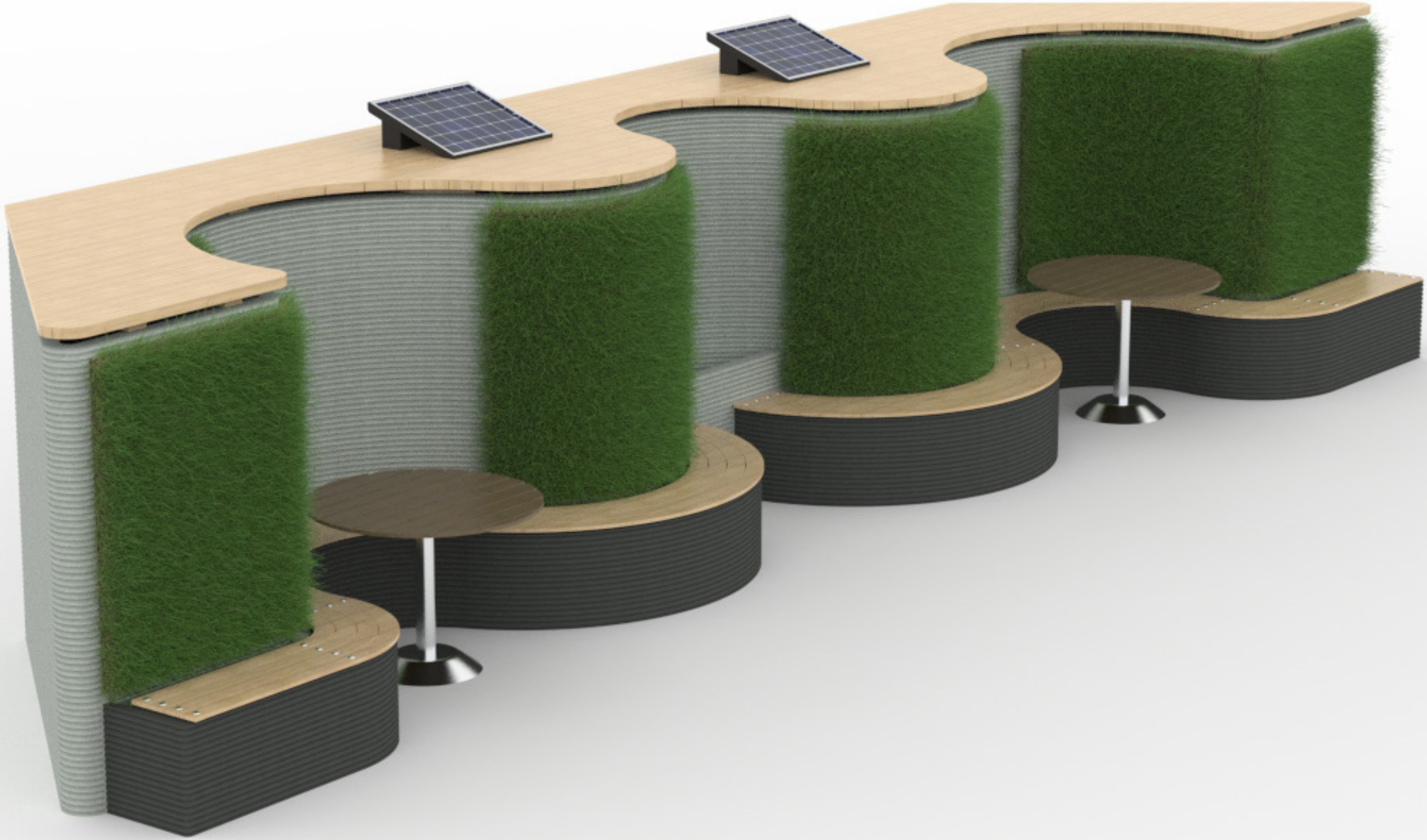
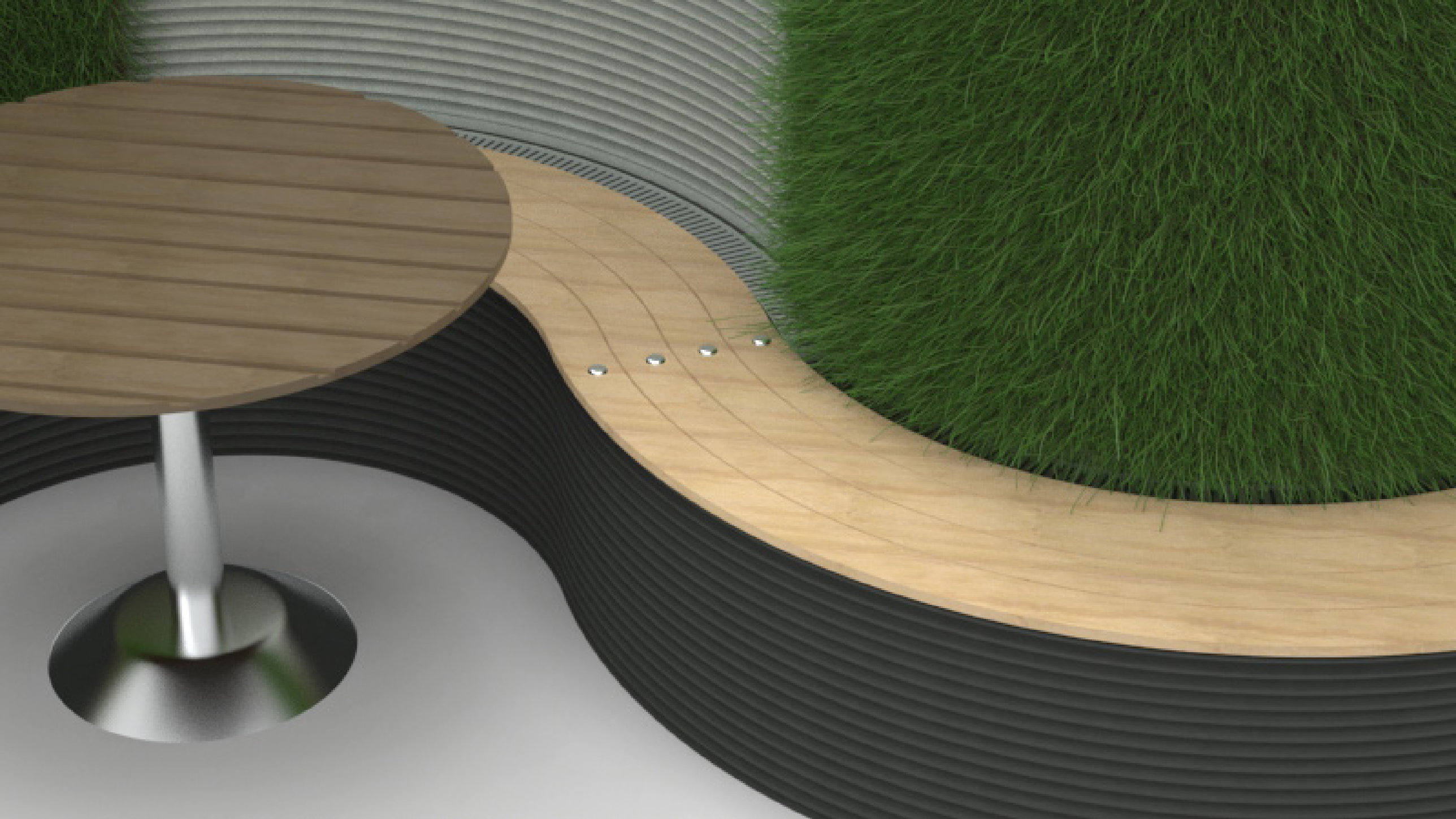
Urban Green Wall & Seating Unit

An Exploration of Concrete 3D Printing Technology

Design Thesis: Process Book

Samantha Gaerk





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Project Abstract

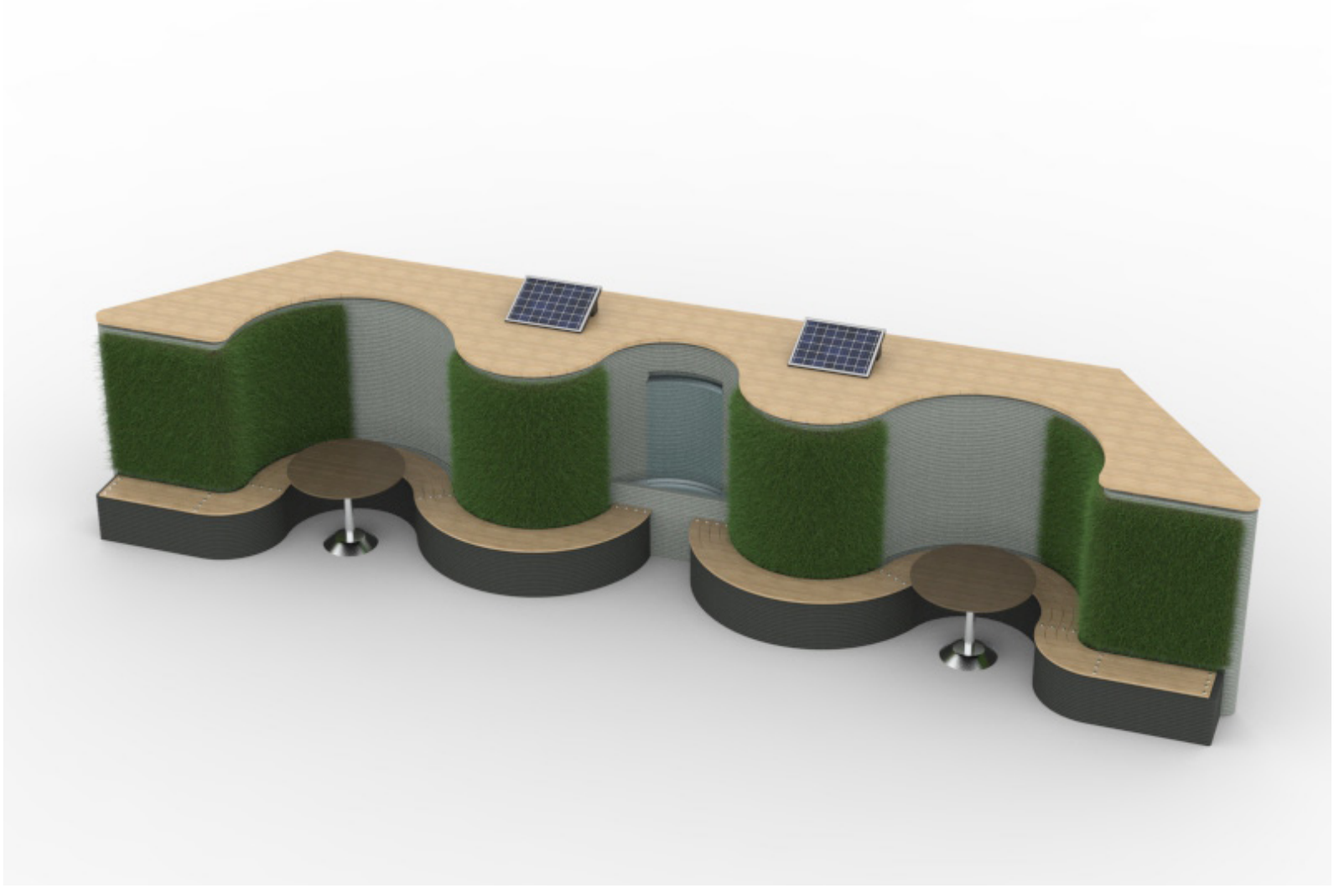
Urban Green Wall & Seating Unit: A Concrete 3D Printing Exploration

In this project, I have developed a green wall and outdoor seating unit with the goal to reintroduce greenery and plant life into urban spaces. Through execution of this goal, I am also exploring potential future applications and possibilities offered by concrete 3D printing technology.

Urban environments have developed with little thought to space for nature, and as a result, it is largely absent from the urban context and absent from the lives of urban individuals.

This green wall and outdoor seating unit provides a vertical structure for plant life to grow and provides its users space to sit and enjoy the thriving greenery. It also features a water fountain irrigation system, not only to maintain the plants, but for added beauty and a relaxing atmosphere.

With the potential to increase individual appreciation for and engagement with nature more actively, this project draws attention to the need for creative solutions for the future of urban development.



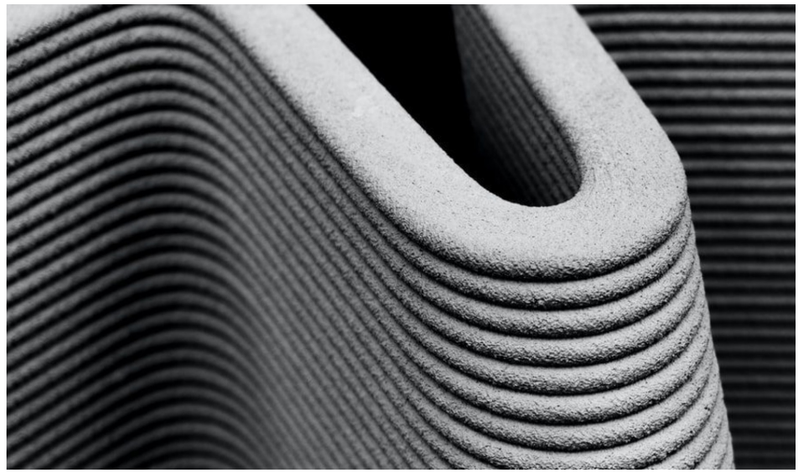
Original Project Abstact Document can be viewed here:
Urban Green Wall & Seating Unit Project Abstract

Assigned Project Brief

Partner: CDME

Scientists, Engineers, and other technologists, often develop new technologies without clear visions for all the purposes they may serve, calling for further creative exploration by people like designers, to maximize the potential of these technologies. Additive manufacturing (3D Printing) is one such area that has been seeying a lot of development in the past few years. Technological developments have allowed to improve and explore things like materials, speed, and printing fidelity. With these developments, new creative spaces or offered to designers to envision uses of these technologies. Through this project, students will be challenged to explore the potentialities offered by the COBOD - BOD2, a large - scale concrete 3D printing recently acquired by CDME. The goal of this project is to provide insight into the creative uses of the technology from the perspective of industrial design. Through these speculative explorations, students will contribute to the expansion of CDME service portfolio but also support expanding knowledge on the uses of new manufacturing technologies.

Keyword: Material and Processes, Speculative Design, Large - scale, R&D



Research Overview

Project Mission/Overarching Goal

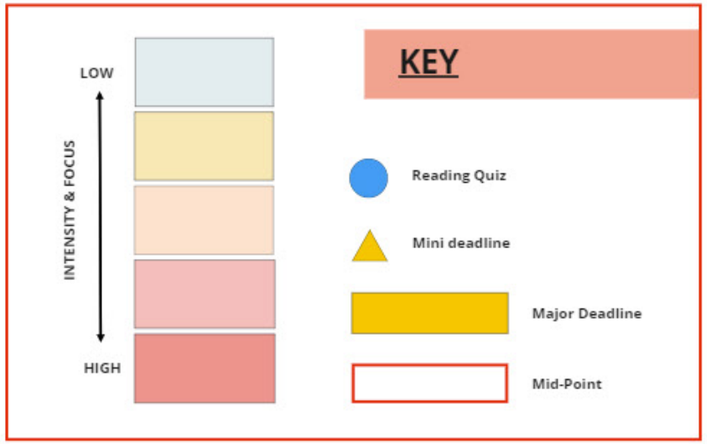
Ohio State's Center for Design Manufacturing and Excellence, or CDME, has recently acquired a new piece of additive manufacturing technology; the COBOD - BOD2, a large - scale concrete 3D printer. With a printing area of approximately 20ft wide, 30ft long, and 10ft tall, this printer has the capabilities to print large sturdy structures.

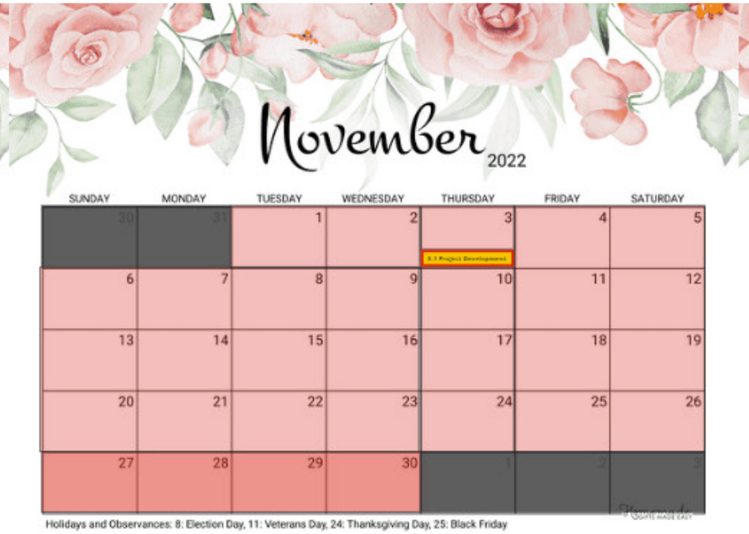
In this project, I will be partnering with CDME to explore potential new applications of the technology. By performing speculative explorations and providing insights into the creative uses of the technology, I hope to contribute to the ever growing and expanding knowledge of concrete 3D printing and additive manufacturing technologies.

NOTE Unfortunately I will not have access to the printer until sometime after this project has reached completion, however I am confident other forms of additive manufacturing may serve the purpose of prototyping and learning for this project.

Research Overview

Early Projected Project Timeline





Research Overview

Going into a project with such a broad topical brief and a nearly endless horizon of design possibilities, I felt it necessary to pick a secondary research direction to develop my project further. After exploring my options and interests, I decided to focus this secondary research, and project as a whole, on urban spaces - specifically greenery in urban spaces. This decision was motivated most notably by the initial survey responses I recieved, which will be explained in further detail in that section of the Op-Ed.

My research was broken into three facets, primary, secondary, and outside sources. Primary and secondary will be explained in further detail in the Op-Ed newspaper section and the outside sources will be explained in the Literature Review newspaper section.

Primary Research

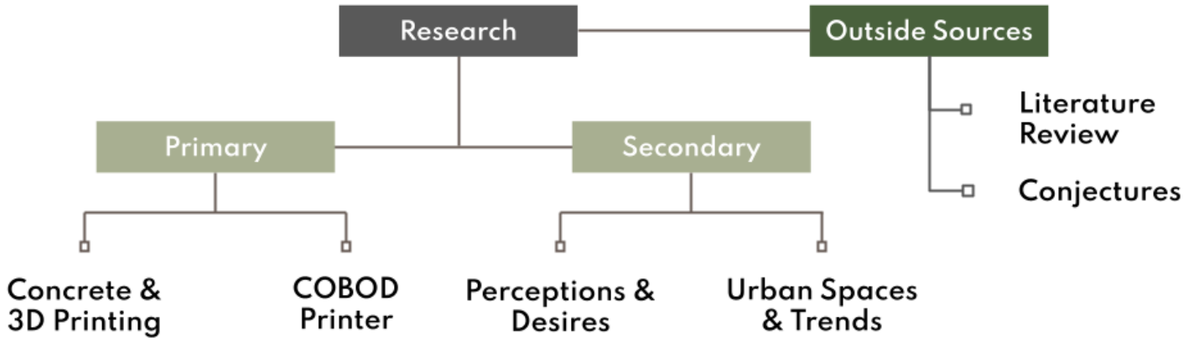
- Concrete material properties and limitations
- 3D printing possibilities and trends
- Current trends/uses for concrete 3D printing
- COBOD printer specs, strengths, and limitations
- Public perception on concrete 3D printer technology

Secondary Research

- Benefits of greenery/nature
- Realities of urban spaces
- Existing green spaces in urban contexts
- Trends in urban style and space
- Perceptions and desires of urban dwellers
- Other project development research

Outside Sources

- Literature Review
  - Knowledge from Additive Manufacturing Focus
  - Developments in Science & Technology
  - Concepts in Business
  - Inspiration from Art
- Conjectures



Research Overview

Thoughout the entire research process, a process that was highly cyclical, various methods were used to gather information, insight, and develop design direction. I primarily utilized six different methods, each uncovering new and nuanced insights. It is also important to note that additional online research was conducted at various points in the design research process.

Research Methods

01 Surveys

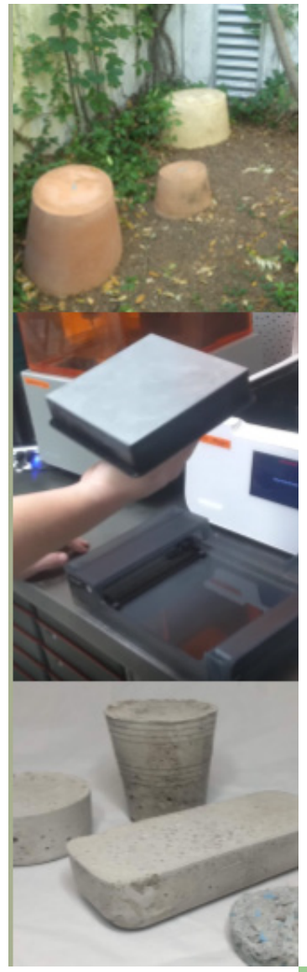
02 Observations

03 Literature Review & Conjectures

04 Expert Consultation

05 Market Trend Analysis

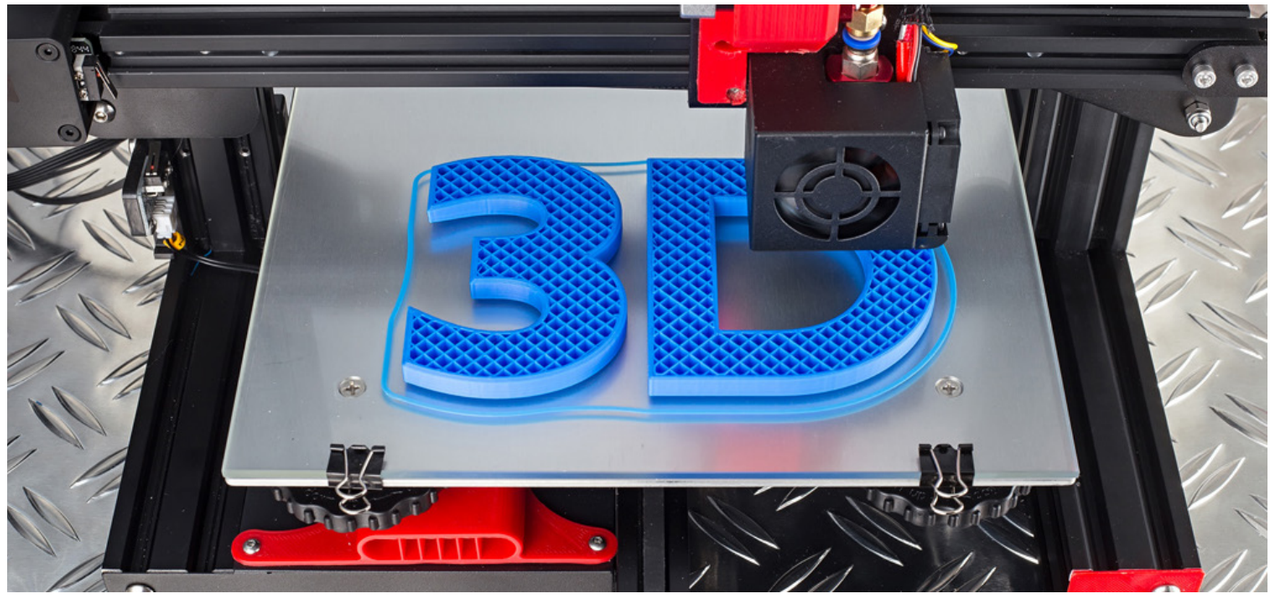
06 Material Exploration & Prototyping



Newspaper Dossier - Op-Ed

Project Op-Ed

This section serves to provide further context into the problematic, situation, issues, stakeholders, and their interrelationships.



