Tolerance space

A physical spatial study about intermediate spaces

Phase 1: Introduction of Tolerance space

- Why do I want to study the tolerance space?

Attracted by **joint tolerance** in furniture assembly, and the **void space** between the circulation and living area in the particular Beijing housing buildings, I become curious about this intermediate space of separation and connection, which I call the **tolerance space**.

- What is the tolerance space?

I understand the tolerance space is the distance that exists within a connection.
It is a void, in tension, waiting for a meeting.

The scales of tolerance space

Different scales of tolerance space can be found in other relationships and situations:

- **Tectonic tolerance space**: The transitional space that created to meet the technical and utilitarian requirements.
- Sometimes, creating the tectonic tolerance space is accompanied by by-products not related to technic or utility, for example, the Beijing housing buildings: suspended circulation is created because of the fire escape norms and for economic reasons, but the by-product is the brutal facade with strong appearance of light and shadow.

- **Conceptual tolerance space**: It is a surplus space that aims to achieve certain spatial qualities or idea clarity rather than the technical or utilitarian resolutions.

- **Integral tolerance space**: The whole structure/architecture acts as an intermedium placed on the site to influence the circumstance around the structure/architecture. For example, the Beijing housing buildings act as the border of the residential city block, enclosing the public area within the block, and separating it from the noise of the street traffic.

Factors of tolerance space

Tolerance spaces are void spaces with their own properties. Furthermore the tolerance space is in relation to internal and external factors. There are varied factors of tolerance spaces, such as territory, light, wind, view, activity.

When my understanding of tolerance space become clear, I realized there are a lot of interesting elements around us related to tolerance space. During trips to Bergen, Italy, and Germany during the summer holidays, I discovered and recorded certain elements and factors of tolerance spaces.

Phase 2: Atlas of Tolerance space

The Atlas is the collection of the elements related to the tolerance space recorded with photography, drawings, and texts. I am interested in three types of elements relevant to the discussion of tolerance space: **Column**, **Hall**, and **Passage**.

I**ntegral tolerance spaces** act as the interstitial elements to separate and connect other parts in the bigger system/environment: The column connects/separates the foundation/floor/lower level to roof/ceiling/higher level respectively; The hall connects/separates rooms around it; The passage connects one direction and divides the other.

The elements column, hall, passage consist of different parts: base, body and cap in the column; centre and periphery in the hall; ends and middle, wall and path in the passage. The **Tectonic tolerance** space can be found in the connection and separation between these parts, for example the column in Parkering Molla P-hus.

I see the conceptual tolerance space as the space between two columns, between the different parts of the column and various surrounding architectural elements, for example the wall in social housing in Giudecca Venezia.

The **factors** that influence and shape these elements are varied, even within the same type. Such as gravity, water, mechanical equipment, light, view, wind, activity, territory, circulation.

The Atlas is the **on-site experience** to test my finding: How can I recognize the tolerance space in the elements? What scales of tolerance space appear in these elements? and which factors influence these elements.

The Atlas as an **archive** of tolerance spaces inspires me to make further spatial studies in the next phase.

Phase 3: Spacial studies of Tolerance space

Based on the Atlas, I start to make physical study models to reproduce the spatial qualities of tolerance spaces. The models are not simply rebuilds of the elements, they absorb the traits of elements and generate their own new forms.

I made four models named with the same titles as the Atlas: **Column**, **Hall**, and **Passage**. It doesn't mean each model is only inspired/influenced by the same type of elements. One model may contain characters from other types in some aspects.

The models are pure, scaleless, and have an open materiality. They express of proportions, relationships, and spaces, and they also carry some properties of the materials they are made of and maintain some common characters as a totality:

- **Structure**: There are two structural elements in every model: the skeleton and the skin. The skeleton is the main structure to resist compression. The skin is hanging on or constrained by the skeleton. The skeleton supports the skin and the skin encloses the space around the skeleton and separates it from the outside environment.

- **Materiality**: The solidity of the skeleton contrasts with the thinness of the skin. The solidity gives the skeleton space to hide connection joints inside its body. The thinness of the skin allows exposed joints, flexible shape, and a translucent atmosphere.

- **Construction**: The skeleton connects to the skin with a distance, the tolerance space. Gaps and voids wrap the connections making room for the encounter of external factors.

- **Space**: Space is anchored by the collaboration of the skeleton and skin, only overflowing to outside through slits in the models. Slits is the intimate space of skeleton and skin, always at minimal distance, connecting/ separating the inside space and the outside spaces.

There are the four physical spacial models:

- **Column**: The column grows up from its center of foot, splits into four branches at the middle, and connects at the cross beam on the top. It supports the floor and ceiling, and hangs four L shape walls. The walls clamp the column in the center and enclose four separated spaces collaborating with the floor and ceiling in four corners. The column transforms from one solid point on the bottom to a reversed pyramid void on the top. Each branch of the column occupies one gap between adjoining corners. The column not only exists to resist gravity, but it is also like the director behind the stage, organizing the relations of spaces inside and outside. Tolerance spaces not only stay inside the column but also exist around it.

- **Hall**: The Hall is enclosed by four walls, each wall is supported by a tilted column that rises from the middle of each foot. These four tilted columns converge on the top and clamp the cross beams. The wall consists of two surfaces and five ribs between the two surfaces. The thickness of the wall changes between its two surfaces: The bottom of the wall is very thin at the meeting of the 2 surfaces, with the distance between the two surfaces becoming wider and wider towards the top. But the 2 surfaces keep intimate distance on the left and right edges to form the integral wall. While the inner space of the hall is transforming with the dynamic relations between the walls and columns: from a square on the ground to a cross opening on the top, the hall is a hollow column with various slit outlets. Behind the tolerance space between the walls and columns, another layer of tolerance space exists inside the walls.

- **Passage No.1**: Three curved surfaces are constrained by the skeleton and interweave with the skeleton in three directions. The skeleton divides the passage into four quarters in section, so the passage has four entrances and outlets. The four paths converge by two T elements on two ends of the passage. A cross element connects with the two T elements via four transversal beams, it occupies the center of the passage, crosses the surface in the middle, and connects the top and ground. The voids and gaps between the skeleton and skin maintain the interdependence for each element and achieve the equilibrium of the totality. There are tensions between the skeleton and skin, the definition between structure and space becomes ambiguous.

