TEXTILE ARCHITECTURE

ZOE YATES

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Textile Architecture (detail): Photo Jo Sittenfeld, 2021

In loving memory of

Grandpa & Papa

ACKNOWLDGEMENTS

First and foremost I would like to thank my family, especially my parents and grandparents, without you none of this would be possible.

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Textile Architecture

A thesis presented in partial fulfillment of the requirements for the degree Master of Fine Arts in Textiles in the Department of Textiles of the Rhode Island School of Design, Providence, Rhode Island by

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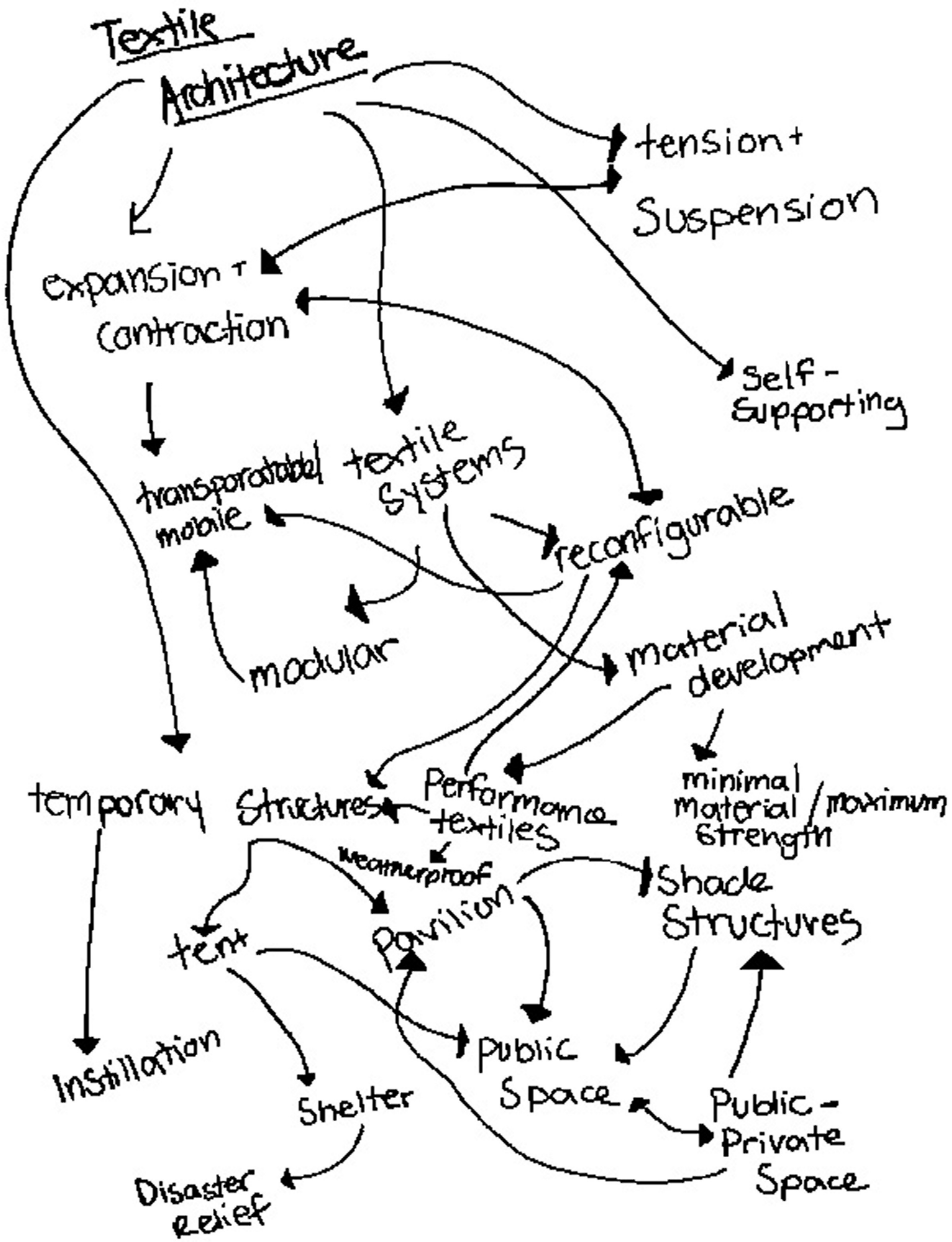
Textile Architecture
tension + Suspension
expansion + contraction
Self-Supporting
mobile
textile Systems
reconfigurable
modular
material development
temporary
Structures
Performance textiles
minimal material / maximum strength
weatherproof
Shade Structures
tent
Pavilion
Public Space
Instillation
Shelter
Public-Private Space
Disaster Relief

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ABSTRACT

The escalating climate crisis has exposed many cracks in conventional building systems. Modern architectural processes contribute to climate change by consuming high levels of energy throughout the building cycle—from sourcing materials to construction to energy use once buildings are in use. Conventional architecture's emphasis on heaviness and permanence makes these problems unavoidable. Light, temporary architecture is a solution to both the environmental impacts of the practice (the cause) and to the challenges of living in ever more impermanent situations (the effect). As climate change continues to manifest in rising global temperatures, sea level rise, drought, unpredictable weather, and natural disasters, the need for new solutions will continue to grow.

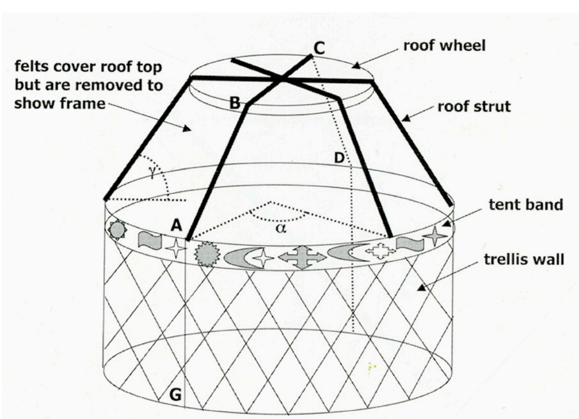
Textile Architecture is a process-led and systems-based design solution for creating transitional architectural spaces from woven jacquard textiles. Jacquard fabrics are especially suited to temporary architecture because complex patterns and structures can be combined seamlessly across a surface of continuous material, and the weaving process can engineer performance into the fabric at strategic locations through weave structure and fiber content. The result is a light, flexible textile that can be adapted depending on the local needs of the user, whether they are children in public greenspaces or people facing displacement. Textile architecture is not new, but it is ready for reinvention and activation by textile designers working in collaboration with architects. It stands as a blueprint and points toward a lighter, more sustainable future for architecture and the earth.

WHY TEXTILE ARCHITECTURE?

THE UNBEARABLE HEAVINESS OF ARCHITECTURE

Textile architecture is not new. Early domestic structures built from textiles protected inhabitants from the surrounding environment while providing a comfortable and portable place to live. Mongolian yurts are a classic example. They have changed very little over thousands of years, although there are many variations throughout Central Asia. For more than 2,500 years Mongolians have been building and living in yurts made from animal hides, wool and animal hair, wood, and animal fats and skins for adhesives and bindings. Yurts are structurally strong and incorporate climate regulating features including ventilation through the crown. The circular dwelling is constructed of a lightweight wooden structure and a textile exterior that makes it easy to reassemble and adaptable to a range of climates.[1] Modern architects and designers, including Buckminster Fuller, have been inspired by yurts, both for their functional and their sustainable qualities.

Over time, as civilizations grew less mobile, people began to develop permanent homes, and eventually cities took shape. Over time trade networks expanded and materials were transported internationally. Throughout the Middle Ages and the Renaissance, architecture became much heavier both aesthetically and materially. Western societies demonstrated their modernity and wealth by constructing lavish stone palaces and villas built from rare materials extracted from their colonies. The Industrial Revolution spurred mass migration in urban areas, and tenement housing absorbed the influx of people who worked in factories. Tenement housing represented a new type of heaviness—density—in urban spaces. By the 1920s, skyscrapers, initially built with heavy metals, began to graze the sky. The Art Deco landmark style of the 90-story Empire State Building in New York City showcases its sturdiness. The bold and solid facade of the building communicated stability and



Mongolian Yurt. Photograph by Richard Isaacso, 2007, *Architectural Textiles: Tent Bands of Central Asia*, Textile Museum, Washington, D.C.

Congress and "Norfolk" tenement buildings: Manhattan. Photograph by Tenement House Department, 1934, Photographs taken by inspectors of the New York City Tenement House Department, New York Public Library Digital Collections, New York, NY, RLIN/OCLC: 793208671

A photo from 2013 shows rescue workers at the site of the eight-story building Rana Plaza which collapsed at Savar, outside Dhaka, Bangladesh. Photograph by Abir Abdullah/European Pressphoto Agency, 2013, "Why Won't We Learn from the Survivors of the Rana Plaza Disaster?" The New York Times, Dhaka, Bangladesch.

trust to the surrounding community and symbolized innovation to the world. Today, 150 new buildings that exceed 50 stories are constructed annually worldwide.[2]

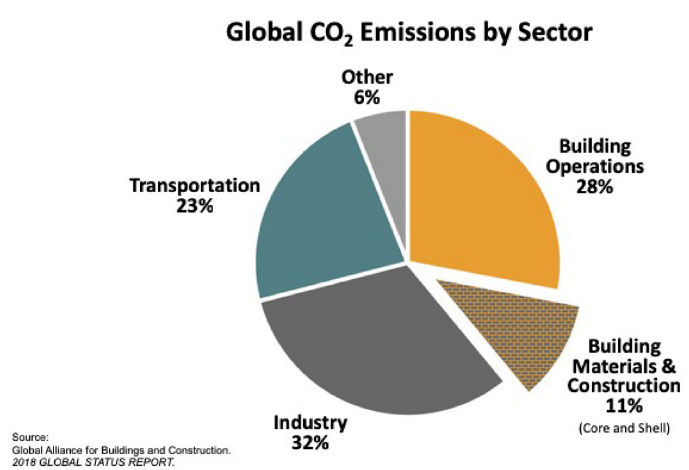
What is it about heaviness in the built environment that gives us so much trust and pride? Most obviously, we associate heaviness with safety and wellbeing. A poorly constructed building can literally kill us, as proven in incidents like the collapse of Rana Plaza in Dhaka, Bangladesh. The facility, which produced garments for many top international brands, collapsed in 2013, killing 1,100 people and injuring 2,500. The building's collapse was credited to poor maintenance and lack of emergency plans for garment workers.[3] It is often the weight of the collapsing building material that kills people as a result of earthquakes. So why do we equate safety and comfort with perceived heaviness? The sheer mass of material can suggest that the building can not be easily knocked over by weather or natural disaster. But this isn't necessarily so. Permanence is another characteristic we seek in architecture and our built environment. In Western society we seek to create strong, stationary structures that can stand the test of time. That assumption ignores the changing needs of society, material innovation, or migration patterns. Iconic architecture in Western Europe like the Brandenburg Gate in Berlin or Arc de Triomphe in Paris are heavy monuments that symbolize nationalism, wealth, and dominance over not only the natural environment but over other nations as well. In other words, architecture became a tool to demonstrate power, using a material language to do so. Lastly, there is simply the fact that we are all creatures of habit who follow our own past experiences and observations. When we repeatedly encounter the same materials in our built environment, we develop trust and belief in the status quo. Through these associations we begin to associate aesthetic and material experiences with quality and performance. The built environment has therefore become a monument symbolizing modernity, innovation, our ability to dominate the environment, safety, and permanence. In reality heaviness isn't always all those things, or the only answer.

These misperceptions and assumptions in architecture have steep environmental costs, which are finally gaining acknowledgement as the effects of climate change are felt globally. Architecture is responsible for a range of environmental destruction from the early to the late stages of its construction and very existence. First, there is the energy and gasses released when we extract, process, and refine raw material into consumable goods for construction. Second, this massive amount of resources crosses the globe through trade, using and producing fuel, energy, and material waste.

The construction industry itself also has an environmental impact, of course, including emissions, sacrificed material, and demolition. For example, one ton of CO2 emissions are released for every ton of concrete produced in the construction industry.[4] About 2,075 gigatons of CO2 have been emitted since the Industrial Revolution (1750), and there is not enough plant life on the planet to photosynthesize all existing emissions.[5] The construction of the individual building only contains a fraction of the total environmental impact. After construction is complete, the building will continue to consume energy to make it functional and suitable for modern life. According to Architectural Magazine, buildings consume up to 40% of carbon emissions annually in the US. The same study also predicts that of buildings standing today will still be standing in 2050, with more buildings being built each year that will continue to consume energy at increasing rates.[6]

A recent study conducted by the AGU Advances describes a literal impact of the heaviness of architecture: the weight of our cities is causing cities globally to sink. The author of the study, Tom Parsons, calculated that San Francisco weighs about 3.5 trillion pounds (not including people or temporary or informal structures), and during the urbanization of the Bay Area, the city has sunk about 3 inches due to weight. In 2020 a group of engineers began working on a plan to stop the sinking of Millennium Tower, which has sunk about 16 inches over the past 10 years. The Bay Area is already estimated to experience a foot of sea level rise by 2050, and the sinking of the region is only going to cause more flooding and natural disasters for residents in low-lying areas. Indonesia is facing similar predicaments, as the city of Jakarta has been named the fastest sinking city in the world and also has one of the largest population densities. The city is estimated to be sinking at about 10 cm per year and causing chronic flooding in many low income parts of the city. Parsons states that when urbanizing a region there is not much that can be done to fight against gravity, but more careful consideration when it comes to material usage and where development is built could help mitigate the effects[7].

Predictions estimate that by 2050 about 70% of the world's population will be living in cities. Our response to the shifts of society in the coming decades will help design the environments of future generations. If our response includes creating more permanent, heavy fixtures in increasingly temporary environments, we will only further exacerbate our past mistakes.



Global CO2 Emissions by Sector. Image by Global Alliance for Building and Construction, 2018, 2018 Global Stats Report

Much of Mission Bay and South of Market could flood by 2100 if sea rise and storm surge exceed 8 feet above current high tide, as some models predict. Red points indicate new development projects, including the Golden State Warriors Arena and Mission Rock mixed-use development. Illustration by Marcea Ennamorato & HyunJu Chappell, 2017, Public Press, San Francisco, CA.

WHY (NOT) TEXTILE ARCHITECTURE?

Textiles are traditionally associated with interiors and fashion in design or as fiber arts in the art world. Textiles make up the clothes we wrap around our bodies, the sheets we sleep in at night, they cover furniture and windows, and the insides of our cars. There are very few areas of modern life that do not in some way include textiles. Due to their presence in our everyday intimate environments, textiles hold connotations of comfort, protection, tactility, and transformation in our societies.

