Building Technology Research Handbook

Selected Works From 2023-2024

Zixiang Zhai

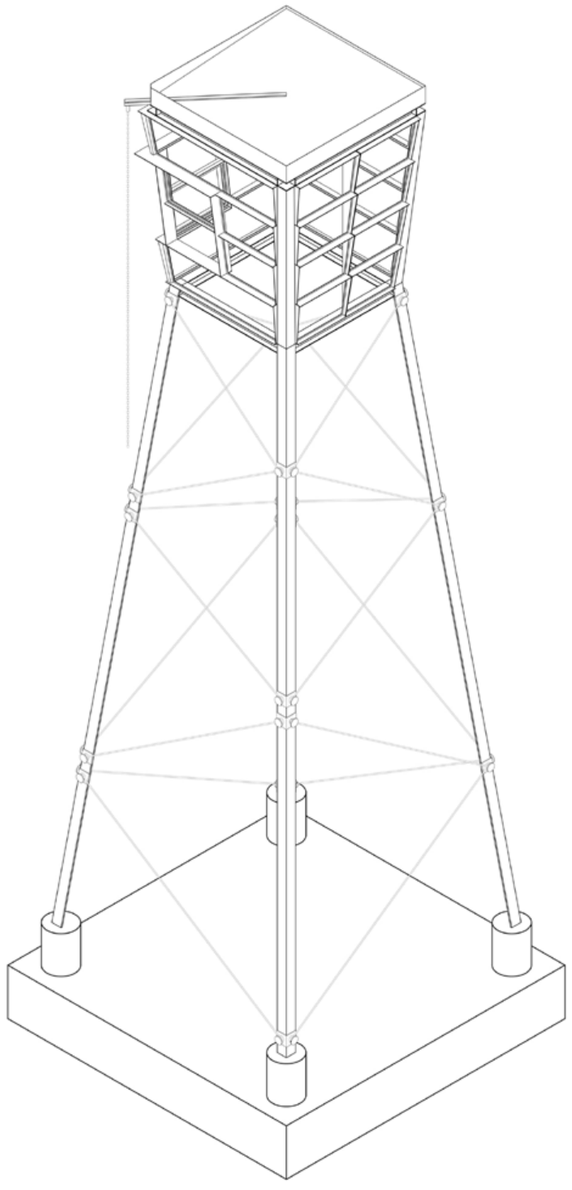
Taken by Zhai Zixiang in 2024.6 ,Wuhan, China.

An abandoned chimney on the roof of an old residential building in the former concession.

The photo above was taken by chance during my site research for a design course. In my life, I have always been deeply interested in the details of architecture. I enjoy studying the combinations of building materials, the application of different construction techniques, and the rational logic hidden behind spaces. In my studies, I prefer to approach the entire design process from a micro to macro perspective. I am often driven by inspiration from a particular detail, which I then expand into the overall design. I tend to carry a specific construction method or logic throughout my entire design.

In this portfolio, I have experimented with various architectural construction techniques, from the steel structure in the first project to the subsequent three wooden structures, including cross beams, square beams, and from pure wood structures to modular steel-wood structures. Throughout this journey, I have immersed myself in the areas that interest me, focusing on extracting suitable construction techniques from the site itself and applying them to address all the issues related to the site. This portfolio is a manifestation of my design philosophy.

Contents



1 — Substation Renovation

Steel structure, Tensile membrane structure, Diffuse reflection materials

As people enter modern society, electricity has become an indispensable part of daily life, and substation plays an increasingly important role in cities. However, due to the inherent architectural characteristics of substations, their purely functional design and the surrounding walls prevent people from understanding them. The functionality of substations often outweighs their design, with many identical standard plans being applied in different cities, making each substation similar to the next. As a result, substations play a blank role in people's lives. Through my design, I aim to transform this status quo and improve the role of substations in urban environments.

Individual Work

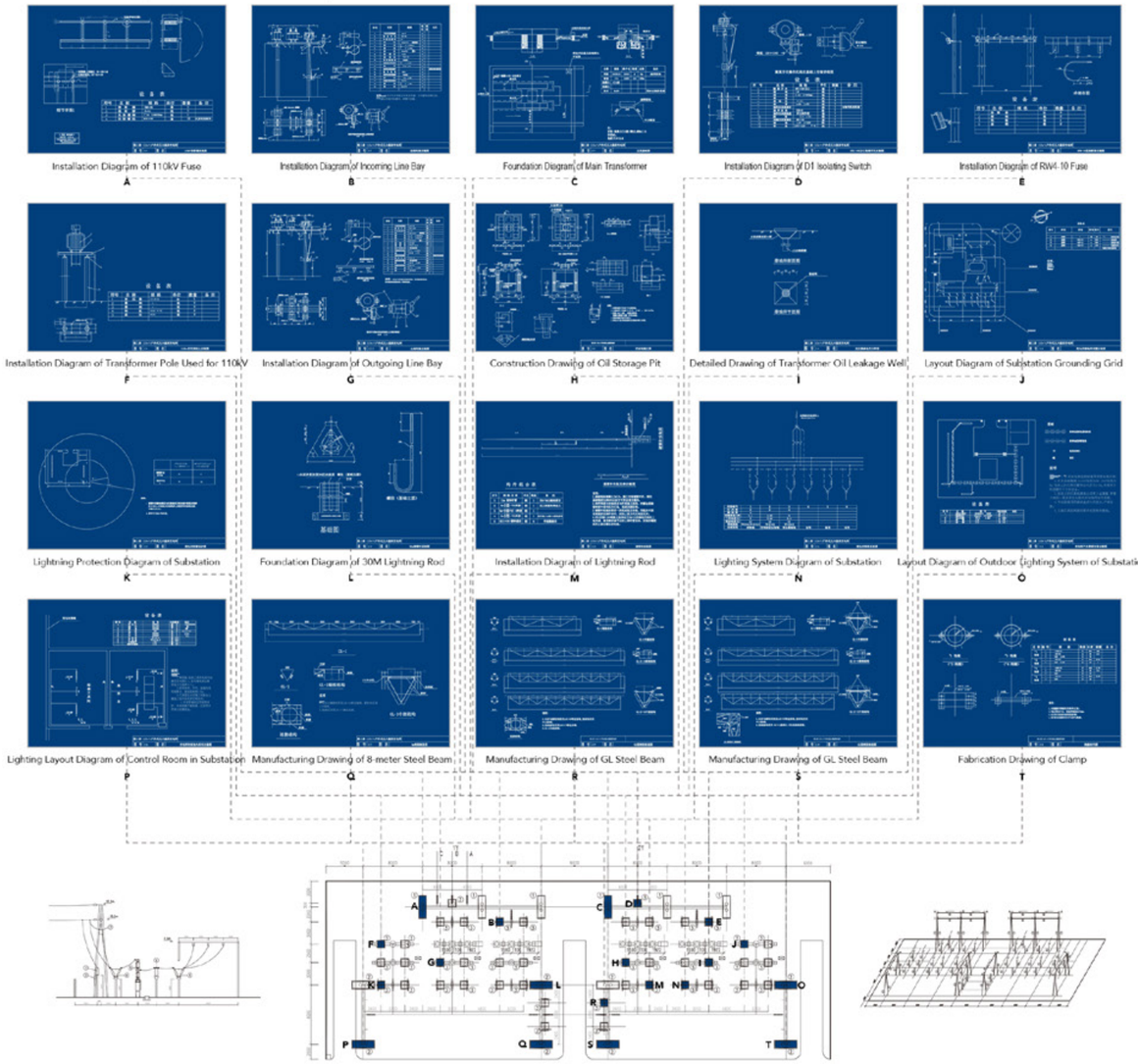
Location: Shanghai,China

Academic Work,2024 Winter

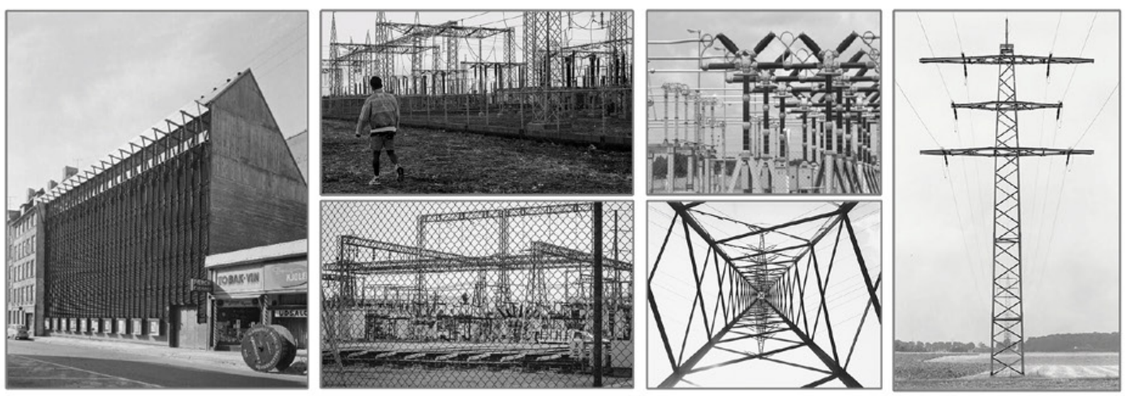
Supervisor: Yiming Yang

Situation of Substation Design

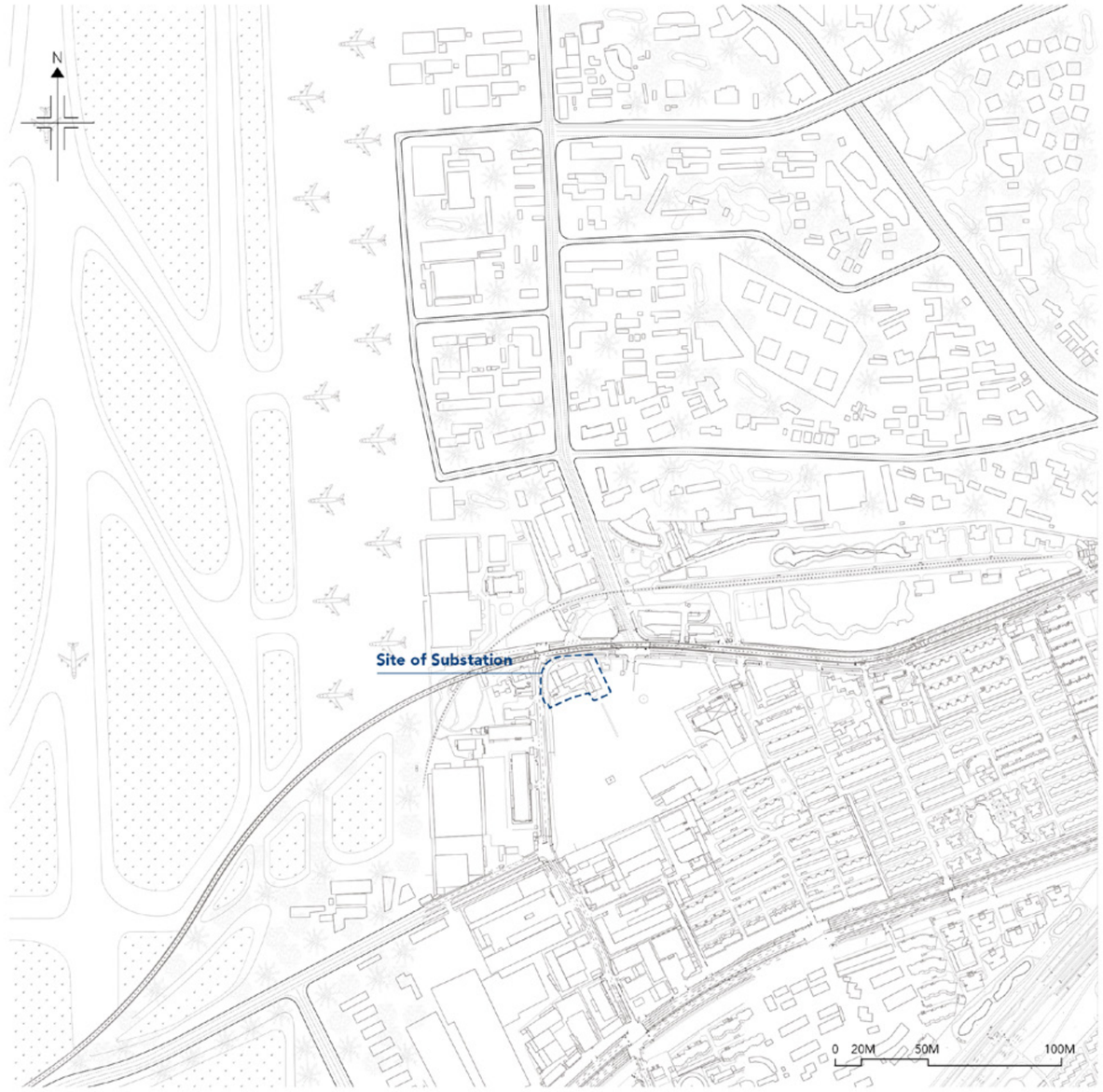
Substations, as an essential infrastructure in cities, prioritize functionality over architectural design. When designing substations with the same specifications, designers typically adopt identical core equipment blueprints to ensure the rigor and reliability of the facilities. As a result, compared to architectural design, substation design resembles the process of placing multiple similar design plans within the boundaries of the site, forming independent "boxes." In many cities today, substations often appear uniform in appearance, with many nearly identical substations scattered across various locations, surrounded by walls that prevent ordinary residents from easily accessing them. They play a blank role in the overall urban environment; while their function is well understood, they remain disconnected from daily life, offering no direct interaction with the public.



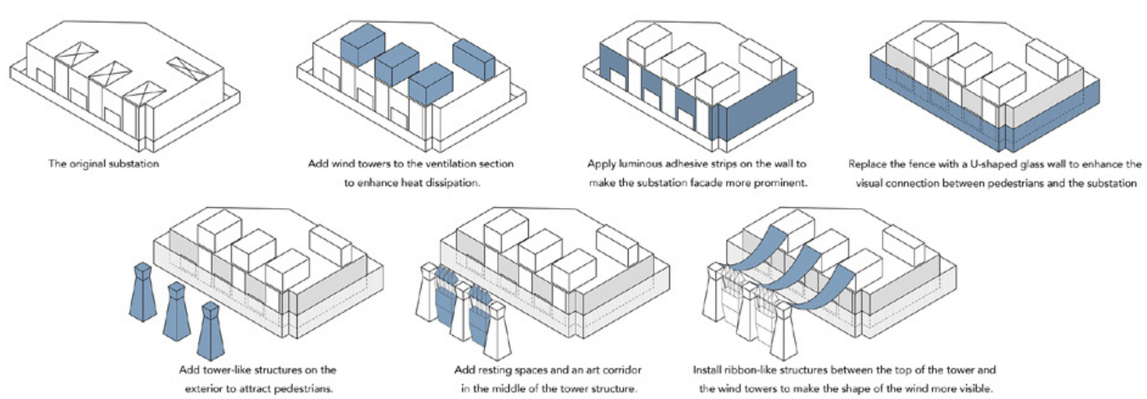
Photographs of the Substation and Related Facilities



Site Plan



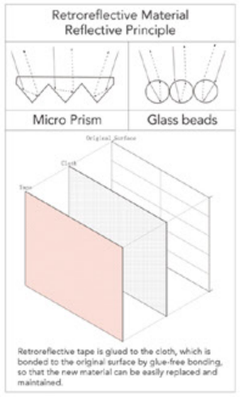
Mass Generation

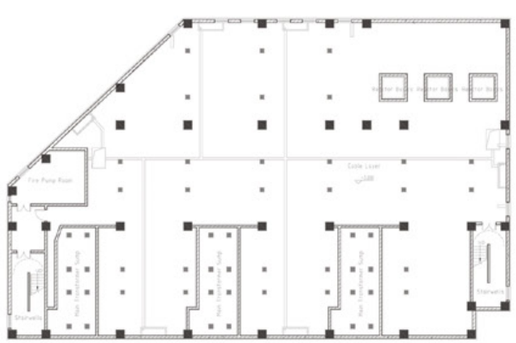


Facade Renovation Analysis

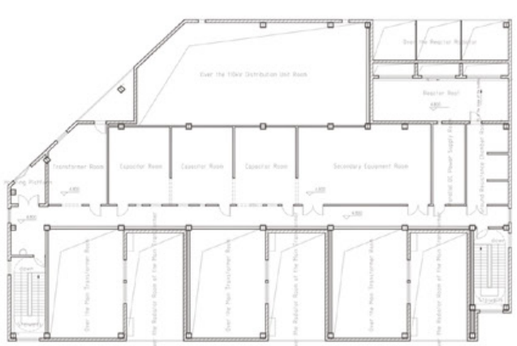
Fluorescent Red/Orange Flame Retardant Reflective Fabric	
Overall Width	50.8 mm
Overall Length	100 m

This red/orange flame retardant fluorescent fabric contains retroreflective lenses that bond to a durable, flame-retardant fabric. Fluorescence properties help enhance the material's visibility during daytime, dawn, and dusk environments.



