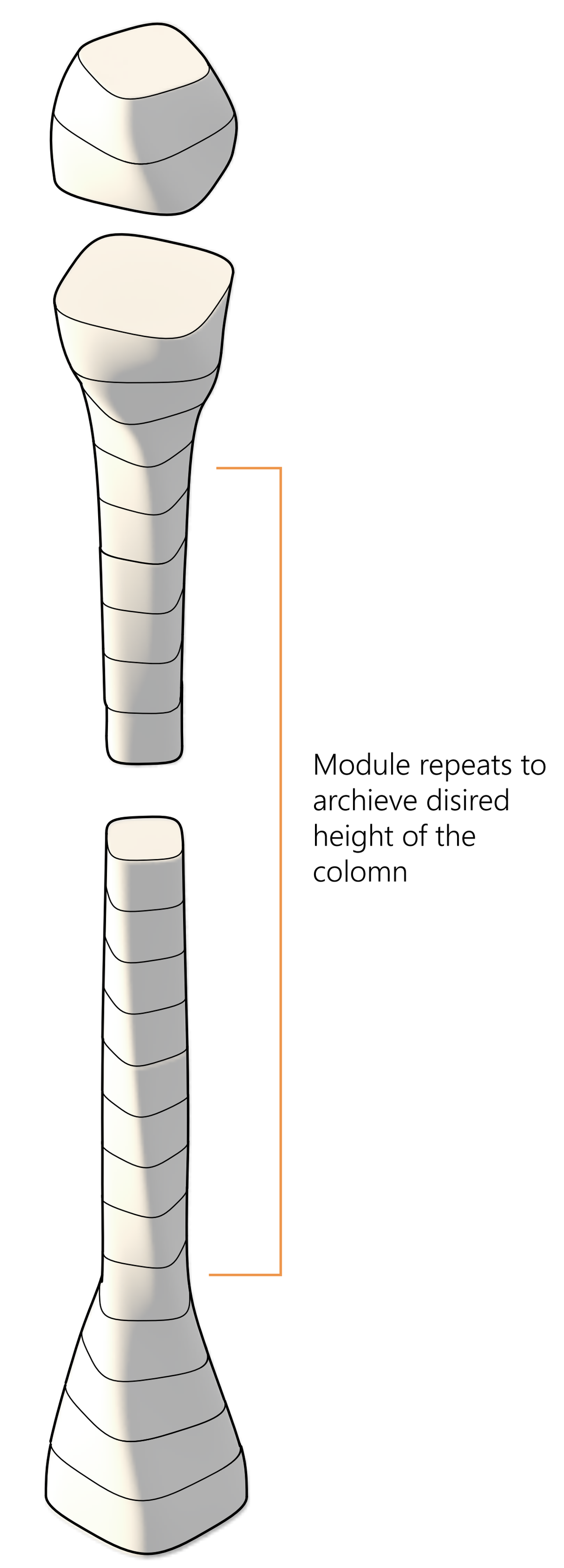
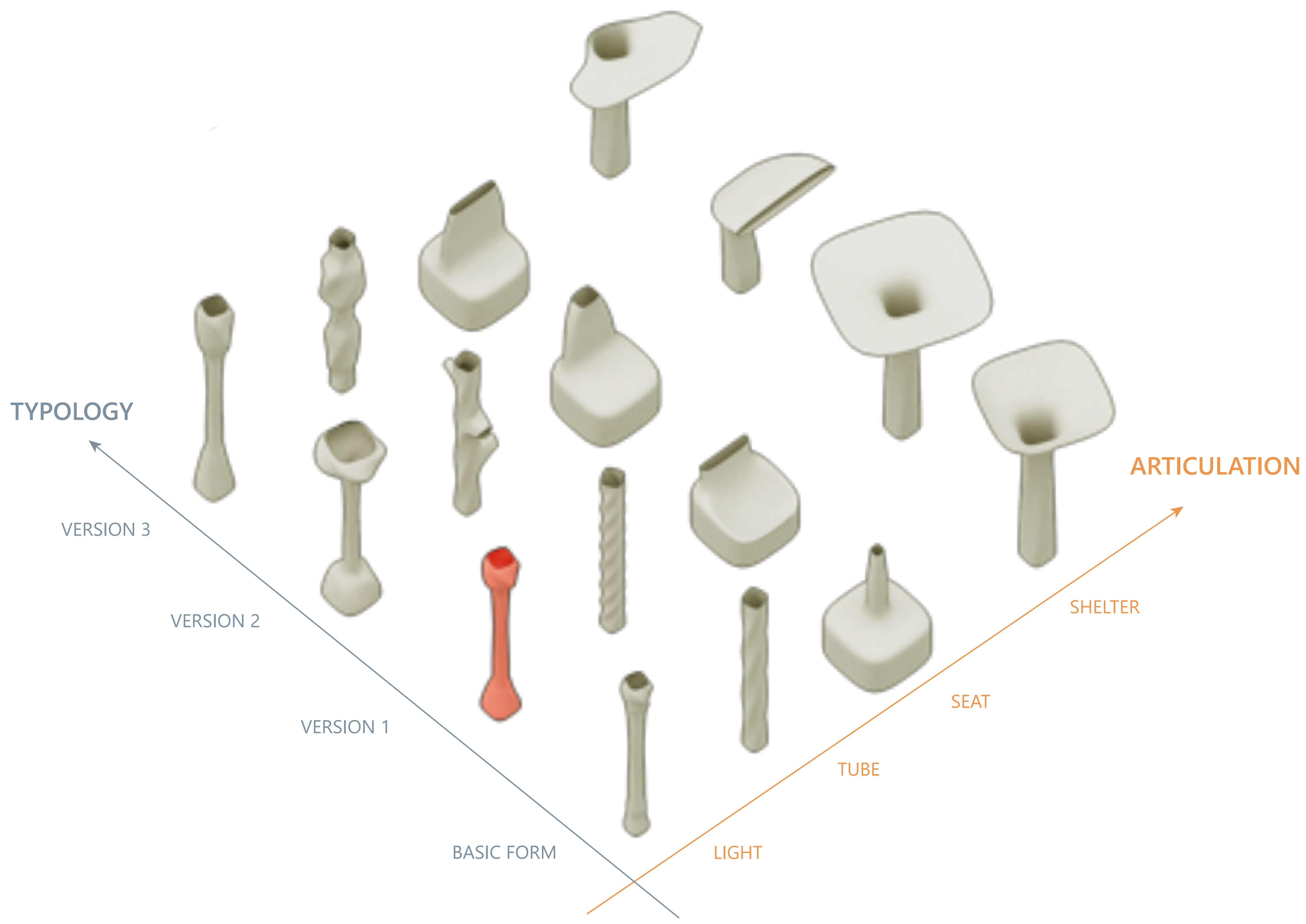
John Butler, Shirley Chen, Lee Chu, Cathy Dong, Colleen Duong, Christoph Eckrich, Vanshika Gandotra, Owen Haft
Fundamentals of Computational Design, Spring 2018

