with analizing the provided literature, each group should find and analyse at least 4 more references of their choice, such as books, papers, architectural objects, etc. You'll be asked to summarize your findings into a concise research report (one A4 page) and deliver a 10-minute presentation.

Task 2 / Model of the surroundings / 29.10
Model:1:200 model of single colour (gray, beige etc.)
All of the students of the studio should collectively produce a detailed physical model of surroundings with the removable building site part.

Task 3 / Design Idea / 12.11
Hand or digital sketches: floor plans with zones, isometries of the whole building, isometries of the building block
Climate concept:choice of the climate parameter, description of its integration in the deisgn
Model: 1:200 draft model of the building volume to insert into the model of surroundings
In the first phase of the project design, four key topics should be addressed: interpretation of program/ organization concept, building concept/urban form, climate concept, construction concept/preliminary concept of the building block produced with SPI or hybrid SPI-timber elements.

Task 4 / Construction & Concept design / 17.12
Drawings: 1:100 Floor plans and two sections, 1:20 drawing of the building block, draft isometry of the building block, schemes of the construction method
Visualizations: draft street view of the whole building, close-ups of the facades and interiors where building blocks are recognizable
Climate concept: Preliminary climate simulations
Models: 1:200 more detailed model of the whole building, 1:20 or 1:10 model of the building block
In the second phase the typology and construction concept are developed simultaneously. The focus is on the combination of the spatial program with an intelligent construction system, based on the methods of SPI.

Task 5 / Final presentation / 04.02
Drawings: 1:100 Floor plans and two sections, 1:10 drawing of the building block, detailed isometry of the building block, detailed schemes of the construction method.
Visualizations: detailed high-quality street view of the whole building, close-ups of the facades/interiors where building block is recognizible.
Climate concept: Climate simulations
Models: 1:200 detailed model of the whole building, 1:10 detailed model of the building block with the usage of the cast gypsum
The project design will be completed. The project objectives need to check the following:
architectural design, climate strategies and SPI technology into one concept - by focusing on SPI-only or SPI-timber hybrid constructions.

Playing with blocks © Ema Krakovská

Playing with blocks © Ema Krakovská

Research

Topics on this page are offered for the Task 1: Research. The literature provided is a starting point for the research. Each group is expected to find and analyze at least four more references: that could be books, papers, architectural projects, research projects.

Digital fabrication & materiality:

1. Building with Blocks

The Cannibal's Cookbook: Mining Myths of Cyclopean Constructions / Brandon Clifford

The Armadillo Vault: Computational design and digital fabrication of a freeform stone shell / Matthias Rippmann, Tom Van Mele, Mariana Popescu et al.

2. Digital Materiality

Digital Materiality in Architecture / Fabio Gramazio and Matthias Kohler

3. **Future of Earth Construction**

Upscaling Earth: Material, Process, Catalyst / Anna Heringer, Lindsay Blair Howe, Martin Rauch

Ten questions concerning the potential of digital production and new technologies for contemporary earthen constructions / Marcel Schweiker, Elisabeth Endres, Joschua Gosslar et al.

4. **Monomateriality**

Mono-Material: Monolithic, Homogeneous and Circular Construction / Till Boettger, Ulrike Knauer

Architected Porosity: Foam 3D Printing for Lightweight and Insulating Building Elements / Patrick Bedarf

5. **Post-Carbon Built Environment**

Material Reform: Building for a Post-Carbon Future / Material Cultures, Amica Dall, Charlotte Malterre-Barthes, Jess Gough *

Climate responsive design:

Building to Suit the Climate: A Handbook - Hardcover / Liedl, Petra; Hausladen, Gerhard; Saldanha, Michael

