Re-Use Huber Pavilion's Materials

Reader

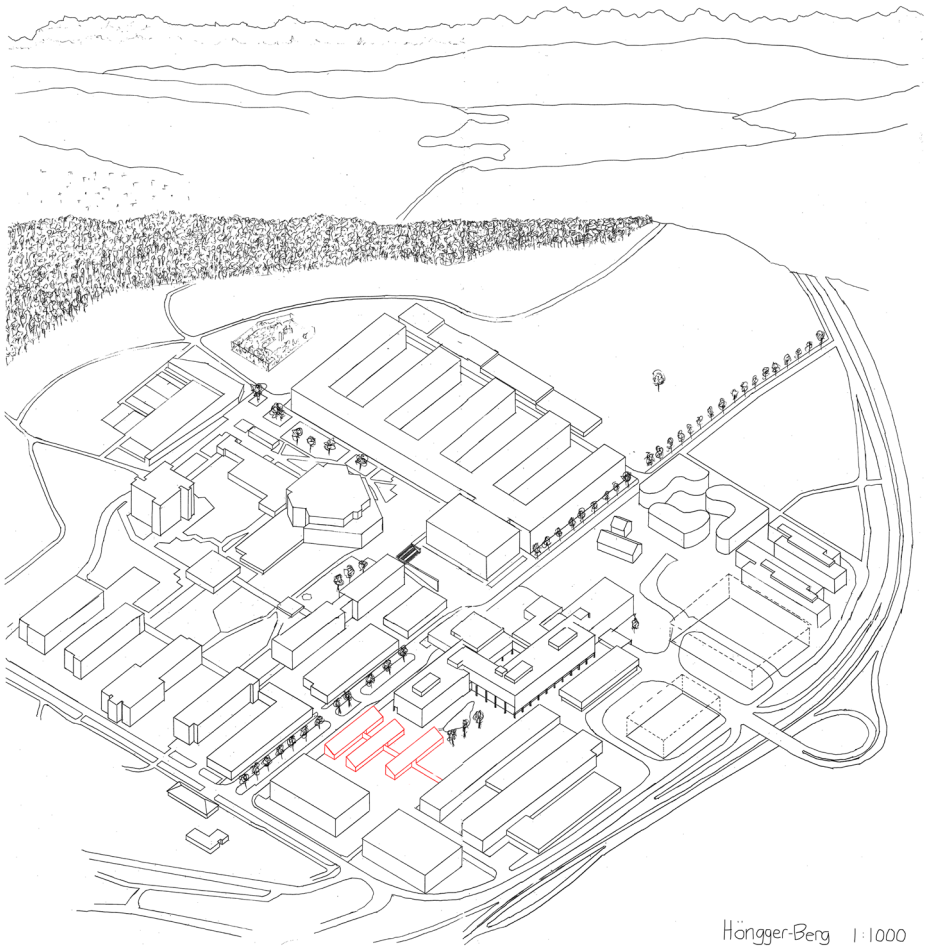
Chair of Architectural Behaviorology
Chair of Circular Engineering in Architecture
Focus Work FS23
ETH Zurich

CONTENTS

ARCHITECTURAL BEHAVIOROLOGY

Architectural Behaviorology being a design theory and methodology that we have adopted with the objective of rediscovering the forgotten values of resources through the lens of ethnography. In essence it tries to find existing barriers and deficits and then challenge them in order to create better accessibilities to local resources. The aim is to activate the behaviors of actors, both human and resource, to create urban-rural commons and rejuvenate community livelihoods with smallscale primary industries, based on scenarios in Switzerland.

Using the core design approach of architectural behaviourology the research project advocates and demonstrates, both theoretically and in real-world practice, the significance of creating urban-rural commons to rejuvenate community livelihoods with small-scale primary industries (farming, fisheries, and forestry), taking both Asia (Japan) and Europe (Switzerland) as geographically distant yet mutually applicable and promising applied settings.



Img. 01: Axonometric View of ETH Campus Hönggerberg and Huber Pavilions (red)

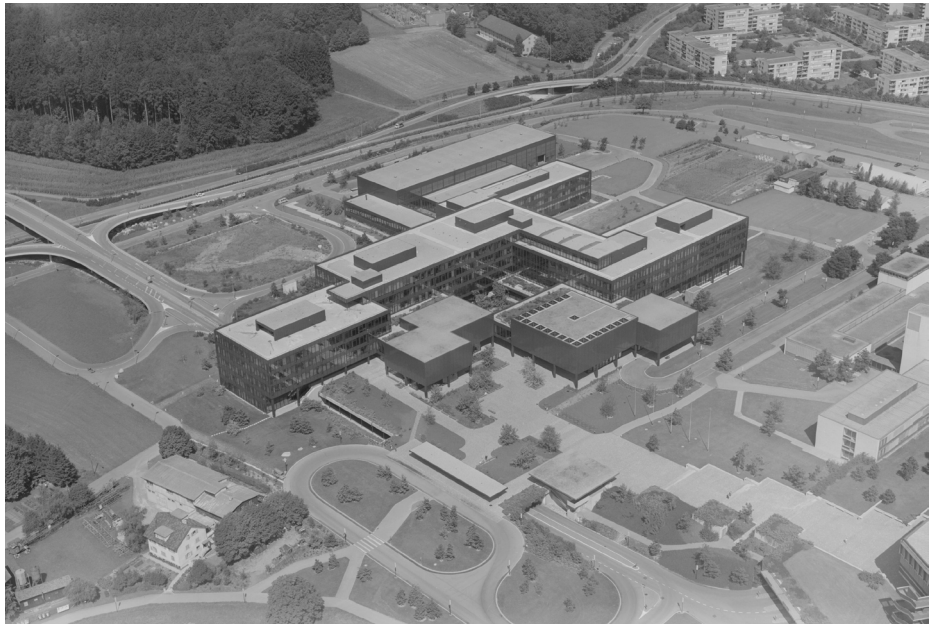
ETH CAMPUS HÖNGGERBERG

The first construction on ETH Campus Hönggerberg started in 1964, when first concrete buildings were built for the department of physics. These building are today at the end of their first life-cycle and the physics department requires additional space.

Many more new buildings have been constructed since, continuing in 1974 with the HIL and HIF buildings by Max Ziegler and Eric Lanter and between 1996-2004 the chemistry building HCI by Mario Campi.

Between 1987 and 1991 the three pavilions were planned and built by Atelier 3 and Rudolf Bolli for the client, architecture professor Prof. Benedikt Huber. The pavilions were conceived as 130 temporary learning spaces for architecture students. The department needed additional spatial resources because it was experiencing a growing number of student enrollments. The Huber pavilions were initially planned to allow future dismantling and re-use.

Img. 02: First construction phase on ETH Campus Hönggerberg, 1964



Img. 03: View of second construction phase on ETH Campus Hönggerberg, 1977

FOCUS WORK

The pioneering focus work "Re-Use Huber Pavilion's Materials" has the unique opportunity to work with saved building components of the Huber Pavilions. These were demolished in the summer of 2022 to make way for the construction of a new physics building. The goal of the course is to construct a re-use pavilion.

The focus work collaborates with the Spring Course "Digital Transformation for Circular Construction" supervised by Prof. Catherine De Wolf and the Chair of Circular Engineering in Architecture (CEA), as well as experienced experts, as Barbara Buser, Pascal Angehrn from baubüro insitu, and Michael Wick of Wiederverwerkle. The goal of the focus work is to design and prepare the construction of a re-use pavilion on campus and will be supervised by the Chair of Architectural Behaviorology.

All D-ARCH students who do the focus work are responsible for the design, all other students inthe CEA course support them using the technologies learned in class and during construction in June.

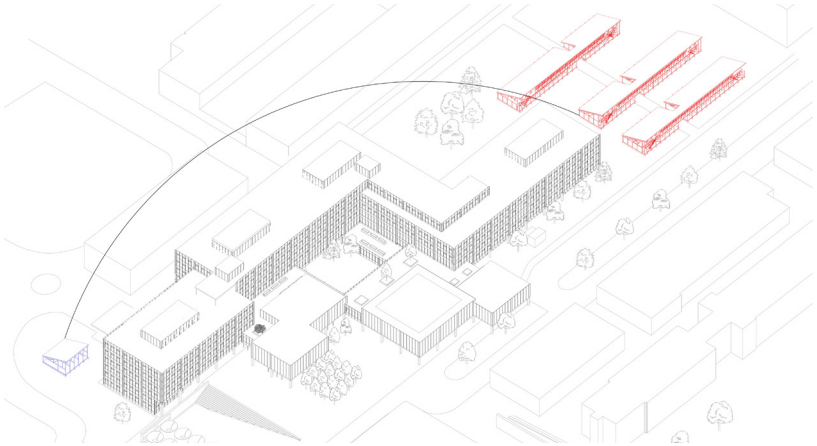
The design is the biggest task and hence is carried by a group of 12 architecture students, who consult with the rest of the students and experienced supervision.

The submissions required for the focus work are separate to the assignments in the CEA spring course and will be credited with additional 6 ECTS.

The focus work amounts to a total of 180 hours. These hours are approximately divided as follows:

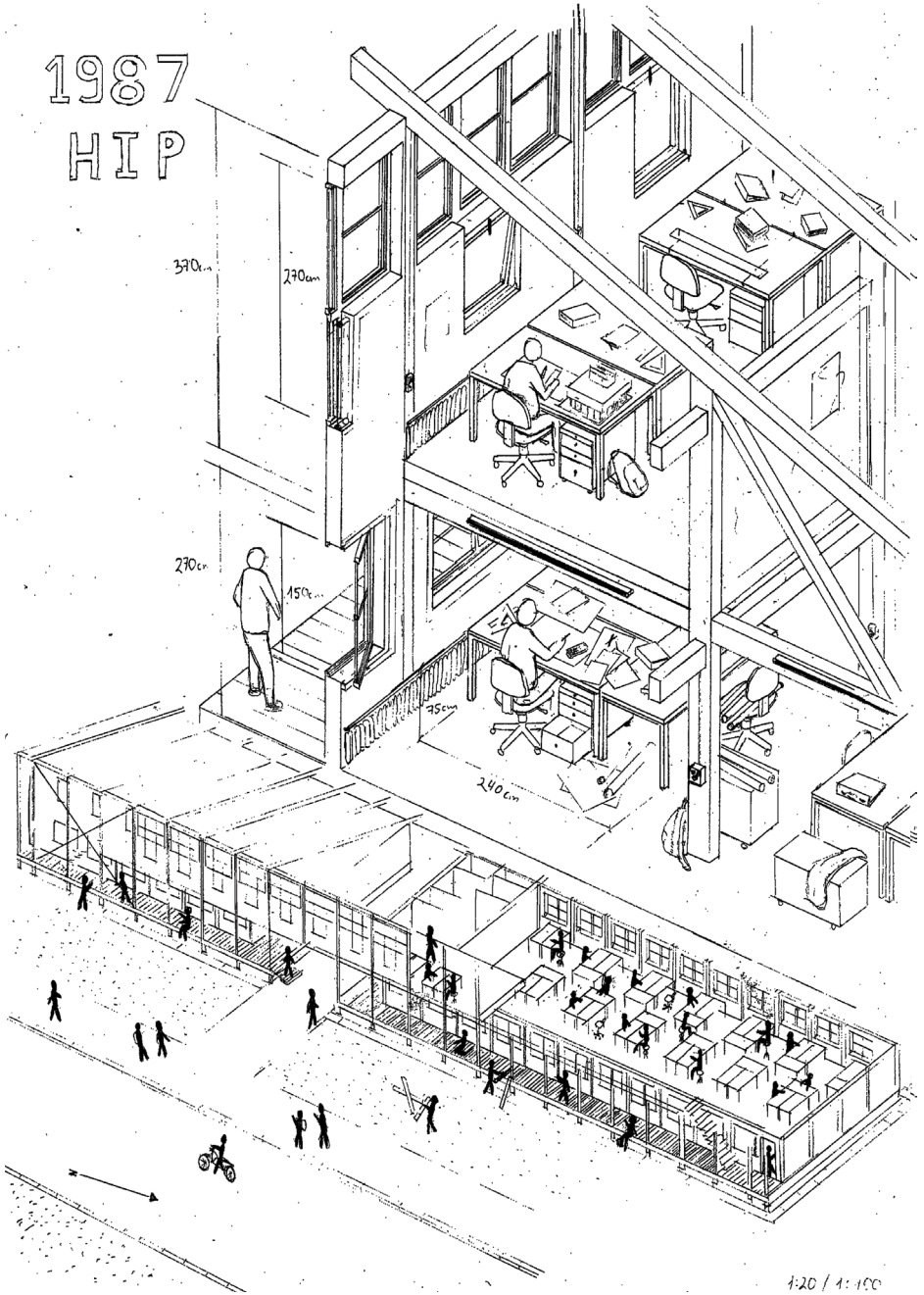
- Inventory - 10 hours
- Design competition - 30 hours
- Preparation - 15 hours
- Construction - 85 hours
- Drawing Report - 40 hours

Total - 180 hours = 3 weeks



Img. 04: Huber pavilions (red) and re-Use pavilion (blue)

HUBER PAVILIONS



Img. 05: Axonometric view of Huber pavilions

RESEARCH OBJECT

Background

The research object "Re-Use Pavilion" aims at the preservation and pioneering reuse of the former so-called Huber pavilions on the ETH Hönggerberg campus.These had to make way in 2022 for the construction of a new building for the Department of Physics (D-PHYS). During the demolition of the pavilions, some materials were obtained and are currently located as dismantled individual parts in an interim storage facility on the ETH Hönggerberg campus.

Reuse

The construction industry plays an essential role in meeting todays climate targets. In replacement construction projects, the demolition of existing buildings results in a large amount of construction waste. The research object at ETHZ tests the construction with reused components and thus makes an important research contribution to the topic of circular construction industry and sustainability.

Research process

Construction with reused components is tested in a pioneering research project. The construction work, which is limited to a 12x12m perimeter, will begin in the summer of 2023 and end after a 3-year period, in 2025, with the dismantling of all structures and the restoration of the existing, intact green space. A building area of approx. 140 m2 has been offered by ETH Immobilien.

Material concept

All available building components originate from the former Huber pavilions. Most iconic are the white wooden trusses in addition to wooden roof panels, windows, doors, sanitary installations, radiators, stairs, formwork boards and ground coverings made of cement and brick.