- **Passage No.2**: This is a passage that continues to offset outward from the middle part. Like the Russian dolls, the outer passage covers the inner passage. The passage wall consists of the skeleton in the middle and two surfaces. The inner surface of the passage's wall extends to the following passage space. It become the outer surface of the passage's wall. The skeleton structure is like Russian dolls where the inner skeleton hangs on the external skeleton. It is like a bridge, touching the ground on two ends and floating in the middle, which cut a slit for the interweave of outside spaces under the passage. The exposed wall sections clarify the construction relations and allow light and wind to go through. The shift of light follows the change of walls, lighting the difference in the structure. This is a passage that starts from one wall, the passage is a dilated wall in human scales for human activities, the wall itself is a passage in another scale for nonhuman factors.

During the making of these studies models, I realized the results of tolerance space do not always follow with my original expectations: it will modify and generate itself by the tension among elements while requiring me to alter the design and look for other proper resolutions. The tolerance space is not a fixed value, it is dynamic.

Phase 4: The Project of Tolerance space

After the physical spatial studies, I want to introduce **scale** and **materiality** into the tolerance space. I chose one of the models and developed a tolerance space with conventional structural **dimensions**. I chose the model: Passage No.1. To maintain the proportions and materiality of the structural elements of the previous space model, I chose wood and steel plates as the construction materials for the skeleton and skin, respectively. The size of the entire structure is developed from the structural properties of these two materials and the scale of human behavior in space. So in the end I got a structure of 24 meters long, 6 meters wide, and 6 meters high.

The structure consist of two main spaces:

- **The ground space** is semi-enclosed by a curved wall, open to the opposite side under the extending ceiling. It has a panorama-like view with a column in the middle and two other columns outside the wall, which constrain the bending wall.

- **The top space** is a passage space covered by a continuous vault. It is a linear space with openings at its ends. The central column grows from the ground to the top space and connects to two wooden tie rods. The three wooden elements are aligned on the central axis of the space.

The two spaces are connected by a ramp/stair. The ramp/stair starts in the middle, rises to both sides along the boundary of the curved wall, and finally enters the two ends of the top space.

There are different **scales of tolerance space** that appear in this structure.

Tectonic tolerance space: The tolerance space generated by structure or tectonic requirements. This kind of tolerance space exists in the connections between component of the same materialist form a large elements, and also exists in the connection of different materials.

- **The central column**: This wooden column is 300*300mm. It acts as the core structural element that extends from the ground space to the top space. It separates into three parts: The lower part, the Middle part, and the Upper part. Each part of the column take different responsibilities for the structure construction of the spaces:
  - Lower part: **supports** the beams and hold the pressure above.
  - Middle part: **connects** beams in 2 directions.
  - Upper part: **constrains** the transverse beams with two tie rods.

- **The vault**: The vault is made up of 15mm steel plates. The whole length of the vault is 24m long, it divides into 7 sections. Each section is 3.6m long, and 7m span. Each section separates into two following the peak axis and leaving 15mm **gaps** for the assembly of the next section. Like roof tile systems, each piece of the vault **overlaps** the next piece by 150mm to enhance the stiffness of the vault. The vault folds up 300mm on the bottom with 30 degrees, collaborating with ribs between the two folding surfaces to resist the lateral thrust of the vault. The **folds** on two sides form two natural drainage gutters with a gentle slope produced by the overlap of the vault sections. In addition to gutters, the separation and overlap of the vault bring another **by-product**: a gentle triangle appear along the peak of the vault along its central axis. This gentle triangular surface is highlighted by light emitted from the 15mm gaps, and corresponds to the triangular space between the central column and tie rods.

- **The curved wall**: The curved wall is also made up of 15mm steel plates. It divides into 7 pieces according to the intersection with the wooden joists. Each piece **folds** 60mm to enhance the stiffness of the wall and also give **overlap** space for assembly with the beams and the adjoining beams. There are 30mm **gaps** between adjoining pieces for the connection beams. The connection beams also act as the hanging beams for the suspended ramp/stairs.

- **The side columns and the curved wall**: The side columns on the ground space detach from the curved wall but constrain the wall by 2 cylinder wooden connectors, to reduce the deformation of the entire structure due to the deformation of different materials.

Conceptual tolerance space: The tolerance space exists beyond the structural or tectonic requirements. It is generated by the requirements of interdependence, tension, and flexibility.

- **The central column**: The solitary central column on the ground space defines the border of the space in a minimal gesture. The 12m spans between the central column to the side column look like they exceed the 0.6m wooden beams capacity. It creates a **tension** between the structure and space, intrigues you to discover the hiding part in the top space.

- **The longitudinal beams and the vault**: Three 300*300mm wooden beams are erect on three columns. They crosses the vault base and exposed their end grains to the outside. The vault bottom covers the top and sides of the beams with a 120mm distance. One cylinder connector crosses through the wood beam and connects to the bottom ribs of the vault. This 150mm setback **clarifies** the two different elements/materials, bringing a **lightness** to this heavy but thin vault.

- **The column head and the vault peak**: The central column and two tie rods that support the central beams and cross through the floor, and converge to the top of central column. It keeps 150mm distance with the vault peak. The intrusion of the column creates tension in the top space, but this 150mm detachment achieves **equilibrium** between the elements.

- **The vault**: The overlap of the vault pieces enhance the **depth of field** on a barely invisible scale.

- **The vault and the floor**: The vault bottom and the floor of the top space maintain a 150mm gap. The gap introduces **light** from the ground to enter the space and diffuse to the whole space.

- **The wall and the floor**: The wall keeps a 60mm gap(the width of the folds of each piece of the wall) to the edge of floors. These 60mm gaps allow **light** to interweave between the ground and the top.

Integral tolerance space:

The structure itself is a tolerance space, and can act like a section of **wall** or **border**. Anchoring the structure on the site, breaks the boundlessness and continuity of horizon, carves out a void for external factors to meet, to blend, to repel… and offers space to experience the different atmospheres around the structure.

