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## Bio-As:Biophilic Redesign of the Residential Home

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# BIO-AS

Thesis Research - 2023

NADIA ALEXANDER



# Bio-As

## Biophilic Redesign

Approval of Thesis Research  
Project Book is Presented to:

Trace Gainey

and to the  
Faculty of the Department of Architecture  
College of Architecture and Construction  
Management

by

Nadia Alexander

In partial fulfillment of the requirements for  
the Degree

**Bachelor of Architecture**

Kennesaw State University  
Marietta, Georgia

May 9, 2023

# ACKNOWLEDGEMENT

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As an expression of gratitude, I'd like to begin to thank my family for being as supportive and gracious as they have been during these years through my nay struggles.

I would like the thank KSU faculty, because of the people I have met who have had a much greater impact on me than they could even imagine and I am very grateful for that.

Lastly, I would like to thank my peers. Because without them I truly don't believe I would have made it this far. From the bottom of my heart, I wish each and every one of them the very best.

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# THESIS POSTER, ABSTRACT, AND METHODOLOGY

# THESIS POSTER



Fig, 1. Thesis Poster



# ABSTRACT AND METHODOLOGY

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Biophilia in architecture is more than just the delicate balance between creating a sustainable future, and the unfortunate side effect of greenwashing. It explores the physical and physiological benefits of plants in design. It is described as the science of making a connection between the building occupants and the natural environment. It is the scientific evidence we have that comprises mankind's need to be close to the natural world around us and how we should take greater responsibility to foster a more prominent connection between people and nature.

However, our predisposition to greenery has been interrupted and called into question more often as of late. Because of the rapid disconnect of man with nature through urbanism which is further exasperated by the global pandemic, the physical and psychological relationship to nature has declined precipitously. The pandemic has forced more people to reevaluate the concept of work and how we carry out our daily lives. With more and more time spent in our homes nowadays, the effect of being withdrawn from the outside world has manifested in many ways recently. A lot of them are psychological. How do we create a better way of life that's "normal" and carve out a way to further the positive effect later on in the future?

The answer to how we recreate a new human experience is changing structurally how we build our homes. The traditional design of the home is probably not going to change any time soon, but if the construction of the home can be built to supplement a better connection between people and the natural environment, why not take that chance? A new idea of the residential home can be centered around a new form of construction within. A component could be modeled that combines a structural display of biophilia that aims to solve, or at least aid in the well-being of the occupants. This structural model's form based on the appropriate scientific response to humans and their home's climate could be to rejoiner to how we redefine the ideal of the residential home for the future.

**Bio-As** is the assimilation of structural design and biophilia in residential architecture. It is the re-imagining of the intervening spaces defining a home through the production of panels, modules, and nodes.

These three differing scales of production can be used to form a connection between the natural environment and traditional spacial structures.



# THE PRINCIPLES OF BIOPHILIC DESIGN

# BIOPHILIC DESIGN



Fig, 2. Growing Succulents

The biophilic concept is an approach in architecture and design that aims to increase the connection of building occupants to the natural environment. Through elements like natural lighting, ventilation, natural landscapes and space conditions, the building serves as the bridge allowing people to connect with nature while indoors.

## 1. Environmental features

Direct contact with greenery is the most straightforward and widely used method of fostering that human-and-nature connection.

In both interiors and exteriors, this is adhered to through the presence of indoor vegetation, water features, outdoor gardens, green walls, etc. On top of that, natural materials such as wood and stone add to the overall natural feel.

As one of the most successful biophilic design strategies, a nature-filled space indoors is usually the first step to achieving biophilia. The feeling of relaxation and respite in these green environments and blue spaces are known to reduce stress, lower blood pressure and heart rate, enhance mood and calm and prompt healing.



Fig, 3. Cape Tribulation House

# BIOPHILIC DESIGN



Fig, 4. Japanese Zen Garden

The term – ‘biophilia’ – was first coined by Erich Fromm, a social psychologist who observed the rapidly increasing disconnect of humans to nature due to urbanization.

## 2. NATURAL SHAPES AND FORMS

Natural environments are complex spaces with varying elements and patterns. While the presence of real plants and natural elements are best in achieving psychological benefits, mimicking nature’s shapes and forms also have some positive impact.

## 3. INTERACTION THROUGH MULTI-SENSORY STIMULI

Seeing greenery around us is good, but being able to smell the flowers or hear the flow of water is even better. Finding opportunities to interact with our sensory systems in and around the built environment is essential to stimulate organic growth.

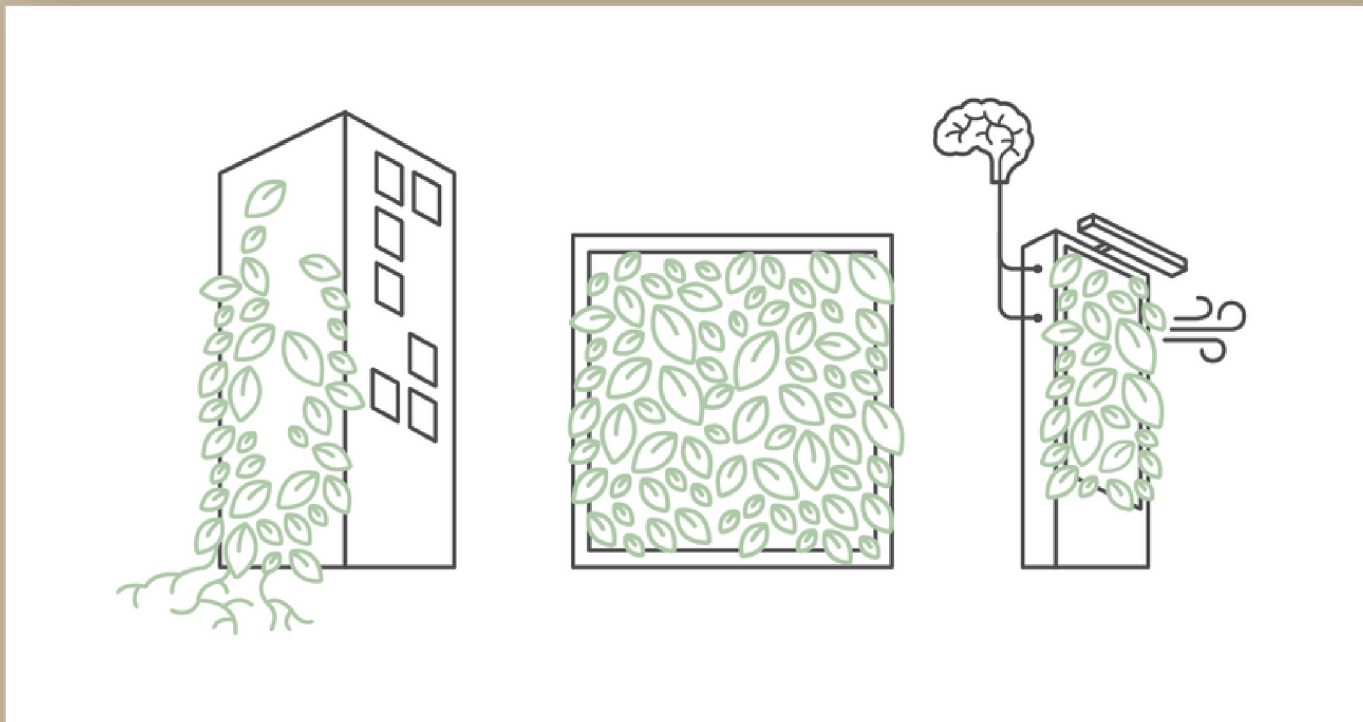


Fig, 5. Tropical Courtyard



# ANALYSIS INTO GREEN WALLS

# GREEN WALLS TYPES



Fig, 6. Green Wall Types

## Left: Green Wall Facade

Green walls differ from facades, which are often seen climbing up the outside walls of buildings, using them as structural support. In green walls, the growth medium is on the surface or structure of the wall, whereas facades are rooted in the ground. Moreover, the greenery of facades can take a long time to grow enough to cover an entire wall, while green walls may be pre-grown.

## Middle: Green Wall

Green walls are vertical structures that have different types of plants or other greenery attached to them. The greenery is often planted in a growth medium consisting of soil, stone, or water. Because the walls have living plants in them, they usually feature built-in irrigation systems.



Fig, 7. Plants for Living Walls,

## Right: Smart & Active Green Wall

Smart and active green walls often look similar to conventional green walls, but serve more purposes due to the use of artificial intelligence and technology. The features of a smart living wall can be automated and monitored, enhancing the effects.

In addition to the visual and biophilic benefits of all green walls, smart and active green walls can feature natural air purification and humidification thanks to the combination of enhanced air circulation, specialized growth medium, and technology.

