Sustainable Technology & Social Ecology with Architectural Design

Jingyi Xu
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Master of Science - Advanced Architectual Design
Cornell University
College of Art, Architectural and Planning

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For more information, please contact: jx358@cornell.edu

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I would like to thank all my professors who supported me in the past years through the research and completion of my degree. I especially thank my parents, who contributed their savings for me to study at Cornell University and provided unconditional love and care. I would not have made it this far without them.

Jingyi Xu
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ABSTRACT

Ecology has become a primary focus of humans in the 21st century. The primary reason is the climate crisis resulting from carbon emissions, and architecture faces the problem at the front line. From the appearance, American cities are becoming more environmentally friendly than ever. LEED-certified buildings are quotidian, and sustainable design has become the mainstream. Architecture is gesturing to promote a low carbon lifestyle and reduce the carbon footprint that causes the climate crisis. Architecture always deals with the relationship between people, architecture, and nature. Many people think that if sufficient trees or green plants are decorated around or inside the building, it can be defined as ecological architecture. However, it involves a wide range of systems, which are cross-disciplinary and comprehensive.

Sustainable technology systems enable the built environment to be energy efficient. Besides technology, architecture also needs to thoroughly understand how human behavior and social discourse relate to sustainability, which is social ecology. Social ecology provides architects with guidelines on how to form architectural form and space based on the needs of people.

In this thesis, I will discuss how technology assists architectural design to be sustainable and how social ecology helps architects develop architectural form and space through specific cases.

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1. Start from Technology

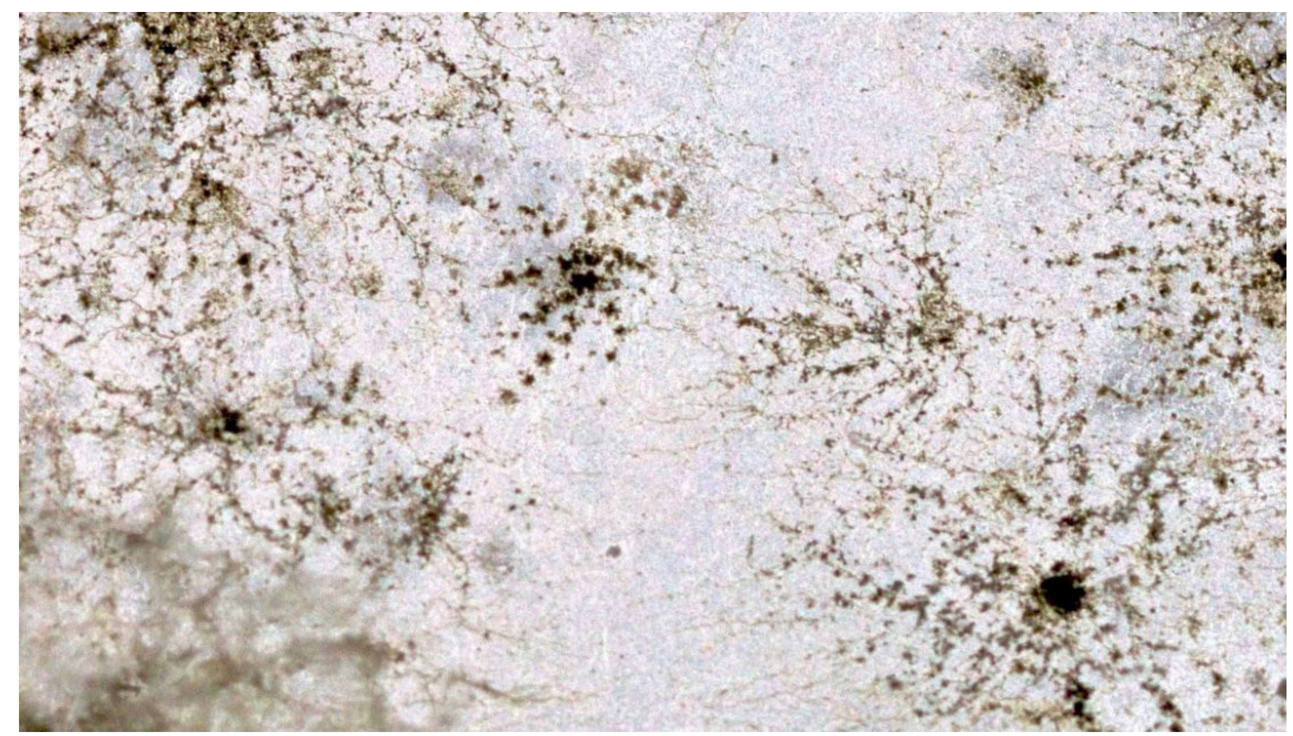
Science and technology are the most direct way to enable architecture to have a fewer impact and more connection to the environment.

Plenty of modern construction projects takes advantage of robots and other complex machines. The most apparent benefit is quantizing the construction environment. Robots and machines can minimize time consumption, improve the efficiency of consuming natural materials, and ensure a relatively sustainable environment for people to live in.

Also, material science is another aspect that advances architectural sustainability. By building from recycled material or experimenting with innovative material options, people can minimize the impact on the environment.

Leslie Lok and Sasa Zivkovic of HANNAH | Ashen Cabin, Ithaca, NY, 2019. Image credit: Andy Chen

They describe their work's structural performance and architectural expression as "inherently derived from materiality, digital construction protocols, robotic routines, and bottom-up design logics." It is a ptototype of sustainable robot construcion.[1]



Circular Constructuion Lab | AAP, Ithaca, NY

MycoBuilt represents a cross-disciplinary research collaboration leveraging the expertise of biologists, engineers, architects and economists from Cornell University and external industry partners to develop both new technologies and a new architectural language combining the specific qualities and potential of urban (construction) and rural (agricultural) waste streams with the incredible potential of fungal mycelium.[2]

1.1 Robotic Fabrication

In recent years, robotic fabrication has helped architecture realize automated construction, accelerating sustainable development and enhancing construction quality. Avant-guard architects take advantage of the efficient techniques and re-think the whole architectural process. Using robotic tectonics to choose and process material and practicing an efficient construction method brings architects new ways of thinking about architecture. Though many of them are experimental practice, it still has great potential to do more with sustainability. For instance, using robot on timber constrcution can not only save time, but also reduce material waste.

Robotic Timber Kerfing Techniques

Fig. 1. An example of straight line kerfing

Fig. 2. An example of straight line kerfing

Fig. 3. An example of straight line kerfing

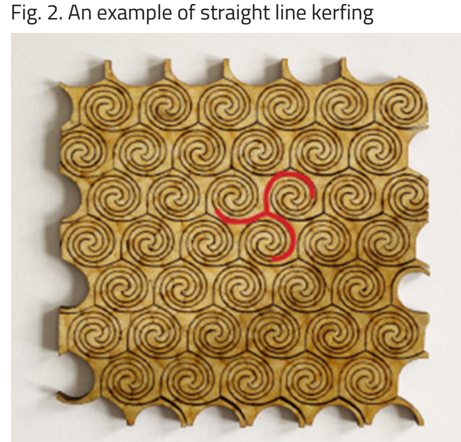


Fig. 4. An example of curve line kerfing

Kerfing is a technique of utilizing patterned cutting to make a rigid sheet, concentrating on wood panels in this research, bendable.

As a building material, wood has a long history. Its properties are ideally suited to the needs of building structures. With the development of modern technology, the properties of wood as a building material and the senses it arises to people also change. Till now, the senses of wood gradually scaled down from dignity and heaviness to human-scaled normality. We can easily change the shape of wood through digital fabrication. There are plenty of examples based on these ideas, and most of them are approached by robotic digital fabrication, which is a fast mass production method to achieve specific forms without changing the properties of wood. In other words, these dynamic forms can be replaced with other materials (precast concrete, 3d printed plastic). Achieving a bending wood component is a material and time-consuming task. This can be done with Lamination's method, but the wood needs to be in a slice before designers can bend. As a result, the wood is wasted for each slice (the thickness of the table saw blade). In the research, we want to challenge how to enable hard timber to be bendable, so we chose to use rigid hard timber as cutting objects. We tested plywood, oak, and poplar. Plywood is the most easily damaged wood because the wood itself is spliced from multiple pieces of material, which loses the willfulness of wood. Thus, plywood is not suitable for robotic arms. Oak is more durable than poplar, but it is more expensive than poplar. Thus, most of our experiments will be tested on poplar. [3]

2D Kerfing Patterns

The following experiments consisted of varying the curvature of the surface by the variable spacing of the pattern elements. Obviously, the sample becomes more flexible as the pattern lines become dense, but the sample may break with the increasing distance. When the distance between the pattern lines was more considerable, the samples did not bend. In this experiment, the pattern was applied to an 8'' x 8'',1/8'' thick wood surface to allow more room for parameter variations in line spacing.

The difference between a curve and a straight line is that the curve can increase the length of the kerf line. The longer the length of the kerf line, the wood is easier to bend and not break easily. Further, increase the limitation of the pattern mentioned above.
The advantage of the curve is that there is no clear directionality so that the wood is no longer very stiff in the process of bending again. At the same time, the shapes of the three spirals snap together again. The curve increases the length of the kerfing line, and the wood will not easily break when it is bent.

The grain plays a vital role in the bending performance of the timber. In the experiment, we kerf on two pieces of timber panel from the same tree and Kerf the timber with lines in the same condition. When the kerfing lines are parallel to the grains, the timber is much easier to bend than the one with kerfing lines against the grain. Double curvature is a method of kerfing both parallel and against the timber grain at the same time. The timber with double curvature has the maximum bending ability, and the 2D intersecting lines and curve patterns discussed before having the same function as double curvature.[4]

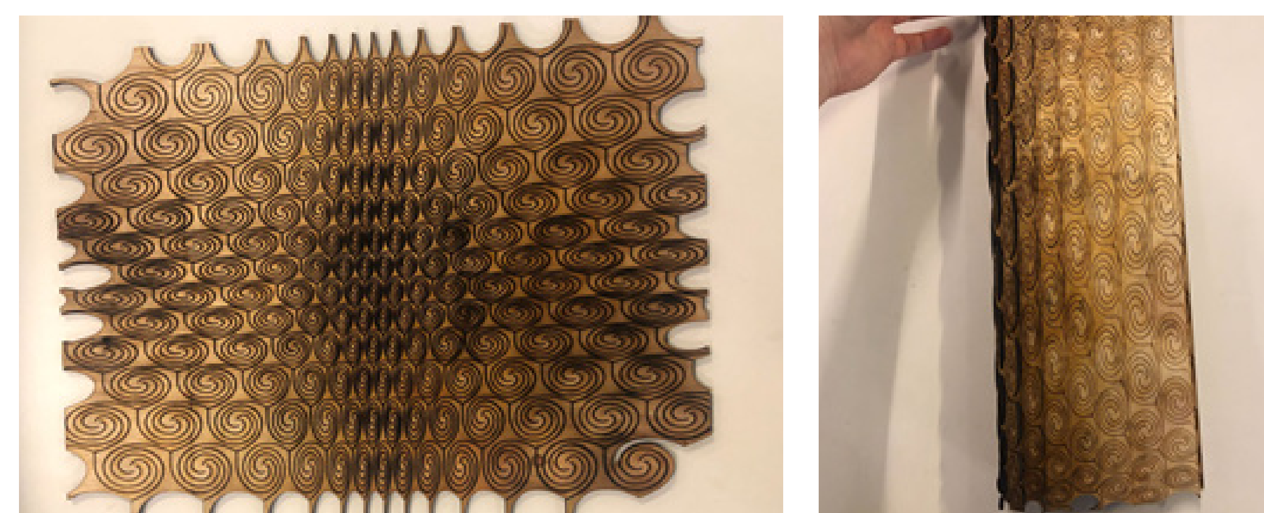


Fig. 5. An example to show the function of kerfing distance

3D Kerfing patterns

The 2d kerf pattern can only be applied on 1/8" thick wood to achieve the best effect. To bend a thicker wood, we need to implement more kerfing methods, including kerfing with angle, double curvature, and double-sided kerfing. The 2D kerf patterns mentioned above are all laser cut, and the blade edge is always perpendicular to the surface of the wood, in order to remove more material from the wood, make the wood softer without breaking. Each kerf line can have an angle, which can increase the area of the tangent line. The robotic arm is a tool to achieve this way. Compared with laser-cut, the robotic arm can control the angle and depth of the kerf line more freely. We use a spindle tool for the end effector of the robotic arm and drill bit. We test the relationship between the kerf angle and the flexibility of the wood. We used a 1/2" thick poplar for this set of experiments, and the cut depth was uniform at 3/16" deep.

Fig. 7. A sample to show 15° cut
There is no notable difference between a fifteen-degree angle and a 90-degree angle. Can slightly feel the elasticity and toughness of wood.

Fig. 8. A sample to show 30° cut
The wood becomes relatively soft, and lightly giving the wood some strength can cause the wood to deform significantly.

Fig. 9. A sample to show 45° cut
In a very balanced state, the wood can bend freely without being easily broken under external force.

Due to the angle problem, the depth of the wood touched by the drill at the same depth also increases. The 1/8'' drill is very fragile. When we tried to use an angle larger than 45°, the drill bit broke.

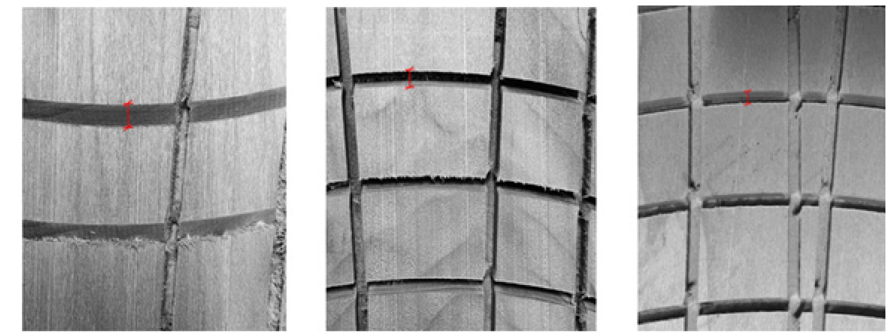


Fig. 11. A photo to show kerfing width. From left to right, the samples are cut in 45°, 30°, 15°

Kerfing Width

The distinct kerfing angle of the miller can obtain various kerfing widths, and increasing the kerfing angle results in an increasing kerfing width. The part with a broader kerfing pit is more bendable than the one with a narrow kerfing pit.