The whole process of the tolerance space study starts from my personal experience of a usual phenomenon, the development of the study also follows my interests in the spatial potential hiding behind this phenomenon. The results were modified and further generated due to the pull and push between the thinking and making with some contingency factors and decisions. The state of concentration in creative process is always a pleasurable experience. Furthermore, the condition of uncertainty attracts me as it enables me to pursue something "new", as it makes me deviate from the initial trajectory and surprise me.

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Diploma: Mingming Zhang
Supervisor: Lisbeth Funck, Matthew Anderson, Per Olaf Fjeld, Dagur Eggertsson

- Passage No.2: Three curved surfaces are constrained by the skeleton and interweave with the skeleton in three directions. The skeleton divides the passage into four quarters in section, so the passage has four entrances and outlets. The four paths converge by two T elements on two ends of the passage. A cross element connects with the two T elements via four transversal beams, it occupies the center of the passage, crosses the surface in the middle, and connects the top and ground. The voids and gaps between the skeleton and skin maintain the interdependence for each element and achieve the equilibrium of the totality. There are tensions between the skeleton and skin, the definition between structure and space becomes ambiguous.

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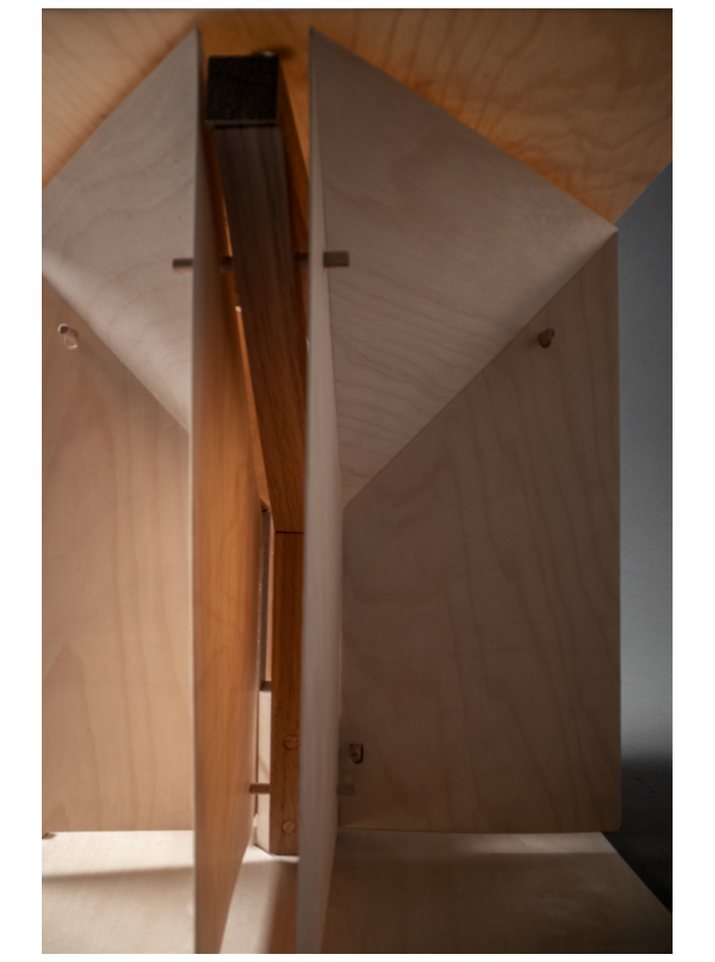

