05
Topology & Pattern

Filament Winding Structure Design

Academic Team Work
Date : Nov 2019
Site : Shanghai, China
Contributions: form finding, parametric programming, pattern design, syntax design, physical-weaving models
Collaborated with ROBOTICPLUS.AI
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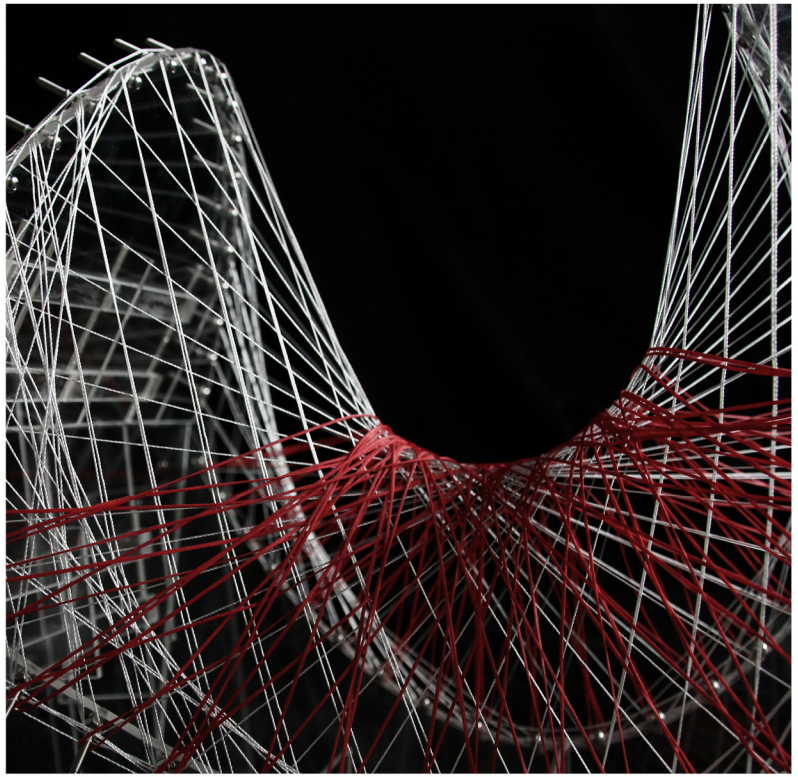
(As the chief designer collaborated with Yicheng Zhang, Pinzhen Li)

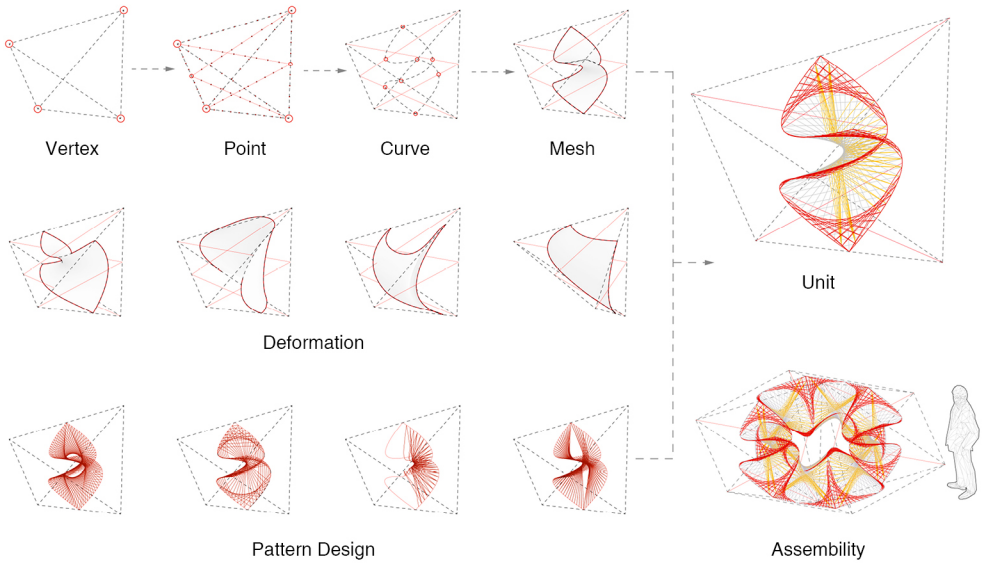
This is a collaboration between topology and architecture, a manifesto for endless possibilities for space design with filament winding structure.