Additive Manufacturing

In recent years, additive manufacturing, more commonly known as 3D printing, has been a topic of conversation within the realms of art, business, technology, and industry. You may have heard about 3D printers in the news or online, and you may even know someone with their own small-scale 3D printer. So what is all of the talk about? What exactly is additive manufacturing and what makes it so special?

Rather than more traditional forms of manufacturing where material is cut away or subtracted from a material to create form, additive manufacturing adds material layer-by-layer to create form. This allows for generally less material waste and offers many opportunities for interesting forms and complex geometry never before possible with traditional manufacturing means.

One aspect of 3D printers that is so unique and interesting is that the technology was developed without a clear direction or vision for all the purposes it would serve. Though additive manufacturing has been around since before the 2000's, the extent of the technology's capabilities has been left largely unexplored. This invites designers and other creative professions to uncover the technology's untapped potential. Advancements in printing speed, printing fidelity, and material capabilities have opened the doors of possibility even further for designers to explore future applications of the technology.

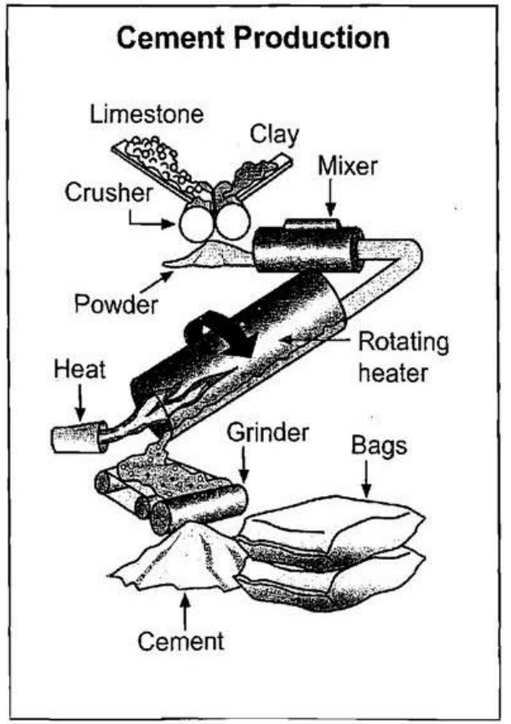
It is at this point where I believe it best to introduce the great opportunity I have been given and the premise of my project.

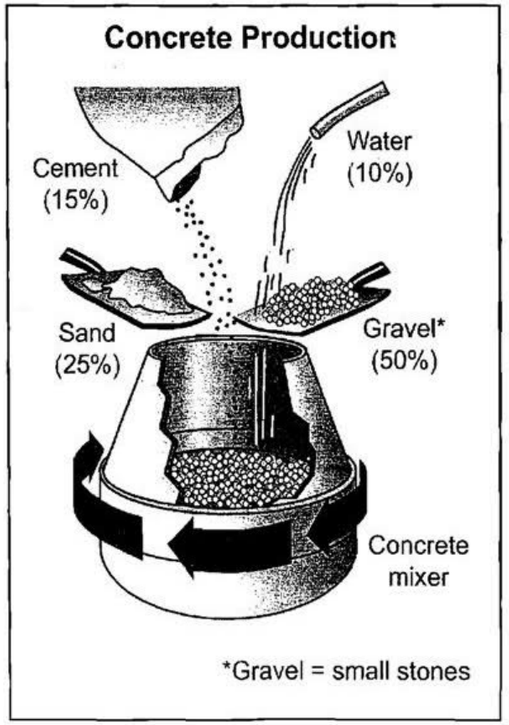
Newspaper Dossier - Op-Ed

Concrete Material

First let's take a look at the material of concrete. Concrete is made from 3 primary ingredients. This includes: aggregate, cement, and water. The percentage of each ingredient varies however aggregates typically make up the biggest percentage. Common aggregates include sand, gravel, and crushed rock. While there are a variety of different cement mixes all offering slightly different properties, the most commonly used mixes feature tricalcium silicate, acetylene sulfide, tricalcium aluminate. In essence they primarily use a mixture of lime, silica, and alumina with trace other elements. Concrete is made through a process of mining, crushing, drying and grinding, and sintering.

Concrete is a very popular building material due to its durability, and low cost. In fact, it is currently the most commonly used building material globally. It is generally considered to be highly sustainable due to its success at resisting fire, weathering & erosion, rotting, and rusting. It also is a good insulator and takes time to heat up and cool down. This means it is helpful in keeping a house warmer in the winter and cooler in the summer. But despite the sustainable properties it lends, there are a few downsides. Production on such a large scale has had harmful effects to the environment. It is reported that its production alone generates roughly 8% of global CO_2 emissions. It is also an extremely dense and heavy material. Making transportation difficult at times.





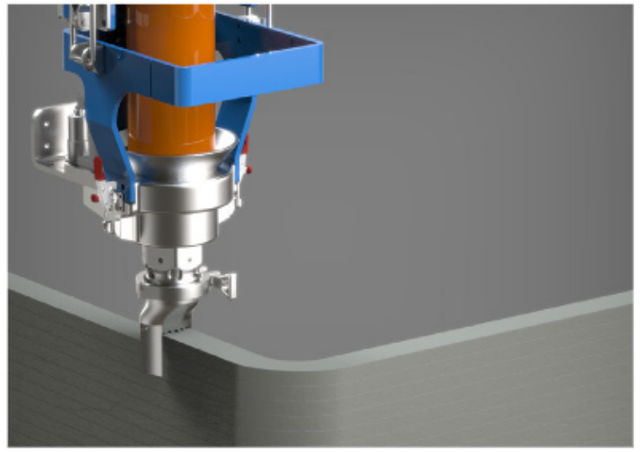
Newspaper Dossier - Op-Ed

3D Printing Concrete

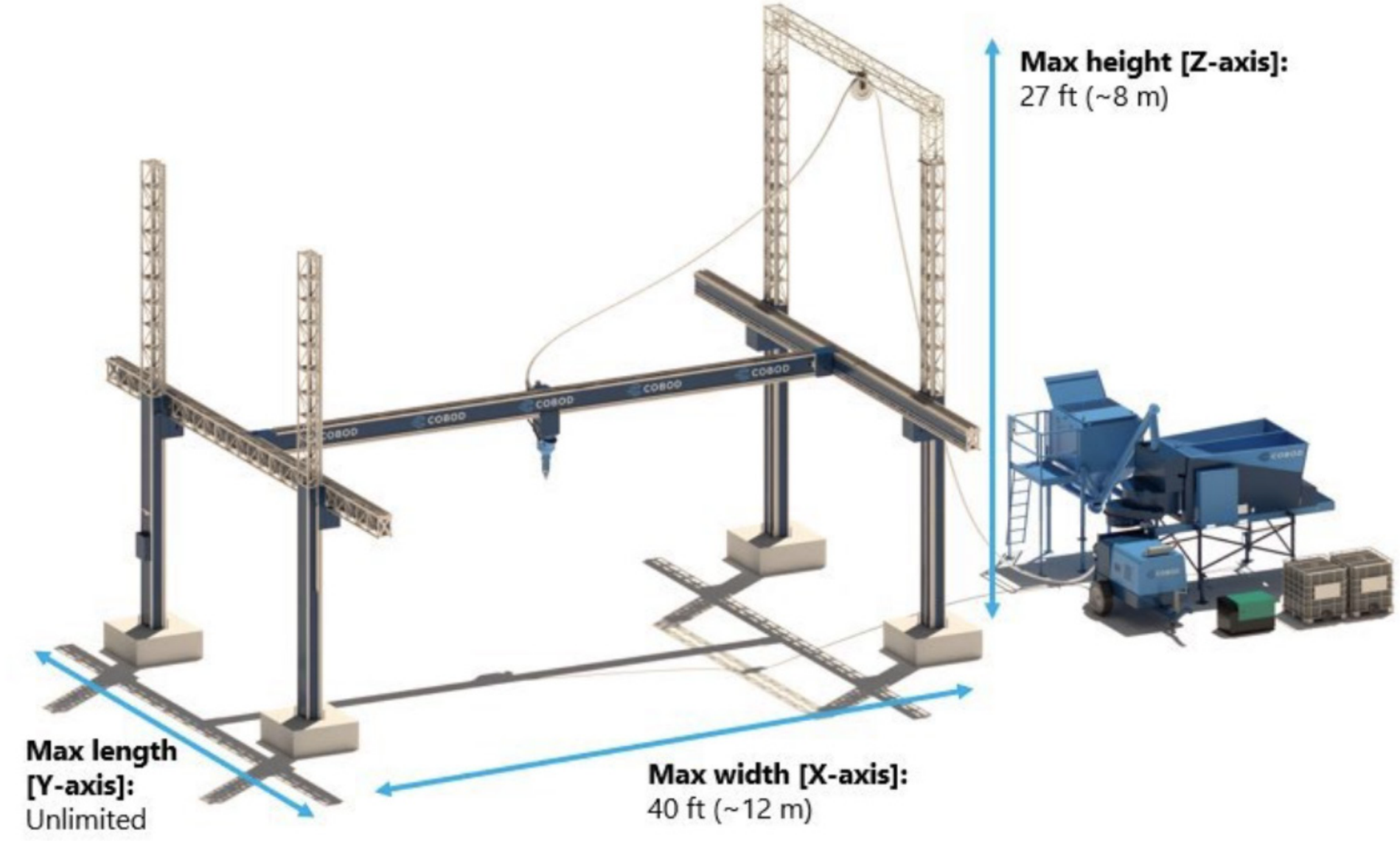
Next, looking into concrete 3D printing, it became apparent right away that this technology is used primarily for architecture and house construction. This is no surprise considering the material and scale, however I had to wonder if there were other uses. The technology seems to lightly dabble in outdoor furniture construction, however I have seen very little application outside of those two areas. With such an interesting and exciting technology, I wonder if there are unseen opportunities here for a new application or market venture.

According to the website, the COBOD - BOD2 is the fastest concrete printer on the market with the ability to print up to 1000 millimeters per second. It also has the ability to print on a 4D axis. This means it can move left/right on an X axis, up/down on a Z axis, forward/back on a Y axis, and the nozzle has an axis of its own allowing the head to rotate in a circular motion, allowing for smooth and curving strokes.

The printer takes between four and six hours to assemble and requires three to four people to operate/attend it. Computer software operated, a CAD model can be made reality layer - by - layer relatively quickly.



Printer and batch plant overview, max printable area, (ft/meters)



Newspaper Dossier - Op-Ed

Strengths

I want to only just barelty touch on these strengths as they are self-evident on COBOD's website. Calling to attention the technology's main strengths and affordances, are its speed, precision, and the ability to develop custom and organic forms.

The technology also excells at developing sturdy bases for larger technologies such as wind turbines, or even itself.

I forsee the technology providing excellent solutions to working around existing obstacles. It has the ability to conform to nearly any form desired and work around odd and unique natural curves.

While this technology excels in a number of areas such as speed, precision, and developing custom forms, there are certain areas where the technology struggles and is not quite as strong.

Newspaper Dossier - Op-Ed

Limitations

The biggest obstacle with Concrete 3D printing are overhangs. Plastic 3D printing handles overhangs relatively easily with the help of support material. Overhangs are filled in with thin and weakly connected material to support overhangs, which is later removed. Concrete 3D printing does not have this option. Concrete will stick to and harden over any support material and will be impractical if not nearly impossible to remove. However, concrete will sag and cave-in anywhere it is not supported. To get around this fact, temporary supports may be added, or permanent metal inserts to be placed on overhangs in construction such as doorways and window frames. Another possible way to get around the difficulty of overhangs is to pre-fabricate (pre-fab). Unique and curving forms may be printed on their side, then, once dry, rotated up-right.

Another aspect that is often seen as a downside, though not always, is the layered appearance the print retains. The striations can be minimized through the use of flaps placed on the sides of the printer nozzle, however there still remains trace signs of striations. When it comes to the appearance of the layered striations, there is some debate but what it really comes down to is beauty is in the eye of the beholder.

Finally, it is important to note that this is a large-scale 3D printer. Therefore it excels best at large forms and features and struggles with small features. Intricate details would be quite difficult to capture without increasing the overall scale of the project. I suspect this limitation, paired with the fact that the housing market is always growing, is the primary reason why the technology is used for construction almost exclusively.

Newspaper Dossier - Op-Ed

Urban Greenery

Greenery, nature, and plant life offer a number of benefits to urban environments and its inhabitants. Beyond beautifying a space, greenery improves air quality and can act as a sound barrier in the bustling and loud city. In addition, studies have shown that exposure and interaction with plant life can improve attitude and increase productivity. Increased exposure to plant life has even been linked to lower mortality rates and longer life-spans.

Despite the benefits, I observed a few things about greenery and its relation to urban settings. First, greenery is often treated as decoration and not a destination. Raised flower beds, trees, and other small installments are flat and do not encourage people to stay to enjoy them. They exist only to beautify the space. And when greenery is made a destination, it is often placed out of the way and receives little attraction because of this- such as rooftop gardens or traffic circles. Many of these locations also fail to keep people coming back due to poor seating and overgrown conditions. It seems there is a balance to be found when it comes to designing elements of nature into a man-made and human-centric environment.

I decided to focus my project on introducing greenery and plant life back into the urban environment.

Newspaper Dossier - Literature Review & Conjectures

Overview

This section serves to measure and broaden the scope of the research problem. Exploring topics outside of the traditional model of primary and secondary research may generate knowledge, insights, and ideas to further the understanding of hte problem and widen the creative breadth of the project.

Breakdown

I began by reading dozens of articles and developing a library to chose from. In each topic section I shared a minimum of five articles that I felt were related and relevant. At the end of each article I shared a critical analysis to explain the potential insights and knowledge it shared. I shared the insights and knowledge as it applied to my project through summarizing what I took away from the article. At the completion of each topic section, a design conjecture was created to explore possibilities and to exercise creative poblem solving.

Sections

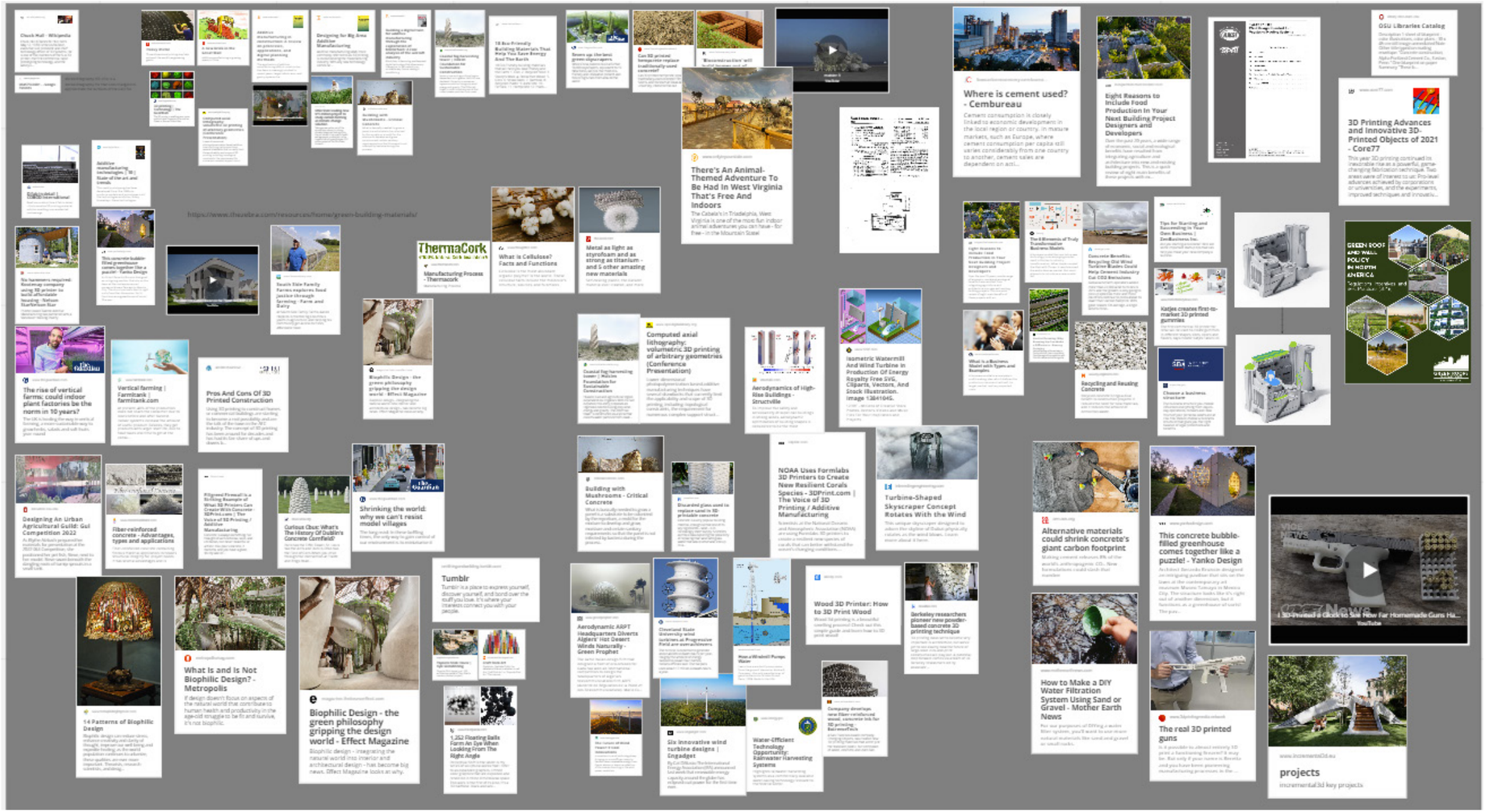
- Focus
- Science & Technology
- Business
- Art




Full Newspaper Literature Review & Conjecture Documentation can be found here:
https://desis.osu.edu/seniorthesis/index.php/sam-gaerke-cdme/

Newspaper Dossier - Literature Review & Conjectures

Article Library



Newspaper Dossier - Literature Review & Conjectures

Focus Section Summary

Permeable/Pervious Concrete

There are ways to design around perceived limitations. Concrete does not have to be “dense.” By experimenting with material and form, there are many creative possibilities with concrete as a material, especially as it relates to water drainage and filtration.

Link: desis.osu.edu - focus - article 1

Philipp Aduatz on Using 3D Printing to Design Colorful Concrete Furniture

Concrete is not typically thought of as “comfortable” or “cozy.” To incorporate good ergonomic design, it seems even concrete can break out of the perception of being “cold, hard, blocky, and uncomfortable.” In addition color pigment can be applied to concrete 3D printing.

Link: desis.osu.edu - focus - article 2

Crushed Glass Could Replace Sand In Shotcrete

Experimenting with materials is an excellent way to change concrete to be more affordable, sustainable, and even offer other benefits. Concrete does not have to follow traditional mixes – more sustainable materials can be utilized such as recycled glass, plastics, or potentially organic fibers.

Link: desis.osu.edu - focus - article 3

Newspaper Dossier - Literature Review & Conjectures

Focus Section Summary Continued...

This Self-Supporting 3D-Printed Concrete Bridge Uses Less Material

Concrete may seem hard to work with when it comes to overhangs and arches, but pre-fabrication and orientation problem solving can help create ways around it. Concrete does not have to be bulky, it can be elegant, innovative, and feature negative and empty space.

Link: desis.osu.edu-focus-article_4

3D Printing in Spiral Layers to Add Strength: Patterns in Concrete

Technical logistics such as pattern and direction are important for structural integrity. Utilizing multiple directions creates strongly bonded layers. In addition, nature can provide great examples of structurally sound forms.

Link: desis.osu.edu-focus-article_5

Alternative Materials Could Shrink Concrete's Giant Carbon Footprint

With an understanding in the background of concrete, I will be able to more acutely explore and stretch the boundaries of concrete's uses and see just how far I can push its applications. Alternative materials in its "mix" could reduce the environmental CO2 impact.

Link: desis.osu.edu-focus-article_6

Newspaper Dossier - Literature Review & Conjectures

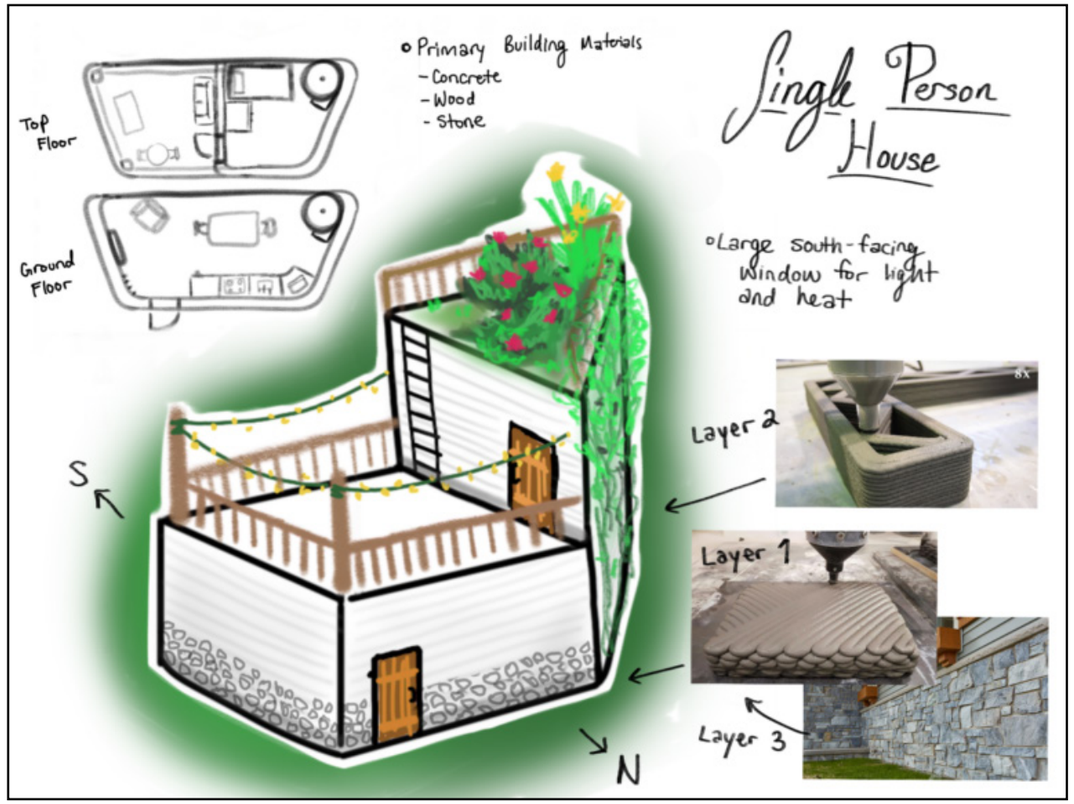
Focus Conjecture: Mini House

For this conjecture, I took the most important elements from my article analysis and converted them into a design idea. I took what I learned about building structure and support to create a stylish building. I incorporated ideas about multidirectional lay-er printing and brought in elements of nature climbing up one of the building's sides. I also imaged an eco-friendly reduced CO2 concrete mix for its construction.