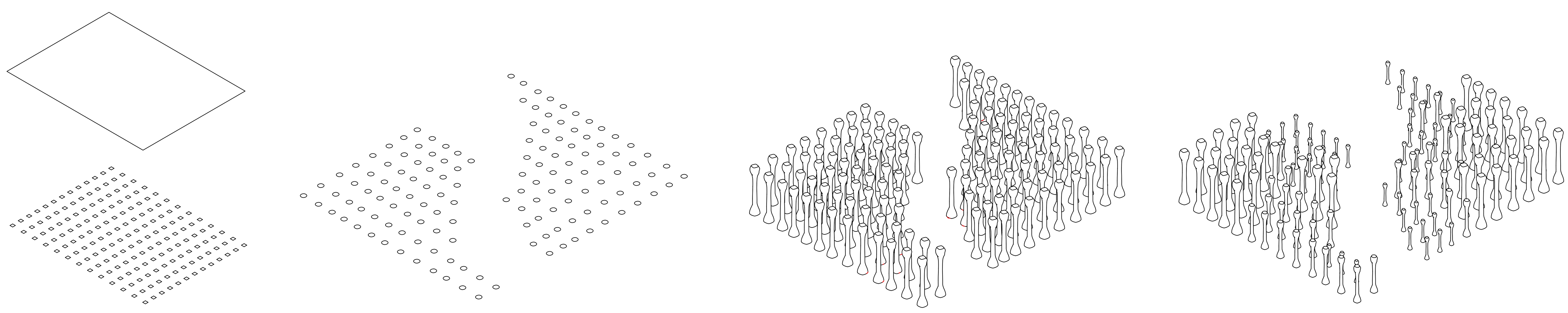
MODULE DIAGRAM



DESIGN MATRIX



COMPUTATIONAL ANALYSIS



Generation of an array to multiply unitary columns to create pavilion

Mapping column density to direct circulation

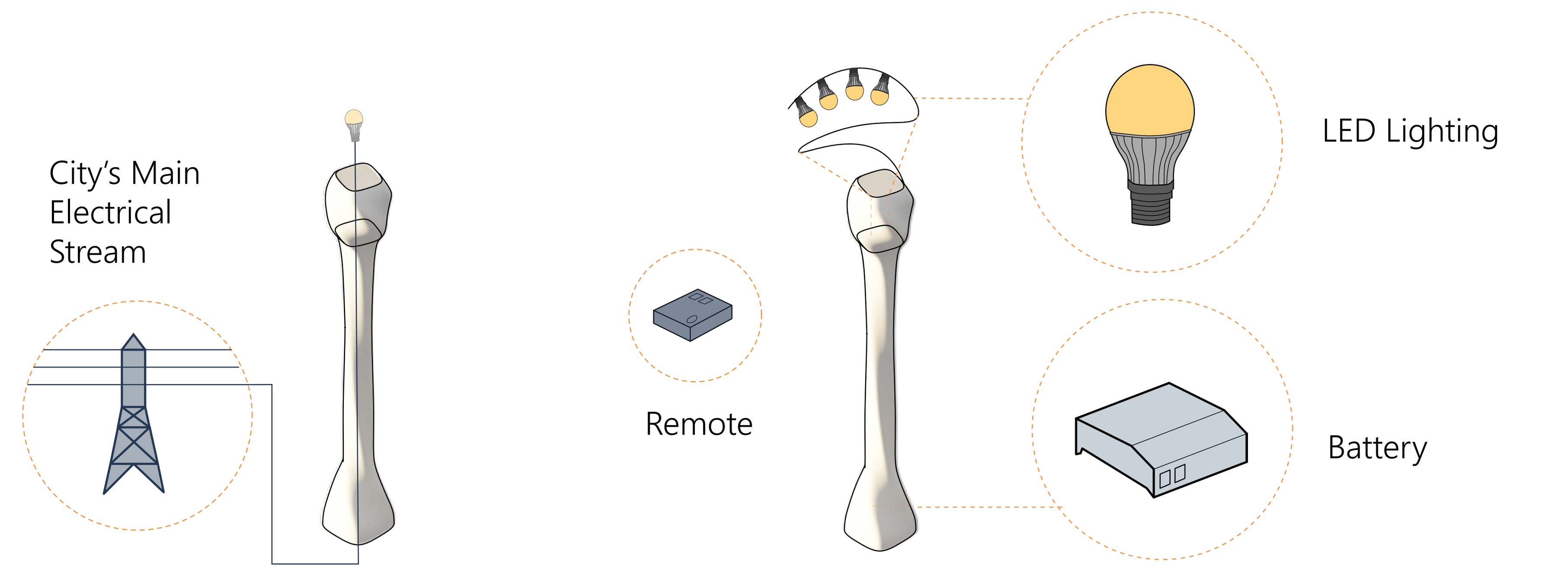
Arraying columns along generated grid as per circulation map

Generating range of scales as per density in circulation map

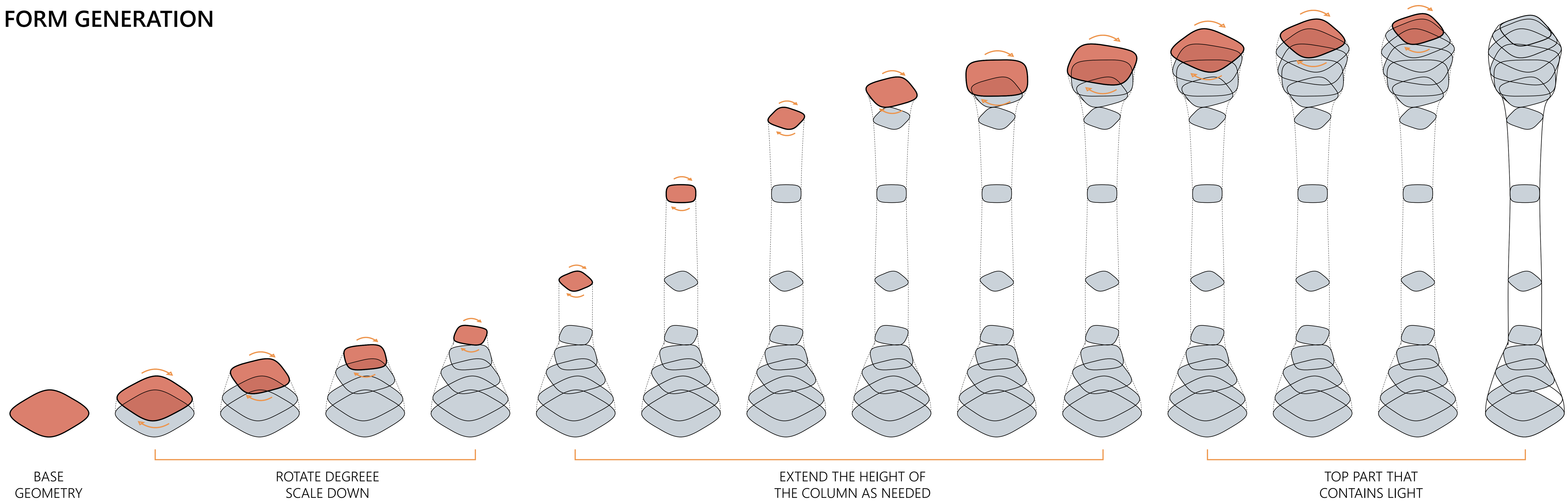
DESIGN DESCRIPTION

The objective of this project is to explore a design-to-material workflow through innovative material research and experimentation. Lux Pavilion consists of a series of light columns, varying in scale. These individual columns will be broken up into modules, which will be fabricated with a 2.5-axis CNC router. After the modules have been produced, a robotic arm will be utilized in weaving fibers around each of the molds.
The individual light columns are based on a rounded square, which is scaled in size to create the silhouette and rotated throughout the entire length of the light (see diagram below). LED lights will be situated within the top of the light column, and because of the nature of the composite material light will diffuse throughout the structure and shine through the individual fibers of the column.
Ideally, this light column can be replicated and mass-produced at different scales as lights or also as pavilions.
This pavilion can be used as entrance for a museum, restaurant, or art gallery, and these individual lighting columns can
be arraged to create paths to direct people go through the pavilion and reach the entrance their destinations.

LED LIGHTING



FORM GENERATION



Lux Pavillion
Research Board

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COMPOSITE MATERIAL USES

ROCA London Gallery
http://www.zaha-hadid.com/interior-design/roca-london-gallery/

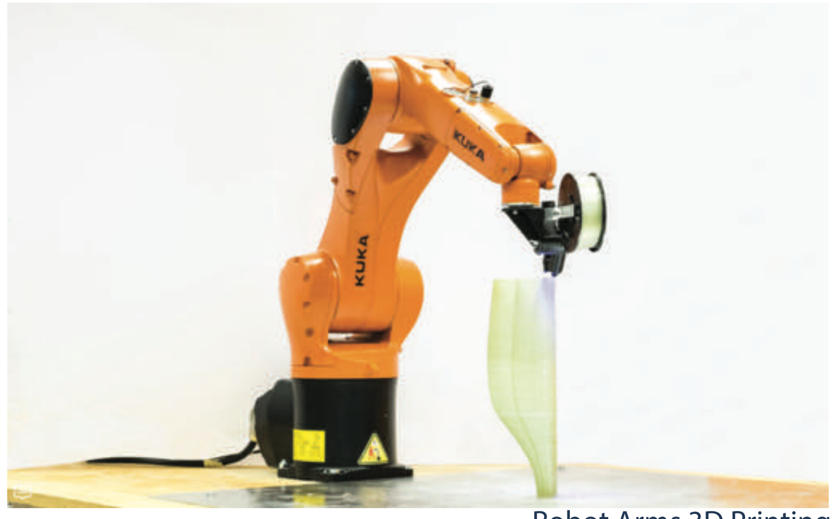
San Francisco Museum of Modern Art
https://www.sfmoma.org/read/made-bay-area/

PRECEDENTS

Urban Light
http://www.latimes.com/entertainment/arts/la-ca-cm-lacma-urban-light-20180214-htmlstory.html

ROBOTIC ARM

KUKA Robot Arm Weaving
https://www.dezeen.com/2016/05/09/carbon-fibre-robotic-production-fourth-industrial-revolution-university-stuttgart-achim-menges/t

