Sparse Matter for Concentrated Natures

Reimagining the Chinese Garden through an Exploration of Materially-Efficient Design Processes

University of Miami School of Architecture
ARC 699 – Directed Research / Pre-thesis
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Team Members: Xuan Bo / Xiaofan Liu / Liwan Wang / Wei Wang

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01.

INTRODUCTION

Sparse Matter for Concentrated Natures

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By research studio
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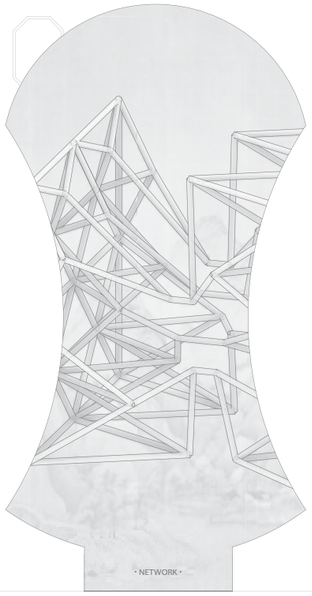
Abstract

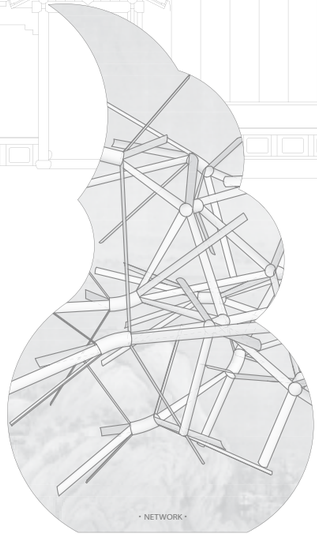
This research studio aims to develop specific materially-driven design techniques, elaborate on their potential outcomes, test them at full-scale, and deploy them as a means to reimagine the Chinese garden in contemporary terms.

The materially-driven process is the proposed method which asks for shifting the role of material from an operator to the decision maker in architecture design. For a long time, as one of the four basic design elements, material has always been hiding behind form, space, and structure. However, As the ultimate carrier of the other three elements, material has the potential to be the “driver”. Since many economic and esthetic benefits have been found in our research, the new design process will probably unfold new design possibilities and innovation in making.

The three techniques, folding, inflation and network, are chosen to be studied and developed. With the techniques, new structures and forms which are transformed from natural materials will help designers to achieve the goal of “maximal performance with minimal resources” both in economic and spatial perspectives. Small-scale testing has been done as a technique learning process, and also a preparation for future full-scale outcomes.

A Chinese traditional garden will be a perfect test case for this design process because to some extent, the essences of the Chinese garden and the materially-driven process are same. Do artificial work with the most fundamental elements more naturally. The potential proposal of replacing elements with new materials will be a perfect experiment for testing the experiential power of these techniques with substance beyond mere novelty because it will create a new cultural and formal relationship between human and nature.





Materially-driven Process

After long-term development, the architecture world has almost reached a consensus about the typical design process. Generally speaking, it's mainly about four essential elements. Space, Form, Structure and Material. Usually, we will start our project from one aspect and then get the other three determined in a specific sequence. However, the conventional design process always begins with space, form or structure and then select the right materials for them. With the traditional methodology, we already have got a large number of successful architectures. For example, Farnsworth house of Mies, starts with space; Guggenheim museum of Gehry, starts with form; Milwaukee art museum of Calatrava, starts with structure. Without any doubt, they are all successful projects and beautiful buildings. However, we don't believe anyone would think that they are perfect. Farnsworth, amazing space but not a pleasant place to live in. Guggenheim museum, attractive shape but too formalistic. Milwaukee art museum, strong structure proposal but somehow still not jump out of the circle.

Since we definitely will exhaust all possibilities within the conventional design process. We need to change to explore more opportunities. In the past, materials are often considered at a later stage, resulting in only a few "good" materials being considered defined by the limitations of costs and manufacturing requirements. As one of the four basic architectural elements, material has been hiding behind the other three for such a long time. Therefore, we are proposing a reimagined design process, start with material. It doesn't mean that future design is just going to play with different materials. The materially-driven process is actually asking for shifting the role of material from an operator to the decision maker in architecture design. However, As the ultimate carrier of the other three elements, material has the potential to be the "driver". In this approach, material precedes form, space and structure. The material itself is the structure of material properties, and also a function of space and environmental performance that generates architectural form. Bringing materials at the early stage of the design process makes it possible to unfold new design possibilities and innovation in making.

Figure 1. Diagram of conventional design process

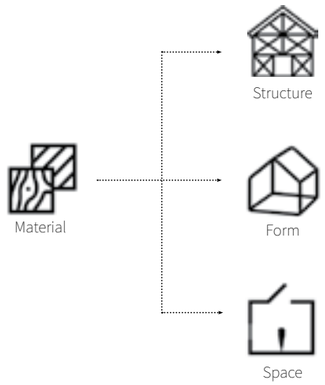


Figure 2. Diagram of Materially-driven design process

Figure 3. Farnsworth House, Mies van der Rohe, 1951

Figure 4. Guggenheim Museum, Frank Gehry, 1997

Figure 5. Milwaukee Art Museum, Santiago Calatrava, 1888

Significant Benefits

This new design process has more benefits than the traditional ones. First of all, we can fully study and take advantage of the characteristics of materials at the beginning of our design to achieve the goal of “maximal performance with minimal resources” and make it an economical design process.

Secondly, during the materially-driven process, we find that the characteristics of materials can be changed by changing their structures. For example, a paper is flexible. But it can be rigid after folding, which is quite different from its original statues. It illustrates that the same material can show distinct properties with different structures.

Thirdly, with the new design process, we can find a large number of unknown form possibilities in the future. Traditional design techniques often lead to thinking stereotypes. However, if we make materials as the driver of design, we can develop it with a new way of thinking and then exploring the infinite possibilities of the forms.

What’s more, there are many examples of this materially-driven process in nature. Many creatures rely on the benefit of it for their living, which shows the process is feasible and useful. For example, although the eggshell is very thin and light, it is strong enough to protect the yolk and let the air go through for the breath. This is because eggshells have unique microstructures under microscopic scale; Insect wings are very soft and folded in their infancy but sturdy and stretched in the maturity. It is the result of the development of the folding structure of the wings; The puffer fish will have a stress reaction and inflate itself to become bigger when it feels danger. The puffer fish will seem not easy to prey so it can escape from the danger. These are all good examples of benefits in the materially-driven process.

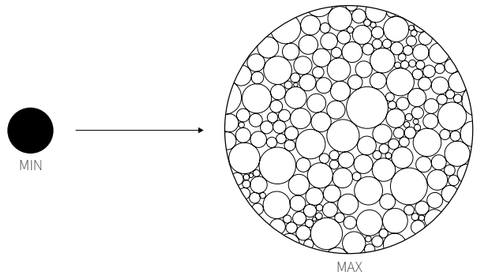


Figure 6. Diagram of economic significance

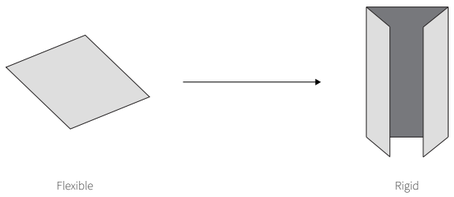


Figure 7. Diagram of structural significance

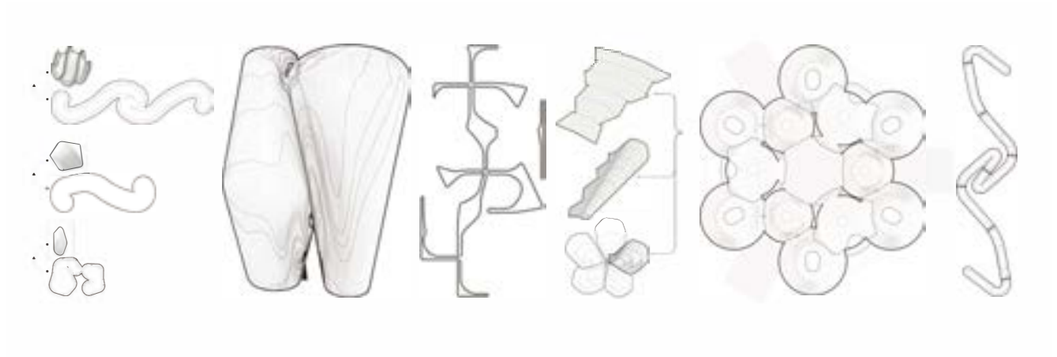


Figure 8. Diagram of possibilities of form

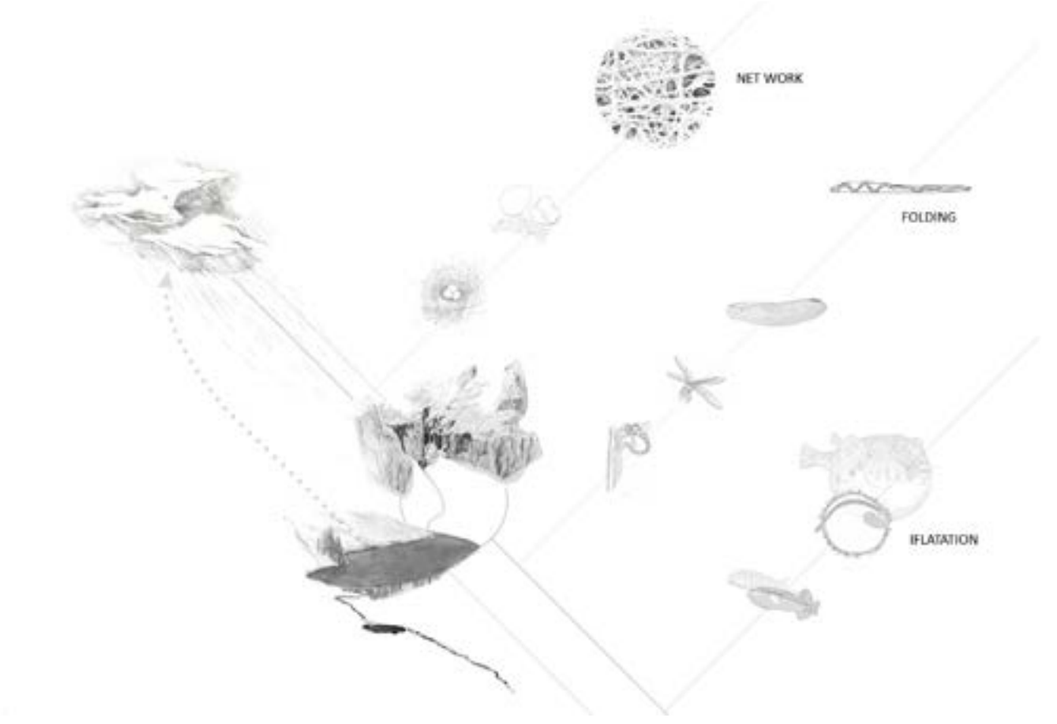


Figure 9. Self-organising systems in technology

Chinese Traditional Garden

An ancient Chinese legend played an important part in early garden design, an island Penglai were palaces of gold and silver, with jewels on the trees. There was no pain, no winter, wine glasses and rice bowls were always full, and fruits, when eaten, granted eternal life. First Emperor of Qin created a replica of Penglai, symbolizing his search for paradise. Since then, Chinese gardens always have beautiful implication.

The Chinese classical garden had multiple functions. It could be used for banquets, celebrations, reunions, or romance. It could be used to find solitude and for contemplation. It was a calm place for painting, poetry, calligraphy, and music, and for studying classic texts. It was a place for drinking tea and for poets to become happily drunk on wine. It was a showcase to display the cultivation and aesthetic taste of the owner.

In literature, gardens were frequently the subject of the genre of poetry called "Tianyuan", literally 'fields and gardens,' The landscape painter Shitao wrote that: "to express a universe inaccessible to man, without any route that led there, like the isles of Bohai, Penglan and Fanghu, where only the immortals can live, and which a man cannot imagine. That is the vertigo that exists in the natural universe. To express it in painting, you must show jagged peaks, precipices, hanging bridges, great chasms. For the effect to be truly marvelous, it must be done purely by the force of the brush." This was the emotion that garden designers wanted to create with their scholar rocks and miniature mountain ranges.

Another important garden element was concealment and surprise. The garden was not meant to be seen all at once, it was laid out to present a series of scenes. Jesuit priest Jean Denis Attiret, who lived in China from 1739, observed there was a "beautiful disorder, an anti-symmetry" in the Chinese garden. "One admires the art with which this irregularity is carried out. Everything is in good taste, and so well arranged, that there is not a single view from which all the beauty can be seen; you have to see it piece by piece."

A more recent view of the garden was expressed by Zhou Ganzhi, the President of the Chinese Society of Landscape Architecture, "Chinese classical gardens are a perfect integration of nature and work by man. They are an imitation of nature, and fully manifest the beauty of nature. They can also be seen as an improvement on nature; one from which the light of human artistic genius shines."

Figure 10. Picture of "Liu Garden"

Figure 11. Mirror view of Chinese Garden

Figure 12. Winter view of Chinese Garden

Proposal

We are human, and we would like to communicate with nature. Chinese ancients create an idealized miniature landscape, which is meant to express the harmony that should exist between human and nature. So, we would like to explore a new way to rebuild Chinese garden, expressing concept of “human, building and nature”.

A typical Chinese garden is enclosed by walls and includes one or more ponds, rock works, trees and flowers, and an assortment of halls and pavilions within the garden, connected by winding paths and zig-zag galleries. Through we analyze a typical Chinese garden, Yan’s family Garden, located in Suzhou in China, we try to figure out what main elements are, and how they are organized in a highly unified poetic space created with the combination of scale, proportion and rhythm. The main six elements are “Grid” - Wall, “Counter” – Building, “Path” - Zig-zag Gallery, “Water” – Pond, “Mountain” - Rock Work, “Plant” - Tree/ Flower.

Because of the great cultural and formal content in the garden, testing the experiential power of the techniques there will be with substance beyond mere novelty. What is the new Chinese garden? How to formalize the techniques to achieve beauty and poetry presented in this idealized miniature landscape? We bring these questions to think about how to rebuild Chinese Garden in further design.

We can image rock works changed by our network, or we can think about to create infallible balls on the pounds, where are air and water. And we can find a new way, such as knitting covering installation, to redesign pavilions. Even we build a space with unfolding paper to deliver old gallery in garden. We can not only represent the elements of Chinese Garden by new techniques, but also create new memory for tour in it. Image that, we try to bring new blood to Chinese garden to make the structure more flexible the form more possible and the experience more variable.

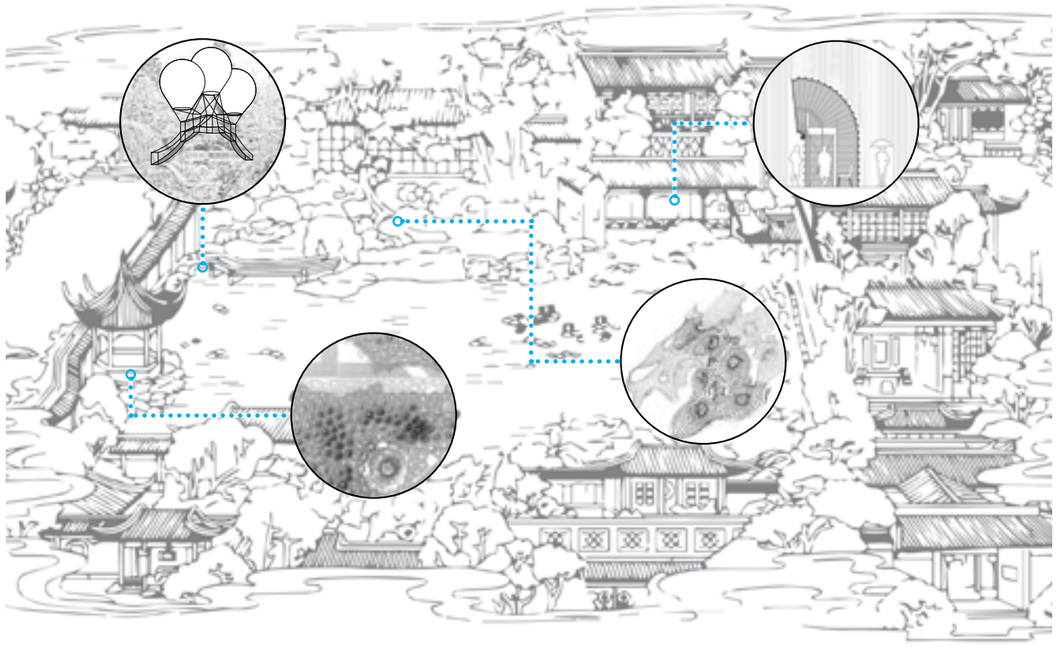


Figure 13. Collage of imagination between Chinese garden and new techniques

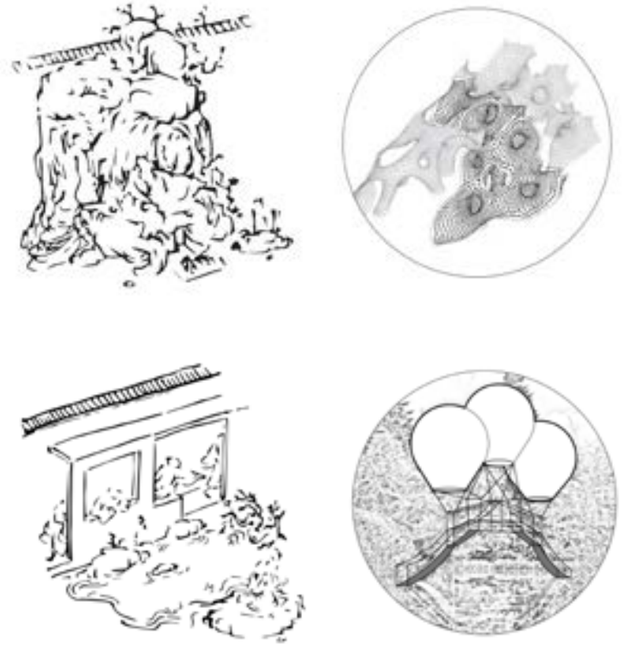


Figure 14. Potential replacement proposal

02.

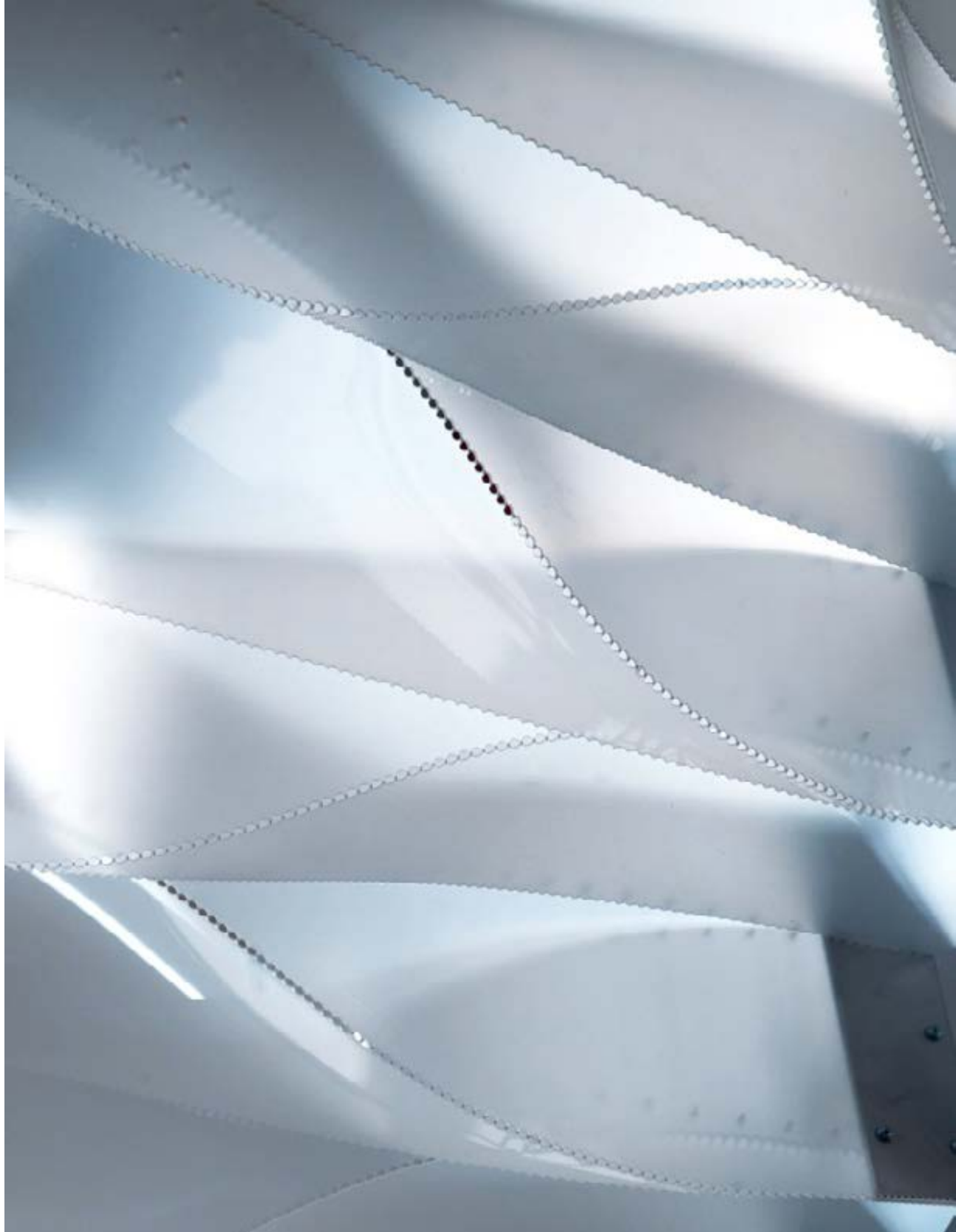
TECHNIQUES

Folding

Apparently, folding is everywhere in our everyday lives. However, it seems that folding has been absent in the architecture world for a long time.

Folding is a technique which could make 3D forms from 2D sheet materials. This explains why folding has not been highly developed or widely used. Sheet materials wasn't able to be part of common building materials because they lack the ability of self-supported. During the process of transforming sheet materials into 3D forms, the folding lines become the rigid structure of the new forms. The folding technique makes it possible to build with some unconventional sheet materials.

Generally, folding technique can be classified as Origami, Kirigami and Curved folding. These techniques need to be studied for future architecture design mainly for two reasons, possessing changeable architectural structure with advantages load-carrying capabilities and generating Esthetic and deployable architectural form.



Precedents

Bao Bao Bag
Issey Miyake/ 2000

Issey Miyake's Bao Bao brand is the first to depart from the classic tessellating triangular structure used since the design debuted in 2000.

Inspired by the metal panels that steelworkers fuse together to create structures, the triangles are attached to mesh cloth to give it movement and the feeling of lightness. Both light and soft, it folds, accommodates and transforms itself after handling to create dramatic new shapes.

The collection is an exceptional line of bags and pouches not only because of the three-dimensional feel mixed with the pixel pattern and futuristic tribute to origami art. Sustaining the creative functionality and modern spirit of our times the accessories by Issey Miyake indulges us in the inspiring game of transformation.

Following the key expression: "roll it, fold it, lay it down and hold it", Bao Bao Issey Miyake extends the meaning of accessories implementing the concept of functional art into our hectic lifestyle. Get twisted into the flexibility of styling and diverse nature of bags that comes along with the vivid array of hues and various styles.

They are cleverly made up of repeating triangles that give the bag a unique flexible shape. The PVC panels mounted onto the fabric mesh underlayer of the bag cause it to take on different shapes as it is used.

Figure 15. The image of Bao Bao Bag

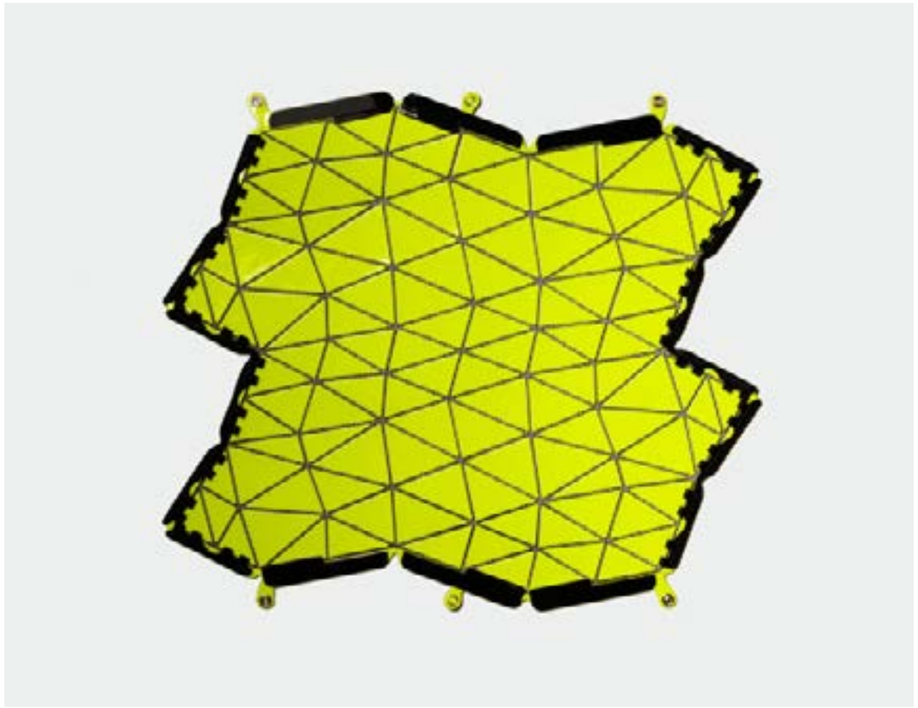


Figure 16. The changeable figures

Rising Furniture
Robert van Embricqs/ 2011

To create his innovative designs, the designer asked himself, “To what degree is the object you’re creating capable of dictating its own design?” Exploring this premise to the fullest, he sought inspiration in nature, observing the intricate transformations found in the natural world around him. So, he took a flat wooden surface and came up with an idea to create an incision pattern in it. By making a few cuts, he got beam-like strands of cut surfaces that could be pulled up. These “beams” revealed a preliminary frame of any customary chair composed of a seat, a back, and legs. The result appeared to be what the designer wanted it to be: thanks to a latticework of seemingly random wooden “beams” that merge to create various arches, the Rising Chair got its recognizable and distinctive organic shape.

Embricqs’ chairs, tables, and bowls start life as flat, single pieces of bamboo. The designer then carves incision paterns to create “woven” bamboo beams that elegantly transform into unique, functional pieces of furniture. Each piece then opens up to find its final form, like a flower in bloom. When not in use, they can be seamlessly folded back up again along barely visible hinges, concealing their secret structure.

Embricqs sees the collection as a collaboration between himself and the material, whereby the final outcome couldn’t be fully predicted. Explaining the end stage of creating a piece, he says, “I still didn’t know what shape the chair would take in the end. This was determined by the various arches of the wooden beams the chair is made of. Folding the chair into its definitive form, as a creator, a special connection to the material was born.”

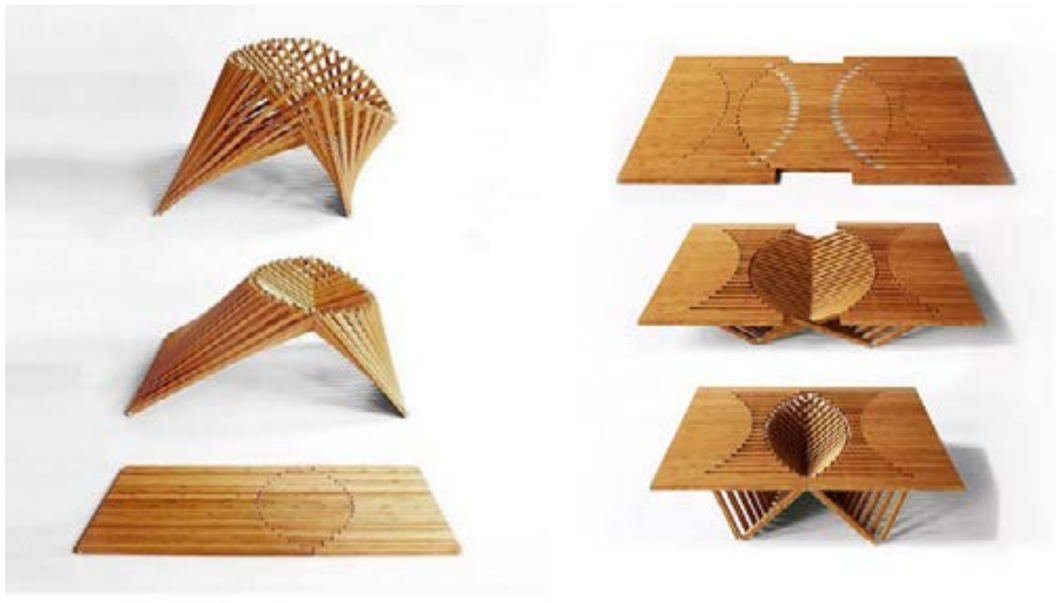
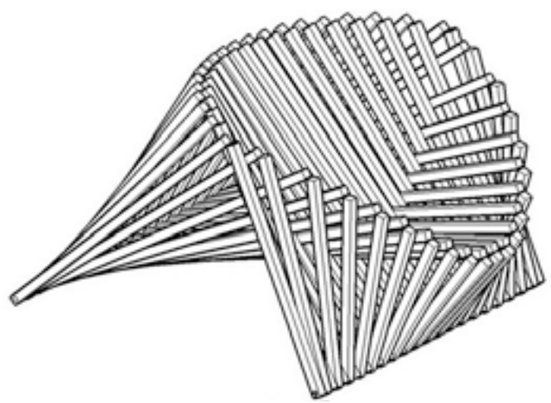


Figure 17. Rising furnitures



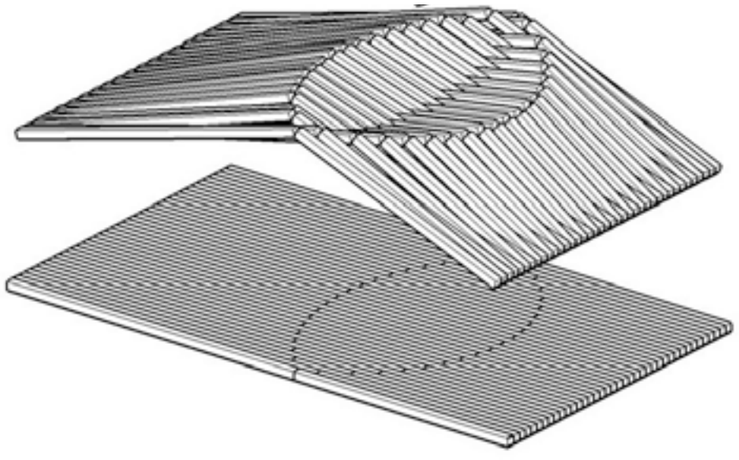


Figure 18. The different conditions of Rising Chair

Al Bahar Towers Responsive Facade
Aedas Architects/ 2012

Using a parametric description for the geometry of the actuated facade panels, the team was able to simulate their operation in response to sun exposure and changing incidence angles during the different days of the year.

The screen operates as a curtain wall, sitting two meters outside the buildings' exterior on an independent frame. Each triangle is coated with fiberglass and programmed to respond to the movement of the sun as a way to reduce solar gain and glare. In the evening, all the screens will close.

At night they will all fold, so they will all close, so you'll see more of the facade. As the sun rises in the morning in the east, the mashrabiya along the east of the building will all begin to close and as the sun moves round the building, then that whole vertical strip of mashrabiya will move with the sun.

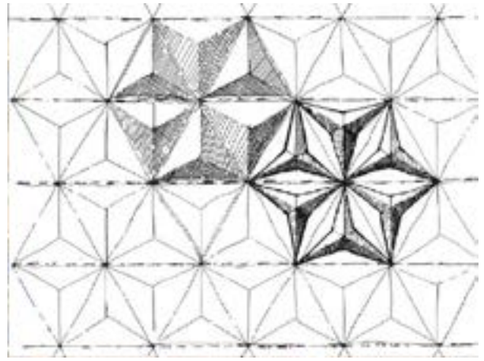


Figure 19. The sketch of figure facade

Figure 20. The picture of facade

Figure 21. Three Folding Panels

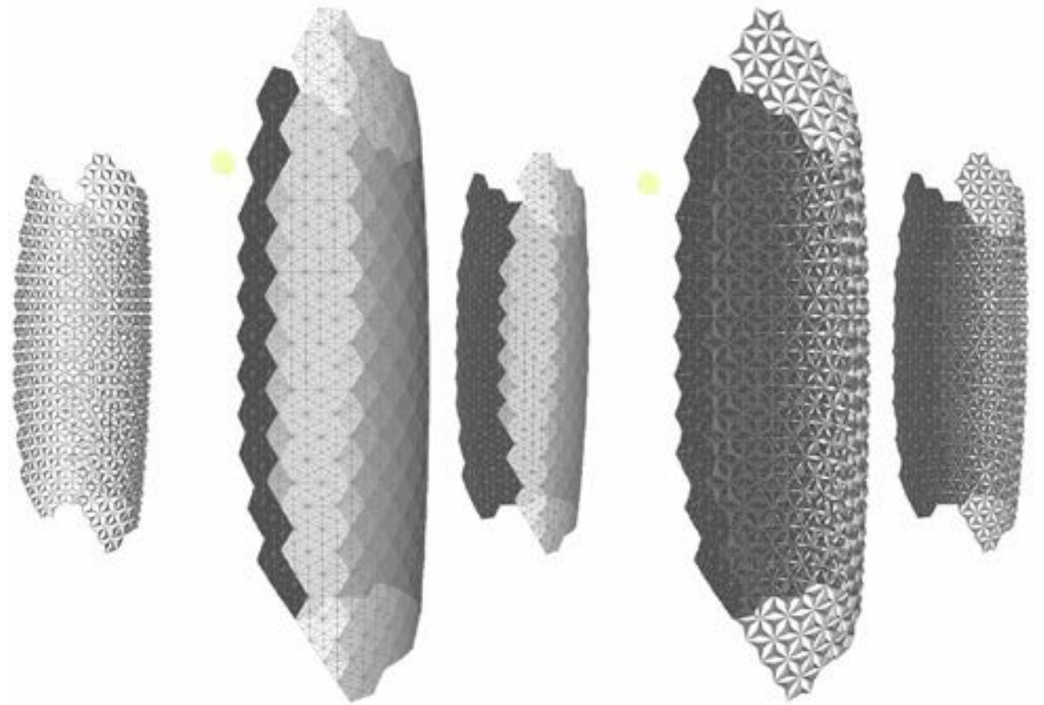


Figure 22. Folding component and different conditions of facade

Test

Test 1 Origami

Origami (from ori meaning “folding”, and kami meaning “paper”) is the art of paper folding, which is often associated with Japanese culture. In modern usage, the word “origami” is used as an inclusive term for all folding practices, regardless of their culture of origin. The goal is to transform a flat square sheet of paper into a finished sculpture through folding and sculpting techniques.

The small number of basic origami folds can be combined in a variety of ways to make intricate designs. The best-known origami model is the Japanese paper crane. In general, these designs begin with a square sheet of paper whose sides may be of different colors, prints, or patterns. Traditional Japanese origami, which has been practiced since the Edo period (1603–1867), has often been less strict about these conventions, sometimes cutting the paper or using nonsquare shapes to start with. The principles of origami are also used in stents, packaging and other engineering applications.

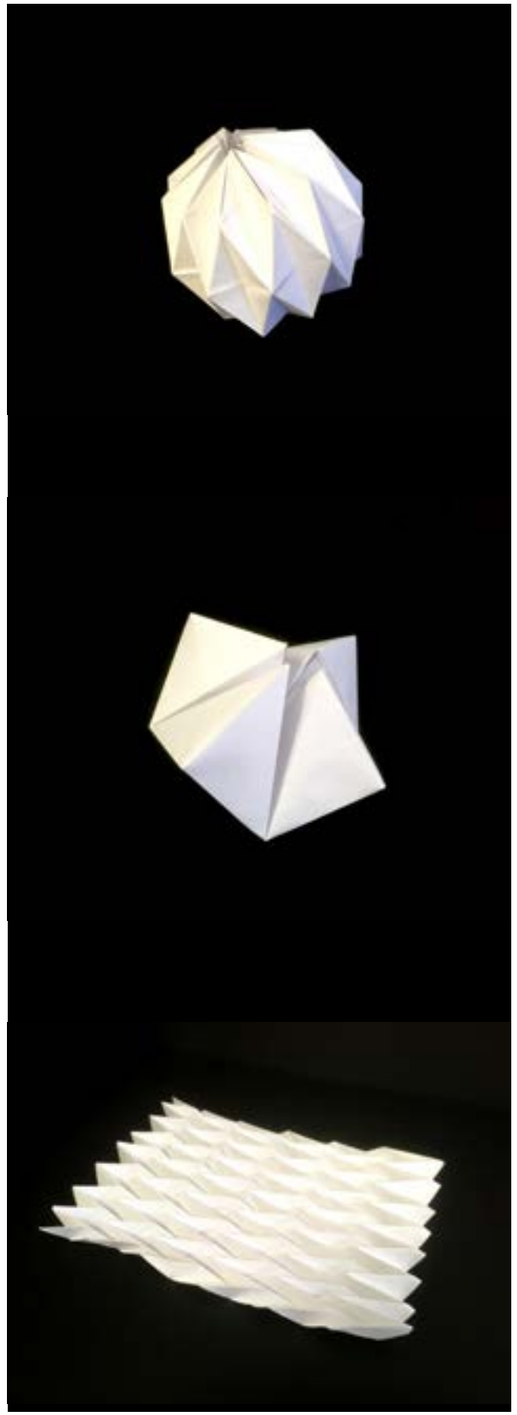


Figure 23. Test models of Origami

Test 2 Kirigami

Modern origami practitioners generally discourage the use of cuts, glue, or markings on the paper. Origami folders use nother Japanese word kirigami to refer to designs that includes cutting of the paper. Kirigami typically does not use glue either.

In the United States, the term “Kirigami” was coined by Florence Temko, from Japanese kiri “cut,” kami “paper”, in the title of her book, Kirigami, the Creative Art of Paper-cutting, 1962. The book was so successful that the word kirigami was accepted as the western name for the art of paper cutting.

Typically, kirigami starts with a folded base, which is then unfolded; cuts are then opened and flattened to make the finished kirigami. Simple Kirigami are usually symmetrical, such as snowflakes, pentagrams, or orchid blossoms. A difference between Kirigami and the art of “full base”, or 180 degree opening structures, is that Kirigami is made out of a single piece of paper that has then been cut.

Figure 24. Test models of Kirigami

Test 3 Curved Folding

The history of curved crease folding goes back to as early as the Bauhaus, where a student had scored circular creases onto a paper in order to study its materiality.

Curved folding is when the fold line is curved, which is more general and complex than conventional Origami. Actually, during the procedure of curved folding, both the fold line and faces between the folds change their curvature, which makes it difficult to use a geometric method to describe curved folding.

One of the most important concepts about curved folding is developable surface. It appears naturally when spatial objects are formed from planar sheets of material without stretching or tearing. The striking elegance of models folded from paper, such as those by David Huffman, arises particularly from creases known as curved folds. Such folds can be generated from a single planar sheet. Early investigations of curved folds are due to Huffman.

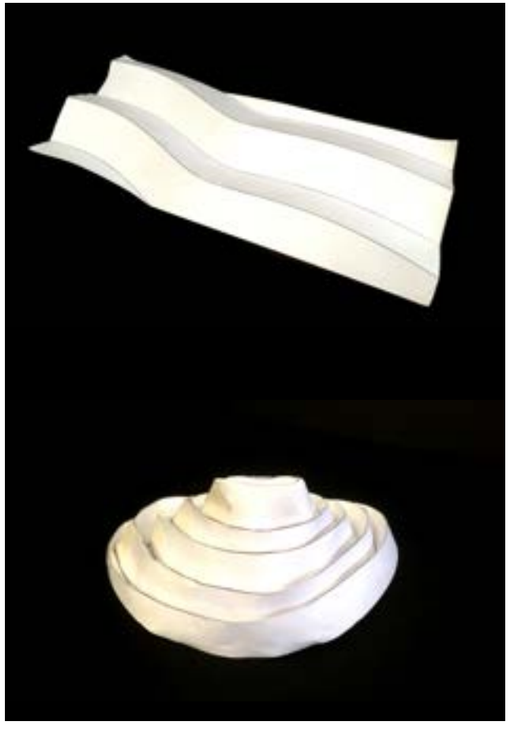


Figure 25. Test models of Curved folding

Test 4 Paper Guard

The concept of paper gourd is a reverse thinking of folding, could be called unfolding. The test was inspired by the paper sculpture of a Chinese artist, Li Hongbo. The essence of paper gourd is actually the honeycomb structure. Honeycomb paper is prevalent in various iterations of Chinese folk art, from children's toys to festive decorations. With the technique, Li creates kinetic paper works which elegantly expand, contract, and retract. Something interesting about honeycomb paper are how simply it is made and the amazing flexibility, resilience and strength of the paper once it is built into layers of hexagonal cubes.

Li creates a fascinating and unpredictable element in his paper sculptures as they stretch infinitely in many ways. Initially inspired by the tradition and the ubiquity that paper embodies, Hongbo plays with its appearance and connotations in order to create static sculptures that transform into unpredictable images, accentuating the difference between restriction and freedom.

The following diagram will show the process of how to make the honeycomb paper. With carving and different kinds of rotating, we will have many different results.

Figure 26. Lihongbo and his paper sculpture

Figure 27. Test models of Paper guard

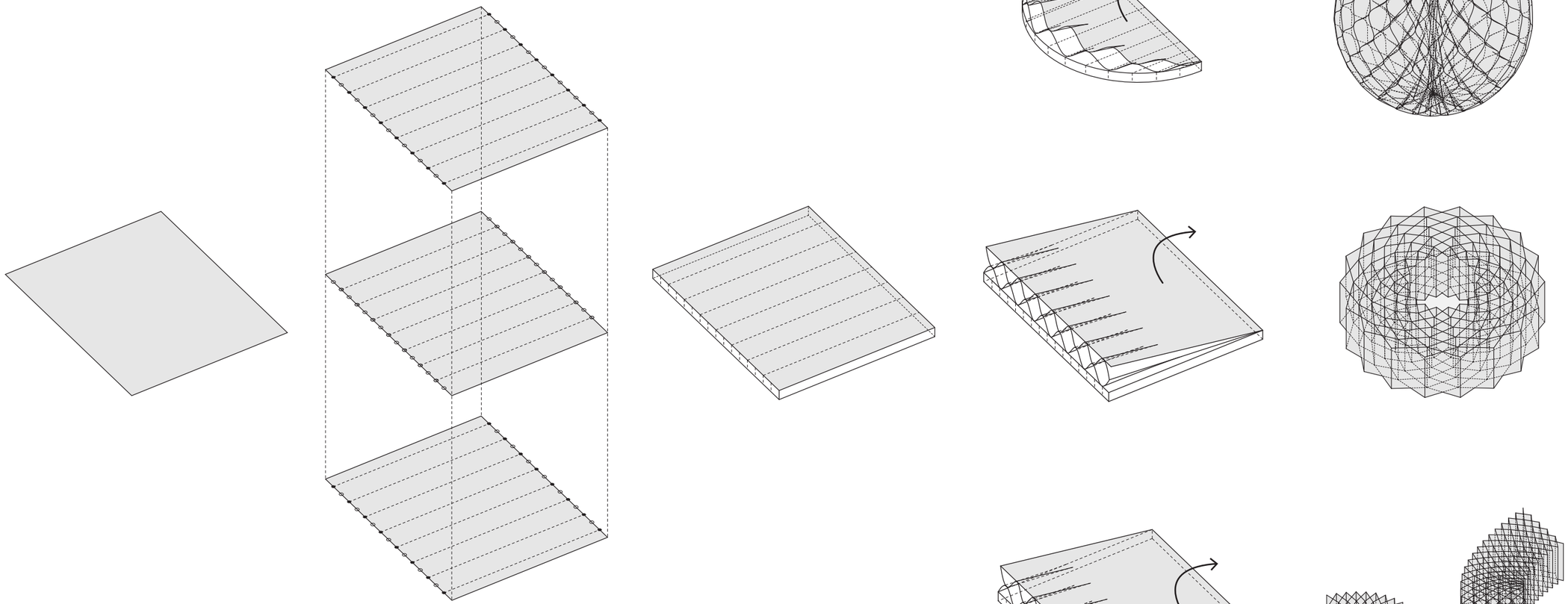


Figure 28. Diagram of paper gourd

Inflation

An inflatable is an object that can be inflated with a gas, usually with air, but hydrogen, helium and nitrogen are also used. One of several advantages of an inflatable is that it can be stored in a small space when not inflated, since inflatables depend on the presence of a gas to maintain their size and shape. Function fulfilment per mass used compared with non-inflatable strategies is a key advantage.