Take-aways

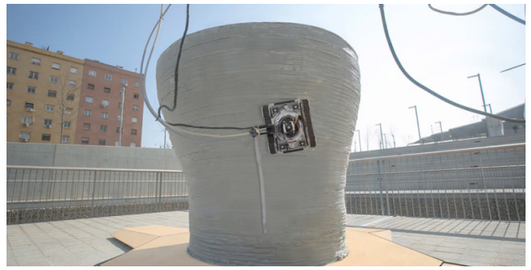
From this conjecture, I took away a number of discoveries. First, I did not want to simply create another piece of architecture. I felt I could stretch the technology's abilities to develop more organic forms rather than a traditional house structure. Second, I really loved the idea of the plant climbing wall. To expand nature into the vertical space is super interesting and worth explor-ing further.

Focus Conjecture Page: https://desis.osu.edu-focus-conjecture



Newspaper Dossier - Literature Review & Conjectures

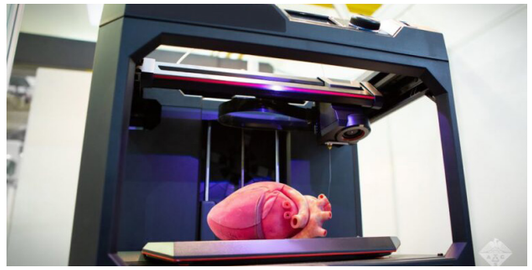
Science & Technology Section Summary



Team Of 3D Printing “Minibuilder” Robots Print Large-Scale Structures On Site

With additional technology, printing on curved surfaces is possible - including printing vertically. Different technology when paired with concrete 3D printing technology can allow for different surface texture results.

Link: desis.osu.edu - science&tech - article_1



3D Printed Organs: The Future Of Transplantation – CNN

Additive manufacturing has many capabilities and when pushed to its limits, new and amazing things are possible. Applications outside the typical field of architecture and construction are worth exploring. 3D printing has the ability to develop extremely complex forms.

Link: desis.osu.edu - science&tech - article_2

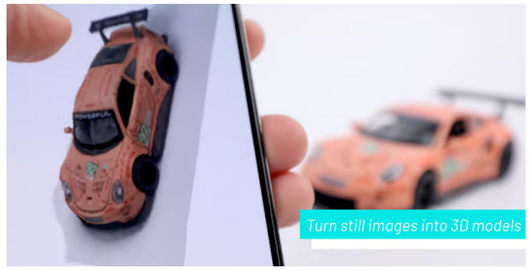
Earthship Homes: The Next Big Sustainable Housing Trend?

Recycled and alternative material may be utilized between layers of a 3D printed form to reduce overall concrete material use and add a unique artistic element to the design. Additional materials can increase the form’s environmental potential.

Link: desis.osu.edu - science&tech - article_3

Newspaper Dossier - Literature Review & Conjectures

Science & Technology Section Summary Continued...



How you can bring photoreal objects into your projects with 3D scanning app KIRI

Other technology can be utilized in the model development phase to create realistic representations of existing forms. Outside technology can help to construct around existing obstacles and spatial realities or urban settings.

Link: desis.osu.edu - science&tech - article - 4

'Bioconstruction' Will Build Homes Out of Flowering, 3D Printed Dirt

Additive manufacturing does not have to be all man-made unnatural materials – natural materials can help implement more sustainable design through biophilia. Additives to an extrusion mixture can drastically change the end result and develop opportunities for the future.

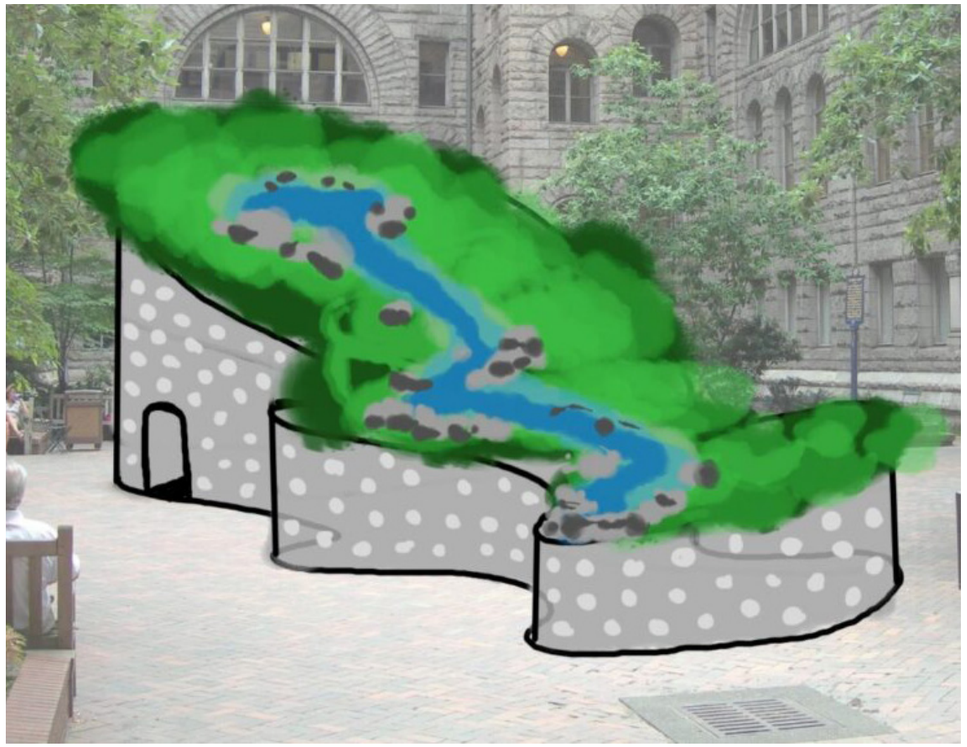
Link: desis.osu.edu - science&tech - article - 5

Newspaper Dossier - Literature Review & Conjectures

Science & Technology Conjecture: Raised Bed Island

For this conjecture, I primarily referenced what I learned from the Earthship article to form the raised bed walls. The walls would feature glass bottles to reduce the overall weight and material amount, as well as to add beauty. The raised bed would have curves and slant downward for waterfall flow. The raised bed island would feature a variety of plants and greenery with realistic looking rocks and the waterfall would cycle through. There would be a basin for water collection at the lower base of the structure with a water pump. Tubes would be attached to the pump to bring the water from the basin back to the top of the waterfall again. Additional technology could be used to develop organic and realistically shaped rock formations.

There is the opportunity to provide curved seating along the exterior walls of the structure for people passing by or who simply want to stop and enjoy the greenery. I also included an area to enter underneath the tall side.There is also the possibility of developing a system where the flowing water powers a motor to power the lights.



Take - Aways

From this conjecture, my favorite aspect is the idea of using glass and mosaic techniques paired with lights. I think this could be very beautiful and be interesting to pair with water and plant life in my future design explorations.

Science & Technology Conjecture Page:
https://desis.osu.edu/seniorthesis/index.php/2022/10/24/science-technology-conjecture-2/

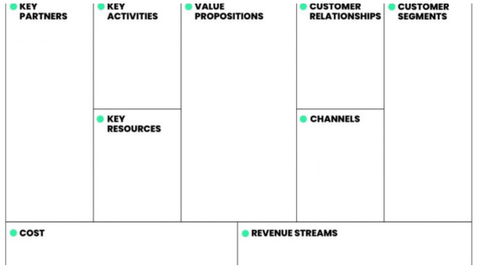
Newspaper Dossier - Literature Review & Conjectures

Business Section Summary

Jewel: Singapore Airport's Very Own Tourist Attraction

User experience and interaction can enhance the lives of commuting travelers. People want an experience even in the mundane things and aspects of life. This can even help boost business profit and popularity. There is potential to turn empty meaningless spaces into atmospheric destinations.

Link: desis.osu.edu - business - article - 1



What is a Business Model Canvas?

A structured business plan model can help keep you organized and be taken seriously by other professionals in the field. It can also help sort out the legitimacy of an anticipated design business concept. It may play a role in developing my final concept.

Link: desis.osu.edu - business - article - 2

Business Ecology Model

Establishing clear boundaries and goals for a business is essential and this model also considers sustainable ventures. Considering how this may be implemented into concrete 3D printing technology, it may help direct design decisions and create a product service system.

Link: desis.osu.edu - business - article - 3

Newspaper Dossier - Literature Review & Conjectures

Business Section Summary Continued...

Could 3D Printed Homes Solve California's Housing Crisis?

Large-scale 3D printing should consider cost. It should consider the entire lifecycle such as who will maintain it, can it be repaired or recycled if damaged, and how will it effect the environment and the people around it.

Link: desis.osu.edu - business - article - 4

3D Printing with Low-Carbon Concrete: Reducing CO2 Emissions and Material Waste

It is important to research material options. Sometimes less is more – redesigning for efficiency can be just as effective as new technology. Challenging what is viewed as a "standard" can lead to relevant innovation in form and material.

Link: desis.osu.edu - business - article - 5

The Rise of Vertical Farms: Could Indoor Plant Factories Be The Norm In 10 Years?

Design and additive manufacturing can consider how to capitalize on vertical space – land and space are expensive and hard to come by so utilizing vertical space is cost effective and debatably more efficient.

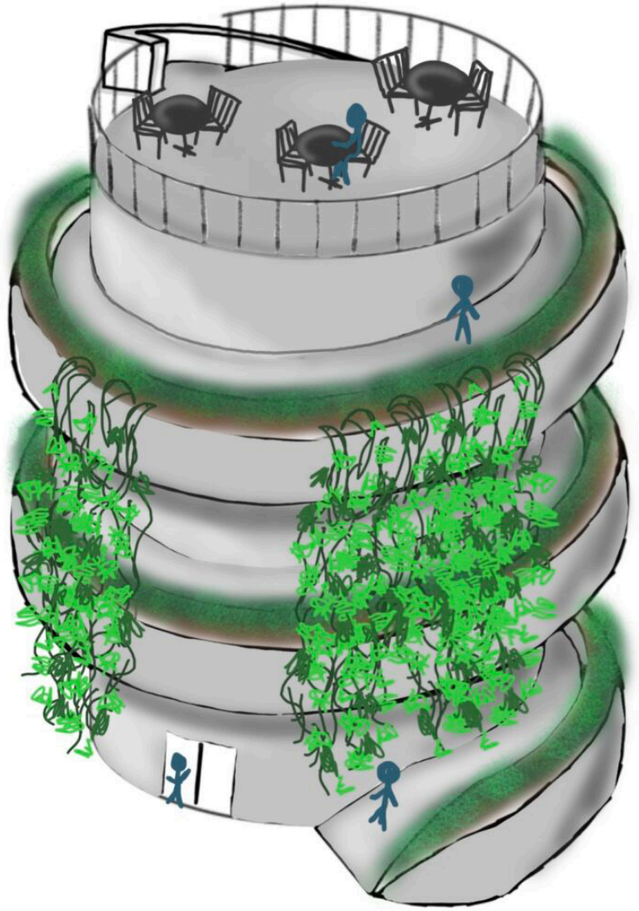
Link: desis.osu.edu - business - article - 6

Newspaper Dossier - Literature Review & Conjectures

Business Conjecture: Nature Walk Cafe

For this conjecture, the basic idea is that the interior would feature a cafe restaurant with plenty of seating space for eating, socializing, or studying.

The first floor would feature the café with some tables and chairs, and the above floors would contain further seating but would be more in union with plant life. There could also exist some floors solely for plant cultivation. The building exterior would feature a spiral path all the way up to the rooftop where more greenery and seating is available. The path features a raised bed all the way up to the top so people could enjoy their walk. There is also the opportunity for plant life to climb or hang from the raised beds, bridging the gap between the two levels. I really wanted to create a destination that provided people with someplace to walk and enjoy nature. I felt using vertical space would be the best way to develop a realistic design within an urban setting.



Take - Aways

From this conjecture, I learned that in my final design, I want to include seating. I think this is essential in welcoming people to stay to enjoy nature. There is certainly room to explore furniture and seating design to be more organic. I am unsure of how realistic this conjecture is due to the scale and since it leans so heavily into architecture, however I think I learned a lot about how I want to create a destination for nature and how nature can melt right in with everyday architecture.

Buiness Conjecture Page:
https://desis.osu.edu/seniorthesis/index.php/2022/10/24/business-conjecture-nature-walk-center/

Newspaper Dossier - Literature Review & Conjectures

Art Section Summary

Would You 3D Print Your Furniture?

Creative exploration of different processes can give way to unique and imperfect results, yet, imperfection can be a positive. Natural and organic curving forms are best developed through a series of "happy accidents."

Link: desis.osu.edu - art - article - 1

This Guy Quit Being a Wall Street Lawyer to Become a Lego Artist

The use of concrete as the primary material at times feels constricting yet, it is possible to achieve complex curves and structure with "blocky" forms – and it is possible with additive manufacturing. Pieces can be stacked or oriented to form almost unlimited possibilities.

Link: desis.osu.edu - art - article - 2

Gorgeous Stone Wall Mosaics Flow in Beautiful Spirals and Waves

Nature in urban spaces can feel stagnant, yet it can be arranged in a way to feel alive and flowing. Man-made architecture and construction does not need to be stagnant either. It can venture to break the confines of horizontal and vertical lines to mimic nature in its natural state (biomimicry).

Link: desis.osu.edu - art - article - 3

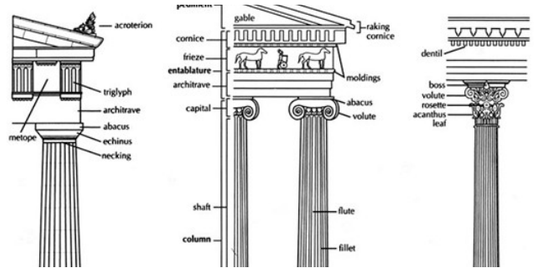
Newspaper Dossier - Literature Review & Conjectures

Art Section Summary Continued...

Contemporary Sculptures of Concrete and Moss by Robert Cannon

Concrete and nature can juxtapose each other, yet compliment each other. Nature can be shaped and formed to conform with unnatural man-made elements and spaces. Similarly, man-made elements and spaces can conform more actively to nature and spatial limitations.

Link: desis.osu.edu - art - article - 4



Greek Architecture – History and Characteristics

Inspiration for structural architecture can be taken from history. There is beauty in intricate and precise details. How might I juxtapose sharp geometry with natural, flowing forms in the development of this design project?

Link: desis.osu.edu - art - article - 5

The Real 3D Printed Guns

There are nearly endless possibliites with additive manufacturing technology. Additional materials can be added to a 3D print to increase its functionality, viability, and appearance. In addition, prints may be done in multiple parts and assembled at a later time/location.

Link: desis.osu.edu - art - article - 6

Newspaper Dossier - Literature Review & Conjectures

Art Conjecture: Water Fountain

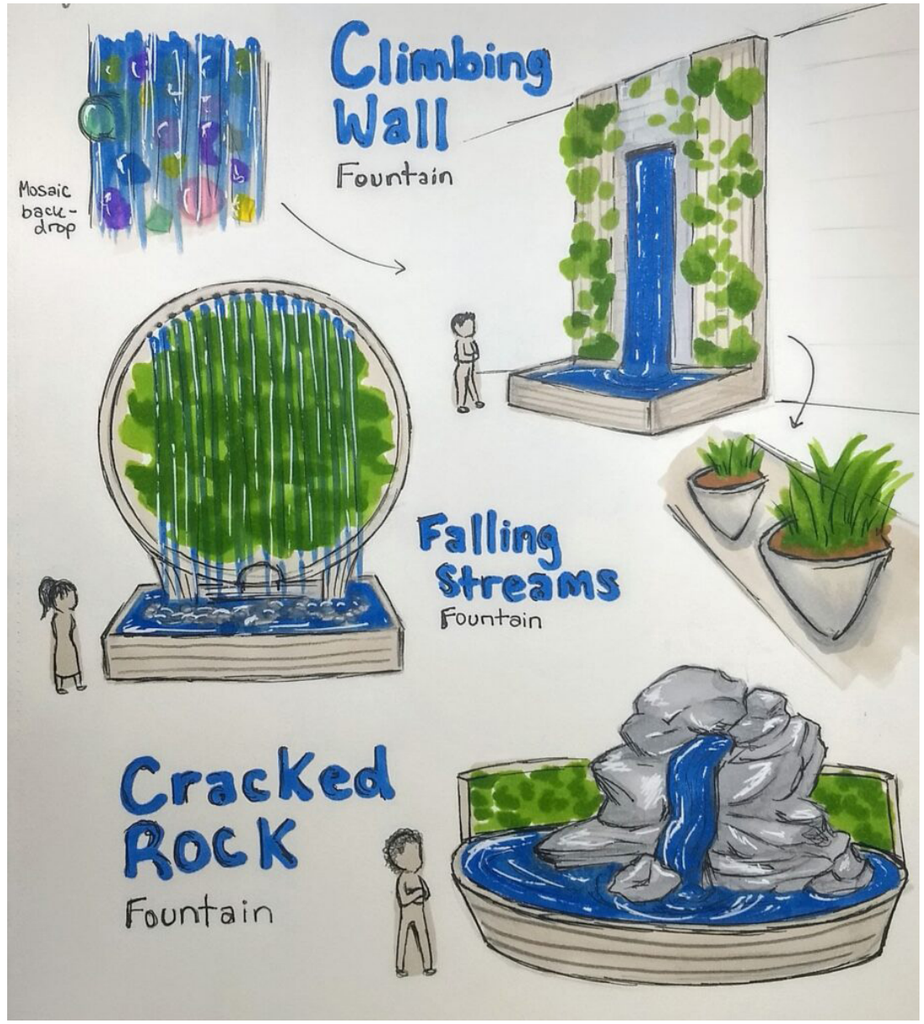
This conjecture is a concept for a public space and focuses on greenery and flowing water. I have developed a variety of designs to demonstrate the variety of combinations and possibilities that exist within the components of a raised bed wall, water, and plant life.

Focusing primarily on the concept titled, "Climbing Wall Fountain," I want to highlight some concept decisions. First, this conjecture is designed to utilize vertical space along a flat wall. It features a water collection area at the base and provides a climbing wall for plants to thrive. The waterfall is the primary focal point and contains mosaic glass set behind for the water to fall over. The water travels out of the water spout located at the top, down the mosaic wall, into the collection pool, and then is transported back up to the water spout using a water filter and pump.

Take - Aways

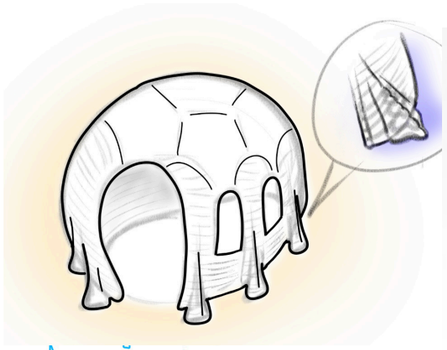
For this concept, I am most excited about the mosaic waterfall wall. I think it would be a beautiful complement to the greenery and could certainly add interest to the concrete appearance. When developing my design further in the future, I will take what I have learned with me.

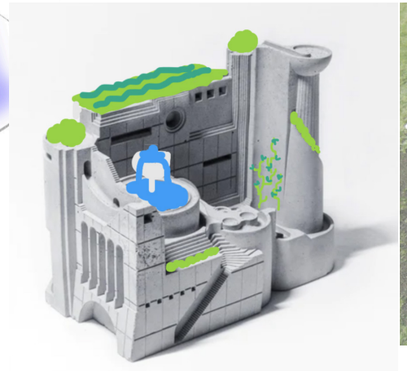
Art Conjecture Conjecture Page:
https://desis.osu.edu/seniorthesis/index.php/2022/09/06/science-tech-conjecture/

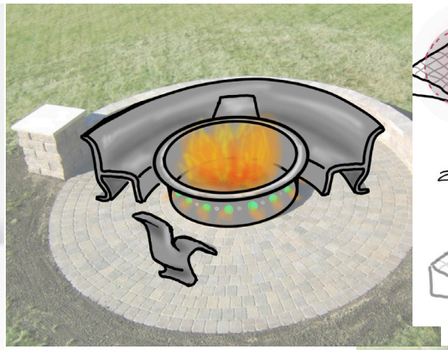


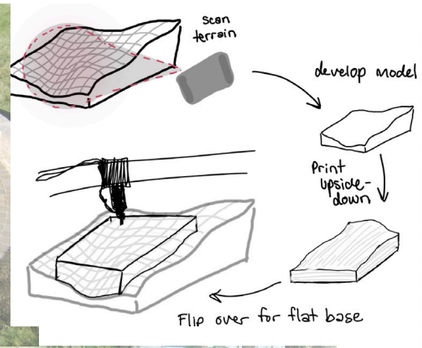
Newspaper Dossier - Literature Review & Conjectures

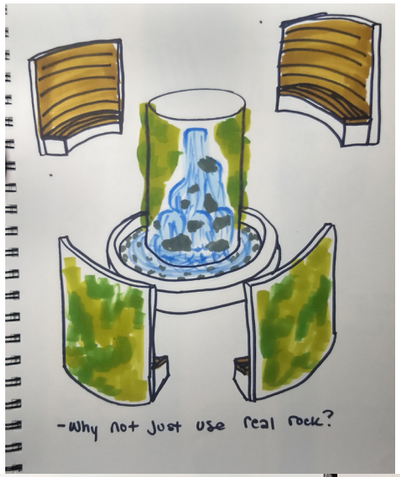
Other Conjectures Concepts

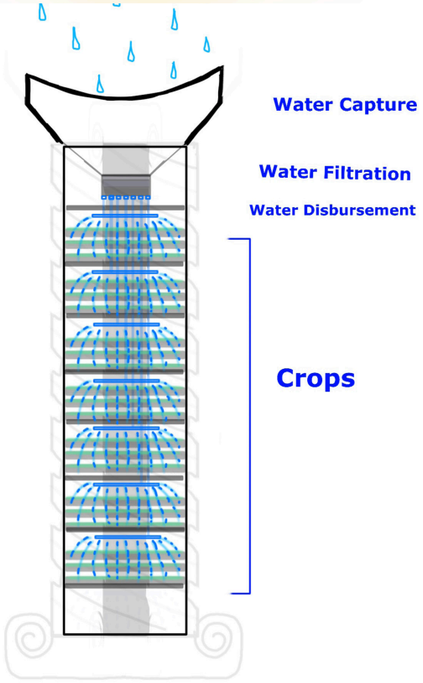


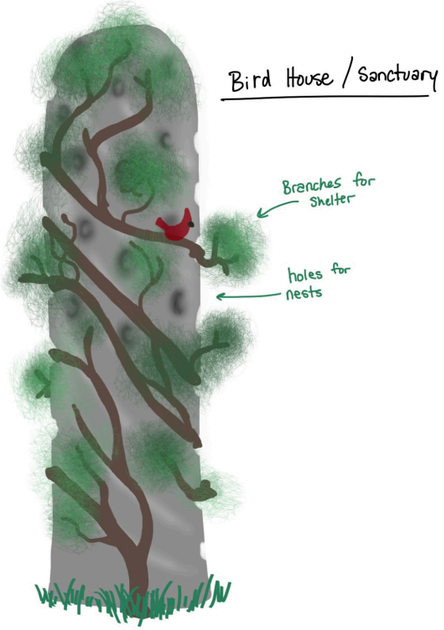


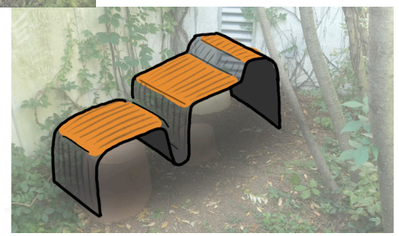


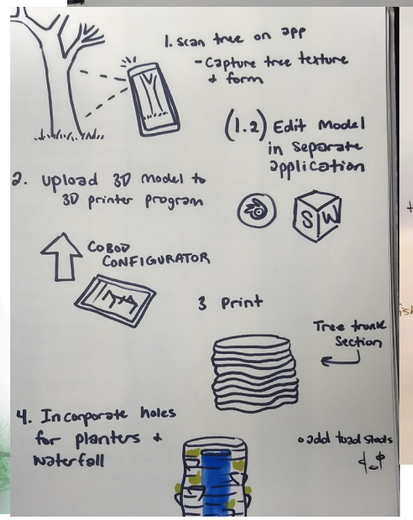


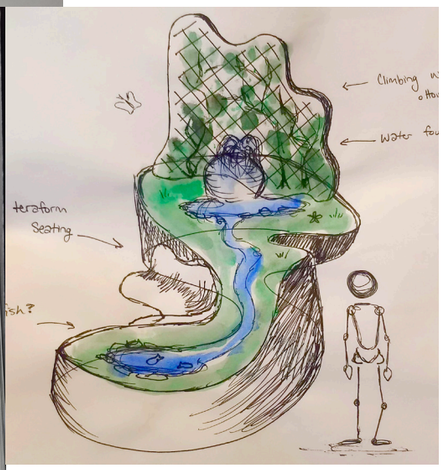












Newspaper Dossier - Survey & Data Visualization

Public Perceptions of Concrete 3D Printing Survey

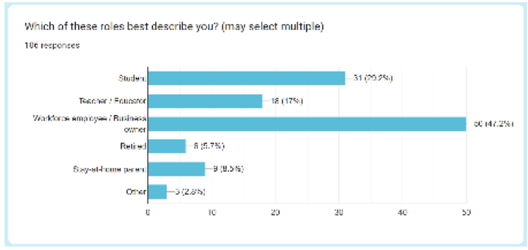
To understand public opinion on the technology and to gain some understanding of social needs and desires, I sent out a 10 question survey via Google Forms over the course of 3 days. The results of this survey helped gain important insight and guide the development of my design brief.