Structure

The research object will be executed as a lightweight construction with reused wooden beams, the type and shape of which is not yet known. The final design and execution of the object will be accomplished by supervised students of ETH. The research object will be designed as a minor complex structure, as no building services such as water and electricity supply or ventilation systems will be installed. Further, the research object will be designed as an open, walk-in pavilion and cannot be closed off for fire protection reasons. The building will be constructed partially free of obstacles by means of wheelchair-accessible flooring.

Mock-up

The material concept, the physical weight of the components and the difficulties of connecting them in a force-fit manner have once been tested on a mock-up, which is temporarily located on the construction site, which has already been fenced in.

Construction process

The two departments of Architecture (D-ARCH) and Civil, Environmental and Geomatic Engineering (D-BAUG) are working together with professional supervision by baubüro insitu ag and Wiederverwerkle GmbH to ensure the reuse of materials in a qualitative manner. The constructional implementation of the research object is being carried out by students within semester courses with Prof. Momoyo Kaijima and Prof. Catherine De Wolf. The students will be professionally supervised on site. A close exchange is maintained with the internal security body of the ETH, the SGU. Preliminary work is planned in April, as well as a two-week construction period in June 2023.

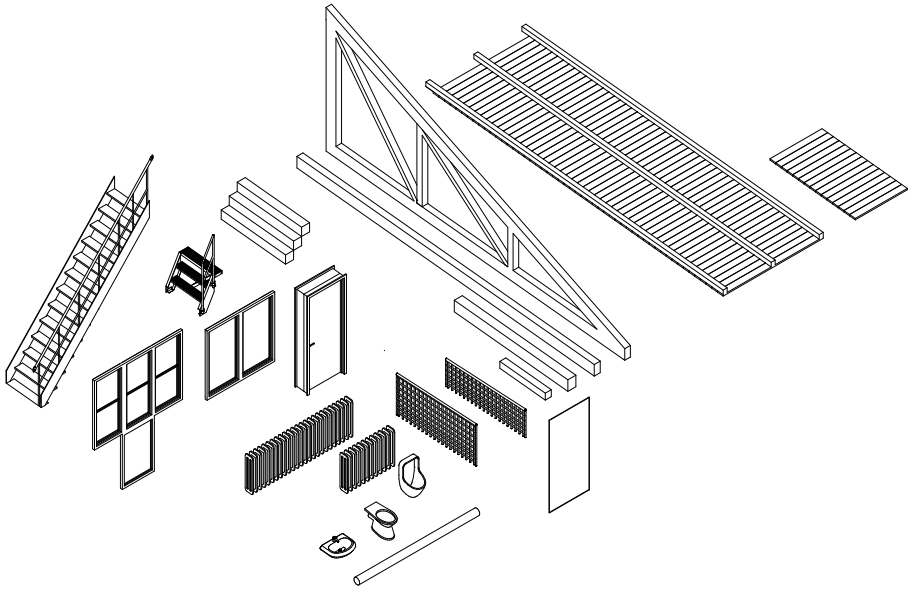
Img. 06: Demolition of Huber pavilions

Img. 07: Group workshop

LEARNING GOALS

Students will work with re-use materials of the former Huber Pavilions at ETH Campus Hönggerberg. By the end of the course students will have achieved the following learning goals:

1. Inventory (March)
2. Design (March)
3. Preparation (April)
4. Construction (June)
5. Drawing Report (July)



Img. 08: Axonometric view of re-use materials

ASSIGNMENTS

1. INVENTORY

In order to properly build with re-used materials, a database of the available stock of materials, their condition and properties is needed. For this, students will undertake the following steps:

- Visit material storage
- Identify building materials
- Study existing inventory excel sheet
- Study existing 1:1 mock-up on site
- Take measurements
- Count available material

Title: Create catalogue of re-use

Workload: approx. 10 hours

Type: Group workshop

Submission date: March 19

Formats: PDF, Excel Sheet, JPG

Upload: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM

Img. 09: Material storage area at ETH Campus Hönggerberg

2. DESIGN COMPETITION

Propose a design solution for a new re-use pavilion on the construction site next to the HIL building. While making your draft, respect the following rules:

- Respect building perimeter (12x12m) next to HIL
- Consider all available materials in storage
- Plan for short construction period (10 days!)
- Allow future semesters to continue construction
- Include concept for future disassembly
- No electrical heating-, or plumbing systems
- Collaborate with D-BAUG students in CEA

Title: Design

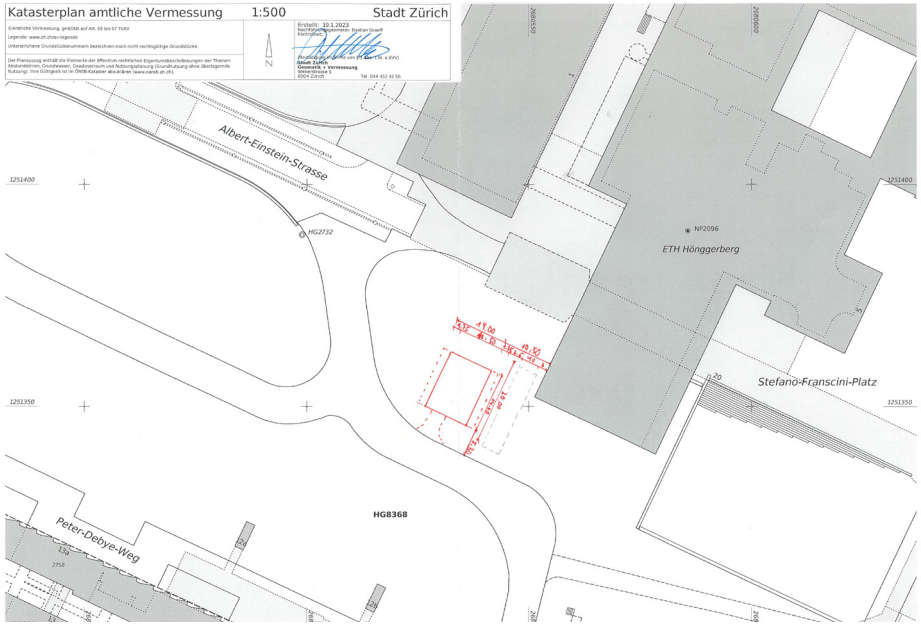
Workload: approx. 80 hours

Type: Individual work or groups of two

Submission date: March 30

Accepted formats: hand drawings, CAD, images, visualisation / model (1:33)

Upload: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM



Img. 10: Construction site next to the HIL building, Katasterplan

3. PREPARATION

Students will prepare the building site and -process and will undertake necessary steps to finalize the design proposal and construction plans respectively.

- Preparation of materials, site and groups:
- Prepare foundation, walls and roof
- Create a schedule of building activities
- Familiarize with SUVA safety check lists
- Create a safety protocol for the construction site
- Form groups for the construction period:
- (Floor / Walls / Roof)

Title: Preparation

Workload: approx. 15 hours

Type: Group workshop

Submission date: June 12

Accepted formats: drawings, text, images, visualisation / models / mock-up

Upload: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM

Img. 11: Storage area and construction site with mock-up

4. CONSTRUCTION

In collaboration with students of different ETH departments you will direct and execute the construction of a re-use research object at ETH Hönggerberg campus. In this phase there will be 3 groups:

Group 1 : Floor / Group 2: Walls / Group 3: Roof

Each group delegates one student responsible for:

- Coordination and safety on site
- Maintenance of tools
- Process documentation
- Plans and drawing

Title: Construction

Workload: approx. 80 hours

Type: Group workshop

Dates: June 19-29 + Vernissage: June 30

All materials generated (drawings, images, film) will be uploaded here:

Upload: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM

Img. 12: Carpentry work with Huber pavilion's materials

5. DRAWING REPORT

After the completion of the construction phase students are asked to review the experienced process and produce a drawing report. See references of previous student reports in the appendix (page 46-50).

- Submit a drawing report on 4 x DIN A3 about your experience and contribution during this course. Highlight one architectural element of the re-use pavilion as part of the three groups floor, walls and roof.
- Include drawings (scale 1:1-1:50) and text (200-600 words) which represent the re-use project from your personal perspective. This may include sketches/ figures/ floor plans/ elevations / sections / isometric views / perspective views / details / visualizations or images.

Title: Drawing Report

Workload: approx. 40 hours

Type: Individual work

Submission date: July 30

Accepted formats: PDF

Upload: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM

Img. 13: Department of architecture in ETH Main Campus, 1930

SCHEDULE

SCHEDULE

Week	Assignment	Date	Time	Program	Goals	Deliverable	Type	Workload
KW 10	1. Inventory	Mar. 6	15:00 -17:00	15:00 Introduction & Input Lecture 16:00 Material Storage	Visit material storage Identify building materials Study existing inventory excel sheet Create catalogue of re-use	-Library of Re-Use	Group workshop	10 hours
		Mar. 13	14:00-17:00	Open format desk crit (voluntary)				
KW 11	2. Design	Mar. 20	14:00 -17:00	Seminar Week (voluntary)	- Material concept -Project concept	- Concept Sketches - Drawings (Plan, Section, Elevation, Detail) -Format: 4 x A3 - Structural Model, Scale 1:33 - Text (3 min / ca. 300 words)	Individual work	30 hours
		March 27	14:00- 17:00	Open format desk crit (voluntary)				
KW 12		Mar. 30	18:00	Submission				
KW 13		Apr. 3	14:00 -17:00	REVIEW with Prof. Catherine De Wolf Barbara Buser, baubüro insitu, Wiederverwerkle				
KW 15	3. Preparation	Apr. 17 - May 8	14:00-17:00	Open format desk crit (voluntary)	-Project concept -Safety Plan -Selection of proposals -Group forming	-Schedule -Protocol - Detailed Drawings (Plan, Section, Elevation, Detail)	Group workshop	15 hours
		Jun. 12		Submission	-Detailed Design			
KW 25	4. Construction	Jun. 19 - Jun. 23	09:00-17:00	Introduction Safety protocol Carpentry workshop	Construction of re-use pavilion	On site presence	Group workshop	85 hours
KW 26		Jun. 26 -Jun. 30	09:00-17:00	Construction (Floor, walls, roof) Clean up	Vernissage on June 30, 18:00			
KW 30	5. Drawing Report	4 weeks	individual	Open format desk crit (voluntary)	Summarize your learning experience in text and representation	Text (200- 600 words) Drawings Images	Individual work	40 hours
		July 30	18:00	Submission				

SUBMISSION GUIDELINES

For Reviews we ask you to submit all the data of your project on the Polybox folder, following the guidelines here below.

Submission of scans

- Please submit each drawing (if several) as separate file
- PDF format only (no multiple layers, no multipage files)
- Mind the scanner settings when scanning the drawings (Contrast, DPI) so no details will be lost.

Submission of images

-Please save each image (renderings, collages, visualizations, model photos, etc.) as separate file.
- JPEG format only
- Resolution: at least 5 Megapixels

Filenames

- Please name all files in the following format:

"YYMMDD_TBW_Event_Surname Name_Description.pdf"
Date of hand-in: YYMMDD (Year, Month, Day) For example 15th of March 2020 --> 200315
Three letter code of the semester: TBW
Event: Midreview, Final Review
Name: Surname Name
Description: Plan, Section, Elevation, Report etc

Example: 210718_TBW_Midreview_Muster Max_Plan.pdf

Access to Server

You will submit all the data by saving them in the polybox folder of our chair, accessible at the following path: https://polybox.ethz.ch/index.php/s/PWv8H5MXcHjQHCM

Submission deadlines

All drawings, model photos etc have to be submitted on time. The deadline is the day before review at 15:00 (17:00 in case of the Final Review). Submission deadlines have to be kept. If out of technical reasons, a submission can not be done, please contact the assistants before submission deadline.

GRADING SHEET

Grading Structural Behaviorology Workshop - Chair of Architectural Behaviorolgy 2022

Student: Eveline Example Date: 13/08/2022

Prof. / Assistant

Hand in	Criteria (Syllabus and Reader)				Maximal Points	Received Points	Grade	Grade Average
1st submission Individual work (30%)	Submission* Layout (A3×4, A4×1)	Plan(s)	1:1-1:5	4,00	0,80	0,80		
		Section(s)	1:1-1:5		0,80	0,80		
		Elevation(s)	1:1-1:5		0,80	0,80		
		Graphic statics	1:1-1:5		0,80	0,80		
		Reading review (text)	500 words		0,80	0,80		
	Understanding of Architectural Behaviorology				0,40	0,10		
	Research Method				0,40	0,15		
	Visualizatoin				0,40	0,20		
	Clear and comprehensible arguments (text)				0,40	0,20		
	Focusing the topic and Originality (text)				0,40	0,10		
	Submission delay				-0,25	-	4,75	4,75
Final submission Individual work (70%)	Submission* Layout (A1×1)	Participation in group work		4,00	-	-		
		Analysis diagram	1:1-1:5		3,00	3,00		
		Analysis (text)	500 words		1,00	1,00		
	Understanding of Architectural Behaviorology				0,40	0,10		
	Research Method				0,40	0,25		
	Visualizatoin				0,40	0,30		
	Clear and comprehensible arguments (text)				0,40	0,30		
	Focusing the topic and Originality (text)				0,40	0,30		
	Submission delay				Fail	-	5,25	4,72
Average 1st S + FS							5,10	4,73
Final Grade							5,00	

*The submission will be judged on whether it has been submitted with the minimum quality of the content.
If everything is submitted on time, student will get 4 points.

Absence: 06.09.

Conclusion:

Student Signature: _____

Img. 14: Kopfbau Halle 118

On the Sulzer site in Winterthur, the Abendrot Foundation created a beacon for climate-friendly and sustainable building that shimmers red in its reused profiled sheet metal cladding. The extension of the head building of Hall 118 for 12 studios, think tanks and a creative laboratory on the first floor was made mainly from re-used building materials.

"All things that are already there plus wood, straw and clay".

Radically formulated, these materials are available for climate-friendly construction methods. Because of great advances in building operation, construction is now responsible for three-quarters of the emissions in the life of a building. For the K.118, the focus was on reducing this gray energy: 60% of greenhouse gas emissions and 500 tons of primary materials could be saved compared to new building components.

