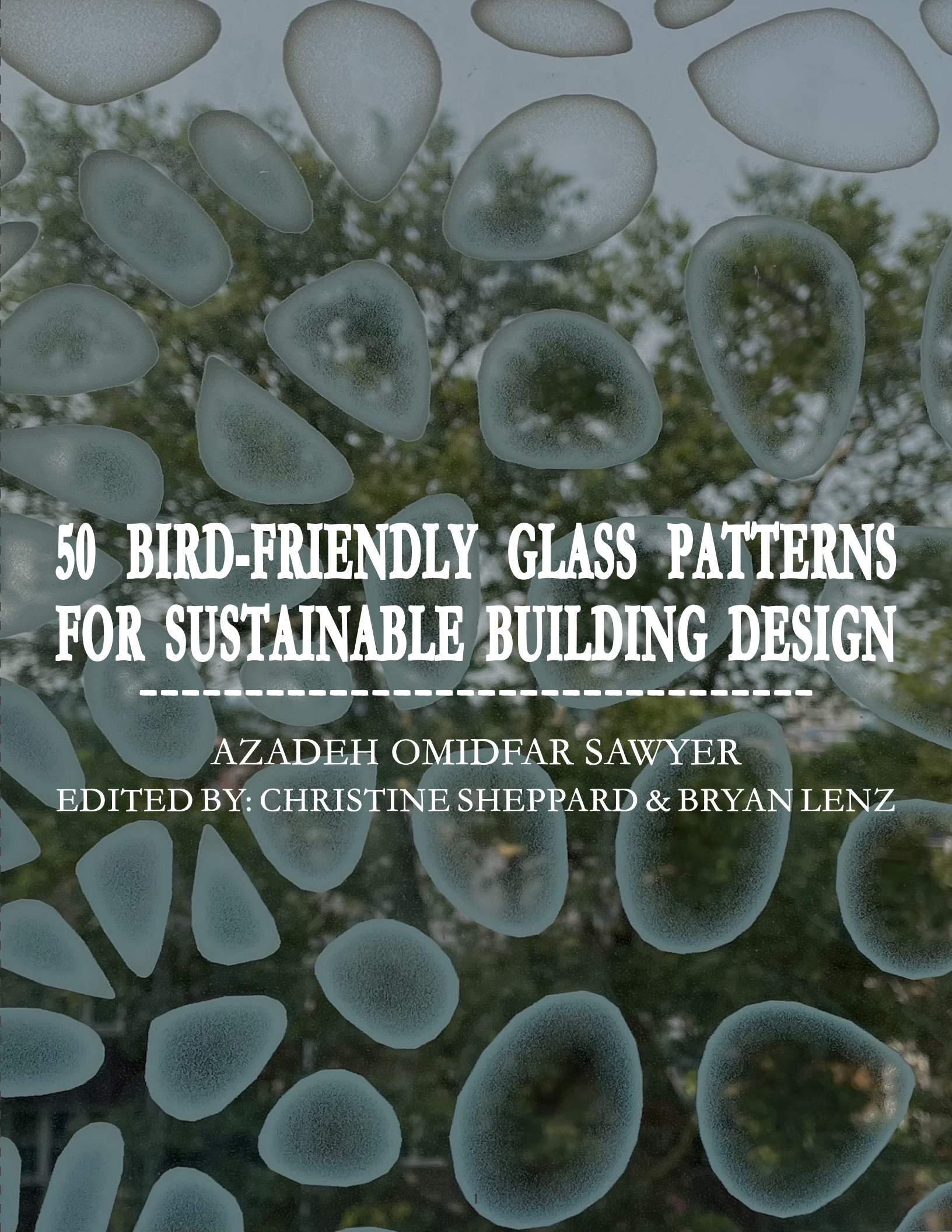


50 BIRD-FRIENDLY GLASS PATTERNS FOR SUSTAINABLE BUILDING DESIGN

AZADEH OMIDFAR SAWYER
EDITED BY: CHRISTINE SHEPPARD & BRYAN LENZ

Acknowledgments

Special thanks to my graduate research assistants at Carnegie Mellon School of Architecture, Colleen Duong, Mohammad Reza Takallouie, Tian Li , Aprameya Pandit, and Niloofar Nikookar, who provided invaluable assistance in the creation of the patterns. This work was made possible thanks to the funding provided by American Bird Conservancy and the Carnegie Mellon University College of Fine Arts' Fund for Research and Creativity (FRC).

Introduction

As cities continue to grow, the impact of the built environment on bird populations becomes increasingly important. One of the biggest dangers for birds is the proliferation of glass in buildings, which they cannot detect or avoid because for them what is reflected in the glass is reality, essentially making the glass "invisible" to them. This results in the death of hundreds of millions of birds each year in the United States alone, making bird collisions with glass a major cause of bird mortality.

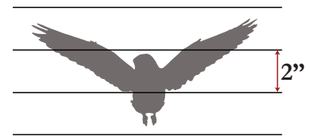
To address this issue, various strategies have been employed to make glass visible to birds so that they can avoid it, by incorporating visual markers into the glass, or retrofitting existing glass with window film and other products. Visual markers, when properly applied to the glass surface with appropriate scale and sizing, enhance visibility for birds. This is achieved by reducing both the transparency and reflectivity of the glass, creating visible markers that serve as clear visual cues for birds. Bird-friendly glass comes in a range of shapes and patterns that not only improve the building's aesthetic but also work in conjunction with other bird-safe measures, such as external shading devices or building skins.

For bird deterrence to be effective, it is crucial that the markers exhibit sufficient visual contrast between the pattern element and the reflected or transmitted image of the glass. This contrast allows birds to easily recognize the presence of a physical obstruction in their flight path. The spacing, size, and color of the pattern elements all play significant roles in determining the overall visual contrast of a deterrence solution. Therefore, paying attention to these factors is essential for creating an effective deterrent system.

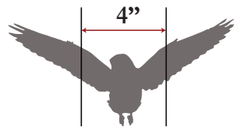
In response to the alarming number of bird fatalities, new regulations mandating bird-friendly facade design have been introduced at both federal and local levels. The guidelines require that glass incorporate patterns or systems that birds can perceive and avoid. Examples of such systems include sustainable strategies like building skins or shading systems, which not only aid in heat and light control but also contribute to reducing bird mortality.

To assess patterns as bird-friendly, American Bird Conservancy (ABC) has developed a tunnel test method to evaluate the materials' effectiveness in reducing bird collisions. Wild birds fly safely towards samples of materials and the results of these tests are used to calculate a Threat Factor to determine the bird-friendly nature of the material. According to ABC, a material is considered bird-friendly if it has a threat factor of 30 or less. It is important to note that the program is continually evolving as they collect new data to better understand the problem.

This book showcases 50 unique bird-friendly patterns that expand beyond the bird-friendly dots and stripes that have traditionally been used to reduce collisions, which can sometimes be restrictive. To ensure that these patterns are truly "bird-safe" and easily visible to birds in flight, they must adhere to specific dimensional constraints developed by ABC. The pattern must follow a strict 2" by 2" or 2" by 4" grid and have a line width of minimum 3 mm or a dot size of at least 6 mm. A 2" by 2" spacing is better at protecting smaller birds, such as hummingbirds which are common victims of collisions. Research shows that songbirds, the group that experiences the most window collisions, avoid flying through a horizontal space that is less than 2 inches high or a vertical space that is 4" wide or less. This is likely due to the shape of a bird with its wings outstretched during flight.



Horizontal lines with a maximum spacing of 2"

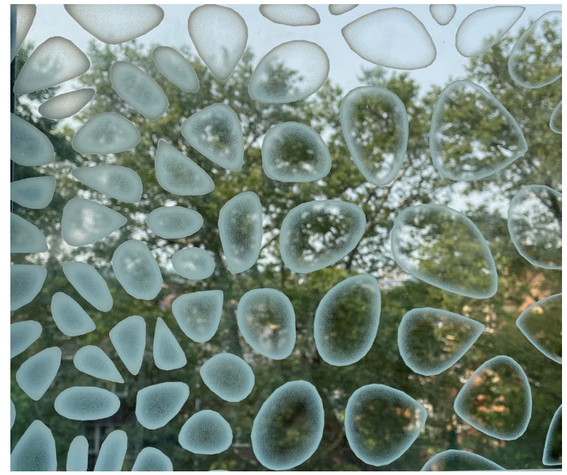


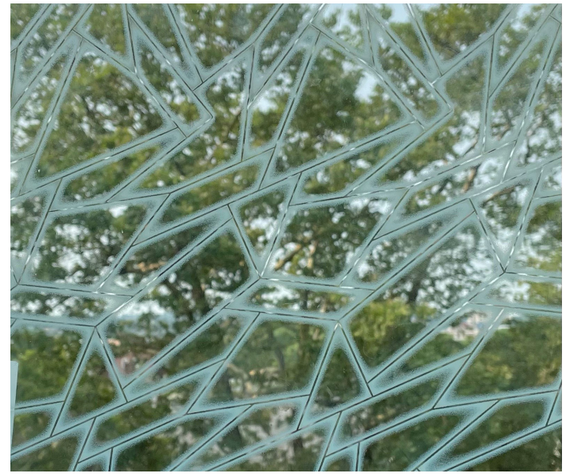
Vertical lines with a maximum spacing of 4"

Birds killed by collisions, collected by FLAP monitors in Toronto, Canada. Photo credit: Kenneth Hrdy.

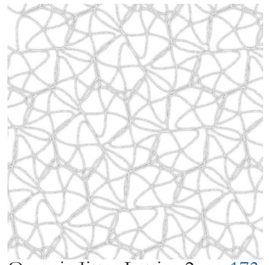
To effectively mitigate bird collisions in various lighting conditions, it is best to apply patterns on the outer surface of the glass, referred to as Surface 1. This placement has shown to be highly effective in deterring bird strikes. Alternatively, patterns on Surface 2 have also demonstrated effectiveness, considering factors like surface reflectivity, pattern design, and color combinations. It is important to ensure that the glass configuration enables clear visibility of the Surface 2 pattern while addressing challenges such as specular and visual reflections when viewed from the outside. ABC has a set of specific guidelines for the glass build up that must be followed to ensure that patterns are visible to birds.

The diverse and unique patterns in this book have been designed to provide architects and designers with more options while still following the 2" by 2" and 2" by 4" guidelines. Each pattern included in this document includes a scale, solar radiation reduction, Threat Factor, a step-by-step Grasshopper definition of how it was created, and renderings of both the exterior and interior of the pattern applied to a test case. By applying these bird-friendly patterns as visual markers on glass or as a building skin while following ABC's IGU composition rules to ensure the patterns are visible to birds, we can reduce both bird collisions and energy consumption. Designing buildings that prioritize the safety of birds not only helps to protect and preserve these important species but also promotes a more sustainable and harmonious relationship between humans and the natural world.

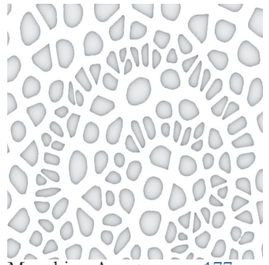




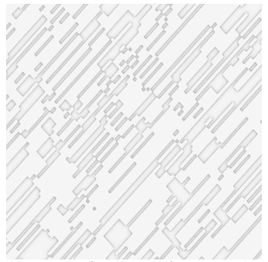
Glass samples displaying unique frit patterns created at Carnegie Mellon School of Architecture and printed by Elevecture, following the 2x2 and 2x4 grid guidelines.



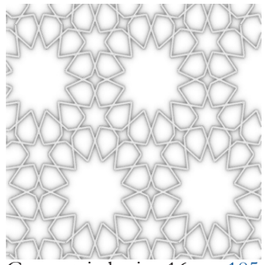
Organic Jitter Lattice 2: pg 173



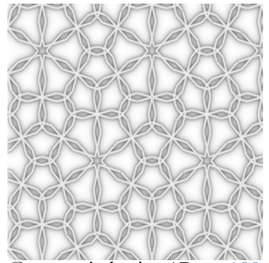
Morphing Aperture: pg 177



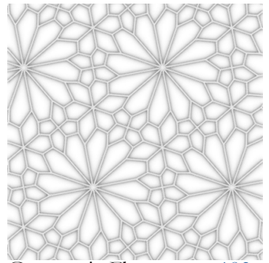
Rectangular Porosity: pg 181



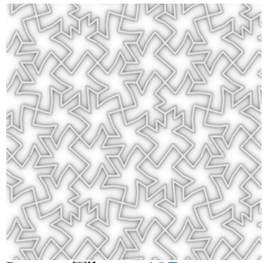
Geometric lattice 16: pg 185



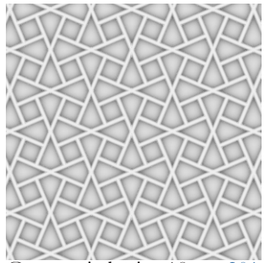
Geometric lattice 17: pg 189



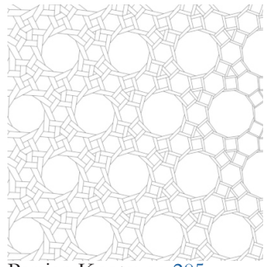
Geometric Flowers: pg 193



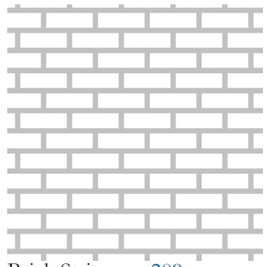
Leaves Tile: pg 197



Geometric lattice 18: pg 201



Persian Knots: pg 205



Brick Strips: pg 209

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Christine Sheppard

Architecture, especially glass architecture, has played a major role in the decline of bird populations across the globe, with bird deaths from collisions with glass rising as improved technology made larger glass panels and even curtain walls possible to fabricate. As many as a billion birds now die each year from this cause alone, in the best studied region, the United States and Canada.

Solutions to this problem began to be developed over a decade ago, with the realization that visual markers of appropriate spacing and dimensions could act as virtual signals that would cause birds to divert their flight paths. The earliest of this work used dots and stripes as visual markers, created using ceramic frits, enamel inks, etching, and UV coatings, with other technologies still in development. Glass companies in the U.S. and Europe, and as far flung as China and Turkey, have developed their own lines of bird-friendly glazing. Although there are few restrictions on what constitutes a bird-friendly pattern, 'dot patterns' have predominated, presumably because they minimize coverage of the glass and are thought to be visually unobtrusive. Unfortunately, the less visible the signal, the less effective at reducing bird mortality.

Architects have been slow to embrace these materials, even as an increasing number of jurisdictions have begun to require bird-friendly design for new construction. One reason for this is that many consider bird-friendly design strategies as outside of the basic design, as an add-on, not as integral to the design. Dr. Azadeh Sawyer, from Carnegie University, has taken a distinctively different approach, noting that bird-friendly patterns can reduce energy costs for building operations, and that bird-friendly patterns can be beautiful in their own right and part of the overall look of a structure. Dr. Sawyer and her colleagues have created scripts that can generate suites of designs that look organic, fractal, geometric and more – and that meet the guidelines for effective bird-friendly patterns. This book collects a range of these patterns, along with their solar radiation reduction, renderings, and the code used for programming each.

Photo Credits: Toronto Met Learning Center - Snøhetta

Bird Friendly Patterns Explanation

Parametric Considerations: Using Grasshopper, the patterns were generated through parametric relationships, enabling easy iteration, rescaling, optimization, and fabrication. To ensure that the patterns designed are bird-friendly, several factors must be considered during the pattern generation process. One of the most important considerations is the dimension of the patterns. **All pattern explorations must adhere to either a 2"x2" grid, a 2"x4" grid, or a hybrid grid.** These specific dimensions are chosen to ensure that the patterns are easily detectable by birds in flight, so they do not perceive the spaces within the pattern as openings to fly through. **Additionally, the patterns must maintain a minimum line width of 3 mm or a dot diameter of 6 mm for markers to further enhance visibility for birds.**

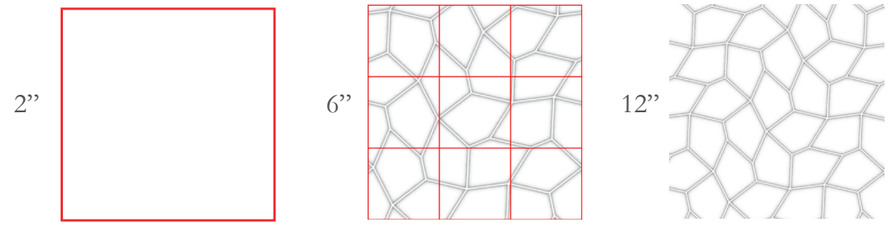
When applying visual markers, the choice of glass surface is crucial. **For maximum effectiveness in preventing bird collisions, it is important to apply the patterns on the outside surface of the glass (Surface 1).** However, Surface 2 patterns can also be effective, taking into account factors such as reflectivity, pattern design, and color. Ensure that the glass configuration allows for clear visibility of the Surface 2 pattern while minimizing specular and visual reflections seen from the outside. ABC has a set of specific guidelines for the glass build up that must be followed to ensure that patterns are visible to birds.

Glass Assembly Specifications: The glass assembly must adhere to the following specifications: The surface one VLR (Visible Light Reflection) should be ≤15%. It should have an opaque frit, ceramic ink, or other opaque marker type, or a Visible Contrast Level >0. Low e coatings must be positioned behind the pattern, with Coating Visible Light Outdoor Reflection also ≤15%. The glass can be clear or low-iron. The pattern should consist of continuous solid lines at least 1/8" wide, spaced no more than 2" apart (edge to edge) for horizontal or angled lines, and no more than 4" apart for vertical lines. Alternatively, it can comprise circular, square, or irregular solid shapes that are no more than 2" away from another shape vertically and no more than 4" away horizontally, or 4.47" diagonally (edge to edge), with each shape having an area ≥0.20 square inches. The pattern can be on either side 1 or side 2, and all low e coatings must be positioned behind the pattern when viewed from surface 1.

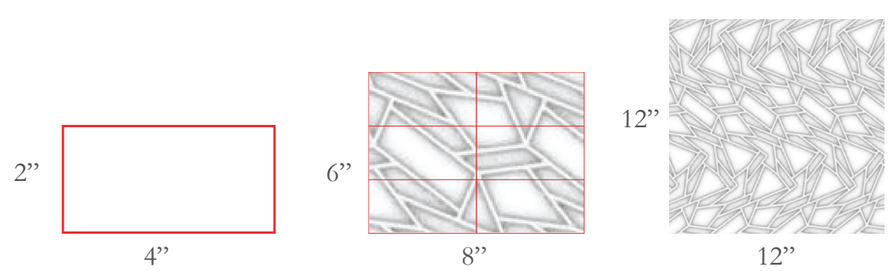
Bird-Friendly Threat Factor: In 2010, American Bird Conservancy and a team of architects interested in advancing the field of bird-friendly design developed the concept of Material Threat Factor (commonly referred to as Threat Factor or TF) as a way to assign scores that provide a relative measure of how well materials with patterns of visual markers cause avoidance by birds. These scores allow architects to design buildings using rated glass and also permit evaluation of products that can be applied to existing glass (retrofits) to reduce collisions.
More details on how TFs are assigned can be found here:ABC-Rating-System

Solar Radiation Reduction: The radiation reduction of each pattern was determined through digital calculations using ClimateStudio, with Pittsburgh's latitude (40°26'26" N) and longitude (79°59'45" W) serving as the location for all simulations. In order to calculate the radiation, the Pittsburgh. Intl. AP.725200_TMY3 weather file was used. To simulate the effects, a grid of sensors was placed behind the surface of each pattern on the south-facing glass. The resulting values indicate the percentage of radiation reduction provided by these patterns on the glass. It is important to note that this evaluation was conducted using computer-based simulations rather than physical tests.
These reductions can greatly reduce energy consumption through cooling of buildings. In climates where more direct solar radiation is desirable, patterns with less coverage can be selected, while in climates where less direct light is desirable, patterns with more coverage would be ideal. By selecting the appropriate pattern, the energy efficiency of a building can be significantly improved, resulting in cost savings and a reduced environmental impact.

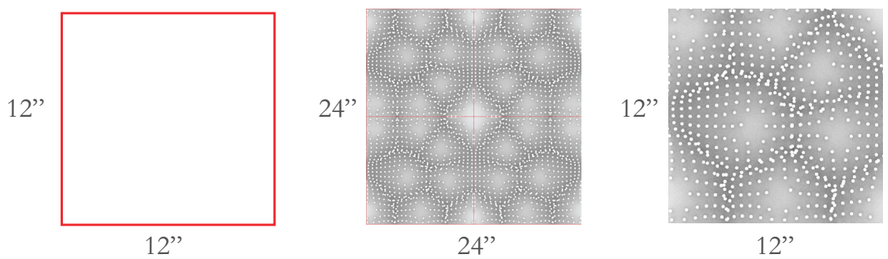
2" x 2" Grid



2" x 4" Grid

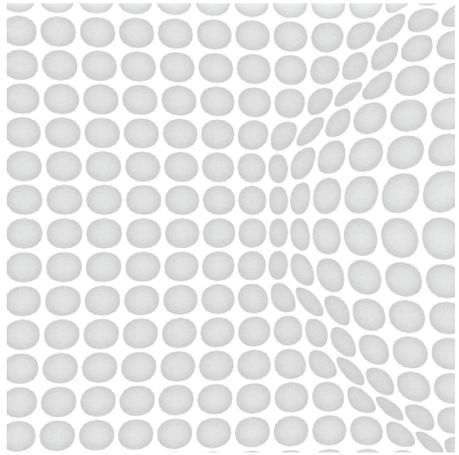


Organic Grid

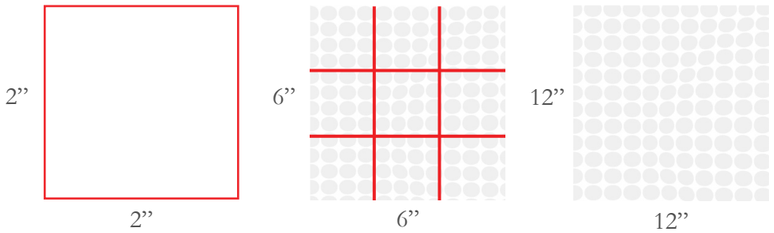


*The images shown above are **not to scale** and are purely for explanatory purposes.*

Distorted Porosity

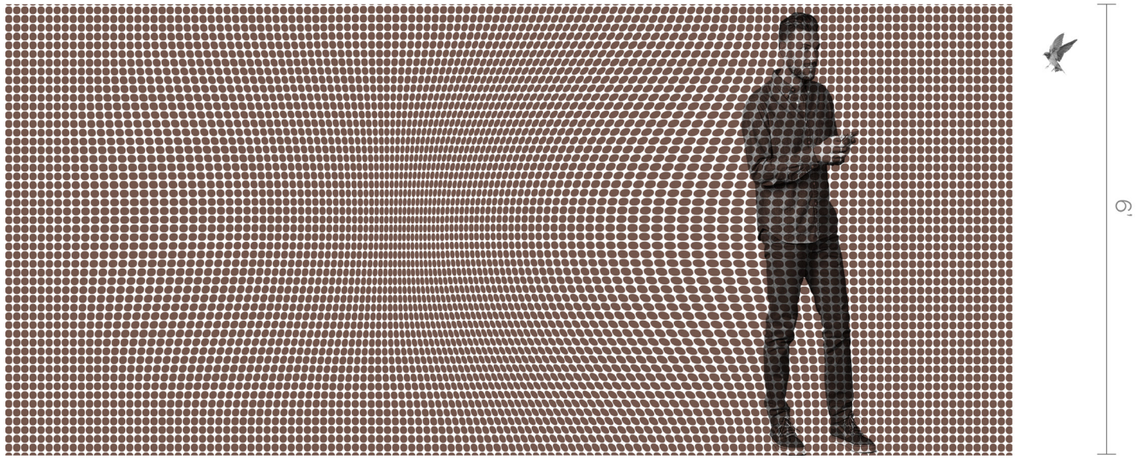


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	60 %



Visualization

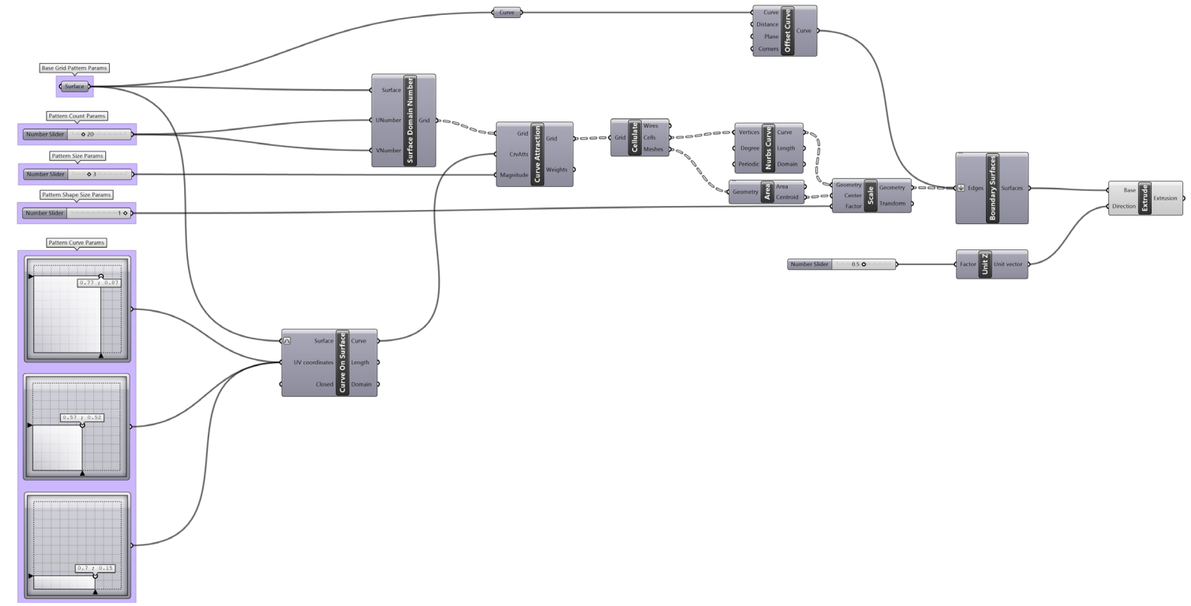
Understanding Scale and Filtering.

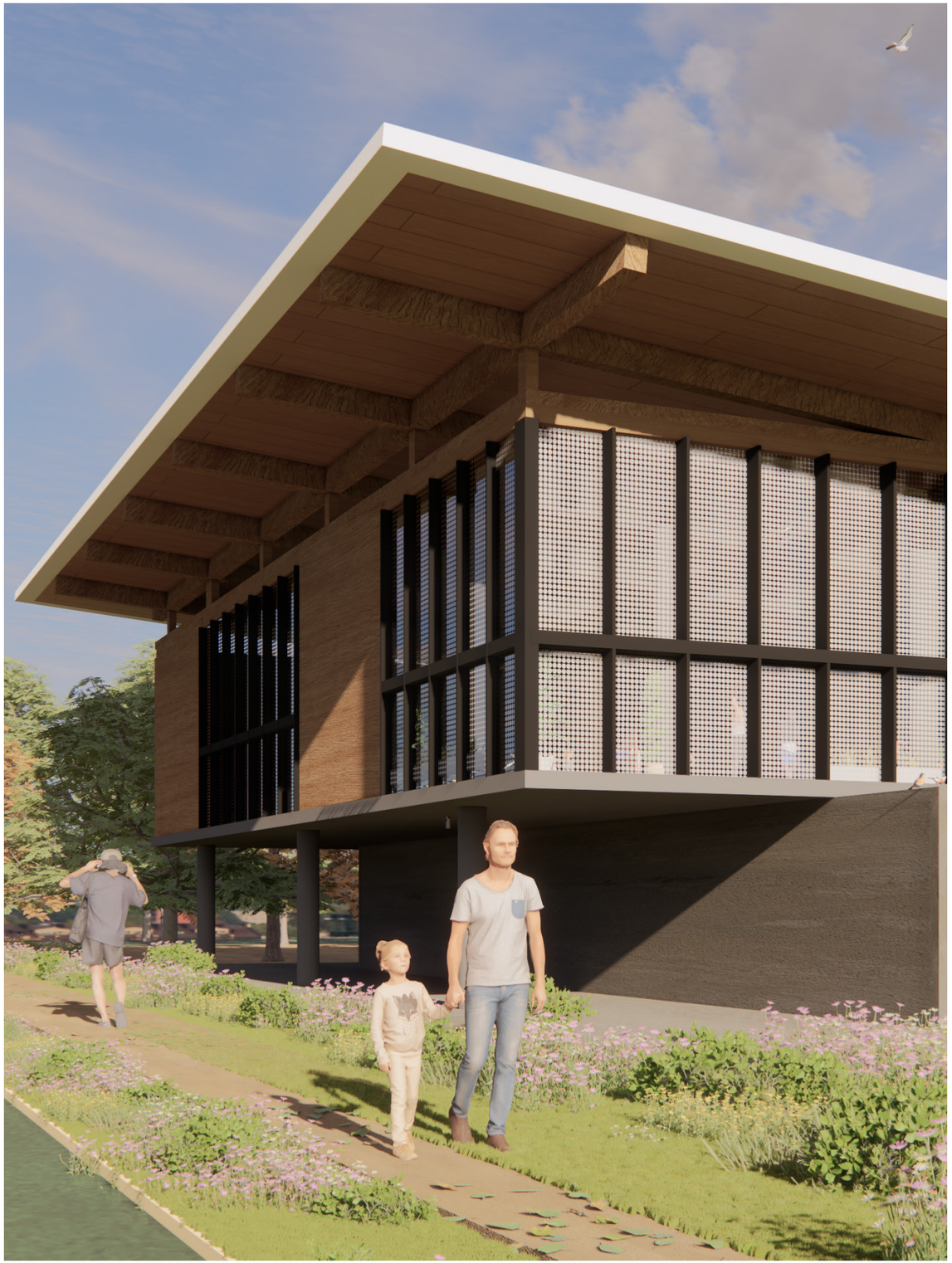


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

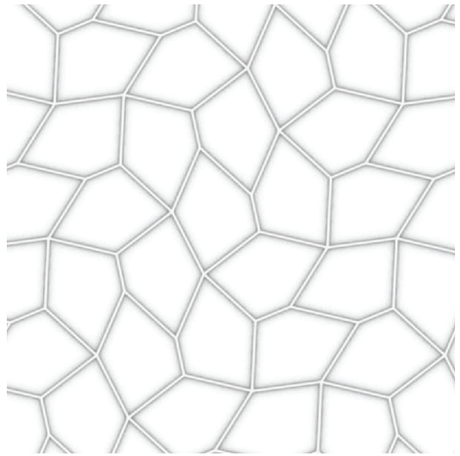
GH Script

A breakdown

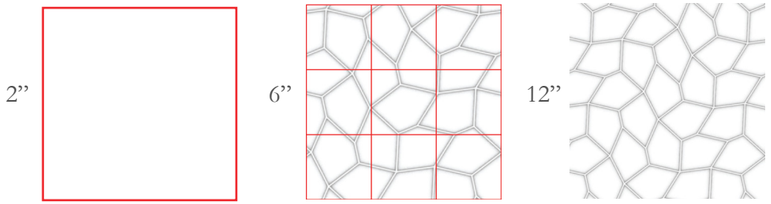




Cellular Lattice 1

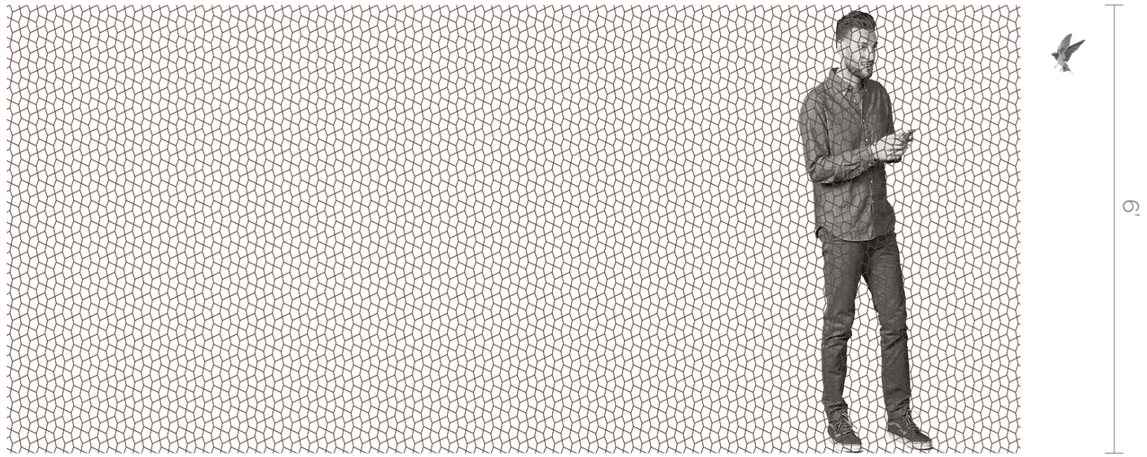


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	15 %



Visualization

Understanding Scale and Filtering.

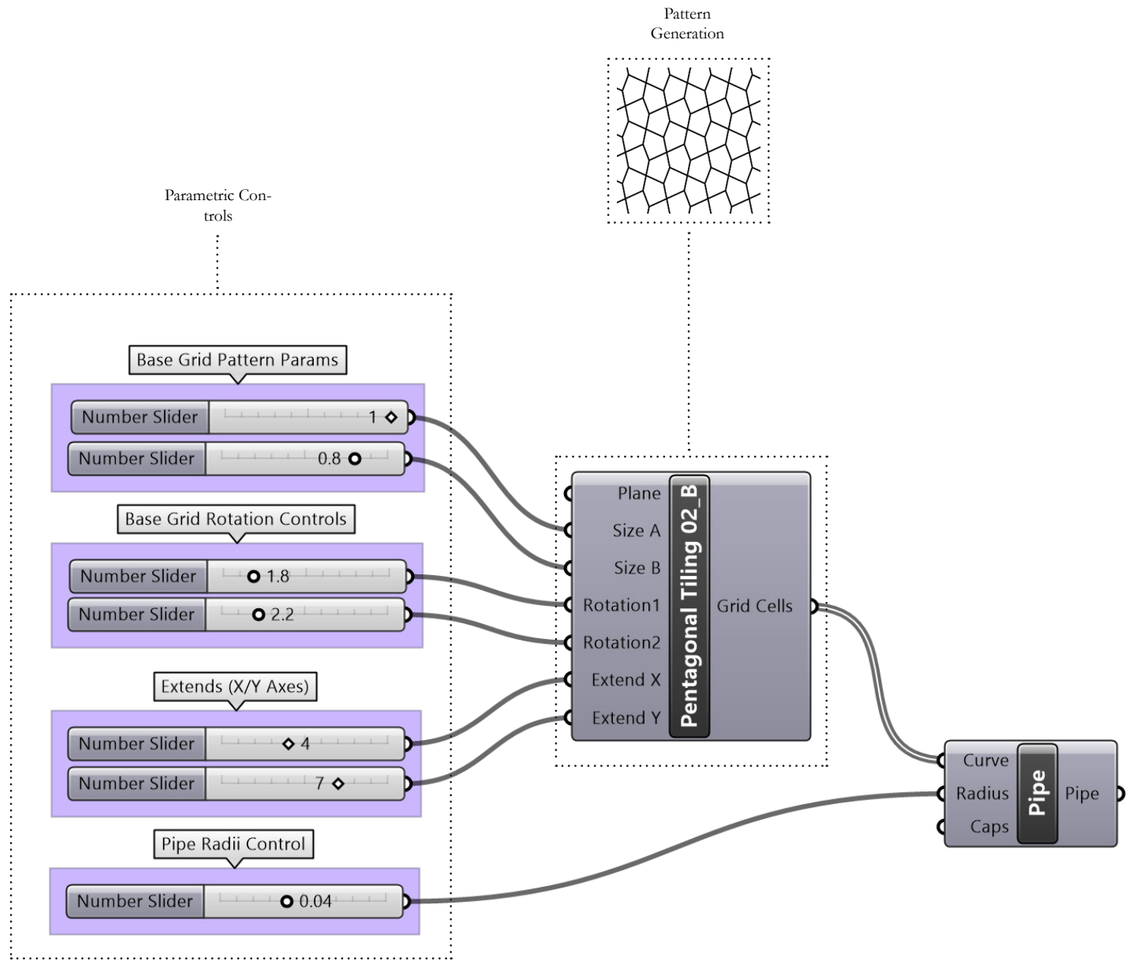


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

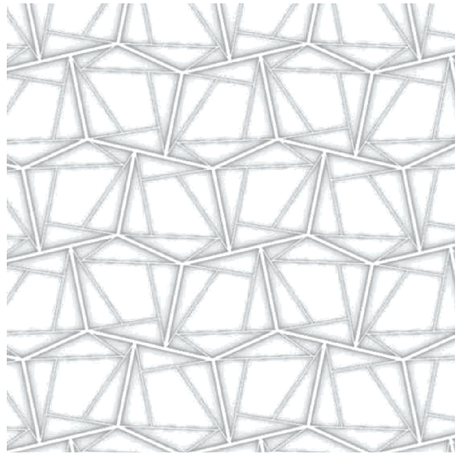
GH Script

Additional Plugins

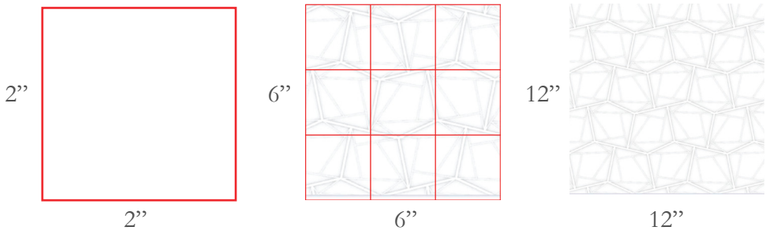
Parakeet



Cellular Lattice 2

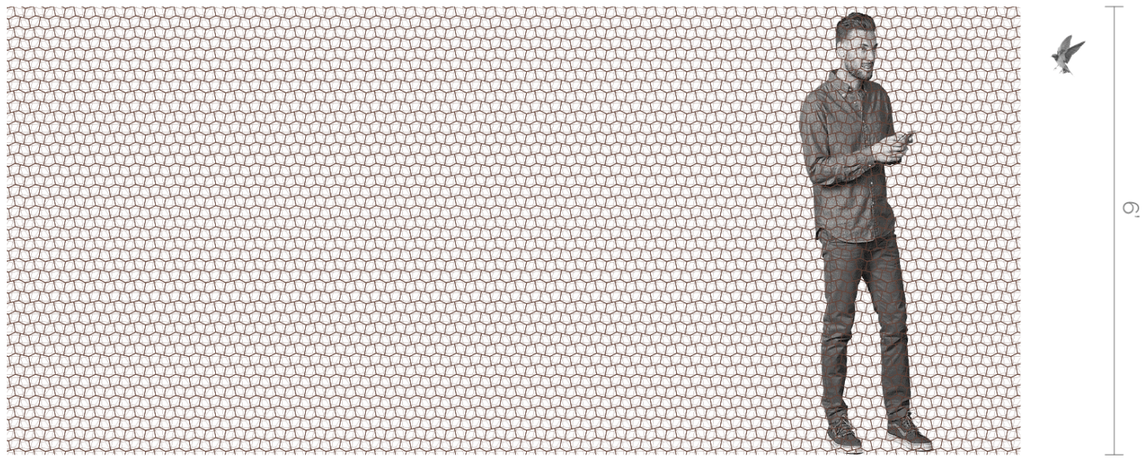


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	32 %



Visualization

Understanding Scale and Filtering.

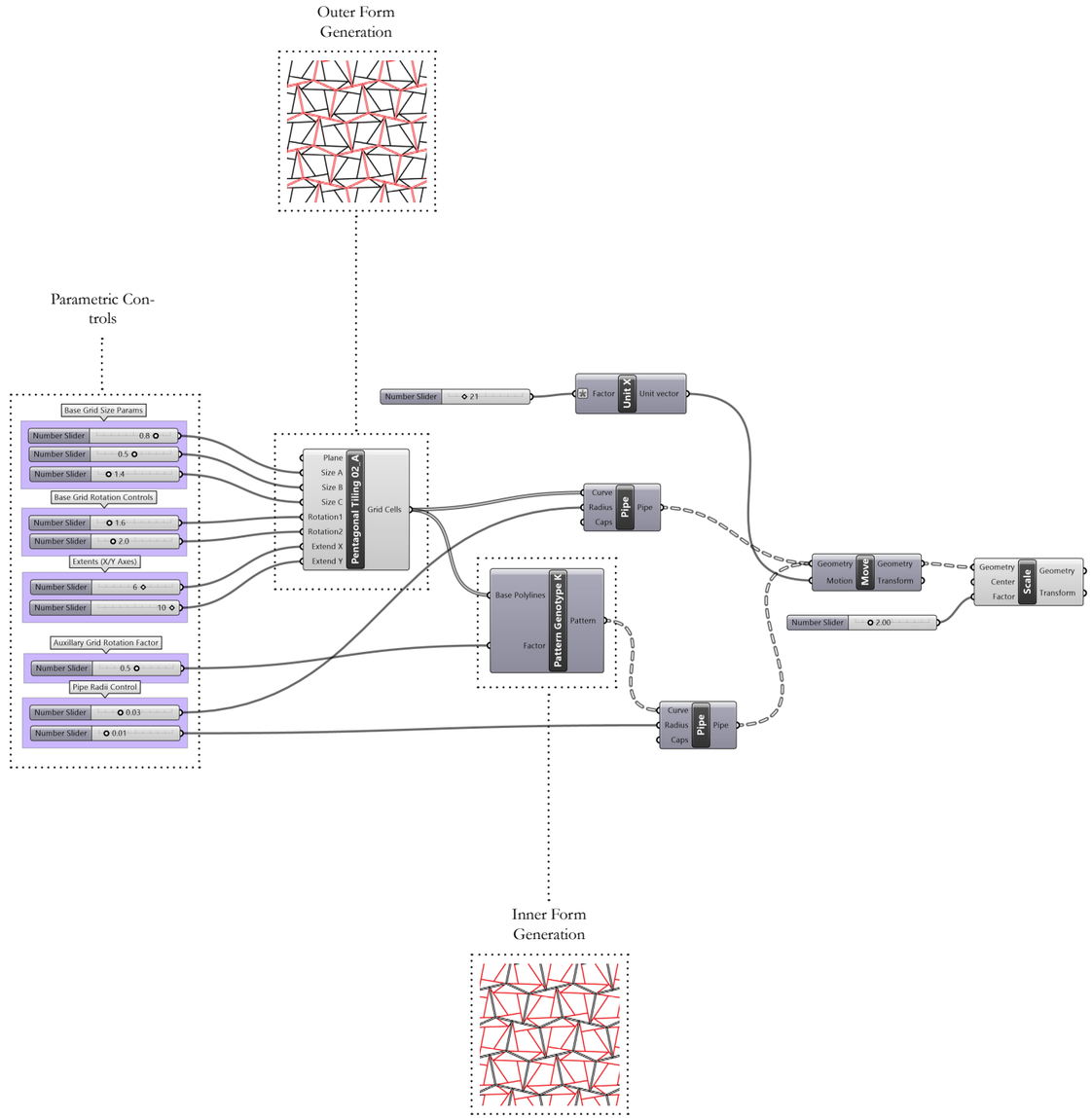


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

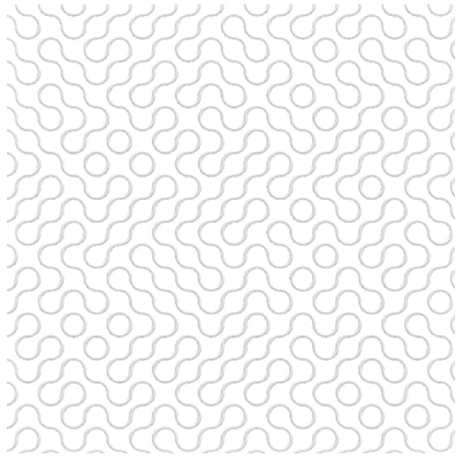
GH Script

Additional Plugins

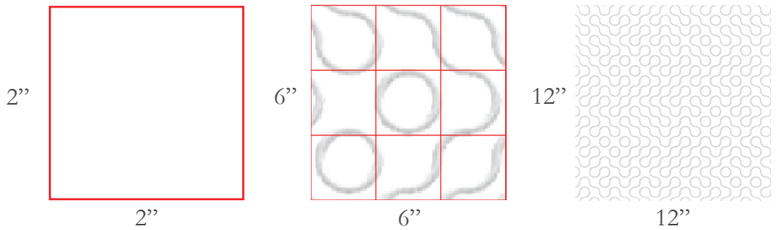
Parakeet



Truchet Tile Quarter Circles

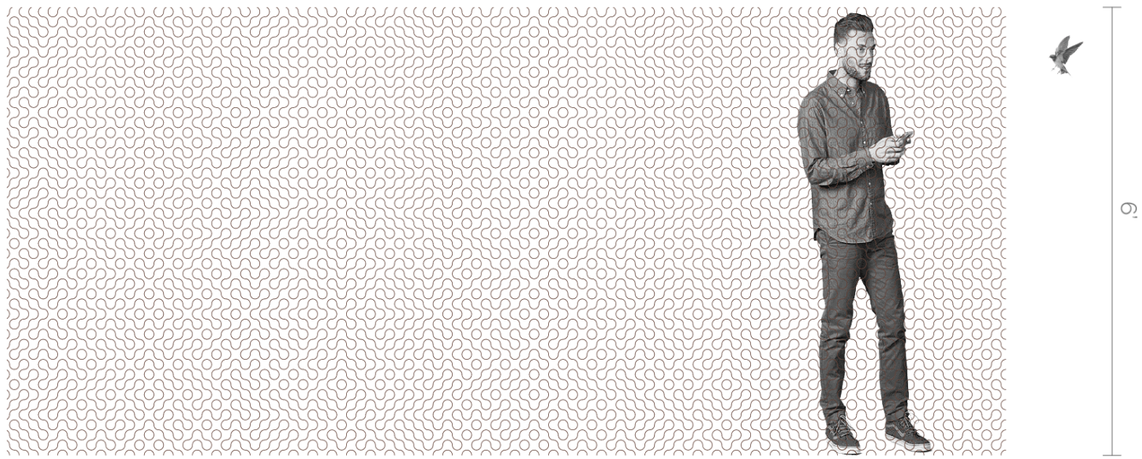


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	18 %



Visualization

Understanding Scale and Filtering.