Einfach Bauen: https://www.einfach-bauen.net/#einfach-bauen

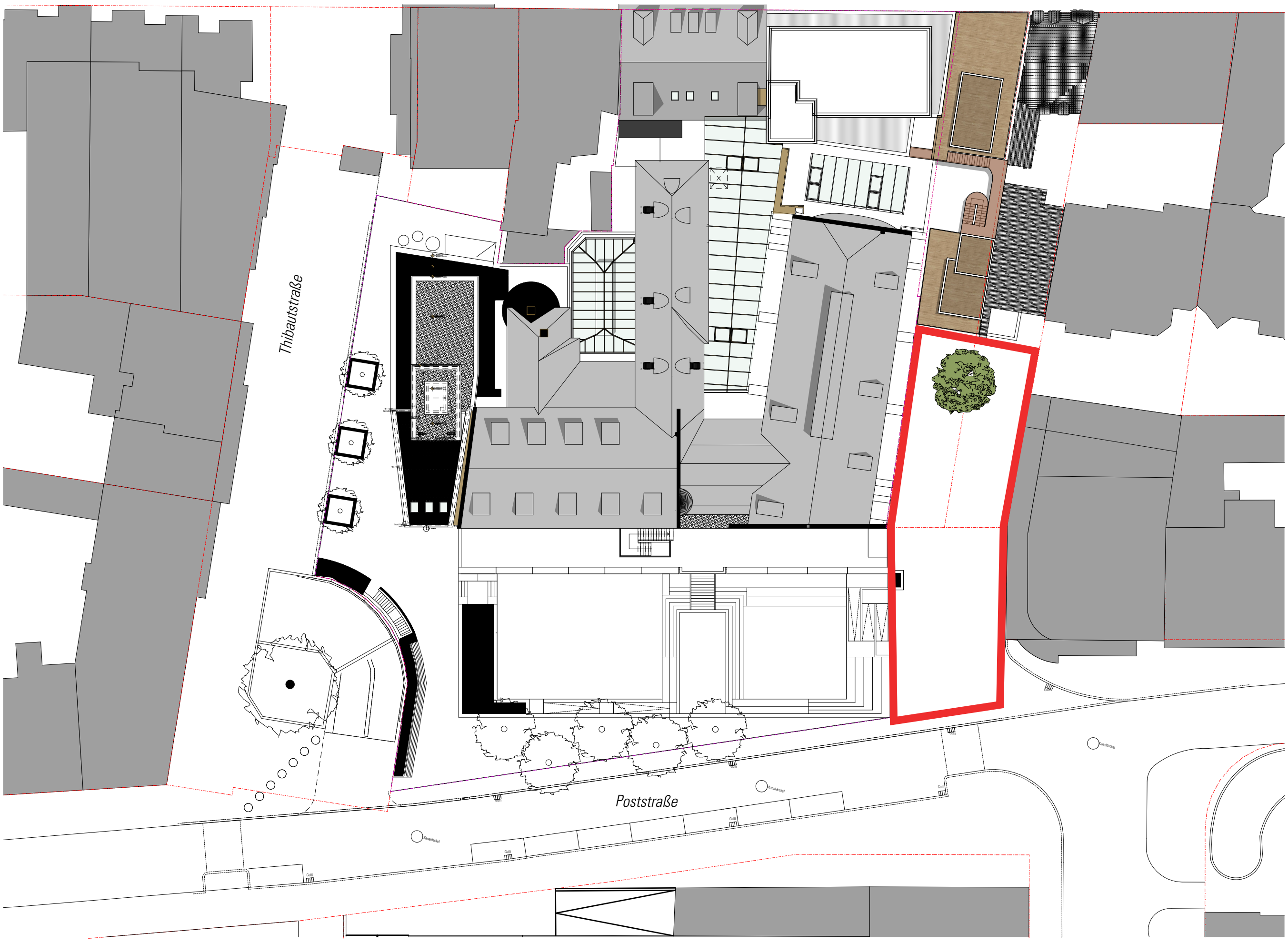
6. **Passive Design: Insulation vs Thermal mass**