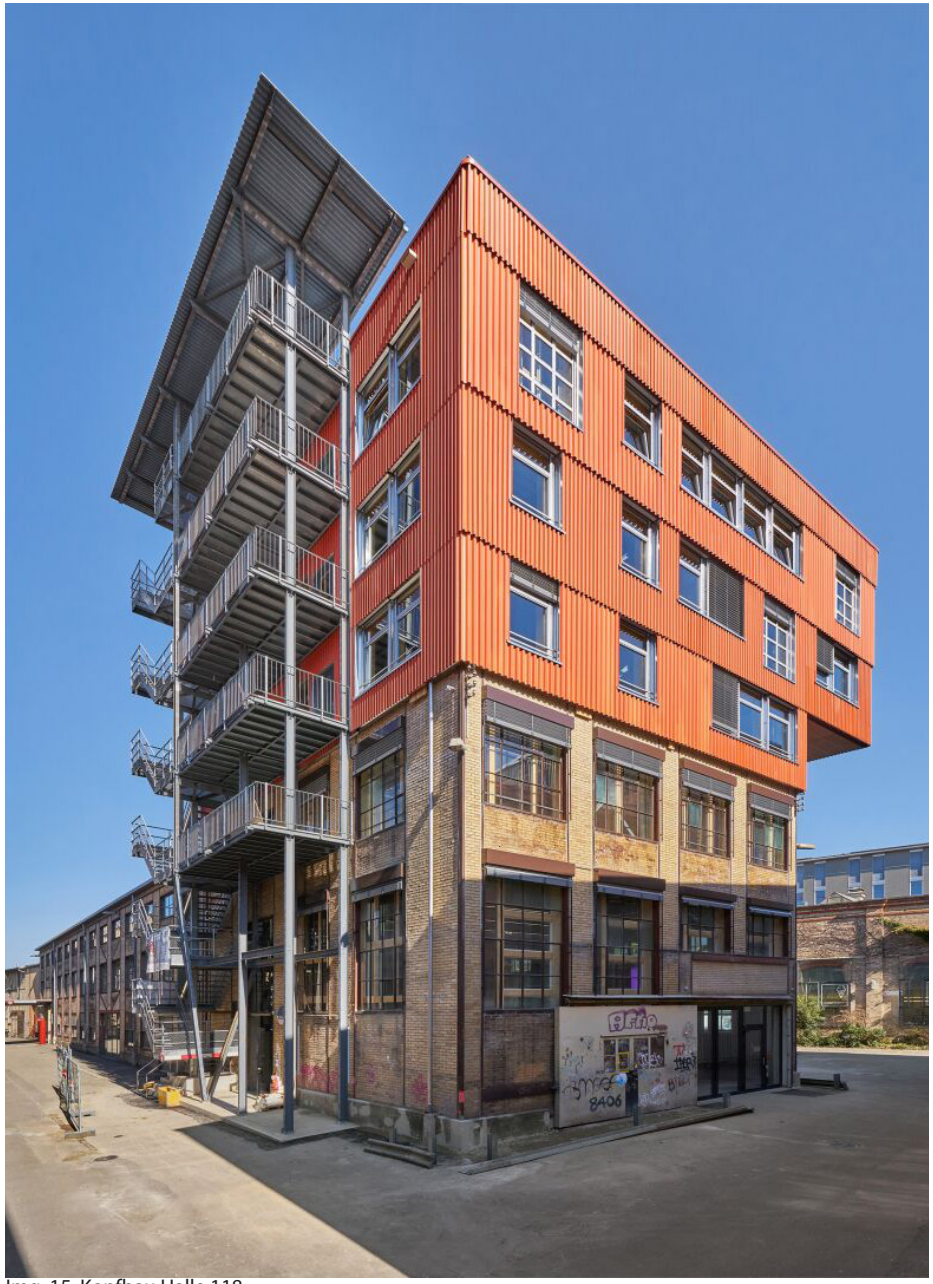
In the pilot project, it quickly became apparent that thinking circularly means thinking in loops: starting with available building components, the planning process turns around: It follows opportunities as they arise and starts with finding materials. Selection is followed by cataloging: In order to reinstall components, we need information and a precise idea of the requirements and installation options. Thus, along the usual planning phases, the design is created in a constant process of weighing, checking and deciding:

A steel skeleton that once supported a distribution center on the Lysbüchel site in Basel forms the supporting structure. Concrete was used only as thinly as necessary and only where it was unavoidable for structural reasons or for sound and fire protection: in the floor slabs, chambered concrete columns and in the foundations. The three new floors built on top of the hall are accessed by the steel exterior staircase from the demolished Orion office building in Zurich. The stair landings determine the floor heights. The granite facades, which have been converted into slabs in the kitchens, toilets and on the balcony arbors, and the majority of the aluminum insulated windows also originate from the Orion building. With the surrounding red facade sheet metal from Winterthur, they protect against the weather and draw the face of the building. Facade sheet metal and the storey-high industrial windows from the neighboring Sulzer Plant 1, which were doubled up to form box-type windows, thus continue to characterize the Winterthur cityscape.

Since material and projected elements are not geometrically related, necessary leeway must be created: Once elements and functions are decoupled in layers, they can overlap and follow their own rules. The scaled facade and visible support structures in K.118 illustrate this. Surrounding reused with adaptable materials is another way: in the prefabricated wooden façade elements, no-cut compartment insulation made of straw bales and interior plaster made of local excavated clay fill the space around the reinstalled windows. Processed with minimal energy, these natural "materiali poveri" remain compostable and provide a comfortable indoor climate. Interior walls made of wood accommodate reused doors and used triple-layer panels from stage construction and score with their adaptability, as do solid wood floors or the roof elements of a temporary wooden structure. Glued wood materials and elements are particularly suitable for repeated use or demand for it, their climate friendliness is far less positive than expected from wood because of the adhesives.

While the CO2 emissions in the construction could be more than halved, the costs remained within the limits of the CT for a similar new building. With the difference that the majority of the expenditure went directly into adding value for the craftsmen involved, because the inexpensive Reuse material requires some manual labor and expertise until it is installed. Sustainability also for the local economy.

- Referenz 088, baubüro insitu ag



Img. 15: Kopfbau Halle 118

KOPFBAU HALLE 118
LAGERPLATZ WINTERTHUR

Img. 16: Kopfbau Halle 118

KLEINE FREIHEIT
CAFE IN CONTAINERS

"The oasis between Weinbergstrasse and Leonhardstrasse invites you to linger in the middle of Zurich with the charm of the self-made and reused. Since 2013, students from the neighborhood have been offering falafel, mezze and drinks in the old shipping container. The initiators had converted the container into a kitchen and toilet according to our plans at Werkplatz Basislager in Altstetten. When the building code became a challenge for them, we advised them to keep their efforts to a minimum. In 2016, they enclosed the container with a winter garden. Where large machines were needed, they were supported by the carpentry firm BeniHolzbau. The reused elements were collected in the region: The tropical wood floor and the sliding doors were saved from incineration during the demolition of the neighborhood hall on the Friesenberg. The large windows could be dismantled during a demolition. The old garden benches and tables, the wooden boxes and pots full of herbs, as well as the sandbox planted with grass and the many green bushes give the gravel parking lot its unique ambience.

Img. 17: Kleine Freiheit

Img. 18: Kleine Freiheit

RE-USE PAVILION CAMPO
STUDIO BARBARA BUSER FS22

The ReUse Pavilion of the campo site was created as part of the spring semester 2022 in the Studio ReUse, which Barbara Buser led at the Architecture Department of ETH Zurich. The focus was: the reuse of building components as a strategy for sustainable and responsible architecture. The 28 students dismantled 6 to of building material at two deconstruction workshops. After in-depth analysis of the salvaged material, they quickly sketched a joint design for a pavilion. The next day they started building the foundations. The detailing of the design continued to be developed and decided together in an ongoing process. In just under two months, the students built this pavilion themselves from 99.9% recycled building materials. The pavilion is being built by the Foundation for Art, Culture and History (SKKG) and its subsidiary Terresta Immobilien- und Verwaltungs AG. The pavilion is a first step in the activation and transformation of this area, which is to be developed into the headquarters of the foundation in the next 3-4 years. In this context, the pavilion demonstrates the technical and aesthetic potential of a circular architecture of reuse.

Img. 19: Re-use pavilion Campo

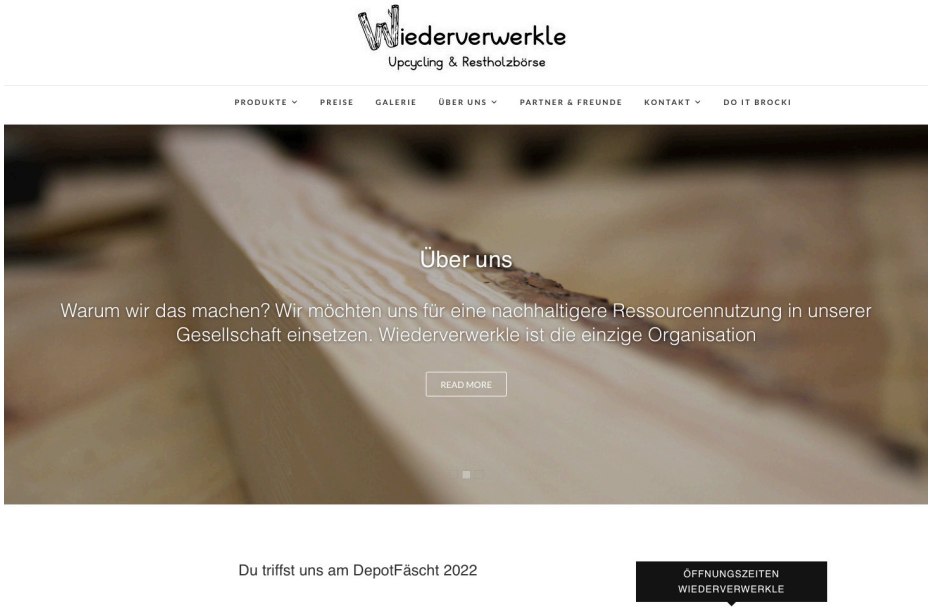
Img. 20: Re-use pavilion Campo

Img. 21: Re-use pavilion Campo

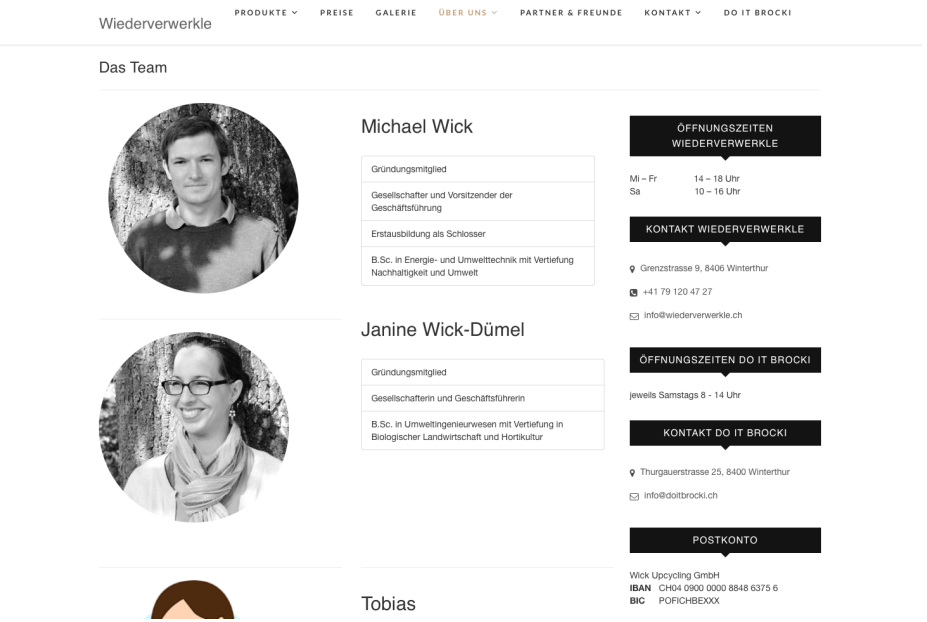
We at wiederverwerkle are committed to a more sustainable use of our resources and offer used wood, metal and upcycled products from them for sale. We want to work for a more sustainable use of resources in our society. Wiederverwerkle is the only organization in Winterthur that offers residual wood for sale at a central location.

The industry would burn the wood, we pick it up and put it to a more valuable use. With your purchase you contribute to a more sustainable use of our resources.

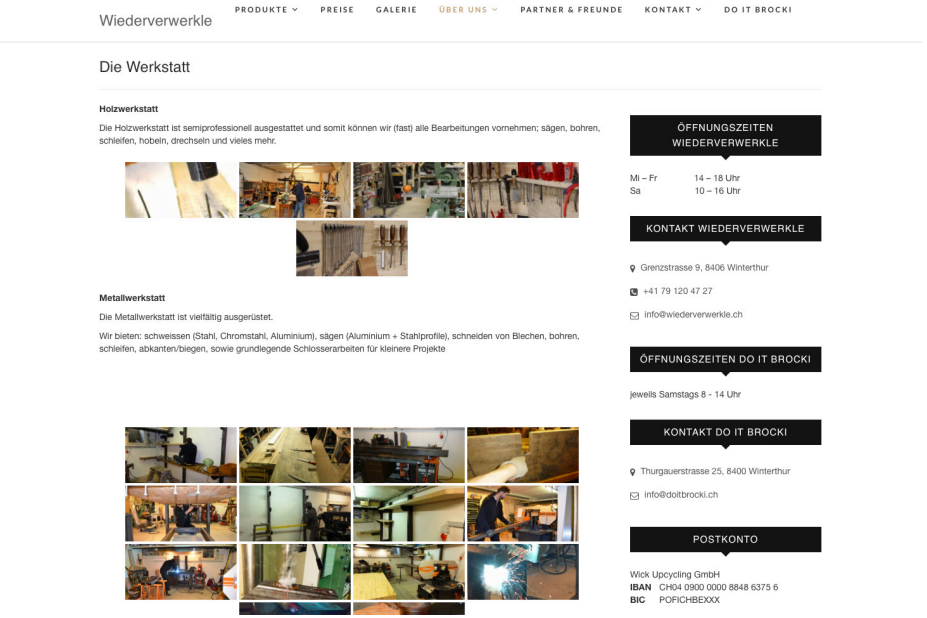
Wiederverwerkle wants to encourage creativity and tries to do so every day. If you have not yet had contact with handicraft activities, we encourage you to do so. This way you can create something useful with your own hands from supposed waste. If you have any questions about the development of your projects, we are of course at your disposal. We wish you a lot of fun developing and executing your ideas!