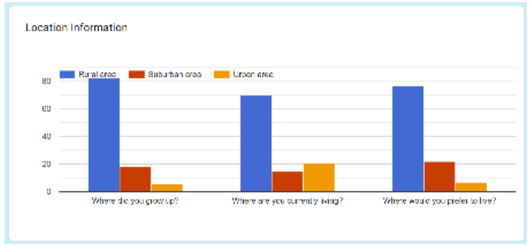
Questions Asked:

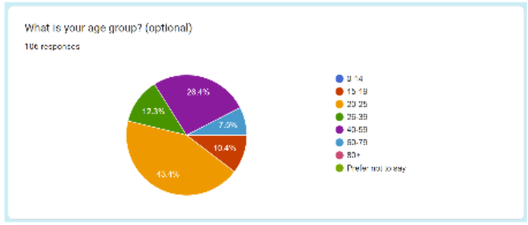
1. Have you ever heard of large-scale 3D printing with concrete?
2. What is your attitude or impression toward this technology?
3. Why do you feel this way?
4. What are 3 words you would use to describe the material concrete?
5. How would you rate the importance of each effort/movement?
6. Have you ever visited a rooftop garden?
7. How would you rate public spaces on their need for amenities?
8. Have you heard of vertical farming before and what is your attitude/impression of it?
9. What gender do you identify with?
10. What age group do you belong to?

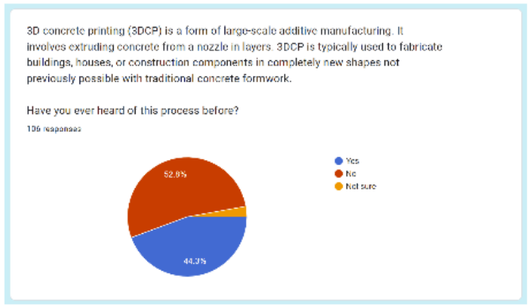
Posted Locations and Platforms:

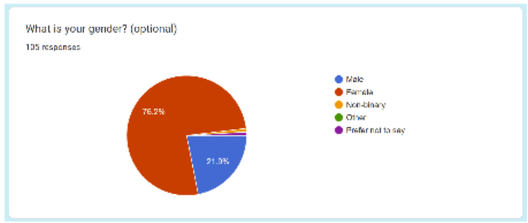
2 Facebook groups, 2 Facebook Homepages
5 GroupMe chats
1 Snapchat story
1 Instagram post, 1 Instagram story

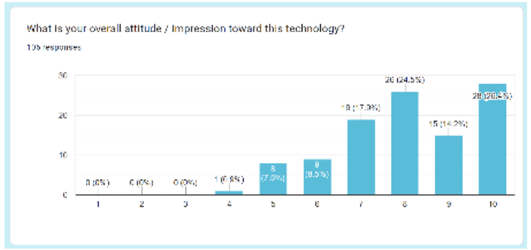












Newspaper Dossier - Survey & Data Visualization

Survey Results

At the conclusion of the survey, there were a total of 106 participants. Of these participants, over 75% identified as female and a majority of the participants were between the ages of 20 and 25.

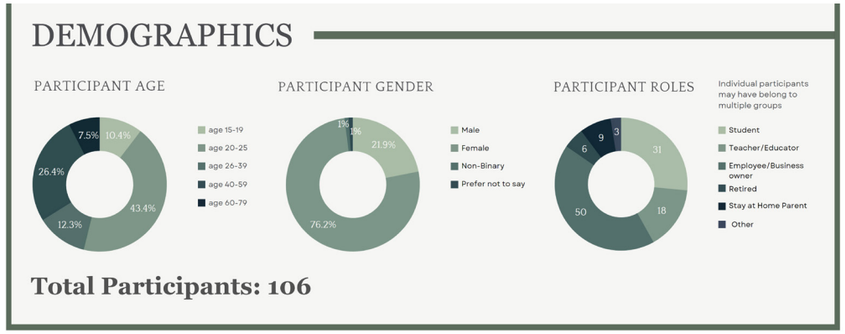
I began coding each participant by their response to each question to discover underlying patterns. However, I quickly realized the time commitment this would require and felt the information I would get out would not be as significant as the overall trends. Therefore, I settled on analyzing the data trends as a whole and uncovered some relevant insights. I then developed a visual poster to display the survey results.

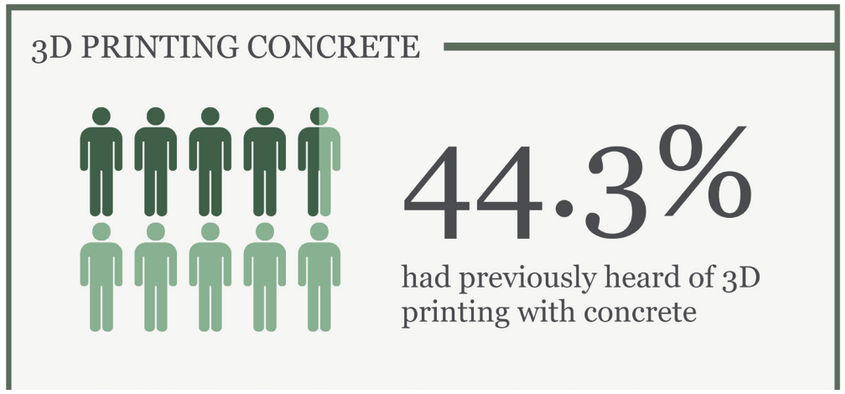
The raw data of this survey collected by Google Forms can be viewed here: https://desis.osu.edu/seniorthesis/index.php/2022/12/12/public-opinion-raw-survey-data/

To view the results on a spreadsheet: https://docs.google.com/spreadsheets/d/1cDesG2n1FFd4kcMUiRp-zI32dIYPU0ycI0gPDvjpQEk/edit#gid=1416306314

Data Visualization Poster:

https://desis.osu.edu/seniorthesis/index.php/2022/09/29/public-perceptions-of-concrete-and-opinions-for-the-future-of-urban-spaces/





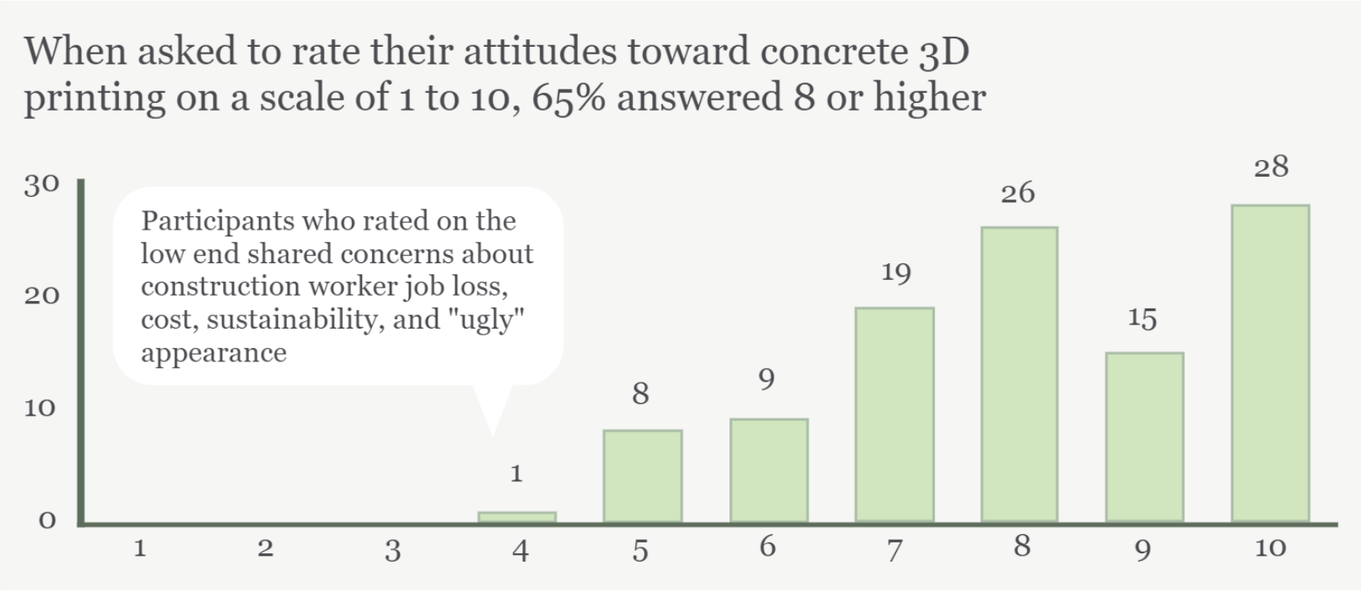
Newspaper Dossier - Survey & Data Visualization

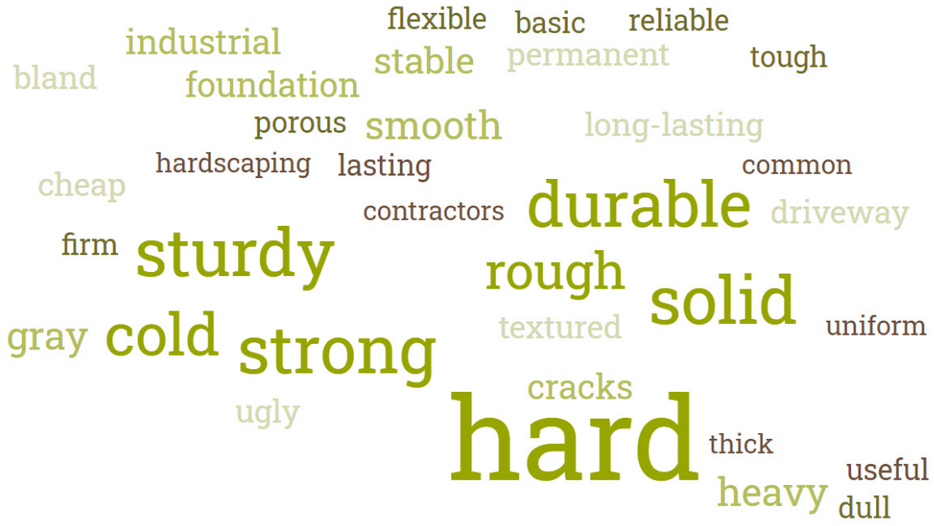
Survey Highlights

I asked for participant opinion and attitude toward concrete 3D printing. Most participants felt generally positive toward the technology, however unsure about its level of sustainability, its cost, construction worker job loss, and its appearance. The appearance seemed to be a main concern with many people not completely sold on the layered striations look.

I also asked participants to describe concrete using 3 of their own words. The results revealed that people saw the value in the material's strengths and viewed concrete as useful and necessary, but found the material to be dull and lifeless.

I asked participants to rate how highly they felt urban environments needed to have various different amenities. Among these, greenery/nature and areas to walk were rated most highly.

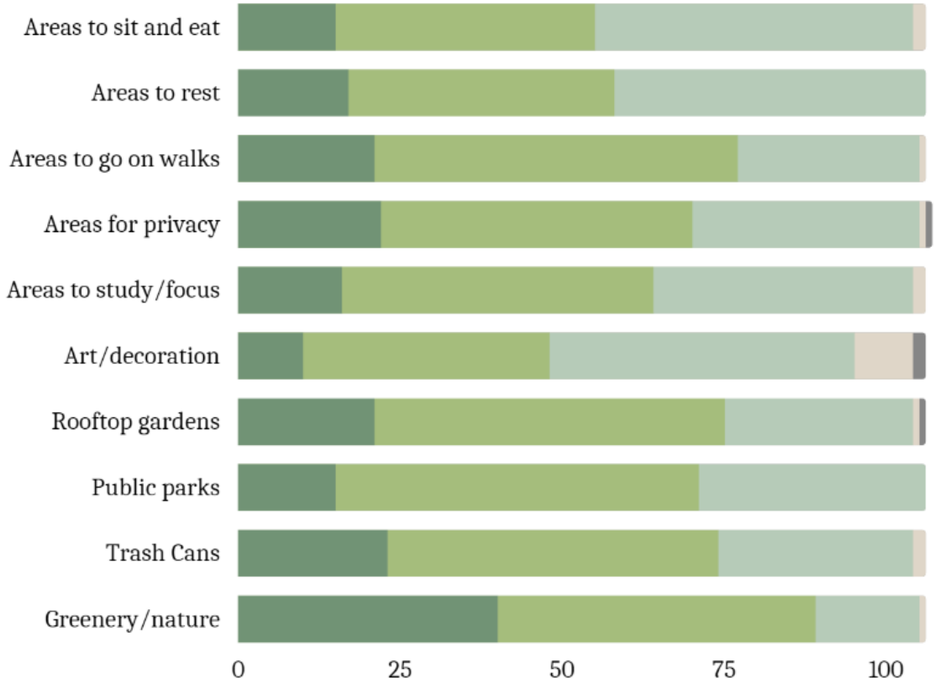




Newspaper Dossier - Survey & Data Visualization

Survey Summary

In summary, this survey revealed to me 3 major insights. First, people (at least according to this sample size) generally feel positive toward concrete 3D printing technology, but have concerns about its cost, sustainability, and appearance. Second, people perceive the material of concrete to be sturdy, useful, and necessary, but find it to be cold, dull, and lifeless. And finally, people want to increase their engagement with greenery and nature in urban settings.



These insights prompted questions like;

- What can be done to make concrete feel less lifeless and dull?
- What can be done to make concrete 3D printing more sustainable, cost effective, and visually pleasing?
- Can something be added to concrete to make it feel more warm, welcoming, exciting, and alive?
- How can urban spaces incorporate more greenery and nature?

I considered, and came to the realization that the last question actually answered at least part of the first two. How can concrete 3D printing be made more visually pleasing, welcoming, and exciting; the answer – greenery and nature/plant life.

Again, full results may be viewed here: https://desis.osu.edu/seniorthesis/index.php/2022/09/29/public-perceptions-of-concrete-and-opinions-for-the-future-of-urban-spaces/

CDME Visit / Expert Consultation

Through the course of this project, I sought out advice and input from experts in their field. This advice was a big help in my project direction and execution.

CDME

Ben DiMarco - Ben was the project partner lead and oversaw the direction of my project as it related to the COBOD printer. He offered valuable directional guidance and shared meaningful resources and contact information.

Michael Lander - Mike provided meaningful experience and input relating to the additive manufacturing and concrete 3D printing technology. He shared creative use ideas and possible avenues to explore. He also gave me a tour of CDME.

Ryan Brune - Ryan oversaw the additive manufacturing lab and helped me produce a small-scale plastic 3D model. He walked me through different additive manufacturing processes and helped me develop a digital CAD file into a physical 3D print.

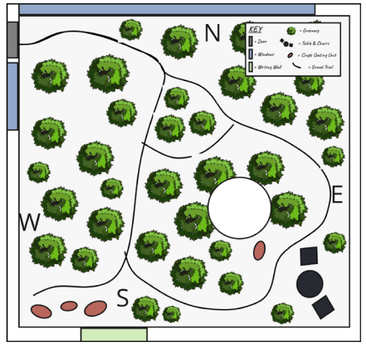
Department of Design

Sebastien Proulx - Sebastien oversaw the project by developing the syllabus and connecting me to my project partner at CDME. He als offering meaningful project communication input.

Emily Stokes - Emily offered level-headed advice and design direction that empowered me to see this project through to its completion. She also shared helpful troubleshooting when developing my rendered model.

Krista Smith - Krista provided supporting input and guidance for my project development.

Knowlton Rooftop Garden Observation



Knowlton Rooftop Garden Observation Summary

In order to understand where current green spaces in urban contexts succeed and fail, I observed Ohio State's Knowlton Rooftop Garden. This was my first experience on a rooftop garden so I felt relatively unbiased in my observation.

Succeeds
- creates an atmosphere that makes it feel like own destination
- areas of privacy
- relaxing atmosphere

Fails
- poor, uncomfortable seating
- overgrown greenery causes directional confusion and safety hazzards
- hard to find entrance, poor signage

Summary & Take-Away

While it is a nice little area with its own atmosphere, it fails to consider human engagement, accessibility, and comfort. Moving forward with my design brief, I want to ensure my project design is acessible and comfortable.

Full documentation: https://desis.osu.edu/seniorthesis/index.php/2022/12/12/knowlton-rooftop-garden-observation-notes-take-aways/

Material Exploration

To understand on a deeper level the material of concrete, I purchased some concrete mix and experimented with it. I explored various ways to add pigment to concrete and came to understand just how heavy the material is. This exploration reinforced the need for more eco-friendly concrete mix options.

Concrete Material Exploration

Form Exploration Models

Having dificullty with sketch iteration, I explored 3D iteration methods. Utilizing polymer cly, coil rope with hot glue, and icing, I be-gan to iterate with a sense of space and scale.

I found that the polymer clay was the fastest and most cohesive way to iterate in a 3D space. The coil rope took a bit too long to iterate effectively, yet I liked how it featured the same stiated layers appearnce as real concrete 3D printing. Finally, I had hoped the icing would allow me to mimick the COBOD's nozzle movements and layer patterns however it melted due to the heat and would not hold its shape.

Polymer Clay Iterations





Form Exploration Models

As previously mentioned, these form exploration materials were not as effective as the polymer clay, yet they remain a step in the process of advancing my iteration progress.

These forms of iteration helped me to develop an understanding for the nozle head path and the importance of its direction. It also allowed me to better imagine more complex patterns layer-by-layer.

Coil Rope and Icing Iterations

Raised Beds Study - Observation & Survey

I conducted research on raised beds to identify pain points and hopefully improve my design concept.

Raised Bed Gardens

Raised Beds Currently

Purpose and uses:
- keep soil in gardens
- keep mulch in flowerbeds

Appearance:
- Boxy with sharp corners- just like traditional concrete construction
- Lined - just like 3D printed concrete

Materials:
- Wood - rots and bends when exposed to too much moisture, not the longest lasting, and harder to find purposefully bent wood (requires steam treatment), splinters
- Plastic - ruins natural look and not very sustainable, ugly hinges
- Stucco - cracks all the time
- Stones, Cinder blocks, Bricks, Patio pavers - need to be secured together to ensure no soil escapes or causes it to fall over, potentially sharp edges, and takes time and effort to install, also houses a lot of ants
- Corrugated metal/galvanized steel - can curve but sharp edges must be covered - wear-and-tear may make them sharp again, still limit to how much it can be bent.
- Straw bales - not aesthetically pleasing, restricted to rectangular shape, holds moisture but requires more watering and has to be remade every year

Downsides to traditional raised garden beds:
- Sharp corners - bad for anyone but especially elderly and children
- No water system - water on own or purchase separate irrigation system
- Ones available online are expensive and offer little personalization
- Upcycled materials can have coats of toxic chemicals on them - draining into food supply

Wood

Connectors/corners

Full Notes & Survey Documentation: https://desis.osu.edu/seniorthesis/index.php/2022/12/12/raised-bed-research-survey-documentation/

Major Insights

Concluding the research phase, I uncovered many insights that helped to guide my project direction. Listed below is a summary of those leading insights.

Primary Research

- Concrete's sustainability is questionable
- People find concrete to be dull, boring, and lifeless
- People are optimistic and interested in the technology but unsure about its practicality and appearance

Secondary Research

- People want more greenery in urban spaces
- Urban areas contain little greener/nature, the spaces that do contain greenery are often out of the way, and do not encourage people to stay
- Urban areas face certain spacitial realities - they often lack space

Outside Source Research

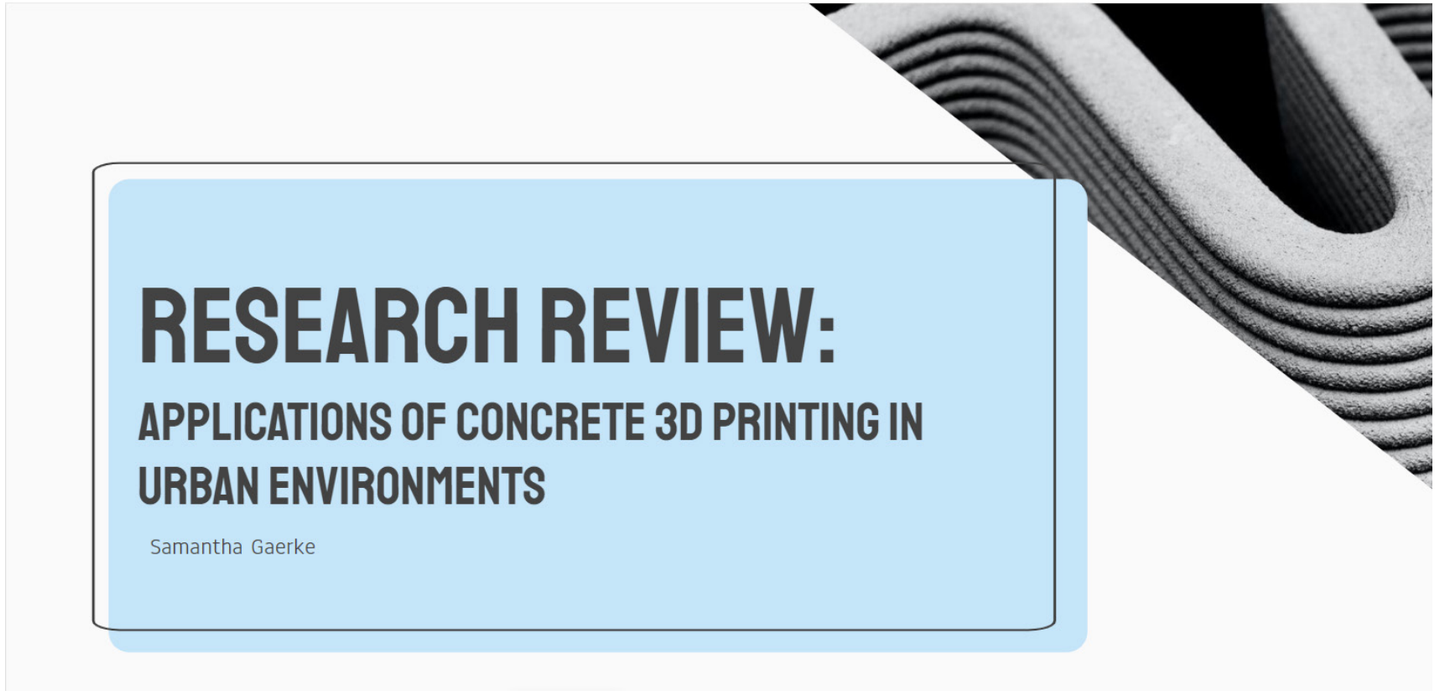
- User experience and interaction design can be just as important and memerable as the product itself
- Utilizing vertical space can capitalize on spacial limitations
- Alternative materials can replace commercial concrete mixes
- It is possible to achieve complex curves with "blocky" forms
- Nature can be shaped and formed to conform with unnatural man-made spaces
- The incorporation of additional technology and materials can bring concrete 3D printing to the next level

Research Review - Presentation & Jurry Comment Reflection

At the midpoint of the research phase, I presented a research review presentation. This presentation summarized my research up to that point, shared my inital design brief, and a scheduled action plan through a WBS and a Gantt Chart.