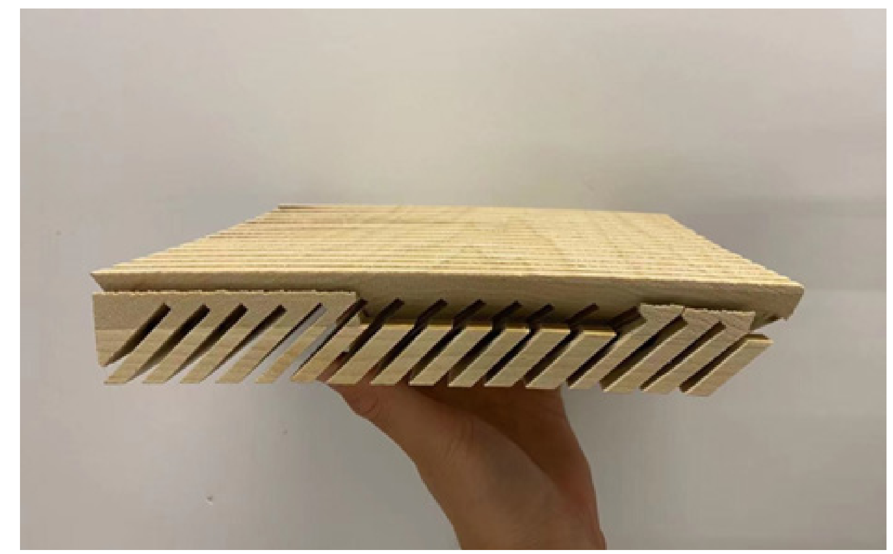


Fig. 13. A photo to show double curvature on both sides of a timber panel

Double sides kerfing

In the experiment, the poplar wood will not be cut through. To improve the bending ability, we would like to try double sides kerfing. The kerfing method can be kerfing lines against the wood grain on one side, parallel to the grain on the other side. To optimize the result, we apply double curvature on one side with kerfing lines parallel to the timber grain.[5]

Kerfing is a way to bend wood to form curved or hyperbolic surfaces efficiently. The manufacturing process is relatively energy saving. Kerfing is not suitable for parts that are too large, resulting in reduced material strength. Not suitable for outdoor use, where the weather causes the material to decay.. In our experiment, if the environment is dry, the poplar wood will lose moisture, which results in fragile and breakable consequences. In this case, the kerfing result will be affected by the environment. If we want to maintain the kerfing result without losing performance, we must store the material in specific humidity. In order to stabilize the curved shape achieved by kerfing, the wood panel needs to be fixed by screws, the opposite of other wood bending techniques.

Timber kerfing techniques are an efficient way to make wood bendable without wasting too many materials. Compared to conventional hand fabrication, a robotic arm can change the cutting angle and depth under control. Both the 2D or 3D kerfing patterns we designed are out of aesthetics and out of the intention to control the bending ability of specific areas. In future development, our research will focus on how to implement the factors to complicated patterns. The most satisfying result we are looking for is to use 3D-pattern kerfing to get a piece of wood to stand freely on its own.

We can see the advantage of taking innovative construction methods through the research. The efficient use of the material is the first step we make to lower environmental impact.

1.2 Material Science

With mass production driven by industrialization and automation, modern materials such as concrete and steel have become the dominant building materials. The consideration of material properties is far less than it used to be since most buildings can be constructed with steel and concrete. The development of parametric and computer-aided design (CAD) has led designers to pursue geometrically complex techniques.
The study of material properties other than steel and concrete has rarely been considered in design and construction. Material is regarded as an “appendage” attached to the surface of geometry. The situation is like a dead-end for sustainable architectural design; In the long term, new material in the construction process is crucial, but in the meanwhile, we think about it after architectural design. The gaps may lie in transferring new material from a laboratory base to the actual construction world and being economically competitive when competing with well-developed traditional material. Though there are dozens of complicated interdisciplinary problems, I still insist that material should precede form according to architectural design, at least in an equal position, since it is an essential component in the long run of sustainability.
Digitalization and innovative technologies in material development ensure the construction industry’s sustainability and efficiency.

Chitosan Film

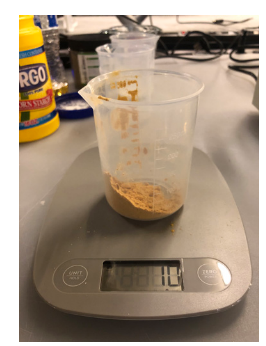
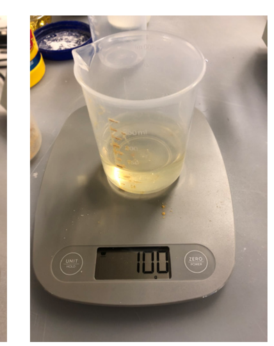
a material in constant dialogue with its environment

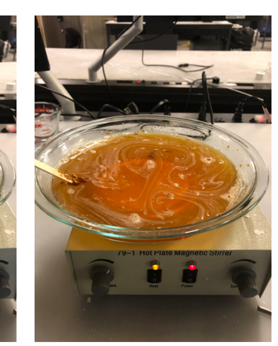
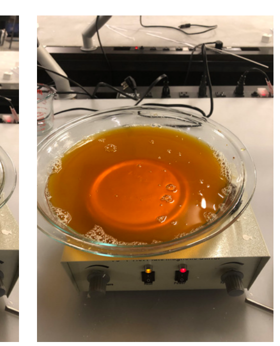
Chitosan Gel in 2%, 8%, 12% Concentration

Chitosan is a versatile biopolymer with unique properties. It is nontoxic, biodegradable and biocompatible. There are more than 400 established applications for chitosan in industries such as water treatment, textiles, agriculture, food processing, and many more.

Chitosan, are found in the shells of crustaceans, such as lobsters, crabs, and shrimp, and many other organisms, including insects and fungi. It is the second most abundant biopolymer in the world. It is biopolymer which is lower cost than synthetic chemicals. Chitin is extremely water responsive -the same material that forms the rigid plates of crustaceans also makes up the flexible material of its joints, depending on how much water the chitin absorbs. Thus, the material respond to the humidity in the air the more humid air, the softer the material. Chitosan is a versatile biopolymer with unique properties. It is nontoxic, biodegradable and biocompatible. There are more than four hundred established applications for chitosan in ind us-tries such as water treatment, textiles, agriculture, food processing, and many more.
The process of making chitosan hydrogel is simple. In this case, it reveals the material’s potentials. When chitosan powder is stirred in to water, it is not soluble. The solution temperature is heated to 37oc, and vinegar is added in ratios of two parts chitosan and one part acid and mixed with a whisk; the acetylation makes the chitosan soluble and the solution starts to thicken and darken. In the process of drying, the moisture in the material evaporates. After four days, the chitosan hydrogel forms a thin film.
The failure I met is that after I added vinegar to the chitosan water, the solution did not thicken, so I tried to add additives like starch. With the additive, the soltion will present as a hydrogel phase.

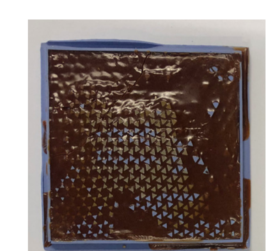
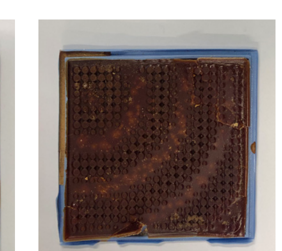
In the application of the chitosan-based material, additives are going to affect the materi-al performance. For instance, the research carried out by Neri Oxman in MIT lab, explores chitosan-based textile. The material is chitosan based, with additives like starch and protein. Also, ingredients such as pectin and cellulose are added to the textile to improve material property. An-other experiment carried out by Paul Kheem, add CaCO3 to the solution, in order to achieve a state like plastic. With various kinds of additives, the chitosan-based material can perform different proper-ties according to distinct requirements.
The result I got was not that satisfying, the samples are kind of fragile. However, they are pretty steady and tough. Therefore, the material may has a good potential for interior decoration. From the research I made, I can tell that in the future, the material has great potentials, since it is a sustainable material. Without additives, it will degrade in six months. With different additives, the chitosan based material can perform differnt qulity, in order to respond to differ-ent kinds of environment. If the chitosan-based plastic can substitude the plastic products nowadys, a huge problem of dealing with plastic wastes will be solved. Also, the chitosan-based textile can take the place of plastic bags.

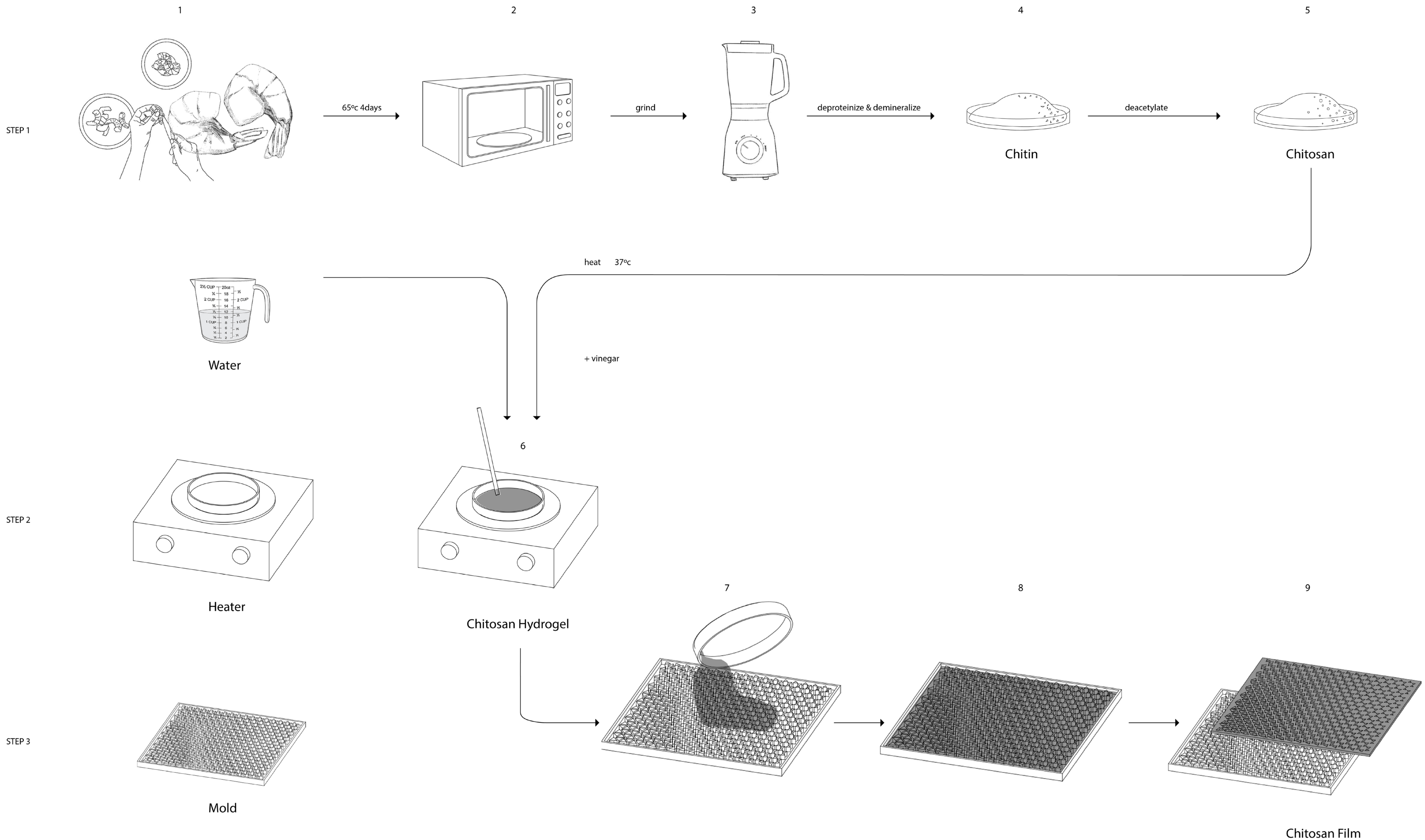



Water, Chitosan powder, Vinegar, Glycerin

1. Water is heated to 37oc;
2. Acetic acid is added in ratios of one parts chitosan powder and one part acid and mixed with a whisk;
3. Acetylation makes the chitosan soluble and the solution thickens immediately.
4. Glycerin is added to improve workability



The Process of Producing Chitosan Film

2. Social Sustainability with Architectural Design

The fundamental goal of the built environment is to provide people with sanitary conditions, clean air, water, and energy. The design should begin with these social basics of the place and community. However, the built environment nowadays needs not only to deal with basic social needs, but those needs come with social progress within the frame of ecology by adopting a comprehensive method to social and technological systems. Except for the technology system, the social aspect of design focuses on balancing the artificial and natural environment and social problems, which embodies social ecology. Scholar Joo Hwa Bay clearly defined the concept of social ecology:

> *Theory of The Third Ecology (Chermayeff and Tzonis 1971) pointed out that social ecology is directly related to the artificial urban fabric, and recently, the much-accepted pervasive framework of the Brundtland Commission Report 1987: Our Common Future, which included more discussions about the interrelatedness with economic equity and the natural environment. Foremost and ultimately, it is about promoting and ensuring the social quality of living now and sustaining that into the future, for all nations, the rich and the poor, through solving the matrix of social, economic, and environmental problems.*

When quantified to design, the social-ecological thinking reflects through the form and space of architecture. Layers of the relationship between the artificial and natural environment and people can be defined by design. Whether to integrate or separate, embrace or against, etc., is what architects should consider. [6]

Volcano eruption in Iceland.
(Credit:Twitter/Brian Emfinger)Volcano eruption in Iceland. (Credit:Twitter/Brian Emfinger)
The relationship between artificial and natural environments is subtle. While people admire nature, they still need shelter from natural hazards. How to balance the two is what sustainable architecture should contemplate.

Lee Statue in Richmond, Virginia
The statue was a monumental symbol created to overshadow a social movement, blunt its course, and attempt to erase its history. The Black Life Matters event drove architects to rethink minimizing the abusive relationship between races.

2.1 Man-Nature relationship to Architectural Form & Space

The growing population and urban life extrude artificial elements into nature, making man and nature stand opposite. The attitude of people is controversial, as people consistently exploit resources and space from the heart and at the same time hope to compensate for the loss. What I propose is to promote nature to occupy the built environment. Architecture can be a time capsule that records every subtle interaction between nature and people from the past to the future.