Precedents

Big Air Package
Wolfgang Volz/ Gasometer Oberhausen, Germany/ 2013

Big Air Package could be experienced from the outside and inside. It nearly spanned the distance from wall to wall of the Gasometer, leaving only a small passage to walk around the sculpture. Airlocks allowed visitors to enter the package, which was self-supporting and kept upright by two air fans creating a constant pressure of 27 pascal (0.27 millibar).

Big Air Package was the largest ever inflated envelope without a skeleton. Illuminated through the skylights of the Gasometer, the work of art was a cathedral of air, creating a diffused light throughout the interior, muffling the usual sounds and thus generating an atmosphere of silence and tranquility.

“The “Big Air Package” nearly spans the distance from wall to wall of the Gasomter, leaving only a small passage to walk around the sculpture. Two air fans creating a constant pressure of 27 pascal (0.27 millibar) keep the package upright. Airlocks allow visitors to enter the package. Illuminated through the skylights of the Gasometer and 60 additional projectors, the work of art creates a diffuse light throughout the interior. Inside the sculpture, an extraordinary experience of shape, space and light is provided.”

“When the Big Air Package was finally installed, it was absolutely unexpected what I saw. The fabric very much transports the light. You are virtually swimming in light when you are inside the Big Air Package,” the 77-year-old artist describes his latest work of art, which is the first one realized without his late wife and artistic partner Jeanne-Claude. “The inner space is probably the most unique aspect of all the Air Packages that we did since 1966. When experienced from the inside, that space is almost like a 90-meter-high cathedral.”

Figure 29. Picture of Big Air Package

Water Cathedral
GUN Architects/ Santiago de Chile, Chile/ 2012

Water Cathedral was the 2011 winning entry for the MoMA young architects program international in its Chilean. The initiative is called YAP_CONSTRUCTO, organised by the Chilean Cultural Platform CONSTRUCTO in collaboration with New York's MoMA, the Museum of Modern Art and MoMA PS1.

The project was proposed as an outdoor summer installation built for public use during the Chilean summer. A vast nave of 700 m2 composed by a field of fabric prisms suspended from steel frames. Which like stalactites in a cave provide a mysterious and playful space. The numerous components are arranged in clusters of variable densities and heights, gently dripping water at various pulses and speeds. Creating a refreshing and shaded atmosphere, enhanced by the sound of droplets falling in different intensities over a ground composed by concrete stalagmites that functioned as seating and water storing elements.

A hydraulic network placed above the metal grid supporting the textile units, distributed the water through canopy. Trickling inside the prismatic stalactites slowly saturating the volume of little stones contained within them and seeping through the fabric's seams. This dynamic process, dosed the water optimising it use over the space. Cooling hundreds of visitors during an afternoon with amounts equivalent to the average daily use of a few families.

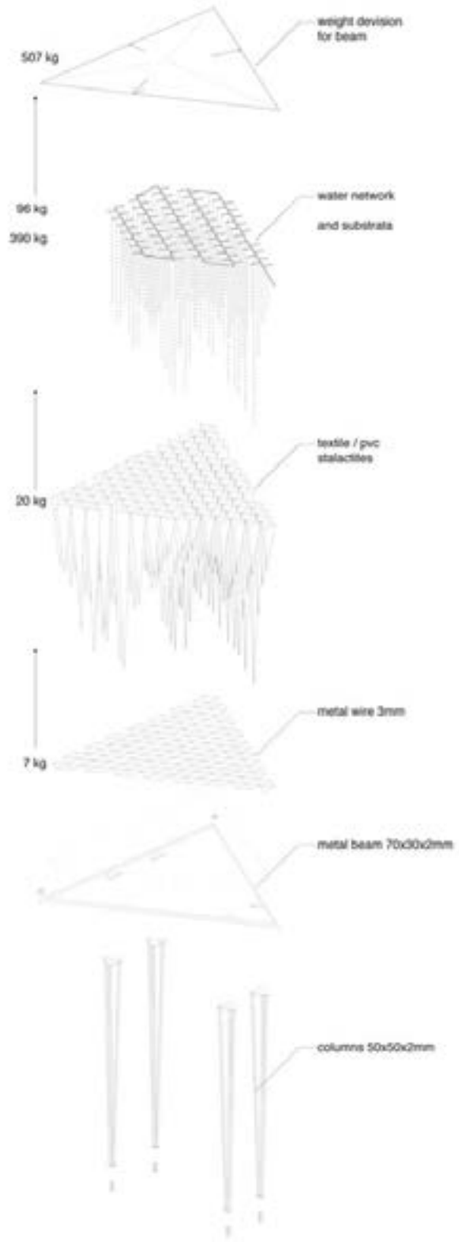


Figure 30. Diagram of structure

Figure 31. Picture of Water Cathedral

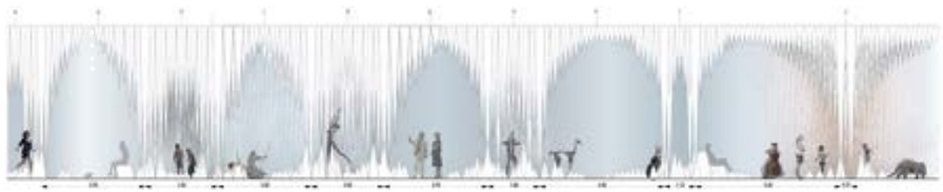


Figure 32. Diagram of design process

Dandelion Vessel: Inflatable Skyscraper For Natural Disasters
Wei Ke Li, Sheng Jiang, Xing Chun Zhi Zhang/ China/
2016 Skyscraper Competition

Nowadays, there is a group of people who are out of the society, because of living in remote areas but transportation is not convenient. So they are gradually isolated from the world. Poor medical and traffic standards result in the reduction of local population. Located in the central area of North Guangxi Rongshui County, the area is 50 kilometers long and 30-35 km wide, with general height of 1500 meters. The Mount Yuanbaoshan is 2081meters above sea level and it is the third highest mountain in Guangxi province. In this valley, people who live in poverty are difficult to communicate with the outside world. In recent years, natural disasters have become worse, and it takes too long time to escape from the town. So when the nature disaster come or the people get sick, they are sentenced to death , so we have to solve the problem.

There is a river flows through the valley, the river is the source of the water for the local people. Usually, the amount of water is relatively stable, but the water tends to rise when the rainfall becomes large. If it keeps rainning, the water level will become higher and higher, resulting in floods , landslides and other natural disasters. Many villagers have lost their life for this reason. We thought of making a‘master asembling station’ . When natural disasters occur, every household can reach the station by the device of the refugees which prepared for every houses quickly. The “station” has many small units for people to live in. In this way we can avoid life’s loss in a better way. In the small container, we provide a place for the villagers to rest and reside in. Even when there is no disaster, the villagers also can go to any places where has medical treatment or other facilities by the devices we designed. The behavior of station looks like dandelion, so we call it ’dandelion vessel’. We made it possible to combine these villages and to transport the people from the bottom to the master station, which can transfer the people who are in emergency while contacting with the outside environment very well. So that people can adapt to nature better, rather than to reform the natural.

The master station’ is made by menbrane and tensile, every house will given a rescues unit which can rise to the station when they need. And the surface of the ‘master station’ is made of strings and tensile, and the menbrane will be inflated to a inflation balloon units which can link to rescue units to get away form station.

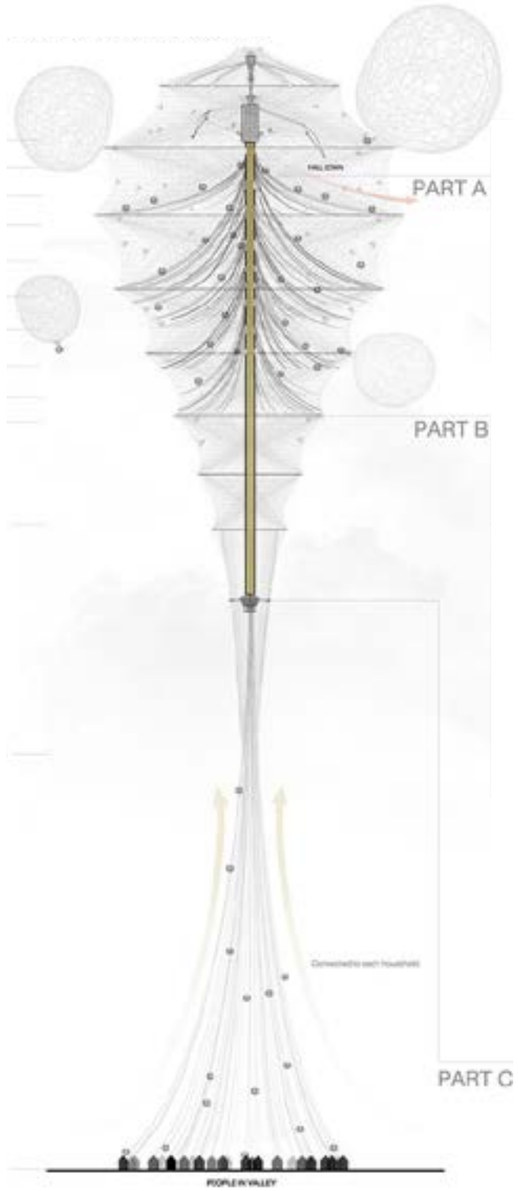
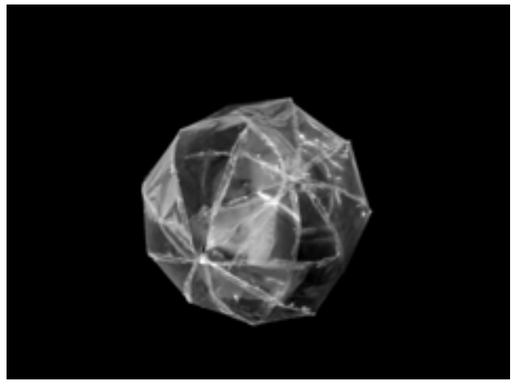


Figure 33. Dessection and transportation system

Test

Test 1 Arch & Dorm

When the inflatable is full of air, it could support itself. The most common are inflatable arches and inflatable columns. After rearch, we find that arch is the most stable form of the inflatable structure, so to make a atable building with inflatable structure, the arches and it's evolved dorms will be the best choice.



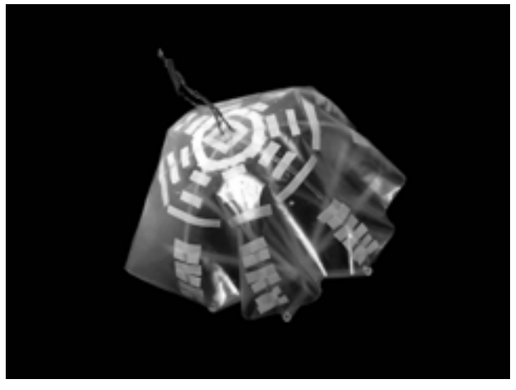


Figure 34. Test model of inflation

Figure 35. Diagram of arc & dome

Test 2 Scale

Inflatables are highly flexible, they could build any complex morphology, and they have different expressions in different scales.

For example, when we use inflatable to build traditional Chinese building's cornices, we can use inflatable in small-scale to accurately express complex architecture structures, or we can also make it looks abstract by using inflatable on a large scale.

Figure 36. Digital model of small scale

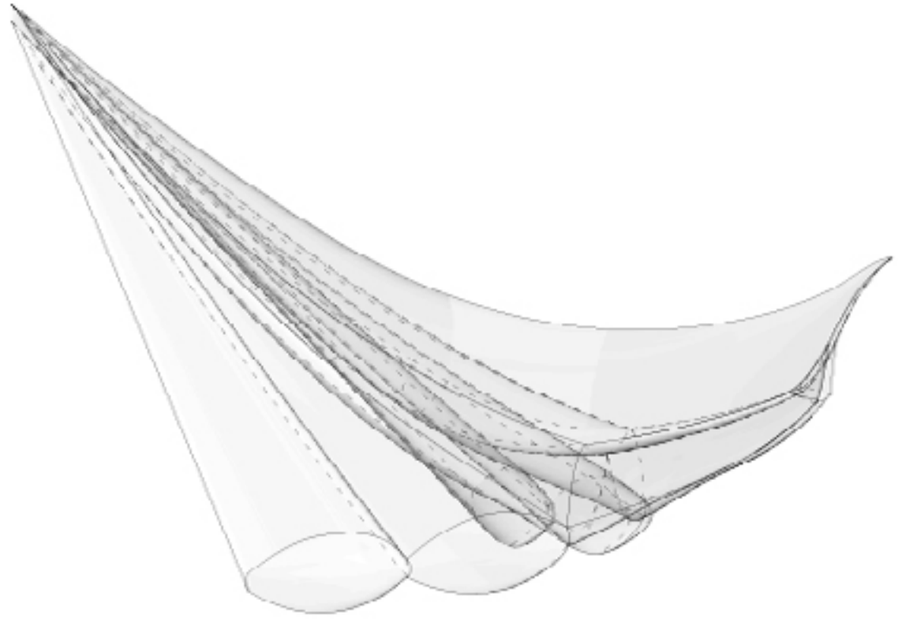
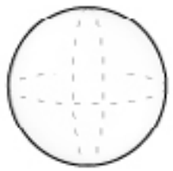
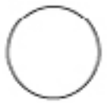
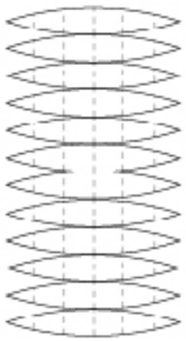
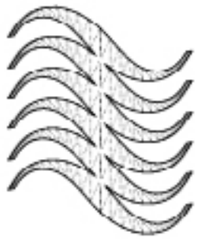
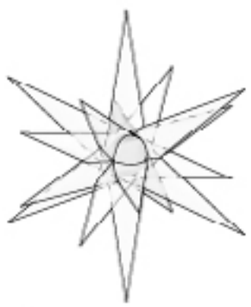
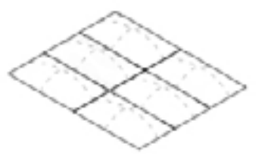
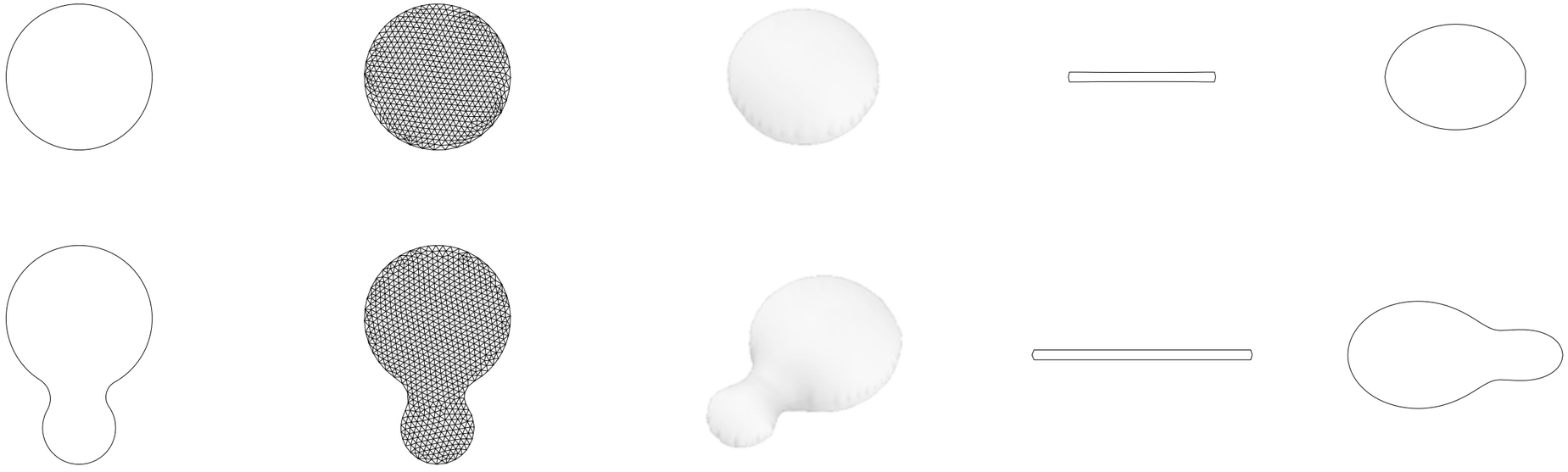
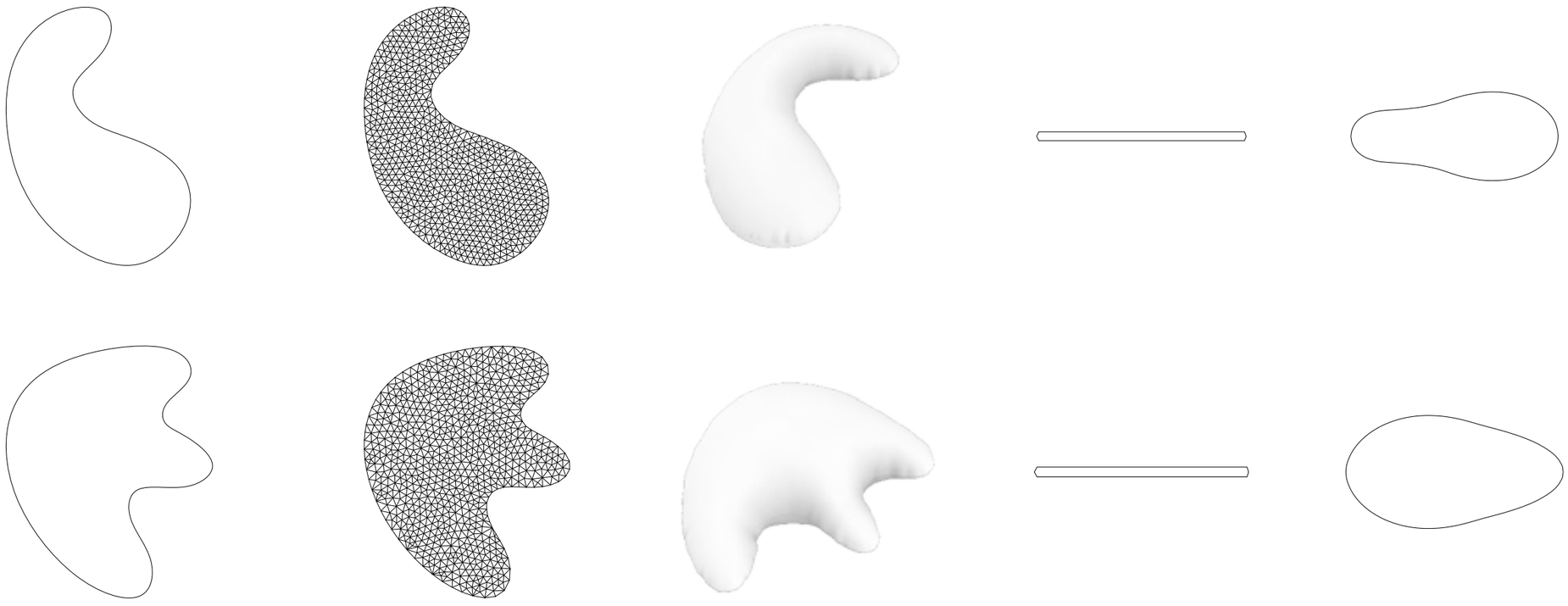


Figure 37. Digital model of bigger scale

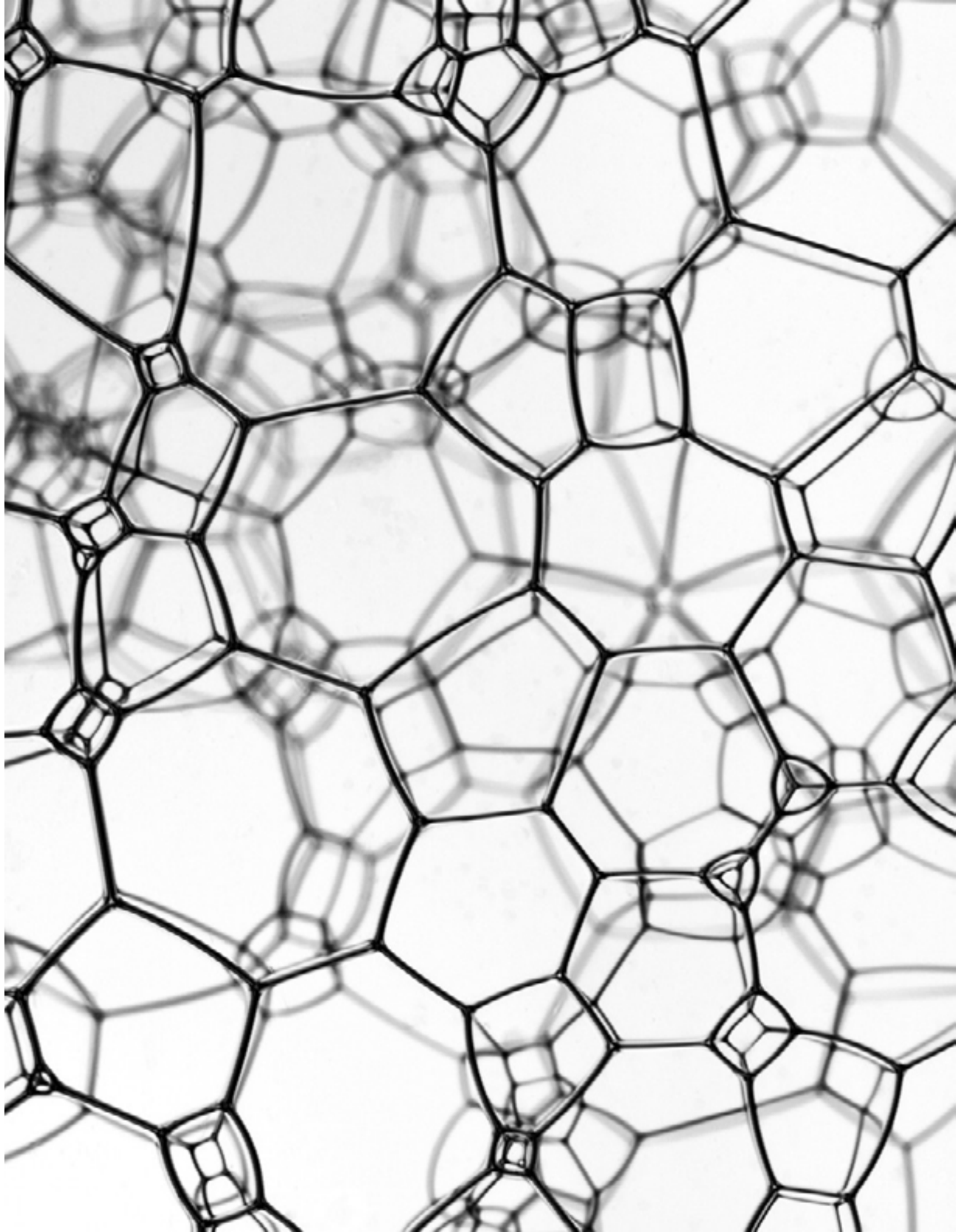
	sphere	torus	corn	pillow	
basic body typies					These four bodies are distinguished from edges, with smooth edges, dots or lines.
section shapes					Inflatable only has three kinds of sections: circle, ellipse or triangle. Other polygons can be seen as a combination of circle and triangle.
surface expansion					Inflatable need to be unfolding to make precise phisical models, sphere and torus are pretty complex
evaluation					Inflatable is highly flexible and has great potential possibility





Network

A particular network is a system of components which are connected and operated together. It is a large number of them that have connections with each other. The system makes itself fit or work together closely and successfully. It is usually to construct from standardised parts, but also can grow together with various units. In a specific network, the node is the most critical part of the system.



The Third Space
Greutmann Bolzern design studio/
Munich, Germany/2011

The Third Space (or Der Dritte Raum in German) is a triangular spider web of 250,000 zip ties clutched over a wooden skeleton. Enter and discover a lounge including lit seating balls and hanging cocoons that invite visitors to lie down and relax and take in the futuristic environment around them. The wind blowing through the zip ties is the only sound and carries all cares away. The material offers an astoundingly sensuous quality and great flexibility, so that the visitor is dipped into an abstract landscape. The Third Space is a place to relax and to come home to surroundings that are otherworldly and shaped by its own lighted beauty.

The third space is a light, see-through, fragile landscape structure . it´s a three dimensional refuge incorporating three aspects: self-projection,cocoon and firepit.

The installation is meant as an experiment which combines the work of all three divisions the course “interior architecture” consists of (interior design, product design and designing in free space). To communicate the trans-disciplinary basic idea of the study course in full size, 52 students created an installation in order to make interior space sensible instead of just showing a retrospect of the students work. The project deals with sociological terms such as profiling, community or privacy and translates them into specific spacious situations. Is there any interior design without form, style and spirit of age? What are the real qualities of good design? How do interior corresponds with outdoor spaces? The visitor is dipping into an abstract/concrete light/landscape. There are several seatings reminding the visitor of a bird´s nest and inviting for “cocooning”. Maybe you want to take a very special bath awaiting you in the light-shower? Get playful by exploring a tent-like structure being made of spiderweb-like braided mesh.

All objects are mainly made of cable straps. The students – organised in teams – explored meshes, patterns and splices and also created the exhibition concept. It´s astounding to find out such sensuous quality, various capability and great flexibility within this material. 52 students not only created this 200sqm space installation but also realized the concept by their own hands during 16,870 hours of work with 1,292,300 recyclable cable straps

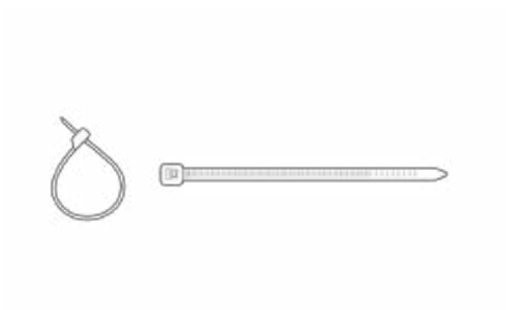


Figure 38. Unit of zip ties

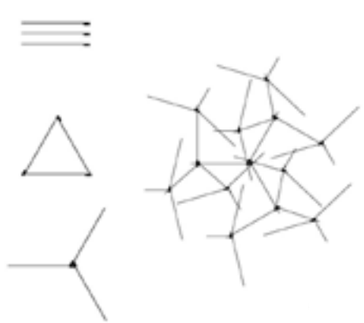


Figure 39. Structure of zip ties

Figure 40. The images the stallation

Lumen
Jenny Sabin/ MoMA PS1, New York, US/ 2017
Winner of The Musuem of Modern Art's PS1 Young Architects Program 2017

Lumen is an experiment, taking risks through collaboration across disciplines. Held in tension within the PS1 courtyard matrix of walls, Lumen applies insights and theories from biology, materials science, mathematics, and engineering. Material responses to sunlight as well as physical participation are integral parts of our exploratory approach to new materials, embodiment, and a transformative, adaptive architecture. The project is mathematically generated through form-finding simulations informed by the sun, site, materials, program, and the structural morphology of knitted cellular components. Resisting a biomimetic approach, Lumen employs an analogic design process where complex material behavior and processes are integrated with personal engagement and diverse programs. Through direct references to the flexibility and sensitivity of the human body, Lumen integrates adaptive materials and architecture where code, pattern, human interaction, environment, geometry and matter operate together as a conceptual design space. Knitting and textile fabrication offer a fruitful material ground for exploring these nonstandard fibrous potentials. As with cell networks, materials find their own form where the flow of tension forces through both geometry and matter serve as active design parameters. Lumen undertakes rigorous interdisciplinary experimentation to produce a multisensory environment that is full of delight, inspiring collective levity, play, and interaction as the structure and materials transform throughout the day and night.

By night, Lumen is knitted light, bathing visitors in a responsive glow of photo-luminescence; by day, Lumen offers succor from the summer heat, immersing participants in delicious ground clouds of cooling mist. Lumen is a socially and environmentally responsive structure that adapts to the densities of bodies, heat, and sunlight. A lightweight knitted fabric of responsive tubular structures and a canopy of cellular components employs recycled textiles, photo-luminescent and solar active yarns that absorb, collect, and deliver light. This environment offers spaces of respite, exchange, and engagement as a misting system responds to visitors' proximity, activating fabric stalactites that produce a refreshing micro-climate. Families of robotically woven recycled spool chairs reveal informal messages and conversations through hydro-chromic materials. It is an open responsive system featuring digitally knitted and robotically woven lightweight, high-performing, formfitting, and adaptive materials. Lumen is a feminine form that offers luminous interiorities, informal networks, social fabrics, and fibrous assemblages that are pliable, transformative, and playful.

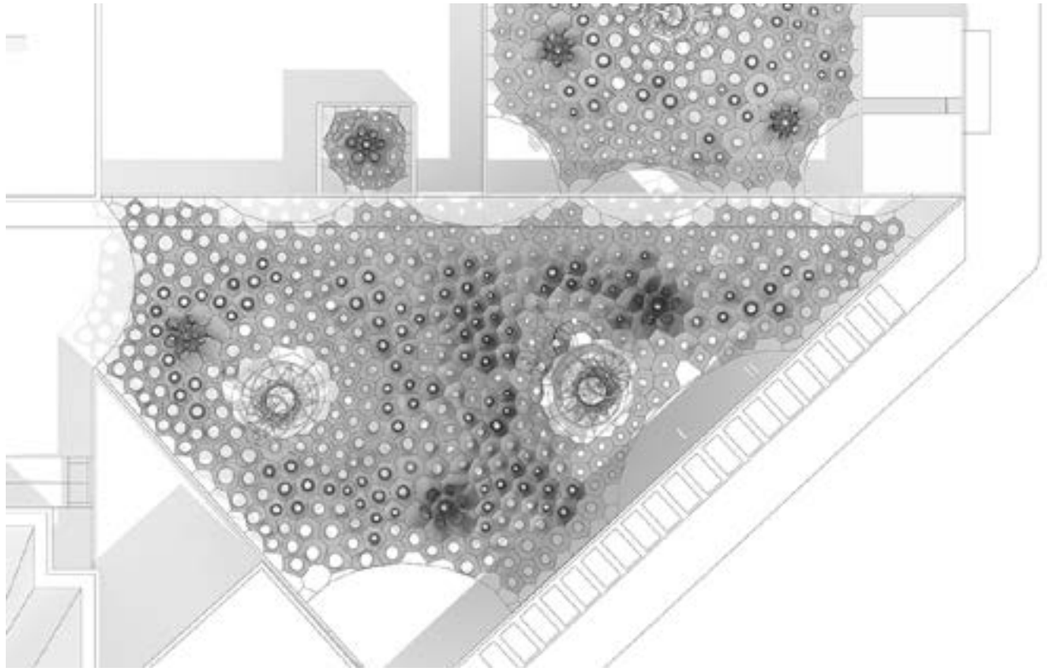


Figure 41. Site plan of Lumen

PolyBrick
Jenny Sabin/ Cornell University/ Ongoing

PolyBrick showcases the next steps in the integration of complex phenomena towards the design, production, and digital fabrication of ceramic form in the design arts and architecture. This work includes advances in digital technology, three - dimensional (3D) printing, advanced geometry, and material practices in arts, crafts, and design disciplines. PolyBrick makes use of algorithmic design techniques for the digital fabrication and production of nonstandard ceramic brick components for the mortarless assembly and installation of the first fully 3D - printed and fired ceramic brick wall. Using customized digital tools, low – cost printing materials, and component - based aggregations, our research utilizes readily available 3D printing technology to develop large - scale forms through the aggregation of interlocking component based systems.

PolyBrick is an ongoing project in the Sabin Design Lab at Cornell Architecture. Originally on display at the San Francisco Museum of Craft and Design as part of the exhibition, “Data Clay: Digital Strategies For Parsing The Earth”. Currently on display at the Centre Pompidou as part of their “Mutations-Créations / Imprimer le monde” exhibition.

Figure 42. Types of PolyBrick

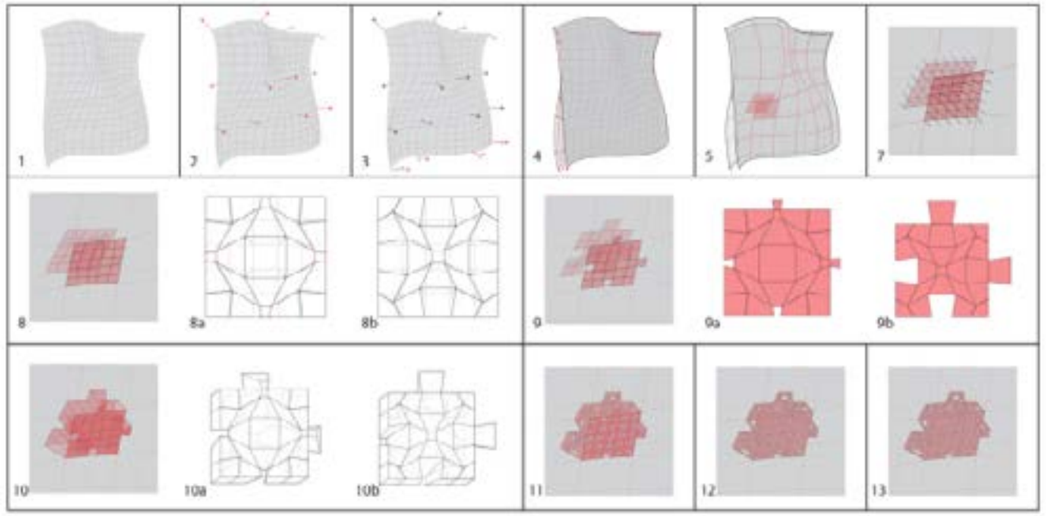


Figure 43. A series of algorithms programs the bricks’ shapes and placement throughout the entire structure.

Test

Test 1 Zip tie

At first, we do the first test for knitting depending on the installation " The Third Space", which is a triangular spider web of 250,000 zip ties clutched over a wooden skeleton. We figure out the process of fabrication. It is made of tens of thousands of triangle modules, which is combined with three zip ties biting mutually. Each unit insert in the gap of the another one with one of the head. The key of fabrication is to take advantage of this self-locking character of flexible nylon zip tie.

We choose the typical 4 inches size of standard cable ties to do testing. It is easier to operate them manually. The results represent the structure of knitting once we finish the connections.

On the other hand, the flexible nylon material expose a weakness. It is not enough rigid to stand by itself. In other words, we think the structure itself is not good enough for further design. It is expected to attribute its instability to the material or the zip tie itself.

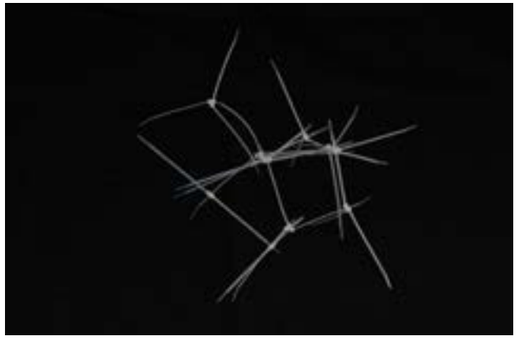


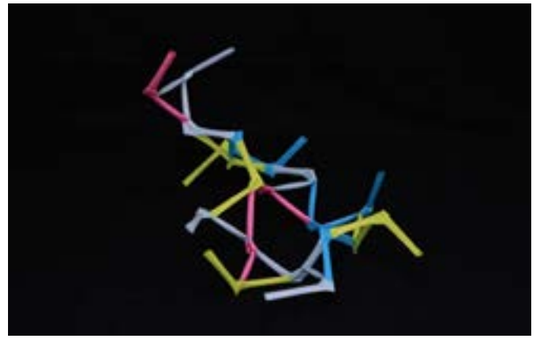
Figure 44. Test model of network

Test 2 Straw

The other test we start from " straw", another production in our daily life. We find straw can concentrate one common shape- tube. Like we use zip tie to do test, the pricinple of production we use is accessible.

This test we focus on the straight straw. We choose one typical kind: the diameter is about 3/8 inch and length is 9 inches. We imitate the thought of zip tie, try to create one self-locking structure by one straw. It is successful to make a node and two branches when we tie it up. Every node has four outputs to connect with another branch. This principle leads us to try possibilities for different shape of network.

The structure is more steady than the one of zip tie compared with. The node itself has rigid structure, which is pentagon with two branches spreading from two sides.



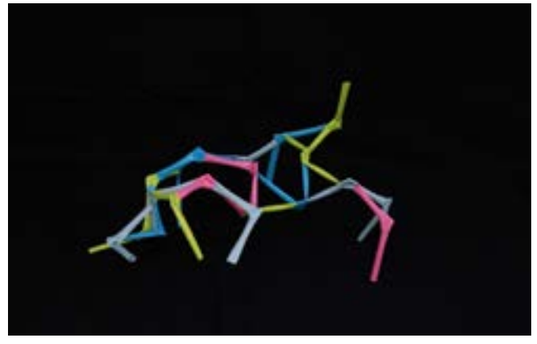


Figure 45. Test model of network

Test 3 Pipe

In test 3, the network is made of a unit with a flexible node. This kind of node makes the network elastic and changeable even after the units are fixed with each other. As a result, the network has unlimited possibilities and plasticity, which make it adapt to surroundings quickly and resist external impact by deformation.

We choose the pipes with the plastic characteristic as the raw material. The middle part is kept unchanged and used as the flexible node. Both ends are split into several strips along the pipe as needed. After that, we get the unit of the network. The strips, which look like branches, are used to connect with other units in the future.

After connecting the units, we get the network, which has the advantages like other kinds of networks, such as light and consuming less than solid structures. What's more, it can be batch produced and built quickly because of the formation of units and the simple way to assemble.

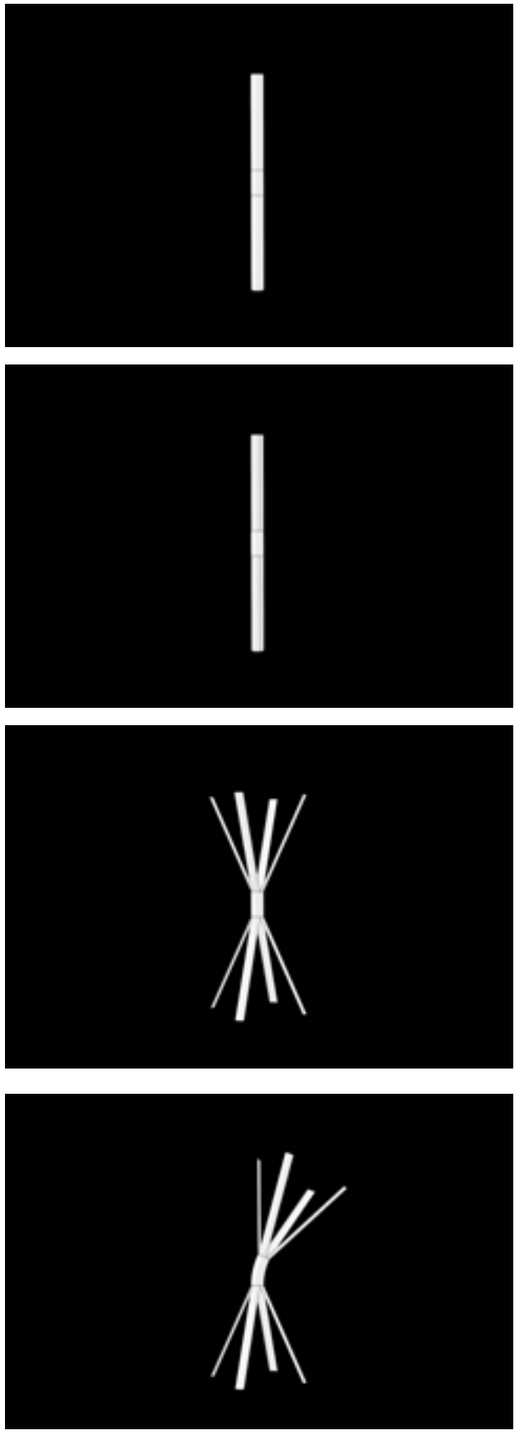


Figure 46. Diagram of pipe

First, we choose straw as our material, using the bending structure in the middle part of it as our flexible node. The two ends were divided into four-part along the straw's direction to serve as the branches. In this way, we got a number of units and assemble them together easily and conveniently as expected.

After that, another material was tested to verify the feasibility of this pattern under different scales. We choose swim noodle, which is made of foamed plastic and has good plasticity. These characters made it an ideal material for the flexible node. The swim noodle was 4.5 feet long before cutting and showed the similar result as the straw test, thus we confirmed that it is a pattern can be developed under different scales and it is feasible in the future design.