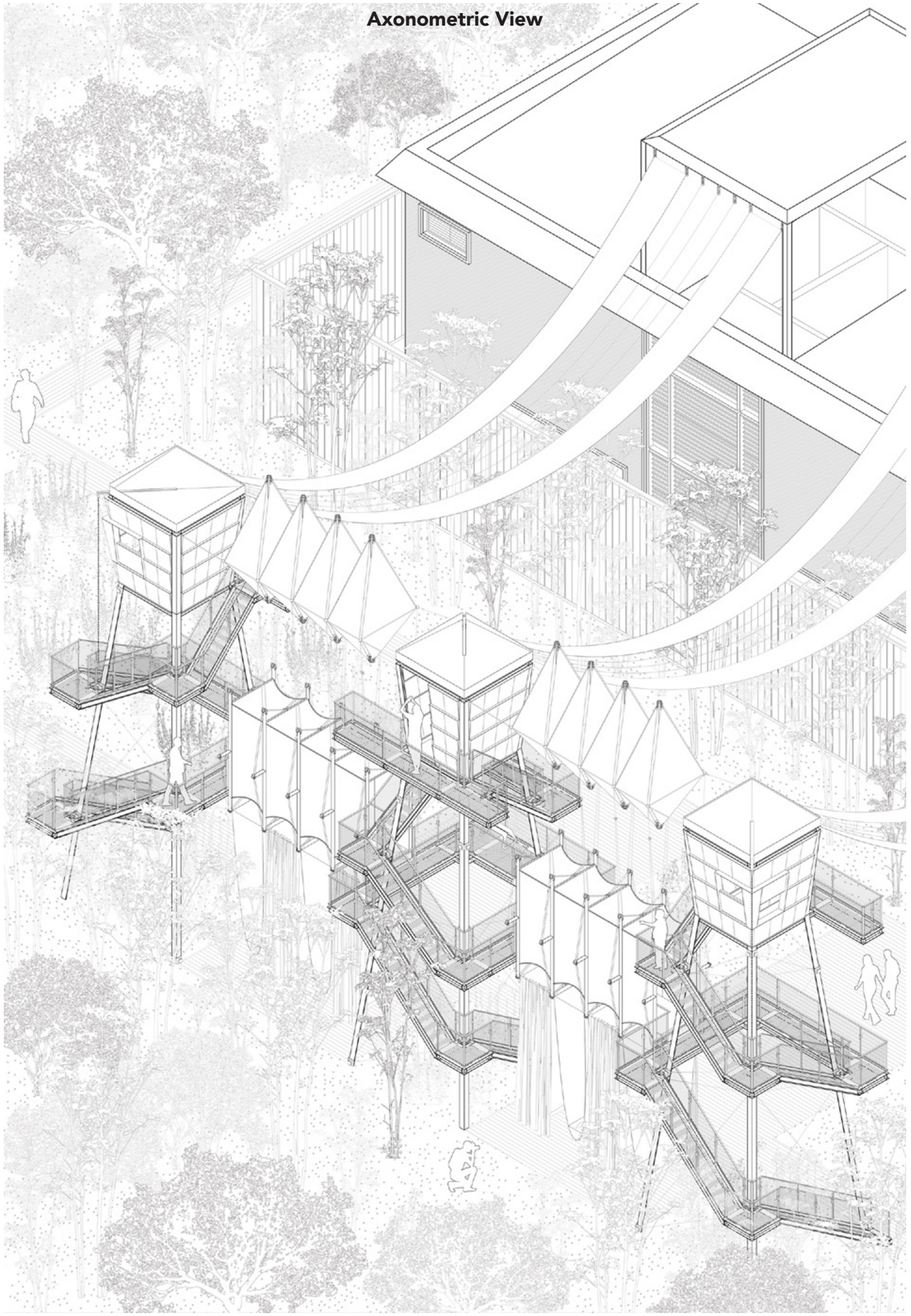


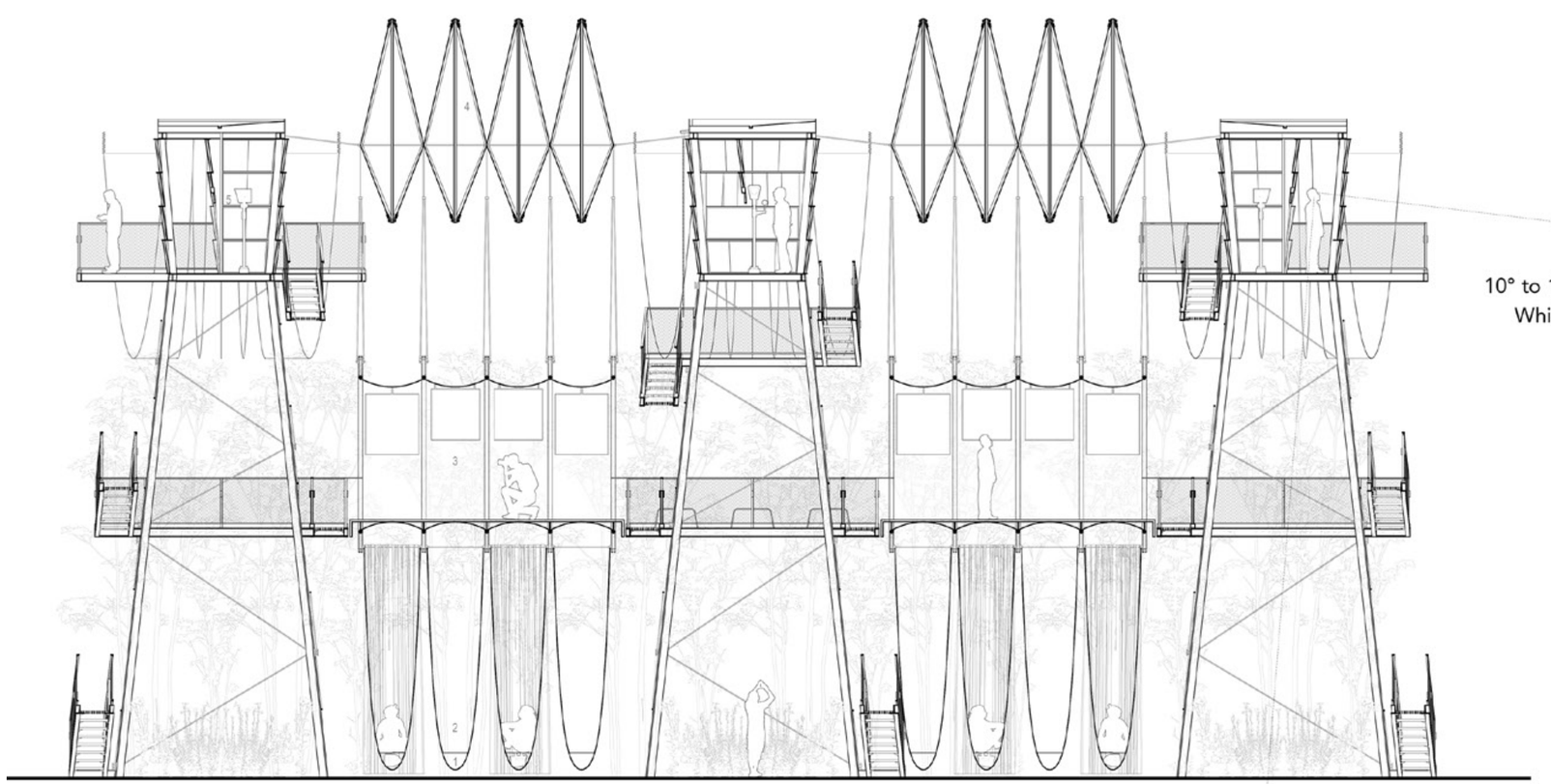
Original - 3.200M Floor Plan 1:500



Original 4.800M Floor Plan 1:500

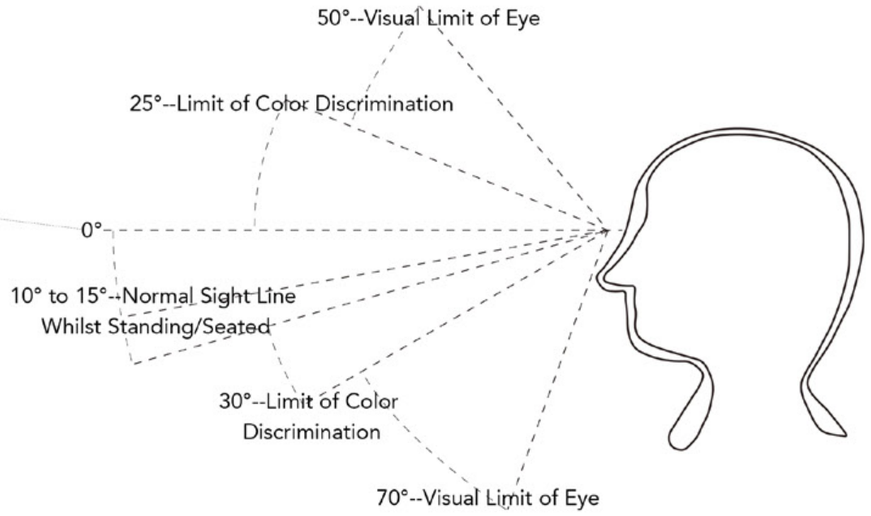
Axonometric View

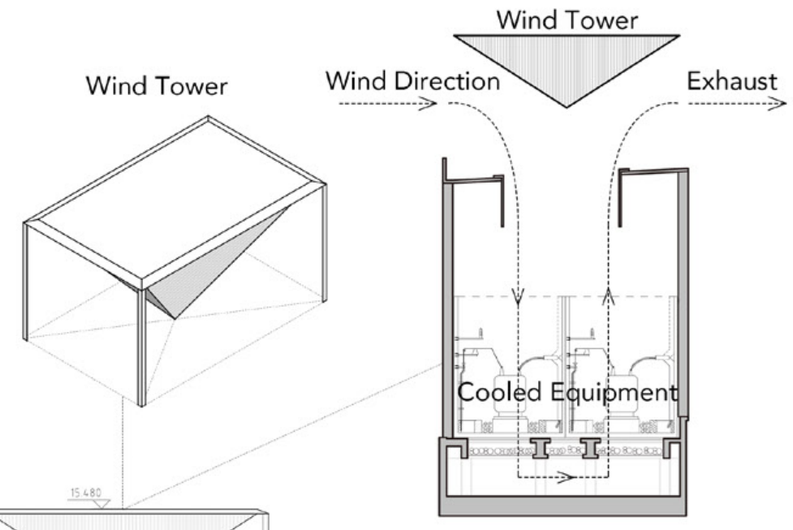


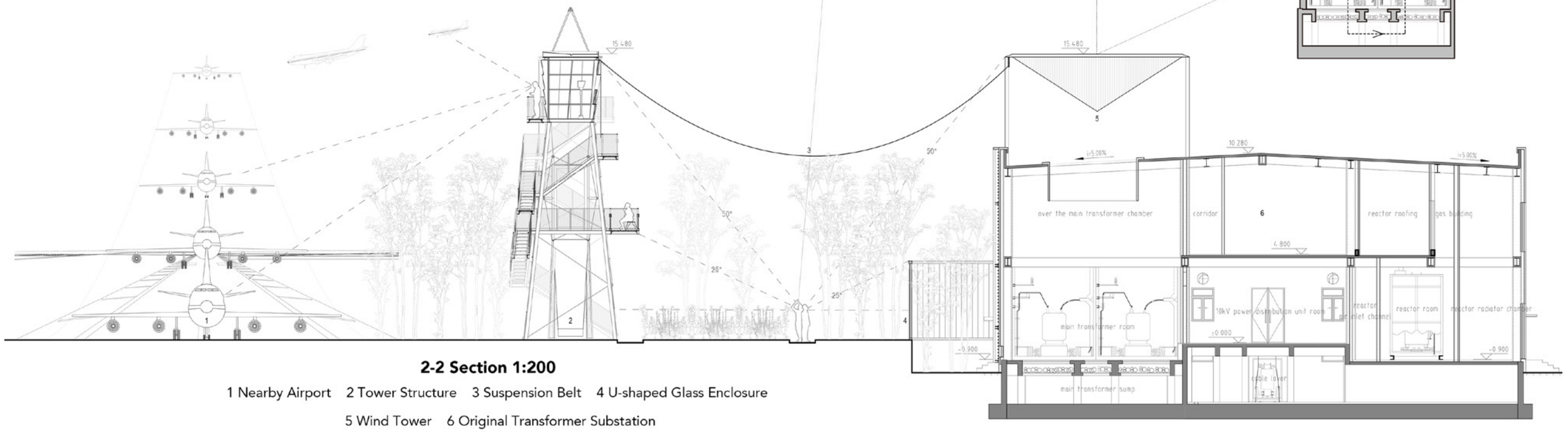


1-1 Section 1:150

1 Temporary Storage　2 Rest Area　3 Gallery　4 Structural Stabilizer　5 Observation Room



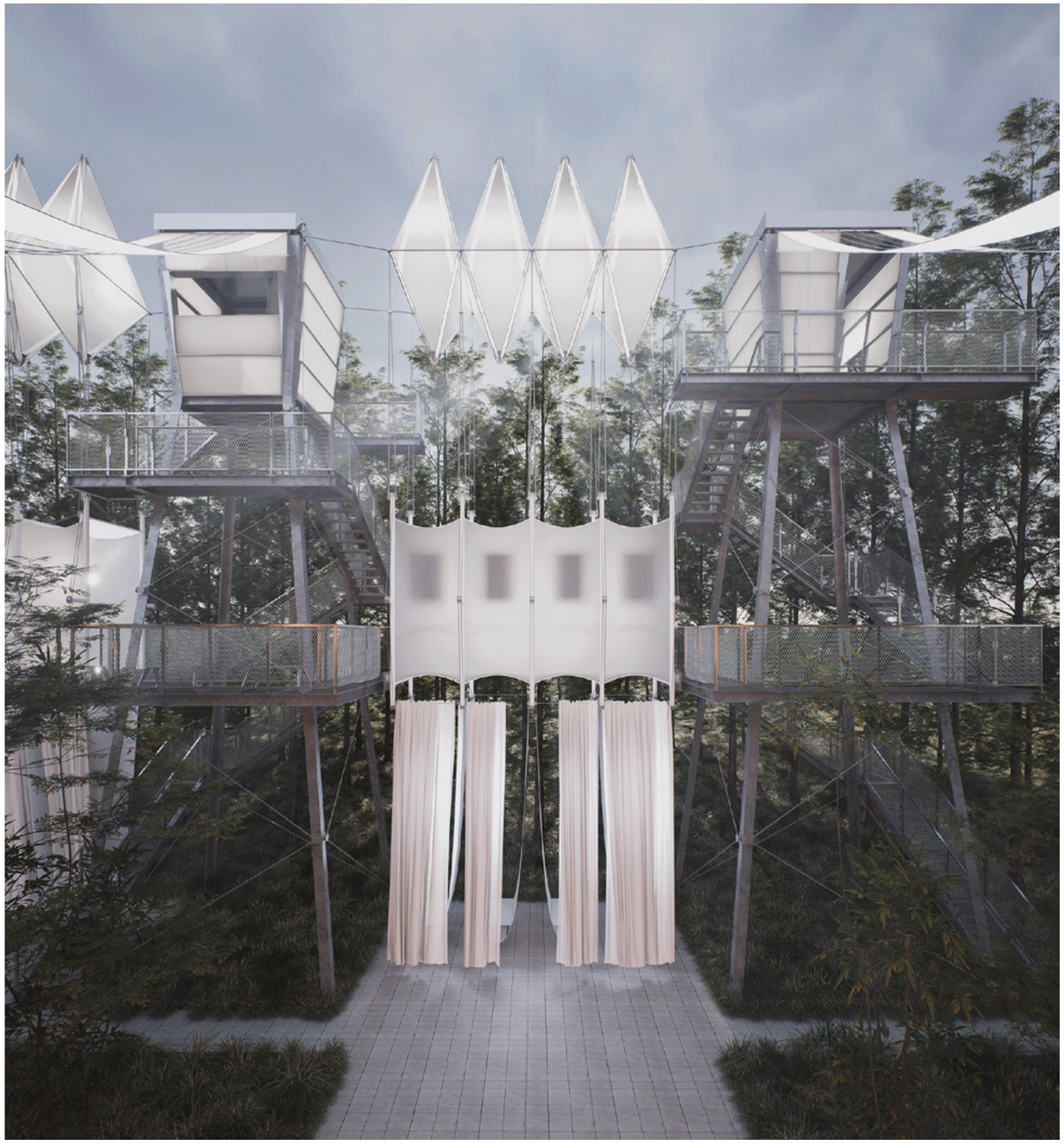




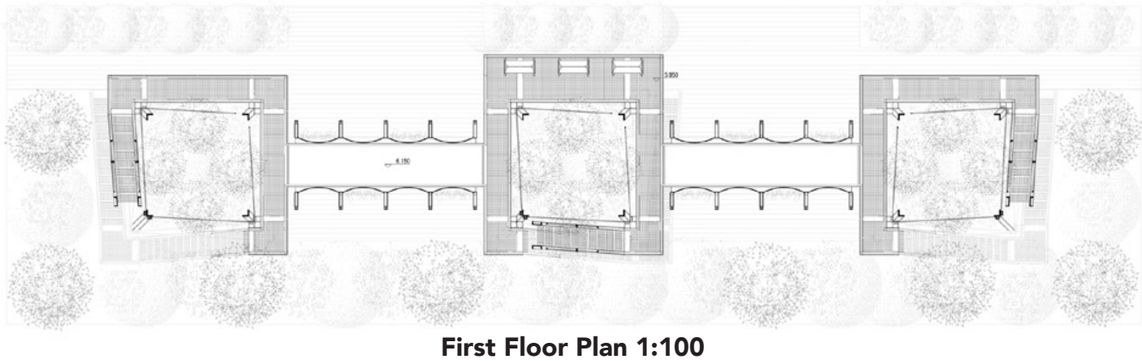
2-2 Section 1:200

1 Nearby Airport　2 Tower Structure　3 Suspension Belt　4 U-shaped Glass Enclosure

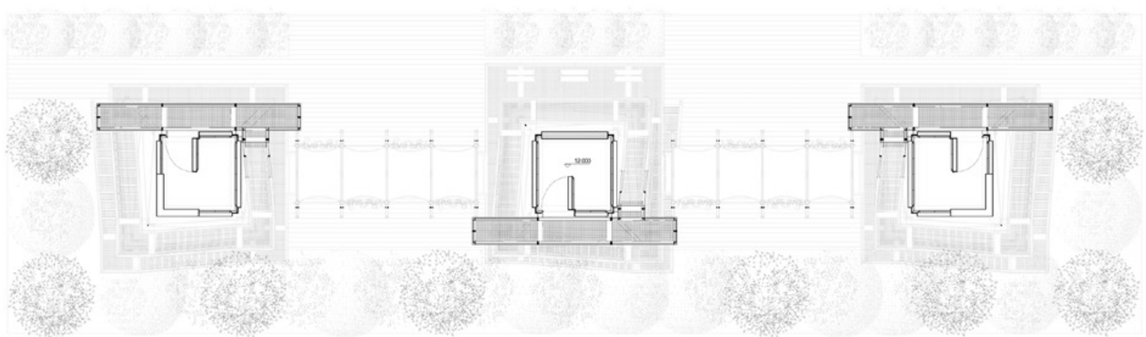
5 Wind Tower　6 Original Transformer Substation



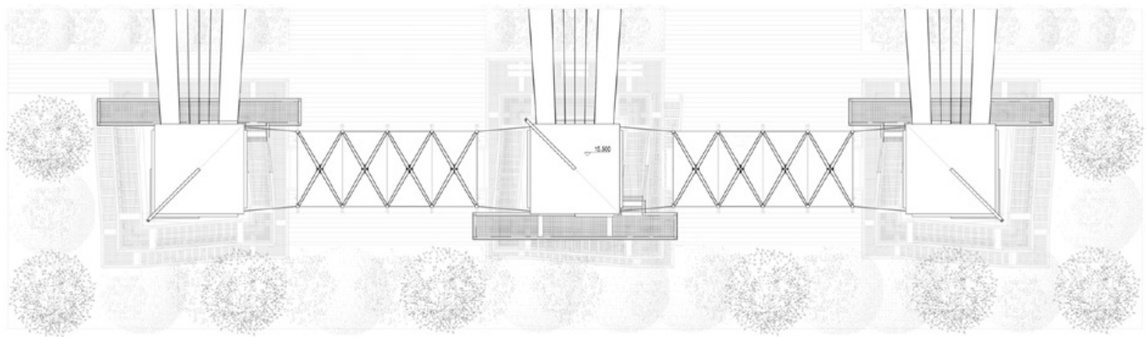
Ground Floor Plan 1:100



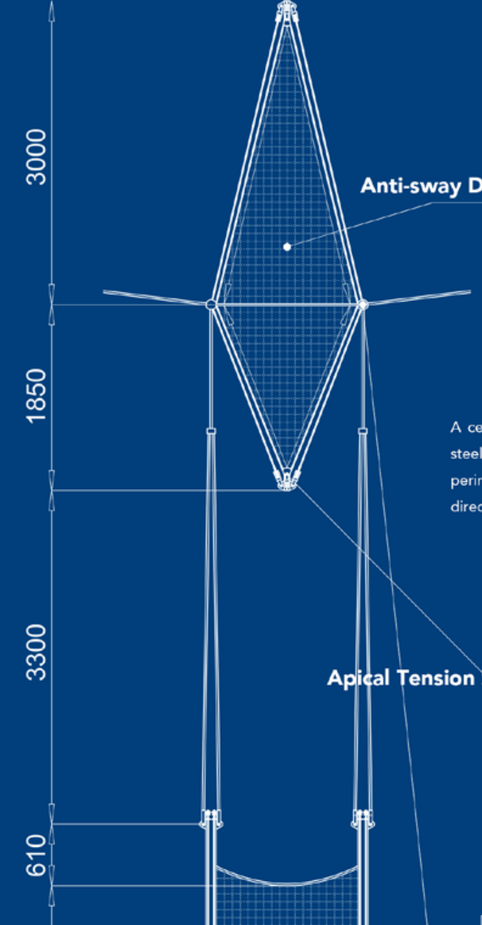
First Floor Plan 1:100



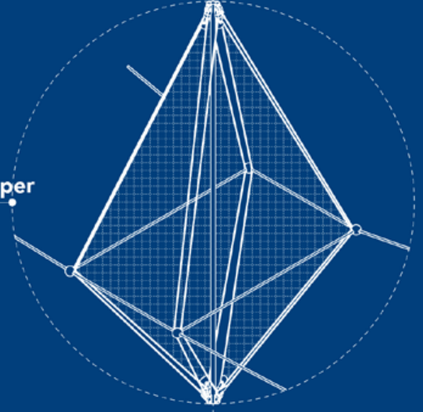
Second Floor Plan 1:100



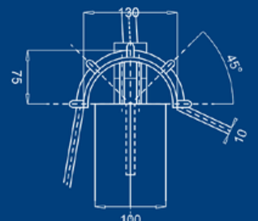
Roof Plan 1:100

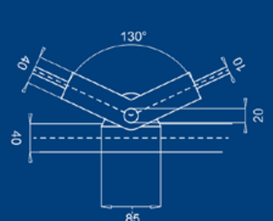


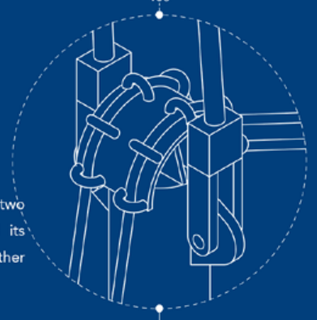
Anti-sway Damper

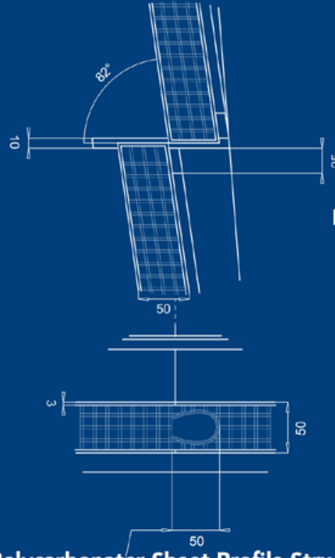


A central rod is connected at both ends by connecting components,with two steel cables linking it to spherical tensioners in fourdirections around its perimeter.When oscillation occurs in one direction,the steel cables in the other directions ensure its stability.