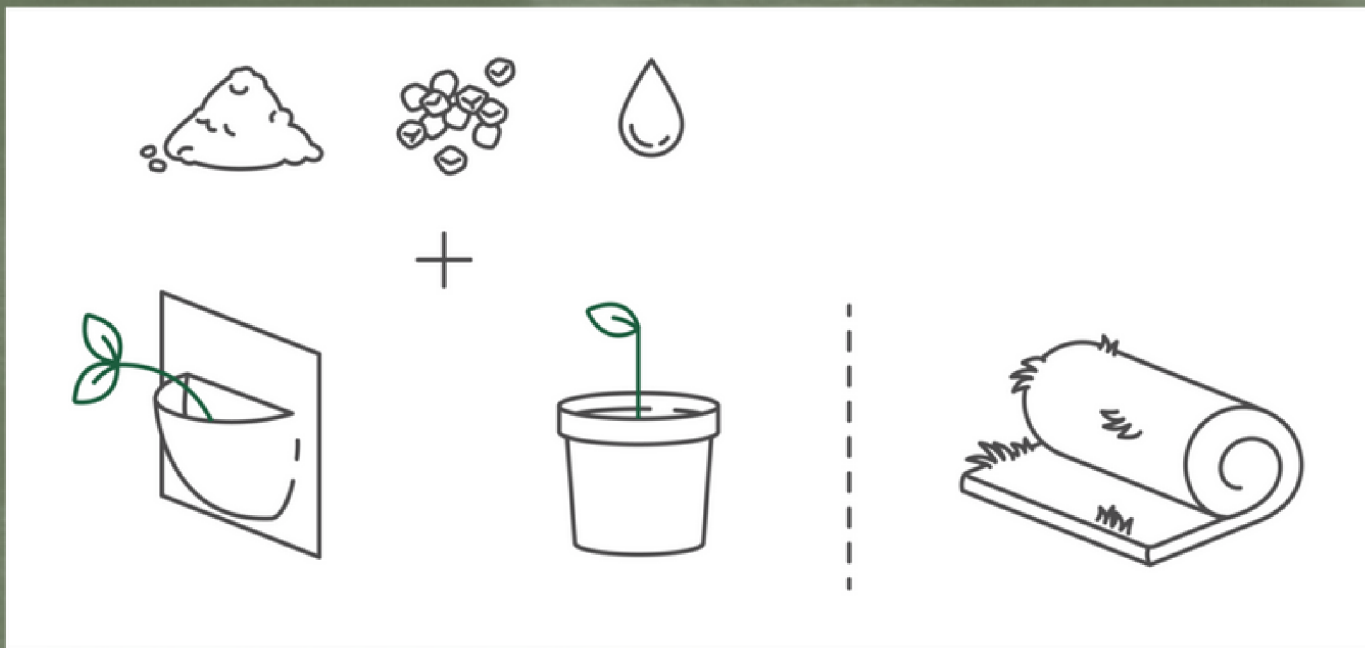
# GROWING MEDIUMS

## Loose Growth Medium

Loose growth medium systems have the soil packed into a shelf or a bag (which are then placed onto a wall)

## Mat Media

Mat media are, as the name implies, mat systems, usually made of thin coir fiber or felt. The plants root themselves directly onto the mat and require no loose media (such as soil).



Fig, 8. Loose Growth Media

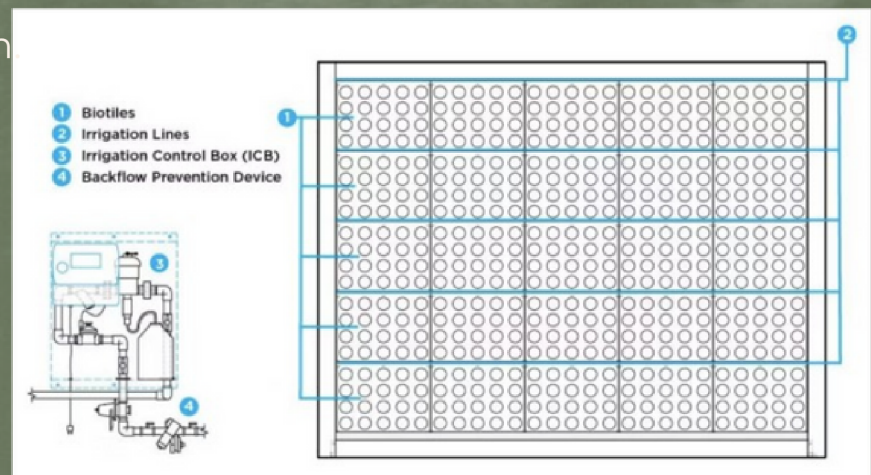
## Structural Media

structural media combine the loose and mat systems by forming a block that can be made in different shapes and sizes. For example, the greenery can be planted into loose media, placed into pots, and laden onto a wall structure with a built-in irrigation

## Sheet Media

Sheet media are akin to mat systems, but consist of patterned inorganic polyurethane sheets more endurant than coir fiber or felt.

# WATER MANAGEMENT SYSTEMS



Fig, 9. Custom Wall Drip Irrigation System

## Drip Irrigation System:

Most custom living green walls are hydroponic systems that are irrigated by a drip irrigation method. These systems link an Irrigation Control Box (ICB) directly into the building's plumbing system. Using horizontal irrigation tubing, drip irrigation systems are self-watering, and can be set to release based on a timed schedule. Drip irrigation tubing is 85% more water efficient than a water tank system.

## Tank Systems:

Tray systems and freestanding walls are essentially just "water tanks." These need to be manually filled and refilled. Tray systems are not typically tapped into the building's water source and therefore require more ongoing labor. They are also less water efficient because they do not automatically recycle unused water.

# GREEN WALLS SYSTEMS

## Panel/Modular System:

Plants are pre-grown into panels that can be used inside or outside, and in any type of climate. A phenomenal example of a panel green wall system is Sagegreenlife's Custom Built-In Living Walls.

These plants are cultivated 6-8 weeks prior to the installation date.

## Freestanding Walls:

Freestanding walls are smaller, movable living walls that can be placed in indoor or outdoor settings. They can be placed against a wall or in the middle of a room, and are ideal for temporary spaces or floor plans that change over time. They can also be used as partitions or room dividers.

## Tray Systems:

Plants are pre-grown off-site and inserted into the wall, which allows for a great degree of design flexibility, especially since trays can be easily removed and replaced. Typically cheaper than panel systems, tray systems are most commonly used in interior settings. An excellent example of a tray green wall system is GSky's Versa Wall.

With tray systems, each individual tray is designed to hold a measured amount of water, which means that plants do not have to compete for hydration. Also, because of the orientation of the trays, neither soil nor water spills forward, which makes them suitable for indoor environments.

Tray systems also come with distinct challenges. Since the plants are rooted in soil, tray systems can lead to bugs, fungus, mold and even pathogens. Therefore, they often have to be replaced at least every month, which can be costly and inefficient.