7. **Passive Design: Solar Design**

8. **Passive Design: using water and vegetation**

9. **Einfach Bauen: technological simplicity vs high-tech**

Building site



Development Plan

Aerial View

Building site

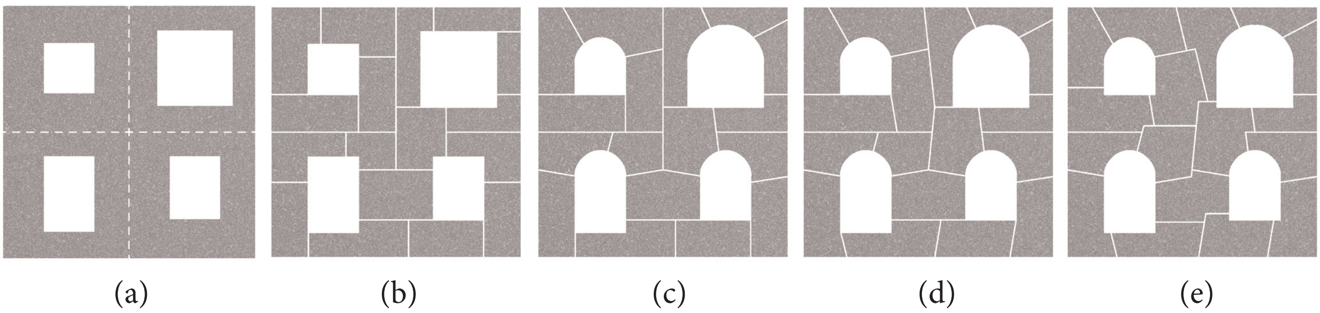
Area of Altes Hallenbad:

Altes Hallenbad (Old Indoor Swimming Pool) in Bergheim, which has been listed under monument protection since 1967, was built between 1903 and 1906 by Franz Sahles Kuhn for its client Alois Voth. After a long period of vacancy, the building complex was extensively renovated and redesigned with additional extensions between 2009 and 2012. As part of this, the “Bergheim 41” hotel was built in a new building on Bergheimer Strasse, right next to the historic main entrance to the Altes Hallenbad.

Vacant lot:

The lot of approximately 260 m² allocated for the project is closed on three sides, with the Altes Hallenbad on the west side, a refurbished hotel on the north side, and a residential building on the eastern side. The southern side is free and is the only access to the plot, facing an open space. At the moment, this plot of land is covered by a big tree and further vegetation, and delimited by a low brick wall.
The open square facing the plot on its southern side, of approximately 210m², serves at the moment as a sort of extension to the Hallenbad’s square. This “unplanned” square acts as a filter space between the first area and the street with cars and is also part of the design task.

Street view



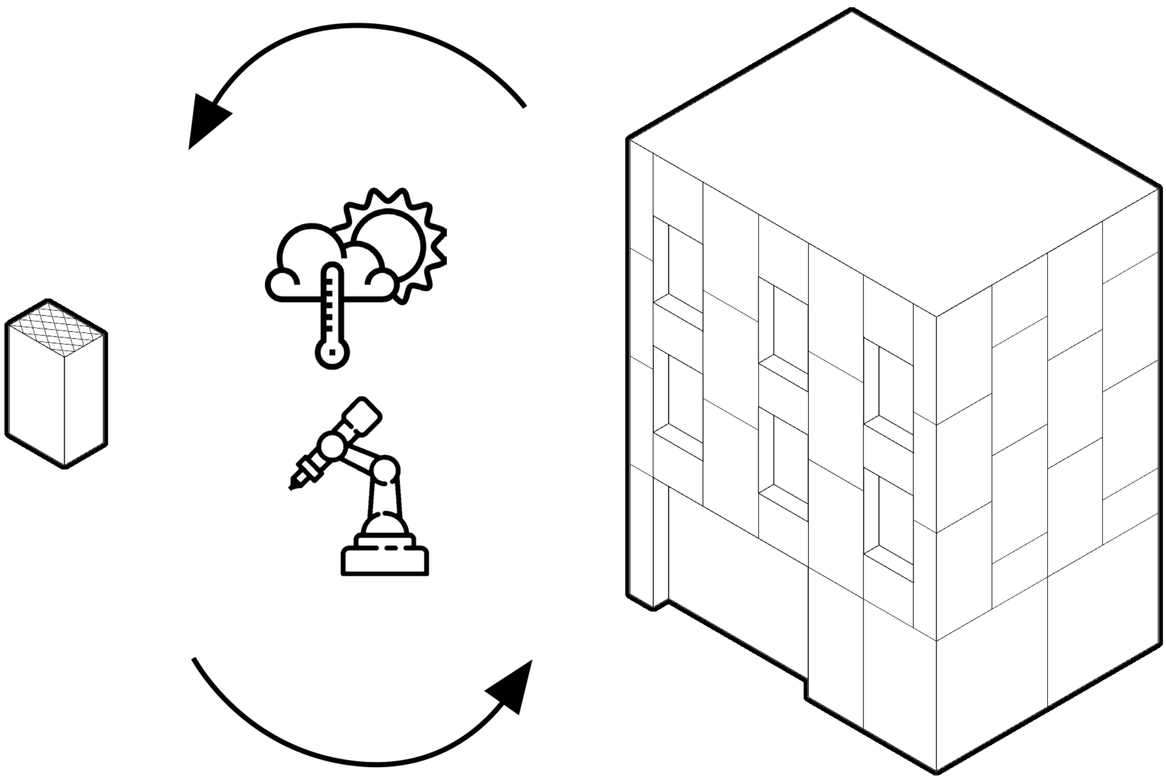
Conceptual scheme of the lightweight SPI design principles: a) initial building design outline, b) segmentation according to the SPI printer size, c) compression-dominant shape adjustment, d) accommodation of the assembly sequence, e) topological interlocking. ©Krakovská et al. 2024