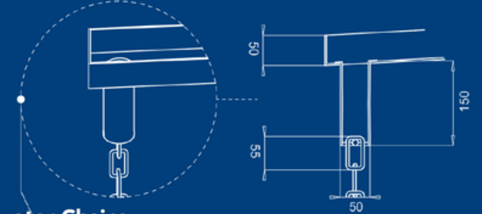




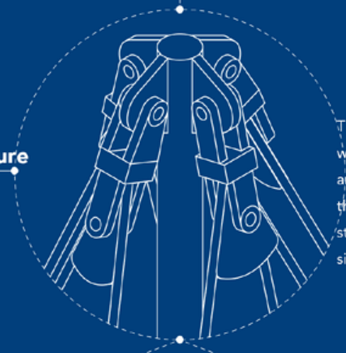




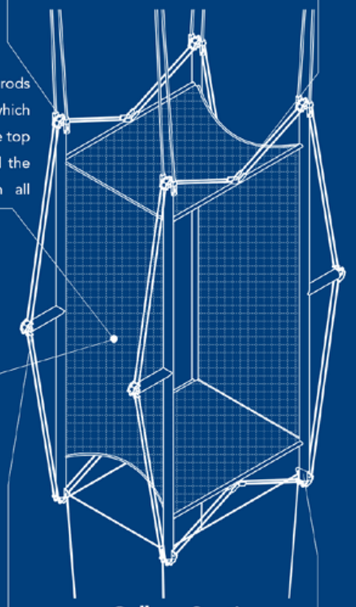
Rainwater Chains



Apical Tension Structure



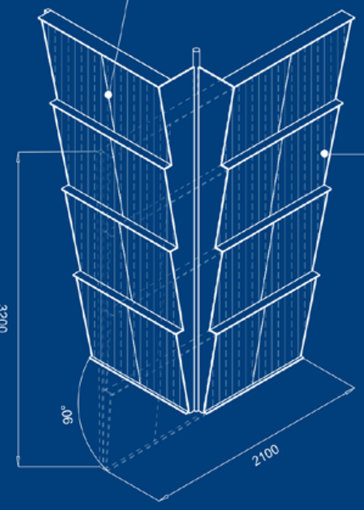
The gallery section is composed of rods with attached translucentfabric,which are connected to the damper at the top through steel cables that surround the structure's connection points on all sides.



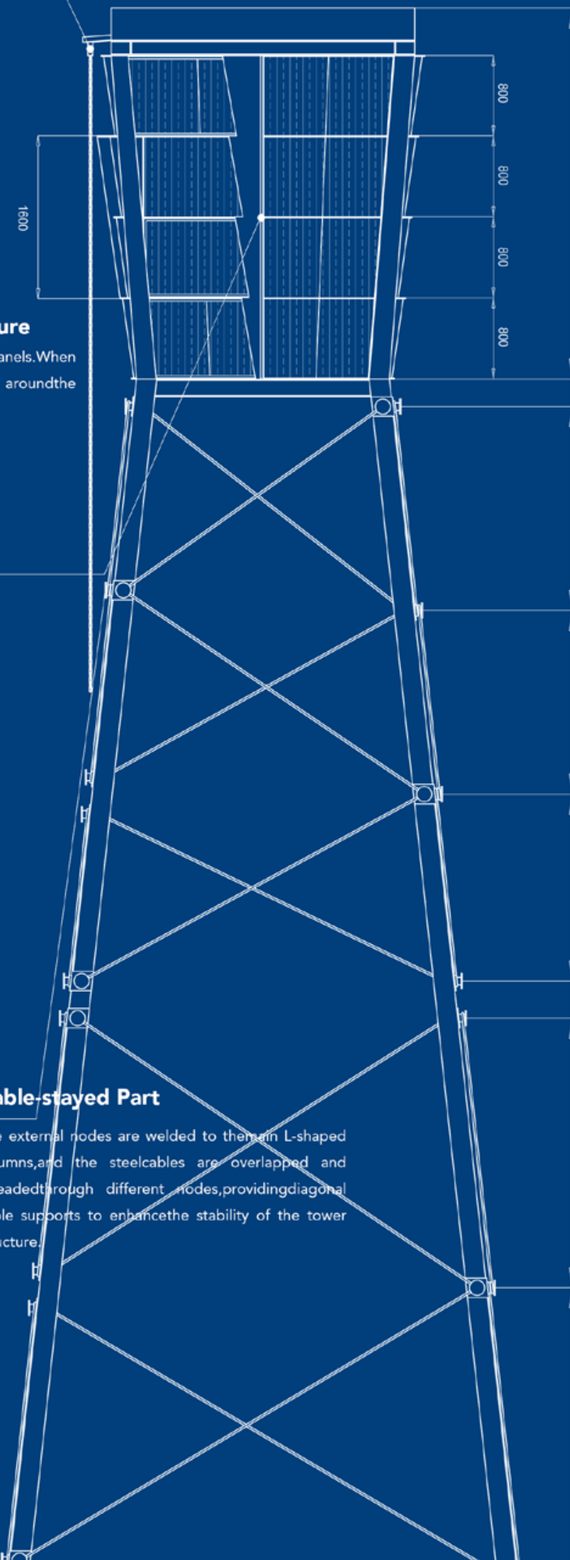
Gallery Section

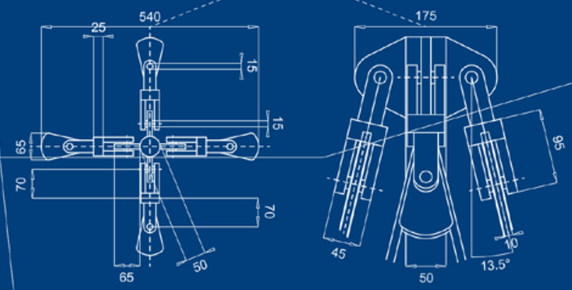
Polycarbonater Sheet Profile Structure

The facade and revolving door are made of polycarbonate panels.When the revolving door is closed,it forms a closed facade aroundthe room,consisting of polycarbonate panels.



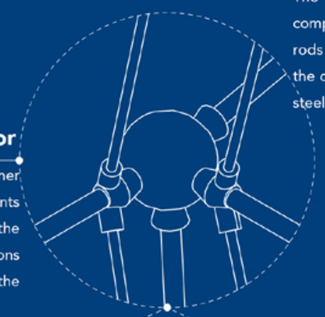
Revolving Door Section



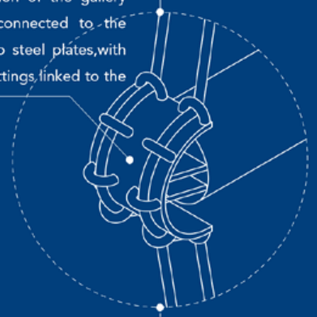


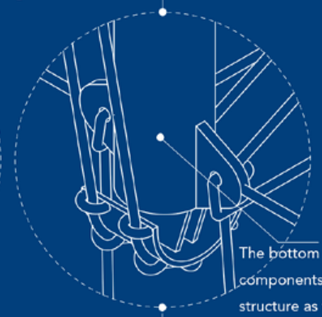
Spherical Retractor

The spherical tensioner is divided into inner and outer layers.The end steelcompdnents of the steel cables are embedded in the solid inner structure,while the cable sections are connected to the duter shell through the tensioning structure.



The middle section of the gallery components is connected to the rods through two steel plates,with the connecting fittings linked to the steel cables.

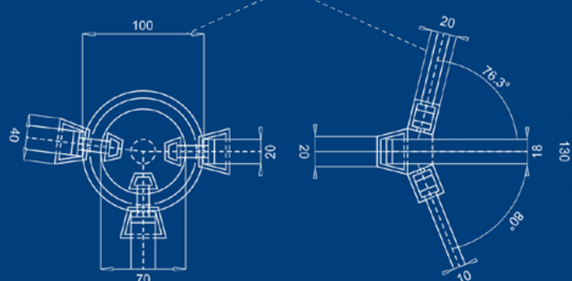


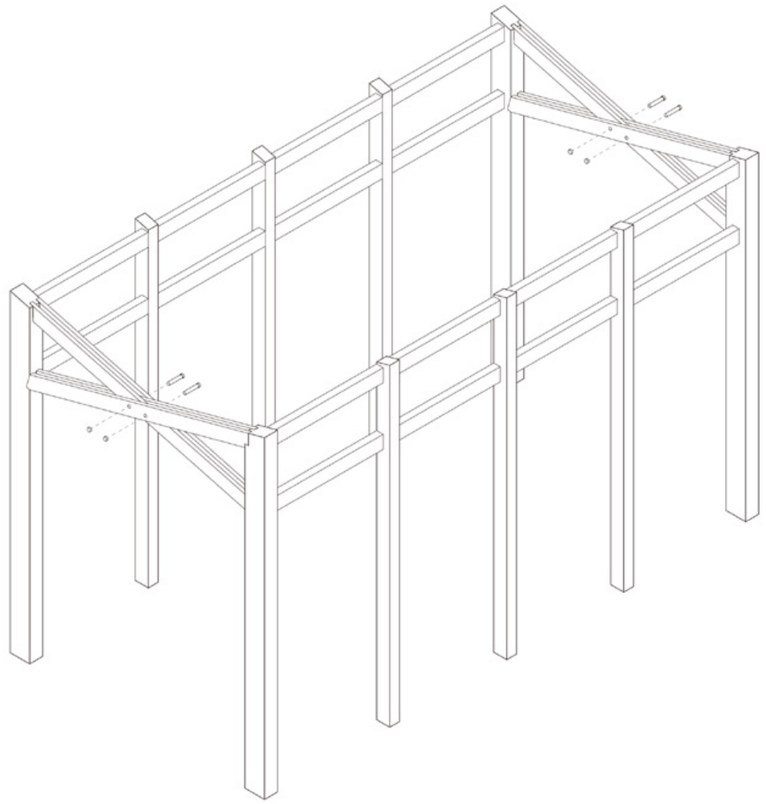


The bottom section of thegallery components maintainsthesame structure as the mainbody and middle section,buteach end of the rods has anembedded component thatconnects to the steel cableframework of the hammocksection.

Cable-stayed Part

The external nodes are welded to themain L-shaped columns,and the steelcables are overlapped and threadedthrough different nodes,providingdiagonal cable supports to enhancethe stability of the tower structure.





2 — Glacier Mountaineering Hut

Lightwood structure, Cross beams, Insulated wood construction

Located within the Kenai Fjords National Park in the United States, Exit Glacier attracts numerous visitors each year. Many climbers choose to spend one to two days climbing the Harding Icefield Trail to get a better view of the glacier. However, the Harding Icefield Trail is rugged and difficult to traverse, and the existing shelter at the trail's end is too old and cramped to ensure the safety and comfort of climbers. Therefore, I selected a site to design a mountain hut, hoping that my design will provide support for every climber on the Harding Icefield Trail.

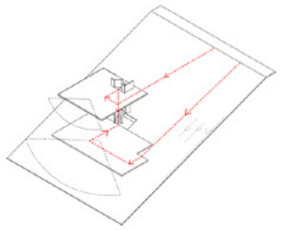
Individual Work

Location: Alaska,The United Staes

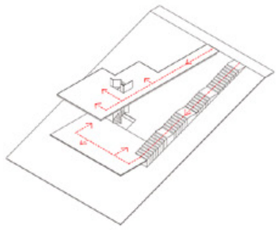
Academic Work,2024 Summer

Supervisor: Wei Qiu

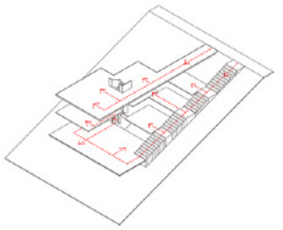
Mass Generation



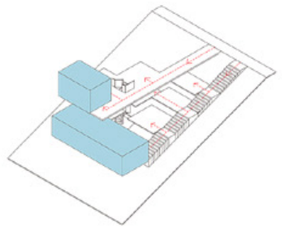
Identify the two main passages and complete the circular streamline.



Identify the main platforms that form the streamline.

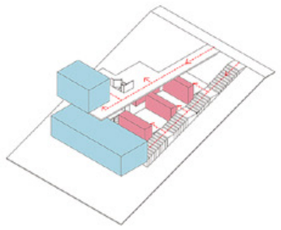


Identify three platforms next to the downward passage.



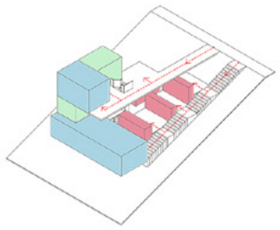
Viewing Spaces

Two kinds of viewing spaces are formed at the end of the passages.



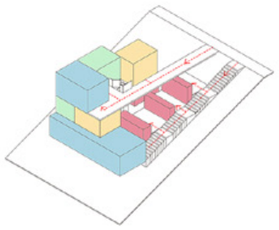
Necessities

Functional spaces attached to various platforms, such as equipment rental, medical treatment, food cooking.



Living Spaces

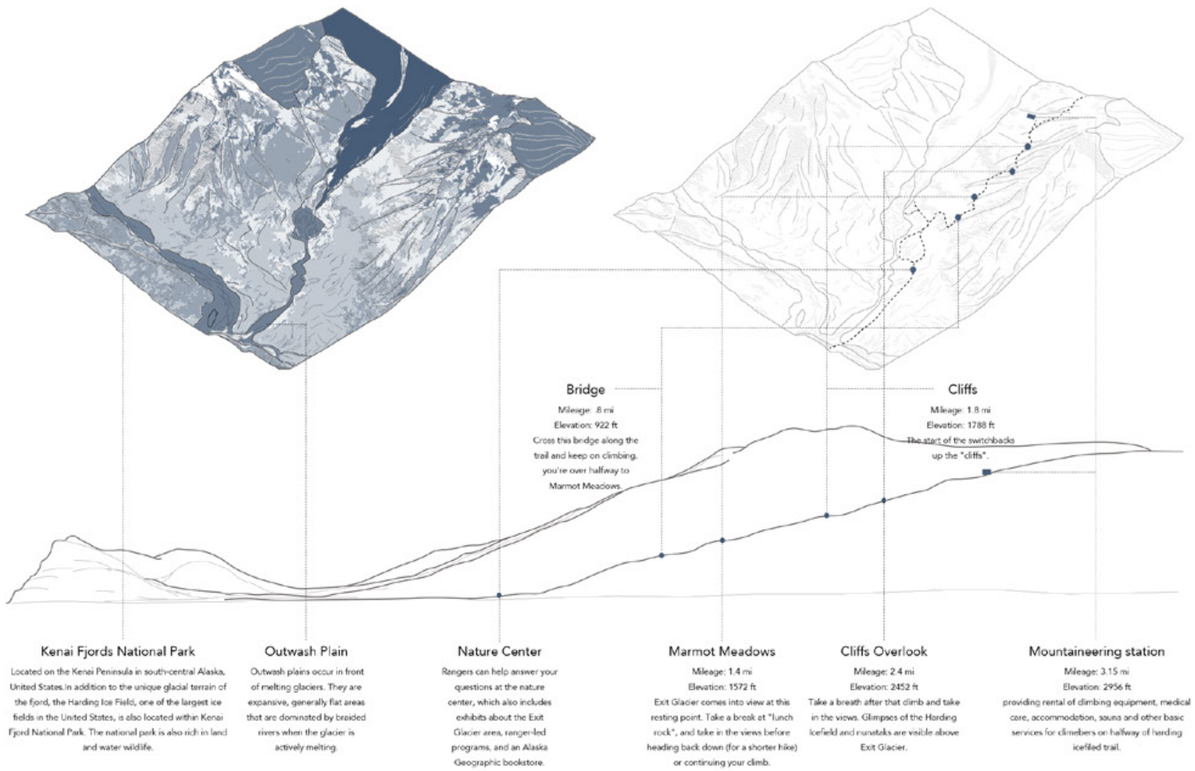
Different types of living rooms located on the second and third floors of the platform.



