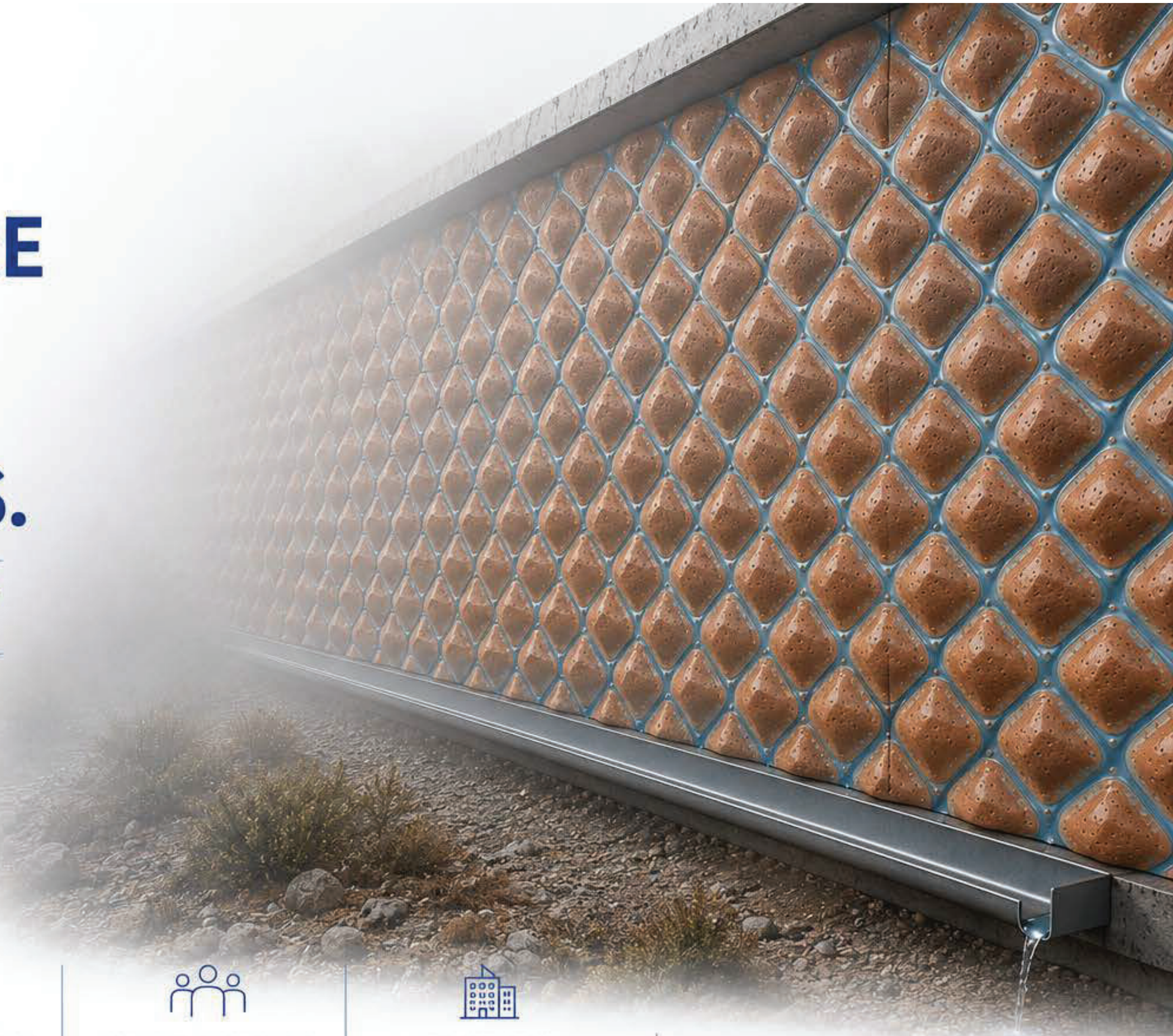
CERAMICS THAT CAPTURE WATER. EMPOWER COMMUNITIES.

BIOINSPIRED ARCHITECTURAL CERAMICS FOR FOG WATER HARVESTING (FWH)

This initiative pioneers architectural ceramic components with bioinspired textures for fog water harvesting (FWH). The proposal advances water self-sufficiency in arid fog prone regions empowering communities by providing accessible clean water by offering a sustainable, durable, nonpolluting alternative to FWH plastic meshes that can be integrated into the built environment.



CAPTURES FOG
Bioinspired textures enhance water collection efficiency.

SUSTAINABLE
Made from natural ceramics. Durable, nonpolluting, and long-lasting.

WATER SELF-SUFFICIENCY
Provides a reliable source of clean water in fog-prone, arid communities.

COMMUNITY EMPOWERMENT
Accessible water solutions that improve health, resilience, and quality of life.

INTEGRATED DESIGN
Architectural ceramic components that seamlessly integrate into the built environment.

INSPIRED BY NATURE. DESIGNED FOR IMPACT.

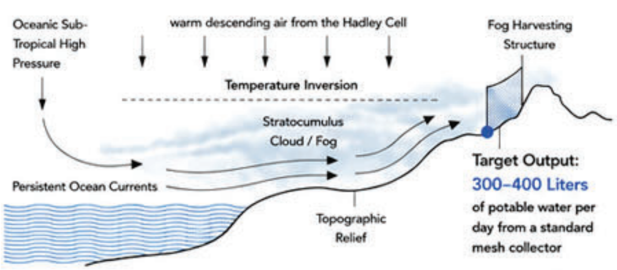
Global Fog Harvesting Potential

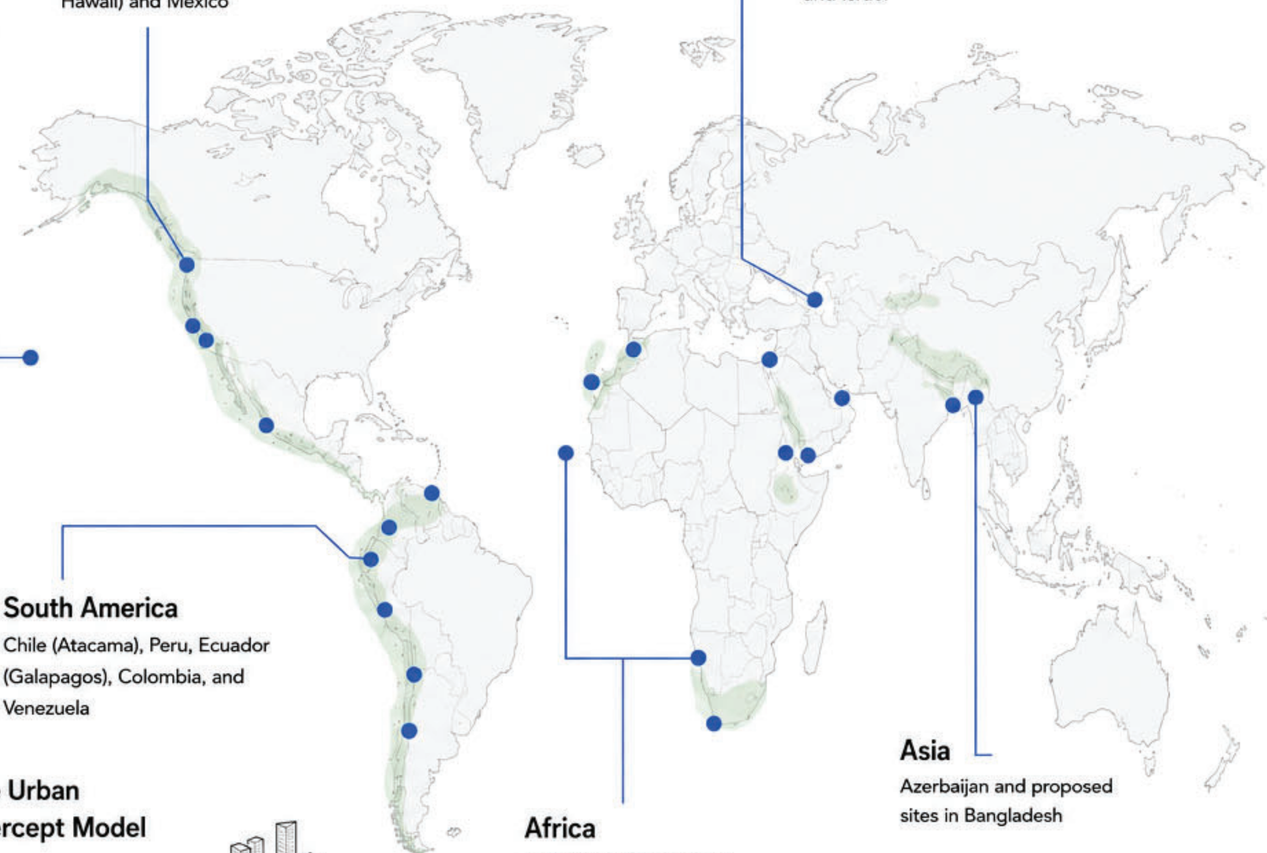
This map identifies regions around the world with the highest potential for atmospheric water collection through fog harvesting.