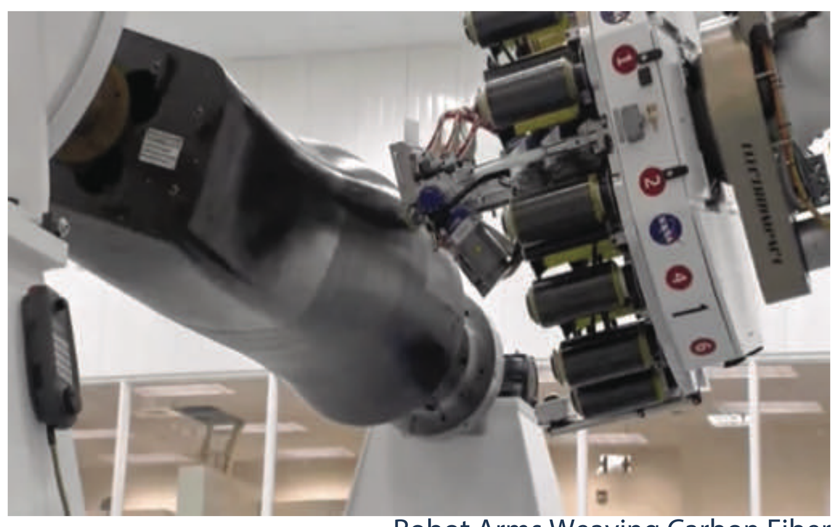


Robot Arms 3D Printing
https://www.archdaily.com/867696/atropos-this-6-axis-robot-arm-can-3d-print-fiberglass-composites

Dior Store
http://compositesandarchitecture.com/?attachment_id=3888

TMW Technical Museum
https://architizer.com/projects/tmw-technical-museum-vienna/

OV Pavillion
http://julies06.wixsite.com/uonat/single-post/2015/10/16/OV-PavilionArch-of-Kuwait



Robot Arms Weaving Carbon Fiber
https://gizmodo.com/this-robot-spins-carbon-fiber-threads-into-rocket-parts-1722022204

We began this project by researching buildings that begin to utilize composite materials in their designs. We found that there were different methods that architects use to incorporate fiberglass into the building's construction. Zaha Hadid Architects used fiber reinforced concrete to build the panels for the facade and extended it up to 2.20 meters in height in the ROCA London Gallery. All the panels were prefabricated in molds and constructed on site. The combination of concrete and fiber made the composite panels very robust. The San Francisco Museum of Modern Art used composite materials at a much larger scale. The architect used fiberglass reinforced panels that were uniquely shaped to construct the facade of the building. This building is the largest architectural use of fiber-reinforced plastic in the U.S. By using FRP panels, the weight of the building is significantly lighter than the glass fiber-reinforced concrete. Each panel required a unique computer numerical control (CNC) machined mold. In the House of Dior in South Korea fiberglass was used in the building construction. This project used fiberglass as a structural shell because of its lightweight property and it was easily assembled andpre-fabricated. Fiberglass is good at forming complex organic shapes.

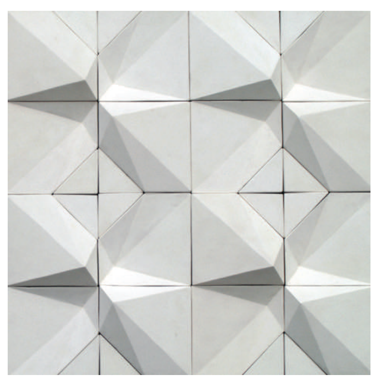
"Automated Fiber Placement (AFP)" is technology that was invented by Electroimpact, which is the automated process of layering and cutting carbon fibers in a bidirectional manner by a specialized robotic arm. It is utilized by NASA to construct large scale, yet lightweight spaceship parts. Similar machines have been used for many years to develop parts for aircrafts. For example, the robotic arm, Atropos, was developed by Architects at the Politecnico di Milano university. It prints thermosetting plastic with fiberglass embedded into the thermoplastic and uses a different method from the traditional one, where the solidification process happens after the fiberglass has been laid into a form mimicking more traditional methods. At the University of Computational Design and Construction in Stuttgart, architects and engineers have been using robotic arms to pre-build frames to "weave" carbon fibres into large scale lightweight shelters. The fibers being used are drawn through a resin bath and then wound around metal scaffolding. These fibres are left exposed aside from their coating in resin, which obviously is not applicable for building materials that require a degree of thickness.

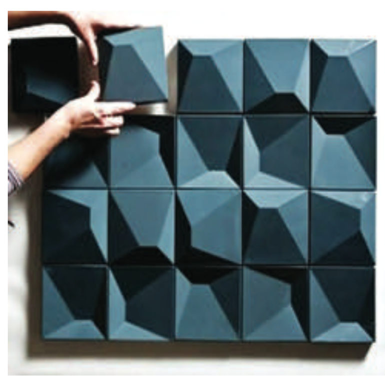
An advantage of weaving carbon fibres to create forms is the elimination of costly moulds and an advantage of using the robotic applications is their programmability and capabilities of mass production of uniform pieces. Using more versatile robots allows for the possibility of custom projects and more cost effective for the production of one-off creations.

From this research we found that the use of fiberglass as constructional materials is secondary, normally being added to other materials to reinforce the structure or acting as a structural shell that needs support from other structures. Therefore, we first came up with an idea of using fiberglass both as structural and ornamental elements. Given the translucency characteristic of the fiberglass, we decided to put lights in the fiberglass structure and manipulate the density of threaded fiberglass to control the intensity of the light coming through the fiberglass structure. Our precedent, LACMA, or Urban Light, is a large-scaled sculpture by Chris Burden located at the entrance of the Los Angeles County Museum of Art inspired us to create a light pavillion that consisted of multiple lighting columns. These columns are made from modules that can produce columns of various heights. Multiple columns can be arranged to create entrances, pathways, or lighting systems for the city.

MODULAR SYSTEM

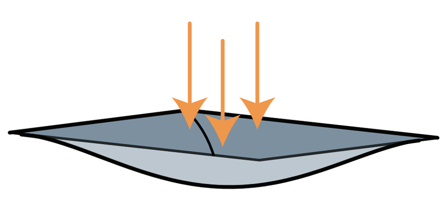
Intertwine



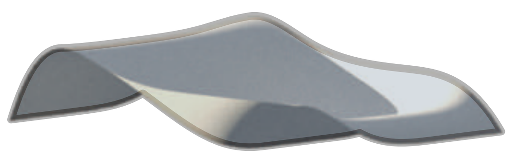


Czech Tile
https://www.behance.net/gallery/3903047/CZECH-TILES

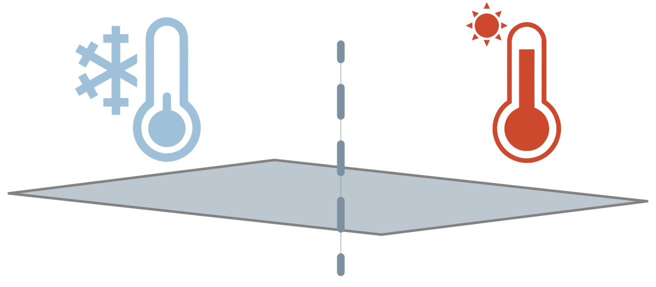
FIBERGLASS ADVANTAGES



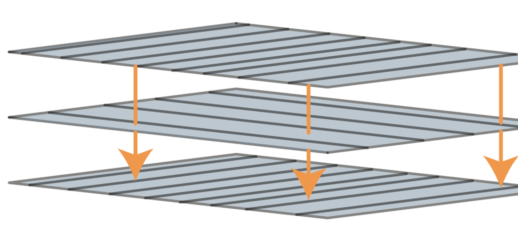
Strong in tension and compression



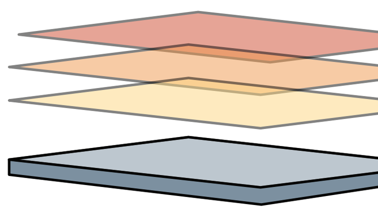
Easy to form organic shape



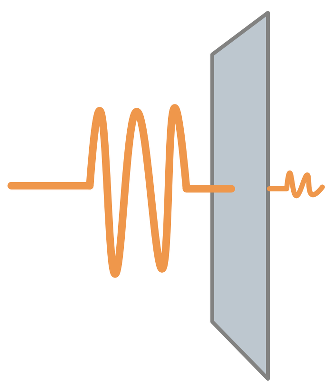
Low thermal expansion or shrink makes it durable.



Overall stiffness and strength can be efficiently controlled by laying layers oriented in various directions.

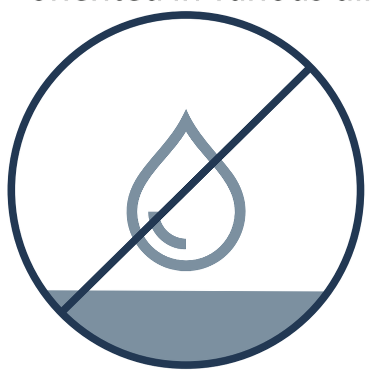


Fiberglass can apply a wide range of surface finishes.