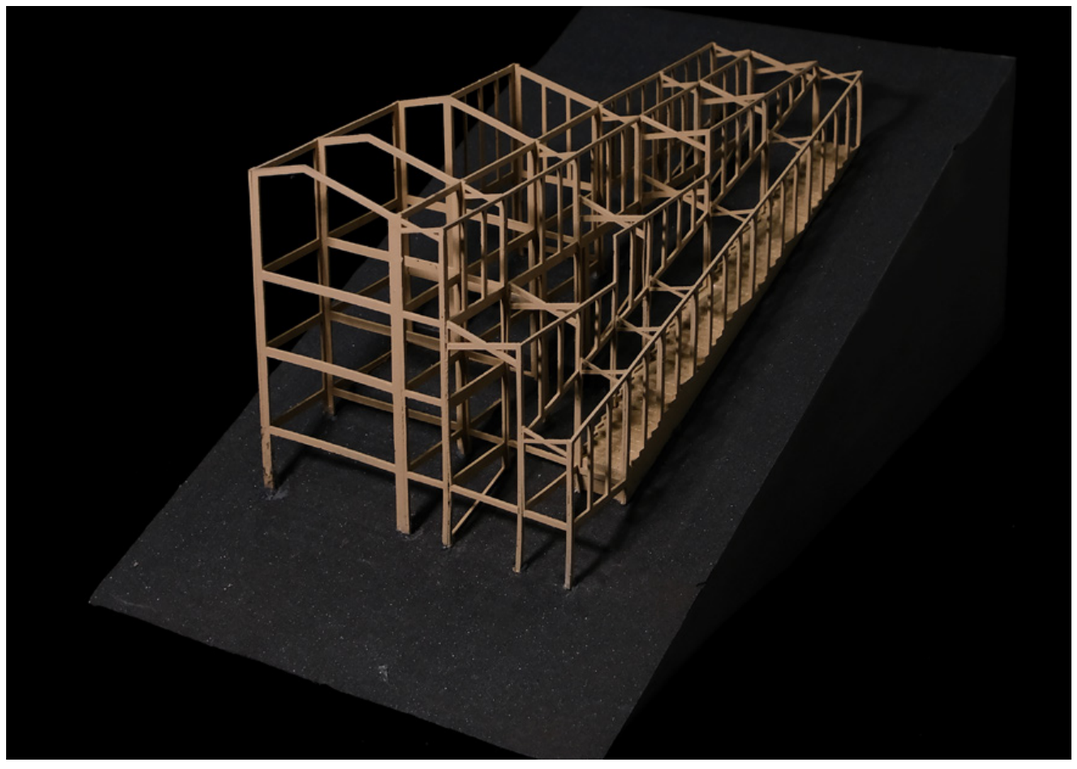
Living Spaces

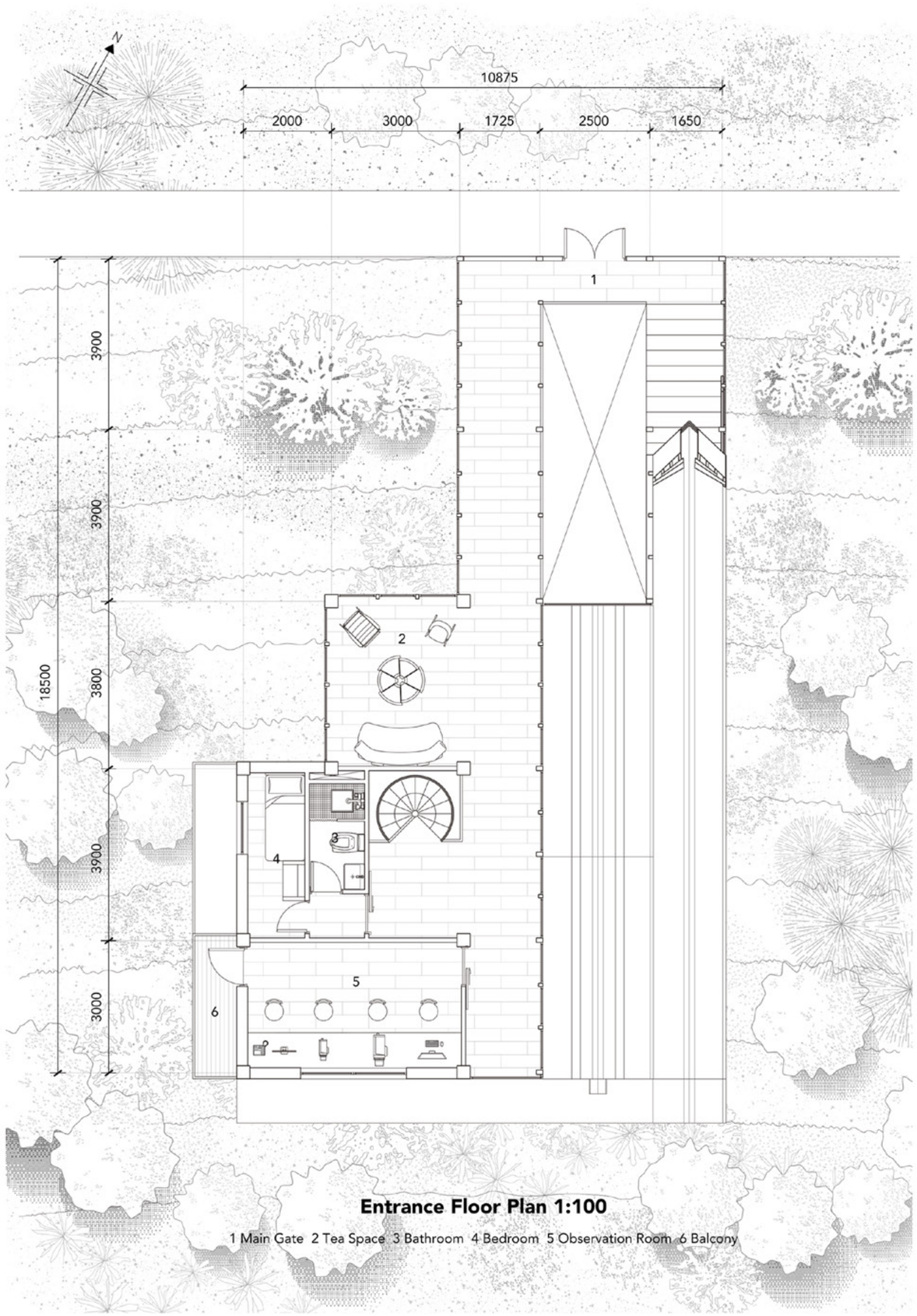
Additional spaces such as a tea room, study room, and sauna are located on three floors.

Geographical Site Plan



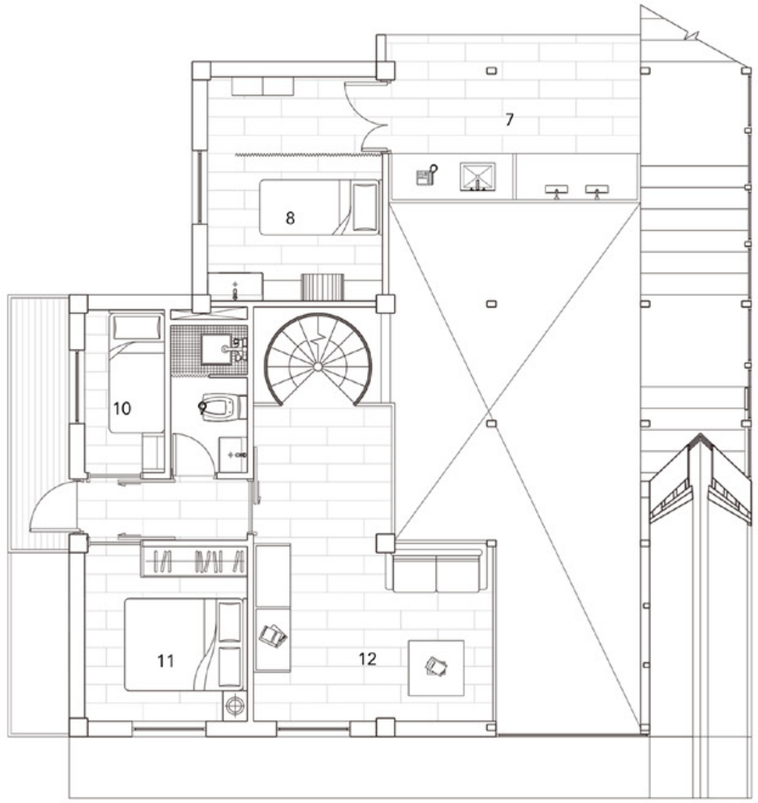
Axonometric Photo of the Model





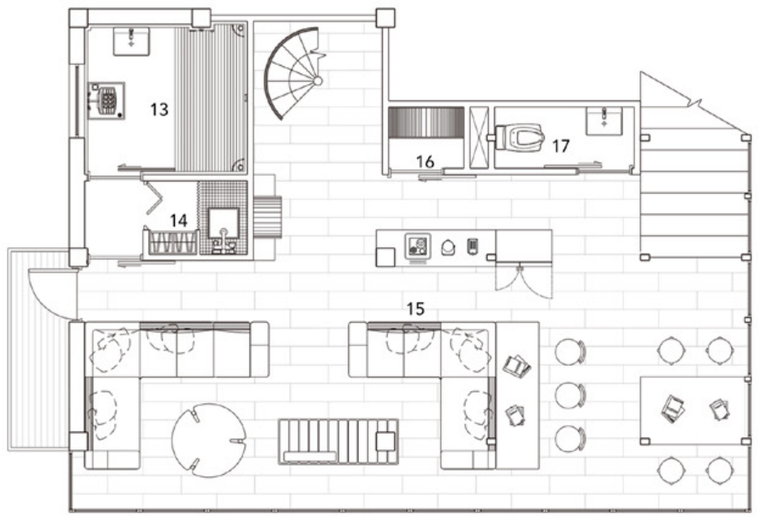
Entrance Floor Plan 1:100

1 Main Gate 2 Tea Space 3 Bathroom 4 Bedroom 5 Observation Room 6 Balcony



First Floor Plan 1:100

7 Medical Platform 8 Medical Room 9 Bathroom 10-11 Bedroom 12 Study Room

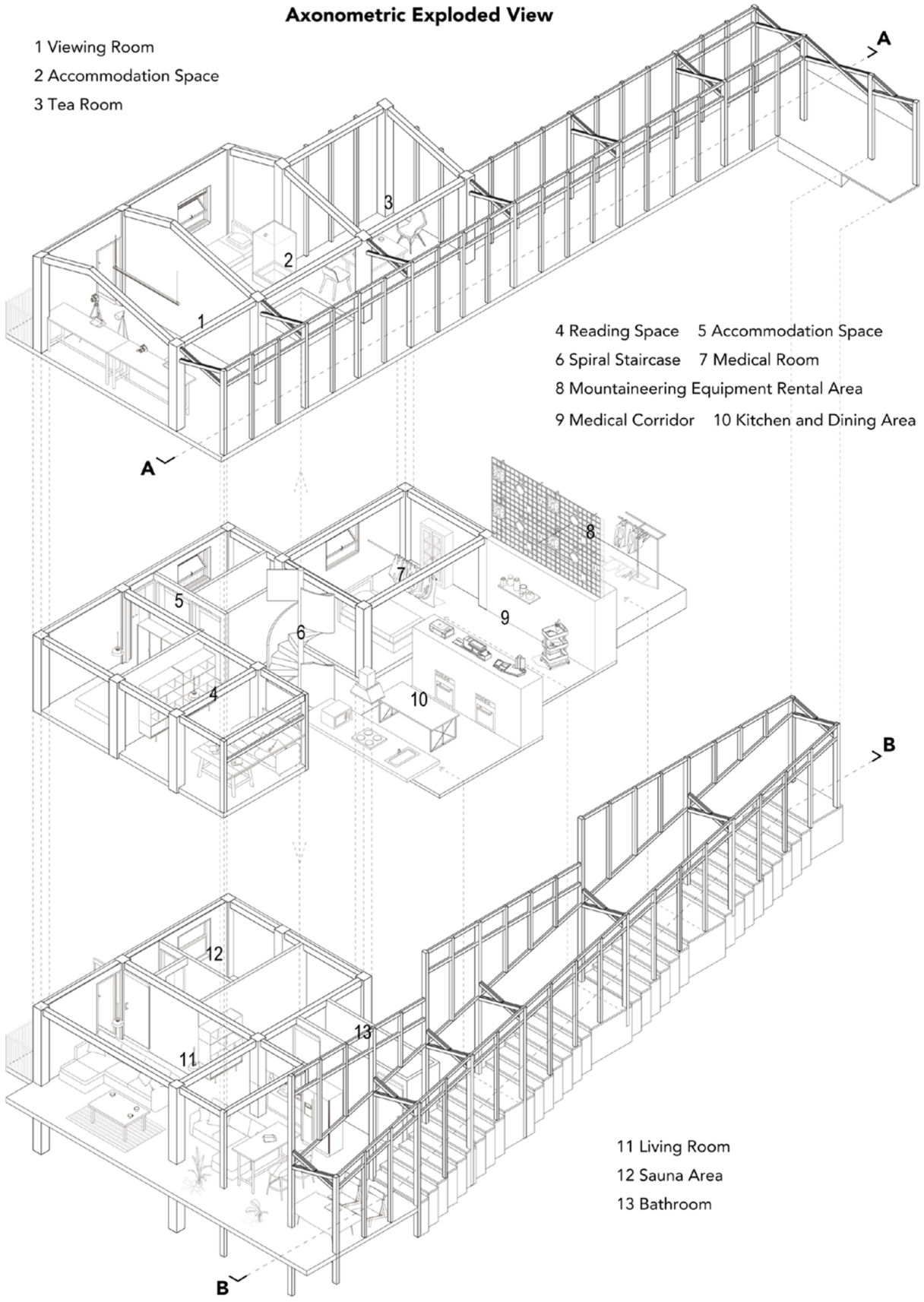


Ground Floor Plan 1:100

13 Sauna Room 14 Changing Room 15 Living Room 16 Equipment Room 17 Bathroom

Axonometric Exploded View

1 Viewing Room
2 Accommodation Space
3 Tea Room



4 Reading Space 5 Accommodation Space
6 Spiral Staircase 7 Medical Room
8 Mountaineering Equipment Rental Area
9 Medical Corridor 10 Kitchen and Dining Area

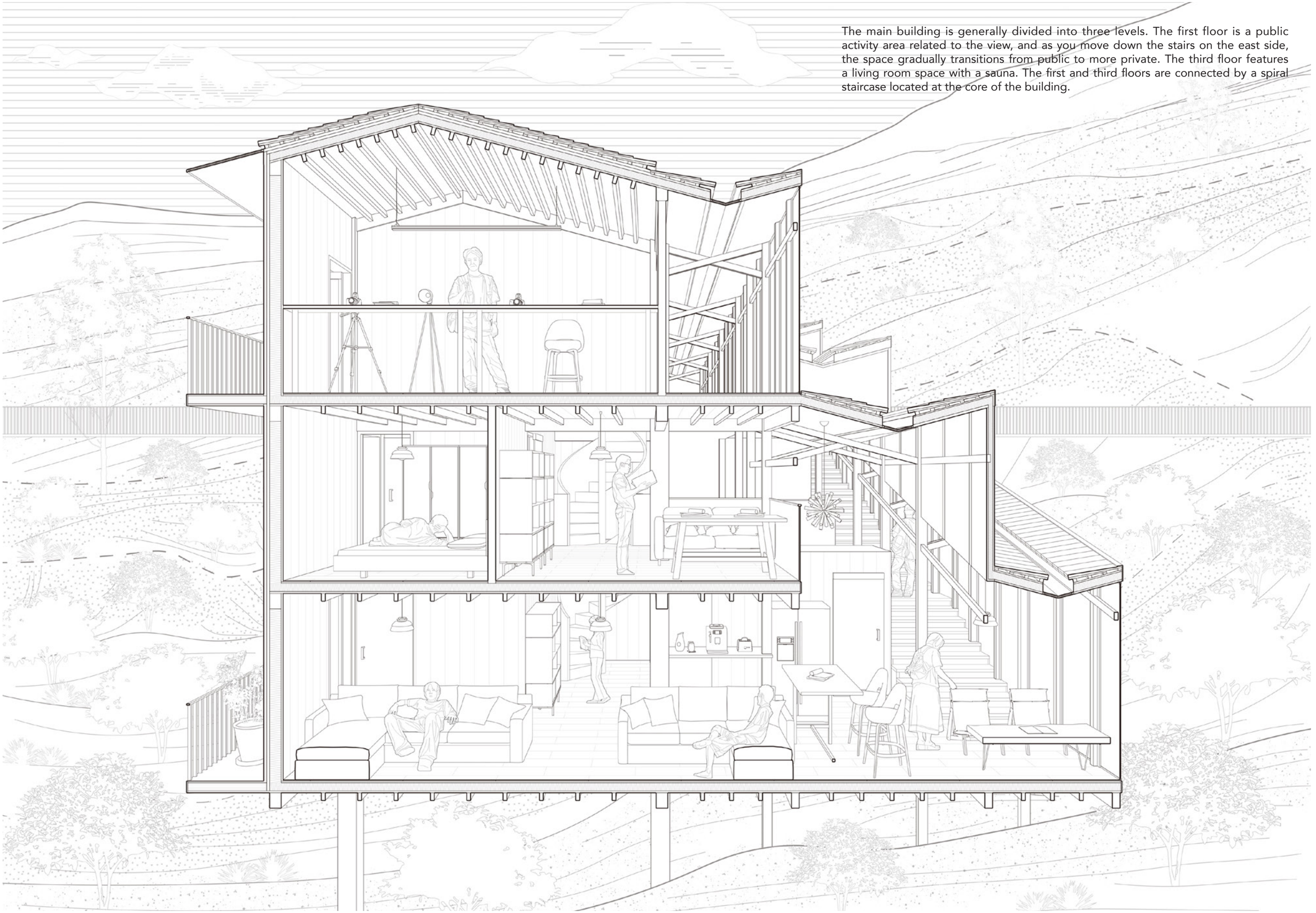
11 Living Room
12 Sauna Area
13 Bathroom

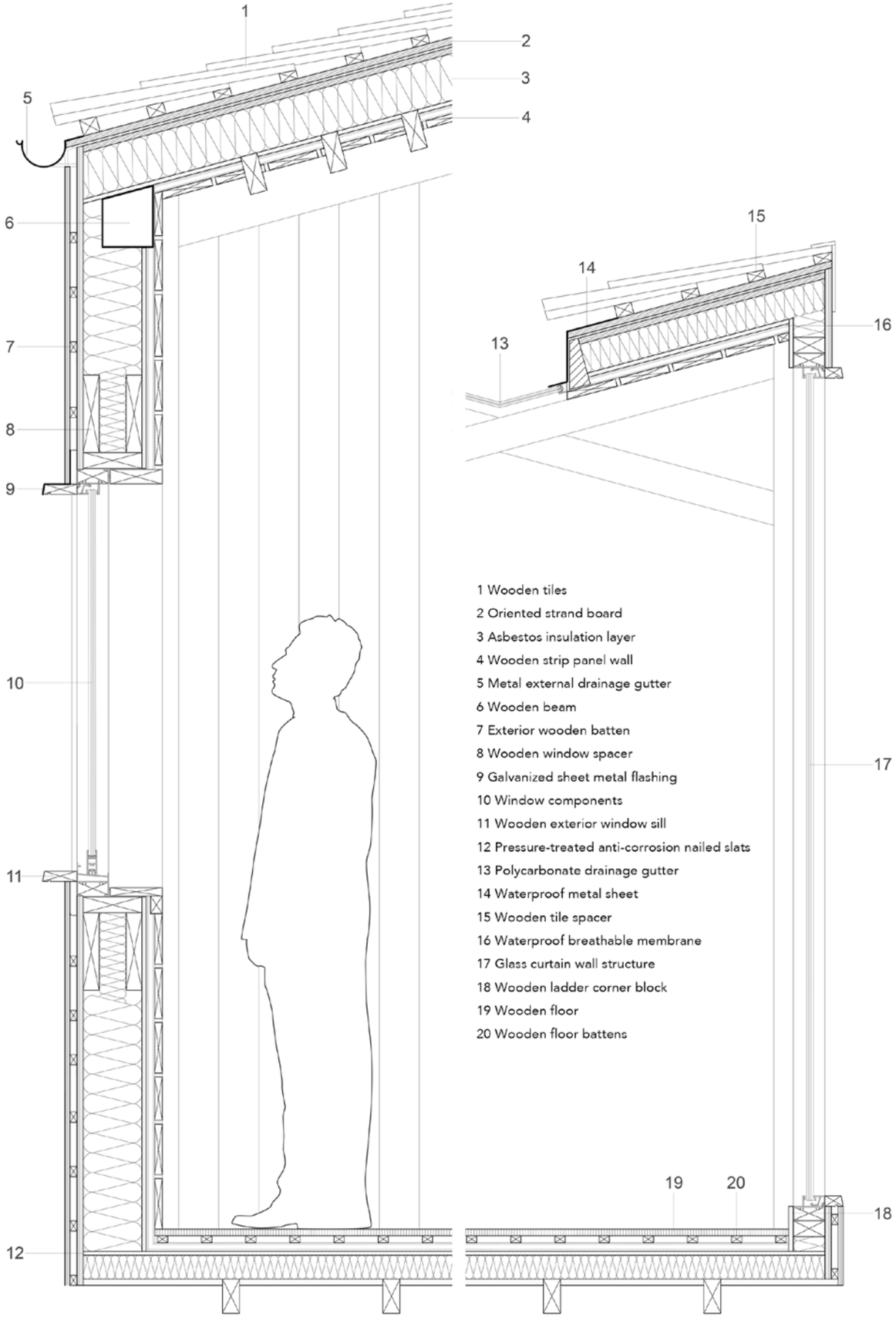
A-A Section 1:150

The overall circulation is divided into two routes. The first route is the straight corridor on the right side of the entrance space, passing through the tea room, spiral staircase, and accommodation area, with its end leading to the observatory on the third floor, which provides a view of the glacier. The second route is the descending staircase on the left side of the entrance space, passing through three functional platforms: one for the mountaineering equipment rental area, one for a passage that provides necessary medicines and medical equipment and connects to the medical room, and one for the kitchen and dining area. The route ends at a living room space on the first floor, which includes a sauna area. The two routes are connected by the spiral staircase and converge at the accommodation space on the second floor, which features a study area.