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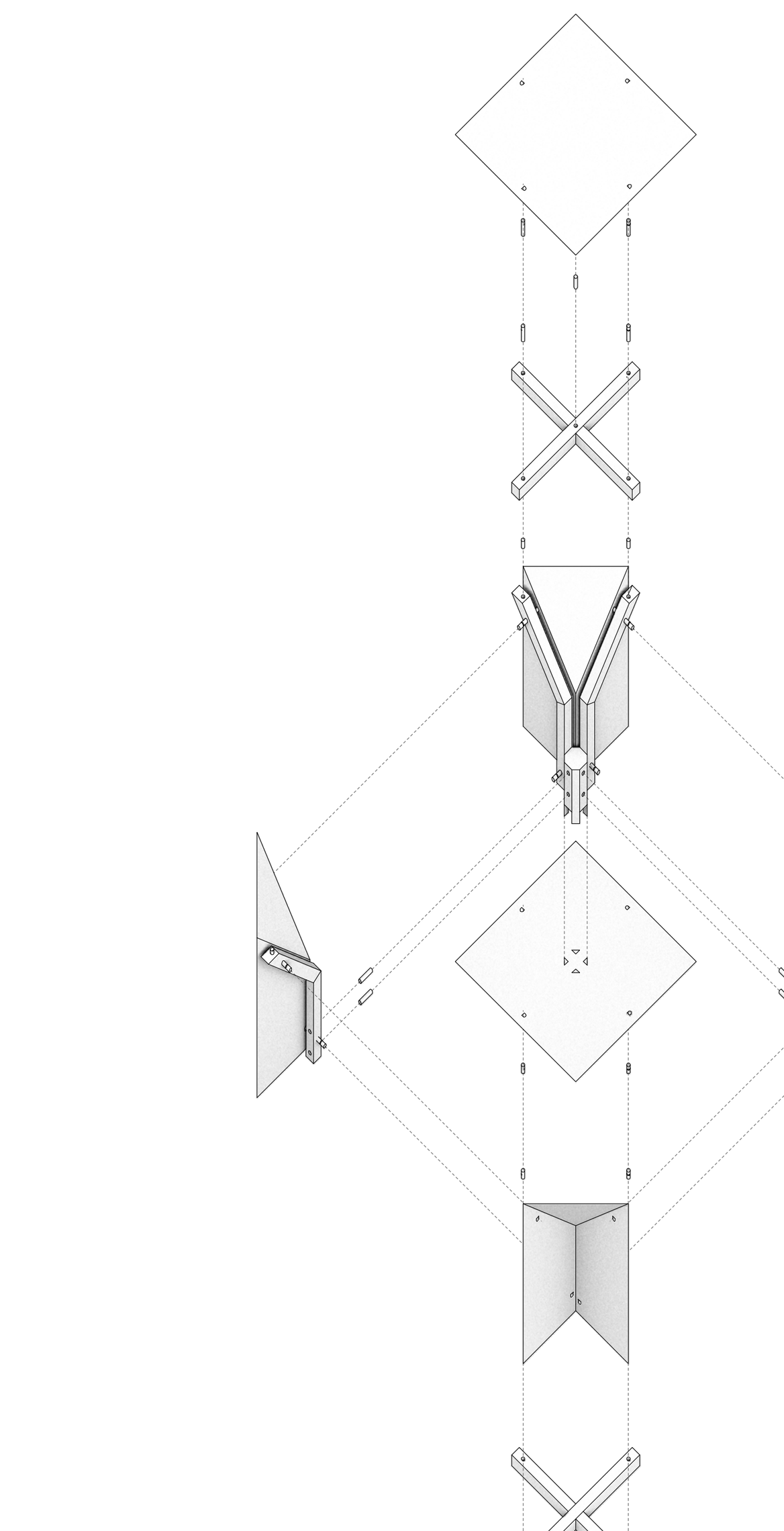
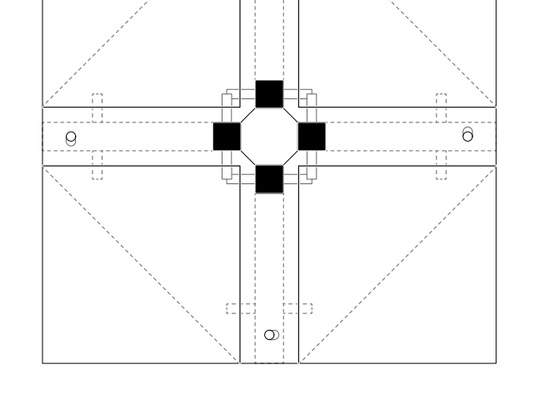
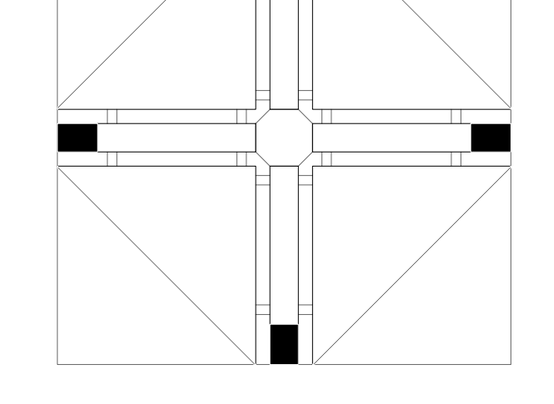
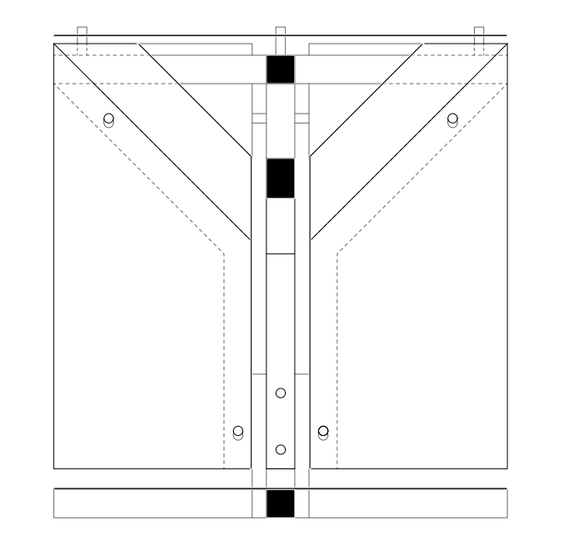