Img. 22: Homepage of Wiederverwerkle GmbH



Img. 23: Homepage of Wiederverwerkle GmbH



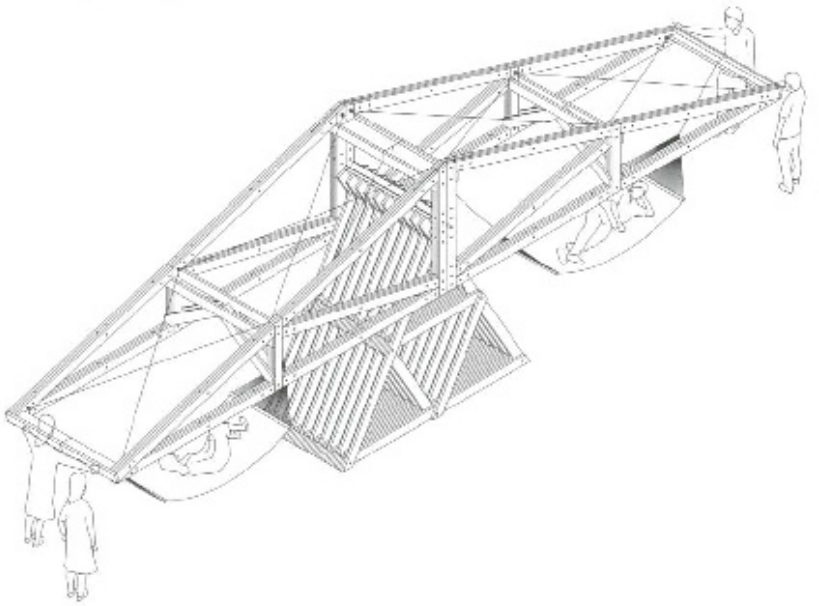
Img. 24: Homepage of Wiederverwerkle GmbH

ATELIER BOW-WOW
HAMMOCK HOUSE LOS ANGELES 2009

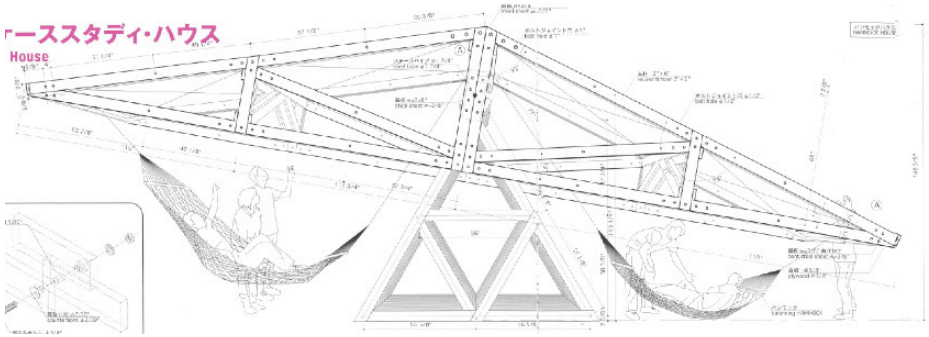
Atelier bow-wow, the Tokyo architecture studio led by Yoshiharu Tsukamoto and Momoyo Kaijima explores the use and function of space within urban environments. Bow-wow developed the term 'pet architecture'—a style of small, ad hoc, multi-functional structures that make the most of limited space, a phenomenon in densely developed cities like Tokyo that integrate need, improvisation and ingenuity.

in its first solo U.S. exhibition, atelier bow-wow shows three micro structures that collectively offer a contemporary spin on the idea of minimal low-cost housing. 'small case study house' consists of 'BBQ coliseum', a circular structure directed toward oil can barbecues, 'sunset house' and 'hammock house', all of which are built with salvaged wood from de-constructed homes in Los Angeles.

Img. 25: Hammock House



Img. 26: Axonometric Small Case Study House

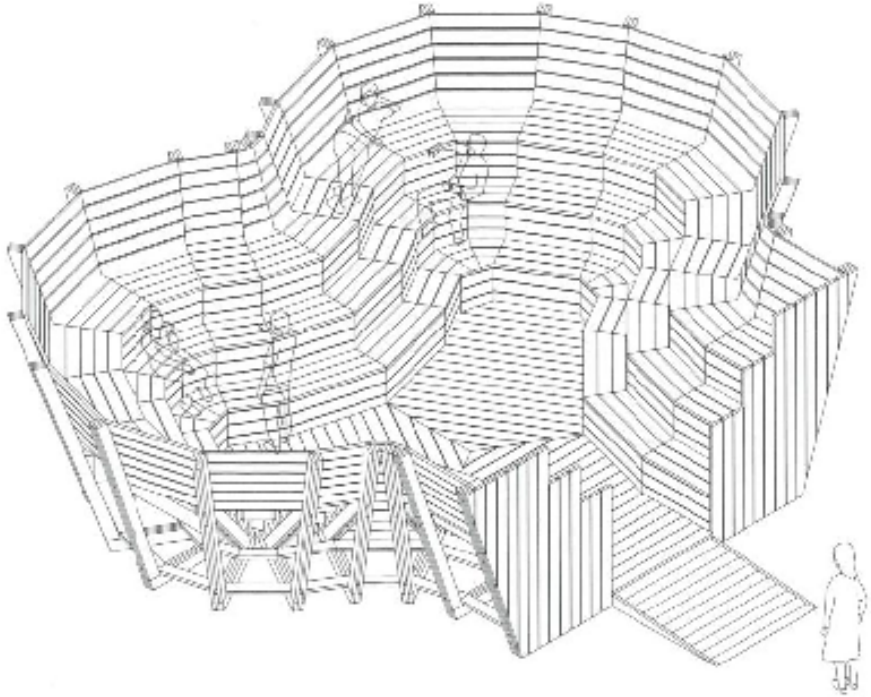


Img. 27: Vertical section perspective

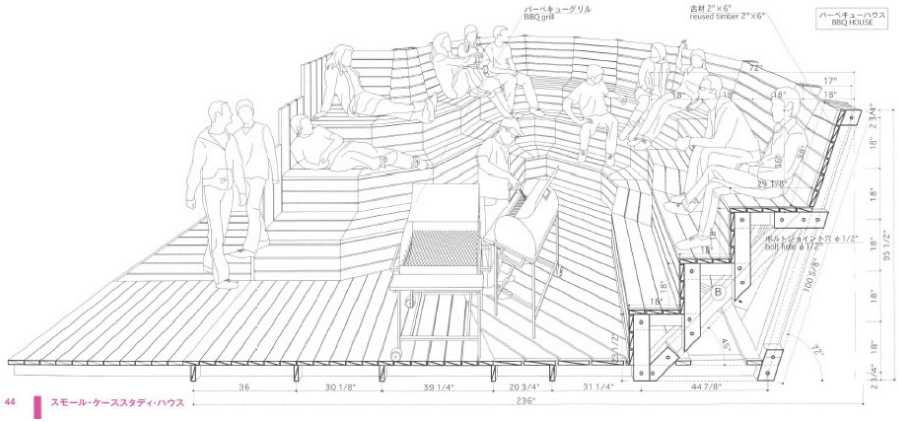
ATELIER BOW-WOW
BBQ HOUSE LOS ANGELES 2009

A group of works exhibited in Los Angeles, USA. Based on the idea of creating a single small house with a single "awareness," the works were inspired by the scenes of "hammocks," "barbecues," and "sunsets" that can be seen in the residential areas of Los Angeles on a daily basis. These works are made of 2×6 lumber and its old wood, which are used in American houses.

Img. 28: Hammock House



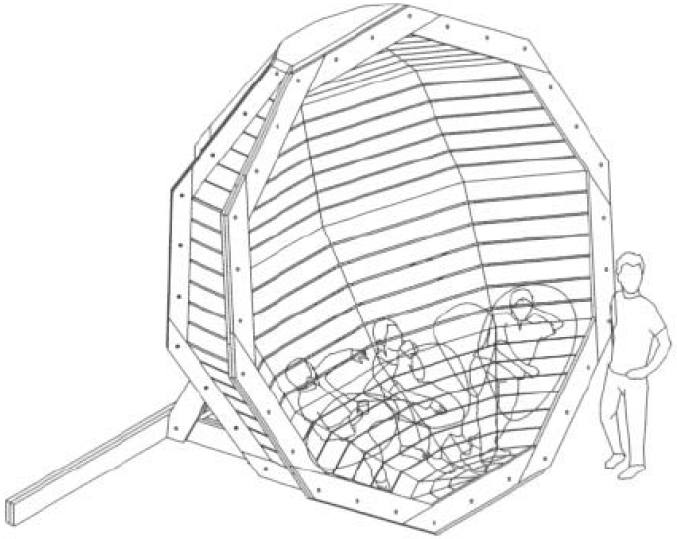
Img. 29: Hammock House



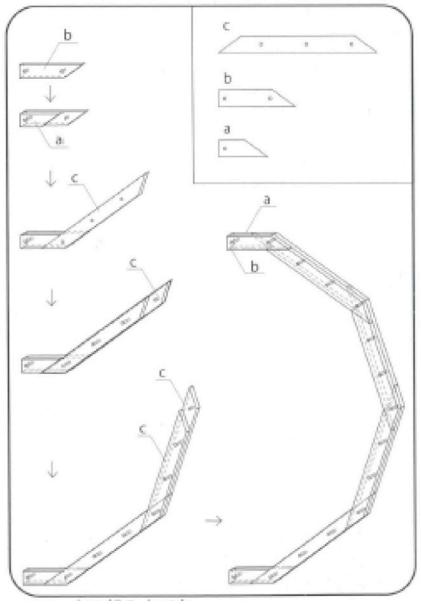
Img. 30: Vertical section perspective

ATELIER BOW-WOW
SUNSET HOUSE LOS ANGELES 2009

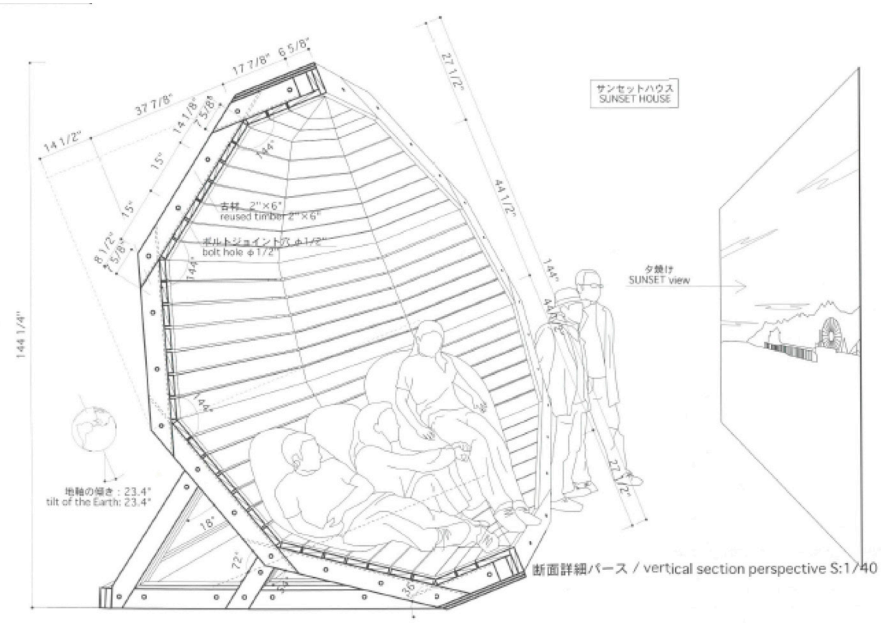
Img. 31: Sunset House (Atelier Bow-Wow)



Img. 32: Axonometric



Img. 33: Assembly instructions for SUNSET HOUSE unit



Img. 34: Vertical section perspective, scale 1:40

PUBLIC SPACE BEHAVIOROLOGY IN SWITZERLAND
STUDIO MOMOYO KAIJIMA

Public spaces fulfill an important role in our civic and urban life. They are places of spontaneous gatherings, demonstrations, markets but also offer spaces for everyday mundane activities such as eating lunch, having a drink, learning how to ride a bike and many more. How well the public spaces of a city or neighborhood work has a big influence on life quality for most of the nearby residence.

But what makes a space a good public space?

To answer this question, the 2nd year students began the semester by using the technique of Public Drawing, to analyze and understand a public space in the Oerlikon/ Seebach area.

Enriched by these observations, they have now turn to public spaces in our neighborhood and worked on enhancing them. By designing a temporary furniture, they invite people to appreciate and rethink these public spaces in their own neighborhood.

1. Sound of Meditation — **Markuskirche**
Höhenring 56
8052 Zürich

Fehrle Kornelia, Keller Iris, Le Mintier de L. Anaëlle, Li Yufei, Melber Antonia, Mujanovic Esad, Puthenpurackal Deepthi, Tempini Alessandro

Composed of a bird bath and a pathway, the project is a meditation space enriched by the sound of water and the chirping of birds placed above a biodiversity zone. The meditative pathway leads to a platform with a seating opportunity. Rising above the ground, the installation has a minimal impact on the ground and plants present at the site. As a transparently glazed timber construction the installation is complementing the natural flair and forms a coherent appearance on site.

2. Triangle Chairs — **Markuskirche**
Höhenring 56
8052 Zürich

Bennet Alexander, Bleichenbacher Dimitri, Connolly Abigail, Knellwolf Fabian, Lurati Arianna, Sandi Gino, von Albertini Gion

Facing Markus church's northern entrance, three prototype chairs offer multiple sitting postures. Introverted or extroverted arrangements let the visitor experience different relationships with the public space. The chairs are a product of continuous improvement by design iteration, both in planning and construction. Which one do you find most comfortable?