Absorbs sound waves more than bounces off, thus giving it extremely good acoustics, for lowering machinery volumes and achieving acceptable and/or required sound.

Fiberglass is non-conductive

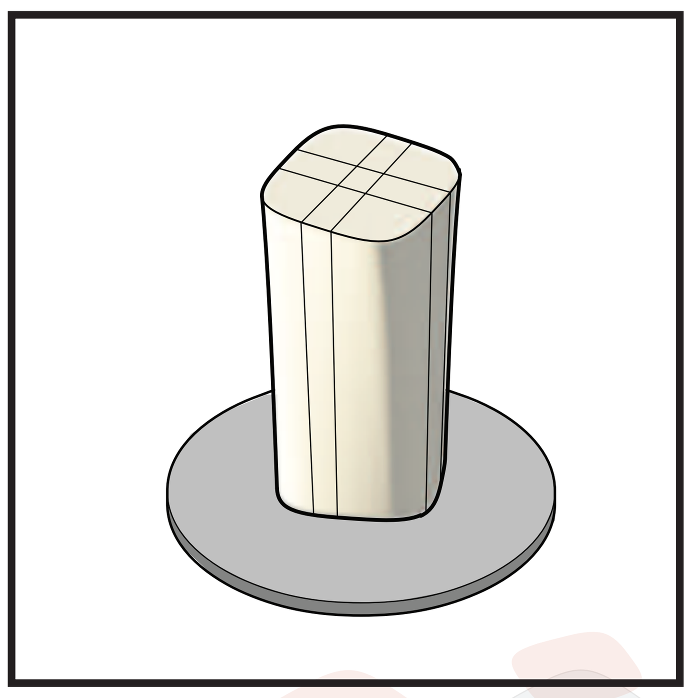


The water absorption is less than 2% when fiberglass is immersed in water at 30°C

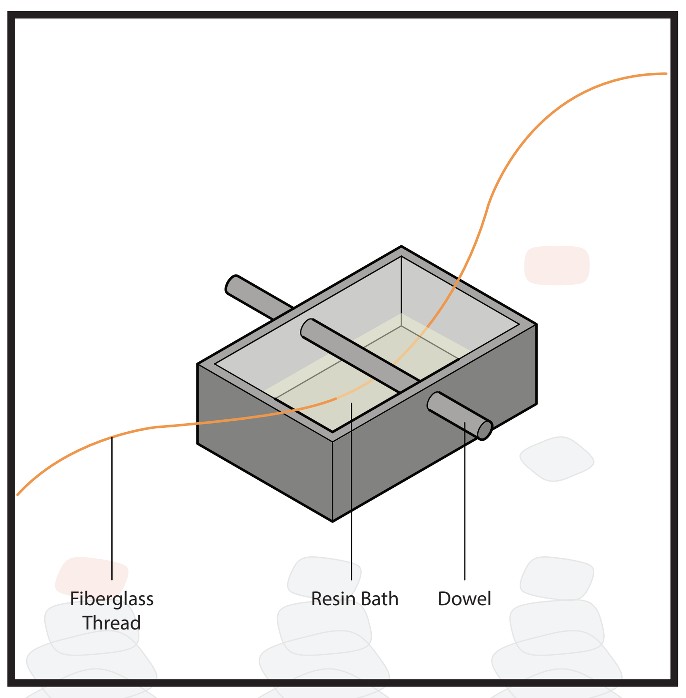
80+

Without any maintenance it can be sustained for more than eighty years
http://www.fiber-techinc.com/capabilities/extras/fiberglass-benefits/

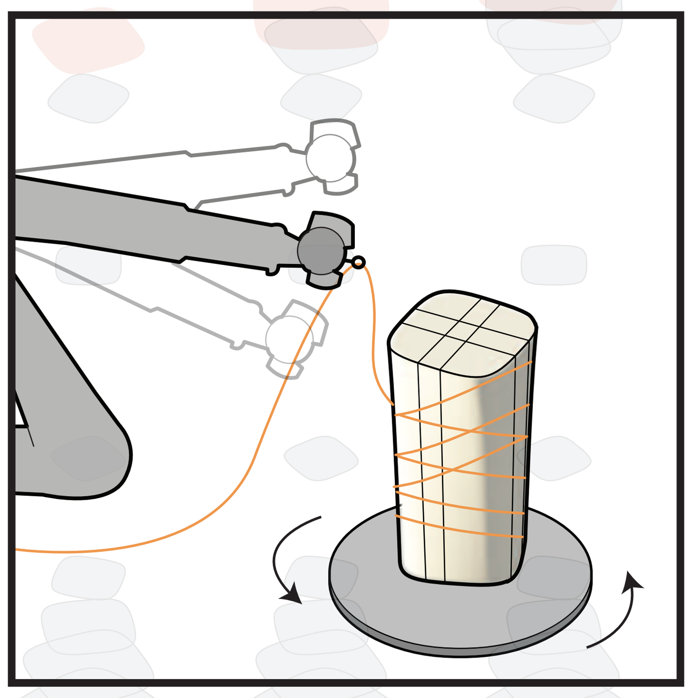
ROBOT ARM WORKFLOW



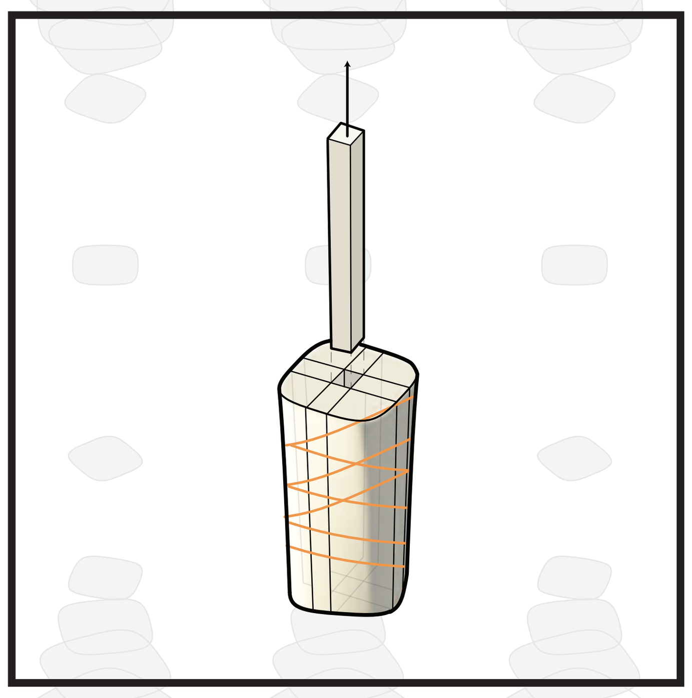
FORM MOLD
Place mold onto rotating stand to keep it static.



COATING THREAD IN RESIN
Using a simple open box, attach a dowel through the center of the box and place the thread underneath the dowel and fill the box with resin.



ROBOTIC ARM MOVEMENT
Robot arm programmed to wrap strand around the static model.



REMOVAL OF MOLD
Slide out split pieces from final structure after dried to remove mold from the fiberglass strand structure.