Like the butterfly effect, a little flap of weaving points will create continuous topological variation that engenders infinite spatial experiences. These topologies can be transformed into different scales for human use and mudular systems accordingly.

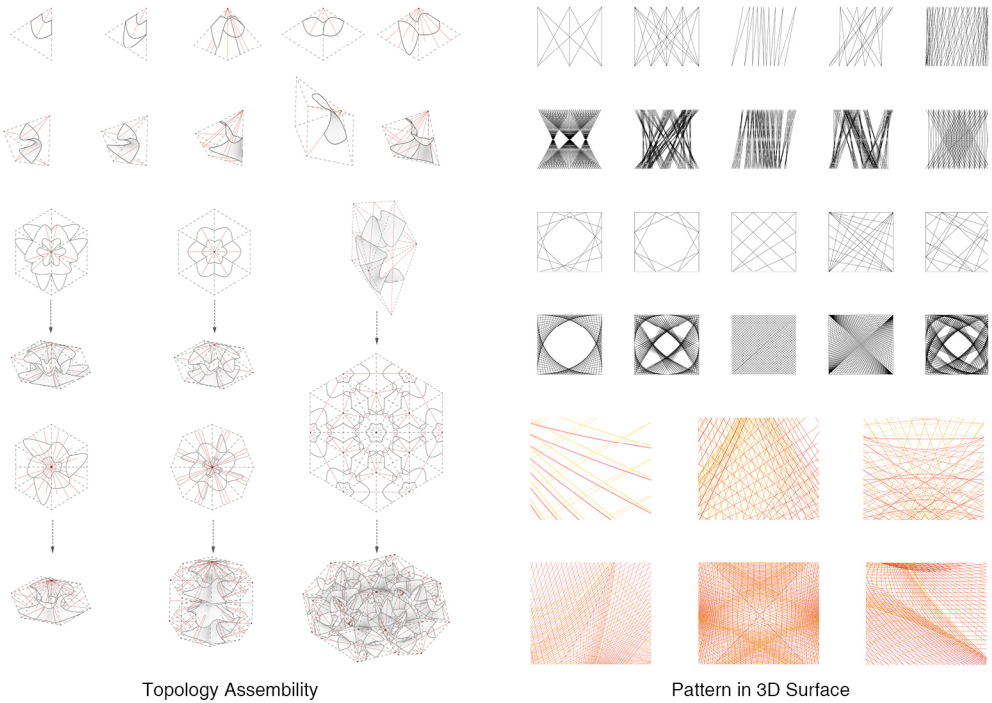
Inspired by ICD's experiments on filament winding structure design and the studio "Material Performance" in GSD, the final design is achieved by simulating woven carbon fiber and glass fiber with a robotic arm, so that the weave pattern means not only a decoration, but a space with internal structural characteristics. Throughout the process, we constantly adjust the fiber weaving sequence and perform stress analysis of mechanics to obtain the most aesthetic form and the design prototype that best fits in the structural logic.