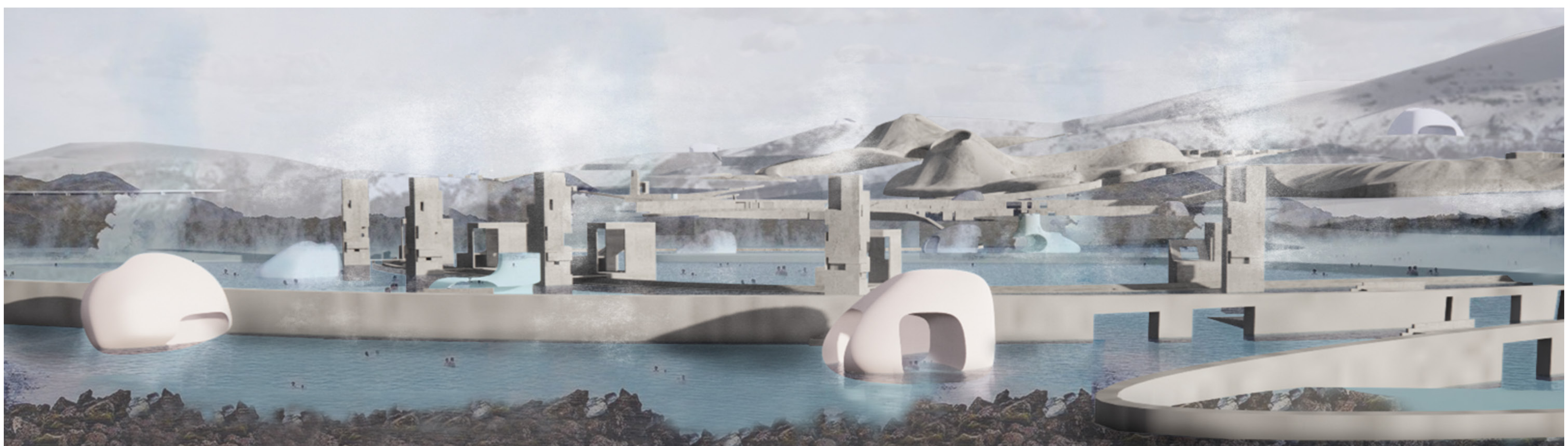
As Stan Allen says, now a parallel trend looks not to the biology of individual species but the collective behavior of ecological systems as a model for cities, buildings, and landscapes: “Architecture is situated between the biological and the geological—slower than living but faster than the underlying geology.” It could be a positive approach if we start thinking again that architecture can also bring nature back into the view and experience of the city.

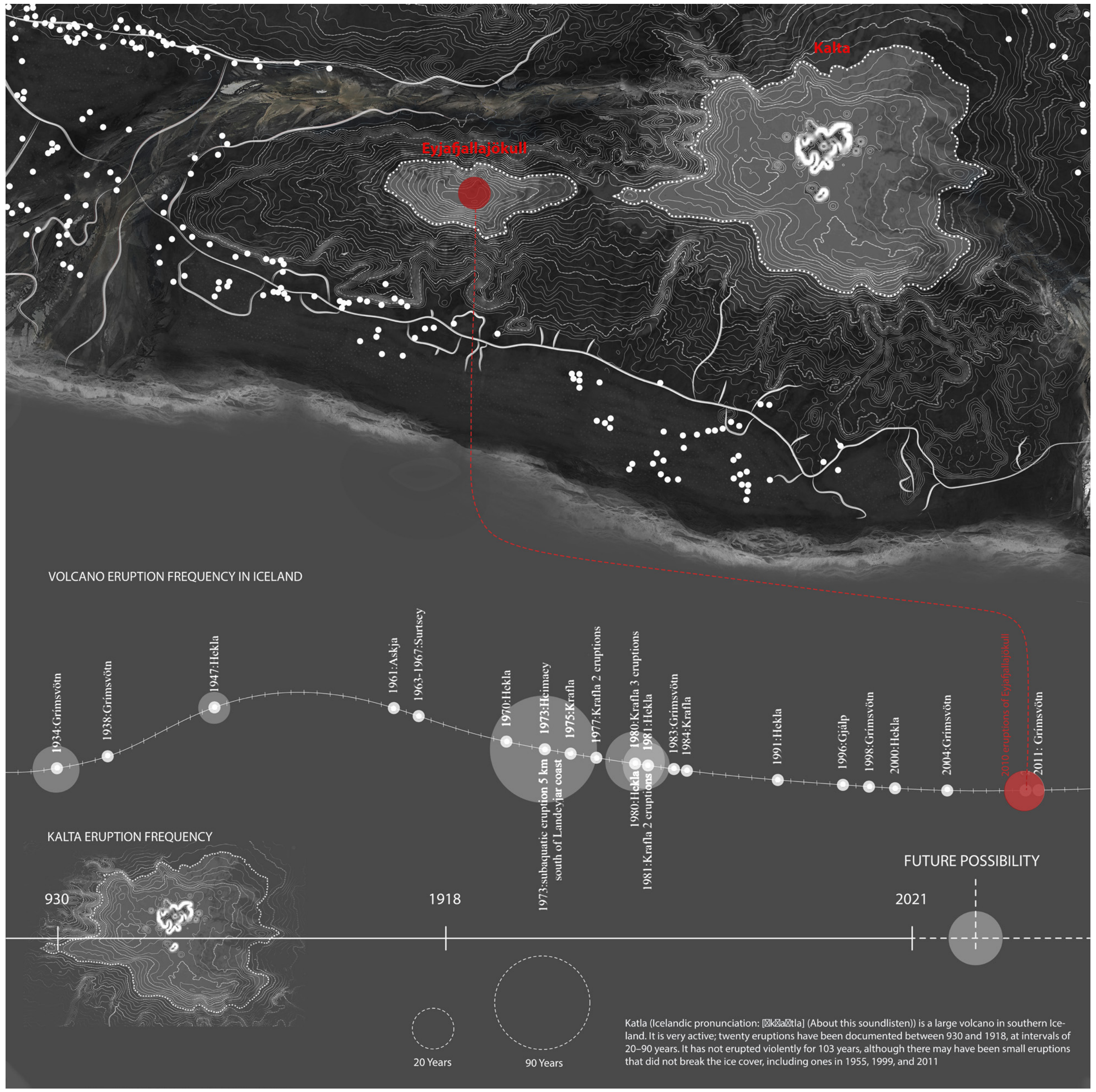
Pilgrimage to Volcanoes in Iceland

Infrastructural Response to Volcano Eruption

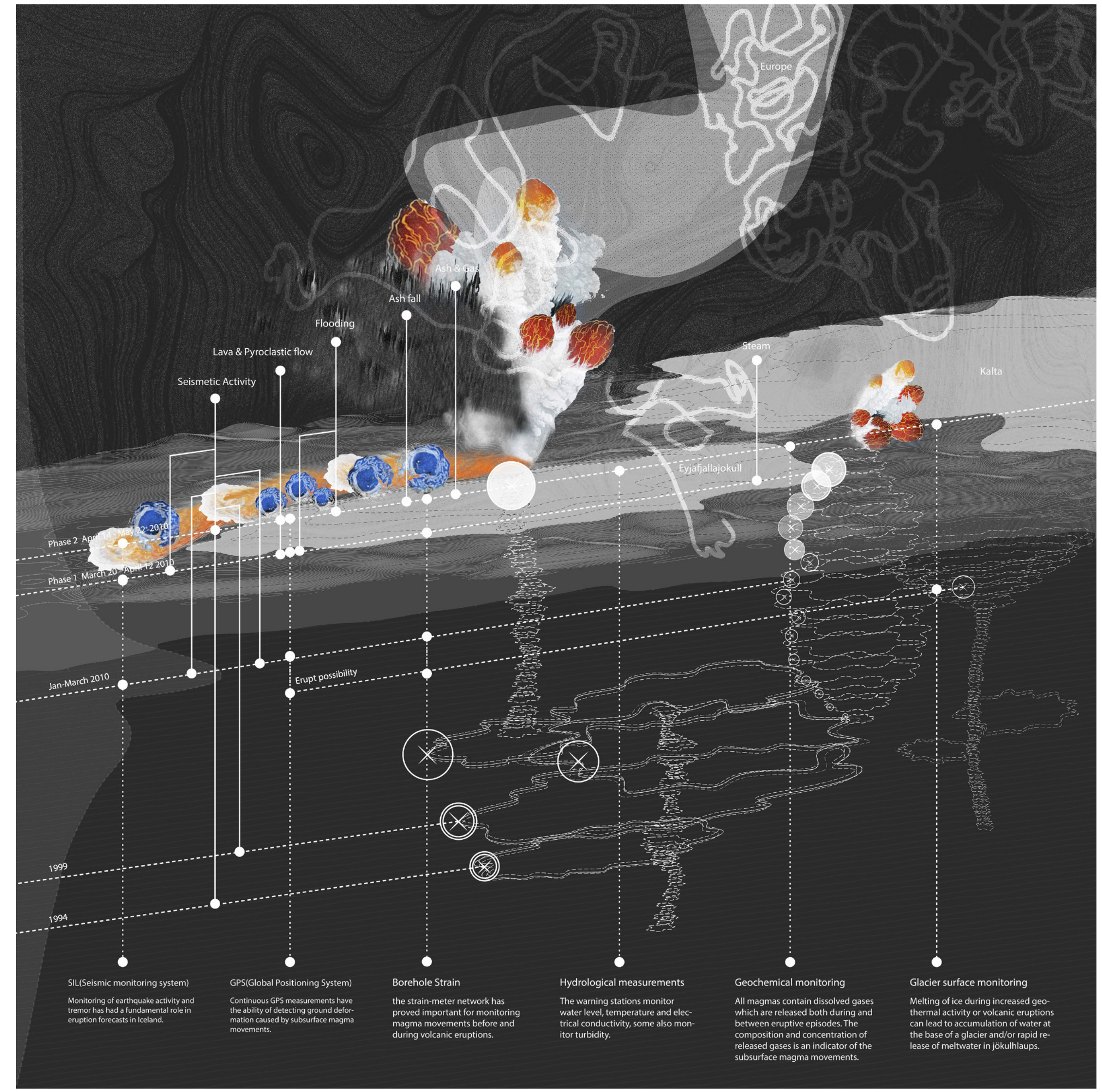
Infrastructure for me is like a bridge between nature and people. It is another layer of the earth. This bridge allows people to live harmoniously with the events happening on earth. I am going to look at Iceland to talk about creating a new infrastructure in response to volcanic eruption.

Iceland is known to be responsible for a third of all the fresh lava on earth. It has approximately 130 volcanoes within 30 active volcanic systems. The country sits on active Mid-Atlantic ridge, which causes all these seismic activities. The event that I am looking at is Eyjafjallajokull volcano eruption in 2010. The volcano is on the south coast of Iceland, above the Mid-Atlantic ridge. The volcano connects to a larger volcano next to it, named Katla. Some volcanoes in Iceland are different from normal volcanos, in that they have large areas of thick icecap above the mountain. Eyjaf and its neighbor Katla are belonged to sub-glacier volcano, which means there will be flooding issue accompanies the eruption.

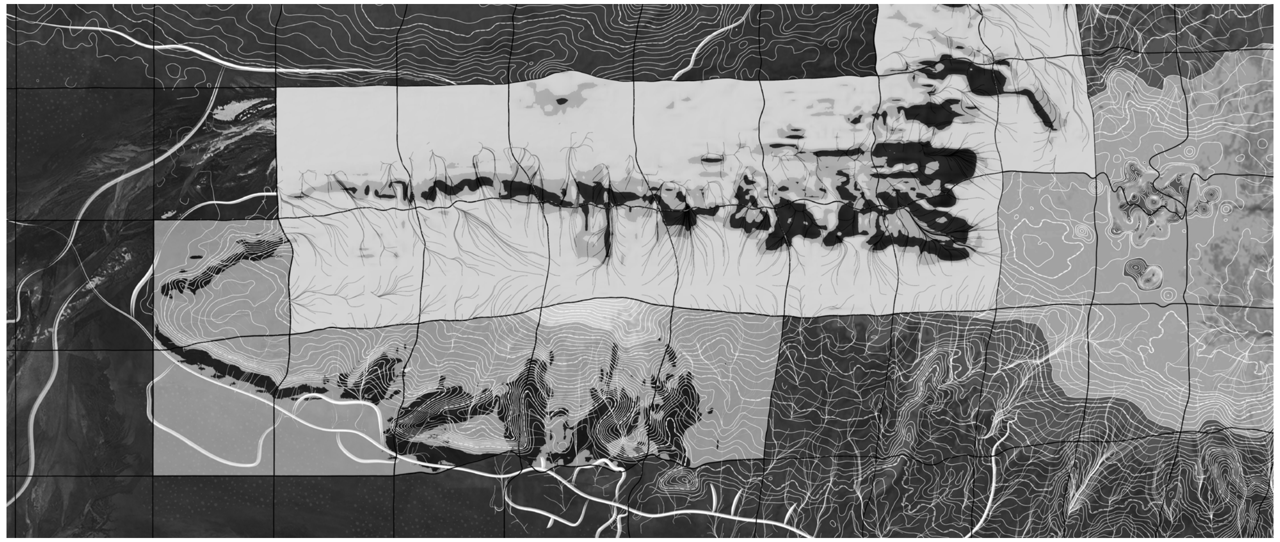




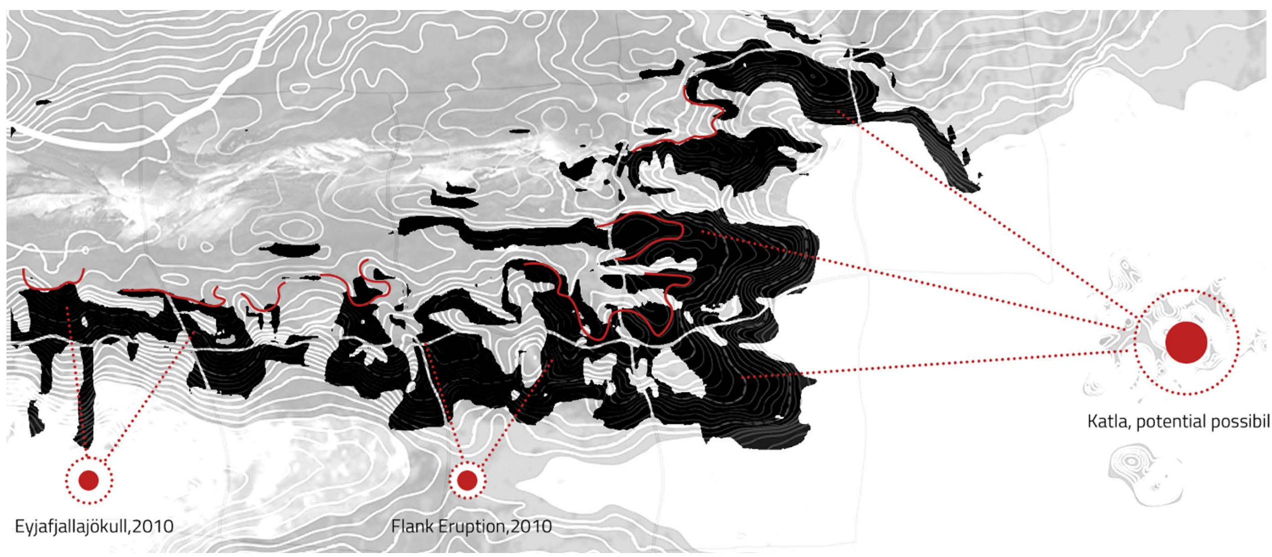
This map shows the traces of lava flow in 2010 eruption and lava flow of Katla hundreds years ago. Based on the frequency study of volcano eruption in Iceland, the area is prone to another volcano eruption by the potential eruption of Katla.