Lux Pavillion
Architectural Representation

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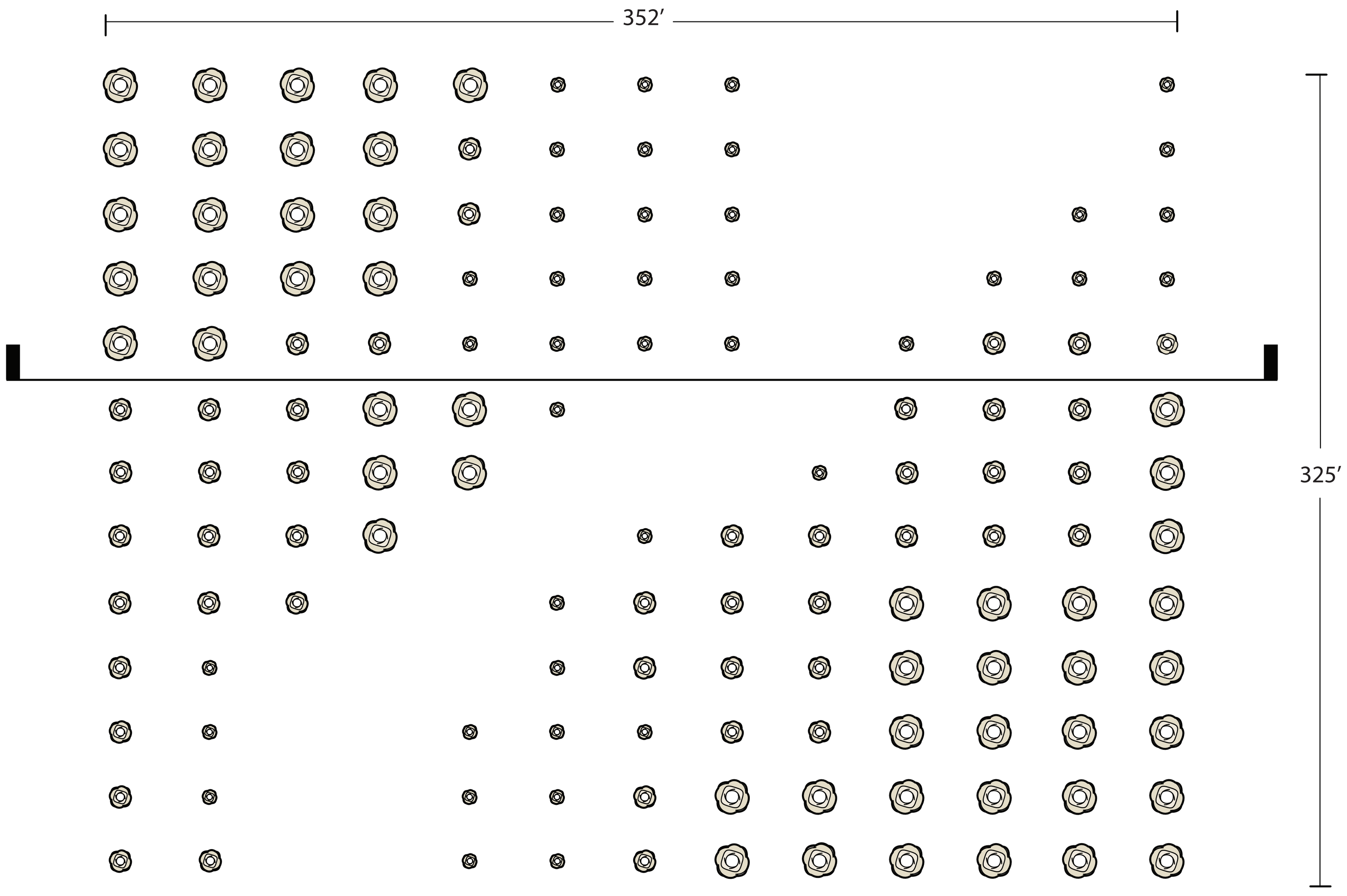
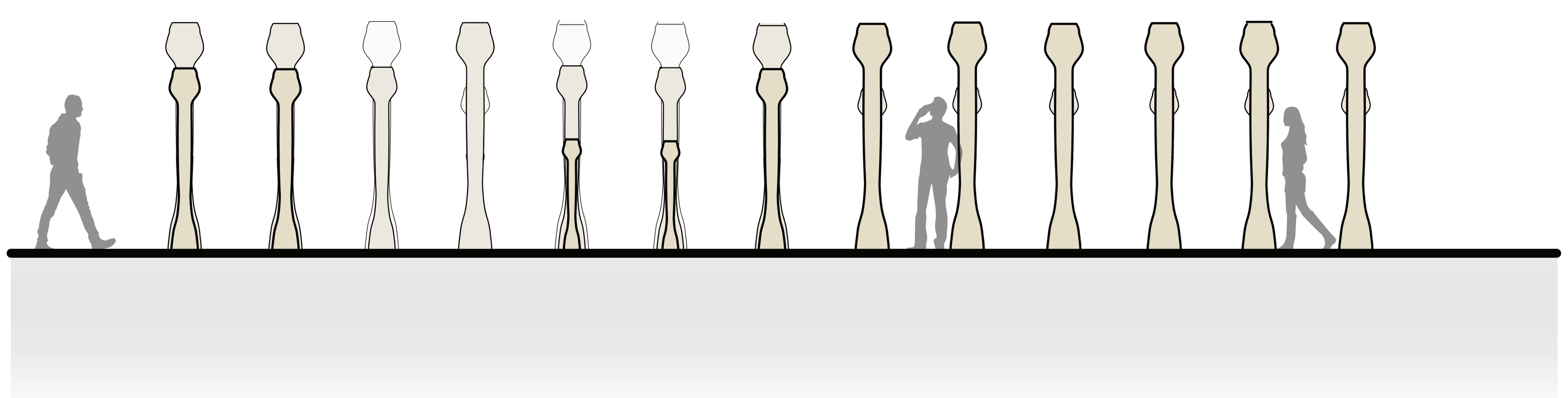
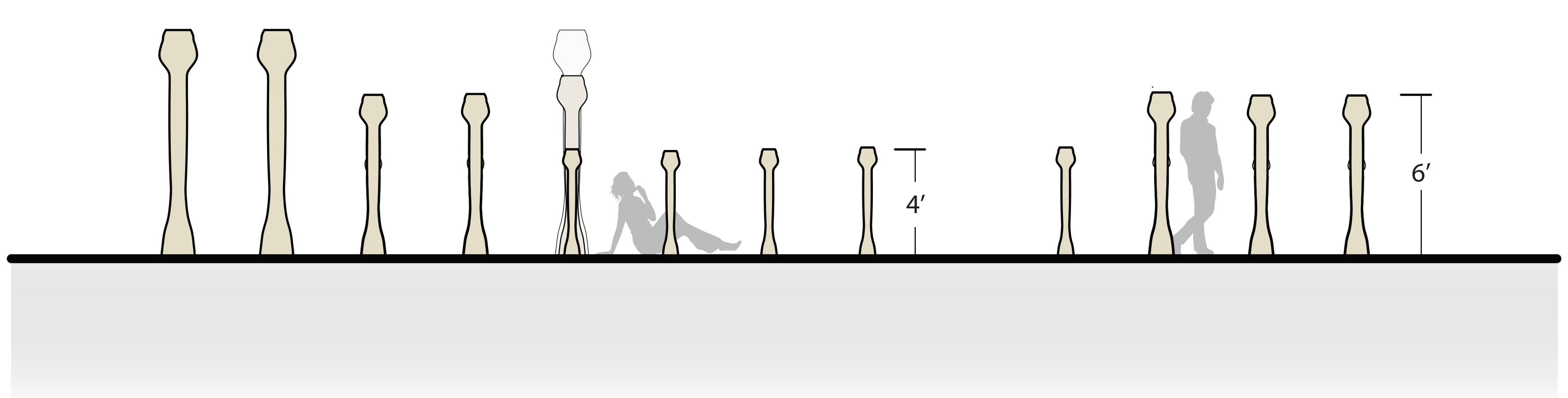