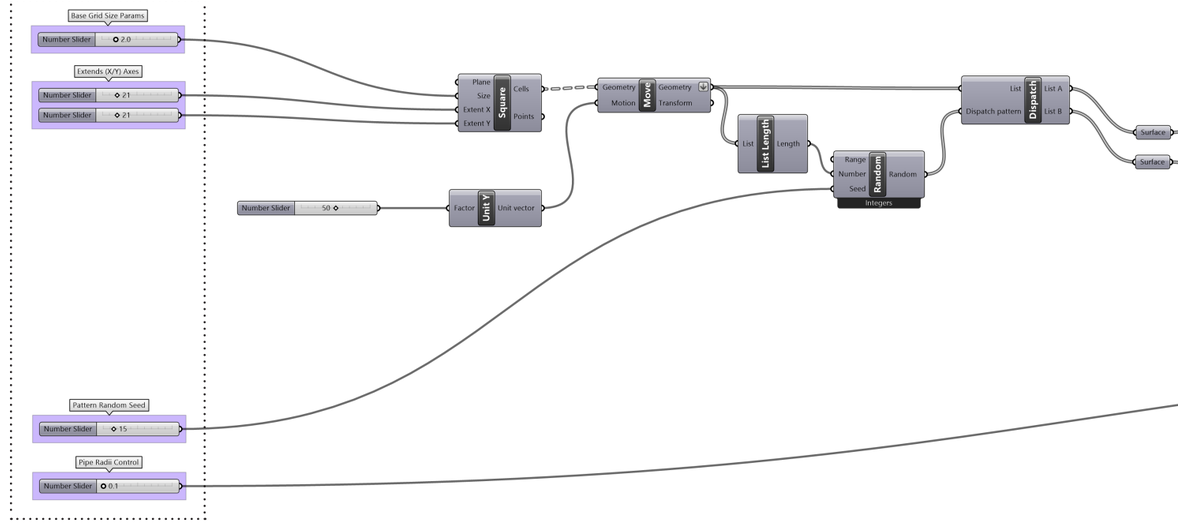
*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

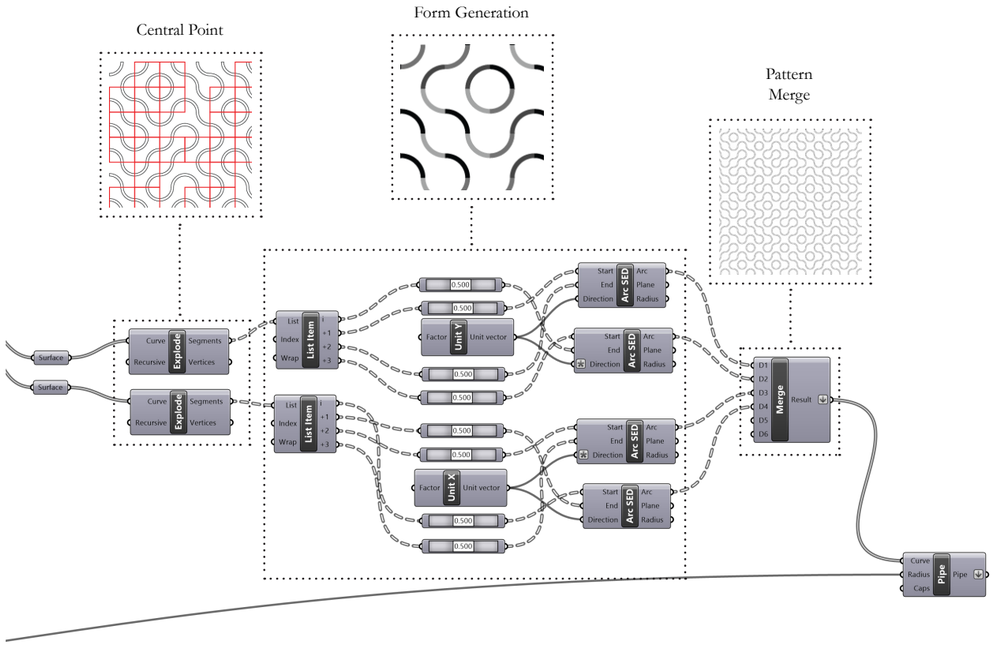
GH Script

Additional Plugins

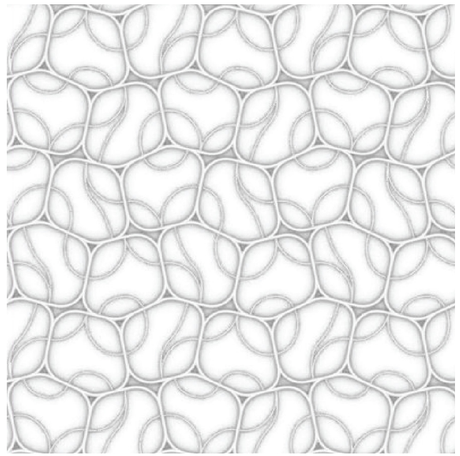
n/a

Parametric Controls





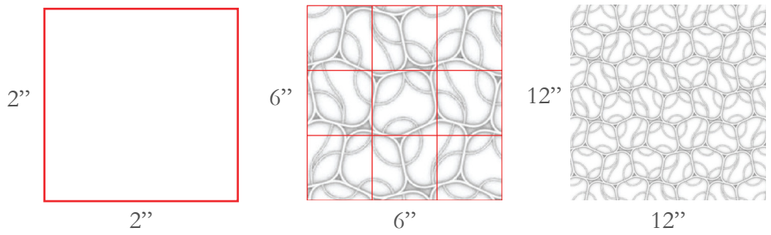
Cellular Lattice 3



SIZE 2x2 grid

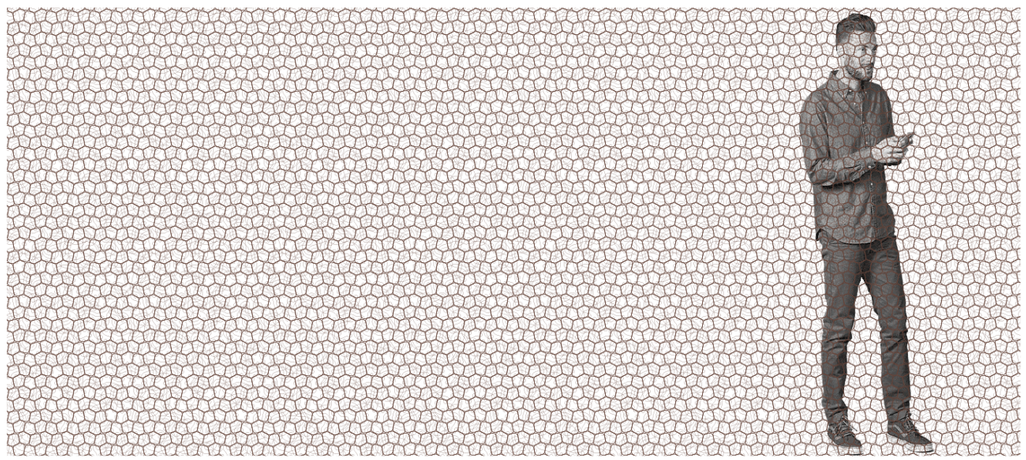
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 22 %



Visualization

Understanding Scale and Filtering.



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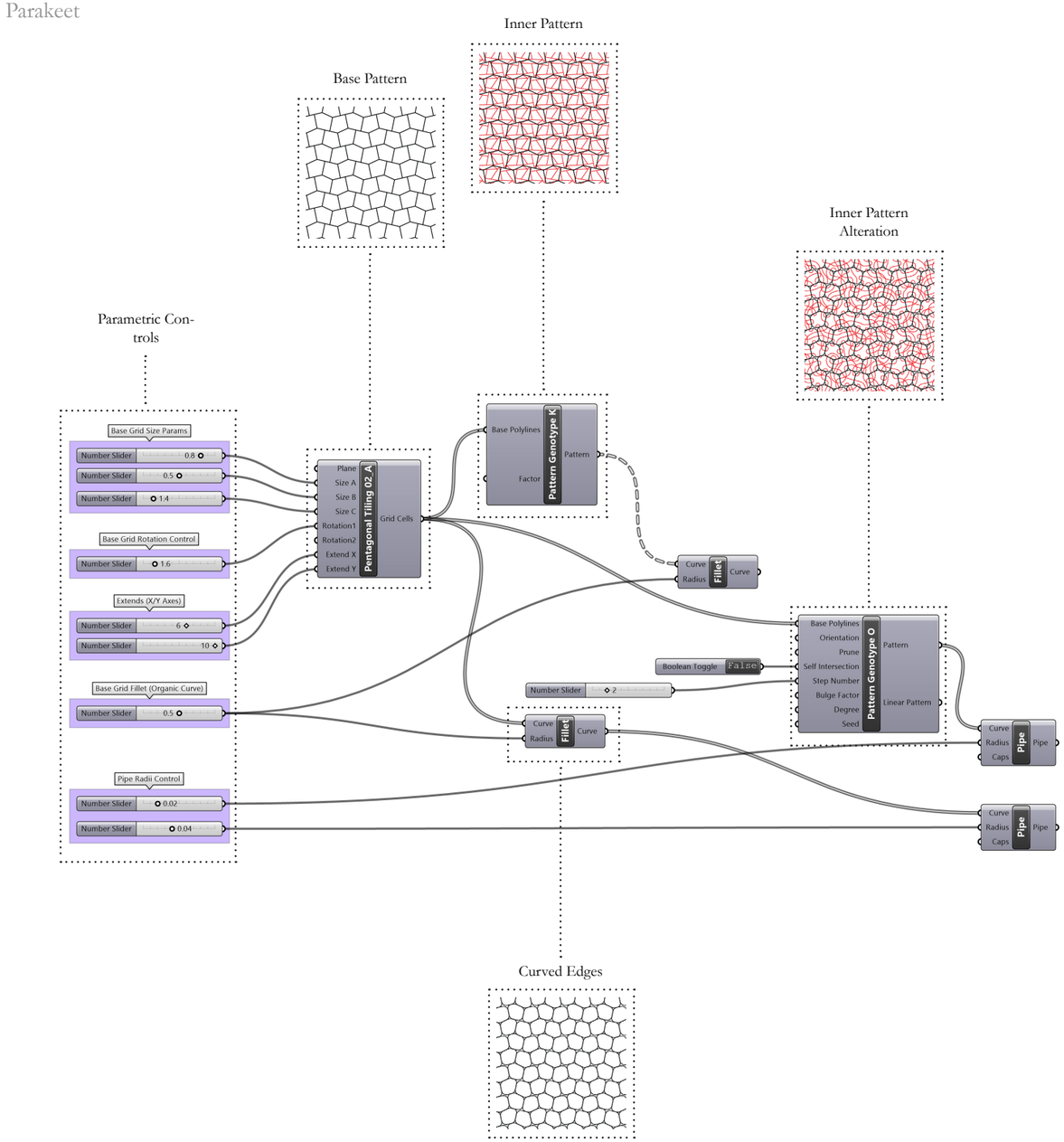
GH Script

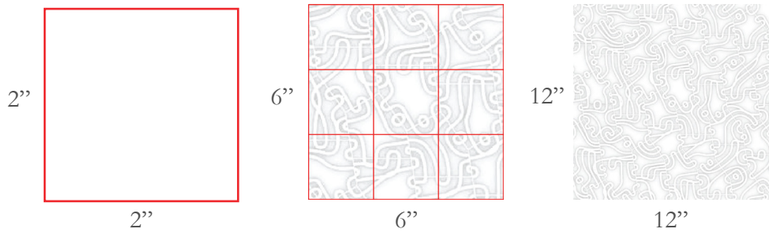
Additional Plugins

Parakeet



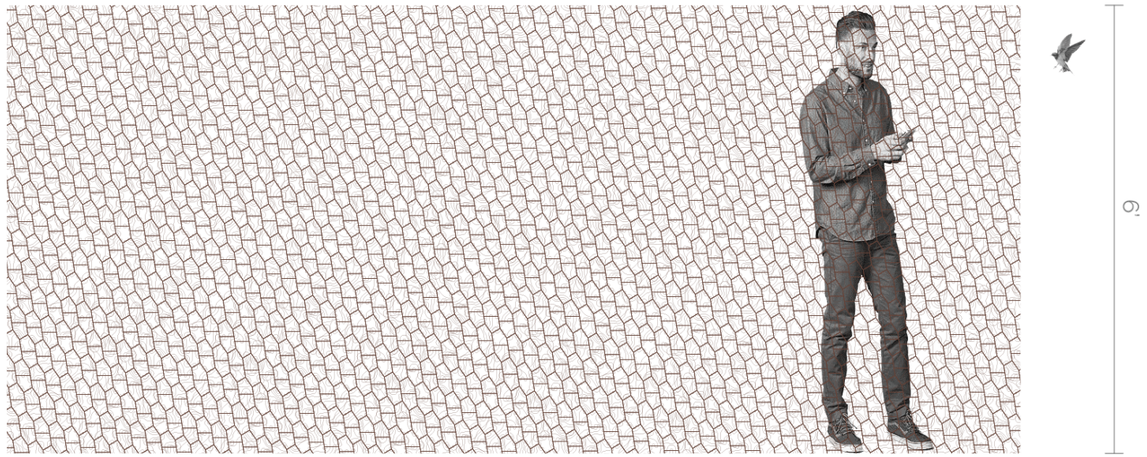
Organic Lattice

SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	26 %



Visualization

Understanding Scale and Filtering.



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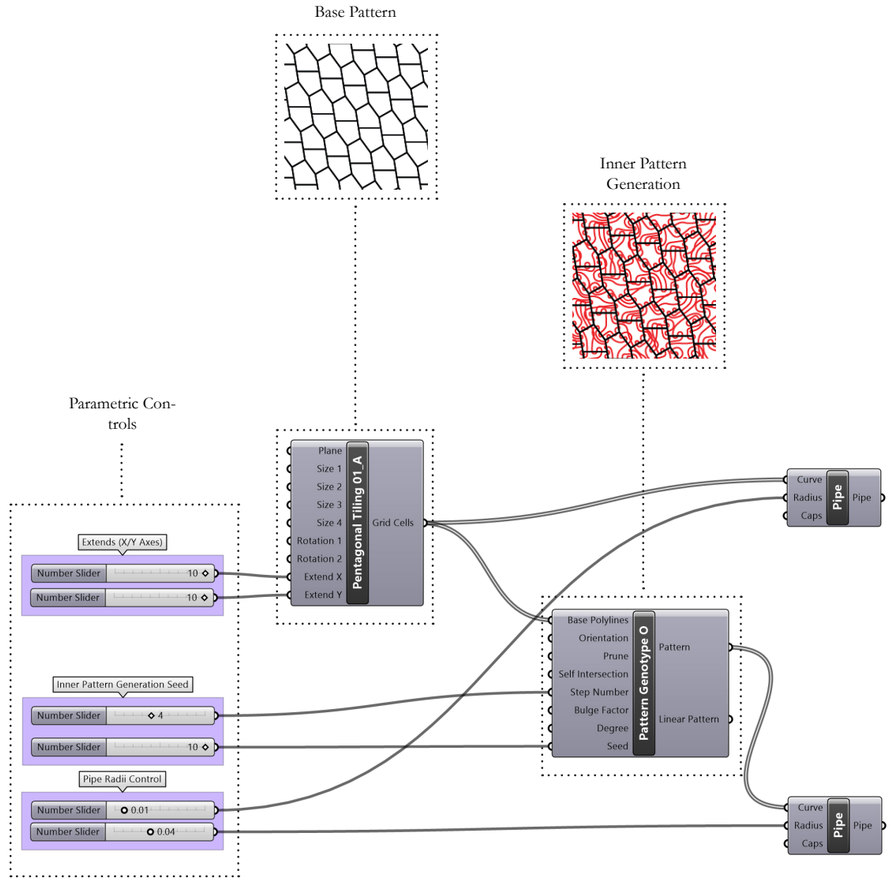
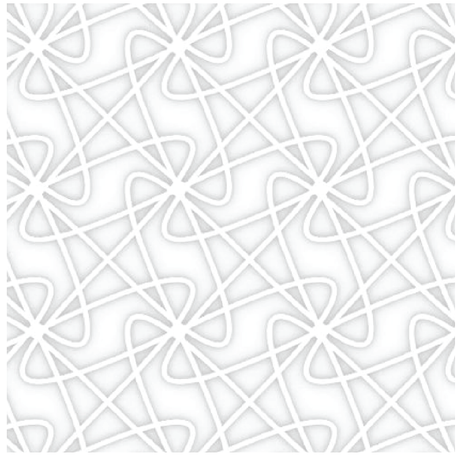
GH Script

Additional Plugins

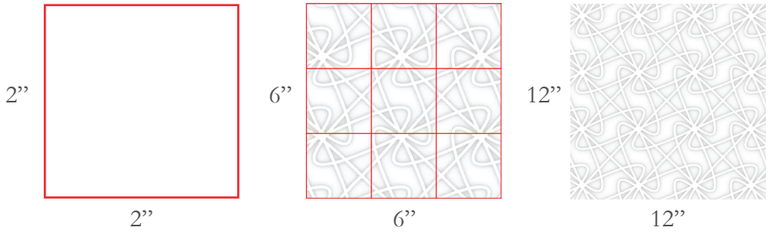
Parakeet



Geometric Lattice 1

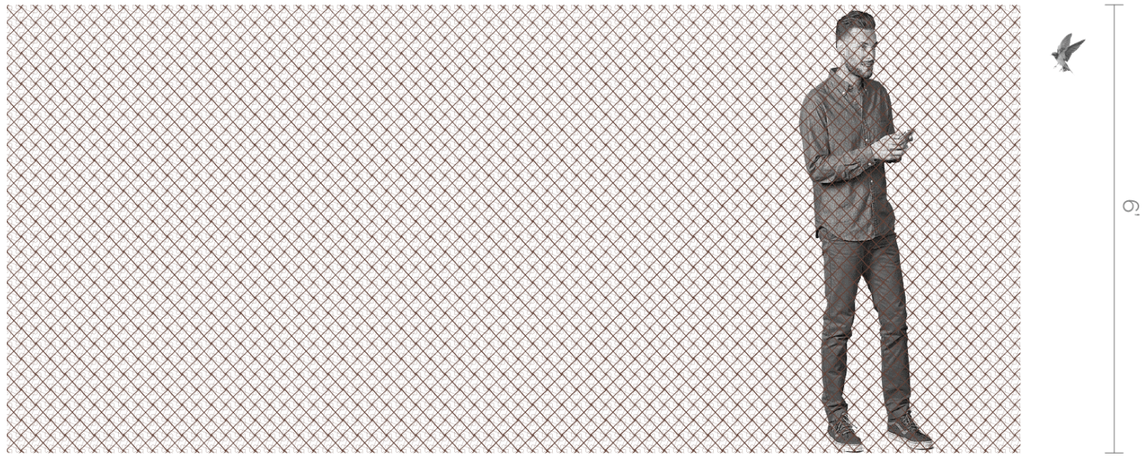


SIZE	2x2 grid
THREAT FACTOR	20 *
SOLAR RADIATION REDUCTION	31 %



Visualization

Understanding Scale and Filtering.



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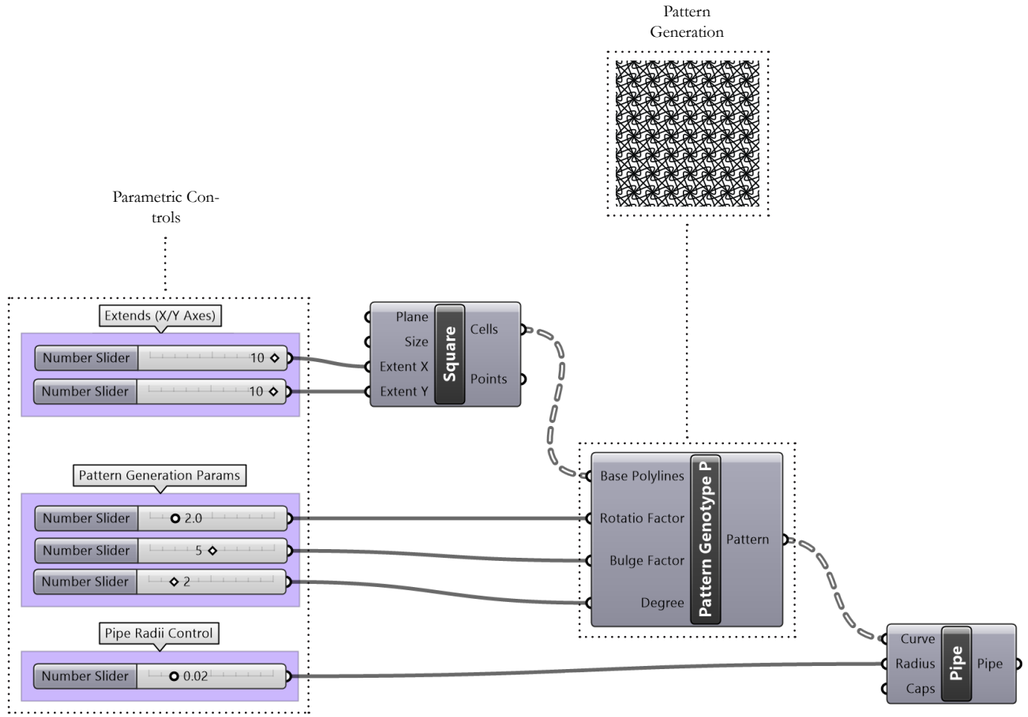
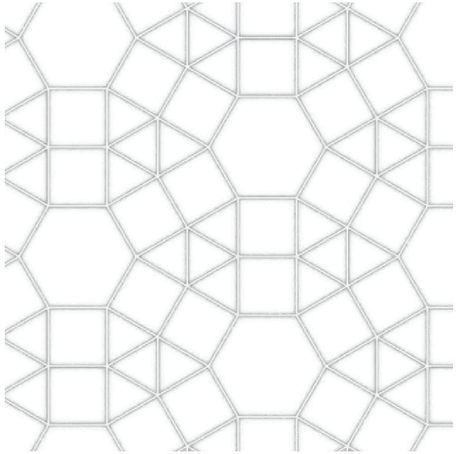
GH Script

Additional Plugins

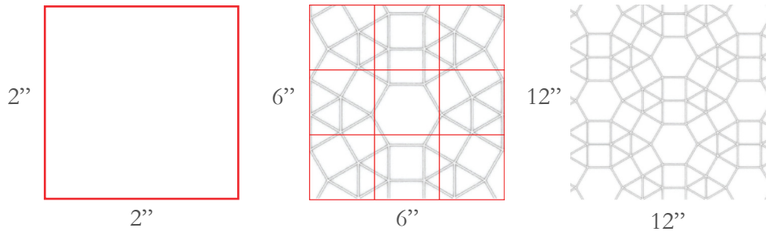
Parakeet



Geometric Lattice 2

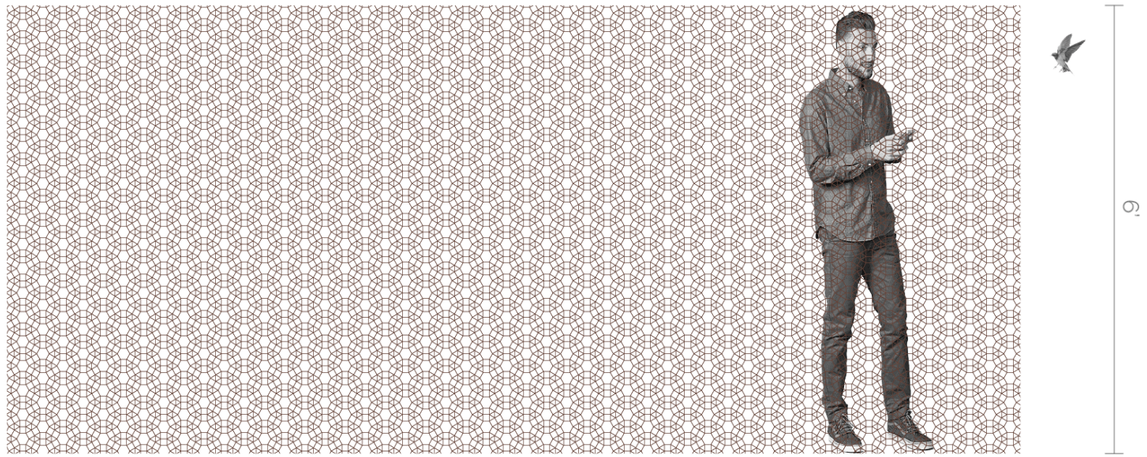


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	10 %



Visualization

Understanding Scale and Filtering.



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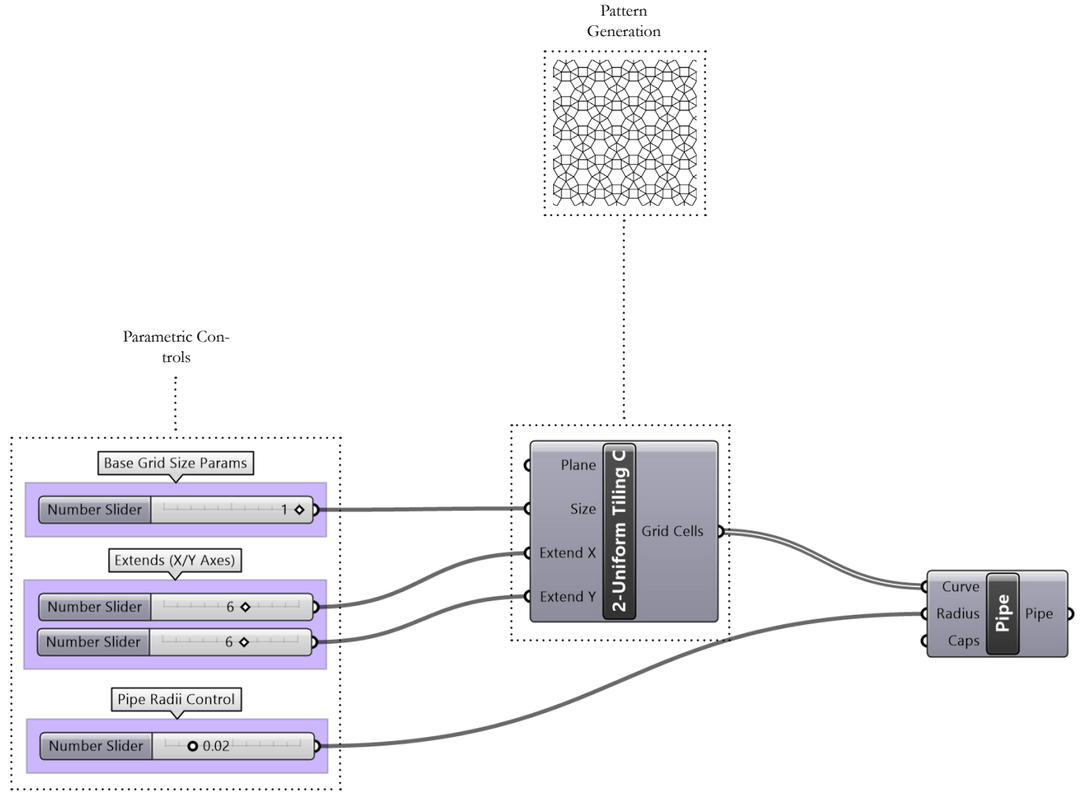
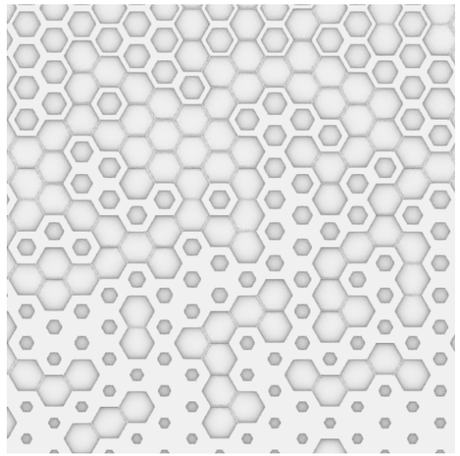
GH Script

Additional Plugins

Parakeet



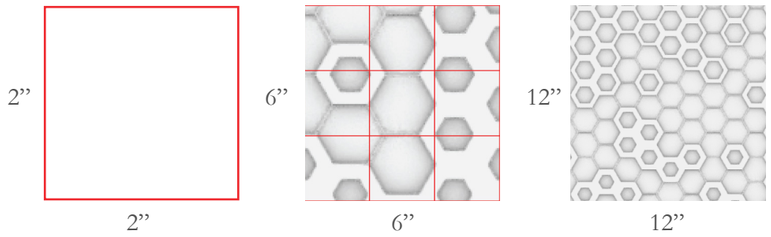
Polygon Porosity



SIZE 2x2 grid

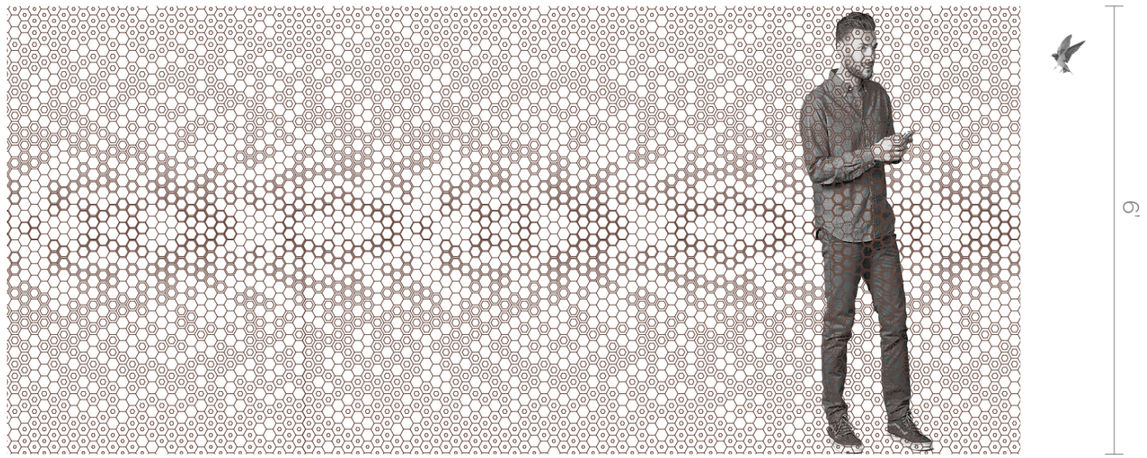
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 50 %



Visualization

Understanding Scale and Filtering.



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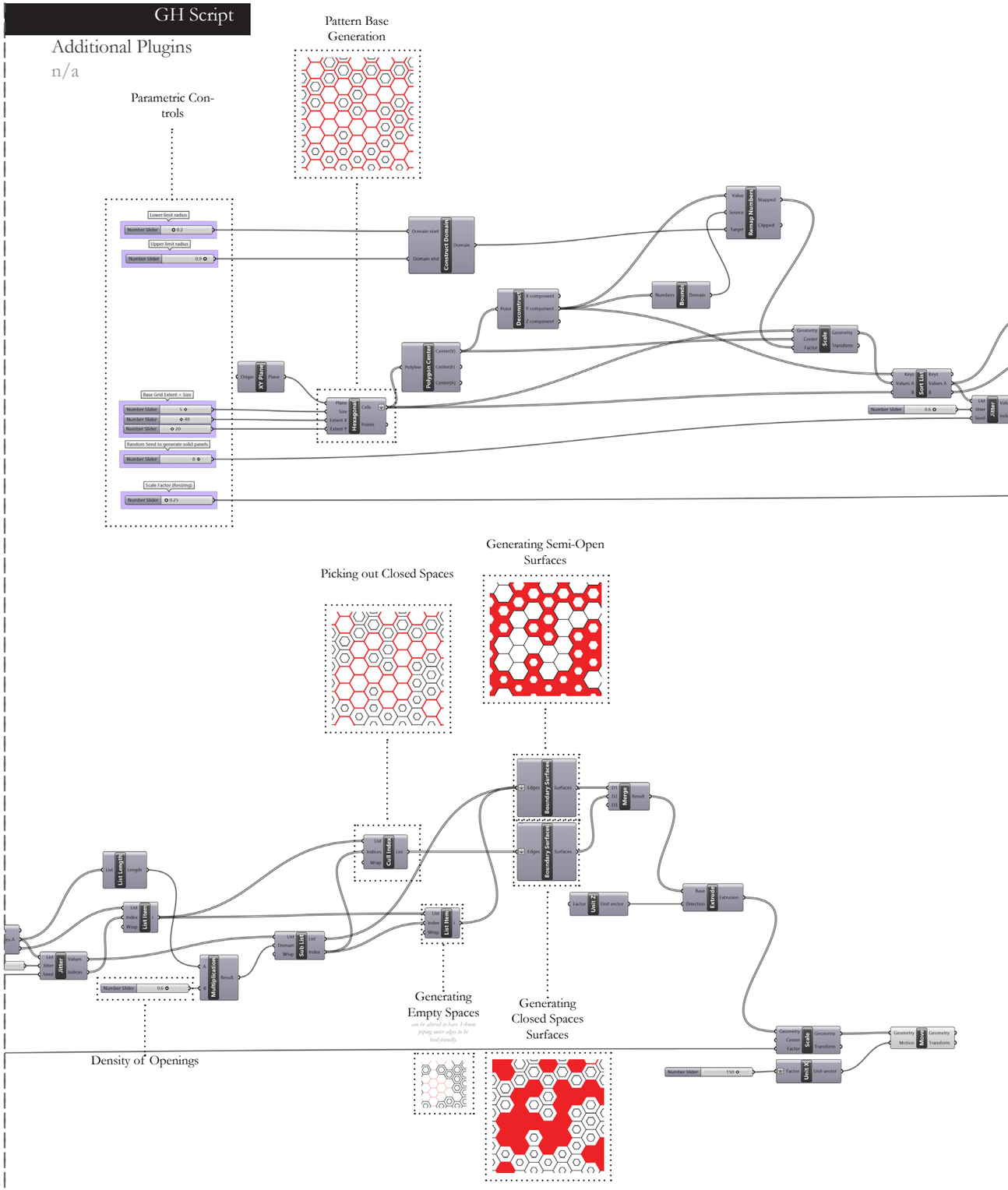
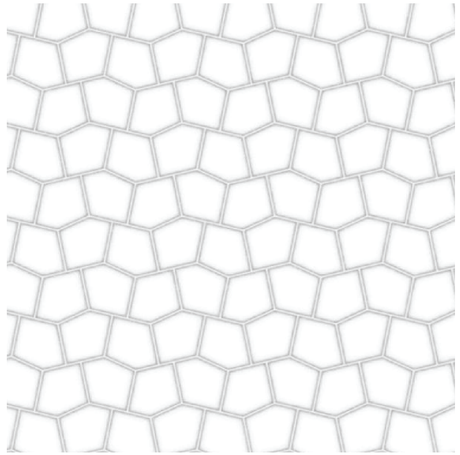
GH Script

Additional Plugins

n/a



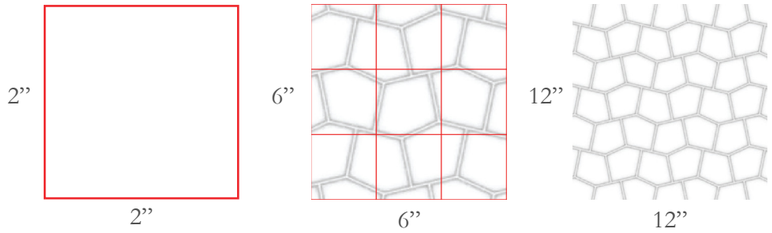
Cellular Lattice 7



SIZE 2x2 grid

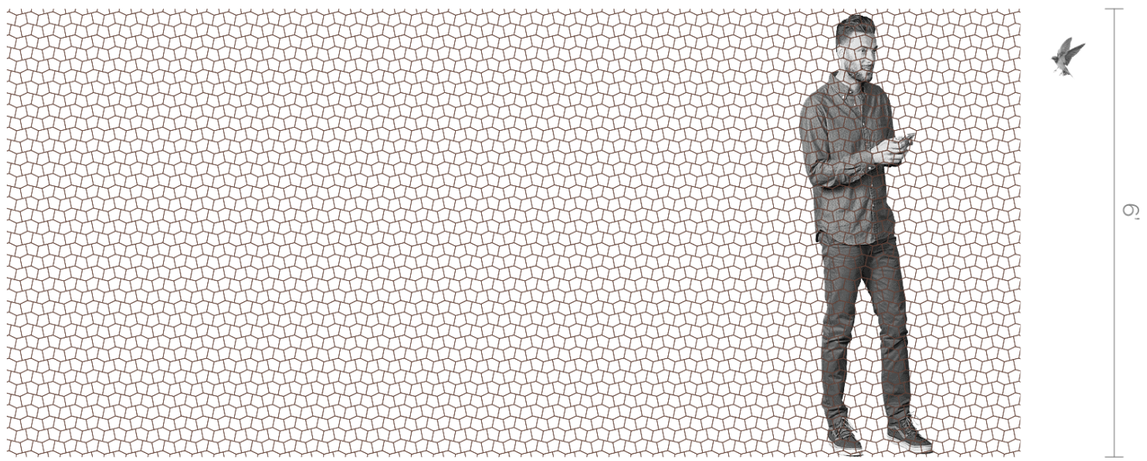
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 30 %



Visualization

Understanding Scale and Filtering.



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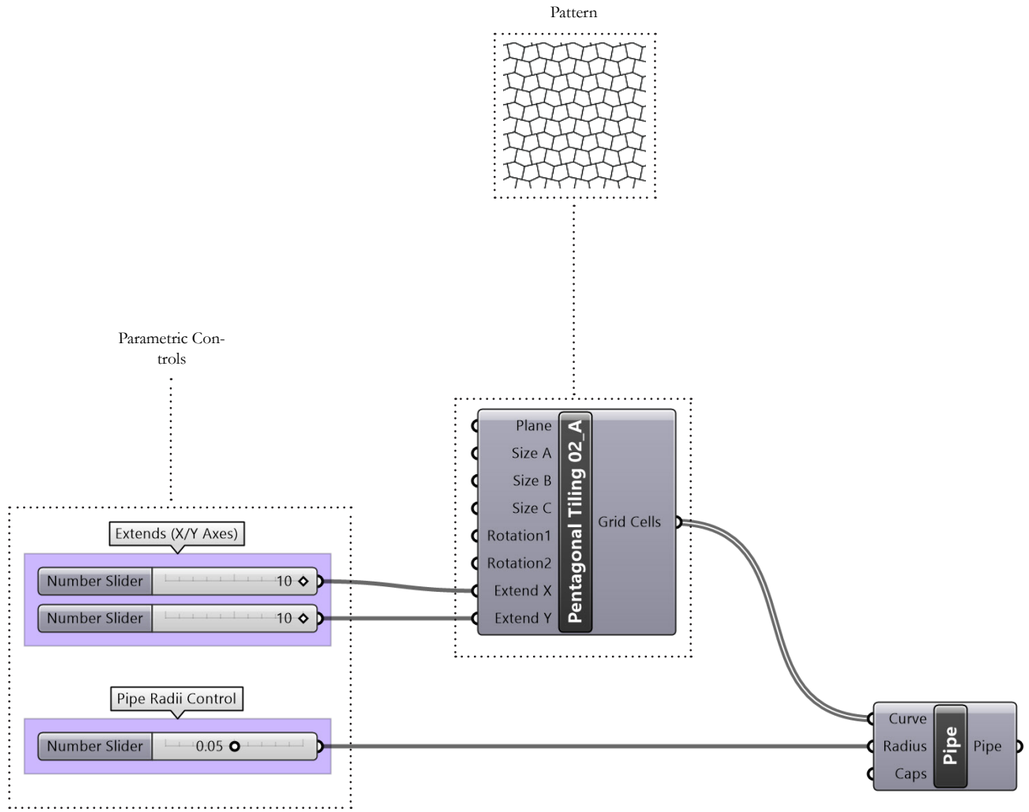
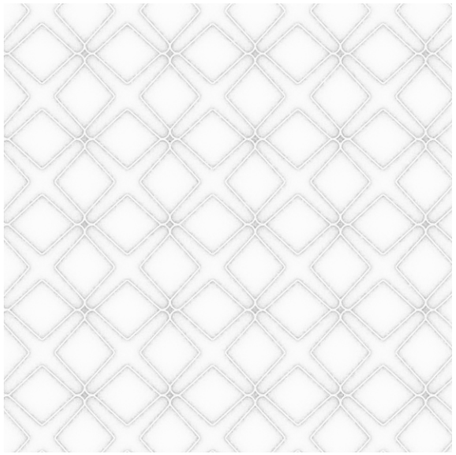
GH Script

Additional Plugins

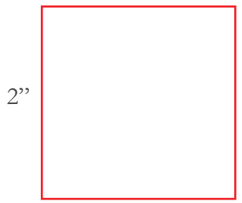
Parakeet

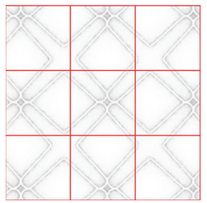


Geometric Lattice 5



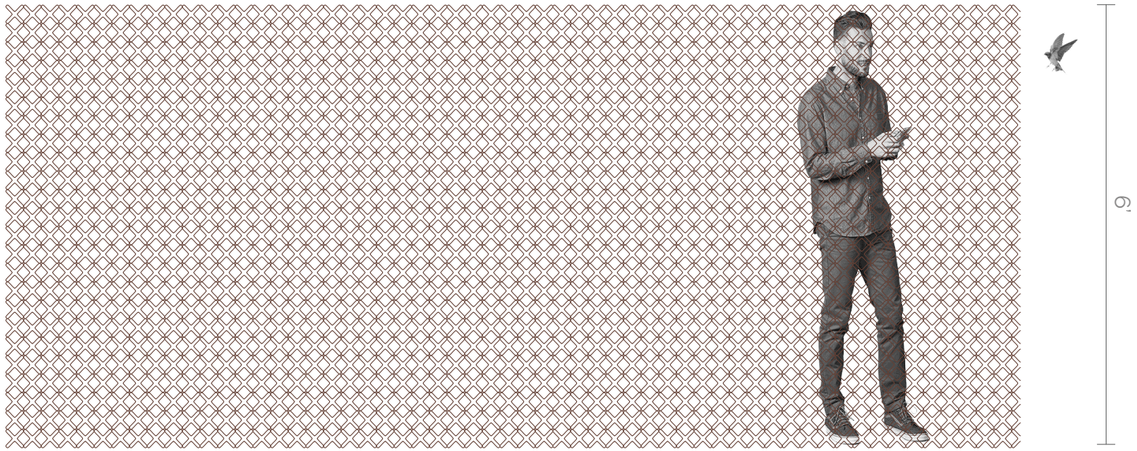
SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	32 %





Visualization

Understanding Scale and Filtering.