Design Task

The studio project “How to Print a House: Extension Altes Hallenbad Heidelberg” aims to explore two key areas.

First, we will investigate architectural form and structure suitable for the 3D Printing method of Selective Paste Intrusion (SPI), offering new perspectives on the construction of massive buildings. 3D printing technology expands the possibilities of monomaterial constructions by enabling large geometric and material customisation. This approach allows for integrating multiple functions—such as structural integrity and thermal performance—into single building components, enhancing material efficiency and offering greater design freedom. Specifically, we will explore the notion of designing with volumetric components within SPI and investigate their potential to store and release thermal energy or act as long-term CO2 sinks. This exploration opens up additional opportunities, such as integrating energy storage capabilities into the building’s mass, thereby giving it a multifunctional role.

Second, we will examine the typologies of mixed-use and residential buildings, focusing on designs that can adapt to changing needs over the coming decades while intelligently interacting with the underlying construction system.



Design from simple building block scale to house scale, taking into consideration parameters such as climate and construction and constantly working on both scales.

Altes Hallenbad South Facade ©SSV Architekten

Design Program

Site
260 m²

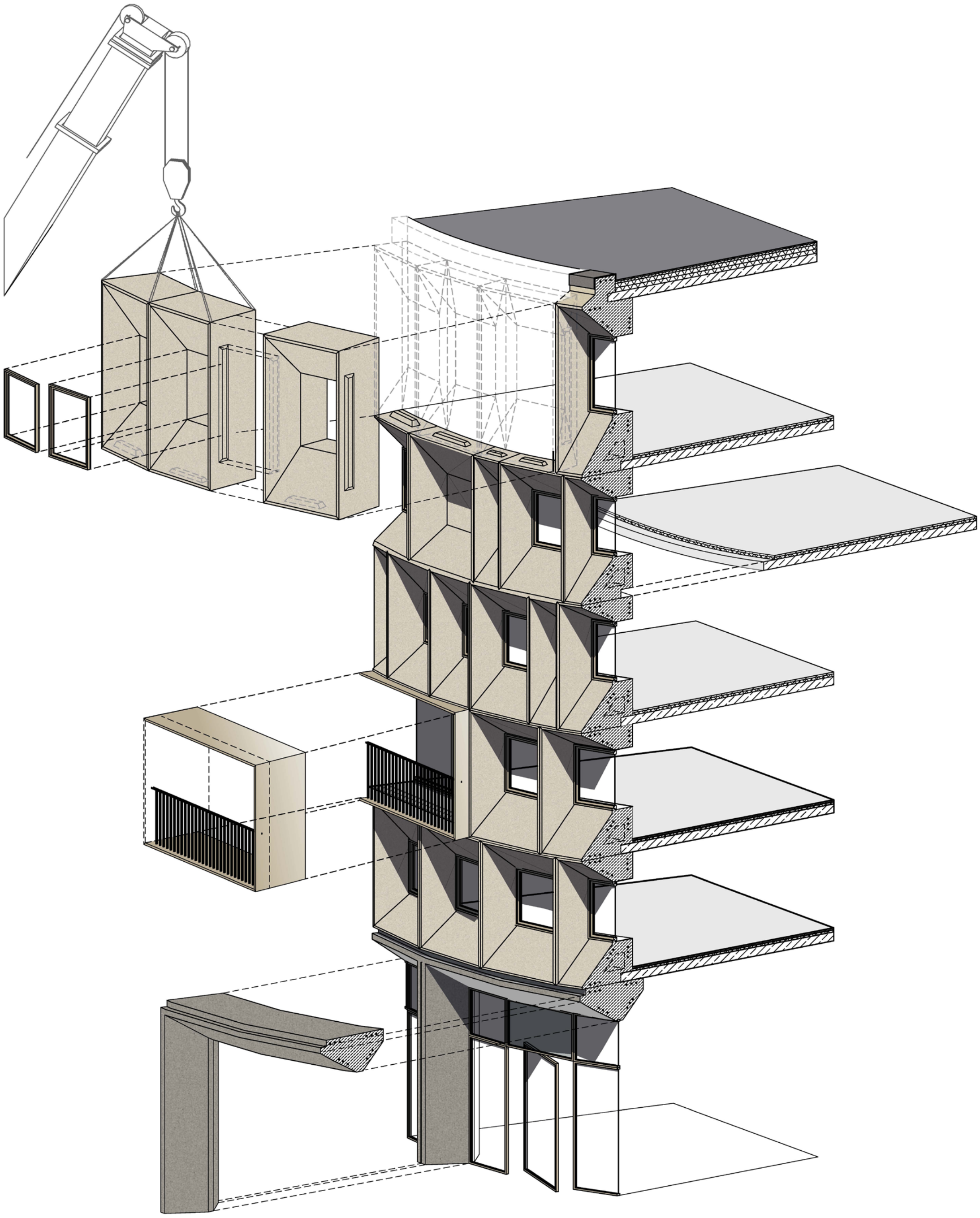
Ground Floor
100-150 m²
Cafe including storage/sanitary Rooms
Shop