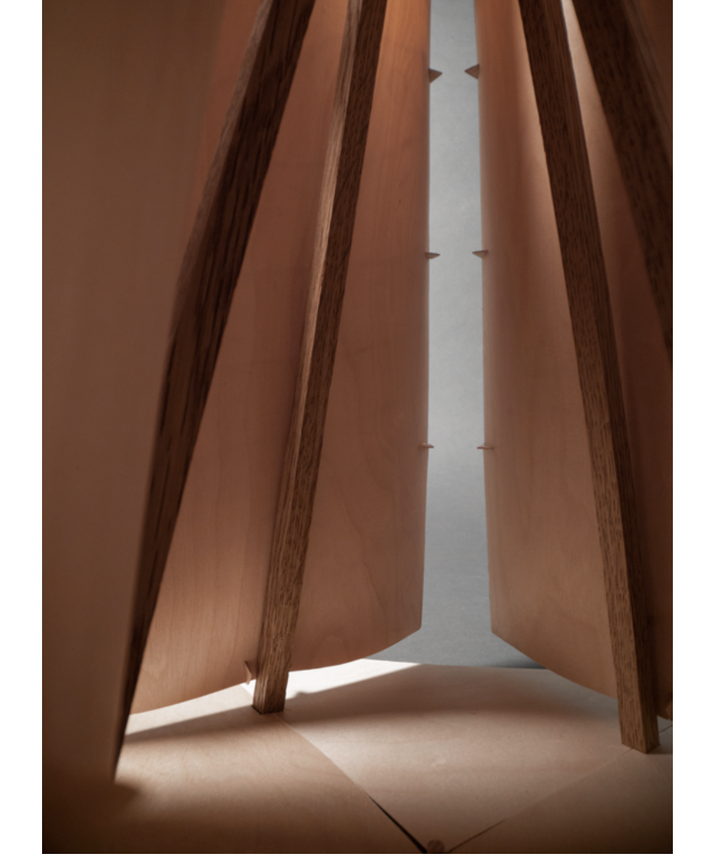
Plan_Ground



Plan_Top



Section



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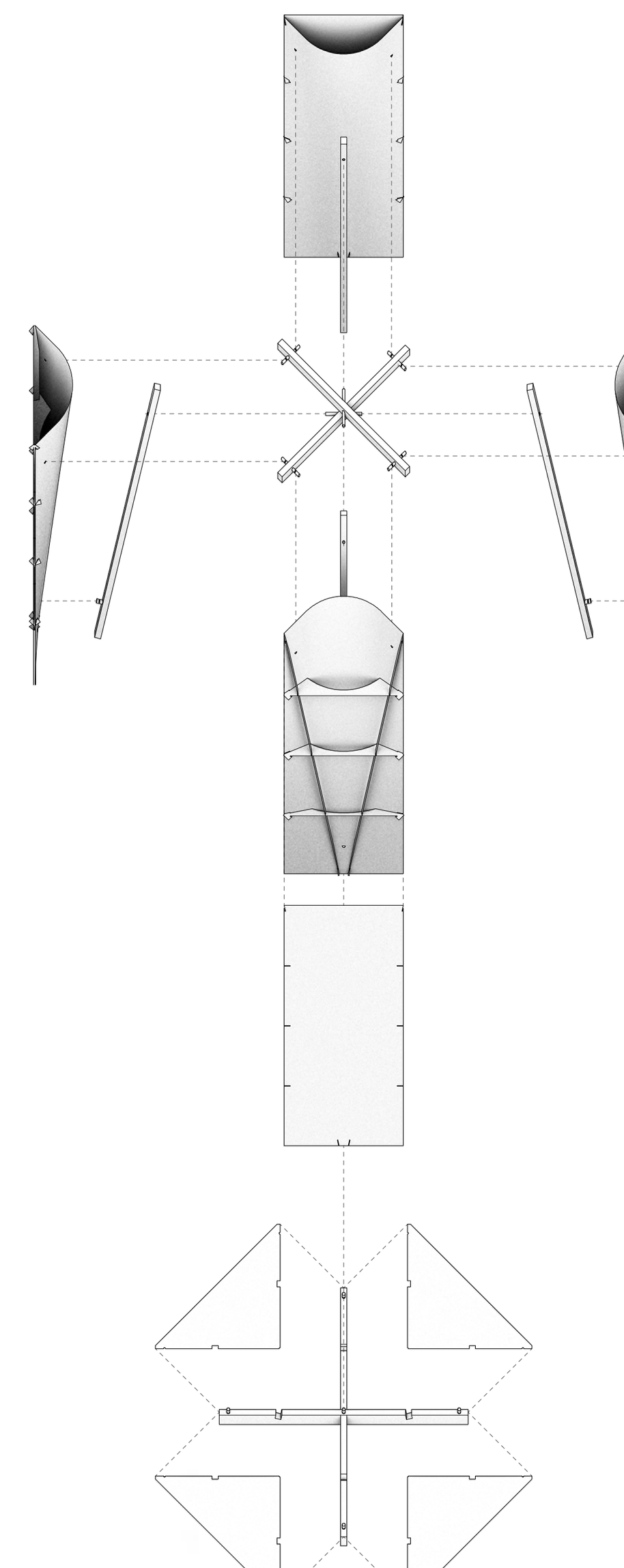
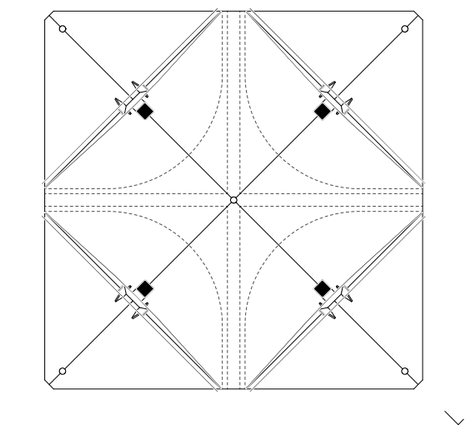
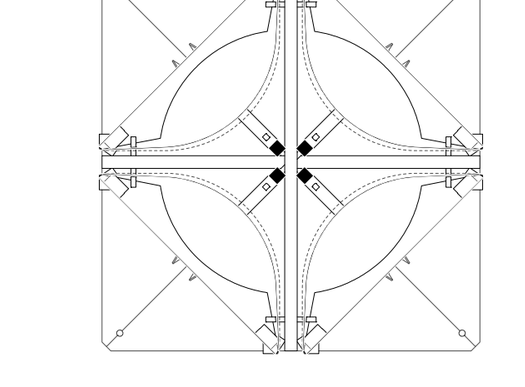
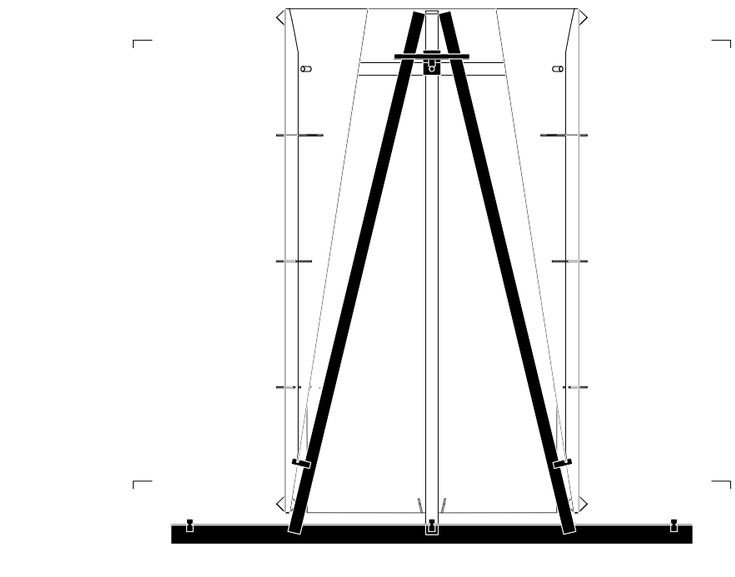