Many textile applications most familiar to the public are associated with natural materials (silk, cotton, linen, or wool) even if they were produced synthetically. However, over the past century, innovations in textile manufacturing and material science have allowed for textile-based products to perform in new ways. The first synthetic fibers were made in 1889, and by 1939 synthetic nylon yarns were available commercially. Early synthetic fibers found their way into the market by providing options for people who could not afford silk or other more expensive natural materials.[8] As manufacturing processes of synthetic fibers matured, material scientists were able to design fibers with performance characteristics designed for specific end uses. By the 1960s performance aramid, kevlar, and carbon fiber materials made it possible to design textiles for extreme situations.

Recent advancements in loom technology, including 3D and triaxial weaving, made it possible to weave complex structures and parts using performance materials. Within the industry, these processes have primarily been used in automotive, aviation, and healthcare sectors. The automotive, aviation, and aerospace industries have been developing 3D woven parts that are formed into composites for engines. Carbon fiber, ceramic fiber, and fiberglass have lightweight material properties and perform at extremely high temperatures. In healthcare, textiles are being developed to create bandages, extracorporeal devices, implants, and more. The biomedical field has also explored the use of biodegradable fibers in internal bandages.[9]

3D weaving capabilities could do so much more. They allow for more precise engineering of loom-shaped products and processes. Specific materials can be placed into complex structures within a woven fabric that would cause the material to react and change form through finishing processes. If textiles were engineered for specific projects, weave structures could place functional materials, structural components, and fiber densities locally into the architecture of the textile. Qualities like strength, weight, wicking, and weatherproofing could be designed into the properties of the fabric. Problem solving in the design process informs where to place specific materials. The manufacturing process can be designed to deliver the maximum performance to the final product while using material strategically. The exact placement of structure and material and a surface of continuous material is unique to textile processes.

Academic programs and research labs have begun to use these design strategies to apply textiles to applications outside of interiors and fashion. However, a variety of barriers have prevented innovative textile solutions from being used in pedestrian applications. First, the cost of the technology, materials, and labor still remains too high for products to be made at affordable price points for the public. Industries that can afford the steep research and development costs often subject their manufacturers to non-disclosure agreements, preventing cross-disciplinary collaboration and limiting the information and materials accessible to students. The longer design process can also create longer lead times and slower manufacturing, making it unappealing to many mass-manufacturing industries. A shift towards this type of highly engineered technology would require a shift in the public's mindset towards the types of services they could expect from textile-based products.

If textiles are used to solve other design problems like engine parts and medical implants, why not apply them to architecture too? Textile-based architecture is perfectly suited to occupy the space between permanent architecture (houses, apartment buildings, institutions, skyscrapers, etc.) and temporary spaces (tents, pavilions, shade structures). *Textile Architecture* can be useful in seasonal industries, temporary spaces (pop-ups, festivals), disaster relief, in places where permanent architecture can harm the natural environment, or places affected by climate change. I am not suggesting that we should replace all permanent structures with *Textile Architecture* but rather allow textiles to be another system of building available to define space. *Textile Architecture* can fill the gaps that traditional architecture created by providing solutions to the in-between spaces; semi-permanent spaces, inside/outside, semi-private/semi-public. But much more importantly, it is lightweight, and therefore provides a solution to one of the most pressing environmental problems of our time.

By rethinking the cultural perceptions surrounding the built environment, we have the opportunity to redesign our relationship to the environments we build. What if the materials we use to design our buildings are flexible, lightweight, can manage airflow, and fluctuate with shifting weather conditions? Would our relationship to our environment change? Would the dynamic between the natural and built environment become more permeable? To reach these in-between spaces architects, engineers, material scientists, textile designers, and computer scientists need to work together to create an overlapping database of knowledge that builds upon one another. Through collaboration, *Textile Architecture*—a lightweight, portable, functional new way of settling on the land —is possible.

PRECEDENTS

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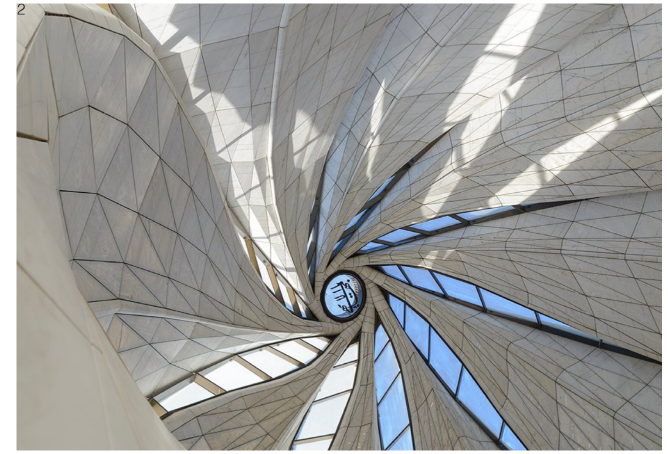

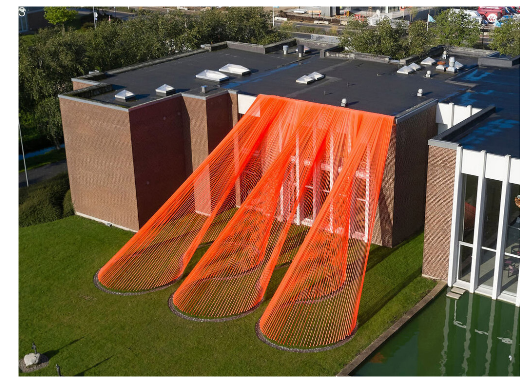

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Above stating top left and continue clockwise: 1. Overtreders W, Brasserie 2050, 2018, temporary architecture. Photography by Jorn van Eck via Dezeen.
2. Hariri Pontarini Architects, Bahá'í Temple of South America, 2016, architecture. Photograph by Ian David via Designboom.
3. Behin Ha Design Studio, Together Apart Billund, 2020, architecture. Photography by Ard Jongsma.
4. Pascal Goetgheluck, Section Through Bamboo Shoot In Soil, 2018, photography.
5. Thomas Jefferson, Serpentine Wall, 1986, architecture, University of Virginia Library. Image Courtesy of James Murray Howard. https://library.artstor.org/asset/30050276.
Opposite start top and continue clockwise:
6. ZAV Architects, Hormuz 2, 2020, architecture. Photography by Soroush Majidi via ArchDaily.
7. Archinoma, Y-Bio, 2011, architecture. Photograph by Archinoma.
8. The North Face, Geodome Tent, Polyester Taffeta, 90.5 x 86 in. Photograph courtesy of The North Face via Designboom.

Artic Weatherbreak Dome, Montreal (Architect: Buckminster Fuller). Photographer Unknown, Department of Art History, Visual Resources Library, Drew University, Madison, NJ, https://library.artstor.org/asset/SS7732535_7732535_12977582.

In the mid-twentieth century Buckminster Fuller developed a theory that architecture should utilize geometry and structure to provide all people with a higher standard of living while using the minimum amount of materials. Fuller was an architect, scientist, engineer, and inventor and one of the first thinkers of his time to intentionally cross the design-science divide with the ambition to create a more sustainable future. Although Fuller's work is frequently referenced in academia, and his theory is widely applicable to the world today, most of his work still remains unrealized. Over his career Fuller developed a body of work which proved that better use of design, engineering, and advanced technology could more effectively use the earth's resources. We could provide for the entire human population by using less energy and materials while simultaneously designing for better quality of life. A number of technological and material advances have emerged since Fuller began his practice, but for the most part they have failed to provide architectural solutions that fulfill his ambitions. In particular, they have largely failed to consider the built environment as temporary and lightweight[10].

A few architects and designers have been inspired by the principles of lightweight thinking. Interestingly, they all use fabric as an architectural material and tool to define space. At the same time, architecture often addresses ideas about lightness through aesthetics without solving the issues of material usage and sourcing, wastefulness, and weight. Many architects seek out material treatments and silhouettes that create the illusion of lightness without addressing the mass of the structure[11]. The following three designers and architects have used textiles to create lightweight structures in progressive and sustainable ways.

FREI OTTO

Frei Otto (1925–2015) was a German architect and engineer who developed research that proves the strength and potential of tensile structures—soft structures that are made stable by inherent tension. His work was driven by his theory of "minimal structure," which he defined as "an attempt to achieve, through maximum efficiency of structure and materials, optimum utilization of the available construction energy"[12]. Otto defined energy as the total amount of labor and materials that went into the construction of the project. His theory of minimal structure supported his belief that architecture that is free from heavy material restrictions is not only more environmentally sustainable, but also creates more livable spaces. By reducing the amount of permanent elements in a structure, Otto argued, tensile architecture can better accommodate the growing desire for flexible interior living spaces[13]. Throughout his career he resisted permanent architecture in order not to "fill the earth's surface with lasting buildings"[14]. His body of work has inspired architects and designers since the 1960s who are challenging the traditional Western view of architecture as heavy, permanent, and monumental, and proving, to paraphrase the design historian Ludwig Glaeser, that impermanence does not mean improvisation but in fact requires a great deal of scientific precision[15].

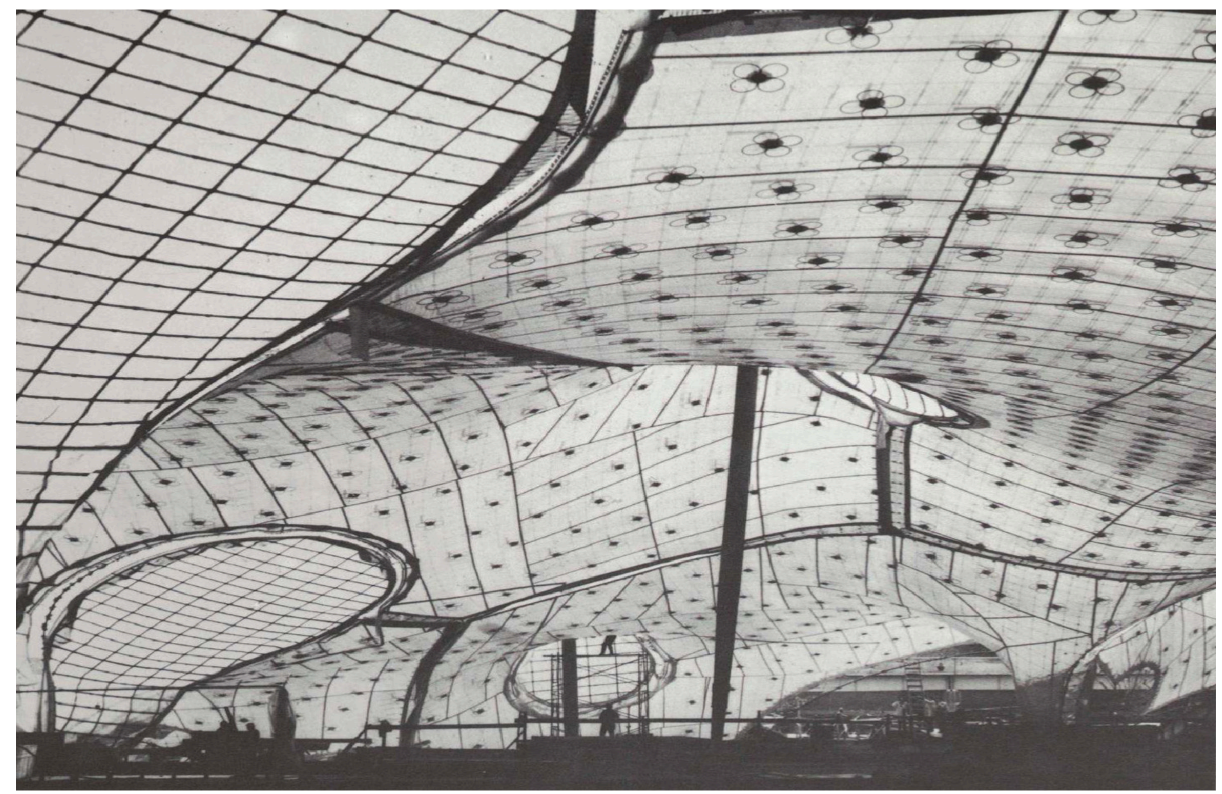
In 1964 Otto founded the Institute of Lightweight Structures at the University of Stuttgart in Germany. The institute served as a research and teaching facility where students and faculty worked together to carry out projects that tested Otto's theories on tensile strength. Together, the institute carried out several large-scale projects including the German pavilion for the 1967 World's Fair in Montreal[16].

Otto was by no means the first person to experiment with using textiles in architectural applications, but his work began to link many of the components that create tensile systems. Many of Otto's lightweight structures use fabric membranes or components held in tension as a strategy to reduce weight but retain the strength of traditional building materials. His work was transformative in the way that many venues, tents, or temporary structures built using tensions and tensile strength can be traced back to him. His research on how different variables would impact the structure was extremely in-depth and is evident in his work.