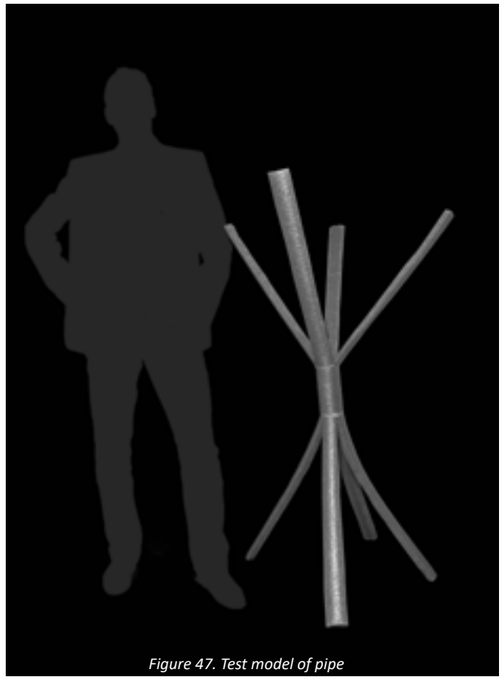


Figure 47. Test model of pipe

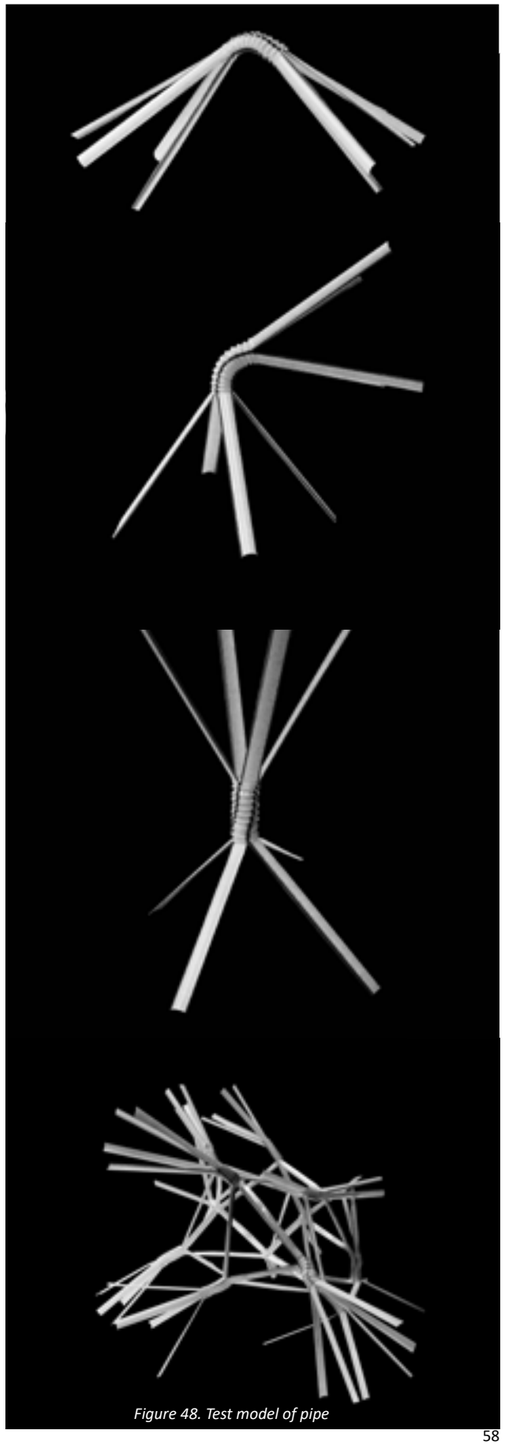


Figure 48. Test model of pipe

Test 5 Digital Model

PLANS 1

PLANS 2

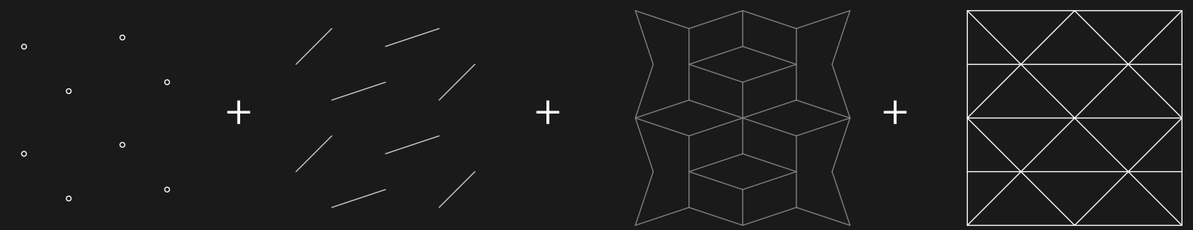
PLANS 3

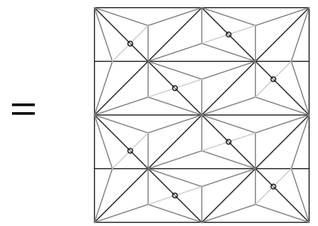
PLANS 4

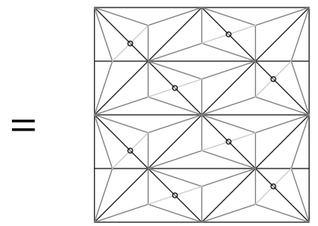
PLANS

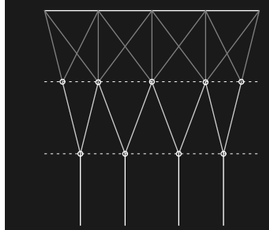
ELEVATION

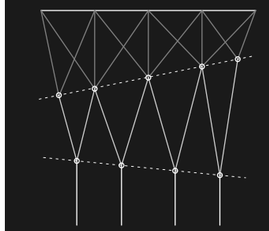
TESTING MODELS

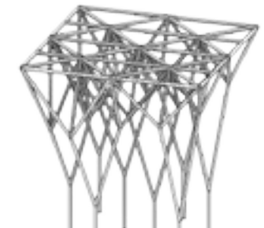






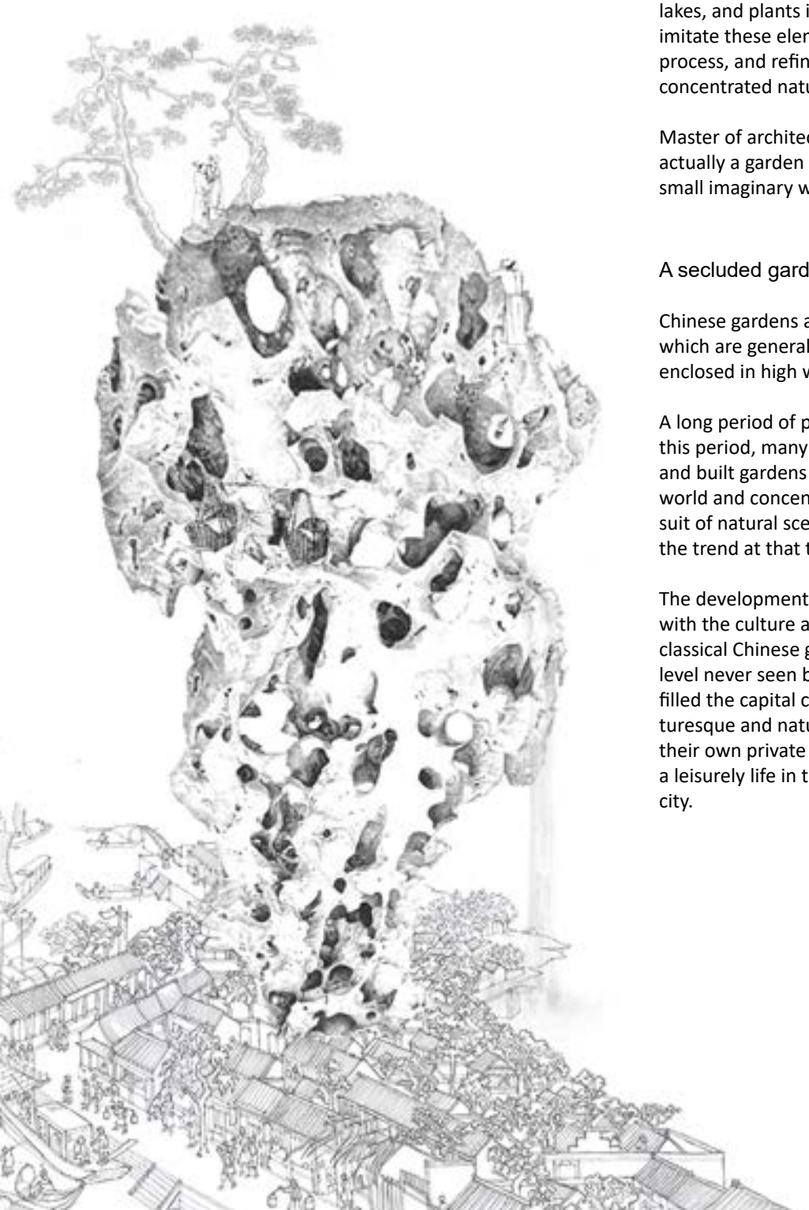






03.

CONTEXTS



Landscape in city

Chinese garden was the most popular form of architecture in ancient China, people Imitate this form of garden throughout the country.
Poets wrote a lot of poems to panegyrize Chinese garden, they all marveled at the fact that people can build such beautiful artificial landscapes in the city.

Chinese gardens contain elements such as Rockeries, lakes, and plants in the natural scenery, they do not simply imitate these elements, but consciously transform, adjust, process, and refine them to express a condensed and concentrated nature. .

Master of architecture Tong said: “Chinese gardens are actually a garden of human nature. It is a real dreamland, a small imaginary world.”

A secluded garden

Chinese gardens are very private, unlike European gardens, which are generally displayed outside. Chinese gardens are enclosed in high walls and isolated from the outside world.

A long period of political instability began in China, During this period, many former government officials left the court and built gardens where they could escape the outside world and concentrate on nature and literature. The pursuit of natural scenery and elegant living in seclusion was the trend at that time

The development of Chinese gardens went hand in hand with the culture and art during the first golden age of the classical Chinese garden. Painting and poetry reached a level never seen before, and new gardens, large and small, filled the capital city, garden design pursued poetic and picturesque and natural landscape. Everyone is proud to have their own private gardens with natural scenery, and enjoy a leisurely life in the city, which is different with boisterous city.

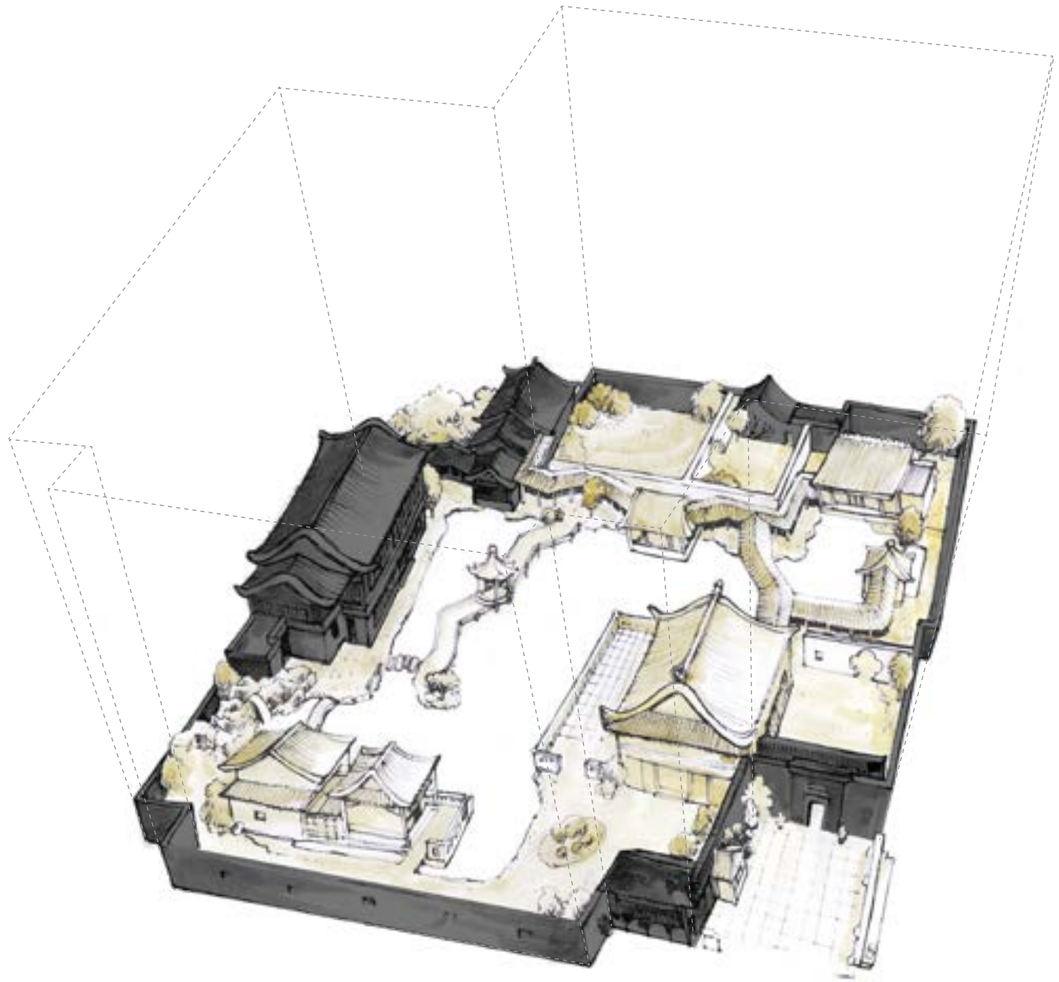


Figure 49. The diagram of Chinese Siheyuan

Elements

As one of the famous gardens in Mudu Ancient Town, Suzhou Mudu Yan's Family Garden is a valuable relic of Chinese garden culture and a place where countless historical figures had settled.

The Yan's Family Garden is a small private garden compared with other famous gardens in Suzhou. It has been in existence for hundreds of years since its inception. Although it is a new restoration and open to public. But the historical value of the preservation can not be ignored.

In the design of Yan's Family Garden restoration plan, the composition of traditional gardens in Jiangnan area of China was fully considered.

As a private garden, it has its own clear spatial organization and exquisite design methods, and the concept of "human, building and nature" with the utmost in the expression, which fully demonstrates the value of the research.

The existing of the Yan's Family Garden is divided into three parts, named as residential part, courtyard part and expansion part, covering a total area of 2.64 acres.

The residential part consists of a residential complex consisting of a foyer, a bridge hall, a hall, and a hall.

The garden part is reconstructed in strict accordance with the plan of the garden of the nursery school, which is measured by the nursery rhyme. The local part is properly perfected and supplemented, and the residential part is arranged in the traditional way.

The expansion is based on the development of future generations of tourism, and it does not have professional research value.

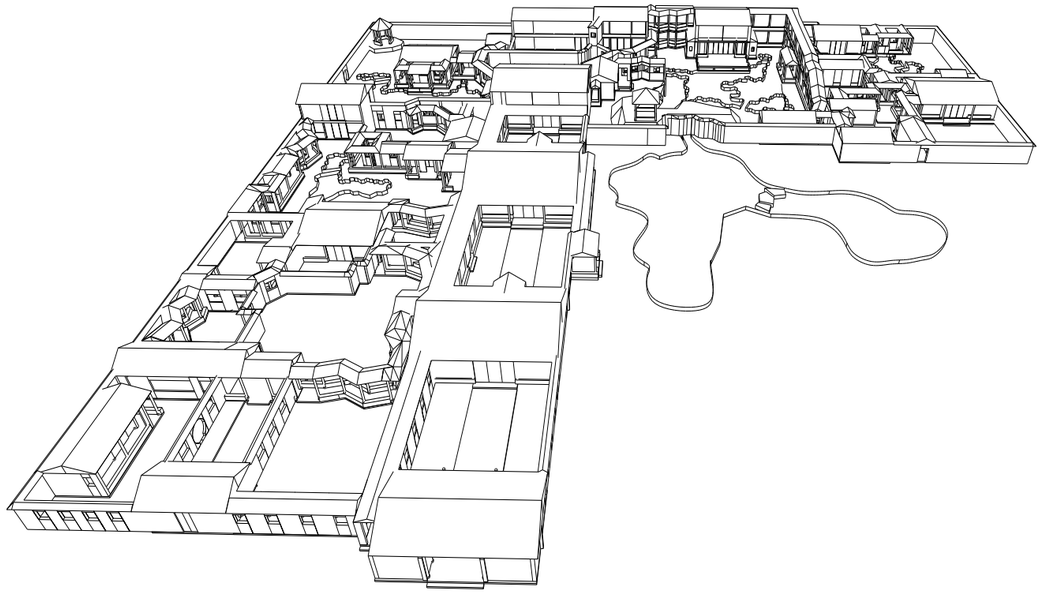


Figure 53. Digital model of Yan's Family Garden

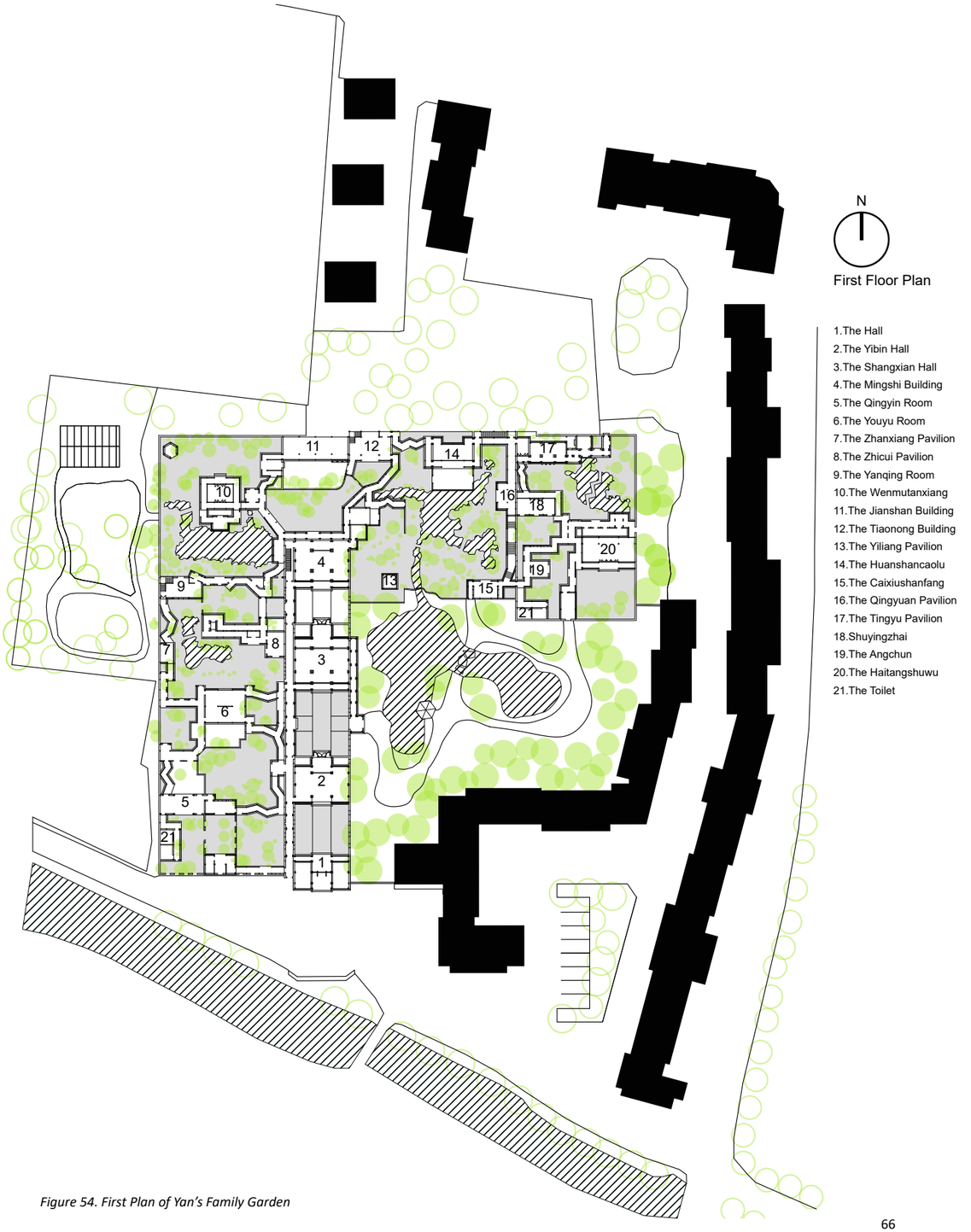


Figure 54. First Plan of Yan's Family Garden

Six main elements

The spatial form of Suzhou traditional gardens is a highly unified poetic space created with the combination of scale, proportion and rhythm.

After sensory understanding of Yan's Family Garden, we tried to create a set of analysis methods for Yan's Family Garden according to the garden concept of "human, builidng and nature", and analyze the various parts of Yan's Family Garden in a clear and hierarchical way.

First of all, starting from the overall plan, outline the wall system of Yan's Family Garden. It can be seen that there is a very clear "grid".

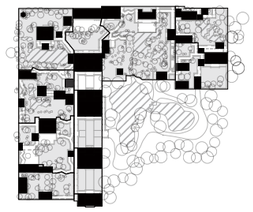
Secondly, on the basis of the establishment of the "grid", each gardening element is filled into this invisible framework. According to the intimacy of the relationship between these elements and human beings, they are "Counter"(building) , "path" (gallery), "water" (pond), "mountain" (rock work) and "plant" (flowers and trees).

These six systems are combined to form the basic space system of Yan's Family Garden. The most important pattern of Yan's Family Garden is the checkerboard grid. There is a regular overall spatial order. Through the division of the wall, the overall space has a regular spatial order, and the sense of spatial sequence is also enhanced.

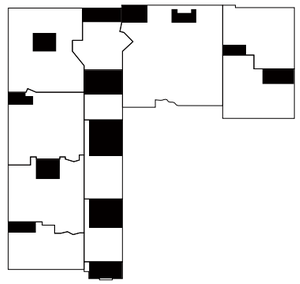
Building

The garden has a variety of architectural forms such as halls and pavilions, which has flexible and unique in shape.

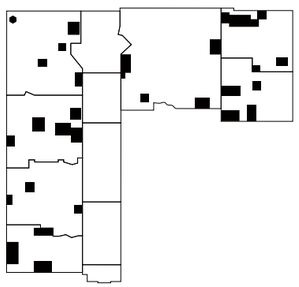
The architectural layout and space combination take practical functional as the first considerations.



Buildings Analysis



The Main Building



The Secondary Building

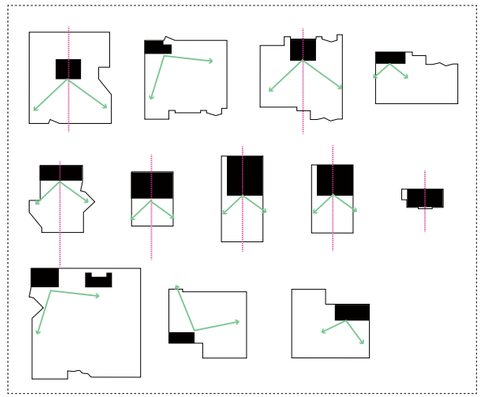
Figure 61. Diagram of building analysis

Building Analysis

The main buildings are distributed in the following characteristics:
1.Mainly along the central axis of each "grid";
2.The outside of buildings are relatively open spaces, providing an open view and pleasant surroundings.

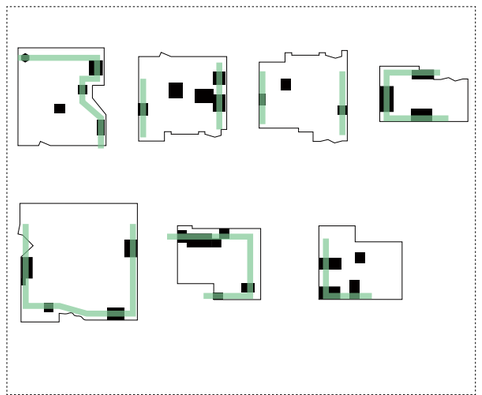
The secondary building has the following characteristics:
1.The building volume is generally medium to small. The volume of the building is generally medium to small. The building is light in shape;
2.Built beside the water or the flower, where has beautiful scenery;
3.Mainly distributed in the periphery of each "grid".

And we split all the "grids" in garden and find that each "grid" has different amount of builidngs and different densities.



12 "Grid"inside the main building layout analysis diagram

Building size distribution



12 "Grid"inside the secondary building layout analysis diagram

Building number labeled figure

Figure 62. Diagram of building analysis

Galley

The gallery is an important part of the road system and the most direct way to connect buildings and buildings. The gallery can be regarded as a covered road.

Those galleries are referred to the road system as “path” and make up the entire walking system in the garden.

Visitors shuttle through the winding corridors and galleries, stop at attractive courtyard platform and climb the rockery caves with varied shapes.

While the overall division of the space by the “grid” and the “counter”, “path“ carefully divided garden into detailed sections.

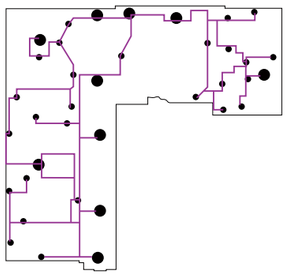
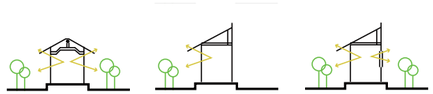
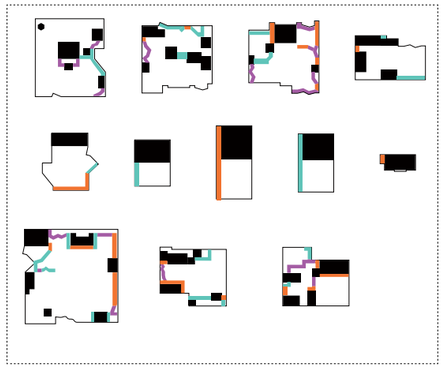


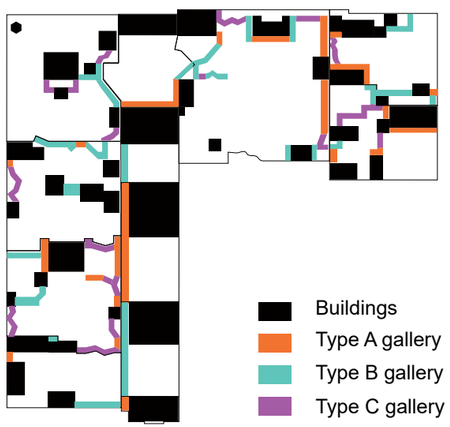
Figure 63. The road and buildings of connection diagram

3 types of view





Different types of gallery profile



Three types of gallery view analysis

Figure 64. Diagram of connection analysis

Effects

Varing Sceneries with Changing view-points. Visitors moved from scene to scene either within enclosed galleries or by winding paths which concealed the scenes until the last moment. The scenes would suddenly appear at the turn of a path, through a window, or hidden behind a screen of bamboo. They might be revealed through round “moon doors” or through windows of unusual shapes, or windows with elaborate lattices that broke the view into pieces.

Figure 65. Diagram of step moving

Figure 66. Pictures of views- part 1

Figure 67. pictures of views- part 2

Figure 68. Pictures of views- part 3

04.

INDIVIDUAL PROJECTS

Site

A site is needed for four individual projects. We choose the traditional Chinese garden as our site because we found similarities between Chinese garden and our proposed materially-driven design process.

Two significant benefits of the materially-driven design process:

a) Work like nature

b) Maximal performance with minimal resources

Two important design concepts of traditional Chinese garden:

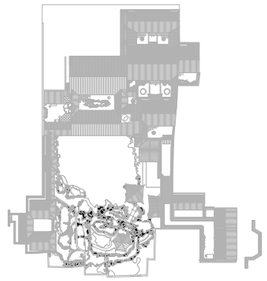
a) Unnatural nature

b) Maximum views within minimum space

We will test the new design techniques at full-scale through four individual projects, deploy them as a means to reimagine the Chinese garden in contemporary terms.

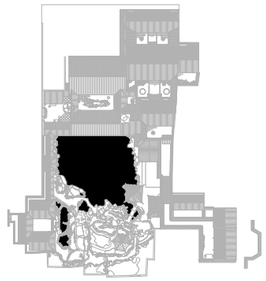
The project is not focus on designing a new Chinese garden. We will move the garden of cultivation located in Suzhou to the south green space of the Murphy studio. It will provide a stage for our projects. The relationship among six fundamental elements of the garden is remained. Only few adjustments has been done to the original plan to fit the new location.

Buildings

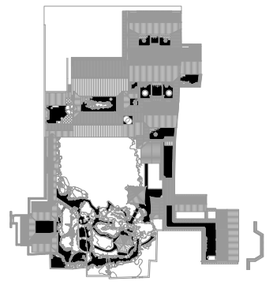


Rocks

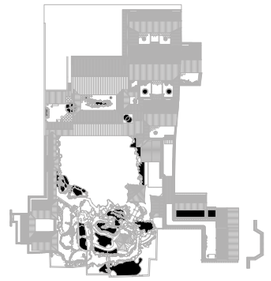
Walls



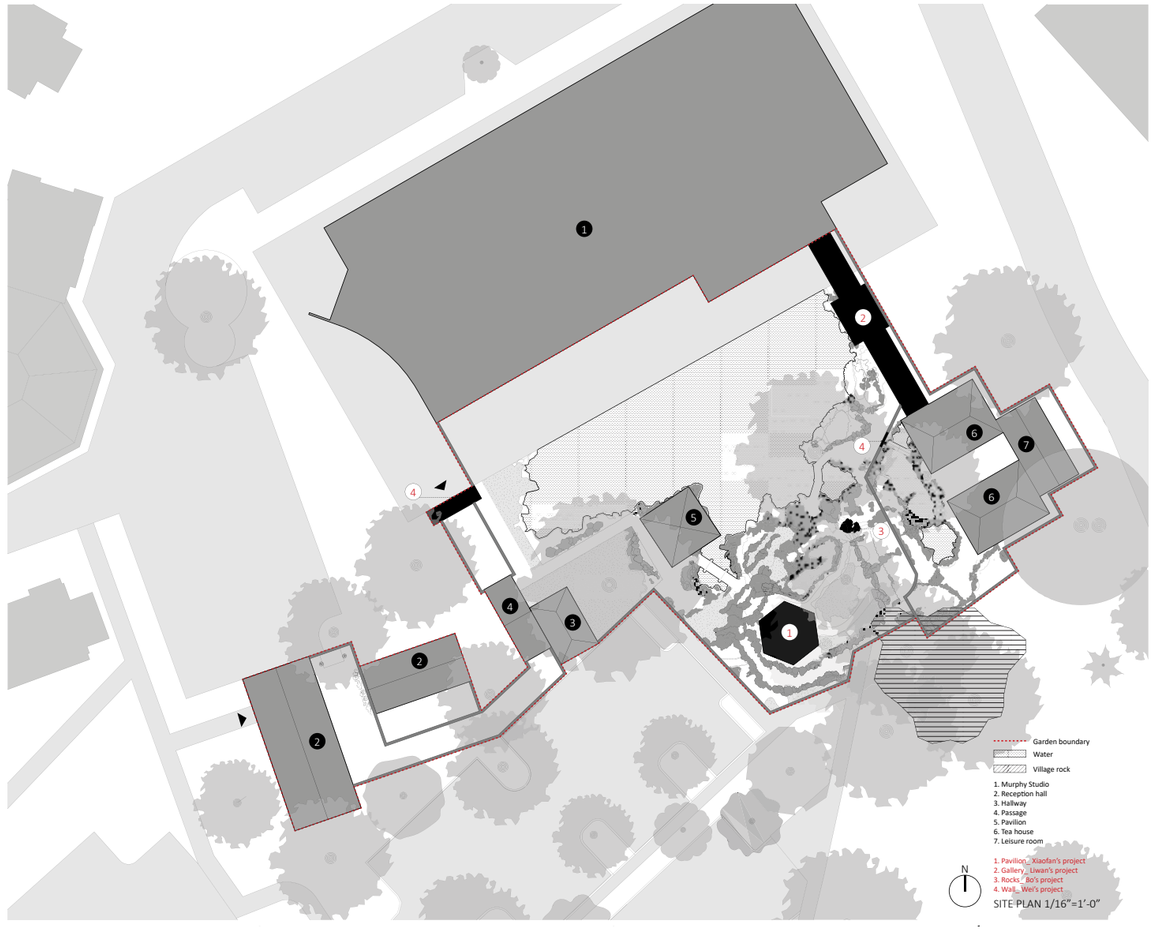
Water



Path

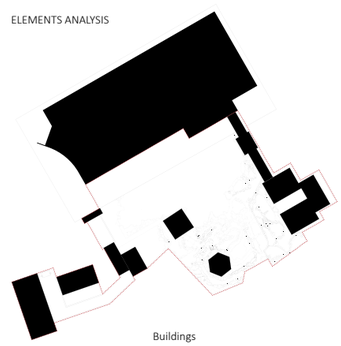


Greens



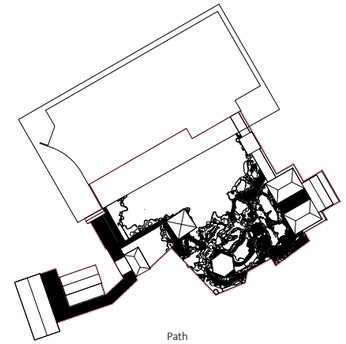
SITE PLAN 1/16"=1'-0"

ELEMENTS ANALYSIS



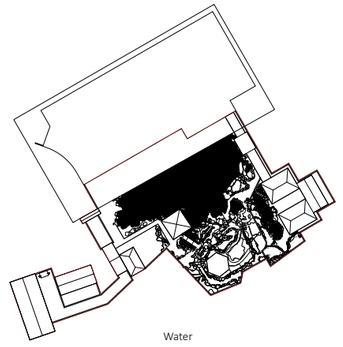
Buildings

Walls

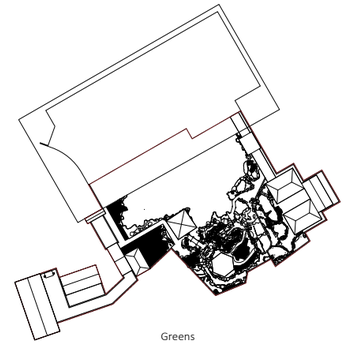


Path

Rocks



Water



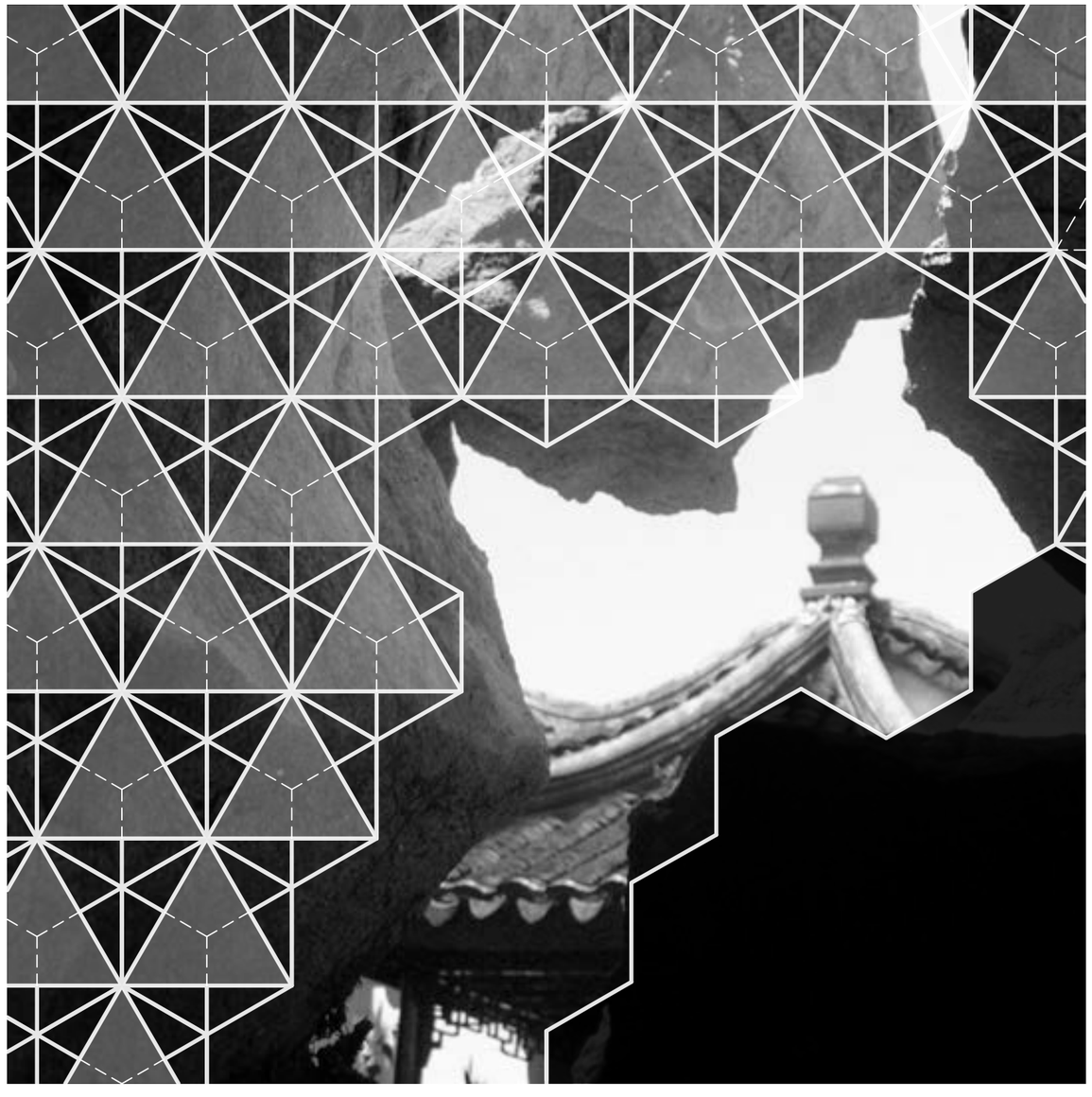
Greens

Project 1
Unsolid as a Rock
Curved Folding for Ultralight Lattice Structures

Abstact

This is a rock-replacement project for the reimagined traditional Chinese garden. The philosophy of this project is to build a lightweight and self-supporting architecture with transparency plastic sheets, that brings out a togetherness in its spatial character, structural performance and ornamenting quality. This project involves technologies like computational design and digital fabrication to process the abstractness of the structure. Finally, the rocklike cellular structure will become a poetic art installation with vision and light lyrically entwined in it, and a playful moment which fades into the garden environment.

The goal of this project is to solve as many problems as possible in the whole process of design and assembly in three different scales. The small-scale difficulty is transforming sheet material into a rigid 3D geometry with folding technique, which can be the structural cell for an ultralight lattice structure. The middle-scale difficulty is designing the lattice structure which can create a stable structure with the folding cells in architectural scale. The large-scale difficulty is developing a global geometry which potentially can be a tunnel, a stair, and a bridge, which are the three most common uses of rock in the traditional Chinese garden.

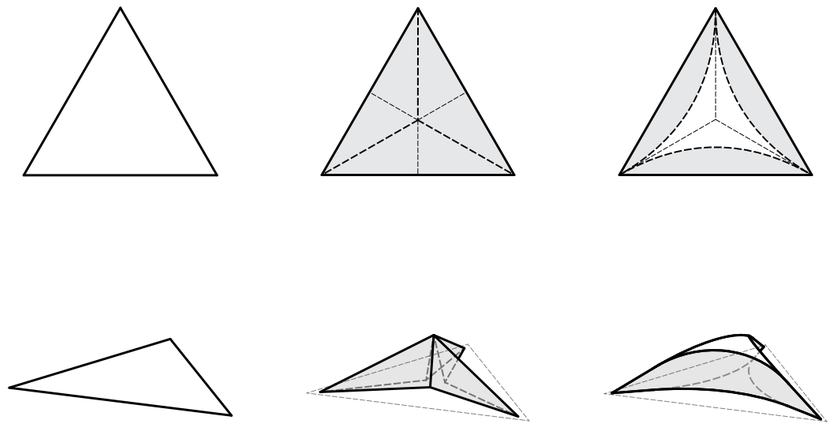


Folding Logic

Folding is the answer of how to make sheet material rigid. After the folding process, the folding lines become the rigid structure of the new forms.

Curved folding is an advanced folding. Usually, curved folding has a simpler structure than an original origami when you try to get a similar outcome. For example, with a regular trangle sheet, curved folding only has three curved crease, while the origami needs six crease and create a corner which is a weak point in the whole structure.

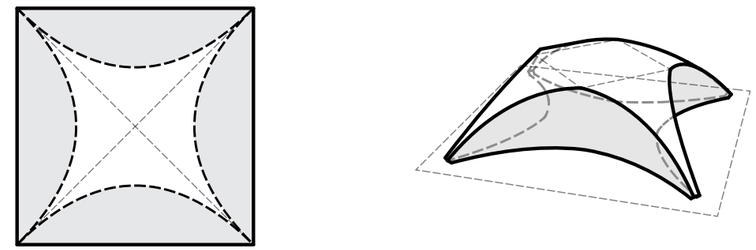
With a simple and clear method of setting up curve crease from different polygons, series of esthetic from can be generated. In this project, polyhedron which are made of different folded polygon surfaces will be used as the basic structural cells for a larger lattice structure.



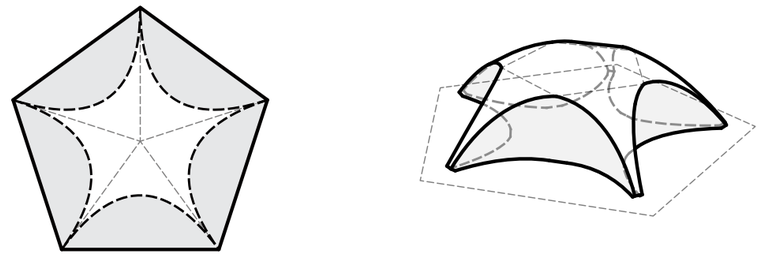
Sheet Material

Origami

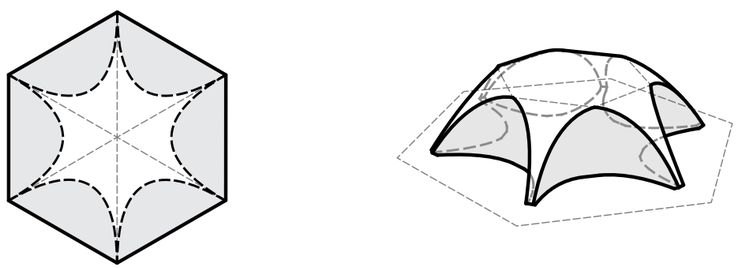
Curved crease folding



Square

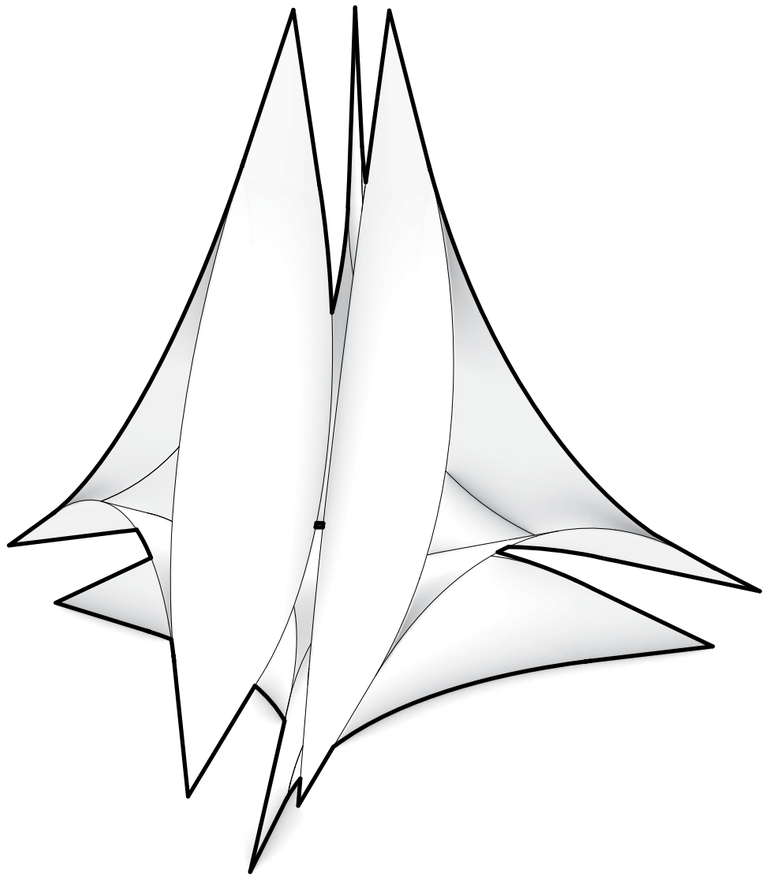


Pentagon

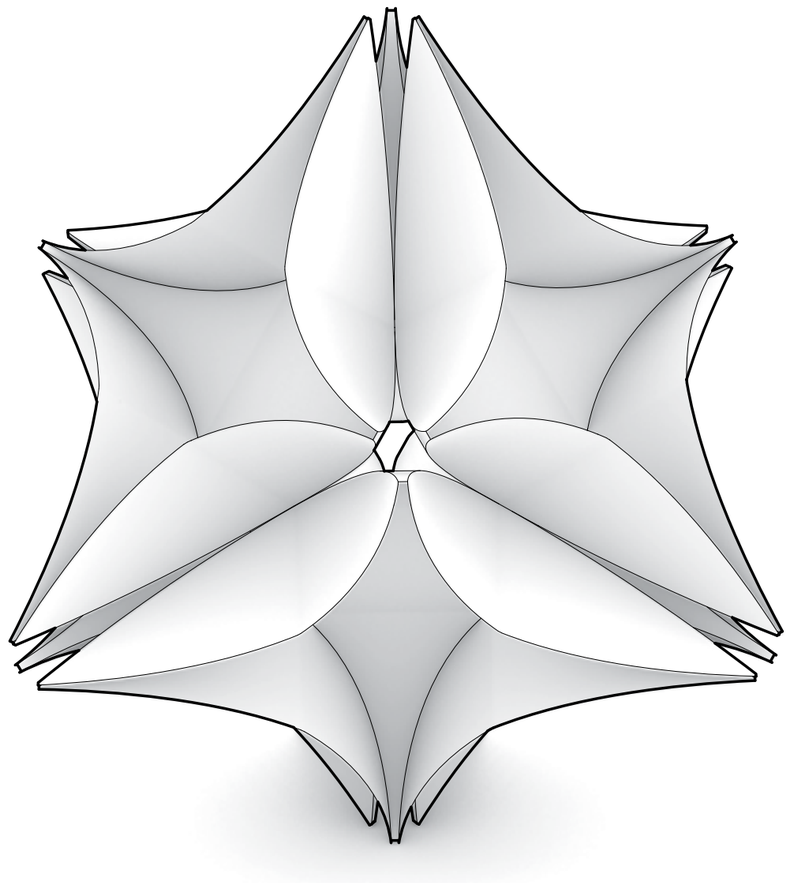


Hexagon

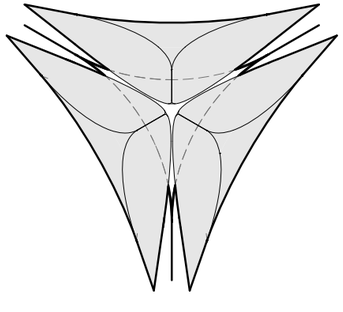
Folded Cells



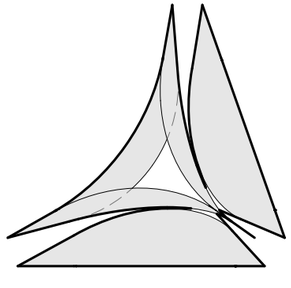
Tetrahedron Cell



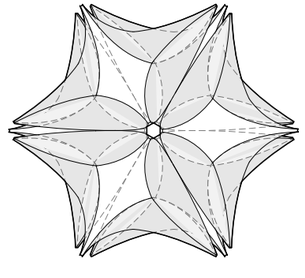
Hexahedron Cell



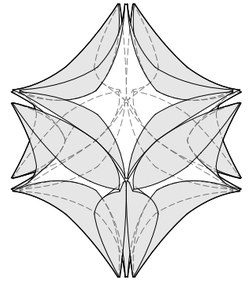
Top view



Side view



Top view



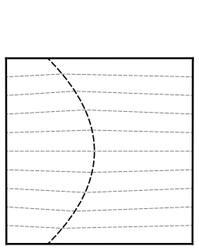
Side view

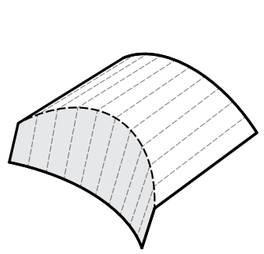
Folding Simulation

The folding transformation can be simulated with Kangaroo plug-in in Rhino. However, for now, the simulation only works with less than two folding creases. For a square sheet, the simulation need to be done four times for all four corners. After adding a flat central surface, a complete folded surface simulation is finished. During the design process, we need to go back and forth between simulation and setting up folding crease. In this way, the simulation is not efficient enough.