The most productive sites occur in arid and semi-arid environments where persistent coastal or mountain-generated fog intersects with topographic barriers. Notable hotspots include the Atacama Desert of Chile and Peru, the Namib Desert of Namibia, the Atlantic coasts of Morocco and the Canary Islands, the mountains of Oman, and coastal California.

In these locations, moisture-laden air masses are forced upward by terrain, causing water droplets suspended in fog to condense on collection surfaces. The combination of reliable fog occurrence, prevailing wind patterns, and significant topographic relief creates ideal conditions for intercepting atmospheric moisture and converting it into a viable freshwater resource.

The Fog Capture Model





North America

USA (Coastal California and Hawaii) and Mexico

Middle East

Oman (Dhofar), Yemen, Saudi Arabia, and Israel

South America

Chile (Atacama), Peru, Ecuador (Galapagos), Colombia, and Venezuela

Africa

Namibia (Namib Desert), South Africa (West Coast), Morocco (Anti-Atlas), Eritrea, Ethiopia, Cape Verde, and the Canary Islands

Asia

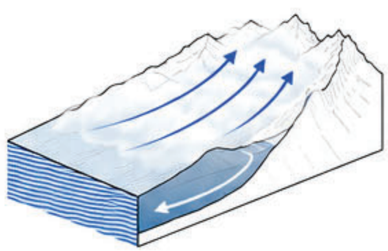
Azerbaijan and proposed sites in Bangladesh

The Mechanics of Atmospheric Moisture

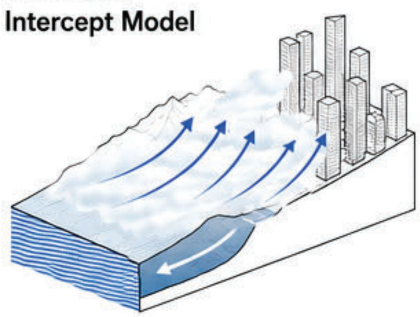
The Climatic Triad

1. **Coastal Advection Fog**
   Driven by cold oceanic currents.
2. **Persistent Winds**
   Consistent directional airflow to transport the moisture.
3. **Topographic Relief**
   Mountains and ridges to intercept the fog layer.

The Topographic Intercept Model



The Urban Intercept Model



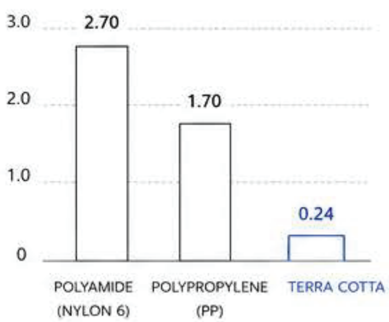
Why Terra Cotta for Fog Harvesting Surfaces?

Current fog harvesting technology relies almost exclusively on plastic meshes. These synthetic materials present critical performance, environmental, and processing limitations that hinder long-term sustainability and architectural integration. Terra cotta offers a rigid, mineral-based alternative with a significantly lower environmental profile and greater durability.

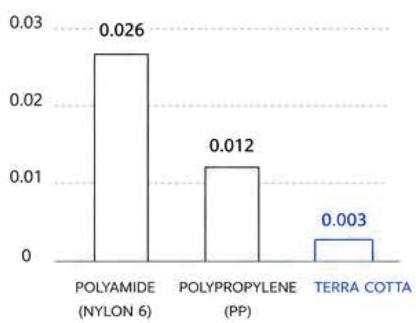
Terra cotta exhibits significantly lower global warming potential and acidification potential compared to high-embodied-energy polyamides.

ENVIRONMENTAL PERFORMANCE (CRADLE-TO-GATE)

GLOBAL WARMING POTENTIAL (GWP)
kg CO_2-eq / kg material



ACIDIFICATION POTENTIAL (AP)
kg SO_2-eq / kg material



CURRENT FOG HARVESTING TECHNOLOGY

PLASTIC MESH INSTALLATIONS

TEARING UNDER HIGH WIND

UV DEGRADATION AND BRITTLENESS

MATERIAL COMPARISON

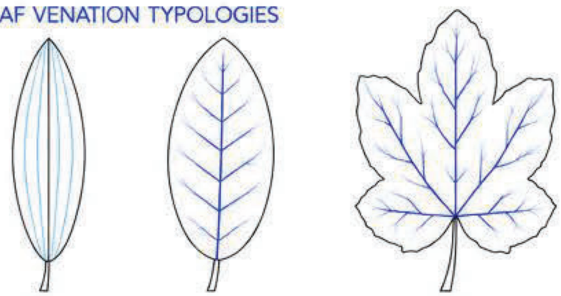
CRITERIA	PLASTIC MESHES (POLYPROPYLENE, PE, NYLON)	TERRA COTTA: A RIGID, MINERAL-BASED ALTERNATIVE
DURABILITY (WIND RESISTANCE)	Prone to tearing and fatigue under high wind loads (> 17 m/s) WIND LOAD (SAIL EFFECT) > 17 m/s	Rigid and stable; no sail effect Long-term durability in outdoor environments
ENVIRONMENTAL IMPACT	High GWP and AP Emits chlorine gas, dioxins, and nitrous oxide Difficult to recycle; toxic fumes when burned Cl_2 DIOXINS N_2O	Low GWP and AP Natural, inert, and non-toxic Fully recyclable and non-combustible
THERMAL STABILITY	Melts or deforms under coating/curing temperatures (~ 100–150 °C)	Stable at high temperatures (> 1000 °C) > 1000 °C
STRUCTURAL BEHAVIOR	Flexible; deforms under load	Rigid; retains geometry and alignment
SURFACE FUNCTIONALITY	Limited tunability; coatings may not bond well or degrade	Highly compatible with durable mineral coatings
SERVICE LIFE	Shorter lifespan; UV degradation and brittleness	Long-term durability in outdoor environments

Biomimetic patterning for Flow Optimization

Leaf Venation as a Model for Fog Harvesting Terra Cotta

Natural leaf venation networks efficiently collect, transport, and distribute water through hierarchical branching systems. This research translates these biological principles into architectural terra cotta surfaces that enhance fog capture, directional transport, and water collection through geometry alone.

LEAF VENATION TYPOLOGIES



CATEGORY II (PINNATE) = HIGHEST ARCHITECTURAL POTENTIAL

- Combines directional flow with distributed collection
- Balances efficiency and constructability
- Most effective for architectural applications

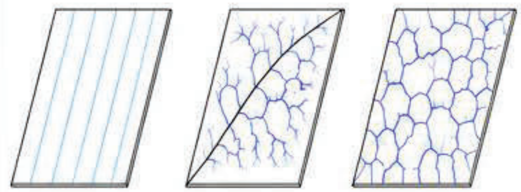
HIERARCHICAL LEAF PATTERN

PRIMARY VEINS
Long-distance transport and structural backbone

SECONDARY VEINS
Local collection and distribution

TERTIARY VEINS
Distributed capture and nucleation

HIERARCHICAL PATTERN TYPOLOGIES



COMPLETELY LINEAR (e.g., parallel veins)

HYBRID LINEAR-NETWORKED (linear major veins with networked secondary veins)

COMPLETELY NETWORKED (e.g., Voronoi patterns)

Hybrid linear-networked patterns (Category II) provide the best balance of directional transport and distributed collection, resulting in the highest efficiency for fog harvesting architectural surfaces.