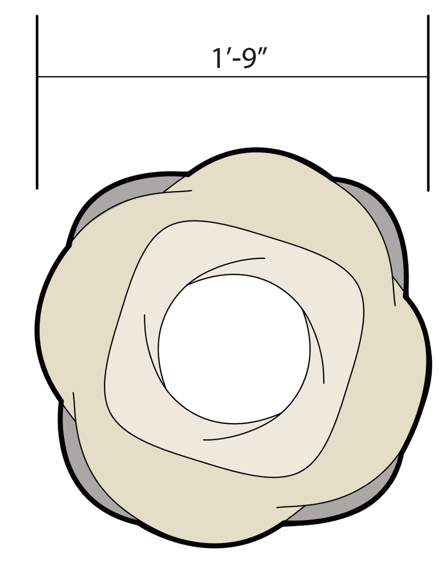
PLAN

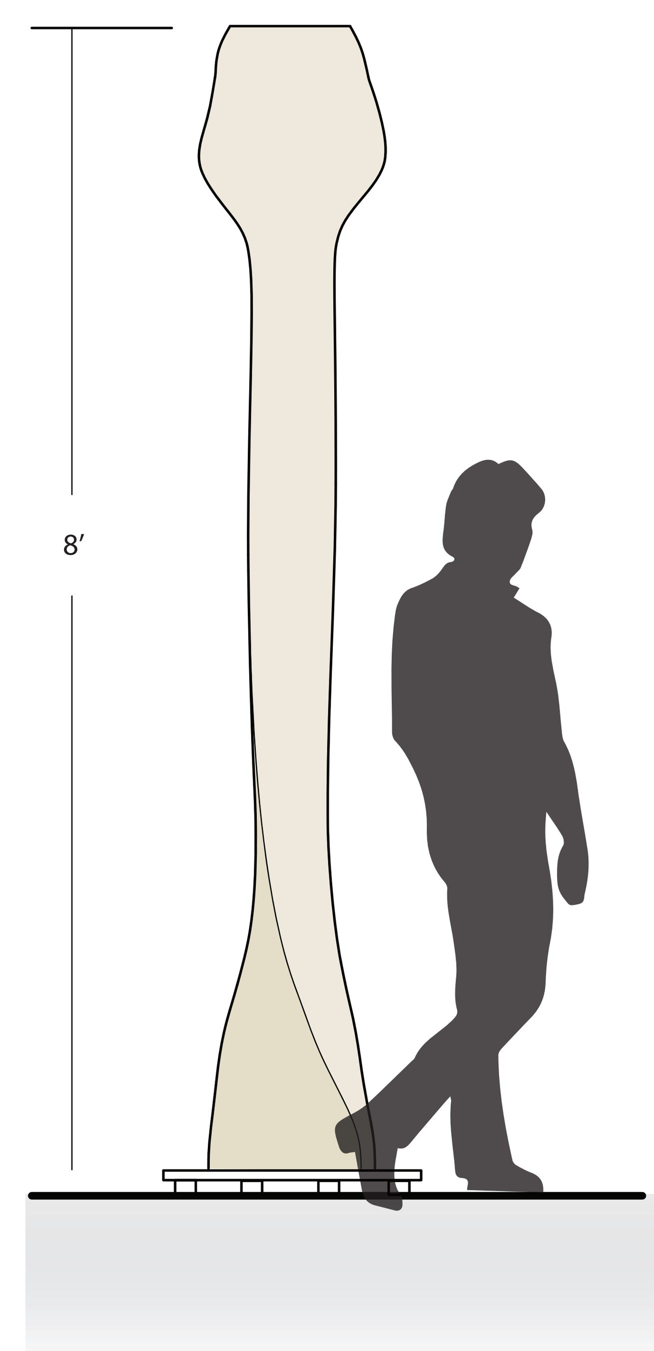


ELEVATION

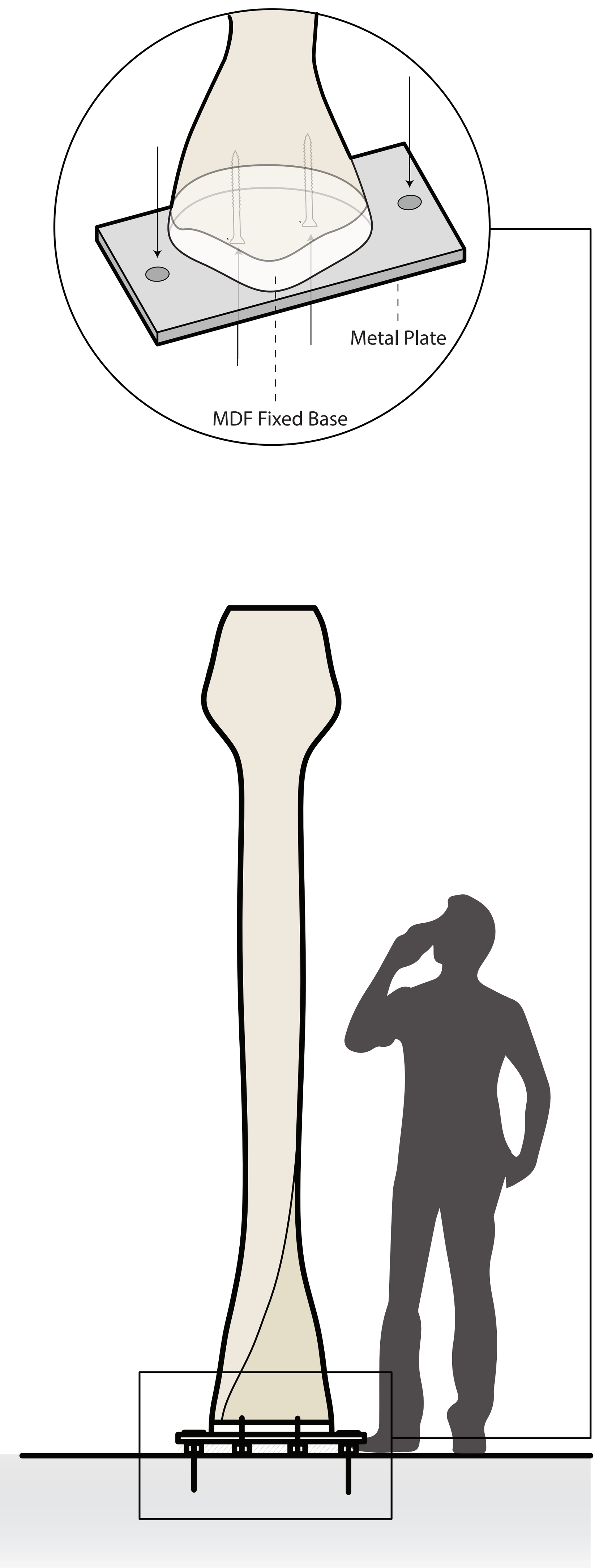


SECTION





ELEVATION



SECTION

Lux Pavillion
Digital-To-Physical Fabrication Workflow

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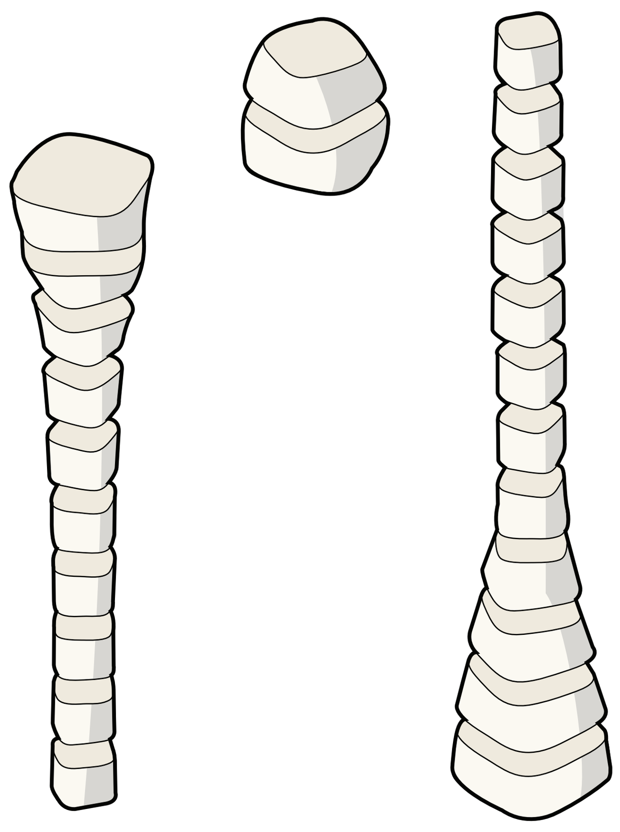
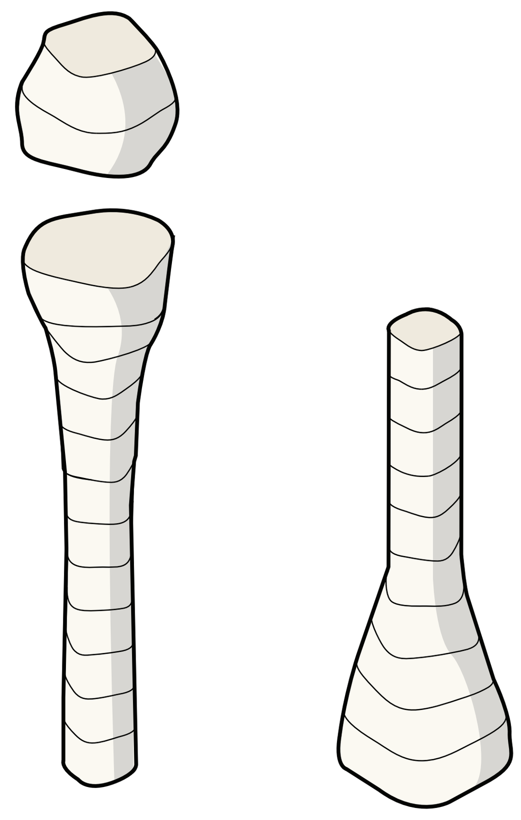


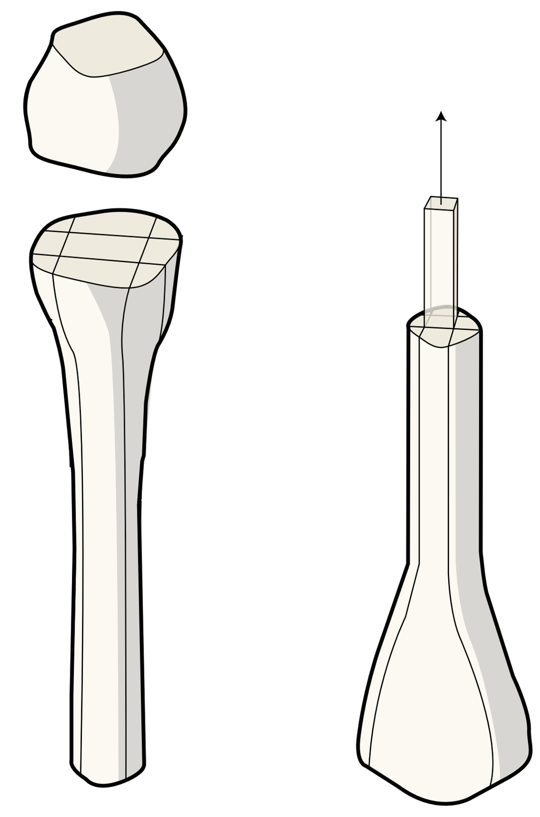
MULTIPLE PIECES

cnc the multiple parts of the entire structure.