Before the eruption, the volcano kept accumulating energy. Over time volcano cannot withstand the pressure in the sills. Then, the volcano erupts. During the eruption, the volcano creates fresh lava, pyroclastic flow, volcanic ash, and flooding caused by the melting glacier.



lava flow simulation & natural low areas



shapes and the ends of natural low areas

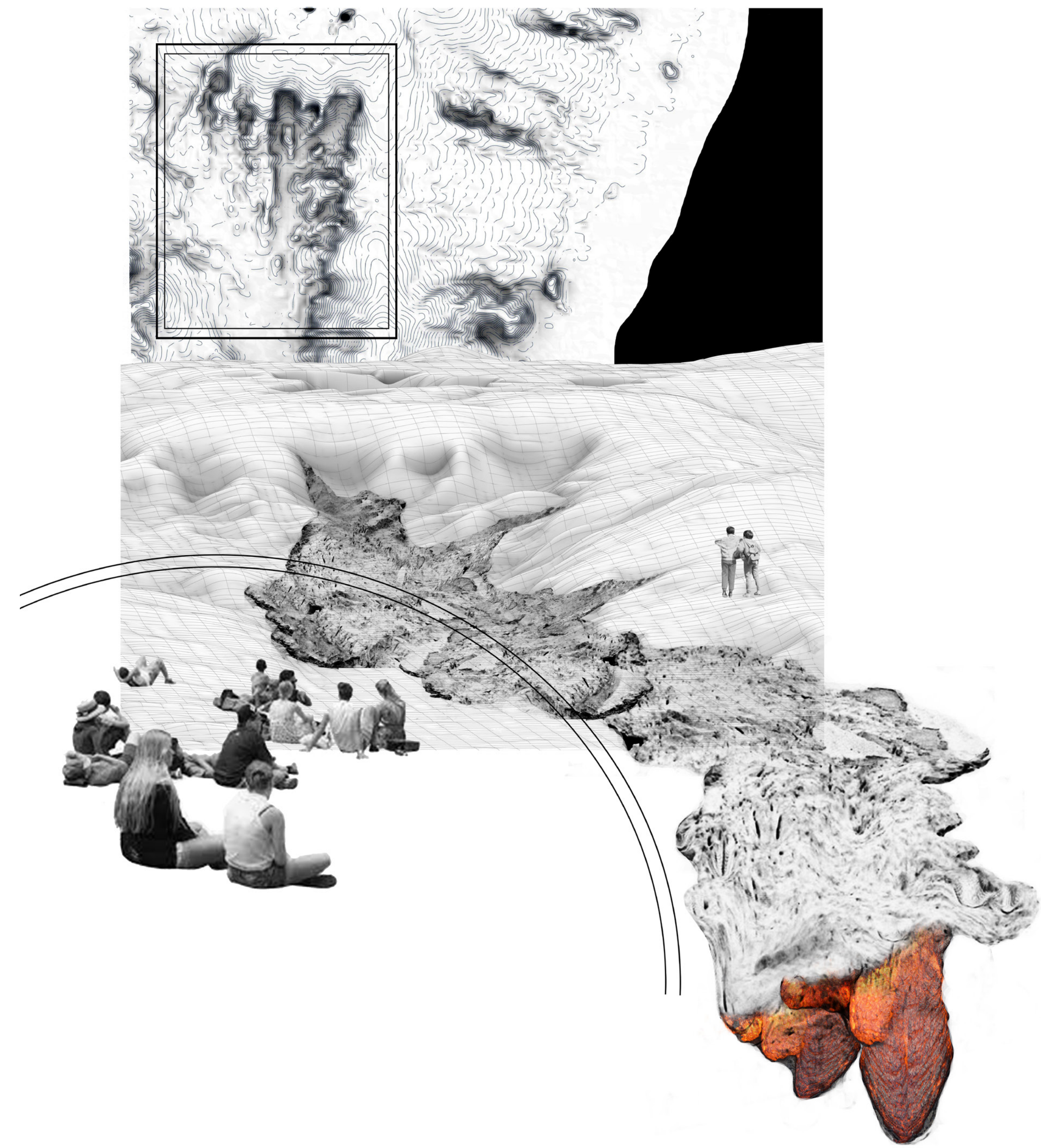
It is interesting to know that during the 2010 eruption, there were 0 casualties. The circles are the villages located next to the volcano. People choose to live in the places that avoid the flow of lava. The black areas have higher hazardous levels than the other area. No matter what has happened or what will happen, the Icelanders choose to live on this continent, living with the volcanoes. The volcanoes are part of their lives.

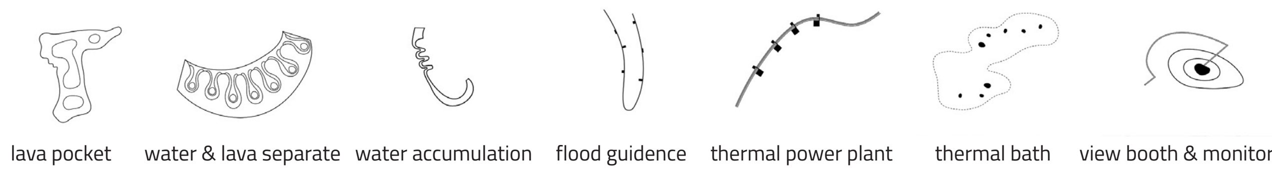
The ghost lines are flow simulation of lava and water. By layering the topography, I find the dark fields to be the natural low area. The flood and lava will pass the natural low areas and flow away. So, at the end of the natural low areas are the perfect places to guide and accumulate the lava and flood. I would like the infrastructure to be a part of nature, so I extract forms from natural topography. Natural low areas, high areas will have distinct functions. Also, the natural curvature of the topography will be the rule of my proposal.

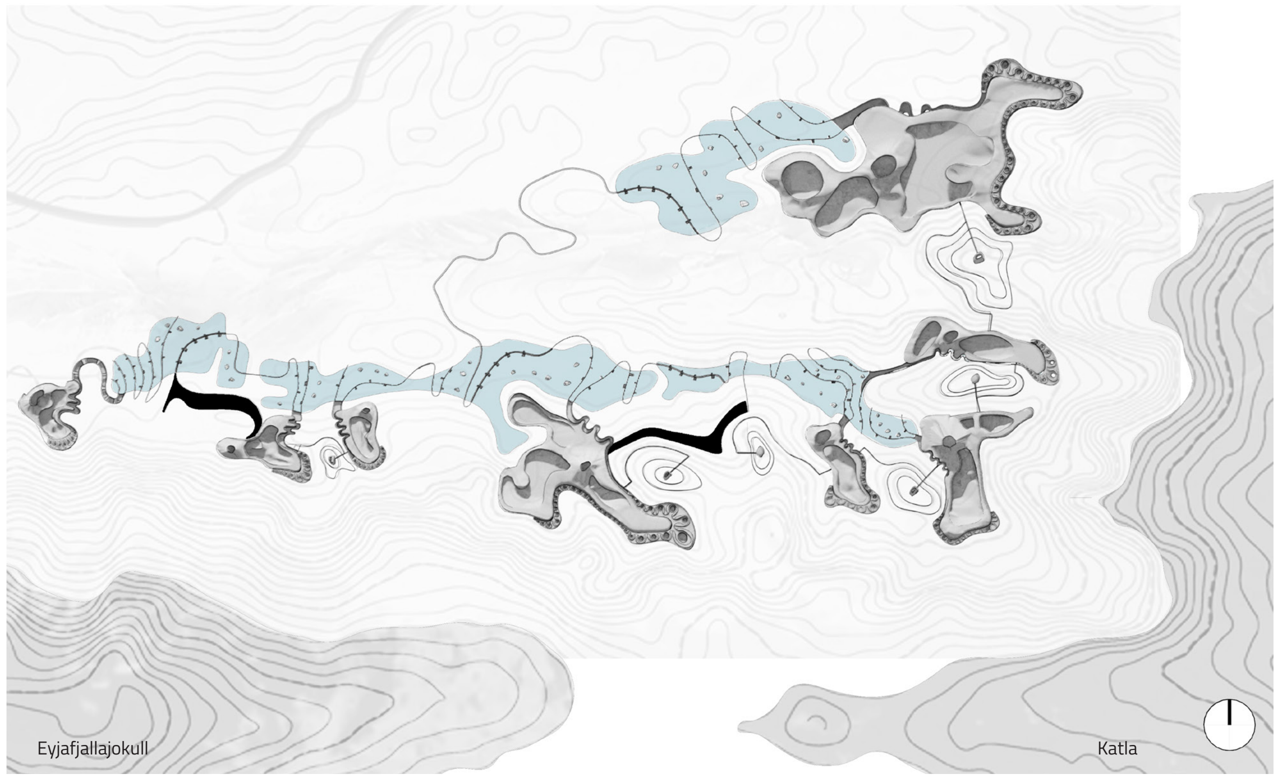
Besides lava and flooding and all the side effects come with volcanoes, the special openings to the magma sill are signs of energy. Geothermal energy generates 98% electricity in Iceland. The red dots in the map are the high temperature fields, where originate the geothermal bath that attract both locals and tourists. It is a lifestyle for the people live there.

During the eruption, if the situation is considered to be safe, the locals will wear a mask and go to appreciate the events. It is like a pilgrimage to witness the power of the planet. When the lava is cooled, basalt rocks form on the original landscape. Then in one decades, moss starts to thrive on the rocks.

My proposal respond to the eruption event aims to create infrastructure that can guide and embrace the hazard comes with volcanoes, and provide people with safe space for pilgrimage to witness nature, before, during, and after the eruption.





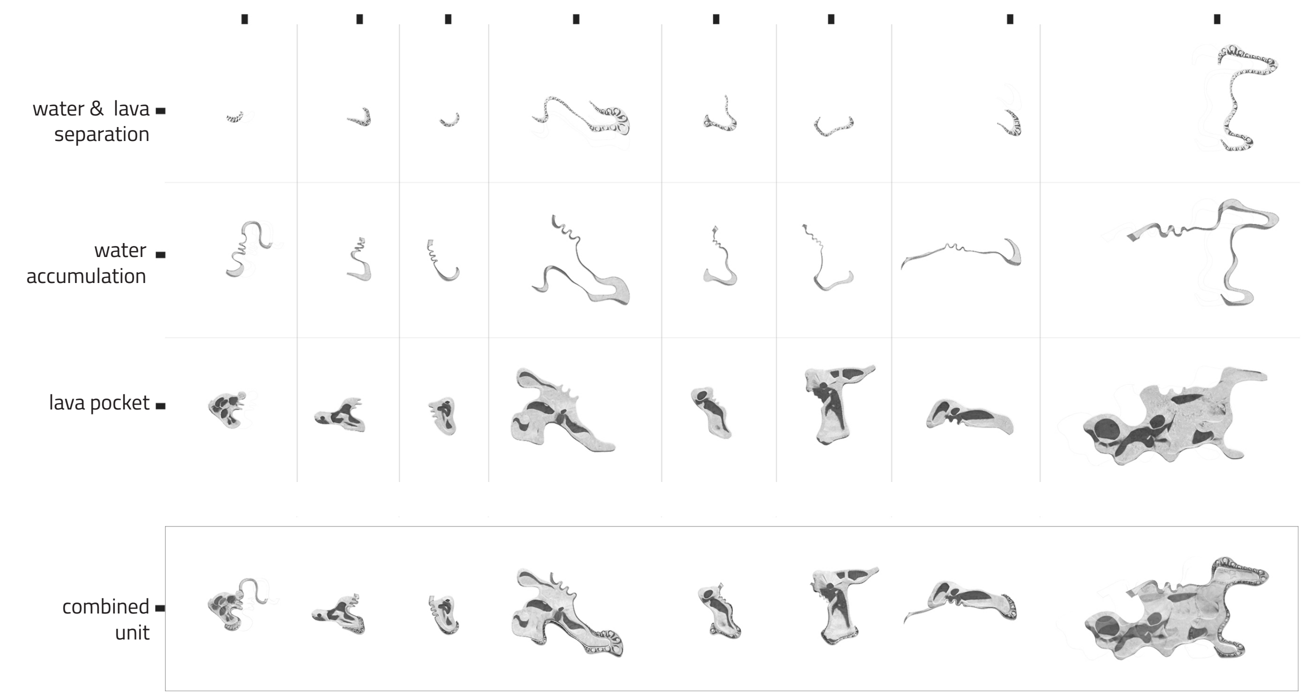


During the eruption, I am going to have lava pockets to store the lava and form a new landscape. The water and lava separation system aims to separate lava into lava pockets and flood into the water accumulation system. Then flood guidance will direct the flood into the thermal bath. Also, to take advantage of the geothermal energy in this area, geothermal energy plants will function before, during, and after the event. Sculpture rocks will be utilized as a recreation place in the thermal bath. They are also the places where the gas monitor and view booth locate. I will also have shelter during the eruption. Before and after the eruption, it will be a hotel.

The components in this catalog are the first system that the eruption will encounter, including the water & lava separation, water accumulation, and lava pockets. Lava and water go through the separation system; since the lava is much more viscous than water, it will go directly into the lava pocket. The water will actively respond to the slope to go down to the water accumulation tunnel. The water will go out from the tunnel and direct by the flood guidance into the open thermal bath. People can walk on the guidance to cross the thermal bath or walk into the thermal bath from the staircase attached. It is also the connection between each element.

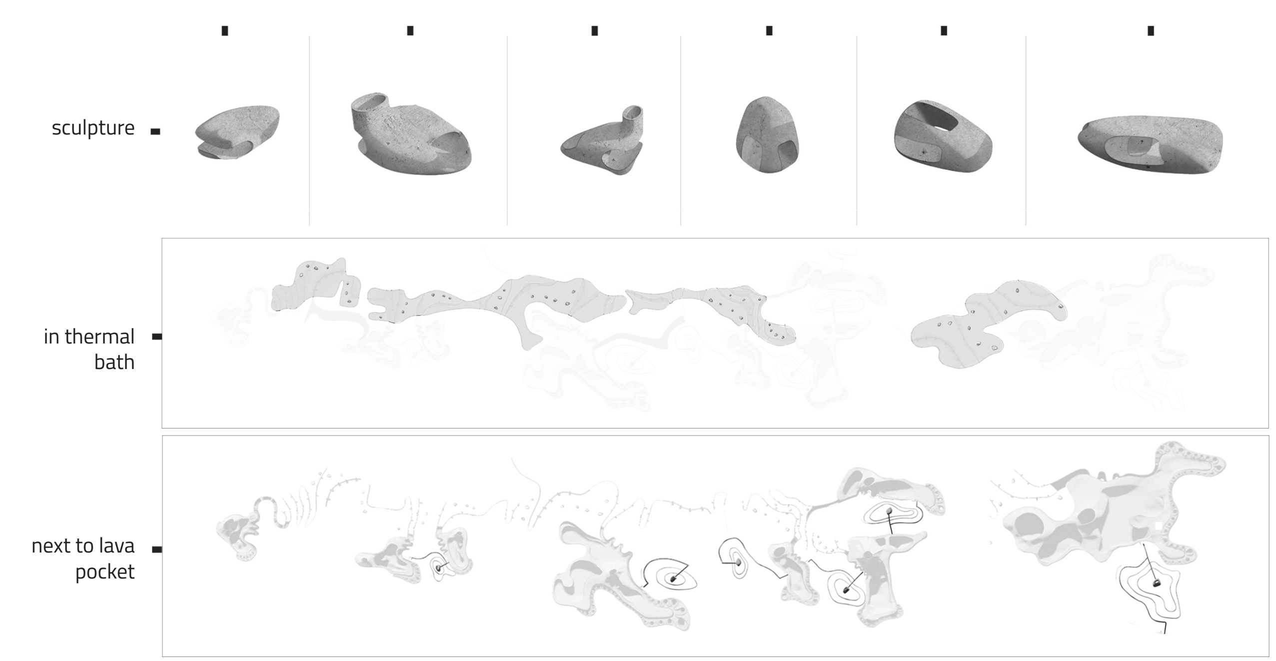
To utilize the rich thermal energy, geothermal energy plants are sitting in the thermal bath. The thermal plant includes three components: Thermal energy extraction and transformation box with thermal pool inside, walkable crater to transmit electricity to the hotel or shelter, and steam tower. These sculptures mimic the cobblestone in nature. In the thermal bath, the configuration creates places for people to have fun and have rest. Lava pockets are in the form of a volcano, and the sculptures are in the form of natural stone. The infrastructures blend into the mountainous volcanic area. The sculptures will also be used as the place to store gas monitor sensors. Since they locate on the mountain's natural high area, the site is also a great view booth for people to pilgrimage the whole events when the condition is safe based on the monitor.