GEOMETRIC OPTIMIZATION FACTORS

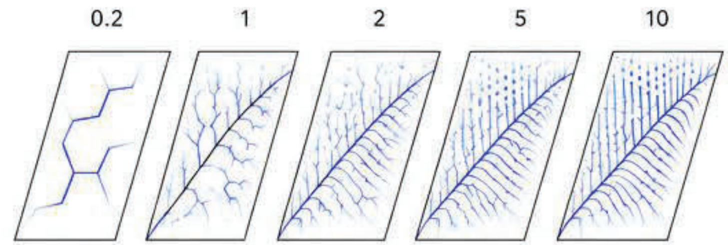
SECONDARY VEINING
Higher-order (secondary and tertiary) veins significantly improve drainage from the margins to the center.

ROUNDED EDGES
Surfaces that combine a central vein with rounded edges outperform strictly linear hierarchical patterns.

VORONOI TEXTURES
Irregular cell geometries increase nucleation sites for droplet capture and coalescence.

HIERARCHICAL NETWORKS
Multi-order branching improves connectivity and transport resilience across scales.

NETWORK DENSITY + CONNECTIVITY



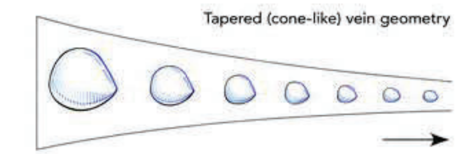
Higher-order (more branches) = shorter transport paths and greater collection efficiency

Increasing branching density shortens transport distances and increases collection efficiency.

DIRECTIONAL TRANSPORT

Laplace pressure gradients generated by asymmetric curvature drive passive droplet coalescence and autonomous transport toward central collection channels without external energy.

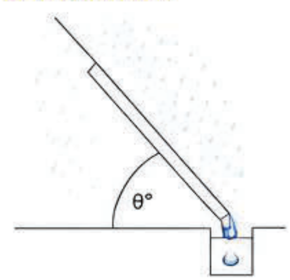
DIRECTIONAL TRANSPORT PRINCIPLE



High Laplace pressure (broad tip)

Low Laplace pressure (narrow end)

OPTIMUM ANGLE

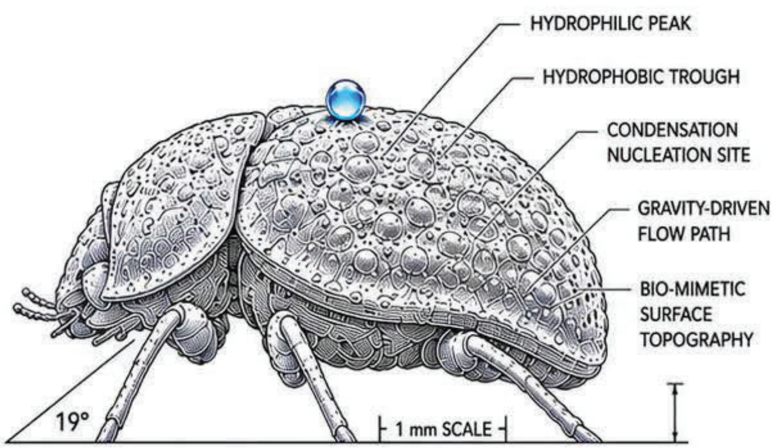


200–400%
Increase in fog collection efficiency compared to simple, non-planar surfaces.

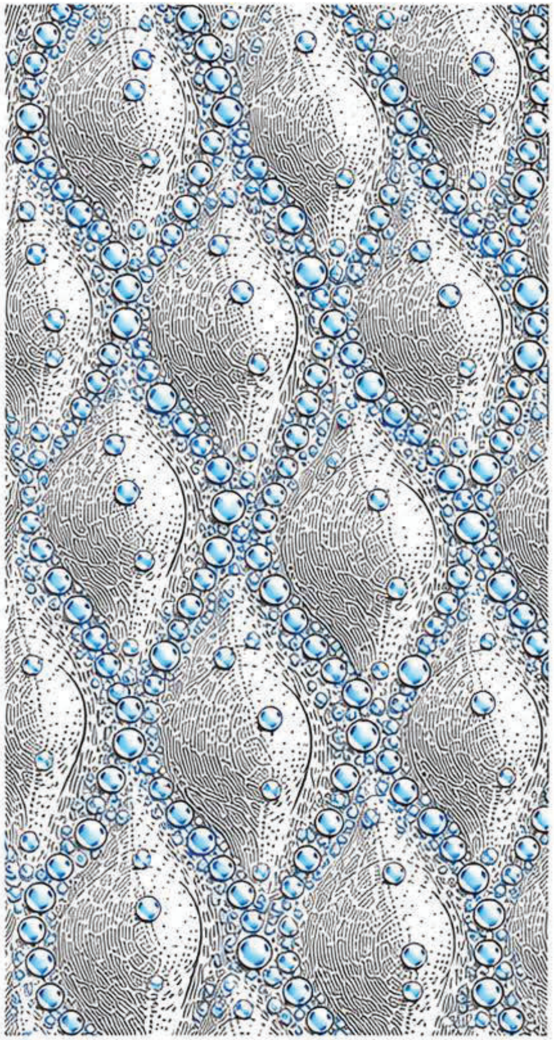
60°
Optimal collection angle for maximum yield based on experimental studies.

Biomimetic Surface Micro-Patterning

The Inspiration: *Stenocara gracilipes* Hydrophilic Leaves



- **Habitat:** Namib Desert (<13mm annual rain; ~30 days of fog).
- **Surface Structure:** Dorsal shell covered in random microscopic bumps (0.5mm diameter, 1–1.5mm pitch).
- **Wetting Nature:** Hydrophilic (water-attracting) peaks surrounded by waxy, hydrophobic (water-repelling) valleys.
- **Method:** Fog basking.

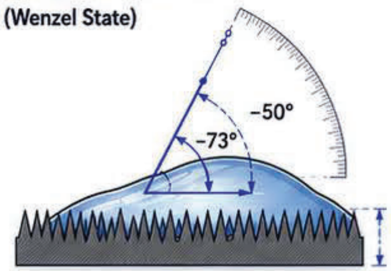


The Engineered Solution: Hybrid Surface

- **Habitat:** Highly scalable natural material.
- **Surface Structure:** Precise grid of printed glaze and clay.
- **Wetting Nature:** Hydrophilic (water-attracting) peaks in a hydrophobic (water-repelling) glazed matrix.
- **Method:** Additive manufacturing, slip casting, robotic glaze printing.

The Physics of Wettability

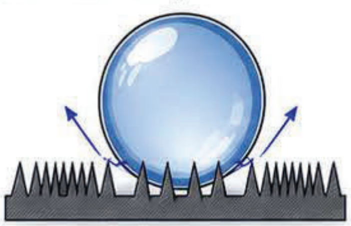
Profile 1:
Homogeneous Hydrophilic (Wenzel State)



Low contact angle (Advancing: ~73°, Receding: ~50°). Water spreads flat, penetrating surface asperities.

Result: Excellent at catching water, terrible at letting it go.

Profile 2:
Homogeneous Superhydrophobic (Cassie–Baxter State)

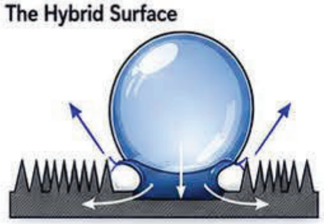


High contact angle

Air pockets exist beneath the droplet, forcing it into a perfect sphere.