Plan_Ground



Plan_Top



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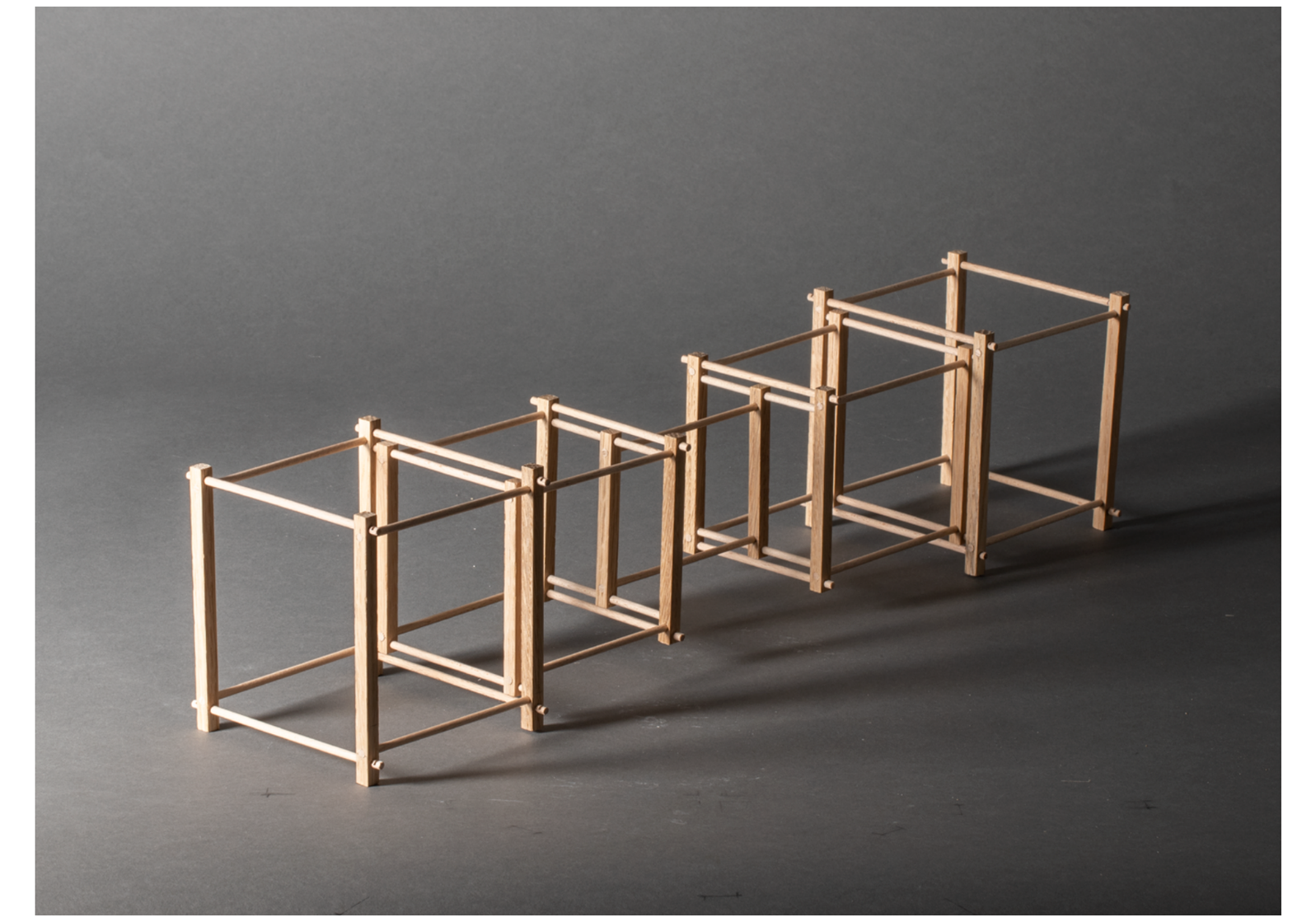