It is important to not that the design brief shared in this presentation is not the final direction I chose to go with.

The presentation can be found here:
Research Review Presentation



Following the Research Review, I recieved feedback from my profesors and from my project partner lead from CDME. The following is a summary of their feedback and input.

The reflection can be found here:
Critical Summary of Jurry's Comments

Research Review - WBS & Gantt Chart

Work Breakdown Structure & Gantt Chart

To plan and manage my workflow over the course of the project, I developed a work breakdown structure and a gantt chart. These organizational methods allowed me to predict all work actions I would have to do and map them on a timeline. While I did not stick to this in its entirety, it certainly helped me to manage my time and keep my project on track.

The original list of work actions can be found here: WBS Action List

The original WBS document can be found here: WBS Action Chart

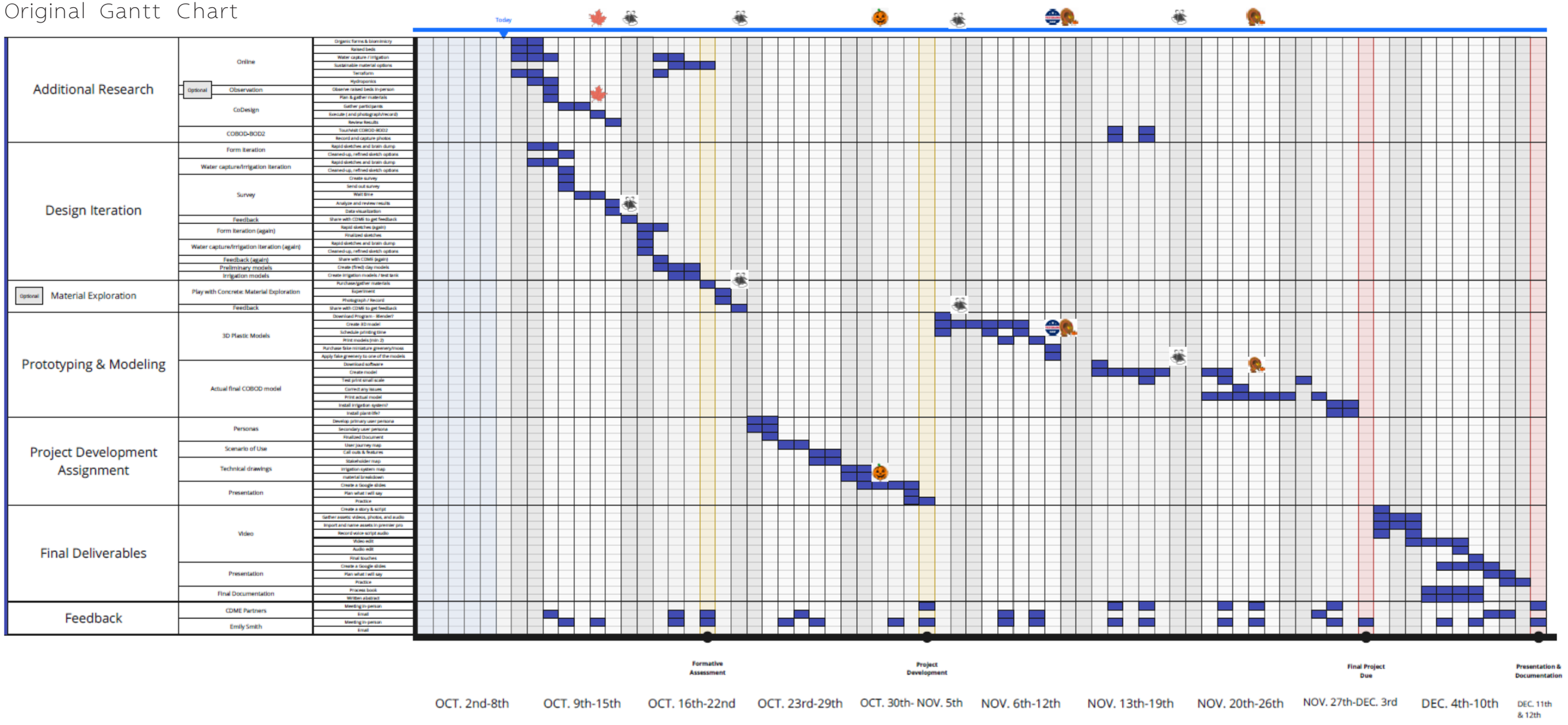
The original Gantt Chart can be found here: Gantt Chart

As I navigated setbacks and new strategies, my progress toward project completion changed. I updated the Gantt Chart document to reflect my progress and shortened timeline.

Here is an updated Gantt Chart from the last 3 weeks of this project:
Updated Gantt Chart

Research Review - WBS & Gantt Chart

Original Gantt Chart



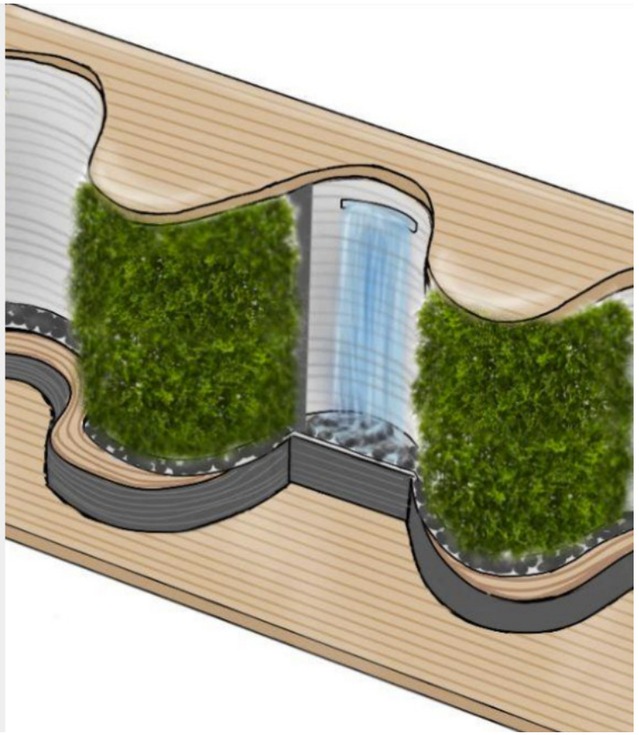
Mid-Point Review & Concept Proposal

At the mid-point of this project, I finally came to a project brief I was content with and a concept worth pursuing. In this presentation, I shared some updates to my research and shared an updated design brief.

View the presentation here:
Mid-Point Review Presentation

Or

View a video of the presentation here:
Mid-Point Review Presentation Video



Concept Proposal

Finalized Design Brief

Problem Areas

- Concrete 3D printing produces a pattern that few find attractive
- Concrete's sustainability is questionable
- Urban areas do not contain enough greenery/nature
- Existing green spaces in urban contexts are out of the way and are not welcoming people to stay

Opportunities

- Beautify urban spaces
- Implement some curved and organic forms into an otherwise "blocky" urban setting
- Explore ways of reducing concrete footprint
- Utilize vertical space

Finalized Design Brief

Problem Statement

Can concrete 3D printing be used to develop infrastructure for plant life in urban spaces that is inviting, accessible, and accounts for urban spatial realities?

How will the creation of this infrastructure impact public perceptions of concrete 3d printing and the future of urban development?

Finalized Design Brief

Design Goal

Utilizing the COBOD 3D printer, I will develop a green wall seating unit to support plant life and facilitate human interaction within the urban setting.

Desires:

- Inviting & open
- Natural and relaxing atmosphere
- Seat multiple people

Finalized Design Brief

01 **Beauty**
Bring beauty through greenery back into urban spaces

02 **Personal Health**
Improved mental health and improved living

03 **Community**
Provide a unique space for socialization and as a topic of socialization

Envisioned Impacts

Finalized Design Brief

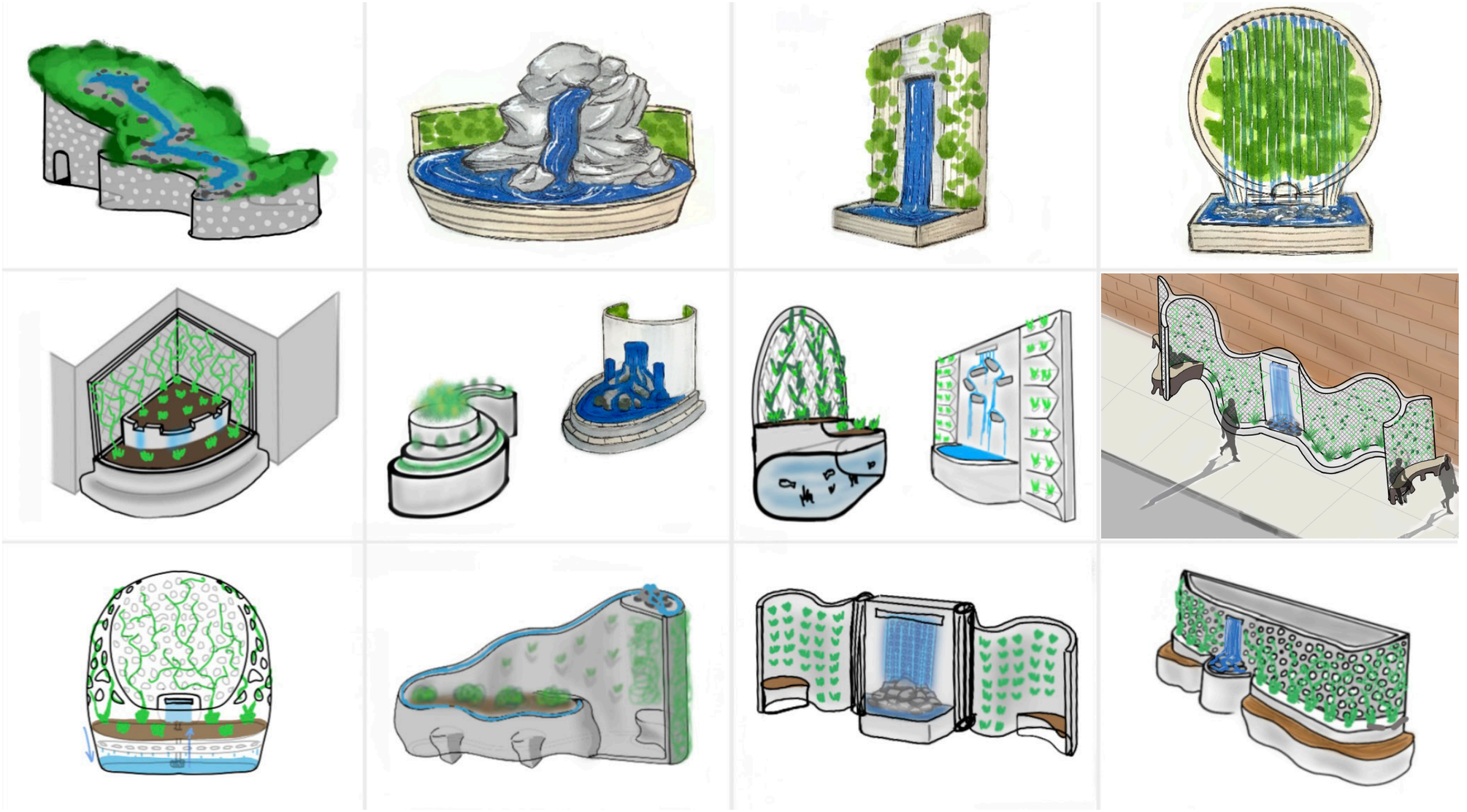
The Larger Impact

Urban Development

Envision a greener future in urban development through new technologies.

By developing shared spaces where the public may experience 3D printed structures, they may be educated on the technology and public perception of the technology may improve

Concept Iteration & Pivot Points



Concept Iteration & Pivot Points

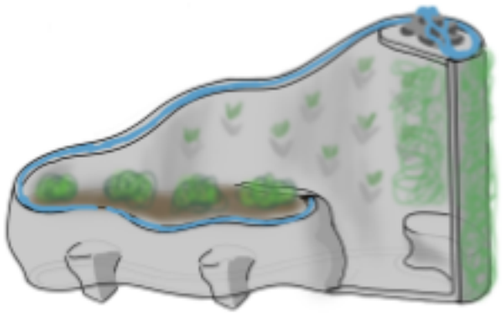
Project Evolution
A Series of Pivot Points

04 - Final Concept

03 - Wall oasis

-Insight : Spacial Realities

02 - Raised Beds



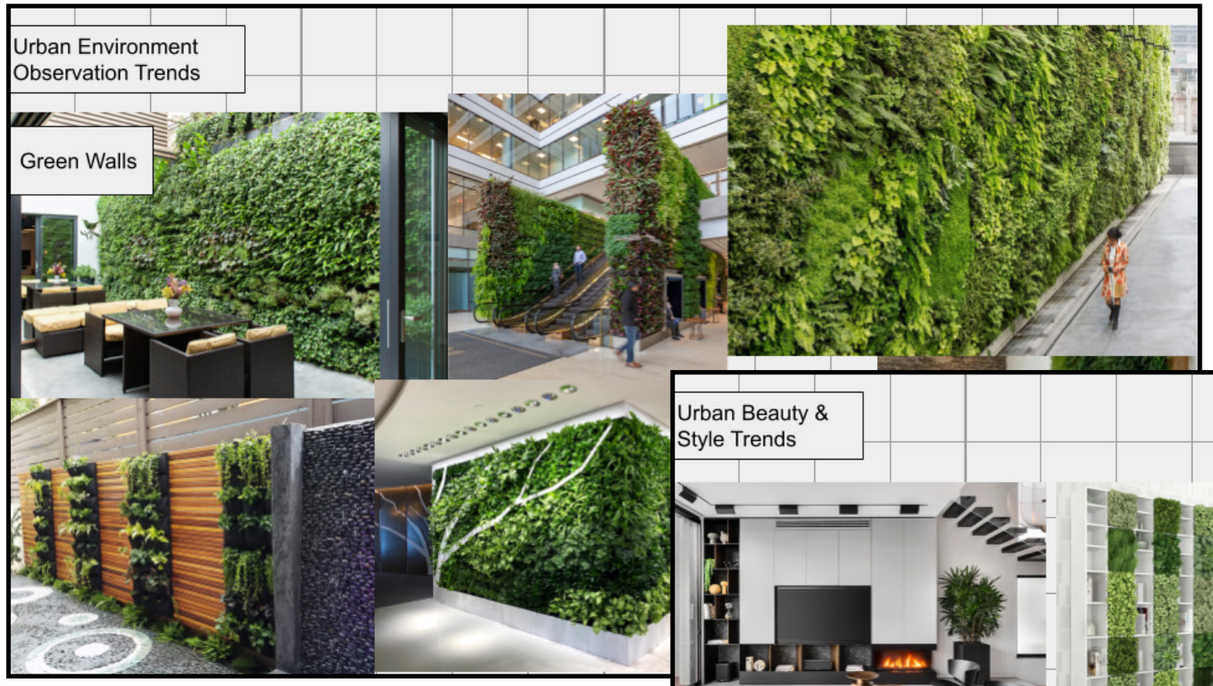
-Not enough seating, central water fountain, too small

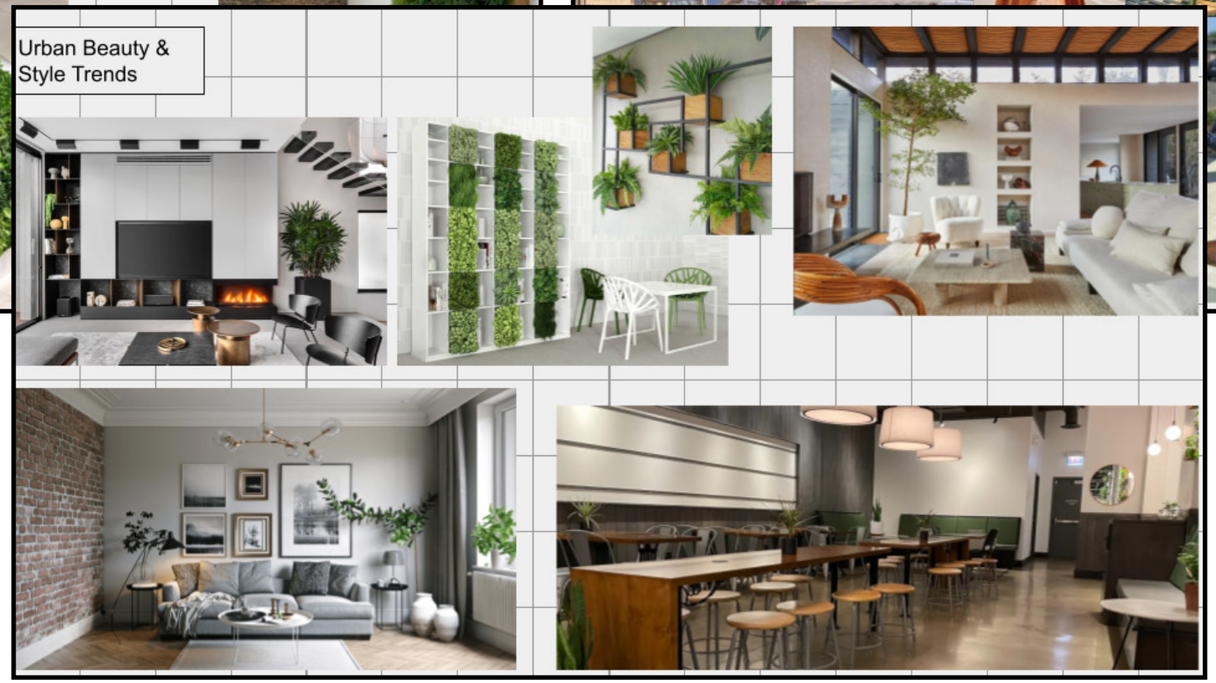
01 - Community Garden

-Too big, not plausible or likely to be successful

Market Research & Mood Board

Trends in Urban Spaces and Uban Interior Design / Style





Market Trends

Urban Green Walls
Urban Parklets

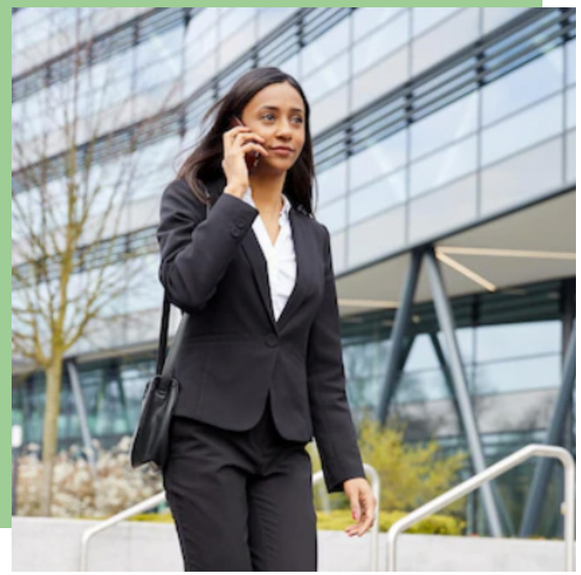
Style

Gray-scale with green accent, wood acccent

Market Research & Mood Board

Mood Board

Persona & Journey Map



Persona

NAME: Kate
AGE: 32

INFORMATION:

Kate is a mother of three and an accountant at a popular business in the city. She has been really stressed lately due to increasing workloads and a demanding boss. She has a crazy schedule and her only time she truly has to herself is during her lunch break. However she is not satisfied with the employee break room. she wants to get some fresh air to clear her head as she eats.