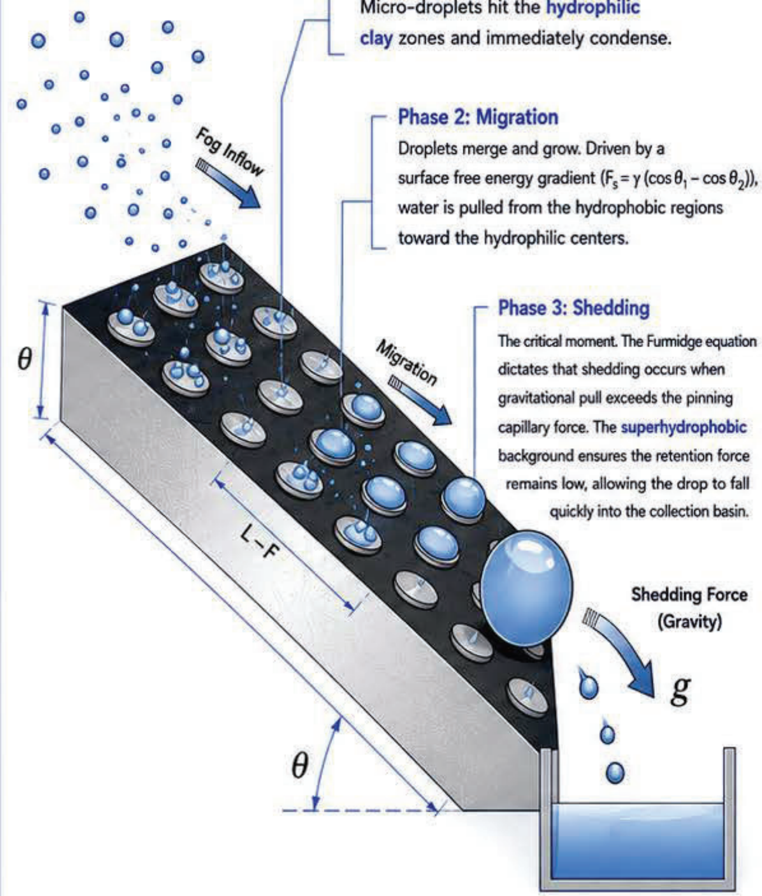
Result: Excellent at shedding water, terrible at catching it.

Profile 3:
The Hybrid Surface



A controlled collision of states. It forces a wetting transition where droplets anchor to the hydrophilic centers but roll off effortlessly once they overflow onto the **hydrophobic** perimeter.

The Droplet Migration Engine



Phase 1: Capture
Fog density dictates the initial collision. Micro-droplets hit the **hydrophilic clay** zones and immediately condense.

Phase 2: Migration
Droplets merge and grow. Driven by a surface free energy gradient ($F_s = \gamma(\cos\theta_1 - \cos\theta_2)$), water is pulled from the hydrophobic regions toward the hydrophilic centers.

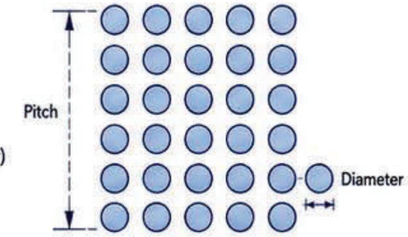
Phase 3: Shedding
The critical moment. The Furmidge equation dictates that shedding occurs when gravitational pull exceeds the pinning capillary force. The **superhydrophobic** background ensures the retention force remains low, allowing the drop to fall quickly into the collection basin.

Engineering the Geometry of Collection

Balancing the **Pitch-to-Diameter** Ratio

The Variables:

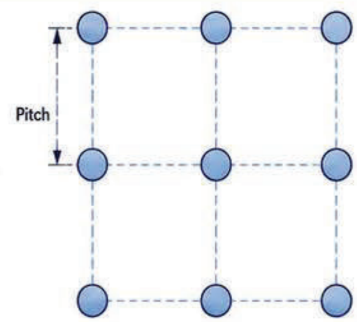
The efficiency of fog harvesting relies on the ratio of the **hydrophilic area** (the catcher) to the **hydrophobic area** (the slide).



Layout A: Closely Packed

The Test Matrix:

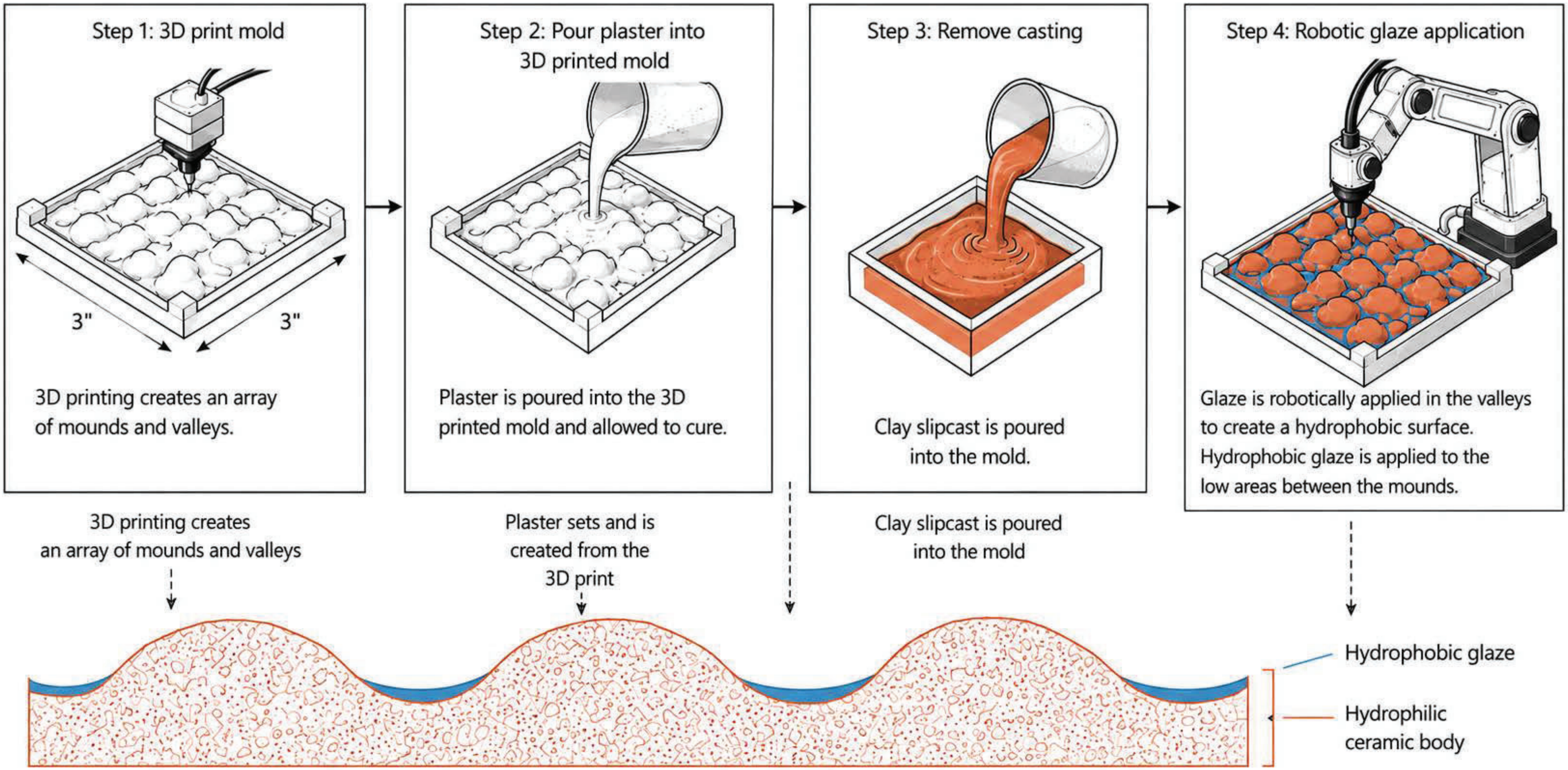
- **Bump Diameters** to be tested: 400 µm and 500 µm
- **Pitches** (Distance between Bump) tested across a range relative to the diameter.
- **Goal:** Find the optimal geometry that maximizes collection before evaporation occurs.