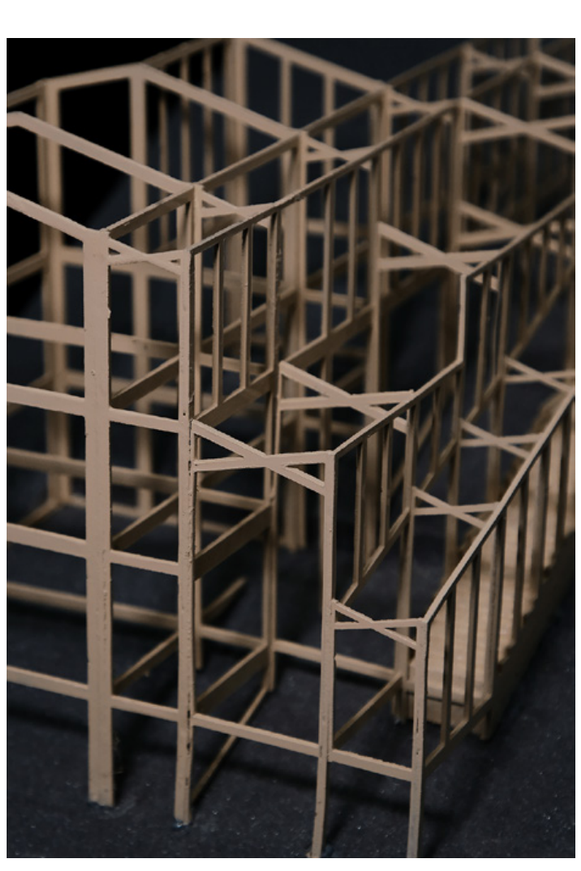
B-B Section 1:150

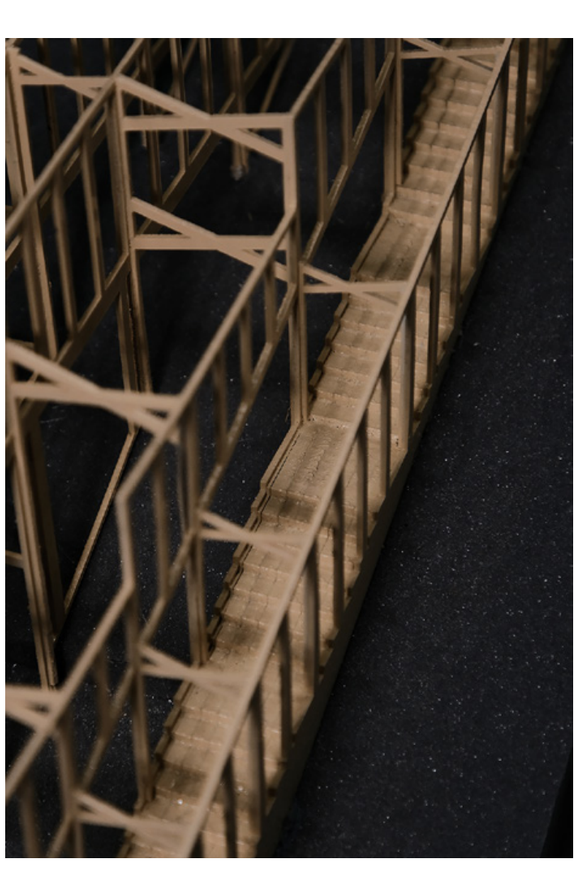
The main building is generally divided into three levels. The first floor is a public activity area related to the view, and as you move down the stairs on the east side, the space gradually transitions from public to more private. The third floor features a living room space with a sauna. The first and third floors are connected by a spiral staircase located at the core of the building.

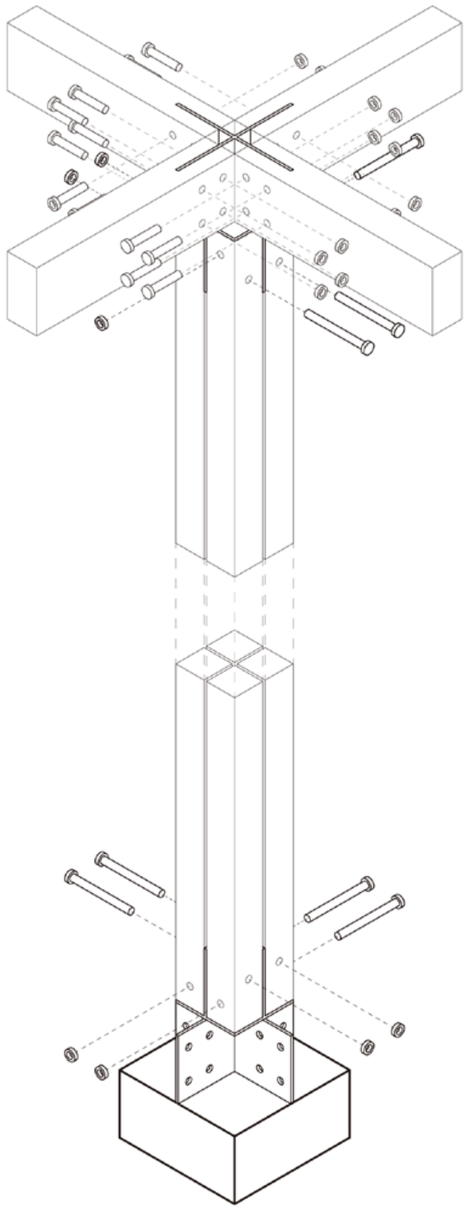




1 Wooden tiles
2 Oriented strand board
3 Asbestos insulation layer
4 Wooden strip panel wall
5 Metal external drainage gutter
6 Wooden beam
7 Exterior wooden batten
8 Wooden window spacer
9 Galvanized sheet metal flashing
10 Window components
11 Wooden exterior window sill
12 Pressure-treated anti-corrosion nailed slats
13 Polycarbonate drainage gutter
14 Waterproof metal sheet
15 Wooden tile spacer
16 Waterproof breathable membrane
17 Glass curtain wall structure
18 Wooden ladder corner block
19 Wooden floor
20 Wooden floor battens







3 — Modular Renovation Strategy

Steel-wood structure, modular structure, spatial composition logic

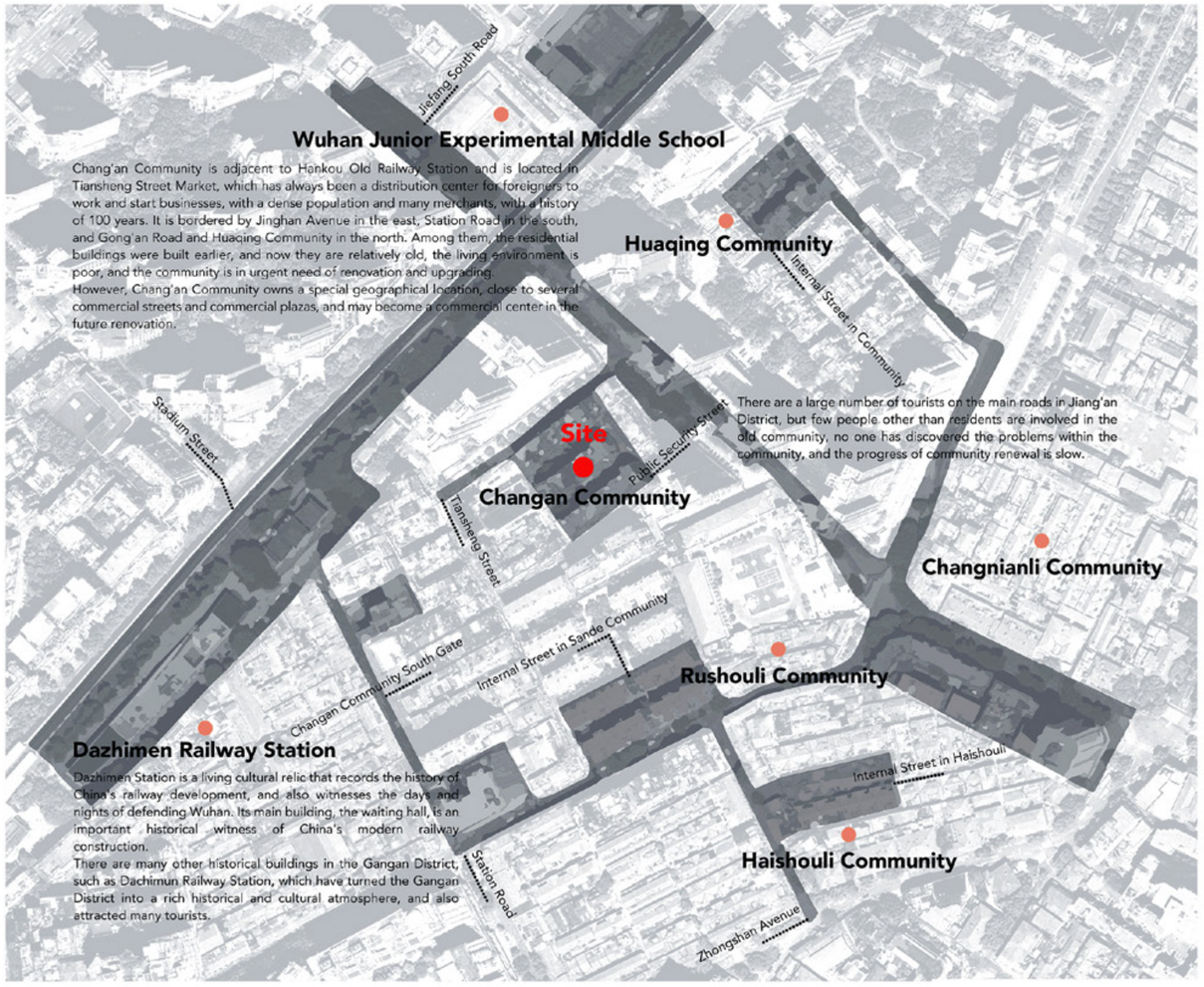
In cities around the world, there are many old residential areas. These areas often have intricate and complex spatial layouts that are fascinating but appear chaotic in terms of urban aesthetics. When it comes to updating these old neighborhoods, the primary strategy has often been large-scale demolition and reconstruction. This approach not only wastes significant amounts of materials and resources but also mercilessly erases the traces of the original residents' lives. I began by looking into the self-building activities of residents in relation to their homes, analyzing the logic behind it, and developed a modular update and renovation strategy. Through my design, I hope to optimize the process of updating old residential areas in cities.

Individual Work

Location: Wuhan,China

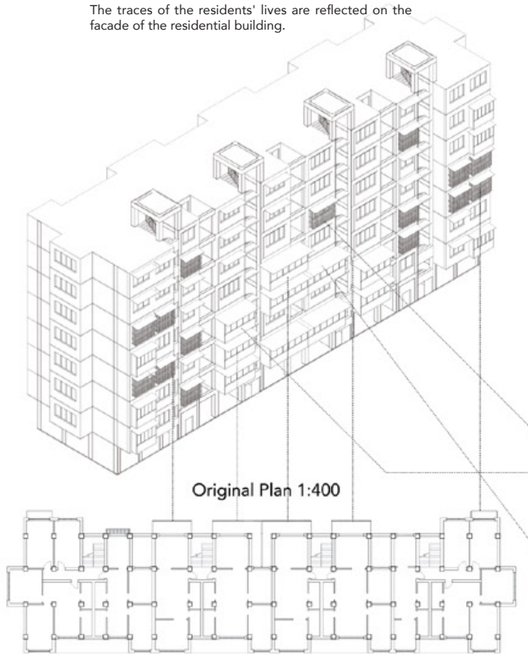
Architecture Heritage Topics,2023 Summer

Supervisor: Takayuki Suzuki



Isometric Diagram of the Original Residential Building

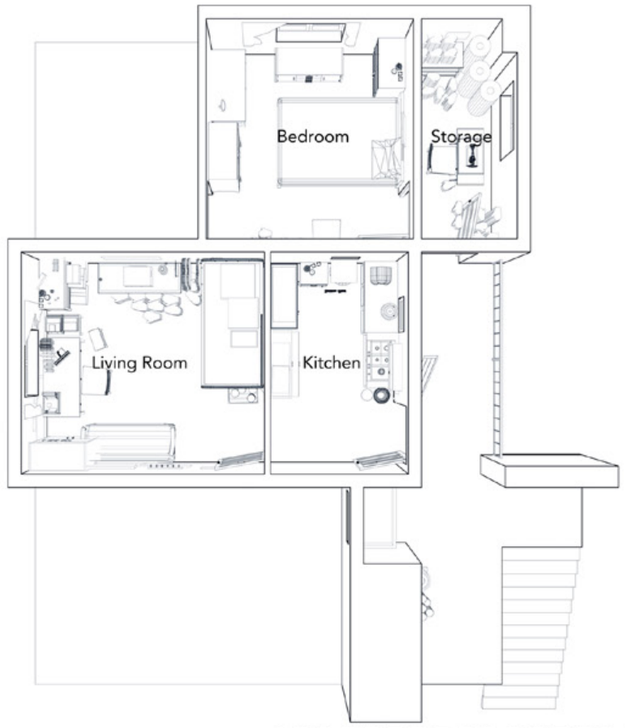
The traces of the residents' lives are reflected on the facade of the residential building.



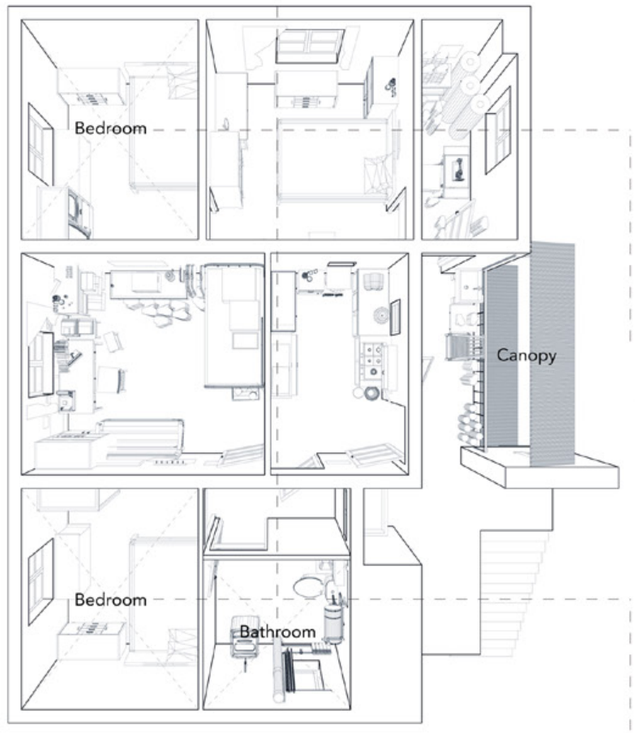
Transformation of old communities in Wuhan in recent years.

Photos of the Residential Building

Diagram of Self-built Activities



Mr. Chen's Home in 2005



Mr. Chen's Home in 2020

Mr. Chen graduated from a vocational college in Wuhan in **2000** and later became an employee at a factory in Jianghan District. Five years later, with the help of his savings and financial support from his parents, he purchased a o**ne-bedroom second-hand apartment** at a low price near his workplace.

In the sixth year of his career, Mr. Chen was introduced to a suitable woman through a matchmaker, and they got married **in 2006**. Mr. Chen renovated the one-bedroom apartment he had purchased a year earlier into a bridal home, adding a **bathroom** in a suitable space.

In the spring of the second year(**2007**) after their marriage, Mr. Chen's **first child** was born. When the child was still young, they could live together in the master bedroom with Mr. Chen and his wife. However, as the child grew, the one-bedroom apartment gradually became too small for the entire family. As a result, Mr. Chen added a **secondary bedroom** next to the master bedroom for his child to have their own space.

In the winter of 2018, Mr. Chen's second child was born. Learning from the experience with his first child, Mr. Chen added **another bedroom** next to the bathroom in the spring of 2019 for the new baby to have their own space.

During the survey around the site,I divide the spaces around Changgang community into three different kinds and create several primary modules due to this.