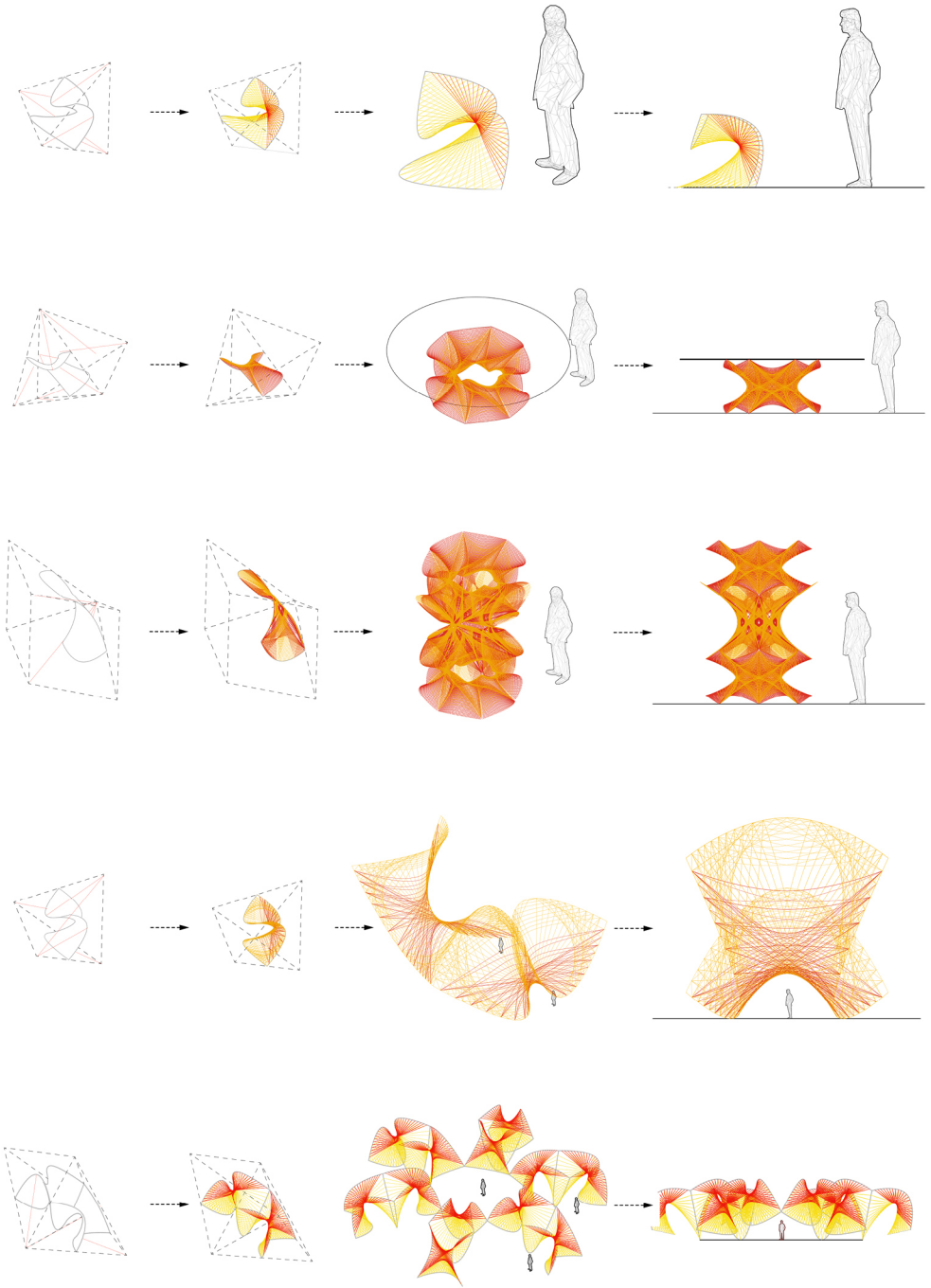
Weaving Principle

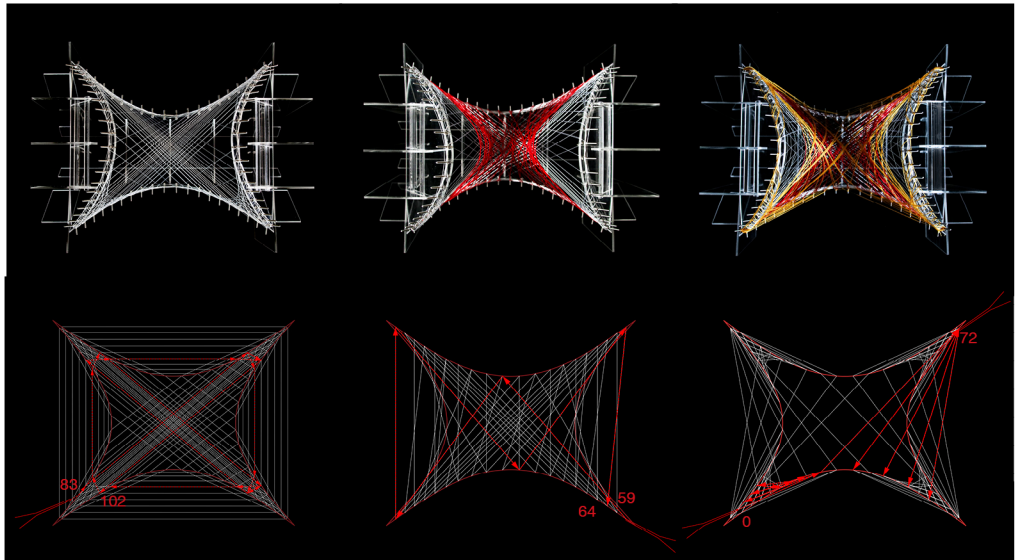


Topology & Pattern Study



Scale Perception Design



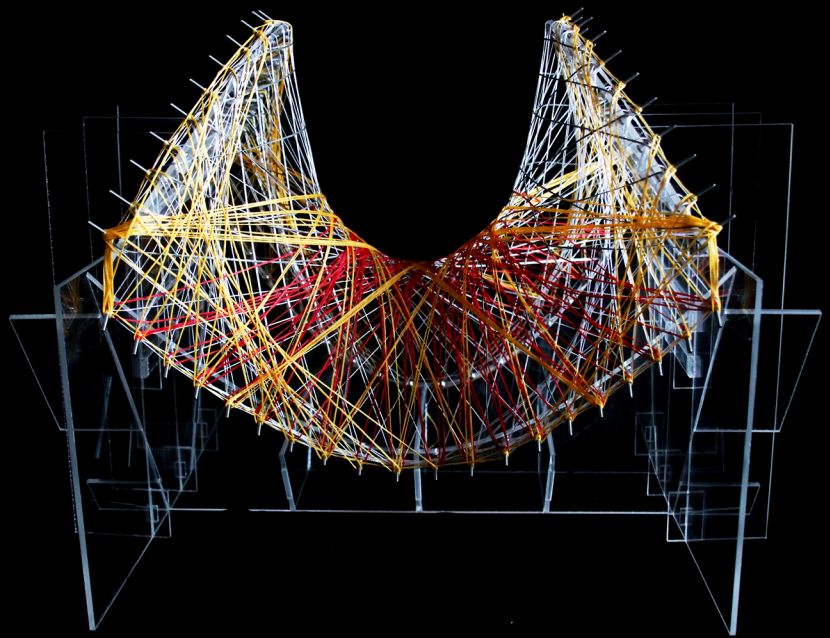


Step 1 : Glass Fiber

Step 2 : Carbon Fiber I

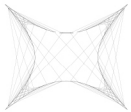
Step 3 : Carbon Fibe II

Winding Syntax



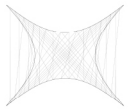
Experimental Model

Pattern Layering



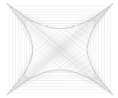
Carbon Fiber I

To avoid the deformation of corners, points on the corners are reversedly weaved to create an X-cross. Four vertices are also stengthened seperately.