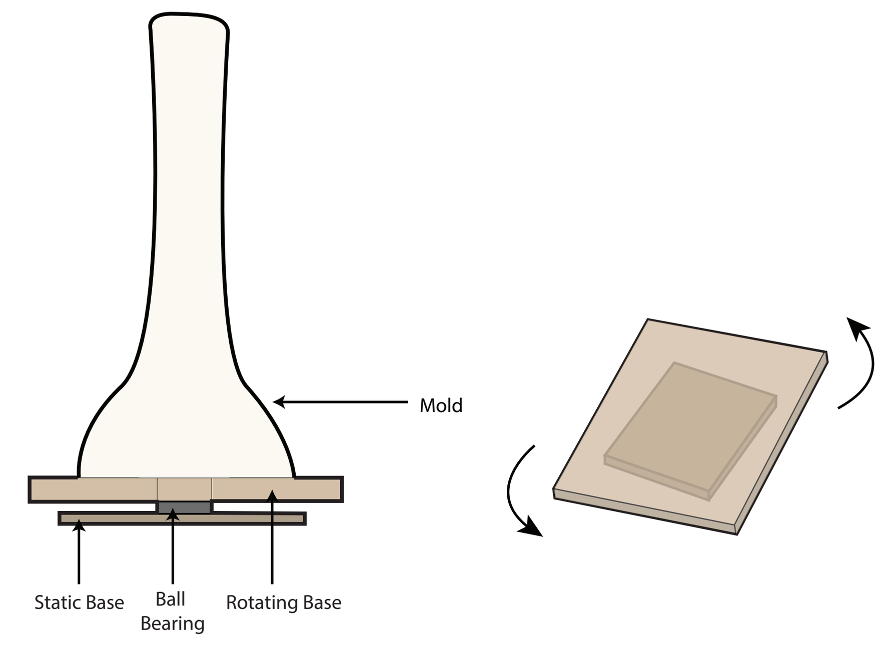
CONNECT

Glue the multiple cnc'd parts together to create three whole molds to use for fabrication.



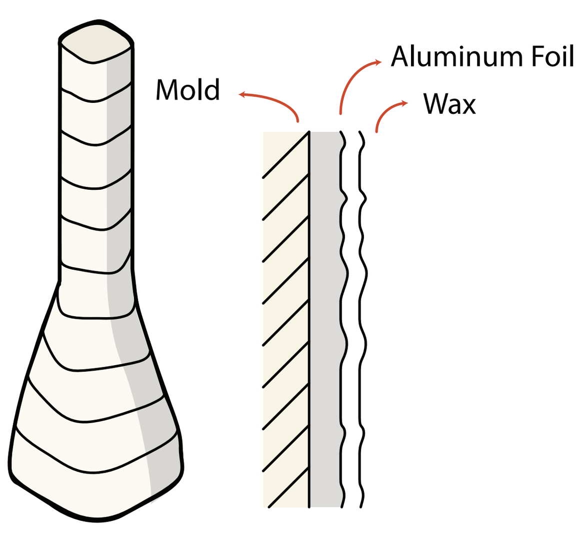
DIVIDE

Divide two of the molds into 9 pieces to allow for the mold to be removed after its used and be reused.



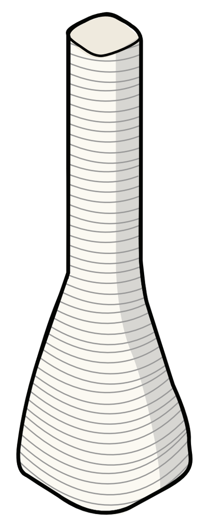
ROTATING TABLE

Using a 6" Lazy Susan (ball bearing), attach it to the center of a piece of wood and rotate it by hand.



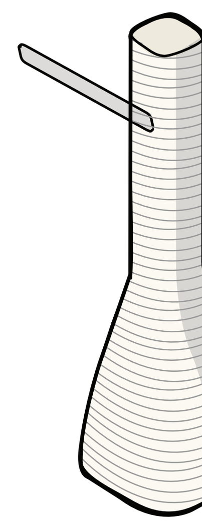
MOLD PREPPING

Apply aluminum foil to the mold and then apply wax to the aluminum foil.



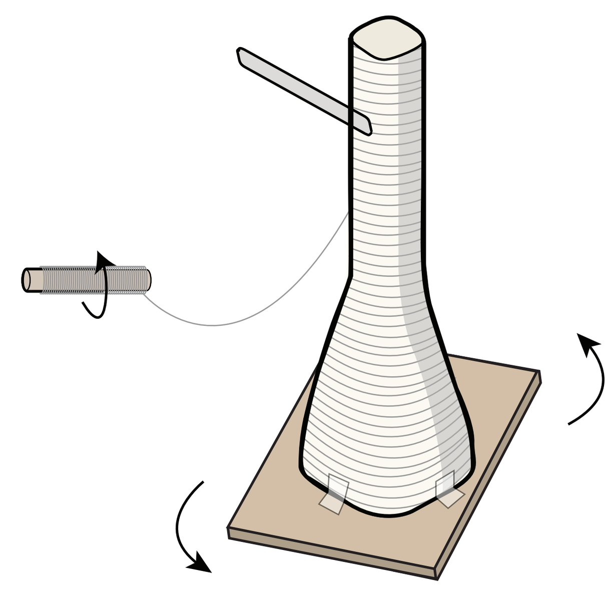
WRAPPING

Wrap the mold with fiberglass string by hand.



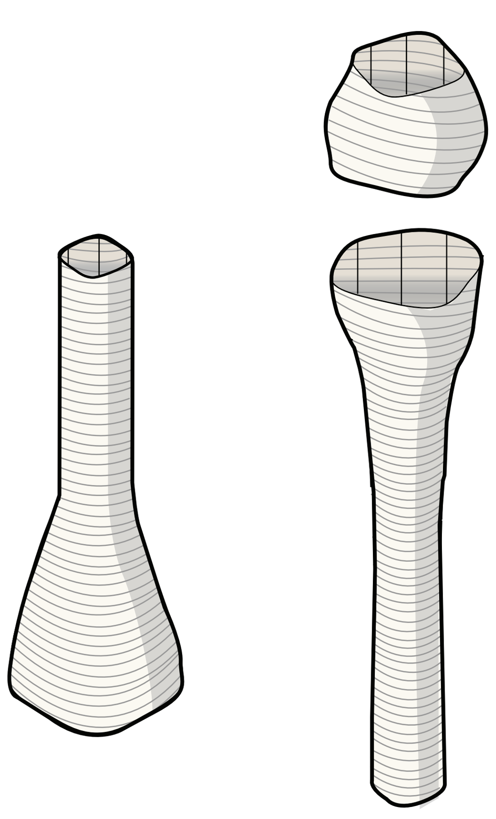
APPLY RESIN

While one person is wrapping the mold with fiberglass, another person apply the resin to the fiberglass.



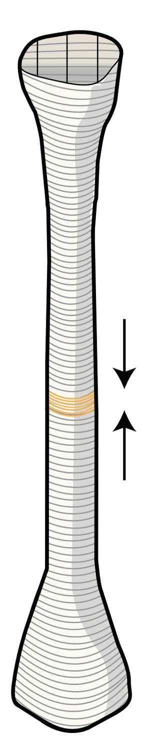
REPEAT

Repeat wrapping and applying the resin until the wanted thickness for that particular piece is reached. (2 layers for the base and 1 layer for the rest of the model). The mold is attached to the lazy susan using tape.



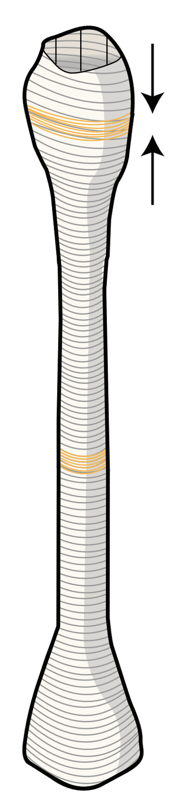
ALL WRAPPED UP

Successfully wrap and apply resin to both molds and let them dry for several hours. Then, remove the molds from the dried model.