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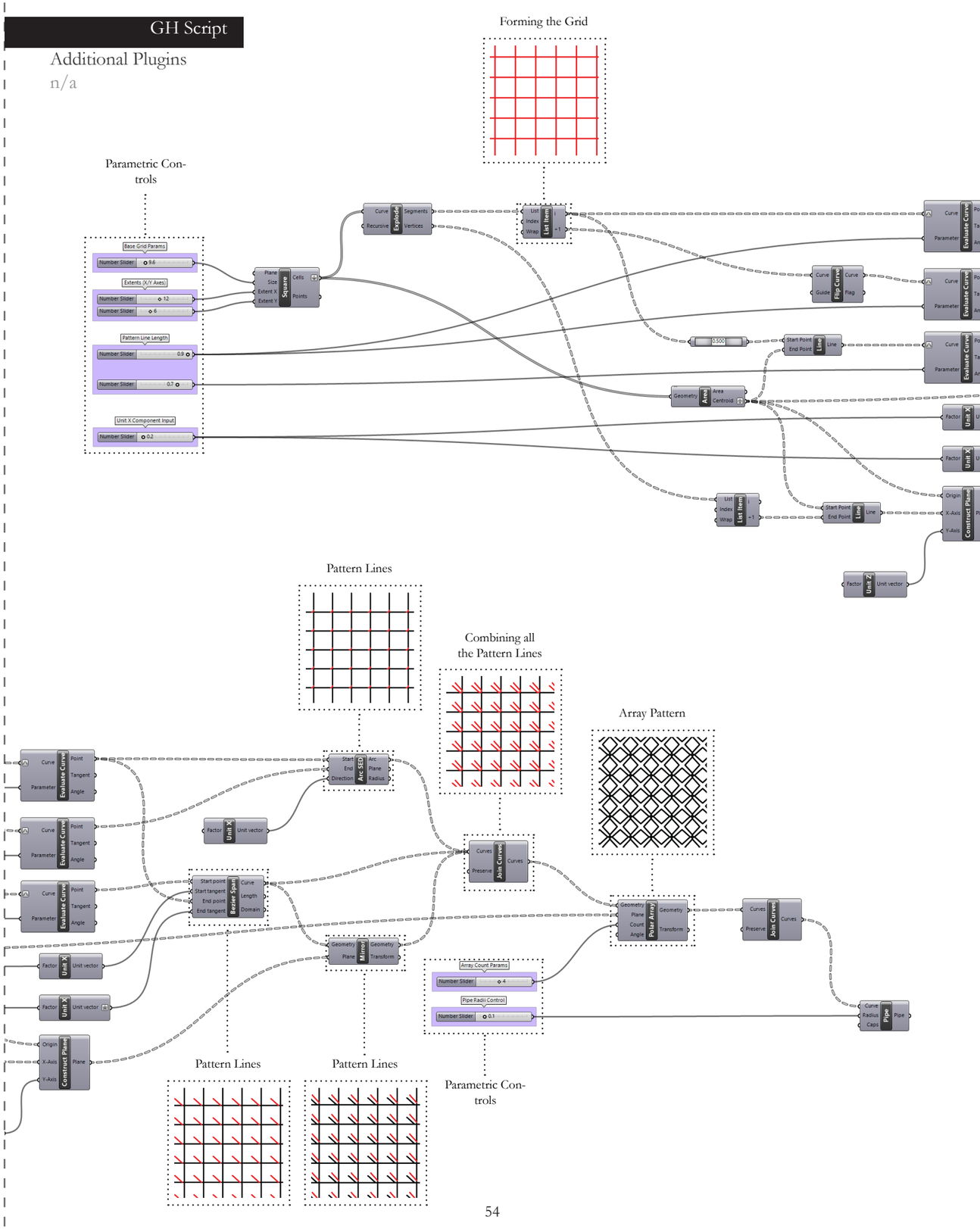
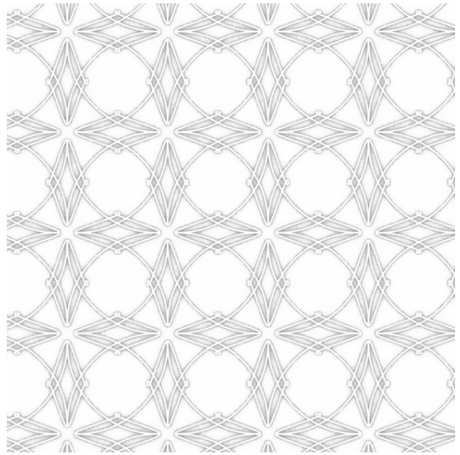
GH Script

Additional Plugins

n/a



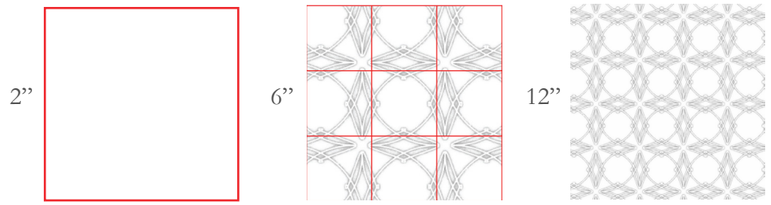
Geometric Lattice 6



SIZE 2x2 grid

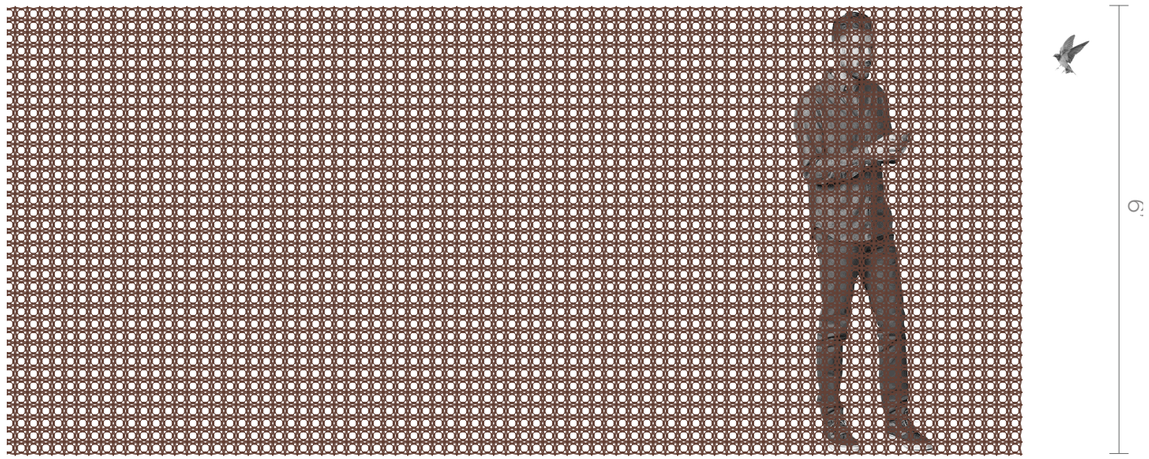
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 48 %



Visualization

Understanding Scale and Filtering.



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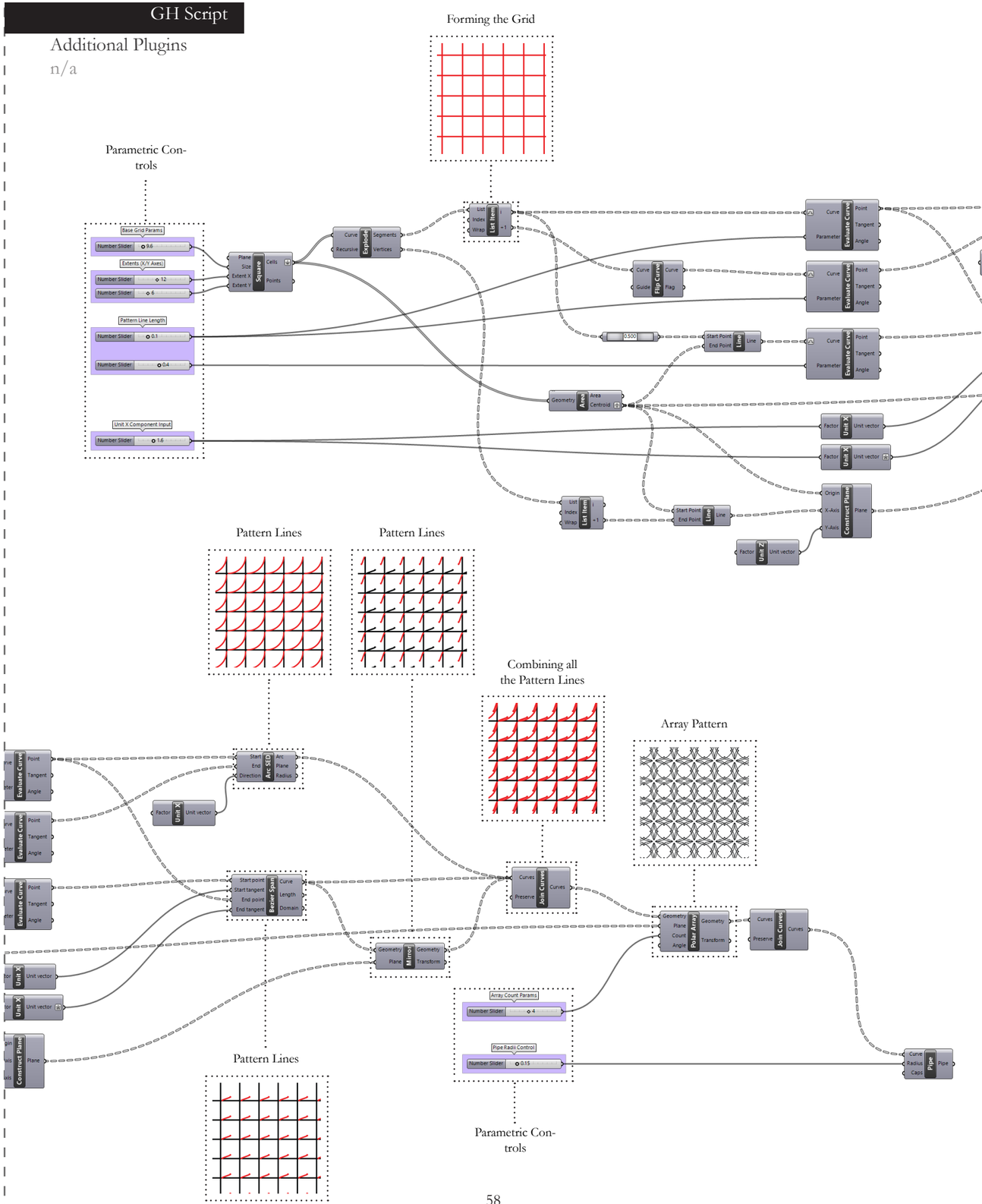
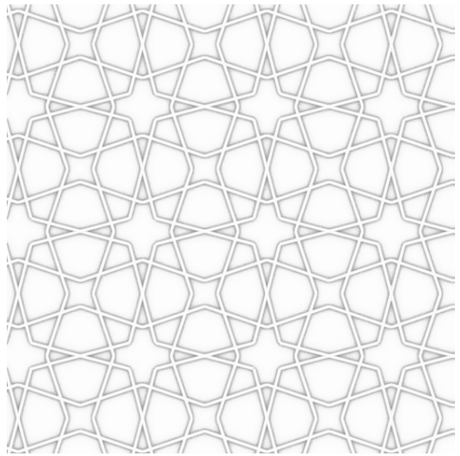
GH Script

Additional Plugins

n/a



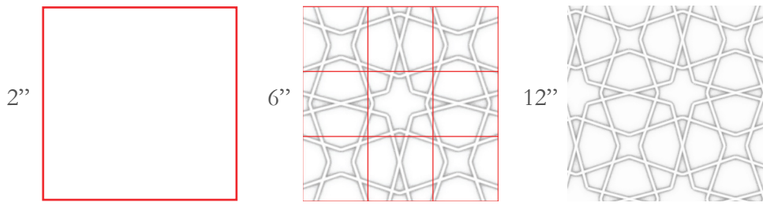
Geometric Lattice 7



SIZE 2x2 grid

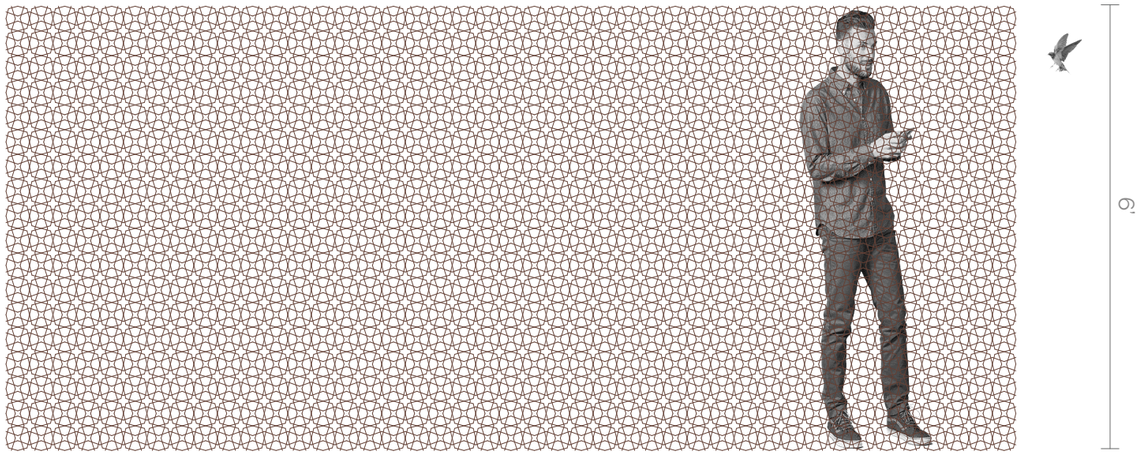
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 35%



Visualization

Understanding Scale and Filtering.



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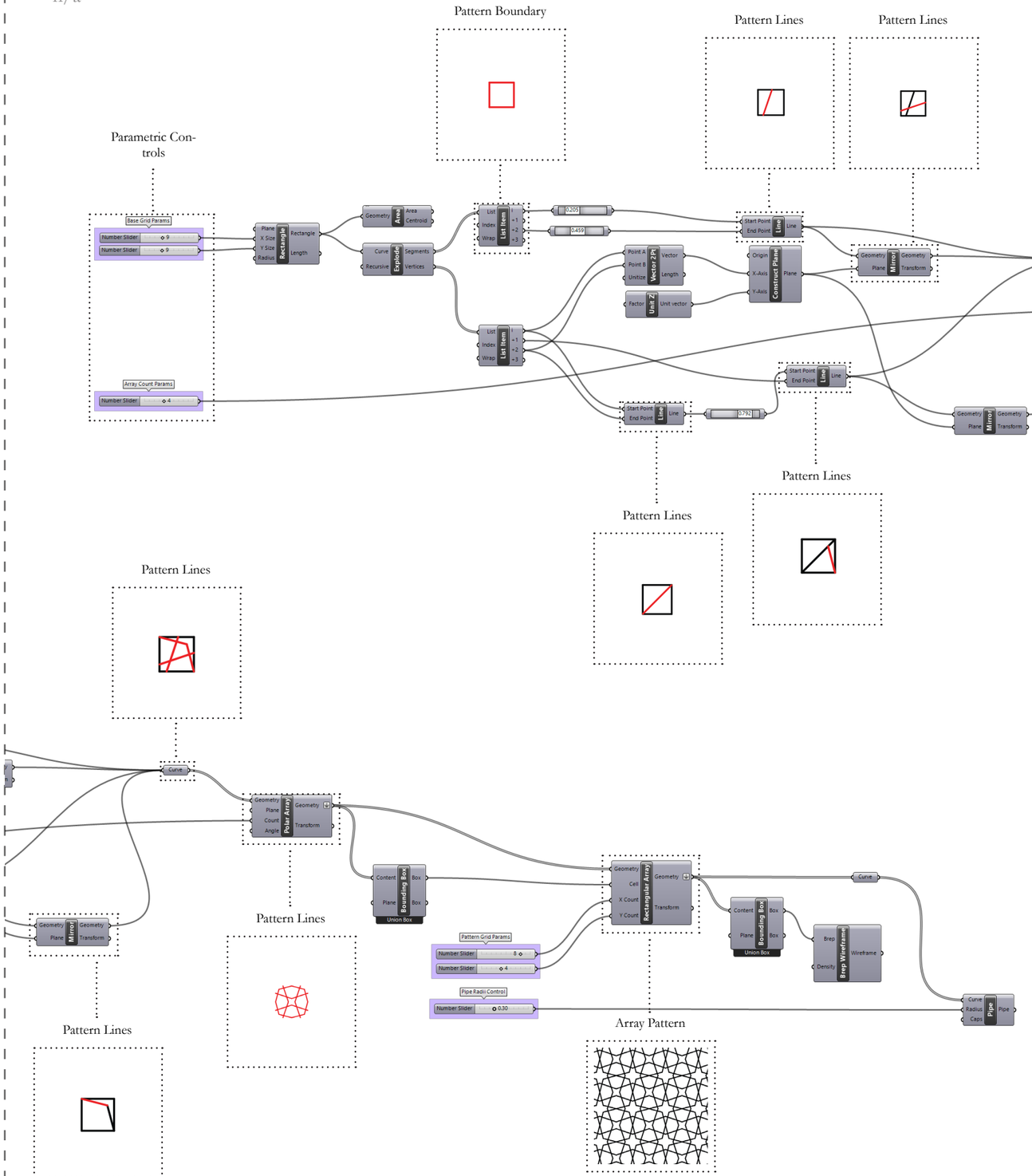
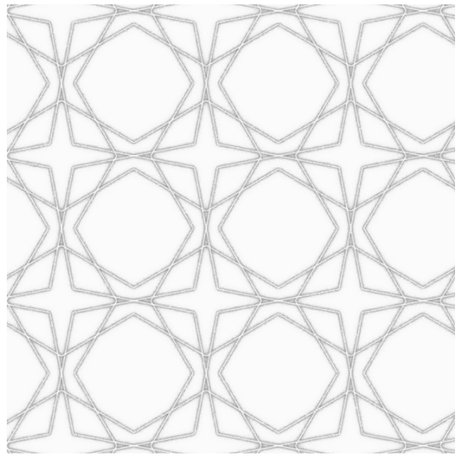
GH Script

Additional Plugins

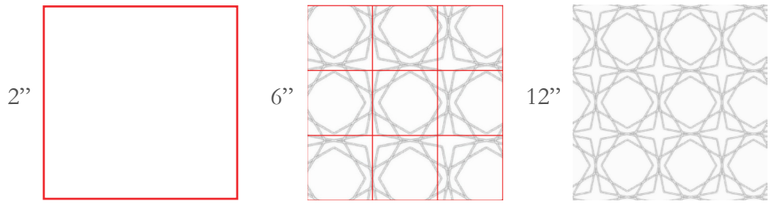
n/a



Geometric Lattice 8

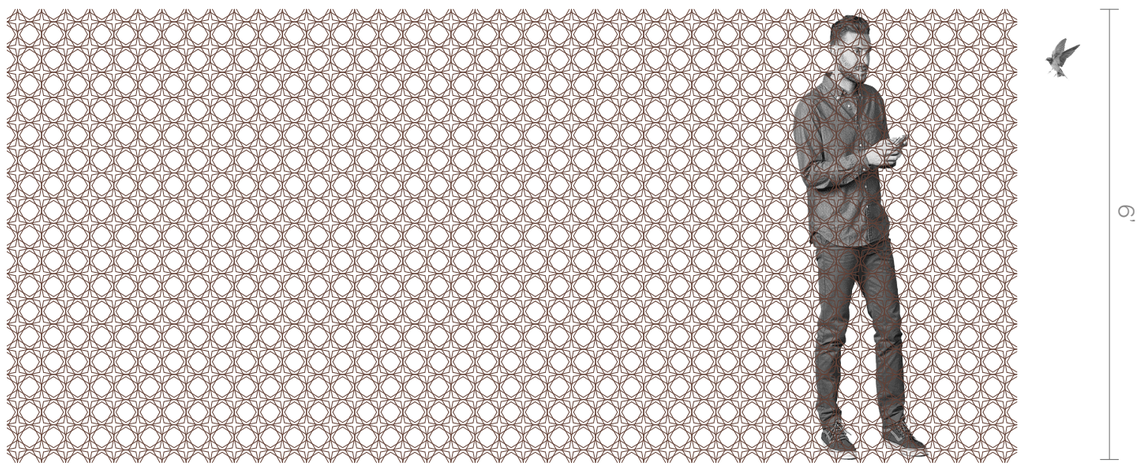


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	35 %



Visualization

Understanding Scale and Filtering.



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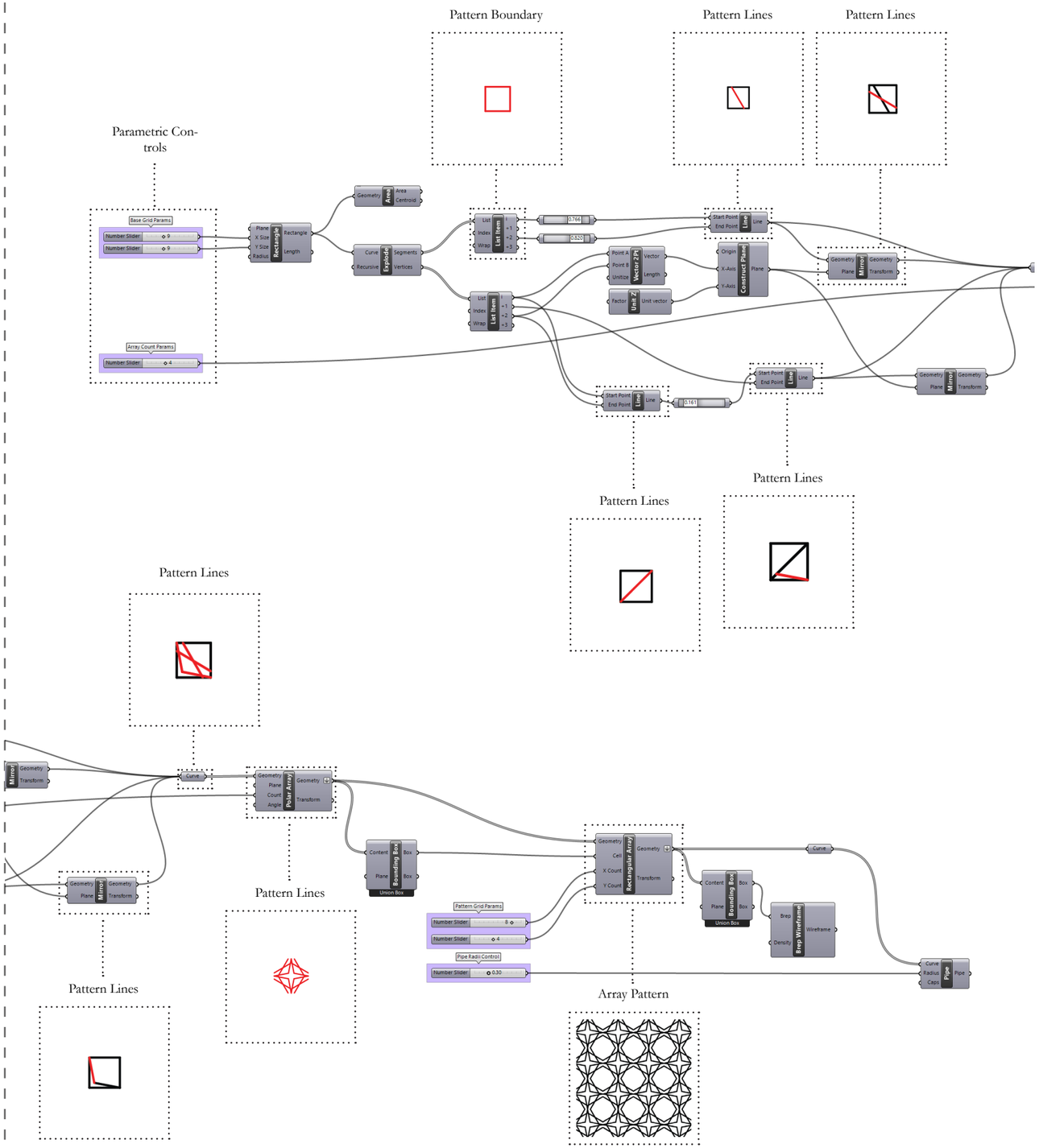
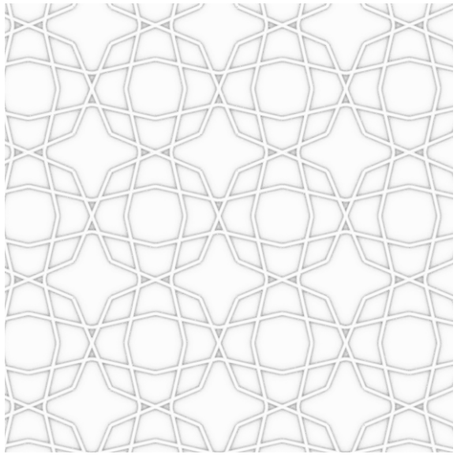
GH Script

Additional Plugins

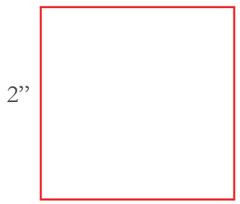
n/a

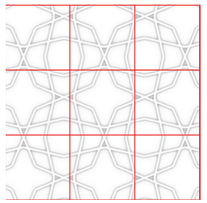


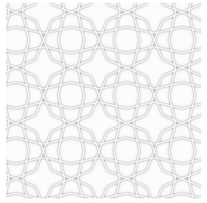
Geometric Lattice 9



SIZE	2x2 grid
THREAT FACTOR	20 *
SOLAR RADIATION REDUCTION	33 %

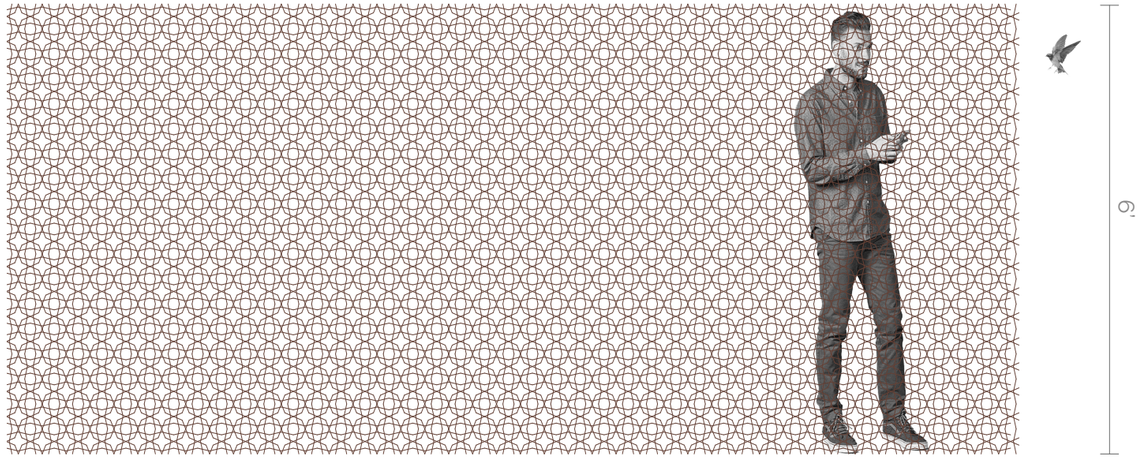






Visualization

Understanding Scale and Filtering.



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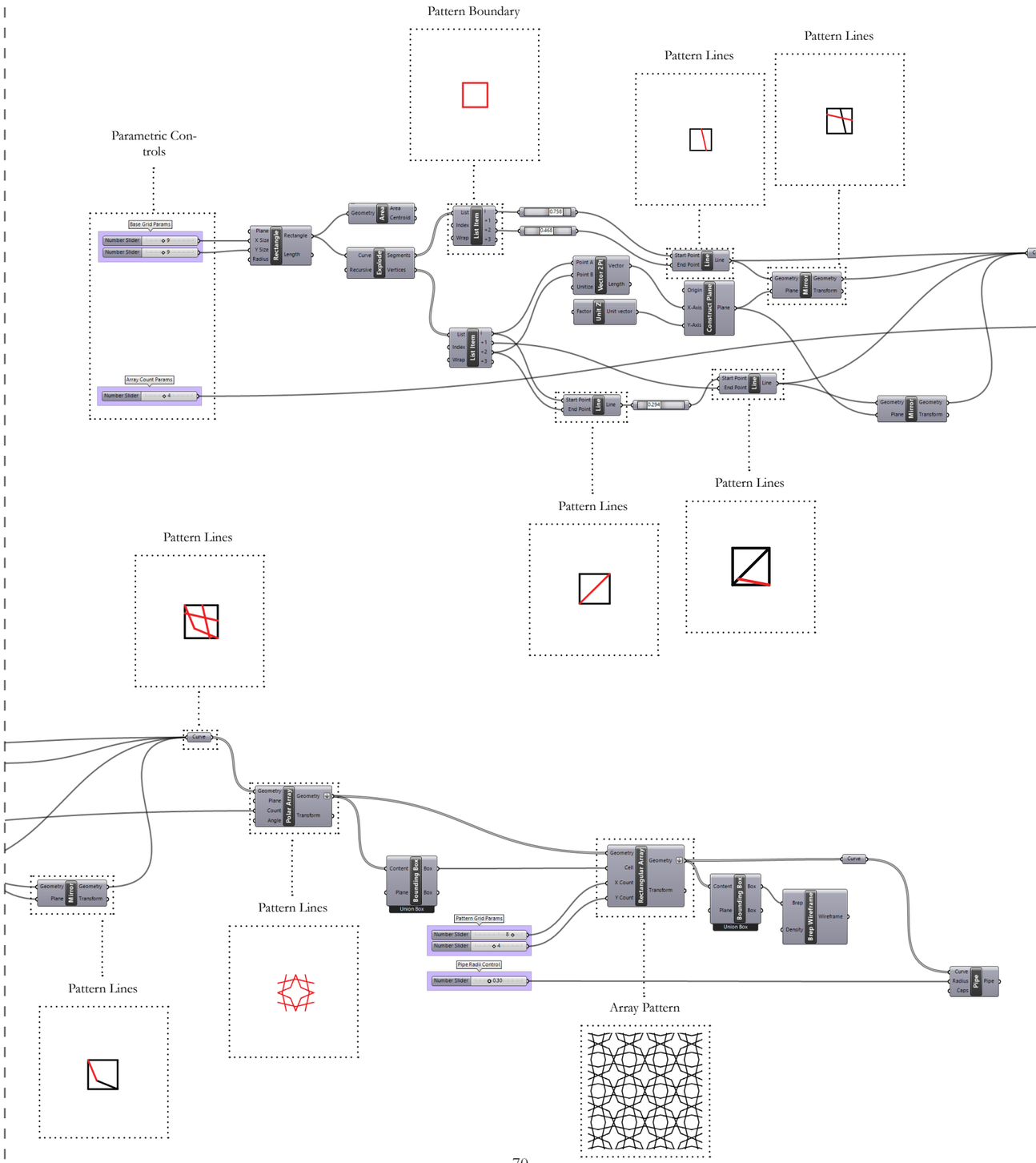
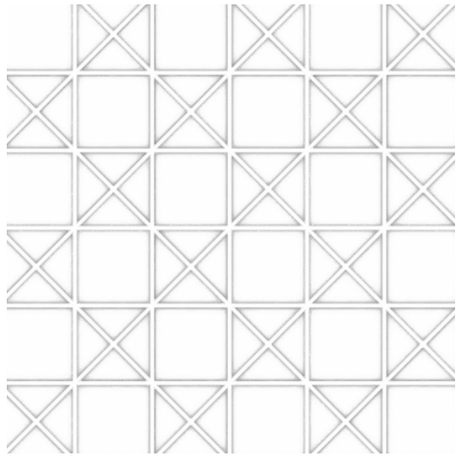
GH Script

Additional Plugins

n/a



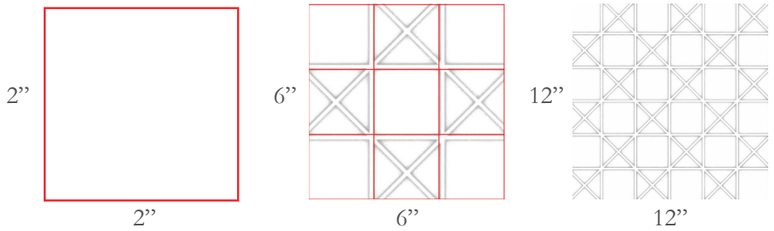
Geometric Lattice 10



SIZE 2x2 grid

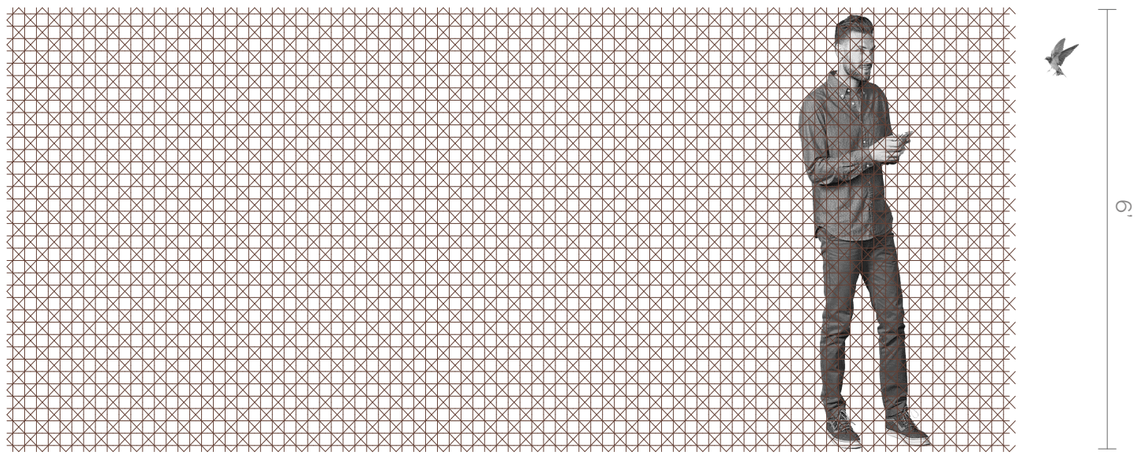
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 32 %



Visualization

Understanding Scale and Filtering.



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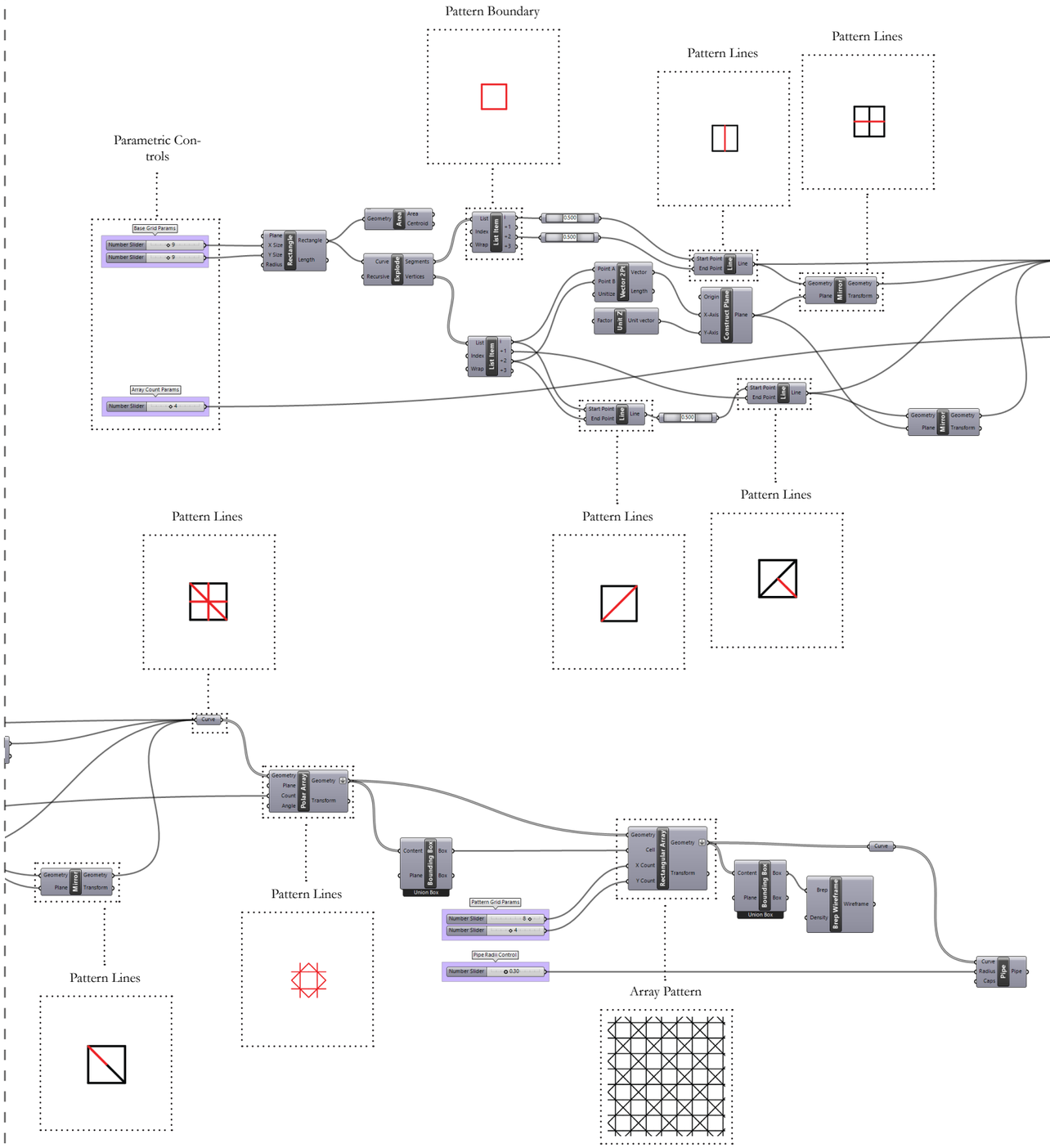
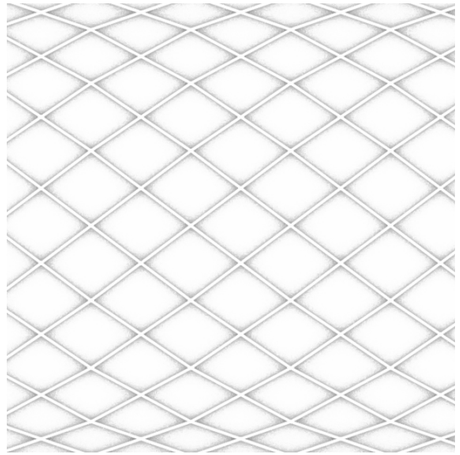
GH Script

Additional Plugins

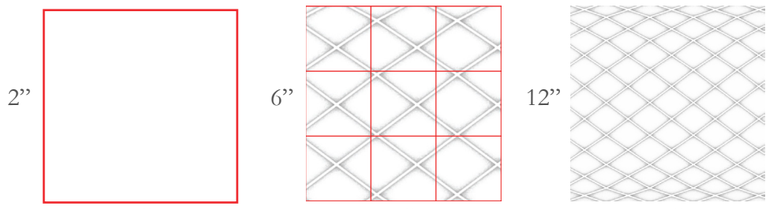
n/a



Curved Horizontal Lattice

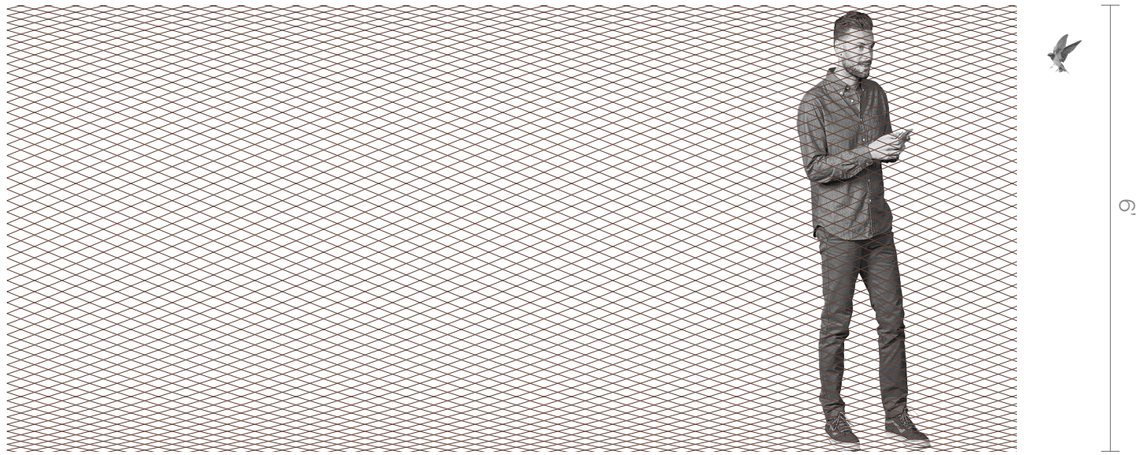


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	12 %



Visualization

Understanding Scale and Filtering.