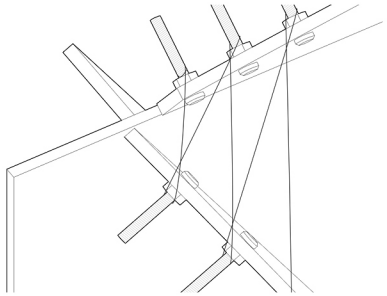
Glass Fiber II

To reinforce the structure of the minimal surface, this layer's pattern syntax is divided into 10 groups to strengthen B&D curves.



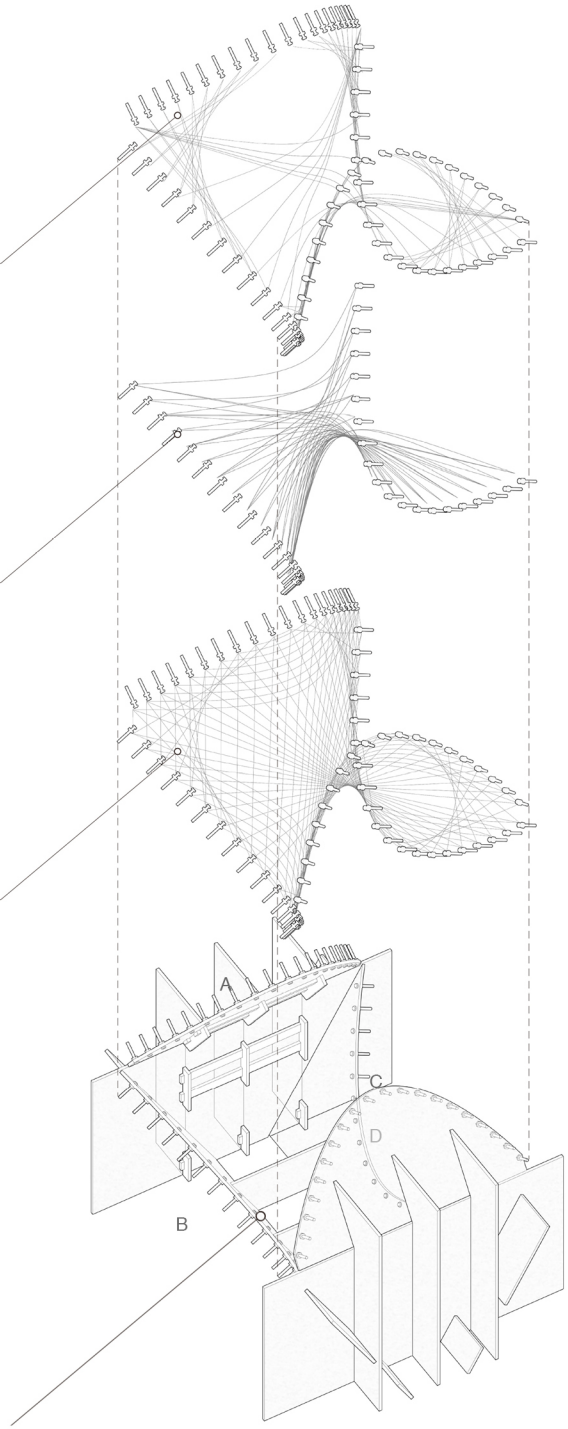
Glass Fiber I

To form the shape of saddle surface,10 groups of fiber curves are intertwined weaved.