3. IntiMate — **Querbeete**
Koschenrütistrasse 5
8052 Zürich

Badrutt Laura Luz, Frei Benjamin, Frey Anna-Lena, Hausmann Maria, Hug Flavia, Peters Laurenz, Sondenegger Finia, Tschopp Eva

Right next to a participatory agricultural field and the Buhnstrasse bus stop, IntiMate provides different levels of privacy and thereby allow visitors to experience the exposed location differently. The structure is made of a bamboo frame and textile walls and roofs. The roofs can be pulled down and used for seating. Additionally, Bamboo mats allow invite you to sit on the floor. Knots hold the Bamboo rods together, allowing for easy assembling and dismantling of the structure.

4. The NetWork — **Stadtgeiss**
Felsenrainstrasse 67
8052 Zürich

Lakshmy Aparna, Müller David, Papadopoulos Sofia, Springfeld Joel, Tanner Lucas, Weinke Florian

A series of benches, combining seating and playing bring people together in a fun way. The benches are placed in a public playground and are offer something for all ages. The benches double as game, where juggling balls have to be thrown into holes. "Targets" are integrated into the backrest. How many points can you score? Play against yourself or others and keep track of your points by using the point counters integrated within the installation.

7. Fliegesthul — **Spielplatz 195**
Friesstrasse 17
8050 Zürich

Hatt Albert, Heimgartner Yannis, Heini Andri, Isenegger Carolyn, Kaiser David, Kaur Lukas, Spada Pietro, Wechsler Anina

Placed on a centrally located playground in Oerlikon station, surounded by a busy public transport hub, the installation put in ralation the fragmented elements of the playground and connecting them. Adjustable hammocks, suspended from cables within a wooden frame, allow people to sit and rest. A roof provides shade and protection from the rain. Lowered, the roof forms a visual barrier and allow people to sit sheltered in a cocoon and find tranquility.

6. Klappbar — **ETH ONA**
Neunbrunnenstrasse 50
8050 Zürich

Ampilogova Alina, Cangemi Alessandro, Cruz Lopez Monique, Dirlar Constantin, Gregorio Leandro, Ritschl Lucy, Schürmann Fidania, Stäheli Nicolas

This installation is a foldable, mobile bar. The bar consists of two wings each with its own foldable tabletops. Amongst the amenities of the KlappBar are the integrated cooling box, a retractable sunroof and foldable stools. It serves as an attractive gathering point and exchange spot during events or after work. Initialy at the entrance of ONA, its flexible dimensions, adaptability and movability allows it to be set up anywhere else and offer refreshments or relaxations.

7. Snake Bench — **ETH ONA**
Neunbrunnenstrasse 50
8050 Zürich

Essig Anna Maria, Furrer Timothy, Hahn-Woernle Anna, Häni Iosé, Martinez-Avial Moira, Moser Nora, Peyer Michelle, Pfeffer Jonas

Eight mobile modules: four long benches, three stools and one table, form a flexible seating opportunity that encourage different forms of gathering. The arrangement of seating and the height of the table is adjustable according to users' needs. Benches are illuminated from the inside, attracting users in ONA's corner entrance even at night. Inspired by sailing ships, the project is made of wooden frames, sailing fabric and ropes to create a weatherproof, durable, light and harmonic furniture.

8. Green Line — **ETH ONA**
Neunbrunnenstrasse 50
8050 Zürich

Bellarosa Lorenzo, Dietz Leandro, Howald Valentina, Soldati Kim, Summermatter Timea, Ulbrich Simon, Wyer Nadjaschda, Zwyssig Timon

Located on the south side of the ONA building at the sidewalk this herb garden invites you to spice up your food, to brew fresh tea or to simply upgrade a glass of water. A roof provides the right amount of water and sun to the plants, while also providing shade for the users. Foldable, lightweight chairs can be used to sit around the table. The height-adjustable table, surrounding the planter can be lowered and used as a bench for additional seating.

Img. 35: Student projects

Img. 36: Public space behaviorology

Img. 37: Public space behaviorology

FUTURE LEARNING SPACES

The interdisciplinary project "Future Learning Spaces" examines the interaction between physical learning spaces and the university students that use those spaces. It is a collaborative project of the Chair of Architectural Behaviorology and Cognitive Science (D-GESS). The project focus is on informal learning spaces across various learning settings. Research questions to be addressed include: What are the characteristics of informal learning spaces and what is good about them? How can the design of learning spaces facilitate active, social, and experiential learning?

In an experimental activation workshop transition spaces were transformed into creative learning spaces in a 1:1 collective design production. An interdisciplinary group of students from ETH conceptualize, design and produce 1:1 installations, in a collaborative process, using resources at their disposal like left over materials of gta Exhibitions' storage room, green, sound, air and light, keeping the budget for such transformation very low, and supporting an open process of transformation.

Img. 38: Workshop in the Foyer of the gta Exhibitions' spaces, HIL Building, in September 2019

Img. 39: "Funnels of Knowledge", by Aude Sahli & Maxime Évéquoz

Img. 40: "Future Learning Spaces", Ideation workshop, HIL foyer spaces, Sep 2019

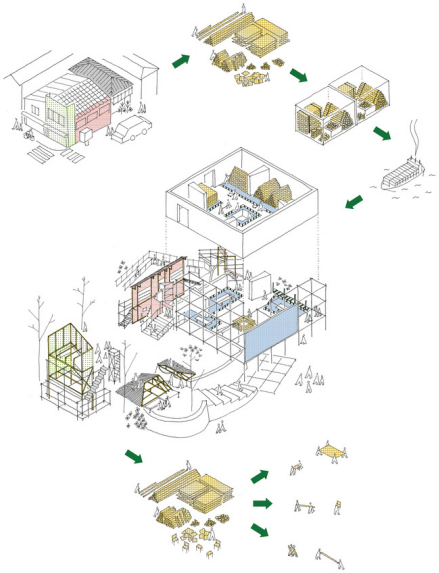
JAPAN PAVILION VENICE BIENNALE 2021
KOZO KODOWAKI

Titled Co-ownership of Action: Trajectories of Elements, the project curated by Kozo Kadowaki involves dismantling an old wooden Japanese house and transporting it to Venice to be reconstructed in a new configuration with the addition of modern materials. The exhibition exemplifies how old materials could be given an entirely new existence by putting the current movement of goods in the service of reuse rather than consumption.

The Japanese contribution to the 17th Architecture Biennale highlights how the ability to quickly and inexpensively move goods around the world has exacerbated mass consumption. Shifting the focus from movement in the service of mass consumption to movement for the purpose of reconstruction and reuse, the curatorial project consists of moving an ordinary postwar Japanese house to Venice, giving it a new existence in a different context. The house is one of the many in Japan that have outlived their usefulness and await demolition due to the country's declining population. The deconstruction of the house unearthed several strata of renovations and expansions, with elements ranging from handmade to mass-produced, which trace a fragment of Japan's construction industry. These layers show how the current project is just one in a series of rewritings in the house's history. Employing the skills and ideas of local and Japanese artisans, the dismantled elements of the house have been re-purposed into objects that furnish the Japan Pavilion's garden, while unused parts will be on display inside the Pavilion. After the exhibition, the house will take on a new trajectory, as there are plans for it to be used as part of a community facility for residents of an apartment complex in the outskirts of Oslo.

Img. 41: Japanese House before dismantling (Image © Jan Vranovský)

Img. 42: Co-ownership of Action: Trajectories of Elements (Image © Alberto Strada)

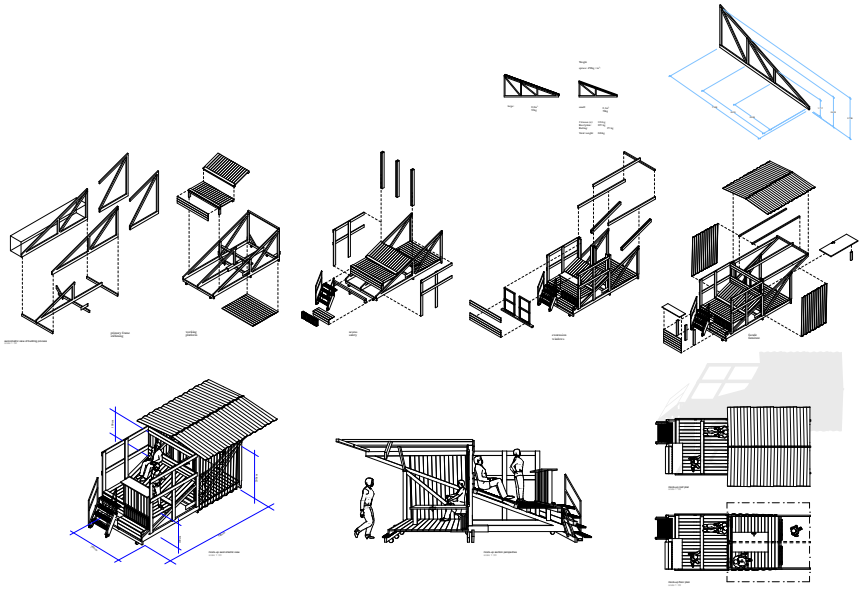


Img. 43: axonometric. (Image © DDAA + village®)

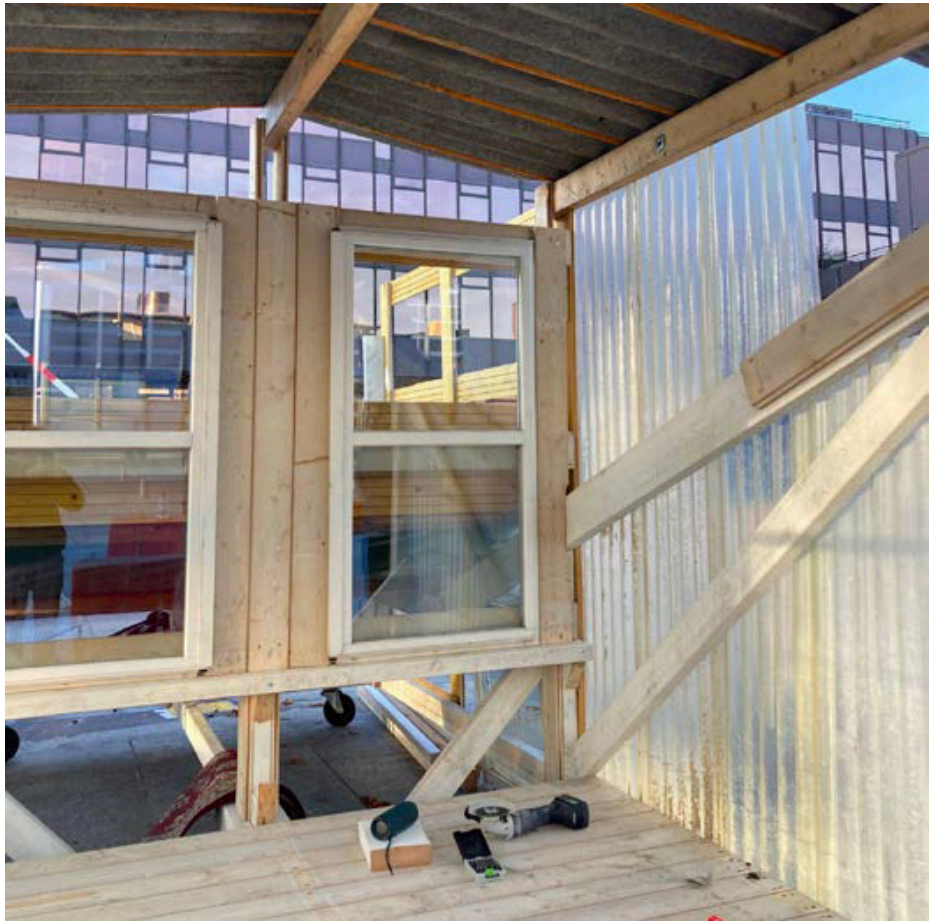
RE-USE MOCK-UP
ELIAS KNECHT

A 1:1 mock-up was built with real components of the Huber pavilions in order to test the different construction methods and joints. It can be dismantled by students to improve further construction. Materials come together in an ad-hoc manner of construction. Designing and testing go in parallel loops. Many options only become visible when testing the a 1:1 situation and revising the plan. The character of the re-use pavilion hereby reflects the experimental use and hands-on experience of an endless laboratory of learning space. A culture of sustainability in construction can be achieved through positive learning experiences during education regarding circular building systems.

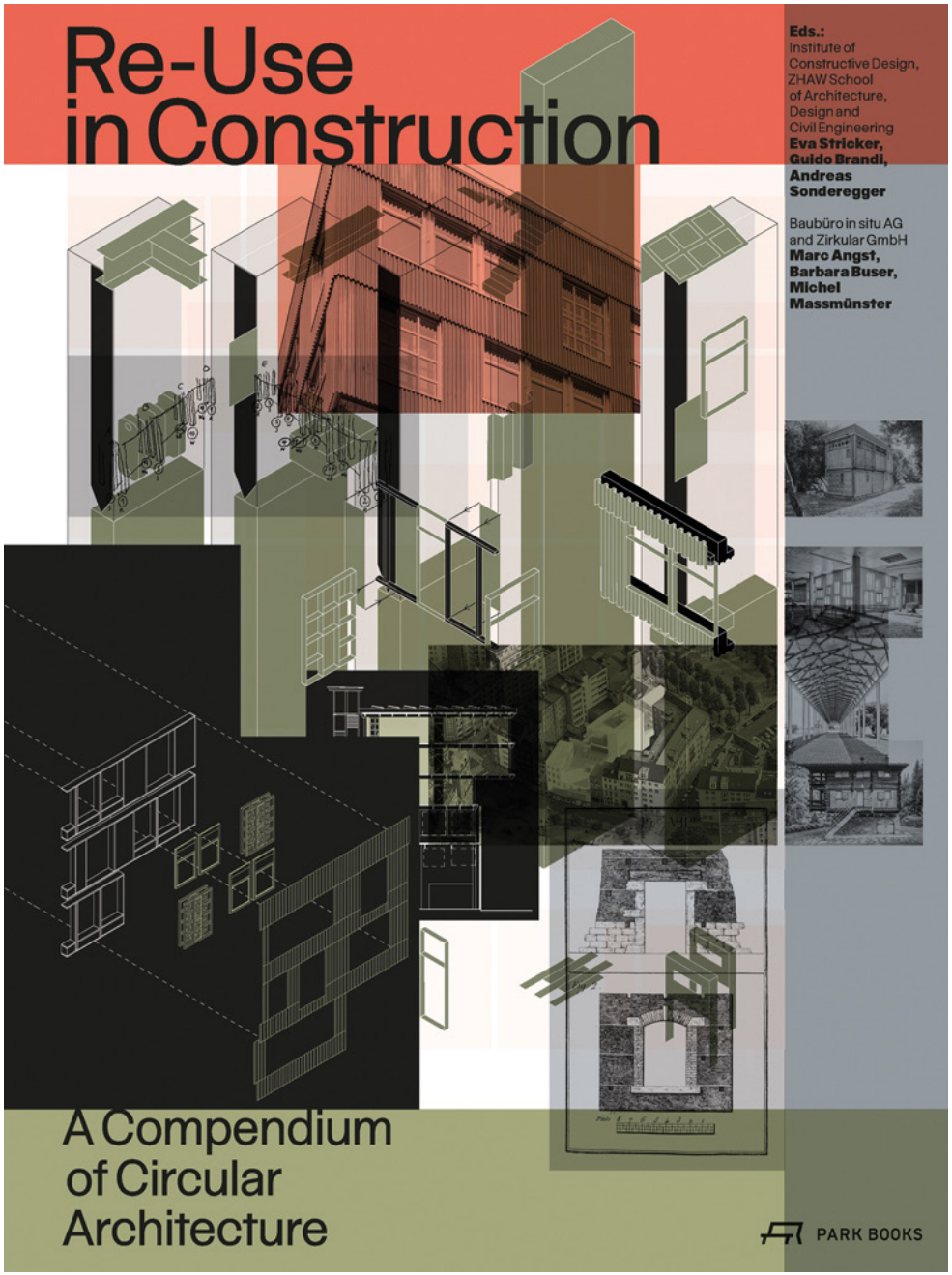
First and foremost, during construction, the protection of health and safety of all protagonists and future users is of most importance. Aside from respecting all building norms (SUVA) and rules for the protection of workers (EKAS), a safety concept is required. This includes an assessment of dangers and risks on the construction site, rules of conduct, principles and organisation of safety instructions and action planning. A healthy culture of safety is fostered with leadership by example and audit of experts and responsible safety officers.



