Breathing Architecture

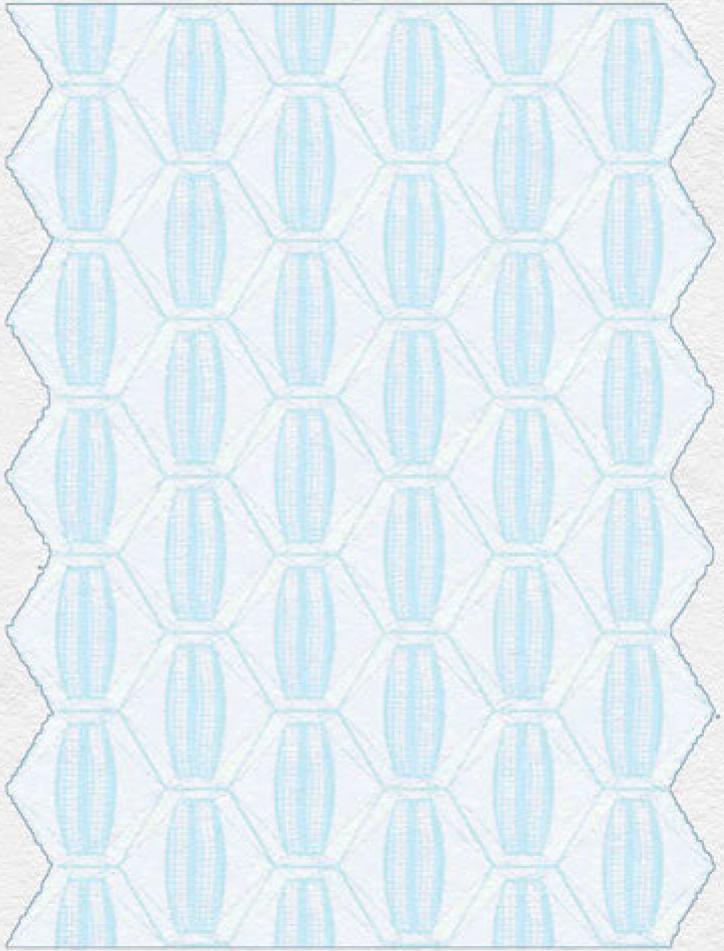
Ventilation * Bio Design * Facade System *Mediterrian Climate

|| UWE_Msc. Computational Architecture

|| UBLLX1-15-M - Crafting systems 22jan_1

|| Aashish Javiya_22057481

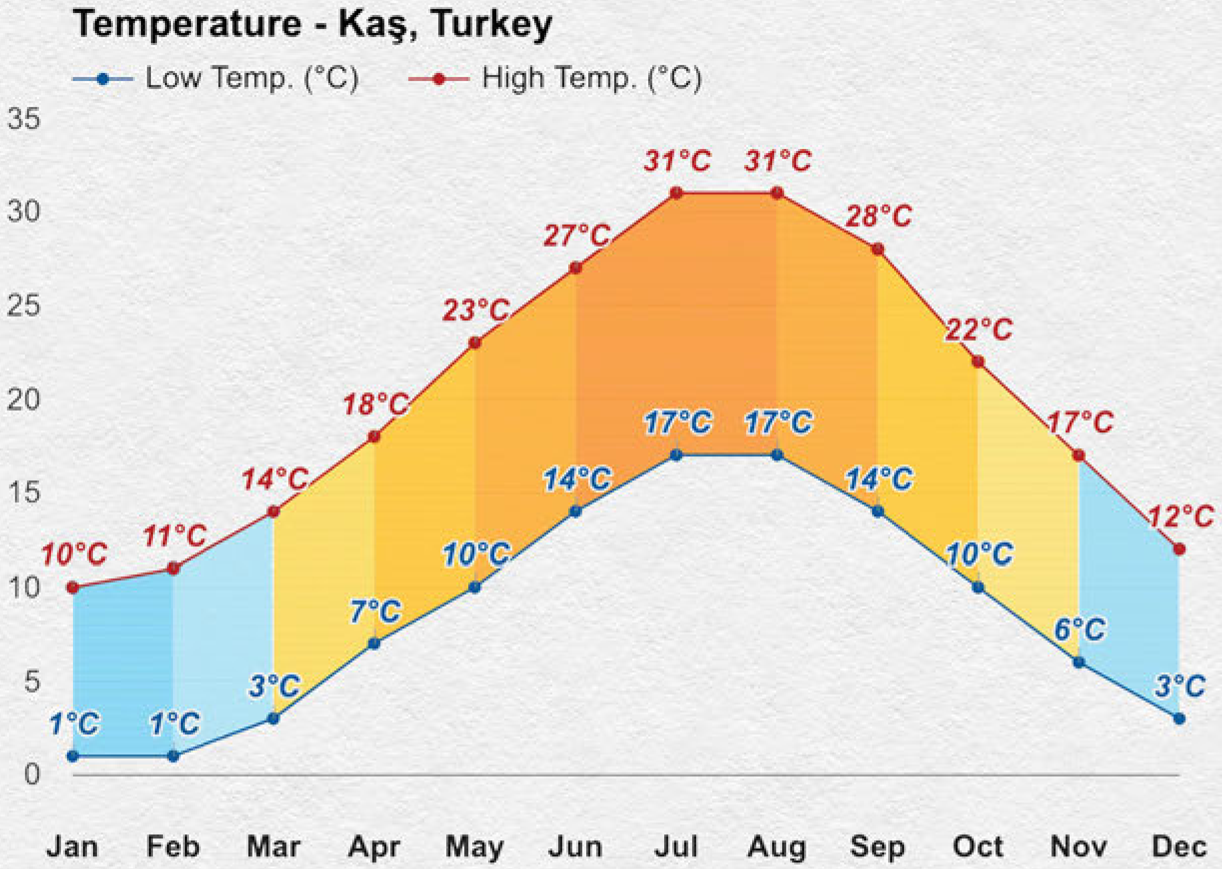
|| Crafting System Portfolio



Content

Introduction

This project proposes a biomimetic design approach inspired by stoma cells to enhance natural ventilation in buildings and improve indoor air quality. The study focuses on a case study in Istanbul, Turkey, which has a Mediterranean climate that often experiences hot and dry summers. The proposed design aims to optimize wind flow into the building and regulate the indoor temperature and humidity levels through a series of structural and mechanical modifications. By emulating the stoma cells' natural process of opening and closing, the design can adjust the ventilation system based on the external environmental conditions. The project aims to demonstrate the feasibility and effectiveness of this approach in improving indoor air quality and reducing energy consumption in buildings in a Mediterranean climate. This research can contribute to sustainable building design practices by introducing nature-inspired solutions for natural ventilation.



Above

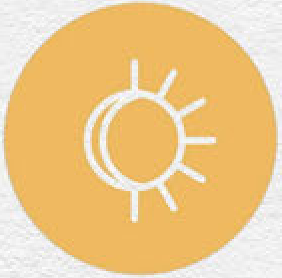
002

Figure Temperature Kash, Turkey

Importance

Ventilation is a crucial factor in maintaining healthy indoor air quality. It plays a crucial role in diluting and removing pollutants generated by various sources such as human activities, building materials, and outdoor sources. The primary function of ventilation is to introduce fresh clean air and remove polluted air, which helps to control temperature, humidity, and moisture levels inside the building. Poor ventilation can lead to respiratory problems, headaches, and fatigue, and may cause the accumulation of harmful pollutants such as carbon dioxide, carbon monoxide, volatile organic compounds (VOCs), and particulate matter.

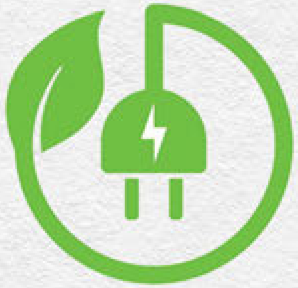
Inadequate ventilation can lead to both short-term and long-term health effects, including respiratory illnesses, cardiovascular disease, and cancer. Good ventilation design is critical to maintaining acceptable indoor air quality levels and protecting the health and well-being of occupants. It is essential to have rapid extraction in situations where noxious gases are released and excessive particulates are created to ensure that the indoor air quality remains at acceptable levels. In summary, proper ventilation is necessary for ensuring a healthy and comfortable indoor environment, controlling temperature and humidity levels, and reducing the harmful effects of indoor air pollution.