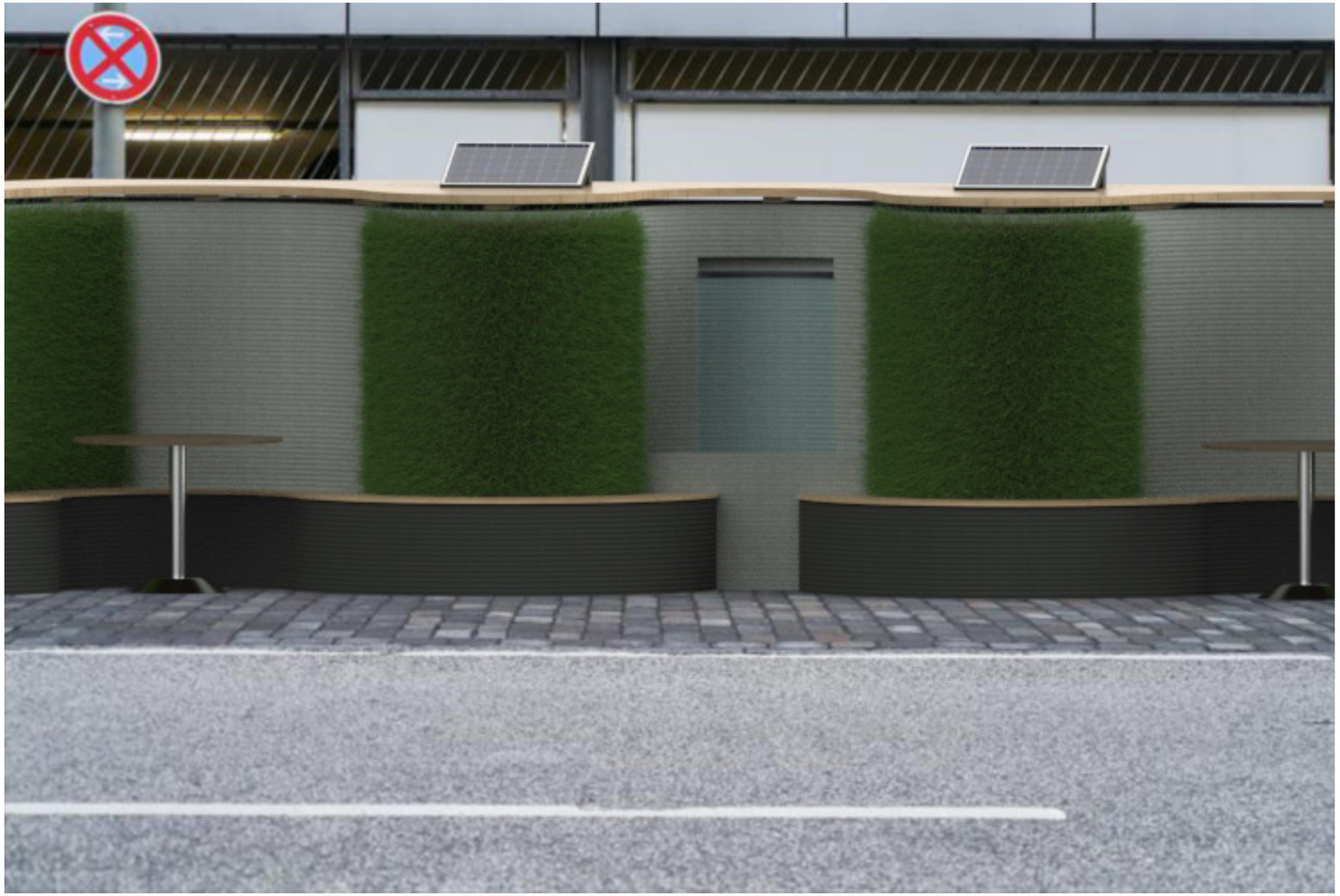
- Gets overwelmed frequently
- Wants peace and quiet
- Would like someplace to get away from her worries during her lunch break

Persona & Journey Map

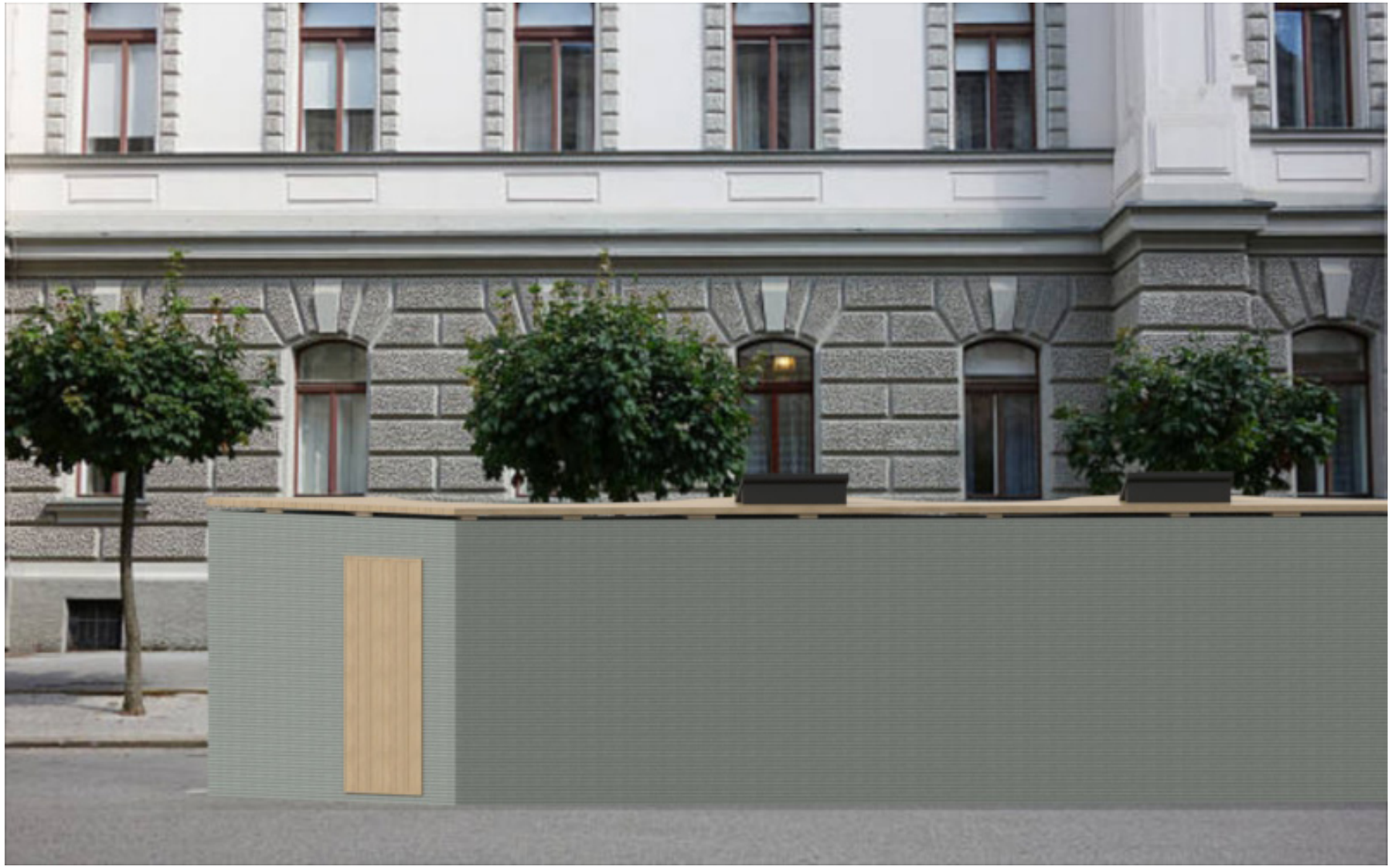
Journey Map

1. Kate has had a hard day at the office. She sees that it is lunch time.
2. She grabs her packed lunch from the employee lounge. She wants to get some air and clear her head.
3. Kate decides to eat outside. She exits her company building and searches for a place to sit. She sees the Urban Green Wall Seating Unit and thinks it is the perfect place.
4. Kate sits down at one of the tables and eats as she enjoys the greenery. She feels relaxed. By the end of her lunch hour, she is mentally rested and ready for the remainder of the work day.

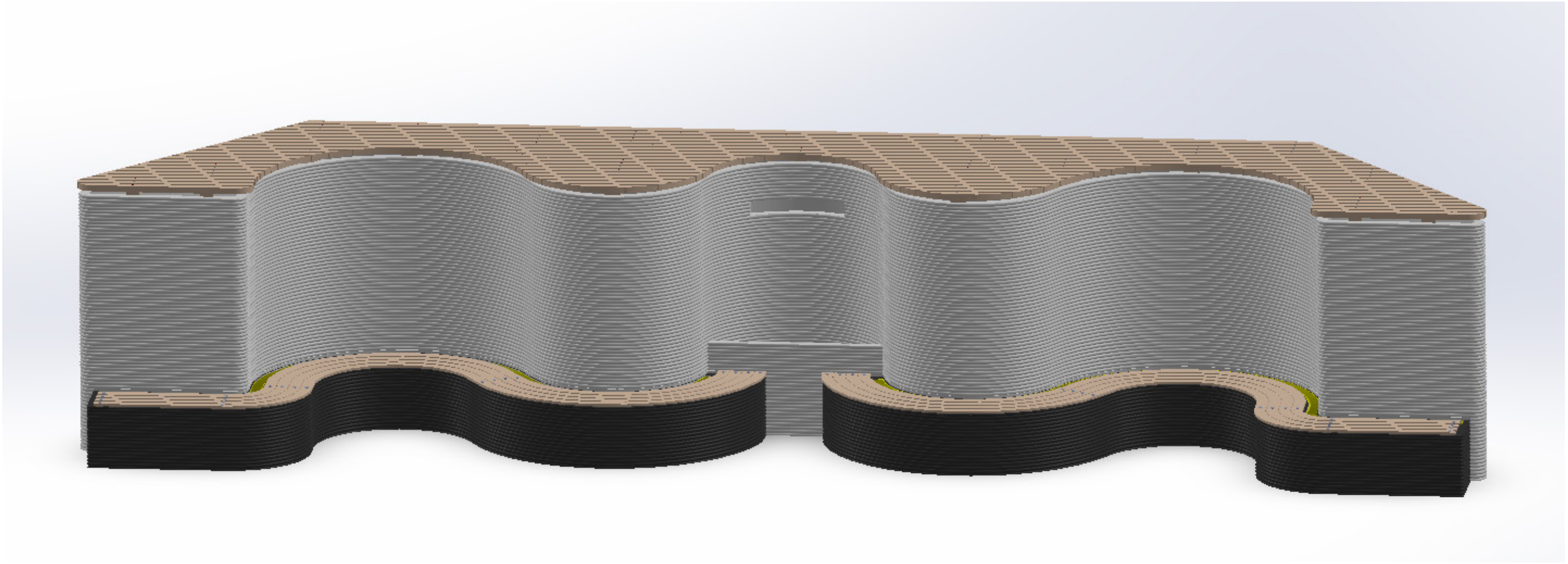
In-Context Render



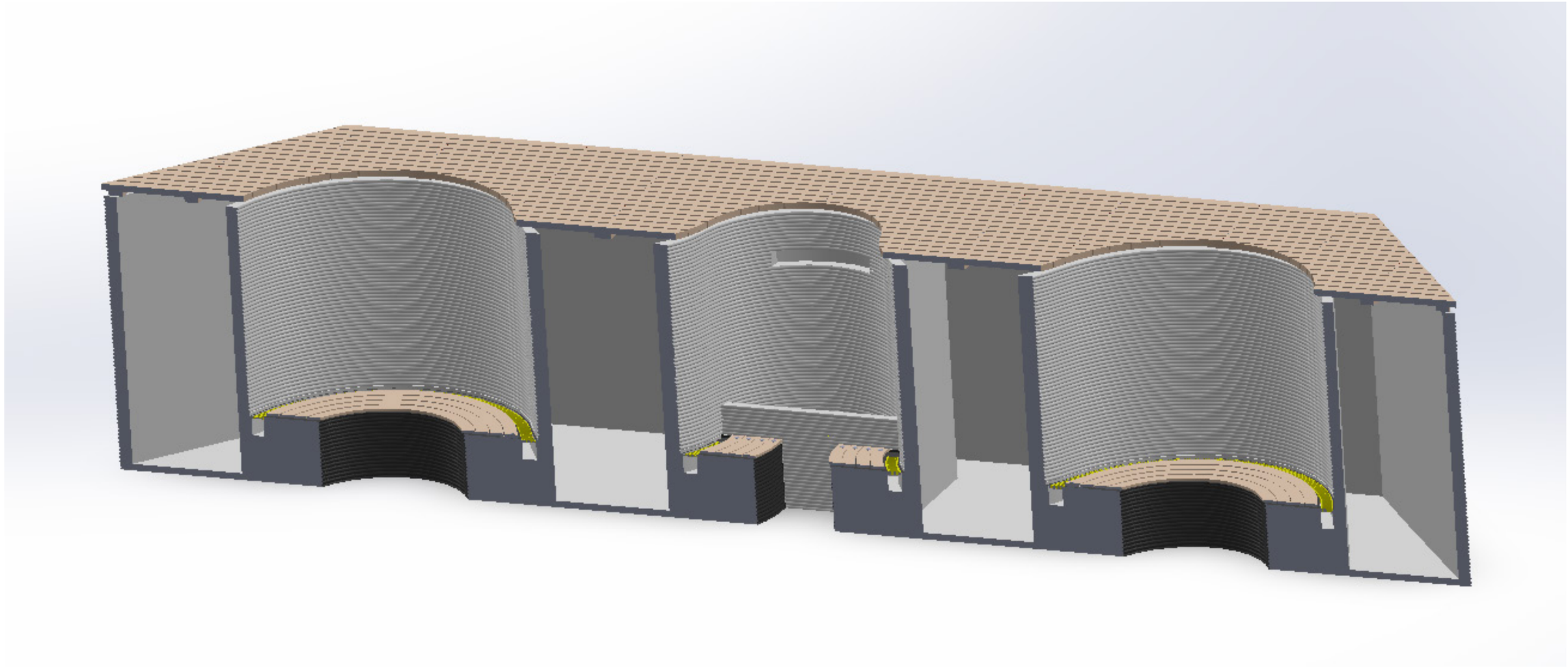
In-Context Render



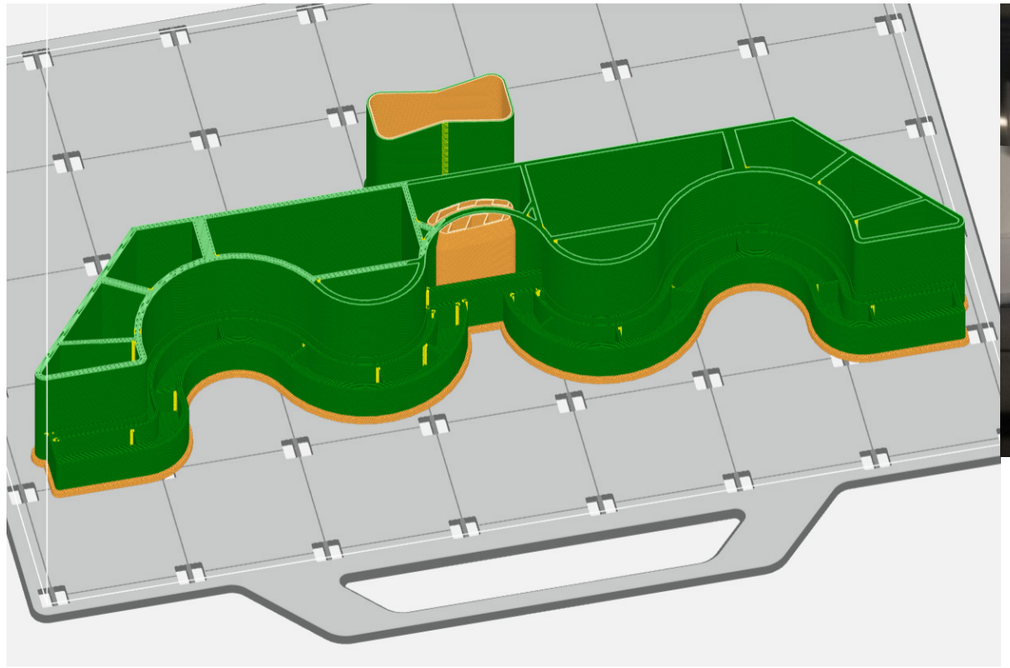
Advanced Prototype -CAD Model

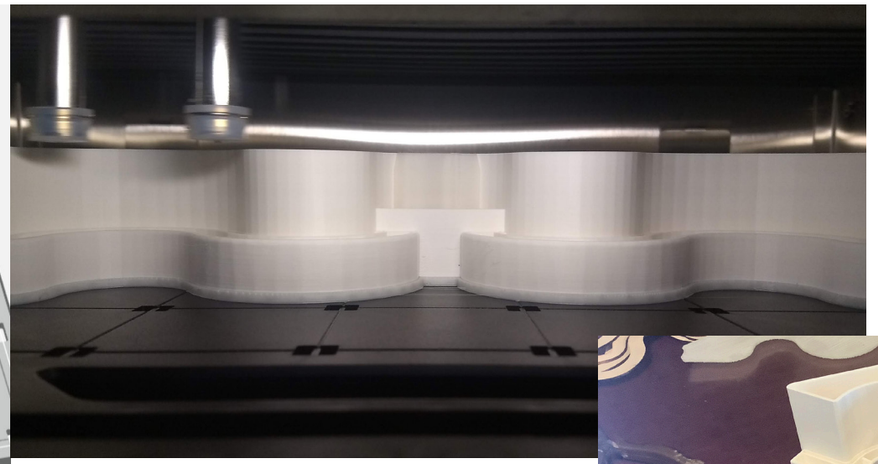


Advanced Prototype -CAD Model



Advanced Prototype -3D Print



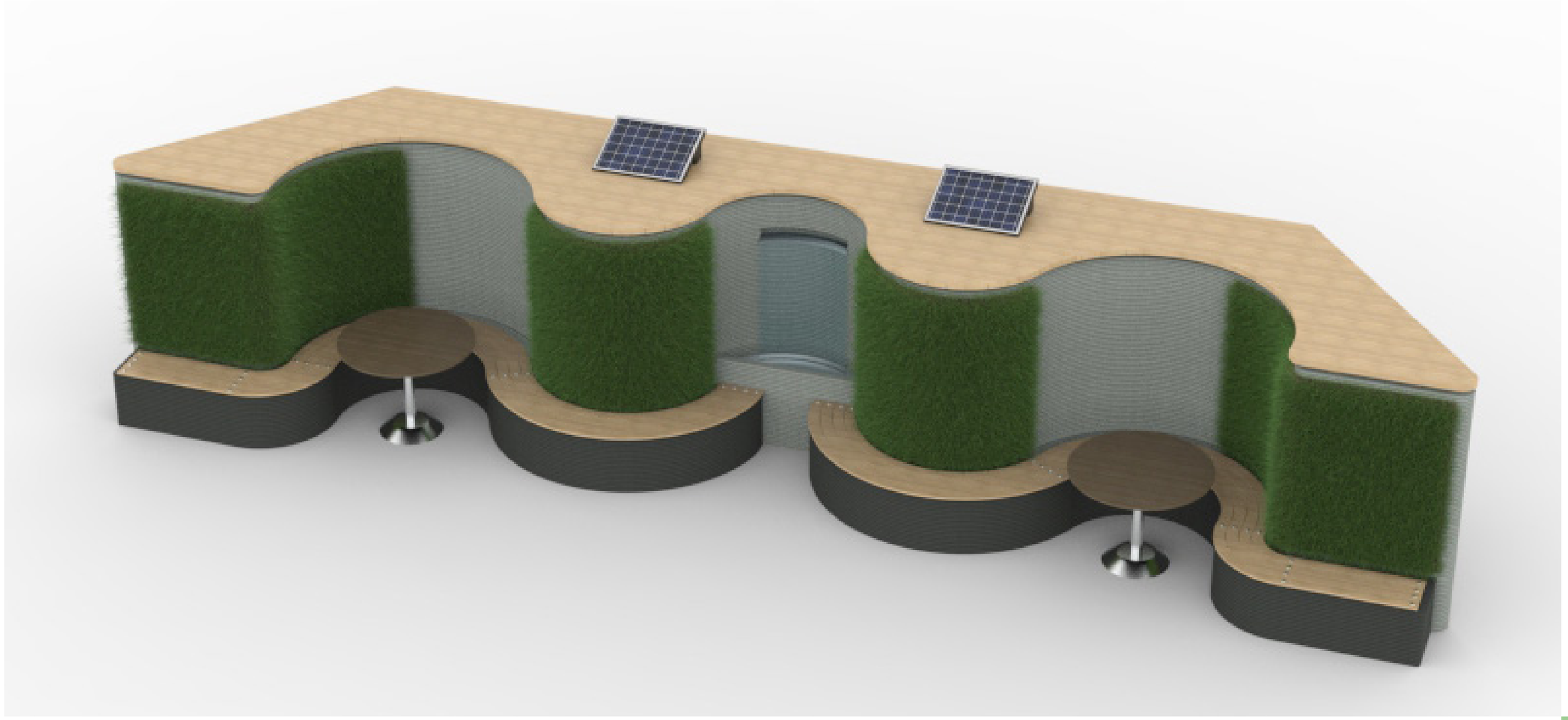


Design Commentary:

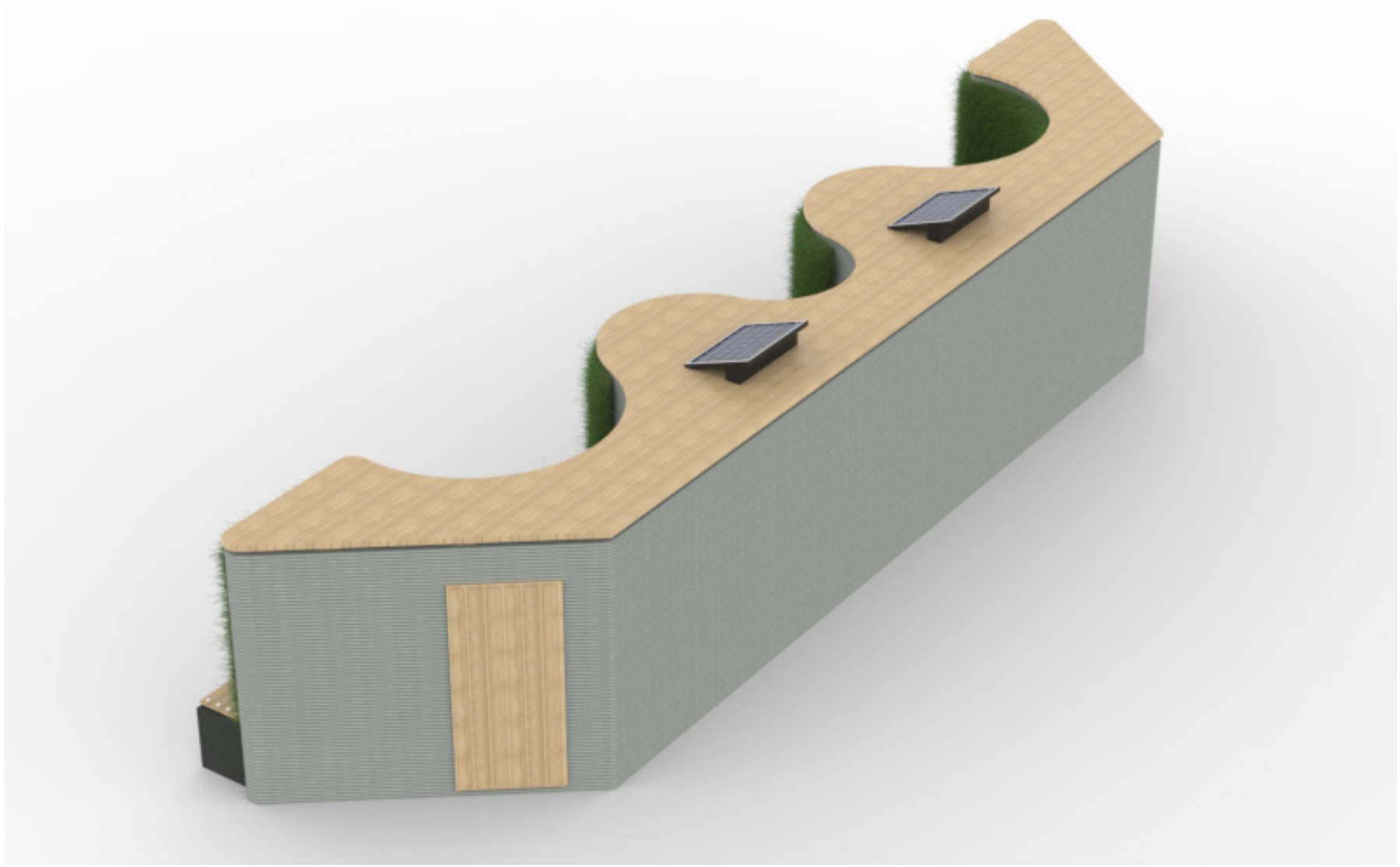
Once completed, the CAD model was put into a slicing program and sent to the printer.

Note: This model's interior would not realistically represent the design's interior due to logistical reasons with the running water.