Red Blocks

Blocks with No Specific Functions

Empty Platform/Fitness Space/Narrow Corridor

Green Space/Entertainment

Blue Blocks

Blocks with Specific Functions

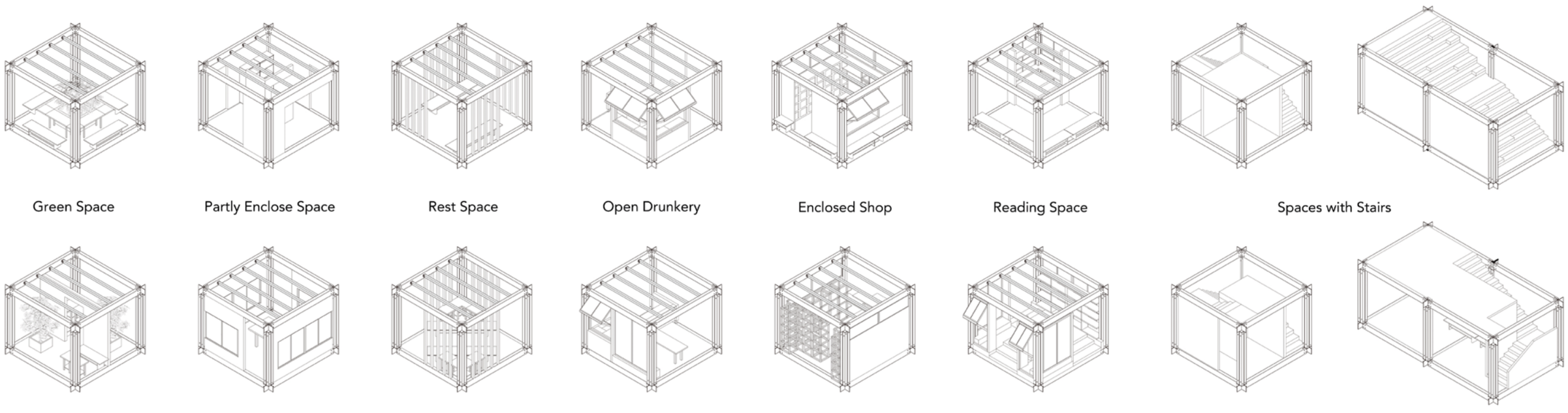
Coffee Shop/Drunkery/Grocery Market

Bookshop/Laundry/Restaruant

Purple Blocks

Blocks Can Connect Different Spaces

Different Spaces with Stairs

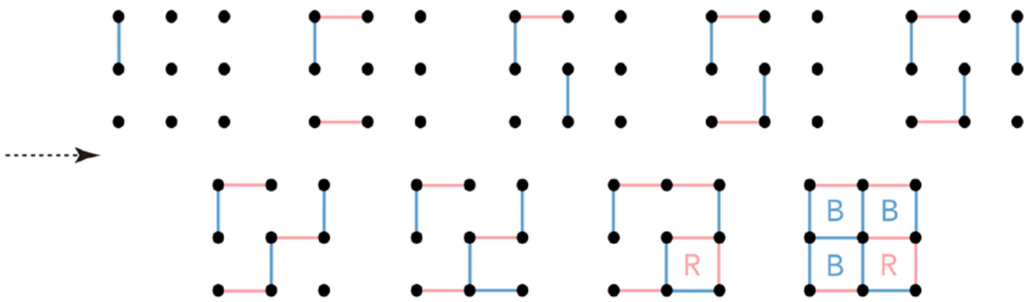


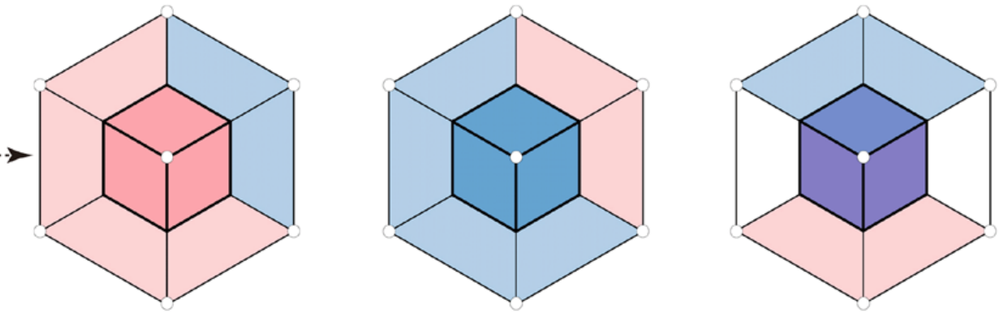
Green Space | Partly Enclose Space | Rest Space | Open Drunkery | Enclosed Shop | Reading Space | Spaces with Stairs

Due to the flexible structure of the modules,modules can change a little in latter design.

François Édouard Anatole Lucas
From 1842 to 1891

As a classic mathematical game, there is a considerable amount of strategic interplay between the two players in their decision-making. In the first part of the game, the players aim to avoid adding the third face to the square. Spatially, this helps to create a more fluid and dynamic space. Its application in three-dimensional space, however, requires specific adjustments.





Based on the above theory, I applied it to the study of the spatial composition logic of self-built spaces by residents in the site and obtained the following results. In spaces of a certain size, the spatial configuration changes with the number and arrangement of different types of spaces. I identified a relatively typical "model space" based on tree species and applied it in the subsequent renovation and upgrading process.

When the same spaces are adjacent, the two spaces can be defined as a whole.

Without purple space, spaces can`t be connected in vertical direction.

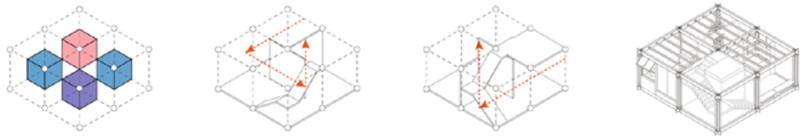
Main Entrance Space

When the different space are adjacent, there will be a barrier between them.

Purple space can connect adjacent space in vertical direction

Commercial Space

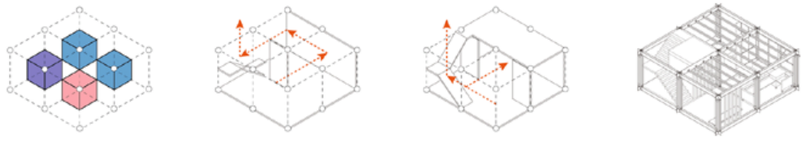
The flow of space will change depending on the arrangement of different spaces.



When there are two spaces of blue but they`re not adjacent.

Composited Space

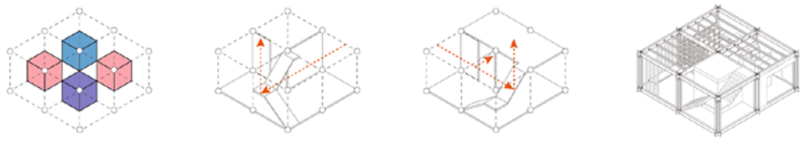
When the number of different spaces are the same.



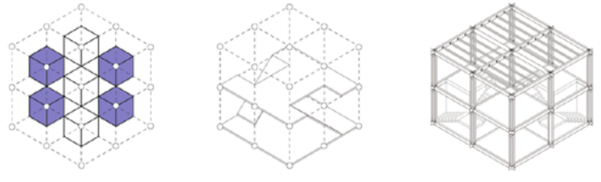
When there are two spaces of blue and they`re adjacent.

Leisure Space

Red space becomes the main entrance of the whole blue sapces.

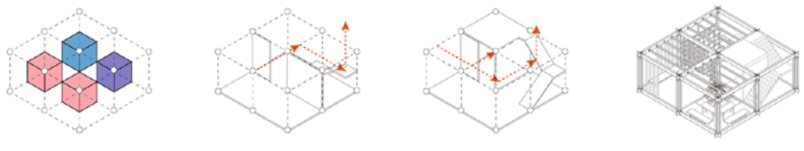


When there are two spaces of red and they`re adjacent.



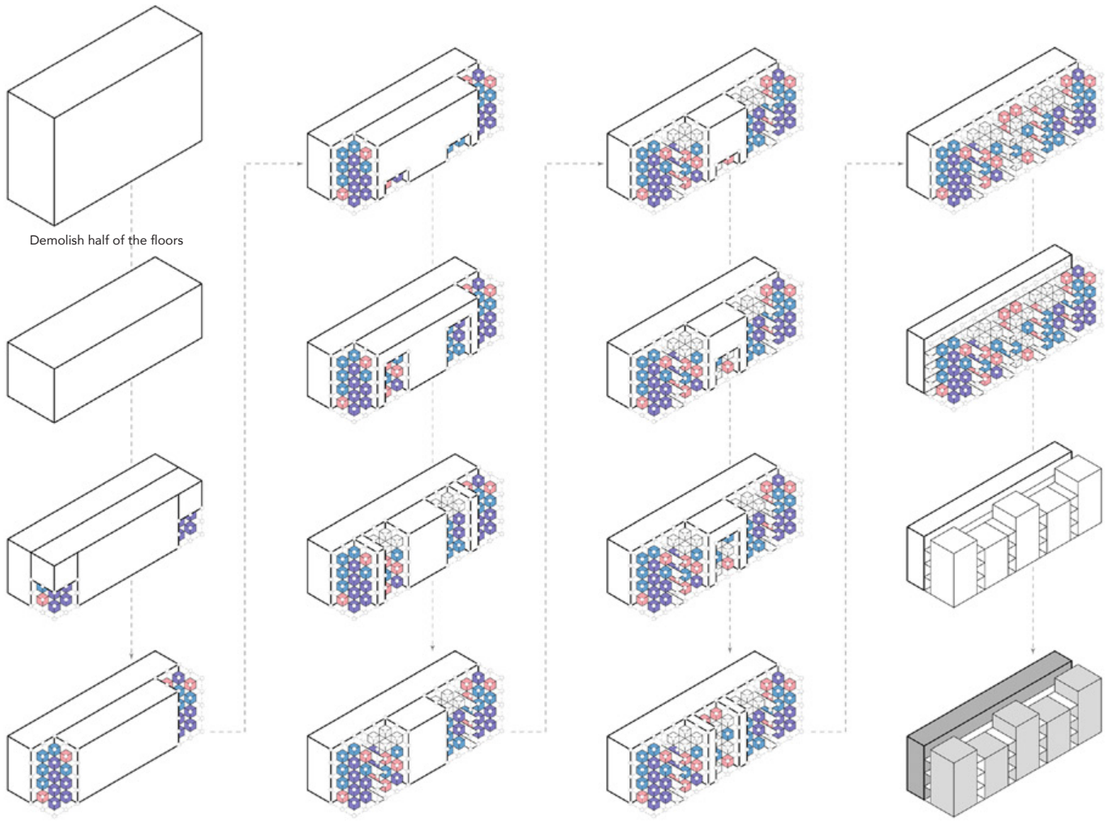
Growing Space

Blue space becomes the accessory space of the whole red sapces.

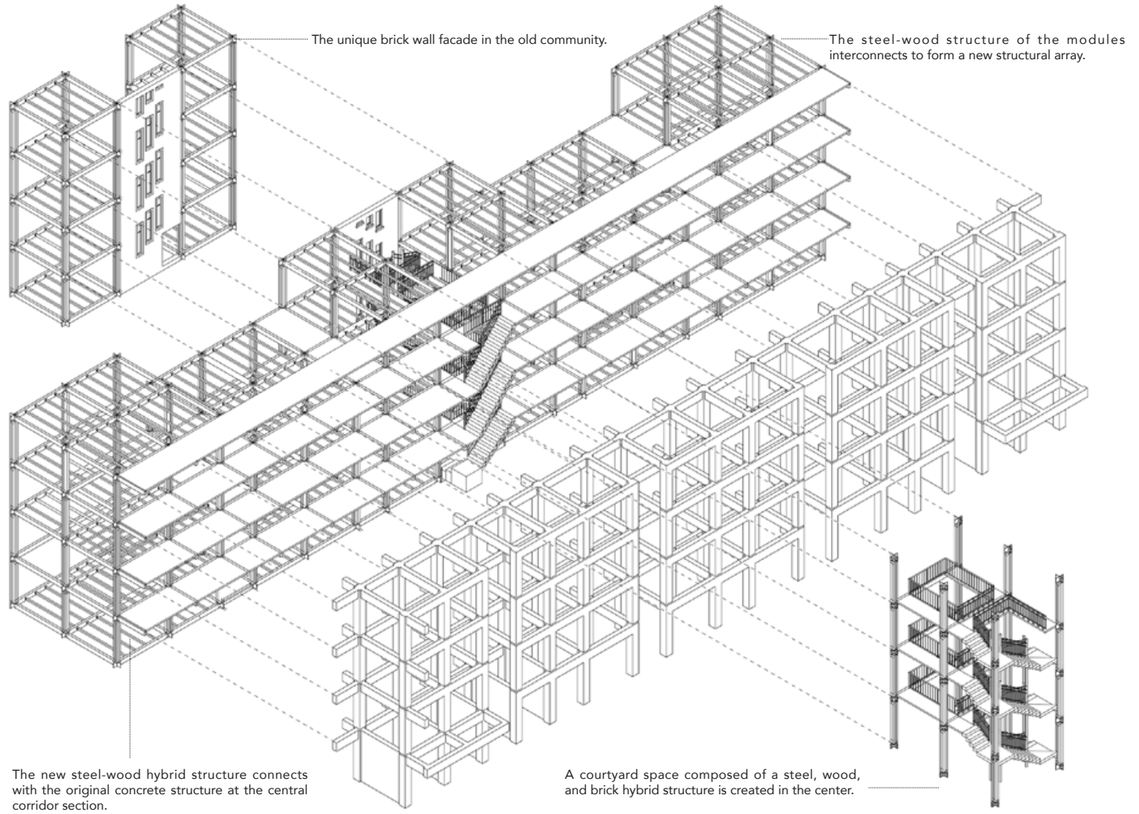


When there are two spaces of red and they`re adjacent.

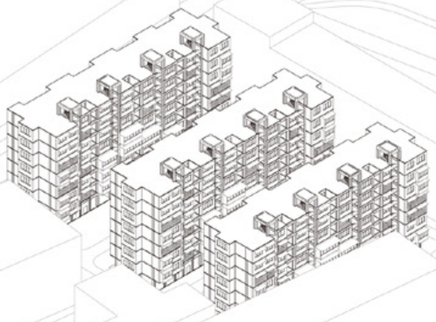
Modular Renovation Flowchart



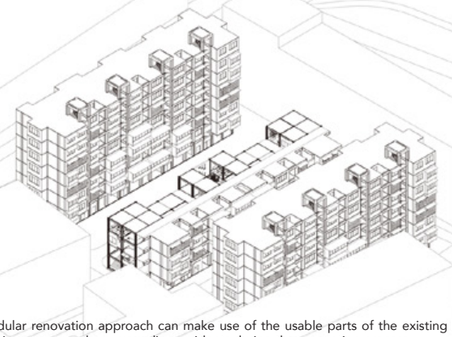
Structural Exploded Isometric Diagram



Original Appearance

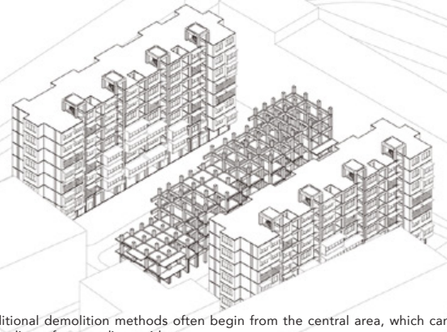


Transformation Method B Process 2



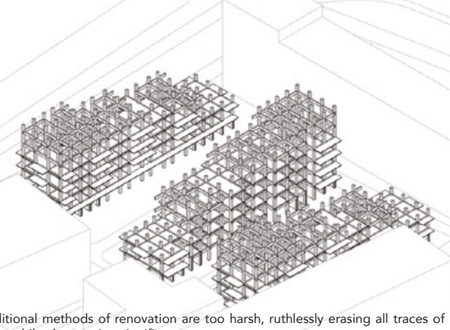
The modular renovation approach can make use of the usable parts of the existing building and continue to serve the surrounding residents during the renovation process.

Transformation Method A Process 1



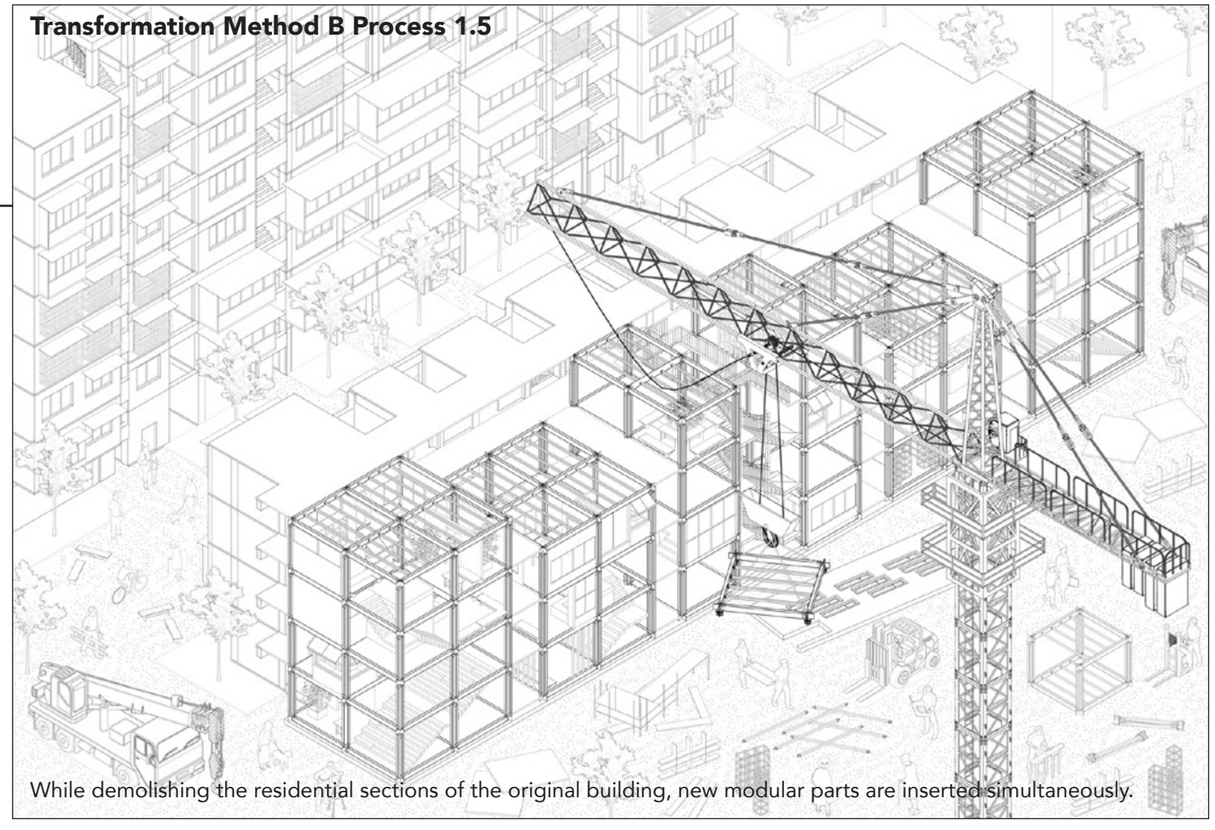
The traditional demolition methods often begin from the central area, which can greatly impact the lives of surrounding residents.

Transformation Method A Process 2

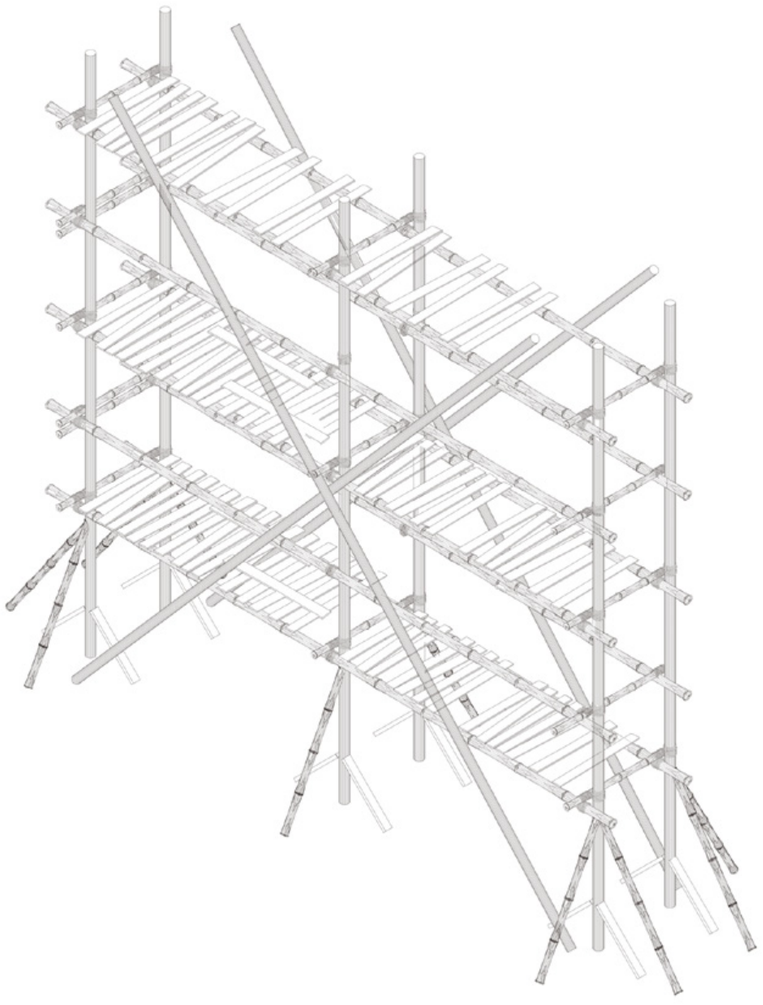


The traditional methods of renovation are too harsh, ruthlessly erasing all traces of people's past lives, while also causing significant waste.