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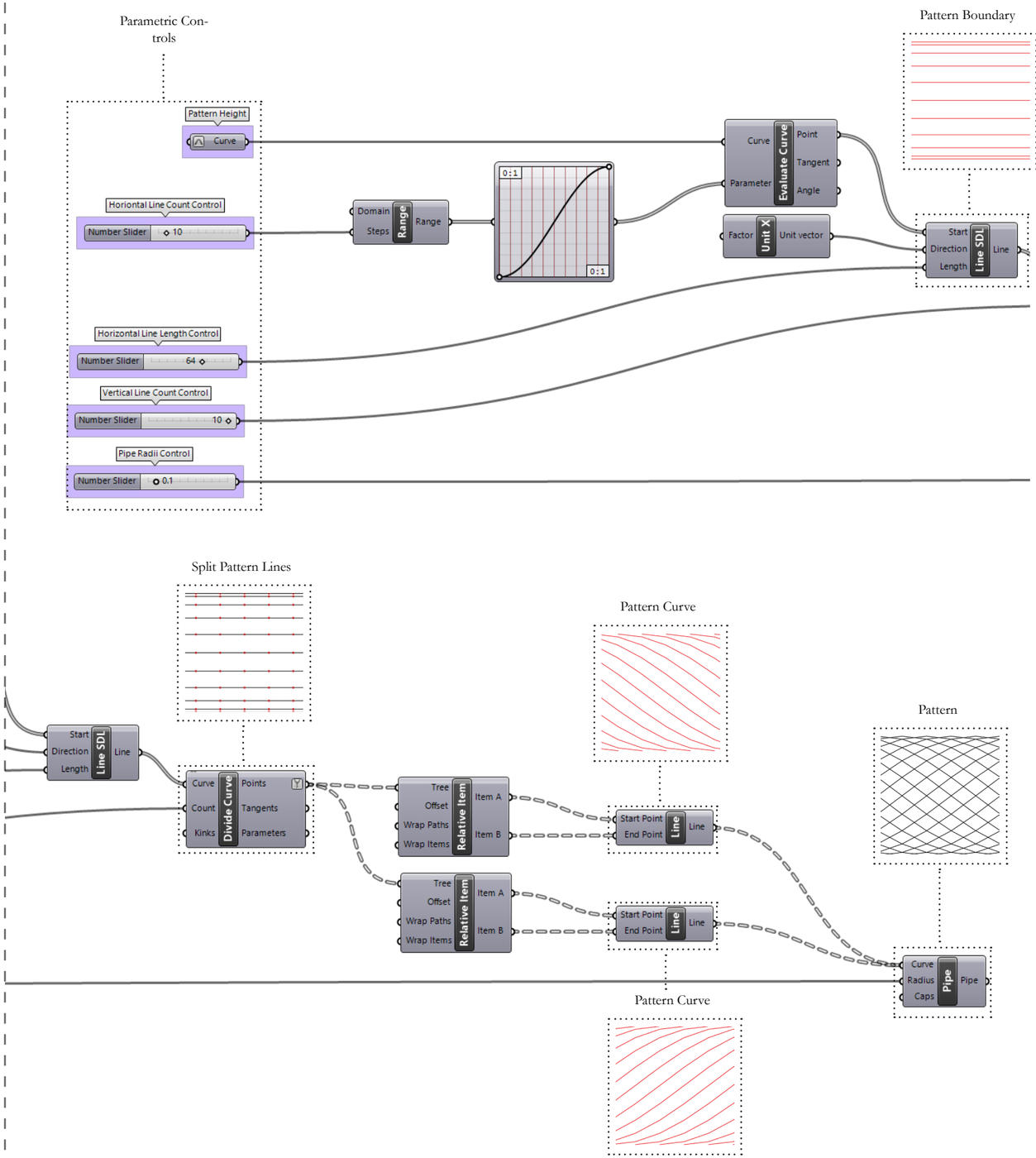
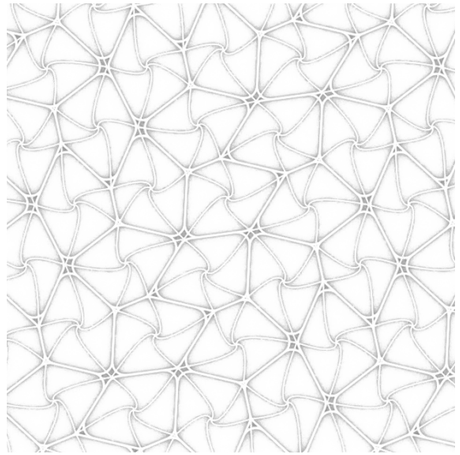
GH Script

Additional Plugins

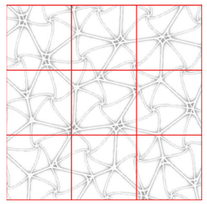
n/a

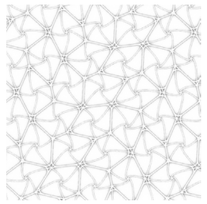


Cellular Lattice 9



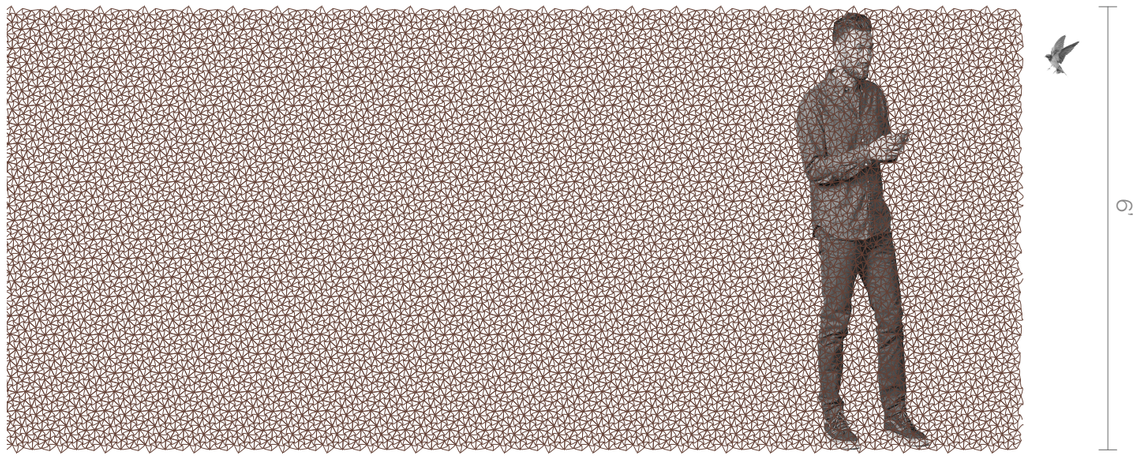
SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	8 %





Visualization

Understanding Scale and Filtering.

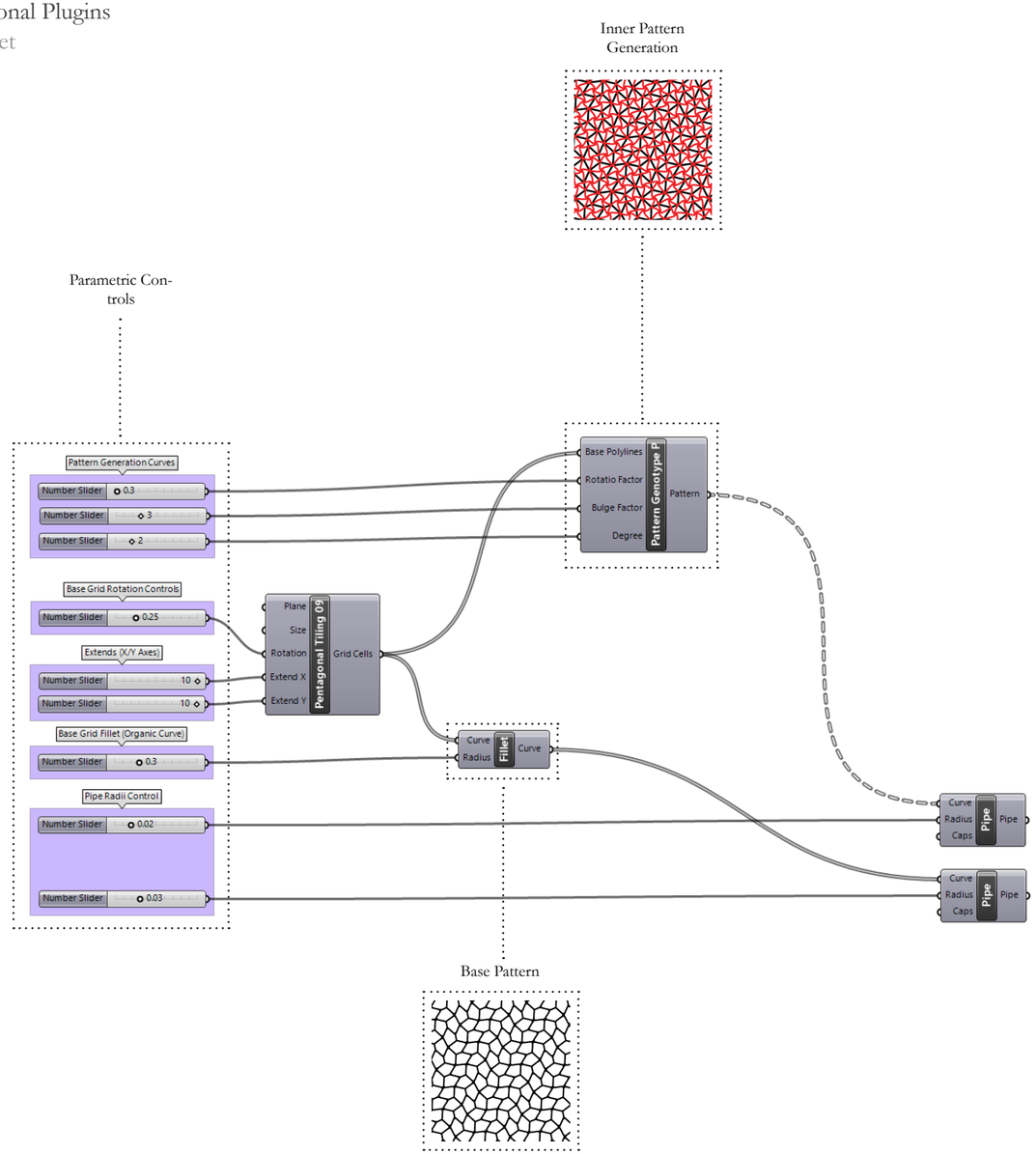


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

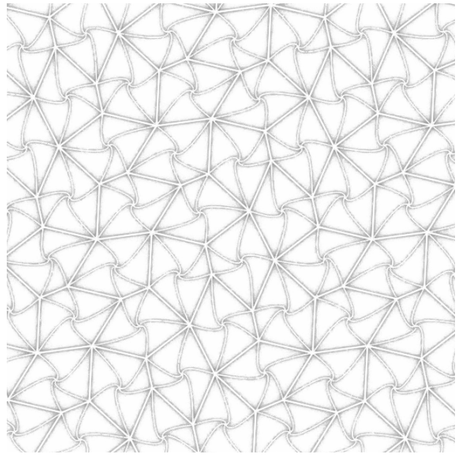
GH Script

Additional Plugins

Parakeet



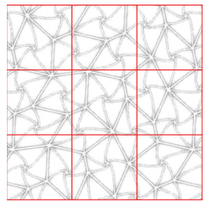
Cellular Lattice 10

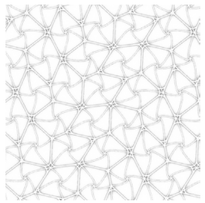


SIZE 2x2 grid

THREAT FACTOR 20*

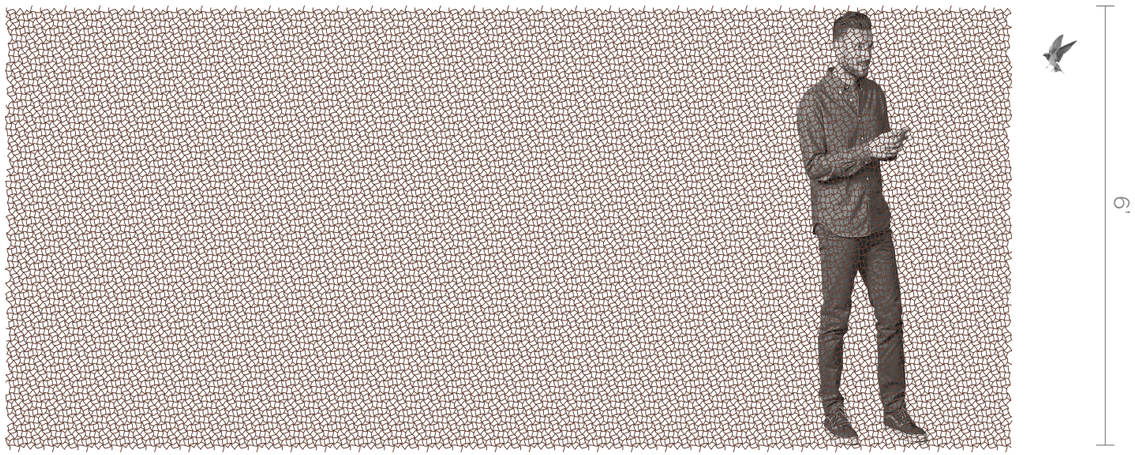
SOLAR RADIATION REDUCTION 13 %





Visualization

Understanding Scale and Filtering.

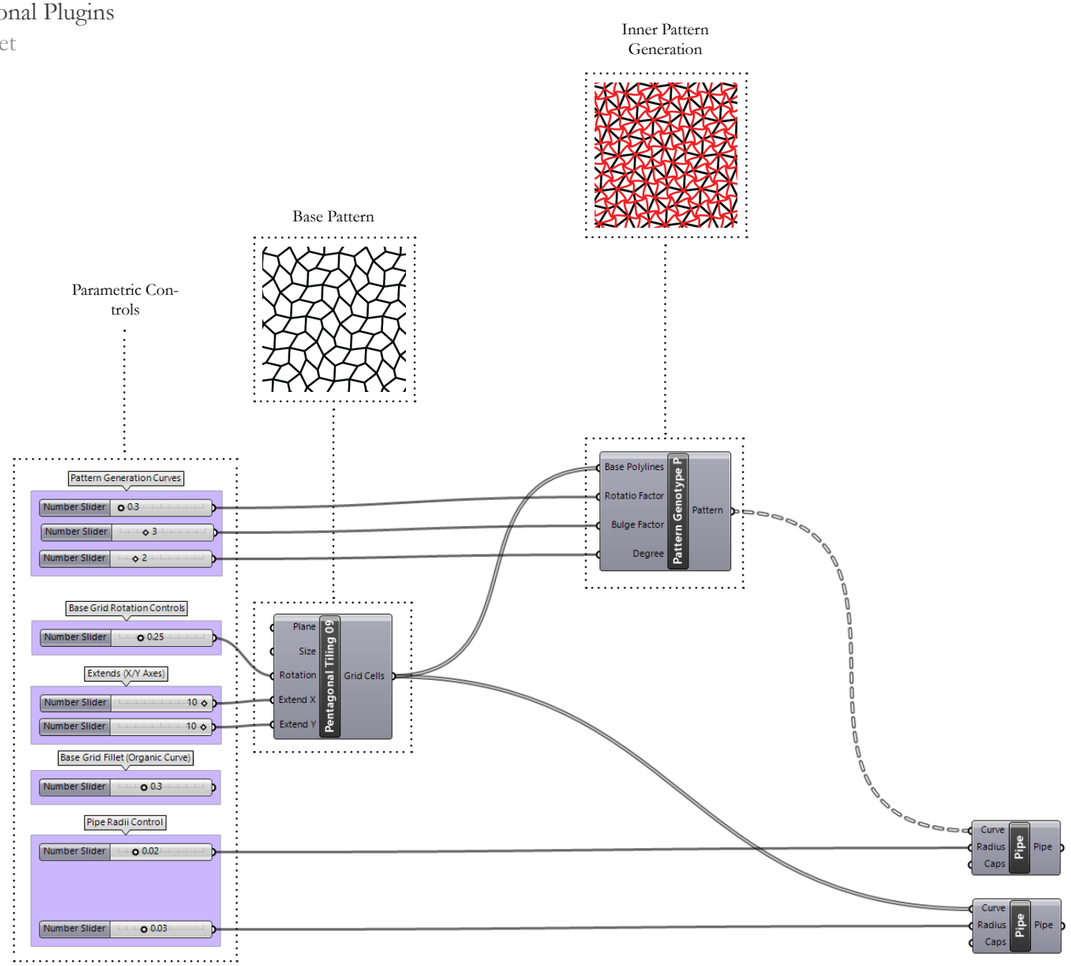


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

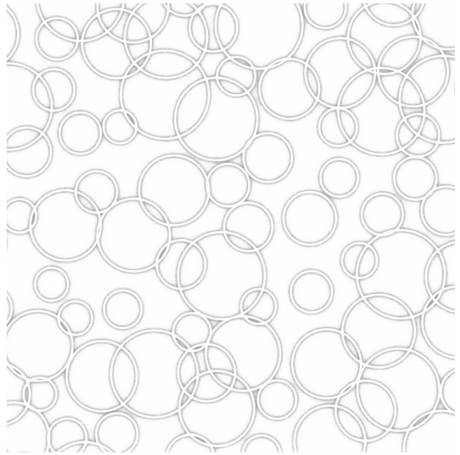
GH Script

Additional Plugins

Parakeet



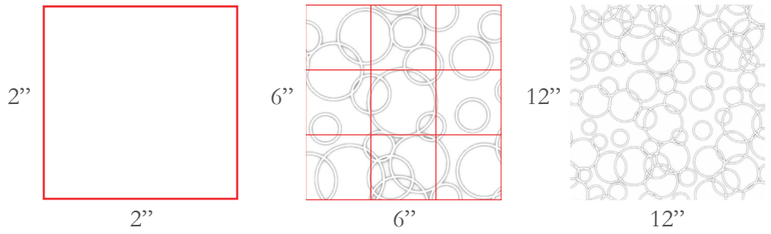
Circular Apertures



SIZE 2x2 grid

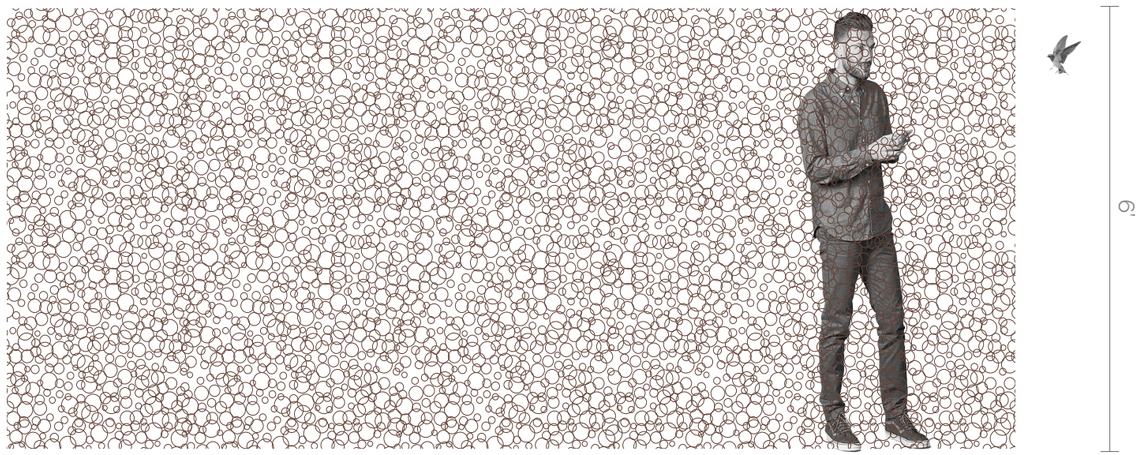
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 26 %



Visualization

Understanding Scale and Filtering.

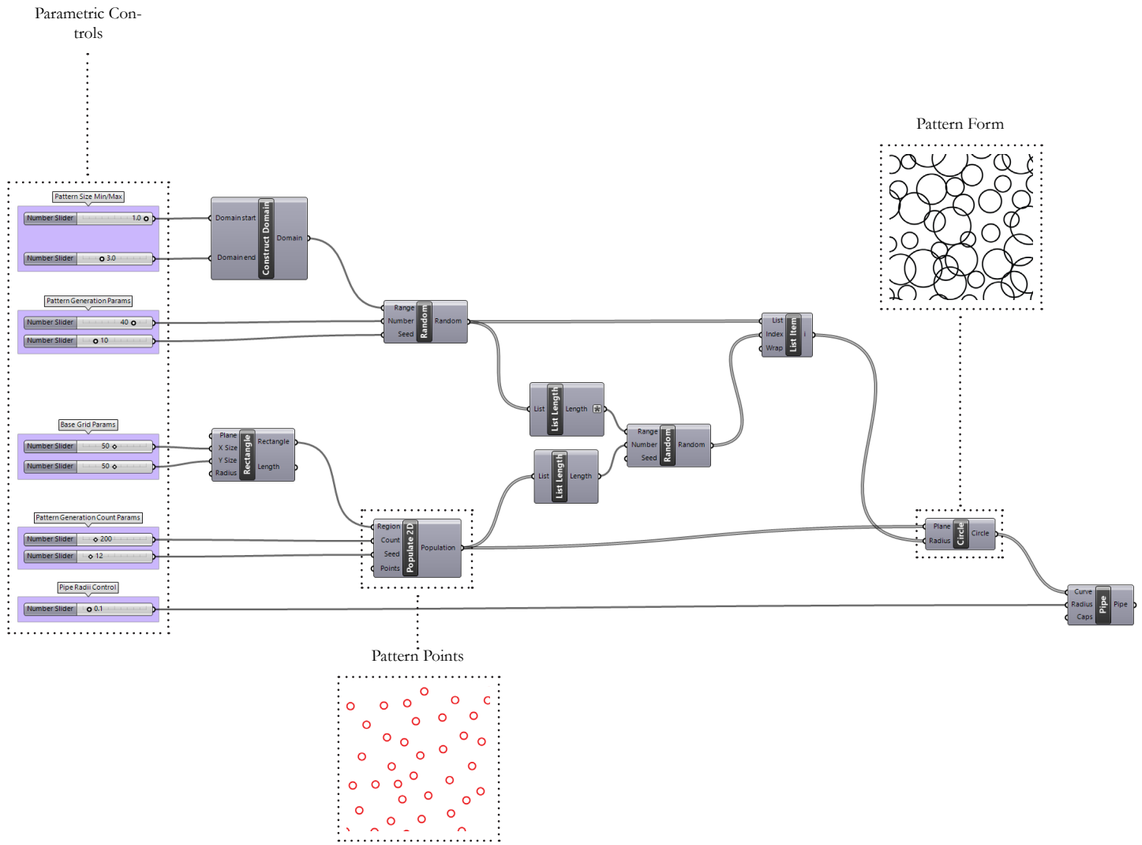


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

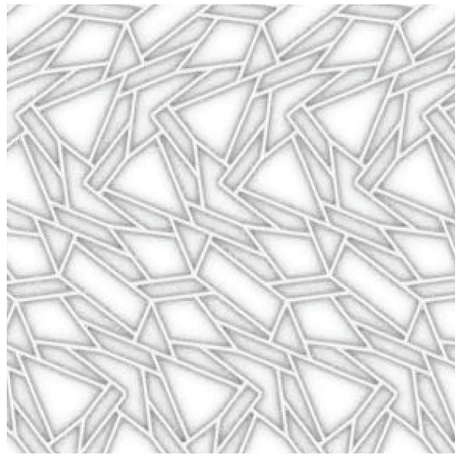
GH Script

Additional Plugins

n/a



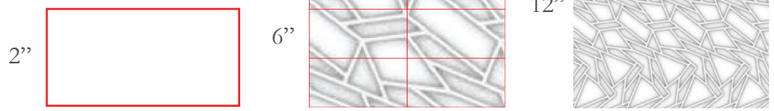
Ice-Ray Cellular Lattice



SIZE 2x4 grid

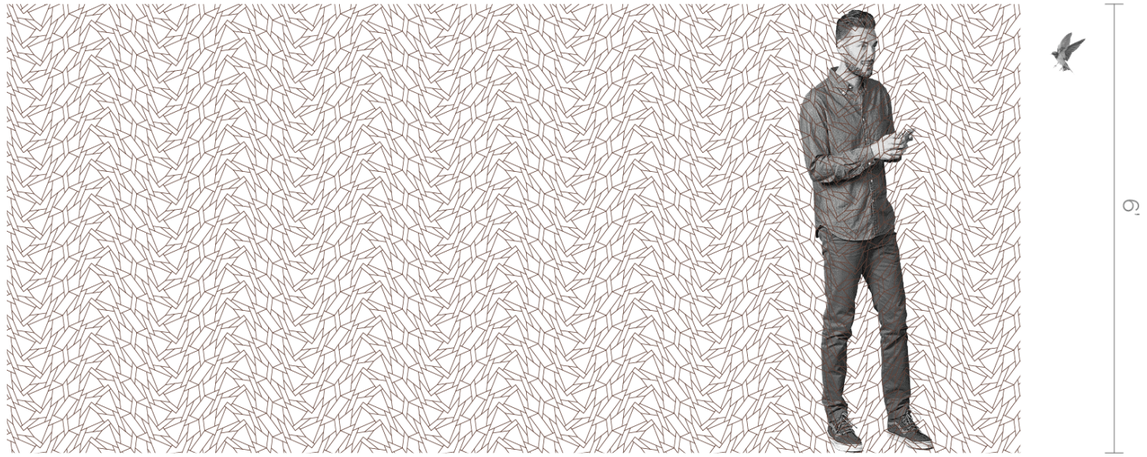
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 5%



Visualization

Understanding Scale and Filtering.

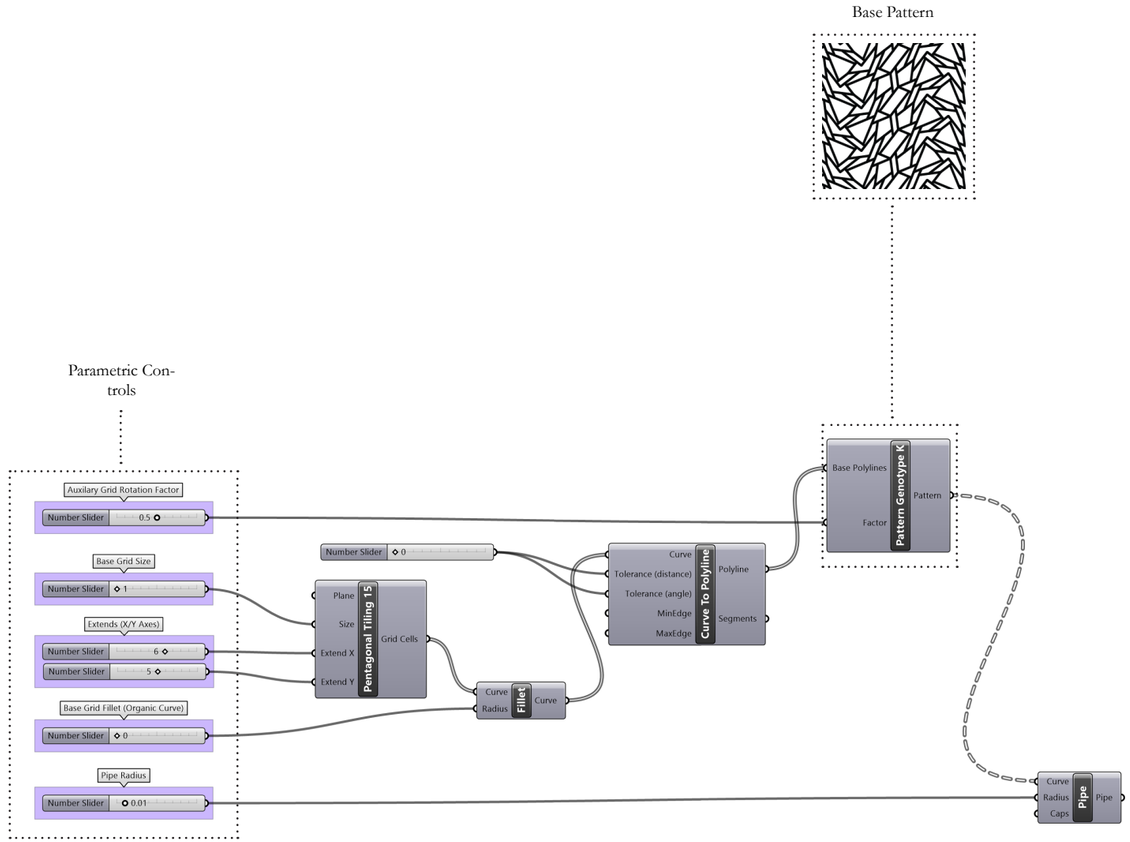


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

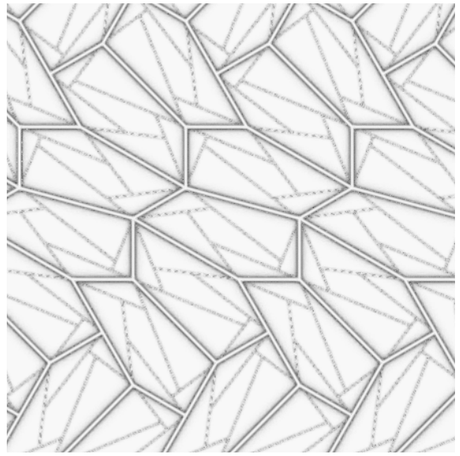
GH Script

Additional Plugins

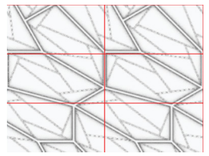
Parakeet



Angled Apertures

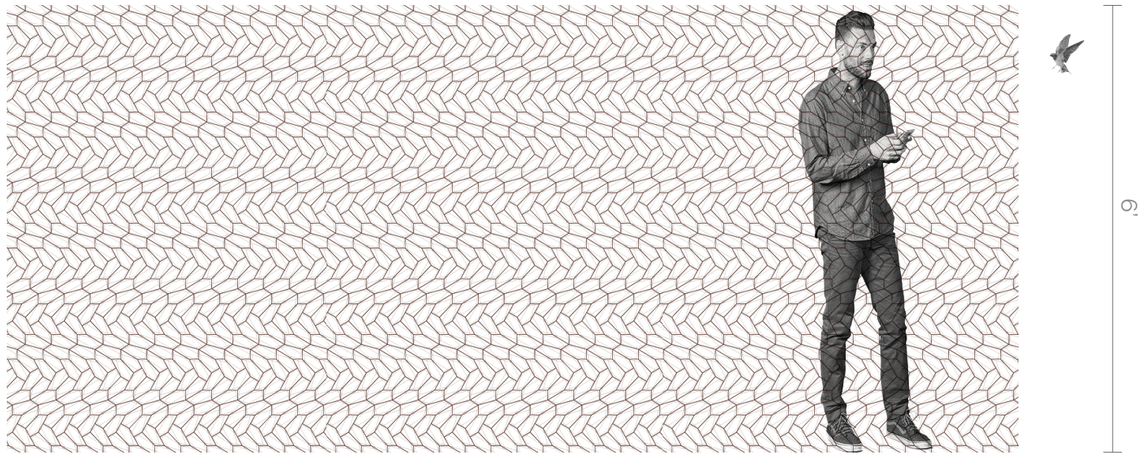


SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	11 %



Visualization

Understanding Scale and Filtering.

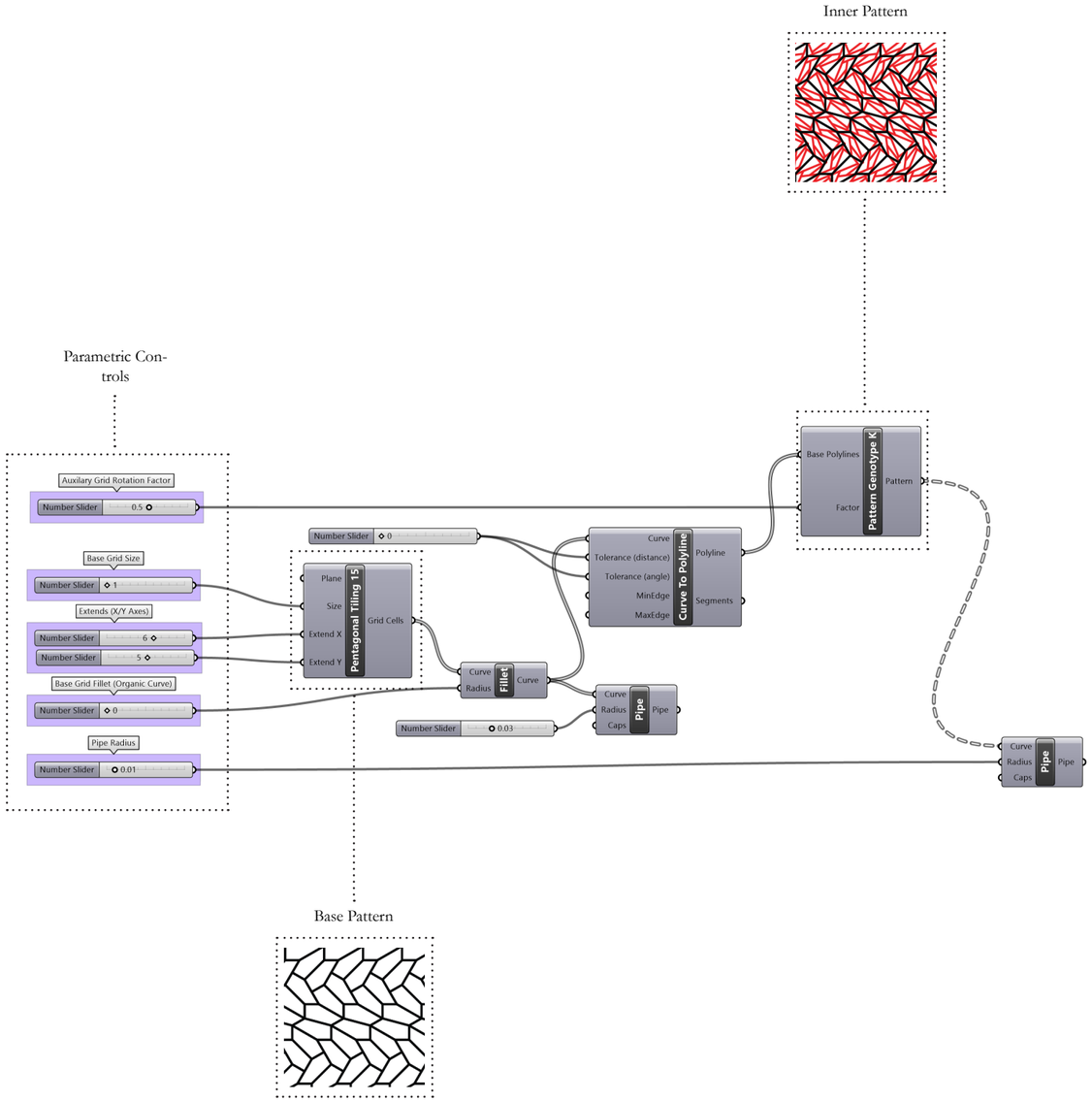


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

GH Script

Additional Plugins

Parakeet

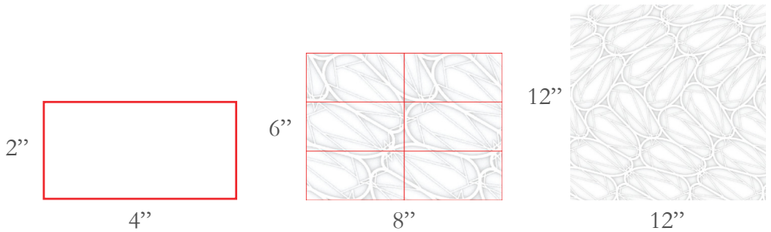


Oval Apertures

SIZE — 2x4 grid

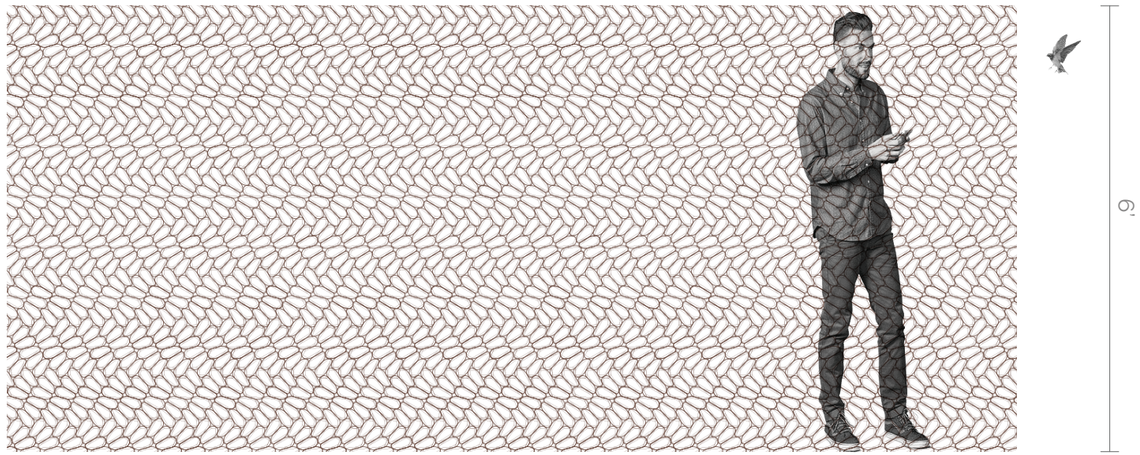
THREAT FACTOR — 25*

SOLAR RADIATION REDUCTION — 12.5 %



Visualization

Understanding Scale and Filtering.

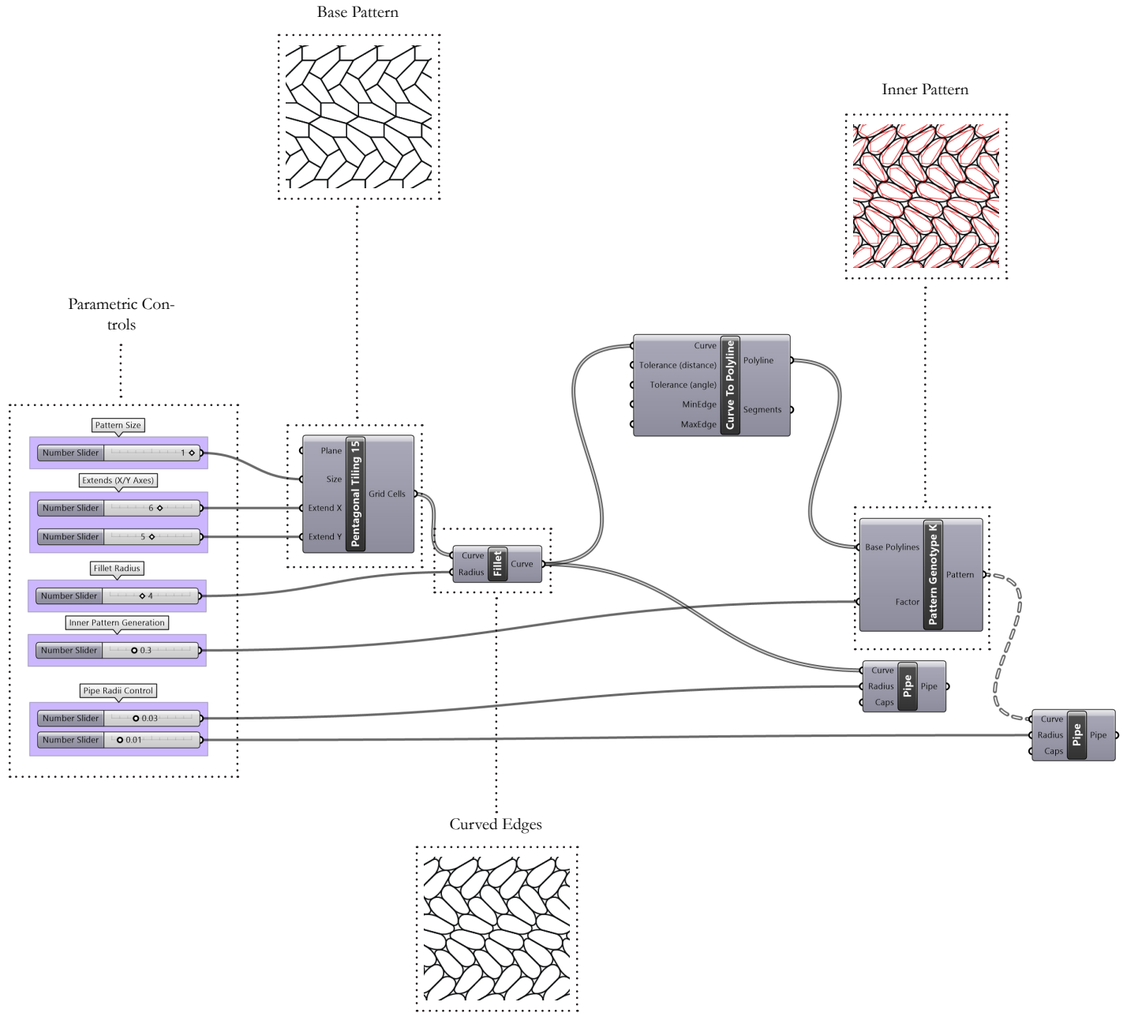


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

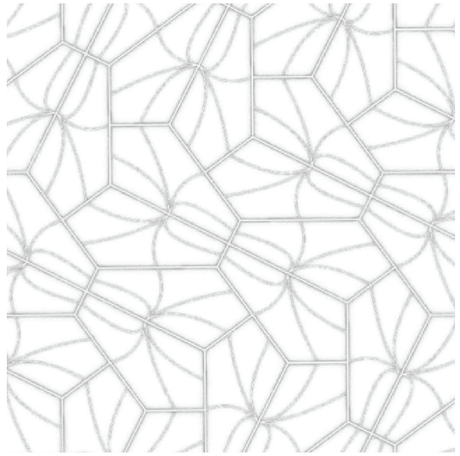
GH Script

Additional Plugins

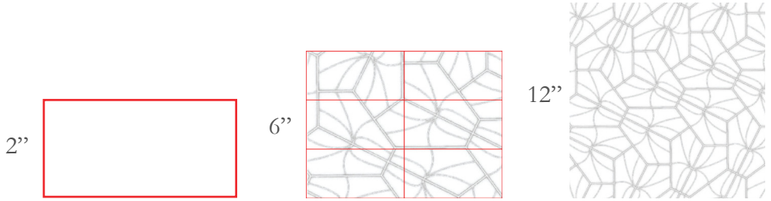
Parakeet



Cellular Lattice 4

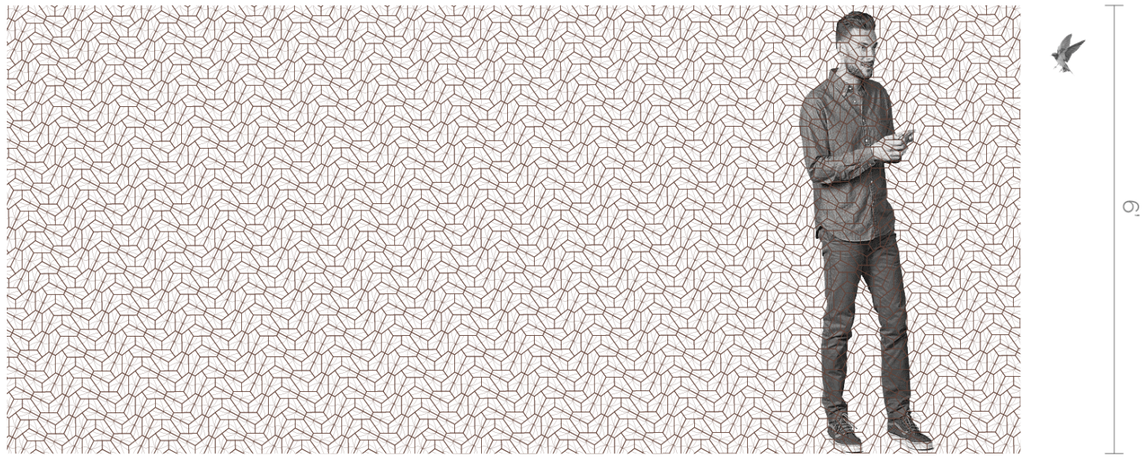


SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	6 %



Visualization

Understanding Scale and Filtering.