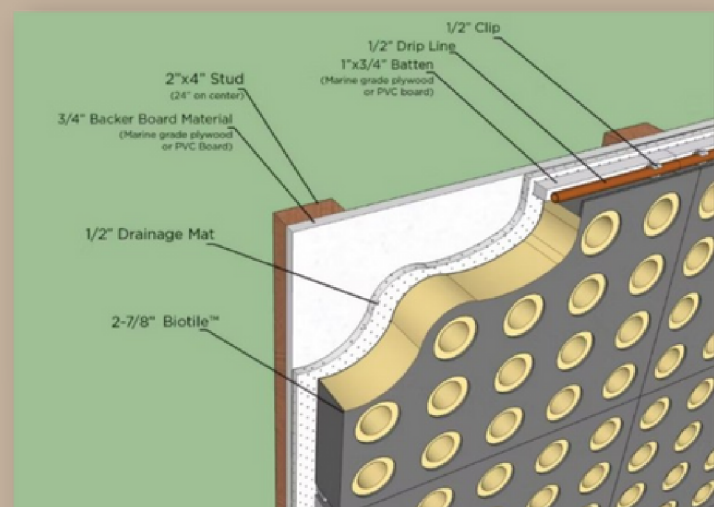


Fig. 10. Custom Living Wall System

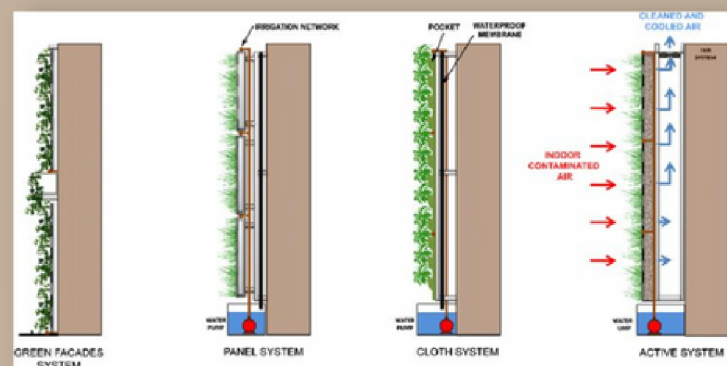


Fig. 11. Vertical Greening System

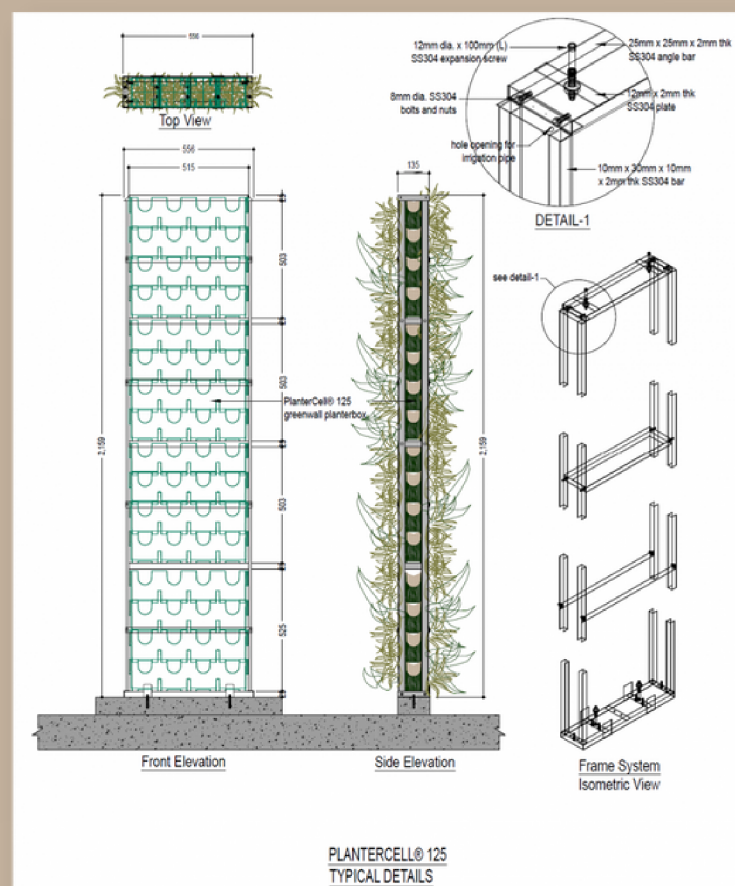


Fig. 12. Vertical Greening Framing System





# PRECEDENT STUDY

# Naava Green Wall



Naava is a 24/7 remote monitoring app-controlled smart green wall. It provides you information on the temperature water percentage, humidity, and natural air created.

In addition to being an air purifier and humidifier, Naava can act as a beautiful space divider. Utilize both sides of Naava by adding even more functionality with a magnetic whiteboard.



Naava is not connected to the plumbing system, making it easy to install and relocate. All you need to do is fill the water tank weekly, and Naava's tech takes care of the daily watering.

The integrated 2000 lux LED light in the colour natural white (5700K) beautifully lightens up the Naava while also vitalizing the plants – and you.

Naava needs an electric outlet. One-sided models consume on average 15 kWh/month, double-sided 30 kWh/month.

There are many advantages to having green walls livening up a space. First of all, the visual benefits of the living wall cannot be ignored. The eye-catching pieces can make a big impact decorating an urban environment made out of concrete and bricks, thus offering alternatives for urban agriculture, gardening, and indoor decor.



Fig. 13. Naava Wall System

# The Street Hostel

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Fig, 14. The Street Hostel

Designed by Sanjay Puri Architects, Taking a cue from the old city streets of Mathura city in India where this project "The Street" is located, this 800 room students' hostel creates organic spaces.

Each hostel room is punctuated with a wedge-shaped bay window oriented towards the north.

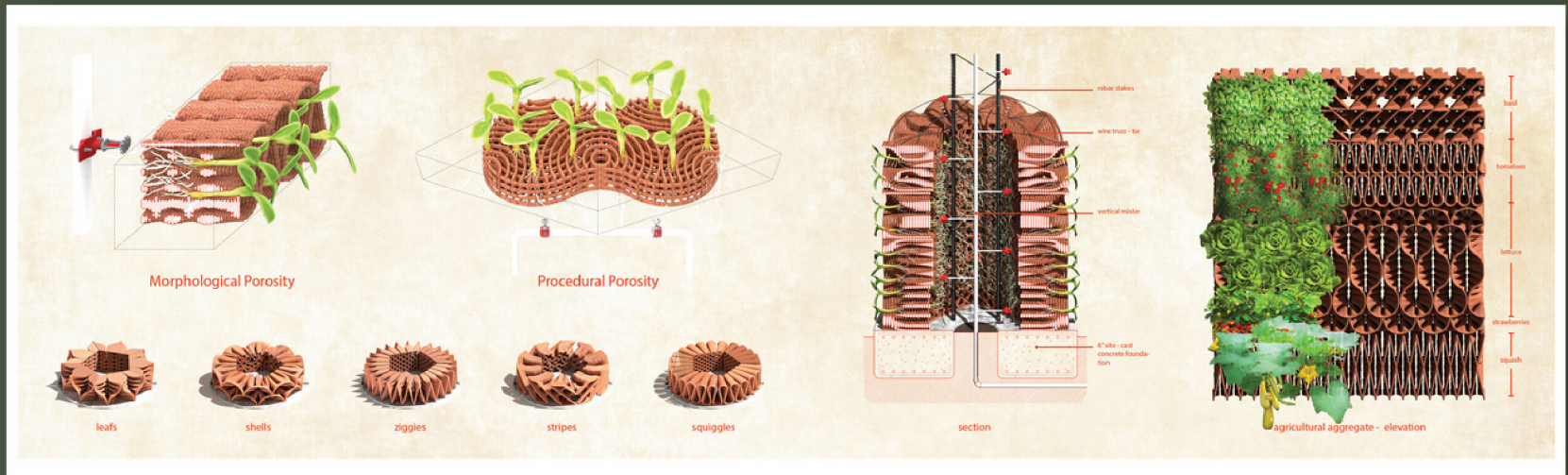
Each hostel room has ventilation openings in the internal corridor facilitating cross ventilation. The linear buildings create small break out spaces at each bending point allowing natural light into the internal circulation spaces.

Designed in 4 level high, 5 linear blocks, the built spaces snake across a wedge-shaped site twisting and turning along their length.

These factors create an energy efficient building minimizing heat gain in response to the climate which has an average temperature in excess of 300 c for 8 months of the year when the sun is in the Southern Hemisphere. During the winter months when the sun is in the Northern Hemisphere, direct sunlight is facilitated to prevent the rooms from becoming cold.

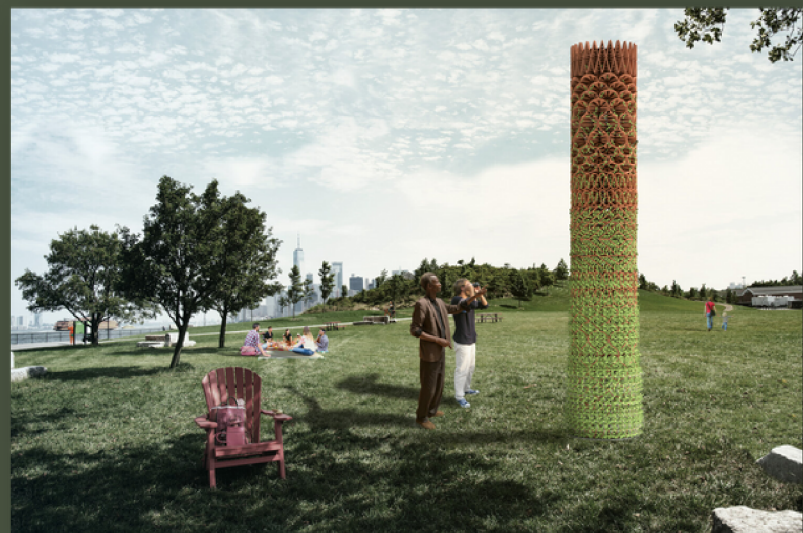
Rainwater harvesting and water recycling and usage of solar panels additionally make the project more energy efficient along with the orientation and facilitation of natural ventilation. The Street is contextual to the climate and the orientation of the site thus creating varied experiences and changing perceptions of space in each part of the 6 acre site.