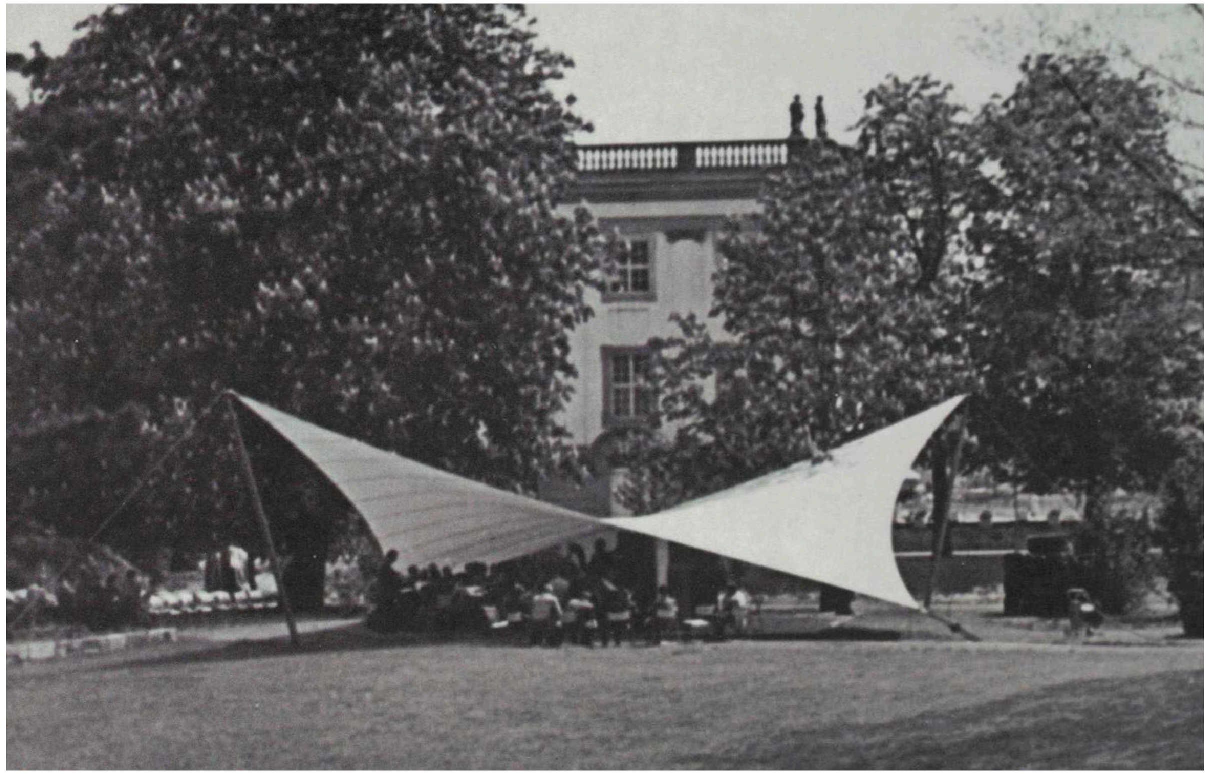
Otto's research spanned varying systems of creating tensile strength. In his Mast and Cable Supported Membranes, for example, he relied on a membrane being supported at various points throughout its surface with a mast and cables pulling the membrane into the tensile attaching the structure to the ground. Otto's first tensile structure was a mast and cable membrane structure used as a bandstand in Kassel, Germany in 1955.

His team also explored retractable roofs, an idea that occurred to him while working on large-scale projects and fulfilled his desire for reconfiguration. The system of retractability mimicked that of a sail by depending on a system of pulleys and winches that hold a cable in tension. When in use they have a minimal impact on the environment, creating temporary covered/uncovered space (figure 8). An early example of the retractable roof was the Open Air Theater Roof in Bad Hersfeld, Germany constructed in 1968 to fit the needs of the theater company and accommodate variation depending on the time of year and performance[17].

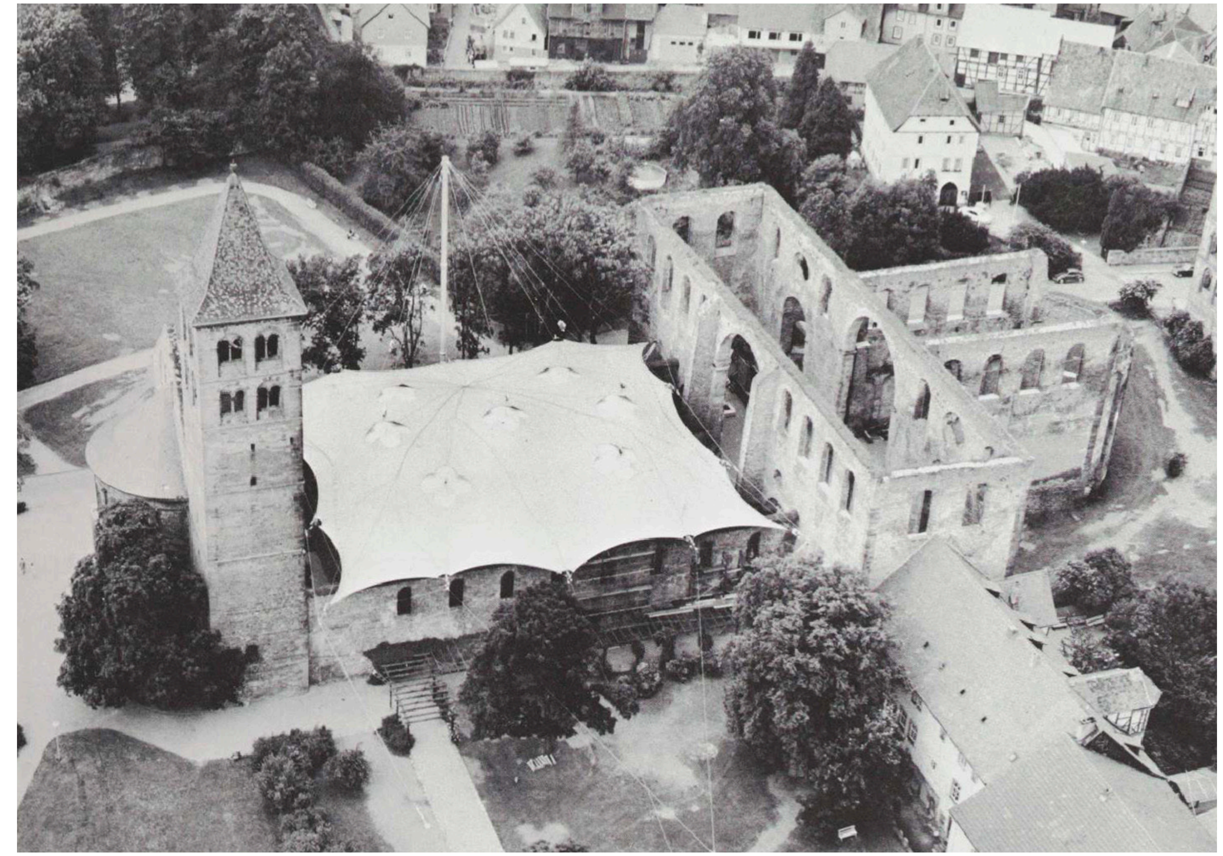
I was inspired by Otto's body of work to identify mobility and transformability, as well as tensile strength, as key components in my design process. His commitment to his process and to building accumulated knowledge based on his own work has impacted the way that I think about my research. His experiments and innovations were ultimately successful because they are seen in many temporary structures today. Structures like wedding tents, pavilions, and sporting stadiums have built upon the legacy Otto left behind. His work has taught me impermanence is not the same as improvisation but is the result of an accumulation of knowledge through process.

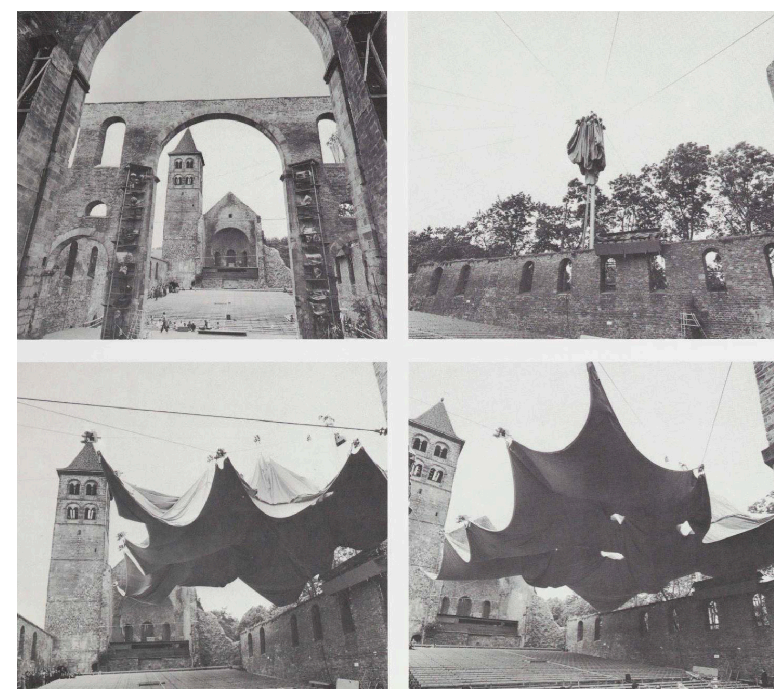


Frei Otto and the Institute of Lightweight Structures, German pavilion at the 1967 World's Fair, 1967, architecture. Photograph courtsey of *The Work of Frei Otto* by Ludwig Glaeser.



Frei Otto, Bandstand in Kassel, Germany, 1955, architecture. Photograph courtsey of *The Work of Frei Otto*, by Ludwig Glaeser. This structure was Otto's first mast and cabel structure.





Frei Otto, retractable roof for an open air theater, Bad Hersfeld, Germany, 1968, architecture. Photograph courtsey of *The Work of Frei Otto* by Ludwig Glaeser.

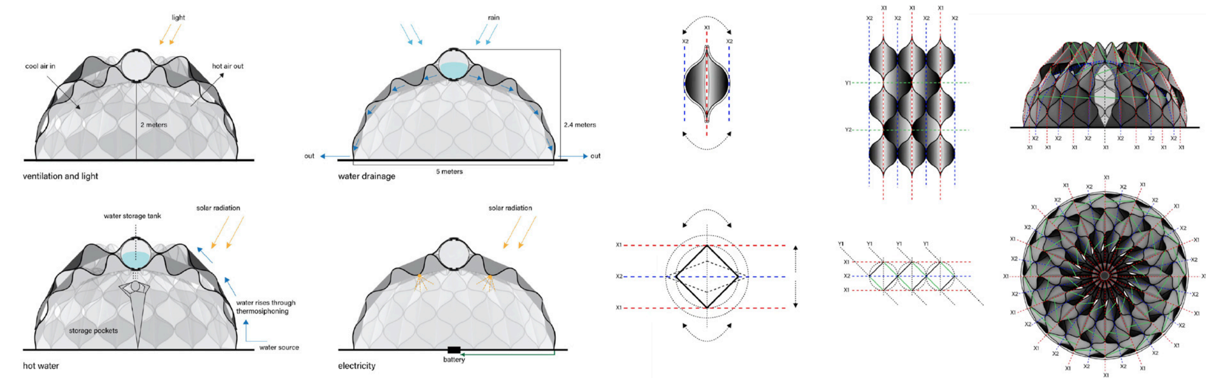
ABEER SEIKALY

> "Shelter represents the most essential boundary that protects and separates us from the exterior world. Home is a sanctuary in and by itself. A space that allows us to heal, to exist, but most importantly to be ourselves."
> —Abeer Seikaly[18]

Abeer Seikaly's architectural practice is centered around ideas of memory and home and her capacity to use design as a tool for social sustainability. Her project *Weaving a Home* investigates the potential for fabric structures to be used in disaster relief. In her home country of Jordan Seikaly visited refugee camps along the border with Syria that have grown in size and permanence throughout Syria's Civil War. The infrastructure she observed at the camps was developed to be temporary in an environment that was quickly becoming permanent. *Weaving a Home* provides amenities like water storage, temperature regulation, and solar energy collection in a home that allows residents to maintain quality of life while living in the camp. Seikaly conducted interviews with residents and found that most were lacking tools necessary for basic survival, such as structurally secured shelter, clean water, fresh food, and proper sanitization. She also observed that any of the people designing the solutions were far removed from the situation unfolding on the ground.

Her solution was to create a textile structure that hid functionality into the architecture of the home. The tent is designed to be mobile

Abeer Seikaly, *Weaving a Home*, Jordan, 2013, architecture. Photo courtesy of https://abeerseikaly.com. Project rendering.



Abeer Seikaly, *Weaving a Home*, Jordan, 2013, architecture. Photo courtesy of https://abeerseikaly.com.
Left Technical drawing illustrating solar and water collection services.
Right Illustrations showing the structural membrane's full range of movement.

and also aesthetically pleasing to reflect the idea that everyone has the right to live in dignity. In her TED Talk she stated,

> "As disaster is inevitably temporary and constant in its movement, a shelter must be transient because disaster implies the breakdown of communities; a shelter must rebuild social interaction. Because disasters destroy the familiar environment, a shelter must transform over what often remains"[19].

Today, over 65 million people worldwide are living in displacement due to political unrest, climate change, or insecurity. *Weaving a Home* developed a textile system that has the capacity to create transportable, temporary structures that incorporate services like water collection, renewable energy collection, and temperature control to provide the comforts of contemporary life. The collapsible structure is based on models that can be translated into textile architecture. The fabric qualities of the structure allow for the shelter to thrive in a range of weather conditions and provide lightweight portability. Abeer Seikaly's work is unique because it is rooted in cultivating a sense of place in spaces that are meant to be temporary. Her work moves beyond humanitarian design because the poetics of her design process and philosophies are reflected in the finished work. I connected with the way she used memory, craft, and history of place to create space.

SAMIRA BOON

Samira Boon is an architect and designer who uses paper folding techniques and textile processes in her architectural practice and research. Her Studio Samira Boon focuses on site-specific architectural solutions for flexible spaces to aid with climate regulation and human comfort.

Boon and her studio have been working on an ongoing research project called Archifolds in collaboration with the Textile Lab in the Netherlands and Tokyo University. The culmination of research was exhibited at the Dutch Textile Museum Tilburg, resulting in dimensional textile pieces inspired by origami paper folding techniques. Through a collaboration with Professor T. Tachi from Tokyo University, who specializes in folding techniques and geometries, Boon explored folding patterns suitable for architectural applications. Her process involved experimentation with a wide range of materials, including paper, mohair, polyester, and abaca, and resulted in textiles with diverse properties. The textile pieces can be used as room dividers or screens and incorporate "smart" capacities. They can regulate temperature, lighting, and noise[20].

Through this project, Boon was guided by three main principles:

1. The possibility of pre-programming folding patterns on a computer
2. Aesthetic and tactile qualities of folding structures
3. Possibility of adding construction elements

Boon's architectural textiles were installed at the Theaters Tilburg in the Netherlands. The folded structure embedded into the textile allowed the same product to be installed multiple ways. Describing his experience with the project, Rob Van Steen, the theater's director said,

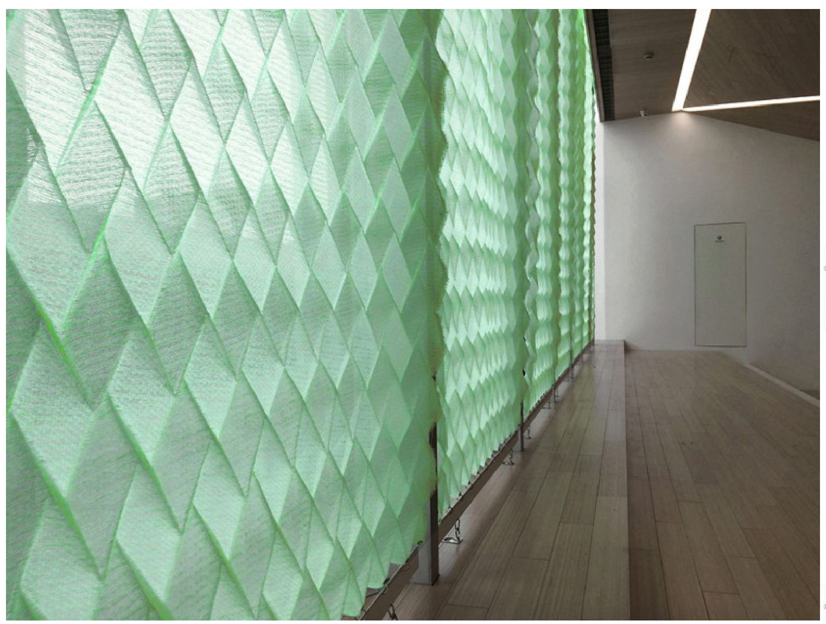
"You can constantly give this object a different look. I always get the feeling as if I'm walking through a visual art work, while at the same time it is a very functional space" [21].