Upper Floors
200-300 m²
Appartements
Community Space

Submission Documents
Master Plan *M 1:1000*
Site Plan *M 1:500*
Plans *M 1:100*
Sections *M 1:100*
Elevations *M 1:100*
Facade Section *M 1:20*
Building Block Details *M 1:5-1:50*
Schemes/Diagram Construction Process
Sketches/Schemes Design Concept
Climate Simulations
Urban Model *M 1:500*
Building Model *M 1:200*
Model of Construction Concept *M 1:20-1:50*
Visualization Exterior min. 2 images
Visualization Interior min. 1 image

Construction concept

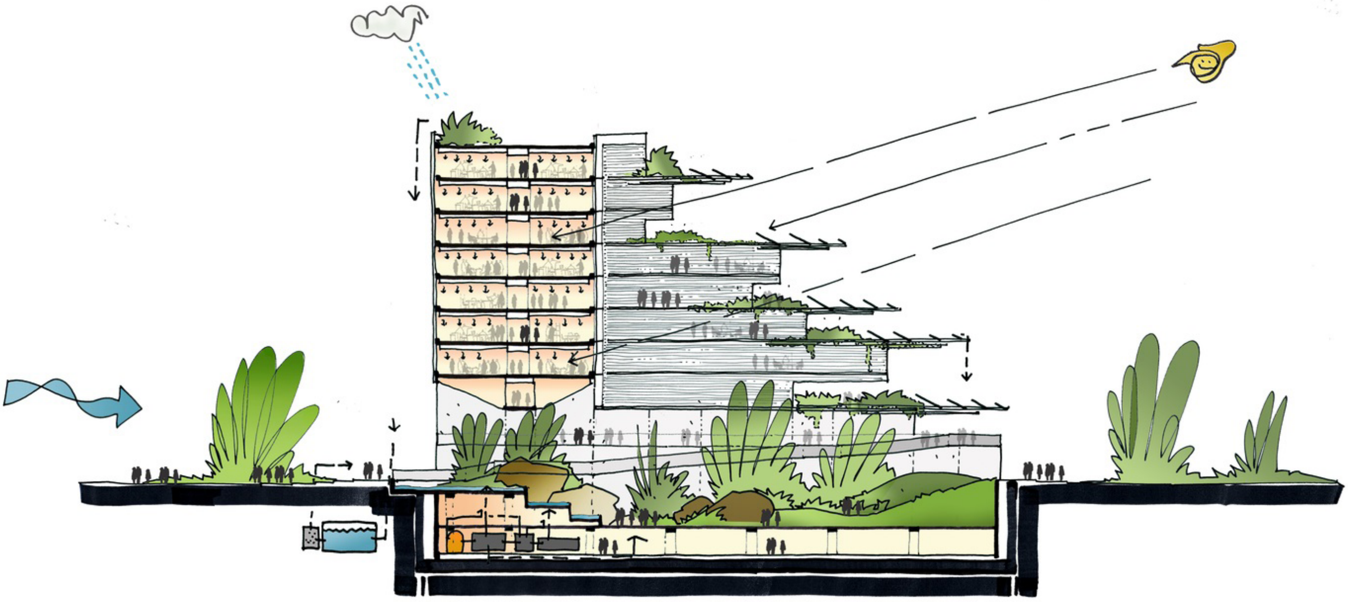
One of the outputs of the studio will be the constructiom concept, including the concept of the prefabricated blocks and their assembly. As such, we will explore not only the design of a building block produced with the 3D printing technology of SPI but also a construction concept for realizing a whole building.