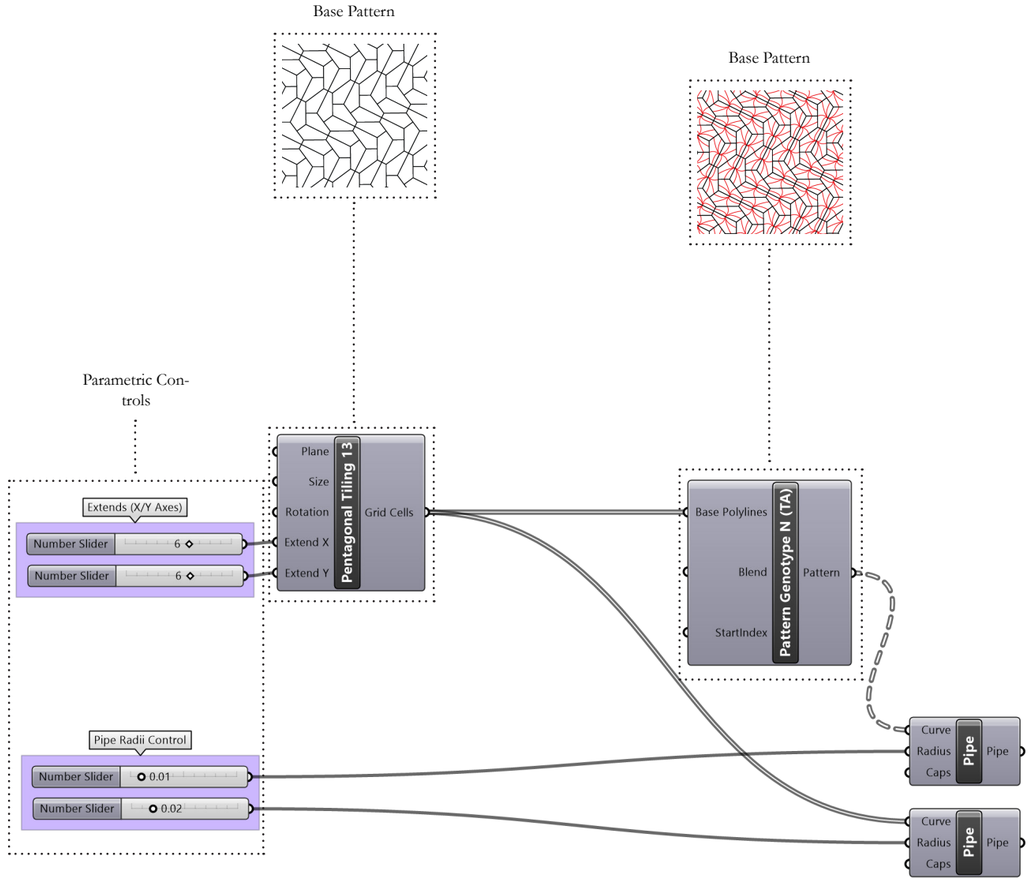


*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

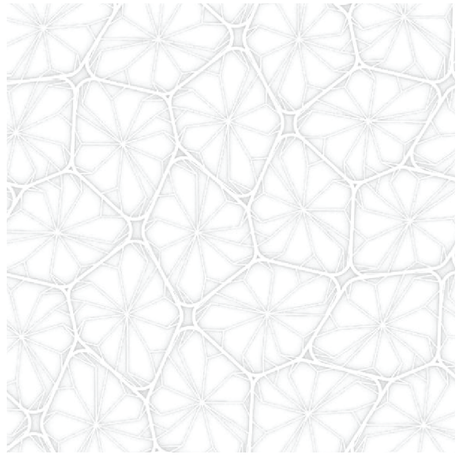
GH Script

Additional Plugins

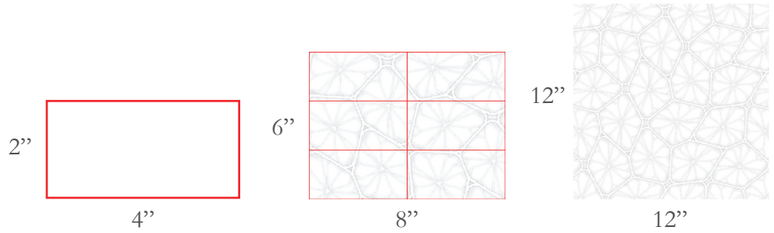
Parakeet



Cellular Lattice 5

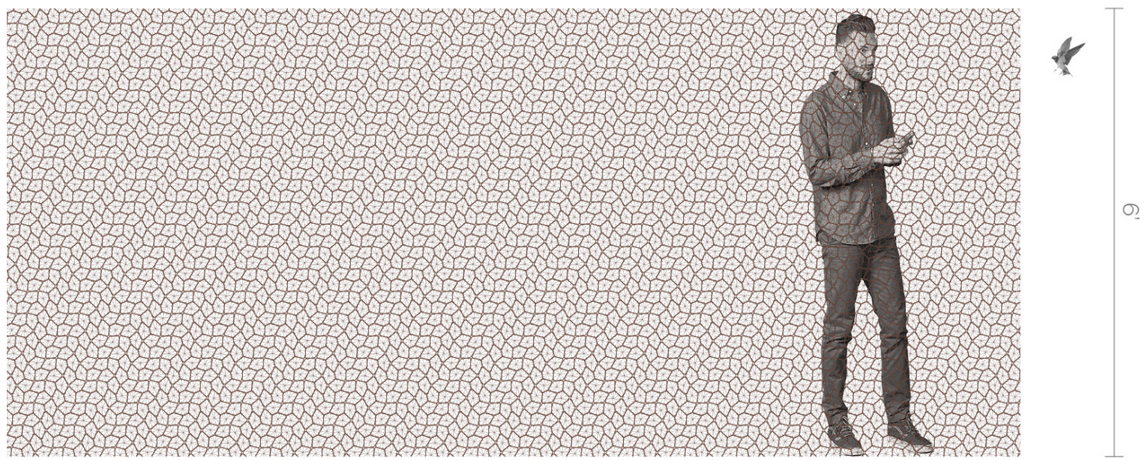


SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	18 %



Visualization

Understanding Scale and Filtering.



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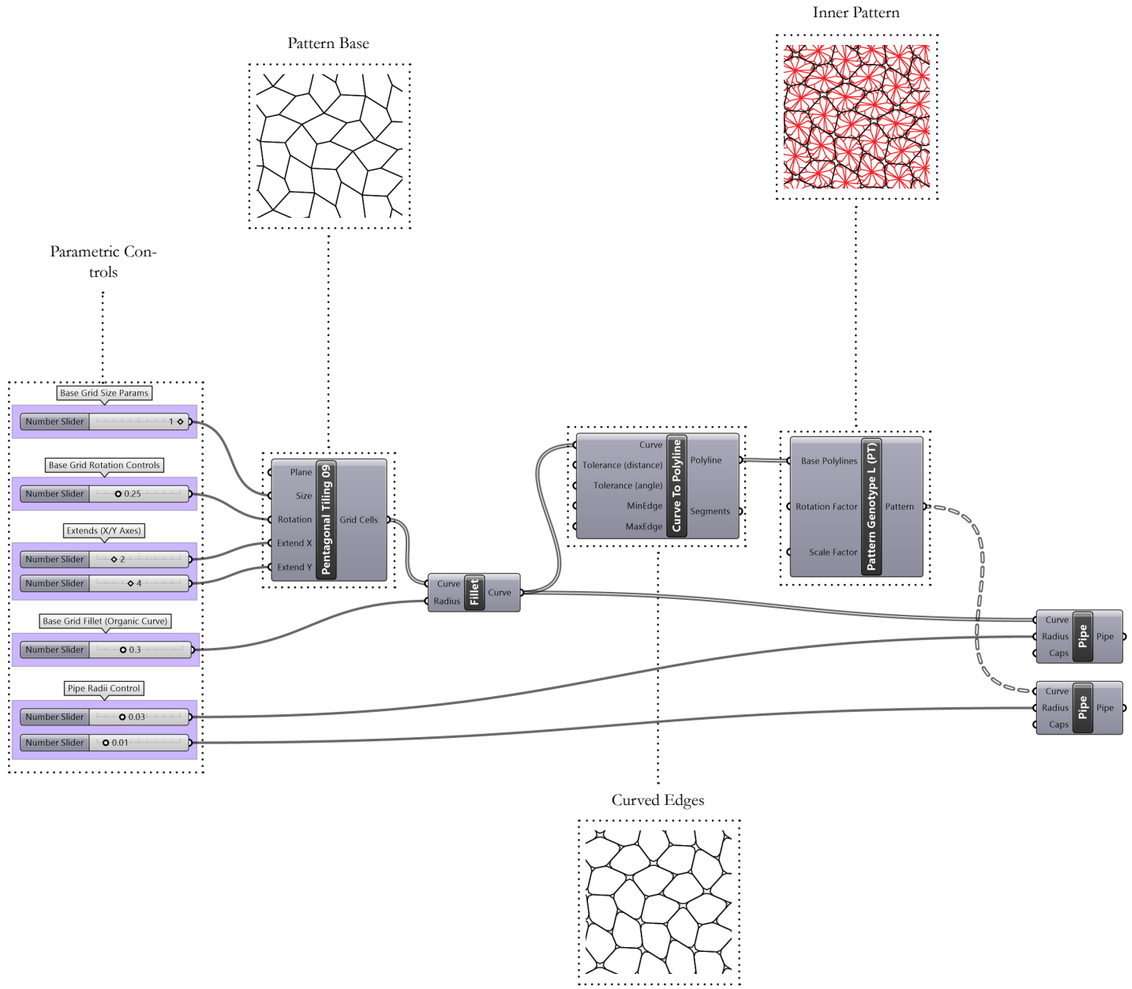
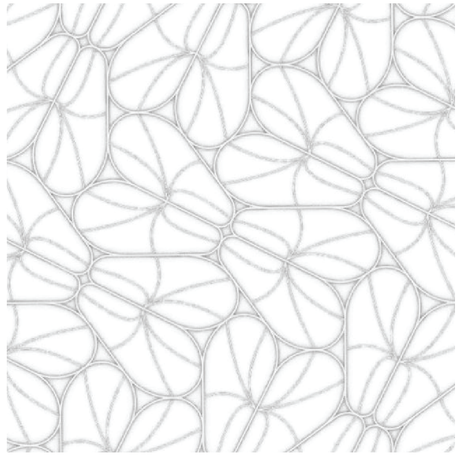
GH Script

Additional Plugins

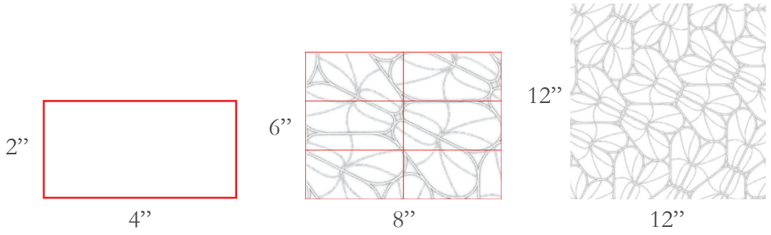
Parakeet



Cellular Lattice 6



SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	7%



Visualization

Understanding Scale and Filtering.

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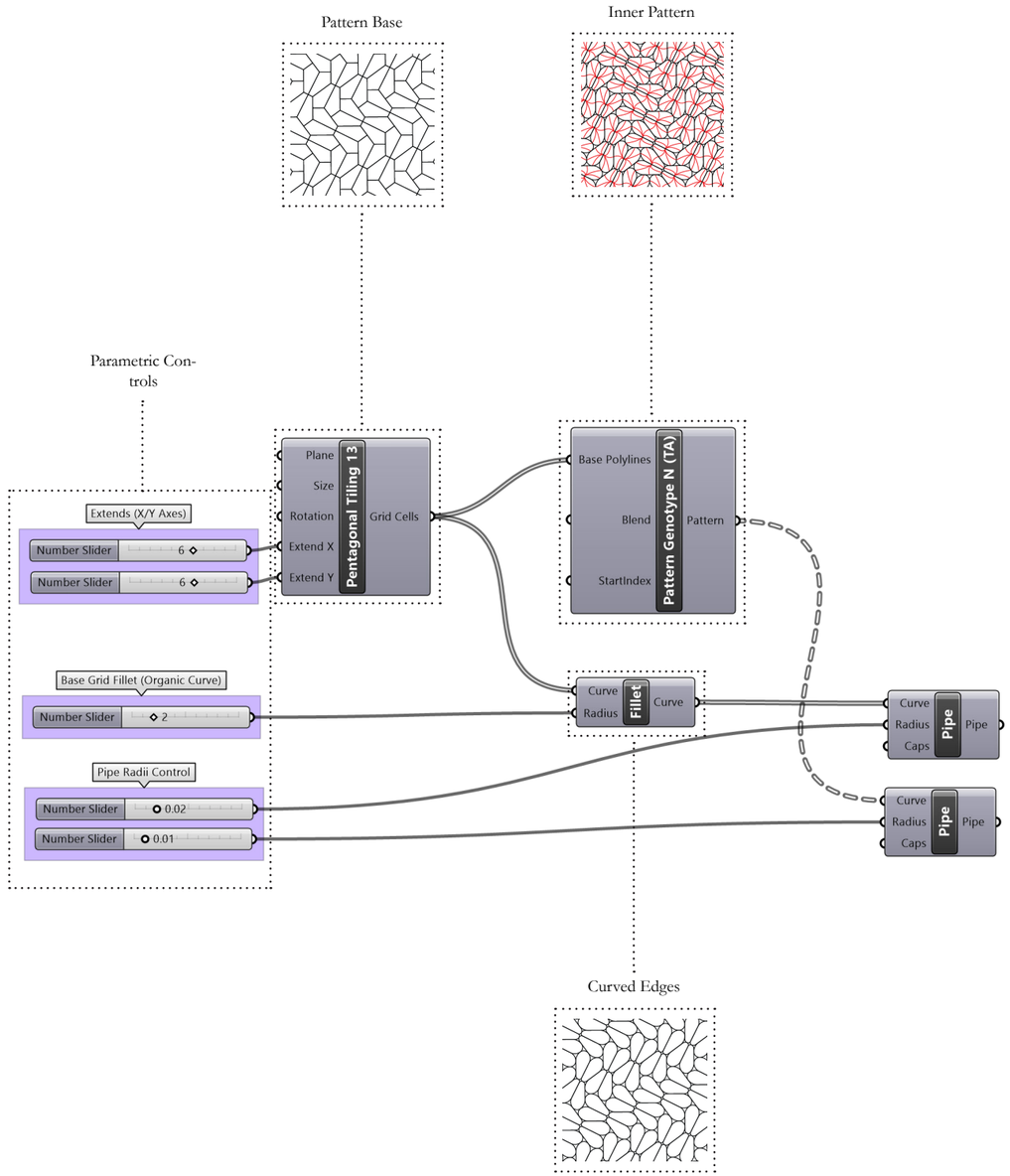
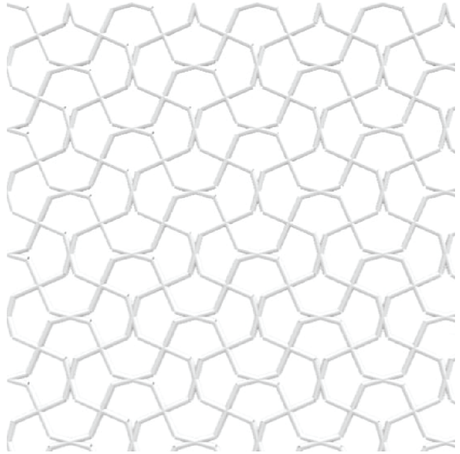
GH Script

Additional Plugins

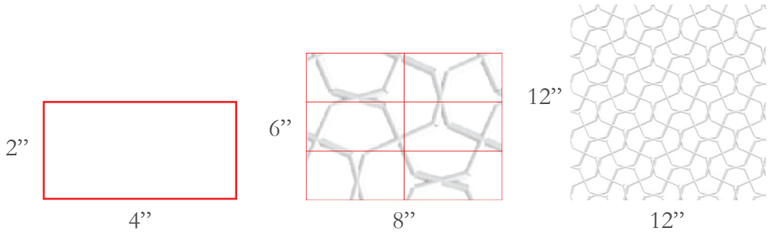
Parakeet



Geometric Lattice 3

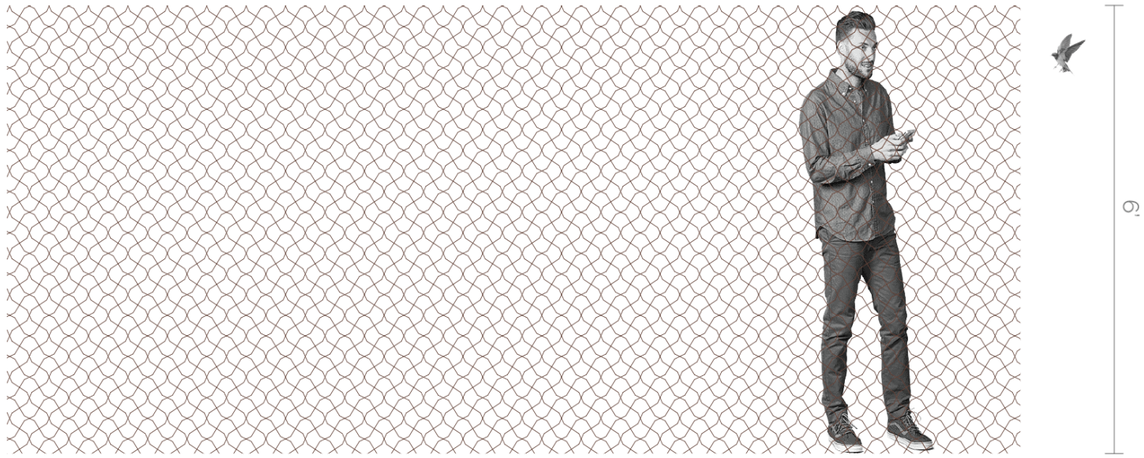


SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	29 %



Visualization

Understanding Scale and Filtering.



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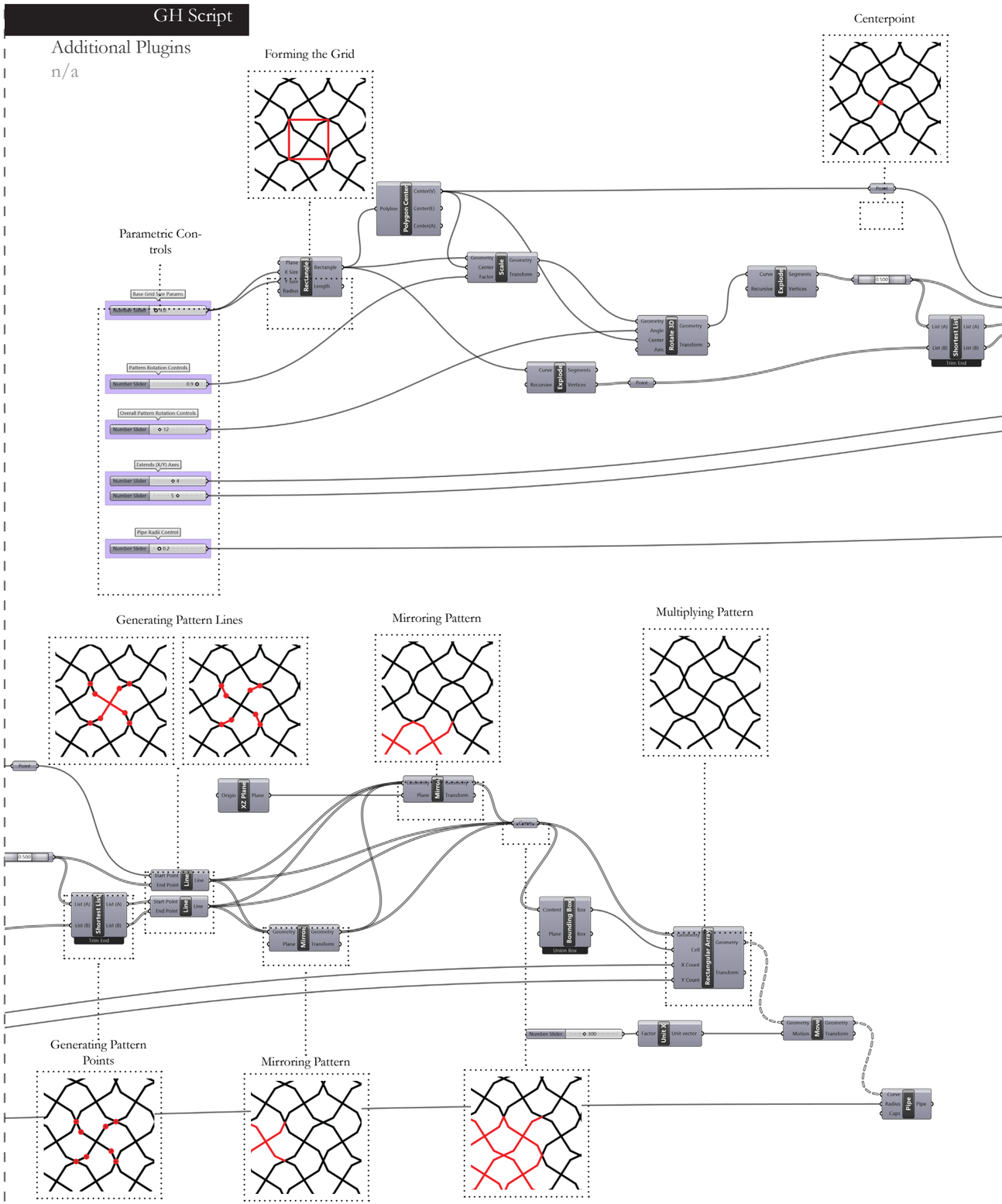
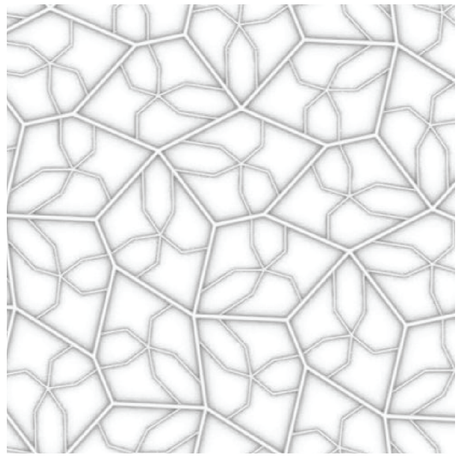
GH Script

Additional Plugins

n/a



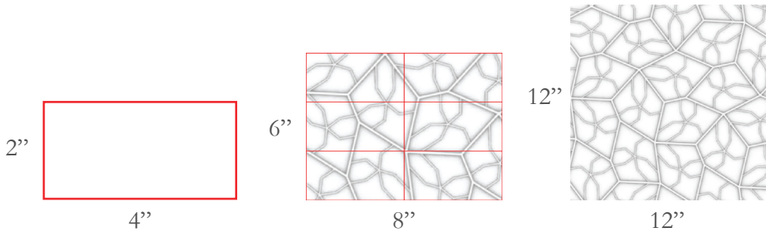
Cellular Lattice 8



SIZE 2x4 grid

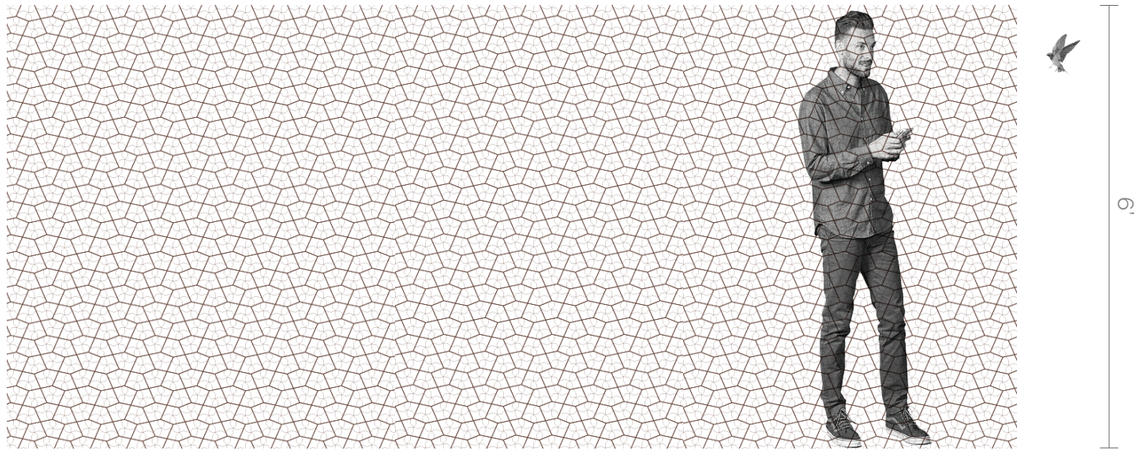
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 13 %



Visualization

Understanding Scale and Filtering.



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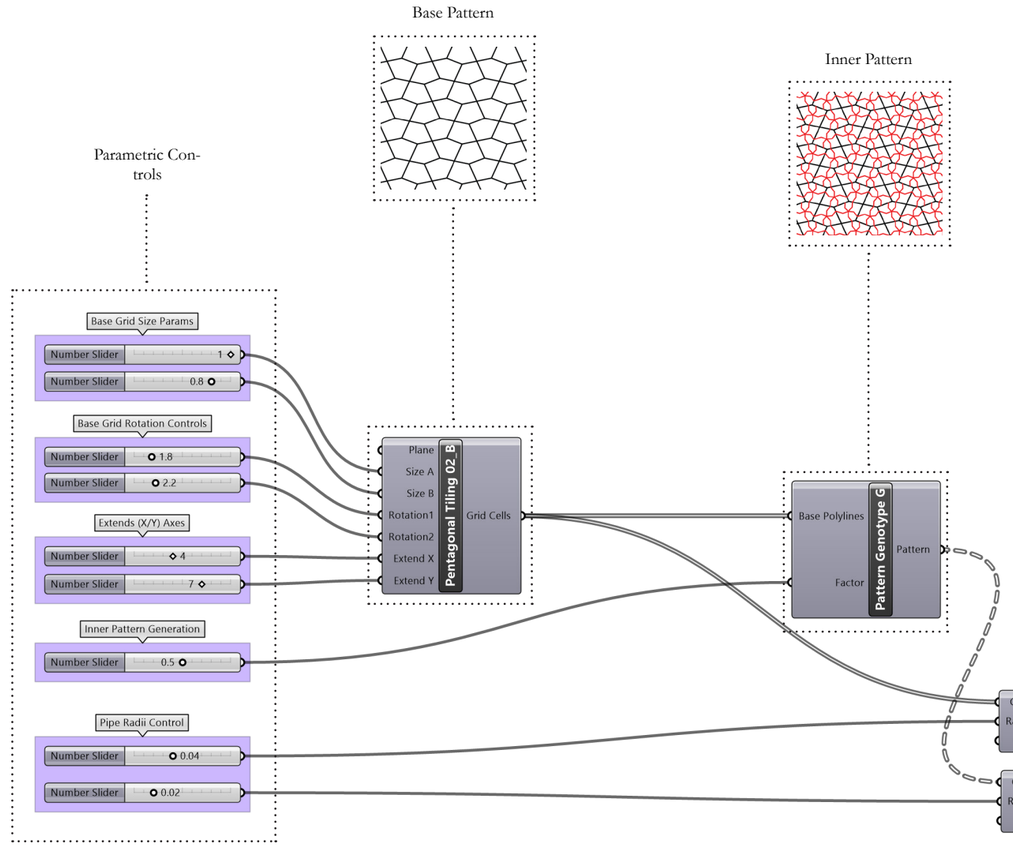
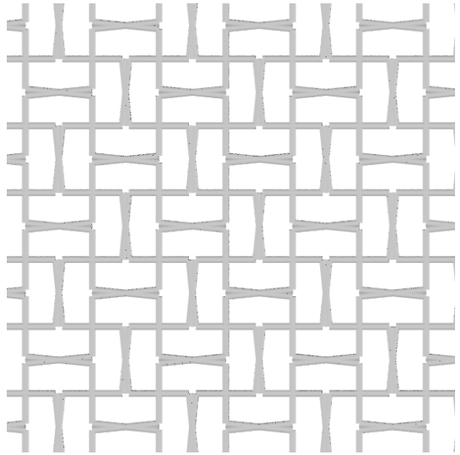
GH Script

Additional Plugins

Parakeet



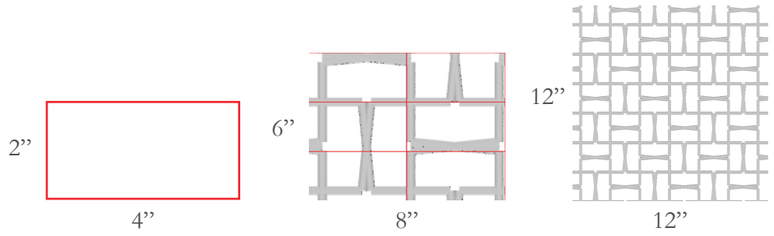
Geometric Lattice 4



SIZE 2x4 grid

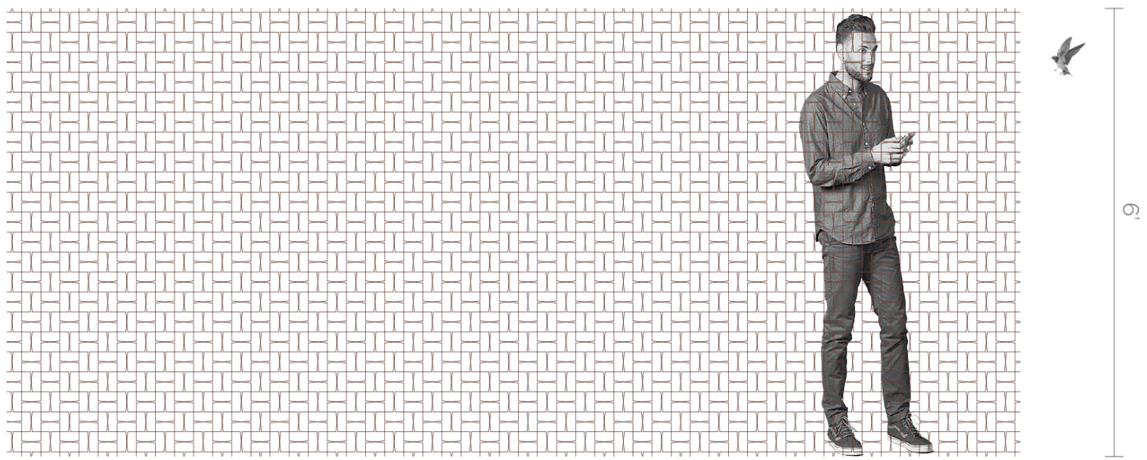
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 34 %



Visualization

Understanding Scale and Filtering.



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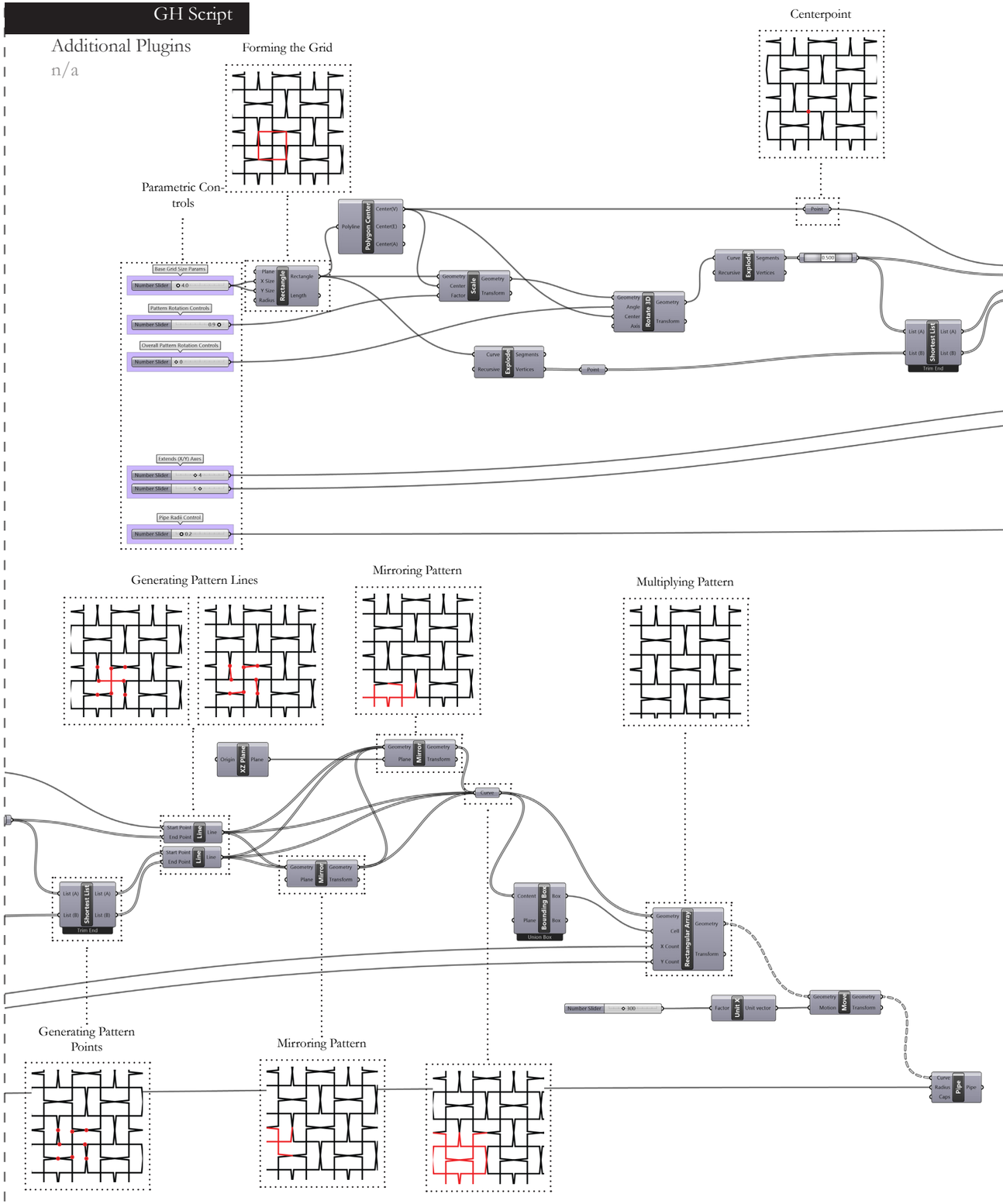
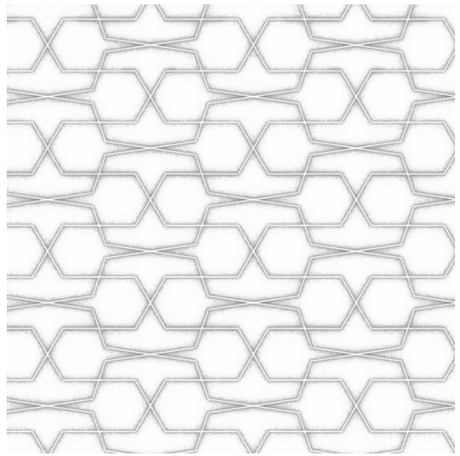
GH Script

Additional Plugins

n/a



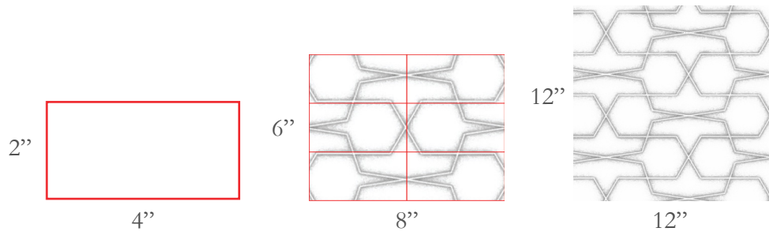
Geometric Lattice 11



SIZE 2x4 grid

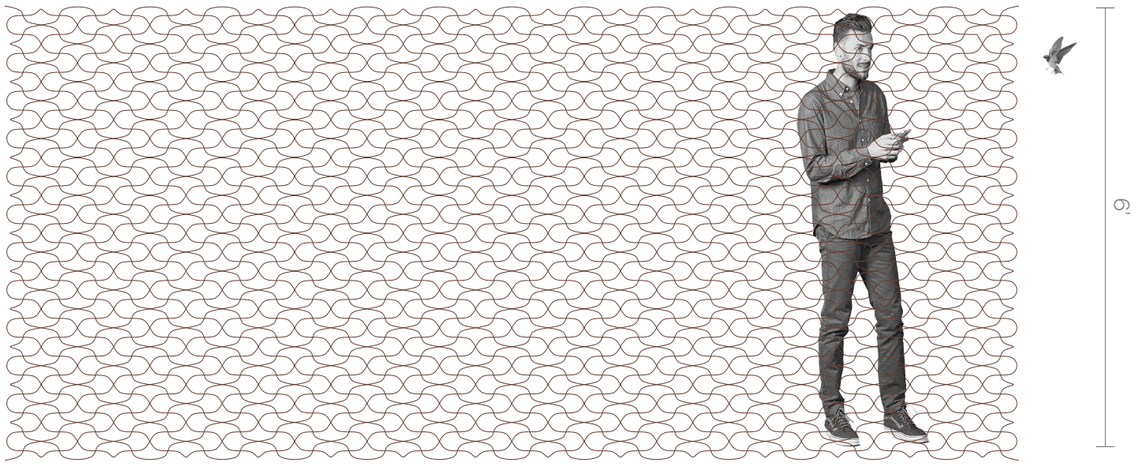
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 17 %



Visualization

Understanding Scale and Filtering.

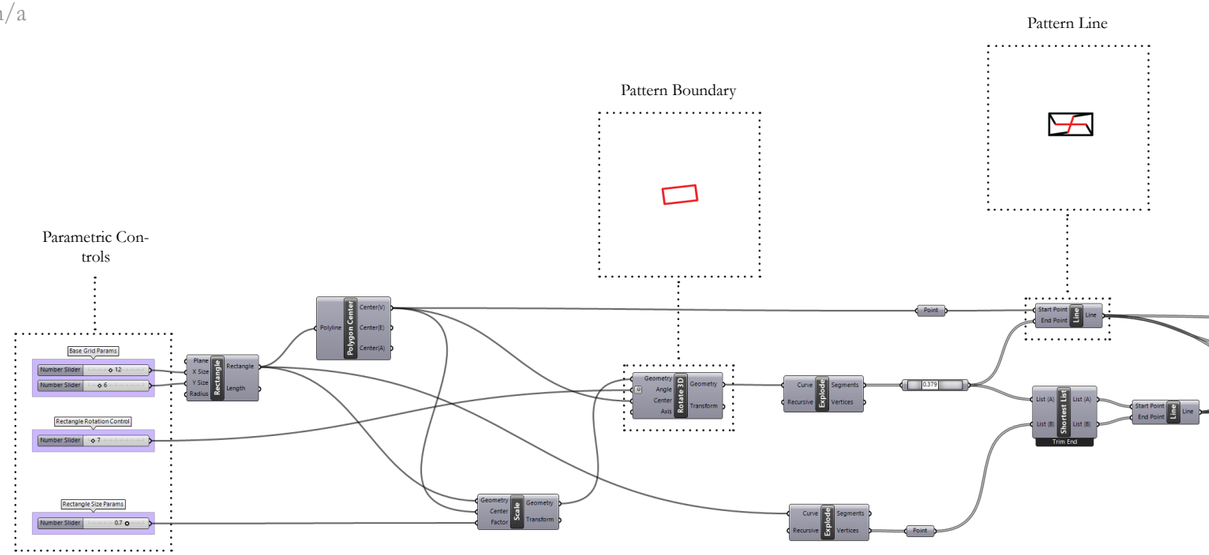


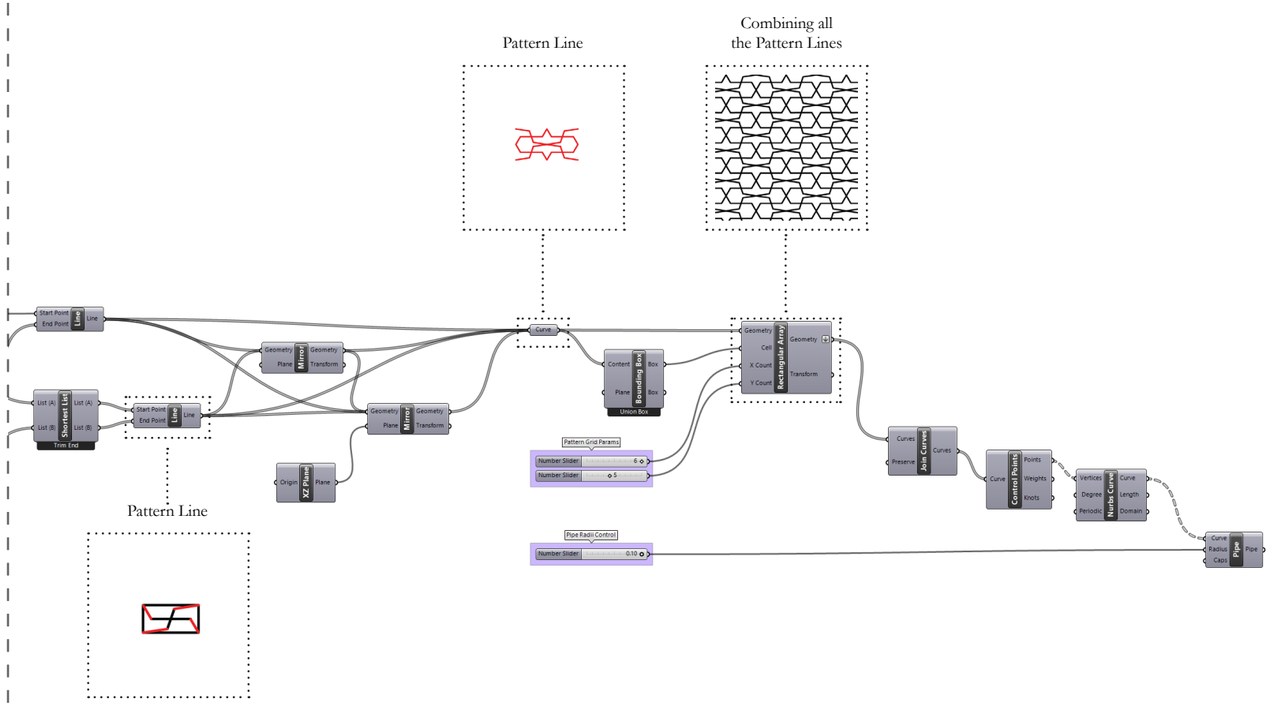
*The Threat Factor assigned to this pattern is based on the dimensions and spacing indicated here, using opaque markers and glass builds as described on page 11. Adjustments to the pattern, the product used to create the pattern, or glass build will affect the Threat Factor.

GH Script

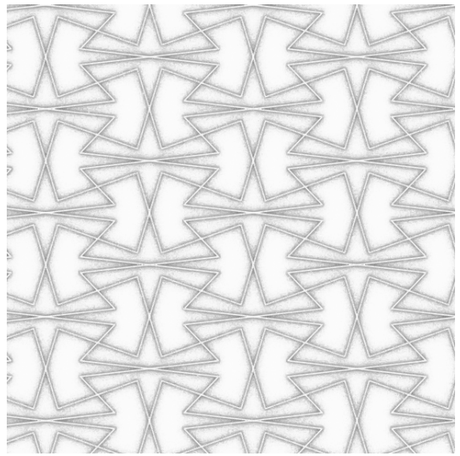
Additional Plugins

n/a





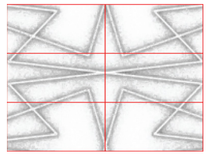
Geometric Lattice 12

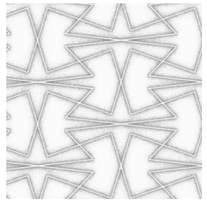


SIZE 2x4 grid

THREAT FACTOR 25*

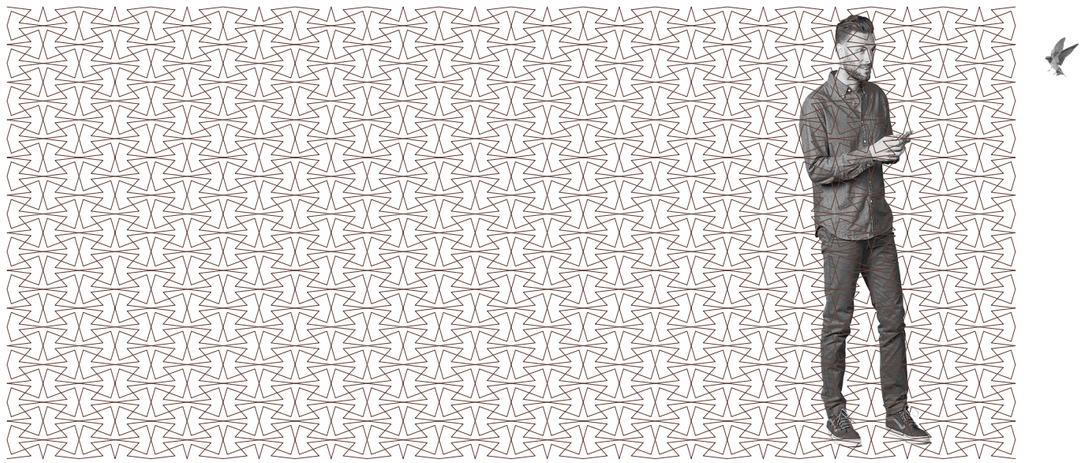
SOLAR RADIATION REDUCTION 25 %





Visualization

Understanding Scale and Filtering.