Img. 44: 1:1 Mock Up with re-use material from the Huber Pavilions (Elias Knecht)



Img. 45: Mock-Up interior



Img. 46: Re-Use in Construction (2021) A compendium for circular architecture

Img. 47: Bauteile Wiederverwenden (2021) Ein Kompendium zum zirkulären Bauen

CARPENTRY
The activity or occupation of making or repairing things in wood. The work made or done by a carpenter

SOFTWOOD
A tree belonging to the order Coniferales. Softwood trees are usually evergreen, bear cones and have needles or scale like leaves. Examples include pines, spruces, firs and cedars. See conifer.

HARDWOOD
Trees with broad, flat leaves as opposed to coniferous or needled trees. Wood hardness varies among the hardwood species, and some are actually softer than some softwoods.

BEAM
A horizontal structural member which supports a load.

POST / PILLAR
A vertical structural member which supports a load.

JOINT
Place were two or more pieces of wood are connected.

TRUSS
A framework, typically consisting of rafters, posts, and struts, supporting a roof or other structure.

STRUT
A rod or bar forming part of a framework and designed to resist compression

RIDGE
The line or edge formed where the two sloping sides of a roof meet at the top.

RAFTER
Structural member of the roof, spanning from the ridge to the purlins

PURLIN
Structural member of the roof, parallel to the ridge

EAVE
Lower part of a roof which projects over the wall.

SPAN
Distance between the structural supports in floors, ceilings, and roofs.

LIFE CYCLE ASSESMENT

REDUCE

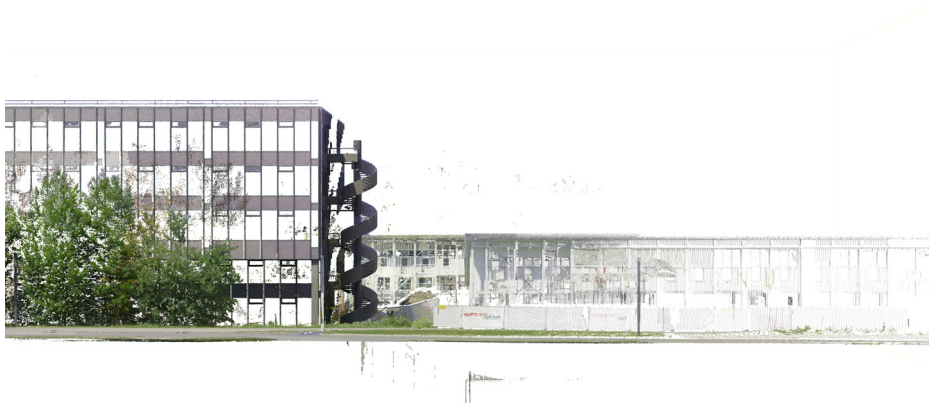
REUSE

RECYCLE

Pavilion Re-Use

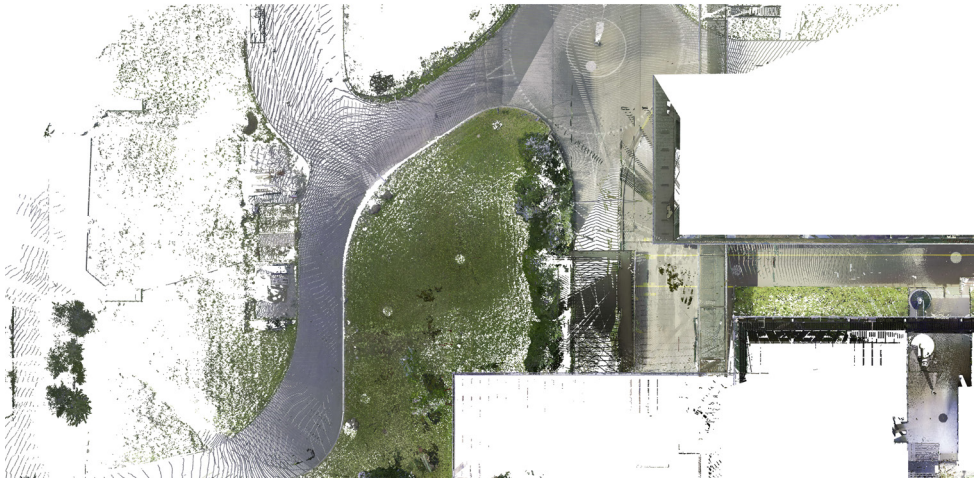
	Material	Origin	Amount	Dimensions	Weight
Primary Structure:					
Truss	Timber	Roof structure	15	270 x 780cm	
Truss-Beam	Timber	Roof structure		15 / 18 x 5,5cm	
Timber < 3m	Timber	Collonade between pavilions	40	11,5 x 11,5 cm	
Timber > 3m	Timber	Beams, Coloumns	15	24 x 14 cm	
Boards, Larch	Timber	Exterior veranda	50	120 x 12 cm	
Boards, Timber	Timber	Roofplates	500	240 cm	
Beams	Timber	Roofplates	30	800 x 7 x 7cm	
Secondary Structure:					
Window sash, large	Wood, Glass		14	80 x 155cm	
Window sash, small	Wood, Glass		21	80 x 100 cm	
Window with frame	Wood, Glass			170 x 176 cm	
Door, interior	Wood, Aluminum		6	84 x 198 cm	
Door, exterior	Wood, Aluminum		5	108 x 205 cm	
Glass, VSG	Glass	Interioir balustrades	2	100 x 200 cm	
Grid bracing	Metal	Roof bracing	1	60 x 200 cm	
Grid balustrade	Metal	Interior balustrades	1	90 x 200 cm	
Eternit panels	Eternit	Roof cladding	200	90 x 250 / 170 cm	
Corrugated roof, small	Plastic		4	495 x 50 cm	
Corrugated roof, large	Plastic		3	495 x 110 cm	
Tertiary Structure:					
Stairs, large	Metal		1	500 x 105 cm	
Stairs, small	Metal		1	90 x 140 x 70 cm	
Radiators	Metal		20	350 x 50 x 7 cm	
Water basin	Porcelain		1		
Clothes hook	Metal		1		
Curtains	Textile		1		
Boiler					
Toilet	Porcelain		2		
Urinal	Porcelain		2		
Fluerescent lamp	Glass				
Spotlight	Glass, metal				
Cable tunnel	Plastic		30		
Motion detector	Plastic				
Pipe	PVC, plastic		3	12 x 200 cm	
Door handle, locker	Metal		1		
Mirror	Glass		2	40 x 50cm	
Exterior:					
Paving stone	Bakestone		450	12 x 24 cm	
Cement plates	Cement		40	40 x 60 cm	
Step	Cement		3	40 x 60 cm	
Rock	Stone		1	120 x100 x50 cm	

Img. 48: Material inventory sheet, Chair of Architectural Behaviorology



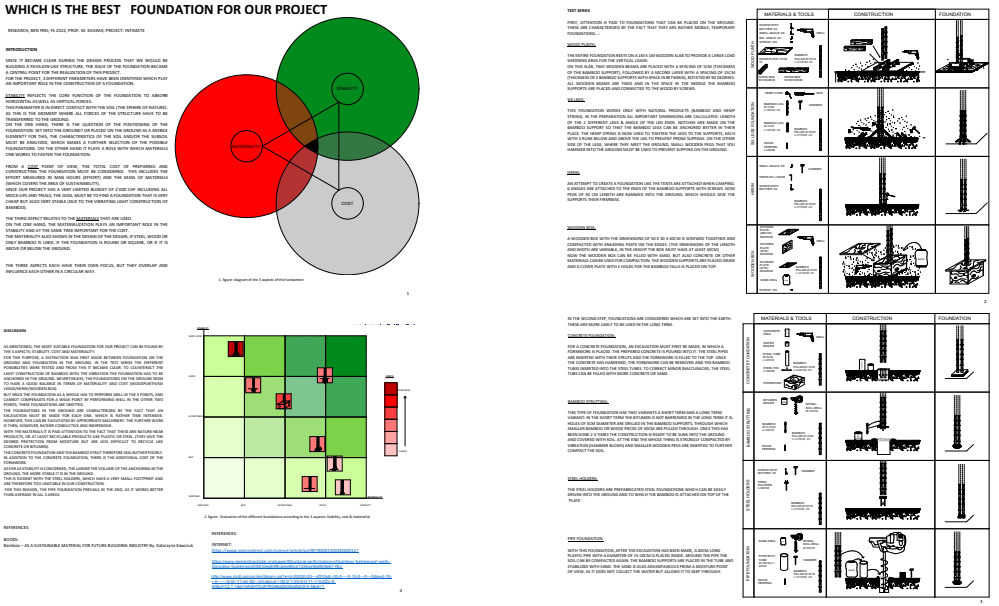
Img. 49: Scan of Huber Pavilions

Img. 50: Perspective scan of construction site

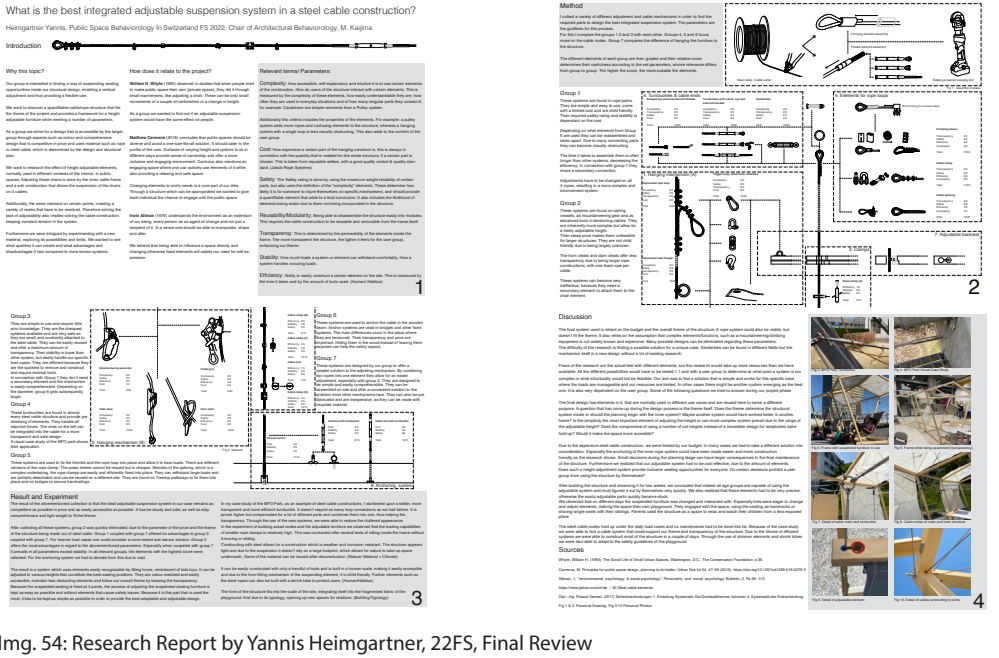


Img. 51: Scan of Construction site

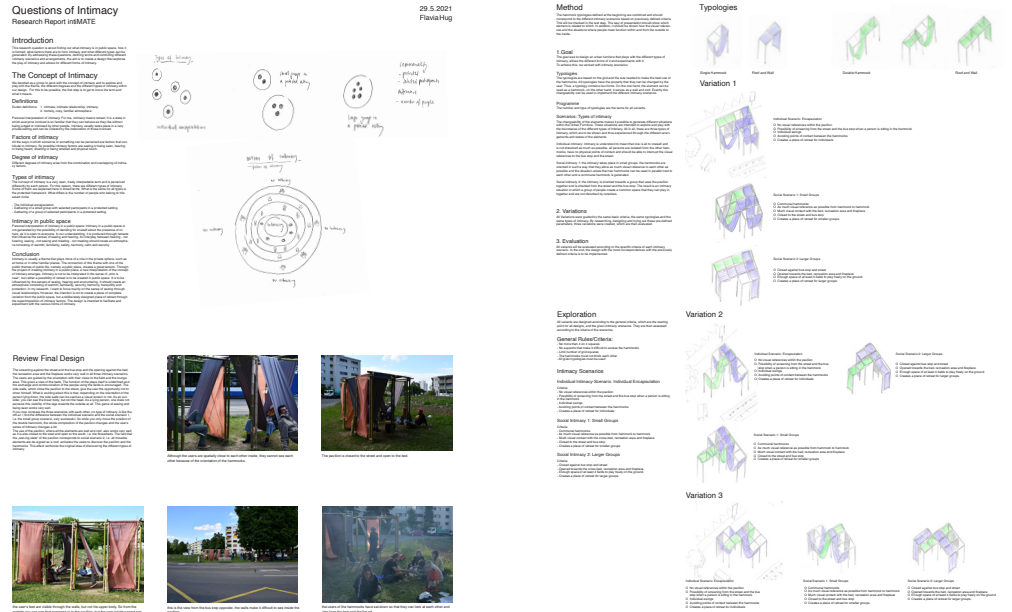
Img. 52: Perspective scan of construction site