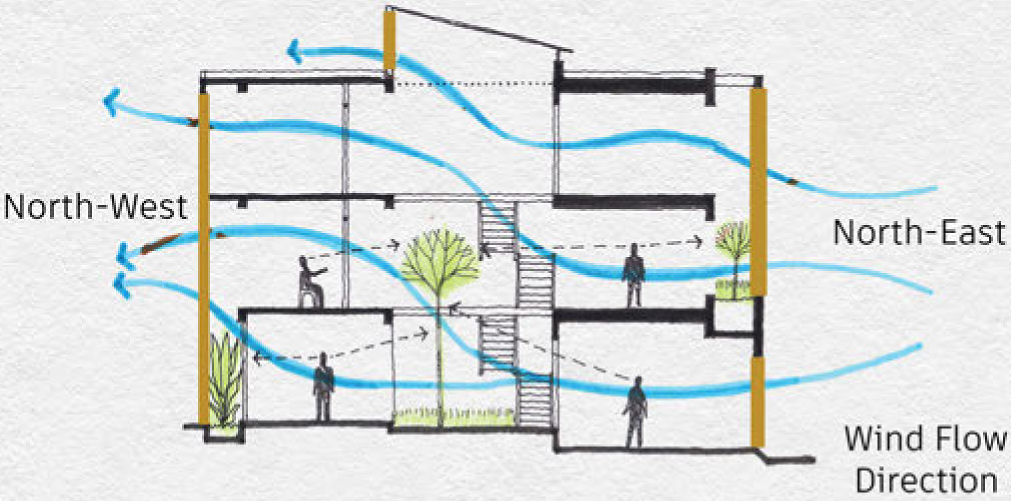
Light Quality

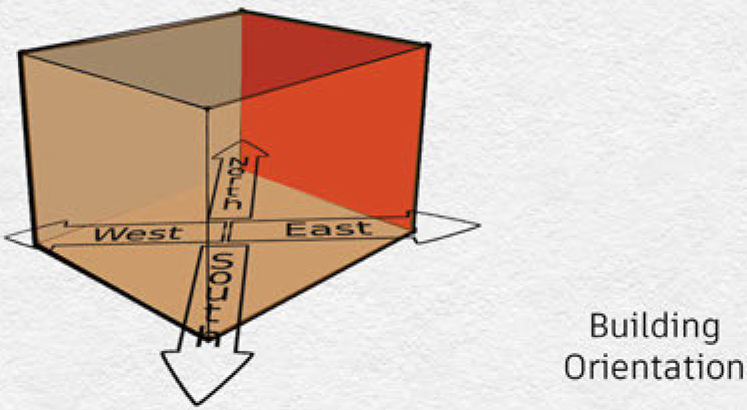
Thermal Comfort

Improve Air Quality



Energy Efficiency





Opposite 001

Figure_ Wind Flow Direction and Building orientation

Challenges

Designing a building that takes into account wind direction to improve indoor air quality can present various challenges. The building's location and surroundings, climate, and building form can all affect the effectiveness of designing for wind flow. Additionally, occupant comfort must be considered, as excessive air flow or drafts may cause discomfort and reduce the efficiency of heating, ventilation, and air conditioning (HVAC) systems. The cost of incorporating wind flow considerations in building design and maintenance requirements should also be taken into account.

In summary, designing a building for wind flow requires a thorough assessment of various factors to optimize indoor air quality. The building's location, climate, and form must be carefully considered, while balancing the benefits of wind flow with occupant comfort, and taking into account potential costs.

Building Parameters

Wind direction can play a significant role in determining the placement of a building, as it can impact the flow of air in and around the building. By designing the building with consideration for wind direction, it is possible to increase air flow in indoor spaces, which can improve indoor air quality.

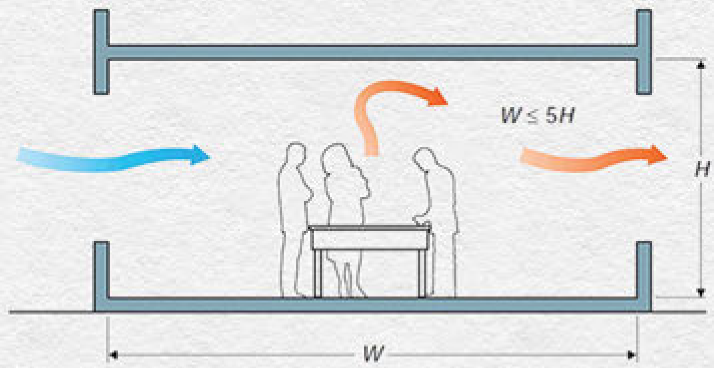
Function

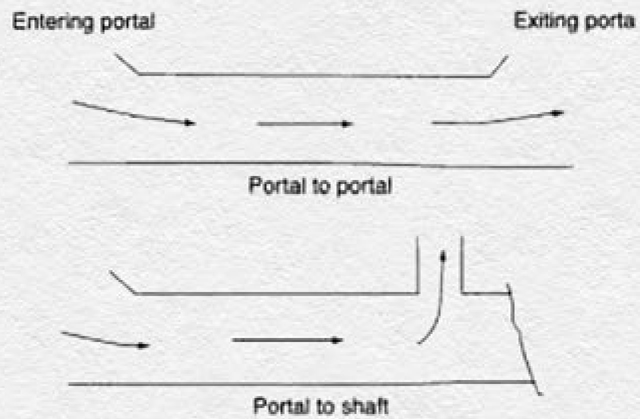
Cross Ventilation

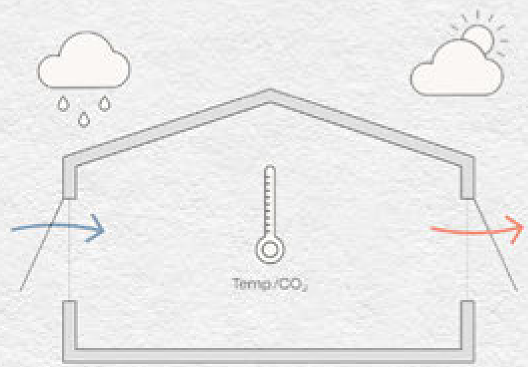
Cross ventilation is a natural ventilation strategy that uses wind pressure to create a current of air through a room or building. The process involves opening windows on opposite sides of the room or building to allow fresh air to flow in and out of the space, which can help to regulate indoor temperature and improve indoor air quality.

When the wind blows against a building, it creates areas of high and low pressure on different sides of the building. By opening windows on both sides of the building, the difference in pressure between the two sides creates a natural airflow through the space, which can help to flush out stagnant air and replace it with fresh air.

In summary, cross ventilation is achieved by using windows on opposite sides of a room or building to create a natural airflow. Adjusting the size of the window openings based on the direction and intensity of the wind can help to optimize airflow and prevent drafts. Cross ventilation is an effective natural ventilation strategy that can improve indoor air quality and reduce energy consumption in buildings.





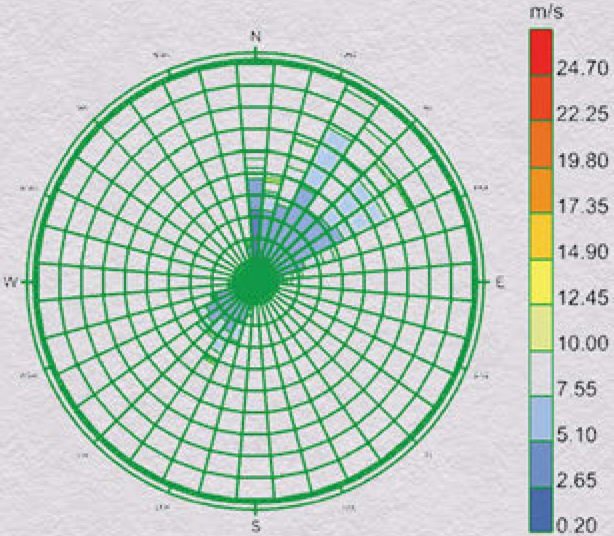


Wind Analysis

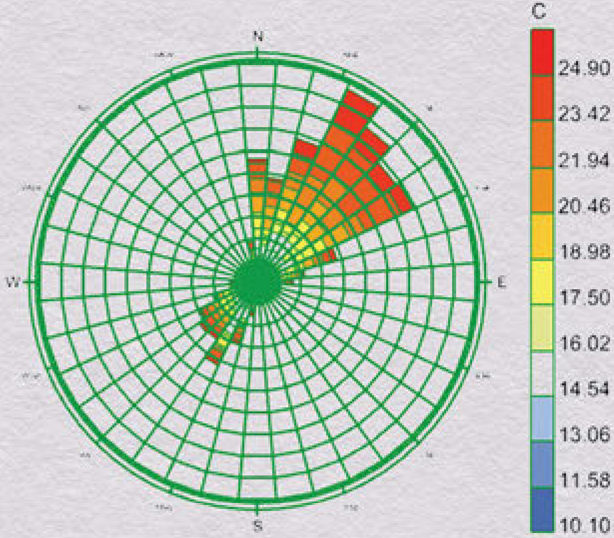
Wind Direction

By analyzing wind direction, we can determine the optimal orientation of the facade units to effectively use prevailing wind and achieve maximum energy efficiency.