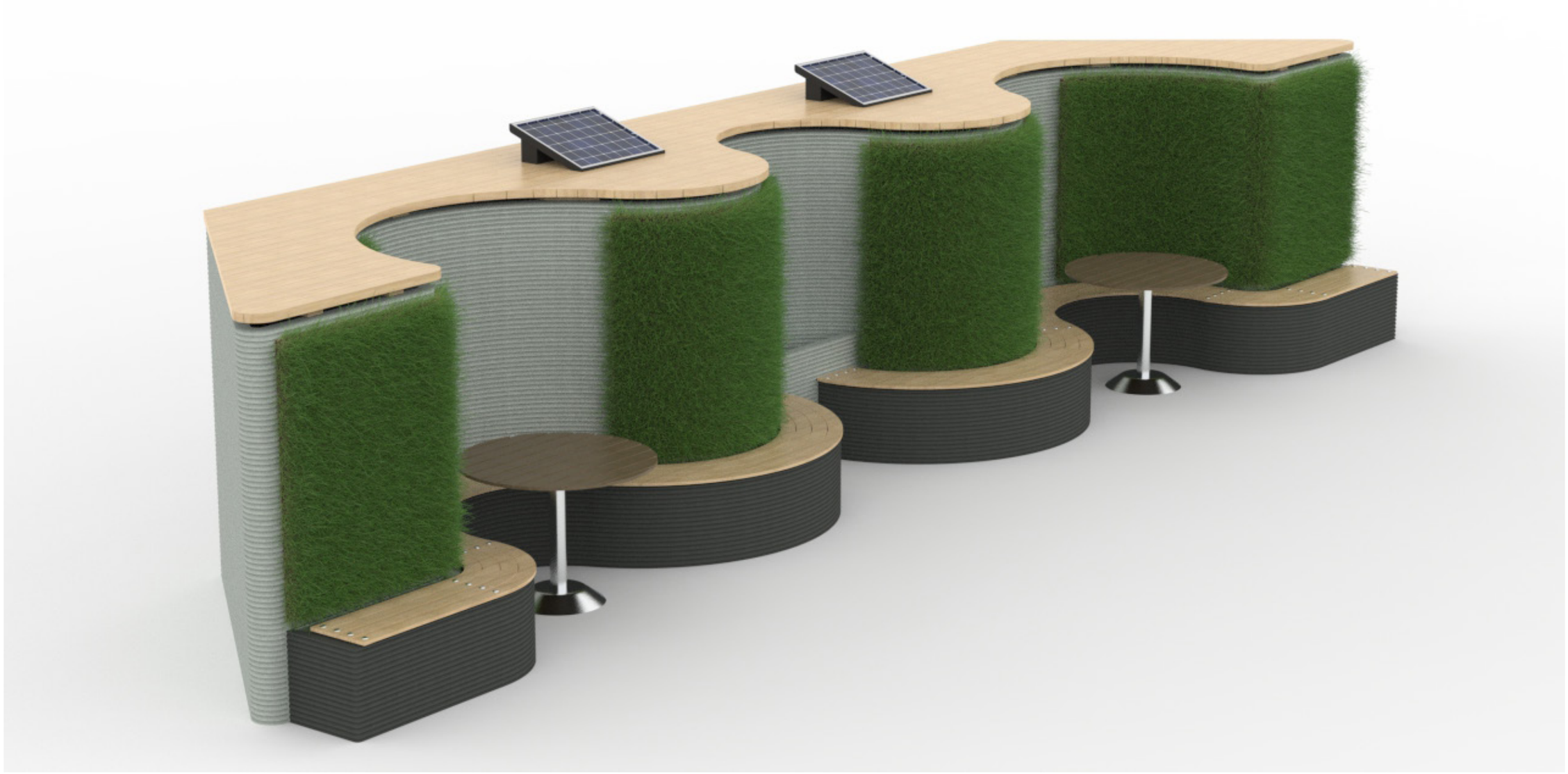
Advanced Prototype - Keyshot Renders



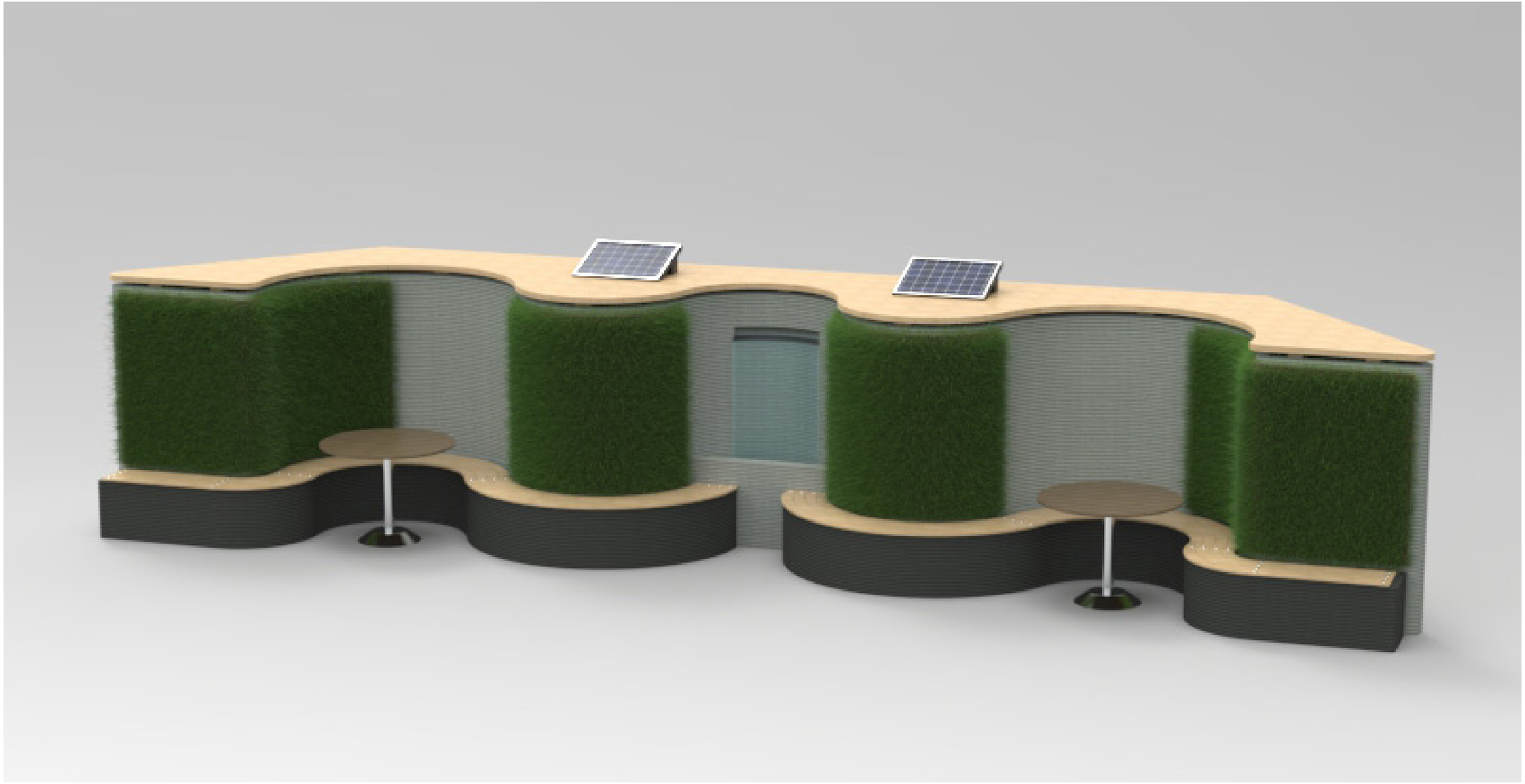
Advanced Prototype - Keyshot Renders



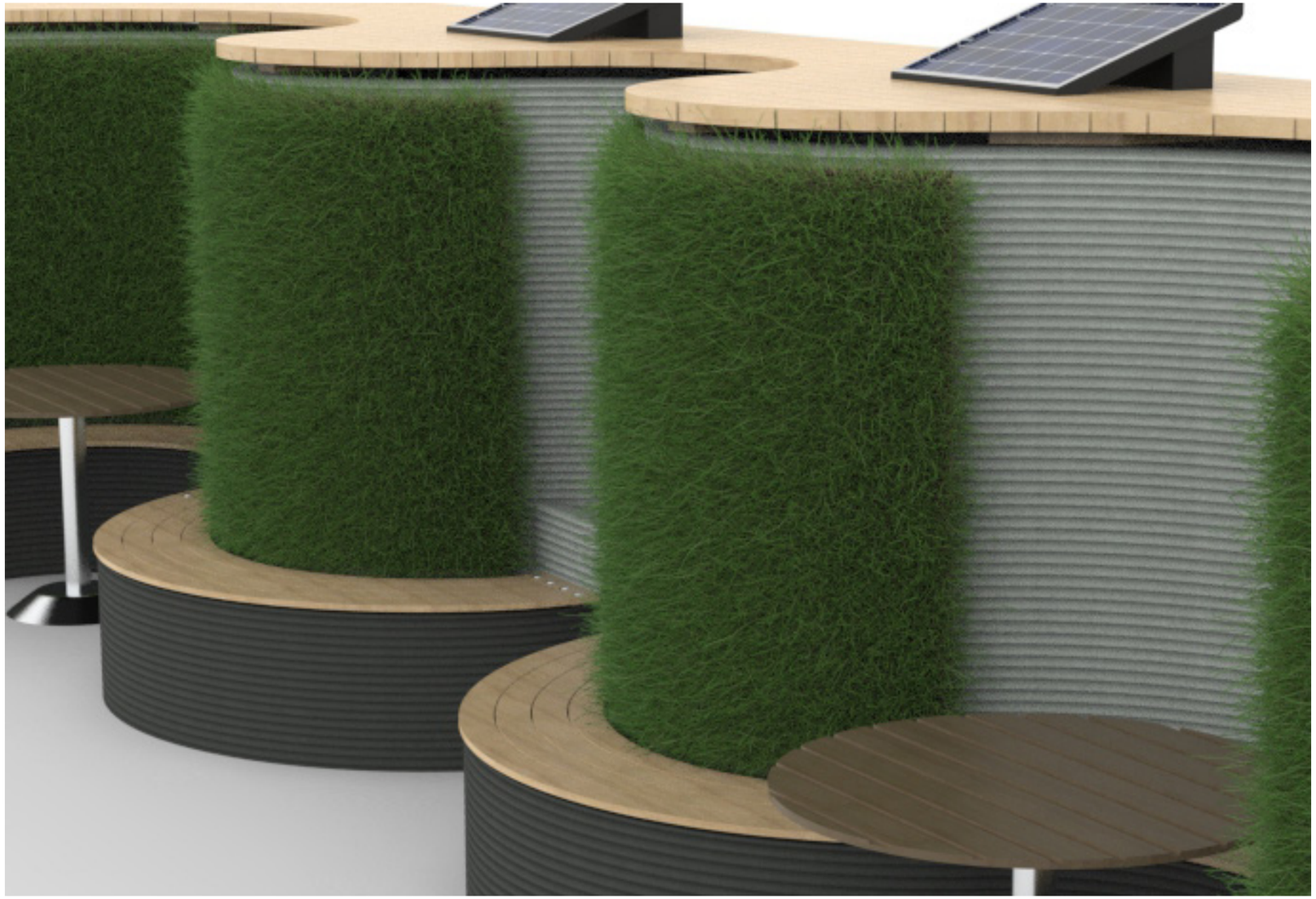
Advanced Prototype - Keyshot Renders



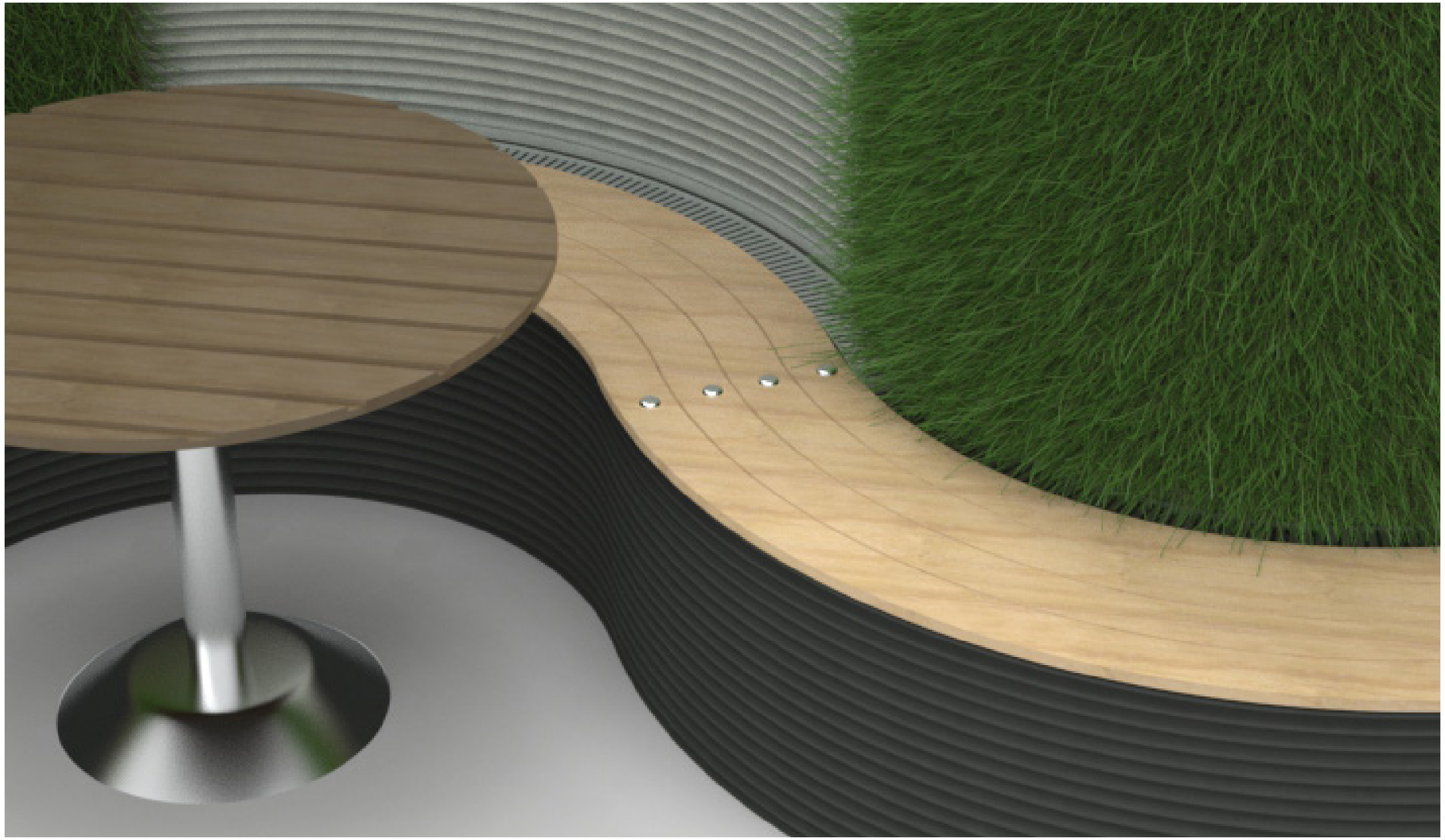
Advanced Prototype - Keyshot Renders



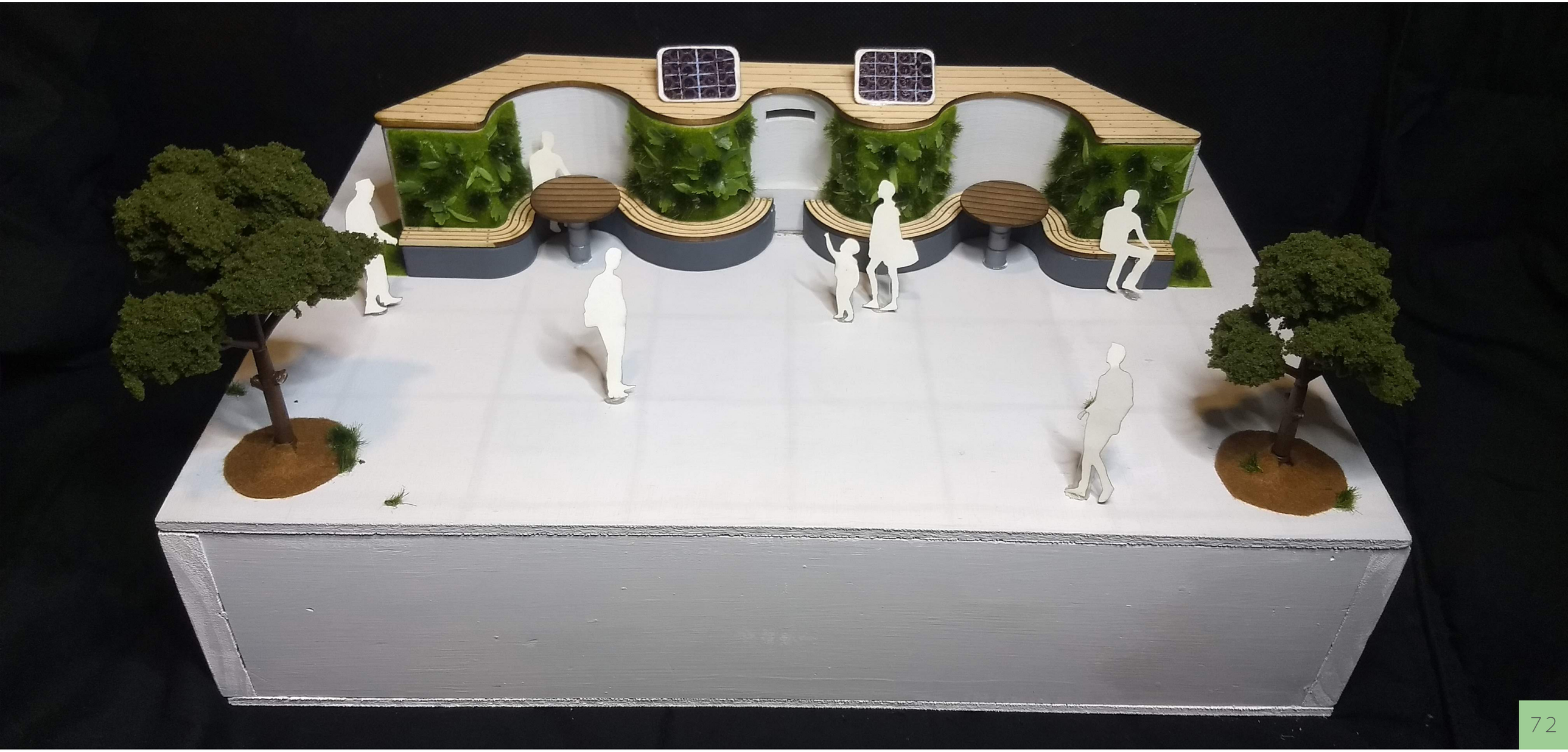
Advanced Prototype - Keyshot Renders



Advanced Prototype - Keyshot Renders



Advanced Prototype - Miniature Model

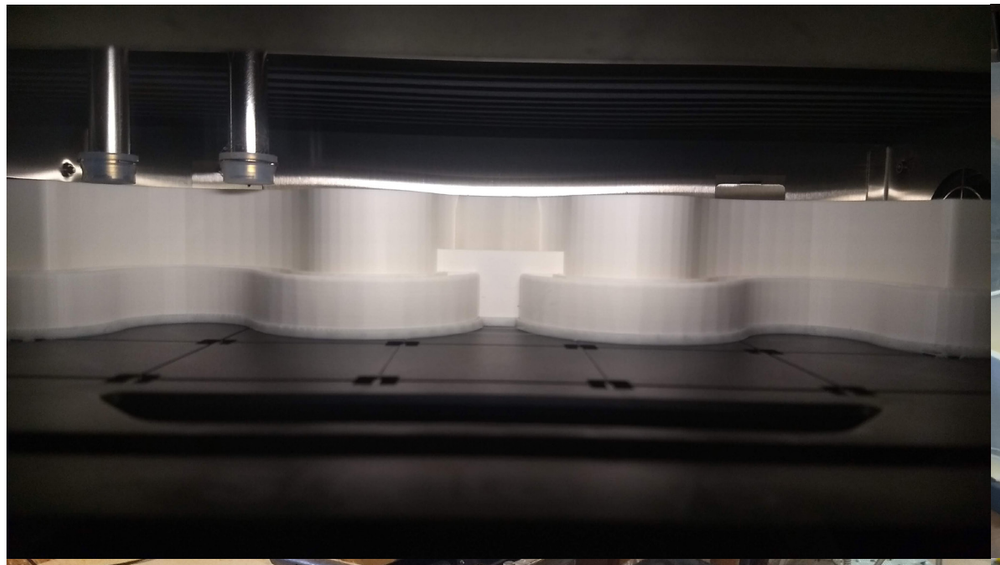


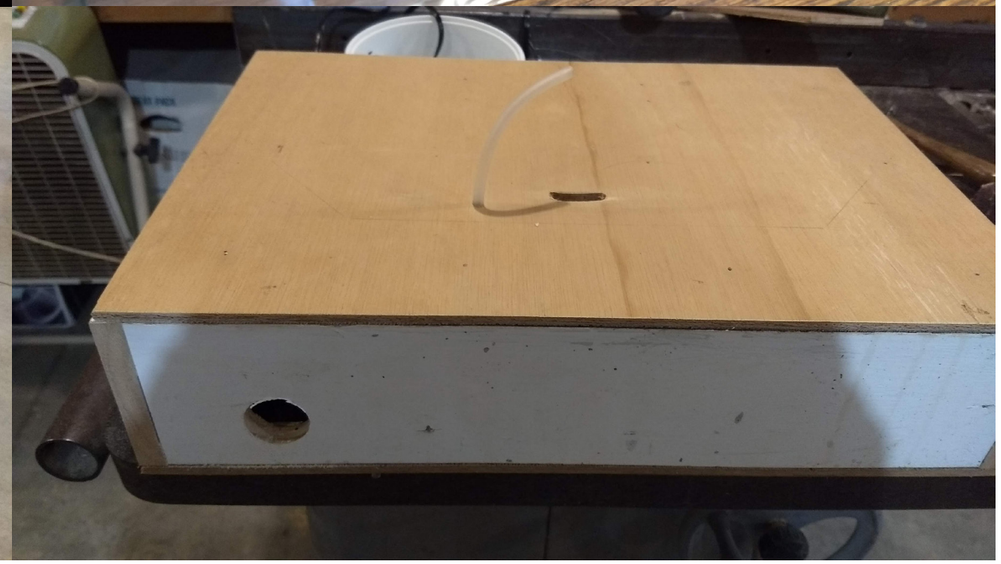
Advanced Prototype - Miniature Model

Advanced Prototype - Miniature Model

Advanced Prototype - Miniature Model

Advanced Prototype - Miniature Model Construction





Design Commentary:

After developing the CAD file, I had it 3D printed in plastice at CDME - it took nearly 12 hours. Nezt I painted it and drilled holes for the tube.

Next I had my grandpa help me make a box to hold the model and to hold the water basin inside. I made sure to leave a hole for the water pump cord.

I then added water-resistant material around the hole to prevent leaks.

Advanced Prototype - Miniature Model Construction

Design Commentary:

From there, I attached the 3D print to the wood base.

I painted the base a white-gray to mimick city sidewalk, and attached fake roll-out greenery.

I attached the wood top and bench and finished the model up by adding additional greenery, model trees, fake tuffs of grass, and silhouette cut-outs of people passing by and interracting with the unit.

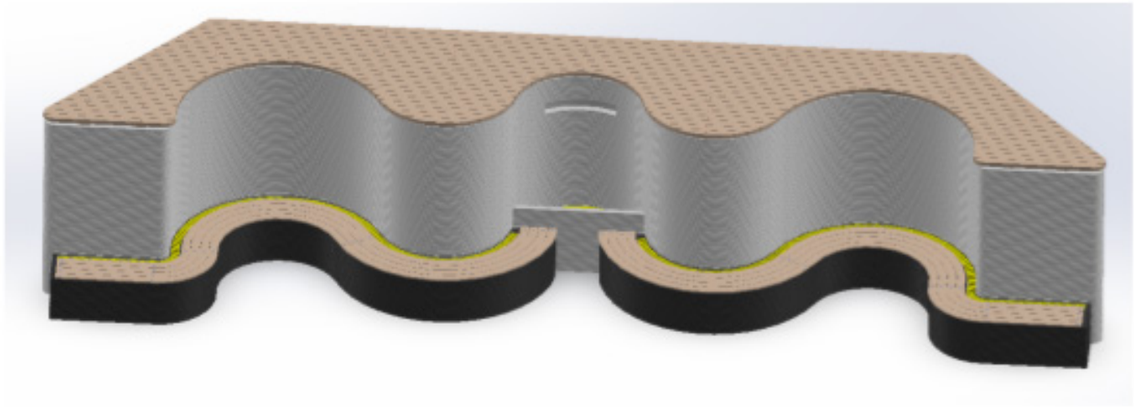
I also made sure to test the fountain and sure eneough it works.