# The Aeroponic Aggregate Pavilion

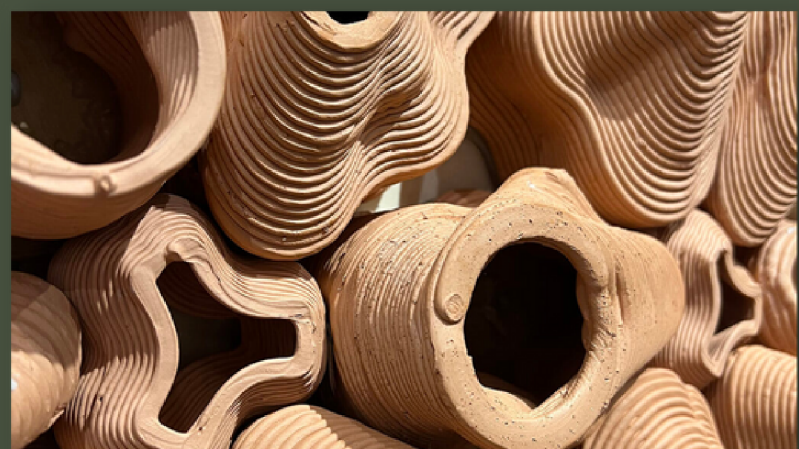
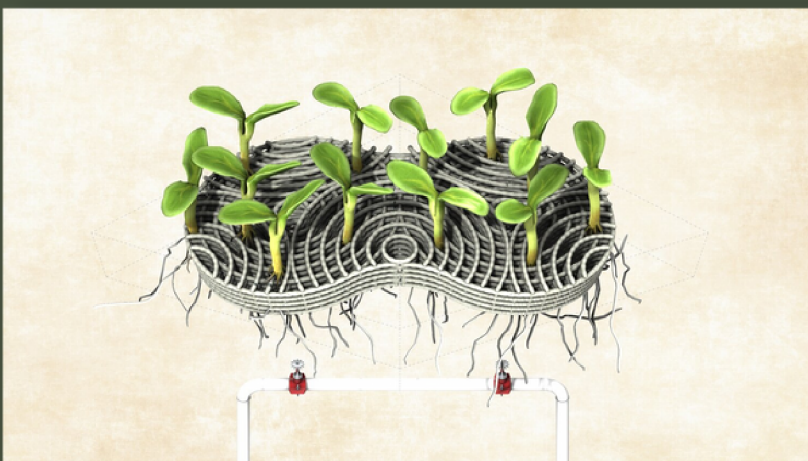
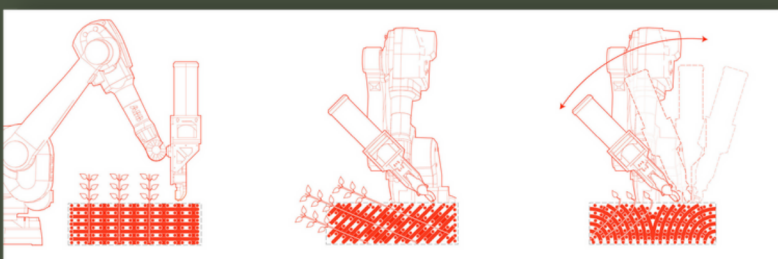


The project seeks a deep integration of the vegetal and structural natures of modular based construction as a critique of the post-modern application of the 'sticker-brick' and 'green-wall' as a commodified cultural lamination.

The promise of this new constructive principle suggests an architecture that re-balances the flora and fauna within the urban ecology, while simultaneously lowering the albedo of our buildings' contribution to the Urban Heat island.



The Aeroponic Aggregate pavilion serves as a meditation on the role of masonry construction within contemporary building culture by re-examining the volumetric nature of the brick as a site of a performative porosity capable of sustaining biological life. The proposed pavilion utilizes ceramic additive manufacturing towards the production of a lattice brick capable of sustaining the exposed root and plant-based aeroponics.



Fig, 15. The Aeroponic Aggregate Pavilion

# Jakob Green Facade



Green Kit is a complete set of cables, spacers, and accessories for the creation of functional and beautiful green facades. It offers creative opportunities and elements to make orthogonal green facades at a low cost. The primary hardware component is made of marine-grade stainless steel and includes HDPE spacers. These high-quality materials and production guarantee long life and slender, robust support for your green façade plants, both indoors and outdoors.

GreenGuide stands for a light, flexible trellis system with appealing design possibilities. It is suitable for all types of climbers. The system is modular and can be adapted to the scale of any project, offering high-quality parts and flexibility in design at very low costs.

GreenGuide can be installed as a single cable or turned into a trellis of any size with the help of horizontal bars. GreenGuide is available as complete sets including the necessary spacers and assembly parts.



Fig. 16. Jakob Green Facade

Jakob Green facade is a wall system where climbing plants or cascading ground covers are trained to cover specially designed supporting structures. The climbing plants are divided into self-supporting plants like root climbers or adhesive-suckers, and plants that need supporting structure, like twining vines, leaf-stem climbers, leaf climbers, or scrambling plants.



The stainless steel wire mesh Webnet is perfect for medium to large greening trellises. With the corresponding spacers and connecting parts, the net forms a modular system that can be easily and efficiently scaled to the size of any project. Cable diameter and mesh aperture are specially adapted to climbing plants and their typical loads on facades.

Webnet is a design solution for dense greening. A dense covering with plants can absorb noise and pollution, and combat the urban heat island effect by providing shadow and evaporative cooling while creating a habitat for insects.



# CONCEPTUAL RESEARCH

# Benefits of Indoor Plants

A 2002 review of the research revealed that people recuperating from several kinds of surgery needed less pain medication and had shorter hospital stays than people who weren't looking at greenery during their recovery periods.

It's important to note that most research focuses on plants and natural scenery in hospital settings rather than at home.

Scientific support for phytoremediation — that's the word for plants scrubbing contaminants from the air

*Improve the Quality of Indoor Air*

*Recover from Illness Faster*

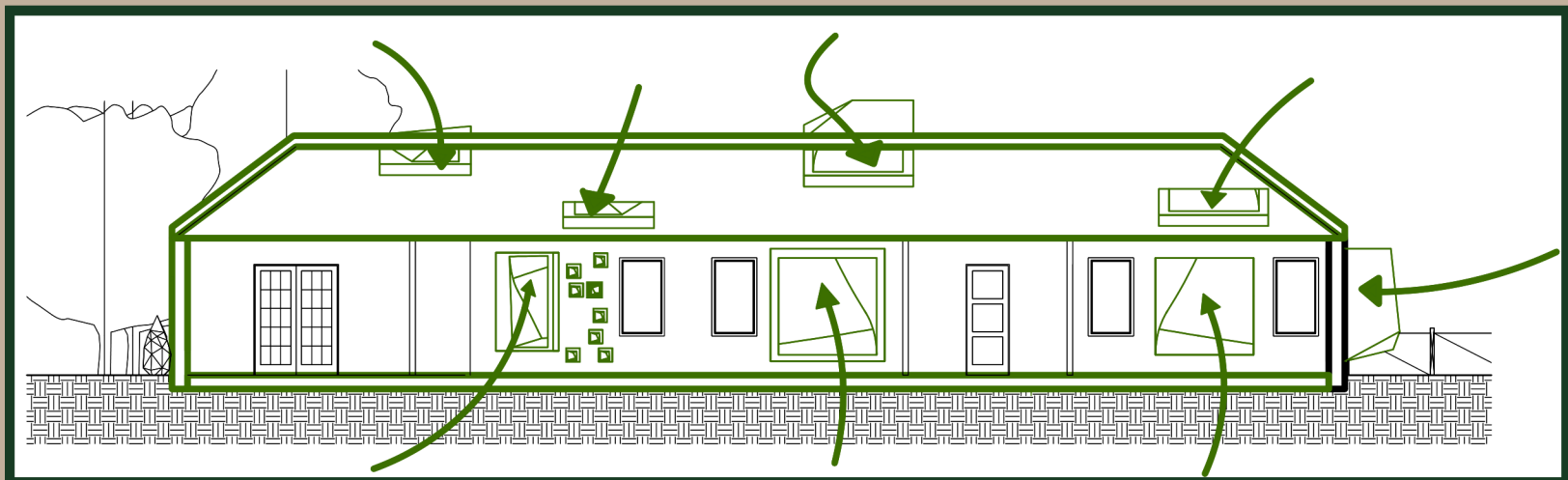
Interviewed over 440 Amazon employees in India and the United States. They found that those whose office environment included natural elements like indoor plants felt greater job satisfaction and more commitment to the organization than those who didn't work around natural elements.

*Improve Your Outlook*

A study published in the Journal of Physiological Anthropology found that plants in your home or office can make you feel more comfortable, soothed, and natural.

Researchers concluded that working with plants could reduce both physiological and psychological stress.

*Reduce Stress Levels*



*Sharpen your attention*

In a small study involving 23 participants, researchers put students in a classroom with either a fake plant, a real one, a photograph of a plant, or no plant at all.

Brain scans of the participants showed that the students who studied with real, live plants in the classroom were more attentive and better able to concentrate than students in the other groups.