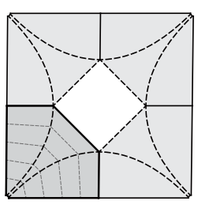
Another problem of the folding simulation is accuracy. We can not get the folding crease from the folded form since the simulation is not accurate. The more accurate the simulation is, the better design result we can get.

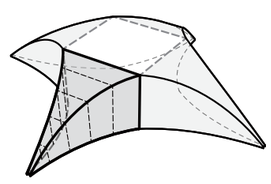
Single Crease Simulation





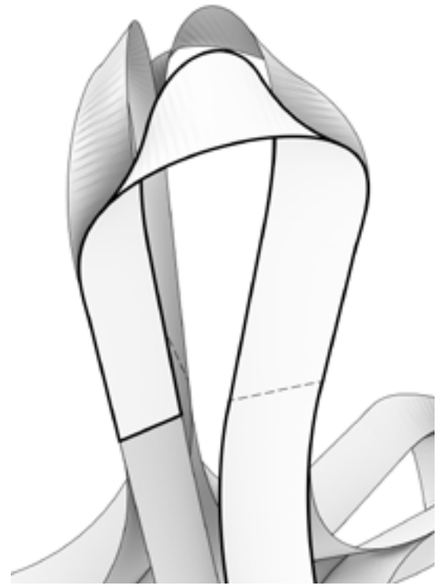
Double Crease Simulation



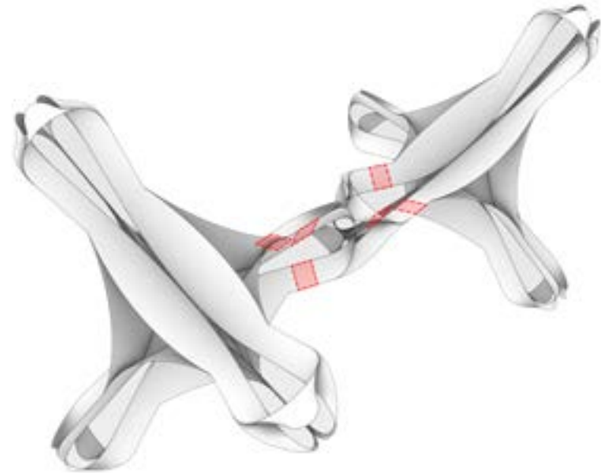


Installation Details

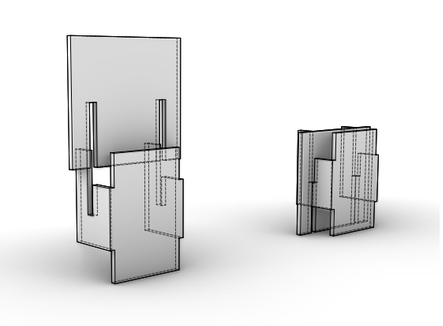
For the cell corner, all the left pieces of the three surfaces of one corner go to the next surface and be immobilized with a customized joint. For the connection between cells, all the right pieces go to the other cell and reach the joint lacation. In order to increase friction, all the surfaces of surface panels and joint where the joint located need to be sanded.



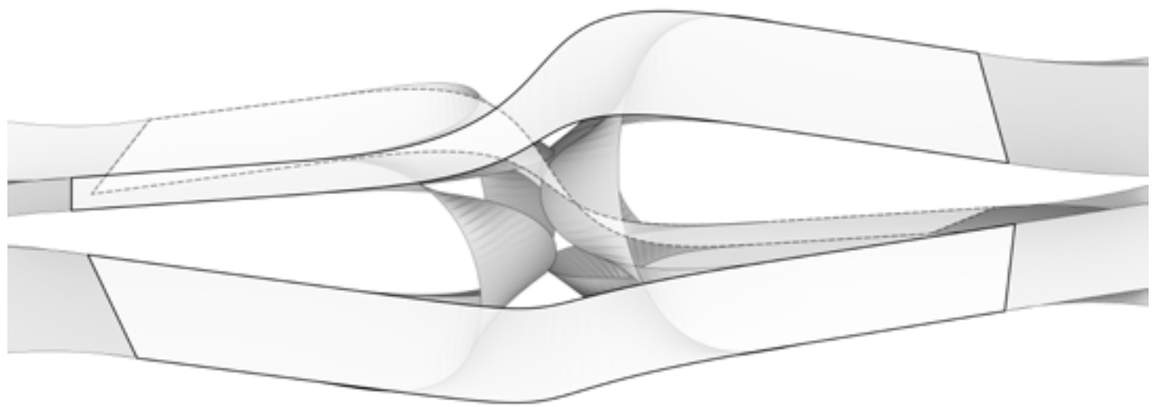
Cell Corner Assembly



Joint Location



Customized Joint



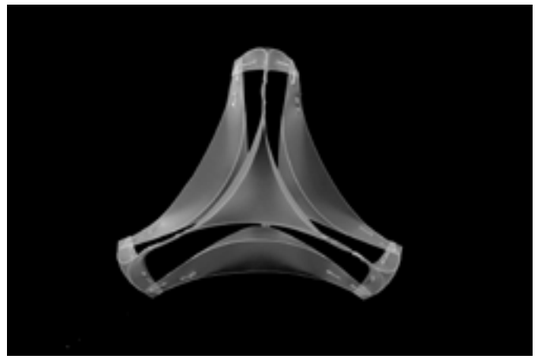
Connection Between Cells

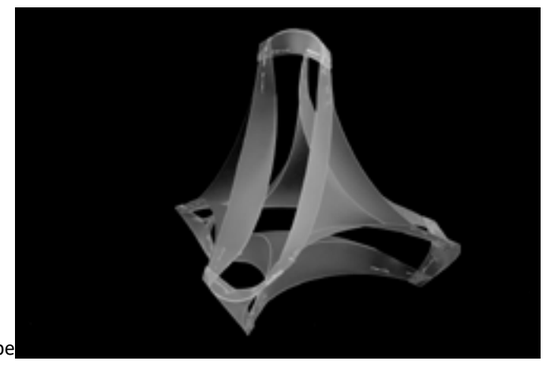
Geometry Inspiration

After having the first tetrahedron cell prototype, Taihu stone, which is the most impportant landscape stone in Chinese garden, came into my mind right away.

Taihu stone is a kind of limestone produced at the foot of Dongting Mountain in Suzhou, which is close to Lake Tai. Due to long-term surging by water, this kind of stone features pores and holes.

The precedent for this project I chose is one of the three most famous stone of Chinese garden. It is called YuLingLong, located in Yu Garden in Suzhou, China. The meaning of its name is the sound of jade.



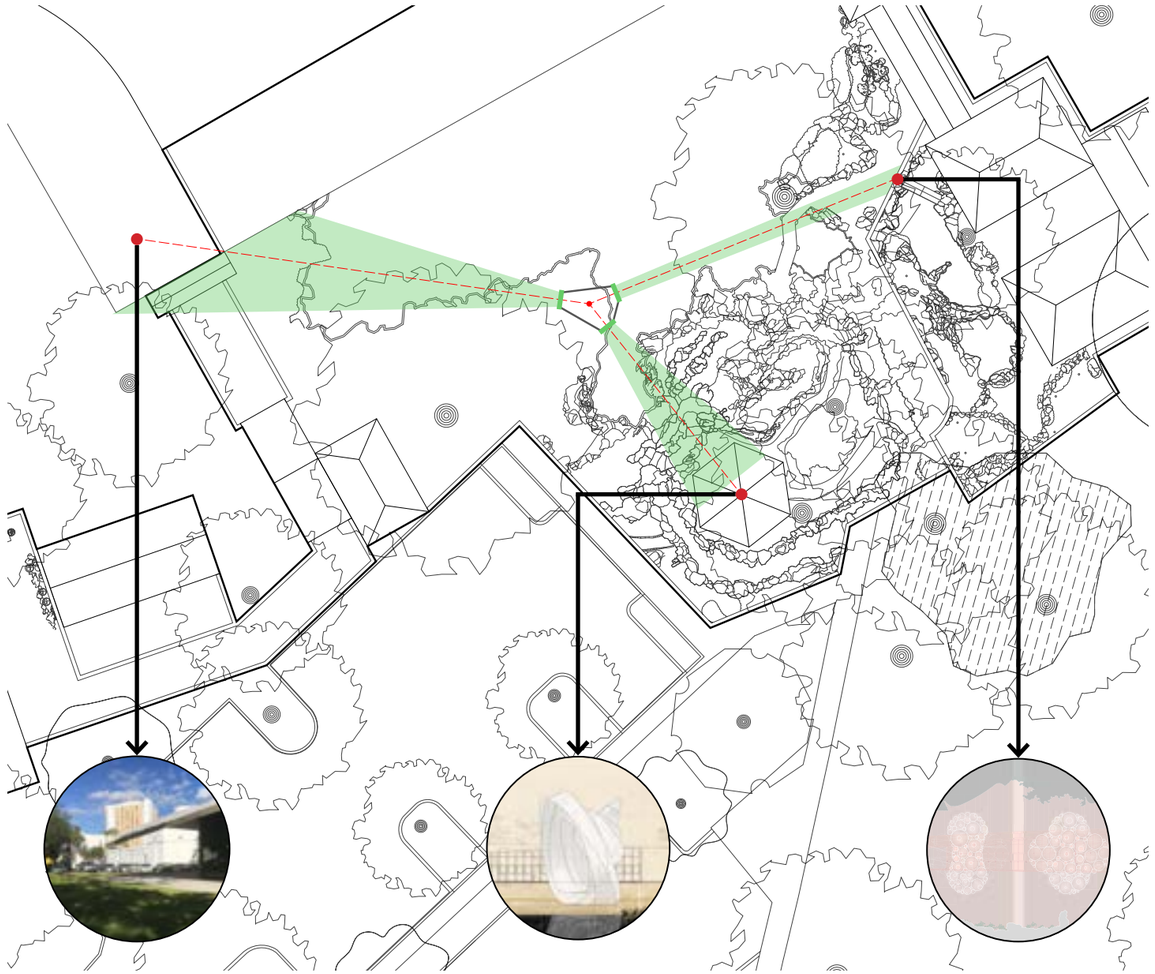


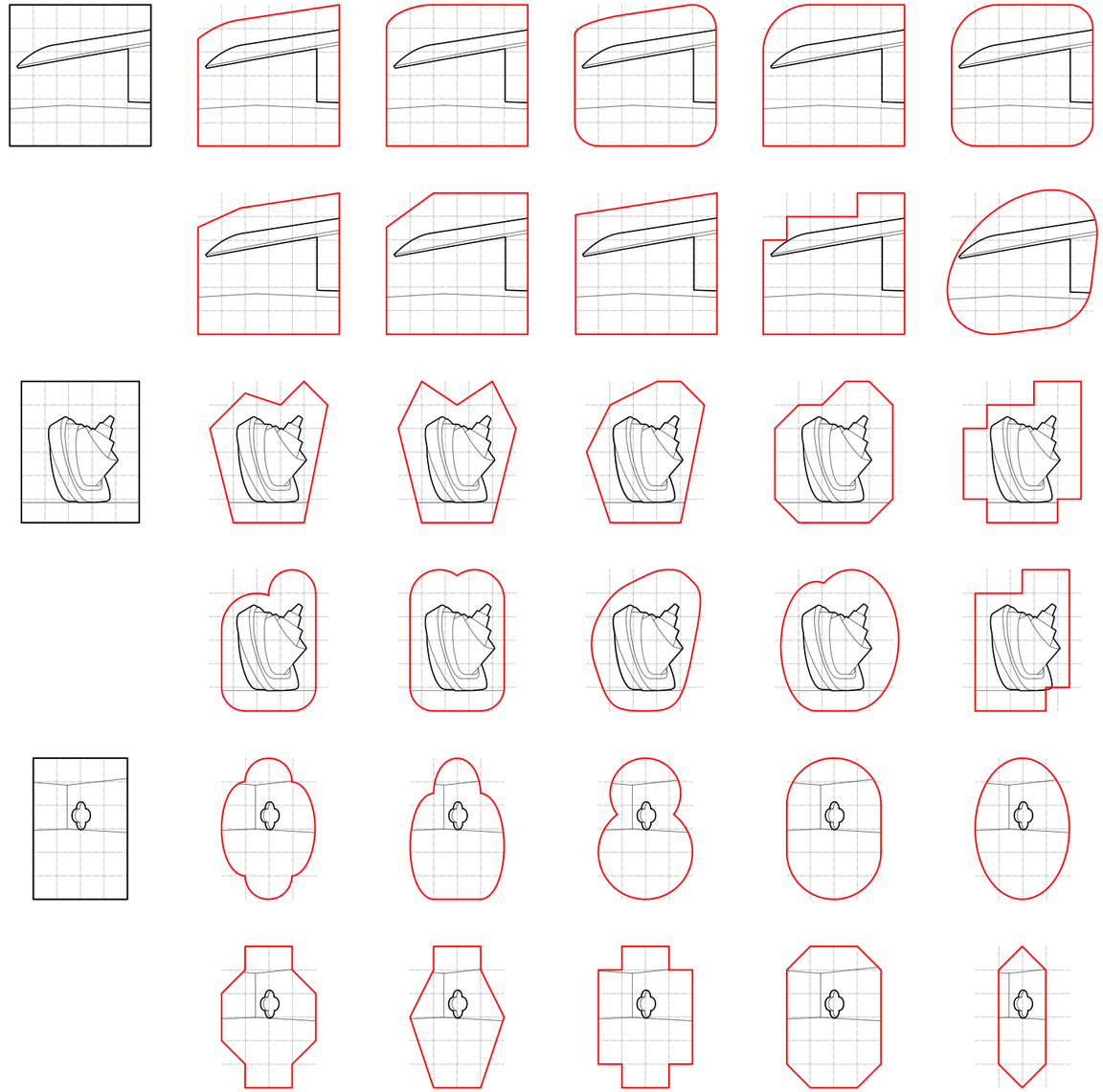
First Tetrahedron Cell Prototype

Precedent: Yu Ling Long

View

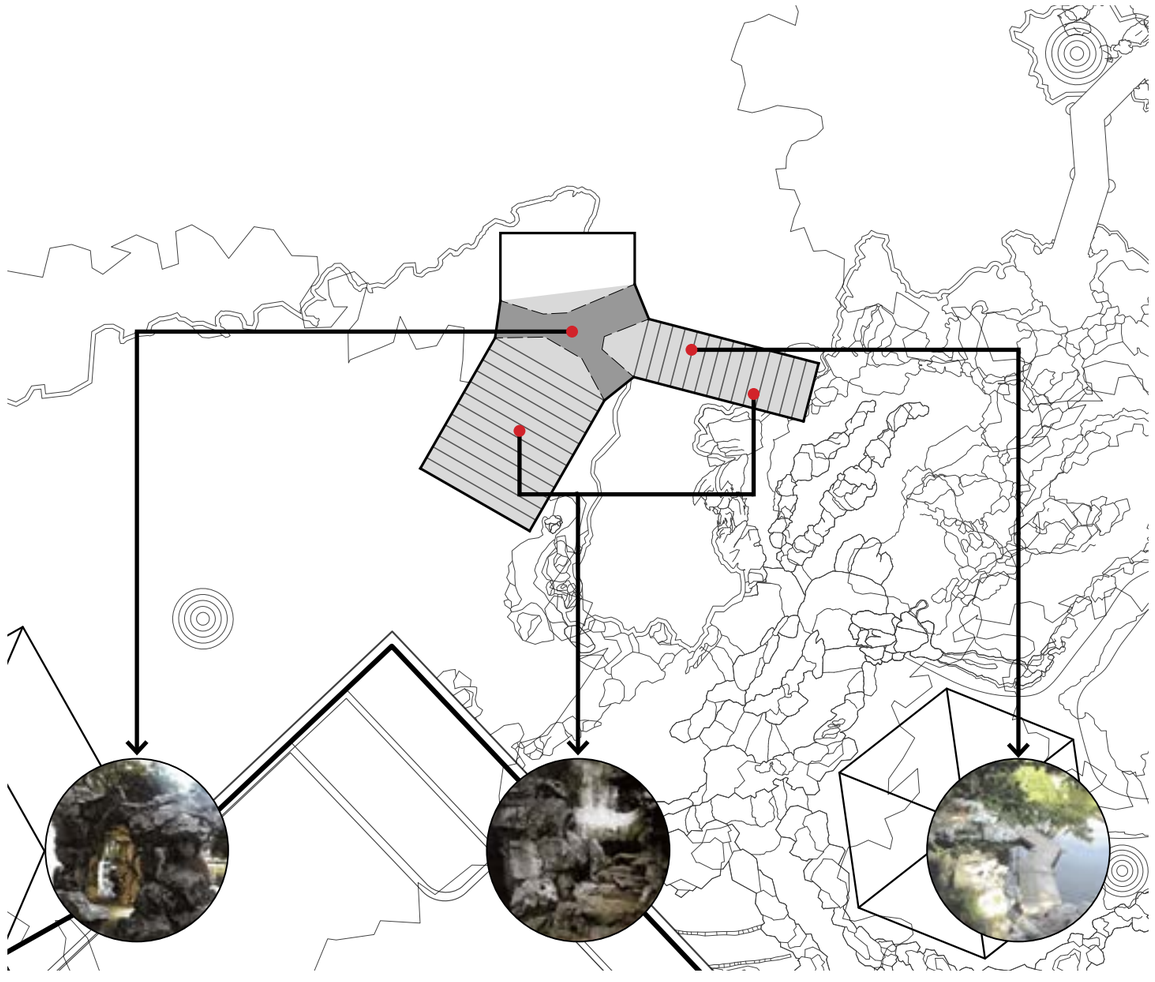
Viewing and being viewed is an important view concept of Chinese garden design. The final structure of this project will become a landscape installation located in the center of the reimagined Murphy garden. The three direction tunnel faces to three other projects in the garden. The profile of the tunnel entrances will became the view frames of the Murphy roof corner, the reimagined wall and the moonlight pavilion. Finally, it will being viewed as an artificial hill and also viewing other elements around it.

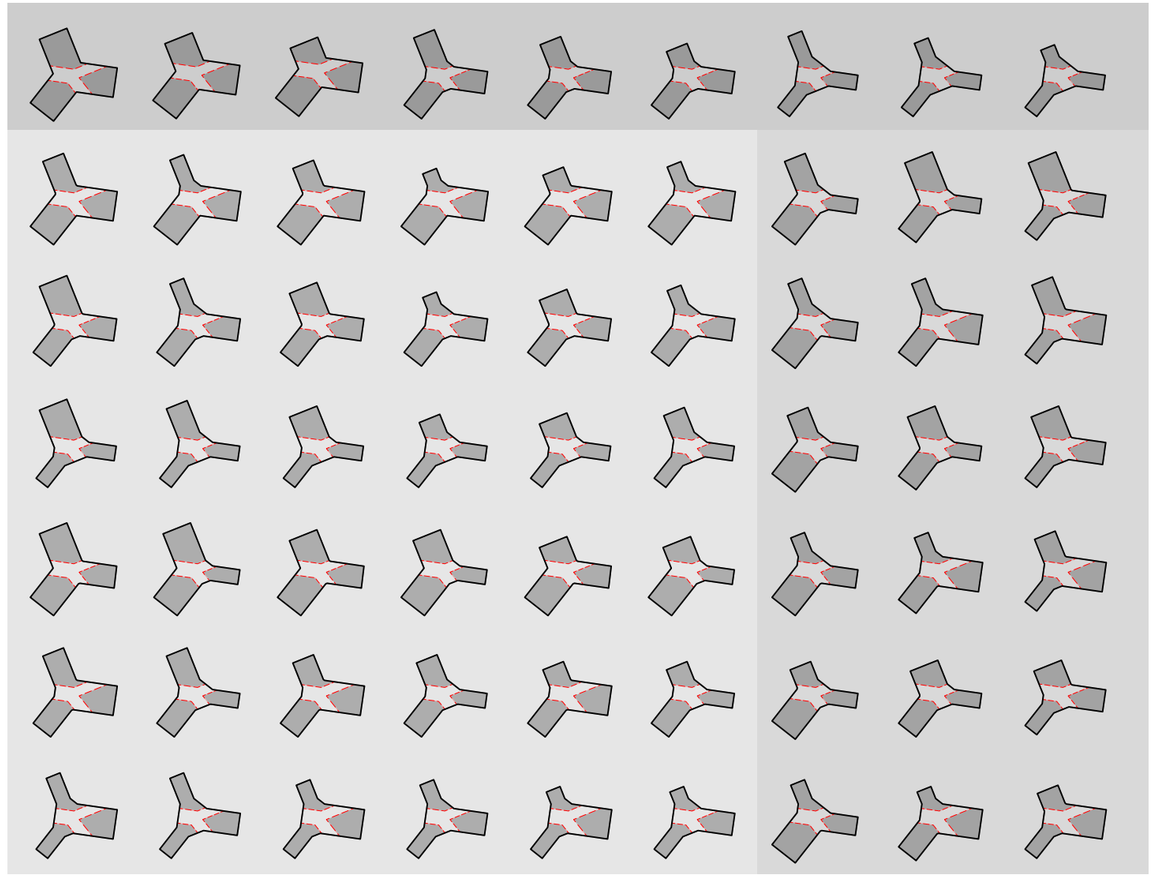




Function

The global geometry is also determined by function. Three most common uses of rock in traditional Chinese garden are tunnel, stairs, and bridge. The structure will have all these three functions. The central part of the structure will be a three direction tunnel. Two of the three branches will function as stairs and one of the stair branch will also function a bridge.



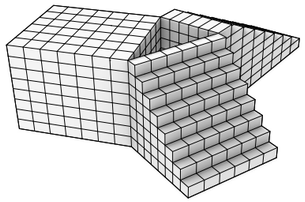


Voxel Optimization

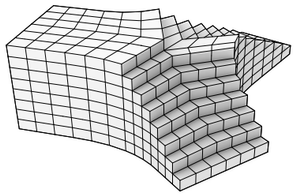
A particular network is a system of components which are connected and operated together. Typically, a large number of standardized components connect with each other makes the global structure work and stable.

In this project, the designed folding cells cannot be applied to a conventional lattice structure. Therefore, a special voxel system has been developed. The voxel system provides a corner-to-corner connection which means each node will only connect two folding cells. The typical voxel is composed of only hexahedrons. However, a tetrahedron can be generated from any hexahedrons and tetrahedron is also a stable structure. That means we will still get a stable system if we replace some hexahedrons with tetrahedrons in a voxel system. At the edges of the global structure, cells will only be connected from one side and became cantilevers. In order to hold edge cells, 53 cover panels need to be added to the system.

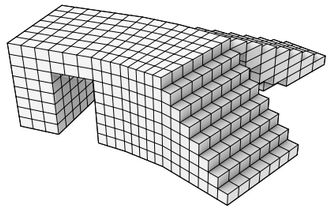
The final structral system has some limitations. A typical voxel usually works better with smaller units or larger geometry. If some nodes for multiple cells connection can be designed, a complete curved voxel will generate more irregular shape with smooth surface.



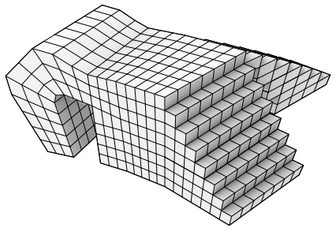
Voxel



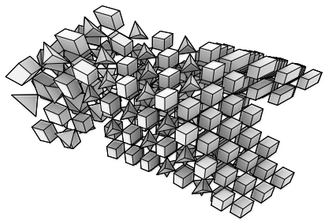
Curved Voxel



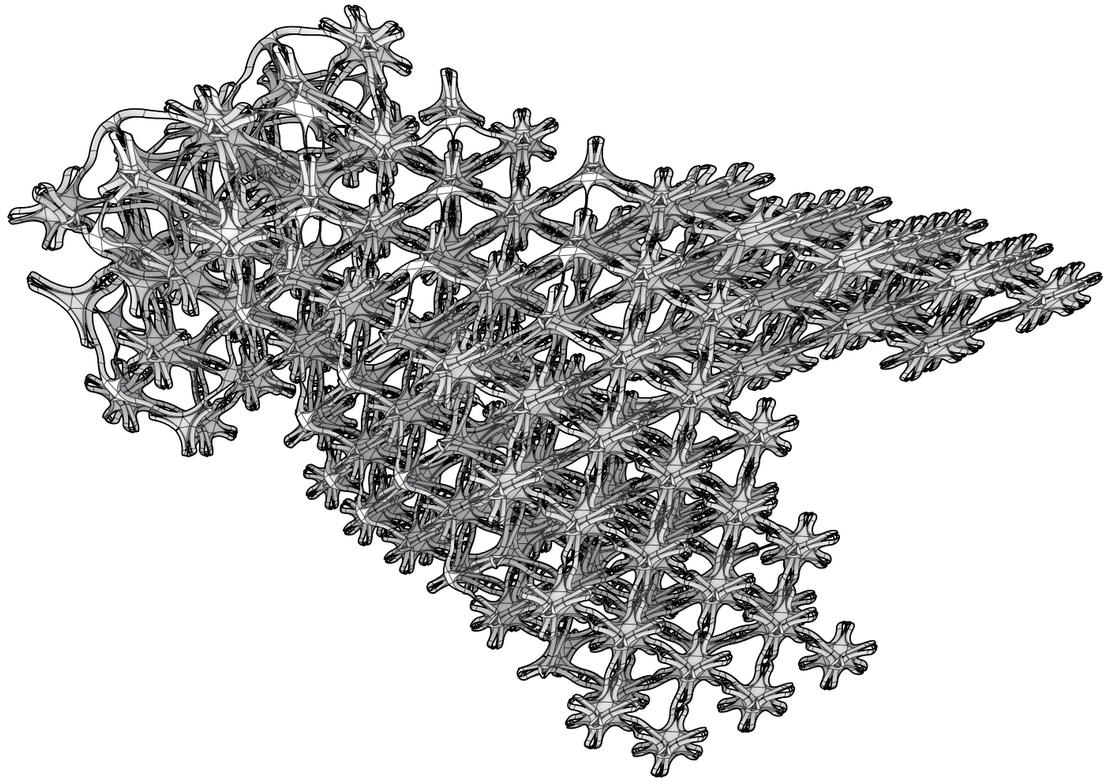
Curved Voxel With Branch



X-Z Plane Partial Curved

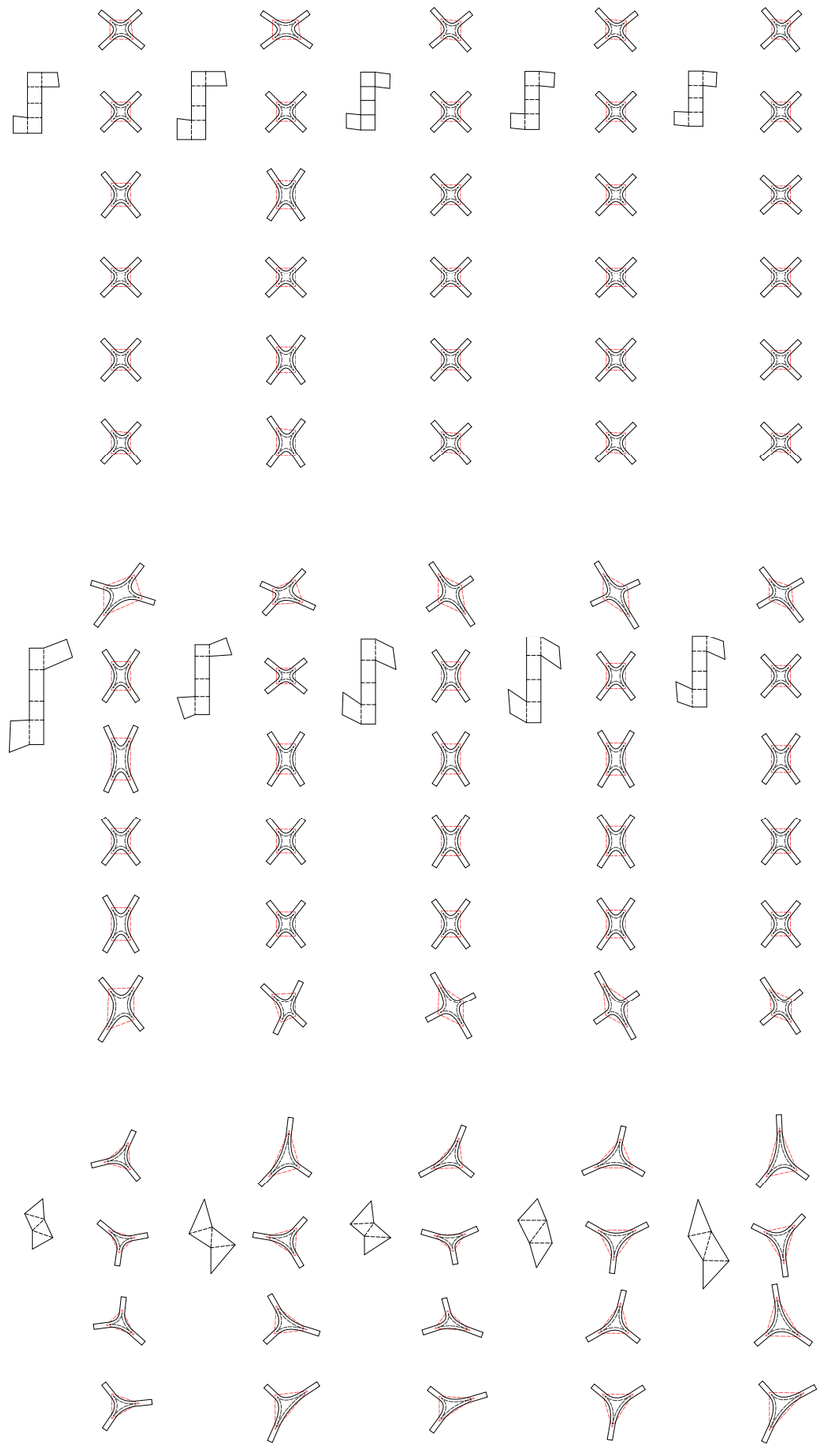


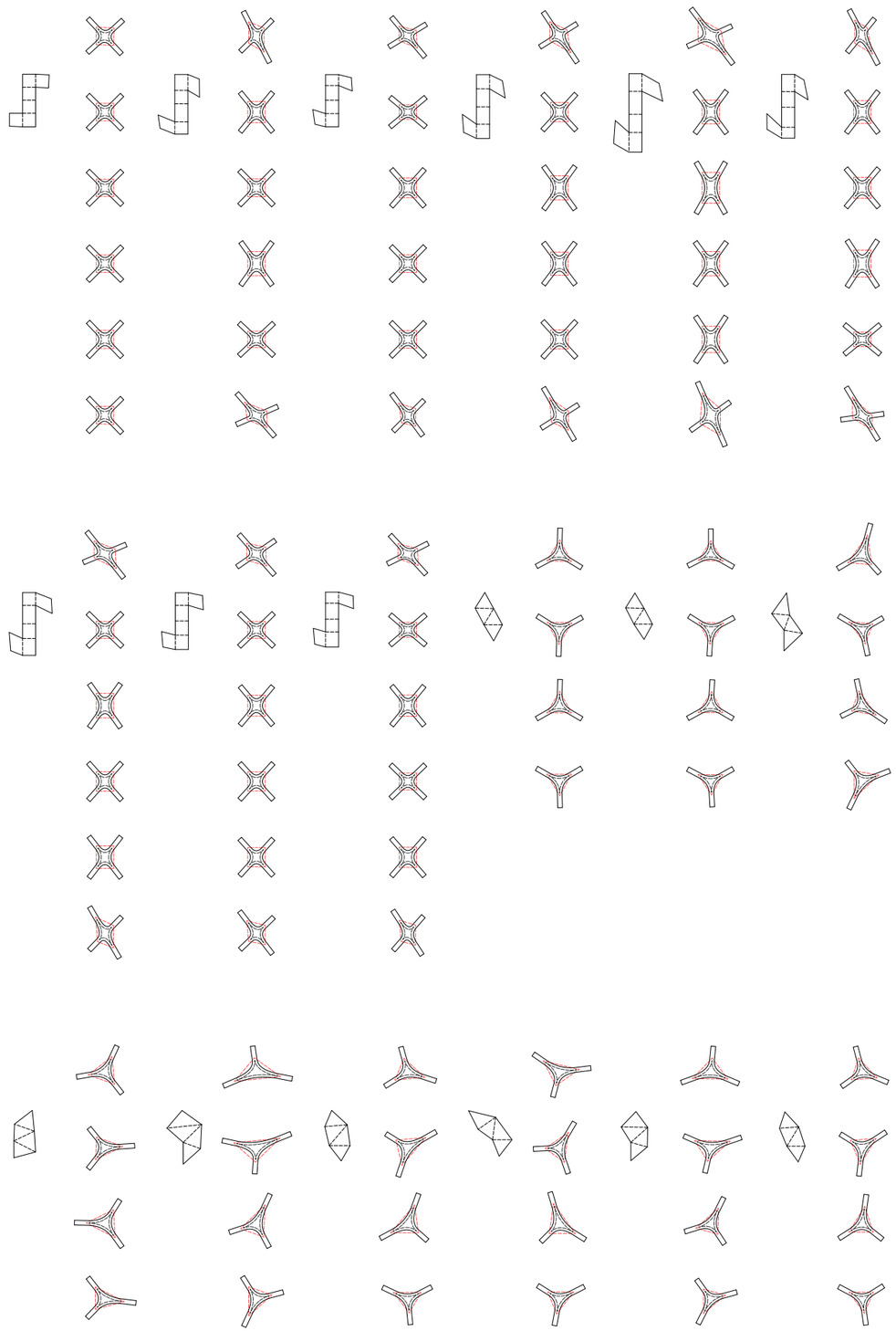
Cell Reduced And Tetra Replacement



Folded Surfaces

Panel Figure For CNC Cutting
(Partial)





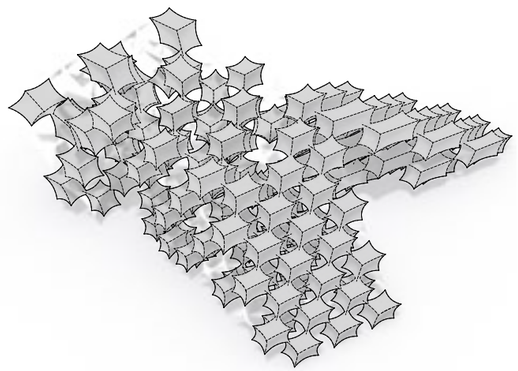
Project Description

Length: 23 ft
Width: 27 ft
Height: 10 ft

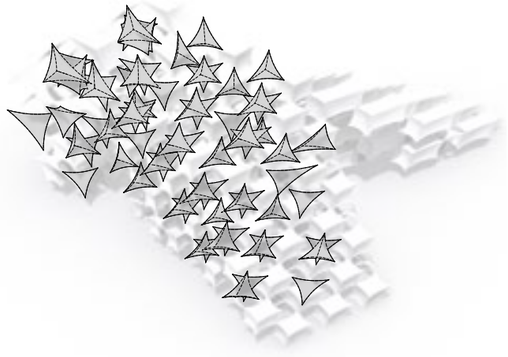
Hexahedron cells: 139
Tetrahedron cells: 68
Edge cover panels: 53

The philosophy of this project is to build a lightweight and self-supporting architecture with transparency plastic sheets, that brings out a togetherness in its spatial character, structural performance and ornamenting quality. Finally, the rocklike cellular structure will become a poetic art installation with vision and light lyrically entwined in it and a playful moment fades into the garden environment.

The project doesn't try to have a perfect architectural outcome. The importance of the project is showing the potential of the material, the structure and the design process.