Once we have a good understanding of the wind direction, we can start to design facade units in a way that allows them to open and close to direct the wind flow.



Wind Speed (m/s)
city: ISTANBUL
country: TUR
time-zone: 2.0
source: IWEC Data
period: 1/1 to 12/31 between 0 and 23 @1
Calm for 3.66% of the time = 179 hours.
Each closed polyline shows frequency of 1.1% = 50 hours.



Dry Bulb Temperature (C)
city: ISTANBUL
country: TUR
time-zone: 2.0
source: IWEC Data
period: 1/1 to 12/31 between 0 and 23 @1
Each closed polyline shows frequency of 1.1% = 50 hours.

Right 004

Wind analysis, generated using ladybug plugin in grasshopper

Precedent

ONE OCEAN PAVILION

The kinetic media façade is an integral part of the Thematic Pavilion, a major and permanent building for the Expo 2012 in Yeosu, South-Korea which was designed by SOMA Architecture, Vienna.

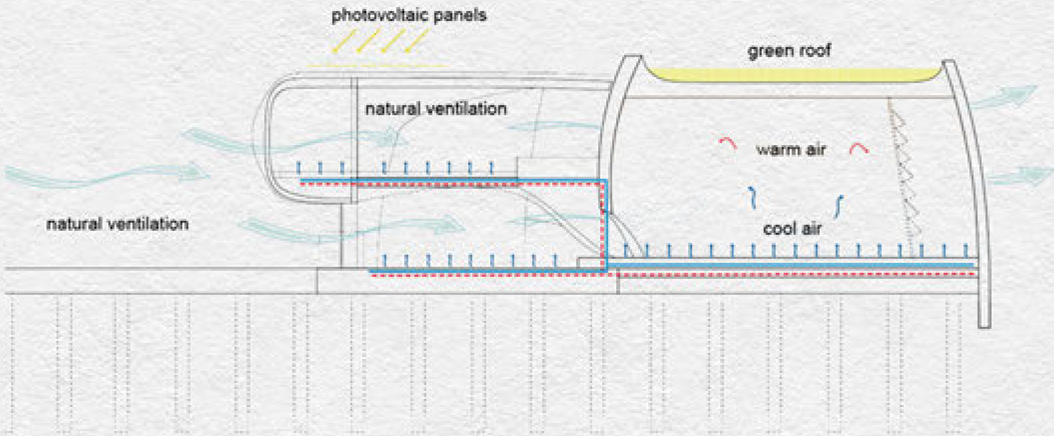
A new type of kinetic façade system is presented which was inspired by flexible deformation principles found in plant movements. The project is a role model for a novel application of glass fiber reinforced polymers (GFRP) for deployable structures as well as for advanced biomimetic research and design.

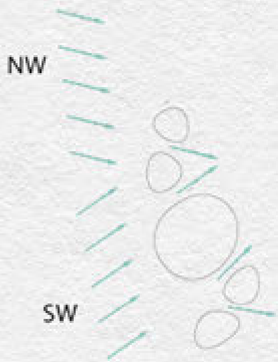
FUNCTIONS

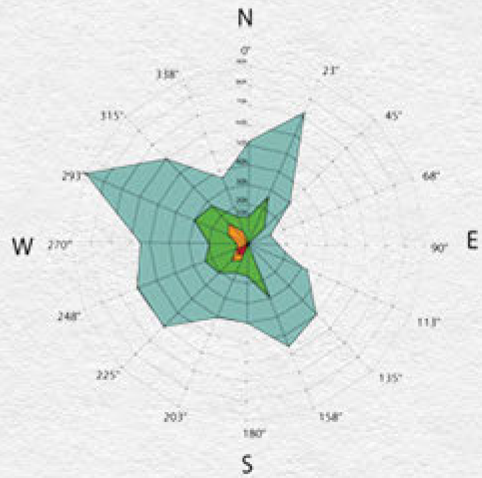
The building's adaptable kinetic facade enhances natural ventilation by capturing and guiding winds through the building during moderate and non-humid intermediate seasons.

During this period, radiant floor systems are directly cooled via a seawater heat exchanger. In peak summer conditions, dehumidification of supply air and radiant floor cooling are powered by highly efficient turbo compression chillers linked to the seawater heat exchanger.

During winter, these chillers are reversed to heat pump mode and use seawater as an energy source to generate heat for the radiant floors and the mechani-

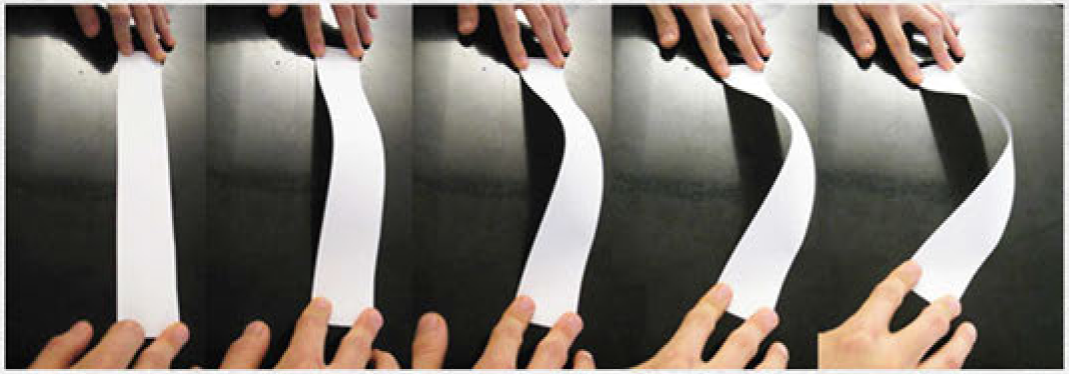


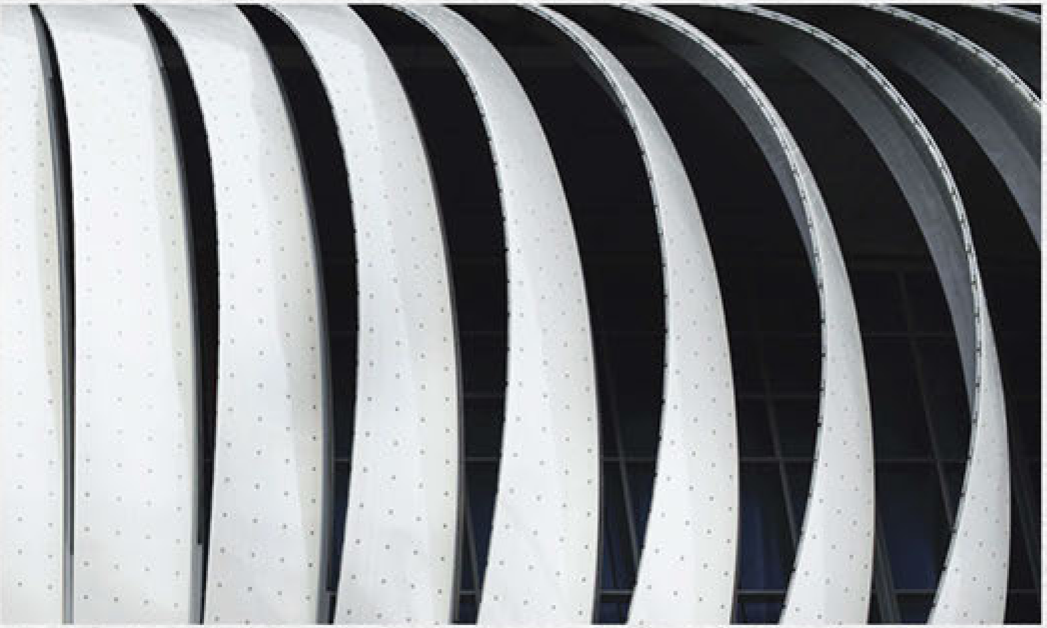




Opposite 009

One Ocean Wind Circulation





Left 010

One Ocean

Precedent

ONE OCEAN PAVILION

Components of the system

The façade consists of kinetic lamellas, supported at the top and the bottom edge of the façade.