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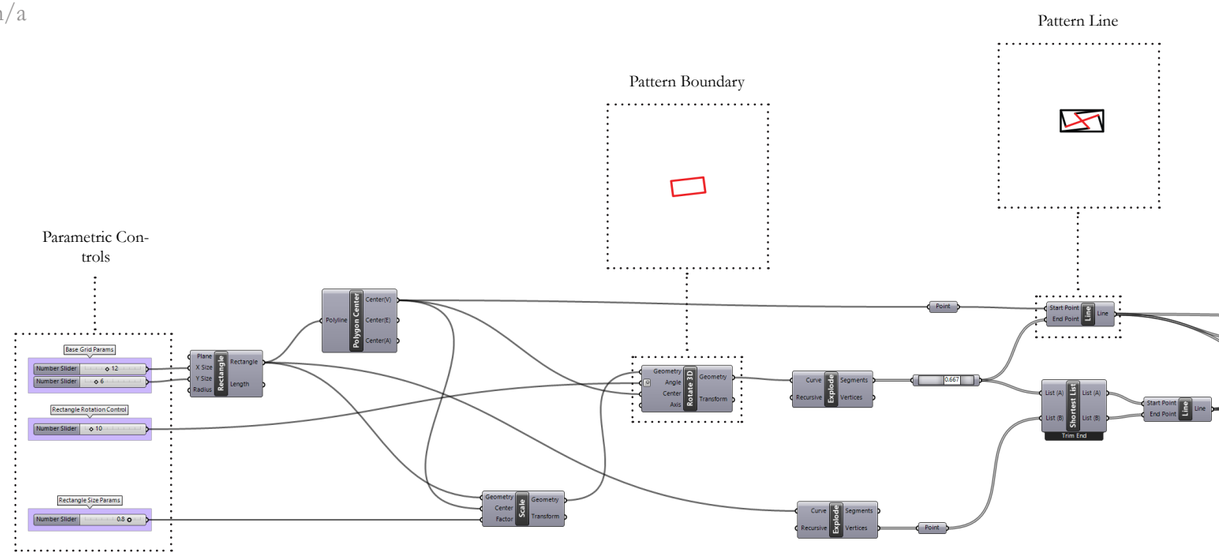
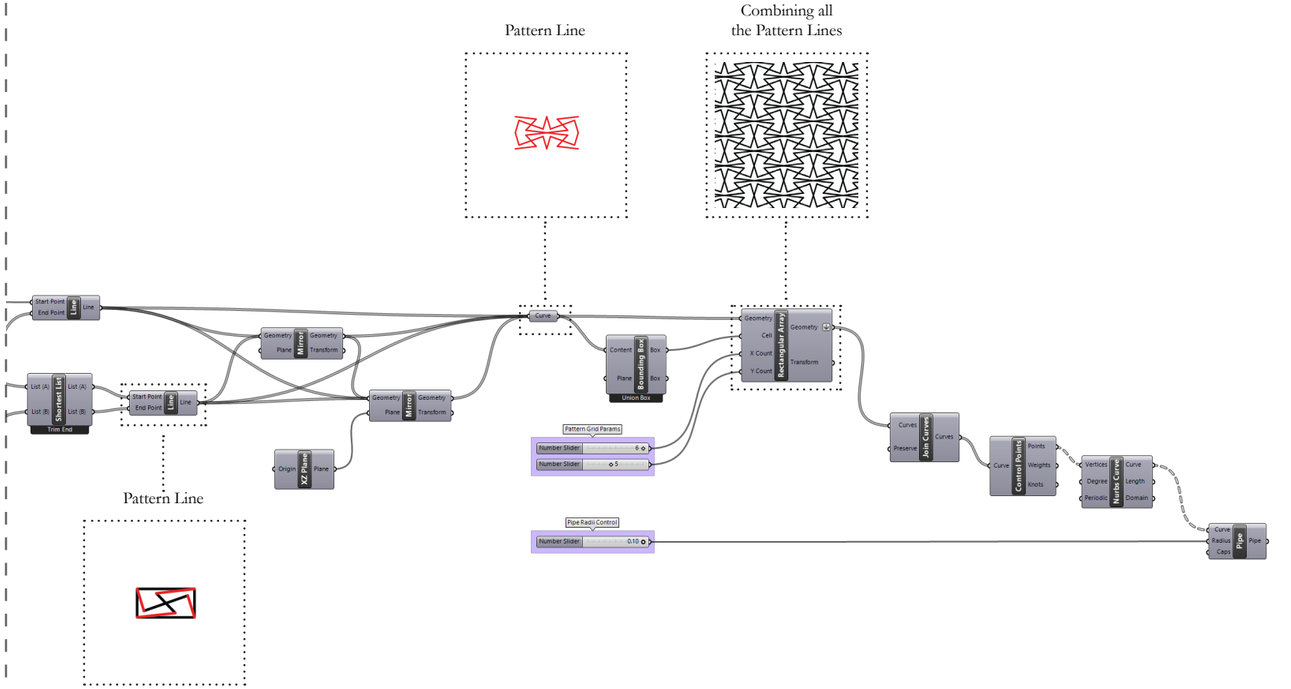
GH Script

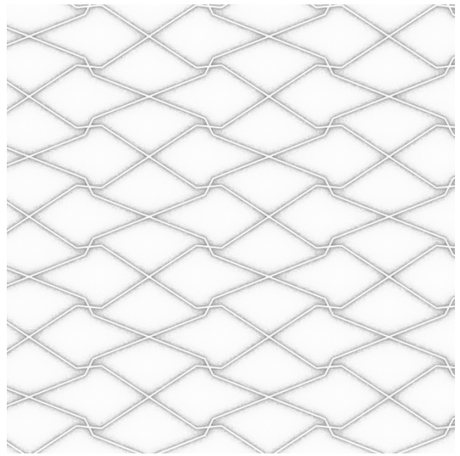
Additional Plugins

n/a

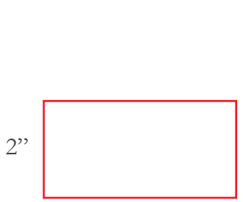


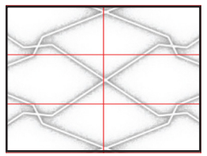


Geometric Lattice 13



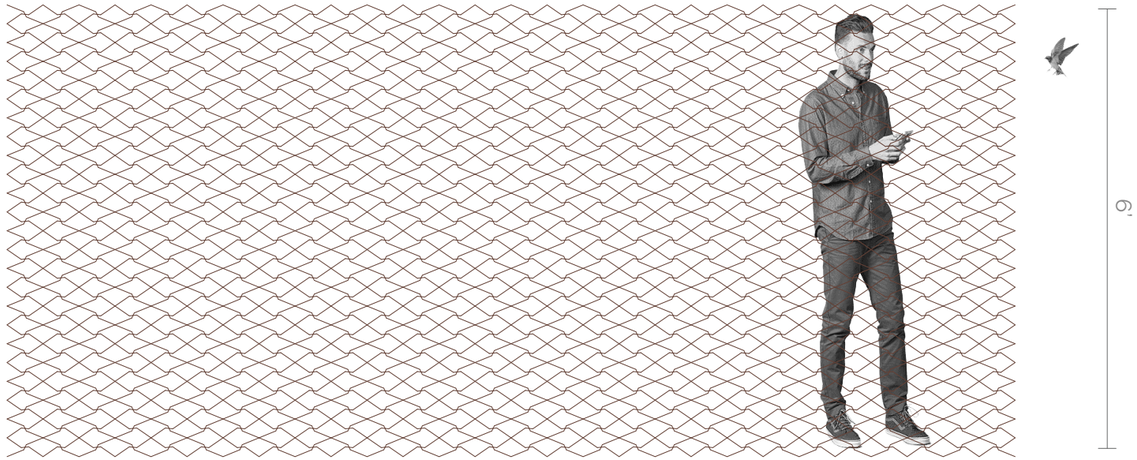
SIZE	2x4 grid
THREAT FACTOR	25 *
SOLAR RADIATION REDUCTION	17 %





Visualization

Understanding Scale and Filtering.



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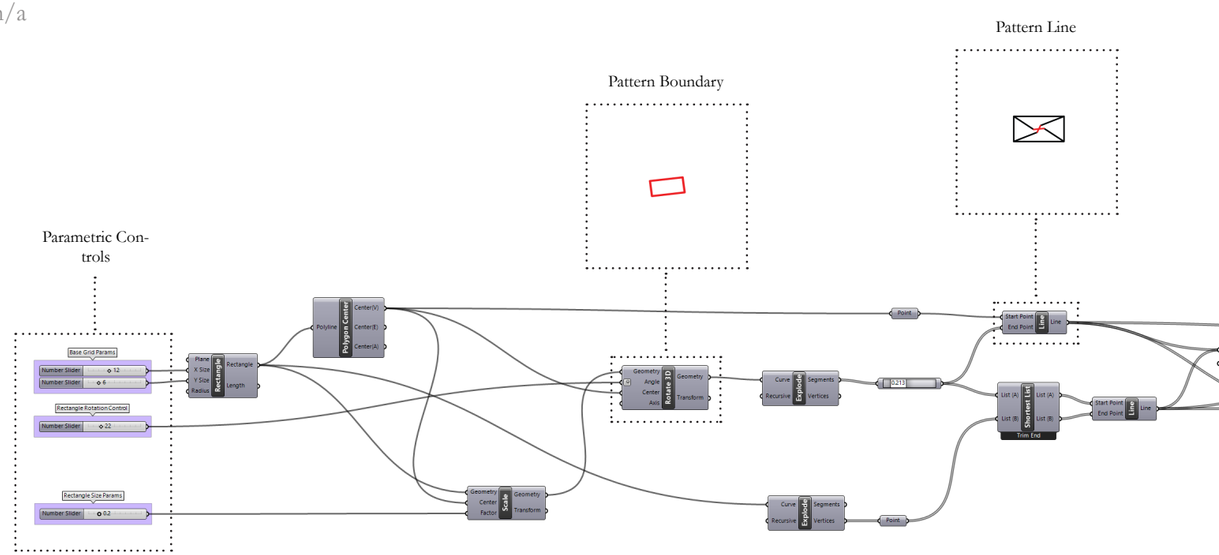
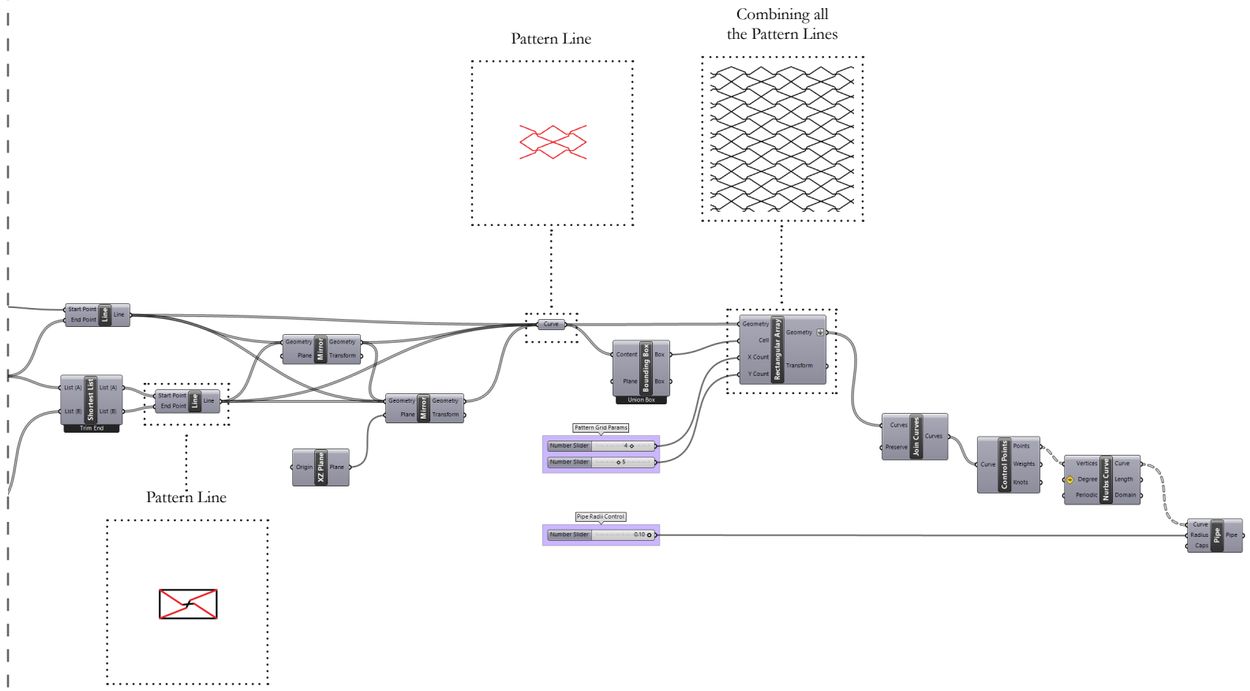
GH Script

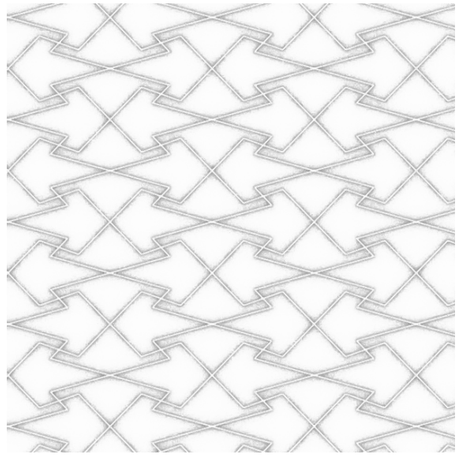
Additional Plugins

n/a





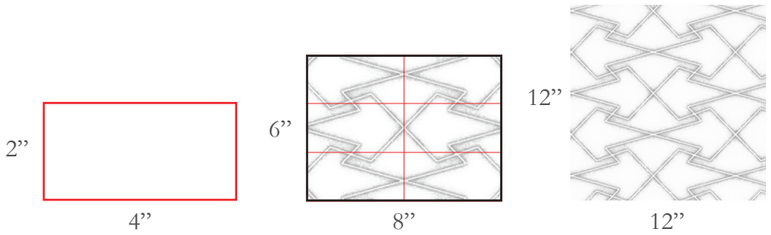
Geometric Lattice 14



SIZE 2x4 grid

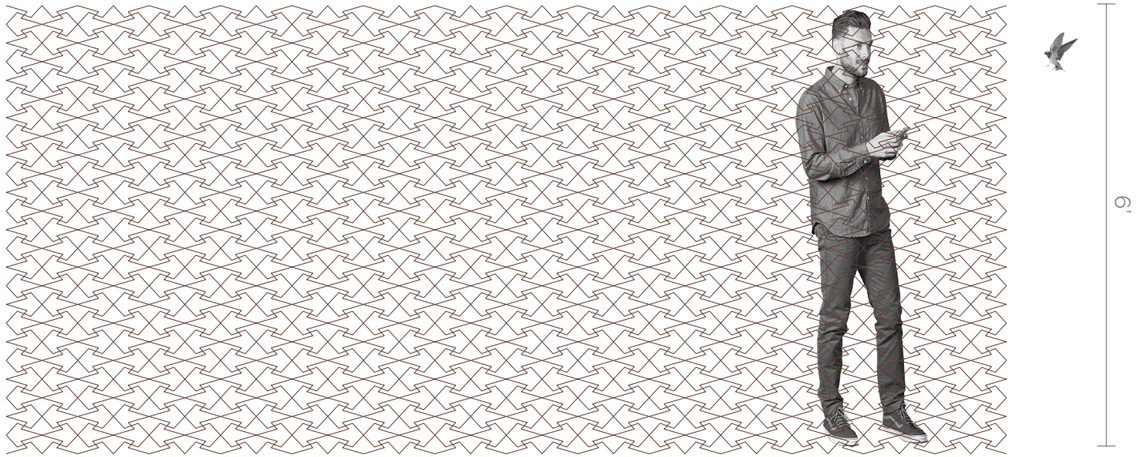
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 20 %



Visualization

Understanding Scale and Filtering.



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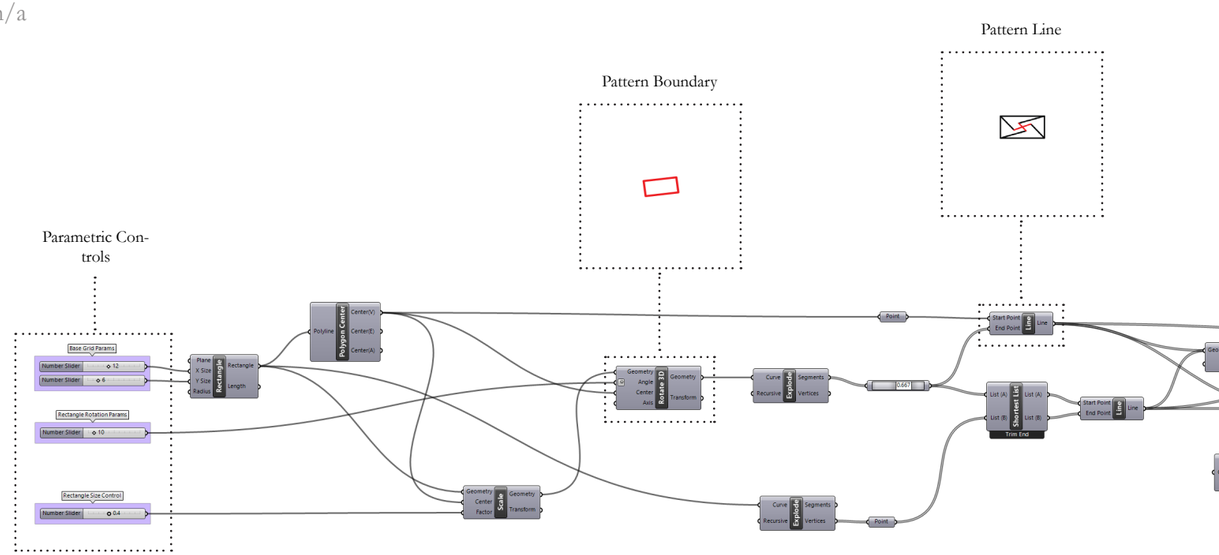
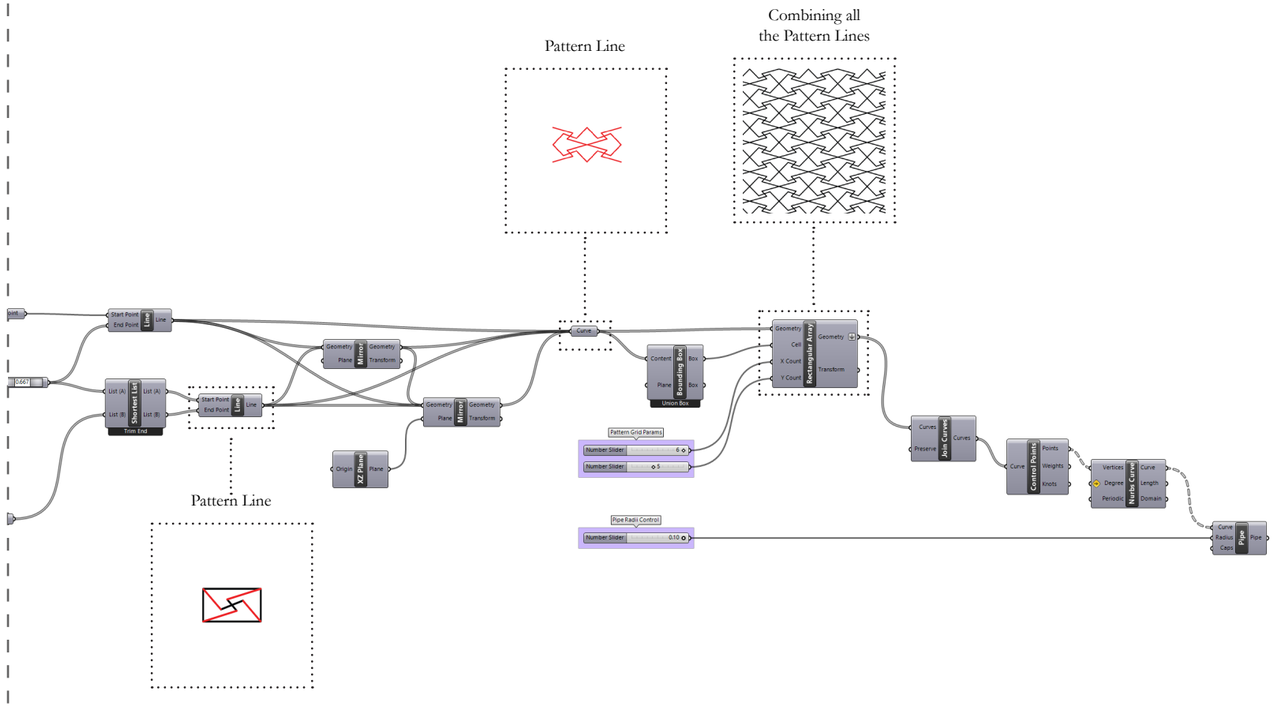
GH Script

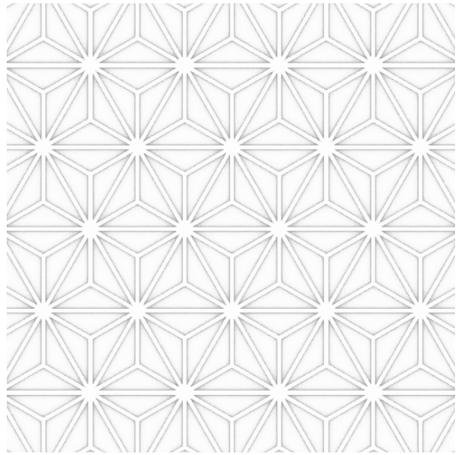
Additional Plugins

n/a





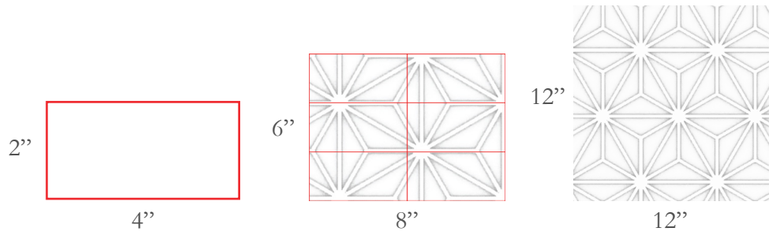
Geometric Lattice 15



SIZE 2x4 grid

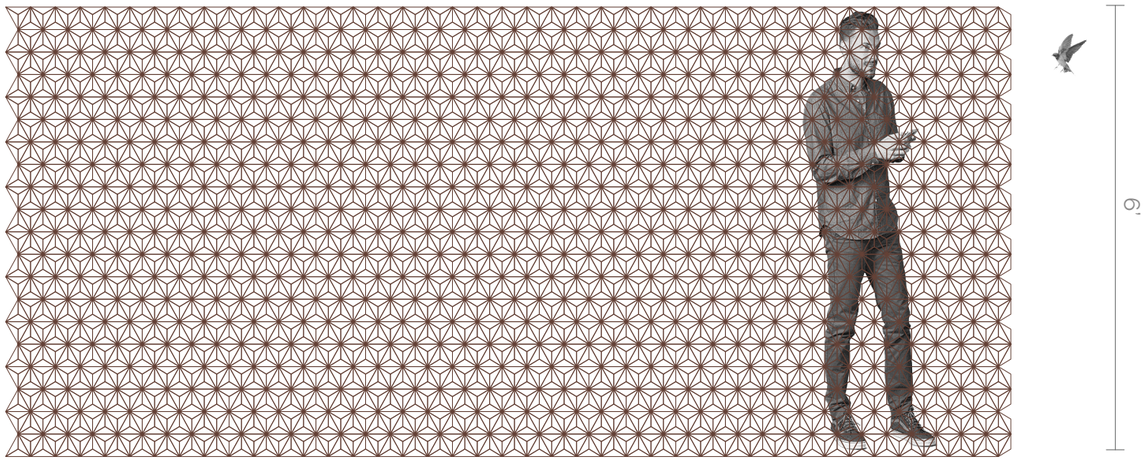
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 36 %



Visualization

Understanding Scale and Filtering.



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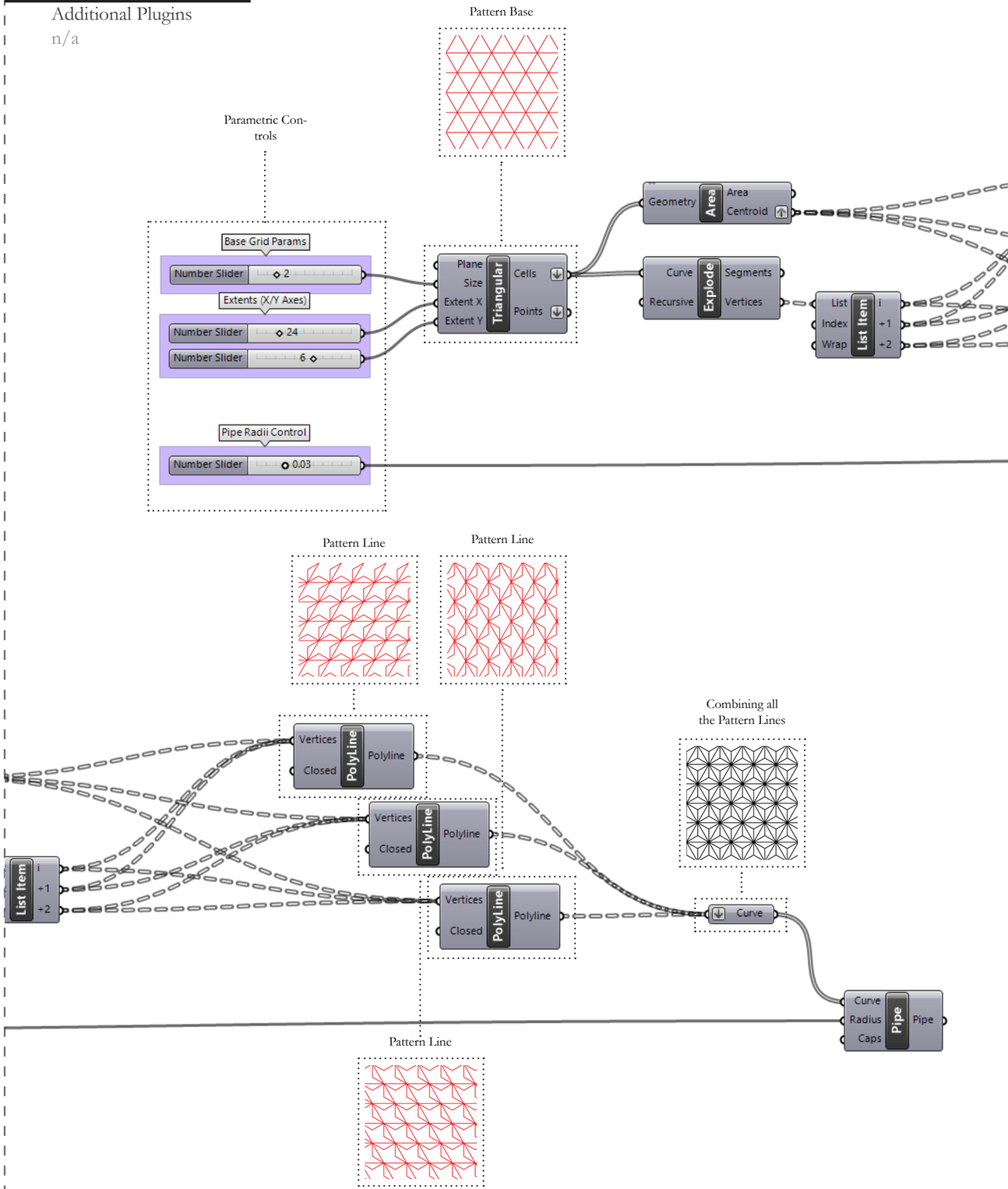
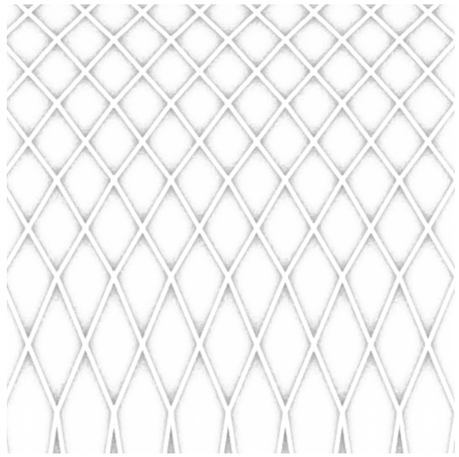
GH Script

Additional Plugins

n/a



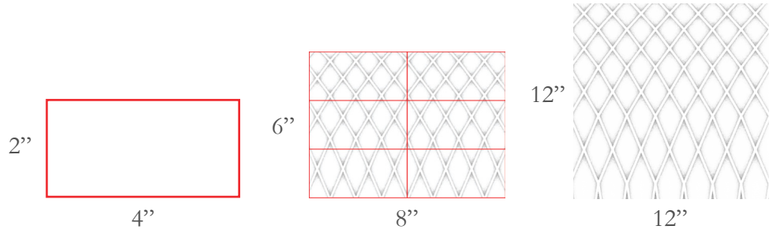
Curved Vertical Lattice



SIZE 2x4 grid

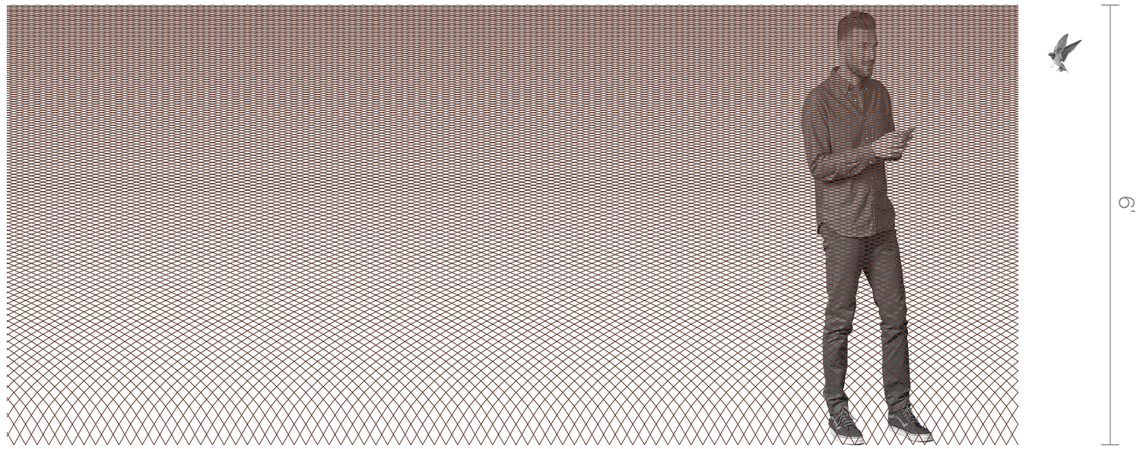
THREAT FACTOR 25*

SOLAR RADIATION REDUCTION 9 %



Visualization

Understanding Scale and Filtering.



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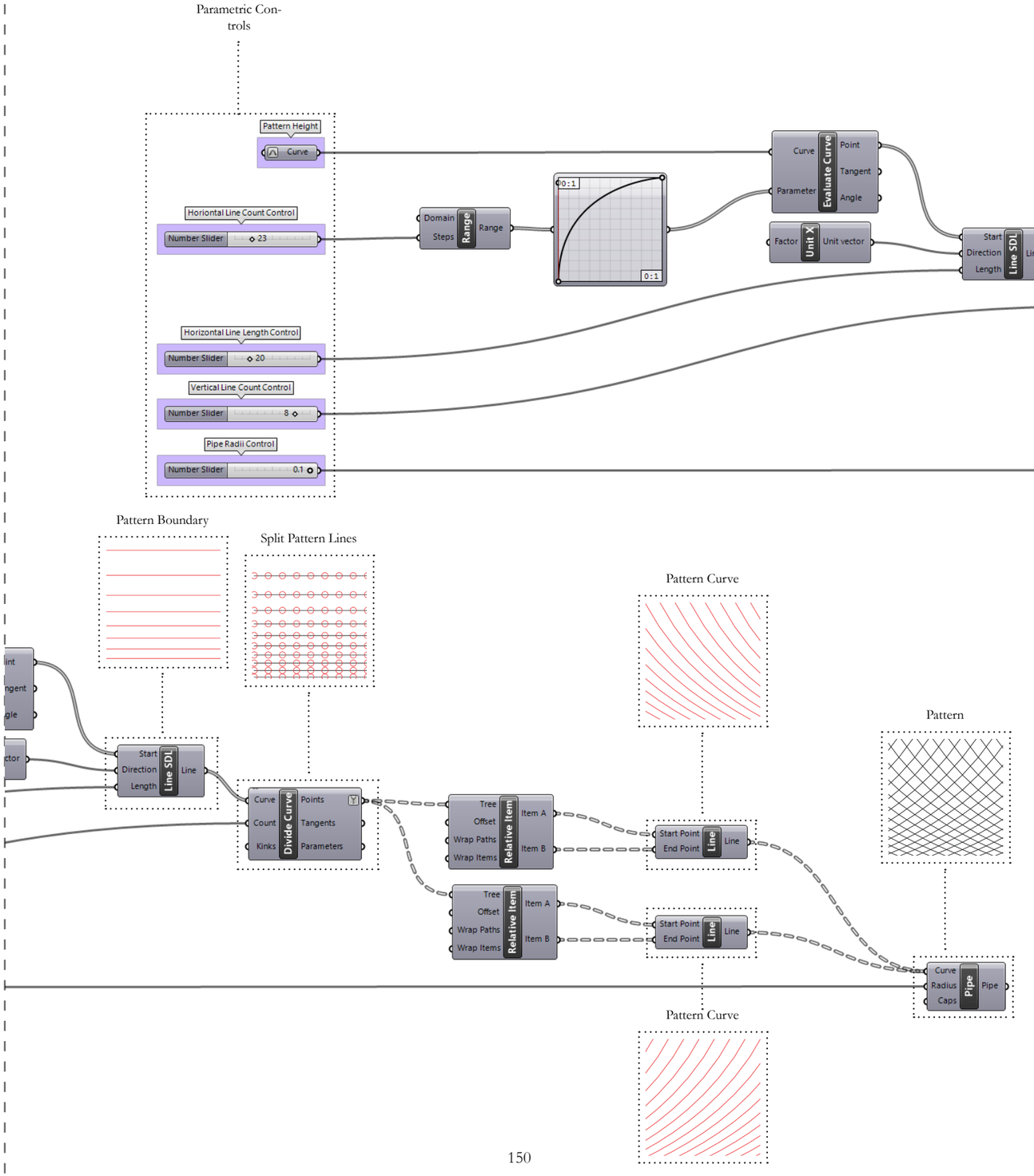
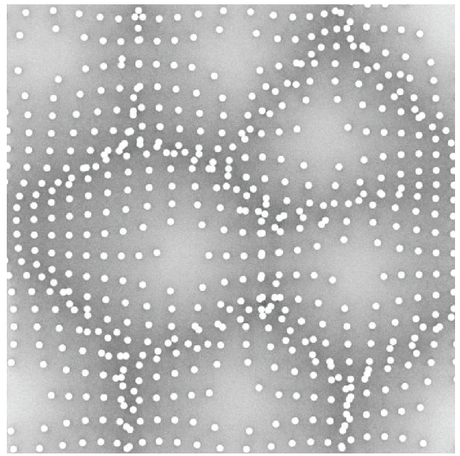
GH Script

Additional Plugins

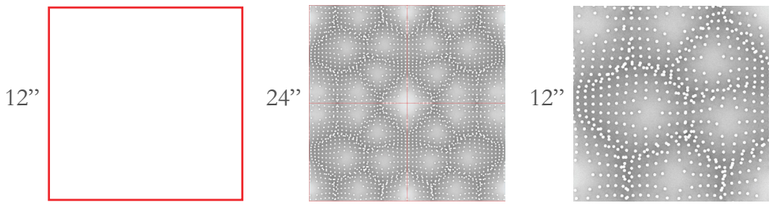
n/a



Magnetic Vector Based Dot Grid

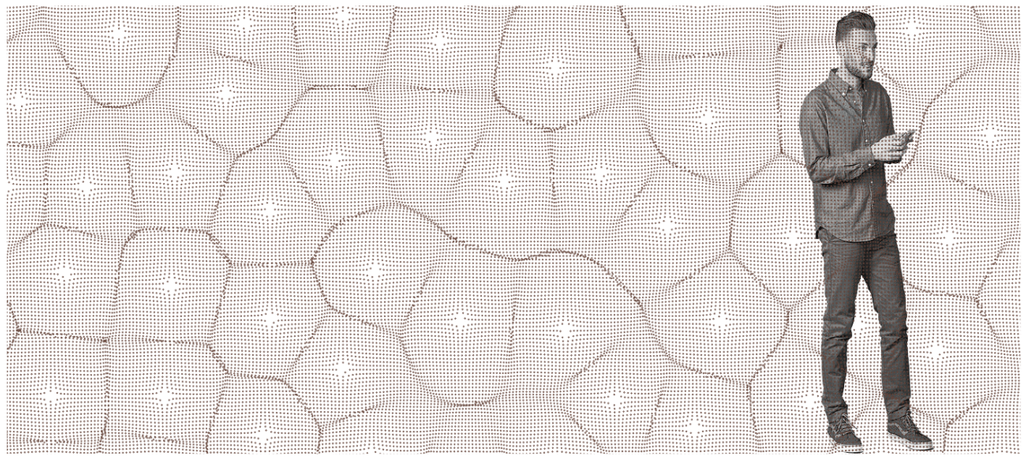


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	34 %



Visualization

Understanding Scale and Filtering.



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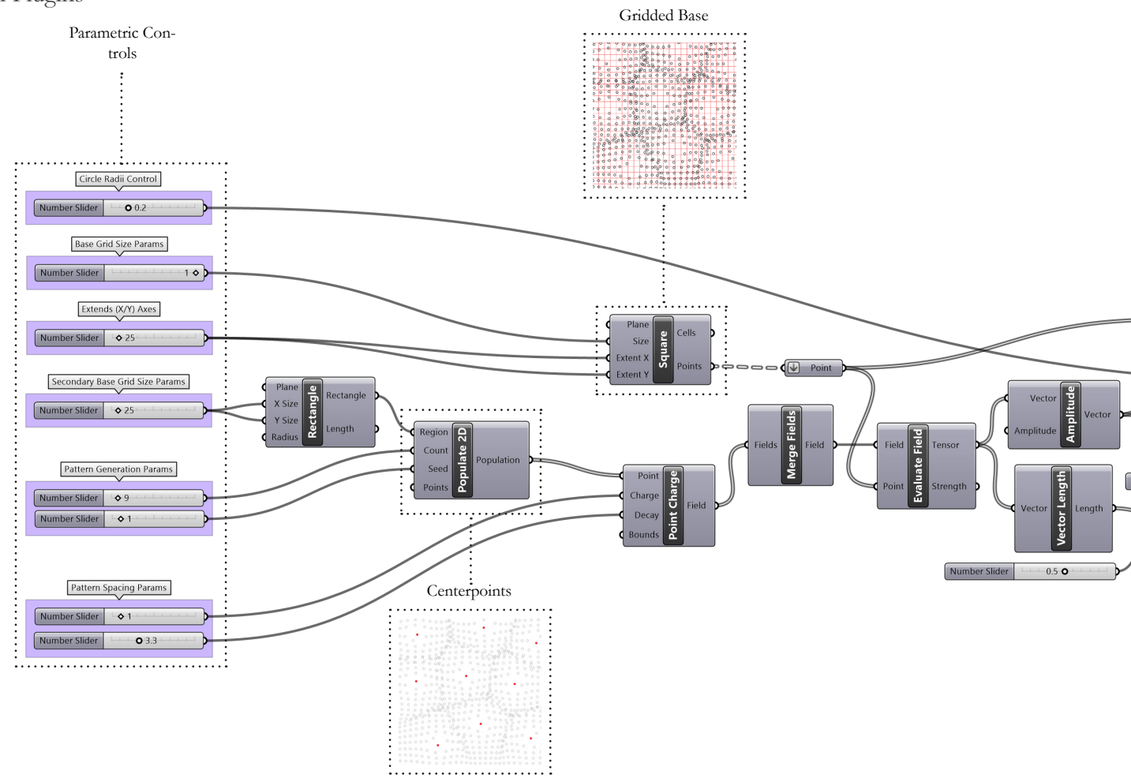
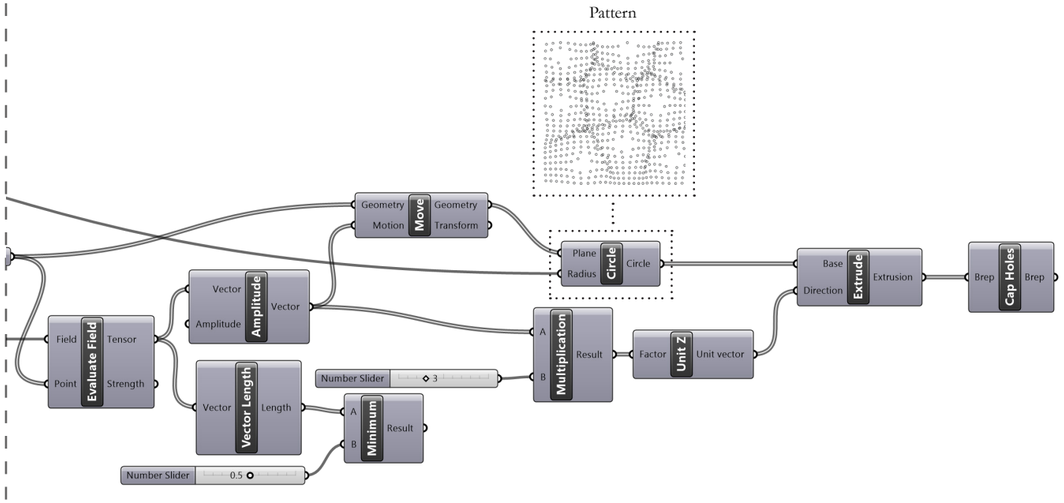
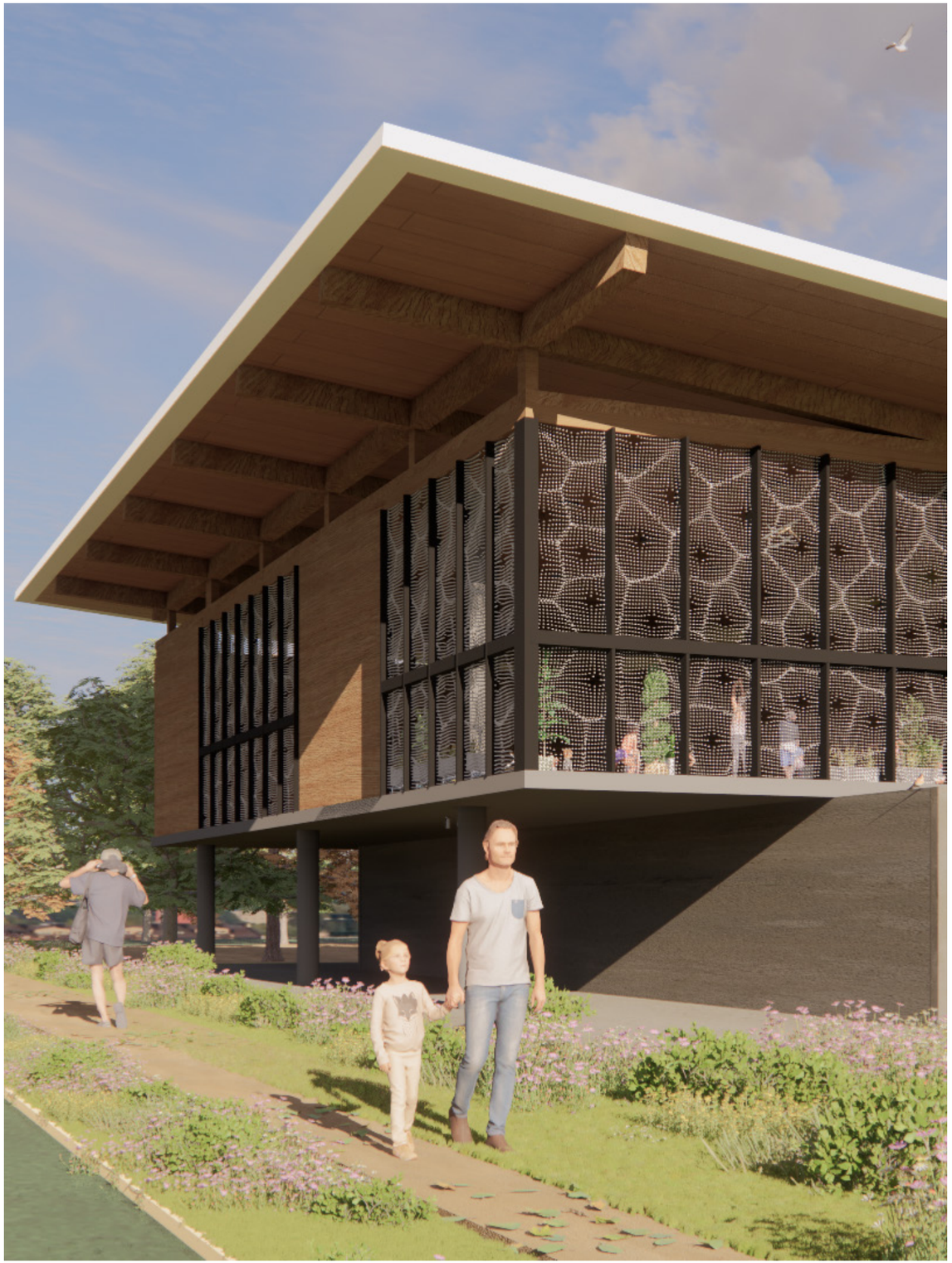
GH Script

Additional Plugins

n/a





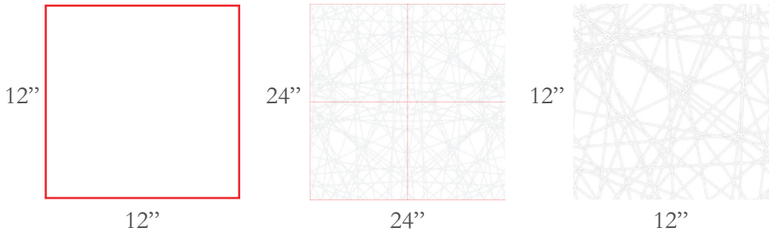


Bird's Nest

SIZE — Organic

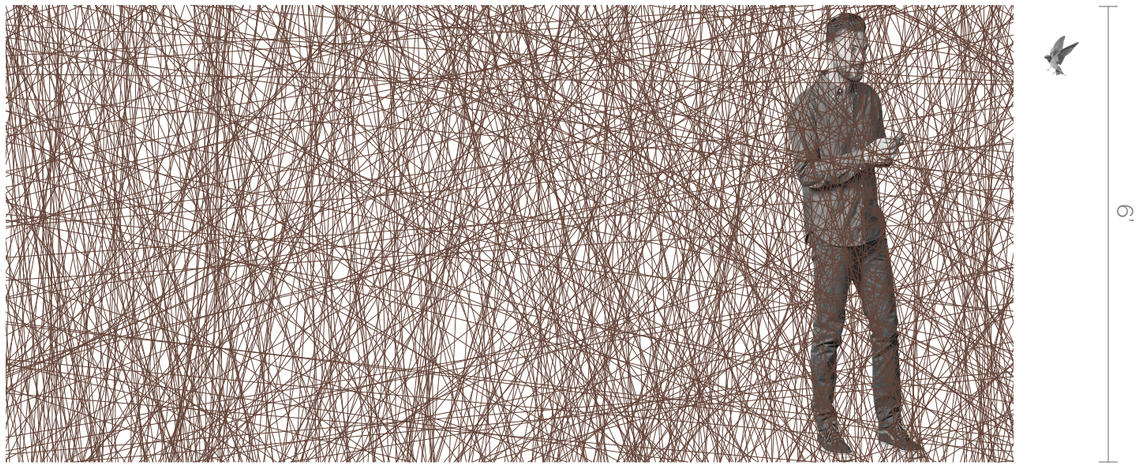
THREAT FACTOR — 25*

SOLAR RADIATION REDUCTION — 19 %



Visualization

Understanding Scale and Filtering.