Layout B: Widely Spaced

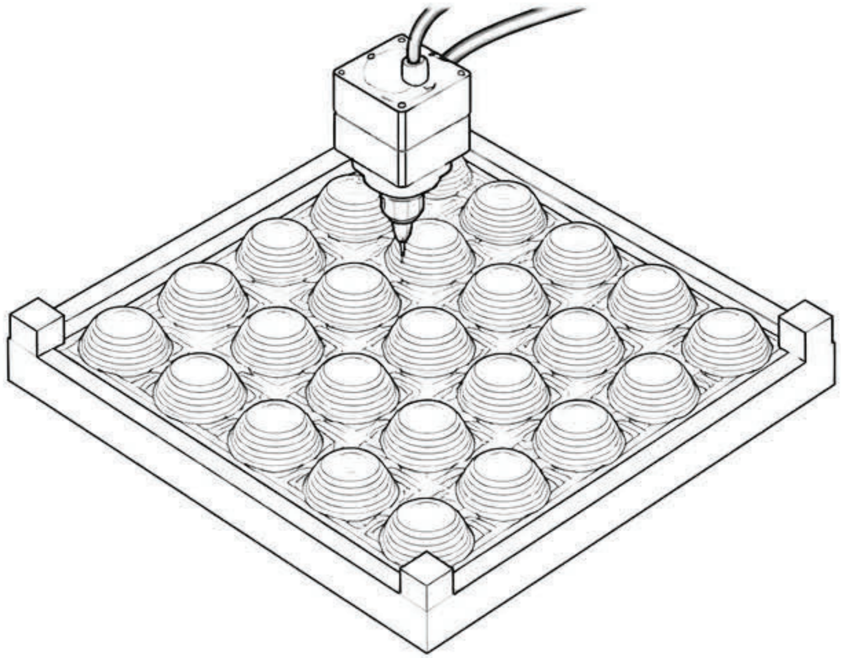
Initial experiments will be done with small samples — with varied patterns of glazed and unglazed clay.

Prototyping Initial tests



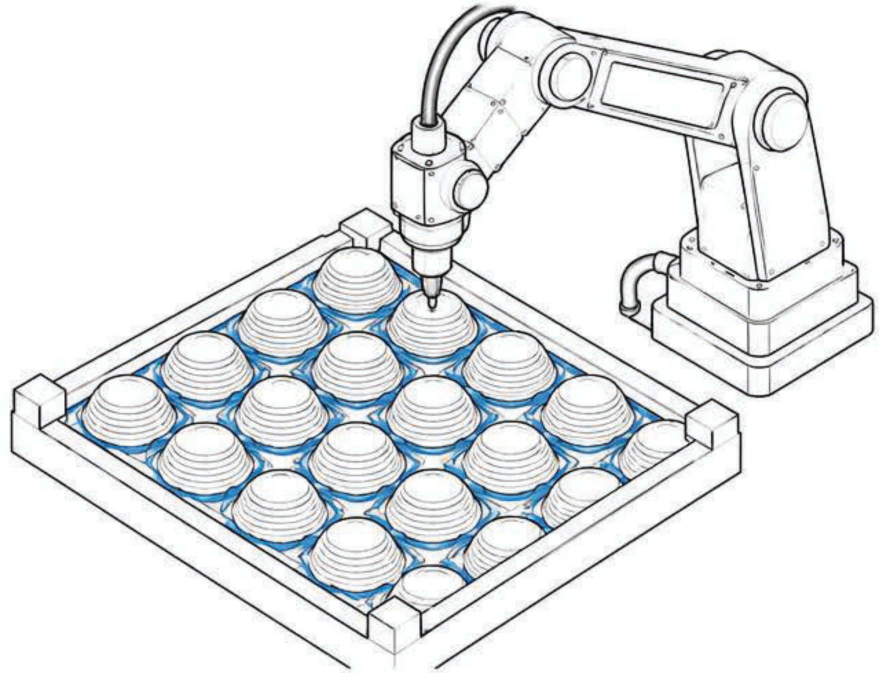
Prototyping II: 3D Printed Ceramic Variations

Step 1: Ceramic 3D print



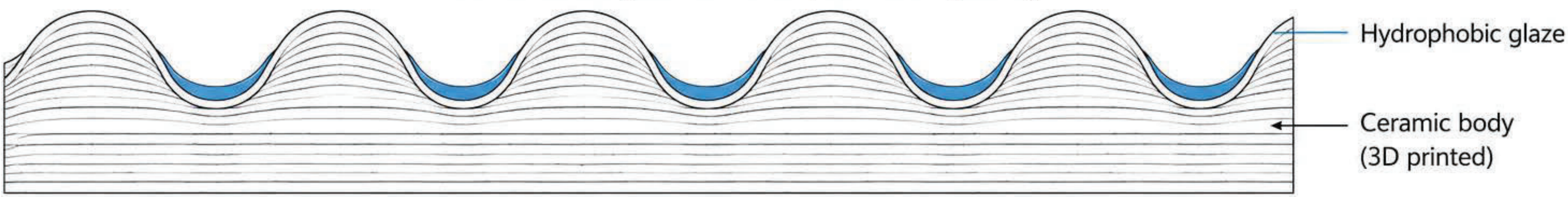
Ceramic material is 3D printed to create an array of mounds with connected valleys.

Step 2: Robotically glaze

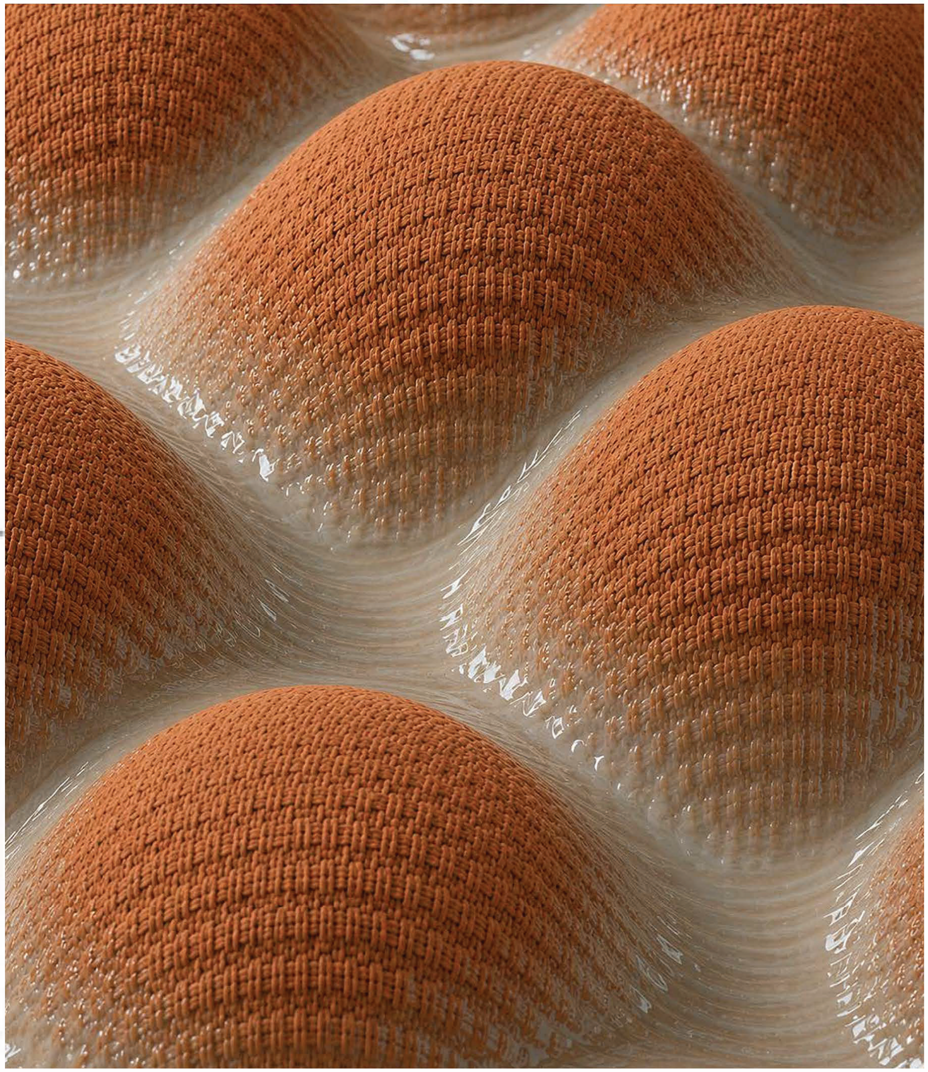


Glaze is robotically applied to the valleys to create a hydrophobic surface.