Technical Drawings - Dimensions

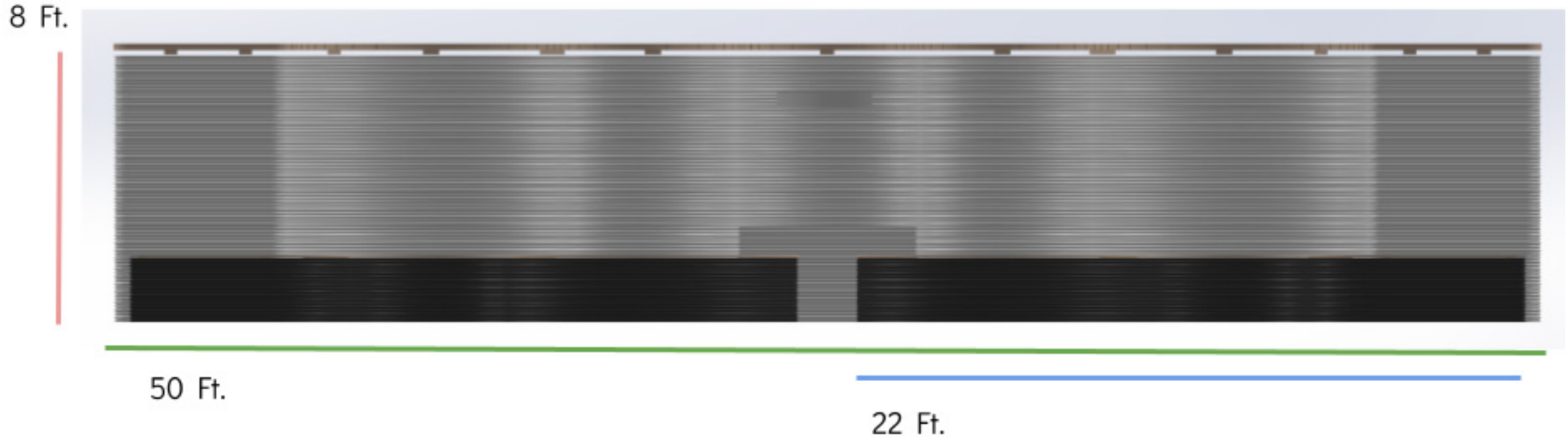
Design Decision Commentary:

I researched dimensions of street parking spaces to determine the square foot amount that my design should cover.

I envision this unit to take up the equivelent of 2 parking spaces.



I chose to develop my design to a height that was tall enough to feel like it blocked the noise of the street and tall individuals could not look over, but short enough where it did not feel daunting or overpowering to the buildings.

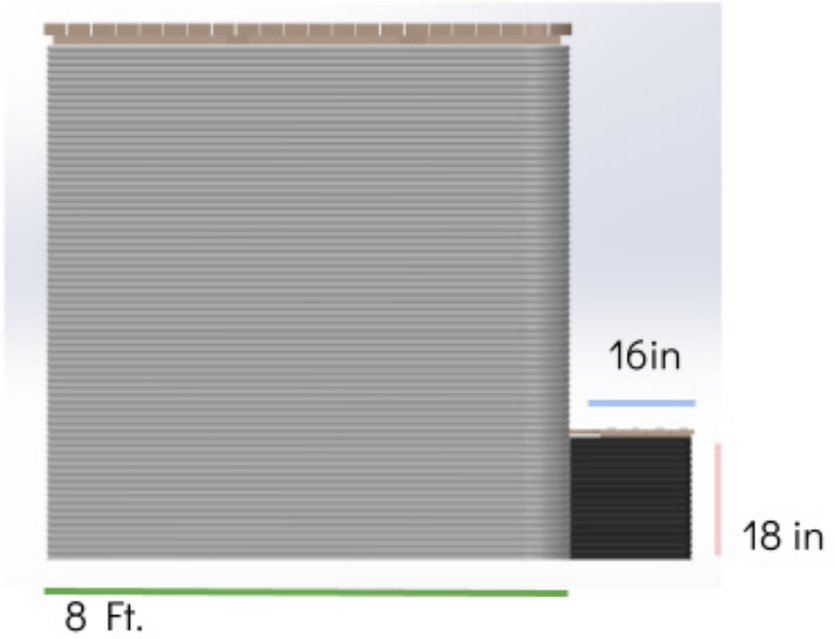


Technical Drawings - Dimensions

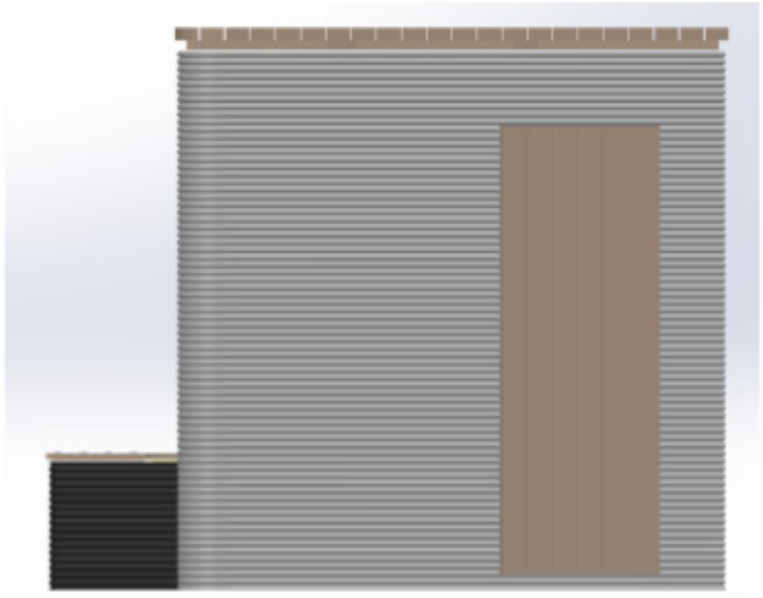
Design Decision Commentary:

I researched anatomical height standards and ergonomic seating. I also measured the hight of a few chairs I had at home. This was the basis of my seating dimension decisions.

I also researched the average dimensions of street-side parking since I wanted the option to place this unit on the street side - similar to how parklets are situated. This was the basis for thte decision for the width of the design



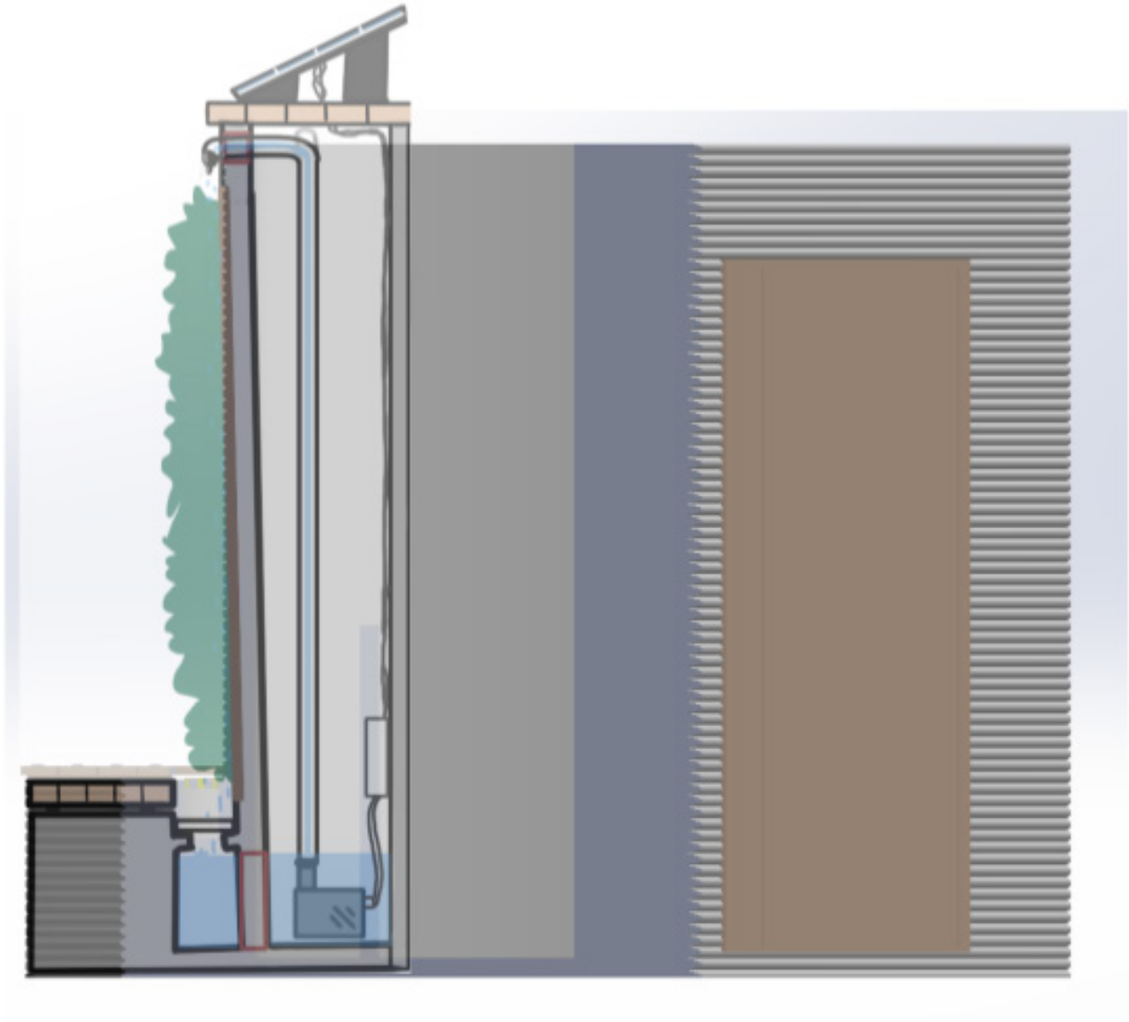
Finally, I researched standard door dimensions and measured a few doorways I had around my home. I decided on a reasonable size and made this the basis for the door's dimensions.



Technical Drawings - Irrigation System

Fountain & Irrigation System

1. Solar panels provide energy to water pump
2. Pump sends water up pipe
3. Water drips from nozzle onto plants
4. Excess water is filtered and drains back into water basin to be used again

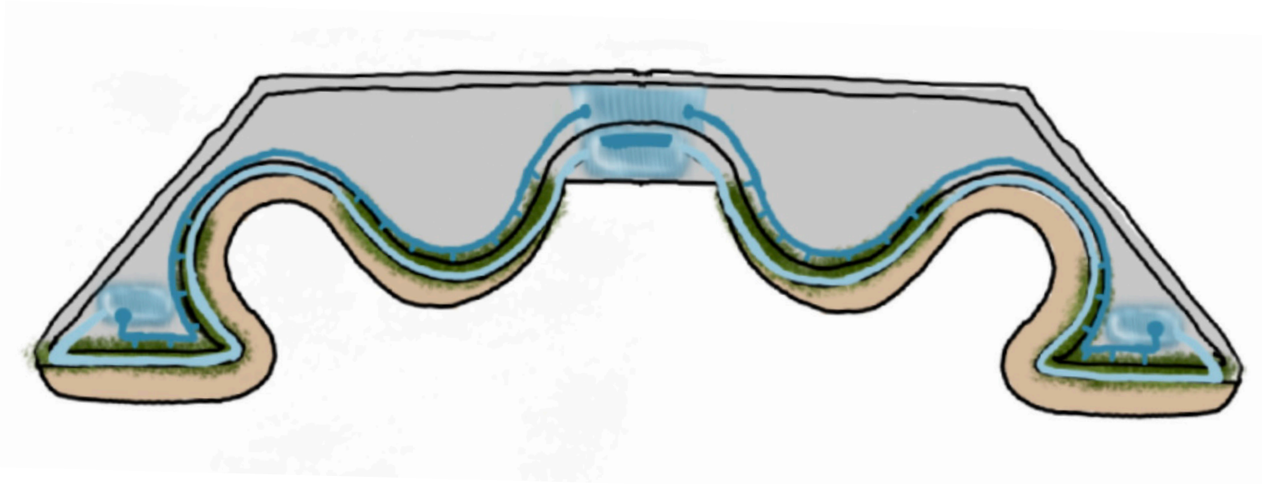


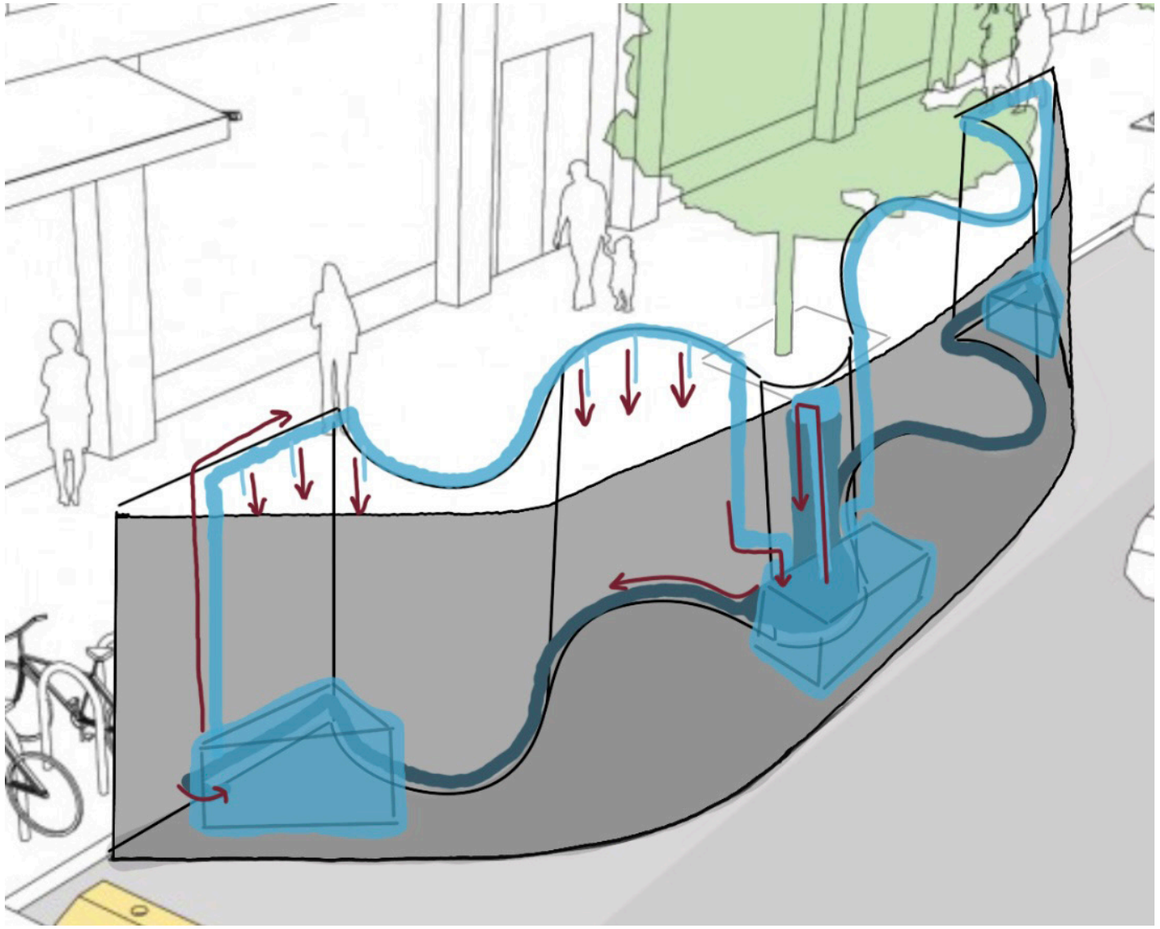
Technical Drawings - Irrigation System

Design Commentary:

The irrigation system operates on solar panels in sunny climates and in less reliable sun access, the water is circulated through other means of electricity.

The water travels through the pipes and drips onto the greenery. Excess goes to the fountain and it circulates again.





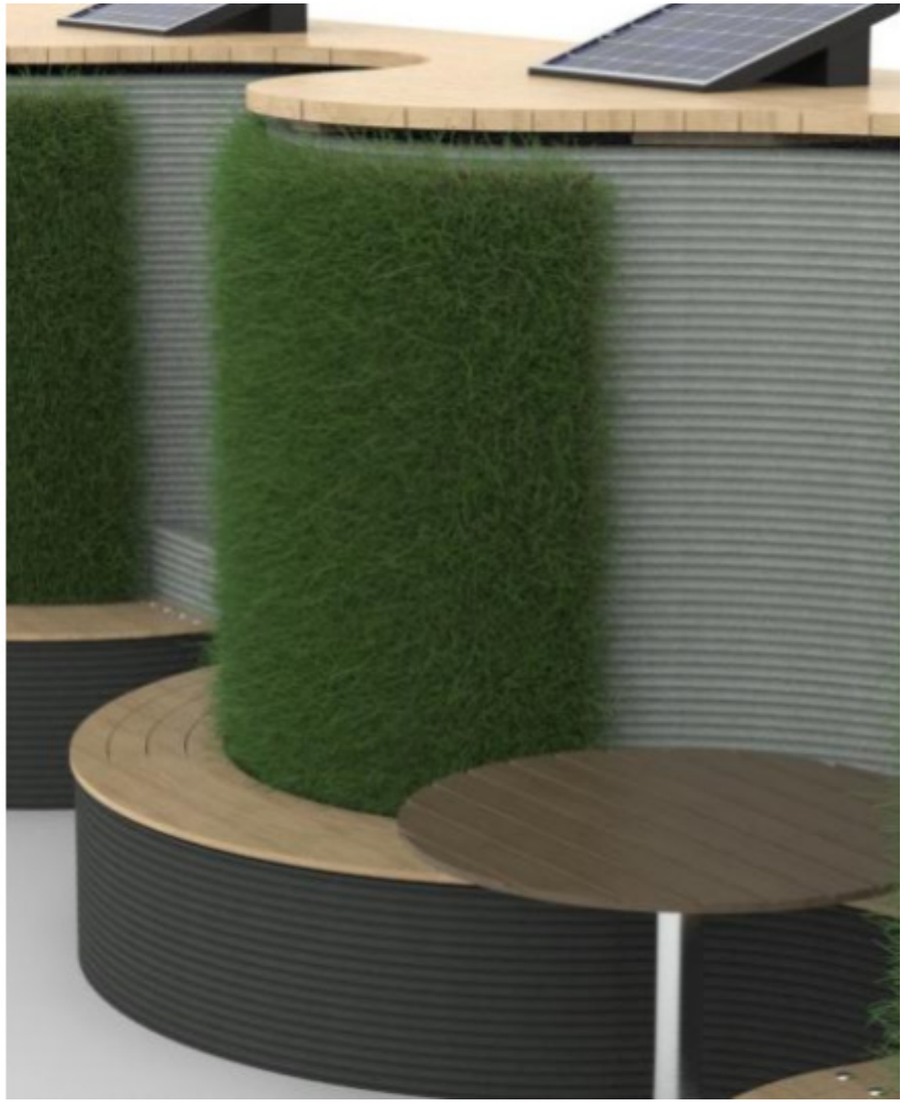
Technical Drawings - Materials

Materials

- Concrete
  - Lightweight, low carbon emission mix, locally sourced materials
- Wood
  - Locally sourced, sturdy but lightweight
- Steel & Aluminum
  - Supports, bolts, grates
- PVC
  - Pipes
- Terra Fibre mats

Outsourced Products

- Solar Panels
- Water filter & pumps



Project Review

For the final project review, I developed a summarized slide deck presentation and an introductory video. Please use the links down below to access and view them.

Design Commentary

For this final project presentation, I shared just a glipse of the research and work that went into the project's completion.

I chose to incorporate research because I felt it was necessary to capture the true spirit behind my design decisions.

Final Project Presentation:
Final Presentation Slides

Final Project Video:
Final Presentation Video

Future Development of Project

Upon reflection of this design concept, I would have liked to have explored further iterations for various locations around an urban setting.

For example, there could be one design that would be ideal specifically for the subway. There could be one design specifically for a building side. Another design could be placed on a set of steps or at the subway stop. This variation would allow the technology to really shine and show its abilities to work around the environmental obstacles and conditions.

I would also have liked to dive further into the technology's ability to develop complez patters with its layer path placement. I believe there is a lot of opportunity here that I simply did not have the ability to explore due to limited access to the printer.

Process & Project Reflection

This project was an excellent experience for me. It allowed me to test my design knowledge and skills in practice and highlighted various areas for self-improvement.

Biggest Challenges

- Making the design decision call on my own
- Time management
- Remaining organized throughout the project
- Stepping back to communicate clearly

Looking Back - What Would I Have Done Different

- I would have chosen my design concept earlier and would have began development sooner. This would have allowed me more time to iterate on that concept and push the development to the next level.

- I would have taken more time to step away from the project to communicate about it. I struggled to look at my project from a distance and because I was in so deep into the details, I stuggled to communicate in my presentations and videos about the picture Idea - why I did what I did and how it was meaningful.

Final Reflection

Overall, this project was a great learning experience for me. I am proud of the work I put in and am pleased with the result. I was able to gain experience in project management and will work hard in the future to develop these skills and myself further.

About the Designer

Samantha Louise Gaerke

I am a product and graphic designer from Midwest Ohio, and am currently a senior at the Ohio State University studying Design and Agricultural Communications.

My experience includes: Product Design, Graphic Design, UX/UI, 3D Modeling, Video & Photo Editing, Graphic Animation, Adobe Suite, & Design Research.

I aspire to bring about sustainable and meaningful solutions through my research and design ventures.

Portfolio Site: https://samanthalgaerke.wixsite.com/website

Resources:

OneDrive Master File Folder: https://buckeyemailosu-my.sharepoint.com/personal/proulx_12_osu_edu/_layouts/15/onedrive.aspx?FolderCTID=0x012000B80E95924D0AC34193DF5D5D7C7C787A&id=%2Fpersonal%2Fproulx%5F12%5Fosu%5Fedu%2FDocuments%2FTeaching%2FF22%2F5200%2D5101%2FCapstone%20IND%202022%20Students%20Work%2FSam

Desis Senior Thesis Website: https://desis.osu.edu/seniorthesis/index.php/sam-gaerke-cdme/

Acknowledgements

Thank You

Ohio State University Department of Design
OSU Center for Design and Manufacturing Excellence
COBOD International

Special Thanks

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Krista Smith - Assistant Prof.

CDME Ben DiMarco - Project Partner Lead
Michael Lander - Additive Mfg. Consult
Ryan Brune - Additive Mfg. Lab

Other My Grandpa - Woodworking Assistant

This project was a collaborative effort between the Ohio State Department of Design and the OSU Center for Design and Manufacturing Excellence (CDME). COBOD was a partner by extension through CDME.

Thank you to all involved parties and individuals. Without you, this collaboration and project would not have been possible. I appreciate all the guidance and resources made available to me through this project and am extremely greatful for the mentorship and feedback I recieved.

I look forward to collaborations and parnterships in the future.

DEPARTMENT OF DESIGN

CDME

COBOD