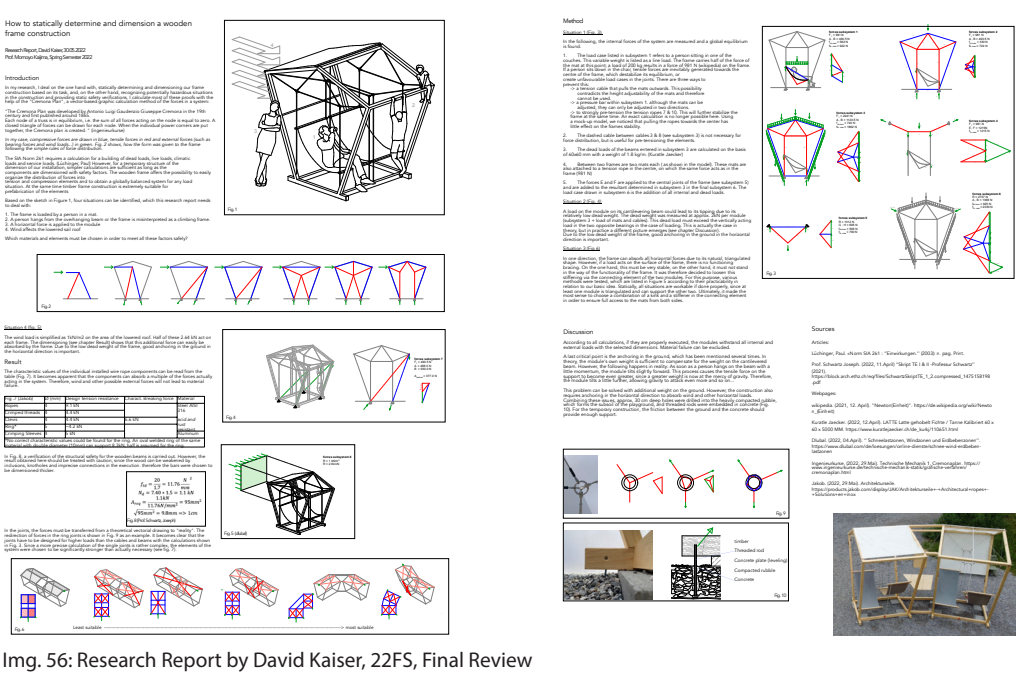
Img. 53: Research Report by Ben Frei, 22FS, Final Review



Img. 54: Research Report by Yannis Heimgartner, 22FS, Final Review



Img. 55: Research Report by Flavia Hug, 22FS, Final Review



Img. 56: Research Report by David Kaiser, 22FS, Final Review

Wood Joints

"What is the best wood joint in small-scale structures?"

Introduction

Why are we researching wood joints?

There's a personal interest in wood joints, as well as a group interest in the topic of joinery so as to solve all kinds of connections for the design of the "Flugstuhl".

Joints are almost always the weakest point in a construction, since various elements with various forces converge at one place, which needs to deal with all the forces at once. Since this semesters topic is about constructions in a 1:1 scale, it is extremely important to have a sturdy structure as to not endanger possible users and passers-by. Therefore the goal is to find a joint which is as strong as it needs to be planned and constructed as well as possible to reduce the risk of failure.

The goal is therefore to create a catalogue of joints and connections through research in order to find out if jointing techniques are quantifiable and if so, what joints are suited best for our type of project.

The Relation to our project is apparent, since the findings and results will have a direct impact on each joint in our structure.

In general: For the "Flugstuhl" project we need solutions for two-way joints, three-way joints, as well as three-way joints with additional elements, such as threads, eye-ends and looped cables. Therefore we need a versatile, easy to construct, multi-directional joint, that is lucrative both in terms of money, meaning material, and in terms of time. At best, we find a joint that solves all these problems in the catalogue created here.

Definition:

Why defining: To clarify, and more importantly to narrow down the possible connection-types chosen for the catalogue, there have to be defined a few key-elements distinguishing our project. The elements to define are given by the research-question, the specific definitions either by literature or by our project:

Joint, Wood-Joint ↑:
- „joint, in carpentry, junction of two or more members of a framed structure."
- „Joinery, or the making of wooden joints, is one of the principal functions of the carpenter and cabinetmaker. „

Best defined for this specific project, can vary across different projects. The easiest joint is the most desirable joint for students, defining therefore criteria as follows:
- as few cuts as possible
- as few angles as possible
- as few tools needed as possible, the tools being simple to operate and widely used
- as few fixings as possible
- as simple to connect as possible
- as economic as possible (material cutoff, fixing needed, material volume, material type)

Small-scale structure: own definition, specific for this project.
- Definition small-scale according to online dictionary: „of limited size or scope", „of limited scope; not extensive" ↑
- Structure refers in this case exclusively to architecture, therefore talking about some type of volume created according to somebody's architectural ideas. Thus excluding cabinet-making and other typologies as such.
- To give „small-scale" some definition, it is limited to volumes ranging from 5m³ to 75m³, mostly single-story constructions.

In general:

The analyzed joints don't represent a complete list, but rather a selection of possibilities that seemed most suiting for the aforementioned small-scale structures. Thus are the results only training a small variety of possible Joints. Further are potential adaptations of joints not separately listed, even though they may vary in range, this to reduce complexity and guarantee clear results.

The findings have to be quantifiable, therefore a grading scheme has to be fixed. After researching, different criteria have been established, which will be necessary to determine the best option, in this situation the most fitting joint for our construction. For each subtopic each joint-technique gets 1-5 points (5 = very good, 1 = very bad), therefore the joint with the most points is the best. The subtopics are as follows (similar to the criteria defined in „best") and refer only to the chosen joints:

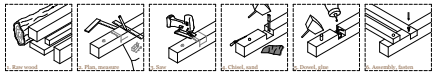
i. Sturdiness / tensile strength
ii. Time (based on complexity in cuts)
iii. Complexity in angles
iv. Tools needed (in relation to commonness and difficulty to operate)
v. Material
vi. Fixing (what is needed)
vii. Versatility (farmer's form, position and direction of joint)
viii. Connectivity (easy buildable / removable)

Joinery Type ↑:

Woodworking and joinery has a rich history and they find their notable beginnings with the ancient egyptians and chinese, which are said to have been the first to join timber with mortise and tenon like connections.

When talking about joints, japanese joinery is often one of the first talking points. Although japanese joinery is very complex, it is also very sophisticated, meaning they are able to connect wooden pieces only by wedging and creating friction and tension by doing so. To achieve these type of connections, there are often three and more directions needed, to create a joint, further they need a lot of material and precision to function.

Therefore, even though the japanese type of joinery is admirable, we chose to use artificial fasteners to ensure simple, material-saving way of connecting wood, while simultaneously keeping high stability.



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Method

"Collecting" - what does it mean?

Collecting means looking at different options in depth, comparing them, and finding a reasoning conclusion. To ensure scientific statements, a quantified approach is important.

Creating a collection helps to find and quantify easily decipherable results in order to be able to discuss them.

Since joints differ from construction to construction, it is more useful to have a broad overview of the subject than to have results from only one experiment on a specific joint. Therefore, the research question is not "What is the best wood joint", but has already been analyzed can be selected is the most efficient way to gather information on the subject.

Finally, it is the approach where the most information has to be processed in order to achieve any results at all.

Frame Joints ↑ 3 4

Dowelled Joint

The dowel joint is based on the simple butt joint or the lap joint, adding extra strength and durability through reinforcement of the connection. It can be found in other joints, such as the lap joint for example.

Dowelled connections use a wooden or plastic pin, which is fitted into holes drilled into the two pieces to join with each other. It is an invisible and reinforced connection.

As a simple construction-method, using only few tools (drill) convenience ↑

The dowel joint is often used in furniture-making, due to it's invisibility and strength. Further it can be found in shelf-construction and toy-making.

Halving Joint

Similar to the lap joint, but vertically arranged. It can be reinforced with fasteners, to achieve tensile strength.

The halving joint is made by removing half of each connecting piece, creating a shoulder, on which the horizontal fibres land. It is a strong connection, due to the shoulder and the large gluing area. A big advantage of this joint are the flush surfaces when assembled.

The halving joint is a versatile joint, however, each relating to where the two pieces are connecting: Corner-halving, Cross-halving, Tee-halving, Dovetail-halving, ...

The halving joint, sometimes in combination with the scarf joint, is often used in bigger scale, such as frame-type constructions in architecture.

Mortise and Tenon

Showing similarities to the dowel-joint, this joint is a strong, immovable, mostly rectangular connection, often used in traditional architecture, where various adaptations can be found.

The tenon, as the male connecting piece, a mortise is created. At the end of the other connecting piece the mortise's counterpart can be found: the protruding tenon. The tenon is simply stuck into the mortise, creating a sturdy, partly invisible and flush connection.

Due to the simplicity of the joint, it is ready due to the mortise & tenon's complexity and their need for various tools to achieve a smooth surface.

Bridle

Using the similar principle as the mortise and tenon joint, the bridle joint is based on the connection of both, due to it's reduced complexity in construction.

But the bridle joint uses the full width of the timber; the tenon as well as the mortise is therefore more weak, resulting in more visible connections. The connections of the bridle joint can be found on the outside edge of the four sides around the tenon. It can be reinforced by angling the cuts or by introducing fasteners.

This joint is often used in architecture, allowing lightweight and simple constructions. An adaptation to the corner-connection is the tee-connection, where the tenon is cut out in the middle of the horizontal element.

Scarf

The Scarf joint is used longitudinally, meaning extending the existing piece with the next piece. Therefore, the joint is often used in bigger scale. The joint often has to be fixed with screws or straps, to avoid shifting open.

Scarf joints vary in complexity, but generally only need few equipment and tools to be created.

Box Joints, Fixing Methods ↑ 4

Butt

The most common and most simple connection of two pieces, lacking strength. It is rarely reinforced with dowels or screws.

Butt joints connect two pieces at their end with glue, creating a rectangular (and differ) connection.

The butt joint is rarely used for simple boxes or frames, as long as there's not much strain on the joint.

Similar to the miter joint, the butt joint cannot be stressed as long as the glued connection hasn't dried out.

The joint is good for forces along its axis, but doesn't hold at all when introduced to horizontal forces.

Lap

Similar if not identical to the halving joint, but horizontally assembled. It is a simple connection, that is rarely used in bigger scale, such as frames.

By having a cutoff in each connecting piece, they can be laid into each other, creating a flush joint in two or three directions.

This joint is also used to extend pieces longitudinally, following a similar principle as the scarf joint.

Lap joints have, many different variations, mostly depending on where the connection lies.

Housing

Also referred to as "Dado" or trench joint, they can be closed, stopped or open, resulting in invisible, partly invisible and visible joints.

By cutting a trench into one piece, the other piece can be placed into the trench, to create a flush connection. This connection is, if not reinforced, very brace, relatively weak.

The main purpose of this join is found in cabinet-making and other small-scale assemblies.

Professional equipment is needed to create the trench, thus is this joint futher complicated to produce.

Dovetail

Due to its complex interlocking pattern, this joint is commonly used in cabinet-making. Similar to the finger joint, works similar to the finger joint, showing dovetail-shaped interlocking elements, thus the name.

A great advantage of this joint is, that it provides tensile strength in both directions of the joint, due to the interlocking parts.

An adaptation is the dibbed dovetail, which connects the connecting pieces, as the finger joint, with a dovetail-crench, in which the dovetail fits.

When dealing with all the different angles, professional equipment is needed.

Finger joint

Resembling stacked lap joints, this joint connects pieces with non-angled, interlocking "fingers".

This joint is relatively strong, due to the high glue-able area, but lacks tensile strength.

As well as the joints above, this joint is often used in cabinet-making, due to the easy method to connect boards longitudinally.

It is an elaborate technique using much equipment and experience to ensure a smooth joint.

Dowels, Biscuits, Nails, Screws and Threads

To strengthen Joints that are generally viewed as weak, fasteners come into play.

These fasteners provide all function by mechanically connecting the joint pieces either through cylindrical rods fit into predrilled holes (Dowels, Nails, Screws, Threads) or elongated, flat, oval plates stuck into notches in the connecting pieces (Biscuits).

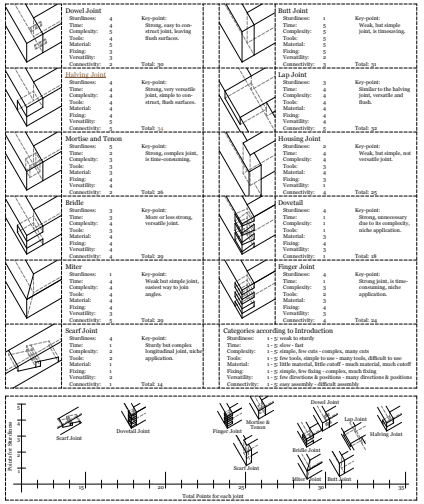
While the fasteners are usually hidden to the joint's visibility, meaning here important the final appearance is, if it should be flush, should have no visible connections, ...

Materiality differs from fastener to fastener, most common are wooden ones (Dowels, Biscuits) and metallic ones (Screws, Nails, Screws, Threads).

Results

It is extremely difficult to classify or list joints, since they vary in execution. There are some traditional classification systems, one of which is the classification according to Gerner ↑, that can be used. Problems with those assessments are however, that they base themselves on the joints' complexity and therefore on their appearance of combinations of joints that therefore cannot be listed correctly and most importantly, their impracticality in accordance to our project (we don't need a „big construction joint").