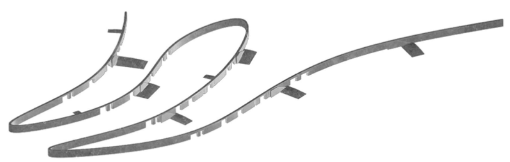
Front System

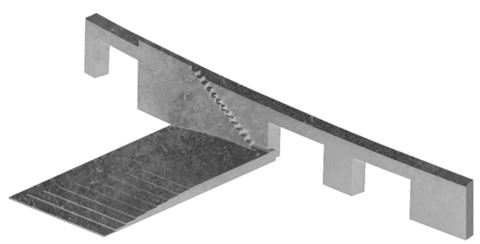


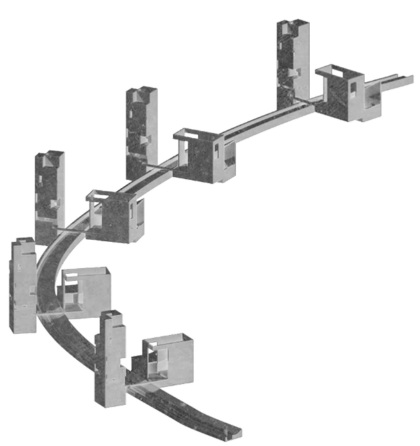
Lava and water go through the separation system; since the lava is much more viscous than water, it will go directly into the lava pocket. The water will actively respond to the slope to go down to the water accumulation tunnel.

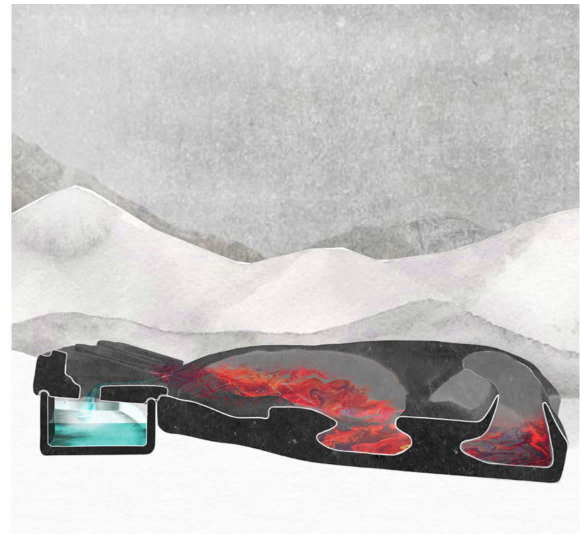
Recreation & Monitoring System











Lava Pocket

Water Guidence

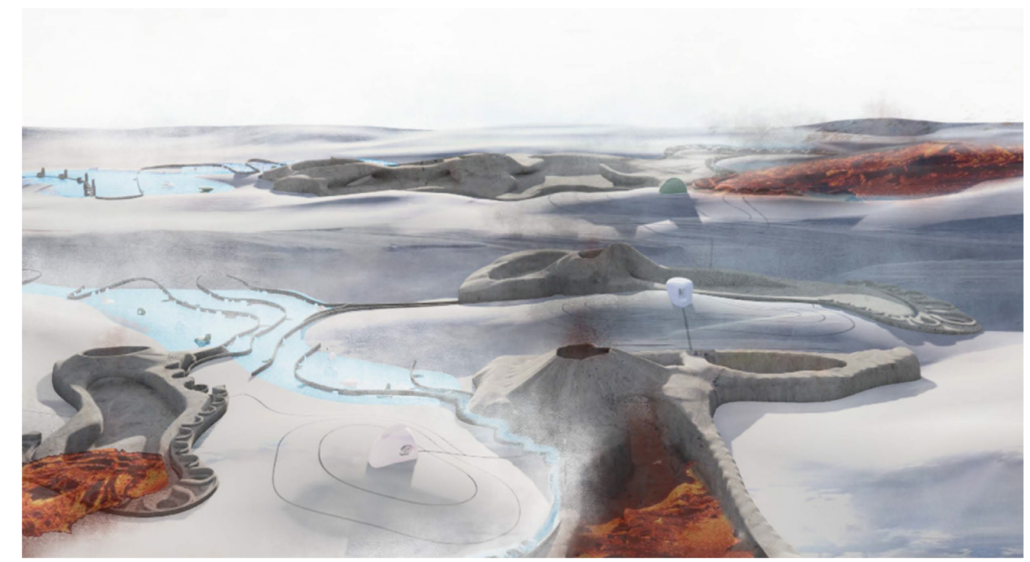
Thermal Energy Plant

Before the Eruption

the lava pockets are forests with all the plants grows in Iceland.

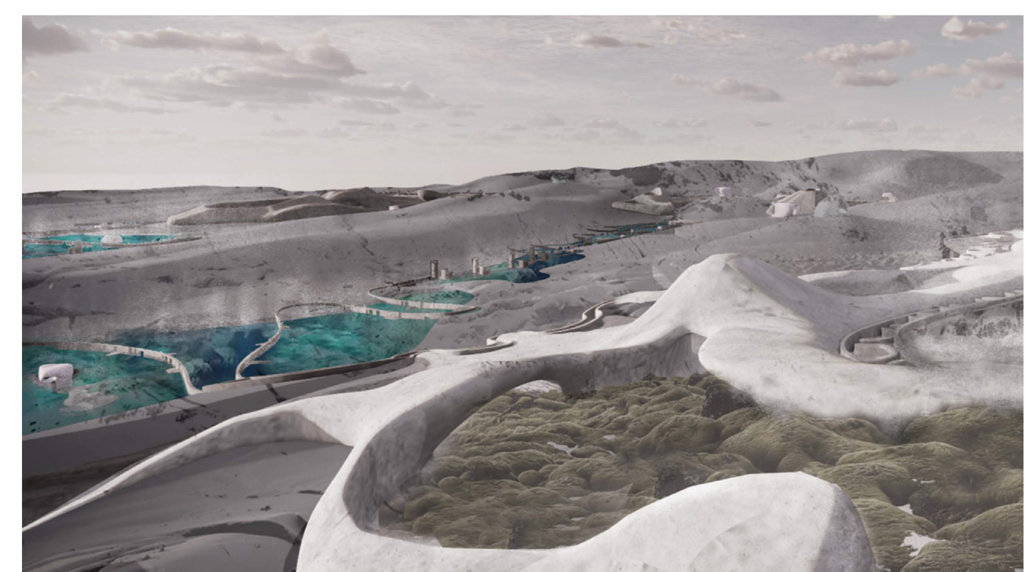
During the Eruption

the whole systems function together to form a new landscape and provide people with a safer place to pilgrimage.



After the Eruption

the lava pocket will turn into a time capsule to record what time does to the new landscape. People will see the cooled lava as basalt rock, and at the same time, subtle changes are going on.

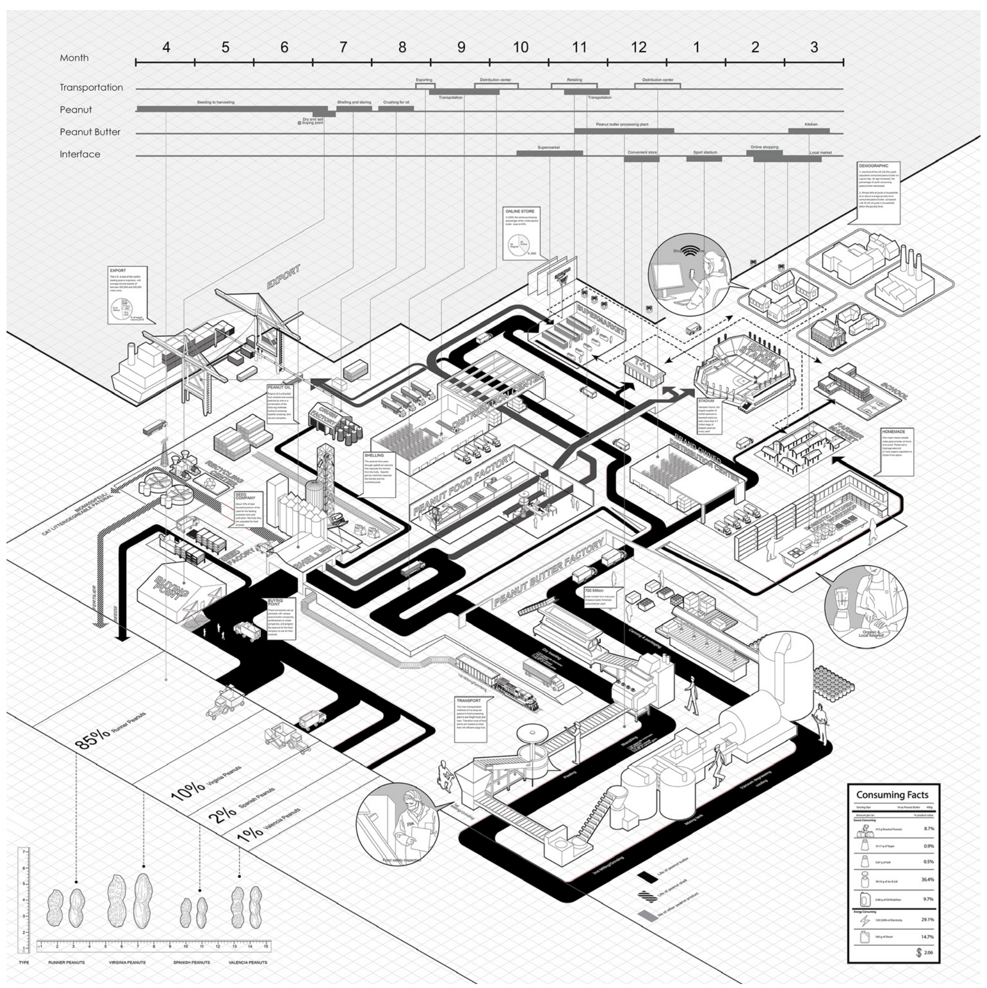


2.2 Social Problems to Architectural Form & Space

The form and space of architecture decide the relationship between people. People from different classes, races, and ages can form complicated relationships. The needs of each group lead to plenty of fascinating design concepts and reflect through the design of form and space.

Study of Food System

Prototype for Food Hub in Food Desert Area



We begin the workshop by exploring a series of food systems that engage the infrastructure of the city. These systems focus mostly on food commodities and in some cases minimally transformed food (e.g. flour, peanut butter). Consider a representative manifestation of one of these commodities (e.g. a bag of flour) and work back as far "upstream" in the product's life to analyze the production and distribution infrastructure necessary to travel from source to shelf.

We begin the workshop by exploring a series of food systems that engage the city's infrastructure. These systems focus primarily on food commodities and, in some cases, minimally transformed food (e.g., flour, peanut butter). Consider a representative manifestation of one of these commodities (e.g., a bag of flour) and work back as far "upstream" in the product's life to analyze the production and distribution infrastructure necessary to travel from source to shelf.

The foodoir is an urban project to answer the problem of uneven food distribution in Rochester. We begin the workshop by exploring a series of food systems that engage the city's infrastructure. We choose the peanut butter industry, as nutrition is concentrated and familiar enough for people. Then, we work back to the "upstream," tracing the life cycle to analyze the production and distribution infrastructure from source to shelf. According to the map on the right, the prototypes will be put in a food desert area in Rochester.

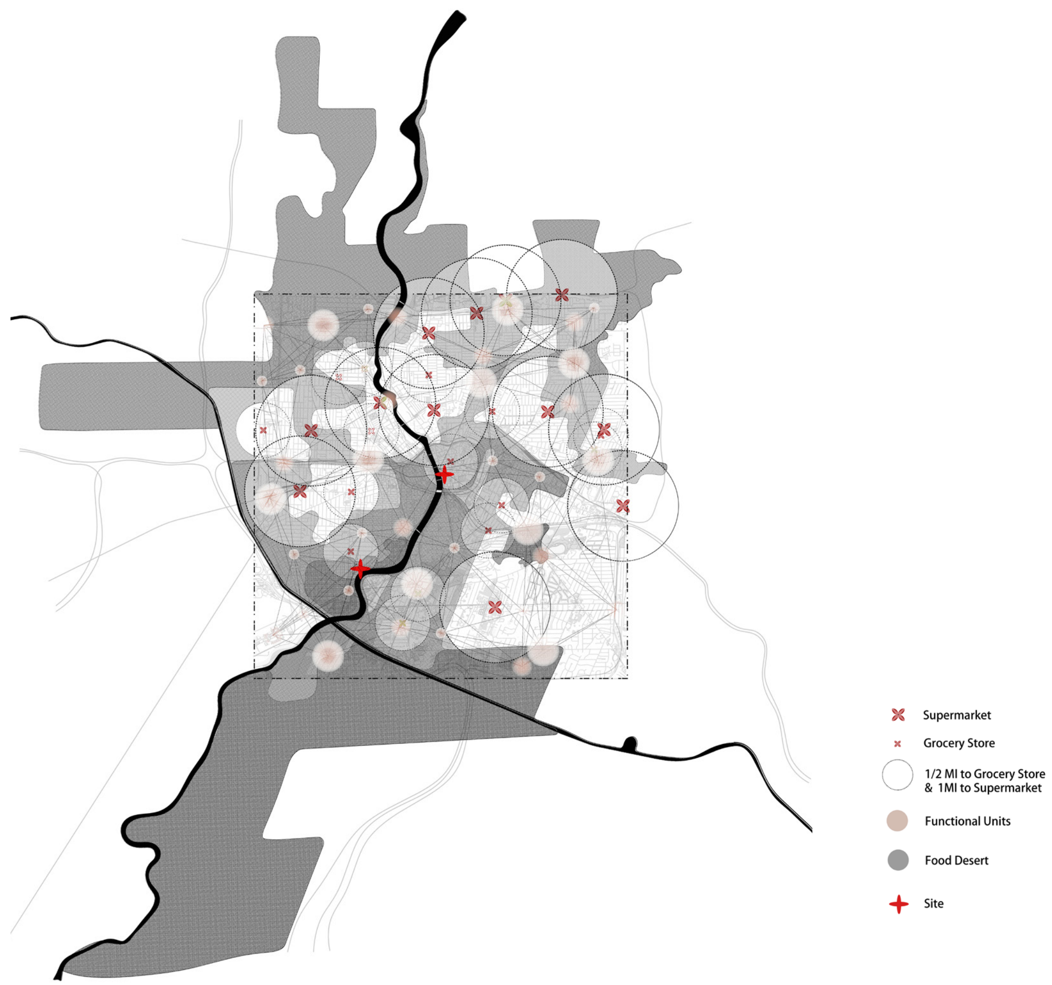
In this case, we are thinking about how the distribution of uneven resources is related to poverty. The people living in food deserts have little access to healthy food sources, and they barely know their eating habits. As a result, these people have a high rate of obesity and high blood pressure. Poverty and diseases enlarge the gap between these people and those with ordinary lifestyles, leading to severe social problems.