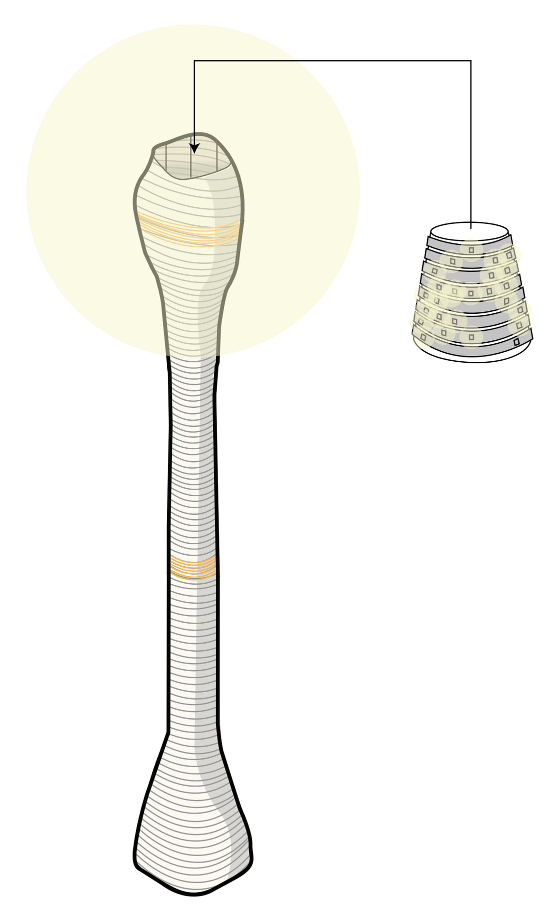
ATTACH 1 TO 2

Attach the two long pieces together using the same method that was used to wrap the mold.



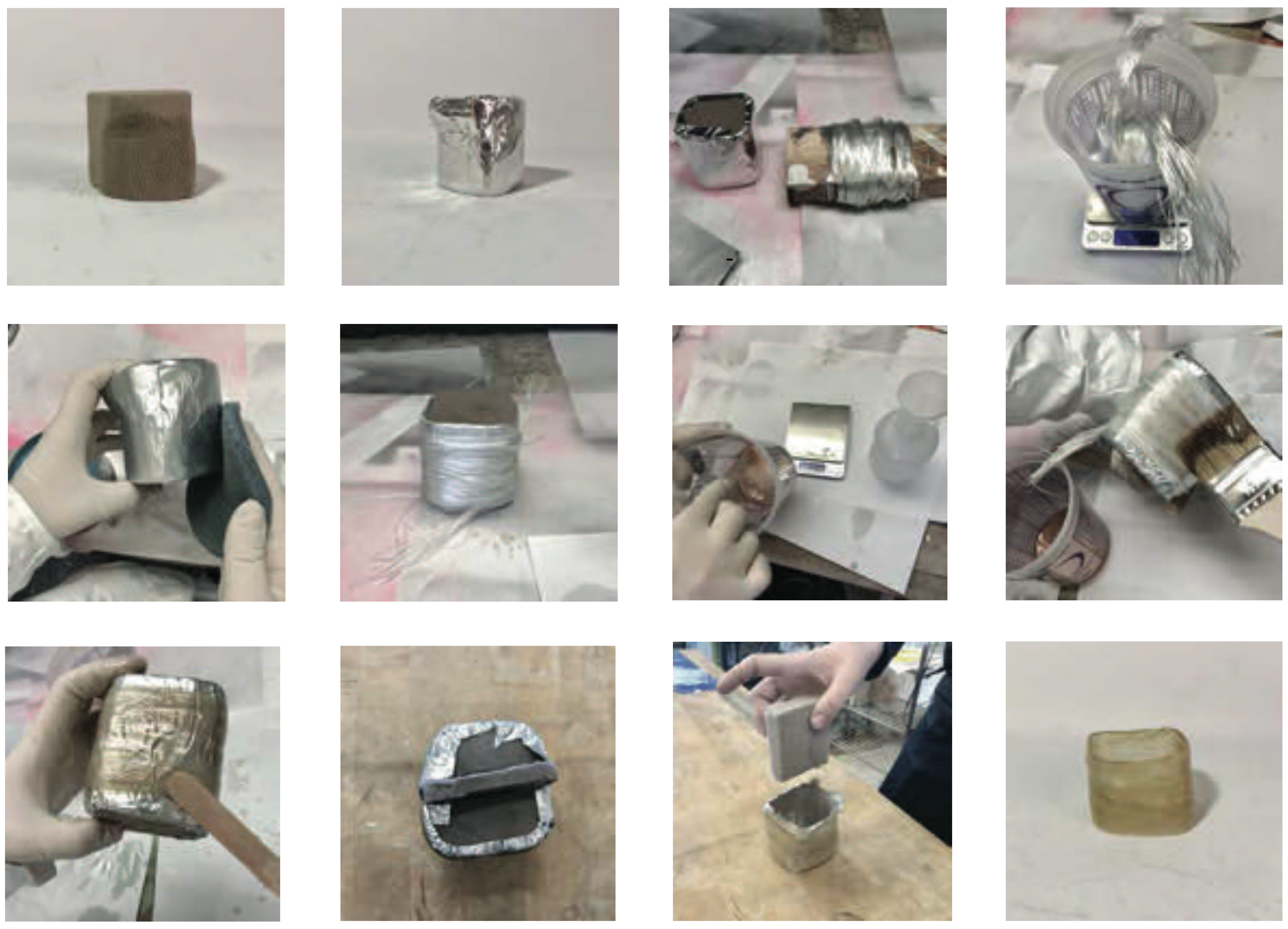
ATTACH 2 to 3

Attach the last piece to the top of the entire structure using the same method as the previous step.



INSERT THE LIGHT

Wrap the lights around a plastic cup and place the cup through the hold at the top of the model. The bottom of the cup is wider than the middle of the model, which will prevent it from falling through.



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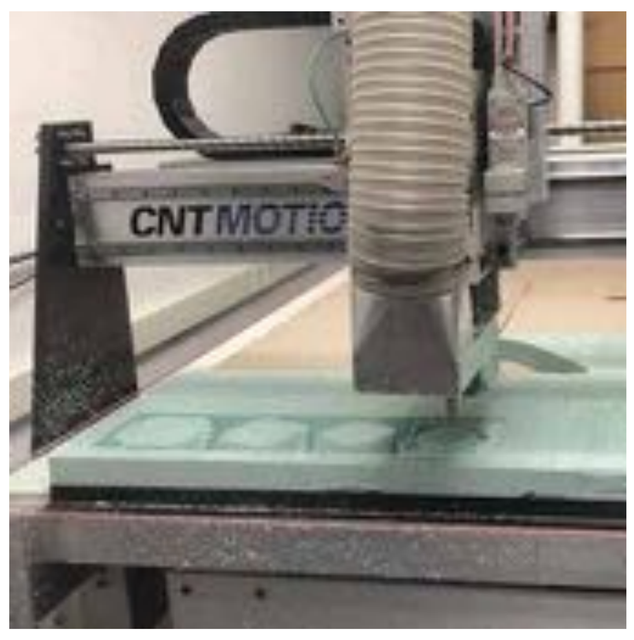
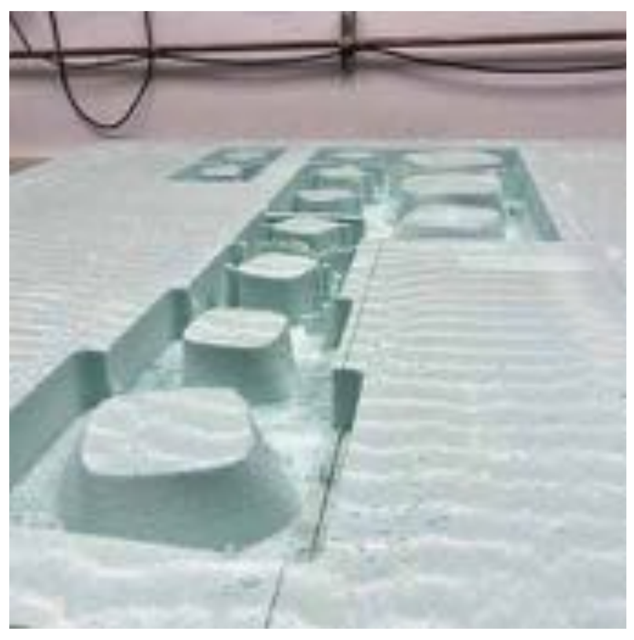
Molds

- CNC molds in separate pieces
- Manually post-process molds
- Assemble molds into three modules







Fabrication

- Prep molds with alumium tape and wax
- Fix molds onto the spinning table
- Mix resin and activator for use
- Apply resin while wrapping the fiberglass string
- Let dry and remove mold
- Sand edges
- Connect three segments with fiberglass string and resin with the same technique
- Keep stable with sticks (taped and waxed)












Final Product

- Assemble LED lights