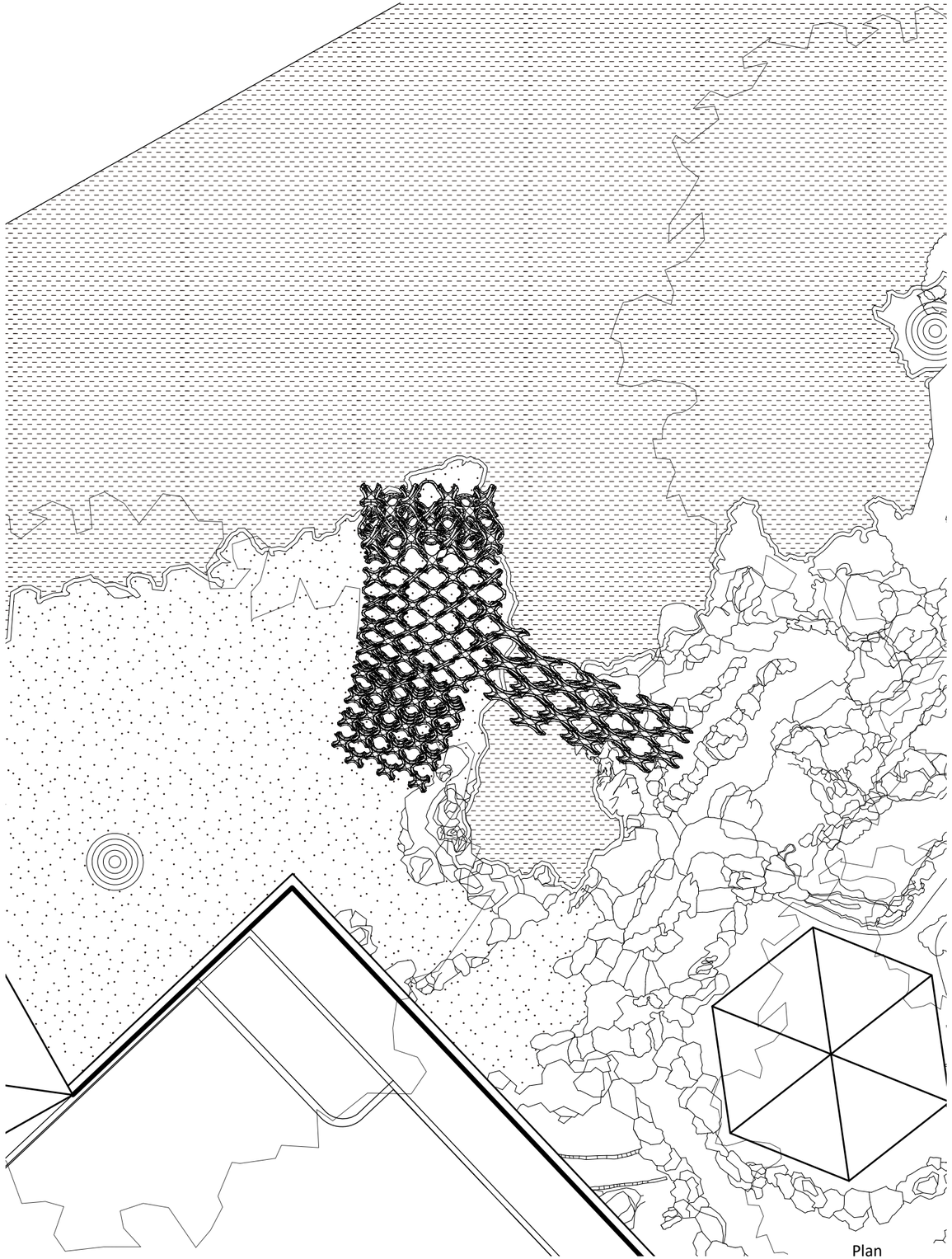
Hexahedron Cells



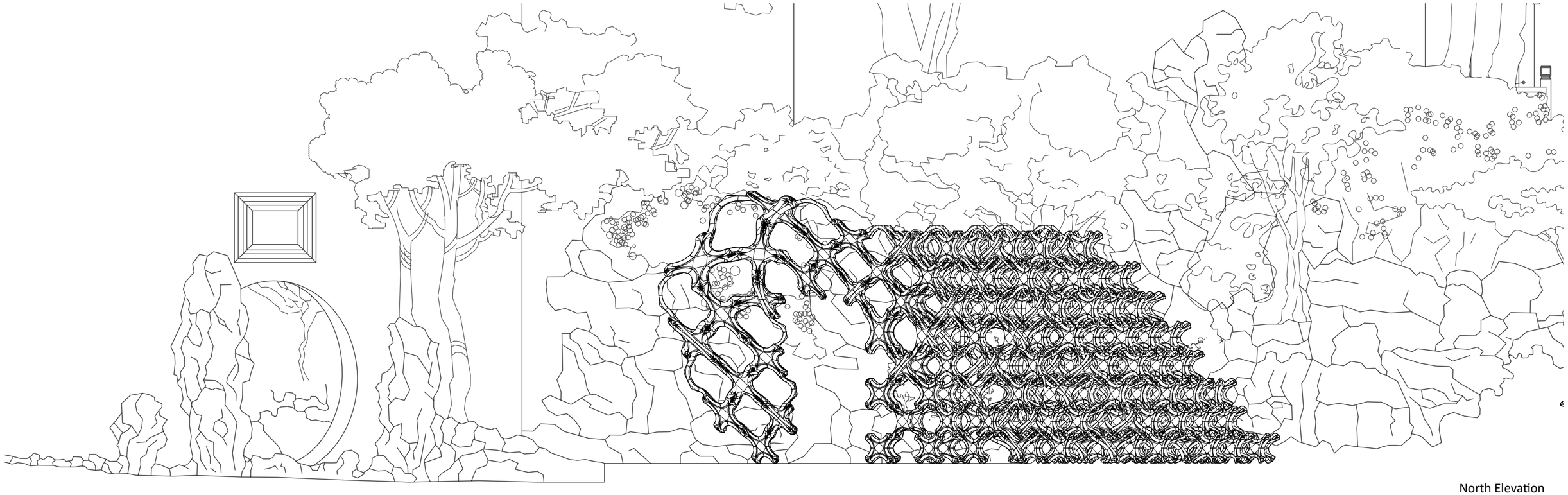
Tetrahedron Cells

Rockery Replacement

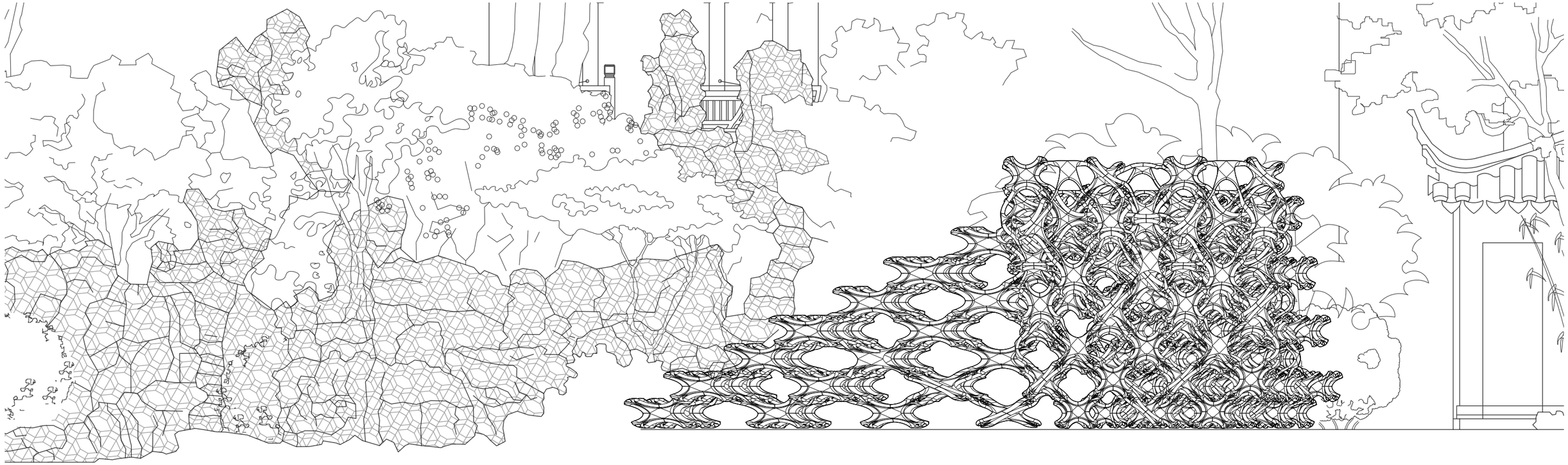
Edge Cover Panels



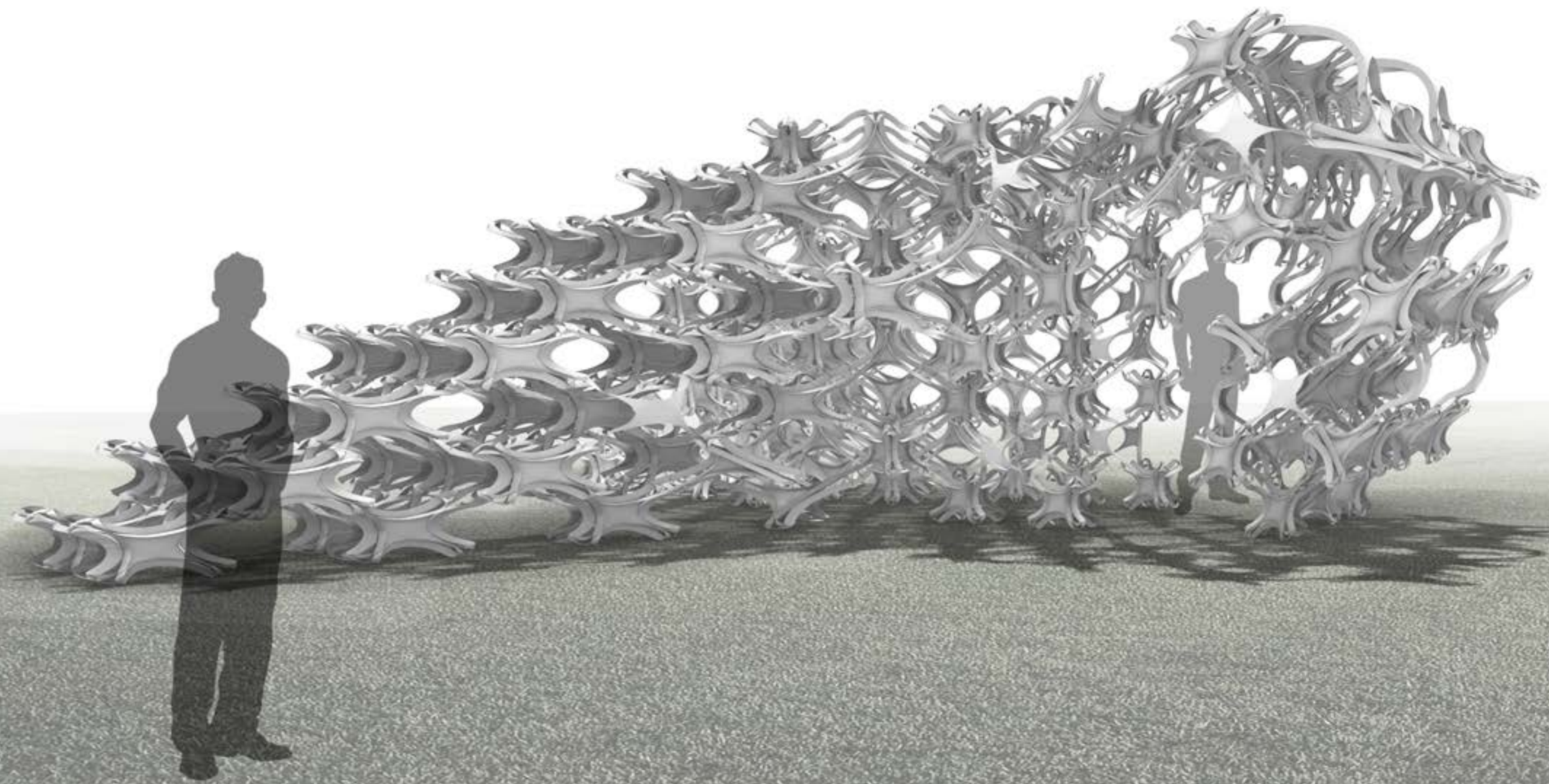
Plan



North Elevation

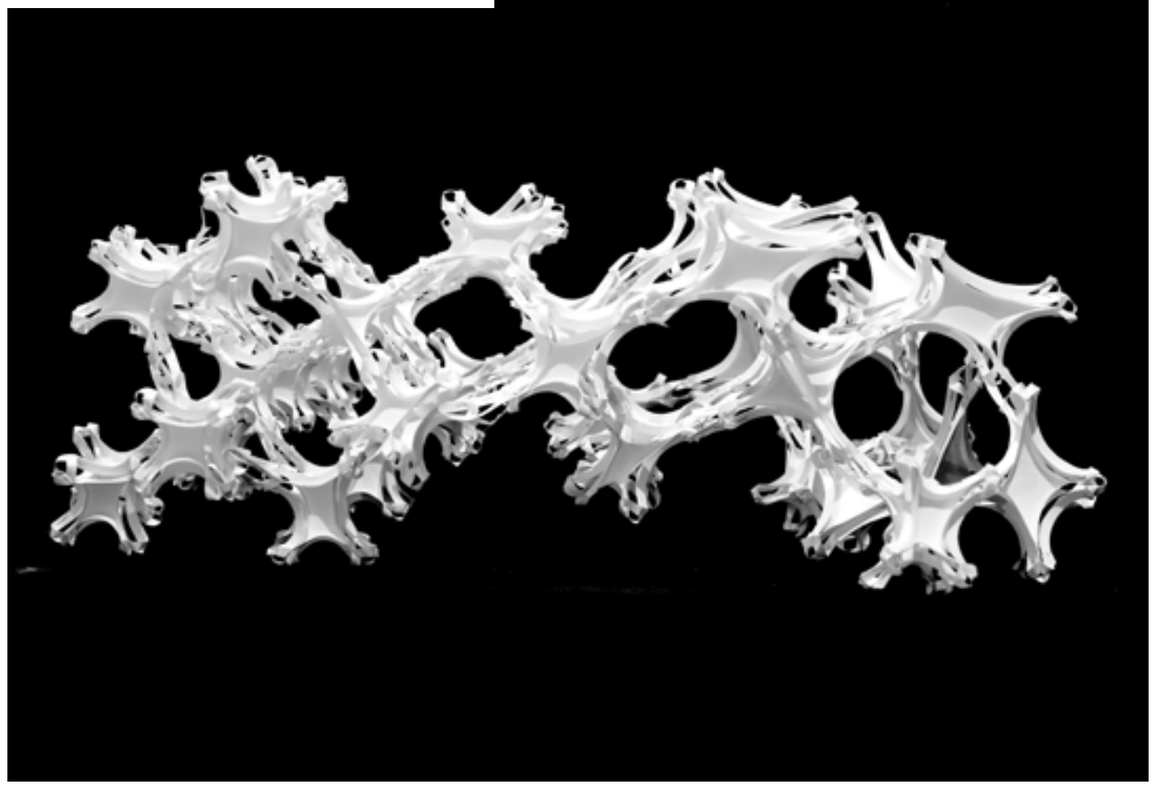


South Elevation

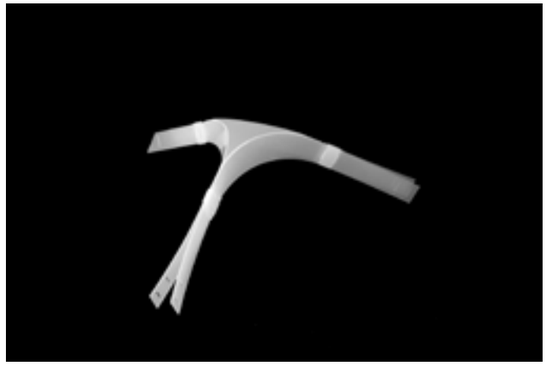


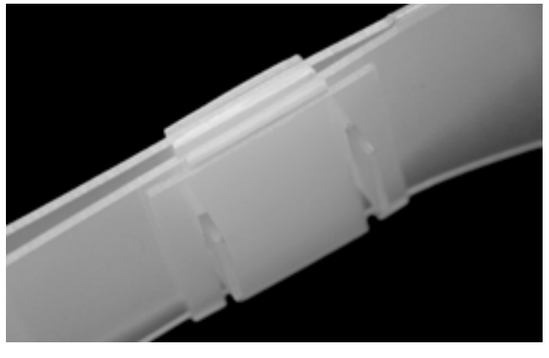
Final Models

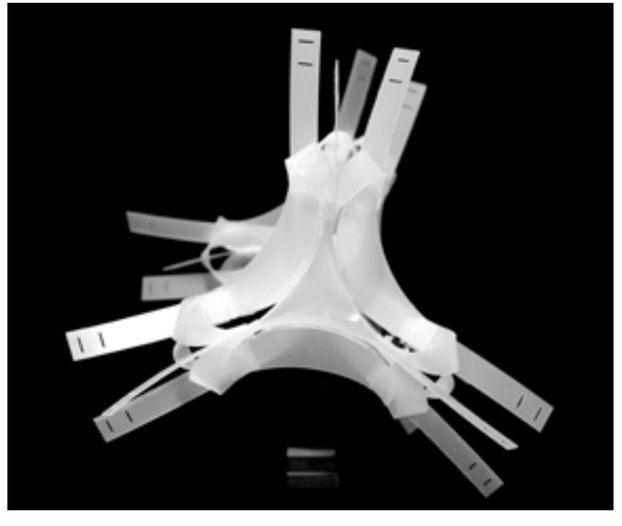
Mockup
1:4
Bristol Board

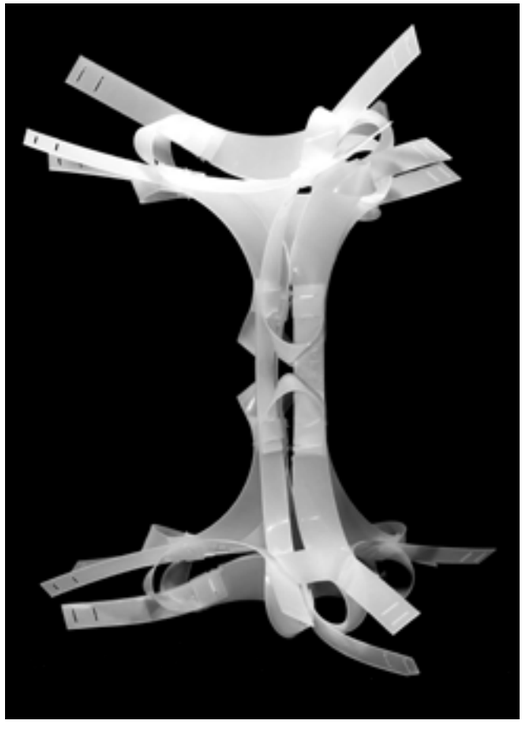


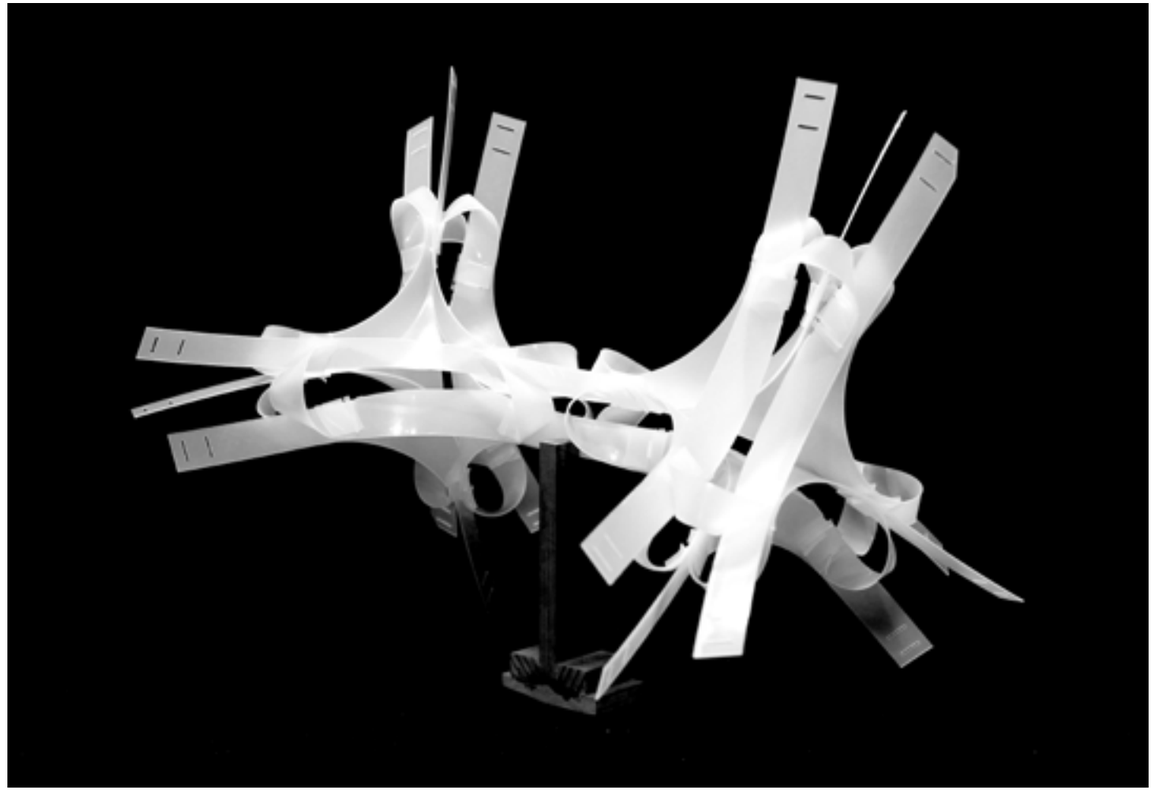
Mockup
1:1
1/16” Polypropylene

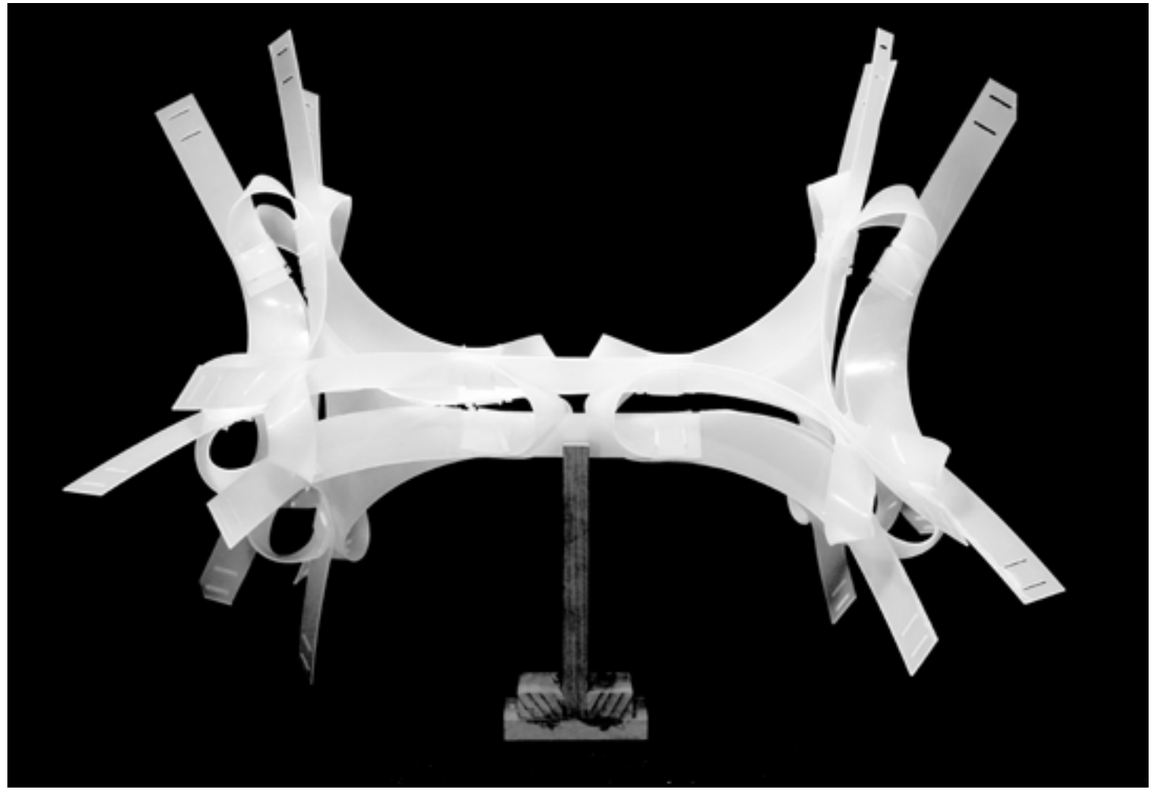










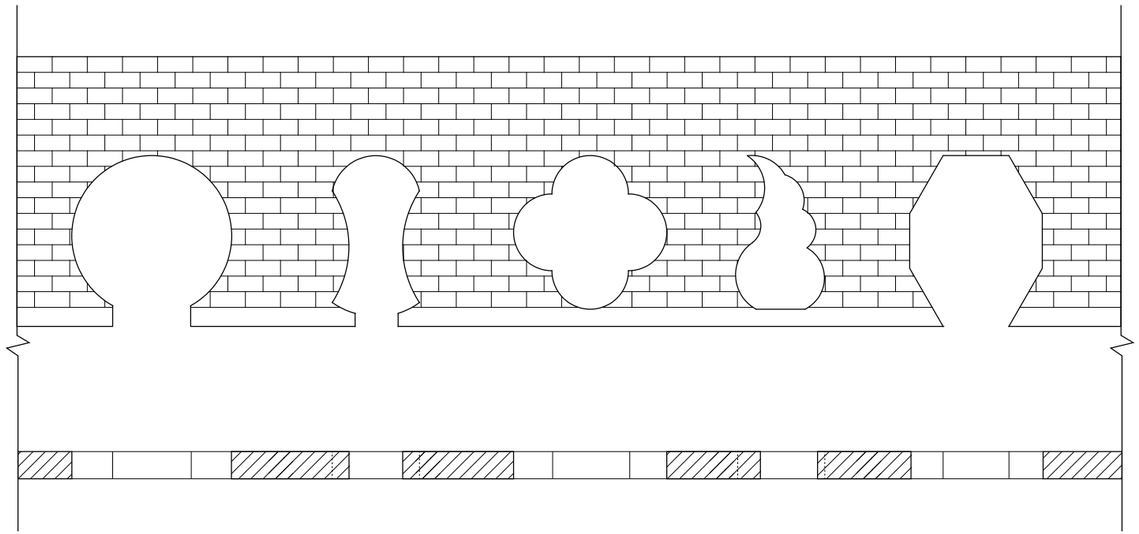


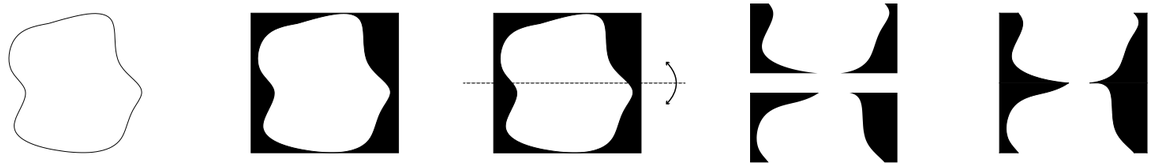
Project 2
Leaking Vision
Heavy Casting with Cone-shaped Inflation to Create Screen and Opening on Walls in Chinese Garden

Abstact

The Chinese garden is usually enclosed in high walls to be isolated from the outside world. It is not a single wide-open space and divided by corridors and walls into courts in which buildings dominate the scenery and attract one's attention. Since the Chinese garden is introversive, it largely depends upon the wall to conceal its beauty, luring the wanderer to a glimpse through a doorway or a tracery.

This project focuses on walls, which is one of six elements in a Chinese Garden, and investigates a new wall with spatial passageways, instead of impenetrable linear forms. The proposal of the project is redesigning special parts of walls, those surfaces being dotted with traceries of exquisite patterns, and doorways shaped like a full moon, a vase or a flower petal. Vision is leaked through ideal makeup geometry in the outline of original figure of opening on walls. Starting by analyzing the function of walls, the method of fabrication produces two types of inflation shapes and combinations. The resulting walls comes from casting inflation within one cubic form to show a series of wall pieces.



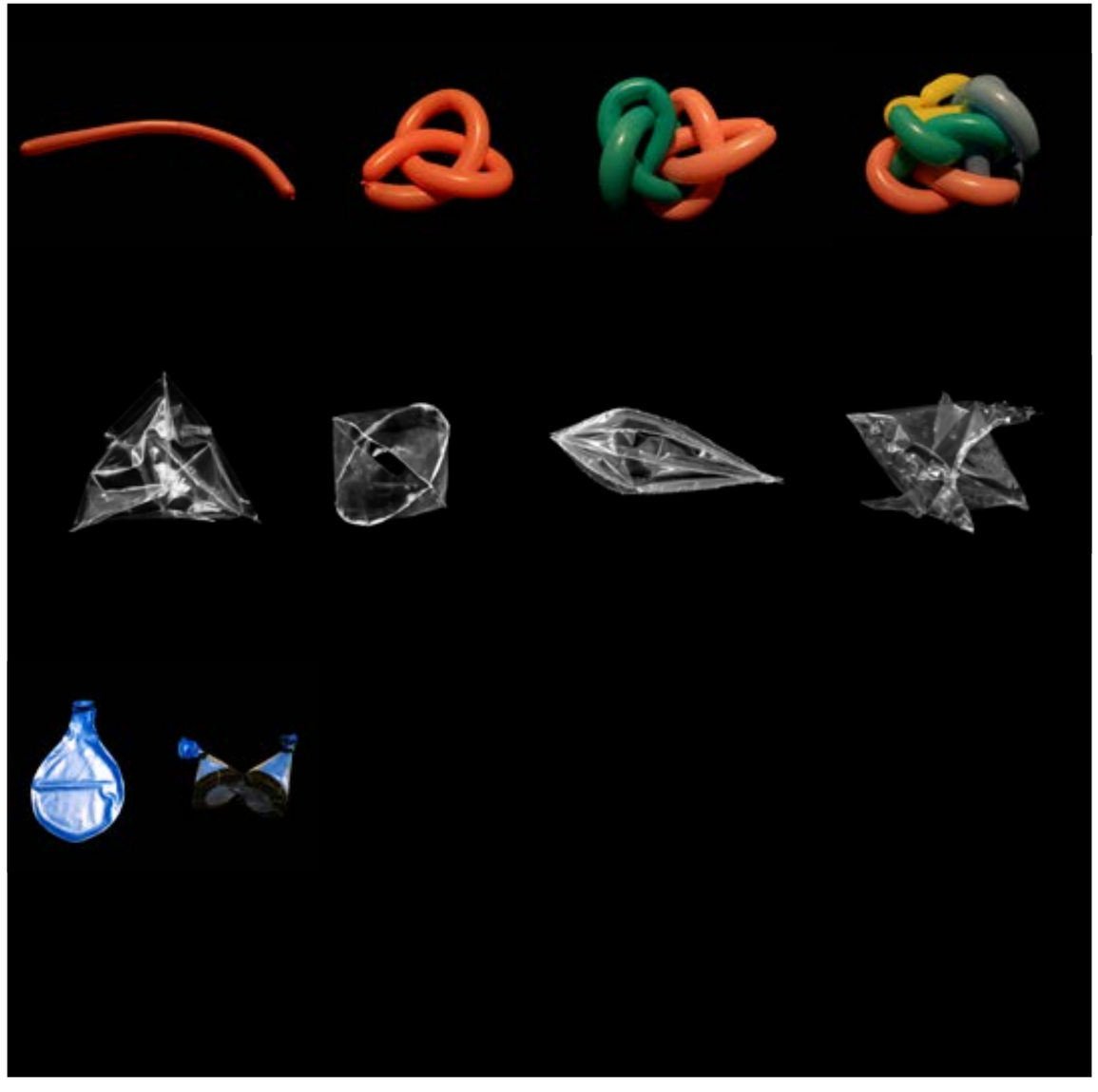


The traditional walls is built with bricks layer by layer, with the new technique, this project is proposed a new way to build wall, rather than a linear space.

The first step is to make an inflation depending on the creation of shape. The second step is to cast with a kind of ideal material (plastic or concrete) after inflation in box. The third step is to cut the result of casting to divide st two different parts. The forth step is to rotate the pieces from the last step. Then to combine the pieces for the final space in the last step.

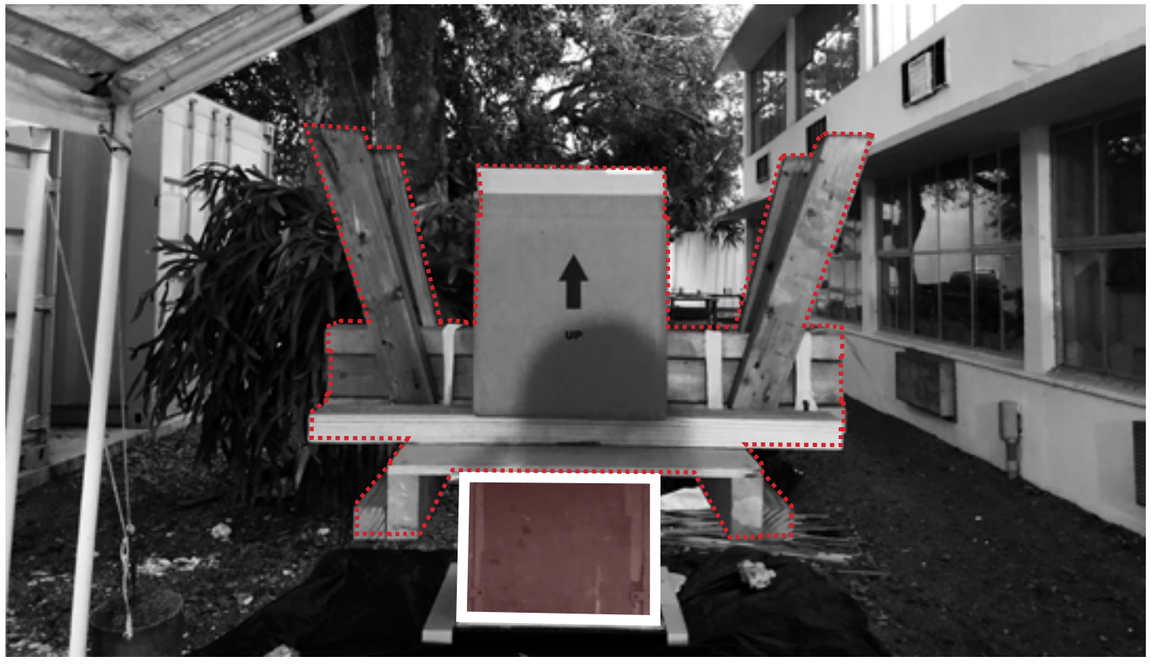
Experiemnts

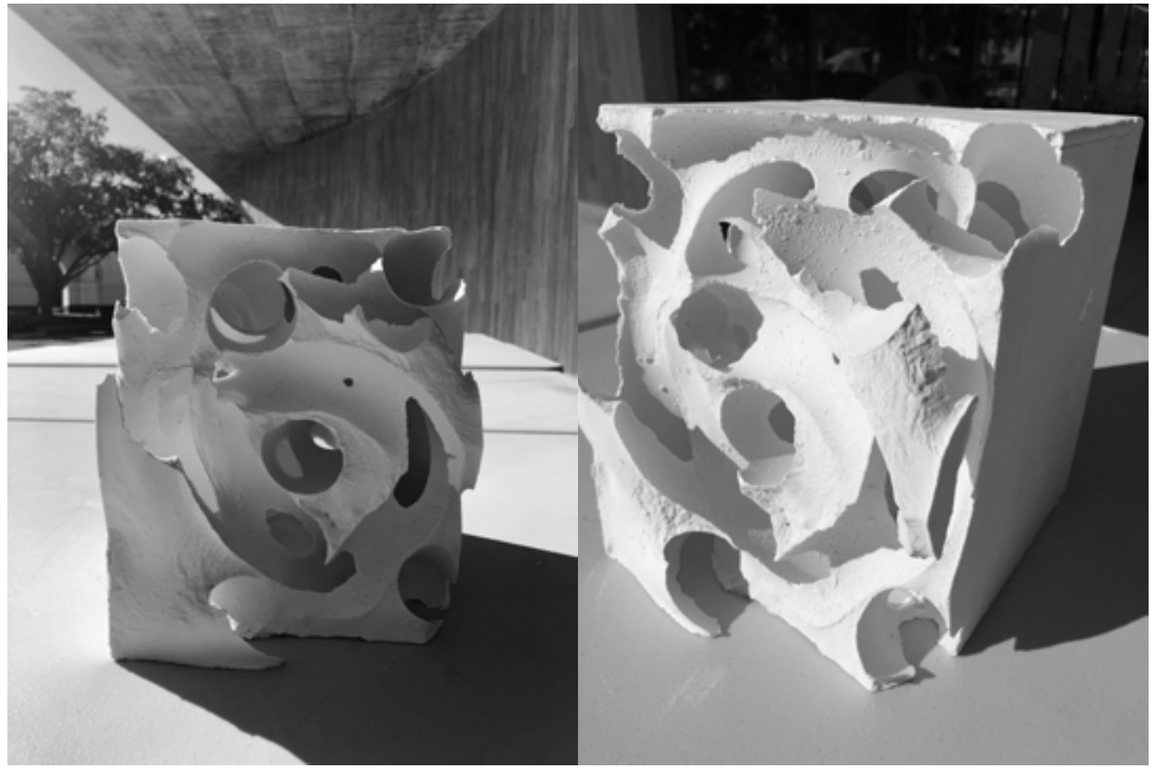
Inflation types:
1. Inflation with balloon
2. Inflation with 2D self sealing
3. 3D shape with tapes at first, then inflation with balloon

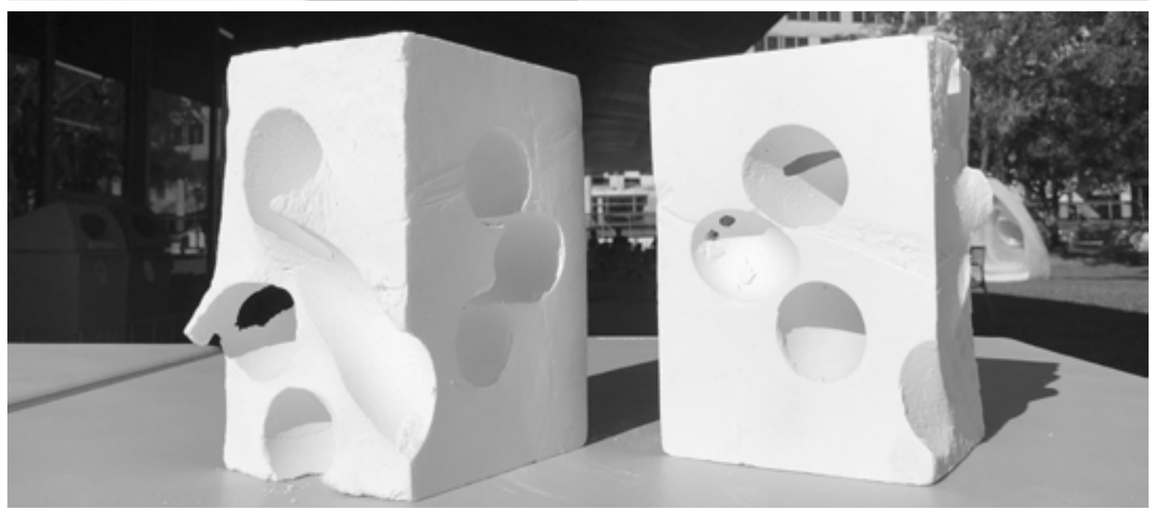


Casting issues:
1. Material for casting, then cutting
2. Floating
3. Leaking
4. Over-heating

		ISSUES		
		CASTING/ CUTTING MATERIAL	FLOATING	LEAKING
THE OPTION OF INFLATION	INFLATION WITH BALLOON	★	★	
	INFLATION WITH 2D SELF SEALING	★		★
	3D SHAPE WITH TAPES AT FIRST, THEN INFLATION WITH BALLOON	★		







Object

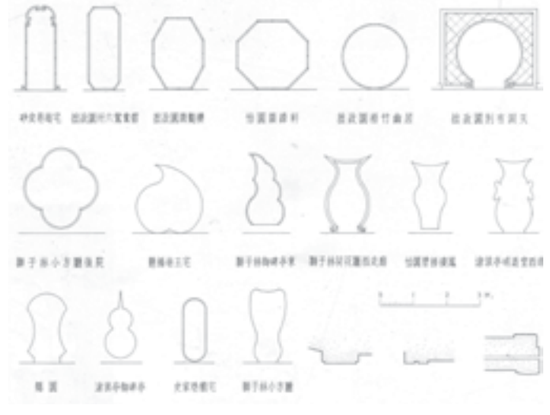
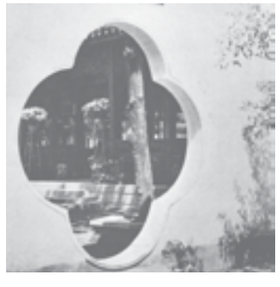
During all the experiments of inflation and casting, I had many issues, such as leaking if keep inflatable, floating, over- heating caused the balloon popup.

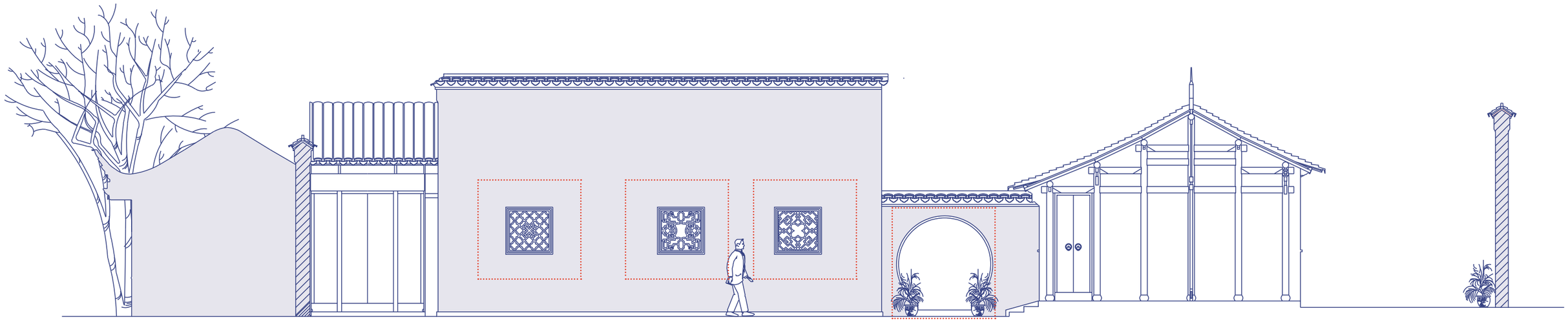
I realized it is too hard to build a whole wall in this way. So, I focus on the opening on the walls. Vision is leaked through ideal makeup geometry in the outline of original figure of opening on walls, such as a doorway or a tracery.

The first thing is that I did the research of figure.
The second thing is to think how to make these figures with inflation quickly. I found one form is perfect one to make, it's cone. Just need a fan-shaped to roll.
The third thing is to pick up the figure made of inner arc because of cone. Each figure is to think about how to draw with circles.

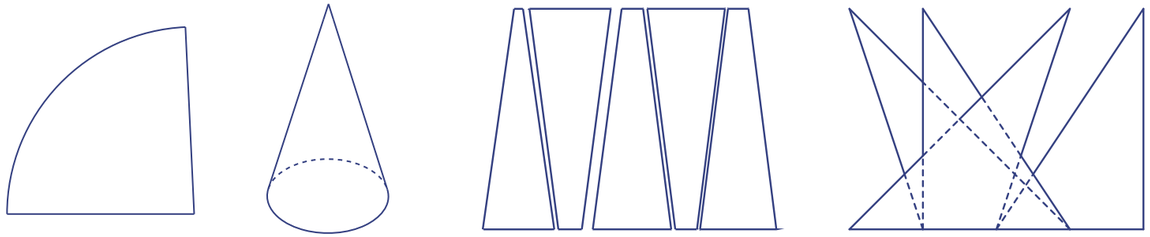




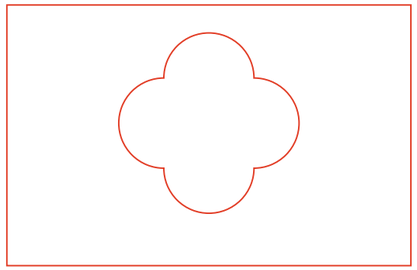



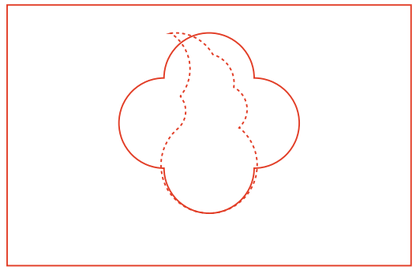



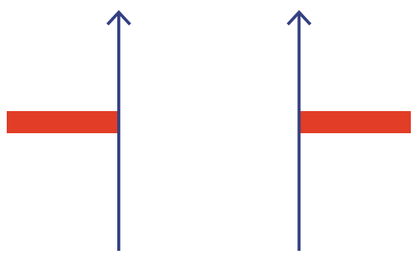
Cones

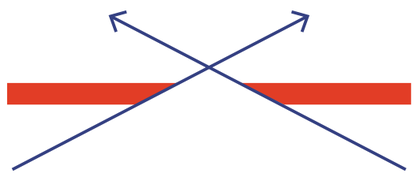


Transfer on wall





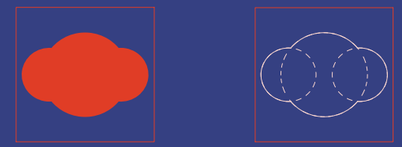




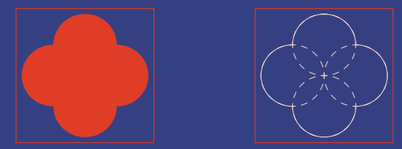
Five basic figures

1 CIRCLE

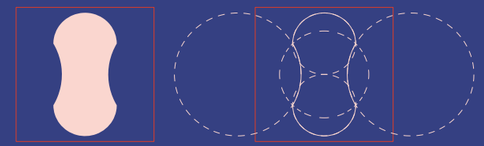
2 CIRCLES



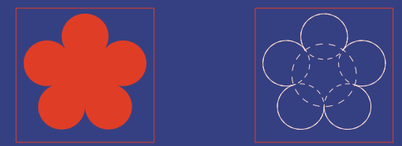
3 CIRCLES



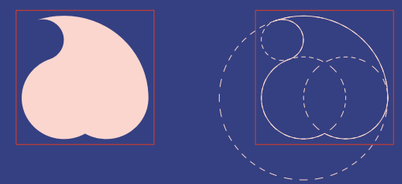
4 CIRCLES



5 CIRCLES



5 CIRCLES



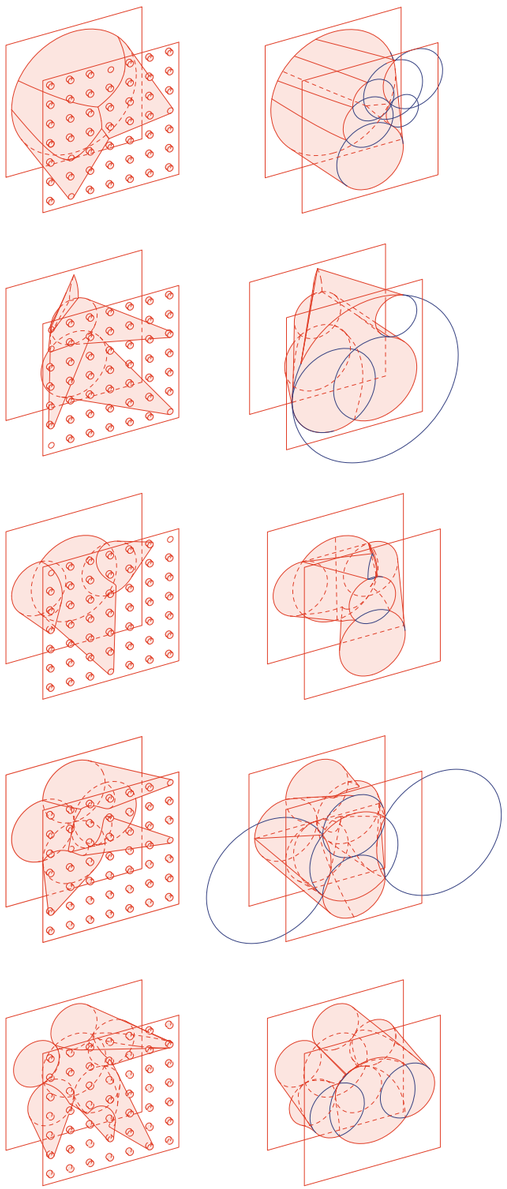
4 CIRCLES

6 CIRCLES

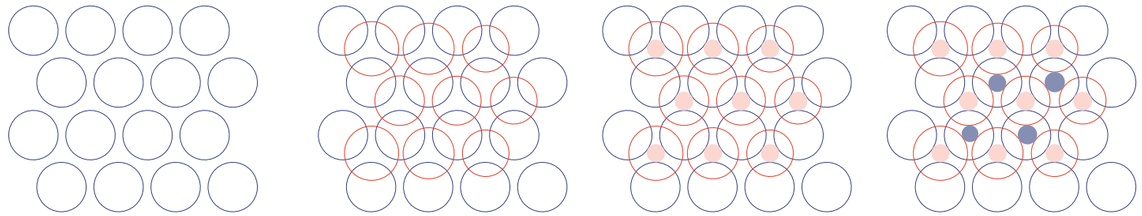
Design Process

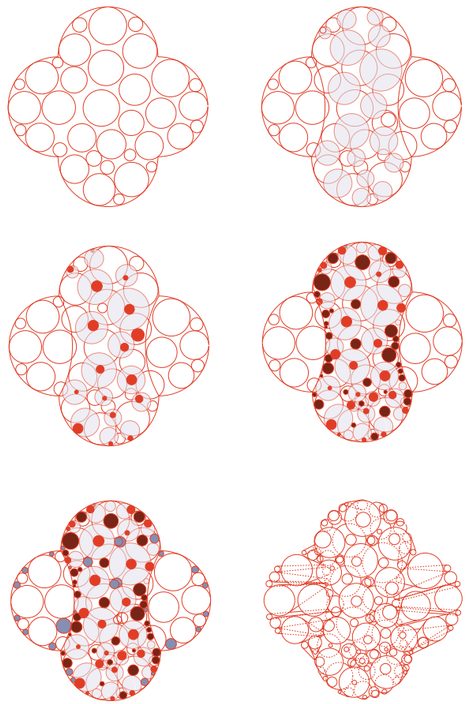
Family 1

Family 2



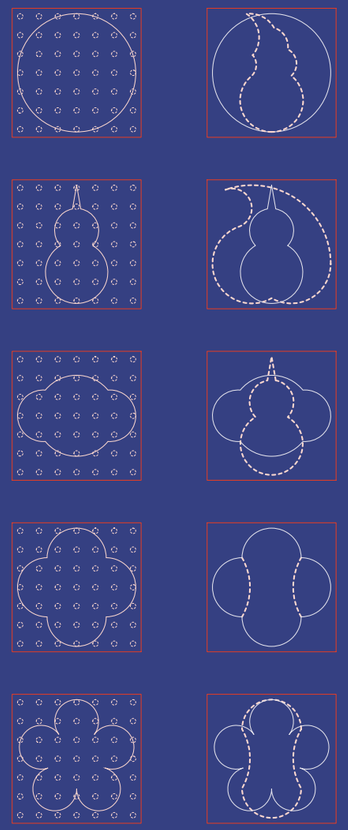
Family 3

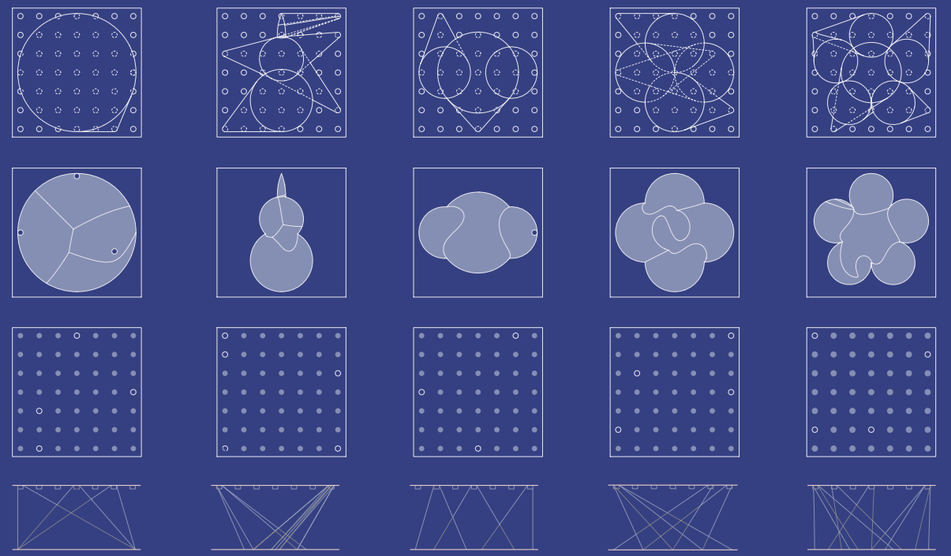




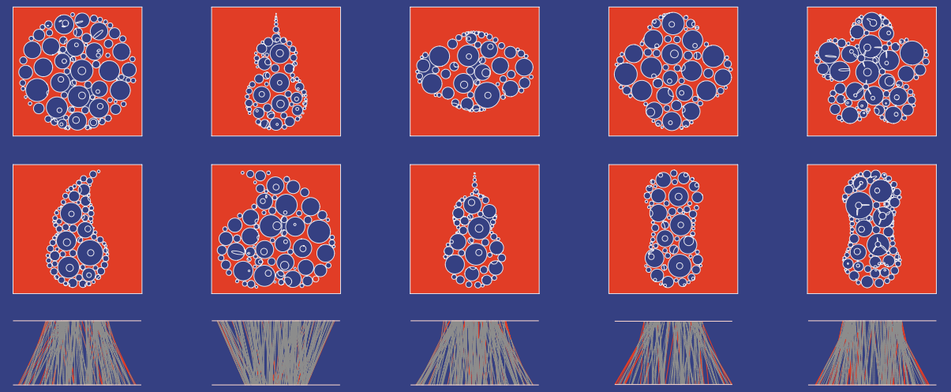
Type 1

Type 2





Family 1



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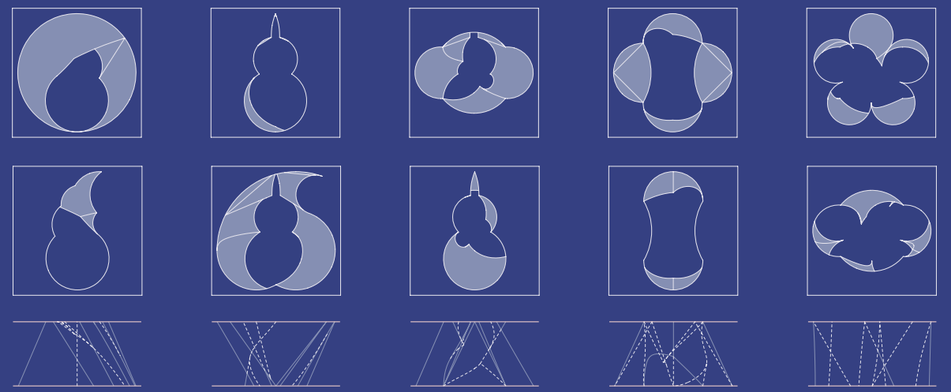