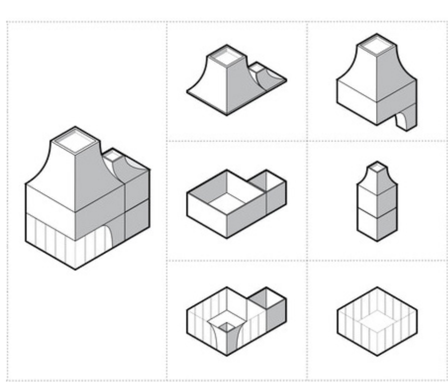
Considering the social problems, we proposed a prototype to alleviate the condition of a food desert and bring the source, the production line, and food education to people in need.

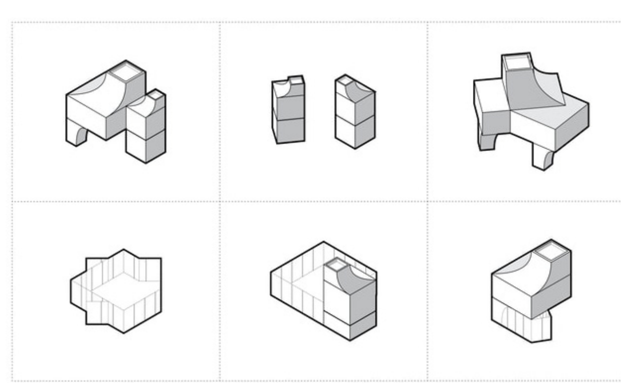
Prototype Cluster

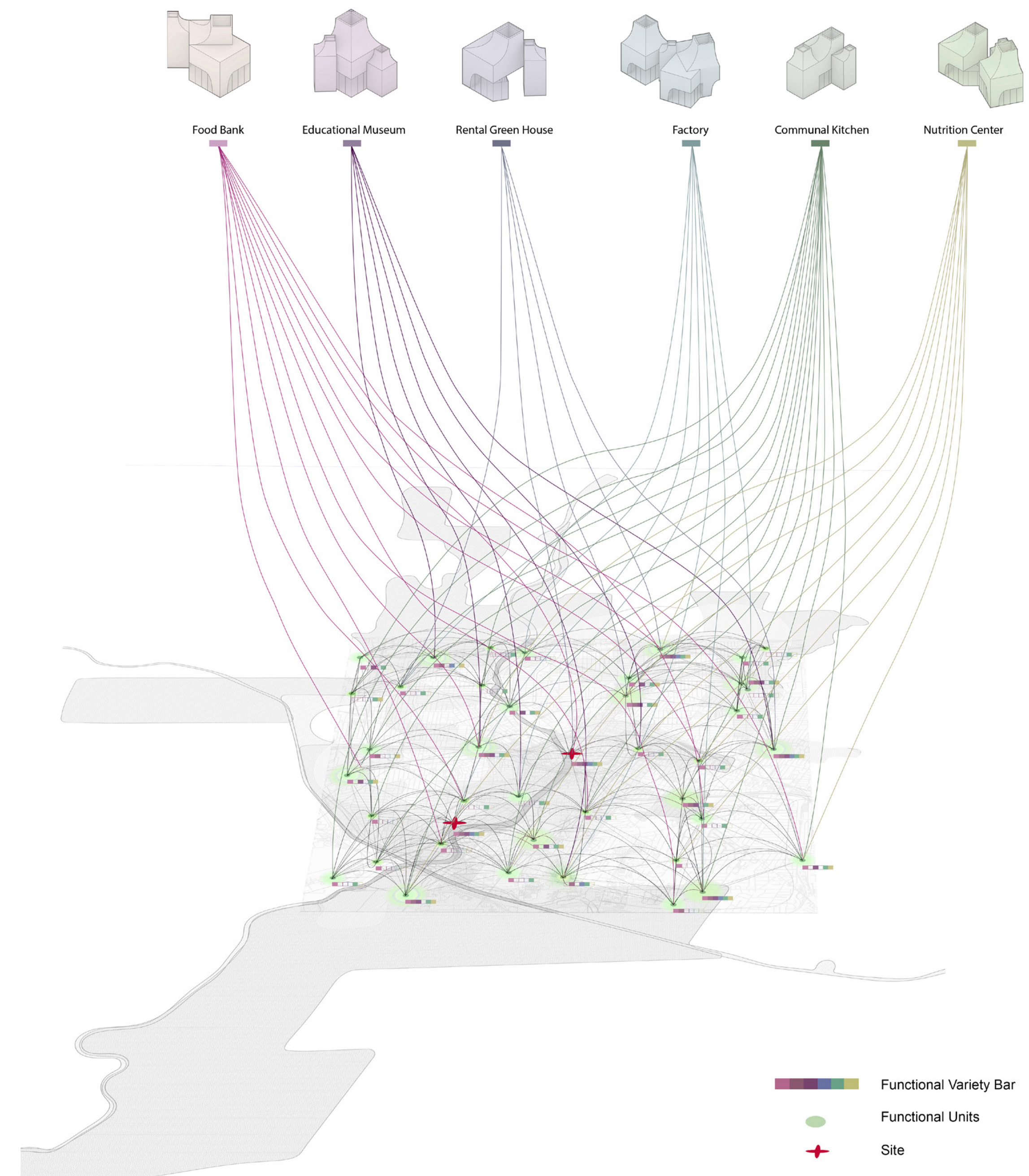
The prototypes will composite six configurations according to missing functionalities in food desert. The configurations will work as food bank to distribute food; Educational museum to provide food education; Rentable green house to provide residents and students to grow their own plants; Factory to process basic food products; Communal kitchen to cook; Nutrition center to provide nutritional knowledge.

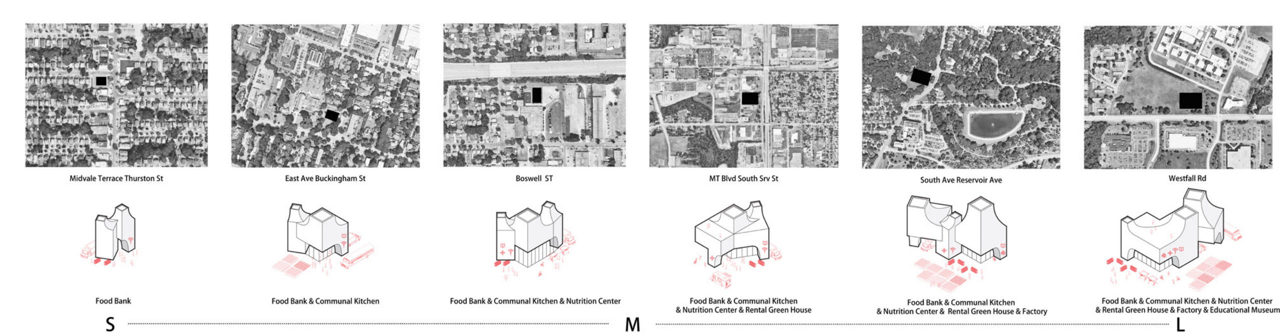
We found two sites in Rochester with specific local conditions. If the prototype exists in anticipation of deployment, the sites will allow it to become active through instantiation. One is near Rochester University which learns special shapes that allow us to put a factory of processing in that area. The other site is in the downtown area which allows more public uses such as a food court for more public use.





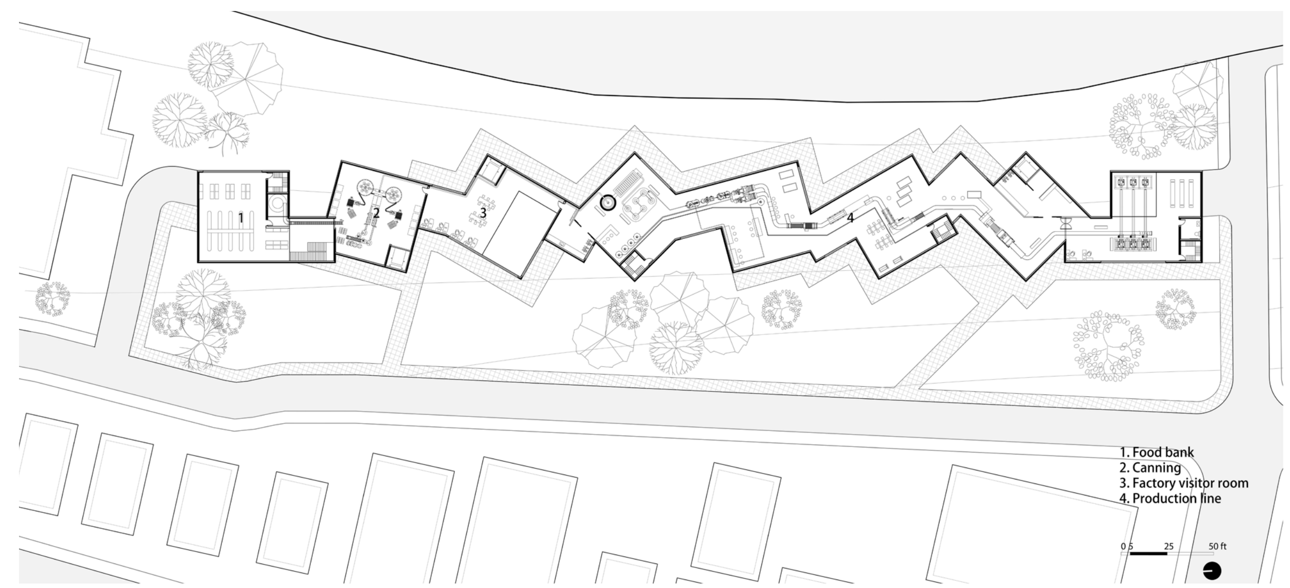






Site next to Rochester University

Ground Floor Plan (University)



Second Floor Plan (University)

Section (University)

We hope the food hub can do more to promote social equity. The linear distribution of prototypes is responsive to the context, which results in a linear way of arranging the product line. People can visit the production of food and acquire food knowledge.

The ground floor plan is a relatively open space for workshop and community kitchen, and the second floor consists of a production line and gallery. The programs needed for the food system result in the specific arrangement of space and form.

Integration & Saperation

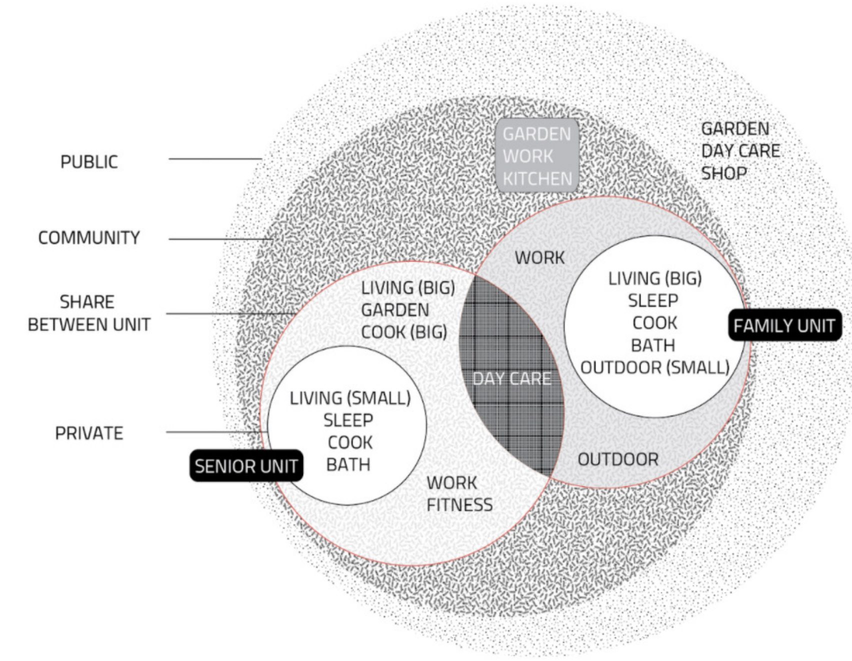
A New Typology for Multigenerational Housing in NYC

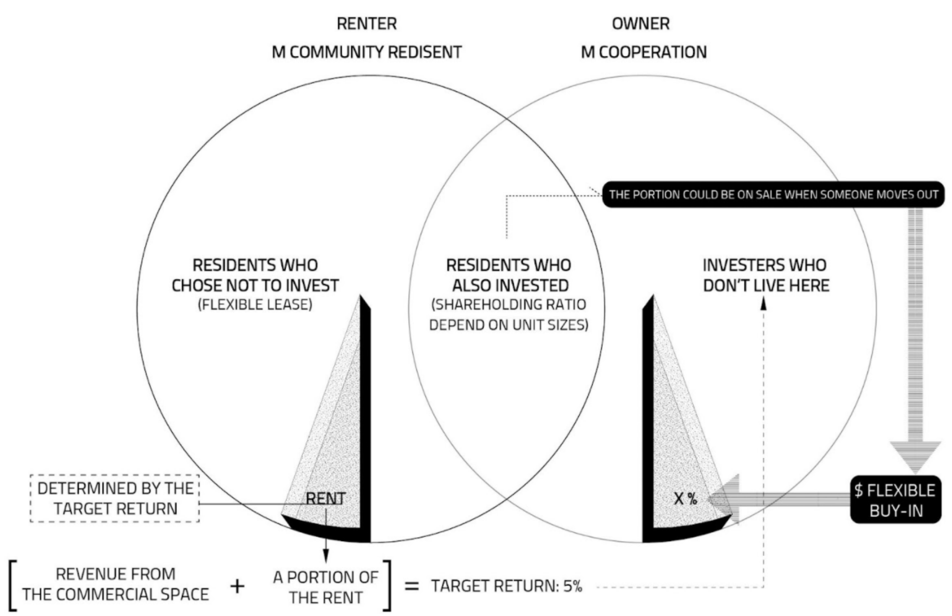
Our starting point in the studio is understanding how housing is an extension of systemic racist policy. Overcrowded conditions are not uniform across the five boroughs. They vary widely by race, ethnicity, geography, and occupation. While less than 10 percent of white New Yorkers live in an overcrowded housing unit, for instance, 15 percent of Black, 24 percent of Asian, and 25 percent of Hispanic New Yorkers do. This project focuses on senior housing problems in New York City during the pandemic period.