Section through ceramic 3D print after glazing

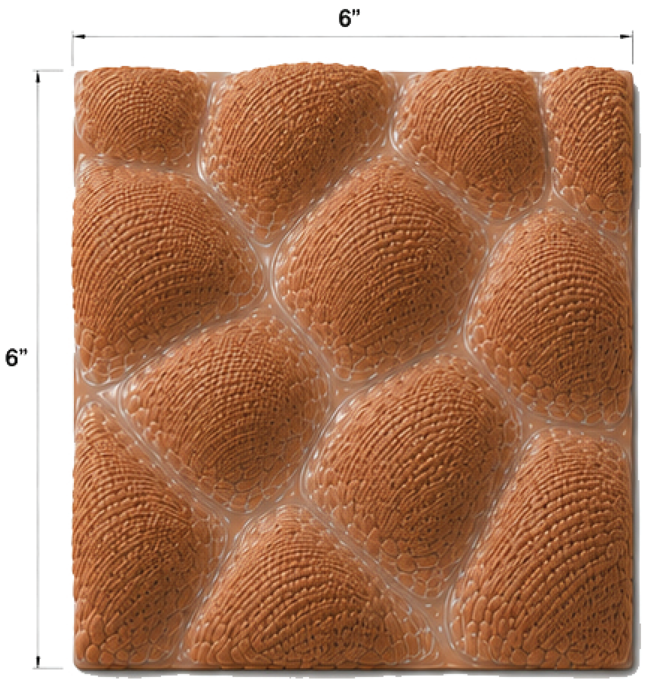


Slip Casr porous ceramic with white glaze

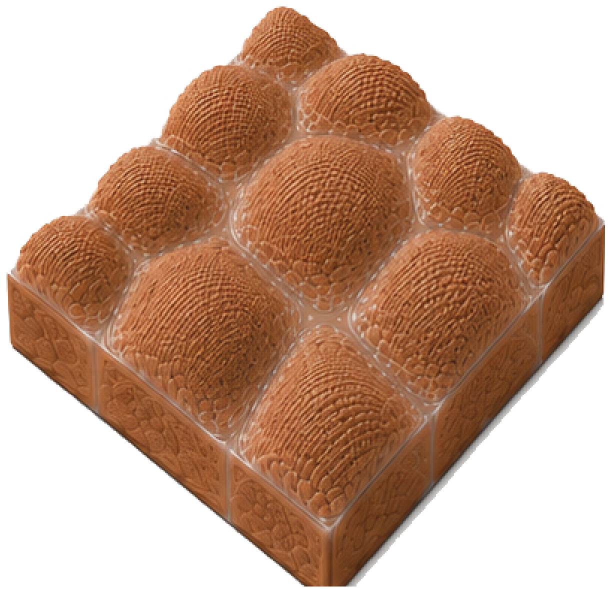


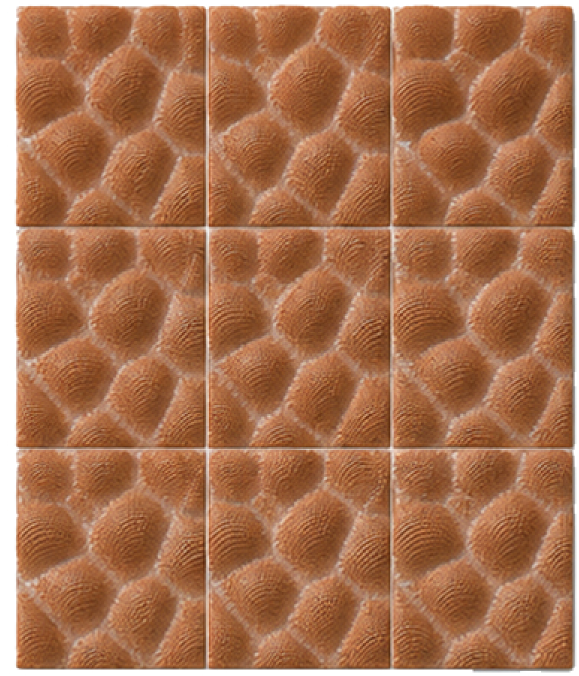
Ceramic 3D Printed texture and white glaze

Ceramic 3D Printed Iteration 1: Networked Hydrophobic Paths



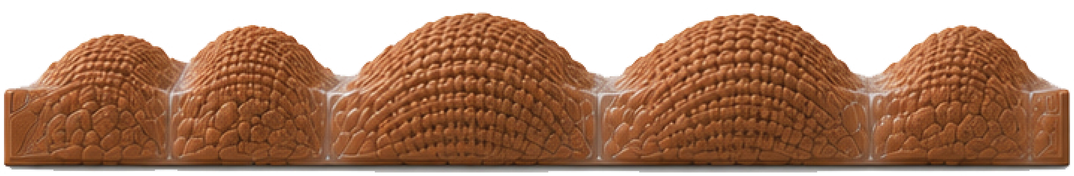
PLAN VIEW





PATTERN LAYOUT EXAMPLE

FRONT ELEVATION



DESIGN MODULAR TILES FOR SMART FACADES

Once the parameters for catchment and flow are established, it is possible to consider the different leaf veining patterns, and assess those for optimization. It also proveides a set of parameters that can be made into a pugin to allow designers to workout their own macro patterns.

TILE VARIATIONS

ORGANIC

Soft, biomorphic flow

INTERMEDIATE

Balanced organic and geometric patterns

GEOMETRIC

Clean, directional geometry

MODULAR PANEL (3×3 TILES)

Integrate into rainscreen systems for atmospheric water harvesting and urban water self-sufficiency.

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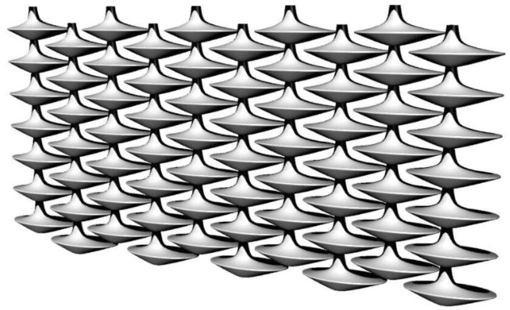
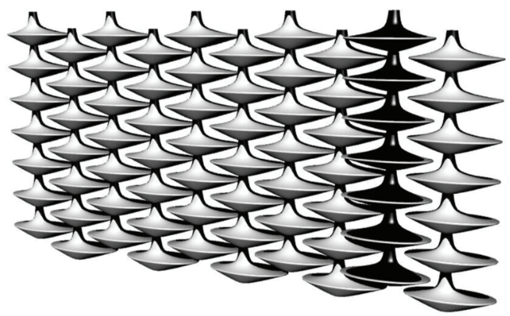
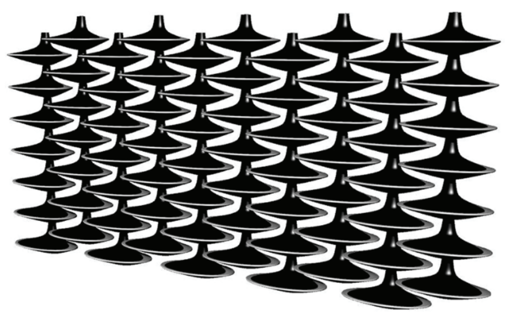
A Catalogue of recent work
in Architectural Ceramics