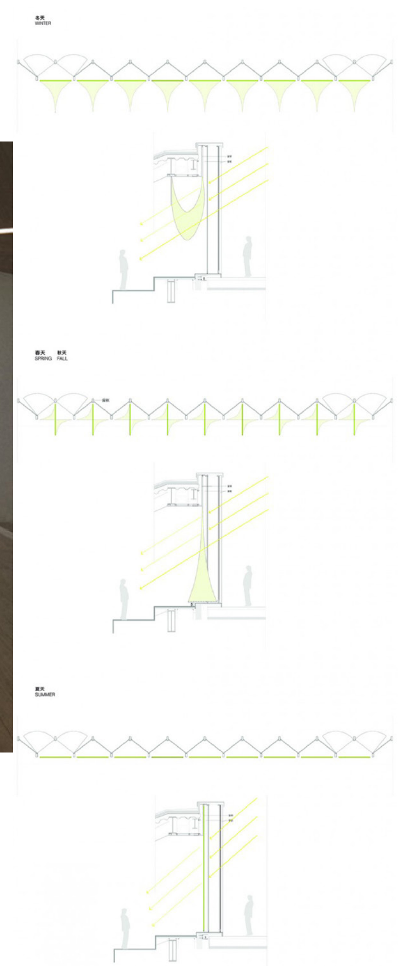
Samira Boon, *Archifolds*, Theaters Tilburg, Netherlands, 2017, textiles. Photo credit Ossip van Duivenbode, courtesy of https://samiraboon.com.

Samira Boon, *Archifolds*, Theaters Tilburg, Netherlands, 2017, textiles. Photo credit Ossip van Duivenbode, courtesy of https://samiraboon.com.

Boon installed a similar piece at the Di Yuan Gallery in Jiaxing, China, as a 5 meter sunshade and acoustic element in the gallery’s auditorium. The textile is installed along the auditorium's floor to ceiling windows to help manage heat gain from direct sunlight and improve natural light quality. Aside from the functional design elements, the textile is a stunning installation piece as well that can be reconfigured to best respond to the changing position of the sun throughout the year[22]. As previously mentioned, maintaining a building consumes significant energy, and design solutions like Boon’s can passively control interior climates without an energy input.

Samira Boon and her studio have shown me architectural textiles were possible. I had not previously seen architectural work where a textile designer was making design decisions that altered the structure of the design. Her work opened my eyes to the potential for loom-shaped design and the ability for weave structures to create architectural forms. A year ago when I first came across Archifolds, I would never have imagined that I would be able to create my own versions of folded textiles. The ideas seemed too complex at the time.





Samira Boon, Jiaxing Gallery, Jiaxing, China, 2016, textiles. Photo courtesy of https://samiraboon.com
Above: Detail of the textile panels installed in the gallery
Right: Technical drawings of the sun interacting with the textile at different times of the year

My research process exposed me to architects and designers who have been working at the intersection of textiles and architecture with goals similar to my own. The advantage of textile driven architecture would be that architectural elements could be incorporated into the textile directly off the loom.

It would reverse the relationship between textiles and architecture from textiles selected to meet architectural purposes to textiles designed to be architectural elements.

My research led me to question what would have happened had textile designers been collaborators from the inception of the project. Further, what if a textile designer had actually taken a lead role in designing lightweight architecture?

UNFOLDING TEXTILE ARCHITECTURE: PROCESS & PROTOTYPE

Textile Architecture is both a designed structure (a product) and a design research method or system (a process) that explores the potential for textiles to be used in creating infinite variations of free-standing architectural structures. The intent behind this research was not to provide immediate solutions to building scale pavilions or temporary structures. Rather it is the beginning of an exploration into what is possible, and the prototype is a proof of concept.

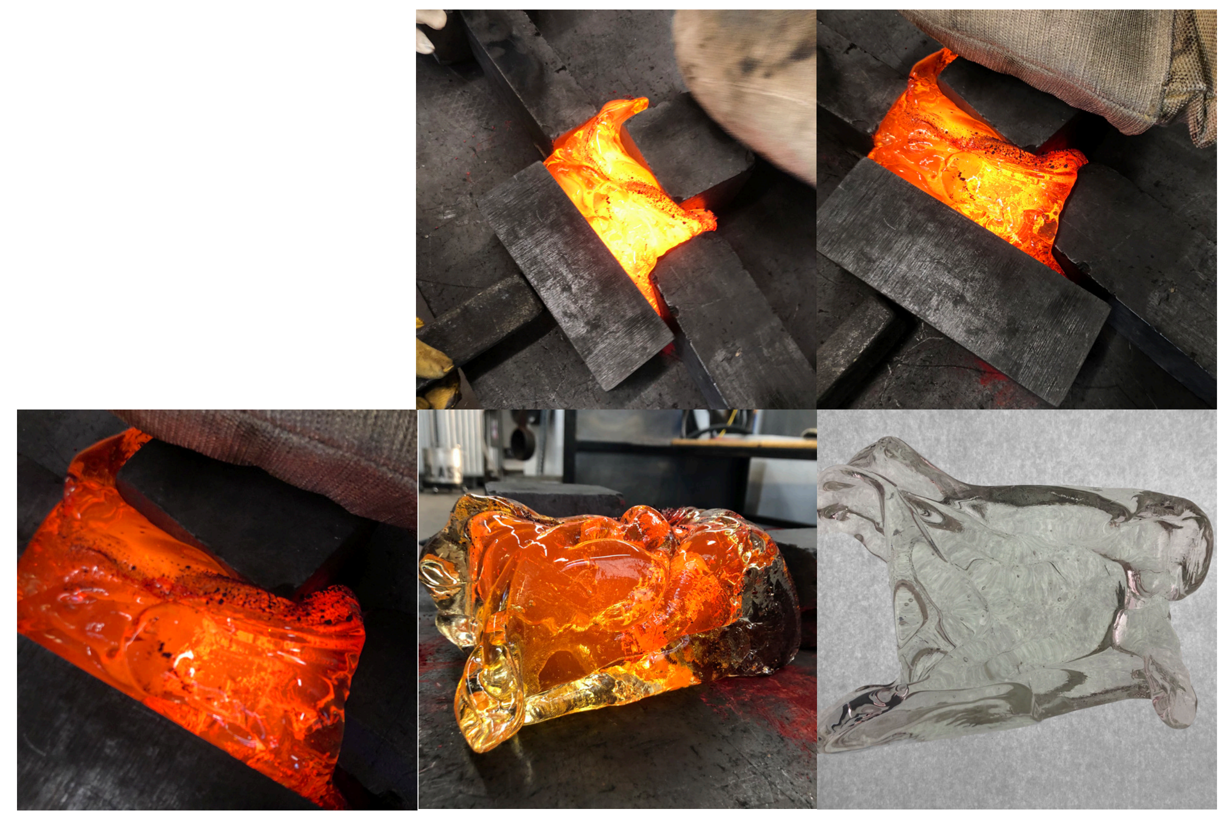
Over the past year, I have gained the skills—specifically working with the jacquard loom—necessary to execute a project I have long imagined. I have pushed my understanding of how weave structure, fiber content, and weaving and finishing processes could be engineered to create an architectural structure made of continuous textile material. While I knew that weaving as a design process had qualities advantageous to architecture, i.e. it can create a continuous surface in both the warp and weft direction, allowing for material strength and performance; in addition to skills, I also needed a set of criteria, restrictions, and parameters in which to make decisions.

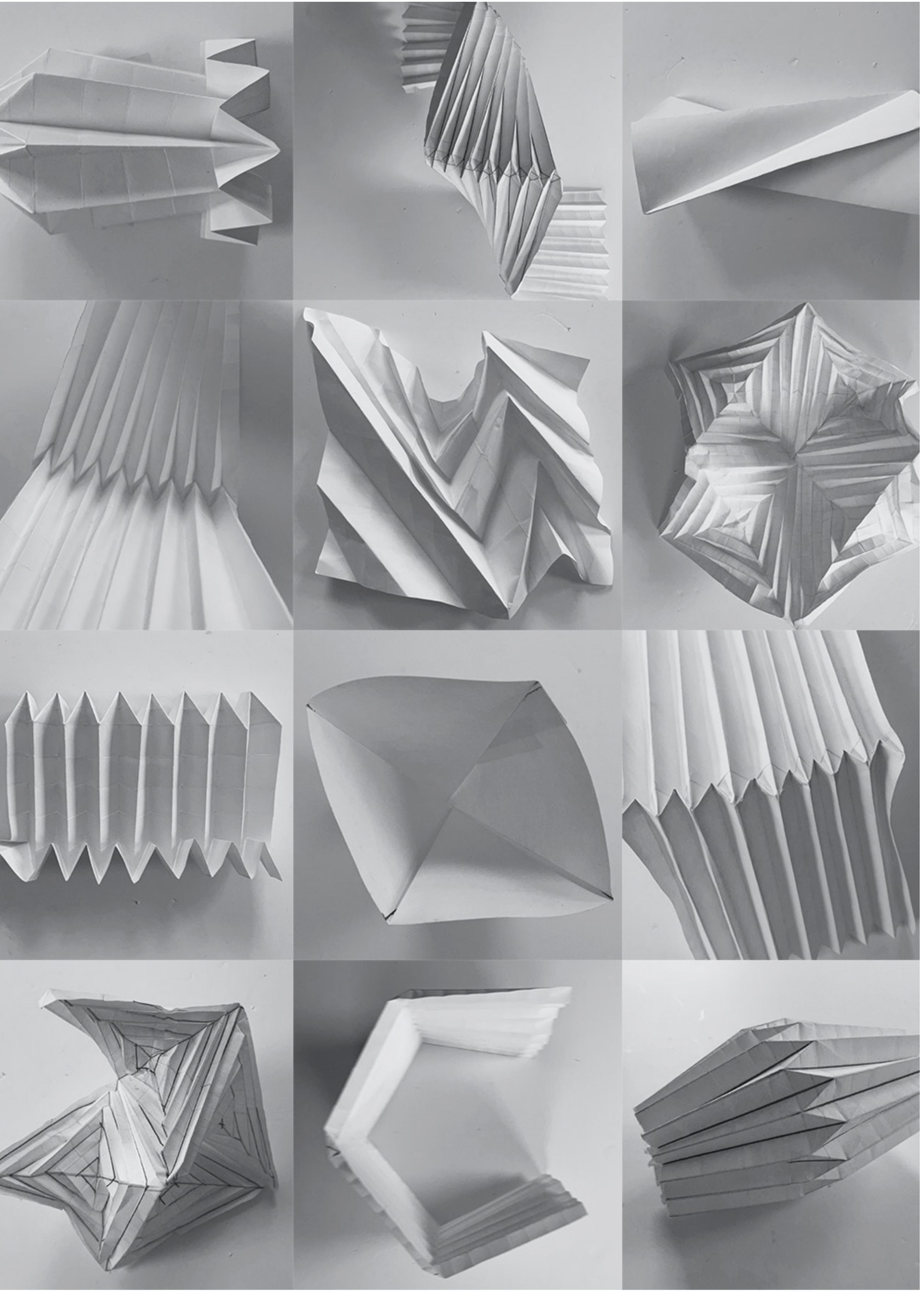
Early in the design process, I established four guiding principles for the structure:

1. it must be as self-supporting as possible
2. it must be easy to transport
3. the jacquard textile could not be cut into
4. the finishing processes would be minimal

In fall 2020, I took a Hot Casting class in the Glass department in which, inspired by Richard Serra, we developed a verb list and acted the verb out on the material. My verb, "contract," led me to press molten glass between graphite blocks, recording the material transformation and the making process. I transferred this same verb-led process to my thesis work, focusing on the following actions: fold, translate, weave, reflect, contract, transform, repeat.

I let my process guide my work but I always come back to the same set of verbs.