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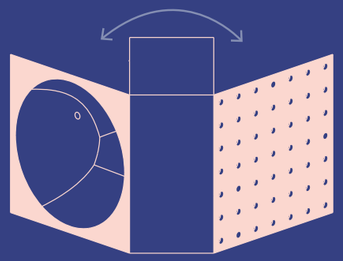
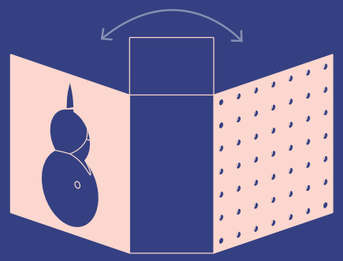
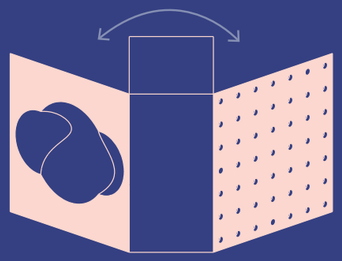
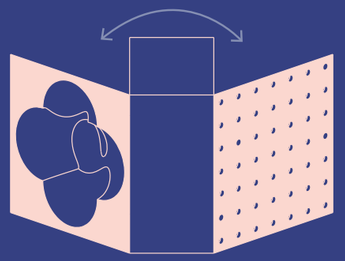
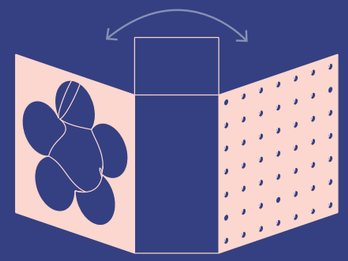
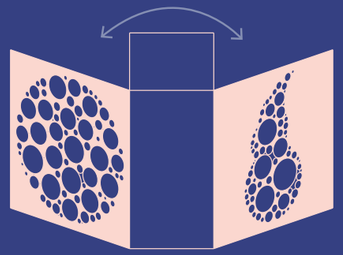
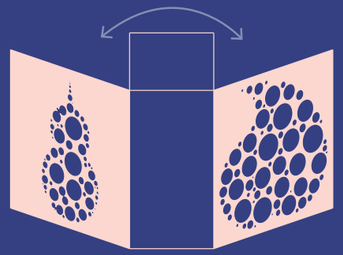
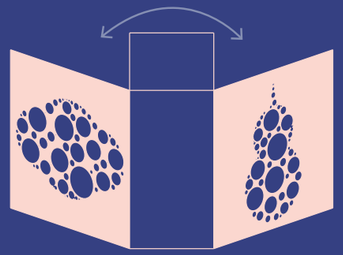
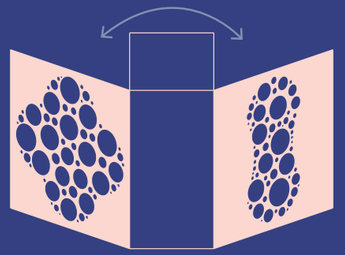
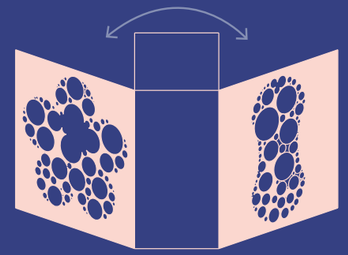
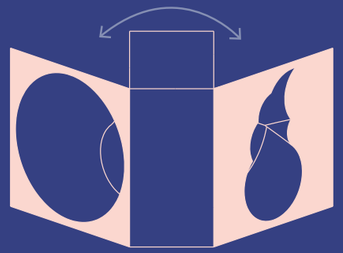
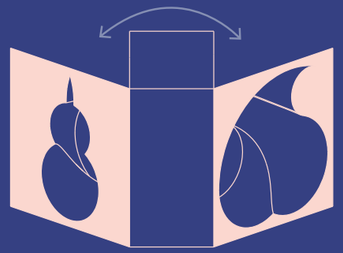
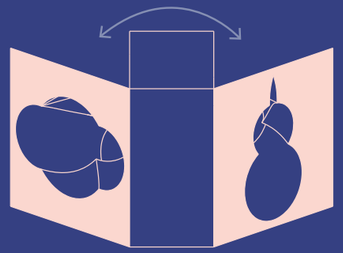
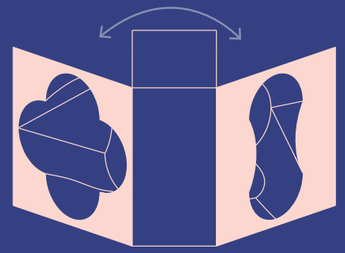
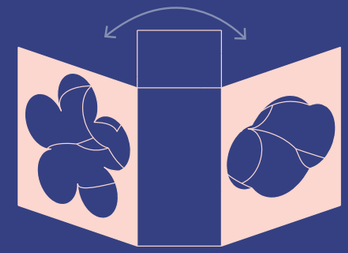
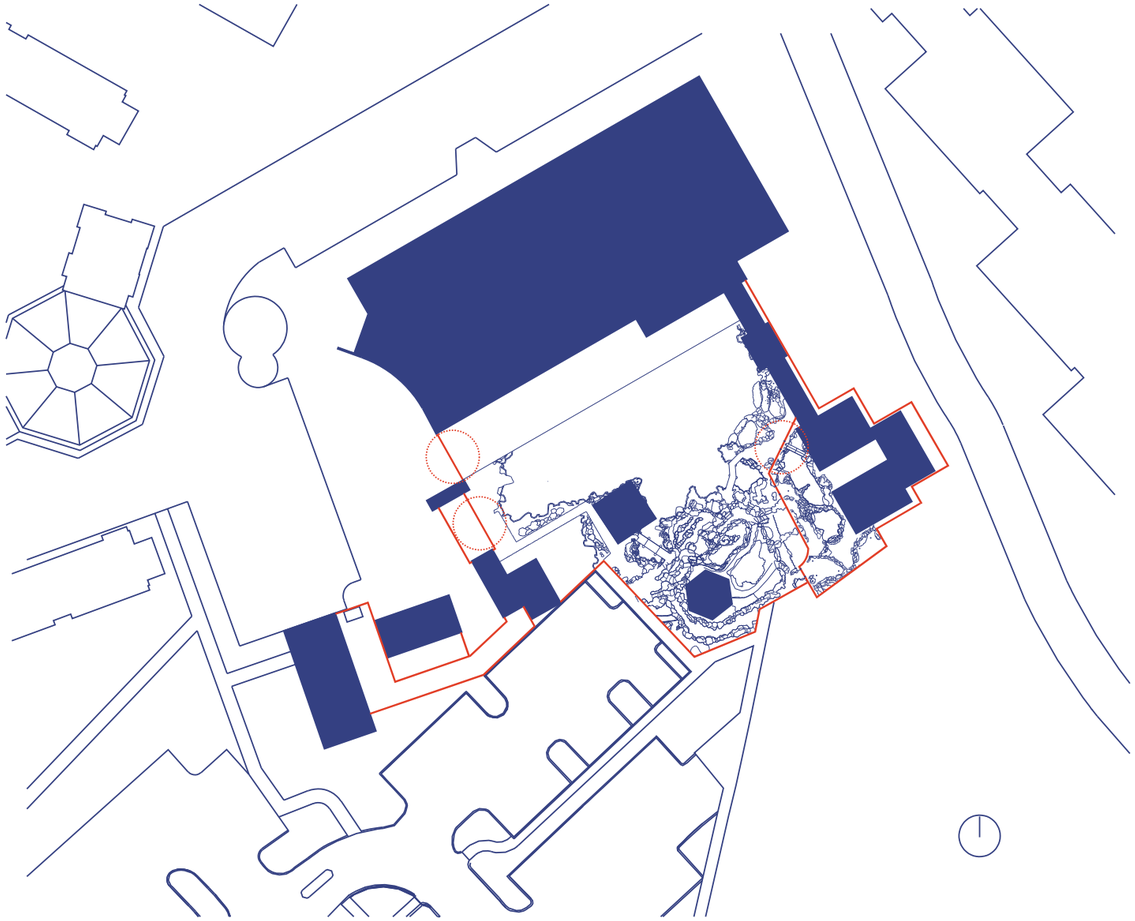
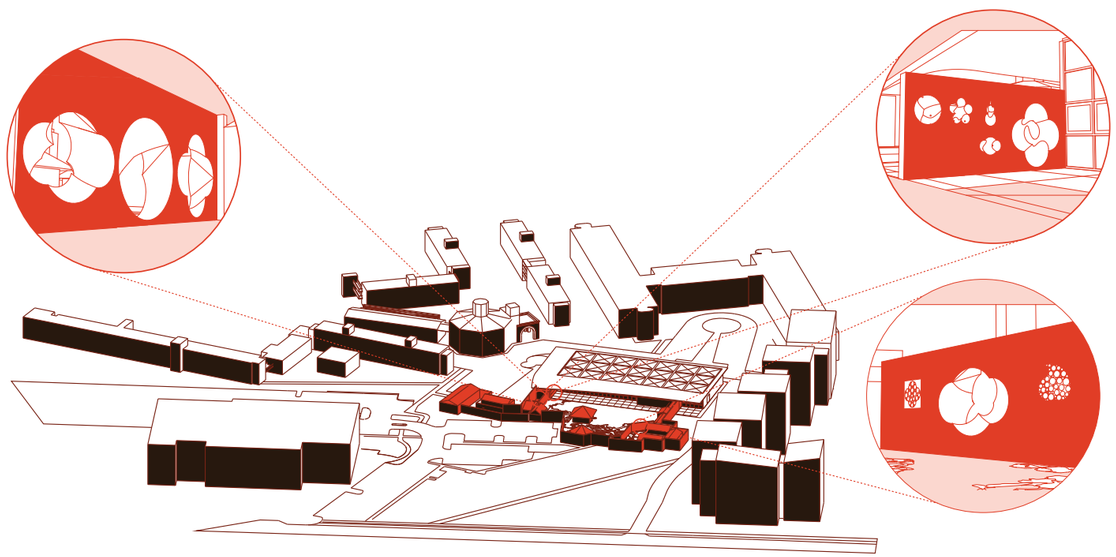
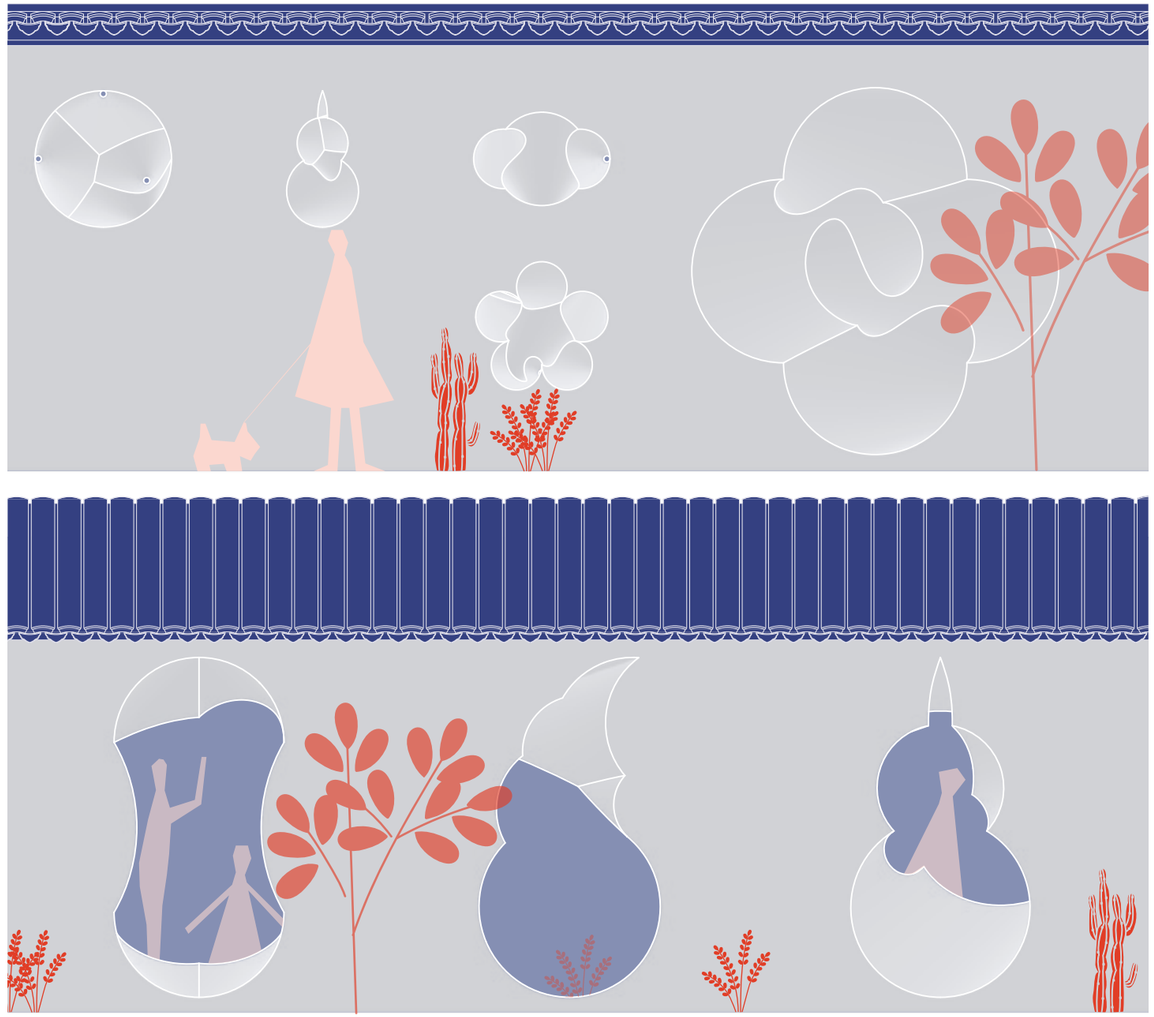
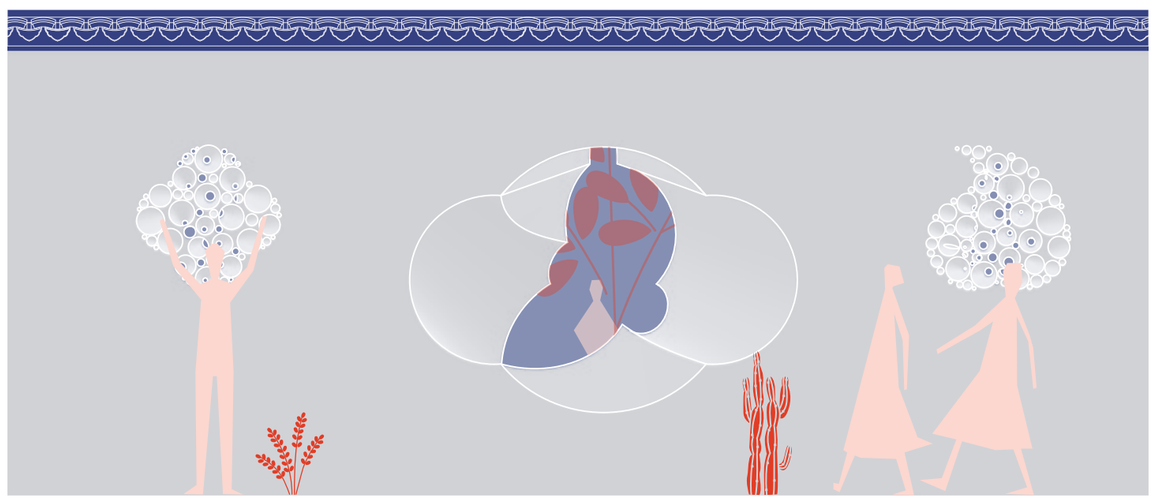
















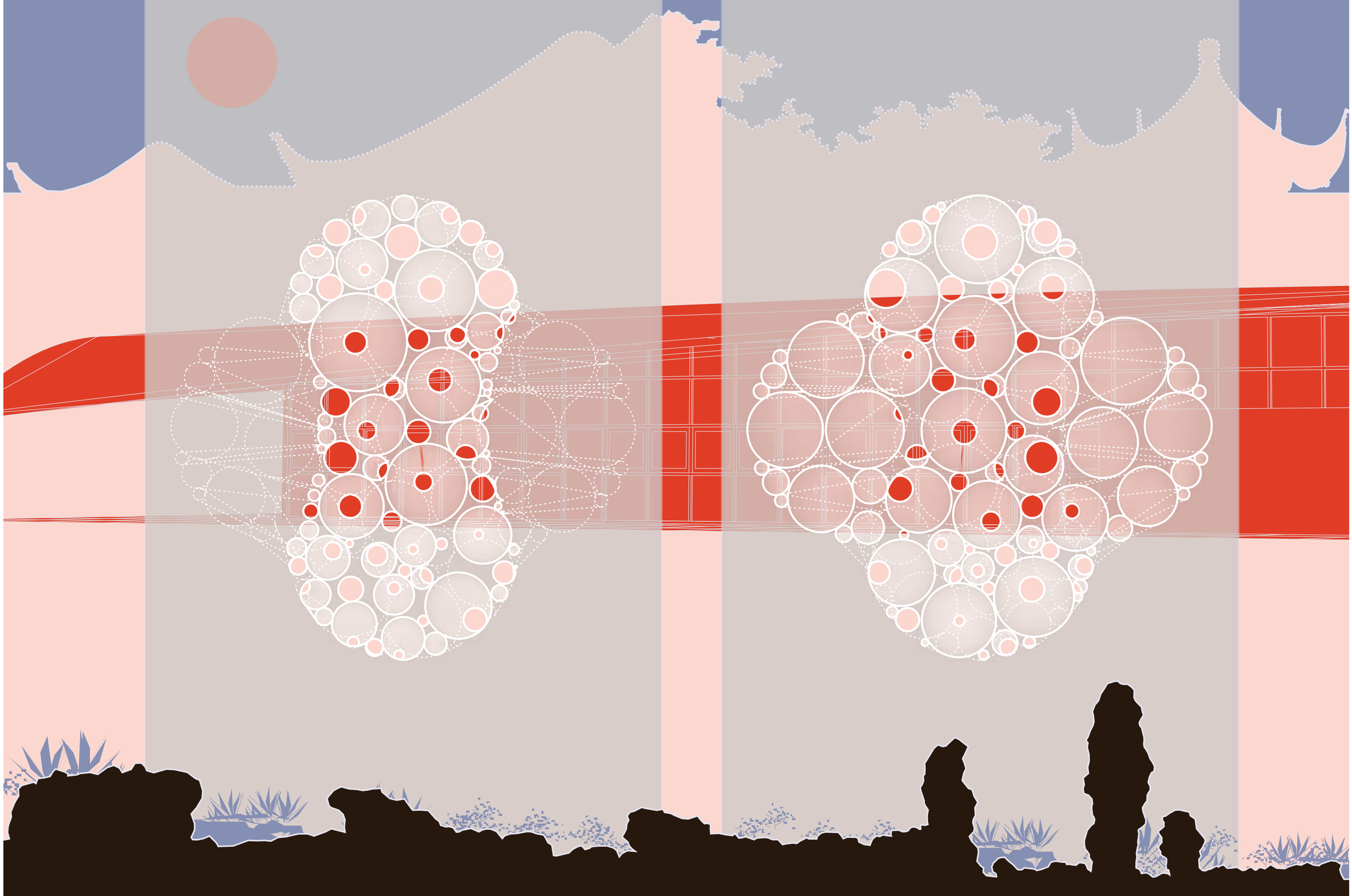
Location





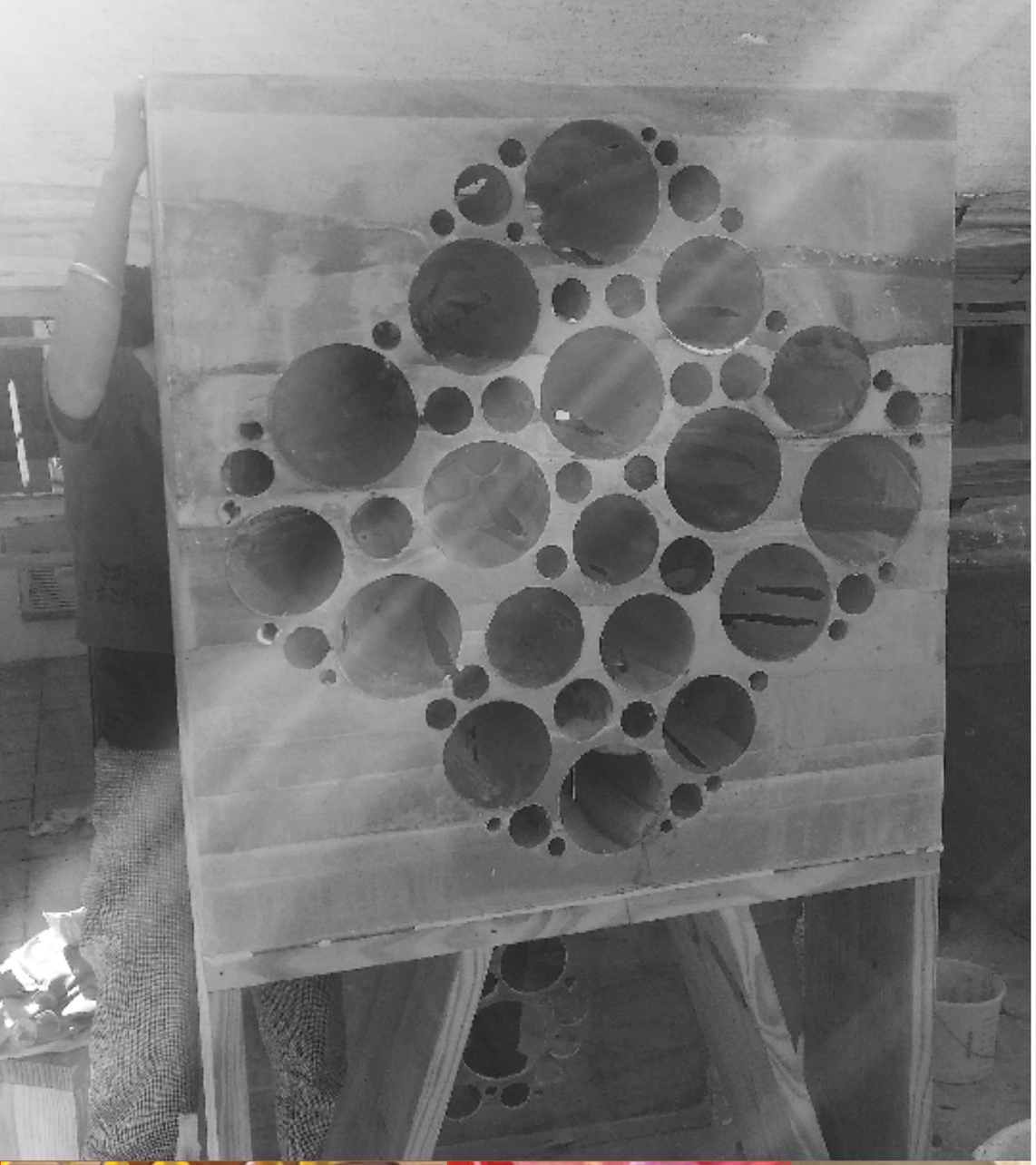




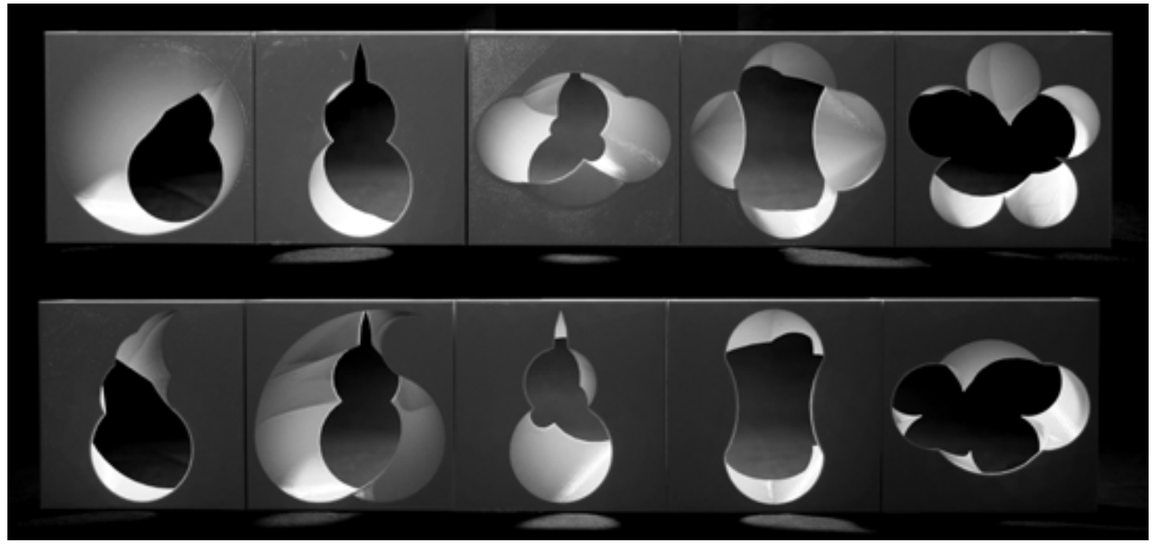


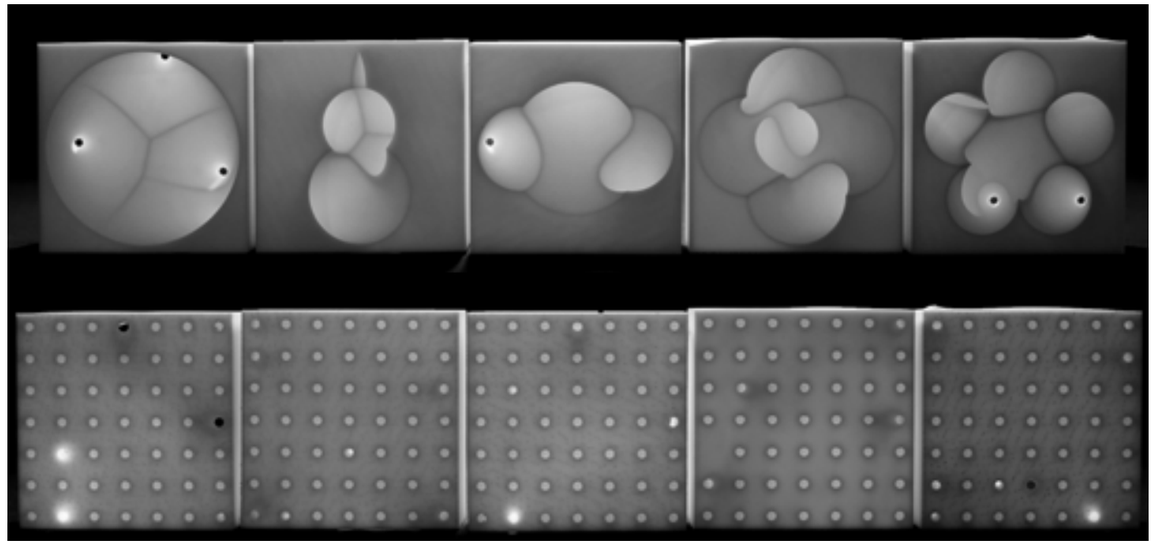
Final Models

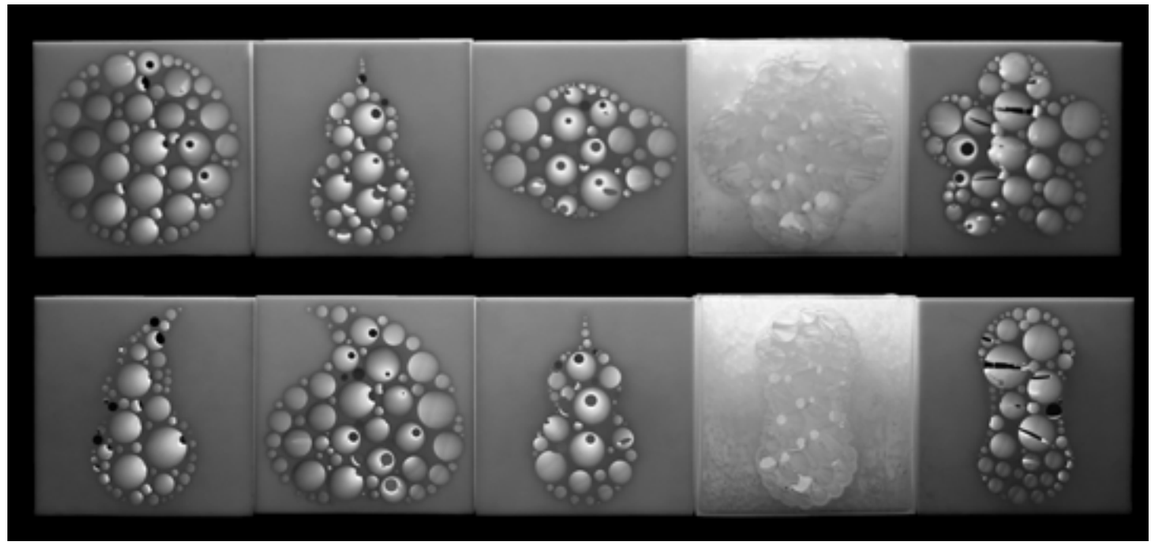
Mock up model
1:1
3’x3’x1’
Conceret

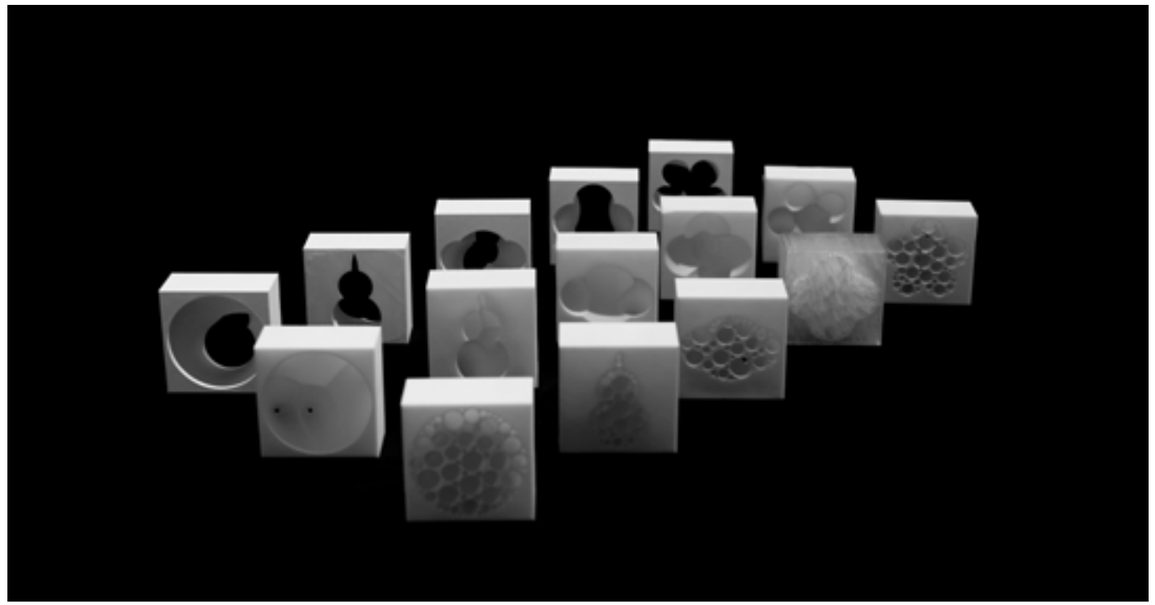


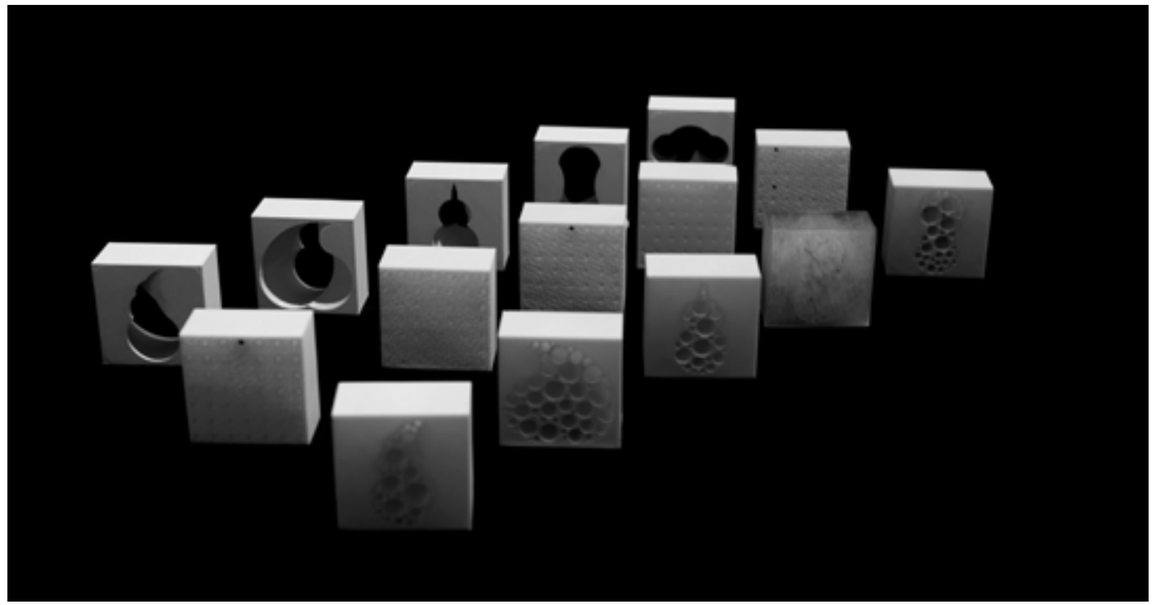
3D printting model
4.5”x4.5”x2.25”
Resin/Plastic











Project 3
Moonlight Pavilion
Translucent Polypropylene Folding Pavilion With Special Moon and Water Shadow.

The inspiration for this project comes from the moon and water reflection in Chinese poems. “As the bright moon shines over the sea, from far away you share this moment with me.” It means no matter how far you are, when we see the moon together, we are together.

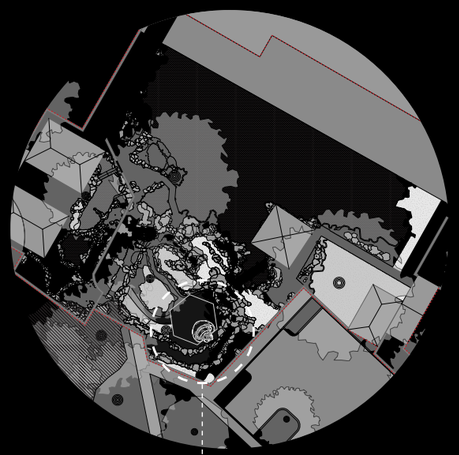
To show this poetic atmosphere, I chose translucent polypropylene sheet material and folded it layer by layer so that the building could cast a water-like shadow in the sunshine.

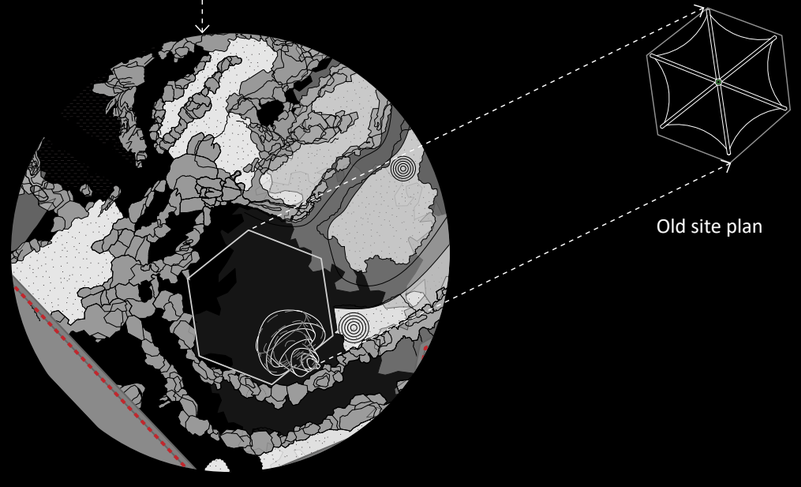
In the broken line part, I will use dotted line hole-punching for folding and connection strength, and in the seat part that needs to be loaded, I will use multi-layer and triangular folding to enhance the load-bearing capacity.

The most special part of this design is the“moon”. At 10 a.m. on the Mid-Autumn Festival, which symbolizes reunion in China, the sunshine can perfectly pass through folded passages, casting a bright spot on the water-like shadow, as if bringing the moon on the other side of the earth to this place, connect distant family and friends.

Old and New

Site



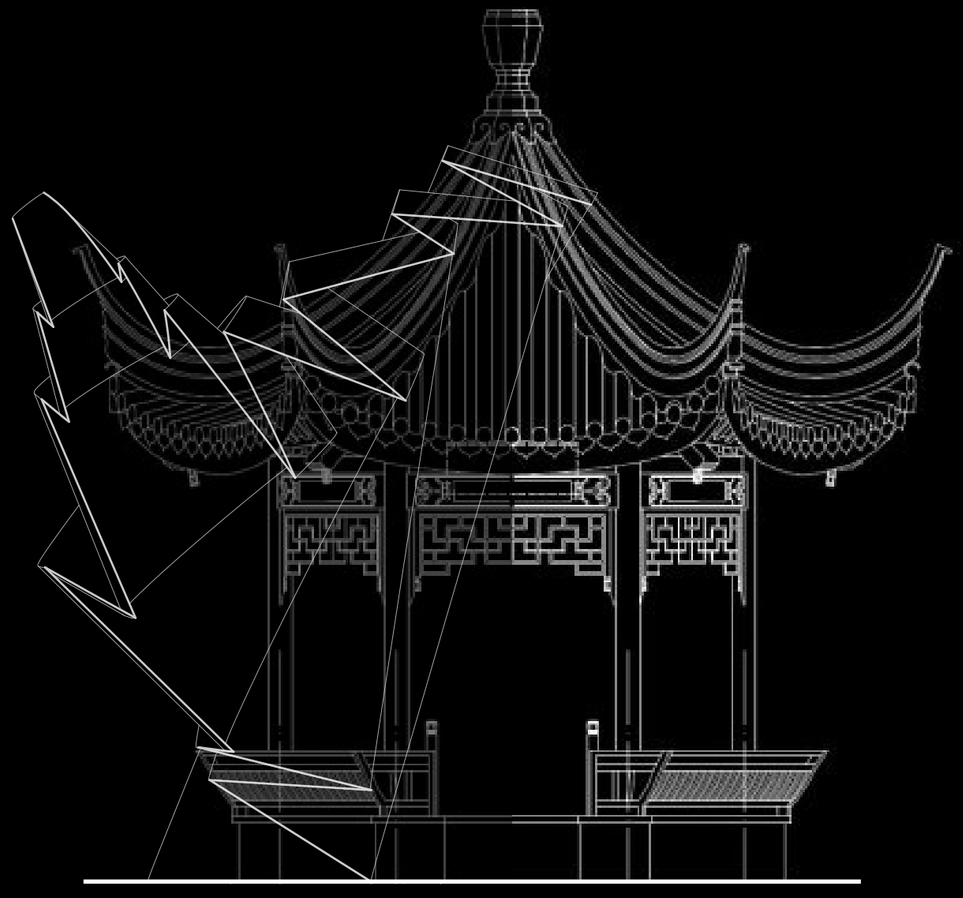


Old site plan

New site plan

Two Importanrt Elements

Roof



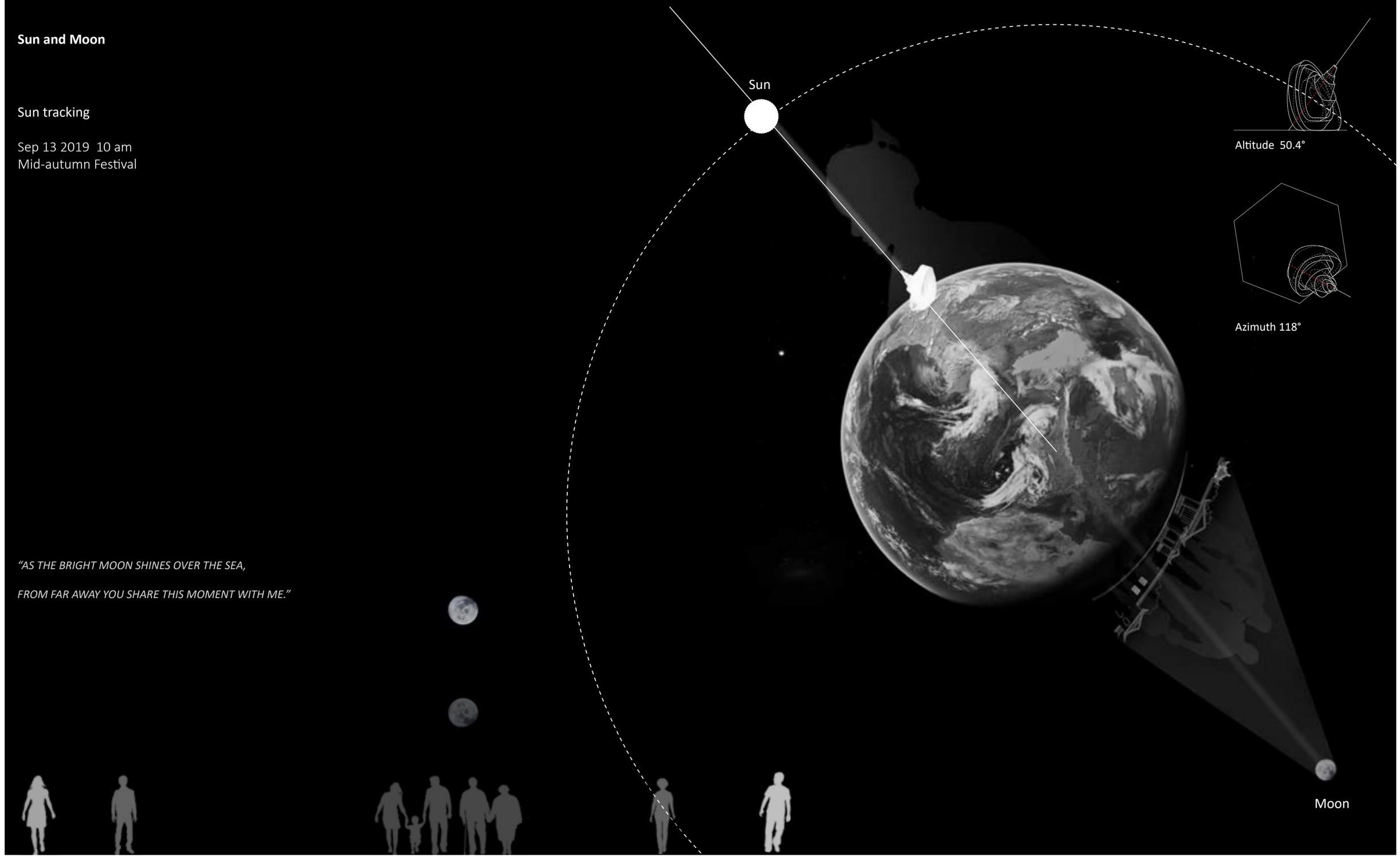
Bench

Compare old and new

Sun and Moon

Sun tracking

Sep 13 2019 10 am
Mid-autumn Festival



“AS THE BRIGHT MOON SHINES OVER THE SEA,

FROM FAR AWAY YOU SHARE THIS MOMENT WITH ME.”