In the book "Brave New Home," Diana Lind suggests innovative ways to ensure that our lives will be less lonely and more affordable. The examples range from multigenerational living to in-law suites and co-living to micro-apartments and rural communities.

We choose to combine the co-living model and multigenerational living to extend a person's time to stay in one community. But the question for us is how multigenerational strangers live together if they are not from the same household?

To find the connection between young families and seniors, we found an interesting model mentioned by Michael K. Gusmano In the article called "Counting Stops". He mentioned a housing complex in France that matches dual-income families with needs for childcare with seniors who don't have full time jobs but happy to spend a few hours a day watching children.





Starting from this type of Mutualism, we've developed a community structure that promotes different levels of sharing, from sharing between units to sharing between the community and the city.

In order to support the various layers of sharing space, we've developed this ownership diagram. We imagine this community will be run by a co-op that provides community services. People could choose to invest but not live here or investing and also live here.

The purpose of this ownership structure is allow people to only pay for their own unit but not sharing space. Of course, People can also choose to rent a unit without investing. For the reason of sustainability, we think it should be for-profit but with a limited target return. After reaching the target return, the extra revenue should be used to subsidised the rent of each resident. This might help to stabilize the rent but with some money to renovate the facilities in the future.

Seniors & Family:

To find the connection between young families and seniors, we found an exciting model mentioned by Michael K. Gusmano in “Counting Stops.”

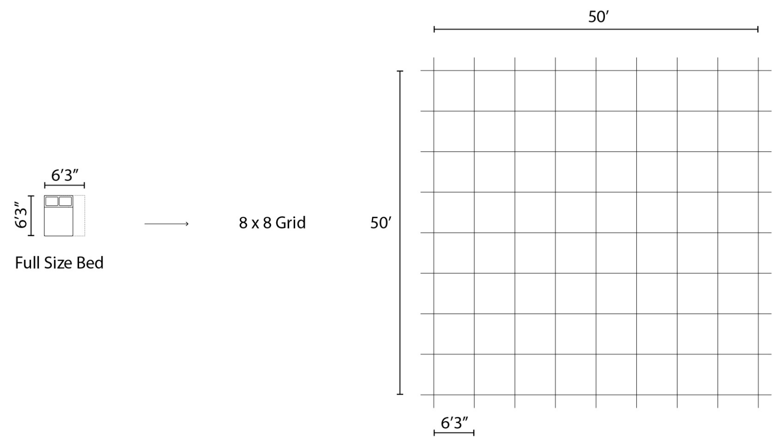
He mentioned a housing complex in France that matches dual-income families with needs for childcare with seniors who don’t have full-time jobs but are happy to spend a few hours a day watching children.

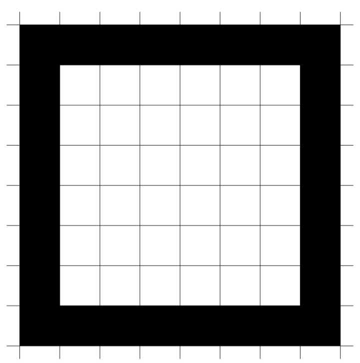
Integration & Privacy

The design question is how to create the sharing space but still provide privacy. Integrating seniors into the society with different layers of sharing space is the theme leading the project.

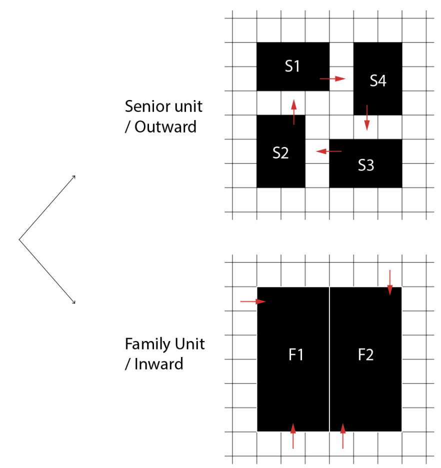
The minimal living space to form a grid is the inner logic of the housing. The the size of that is based on the size of a full size bed, which is 6’3” by 6’3”. With the testings by the massing models, the basic grid is a 8 by 8 grid, which is the basic size of one chunk.

Building on that grid, we try to make the grid more flexible when connecting together. Our way is to define the outer loop for flexible use, to create voids to avoid creating a massive volume while connecting them together.



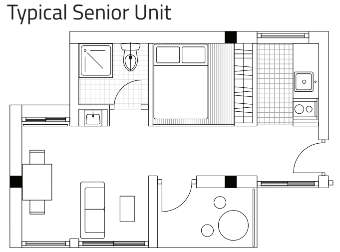


Flexible Area for balcony and void between chunks

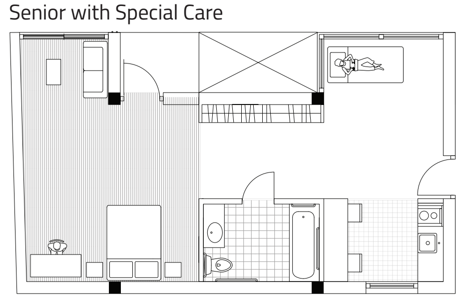


Senior & Family Living Area 1’-0” = 1/8”

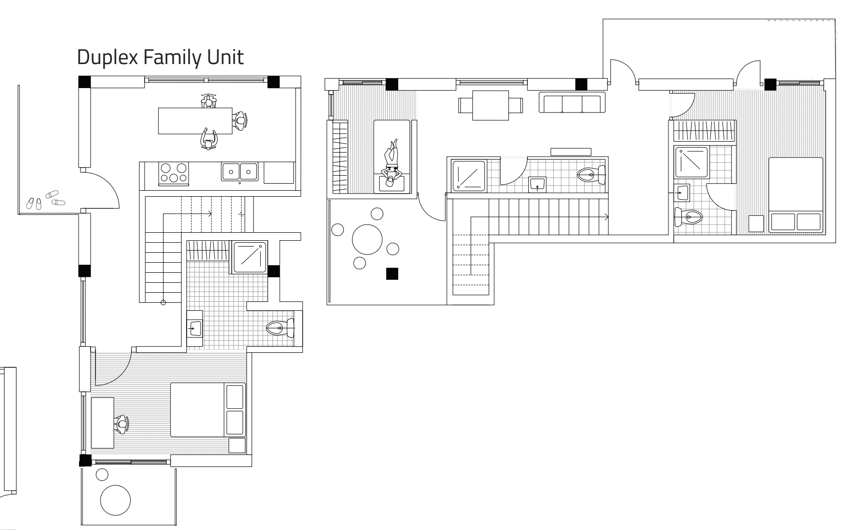
Typical Senior Unit



Senior with Special Care



Duplex Family Unit

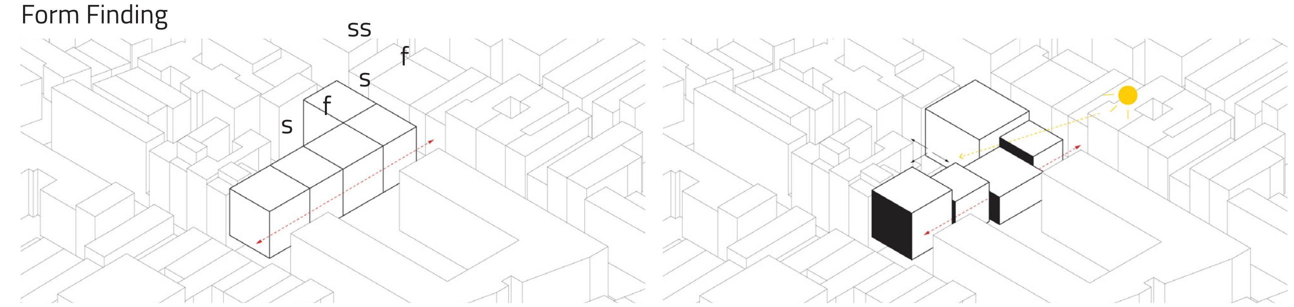


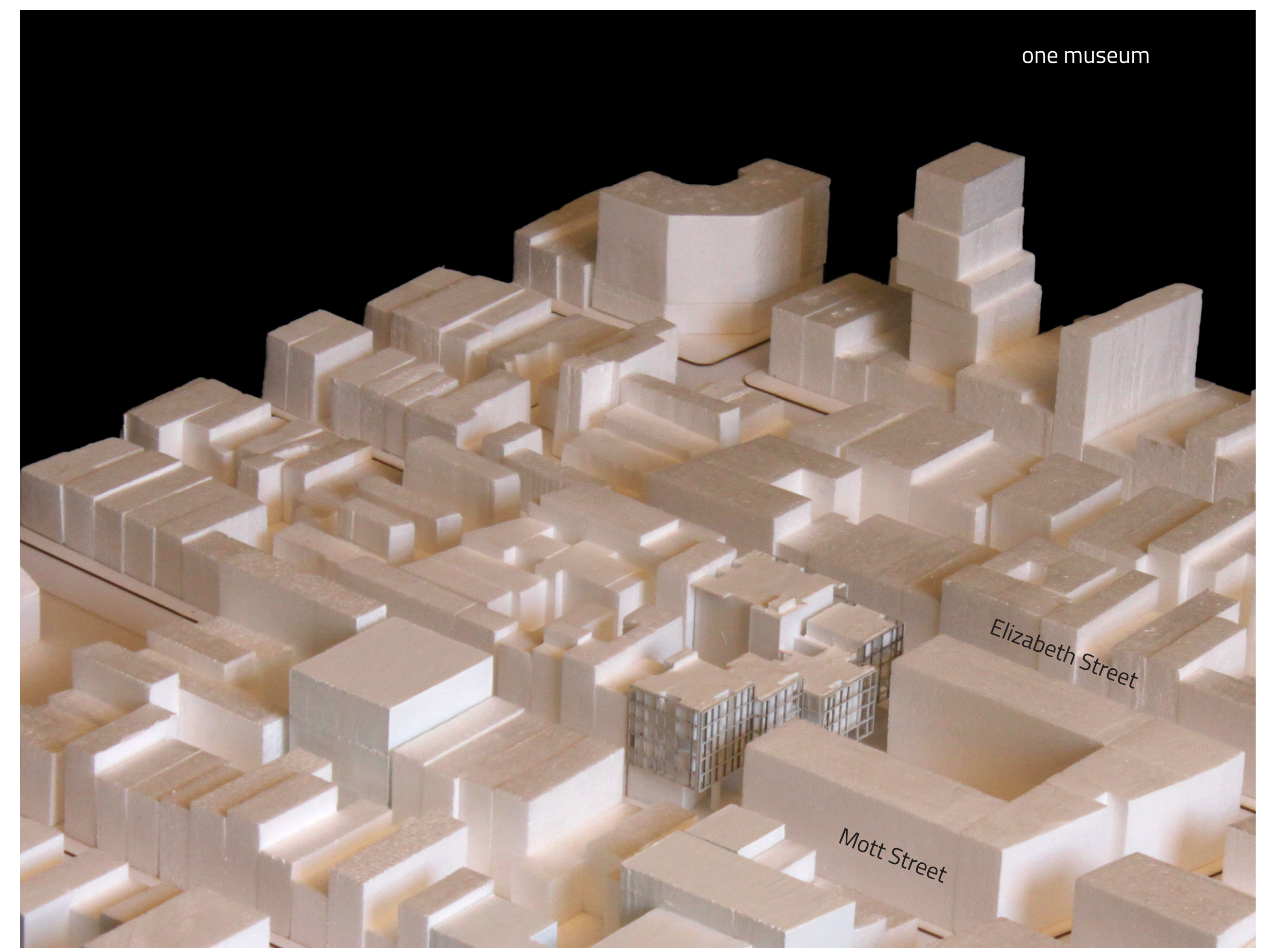
There will be 24 typical senior units and 15 special care senior units and 16 family units. Each of the units is going to have a private outdoor terrace.

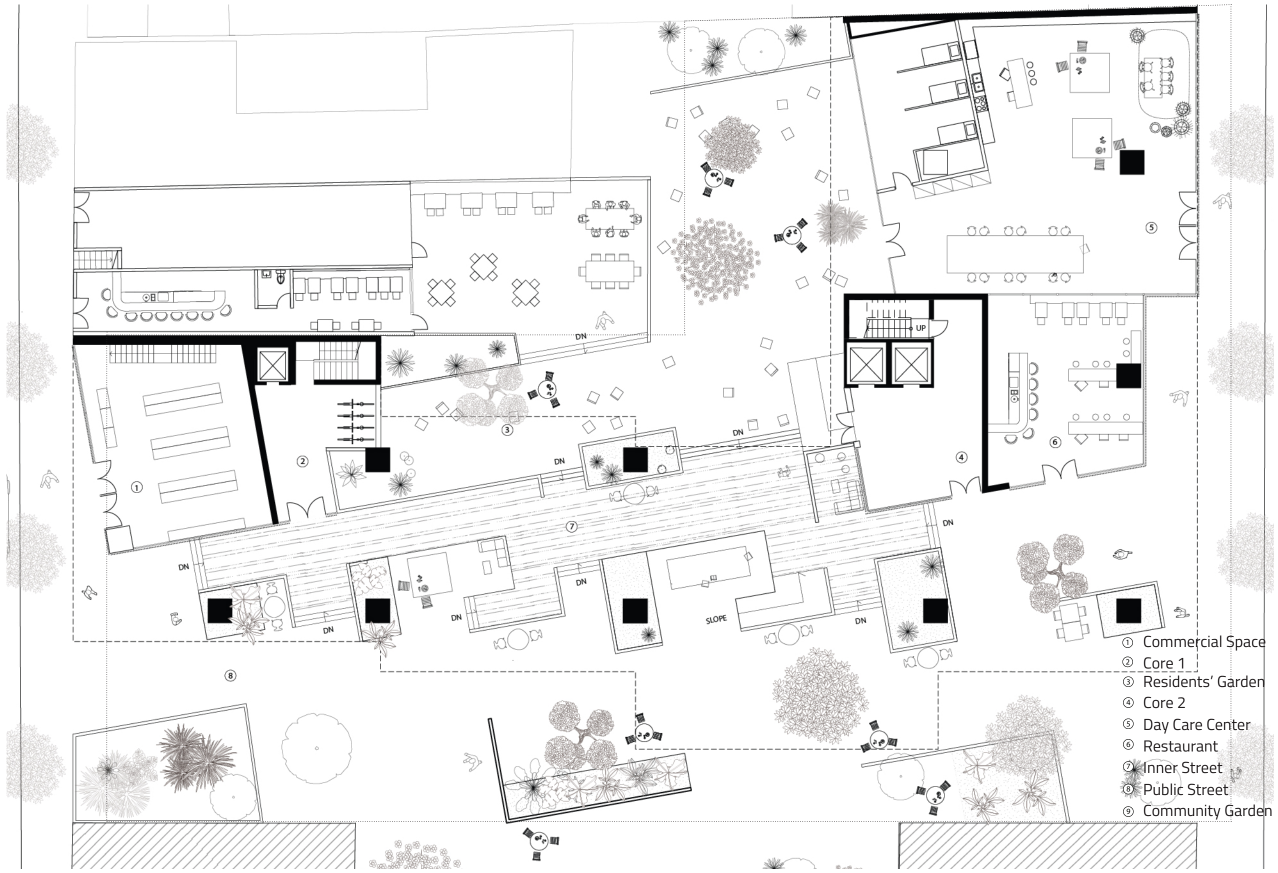
Three Trunks

Typical SeniorChunk(s) Special Care Trunk (ss) Family Chunk(f)