The lamellas are moved by actuators on the both the upper and lower edge.

The longer the single lamella – the wider the angle of opening and the bigger the area affected by light

The louvers are moved by actuators located on both the upper and lower edge, inducing compression forces to create the complex elastic deformation.

They reduce the distance between the two bearings and in this way induce a bending which results in a side rotation of the louver.

The actuator of the louvers is a screw spindle driven by a servo-motor.

A computer controlled bus system allows the synchronization of the actuators.

Each louver can be addressed individually within a specific logic

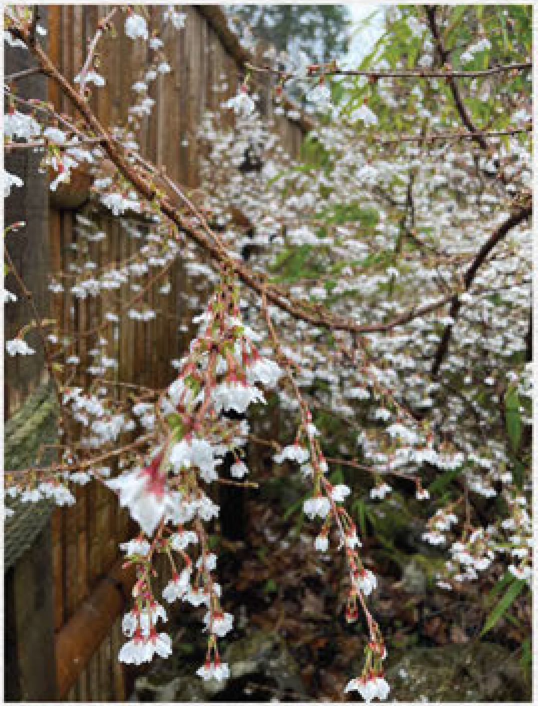
Precedent Projects

One Ocean

Botanic Garden Visit

Above

Botanic Garden



Botanic Garden Visit

Above

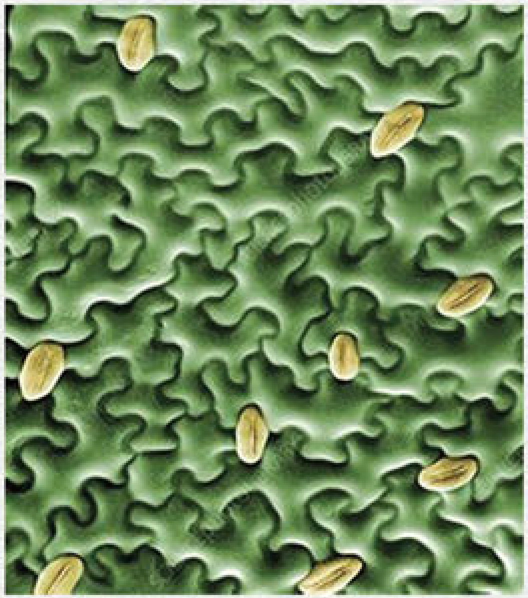
Botanic Garden

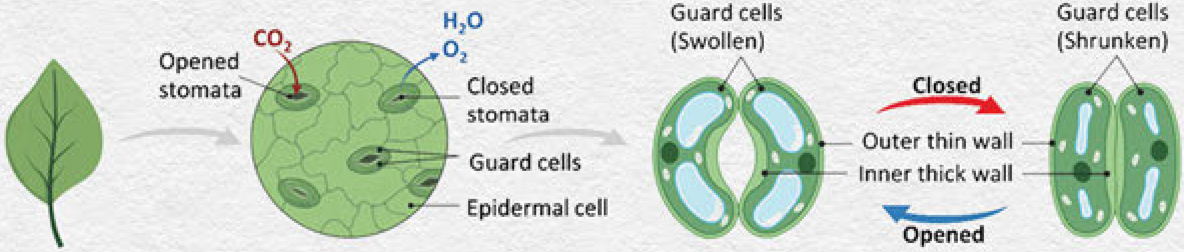
Inspiration

Stoma Cell

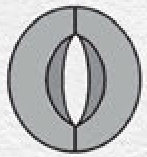
Stomata are tiny openings found on the surface of plant leaves that regulate the exchange of gases and water vapor between the plant and the environment. The opening and closing behavior of stomata can indeed serve as an inspiration for responsive facade design. Just as stomata regulate the exchange of gases and water vapor between a plant and its environment, a responsive facade can be designed to regulate the flow of air and light into a building.

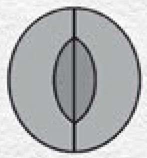
Opposite
Stoma Cell





ENVIRONMENTAL ISSUES	CONTROLLED VARIABLE		STOMATAL MOVEMENT
humidity or water availability →	CO_2 concentration within a leaf	low concentration →	OPENING
temperature →		high concentration →	CLOSURE
atmospheric carbon dioxide concentration →	H_2O level (turgidity) within a leaf	high level →	OPENING
light intensity →		low level →	CLOSURE





Above 007

Stoma Cell

Responsive Process

The opening and closing behavior of stomata can indeed serve as an inspiration for responsive facade design. Just as stomata regulate the exchange of gases and water vapor between a plant and its environment, a responsive facade can be designed to regulate the flow of air and light into a building.

For example, a facade system with movable panels or louvers can be designed to open and close in response to changing environmental conditions. Sensors can be used to detect changes in temperature, humidity, and sunlight, triggering the panels or louvers to adjust their position and regulate the flow of air and light into the building. This can help to reduce energy consumption by minimizing the need for heating and cooling, while also providing occupants with a more comfortable and visually engaging space.

In addition to regulating environmental conditions, a responsive facade inspired by stomata can also provide aesthetic and architectural benefits. By mimicking the pattern and texture of stomata, a facade can create a visually striking and biophilic design that connects occupants with the natural world.

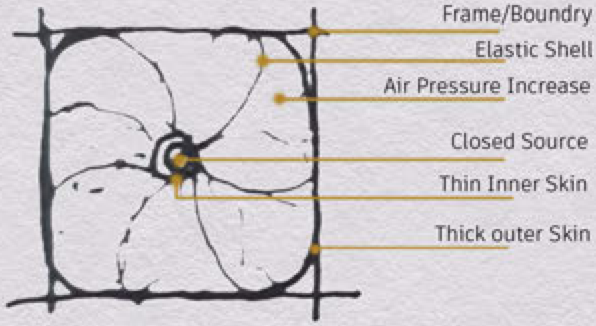
Design Process

Initial Investigations

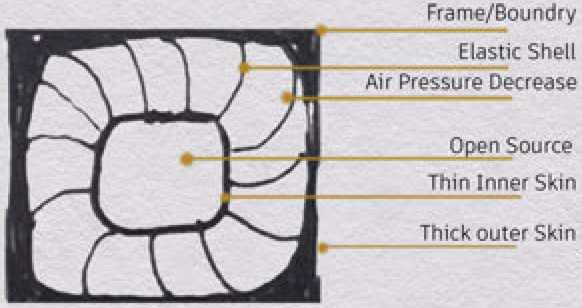
This research endeavors have attempted to replicate the behavior of stomata cells in the design of building ventilation systems. By mimicking the opening and closing of stomata cells, it is hoped that these systems will provide a more sustainable and energy-efficient solution for controlling indoor air quality and air flow within buildings.

In order to achieve this, we have developed a pattern that replicates the structure and behavior of stomata cells. By comprehending the functioning of these cells, they can be modeled and utilized in the design of artificial systems that can simulate the opening and closing of stomata pores.

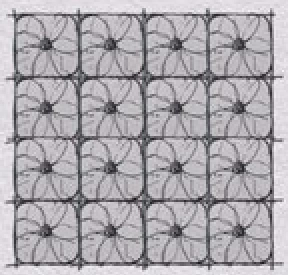
Subsequently, this behavior is integrated into the design of the ventilation system to facilitate airflow into the building. This novel approach is anticipated to provide more efficient control of indoor air quality, reduce energy consumption, and enable a more sustainable solution to building ventilation.