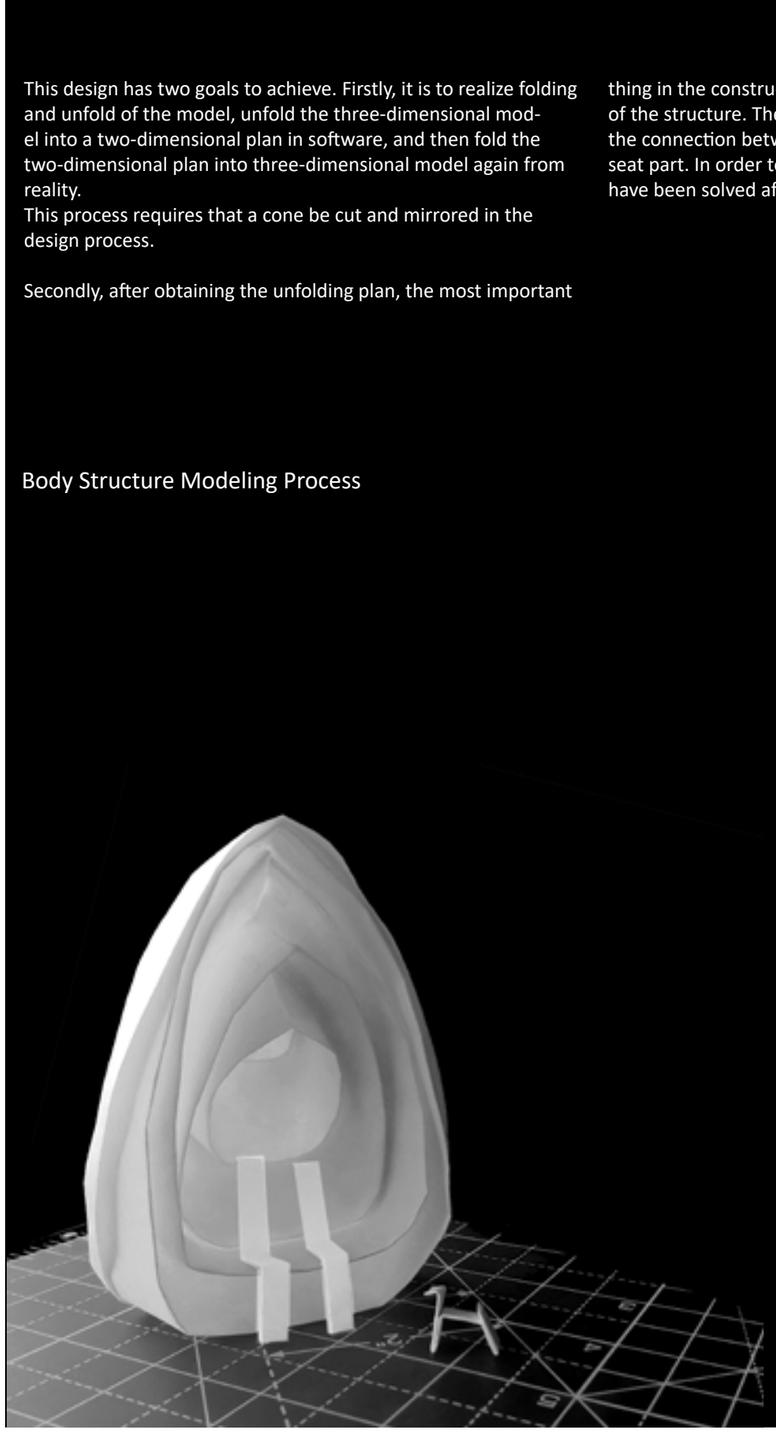
Shadows

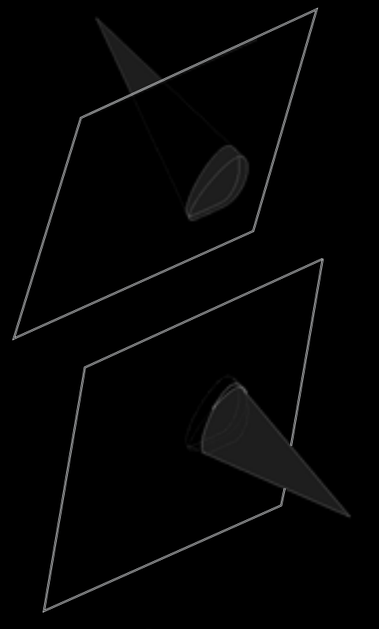
Process

This design has two goals to achieve. Firstly, it is to realize folding and unfold of the model, unfold the three-dimensional model into a two-dimensional plan in software, and then fold the two-dimensional plan into three-dimensional model again from reality.
This process requires that a cone be cut and mirrored in the design process.

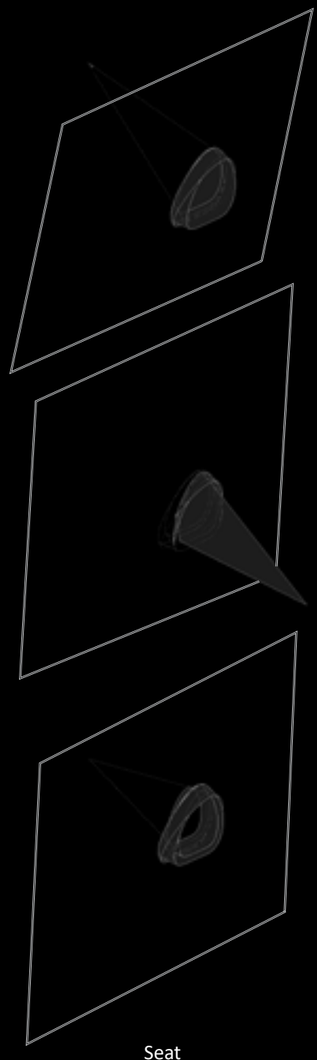
Secondly, after obtaining the unfolding plan, the most important thing in the construction process is the stability and strength of the structure. There are three weaknesses in the structure, the connection between the materials, the folding line, and the seat part. In order to obtain a strong structure, these three parts have been solved after testing.

Body Structure Modeling Process

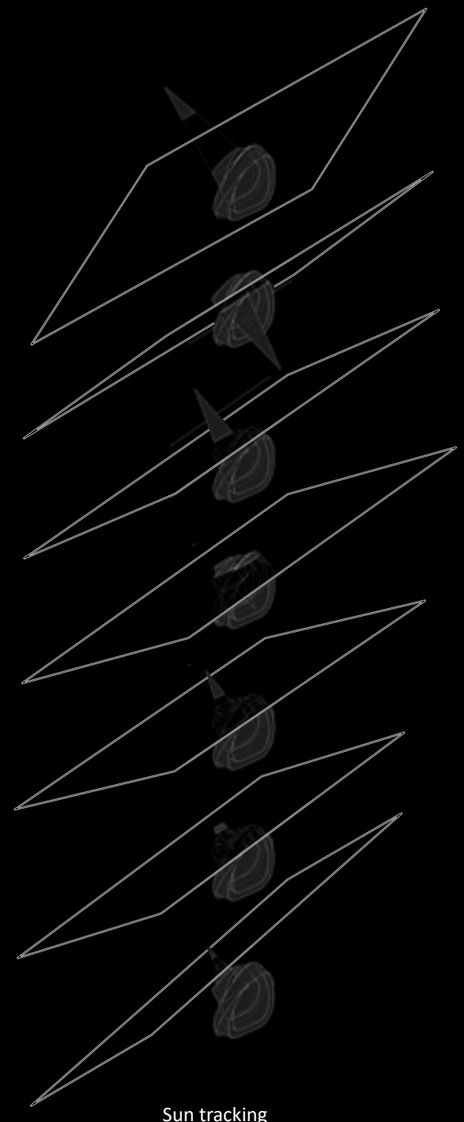




Balance

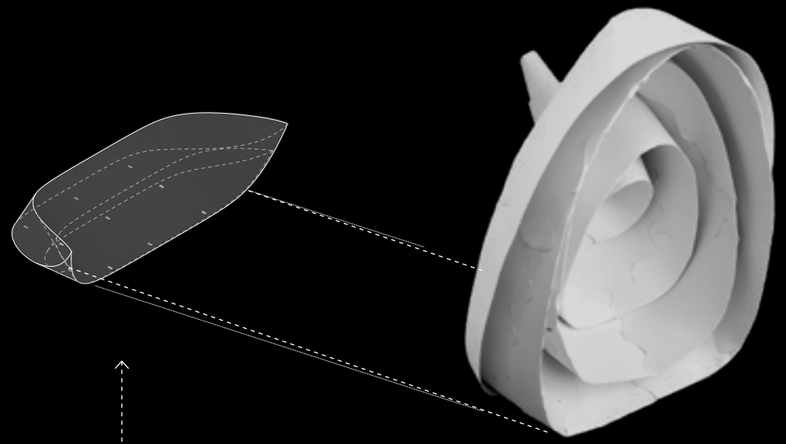


Seat

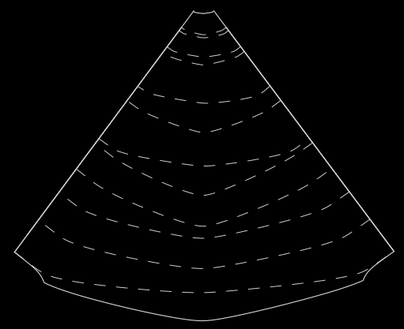


Sun tracking

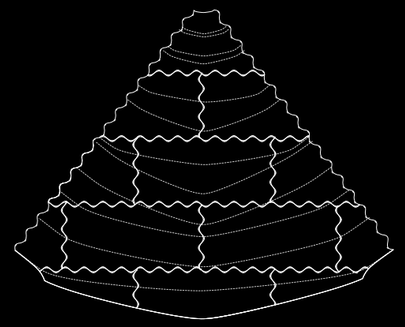
Support Structure



Body Structure plans

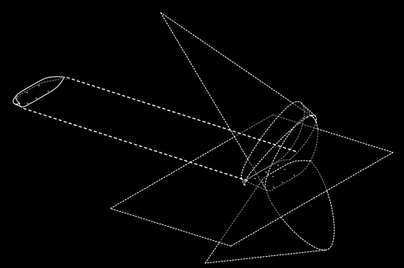


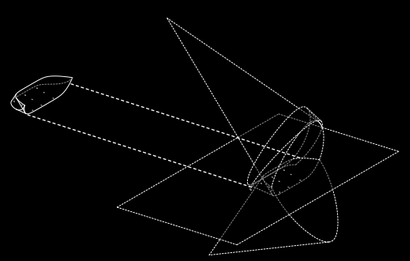
Unrolled Folding Plans



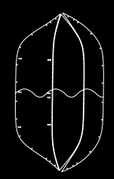
Unrolled Plan

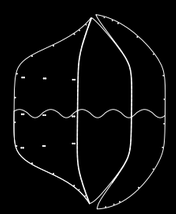
Method

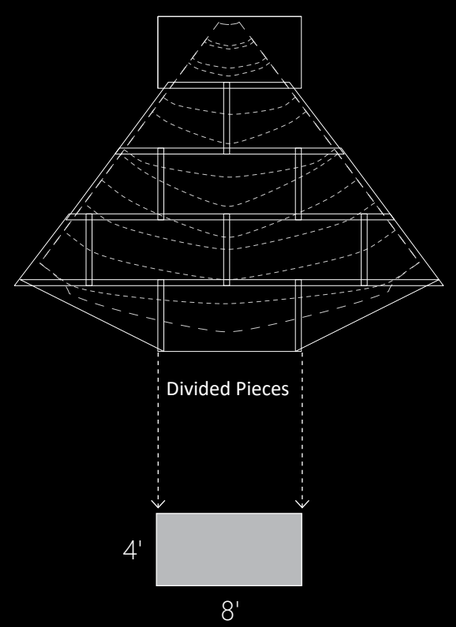




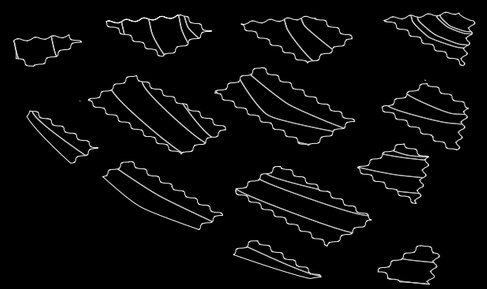
Unrolled plans







Limited Material Size
(used 9)



Pieces for CNC

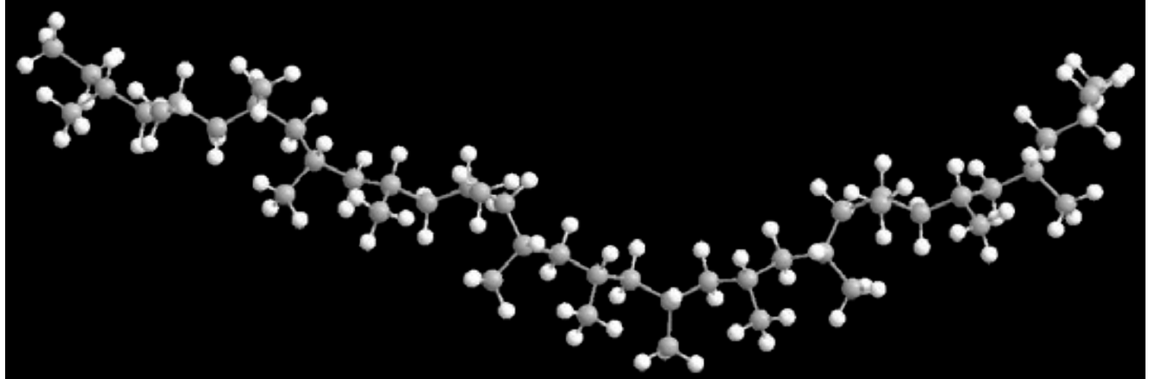
Material (Polypropylene)

Size

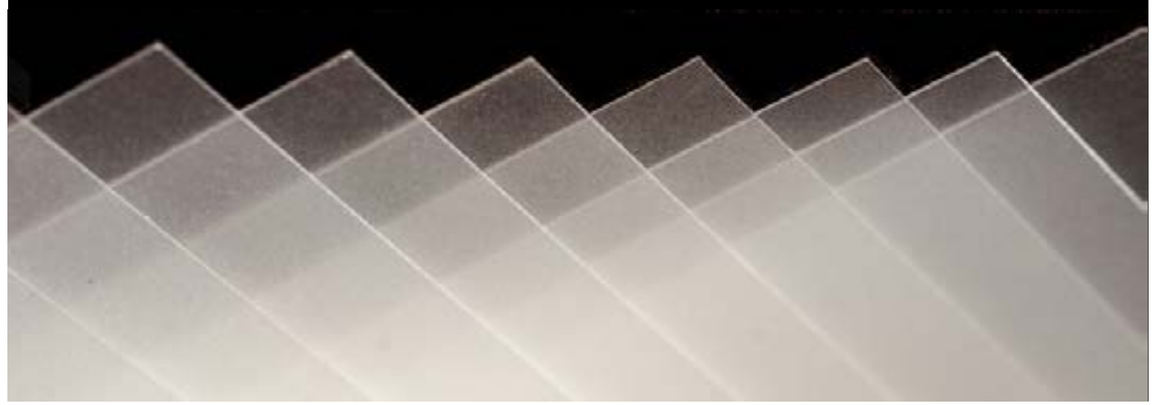
48” x 96” X 1/16”

Flexible & Durable

Polypropylene is a lightweight and flexible thermoplastic with stress crack resistance and does not break when bent repeatedly.

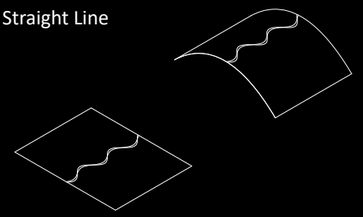


Translucent

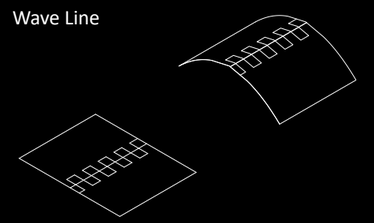


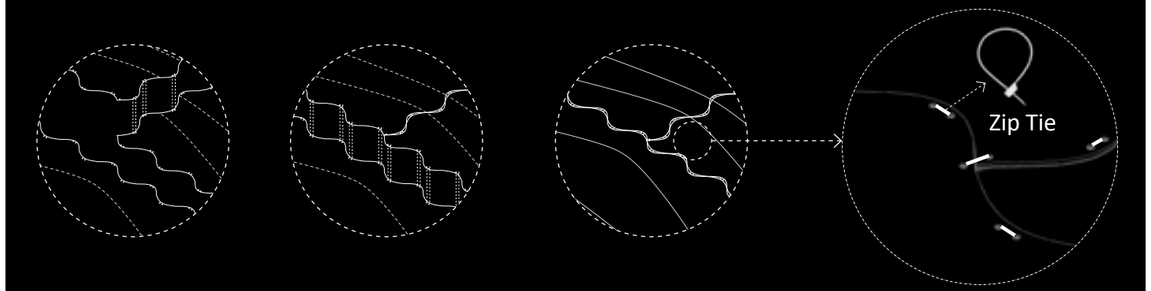
Joint

Straight Line



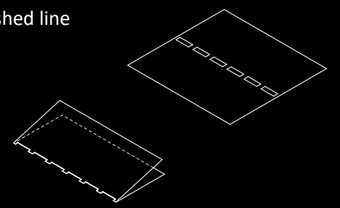
Wave Line



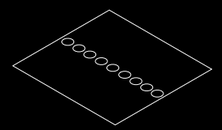


Folding Line(Hole)

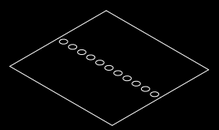
Dashed line

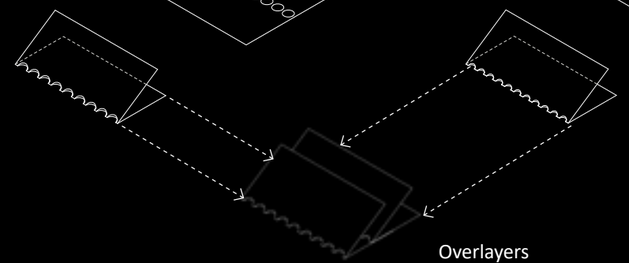


Big Dotted Line



Small Dotted Line





Overlayers

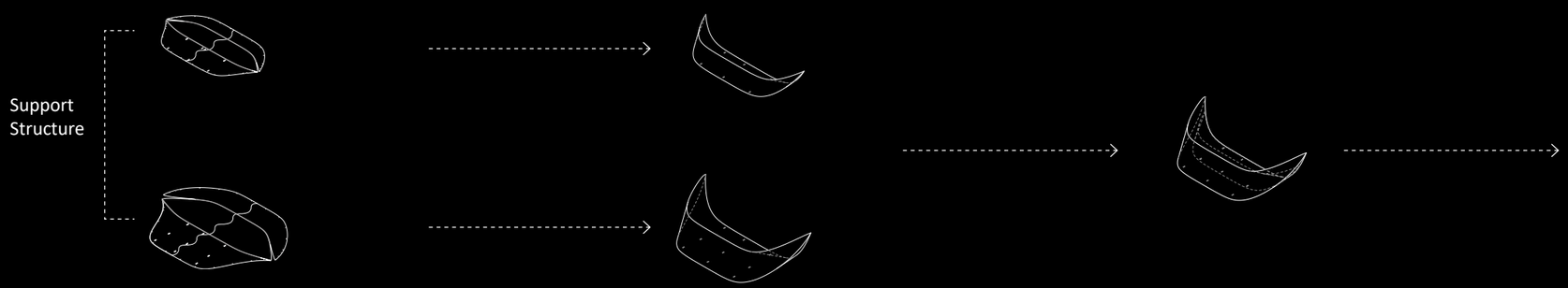
Building Process

Support Structure

Segmental Connected Folding Plan

Fold

Connect 2 Pieces



Insert

Body Structure

Segmental Connected Folding Plan

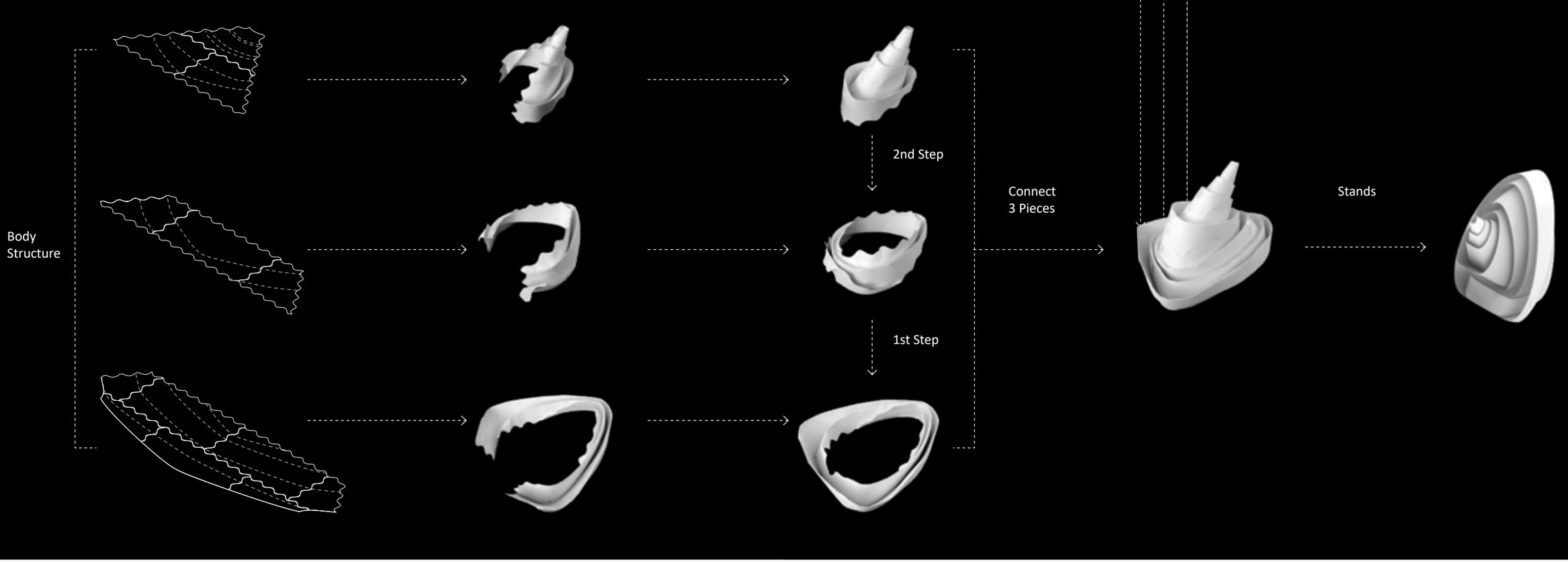
Fold

Zip Tie Zip

2nd Step

1st Step

Connect 3 Pieces



Stands

Final Model

Mock up model
1:1
7’2” Tall
Polypropylene

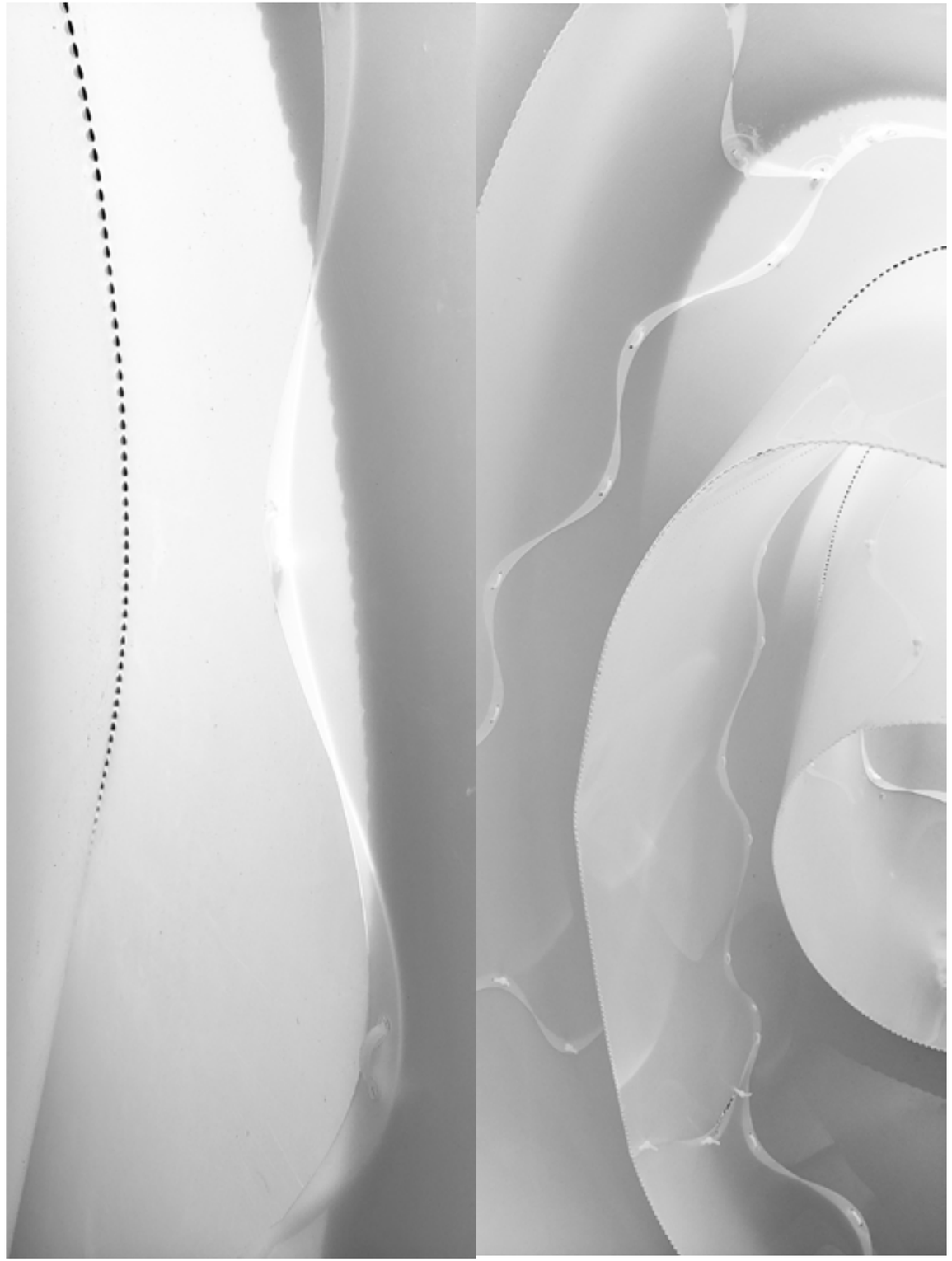
CNC

Segmental Connected by Zip Tie

Fold and Connected by Zip Tie

Assembly Finished



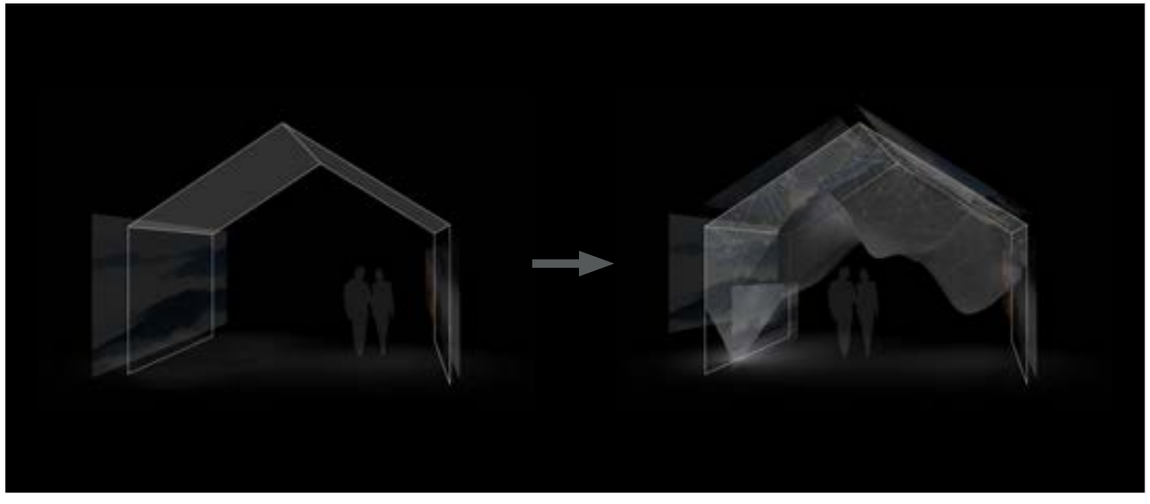
Project 4
Enframed Mountain
Gallery with entramed mountain in a network system

Abstact

The concept of the project comes from a famous ancient Chinese poetry, which means " my window frames the snow-crowned western mountain scene". Enframed scenery is one of the scenic arts in traditional Chinese garden design.

As a kind of new Chinese garden design, the relationship between figure and ground is reversed to provide people with a fresh experience which is different from the traditional one. The mountain in the poetry is enframed in a gallery by the means of the network. When people walk through the gallery, they can enjoy and have a different view of the scene of the mountain.

The project uses PETG tubes as material. Each tube has notches at both ends. By joining the notches, every six tubes can make up a tetrahedron, which is the elementary unit of the project. The shape of the units can be varied with different side length and angle. Every two units are connected with a notched ring and finally, these units make up the whole gallery with an enframed mountain. The closer to the surface of the mountain, the smaller the units are. As a result, the topography can be expressed accurately and the material can be saved from the unimportant part.

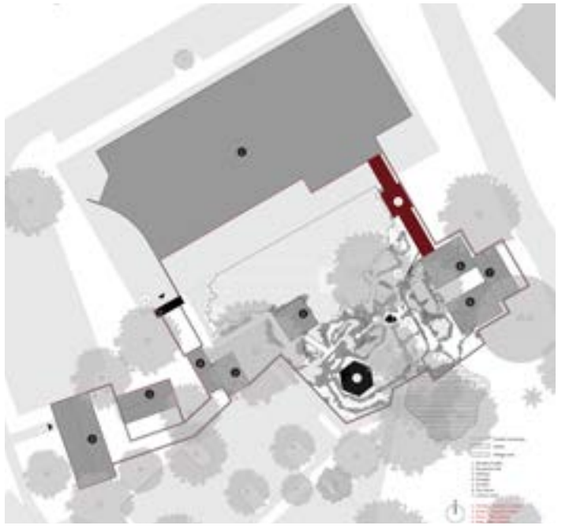


In a traditional Chinese gallery, people can see outside scene from only two sides. Take the Xiangyue gallery in the Garden of Cultivation for example, which is built beside a wall, it has only one side with the outside scene.

To improve the visual effect, the project takes the mountain scene inside the gallery to provide people scenery not only from the two sides as a traditional one but also from the roof. As a result, people will be personally put into the scene when they walk through the gallery.

GARDEN OF CULTIVATION PLAN

CHINESE GARDEN SITE



XIANGYUE GALLERY

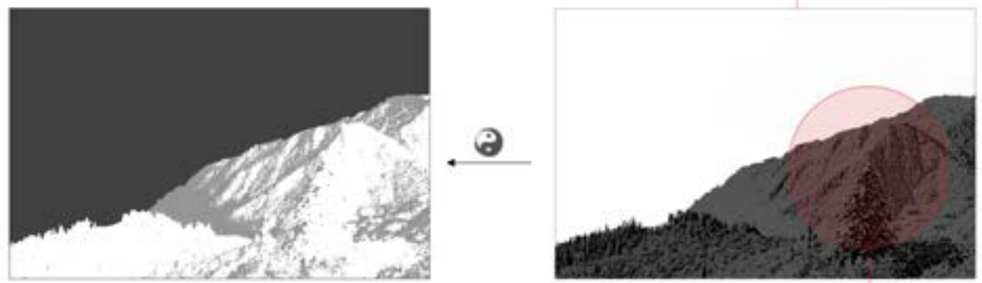
GALLERY SITE

MOUNTAIN SCENE TO BE FRAMED

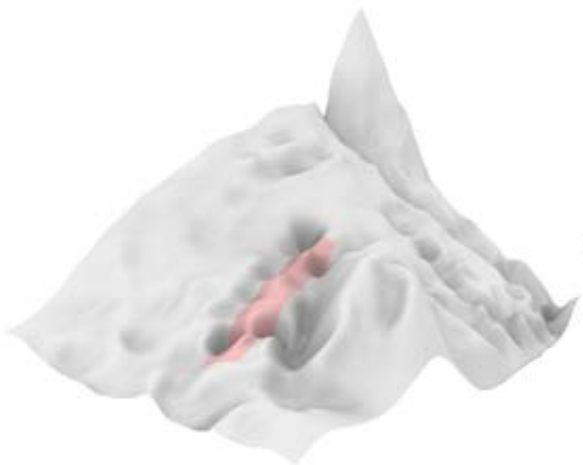
CHINA-SICHUAN

SICHUAN-CHENGDU

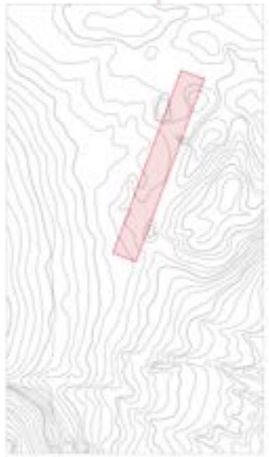
FIGURE-GROUND RELATION



SELECTED-AREA FOR THE GALLERY



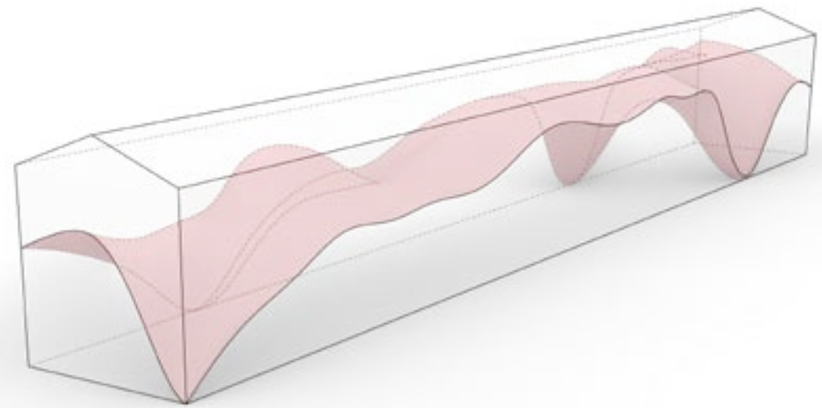
CONTOUR LINE



The project chooses the mountain named Xiling in the poetry as a reference, which is located in Chengdu, Sichuan Province, China. The figure-ground relation is changed, which means the real part and the empty part in the photo are reversed. The original skyspace will be put in the gallery as the entity roof.

The model of the mountain is built according to its contour line and one piece of it is chosen to be enframed into the gallery. It has four points touching the ground to support the whole structure.

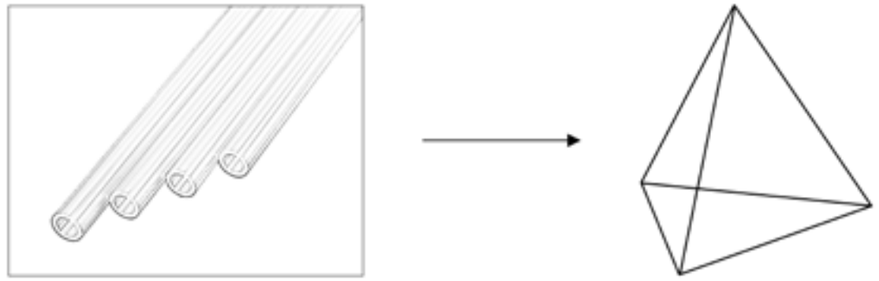
ENFRAMED MOUNTAIN IN THE GALLERY



The gallery chooses network as its structural type. The network system is denser and denser from top to the bottom. The lower surface is divided into smaller units to present the shape of the mountain. The smaller the units are, the more similar it is to a curved surface. For the upper surface, it does not need to be present carefully because it is much further to people's eyes and is blocked by the lower part. So it is less important in the appearance aspect. It functions as a structural part to the most extent. This sparse-dense system can not only save fabrication time but also save material.

The material of the gallery is PETG tubes because they are light and will not change their shape after being bend. The lower part is bent more to adapt to the curved surface shape while the upper part and structural part take the simple and straight form.

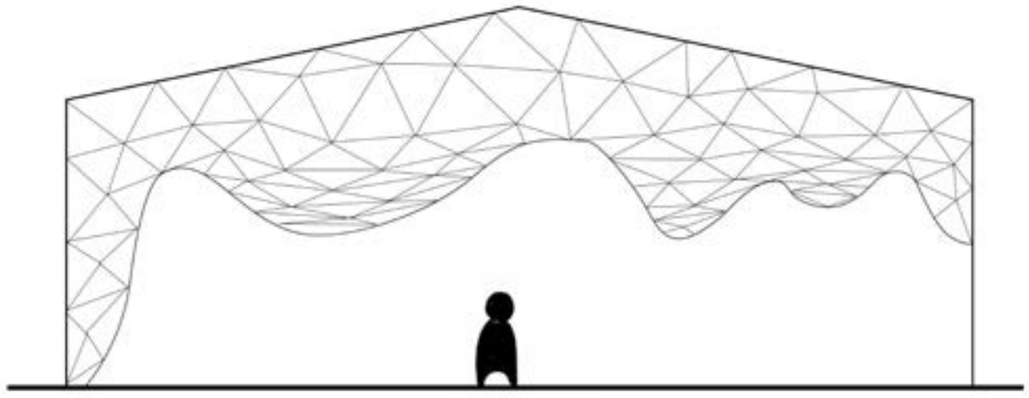
MATERIAL



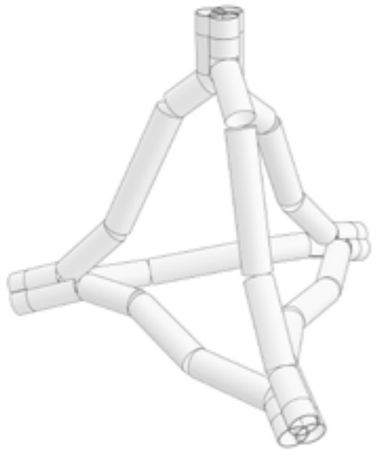
PETG

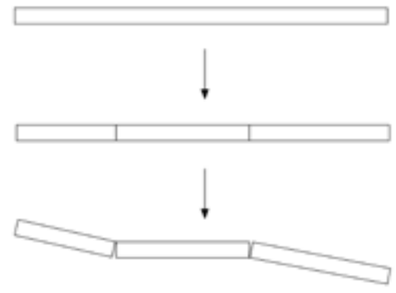
TETRAHEDRON

SECTION



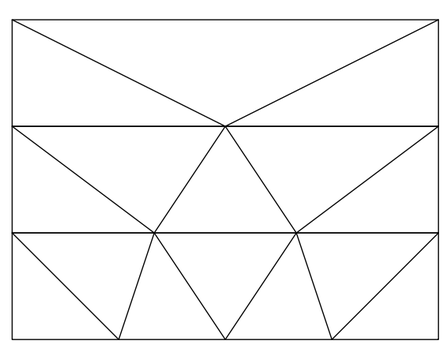
BENDING TECHNIQUE

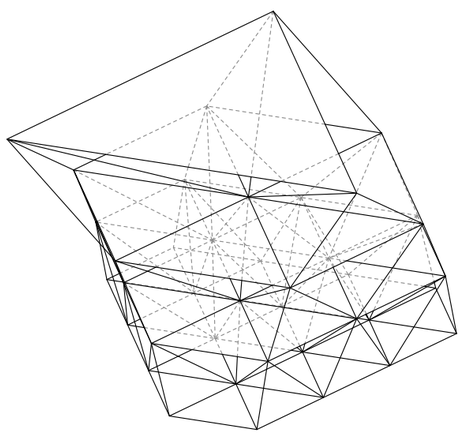


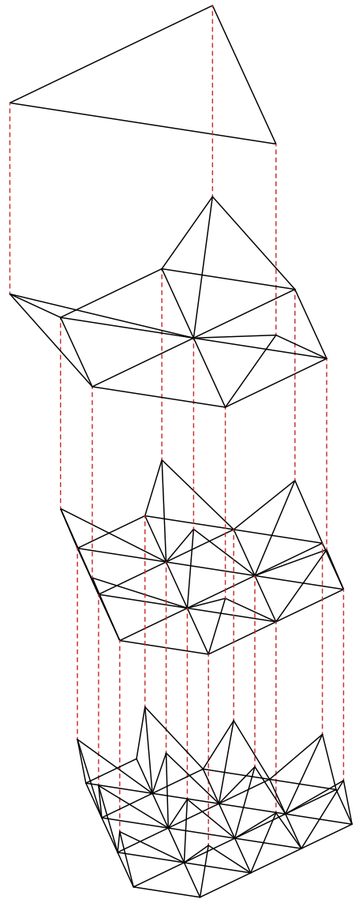


CONNECTION METHOD

Since the tetrahedrons will be smaller and smaller, the quantity will be larger and larger. As shown in the connection method graphic, one triangle will develop into three tetrahedrons, then seven tetrahedrons, and finally twelve tetrahedrons.