Thus the List detailed in the Method-section is faulty in terms of limitation, meaning that only a few joints were considered, and that only a few specific joint combinations which were not considered. The chosen assortment represents those jointing techniques that seemed, before analyzing, most suiting for our project. Therefore the following visualization of results is done across this list, and traditional classification systems like Gerner's is reduced to a single criteria „versatility".



The grading is done based on literature, experiments and models to ensure a point of view that is as objective as possible. Nevertheless there is a bias to some extent, mostly influenced by aesthetic ideals and ideas of solving jointing problems in our own, personal way. Therefore, this has to be taken into consideration when looking with the following results.

Further there is ones again the note, that this grading sheet is intended for the "best wood-joint in small-scale-structures", and therefore most certainly differs from other evaluations, which deal with either smaller scales like cabinet-making, or bigger scales like bridges.

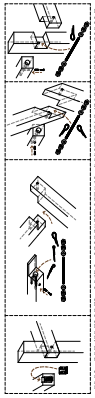
What wasn't considered when grading was the wood-type, which would influence criteria like "Time", "Material", "Tools" and "Sturdiness" to some extent. But the difference is assessed to be minimal and therefore negligible.

Discussion

As seen above, the halving joint, secured with dowels or screws seems to be one of the best joints, closely followed by the dowel joint and the butt joint. They all show a rather high simplicity while being sturdy if fastened. Moreover, due to their simplicity, they allow for a low construction time, low needed knowledge and pose a high flexibility.

Further it seems that one or two criteria can already eliminate a joints chances of being chosen the best. This may interfere with the results, and indicates, that some criteria may be more important than others. To counteract this tendency of skewed distribution, there would have to be introduced an adjusted grading system as discussed before.

Further summarized and thus helping designing new joints and checking proposed designs, the following can be said: The more interlocking elements, the stronger the joint, but likewise the more time, knowledge, precision and material is needed and vice versa.



In our project there are five different ways how two or three pieces connect. Due to different requirements from our project, we needed to work with more than one joint-type, resulting in a connection composed of two different joints, creating the best solution for their respective environment.

The first connection is within the frame, which is prefabricated and can be viewed as a single element, due to the assembly-process of the frame. Here, we chose the halving joint as a halving joint, through which threads run that act as dowels. The single fastener always put in the middle of the joint, ensures that the joint can flow within the structure in order to tackle different load-cases, executing horizontal forces generated through wind and additional vertical forces like people scaling the structure, as well as the dead load. The halving joint does this value out the usage of either glue or fasteners stifling out the connection. Additionally to the simple halving joint used in the frame, the rope-system, which stabilizes the frame, is integrated. Here, the joint is integrated and load directly onto the axial points, again due to the force-flow: One, or exceptionally at the gable two, ropes are put around a dibable, fixed together by pressed eye-sockets on the ropes. The dibable is inserted around the thread in the halving joint.

The second connection is the three-way connection in the base of the construction, where the horizontal pieces fit onto the frame. Here, we chose a butt joint, where the frame piece has to fit onto the thread and thus needs two types of holes: a smaller, deep one to fit the thread and a bigger one/notch to provide space for the nuts on the thread. By fitting a hole, drilled onto the deep hole for the thread, with a threaded dowel and a screw, the wooden piece can be locked by tightening said screw.

The third connection, similar to the second one - the highest horizontal piece hosts the gable of the frame. The construction process as well as the locking mechanism is similar to the second, only the location within the structure is not.

The fourth connection is, again, a three-way connection in the edges of the frame, where horizontal pieces meet the halving joint of the frame. To rule out twisting, this joint is secured with a screw and a nut. The difficulty here is to manage all the ropes that have to go directly into the axial point. Due to material-properties, the additional ropes are fitted outside the halving joint onto the thread. Additionally to the two eye-sockets, there have to have capsule for the pressed eye-sockets on the ropes. The horizontal piece is locked similarly to the second and third connection.

The last connections are the butt-joints between the frame and the horizontal, flat wooden Sherpa-pieces modularity, due to rope-system, going through the cutouts in the horizontal beam, would have been enough to rule out twisting of the piece.

All five types of connections in one image: The section in-between two modules, where Sherpa-pinned horizontal pieces both connect and stiffen, as well as support and give tension to the rope-system carrying the modulable table. This section posed the most problems due to its complex connections, but due to its modularity, needs to be installed at the same time. When fabricating this section, becomes the most important part of the structure, ensuring the horizontal stability, which is rather important on a playground.

This photo shows the difficult three-way halving joint. The butt parts, the prefabricated frame with the rope-loops inserted into the halving joint and going around the thread, and the horizontal part, which has to fit on the thread and the frame-piece. The joint has to be executed as precise as possible for them to work. If the necessary precision is met, it results in a complex, aesthetically pleasing joint, that works the way it's designed. Viewed from the inside, the joint poses no problems. But, as discussed before, when viewed from the outside there is one apparent fault.

Visible here are a Sherpa-joint and a three-way joint in the base of the construction. The three-way joint works as intended, but there is one thing that is happening even though it shouldn't: Twisting. Due to imprecision to a certain degree, the connection is not in the same plane, which is why the Sherpa-piece, which is fixed, while the piece is floating and it can therefore be twisted. Since the dowel joint in the horizontal connection only works with a single dowel, it doesn't prevent twisting. The connection isn't a problem, because the inner rope-system is preventing twisting, but the connection as a whole is still uncomfortable to look at. What has to be said is that this isn't a design-mistake, but rather a construction-imprecision.

This photo shows a Sherpa-joint and the complex three-way joint in the base of the frame. Visible here is, that there are a few remarks about the Sherpa-joint. It works perfectly fine as long as it fits easily: At soon as the conditions change, for example snow-covered wood or just a small difference of angles in the connections, the fitting of the Sherpa-piece becomes difficult, if not impossible. The cut-parts further there is a locking screw to prevent movement of the joint after assembly. Again, the system works well, as long as the two Sherpa-parts fit tightly. If they don't, the locking screw wedges itself between the parts, which is why it is important to use a 45mm-millimeter connection, allowing a quick installation.

As visible here, the three-way halving joint began to split after about one week on site. There two different reasons for this: The first one, material-properties, due to moisture, the fit-width of the beam is not always equal, resulted in imprecise measuring, thus imprecise drilling. Therefore the halved part of the horizontal piece is stressed where it normally wouldn't be. Second, the horizontal piece is stressed by the rope-system, which is constantly pulling down and, as a result, people hanging from the piece. One way or another, the joint could have been designed as a dowel joint or a halving joint, because the rope-system, going through the cutouts in the horizontal beam, would have been enough to rule out twisting of the piece.

Conclusion

Overall, the joints found and rated best in the method section, work as reviewed. What became apparent during the construction-process is that some criteria like "Time" and "Complexity" are more important than others. Criteria like "Time" and "Complexity" become less important while constructing, because of the tight schedule and the limited general knowledge that can be expected from those, that did not research joints, but still have to help construct them.

On the contrary, there are less relevant criteria such as "Fixing" and "Tools". Due to the fact, that fasteners are necessary for some joints, which then have to be organized somehow, but generally every joint-construction, had to be constructed with similar tools and similar knowledge.

As already discussed, there are some criteria that seem to skew the results' "Sturdiness" to one of them. While being the most important criteria for our project, it is also overrepresented. The dowel joint, for example, is not the least sturdy, but otherwise almost perfect (very simple, fast, needs only few tools, ...), can score almost as well as the halving joint. Nonetheless it is no choice for the joints in the frame due to its minimal sturdiness. Another suitable approach would have been to define the most important criteria and count them double, to see, if the results change. This would have, as mentioned before, helped showing the differences and solidifies the importance of sturdiness.

The chosen method of collecting, in combination with a grading system proved to work well. It supported the designing process with information and implied own connections by showing advantages and disadvantages of different joints. Further helpful was the broad analysis of literature to better understand each joint.

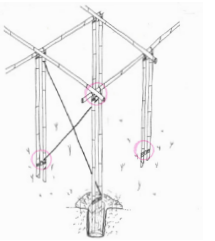
Img. 57: Research Report by Lukas Kauz, 22FS, Final Review

Public Spaces
Studio M. Kaijima
Research Report
Eva Tschopp FS 22

how to join intiMATE structure

The joints of the intimate bamboo structure are connected only by hemp rope.
The frame structure is supported by doubled pillars on which the beams lye in two layers.
The four braces stiffen the construction with a cross of hemp rope.

Introduction



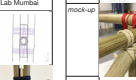
To connect the frame structure a joint needs to combine three elements. The pillar with two beams. The joint must be easy to assemble and stable to bear the loads of the people hanging in the structure. The structure needs to be modular so the elements can be reused.

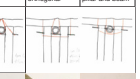
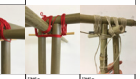
Method

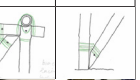
The following joints are developed with the tool of building mock-ups. In the first step a reference (Guggenheim Lab in Mumbai, *Atelier bow-wow*) was analyzed and a bamboo construction book ("Bambus-Bamboo", Universität Stuttgart) studied to pick suitable joints for the mock-ups. Experimentally the different options were tried out and adjusted in the mock-ups.

The tables give the opportunity to directly compare the different joints and give an ordered overview over the experiment. The joints are compared considering what material they are made of, how much time they take to assemble, how stable they are and from an aesthetic viewpoint how trustable they appear.

joint 1 pillar to beam	joints without rope	joint with bolt
drawing		
time	much (for the bolts to suit exactly!)	medium (saw a hole and rounding the end of the pillar)
material	bamboo and bamboo bolts	bamboo and bolt and rope
stifness	pillar gets weakened by the hole	stable
aesthetic	appears clean, one can see how it works	appears stable with rope and bolt

joint 2 double pillar	single pillar	double pillar wood	double pillar Guggenheim Lab Mumbai
drawing			
mock-up			
time	medium	little	much
material	bamboo and bolt and rope	wood and screws	bamboo and wood and rope
stifness	unstable, tilting	stable	unstable
aesthetic	appears unstable	appears clean and stable	appears stable

joint 3 frame	rope crossed	rope orthogonal	bolt through pillar and beam
drawing			
mock-up			
time	little	little	little
material	bamboo and rope and metal bolt	bamboo and rope and metal bolt	bamboo and rope and metal bolt
stifness	stabel if beam lies on two pillars	stabel if beam lies on two pillars	stabel if beam lies on two pillars
aesthe-tic	appears stable but confusing	appears stable and clean	appears stable and secure with bolt

joint 4 brace	upper brace to beam	lower brace to ground
drawing		
mock-up		
time	much (for the brace to fit to the beam exactly)	much (for the brace to fit to the pillar exactly)
material	bamboo and rope and bolt	bamboo and rope and bolt
stifness	stabl	stable but vertically sliding
aesthetic	appears stable with rope and bolt	appears clean but not stable

Result

Considering the set goals (reusable elements and organic material) the final joints have no steel bolt as they are only assembled with hemp rope. To prevent sliding in the frame joint, holes are added through which the rope and bamboo get feed, and the pillar's ends are rounded so the beams don't rupture. The frame joint is divided in two knots, one connecting the pillar with the lower beam and one connecting the lower with the upper beam.

joint 3
frame

joint 4
brace

The braces are implemented as a hemp rope cross which allows to adjust tension on site and is much easier and quicker than fabricating bamboo braces.

joint 2
double pillar

To each of the double pillars two bamboo spacer are added to keep the distance between the pillars and still pull them together.
In this particular joint a third spacer is added to prevent the textile from falling as it is not movable.

assembly

The hemp rope is fabricated in Switzerland (Seilerei Kislig Winterthur) and with its rough surface grips on the slippery bamboo's surface. When wet the hemp fiber tightens and releases again when dry. After two years outside the rope decays because of weathering.

All knots are ended with a square knot. The ends of the hemp rope are sealed with wood glue to prevent the rope from coming undone.

1 connect pillars to lower beams
2 insert pillars with lower beams into foundation
3 connect upper beams to lower beams

Discussion

assembly
The bamboo was pre-fabricated (cutted, sawed and filed) by us and brought on site to assemble. First the pillars were inserted into ground.

To improve precision in constructing, first the lower beams were joined to the pillars. Then the pillars with beams were inserted into ground and finally the upper beams joined.

time
Threading the rope through the holes takes time and craft.

bamboo as building material
Bamboo is not evenly thick or straight. To make the beams fit better to the pillars, binding the grid of beams first and suiting the pillars to the particular point of the beam may help.

Joining with bolts can be easier in assembly and done in piecework. Nevertheless developing a system that works for several joints would be complex and take time.

rope sliding
The hemp rope can still be sliding slightly and the joints are not stiff.

To stiffen the joints and make it easier for not practiced constructors to join bamboo, freefix (elastic band) can be used.

maintenance
The structure needs regular maintenance. During construction phase and after it requires much human labour.

Caring for the structure and its surroundig keeps it longer living and encourages exchange between structure, constructor and user.

modular structure
The modular system allows a simple construction method. The structure can be extended or shrinked according to different needs or a different site.

sources
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Img. 58: Research Report by Eva Tschopp, 22FS, Final Review

SOURCES - TEXT & Image

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Img. 2: ETH Hönggerberg, 1st construction phase, ETH Bibliothek, Comet Photo AG

Img. 3: ETH Hönggerberg, 3rd construction phase, ETHZ, Alessandro Della Bella

Img. 4-12: Future Learning Spaces, Elias Knecht, 2023

Img. 13: ETH Image archive, https://ba.e-pics.ethz.ch/catalog/ETHBIB.Bildarchiv/r/1019/viewmode=infoview/qs-r=Ans_00955

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Img. 44-45 & TEXT: https://works.arch.ethz.ch/thesis/future-learning-space

Img. 46-47: bauteile Wiederverwenden, 2021, Ein Kompendium zum zirkulären Bauen, IKE, ZHAW, Eva Stricker, Guido Brandi , Andreas Sonderegger

Img. 48: Research Object Inventory Sheet, Future learning Spaces,Elias Knecht, 2023

Img. 49-52: Point Cloud Scans of HIL Building, Chair of Digital Fabrication

Img. 52 - 58: Research Report, Final Review, Public Space Behaviorology, Chair of Architectural Behaviorology, FS23

Chair of Architectural Behaviorology

Institut für Entwurf und Architektur - ETH Zürich
Prof. Momoyo Kaijima

Assistant:
Elias Knecht

Office:
ETH Zürich
ONA G36
Neunbrunnenstrasse 50
8050 Zürich
Switzerland

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