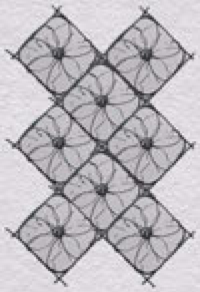


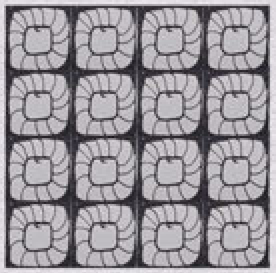
Inflated Form /Low air Presure outside

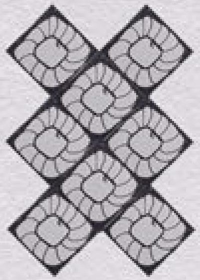


Deflated Form/ High Air Pressure









Design Process

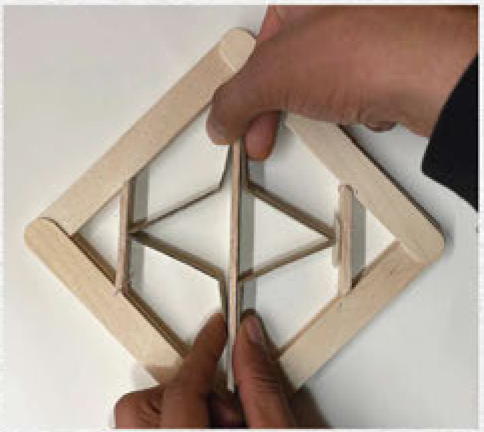
Initial Model

Below 013

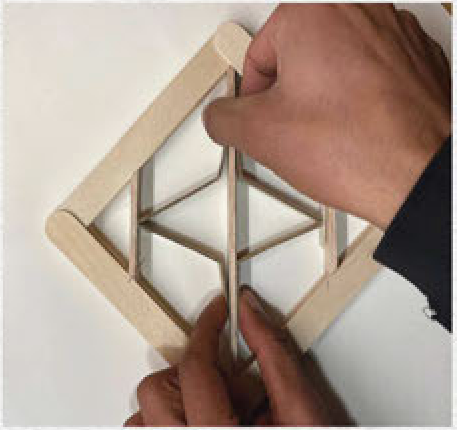
Initial Investigations

Initial State (Closed)

opening iteration 1



Opening Iteration 2



Final State (open)

Design Process


Left 013

Cardboard model ex-pirementlon baloon in-faltion in curve shape

Initial Investigations

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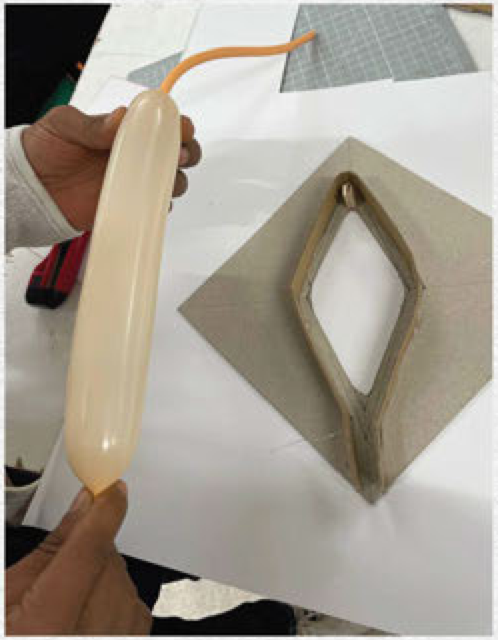
We devised a unit shape that demonstrates an opening and closing behavior, based on the structure of balloon-like stomata guard cells. Specifically, the unit shape operates by inflating to close and deflating to open. To optimize this behavior, we explored various configurations and assessed their effectiveness.

Left 013

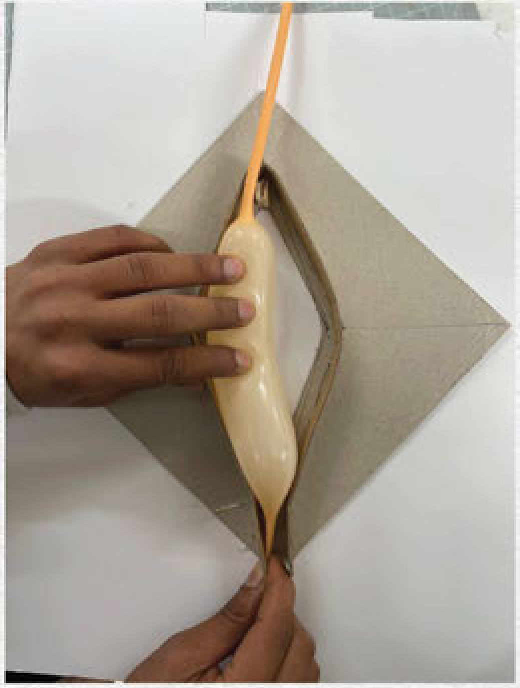
Cardboard model ex-piremention baloon in-faltion in stoma in-spired shape