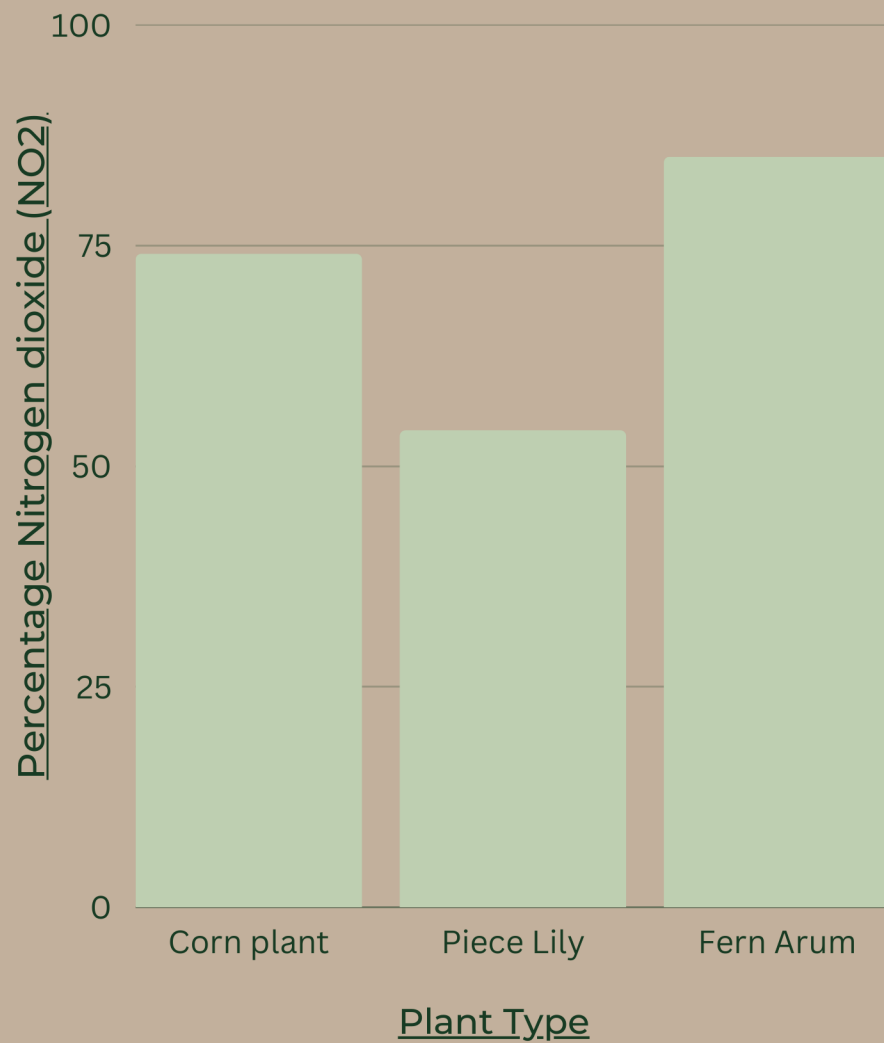
*Therapeutic*

Although horticultural therapy has been around for centuries, it has found a modern expression: Medical clinics in Manchester, England are now "prescribing" potted plants to patients with depression or anxiety symptoms.

*Boost Productivity*

Multiple studies have found that plants in the workspace increase both productivity and creativity. One frequently cited study from 1996 found that students in a campus computer lab worked 12 percent faster and were less stressed when plants were placed nearby.

# Improving Air Quality

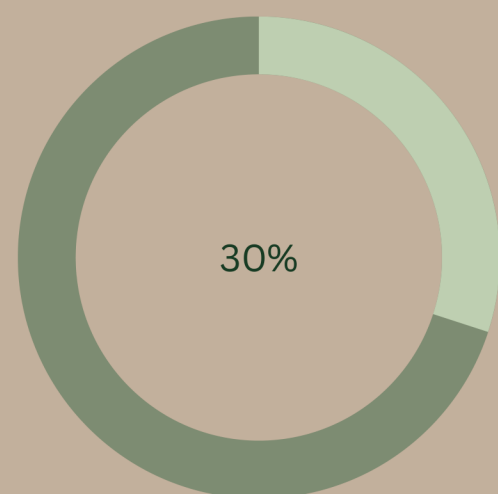


Over a period of one hour, the team calculated that all the plants, regardless of species, were able to remove around half the NO2 in the chamber. The performance of the plants was not dependent on the plants' environment, for example whether it was in light or dark conditions, and whether the soil was wet or dry.

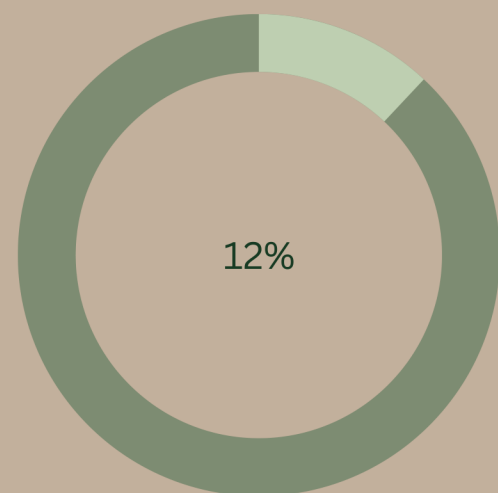
This is very different from the way indoor plants take up CO2 in our earlier work, which is strongly dependent on environmental factors such as night time or daytime, or soil water content."

	Green Wall	Smart & Active Green Wall	Facade
Visual element	✓	✓	✓
Biophilic effects	✓	✓	✓
Improved acoustics	✓	✓	✓
Air purification	✗	✓	✗
Insulation (outdoors)	✓	✗	✓

## Retail Therapy



Consumers Rate Quality of Products 30% Higher



Consumers Willing to Pay 12% More for Goods



# Material Study

## PTFE Panels

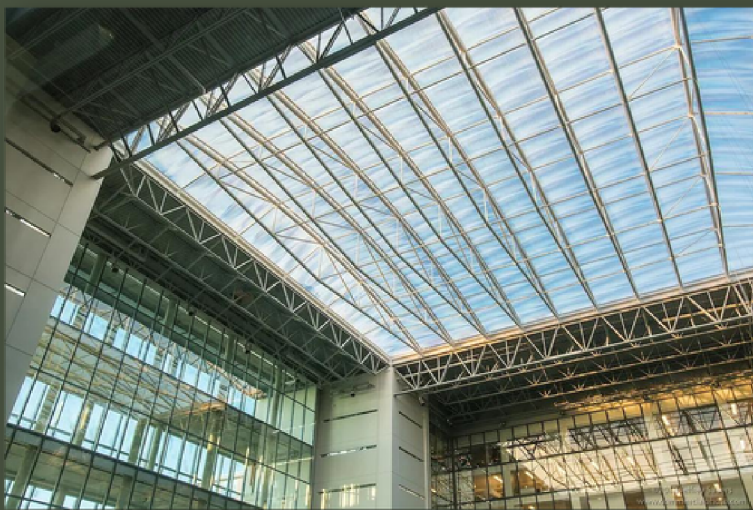


### Applications

Can be applied with/by:  
Gaskets and seals, slide bearings, insulators, washers and rollers.

### Key Aspects

- Temperature: -200 degrees C up to 260 degrees C
- Excellent Resistance to low and High temperatures
- Anti-Adhesive and very good sliding properties.
- Excellent resistance to chemicals and Ultraviolet light
- Gamma radiation sensitive and non-melting
- Self Extinguishing V-0
- Food Safety Approved



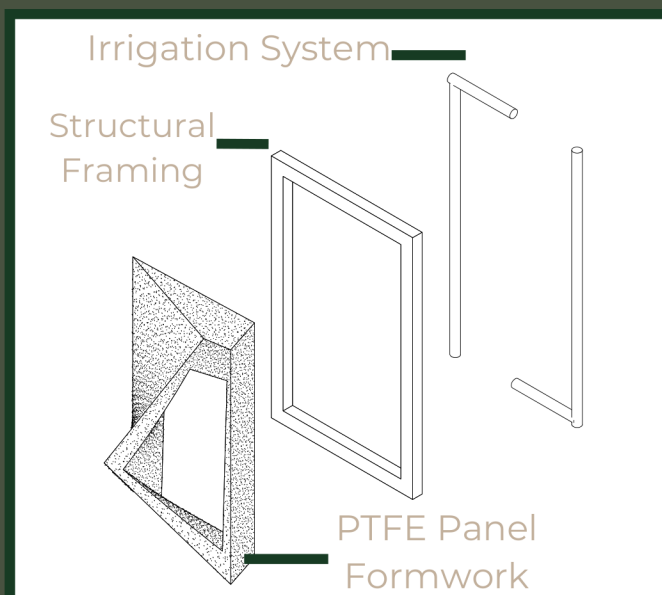
Polytetrafluoroethylene is used as a non-stick coating for pans and other cookware. It is non-reactive, partly because of the strength of carbon-fluorine bonds, so it is often used in containers and pipework for reactive and corrosive chemicals. When used as a lubricant, PTFE reduces friction, wear, and energy consumption of machinery. It is used as a graft material in surgery and as a coating on catheters.



Fig, 17.PTFE Panels

In fact, PTFE can be used to prevent insects from climbing up surfaces painted with the material. PTFE is so slippery that insects cannot get a grip and tend to fall off.