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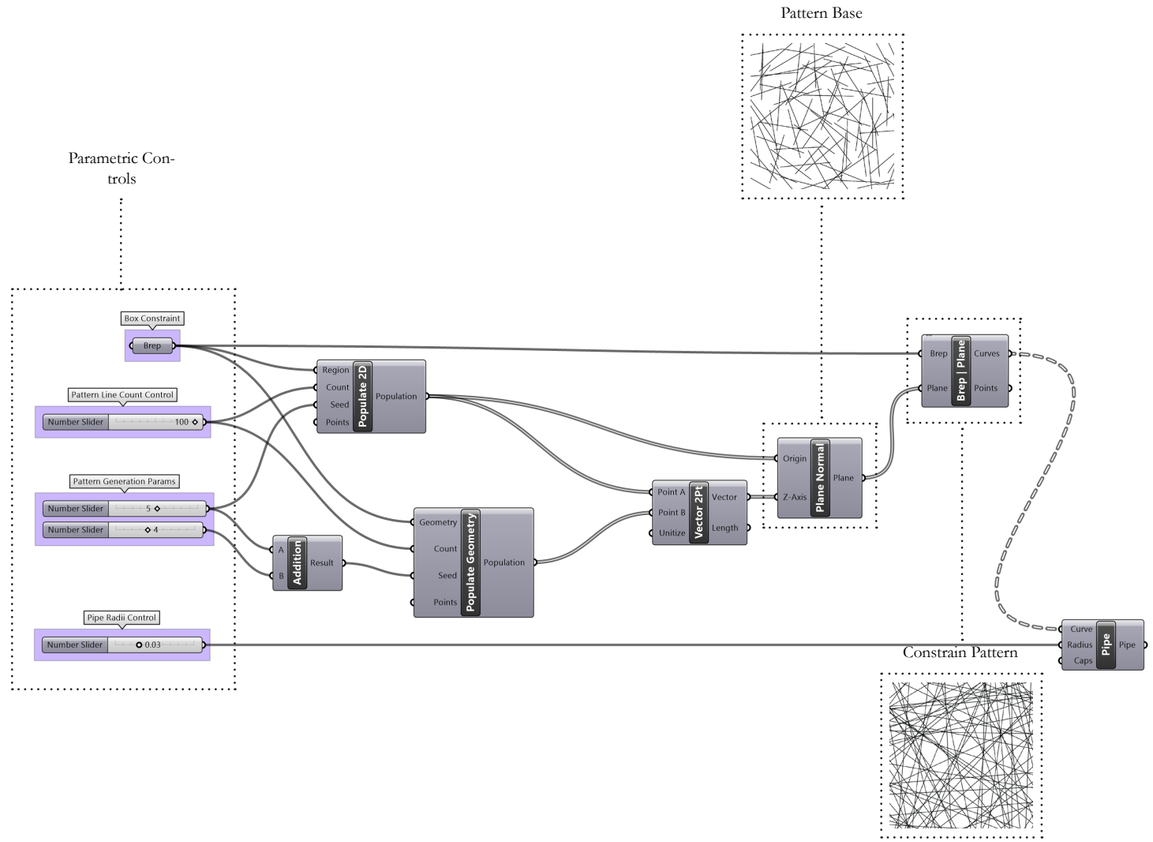
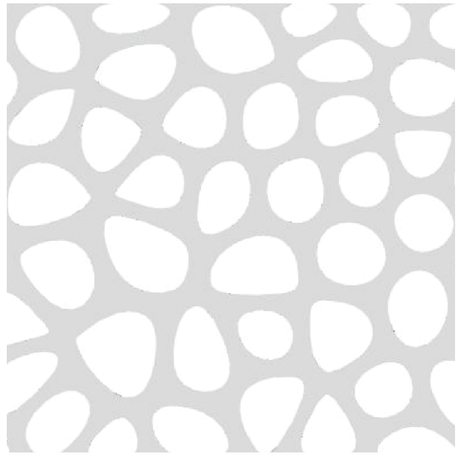
GH Script

Additional Plugins

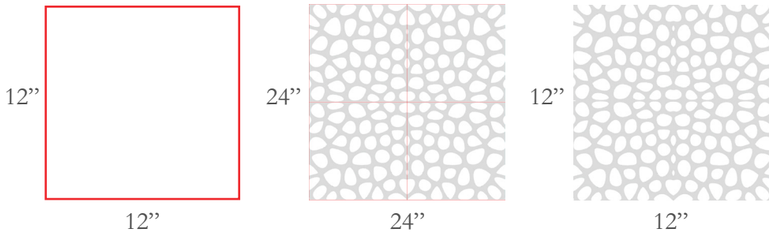
n/a



Voronoi Density Variation

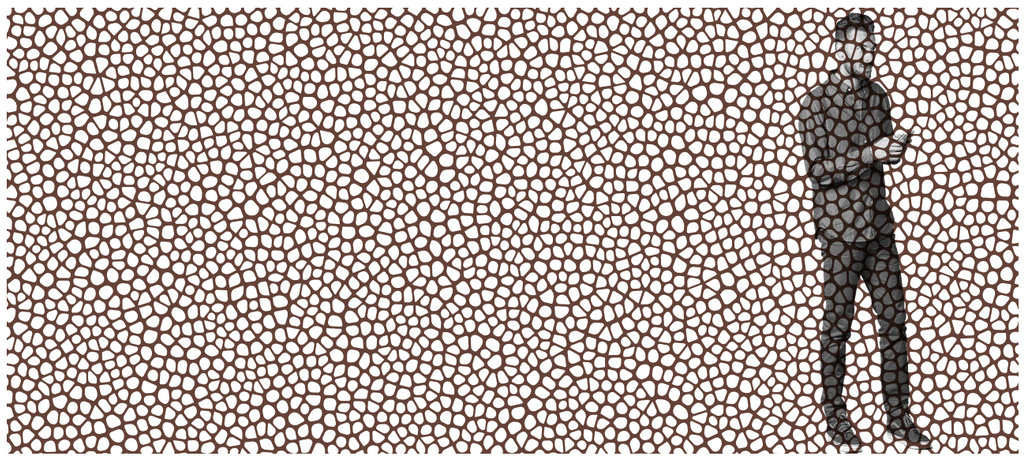


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	34 %



Visualization

Understanding Scale and Filtering.



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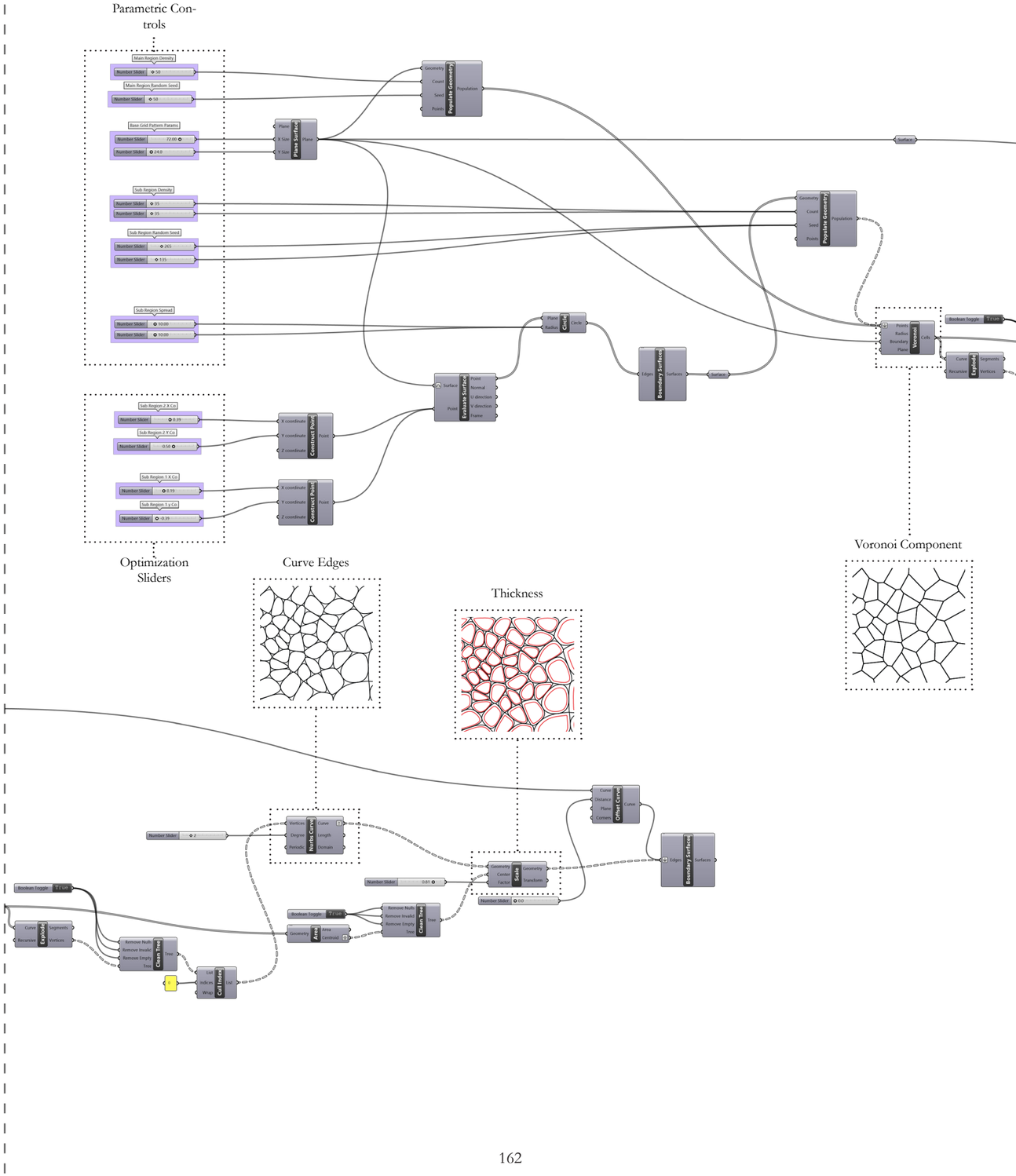
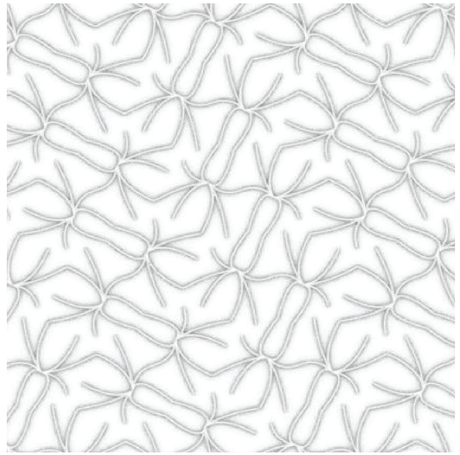
GH Script

Additional Plugins

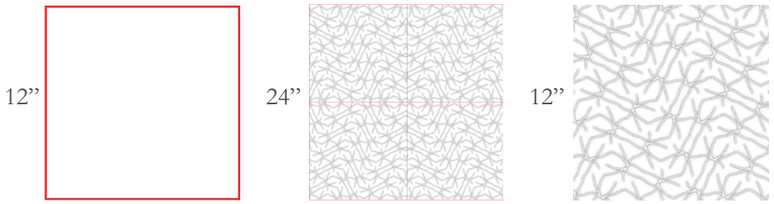
n/a



Organic Lattice 2

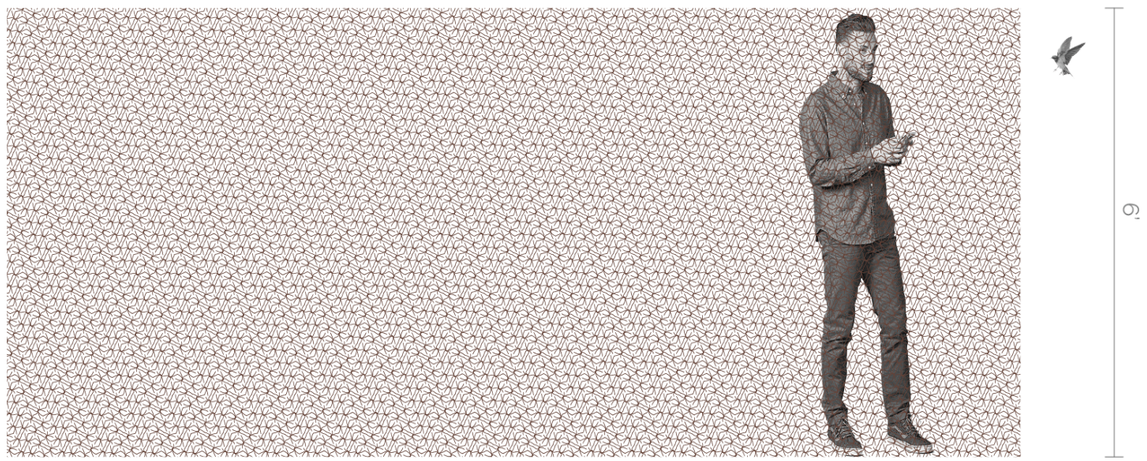


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	5 %



Visualization

Understanding Scale and Filtering.



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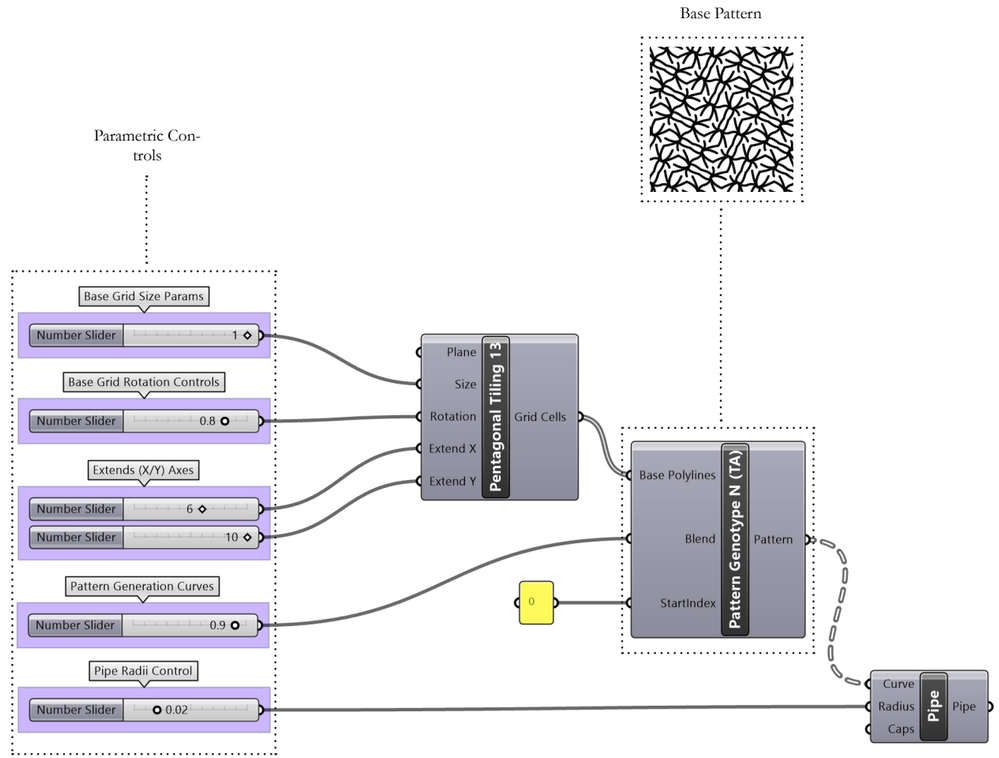
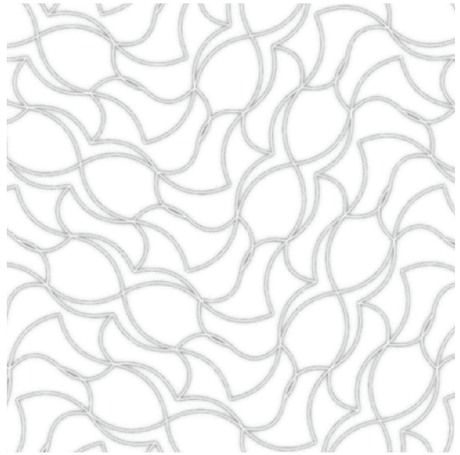
GH Script

Additional Plugins

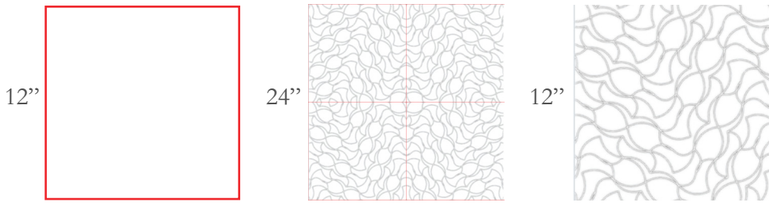
Parakeet



Organic Jitter Lattice 1

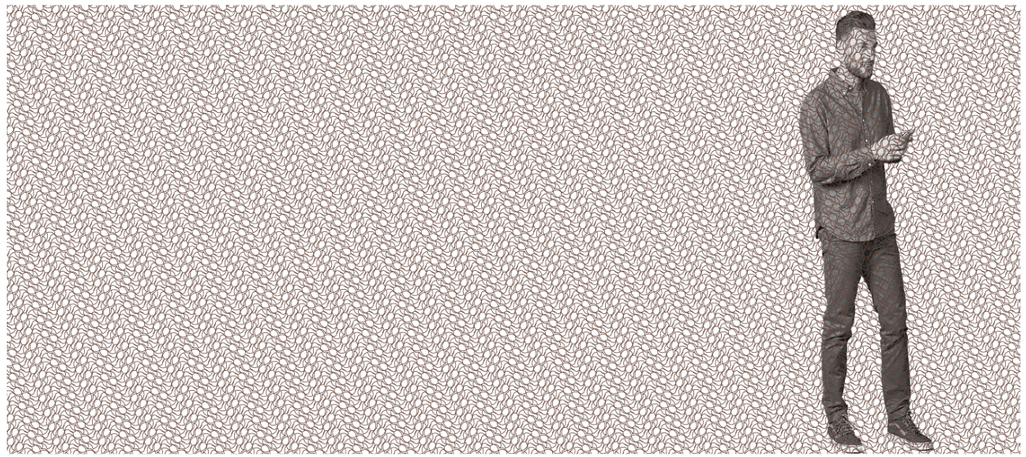


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	6 %



Visualization

Understanding Scale and Filtering.



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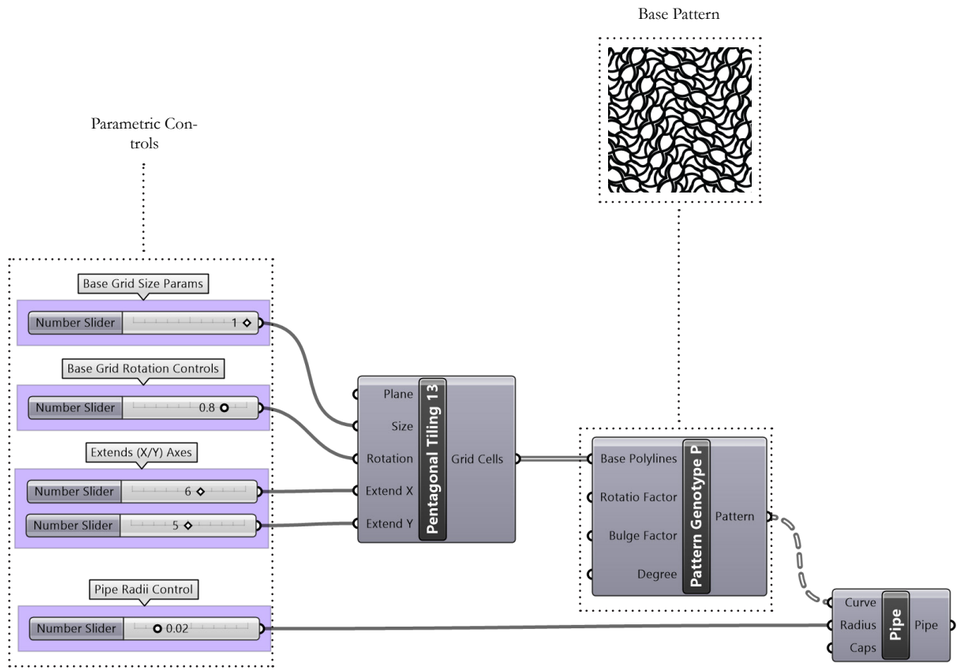
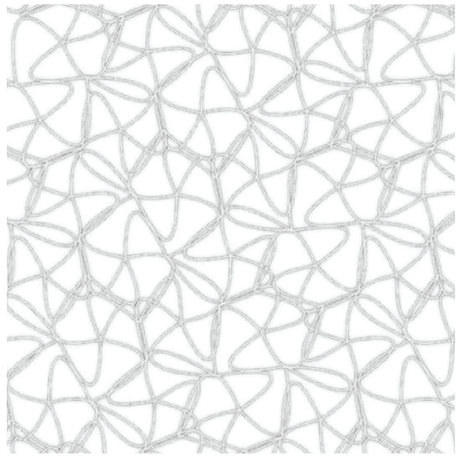
GH Script

Additional Plugins

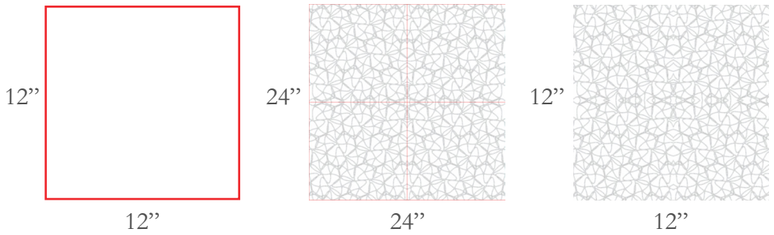
Parakeet



Organic Jitter Lattice 2

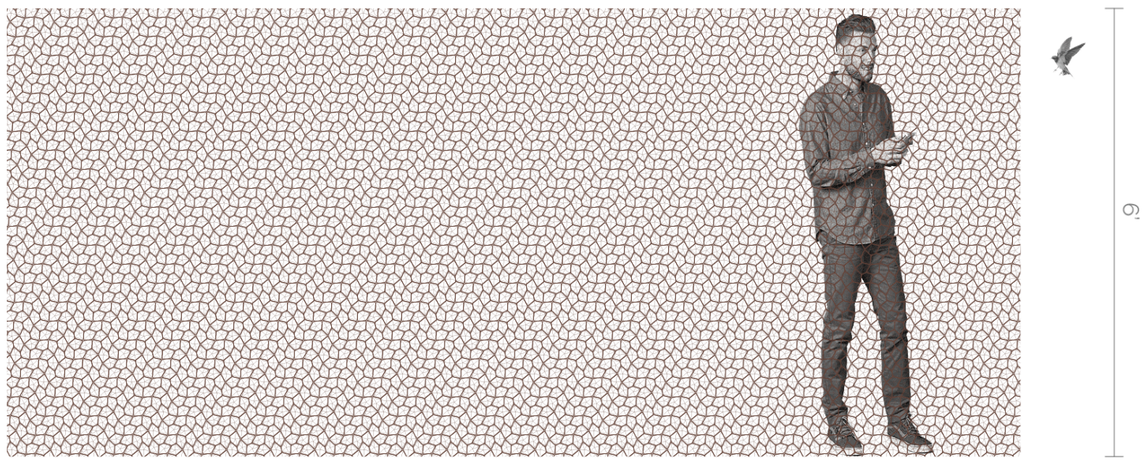


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	12 %



Visualization

Understanding Scale and Filtering.



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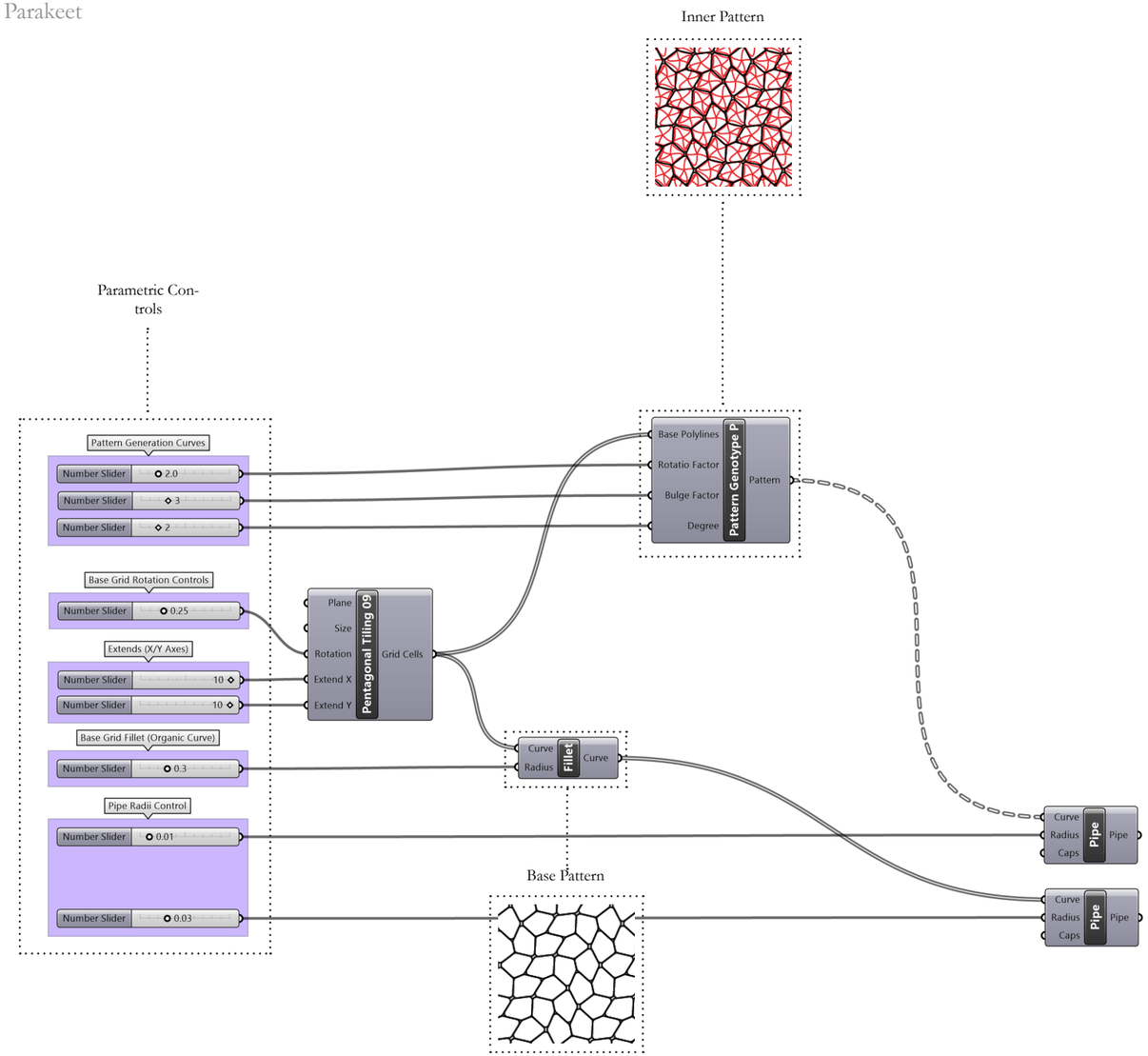
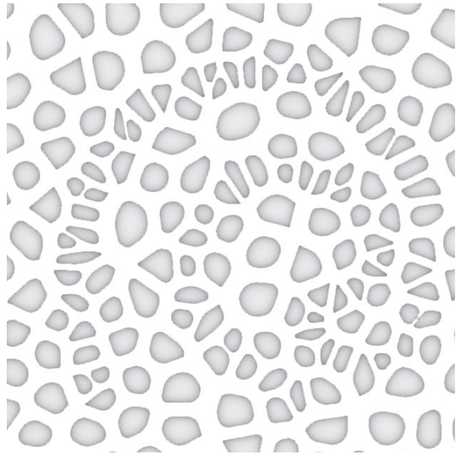
GH Script

Additional Plugins

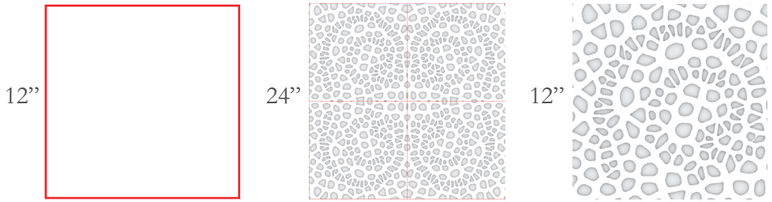
Parakeet



Spiral Morphing Aperture

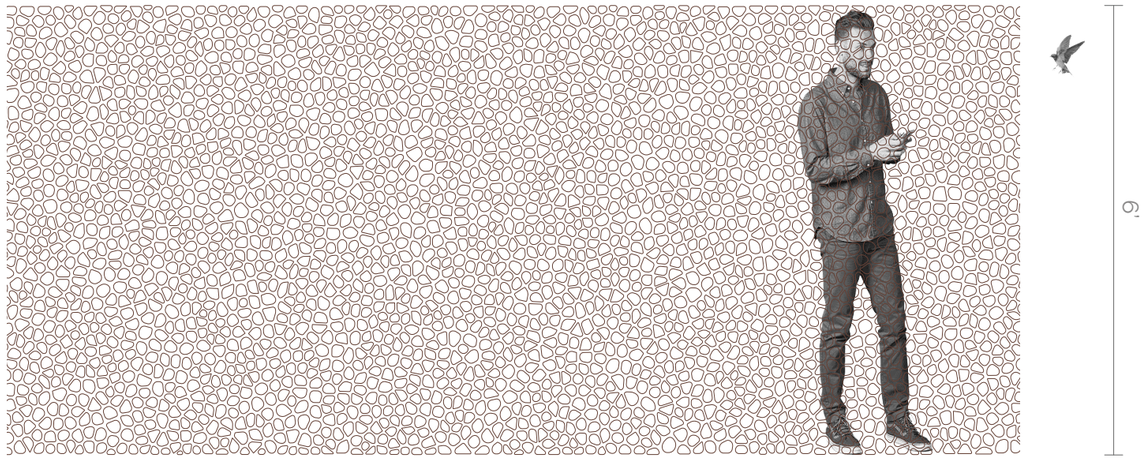


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	38 %



Visualization

Understanding Scale and Filtering.



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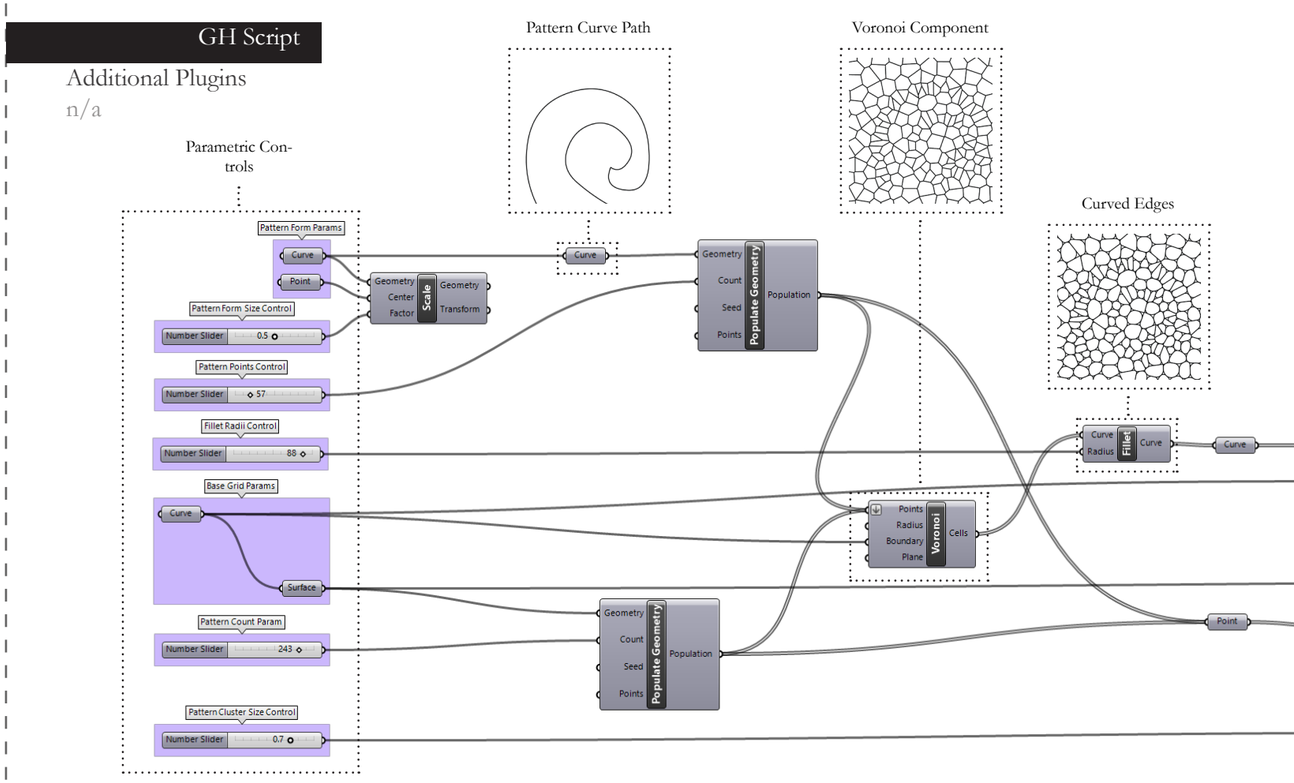
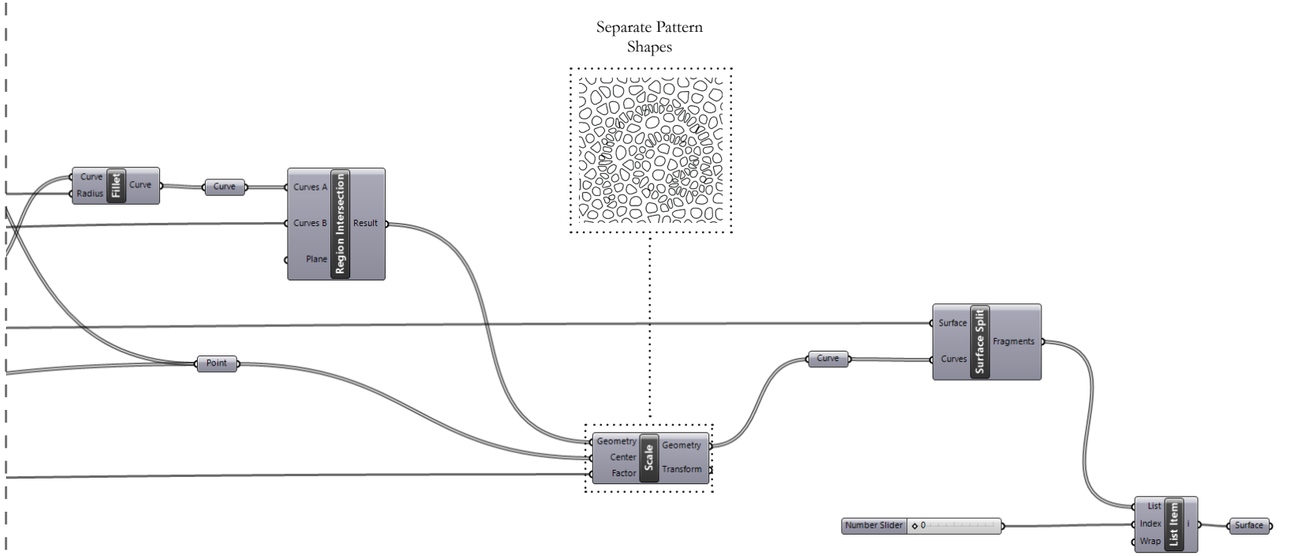
GH Script

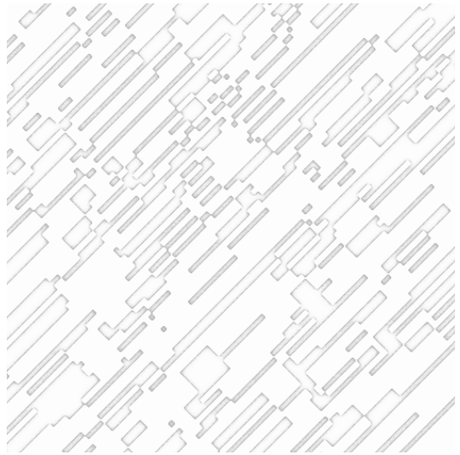
Additional Plugins

n/a

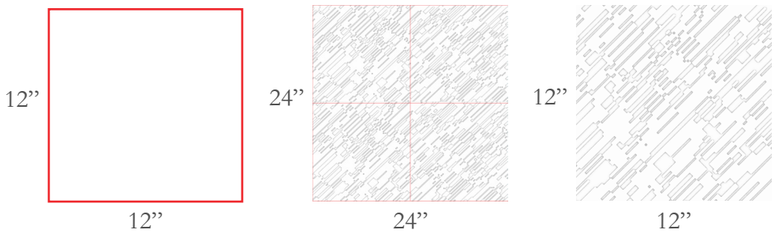




Rectangular Porosity

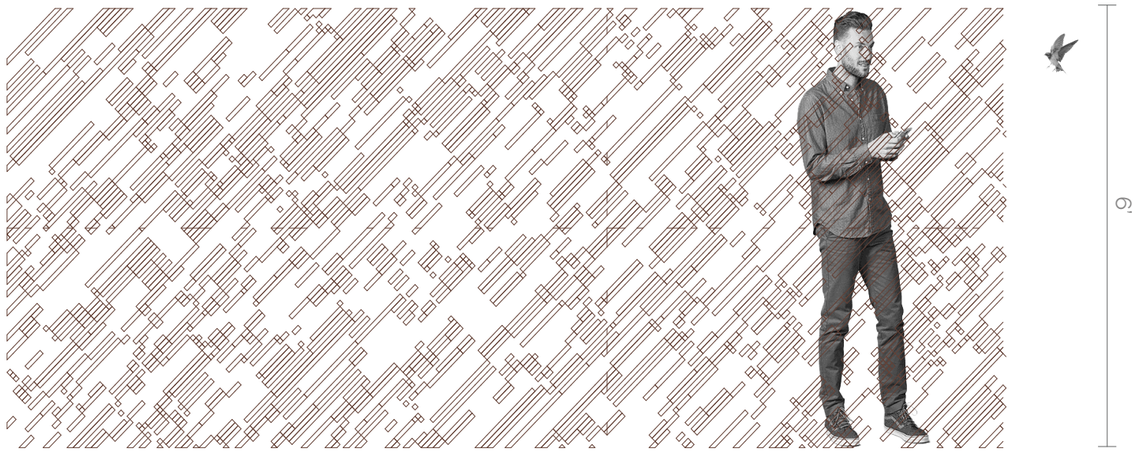


SIZE	Organic
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	36 %



Visualization

Understanding Scale and Filtering.