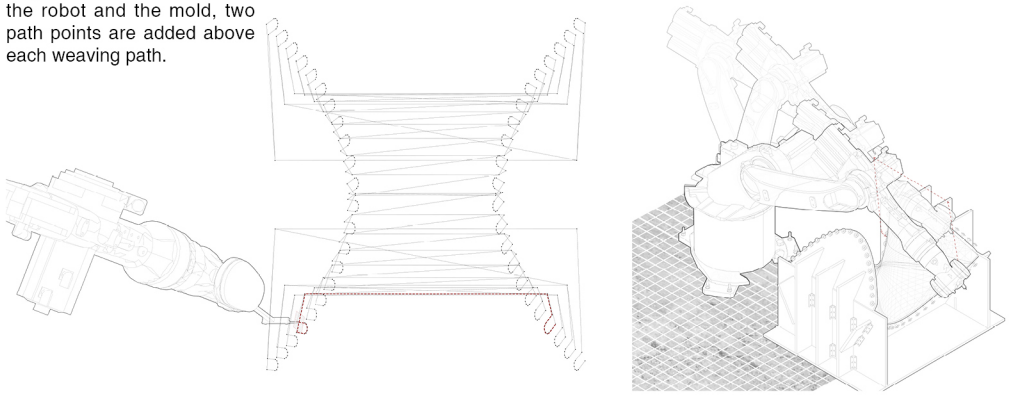
1:2 Acryl Support

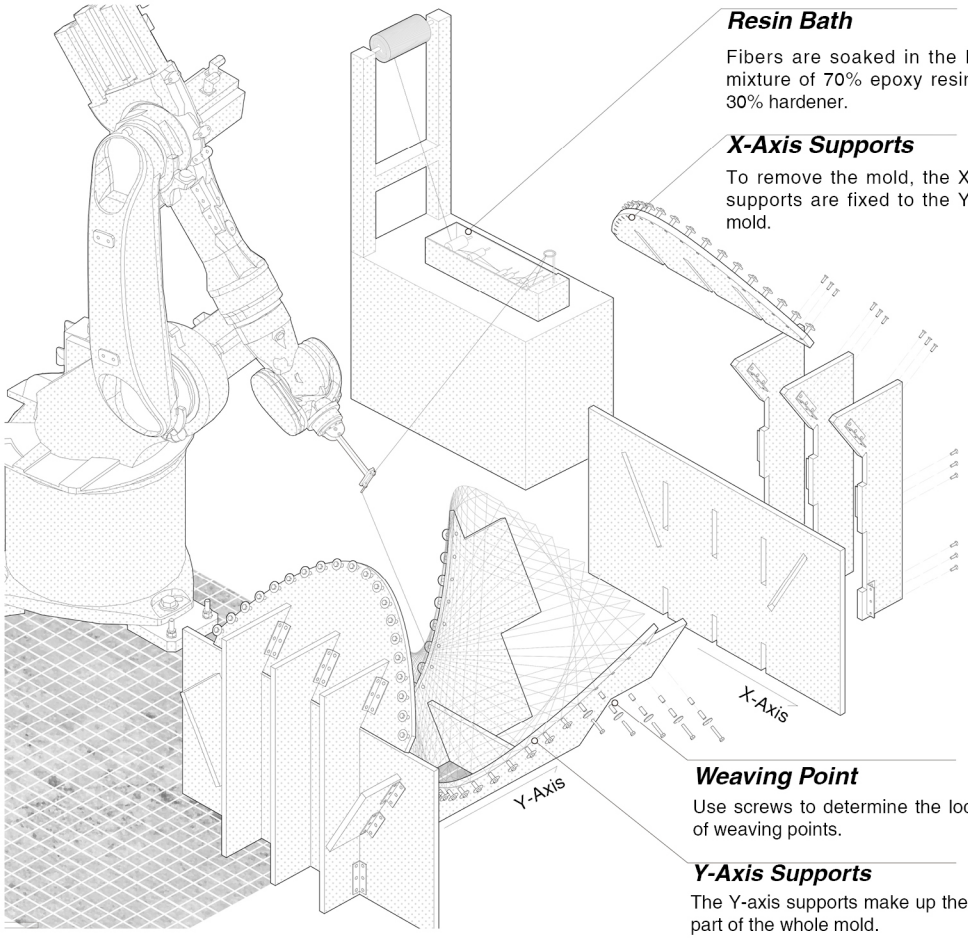
Using transparent Acryl, the weaving pattern can be seen from all angles. 20 screws are installed along each curve to bind the weaving lines.



Robot Simulation

To prevent collisions between the robot and the mold, two path points are added above each weaving path.