## Exploded Panel System



## Direct Irrigation System

A direct irrigation system does not have a water tank or pump. Instead, irrigation water comes directly from an external water source (i.e. city water) and is sometimes injected with fertilizer. A pump is not needed for direct irrigation because of the existing water pressure of the water lines. Water is channeled to the green wall and distributed to the plants on the wall. As water is pulled downward by gravity, any excess irrigation water is collected and sent to a sewer drain (not recirculated).

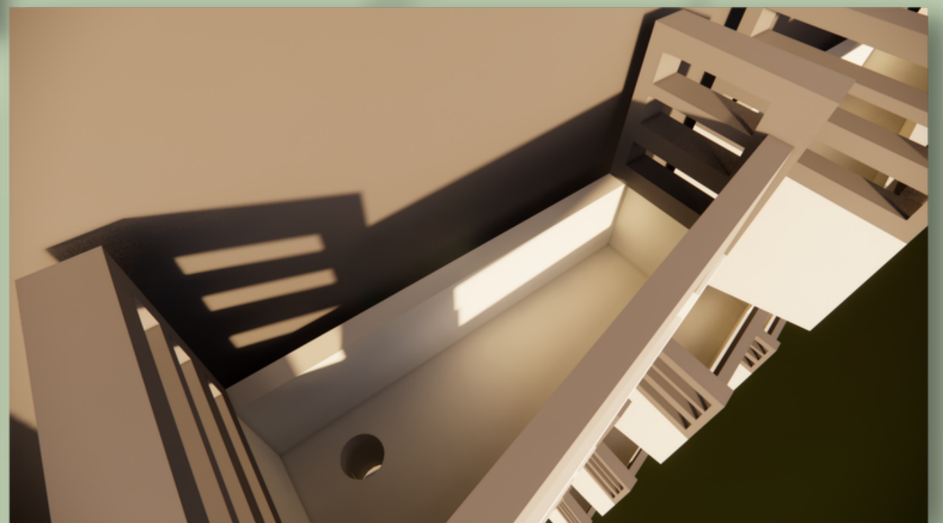


# DESIGN PROCESS

# Initial Design Idea



Biophilia in architecture is more than just the delicate balance between creating a sustainable future, and the unfortunate side effect of green-washing. It explores the physical and physiological benefits of plants in design. It is described as the science of making a connection between the building occupants and the natural environment. It is the scientific evidence we have that comprises mankind's need to be close to the natural world around us and how we should take greater responsibility to foster a more prominent connection between people and nature.

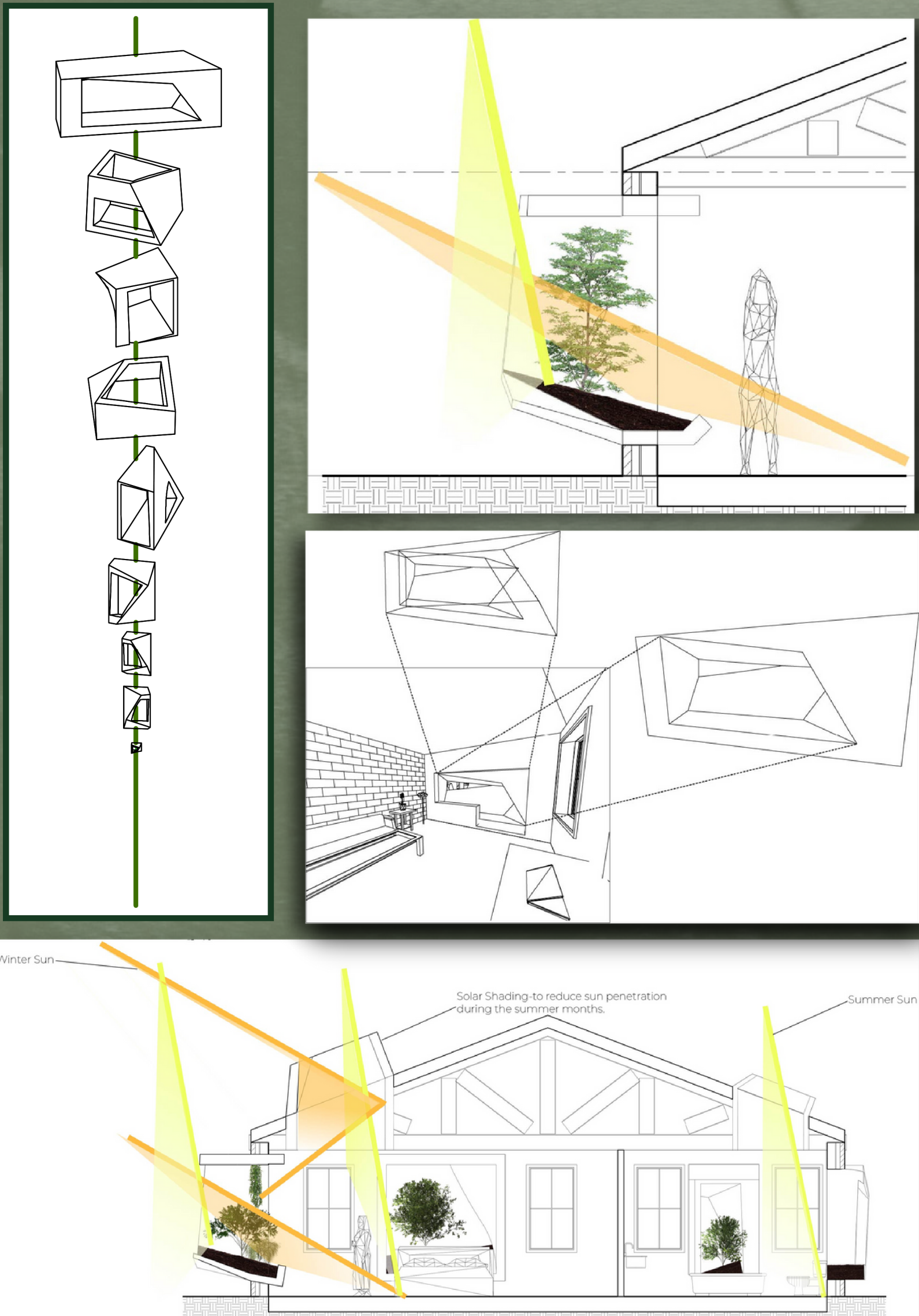


A new idea of the residential home can be centered around a new form of construction within. A component could be modeled that combines a structural display of biophilia that aims to solve, or at least aid in the wellbeing of the occupants. This structural model's form based of the appropriate scientific response to humans and their home's climate could be to rejoiner to how we redefine the ideal of the residential home for the future.