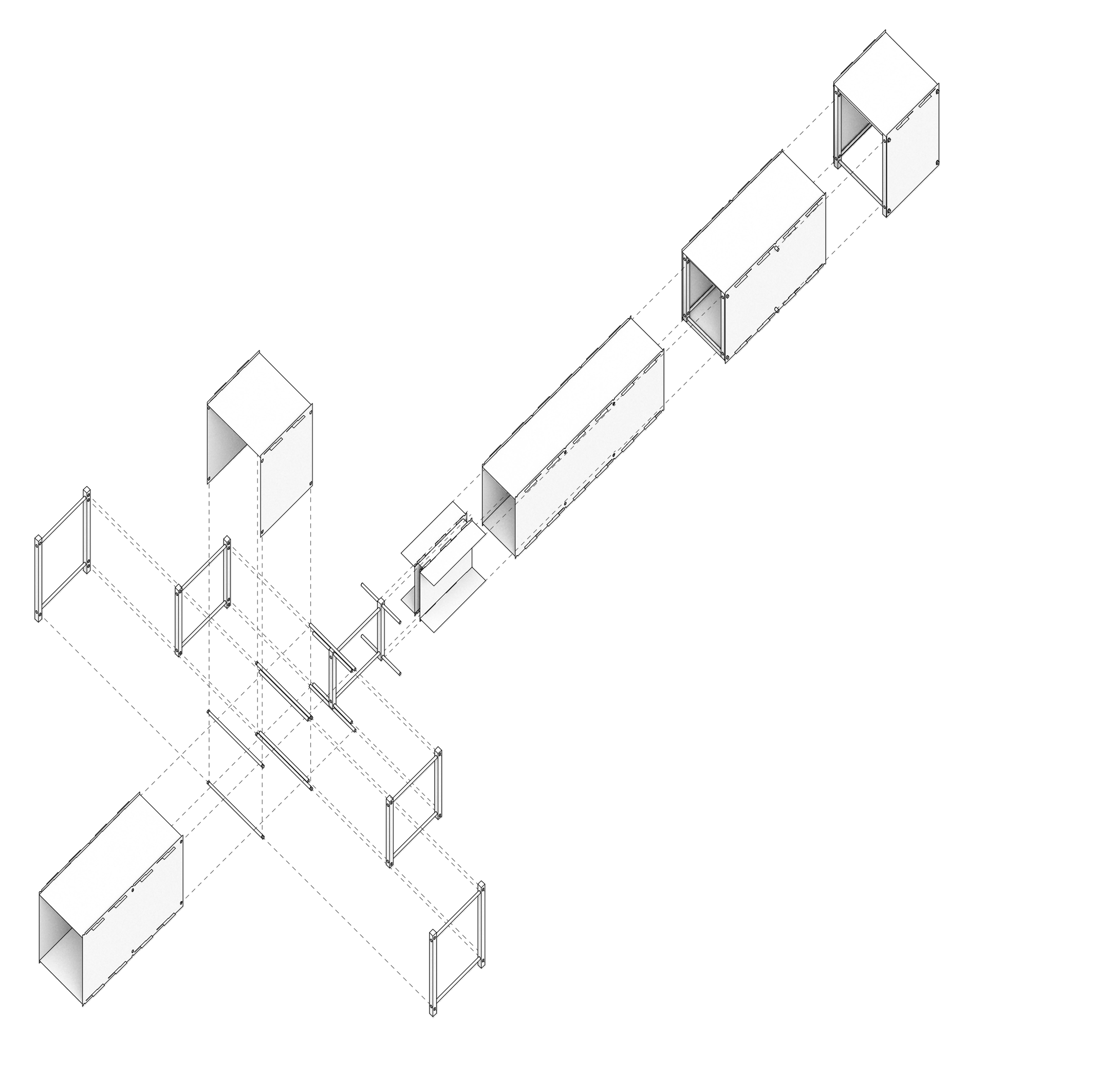
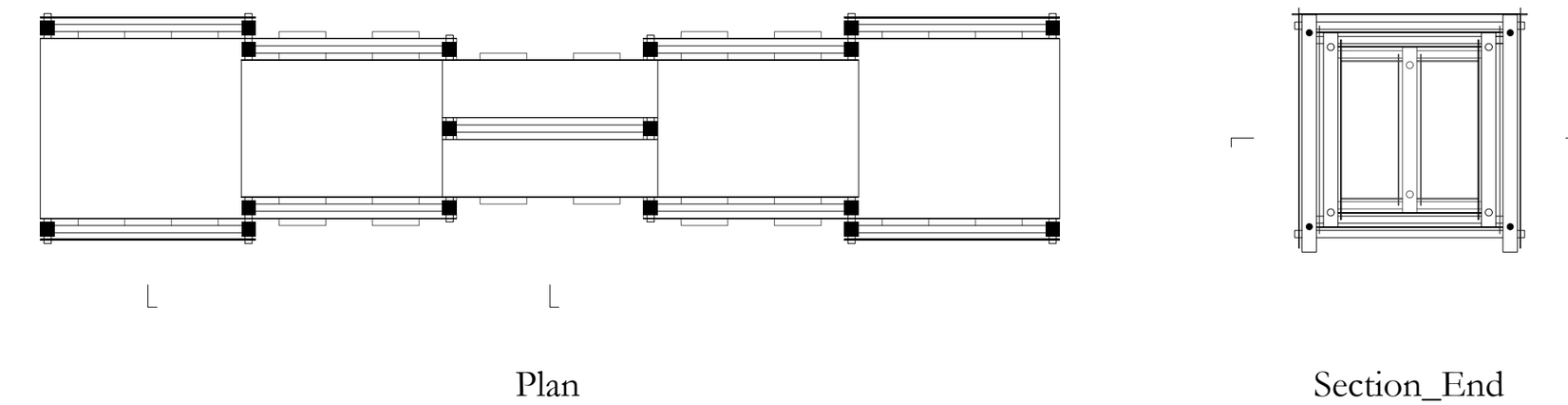
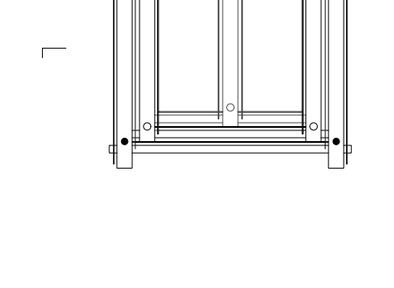