Resin Bath

Fibers are soaked in the liquid mixture of 70% epoxy resin and 30% hardener.

X-Axis Supports

To remove the mold, the X-axis supports are fixed to the Y-axis mold.

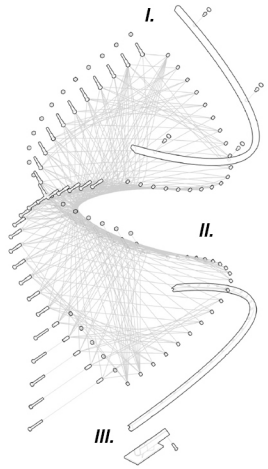
Weaving Point

Use screws to determine the location of weaving points.

Y-Axis Supports

The Y-axis supports make up the main part of the whole mold.

Modular Design



I. Edge Strip + LED Light

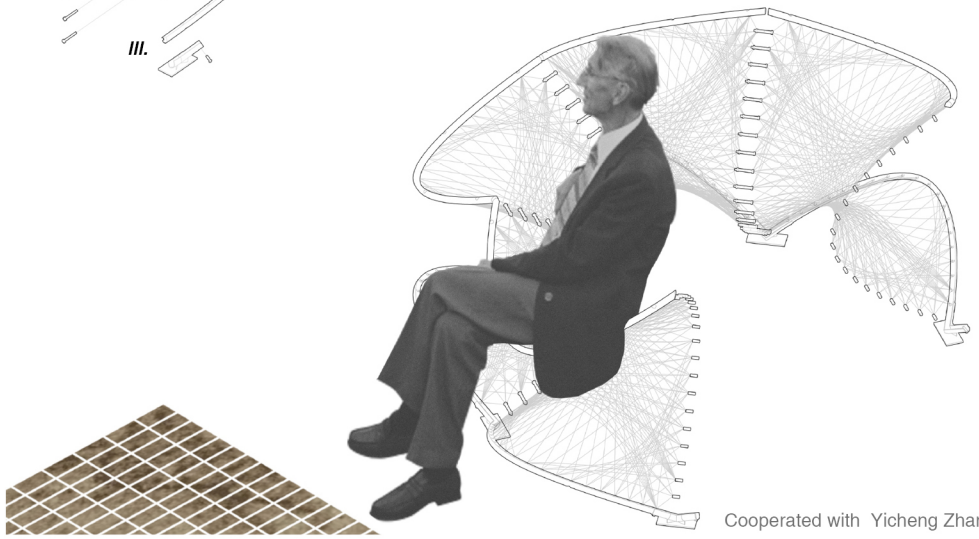
The edge strip can be made from wood or mentals. This detail design ensures that the whole seat can be used normally.

II. Mental Joints

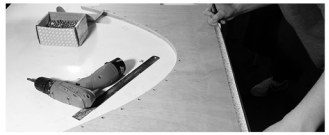
The mental joint includes screws and casings, which are the main connections between two units.

III. Grounding Detail

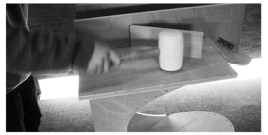
Custimized mental joints are adopted to immobilize the seat, making it stable. The joints are also used in connecting each unit.

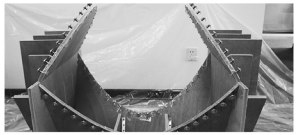


Cooperated with Yicheng Zhang

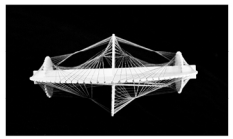
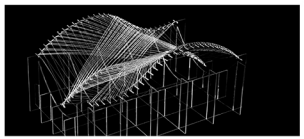
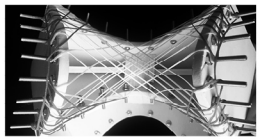
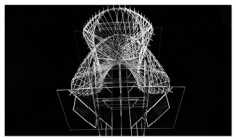
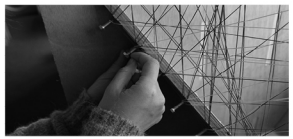