Design Process

Initial Investigations

Left 013

Inflation inside stoma inspired shape tile

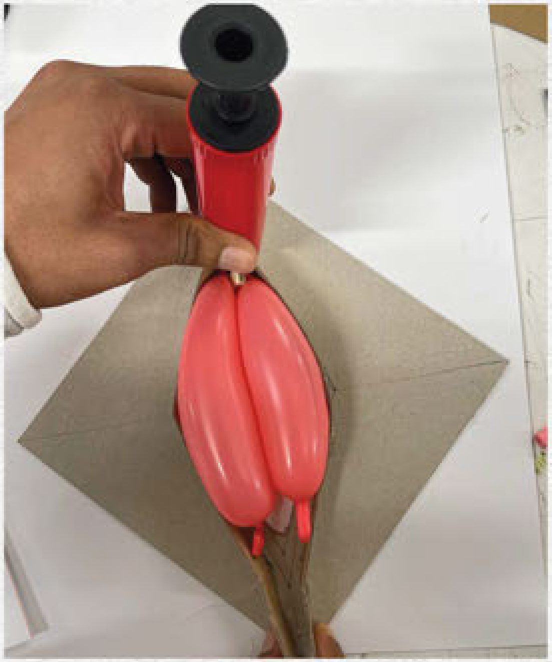


Design Process

Initial Investigations

Left 013

Inflation inside stoma inspired shape tile with cover



Design Process

Model Component

Below 013

Air Pump, Baloon and 3D Print Tile Inspired by Stoma shape

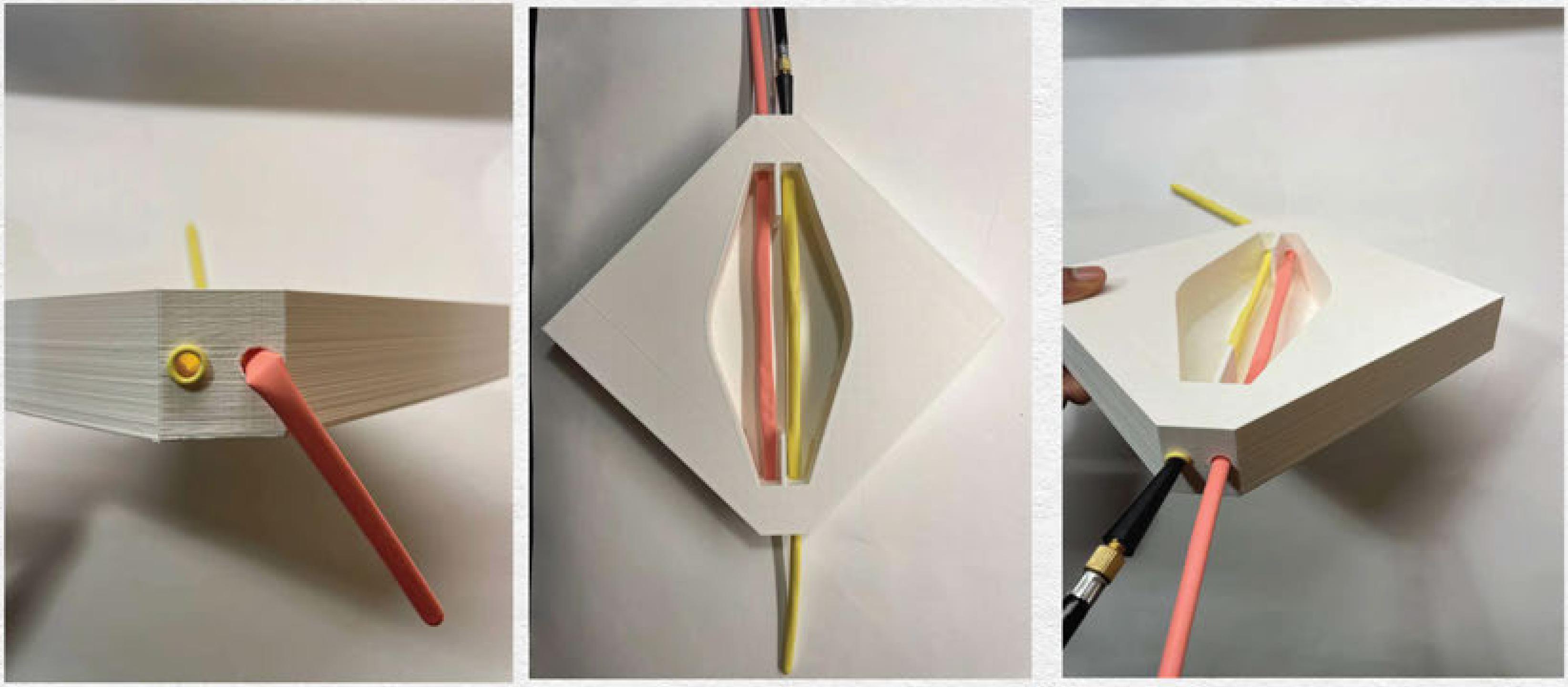
Scan for the Animation

Design Process

Initial Model

Below 013

Arrangement of Components

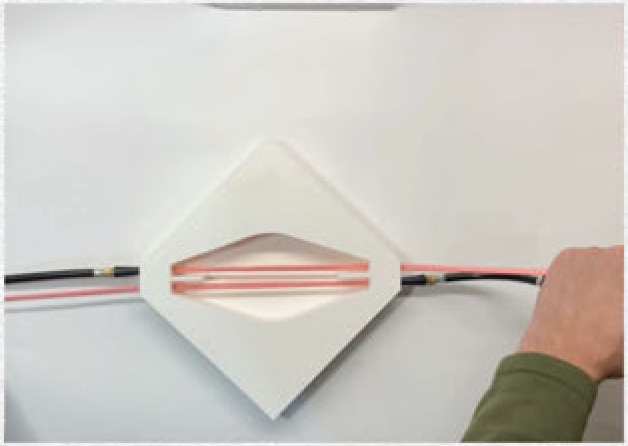


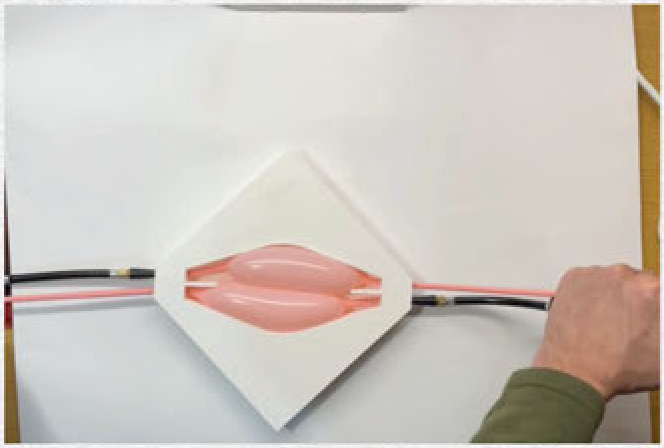
Design Process

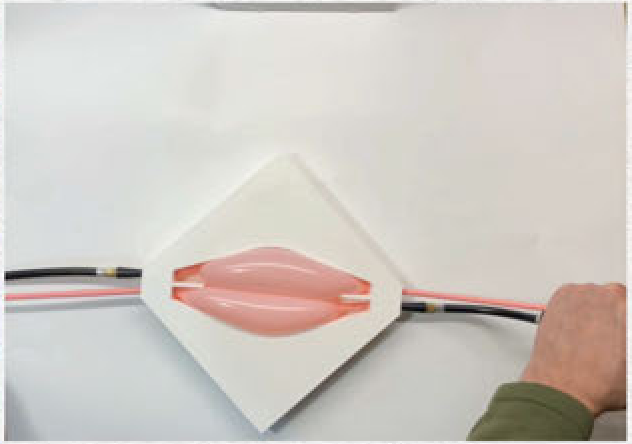
Initial Model

Below 013

Infation of ballon inside tile without cover





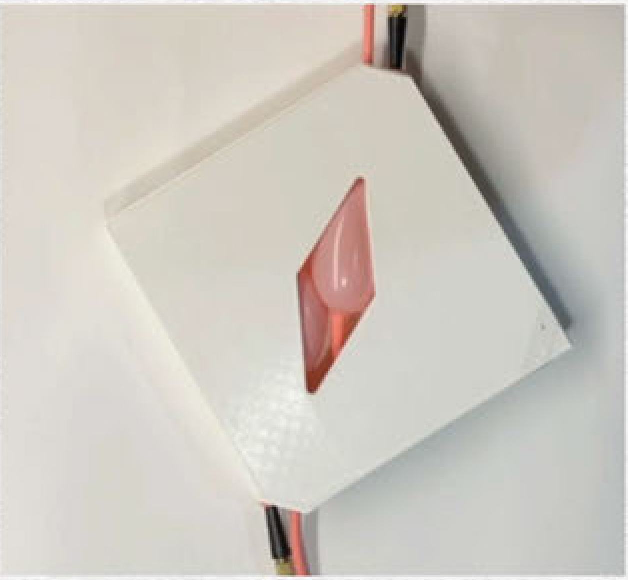


Design Process

Initial Model

Below 013

Infation of ballon inside tile without cover

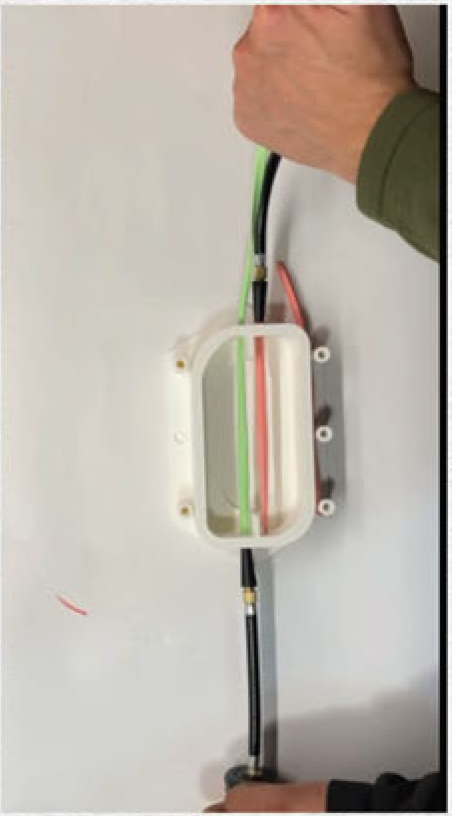


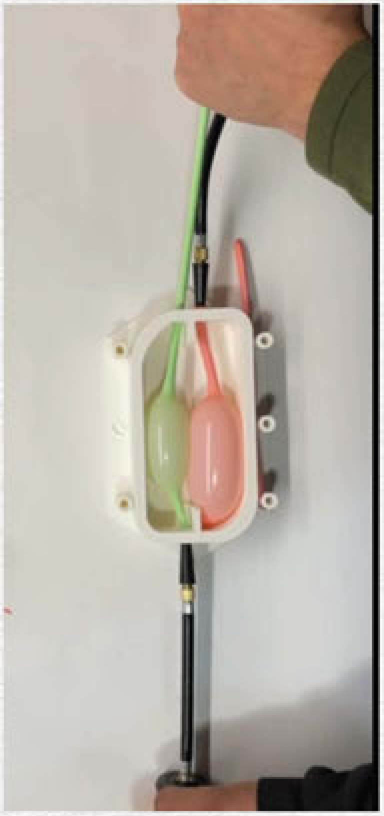
Design Process

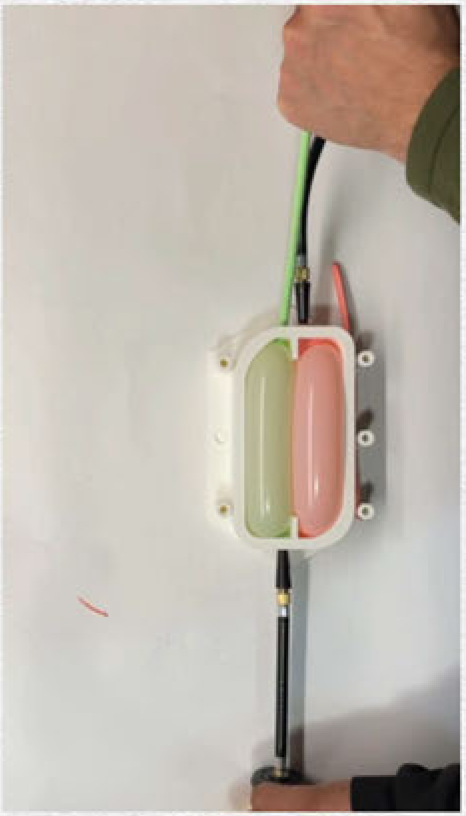
Initial Model

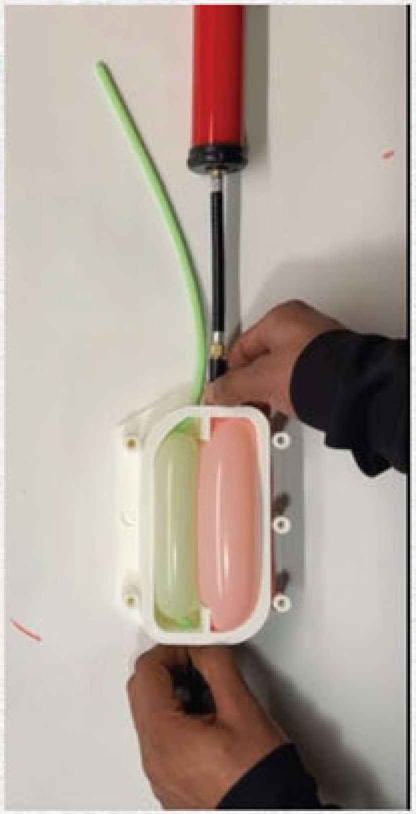
Below 013

Infation of ballon inside straight shape tile







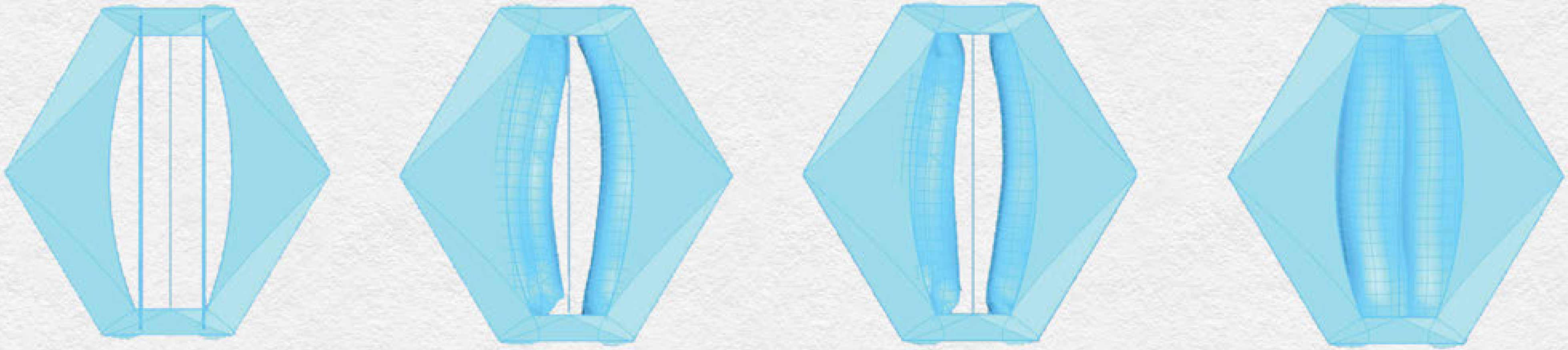


Design Simulation