Passage_1

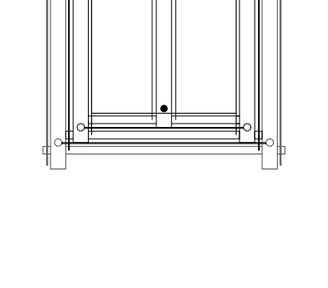




Plan

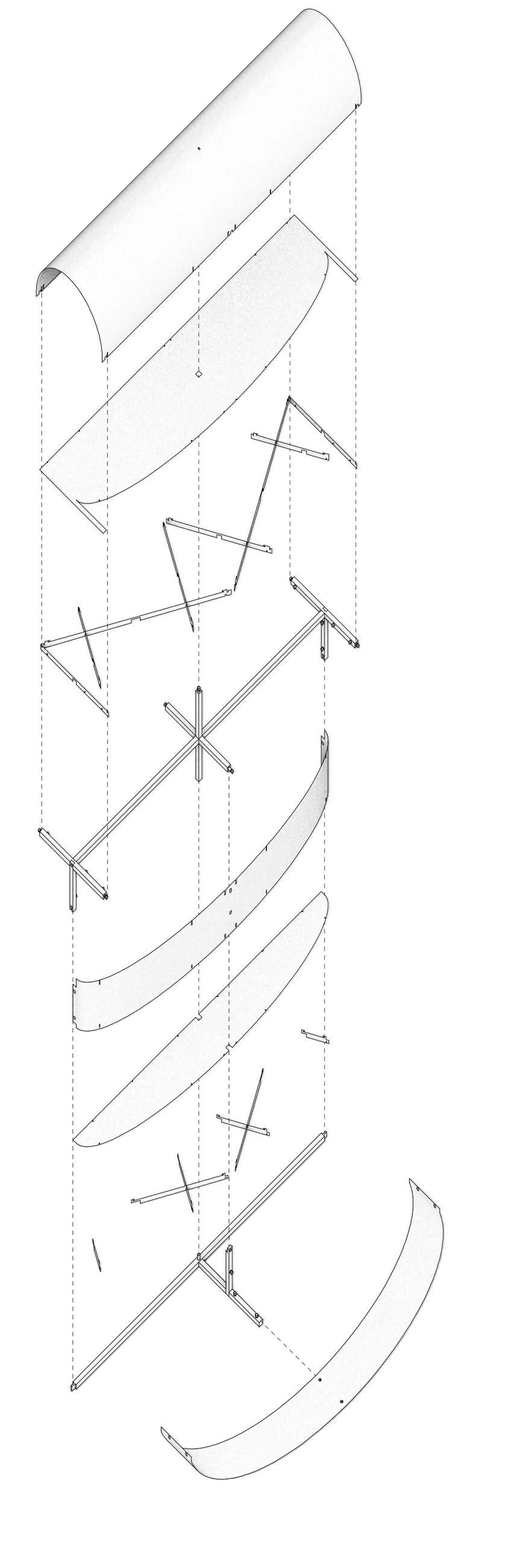


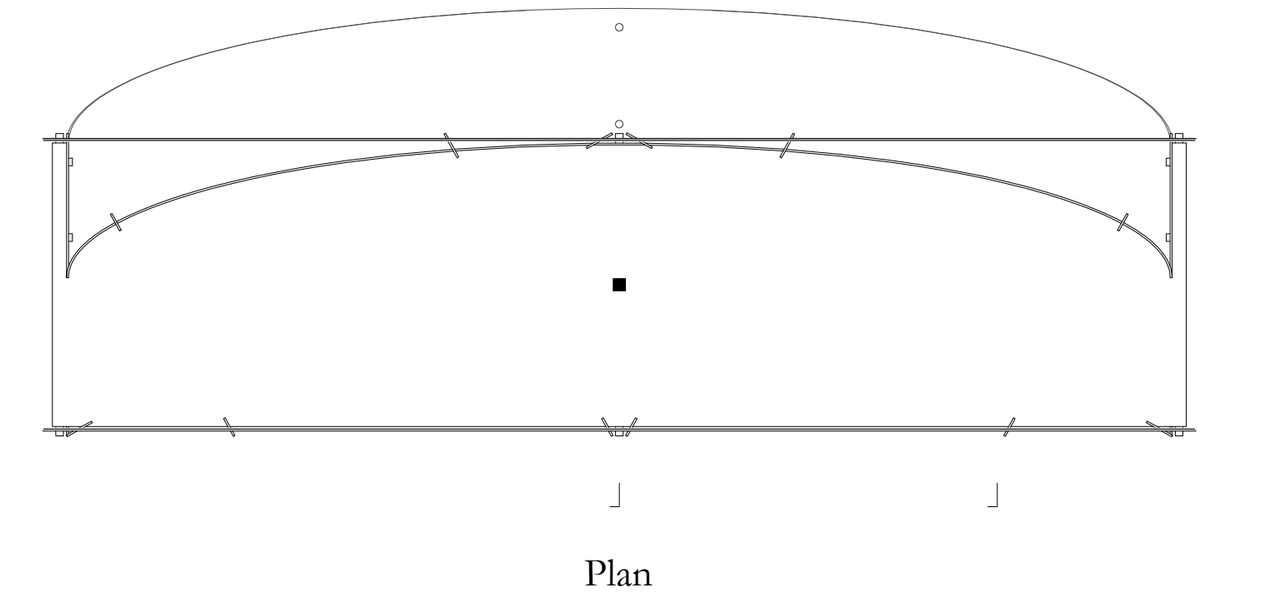
Section_End



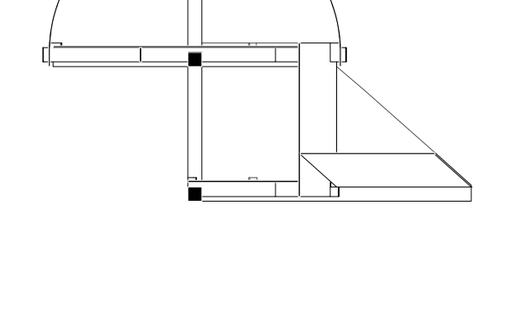
Section_Middle

Passage_2

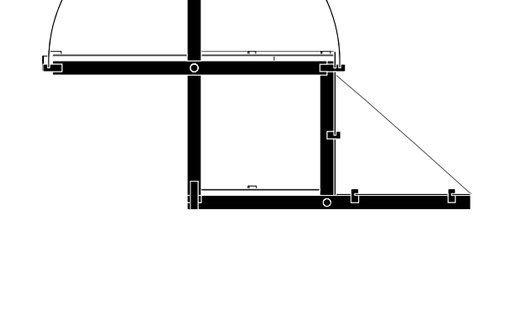




Plan



Section_End

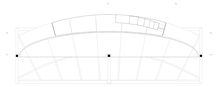


Section_Middle

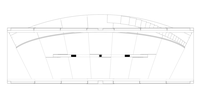
Ground Space

Top Speae

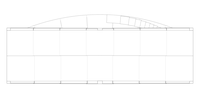
Ramp / Stair



Plan_ Ground

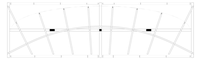


Plan_ Top

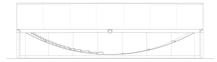


Roof Plan

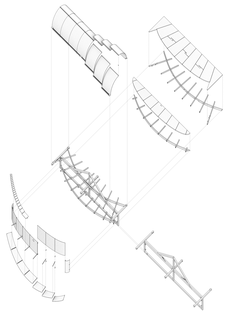
Structure Plan_ Ground



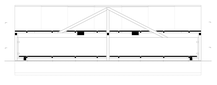
Structure Plan_ Top



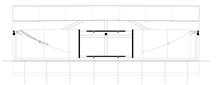
Elevation_Stair



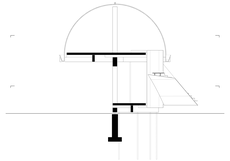
Axonometric



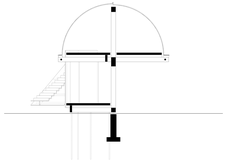
Section 1



Section 2



Section 3



Section 4