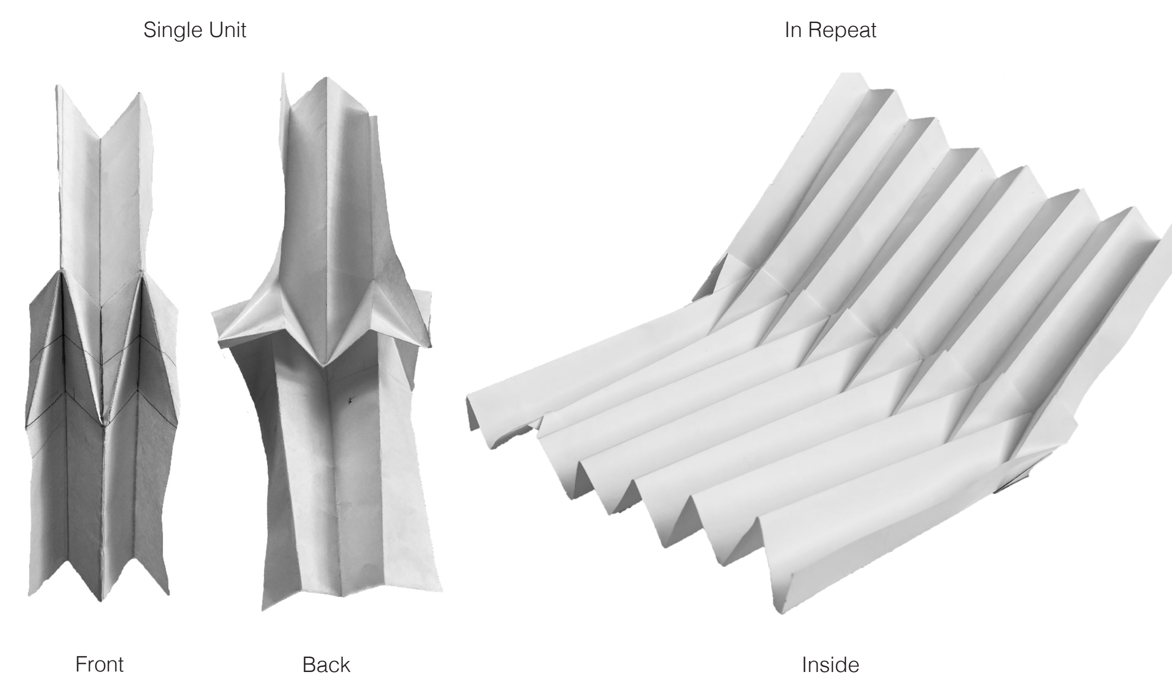


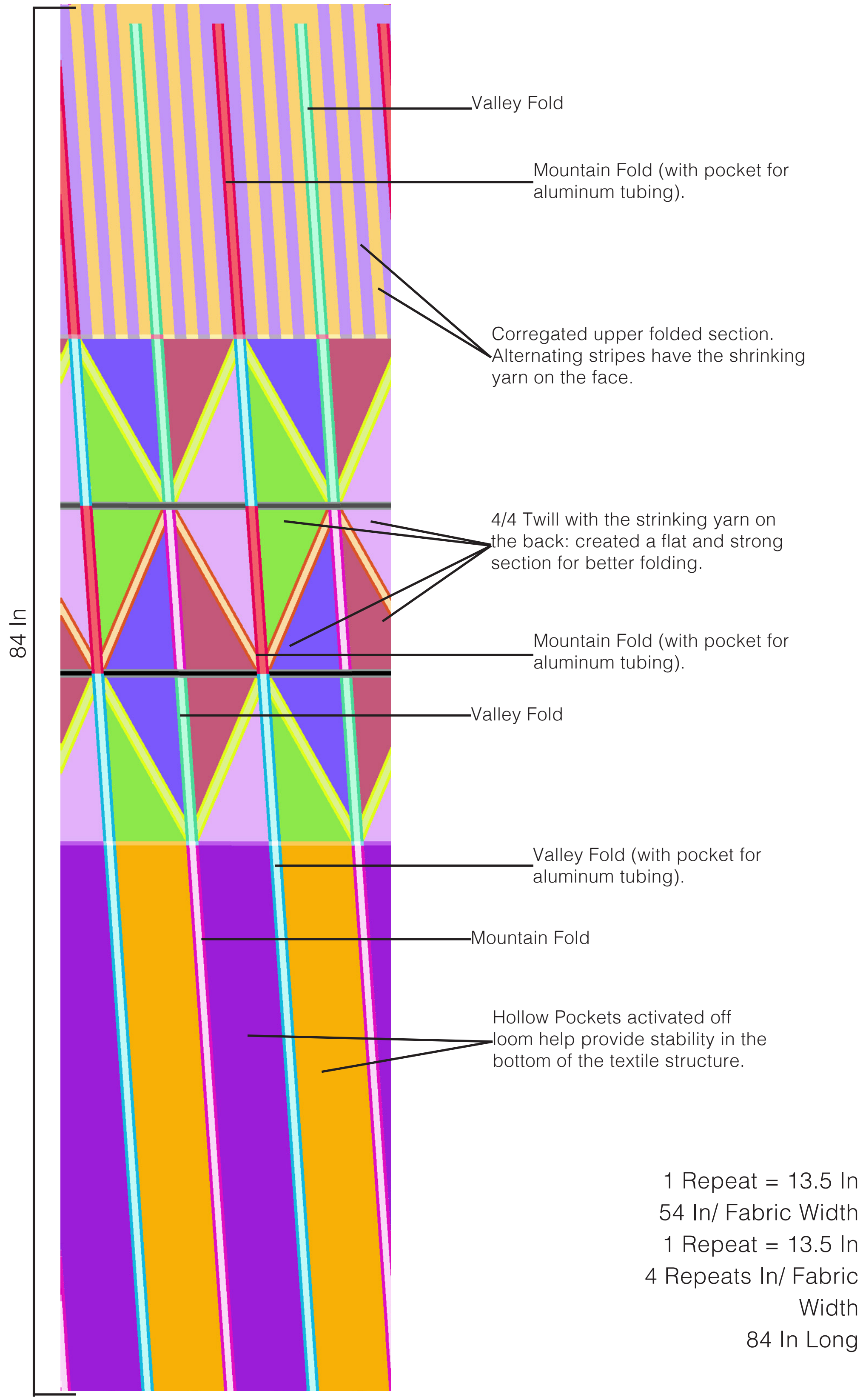


FOLD

At the conceptual stage I begin by “sketching” forms to generate ideas for 3D textiles by folding paper. I then generate many quick “paper studies” of different folding patterns. I observe how they bend and what shapes are made as the form is moved and repeated. Based on my observations of how the form can transform and to support itself, I ask myself: What is the natural behavior of the form? How can I let the tendencies of form guide the structure I am trying to create?

Using origami paper folding techniques gives me the ability to generate forms and different surfaces quickly. Paper, like woven textiles, is a 2D material. Through a series of folds it can be transformed into a 3D form that can be functional, structural, sculptural, or decorative. Paper folding techniques generally began with a single unit that can be repeated. I am drawn to folded textiles because they can be assembled and disassembled or expanded and contracted to accommodate different spaces. Using folds to create a structure also allows continuous material which can create a stronger surface and has the potential to produce less waste than cut and sewn processes. Designing in repeat translates easily into a jacquard graphic. In jacquard weaving, there are a few limitations to consider as you design the fabric, including the repeat size. At RISD our repeat size is 13.5 in, so when I begin to fold paper, I start with that repeat size in mind.

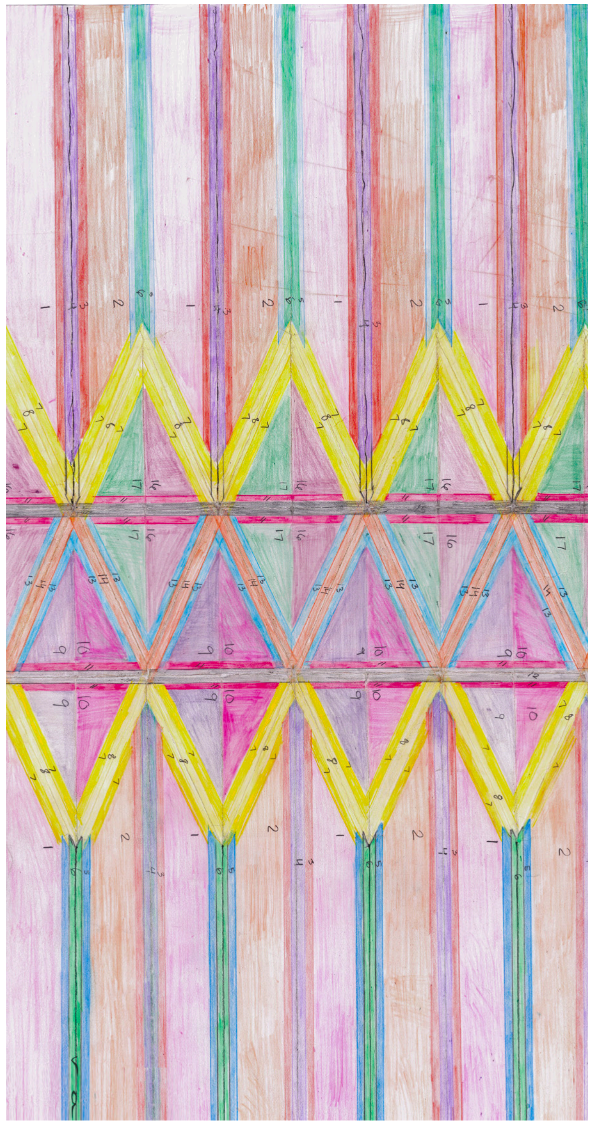


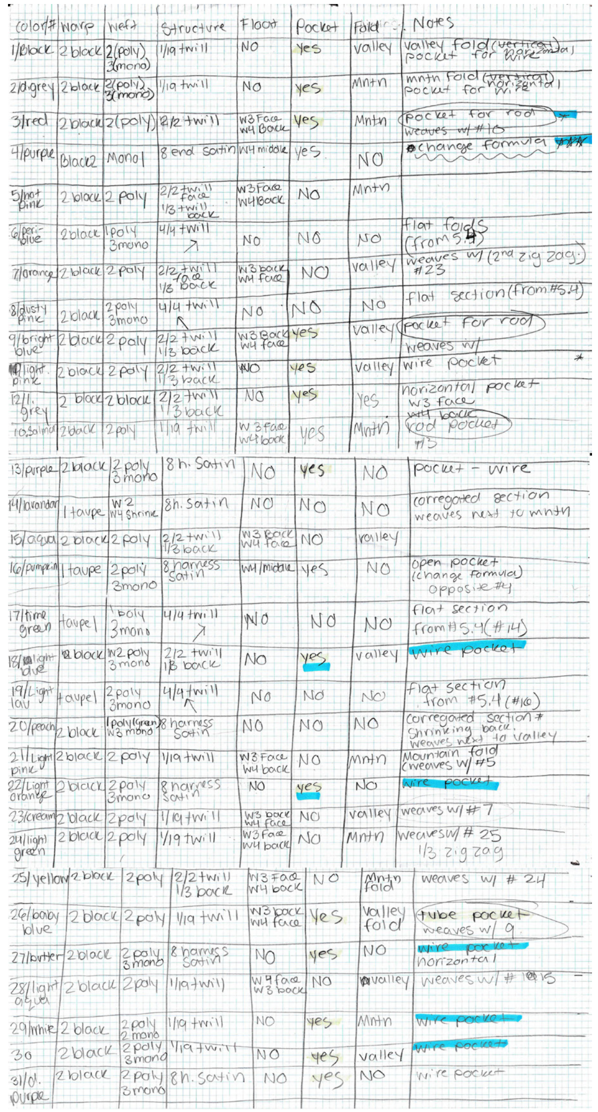


TRANSLATE

After creating the paper studies, I mock up the final form of the textile structure with a paper model that becomes the origin point for my jacquard graphic. The graphic begins with line drawings illustrating the mountain and valley folds. Using solid technical colors I begin dividing the planes between the folds. After the technical plan has been made, I will then begin to think about surface design.

When translating the paper-folded model into a graphic, I create a technical plan that allows for the proper function off loom. Dividing the planes creates sections that correspond to weave structures. Yarns and structures can be assigned in specific places that will create different performances. This helps the flat textile to begin to take its final form. After an initial sample to test the structures and scale, I then design the color and pattern that works with the form of each structure. This allows the color and pattern to support the structure.