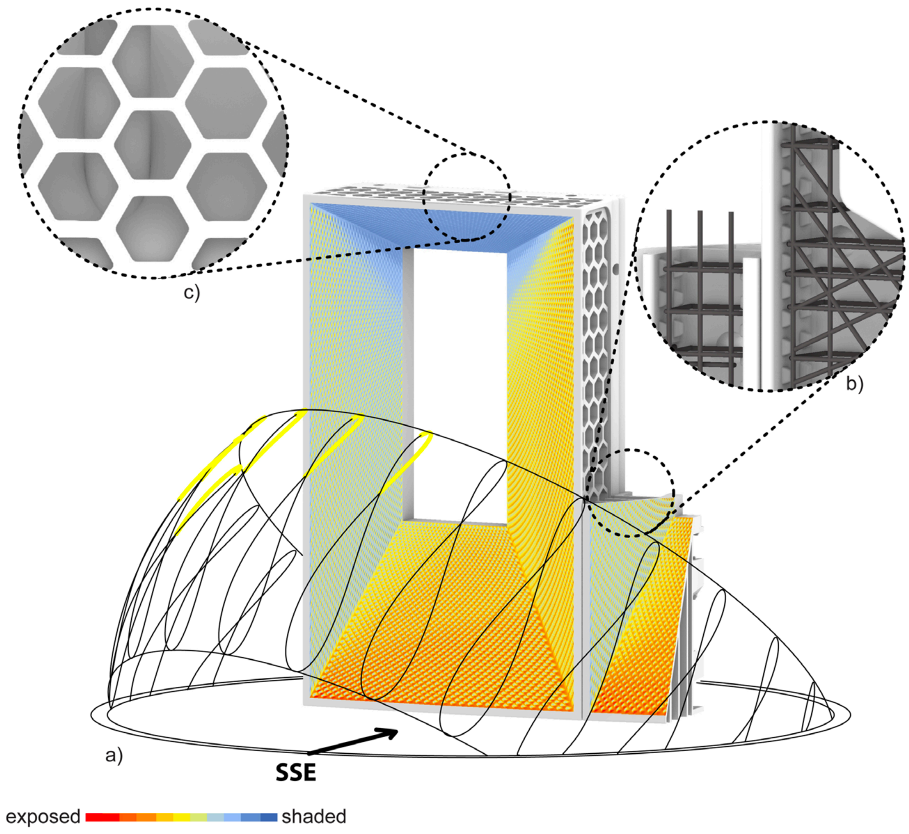
Example of the construction concept scheme © [BREUER X AM]
Mia Düpree & Mareen Fechner / TU München

Climate concept

Another output of the studio is the climate concept of the architectural design, presented schematically at the architectural level (1-2 relevant sections, 1:100), and at the technological level (building skin, 1:50). The relevant simulations will depend on the design concept and will be discussed with the teaching team.



Example of the climate concept scheme for winter: SIEEEB, Mario Cucinella Architects



Fleckenstein, J. et al