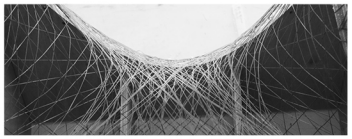




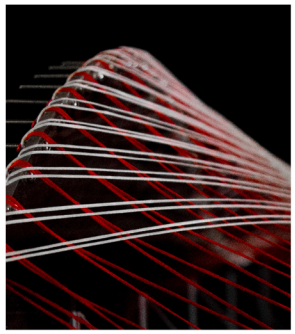
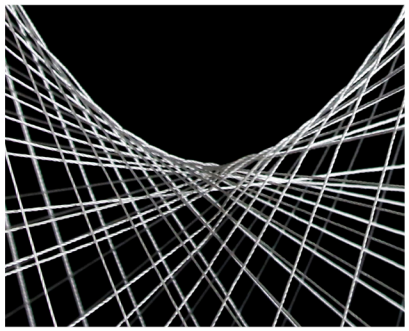
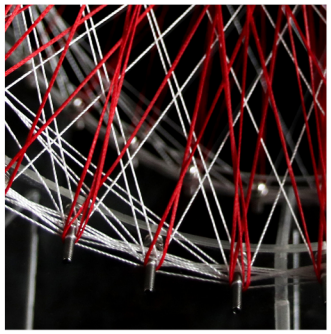
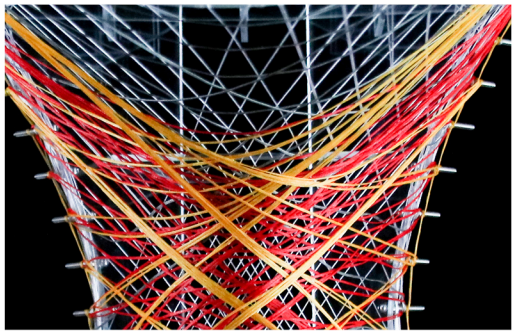


Support Design

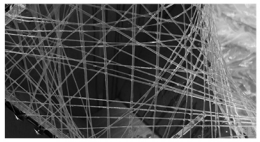


Syntax Design

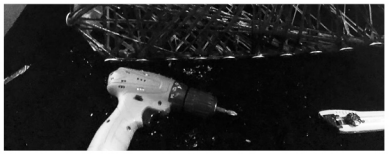

Weaving Pattern

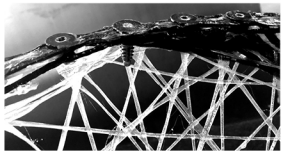


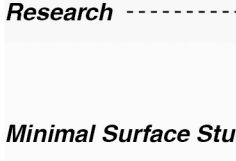

Filament Winding

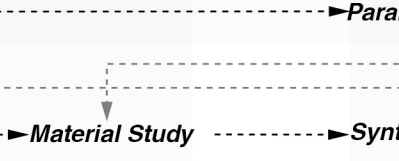


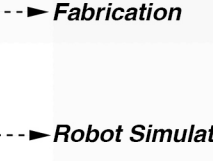


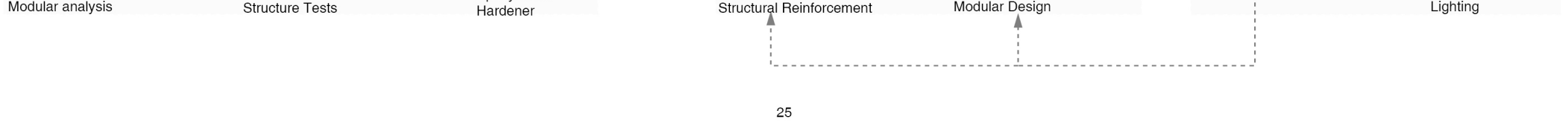



Demolding





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