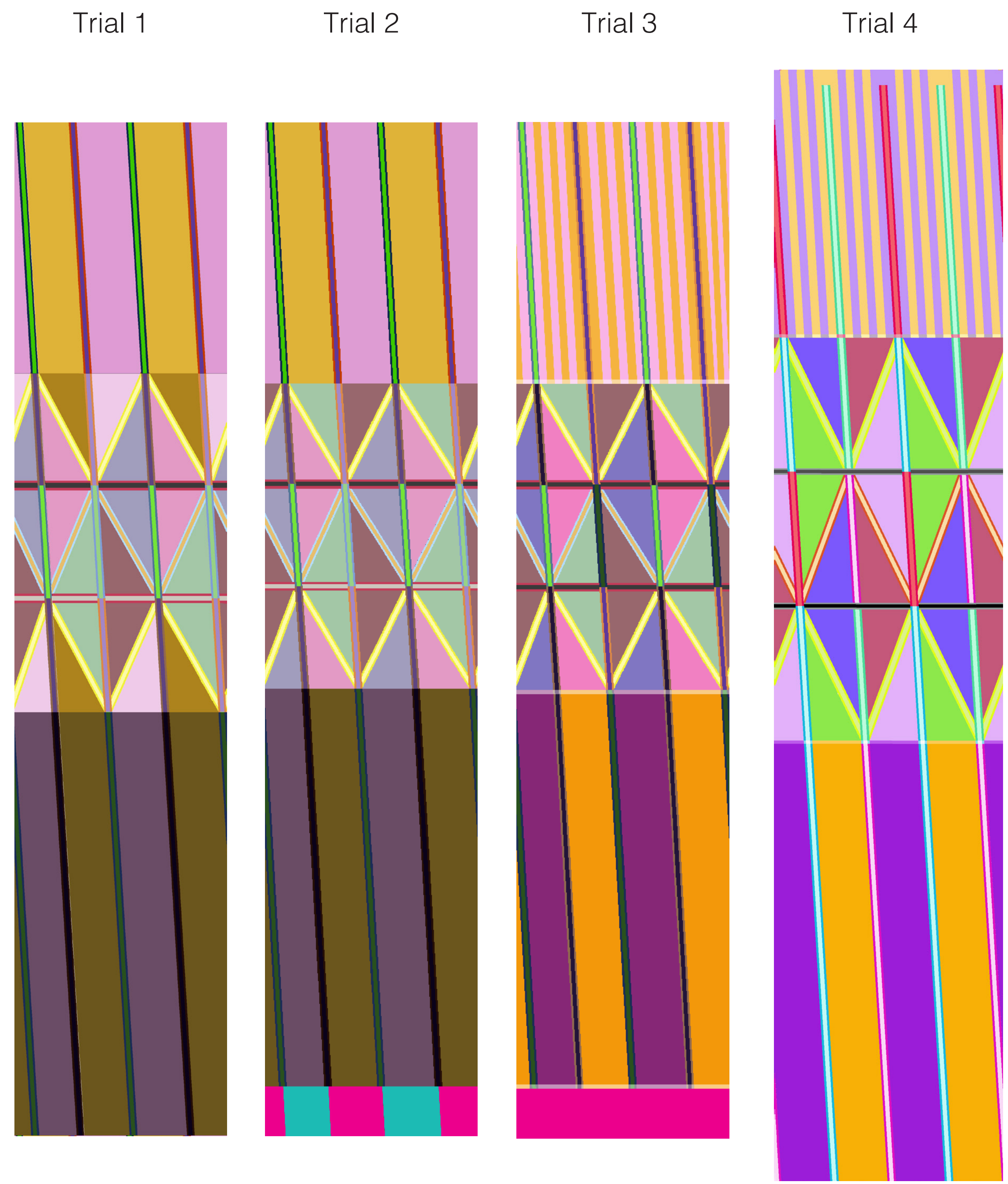




Color/#	Warp	Weft	Structure	Float	Pocket	Fold	Notes
1/Black	2 black	2(poly) 3(mono)	1/19 twill	NO	yes	valley	valley fold (~~vertical~~ horizontal) pocket for wire
2/d.grey	2 black	2(poly) 3(mono)	1/19 twill	NO	yes	Mntn	mntn fold (~~vertical~~ horizontal) pocket for wire
3/red	2 black	2(poly)	2/2 twill	W3 Face W4 Back	Yes	Mntn	pocket for rod * ~~weaves w/ #10~~
4/purple	Black2	Mono1	8 end satin	W4 middle	yes	NO	change formula ***
5/hot pink	2 black	2 poly	2/2 twill face 1/3 twill back	W3 Face W4 Back	NO	Mntn	
6/peri-blue	2 black	1 poly 3 mono	4/4 twill ↗	NO	NO	NO	flat folds (from 5.4)
7/orange	2 black	2 poly	2/2 twill face 1/3 back	W3 back W4 face	NO	valley	weaves w/ (2nd zig zag) #23
8/dusty pink	2 black	2 poly 3 mono	4/4 twill ↖	NO	NO	NO	flat section (from #5.4)
9/bright blue	2 black	2 poly	2/2 twill 1/3 back	W3 Back W4 face	yes	valley	pocket for rod weaves w/
[illegible]/light pink	2 black	2 poly	2/2 twill 1/3 back	NO	yes	valley	wire pocket *
12/l. grey	2 black	2 black	2/2 twill 1/3 back	NO	yes	Yes	horizontal pocket W3 face ~~W4 back~~
10/salmon	2 black	2 poly	1/19 twill	W3 face W4 back	yes	Mntn	rod pocket #3
13/purple	2 black	2 poly 3 mono	8 h. Satin	NO	yes	NO	pocket – wire
14/lavandar	1 taupe	W2 W4 shrink	8h. satin	NO	NO	NO	corregated section weaves next to mntn
15/aqua	2 black	2 poly	2/2 twill 1/3 back	W3 Back W4 face	NO	valley	
16/pumpkin	1 taupe	2 poly 3 mono	8 harness Satin	W4/middle	yes	NO	open pocket (change formula) opposite #4
17/lime green	taupe 1	1 poly 3 mono	4/4 twill ↗	NO	NO	NO	flat section from #5.4 (#14)
18/light blue	2 black	W2 poly 3 mono	2/2 twill 1/3 back	NO	yes	valley	wire pocket
19/Light lav	taupe 1	2 poly 3 mono	4/4 twill ↖	NO	NO	NO	flat section from #5.4 (#16)
20/peach	2 black	1 poly (green) W3 mono	8 harness Satin	NO	NO	NO	corregated section # shrinking back. weaves next to valley
21/Light pink	2 black	2 poly	1/19 twill	W3 Face W4 back	NO	Mntn	Mountain fold (weaves w/ #5
22/Light orange	2 black	2 poly 3 mono	8 harness Satin	NO	yes	NO	wire pocket
23/cream	2 black	2 poly	1/19 twill	W3 back W4 face	NO	valley	weaves w/ #7
24/light green	2 black	2 poly	1/19 twill	W3 Face W4 back	NO	Mntn	weaves w/ #25 1/3 zig zag
25/yellow	2 black	2 poly	2/2 twill 1/3 back	W3 Face W4 back	NO	Mntn fold	weaves w/ #24
26/baby blue	2 black	2 poly	1/19 twill	W3 back W4 face	Yes	valley fold	tube pocket weaves w/ 9
27/butter	2 black	2 poly 3 mono	8 harness Satin	NO	yes	NO	wire pocket horizontal
28/light aqua	2 black	2 poly	1/19 twill	W4 face W3 back	NO	valley	weaves w/ # 15
29/white	2 black	2 poly 2 mono	1/19 twill	NO	yes	Mntn	wire pocket
30	2 black	2 poly 3 mono	1/19 twill	NO	yes	valley	wire pocket
31/d. purple	2 black	2 poly 3 mono	8h. satin	NO	yes	NO	wire pocket

Above left: Original folding pattern on paper. Each color and number in the graphic corresponds to a weave structure.
Above right: Notes for a jacquard trial detailing warp and weft choices, weave strucutres, and any other details necessary for creating the jacquard file.

Opposite page: The progression of the jacquard graphic from the first trial to the last. The colors were changed to reflect changes in the pattern or weave structures.



WEAVE

I weave with a jacquard software called PointCarre that compiles all of the woven structures into the graphic. I choose the yarns and a yarn sequence after researching what yarns are available and what material properties, sizes, and colors they come in. After specifying my yarns and setting up the jacquard file, I begin to assign the weave structures to correspond to colors in my graphic based on where I want the fabric to be stiff or flexible. It is through the structures that I also consider color choices, patterns, and aesthetics.

I use what I refer to as an additive design approach to jacquard weaving.

- My first trial is often very simple and is mostly a technical trial on a smaller scale to get a feel for how the weave structures are working together, what the folded structures look like in textile form off loom, and scale.
- After each trial I evaluate what I did and what I want to improve. Throughout the weaving process I take detailed notes that inform my process moving forward.
- During the process of creating the *Textile Architecture*, I sample different color effects and patterns and fine tune the structures and surface of my final yardage to make sure it has a seamless visual structure.
- Each time I weave a trial I make changes that allow me to better control my textile structure. By working through the process in an additive way, I can also better identify why there are problems during the weaving process if there are limited variables each time. It allows for a systematic approach to a trial-and-error-based process.
- This way of working was especially effective during COVID-19, because I was not able to be present for the weaving process. I had to have my yarns selected and organized before my weaving slot and my file prepared with any necessary notes. It was easier to communicate about what was going wrong when I was systematically trying different improvements each trial.

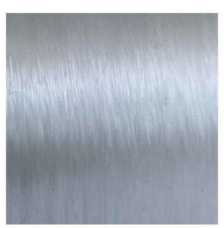
The yarns I used for the *Textile Architecture* structure were selected for color and performance qualities. I chose a shrinking yarn to speed up the finishing process and design the memory of the fabric through material properties. I choose monofilament yarn because it helps the textile be more lightweight and transparent and can also help to stiffen some areas of the fabric to give more rigid qualities. I also used two colors of fine polyester yarns to help the fabric permanently pleat and for color.

Although it is possible to predict what the woven fabric will look like, a big part of my design process is sampling different colors, structures, and yarn placements.This has allowed me to select the trials that worked best for the results I am trying to achieve. Sampling also allows me to test the compatibility of all the weave structures, find what structures work best, what creates tension issues on the loom when weaving, and to find the best amount of picks per inch (the density of the fabric).

Performance and visual appearance are not the only important factors. You need to be aware of the loom's specifications. The type of loom, the warp take up, and the repeat size are all limitations that need to be factored into the way the jacquard file is designed. These limitations create design challenges, and the creative problem solving lies in finding the right balance between what the designer wants to achieve and what the loom can do.

Final Yarn Choices for *Textile Architecture*

Shrinking Yarn

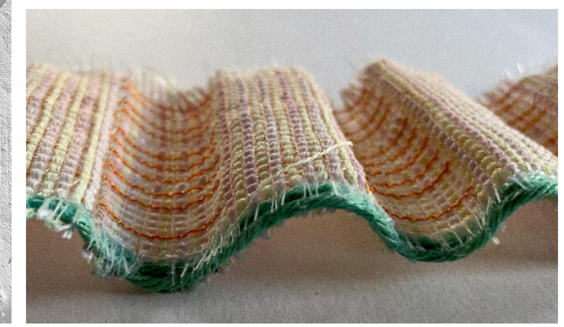


Monofilament

Polyester (Metallic)

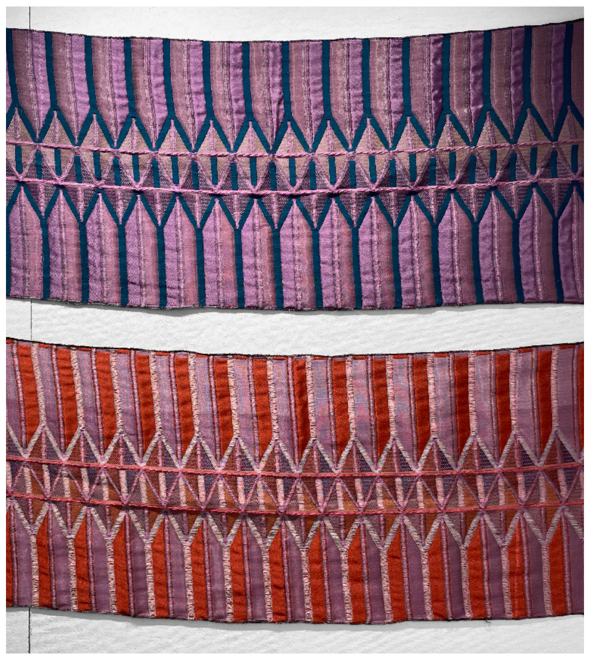
Polyester
("Shimmer Green")

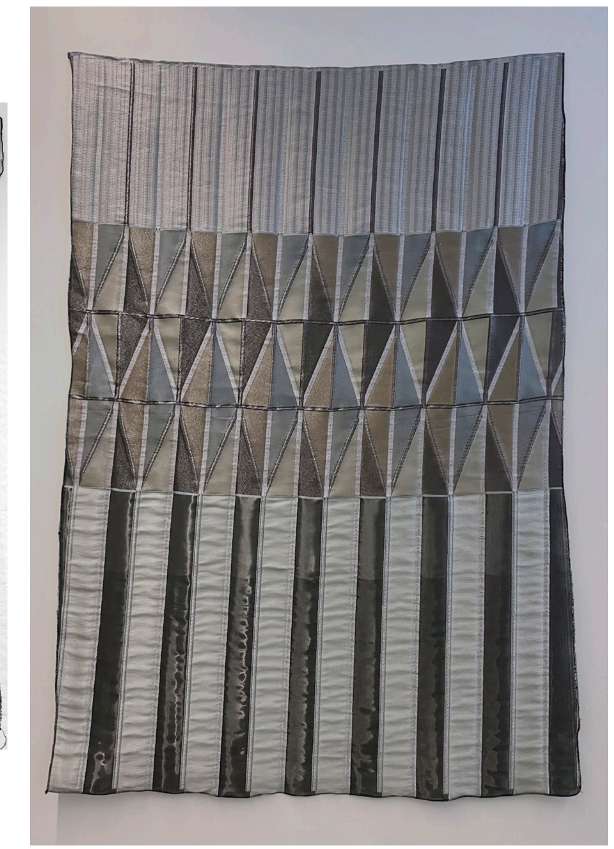
Samples woven on a 24 harness dobby loom.
Above & right: Monofilament pleats compose the top and bottom layers with a layer of wool floating in the middle. The wool shrunk and caused the monofolament to pleat further. This structure inspired the botttom part of *Textile Architecture.*



Dobby samples using self pleating techniques. Handwoven studies help to understand how yarn placement and weave structure can effect the behavior of the textile off loom.
Left: The samples helped develop the top part of the *Textile Architecture.*

Building off what I learned on the dobby loom, I did several jacquard samples in different color combinations and weave structures for each section of the graphic. The final iteration of *Textile Architecture* has color and material choices and weave structures similar to the samples above.





Trial 1

1/8 Scale
4 Folds/ Repeat
24 In Long

Trial 2

1/4 Scale
2 Folds/ Repeat
60 In Long

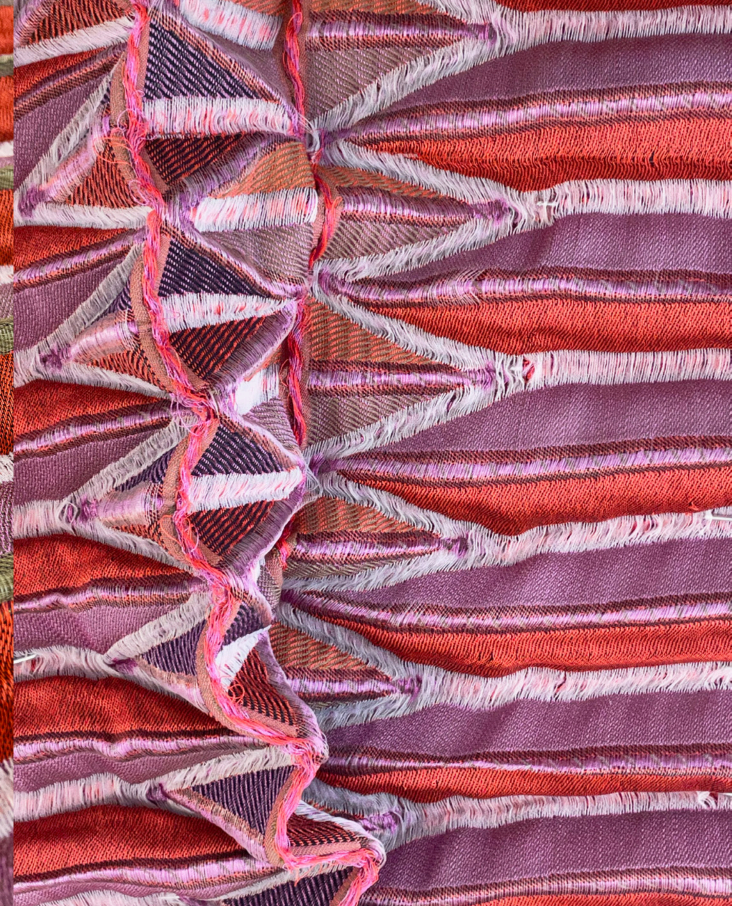
Trial 3

1/4 Scale
2 Folds/ Repeat
60 In Long

Trial 4

1/2 Scale
2 Folds/ Repeat
84 In Long

The progression of jacqaurd samples from the beginning of the design process. The trials above correspond with the graphic progression on page 34.



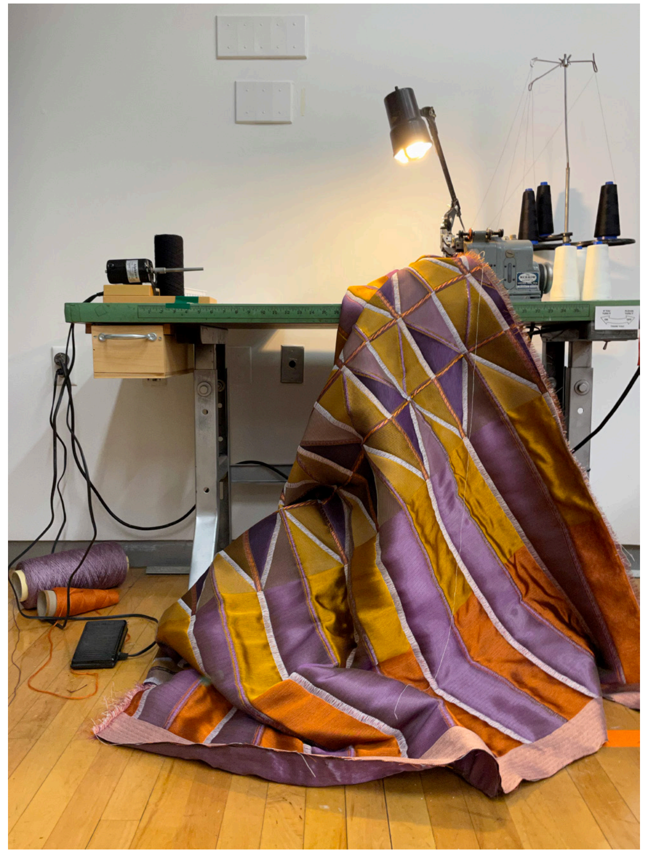
FINISH

One of my research goals in this project was to create a textile that is designed to have memory when it comes off the loom. The finished textile takes shape as a result of fiber placement and weave structure within the jacquard graphic.