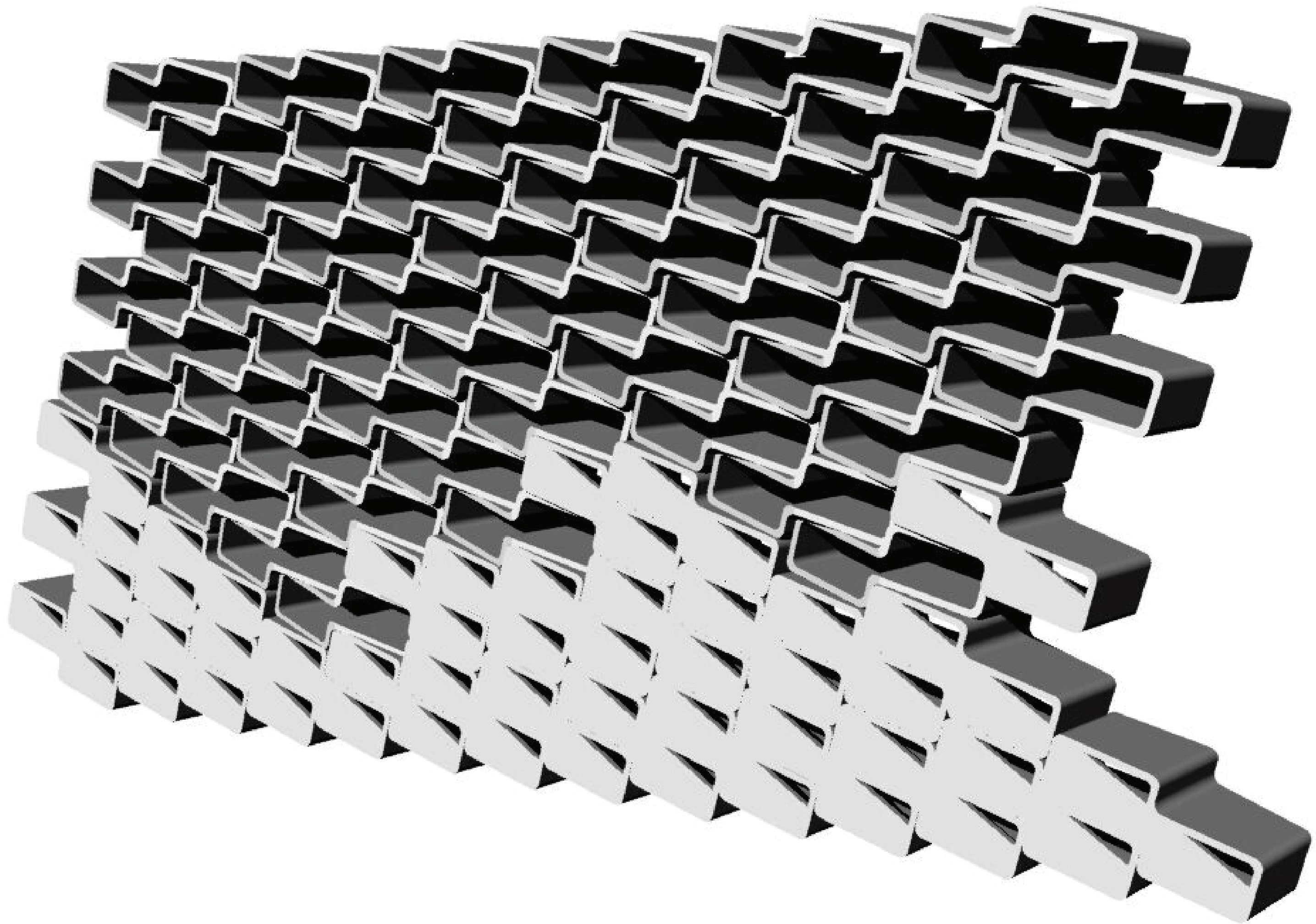
Vessels- Imagine a screen composed of vessels filled with oil that can absorb and radiate heat. Facing outward the vessels can absorb the heat of the winter sun. Facing inward their backside reflects the summer rays. The vessel is a natural form for clay to take. All the forces act inwards putting everything in compression. The vessel alludes the hand, to touch and tactility. To the potter's wheel and soft clay that is molded around the hands.