Fig. 18. Initial Renders

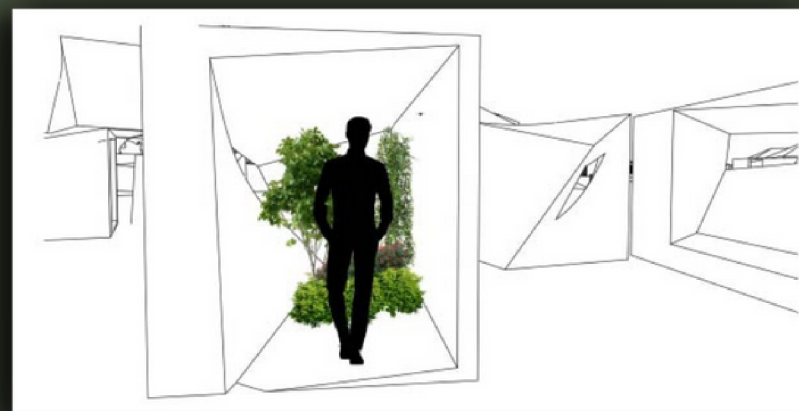
# Structural Format



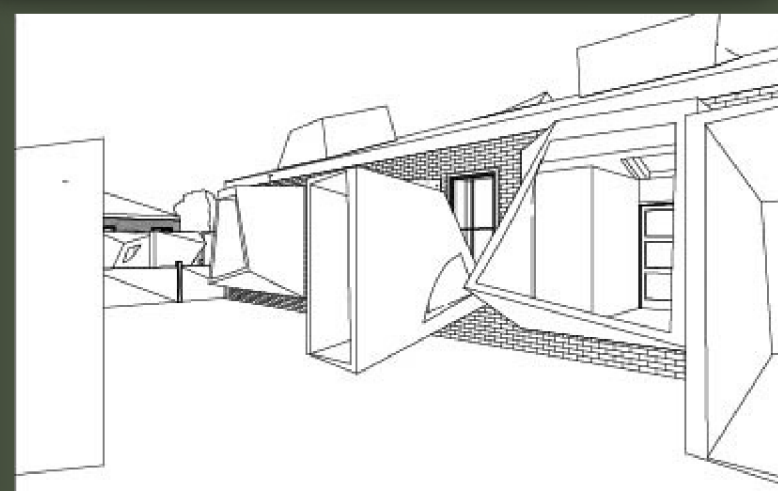
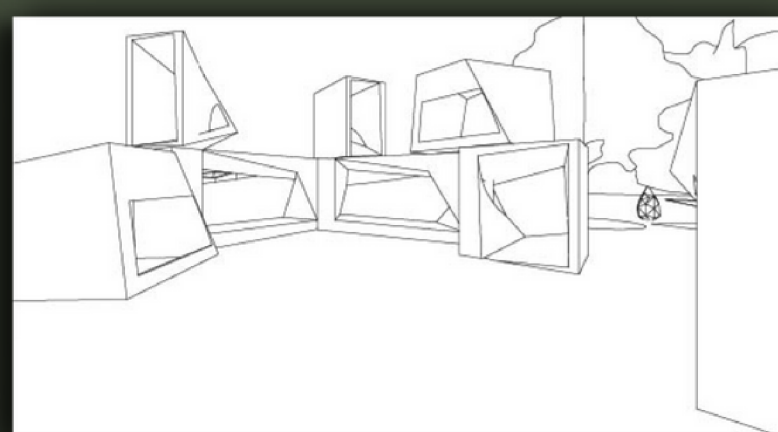
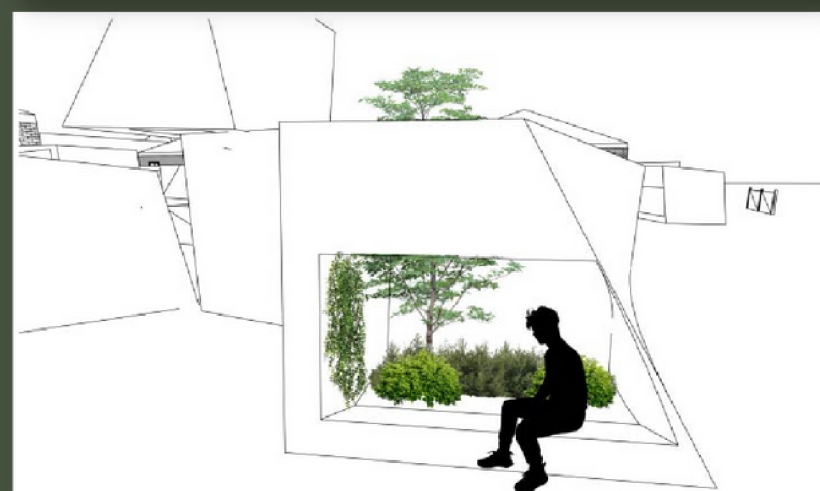
Fig, 19 Structural Drawings

The iterative process of design produced a set of designs that encompass the form of biophilic structural architecture. There are a minimum of 9 base designs that are referenced for all the structures. The extrapolated forms lend themselves to being able to fit into the needs of the homeowner.

# Design Views



The modules are used in many different ways in a home. They can be used similarly to skylights, windows, doors, and sunrooms. They can also so be detached from the home and serve as their own contained environment that can also be modified as a basic structure as well as be equipped with amenities.

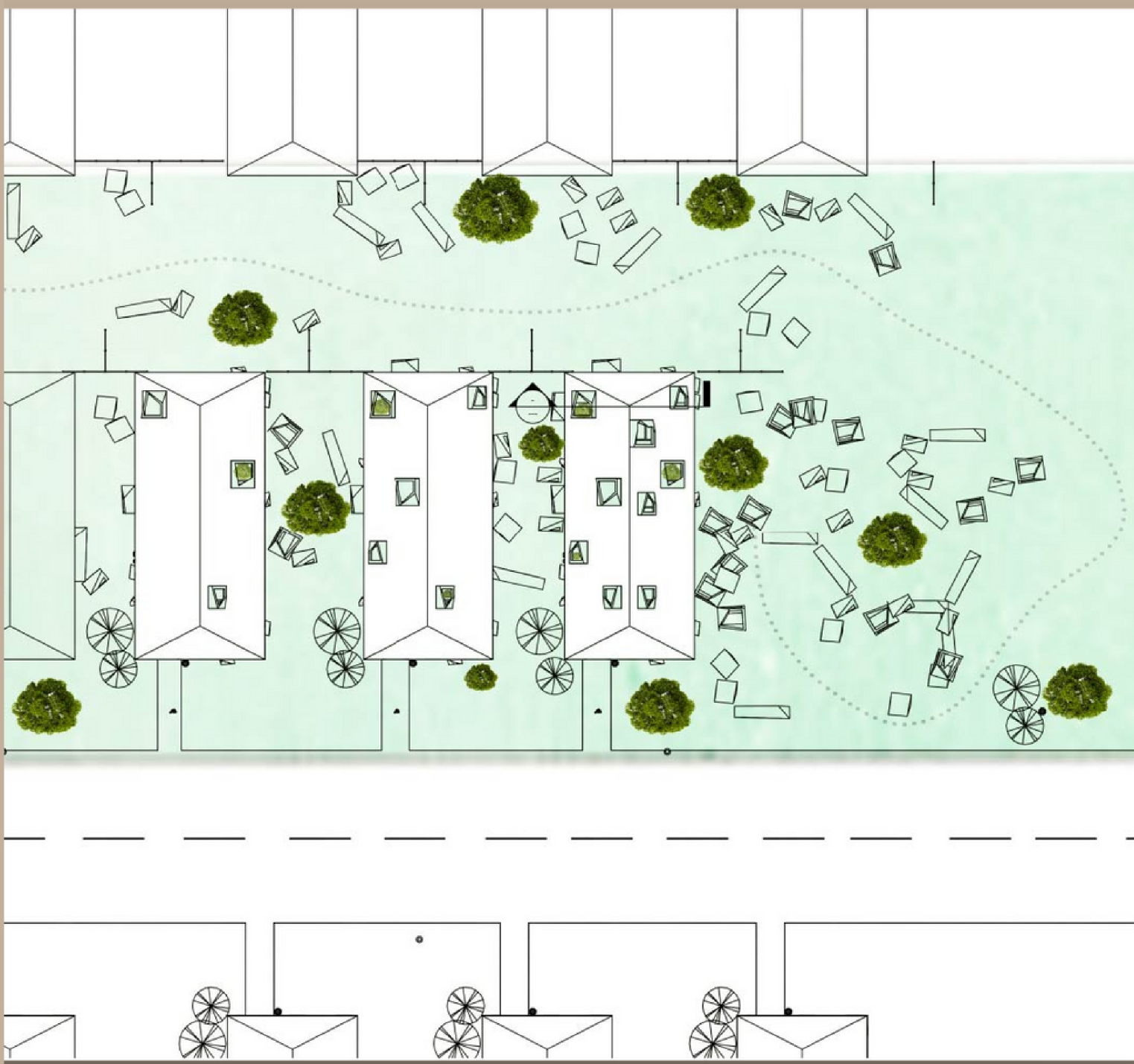


Fig, 20.Render View



# DESIGN SYNTHESIS

# Final Concept



Fig, 21. Render Drawings

The site showcases the overall effect and design of the plan of the modules. Here we can see that the modules not only are nestled and attached to the boundary of the home but also extends outward into the yard/lawn of the home.

The drawing institutes the fact that the nodes are an ever-creeping/changing structural form that is not beholden to the confines of its main purpose in a home but also extends past that into the intervening space for new utilization.

# Final Concept



Fig, 21. Render Drawings

The view of the drawing demonstrates a closer look at the nodes and the interaction that they have with the houses. As you can see their disbursement is not uniform. Demonstrating the varying degrees of implementation.



# Final Concept



Fig, 21. Render Drawings

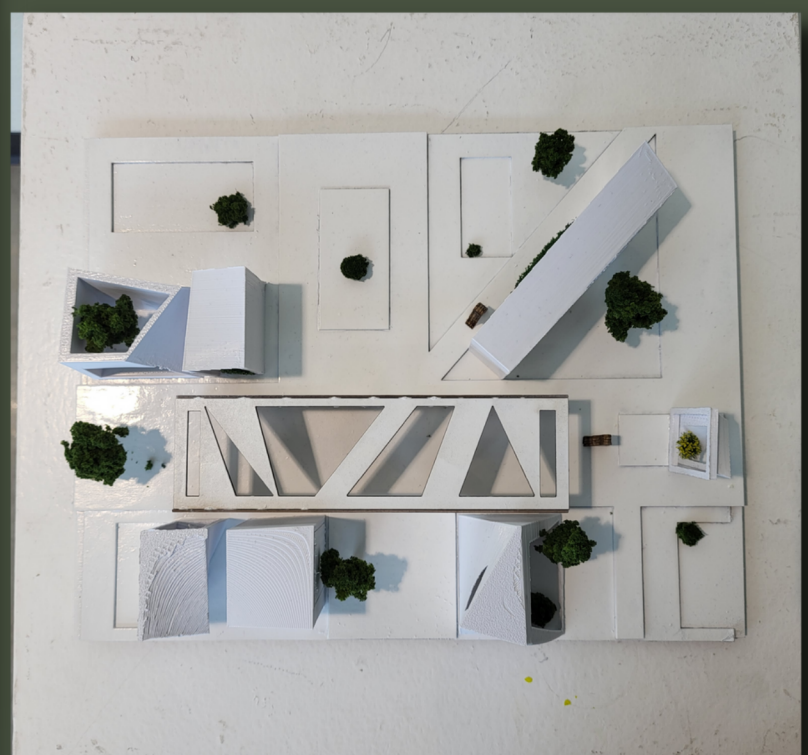
This plan view exhibits the exploration into a new genre of urbanism with the application of the node, modules, and panels. The image draws an inquiry into the interaction of the people with the structural form. It gives an exposition about the different spaces that the nodes can make. That they can not only be individual pieces but can also be a combination of nodes to probably create their own community.