Transformation Method B Process 1.5



While demolishing the residential sections of the original building, new modular parts are inserted simultaneously.



4 — Lakeside Community Pavilion

Square columns, flexible wood construction, continuous structural variation

The lives of the villagers in Tangxun Lake Fishing Village, Wuhan, have undergone significant changes due to the Yangtze River's 10-year fishing ban policy, which began in 2021. Residents were forced to put aside their fishing boats and suspend their fishing livelihoods. Some have gone to work elsewhere, and many houses in the village have gradually been abandoned. The government hopes to help the villagers sustain their livelihoods by developing tourism in the area near the village. Through my design, I aim to combine the government's policies to help the entire fishing village survive through this 10-year fishing ban period.

Individual Work

Location: Wuhan,China

Academic Work,2023 Winter

Supervisor: Xiangyu Zhang

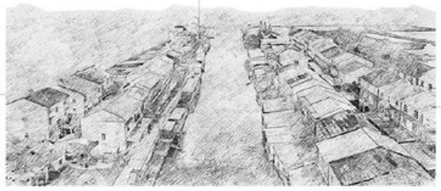
Fishing Ban--Lasts Ten Years

From 2021--2031

Since January 2021, a tentative 10-year perennial fishing ban has been implemented, during which productive fishing of natural fishery resources is prohibited. After the ban on fishing in the Yangtze River, aquatic biodiversity has gradually recovered, and retired fishermen have been transferred to jobs and resettled to obtain guarantees, and the fishing ban has achieved phased results. The ban on fishingmeans that the license is cancelled, the boat is sealed, the net is destroyed, and the person goes ashore.

Tangxunhu Village--A Fishing Village

Back to Life of Fishing in Ten Years



Make A Living by Fishing

Each single family owns at least
one little boat to fish.

Handle Food

Villagers will marinate,dry and process meat and
fish to make preserved fish and bacon.

Then Repair Fishing Vessels Regularly

Firstly Repair Abandoned Houses

How to survive the livelihood of fishermen ?

Maintain their current life

Young and middle-aged workforce go out to work
(mostly in construction field)

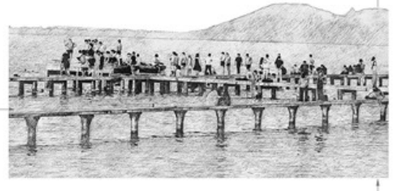
causes

prepare for life after fishing ban ends

Develop the Tourism Industry in the Village

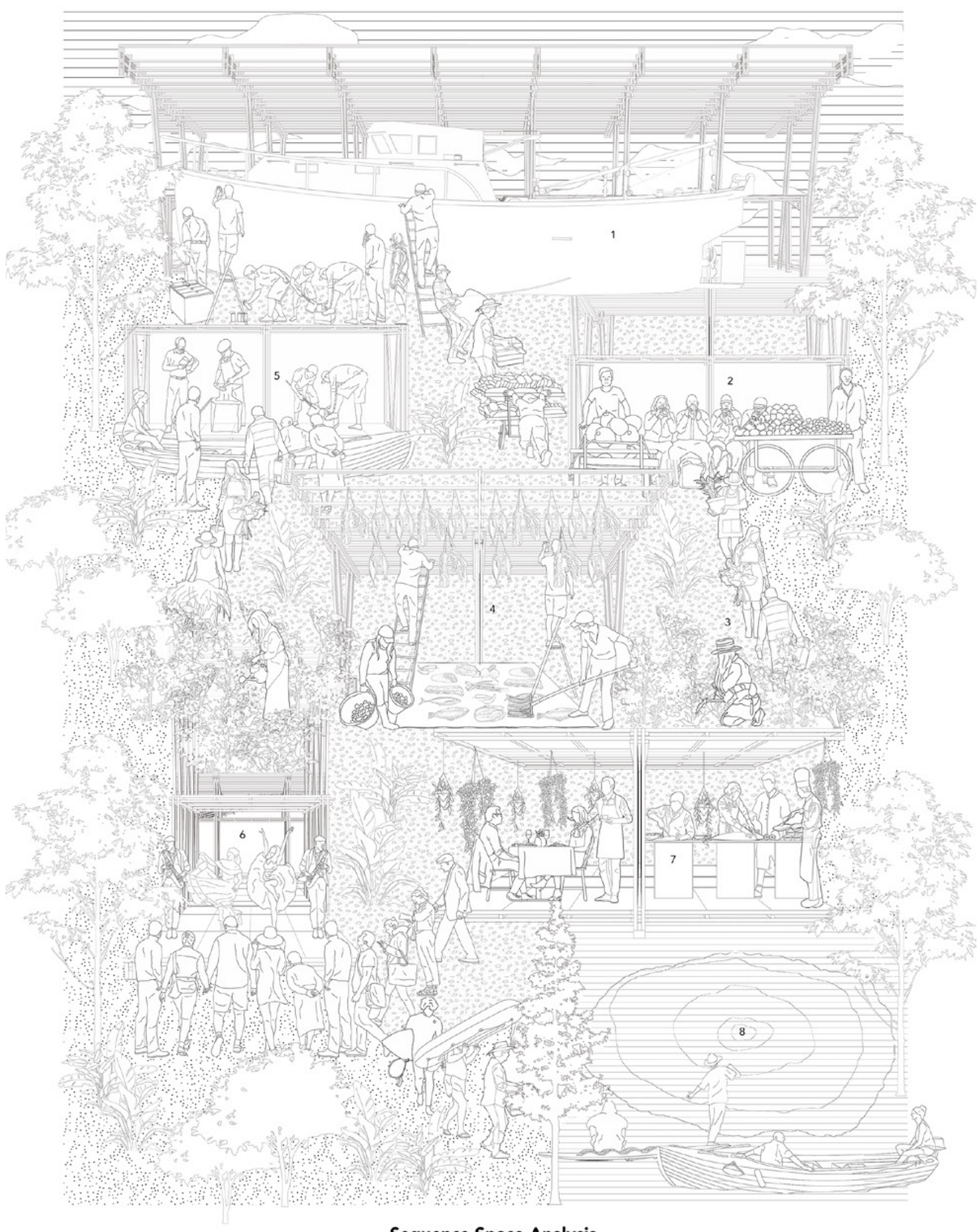
Advertised as an attraction

Tourists come for swimming



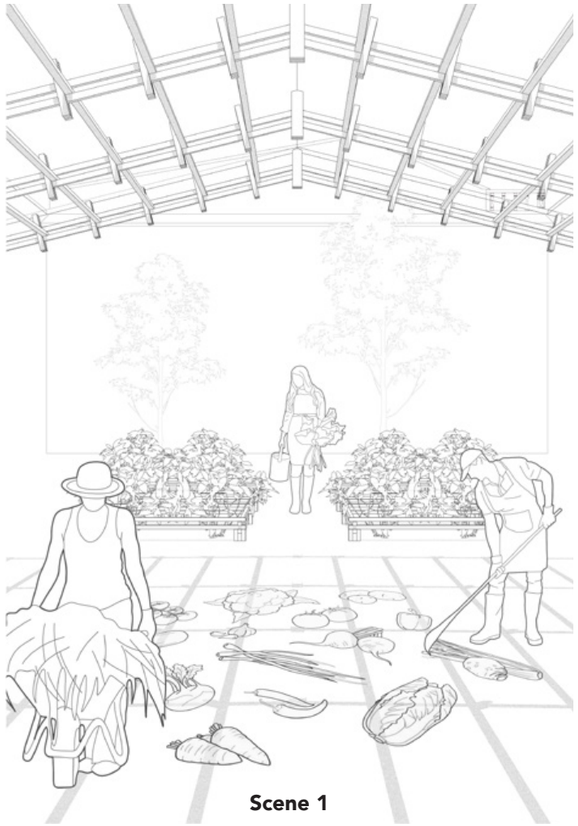
Abandoned Houses

Villagers transport part of their houses into restaurants to
treat tourists

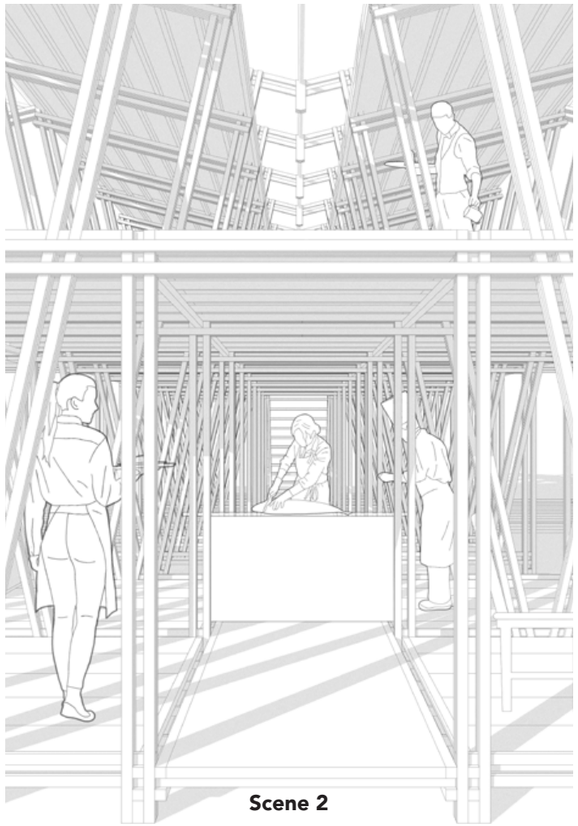


Sequence Space Analysis

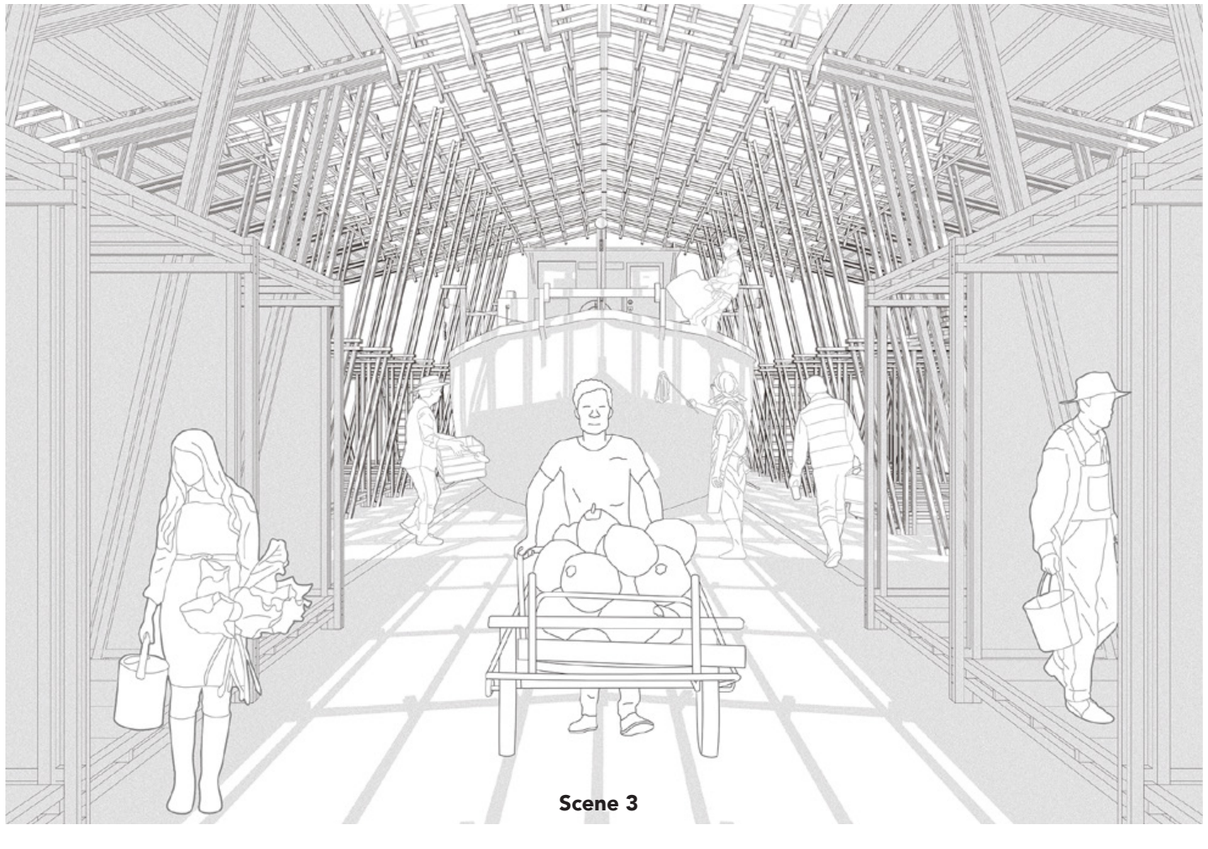
1 Dock//The cargo ships that come and go unload the daily necessities required by the villagers at the village's dock.**2 Market**//The people who receive the supplies will transport them to the market in the village for sale.**3 Vegetable Garden**//The vegetables grown by the villagers themselves also become commodities in the market.**4 Food Processing**//According to tradition, the villagers process meat and fish into dried fish and cured meat.**5 Boat Repair**//All the boats in the village undergo regular maintenance and repairs.**6 Stage**//The village holds regular performances for both local villagers and visiting tourists to enjoy.**7 Home-cooked Dishes**//The village has many home-cooked restaurants where visiting tourists can dine, and some villagers make a living by operating these establishments.**8 "Anticipation"**//The villagers hope to get through the fishing ban period in various ways and return to their fishing life once the ban is lifted.



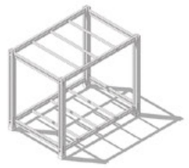
Scene 1



Scene 2



Scene 3

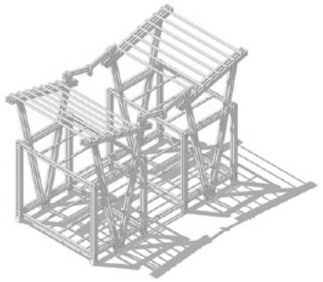


Module 1

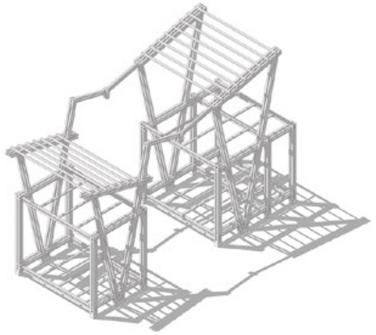
Module 2

Module 3

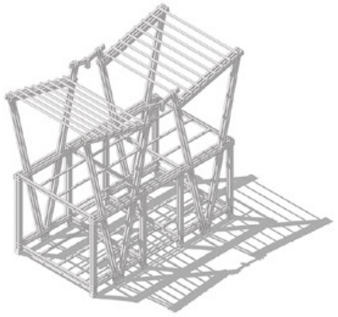
Module 4



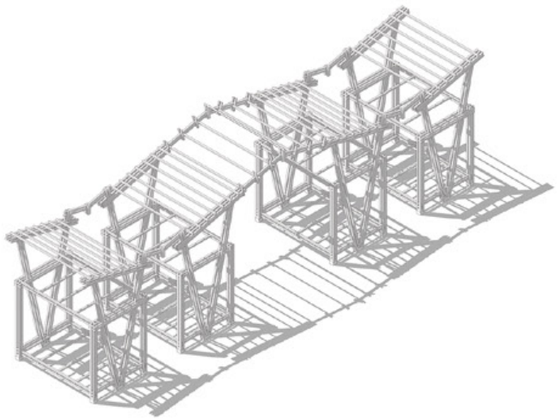
Module 5



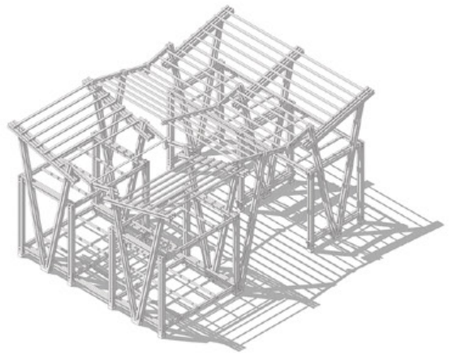
Module 6



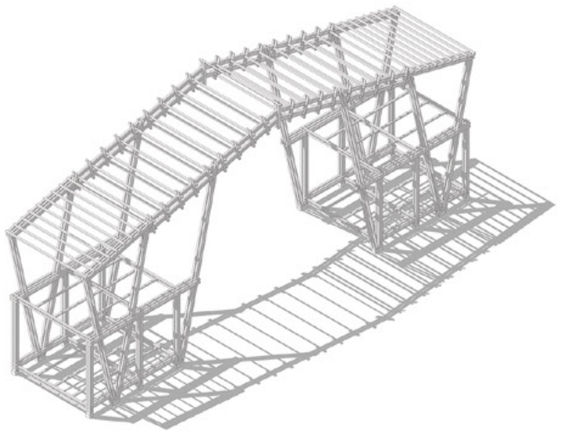
Module 7



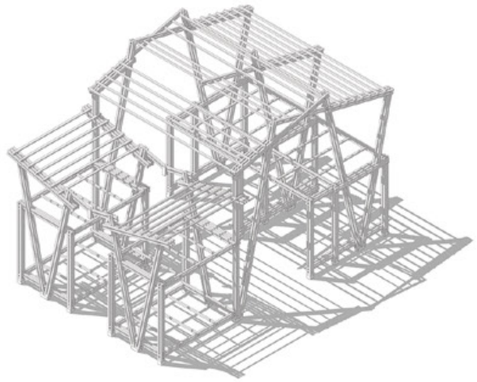
Group 1 (5+5)



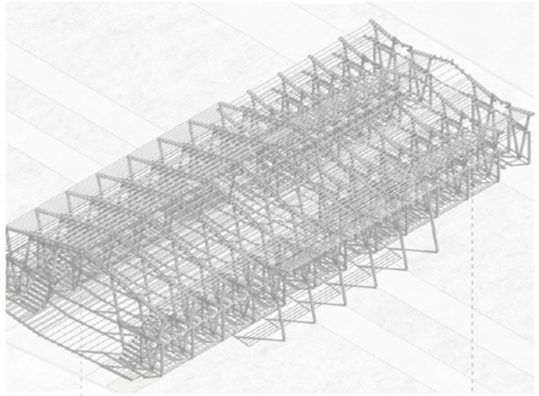
Group 2 (5+5)



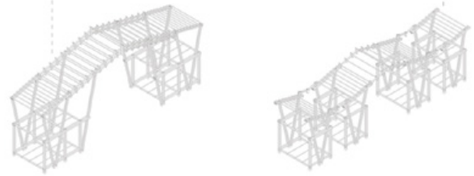
Group 3 (4+4)



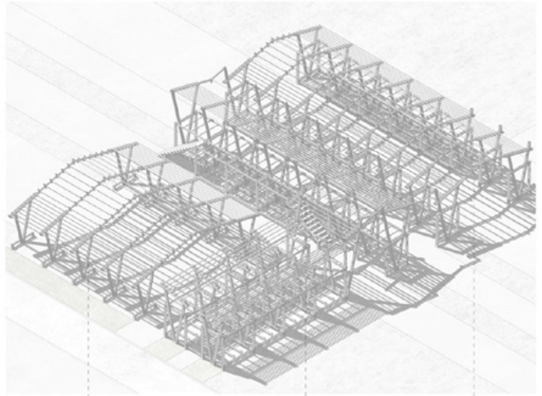
Group 4 (5+4+4)



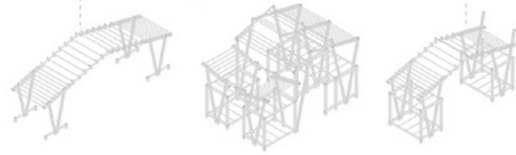
Combination 1



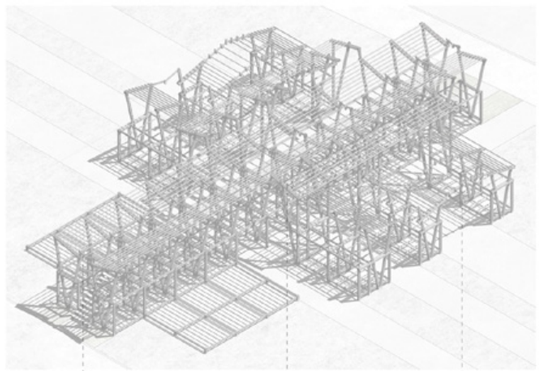
Combination 1 is a combination of a dock and a market, where people get supplies from the city on small boats and place them in the market or transport them to other parts.