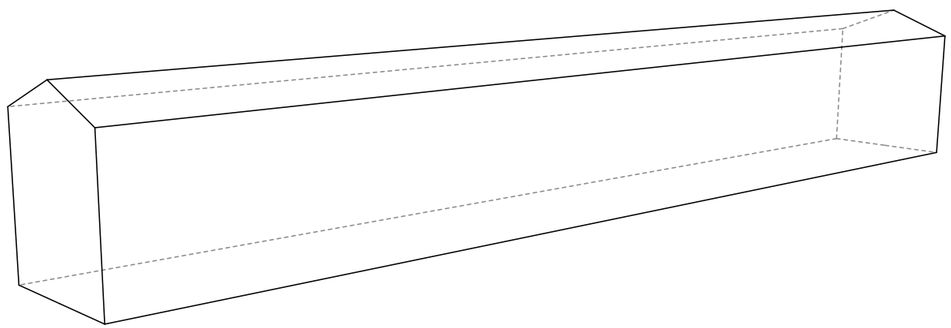


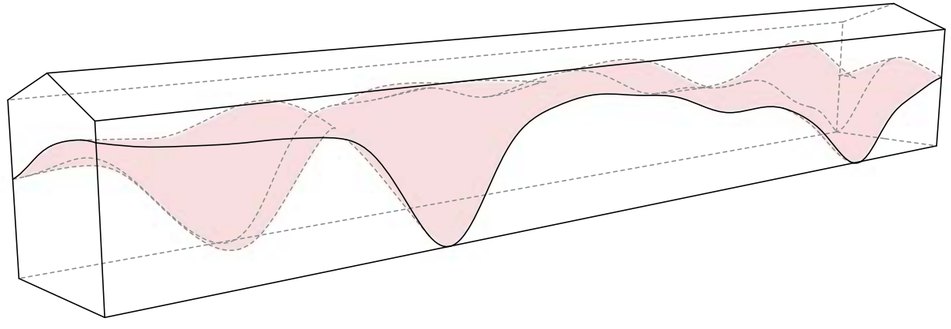


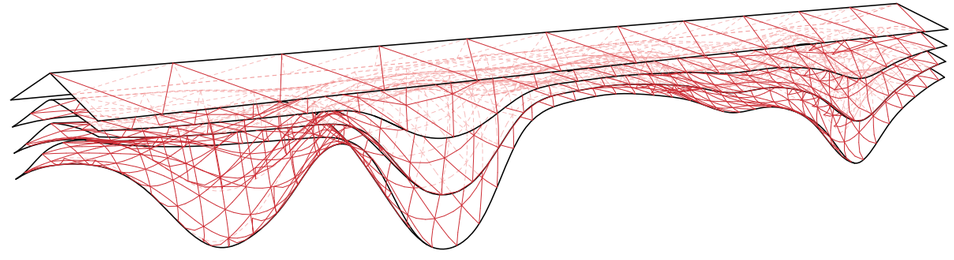


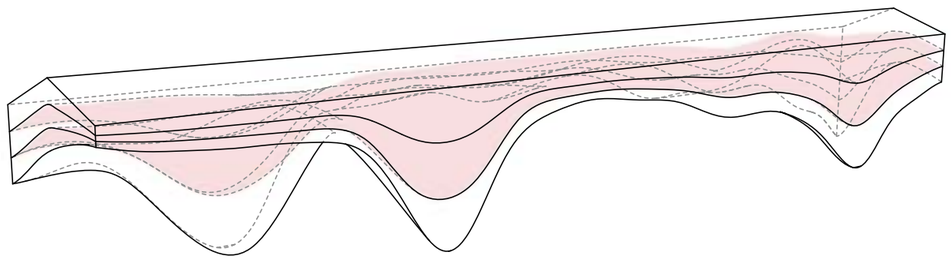
GENERNATION

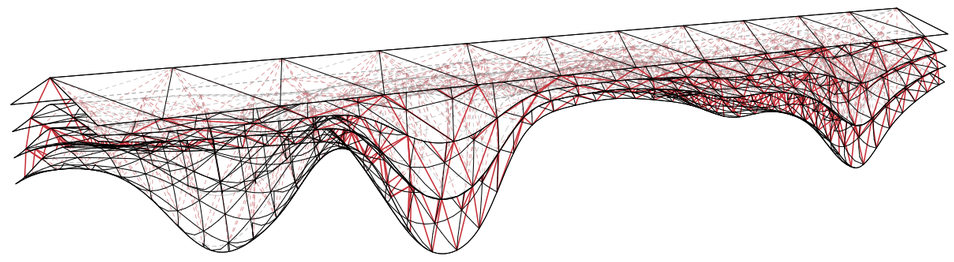
In the generation process, a piece of Xiling mountain is put in the gallery and then two curved surfaces are added between it and the roof. These surfaces are subdivision into different size of triangles. The upper the surface is, the bigger the triangles are. Then the triangles are connected in the vertical direction according to the connection method and the whole network system generates.



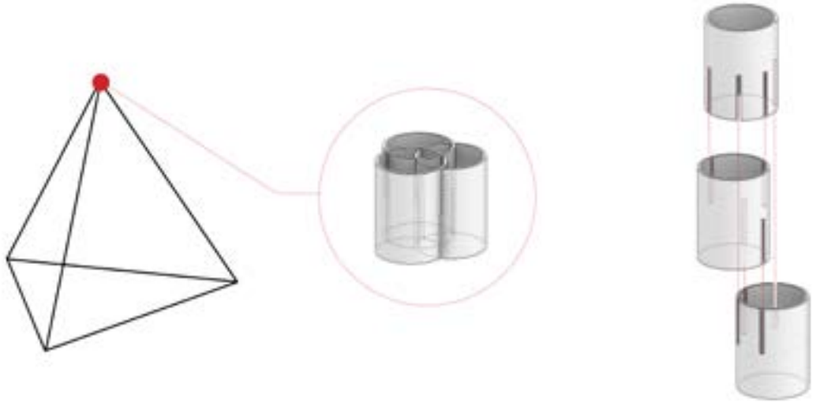




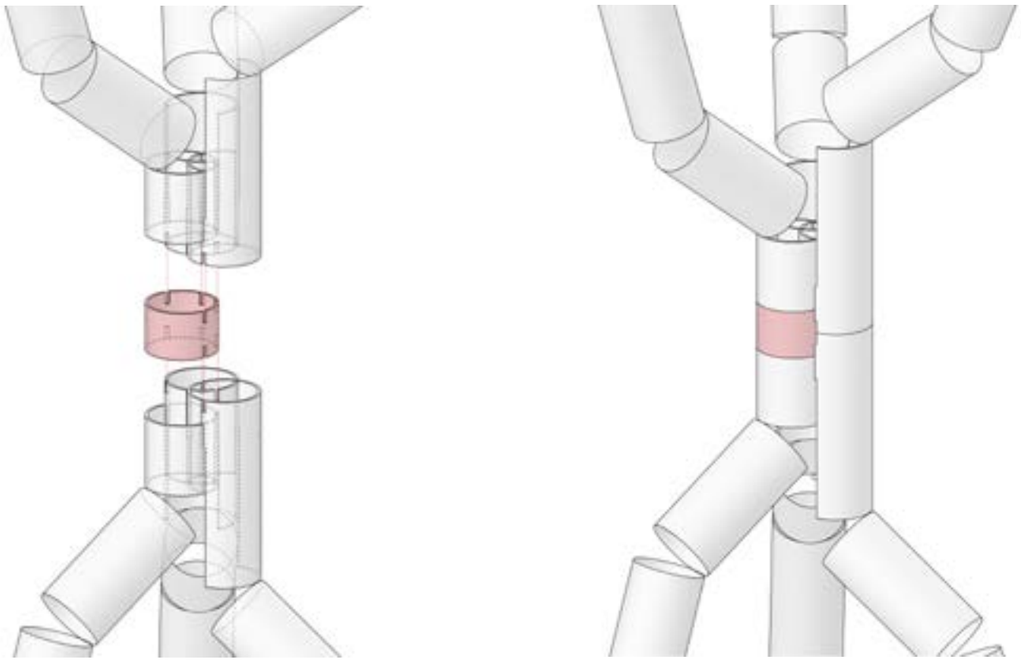




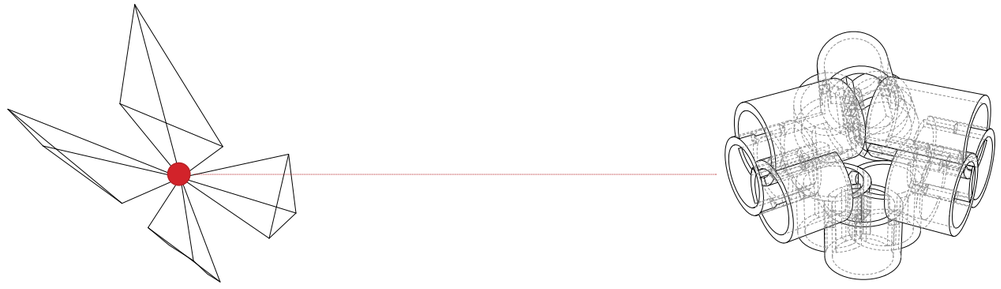
TETRAHEDRON JOINT



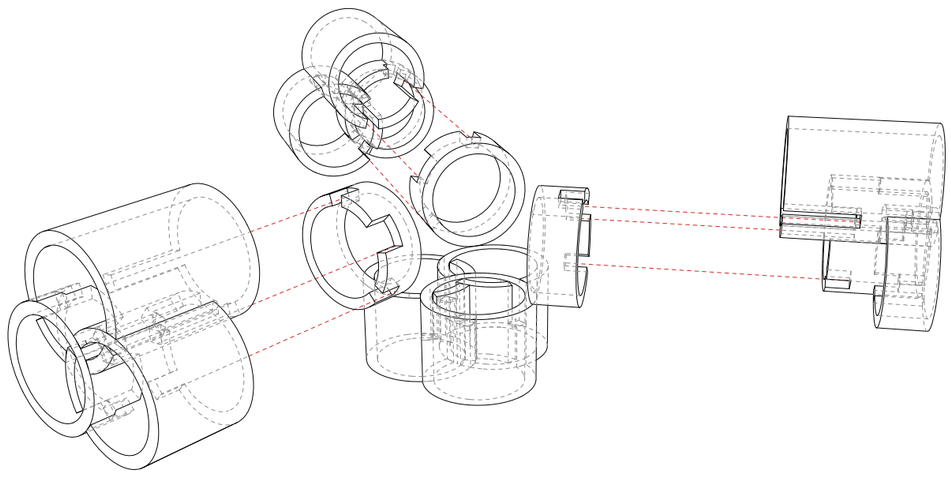
CONNECTION BETWEEN TWO TETRAHEDRONS



NETWORK JOINT



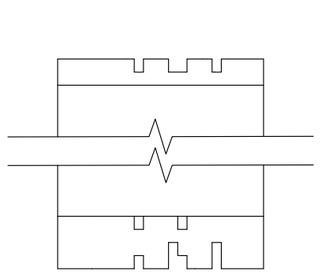
CONNECTION IN THE NETWORK SYSTEM



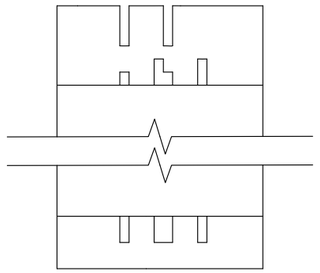
UNROLL TECHNIQUE

When cutting the notches at the ends of each tube, the digital models of them are unrolled into flat surfaces. The surfaces are printed and rolled along the PETG tubes. After that, we can get the accurate and location and shape of each notch.

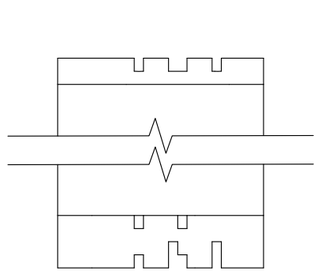
Each joint which is connected with four tetrahedrons in the network system is made of twelve tubes. They have six shapes, which are named with A, B, C, D, E and F. Every tube with the same name in different joints has the same notches. The only difference is the length of the middle part.



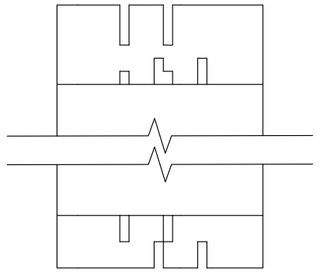
PIPE A



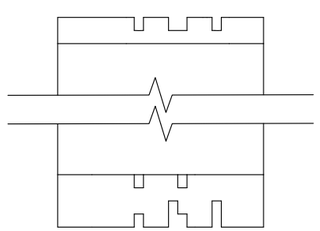
PIPE B



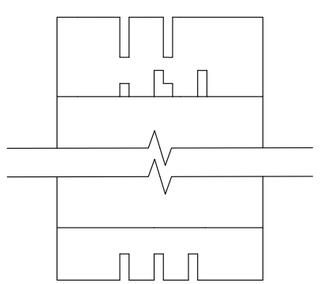
PIPE C



PIPE D



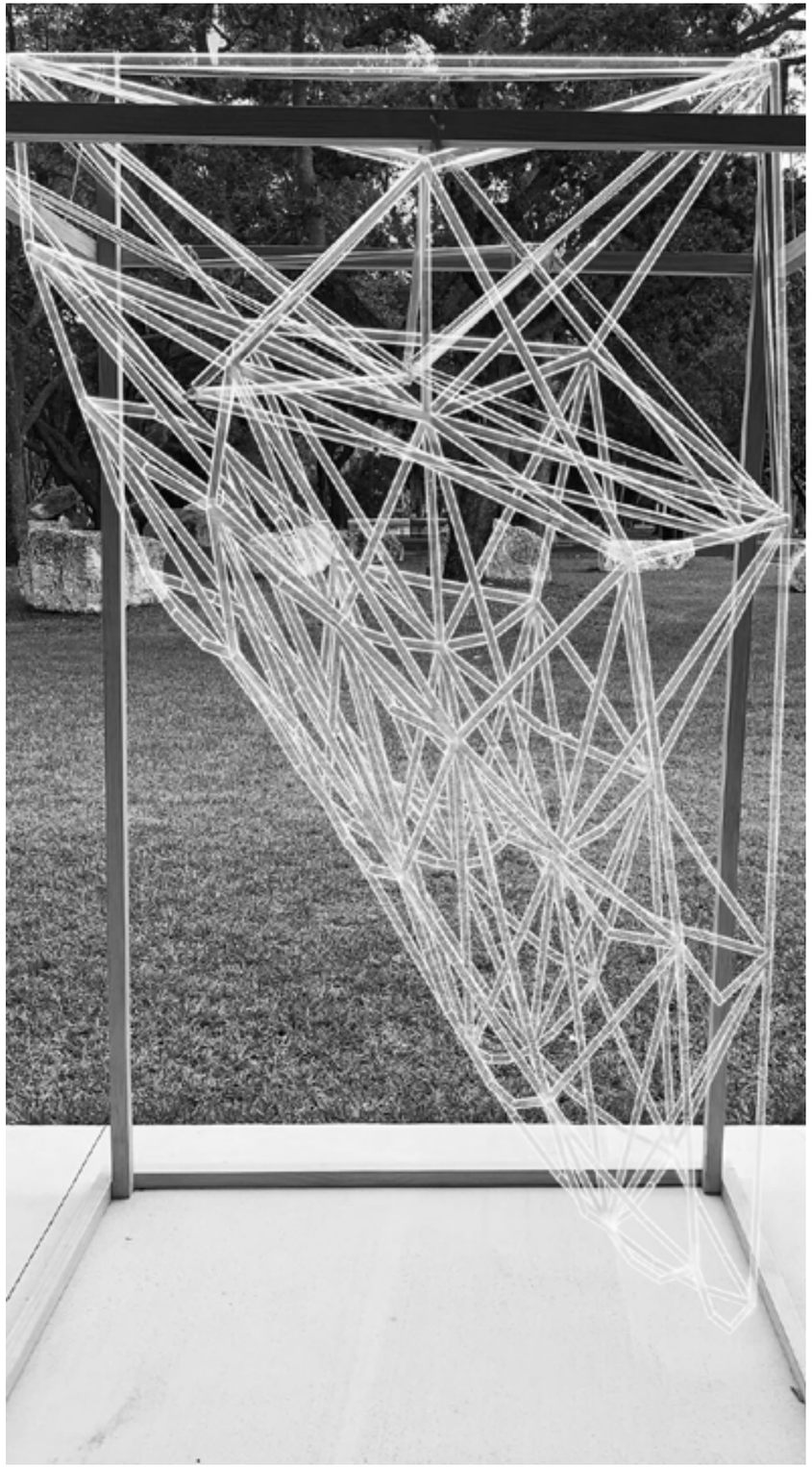
PIPE E

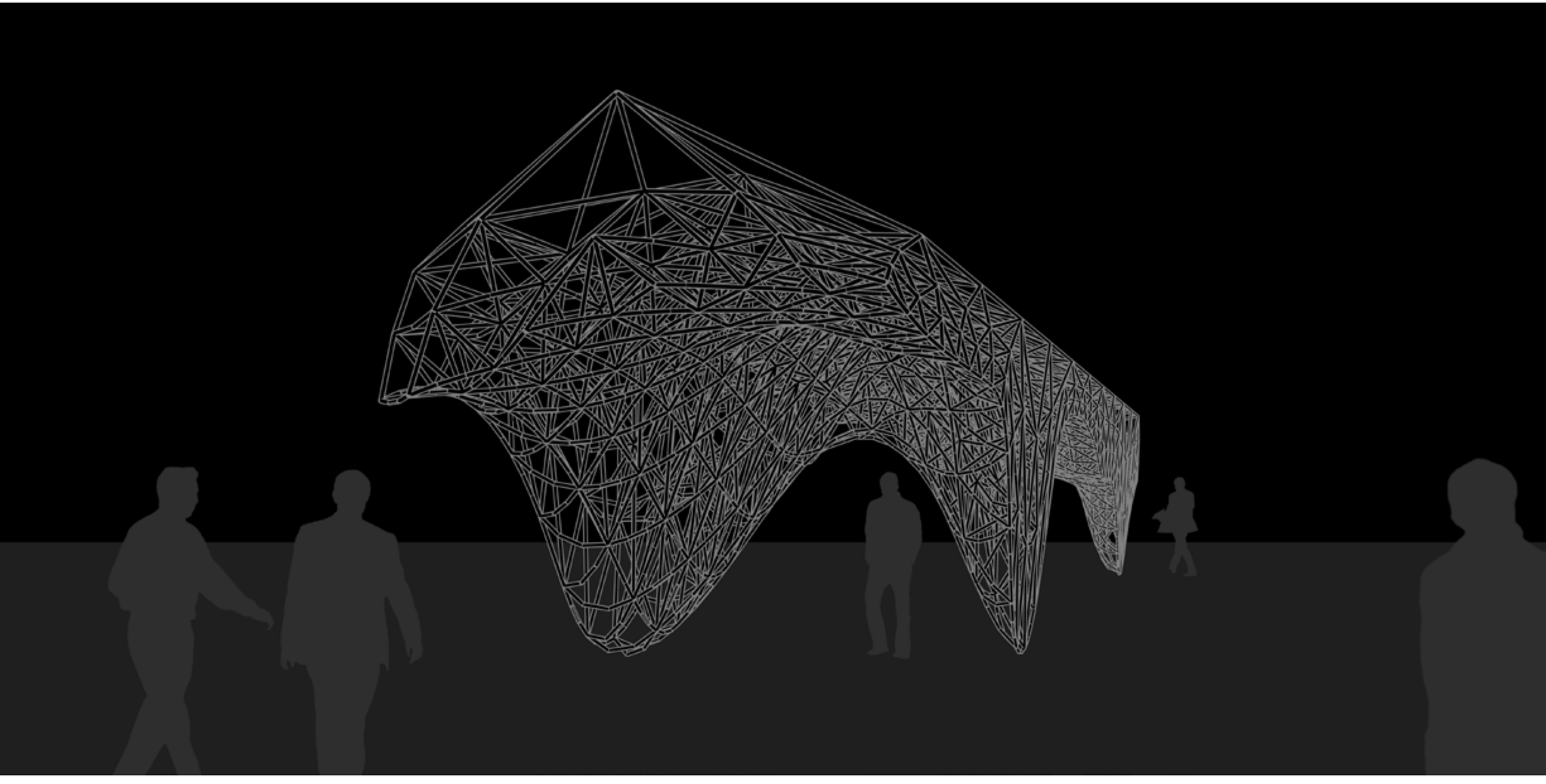


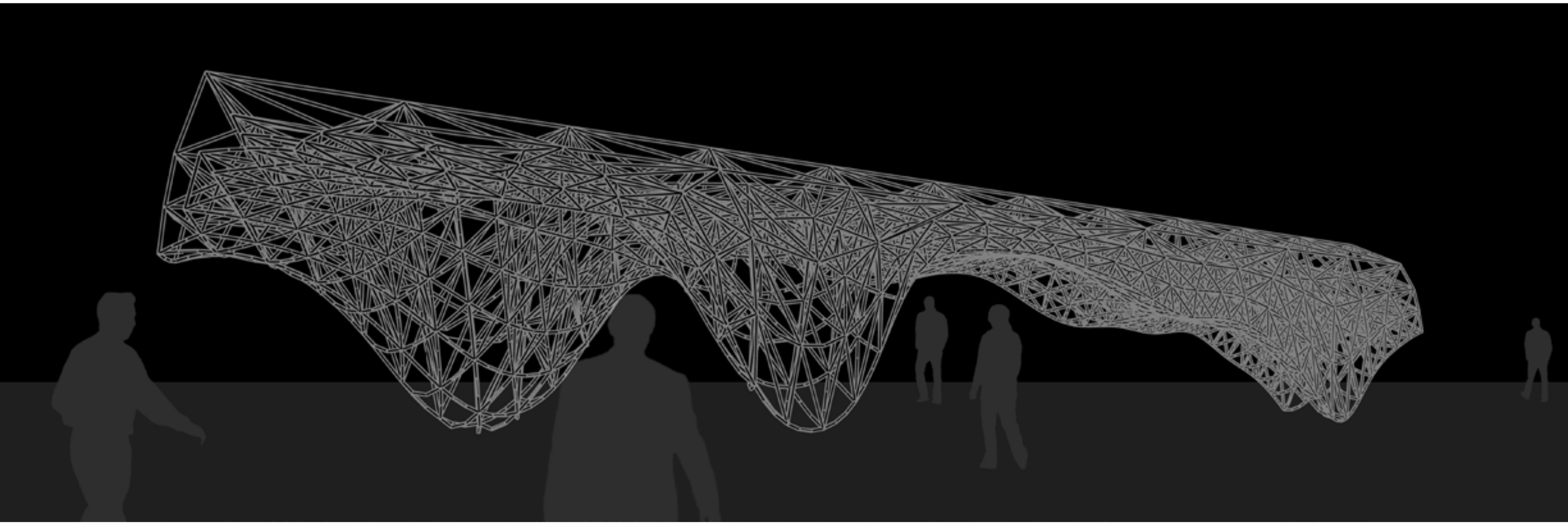
PIPE F

Final Models

Mockup
1:1
PETG Tubes







05.

APPENDIX

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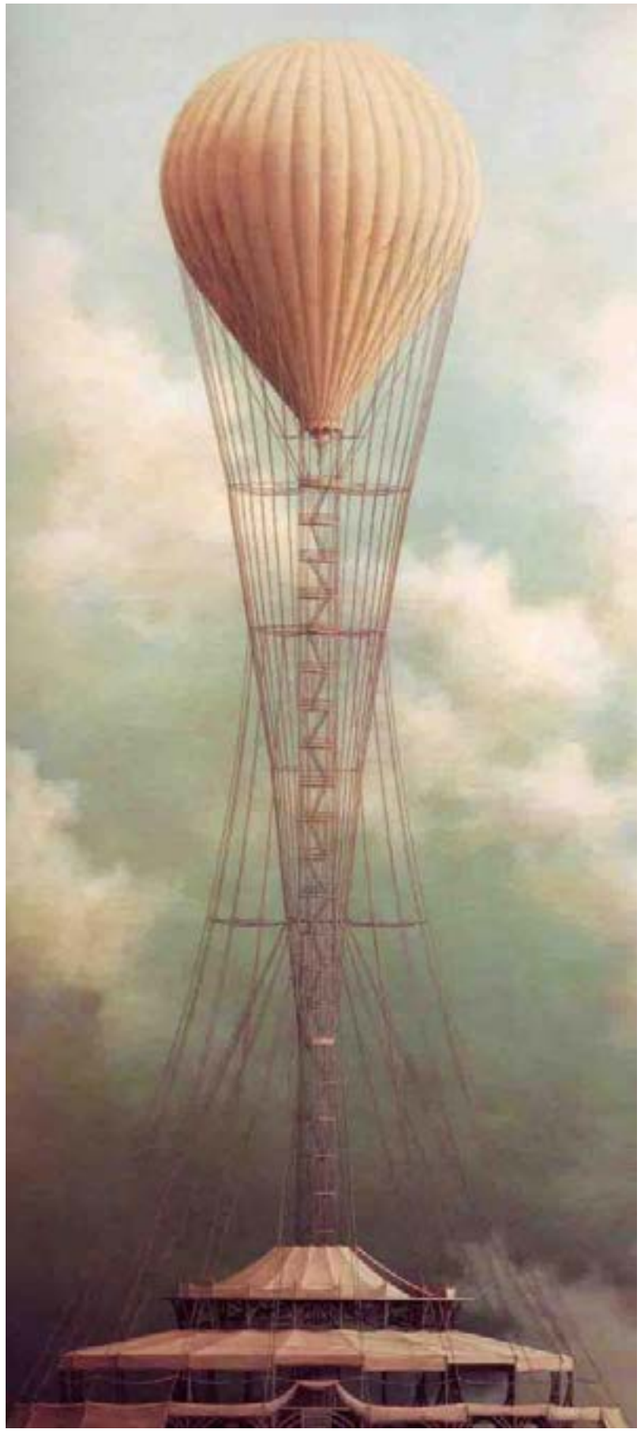
Alternative Sights

Nomata Ka/ 2010

“Fantasy Architecture” This is a memory like a distant place. However, it is a fantasy building that never exists. Reality and unreality are neither past nor future. Stretching is like reaching the sky. The existence of work should also be isolated.



NonLin/Lin Pavilion

Marc Fornes & THEVERYMANY/ 2011

The non-linear architectural structure is derived from the interconnected morphology of the pavilion from the “Y” model – the basic representation and lowest level of multi-directionality. This hypothesis was formed challenging issues of morphology as tri-partite models are not illustrative through a single bi-directional surface – “which is still one of the main medium of representation within the avant-garde architectural repertoire.” In order to overcome this problem, the morphological models are dealt with the split method or recombination –how two can become one and vice-versa. The prototypical structure examines the transformation from the network state to the surface condition - the structural network opens up to only combine into larger apertures (network) while the reverse side creates the surface condition, providing the user with a feeling of coral.

The custom computational protocols describe the structure of the pavilion. This procedure is known as descriptive geometry as a model of description through development. The protocols end up in a set of linear elements which are then cut out into flat sheets of material. The non-linear nature of the model requires the application of a unique procedure each and every time as the application of a standard format would fail due to the shifts occurring in the network – nodes with the differentiated number of branches, varying radii, curvature, etc. A tremendous amount of work and research has been put into this pavilion as each sub-structure requires a massive number of properties in order to create the different branches, holes, connections, grounds and more, translating from mass-customization to massive customization with a high degree of morphological differentiation with which to interconnect these elements.

Paper Sculpture

Li Hongbo

Li Hongbo is best known for his interpretations of paper. His reinvention of the material's form challenges viewers' expectations of the medium as an artistic vehicle.
v
Li Hongbo observed that honeycomb paper is prevalent in various iterations of Chinese folk art, from children's toys to festive decorations. His fascination with honeycomb paper continued as he discovered how simply it is made and the amazing flexibility, resilience and strength of the paper once it is built into layers of hexagonal cubes.

Invisible Border

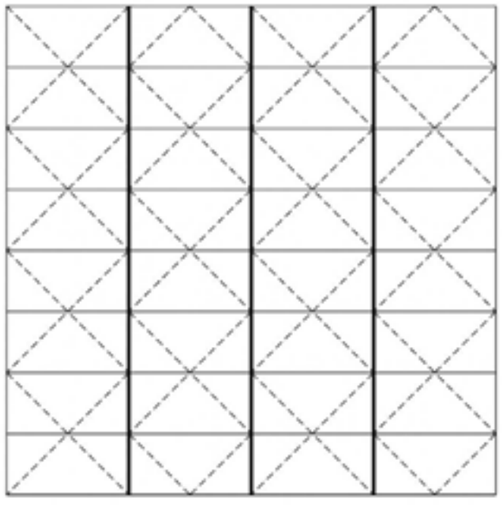
MAD studio architects
Milan Design Week/ 2016

A wavy metal frame is used to hold the strips taught, forming an extension of the building's covered passages for visitors to walk under.
the design takes its cue from an interpretation of the past to react as a crystallization of the present. the installation presents a sculptural gesture that is interested to break the perfect balance of the cortile d'onore, but also acts as a filter through which one can reinterpret the historical forms of the building. the facade reflects the hues of the sky during the day, leaving glimpses of the columns and loggias. in the evening it becomes a luminous surface that brings the courtyard to life with new colors.

Origami Magic Ball

Kade Chan

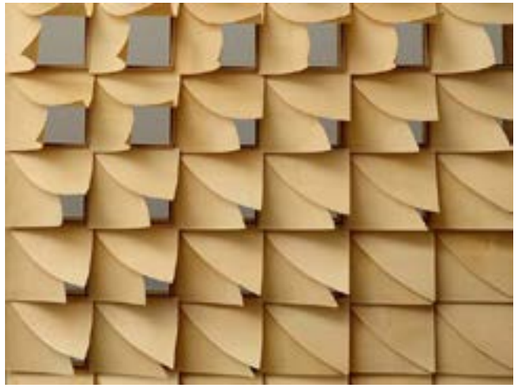
Magic ball is an amazing origami toy - ball which can be formed into different shapes.

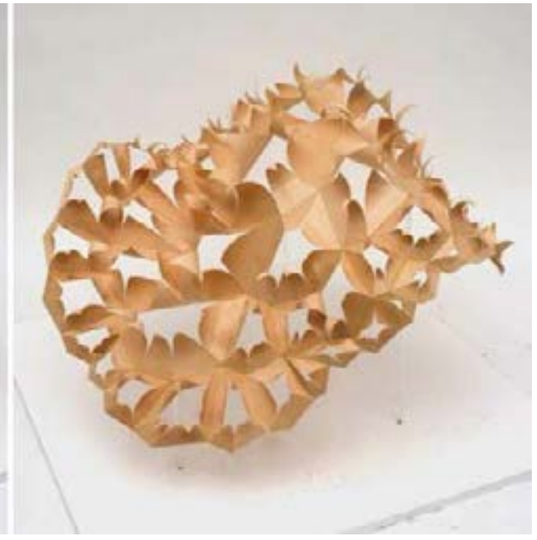


Responsive Surface Structure II

Steffen Reichert/ 2008

The second research phase of the Responsive Surface Structure project focused on the development of a more integral system that constitutes both the reactive skin and the load bearing structure within one material system. Through variations in local thickness and fibre direction it is possible to construct the system from wood laminates only. The ordering system of the four to seven sided polygonal elements is algorithmically derived. The computationally evolved surface structure allows for articulating globally doubly curved surfaces with varying densityof elements in response to different structural requirements.

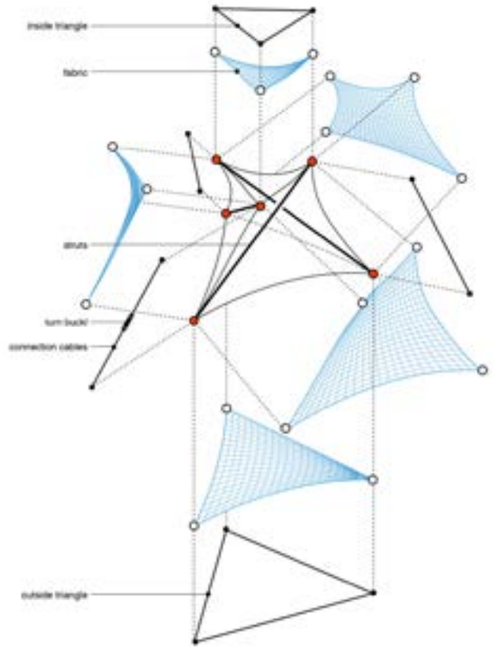




Students of Ball State Construct Parametric Tensegrity Structure for Local Art Fair

Ball State University
Muncie, IN, USA/ 2014

The parametric tensegrity structure, made from 56 light-weight, self-shading modules of Elastan fabric, provides visitors with refuge from the sun and framed views of the surrounding landscape. The Underwood pavilion's modules were developed from different variations of a 3strut tensegrity module. Varying the distance between the upper face and the lower face and varying the scale between the upper face and the lower face of the module informed the curvature of the envelope. The structural simulation engines Rhino Membrane and Kangaroo were essential tools in the form finding process of the pavilion's structure.



Fermid

Behnaz Babazadeh
2011

Behnaz is interested in the relation between movement and space. And with Fermid his hope is to portray an artistic representation of the natural kinesthesia that can be found in living organisms and how it relates to human perception of body and space, an interesting sense of breathing movement has been achieved through the use of technology and parametric design principles. The resulting movement is seducing and engaging to a viewer.

Magnetic Curtain

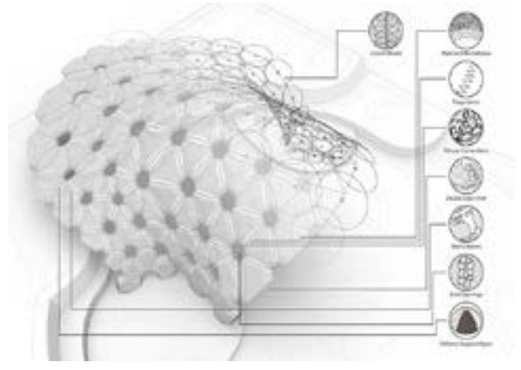
Florian Krautli
Lodon

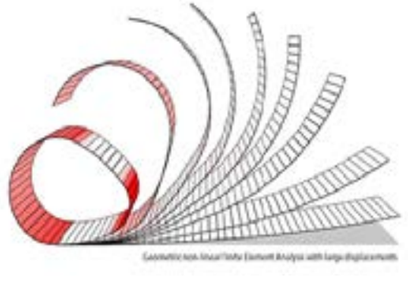
Florian has designed a Magnetic Curtain. He claims it's a curtain that you can shape to any structure. The way he made it was he embedded magnets that are in a diamond shaped grid within the curtains fabric, which would allow the consumer to shape the curtain in a number of ways.

ICD/ITKE Research Pavilion 2015-16

Achim Megens(ICD)/Jan Khippers(ITKE)
Stuttgart, Germany /2015-2016

The development of the ICD/ITKE Research Pavilion 2015-16 is characterised by a twofold bottom-up design strategy based on the biomimetic investigation of natural segmented plate structures and novel robotic fabrication methods for sewing thin layers of plywood. The project commenced with the analysis of the constructional morphology of sand dollars. At the same time, a fabrication technique was developed that enables the production of elastically bent, double-layered segments made from custom-laminated, robotically sewn beech plywood. Introducing textile connection methods in timber construction enables extremely lightweight and performative segmented timber shells.

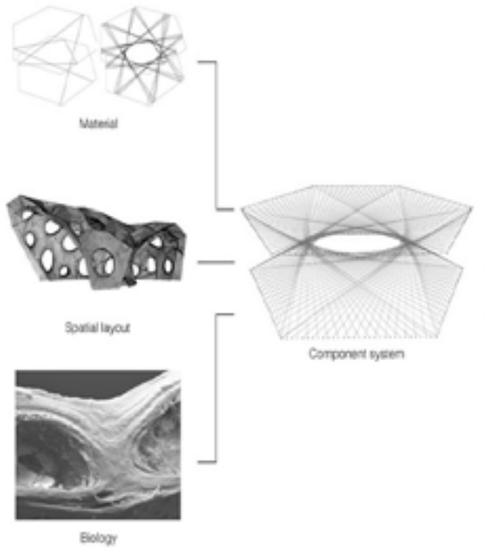




ICD/ITKE Research Pavilion 2013-14

Achim Megens(ICD)/Jan Khippers(ITKE)
Stuttgart, Germany /2013-2014

The focus of the project is a parallel bottom-up design strategy for the biomimetic investigation of natural fiber composite shells and the development of novel robotic fabrication methods for fiber reinforced polymer structures. The aim was the development of a winding technique for modular, double layered fiber composite structures, which reduces the required formwork to a minimum while maintaining a large degree of geometric freedom.



HygroScope: Meteorosensitive Morphology

Achim Menges in collaboration with Steffen Reichert
Centre Pompidou Paris /2012

The project explores a novel mode of responsive architecture based on the combination of material inherent behaviour and computational morphogenesis. The dimensional instability of wood in relation to moisture content is employed to construct a climate responsive architectural morphology. Suspended within a humidity controlled glass case the model opens and closes in response to climate changes with no need for any technical equipment or energy. Mere fluctuations in relative humidity trigger the silent changes of material-innate movement. The material structure itself is the machine.

ColorFolds

Jenny Sabin
Cornell University/ 2014

ColorFolds follows the concept of “Interact Locally, Fold Globally,”

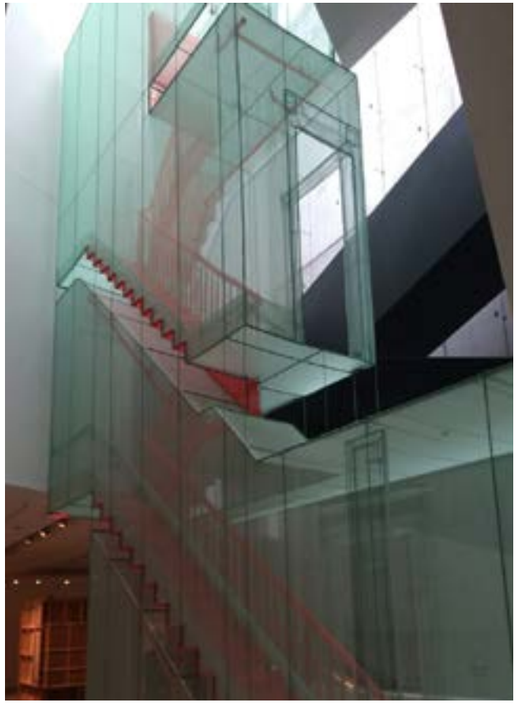
ColorFolds incorporates two parameters that the team is investigating: optical color and transparency change at the human scale based upon principles of structural color at a nano to micro scale. In addition to these material proprieties, ColorFolds features a lightweight, tessellated array of interactive components that fold and unfold in the presence or absence of people.

Fabric New York Apartment Series in Color

Do Ho Suh
Jones Center, Austin/ 2014

This installation is based on the artist’s New York home. It serves to highlight the permeable margins that are said to disconnect private and public in addition to the normalized concepts global identity, space and place, diasporic movement, memory, and displacement. Do Ho Su’s biography is the inspiration of the architectural settings and abstracted figures.

The main installation seems to represent almost any and every single bedroom apartment in New York with its one living room, bedroom, kitchen, and bathroom. Each piece of the home-like installation hanging in apparent stability, however, with the lack of foundation alerts audiences to the precarious fragility of the polyester home.

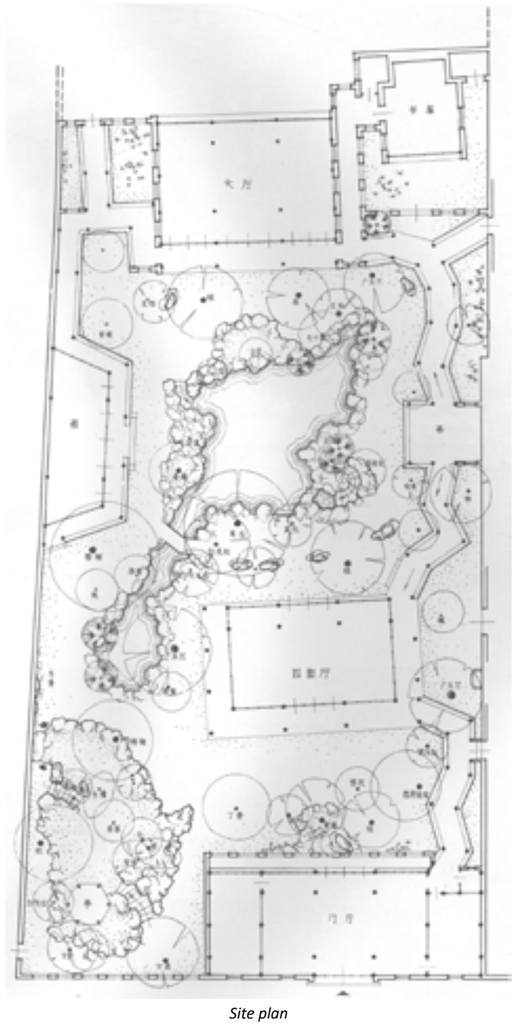


Pocket Gardens

Hok Yuen
Area: 13500 sq ft

Pond side

Zigzag gallary



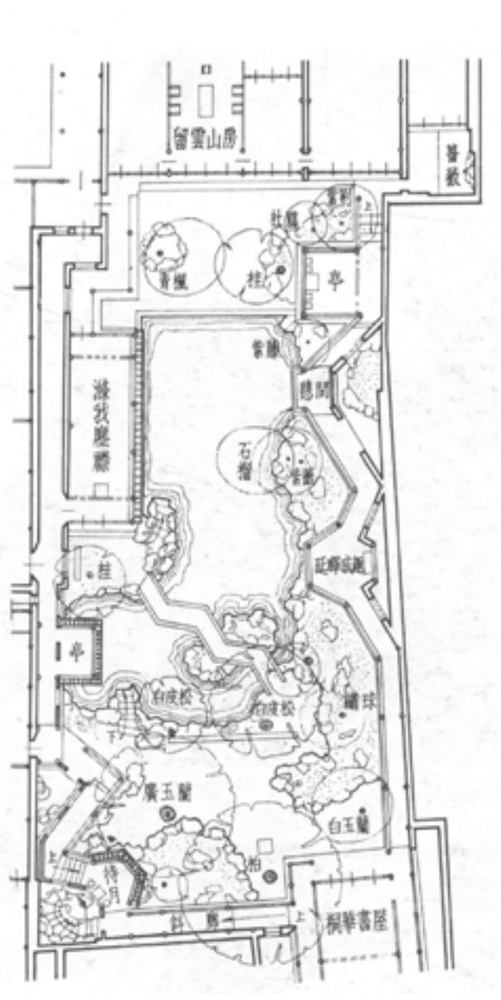
Site plan

Pocket Gardens

Chang Yuen
Area:6970 sq ft

Moon Door

Center view

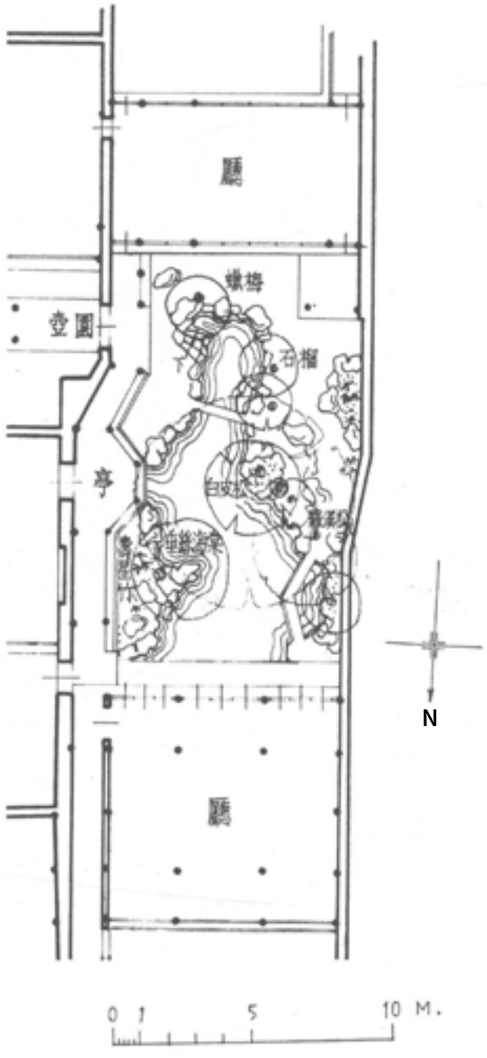


Site plan

Pocket Gardens

Hu Yuen
Area: 3224 sq ft

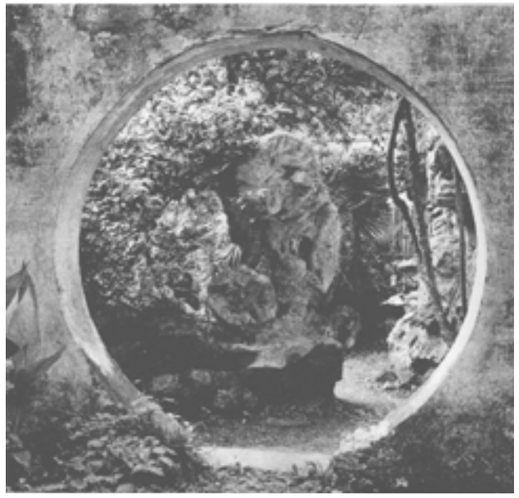
View sketch



Site plan

Pocket Gardens

Canli Yuen
Area: 1525 sq ft



View inside a door frame

Detailed garden plan

Site plan