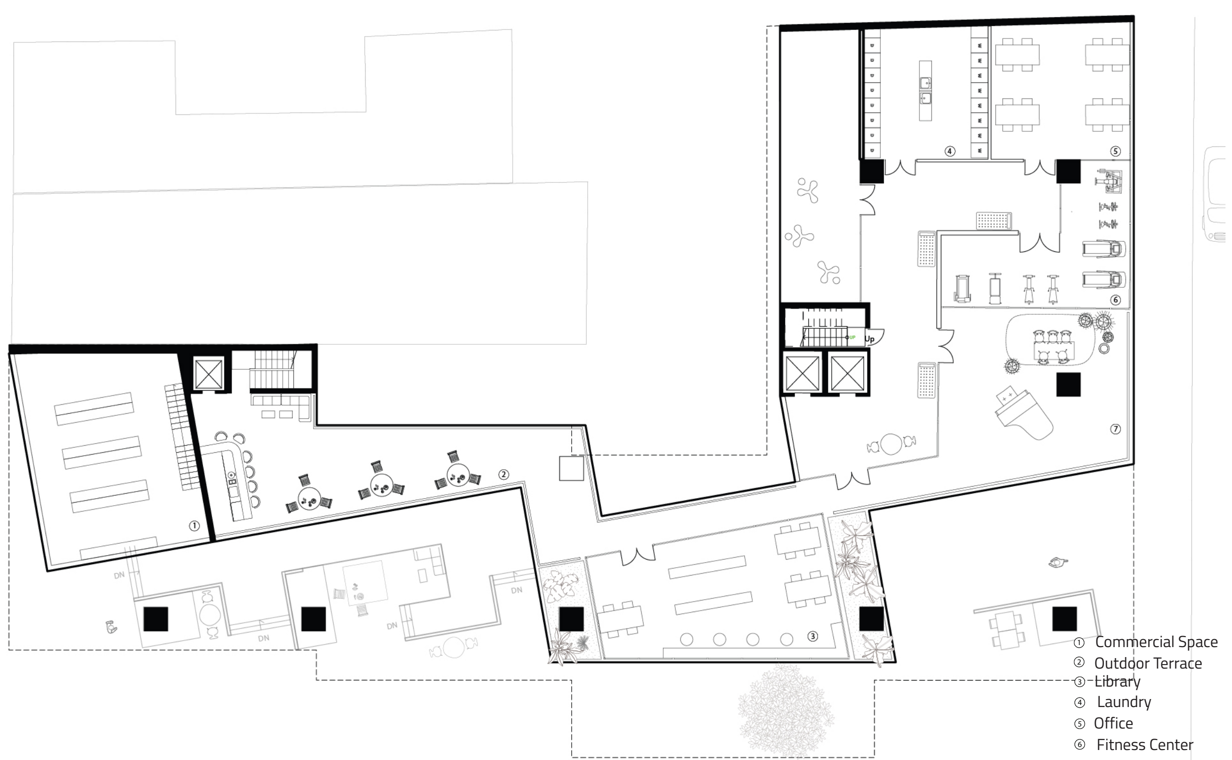
Form Finding







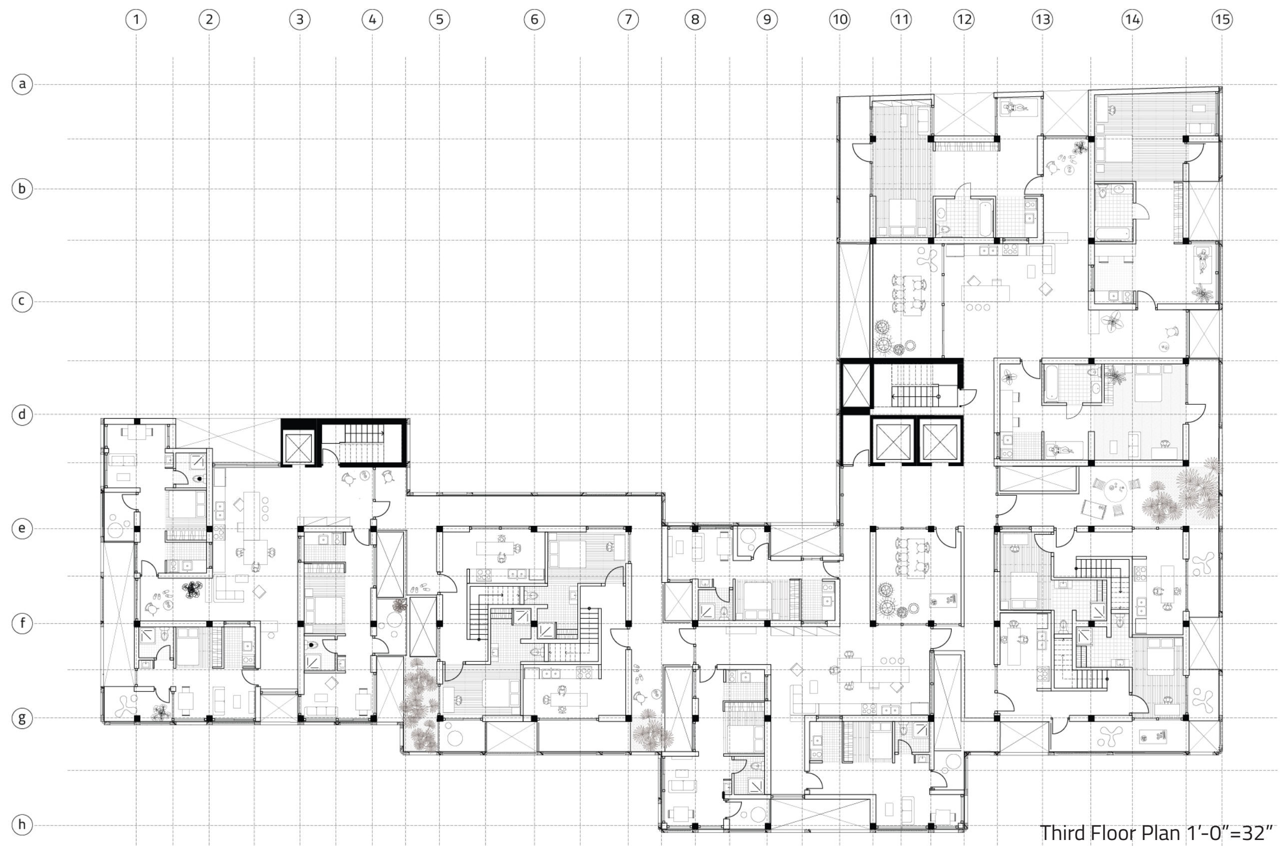
Ground Floor Plan 1'-0"=32"



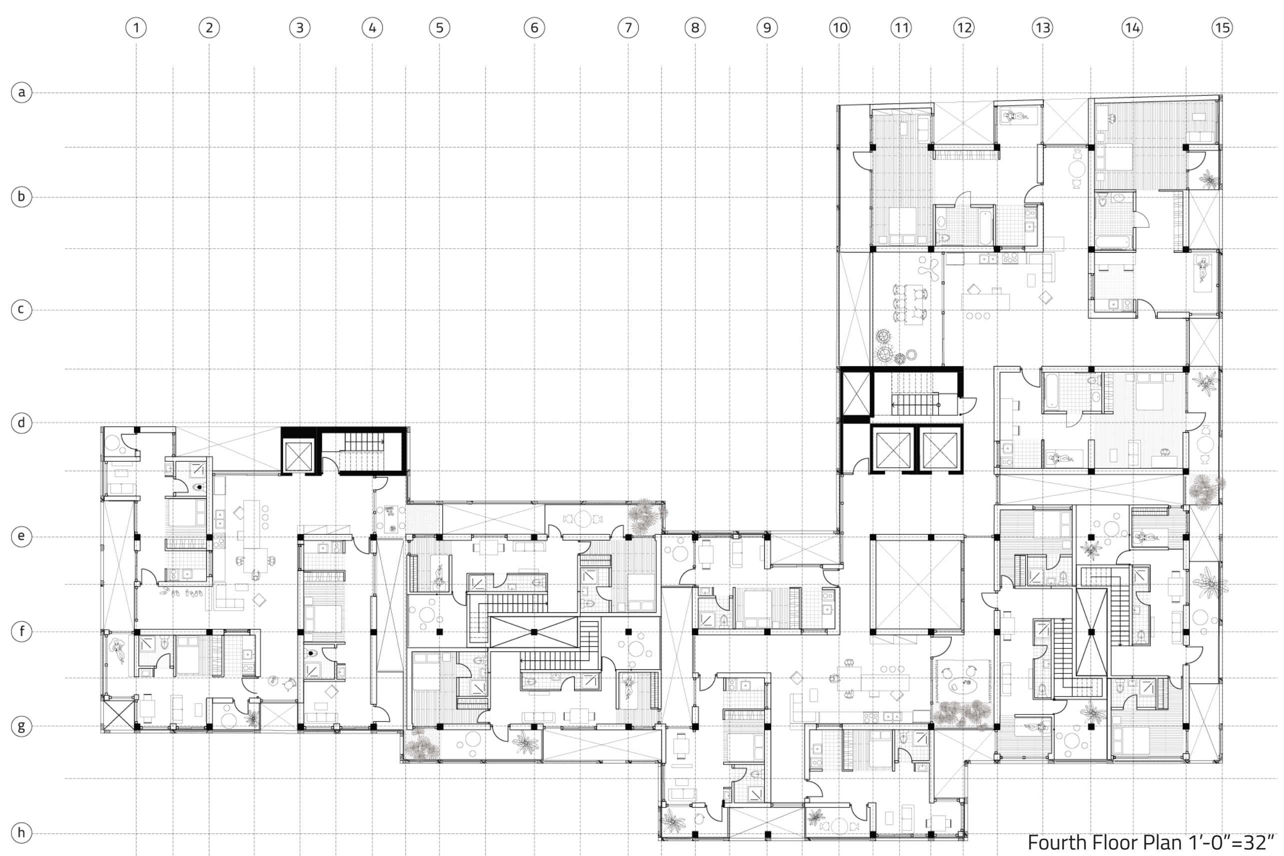
Second Floor Plan 1'-0"=32"

View on Mott Street (physical Model)
From the street, people can see different layers of trunks. The facade is consistant with the context.

Public Street through the Site
This passway spans across the site. It invites the community to this inner public courtyard, which preserves the natural and chilling vibe of the original Elizabeth garden. From a community and city perspective, we created three levels of public space: the inner garden, inner street, and shared garden.



Third Floor Plan 1'-0"=32"



Fourth Floor Plan 1'-0"=32"

Lobby in front of Elevator (physical Model)
The sizeable social space is what people will see when coming out of the elevator.

In-between Units 1 (physical Model)
This is an inner yard between senior units, and the seniors will arrive to enter their room.

In-between Units 2 (physical Model)

This narrow space in front of the door is the semi-public space residents can occupy.

In-between Chunks

In-between the chunks are semi-outdoor spaces where all the generations meet.

Physical Model Ariel View (physical Model)

The kitchen with openings provides eye contact between the seniors in the unit and the seniors in the sharing space. We want to address the interweave of privacy and integration in this project.

Ariel View (physical Model)

Different layers of sharing space encourage people to interact without sacrificing privacy. In the end, we try to integrate senior housing into society to prevent isolation in order to achieve social ecology.

Sustainable architecture always embraces advanced technology and the intention to achieve social ecology. It is not a label, but the norm architect should engrave in mind at every design and construction phase.

END NOTE

1. "Leslie Lok and Sasa Zivkovic of Hannah." The Architectural League of New York, July 30, 2020. https://archleague.org/leslie-lok-sasa-zivkovic-hannah/.

2. "CCL Awarded Atkinson Academic Venture Fund for MycoBuilt Research." Circular Construction Lab at Cornell AAP. Accessed December 13, 2021. http://ccl.aap.cornell.edu/ccl-awarded-atkinson-academic-venture-fund-for-mycobuilt-research/.

3. Zarrinmehr, Saied, Ergun Akleman, Mahmood Ettehad, Negar Kalantar, and Alireza Borhani. "Kerfing with generalized 2D meander-patterns: conversion of planar rigid panels into locally-flexible panels with stiffness control." (2017).

4. Al-Qaryouti, Yousef, Kim Baber, and Joseph M. Gattas. "Computational design and digital fabrication of folded timber sandwich structures." Automation in Construction 102 (2019): 27-44.

5. Kalama, Andriani-Melina, Danai Tzoni, and Ioanna Symeonidou. "KERF BENDING: A GENEALOGY OF CUTTING PATTERNS FOR SINGLE AND DOUBLE CURVATURE."

6. Bay, Joo Hwa. "Towards a fourth ecology: Social and environmental sustainability with architecture and urban design." Journal of Green Building 5, no. 4 (2010): 176-197.

PROJECT APPENDIX

The appendix includes all the essays and projects I have done following the Master of Science of Advanced Architectural Design degree curriculum at Cornell University.

1. Robotic Timber Kerfing Techniques
   (Seminar)
   Collaborated with Junfu Cui
2. Chitosan Film
   (Seminar)
   Individule
3. Pilgrimage to Volcanoes in Iceland
   (Studio Project)
   Individule
4. Study of Food System
   (Studio Project)
   Collaborated with Junfu Cui, Ying Xiong, Junfei Pei, Hancheng Zhang
5. Integration & Separation
   (Studio Project)
   Collaborated with Po-yu Chung

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Al-Qaryouti, Yousef, Kim Baber, and Joseph M. Gattas. "Computational design and digital fabrication of folded timber sandwich structures." Automation in Construction 102 (2019): 27-44.

Bay, Joo Hwa. "Towards a fourth ecology: Social and environmental sustainability with architecture and urban design." Journal of Green Building 5, no. 4 (2010): 176-197.

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Kalama, Andriani-Melina, Danai Tzoni, and Ioanna Symeonidou. "KERF BENDING: A GENEALOGY OF CUTTING PATTERNS FOR SINGLE AND DOUBLE CURVATURE."

"Leslie Lok and Sasa Zivkovic of Hannah." The Architectural League of New York, July 30, 2020. https://archleague.org/leslie-lok-sasa-zivkovic-hannah/.

Zarrinmehr, Saied, Ergun Akleman, Mahmood Ettehad, Negar Kalantar, and Alireza Borhani. "Kerfing with generalized 2D meander-patterns: conversion of planar rigid panels into locally-flexible panels with stiffness control." (2017).