Opening Iteration

Below 013

Stimulation Showing In-
fation stages

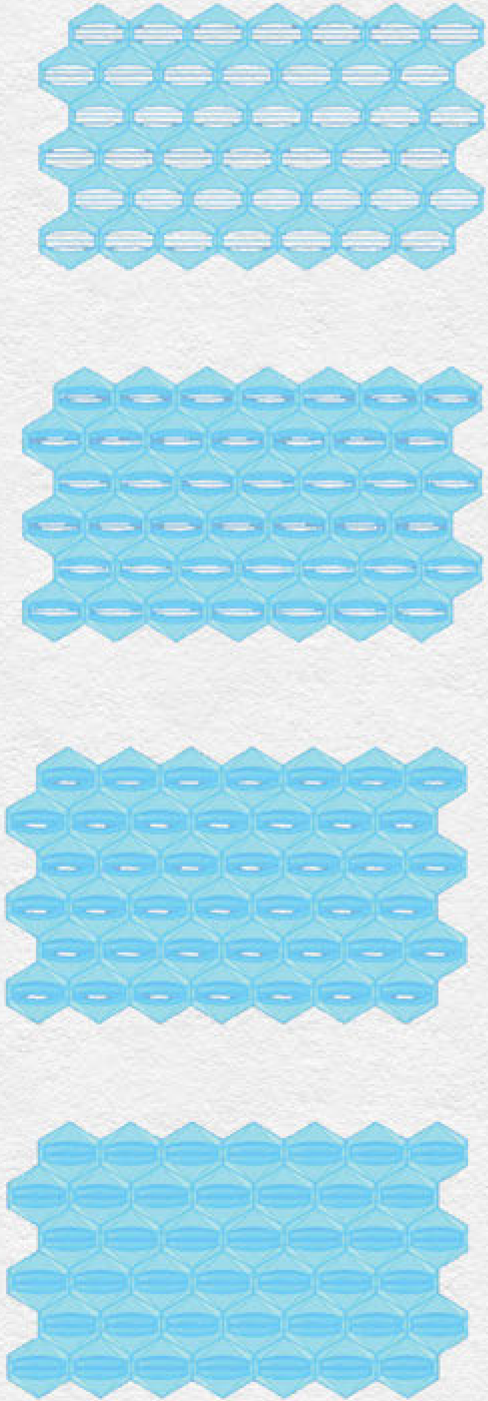


Design Simulation

Opening Iteration

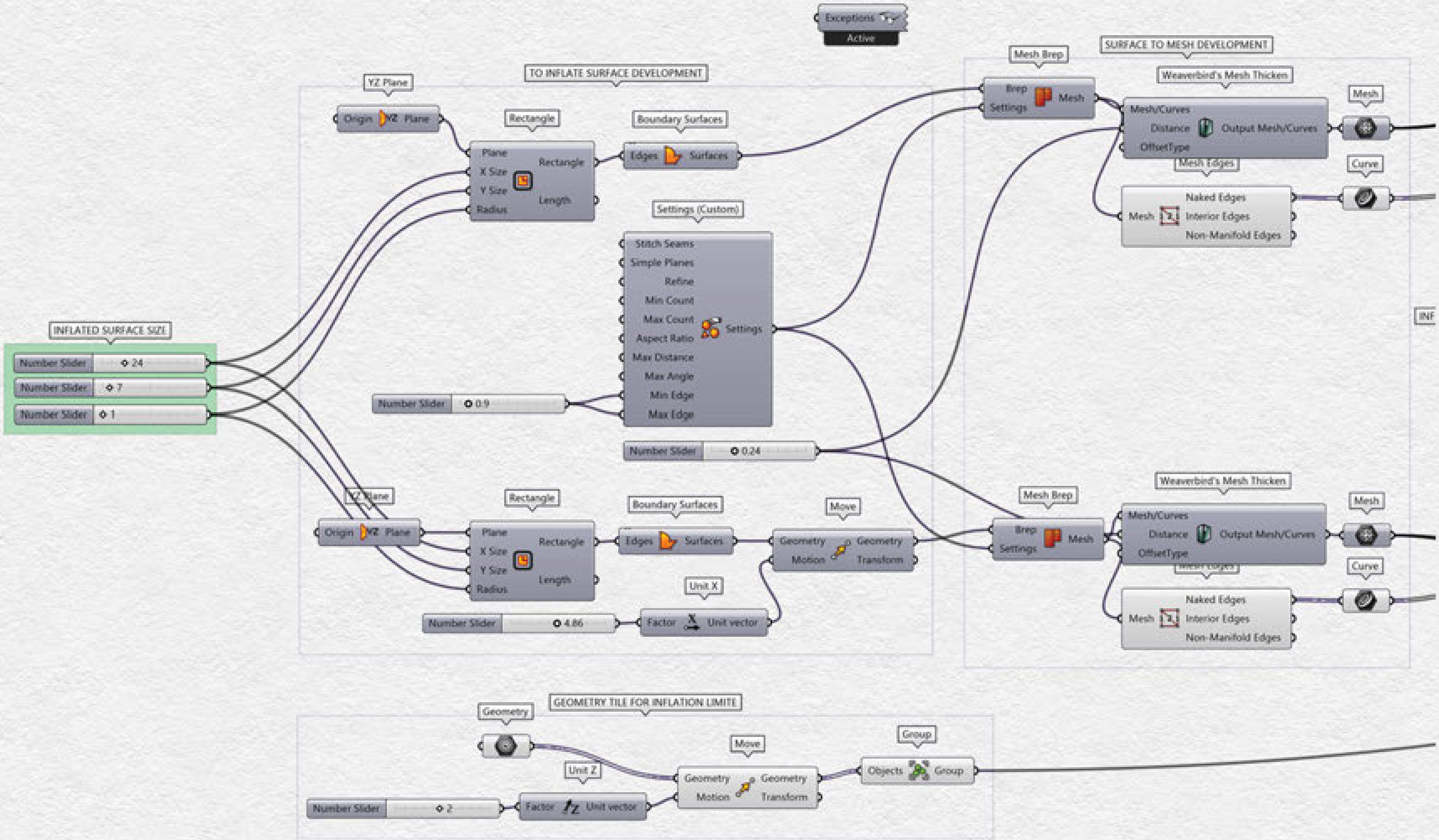
Below 013

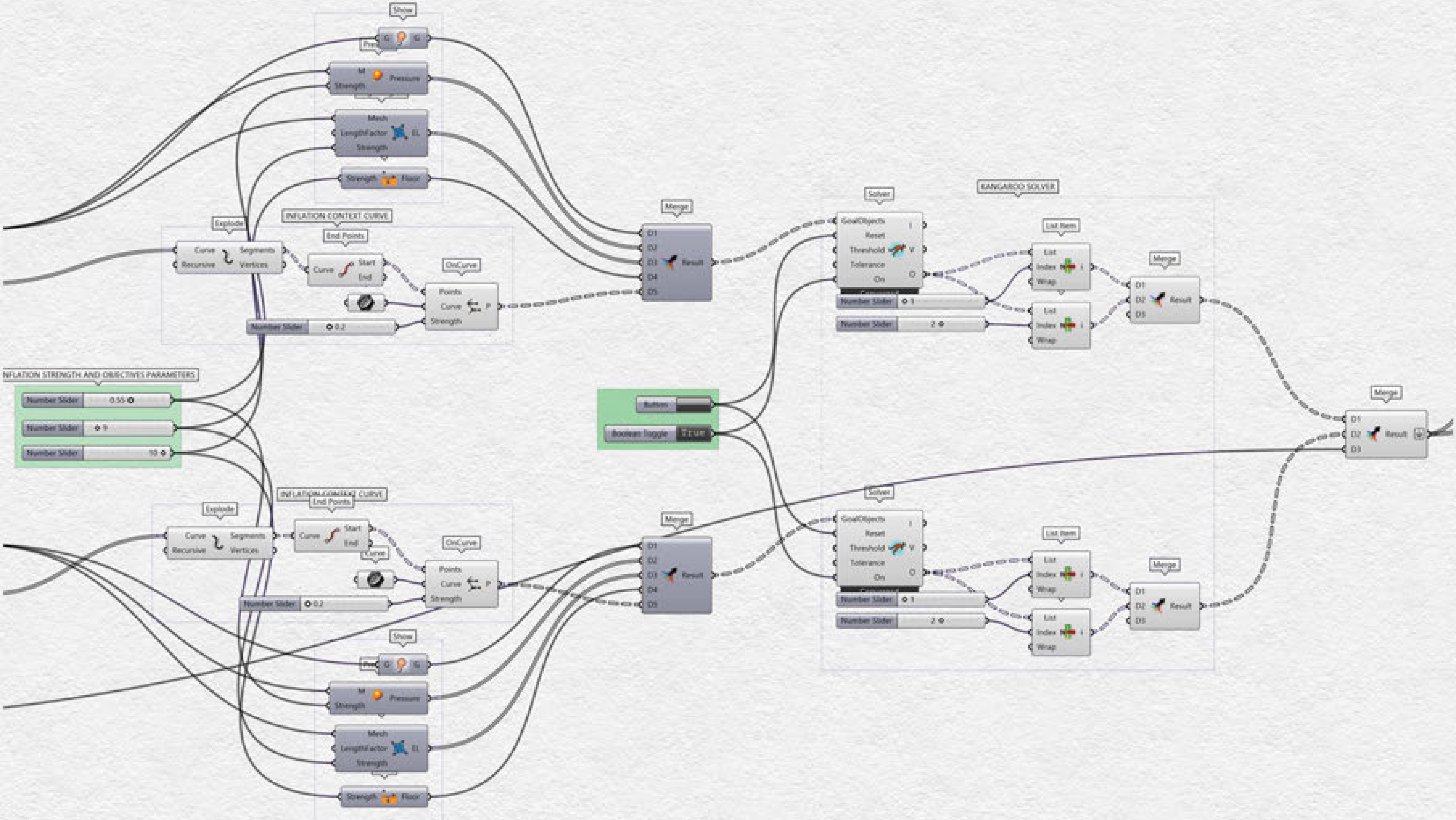
Stimulation Showing In-fation stages in grid



Scan for the Animation

Grasshopper Code





Show
Pressure
M
Strength
Mesh
LengthFactor
EL
Floor
Explode
Curve
Recursive
Segments
Vertices
INFLATION CONTEXT CURVE
End Points
Start
End
OnCurve
Points
P
Number Slider
0.2
NFLATION STRENGTH AND OBJECTIVES PARAMETERS
0.55
9
10
Merge
D1
D2
D3
D4
D5
Result
Button
Boolean Toggle
True
Solver
KANGAROO SOLVER
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Reset
Threshold
Tolerance
On
I
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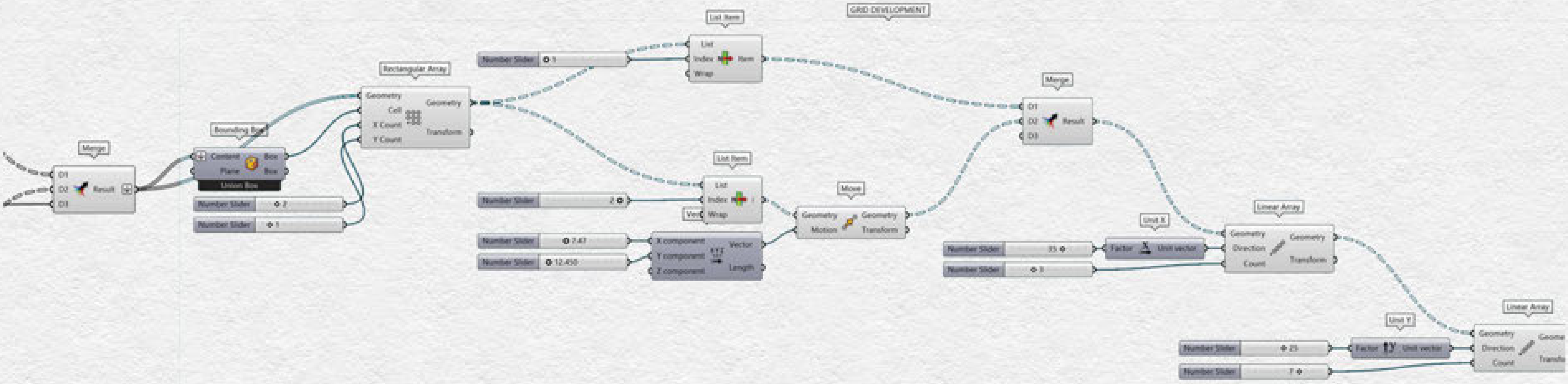
List Item
List
Index
Wrap
i
1
2


GRID DEVELOPMENT
Merge
D1
D2
D3
Result
Bounding Box
Content
Plane
Box
Union Box
Number Slider
Rectangular Array
Geometry
Cell
X Count
Y Count
Transform
List Item
List
Index
Wrap
Item
Move
Motion
Vector
X component
Y component
Z component
Length
Unit X
Unit Y
Factor
Unit vector
Linear Array
Direction
Count

Conclusion

In conclusion, this Portfolio presents the design and implementation of a biomimetic responsive facade aimed at improving indoor air quality by providing natural ventilation. The proposed facade design is inspired by the opening and closing behavior of stomata cells, which respond to environmental stimuli such as light, temperature, and humidity. The designed facade unit is capable of opening and closing based on the indoor air quality, with the opening mechanism activated when the air quality deteriorates and closed when the air quality improves.

To demonstrate the effectiveness of the proposed design, a small-scale model was built using a balloon and an air pump. The results from the model showed that the proposed design is capable of providing natural ventilation while maintaining a healthy indoor air quality.

The use of biomimicry in building design offers a promising approach to address sustainability challenges and improve indoor air quality. The proposed design has the potential to be implemented in real-life building applications, offering a sustainable

Refrence

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