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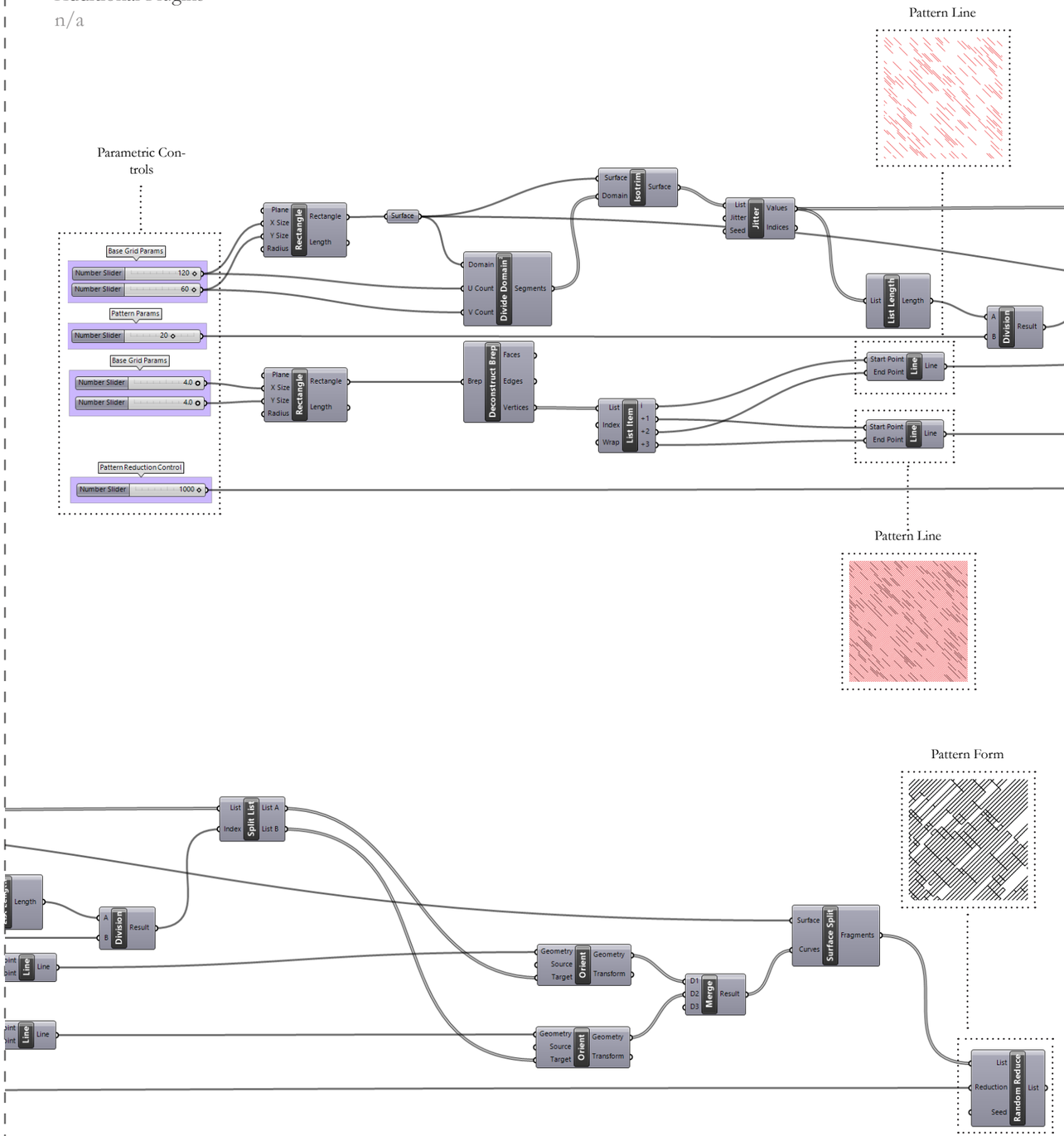
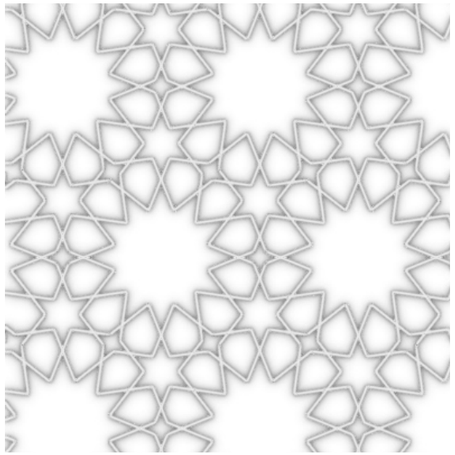
GH Script

Additional Plugins

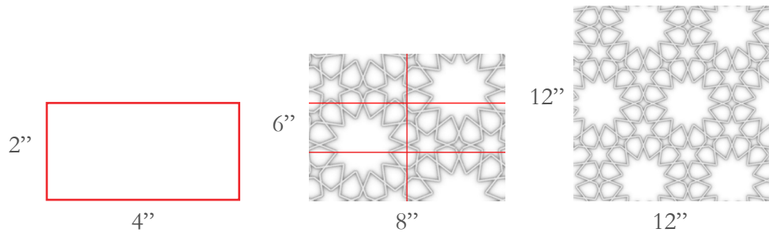
n/a



Geometric lattice 16

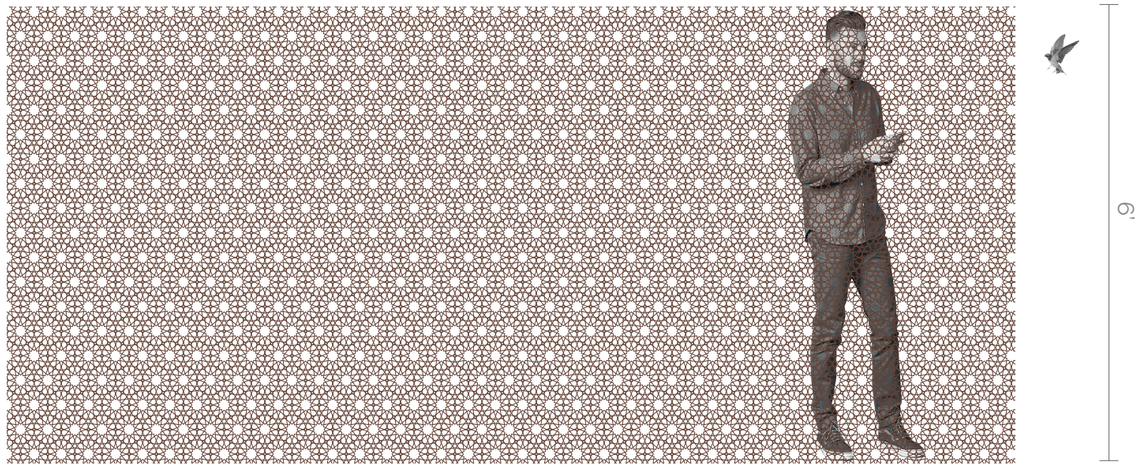


SIZE	2x4 grid
THREAT FACTOR	25*
SOLAR RADIATION REDUCTION	24 %



Visualization

Understanding Scale and Filtering.



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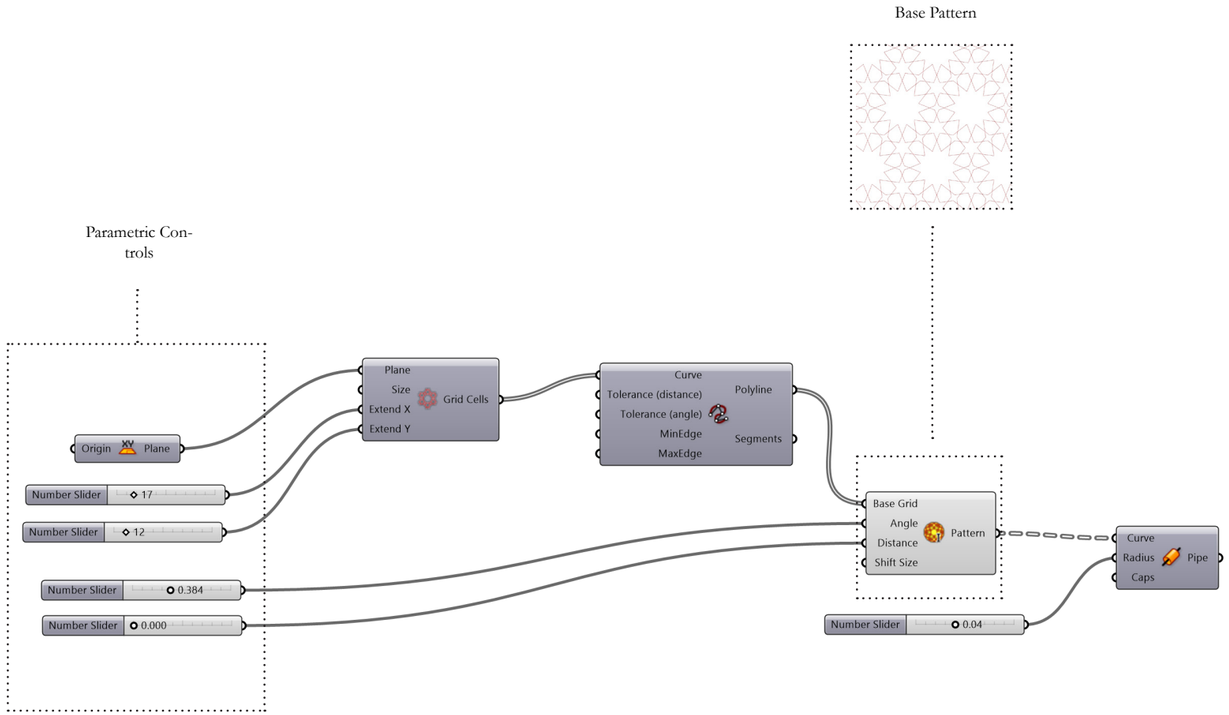
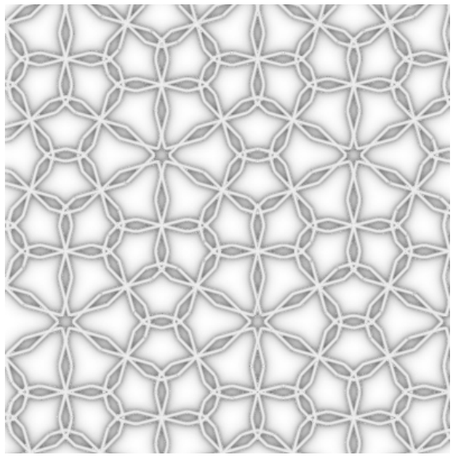
GH Script

Additional Plugins

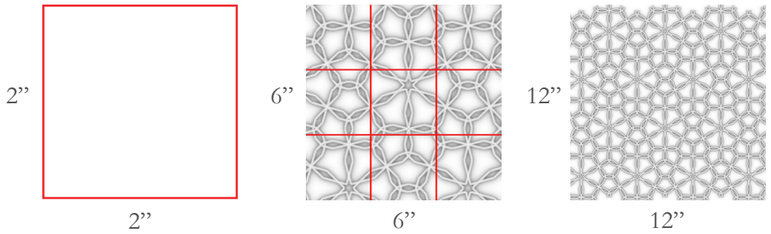
Parakeet



Geometric lattice 17

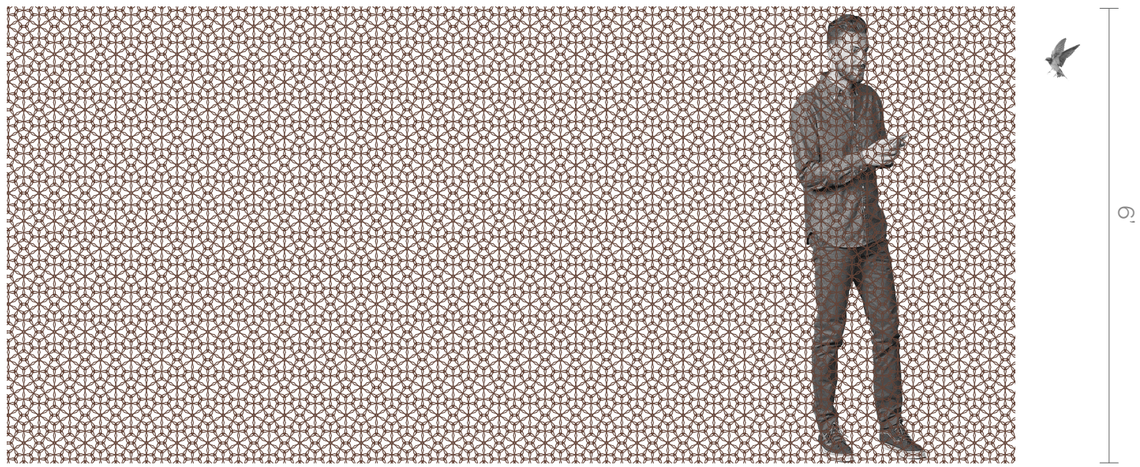


SIZE	2x2 grid
THREAT FACTOR	20*
SOLAR RADIATION REDUCTION	32 %



Visualization

Understanding Scale and Filtering.



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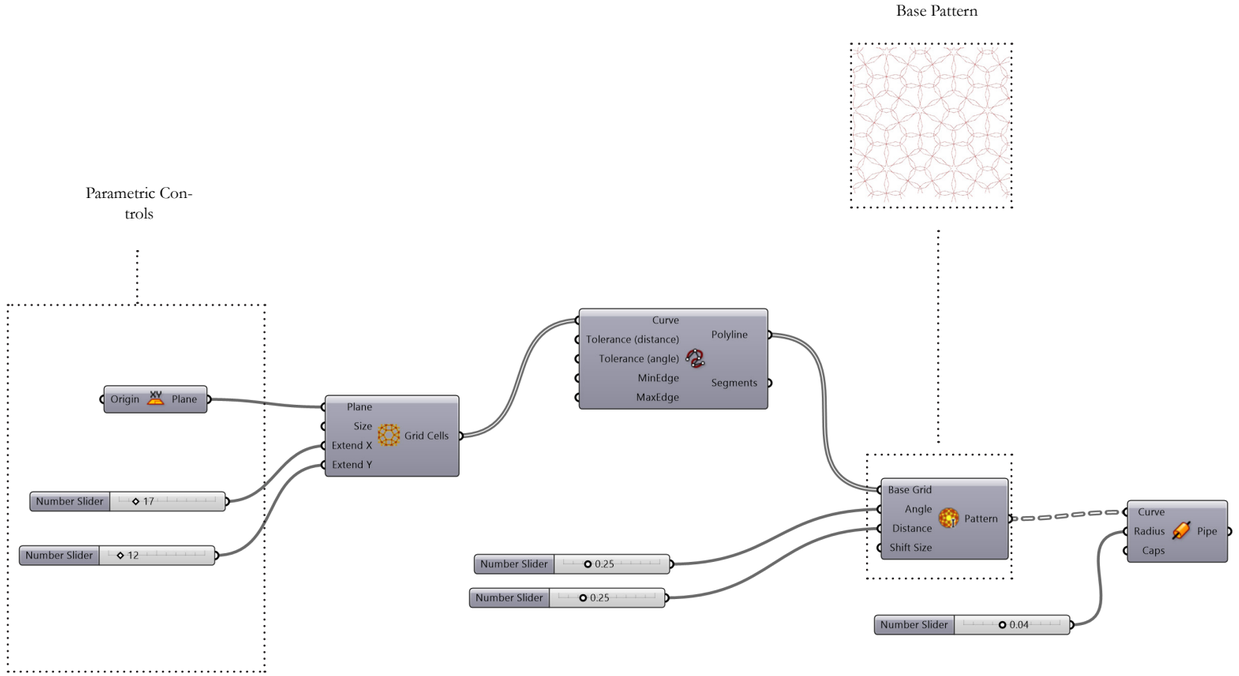
GH Script

Additional Plugins

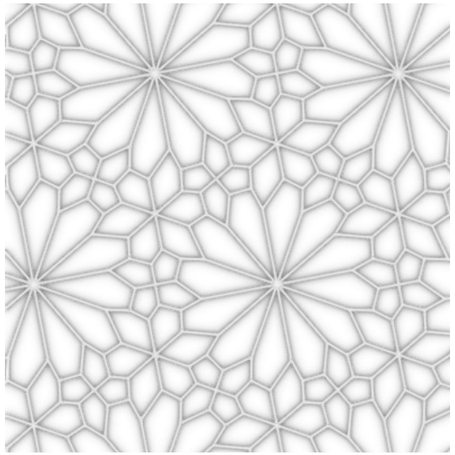
Parakeet



191

192

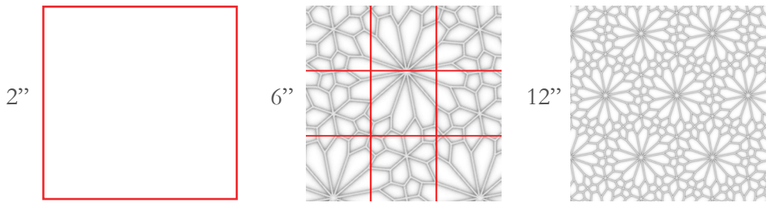
Geometric Flowers



SIZE 2x2 grid

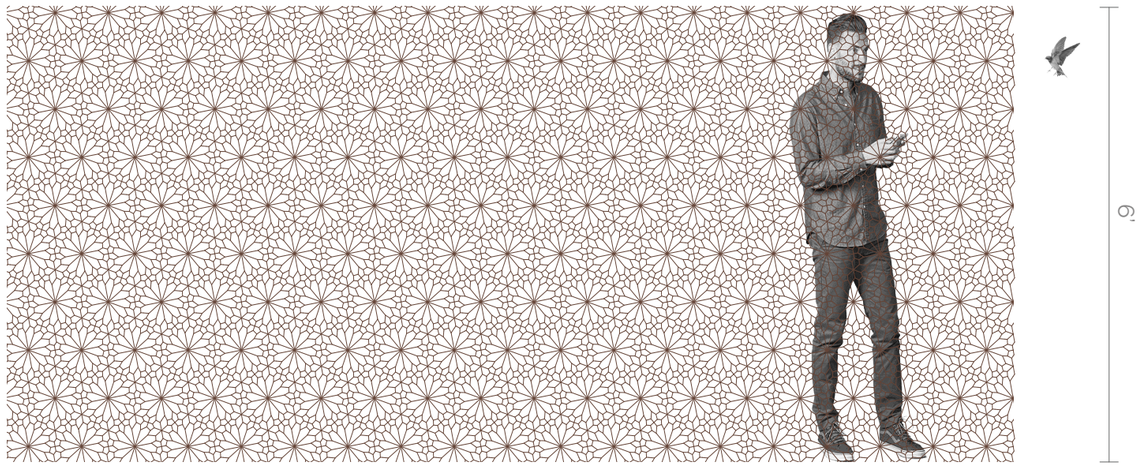
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 18%



Visualization

Understanding Scale and Filtering.



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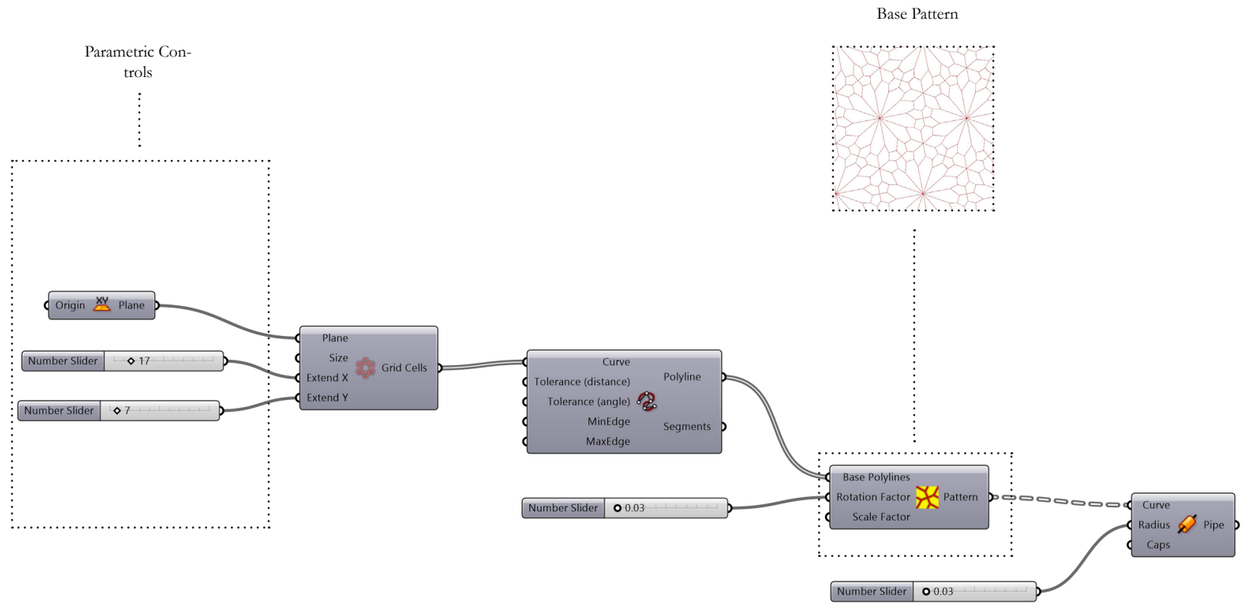
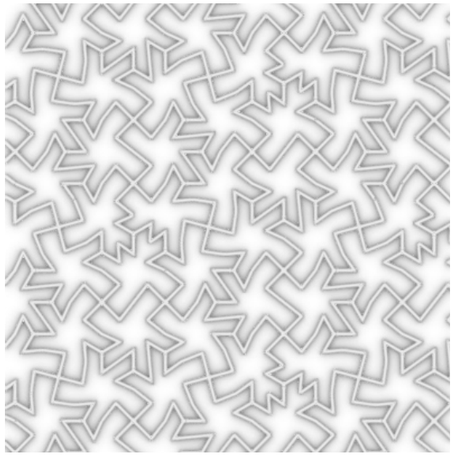
GH Script

Additional Plugins
Parakeet



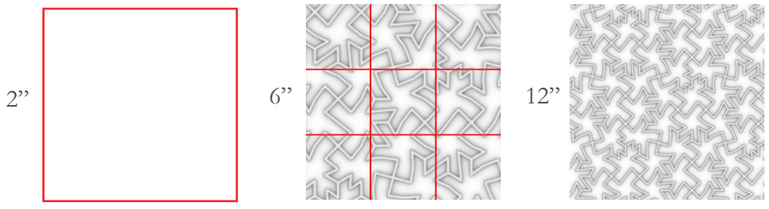
Leaves tile



SIZE 2x2 grid

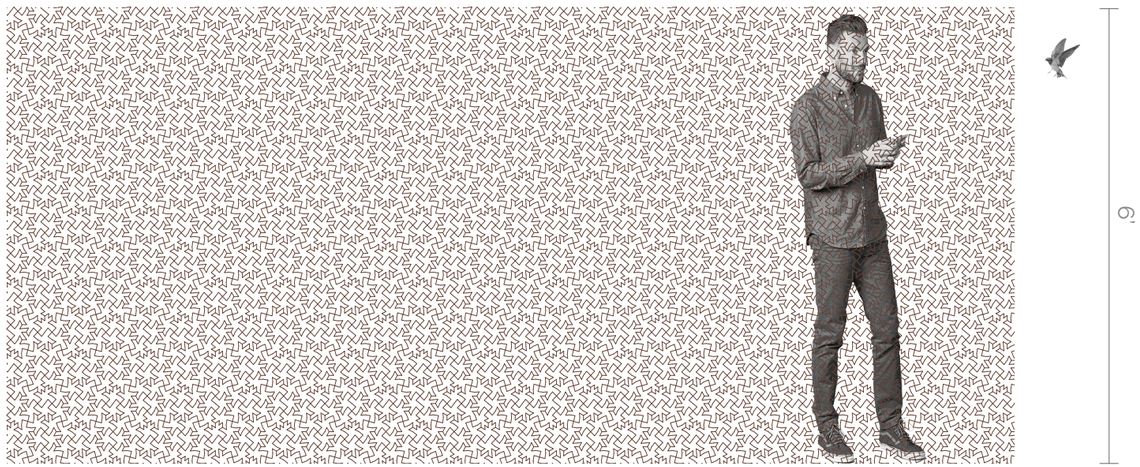
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 23%



Visualization

Understanding Scale and Filtering.



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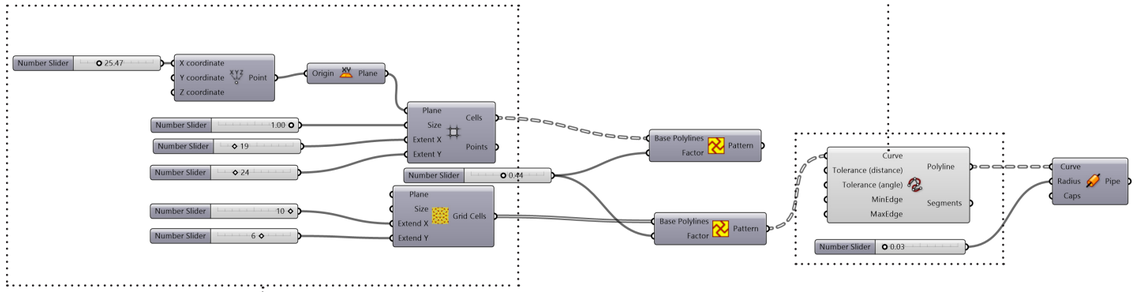
GH Script

Additional Plugins

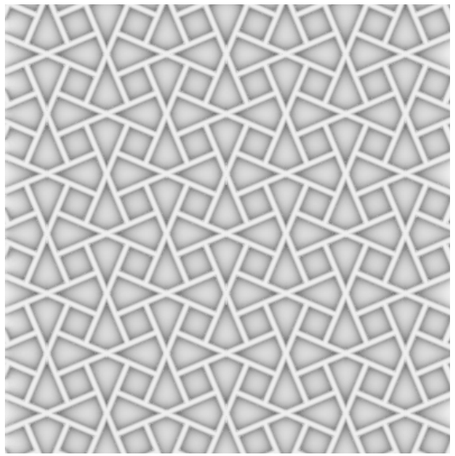
Parakeet

Base Pattern



Parametric Controls

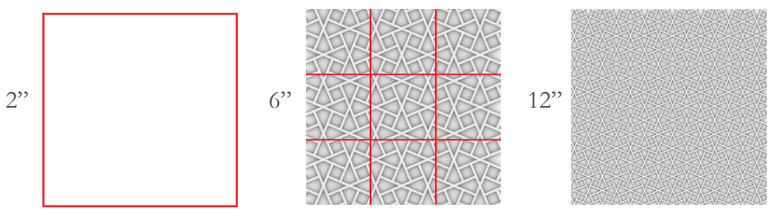
Geometric lattice 18



SIZE 2x2 grid

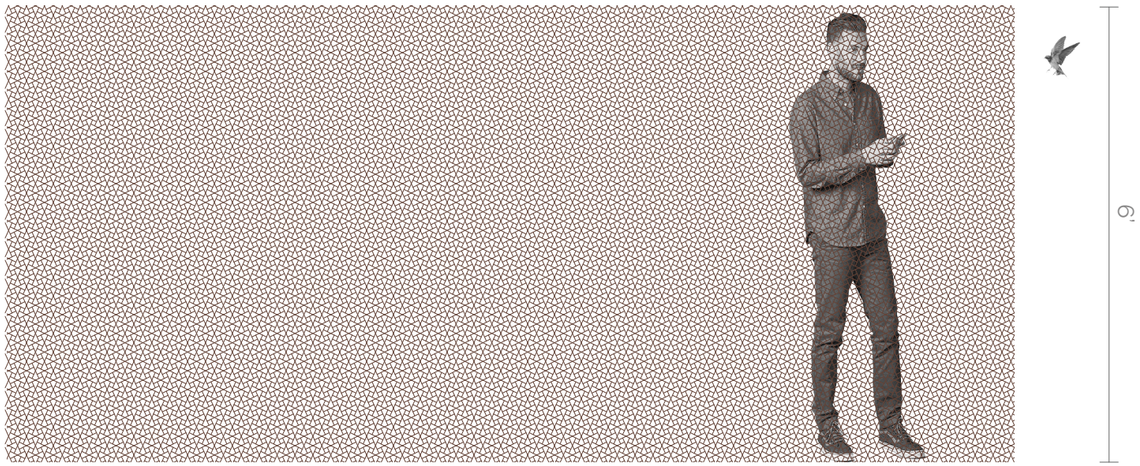
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 41 %



Visualization

Understanding Scale and Filtering.



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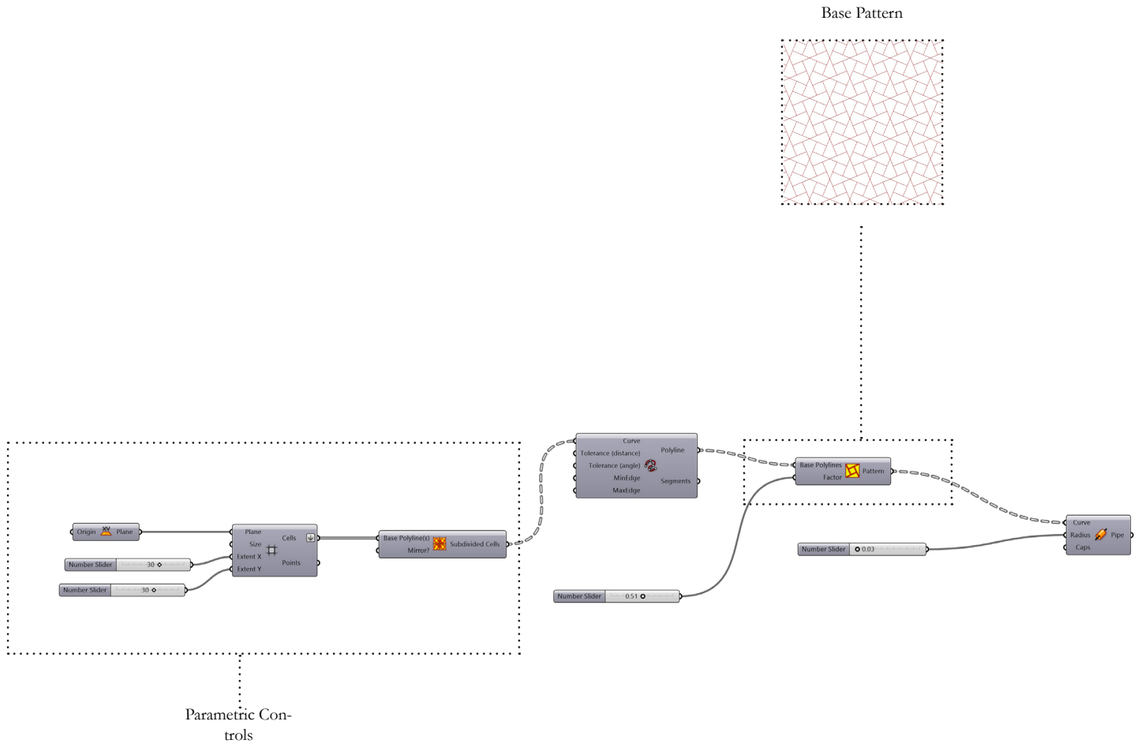
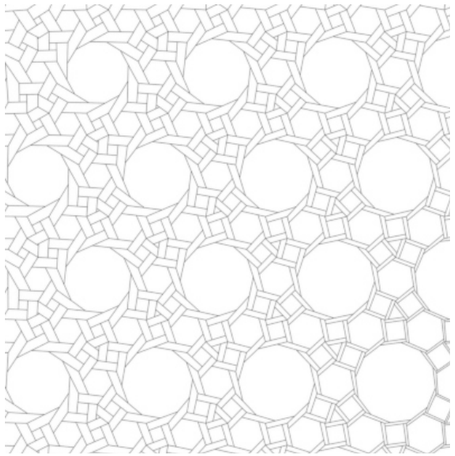
GH Script

Additional Plugins

Parakeet



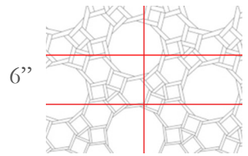
Persian Knots

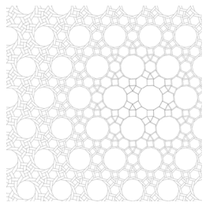


SIZE 2x4 grid

THREAT FACTOR 25*

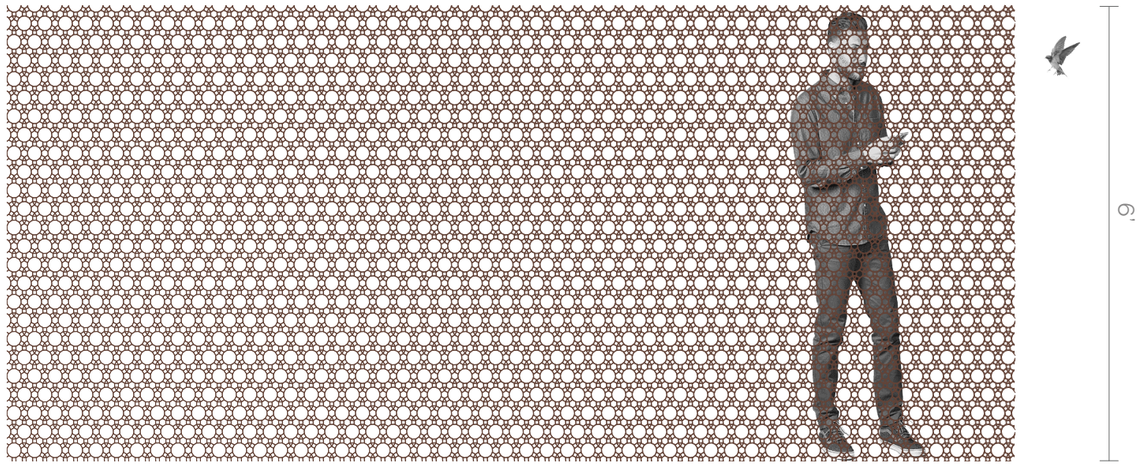
SOLAR RADIATION REDUCTION 10 %





Visualization

Understanding Scale and Filtering.



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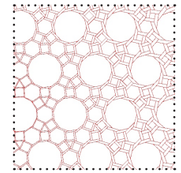
GH Script

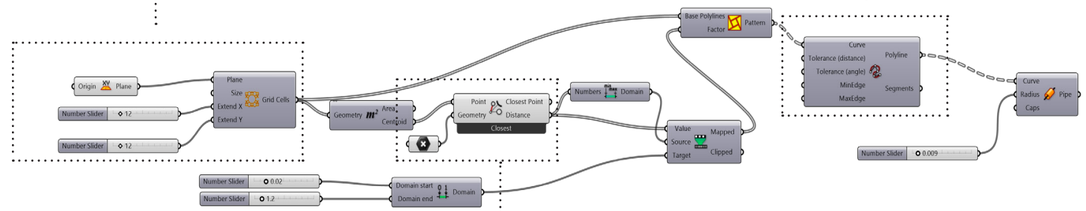
Additional Plugins

Parakeet

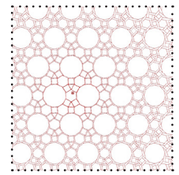
Pattern Generation



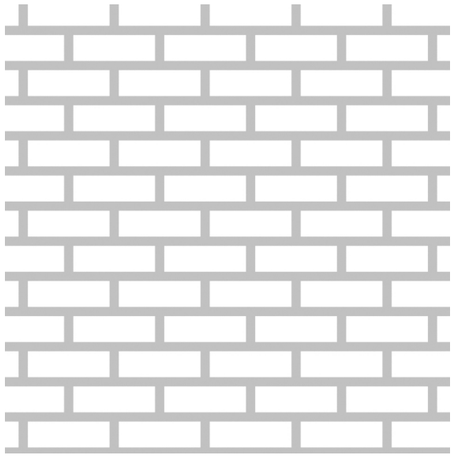
Parametric Controls



Thinner wider Circles



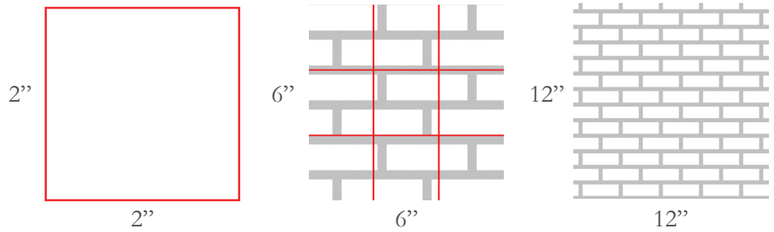
Brick Strips



SIZE 2x2 grid

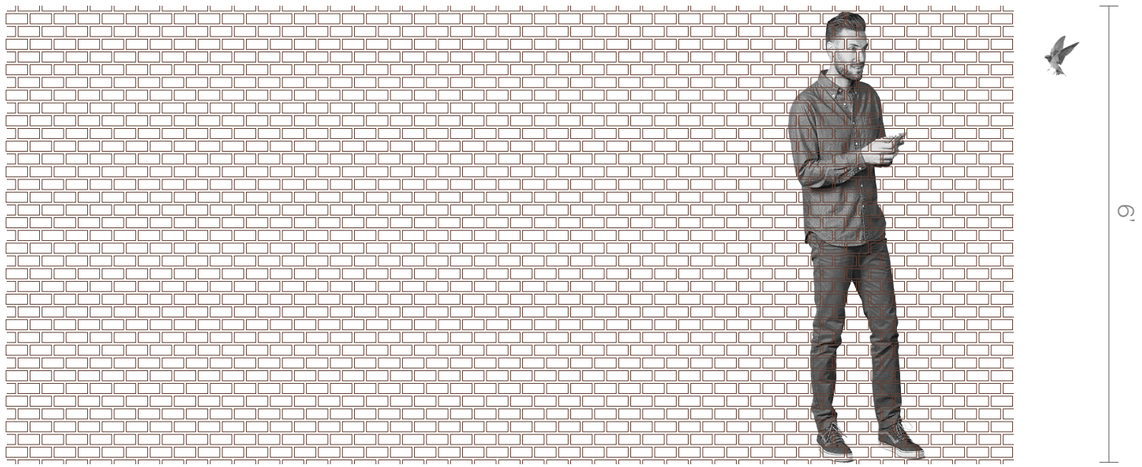
THREAT FACTOR 20*

SOLAR RADIATION REDUCTION 34 %



Visualization

Understanding Scale and Filtering.



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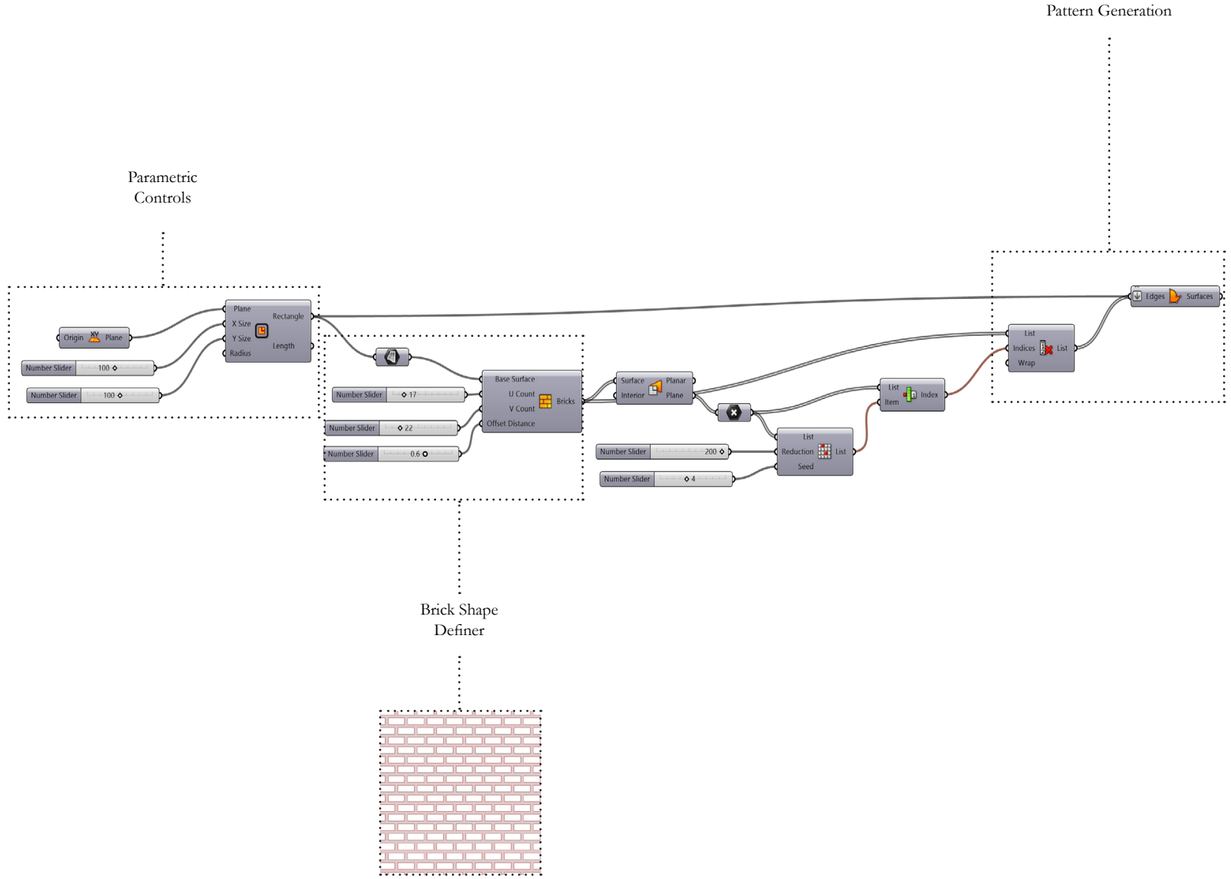
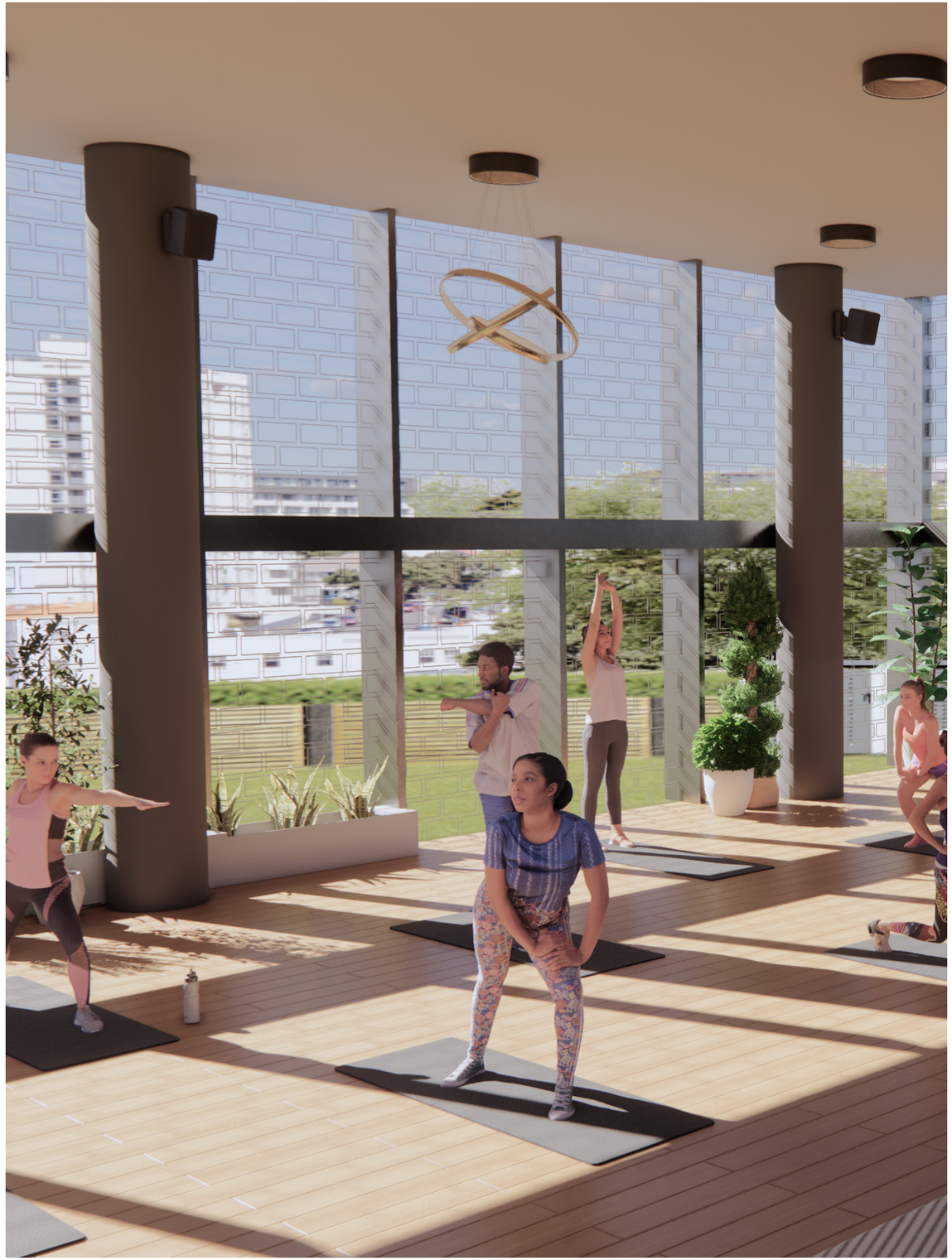
GH Script

Additional Plugins

Parakeet





A Path Forward

As we conclude this book, we find ourselves at a pivotal moment in the journey towards creating bird-friendly environments. The recognition of the dangers posed by glass and the devastating impact on bird populations has led to concerted efforts for change. Through extensive research and collaborative initiatives, significant strides have been made in finding practical solutions that protect our avian friends.

The extensive bird-friendly patterns showcased in these pages offer a practical toolkit for designers and architects to create safer buildings that prioritize the safety of birds. By adhering to specific dimensional constraints and following guidelines set forth by organizations like American Bird Conservancy, these patterns can offer both aesthetic appeal and functionality.

But our work does not end here. The adoption of bird-friendly design must extend beyond the confines of this book. It requires the collective commitment of architects, developers, policymakers, and individuals to prioritize the safety of birds in our built environment. By integrating functional patterns into our buildings, we can create a world where birds can navigate our urban landscapes without unnecessary risks.

The journey towards bird-friendly architecture is a dynamic and evolving process. As we continue to gather data and refine our understanding, it is essential to remain open to new insights and innovative solutions. By embracing continuous improvement, we can ensure that our efforts are effective and adaptive to the needs of both birds and humans.

Our hope is that this book serves as a source of inspiration, and a reminder of the importance of our actions. As we apply these patterns and design principles, we contribute to a more sustainable and harmonious relationship between humans and the natural world. The preservation of bird populations not only enriches our ecosystems but also reminds us of the interconnectedness of all life on Earth.

By embracing bird-friendly architecture, we take a step forward on the path towards a more compassionate and responsible cohabitation with nature.