The process began with my first tent prototype that I began last semester. The finishing process was time consuming and laborious. In this iteration of Textile Architecture I was interested in letting more of the finishing process happen through yarn choices and make the process more passive and efficient.

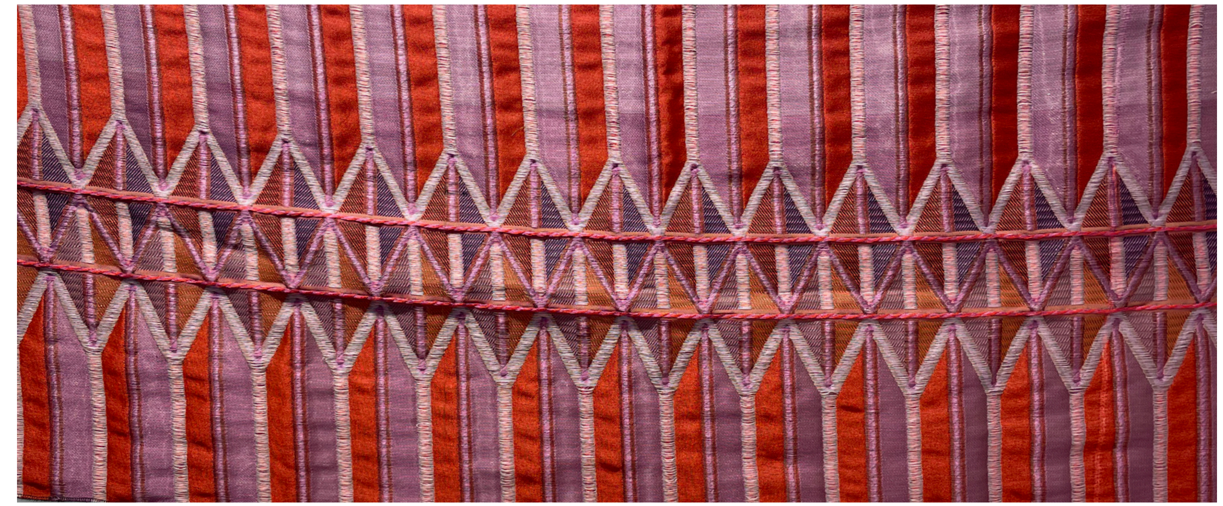
The finishing process for *Textile Architecture* involves steaming and binding the jacquard fabric. After the fabric comes off the loom, it is steamed at a high temperature. After steaming, I fold and then bind the textile into its folded position. I leave it bound for 24 hours.

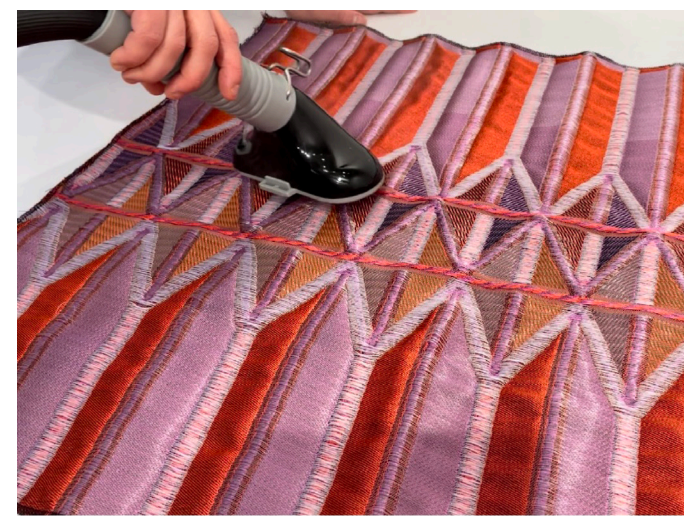
Steaming causes the shrinking yarn to contract and the monofilament to buckle. The opposing properties on opposite sides of the fabric create natural folds in the fabric. The polyester yarns in the fabric help the folds to permanently set. By designing for a minimal finishing process, I am able to concentrate my effort and time into the design and prototyping process and less into laborious finishing processes.



Material and finishing samples. These trials helped to identify the best materials and finishing processes for *Textile Architecture*.
Left: shrinking yarn with steam finishing only.
Right: wool washed in high temperatures and put in the dryer to felt.

Fabric before finishing directly off the loom.





Steaming the fabric to activate the shrinking yarn.

After steaming the textile is folded and secured using clips for 24 hours.

MODEL

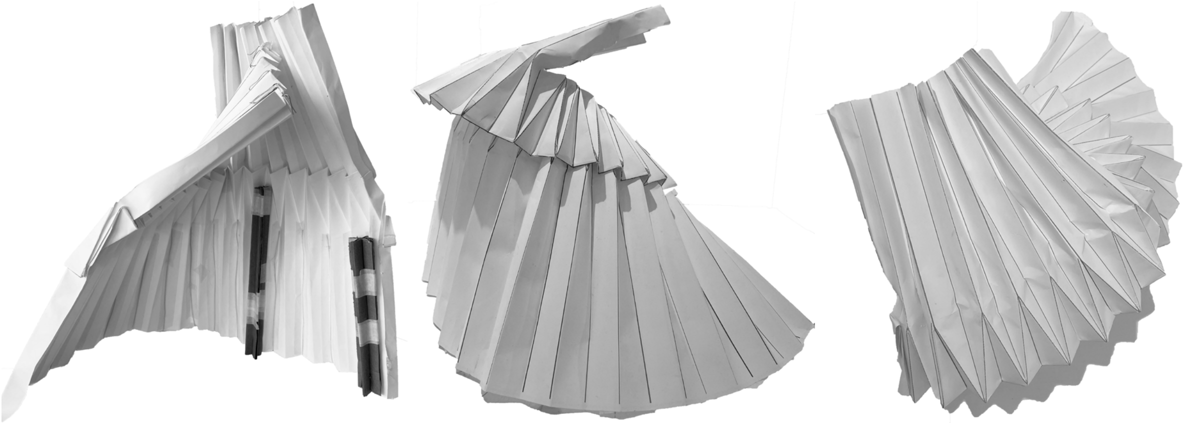
When creating *Textile Architecture*, I have constantly gone back and forth between designing, revising the design, and creating physical models in increasing scales.

In this process specifically, I began by defining the finished, full-scale dimensions for the pavilion as 10 feet wide by 10 feet tall. I have decided that my final deliverable for the thesis work will be a ½ scale model of 5 feet wide and 5 feet tall. My first model was at a scale and was originally made out of paper and thin steel wire. Then I wove the first jacquard trial at the scale to see how the folded structure would translate as it is draped over the paper model. After observing the scale model, I increased the scale and created a ¼ scale model. I encountered structural issues when scaling up and was looking for the proper supports to insert into the textile structure. The first wires I used were much too weak to hold a sharp shape and create smooth edges. I then was able to identify the proper support material and counter weight at the ¼ scale and make the necessary adjustments when editing the file for the ½ scale model.

The paper model lets me experiment with different configurations and becomes a template for my jacquard graphic in the unfolded state. Starting small allows me to use less material in the early prototyping stages of the process and also solve structural issues on the smaller scale. As I scale up, I need to fine tune the design, properly scaling dimensions and dealing with changes in structural challenges to work through issues of scale, as well as consider how I want the fabric to behave and where the pockets will be placed.

By scaling up I was better able to see how materiality and color would impact the way *Textile Architecture* would be received and what visual associations people had. I began the process of weaving with bright colors but the structure was reading as a circus tent which was not the language I hoped to communicate. Testing different color combinations allowed me to make choices that better referenced architectural materials.

Developing a seamless process of going back and forth between modeling, designing, and weaving has allowed me to let the making guide my process and problem solve through various challenges I had not anticipated.



Paper Model
1/8 scale model

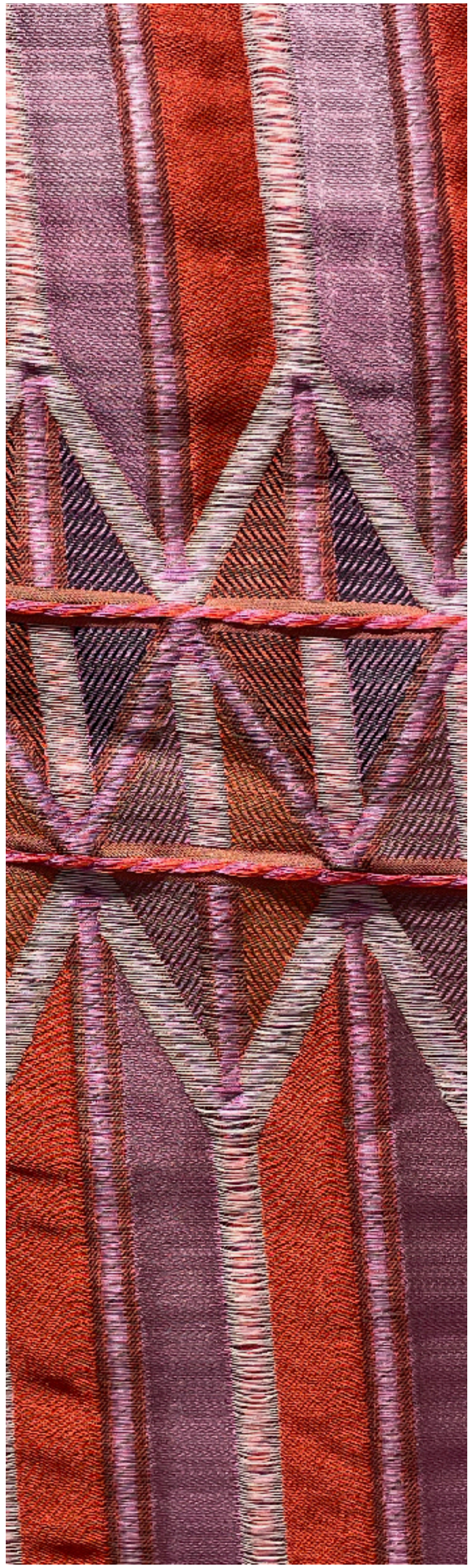
- The first scale model made for *Textile Architecture*.
- Explored the range of formations possible from a single folding unit.
- Considered how the structure could be self standing by designing that folds on itself.

Jacquard Model 01
1/8 scale model

- The first scale model made from a jacquard woven fabric.
- Explored the placement of supports within the structure.
- Gained a greater understanding of the materiality needed to create a stiff surface.

Jacquard Model 02
1/4 scale model

- The second scale model made from a jacquard woven fabric.
- The jacquard pattern in this model was futher developed but still explored placement of the rods.
- Tested many different types of support systems and bases.
- Made further adjustments to yarn placement and weave structures.



INSTALL

The final iteration of *Textile Architecture* is composed of three main components: the jacquard fabric, aluminum tubing, and a wooden platform. I replaced the steel rods used in the ¼ scale model with aluminum tubing because aluminum is strong, lightweight, and does not rust like steel. Similar to bamboo, the aluminum tubing was hollow and only had material where it supported structural integrity, to reduce weight and increase strength. The weighted concrete and sand bricks used in past models were replaced by a six-inch wooden pedestal that served as a base and counter weight for the structure. The jacquard is composed of cotton, polyester, monofilament, and a shrinking yarn. The textile can be folded with the aluminum tubes inserted into the pocket, like an umbrella, and bound for easy transportation. Upon arrival at the destination (in this case the RISD Museum), the structure can be assembled by systematically inserting the aluminum rods into the base of the wooden structure. The rods pass through holes on the top and bottom of the platform to help create stability. A systematic approach to design with transportation in mind made for a seamless installation process.

Building the platform.

Each of the aluminum rods was bent using a clamp and measured against the pattern.

Textile Architecture ready for aluminum rods to be inserted into the pockets.

All the components of *Textile Architecture* packed and ready to be transported.

TEXTILE ARCHITECTURE

TEXTILE ARCHITECTURE

Jacquard (cotton, polyester, monofilament, & shrinking yarn), aluminum, wood. 2021.

Textile Architecture is a system designed to create foldable, flexible, portable architectural space. Constructed from aluminum tubing, a wooden base, and a jacquard fabric, all of the technical components of the seemingly freestanding structure are hidden within the textile. The color combinations mimic the glimmer of granite, steel, or glass. At different angles, the light illuminates the line quality of the yarn, reinforcing variation in form through color and material. The inside of the structure is softened by a white band through the middle of the fabric. The contrast of the shadows cast by sharp, predetermined folds and the folded form causes a secondary pattern to emerge, one defined by the external environment. This subtle effect serves as a reminder that *Textile Architecture* aspires to live outdoors, alongside other systems of building.

Unless otherwise noted, all photos in this chapter: Jo Sittenfeld

EVALUATION & FUTURE PROVOCATIONS

EVALUATE

Textile Architecture was an experiment. Produced at half scale, it allowed me proof of concept, a blueprint for what is possible in the future. While smaller than lifesize, the textile structure is large enough to show that the structure would function at full scale. It allowed me to transition from an idea to a tangible, viable form. The next iteration of this project will build on what I learned. At this stage, I worked within a lot of limitations, like time, budget, access to materials, and equipment specifications at RISD. While these constraints helped me become a better designer, moving forward I would like to explore different manufacturing techniques and processes in the textile industry to push the idea further.

While weaving *Textile Architecture*, I had to find the correct balance in yarn content and structure that would allow for easy weaving and create the material properties I was looking for. I struggled along the way with yarn tension issues. The RISD loom has a single beam set up, meaning all of the warp threads are wound onto a single beam. The structures and "warp take-up" must remain in sync or the file can cause tension issues on the loom. One of the characteristics of weaving is that one set of yarns is held in even, constant tension by the loom. If that tension becomes uneven, it can break warp yarns or create an uneven woven surface. Surprisingly, having uneven warp take-up can be advantageous to the weaving process. It creates useful variations, but you have to be able to control it.