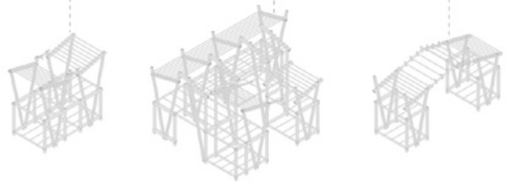
Combination 2



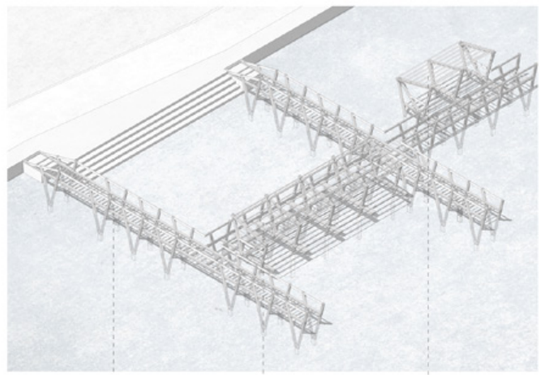
Combination 2 is the main scene in which people handle food. After getting food, people will first clean and air dry it in a space of different heights, then dry it in an open space, and finally package it for preservation.



Combination 3



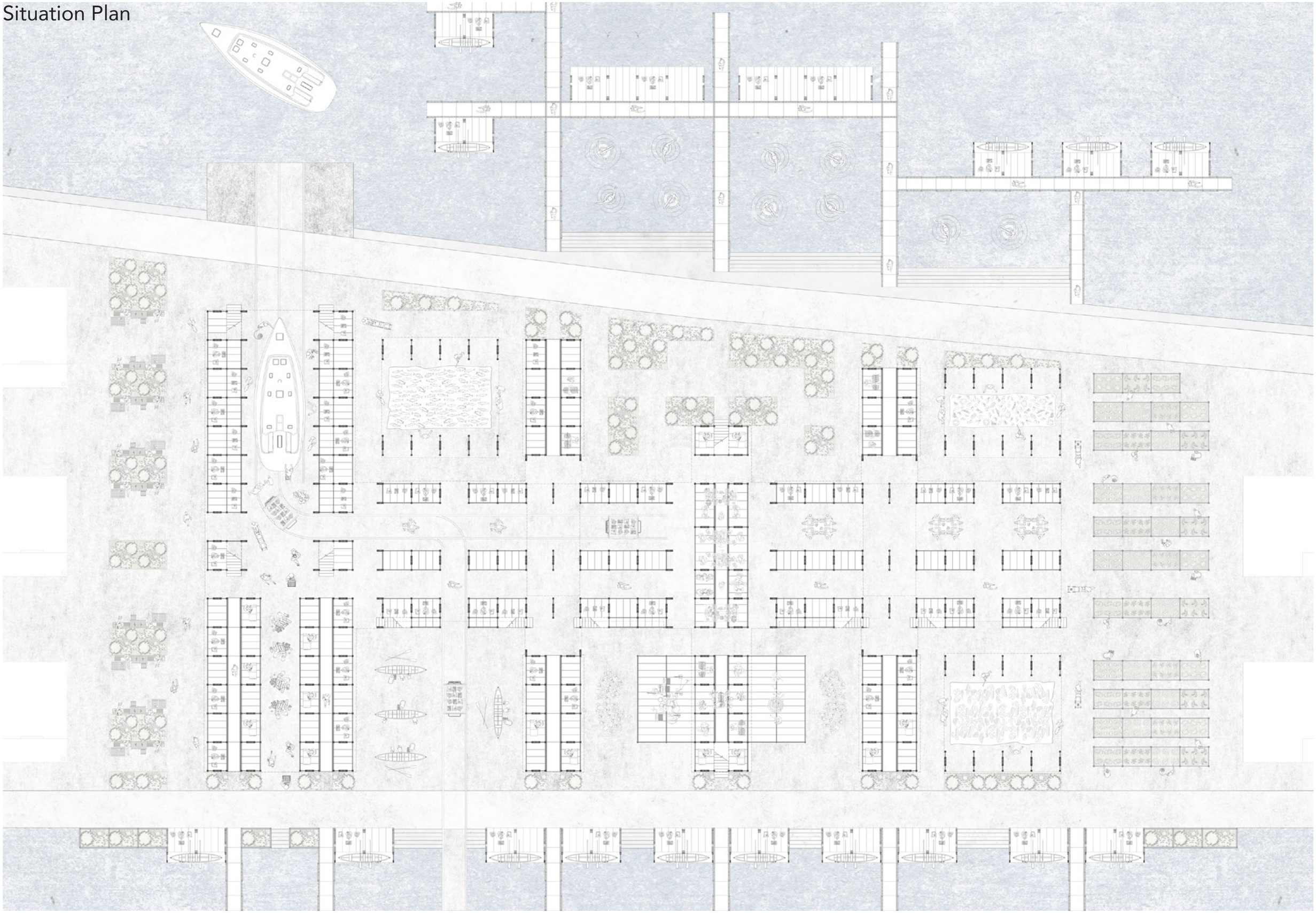
Combination 3 is the main place for people to have leisure and entertainment on the land. People can cook and eat in the public kitchen on the first floor with processed food, and play chess, mahjong, chatting and other entertainment activities in the platform on the second floor.

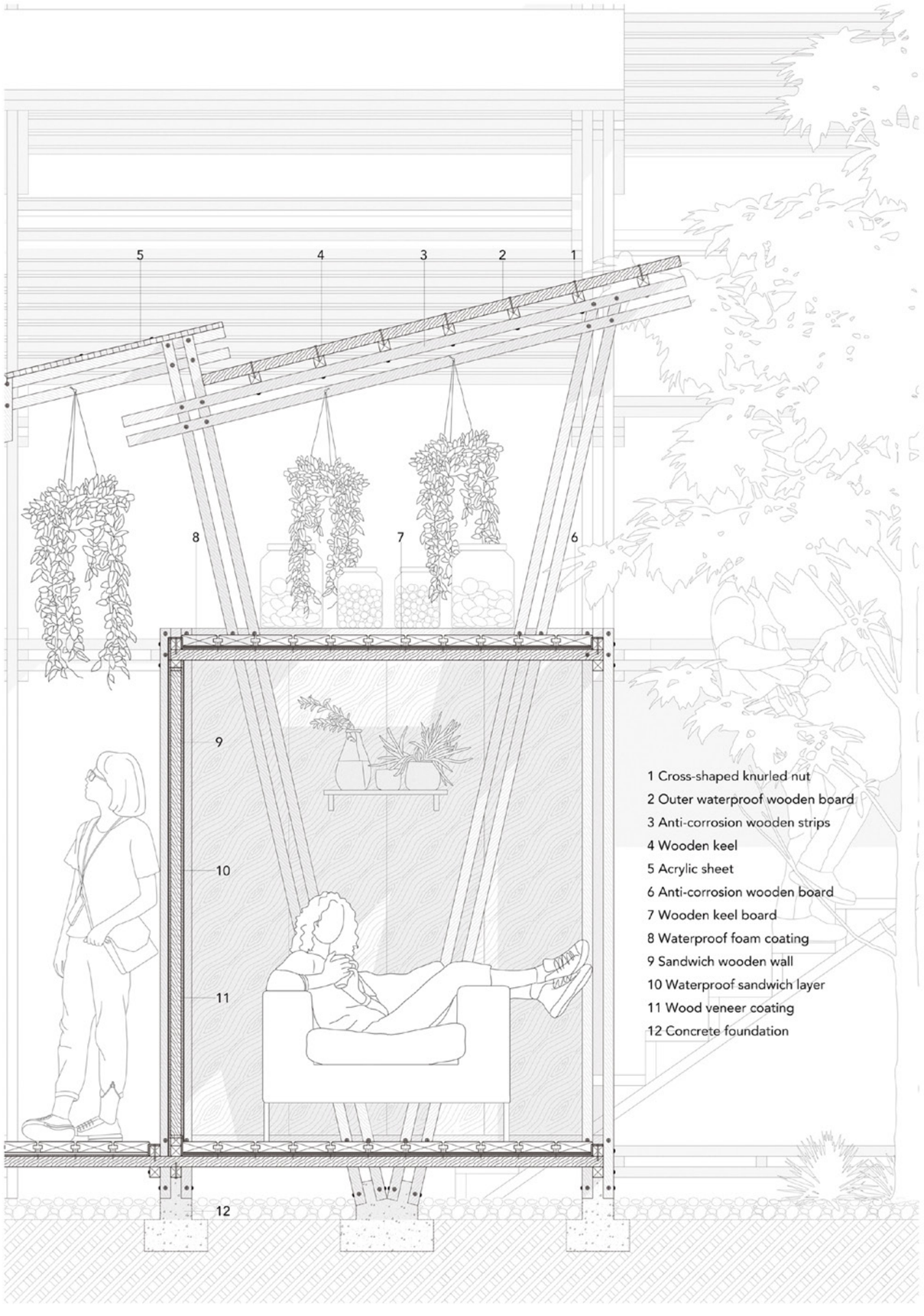


Combination 4

Combination 4 is the main place for water activities, where people can swim in the enclosed safe waters, and walk and stay in the walkways and pavilions on the water surface, where fishermen can dock their boats later in life.

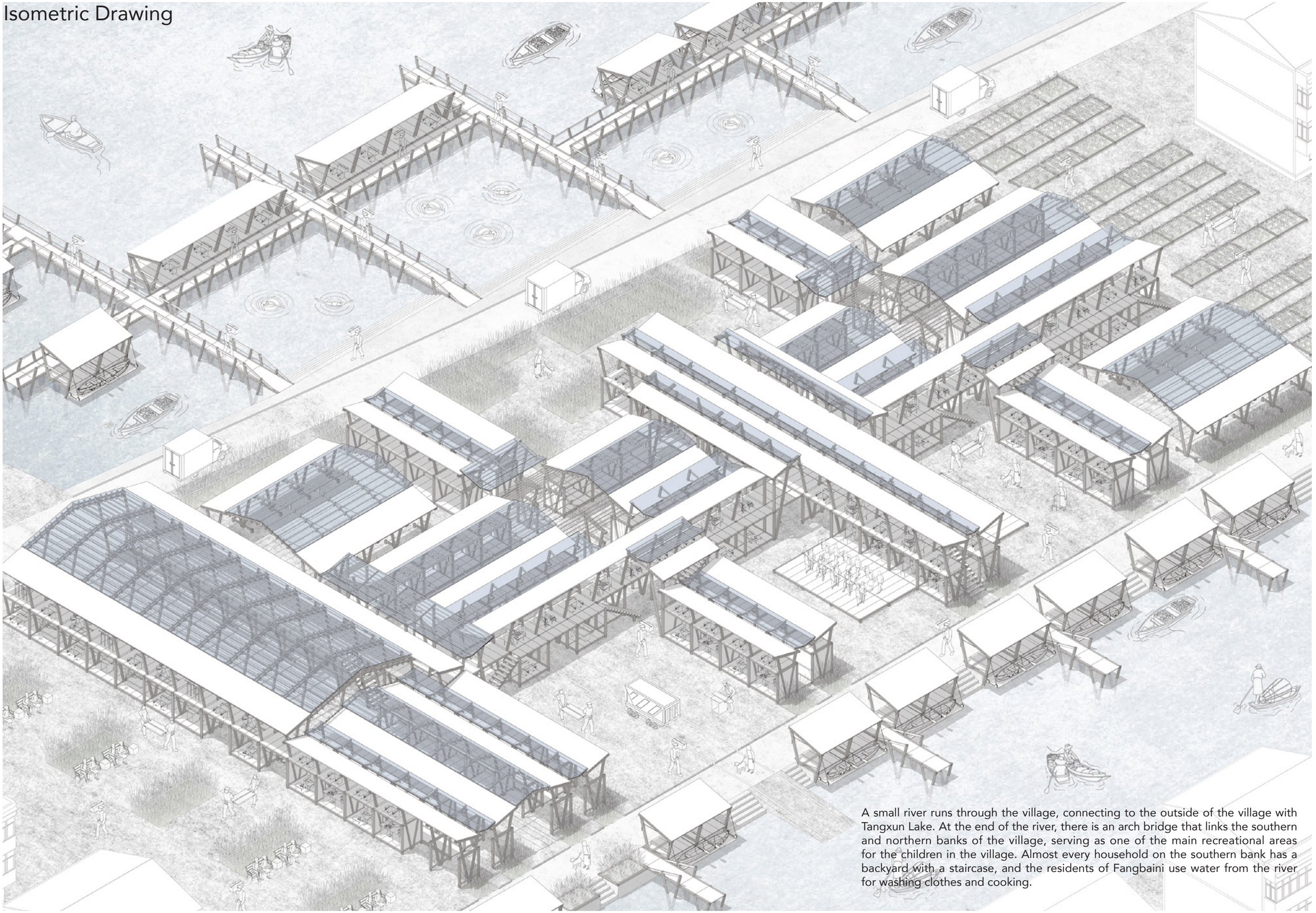
Situation Plan





1 Cross-shaped knurled nut
2 Outer waterproof wooden board
3 Anti-corrosion wooden strips
4 Wooden keel
5 Acrylic sheet
6 Anti-corrosion wooden board
7 Wooden keel board
8 Waterproof foam coating
9 Sandwich wooden wall
10 Waterproof sandwich layer
11 Wood veneer coating
12 Concrete foundation

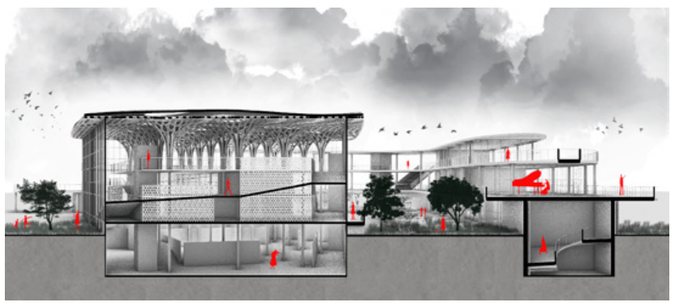
Isometric Drawing



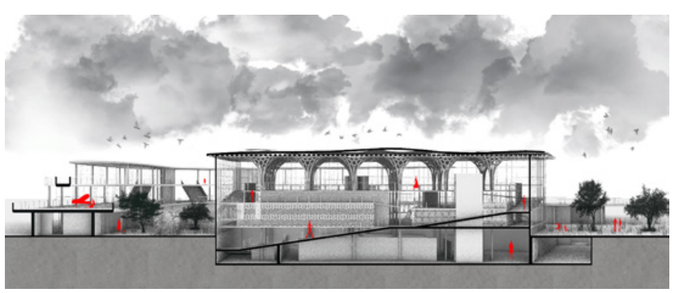
A small river runs through the village, connecting to the outside of the village with Tangxun Lake. At the end of the river, there is an arch bridge that links the southern and northern banks of the village, serving as one of the main recreational areas for the children in the village. Almost every household on the southern bank has a backyard with a staircase, and the residents of Fangbaini use water from the river for washing clothes and cooking.

5 — Other Works

I studied architecture under the joint program between Wuhan University and the University of Dundee, during which I had the opportunity to meet many professors from around the world and acquire a wealth of professional knowledge. Below are several works I completed during this period.



Section-perspective 1



Section-perspective 2

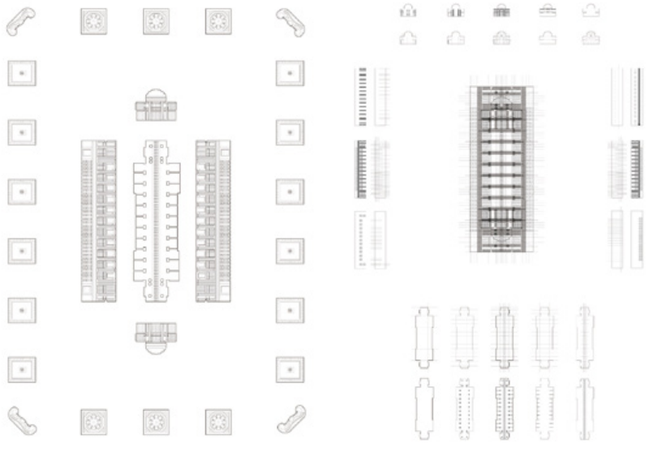
2022.12.26 Museum Design

The exhibition space of the museum is separated from the public areas, with the exhibition space surrounded by a garden. Inside, irregularly woven columns and surrounding walls are created to further enhance the spatial atmosphere.

2023.12.29 Urban Design

In the urban design course, my team and I based our city planning on the principle of the "eight-hour workday." In the overall design, I was responsible for the residential design and transportation planning. On the right is an interior rendering of the residential design that I created.

Interior Room Rendering



Compositional Analysis of the Playfair Library

2023.8.15 Summer Workshop

In the summer of 2023, I attended a workshop in Dundee, where my team and I conducted research on the Playfair Library and created analytical diagrams.

2024.6.7 Hospital Design

This project involves designing a hospital for the year 2050. I have completely separated the medical and inpatient areas, connecting them with an elevated skybridge. In the central open space, I created numerous gardens, allowing hospitalized patients to benefit from the therapeutic effects of nature.

External Garden Rendering