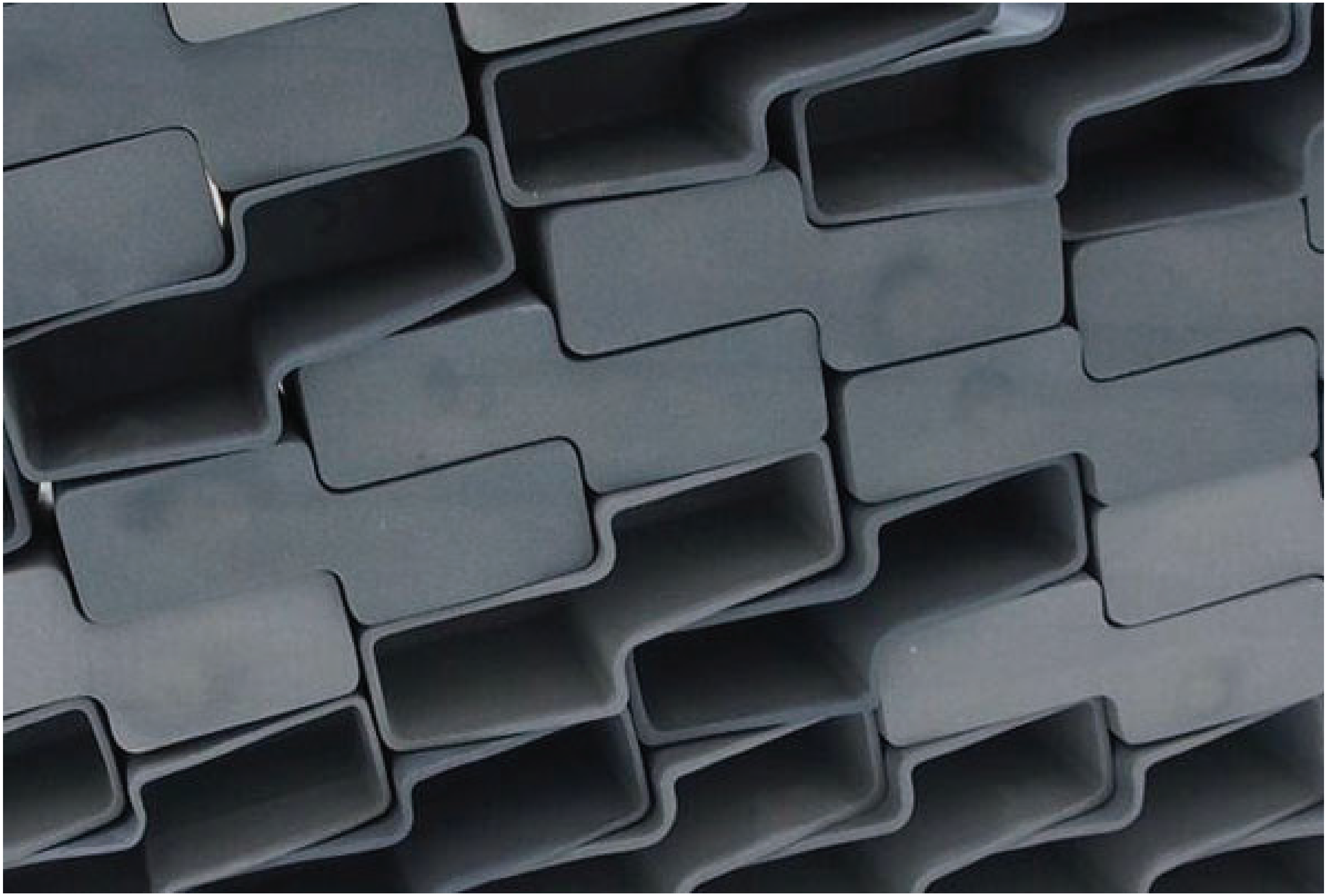


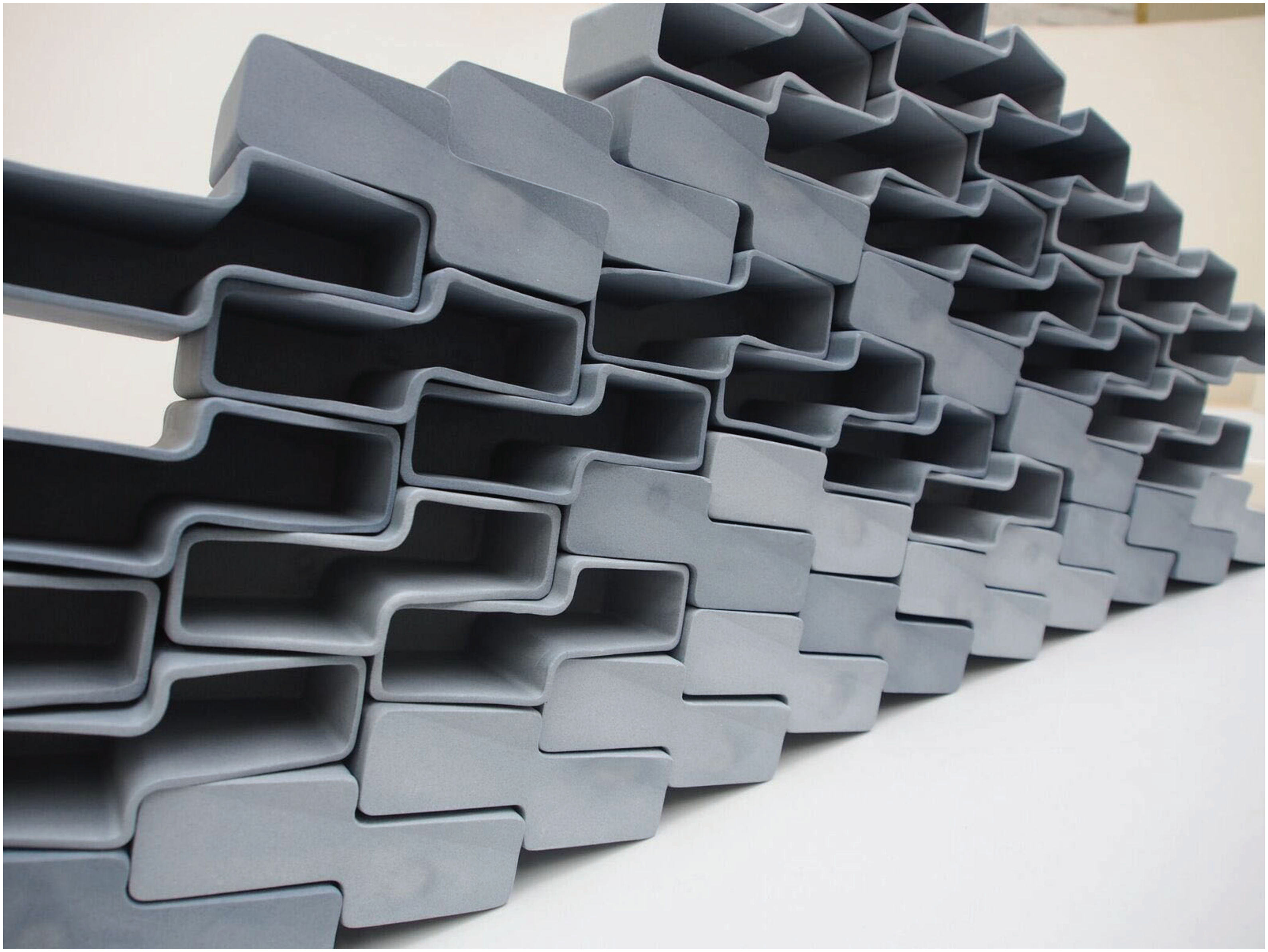




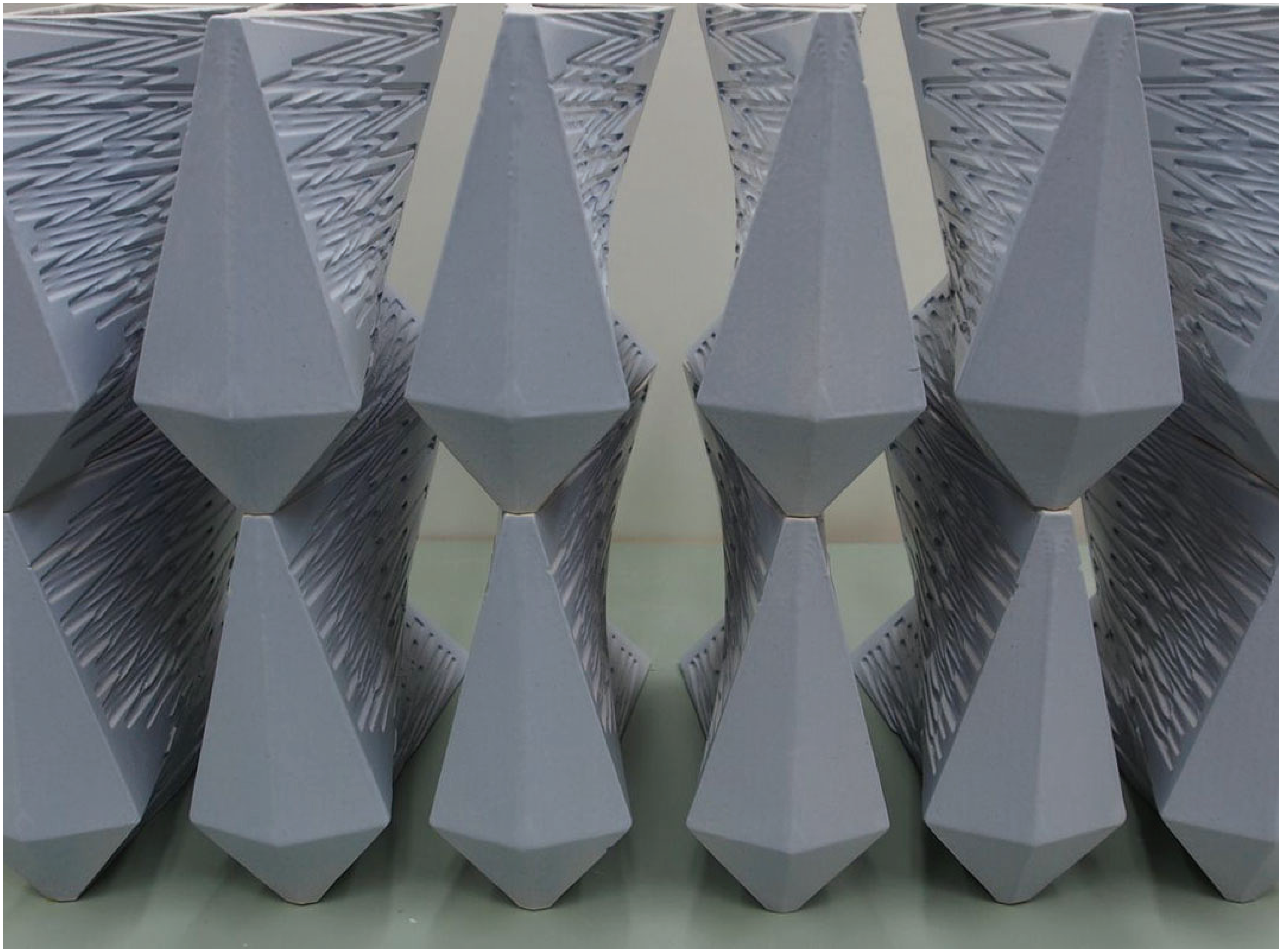
Bricks- Imagine a wall falling that stays up. The earth's strata attests to the fact that even rock is not stable. To defy gravity it must keep moving and reshaping. The bricks have cavities that allow air and water to occupy them. The heat of the sun can warm, while the wet of the rain cools. They are singular and multiple with endless reconfigurations that grow even as the fall.







Blocks- Imagine a screen composed of blocks that are filled with water. The wind accelerates through the gaps between them. As the water overflows and trickles down, the wind picks it up and cools the air on the other side. The earth stores water in its depth and clay is a product of this saturation. Reshaped into blocks it alludes to the deep wells and flowing aquifers that feed the soil. Of the earthen pots that keep the desert water cool.



Shingles- Imagine a tile the host's natural growth. A surface that can harvest water and allow moss and mushrooms to grow on it. A surface whose pattern, like a field, changes based on the season. Snow flakes grasp the crevices, highlighting the lines, turning to glistening ice that melts into barely visible shadows as the seasons swing, and then re-emerges as a soft green cushion in the shade of a north facing wall. The earth in shade and moisture fosters a subtle growth.