Ideally, I would like to weave this project with a double beam, creel set-up, or a combination of both that would let the warp yarns of different materials in key places rool off the spool individually and at varying rates. This would allow for more variation of fiber volume across the surface, which would create more drastic changes between the stiff and flexible parts of the fabric. I believe that having different warp densities would help to create structure inside the textile, pole-like elements that would self-support the structure.

The RISD loom has a cotton warp which did not provide any material or structural advantages to *Textile Architecture*. In future iterations of this project I would work with a warp material that provides more structural materiality, using high-performing yarn. Accessing performance materials at RISD has been a challenge. There are barriers preventing students from accessing industry-quality yarns and fibers. First, there is little readily accessible information for students to become familiar with the range of materials available to the industry. Further, mills have high minimum order requirements that are unsustainable for student production and far too expensive. Many mills also decline to work with students in a smaller capacity. Giving students access to industry standard materials could help them develop a more advanced practice and initiate breakthroughs in the industry.

COLLABORATE

The success of future iterations of this project will depend on collaboration with people across disciplines, including but not limited to architecture, material science, design, textiles, fiber manufacturing, and engineering. One of the biggest takeaways from this process is that I have begun to develop my piece of the puzzle, and the next step is to learn how to let that piece fit into the larger puzzle that is cross-disciplinary collaboration.

The making of *Textile Architecture* did not include CAD models or technical drawings.

As a textile designer, I worked in the best way I know how, moving between modeling, folding paper, and creating jacquard fabrics. This approach utilized the tools I had to create a free standing textile structure. I can only imagine what type of structure would be possible if I worked with an architect from the conception or an engineer in the refinement. However, for a project like *Textile Architecture* to be successful, each discipline must be equally as important in relation to the collaborating disciplines. The system relies on all facets of the design, not only one.

PROVOKE

This project was never meant to be only mine. To create the first iteration of *Textile Architecture*, I was working alone and navigating many of the challenges outlined above. The original idea for this project was to create an outdoor structure that would provide shade and space for recreation in seasonal spaces like the beach. I made some critical design decisions that moved the pavilion from an outdoor application to an indoor one primarily because of material access. Reflecting back on my process, I am glad I made this decision because it let me develop architectural jacquard fabrics, as well as a process and system, without the added pressure of having the pavilion perform a certain function in the environment.

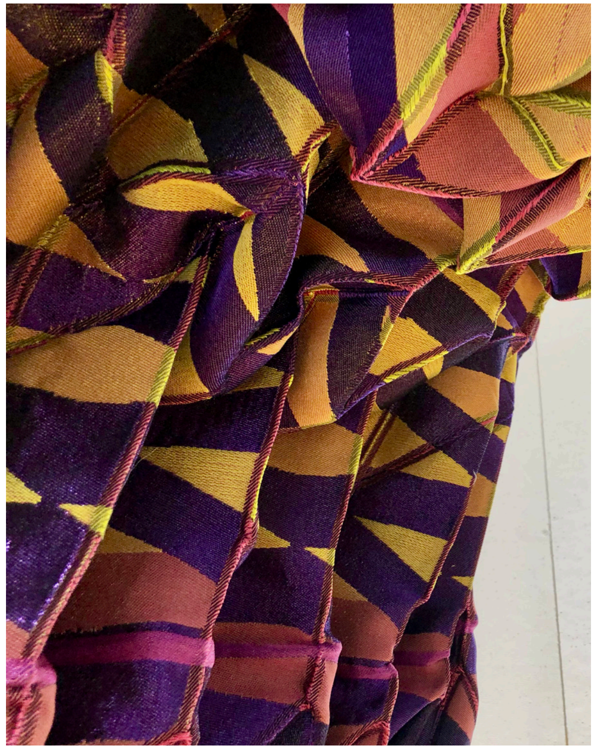
Eventually, I envision *Textile Architecture* to live outdoors and to have a purpose larger than recreation or exhibition. *Textile Architecture* has the potential to create solutions in temporary and in-between spaces that can have large social benefits. Specifically, it can be used to create shade and shelter.

Shade is a political inequity issue. Shade is a climate issue. It seems like an extremely obvious and simple application but one that provides a frequently overlooked and essential service. If you have spent time in any major city in the United States, you often see access to greenspace and greenery change along neighborhood lines. It would be too easy to assume that some neighborhoods prefer greener streets. The reasons why green spaces are so unevenly distributed throughout most US cities is rooted in redlining and prohibitive zoning laws. Urbanist Sam Bloch shared on the podcast 99% Invisible that shade is a leading factor in human comfort, and lack of access to shade can be linked to heat stroke, dehydration, overheating, and even death[23]. Populations like pregnant women, the elderly, or people with preexisting medical conditions are at disproportionately high risk. Members of those populations who live in neighborhoods with historically low percentages of green spaces are at even higher risk. Those neighborhoods are often low-income or working neighborhoods. In cities like New York or Los Angeles, the building or business owner, renter, or property manager is often responsible for the upkeep of the sidewalk and greenery in front of their building. Tree planting may be done by the city, but nurturing and maintaining the tree or plants falls on the property manager. As a result, properties with higher income owners and tenants—and hired help—have beautifully cultivated shade through green spaces while those with fewer resources have little greenery and shade, parched ground, and an awning if they are lucky. Further, working neighborhoods were always designed to be denser and have narrower sidewalks. Space for parked cars and traffic is a priority over tree-lined streets that can be seen in more affluent areas.

Shade pavilions are also inaccessible due to zoning laws, upkeep, and permits. The urban planning laws have made the process of implementing shade structures just inconvenient enough to dissuade people. When a city leaves capitalism to guide zoning and policy, it prioritizes maximizing property and forgoing public services. Current zoning laws in many US cities are prohibitive. Planning must go beyond rewarding developers for building private/public spaces that are designed to be cold, leaving them "accessible" to all but only welcoming to few.

Textile Architecture is suited to tackle many of the obstacles preventing the implementation of shade structures. *Textile Architecture* is adaptable and designed to fit into a range of spaces. The development of the *Textile Architecture* system could meet current zoning laws and connect with existing architecture. Although start up costs would be high, it could be offset through corporate giving programs or developers who have fueled changing neighborhoods. The production, assembly, and installation could be minimal. City planning departments are often overloaded, so a systemic and adaptive approach to implementation would be advantageous. *Textile Architecture* could be used to create shade structures and pavilions at bus stops, shopping corridors with little shade, public parks, and plazas.

In the future I hope *Textile Architecture* will be used as a way to combat the exact problem that drove me to create it in the first place: the climate crisis. The climate crisis is projected to grow exponentially in the coming years and continue to uproot people from their homes. Natural disasters will not be the only



An iteration of textile architecture was made in the Fall of 2020. The structure was intended to be hung to provide relief from the sun to people in urban spaces while being visually uplifting.

factors pushing people across the globe into mass migration. Increasing environmental strain will lead to increased rates of food and water insecurity and labor shortages which will continue to strain political systems, upheld by people intent on hoarding their resources. Needless to say, the number of climate refugees who will be forced to relocate globally in the coming decades will continue to grow steadily.

Many refugee camps and disaster relief solutions are undignified and only focus on housing people but do not consider quality of life, dignity, or the trauma experienced by those who are relocated. Many of these points were addressed by Abeer Seikley in her project *Weaving a Home*. *Textile Architecture* is composed of three panels and was woven in three hours with minimal finishing process. This efficiency would allow for homes to be woven in real time and distributed to people facing natural disaster or political unrest all fueled by the growing climate crisis. Shipping would also be facilitated easily, because the textile component is lightweight, collapsible, and was designed with movement in mind. There are many functional and structural elements that would need to be further worked out to ensure safe and dignified living conditions for all people who it could reach. Replicability is also an issue that would need to be addressed. Collaboration will not be a miracle cure to working out these issues, but in the same way that I used problem solving to build *Textile Architecture*, future iterations will depend on fine tuning a process that has the potential to change the way we interact with textiles in our built environments.

Textile Architecture will take many forms. Each iteration will be tackling its own challenges. Each iteration will be designed with a purpose. These designs can always be adapted to fit exhibition spaces and public plazas, but the future of *Textile Architecture* lies in its ability to create solutions to urgent problems. It is my hope that this thesis has provided a proof of concept to how textiles, and weaving specifically, can be strategically applied to alleviate symptoms of the climate crisis and improve quality of life for all people.

ENDNOTES

1 Tsovoodavaa Gantumur, Rowell Shih, Mohammad Ganjali, & István Kistelegdi "A Review and Systemization of the Traditional Mongolian Yurt," Pollack Periodica (December 2018): 19-30, https://doi.org/10.1556/606.2018.13.3.3.
2 Adrian Beukers and Ed Van Hinte, Designing Lightness (Rotterdam: naio10, 2020), 32.
3 Dana Thomas, "Why Won't We Learn from the Survivors of the Rana Plaza Disaster?," The New York Times, April 28, 2018. https://www.nytimes.com/2018/04/24/style/survivors-of-rana-plaza-disaster.html.
4 Adrian Beukers and Ed Van Hinte, Designing Lightness (Rotterdam: naio10, 2020), 32.
5 Corinne Le Quéré, Robbie M. Andrew, "Global Carbon Budget 2016" (Scientific Report, Copernicus Publications, 2016), 607.
6 Ned Cramer, "The Climate Is Changing. So Must Architecture.," Architect Magazine, October 4, 2017, https://www.architectmagazine.com/design/editorial/the-climate-is-changing-so-must-architecture_o.
7 Linda Poon, "Cities Are Sinking Under the Weight of Urban Development," Bloomberg Magazine, February 23, 2021, https://www.bloomberg.com/news/articles/2021-02-23/big-buildings-can-cause-cities-to-sink-faster.
8 Sara J Kadolph, "The Fiber Manufacturing Process," in Textiles (Pearson Prentice Hall, 2007), 122.
9 Ram Meena, Chet, et al. "Medical Textiles." TechnicalTextile.Net, 17 Apr. 2021, https://www.technicaltextile.net/articles/medical-textiles-2587.
10 R. Buckminster Fuller, Utopia or Oblivion: The Prospects for Humanity (Zurich: Lars Müller Publishers, 2019).
11 Beukers and Van Hinte, Designing Lightness, 29-32.
12 Ludwig Glaeser, The Work of Frei Otto (New York: The Museum of Modern Art, 1972), 10.
13 Ibid, 10.
14 Ibid, 9-10.
15 Ibid, 9-10.
16 Ibid, 9-10.
17 Ibid, 66.
18 Abeer Seikaly, "Making Your Home, Wherever You Are.," TED Talk, October 8, 2018, video, https://www.youtube.com/watch?v=tYFzy1_EmBM.
19 Ibid.
20 Samira Boon, "Studio Samira Boon's 3D Textile Structures Translate Origami into Digital Weaving," Design Boom, March 22, 2018. https://www.designboom.com/architecture/studio-samira-boon-3d-textile-structures-origami-digital-weaving-03-22-2018/.
21 Ibid.
22 "Jiaxing Gallery" studio Samira Boon,https://samiraboon.com/2019/01/16/jiaxing-gallery/, accessed, May 25, 2021.
23 Roman Mars and Sam Bloch, "385: 99% invisible," January 14, 2020, in 99% Invisible, podcast, MP3 audio, 34:24, https://99percentinvisible.org/episode/shade/.

BIBLIOGRAPHY

Ann Richards. Weaving Textiles That Shape Themselves. 2nd ed. Wiltshire, UK: The Crowood Press Ltd, 201AD.

Beukers, Adrian, and Ed Van Hinte. Designing Lightness. Rotterdam, the Netherlands: naio10, 2020.

Boon, Samira. Jiaxing Gallery. 2016. Textile, 5 M. https://samiraboon.com/2019/01/16/jiaxing-gallery/.

———. "Studio Samira Boon's 3D Textile Structures Translate Origami into Digital Weaving." Design Boom, March 22, 2018. https://www.designboom.com/architecture/studio-samira-boon-3d-textile-structures-origami-digital-weaving-03-22-2018/.

Cramer, Ned. "The Climate Is Changing. So Must Architecture." Architect Magazine, October 4, 2017. https://www.architectmagazine.com/design/editorial/the-climate-is-changing-so-must-architecture_o.

Gantumur, Tsovoodavaa, Rowell Shih, Mohammad Ganjali, and István Kistelegdi. "A Review and Systemization of the Traditional Mongolian Yurt." Pollack Periodica, December 2018. https://doi.org/10.1556/606.2018.13.3.3.

Glaeser, Ludwig. The Work of Frei Otto. New York, NY: The Museum of Modern Art, 1972.

Kadolph, S.J. Textiles. Pearson Prentice Hall, 2007. https://books.google.com/books?id=iHgrAQAAMAAJ.

Le Quéré, Corinne, and Andrew Robbie M. "Global Carbon Budget 2016." Earth System Science Data. Copernicus Publications, 2016.

O'Mahony, Marie. Advanced Textiles for Health and Well-Being. New York, NY: Thames & Hudson, 2011.

Pawlyn, Michael. Biomimicry in Architecture. Second. London: RIBA Publishing, 2016.

Poon, Linda. "Cities Are Sinking Under the Weight of Urban Development." Bloomberg City Lab, February 23, 2021. https://www.bloomberg.com/news/articles/2021-02-23/big-buildings-can-cause-cities-to-sink-faster.

R. Buckminster Fuller. Utopia or Oblivion: The Prospects for Humanity. Edited by Jaime Snyder. Zurich: Lars Müller Publishers, 2019.

Ram Meena, Chet, Nitin Ajmera, and Pranaya Kumar Sabat. "Medical Textiles." TechnicalTextile.net, April 17, 2021. https://www.technicaltextile.net/articles/medical-textiles-2587.

Roman Mars. "Shade." Audio. 99% Invisible. Accessed May 21, 2021. https://99percentinvisible.org/episode/shade/.

Seikaly, Abeer. "Making Your Home, Wherever You Are." Presented at the TEDXKlagenfurt, 08 2018. https://www.youtube.com/watch?v=tYFzy1_EmBM.

Stattmann, Nicola. Ultra Light-Super Strong. Frankfurt, Germany: Birkhauser, 2003.

Thomas, Dana. "Why Won't We Learn from the Survivors of the Rana Plaza Disaster?" New York Times. April 28, 2018. 4/27/21. https://www.nytimes.com/2018/04/24/style/survivors-of-rana-plaza-disaster.html.

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