# Model Design



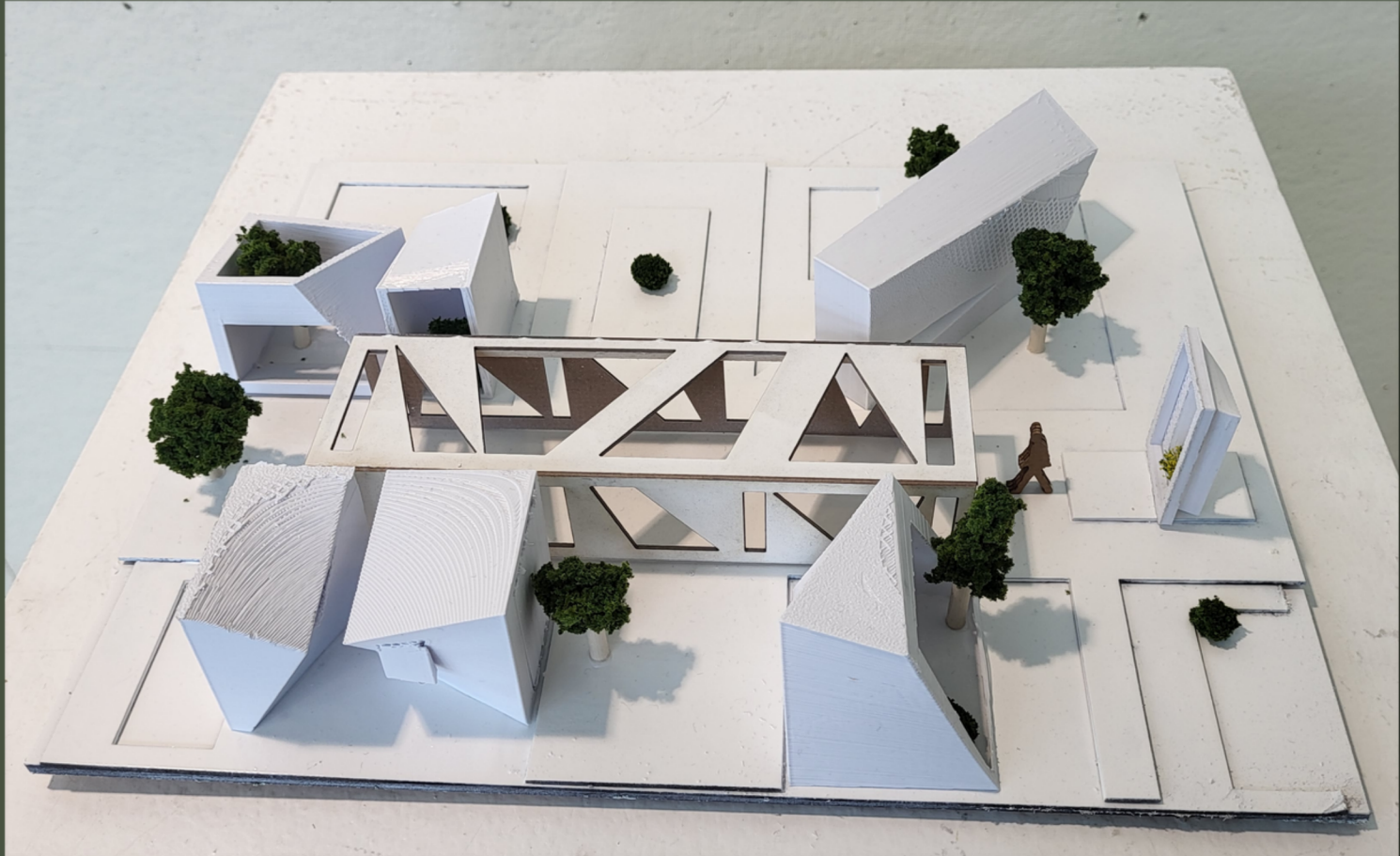
The model design actualizes a concept in which the modules, panels, and nodes could be arranged. It shows that the nodes have become their own separate entity from the home. This is a way to convey that the nodes could be their own stand-alone form and that the nodes can be used as a singular module in a space or can be combined with others to possibly build a community use.

The model gives a feel of continuity and moveability through the nodes despite the rigid structure of their placement. It invites you to explore the many different forms.

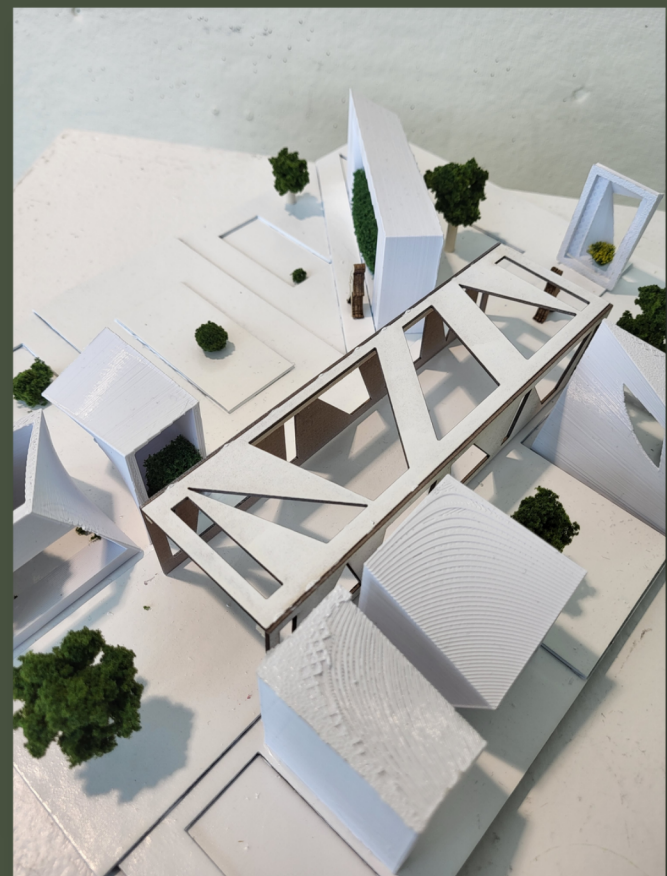
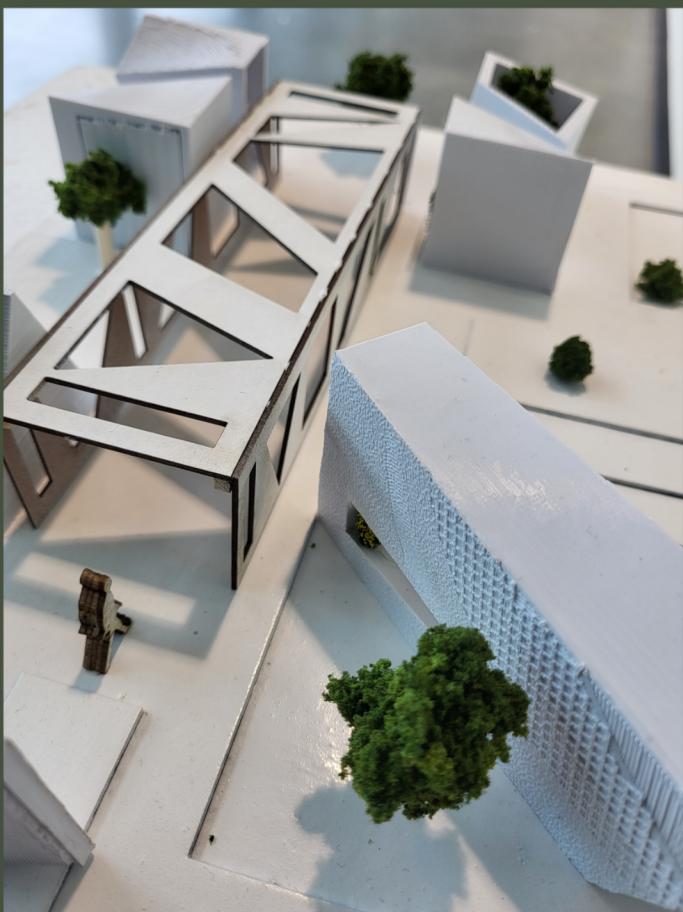


Fig, 22. Model Pictures

# Model Design



Fig, 22. Model Pictures





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THANK  
YOU

