

**Grant Proposal Title:  
Under Fire**

*Virginia San Fratello and Ronald Rael for Emerging Objects*

*Report: January 31, 2026*

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**Research Objective:**

Our research examined how we can design and build for a fire-ravaged future by incorporating local, recycled, and indigenous materials into the 3D printing process.

**This research focused on:**

1. An exploration into **wildfire ash**, and how it can be 3D printed and used in the creation of interior building components for the future - pieces that help us remember what we have lost.
2. 3D printing an **earthen fire-resistant building prototype** for testing various environmental conditions.
3. Develop new work for a **mid-career survey of the work of Rael and San Fratello** for the YBCA. The exhibition will include material samples and images of the earthen and wildfire ash research conducted herein.

## **3D Printed Wildfire Ash: Smoke Screen**

### **1. Wildfire Ash Project Synopsis:**

Wildfires don't discriminate. We saw in both the Eaton fire and the Palisades fire in Los Angeles that anyone can become homeless due to wildfires. This project speaks both to loss and recovery. Wildfire ash can be compounded with biopolymers and converted into a homemade biological-based filament for the creation of 3D printed objects that sequester carbon. The objects that we make out of this material can be a form of helping us remember what we have lost. For some, this can serve as a healing element. Due to climate change we are seeing more frequent wildfires and the designs created

with it, represent both commentary on the current climate crisis as well as present practical and artistic applications and uses for the material, raising the questions: Can we rebuild using the ashes from the wildfires? Can wildfire waste be used in conjunction with emerging technologies to create bio-digital materials? How can materials that are a product of destruction become materials for construction? Can these materials be handled safely? What artifacts can help us remember what we have lost?

## 2. Project Milestones Wildfire Ash:

1. Collect ash - complete.

Ash was collected from both the 2020 CZU lightning complex fire and the 2025 Eaton fire.

2. Create wildfire ash / bioplastic compound – complete.

The west coast based company Protopasta sifted and compounded the ash into a bioplastic polymer. They then extruded the filament into 1.74 mm filament suitable for any desktop FDM 3D printer.



3. Test 3D printing parameters (nozzle size, flow rate, etc.)

The filament works best with .4 and .6 mm nozzles. The material was tested on a Bambu X1C desktop printer. Standard flow rates of 100% apply.

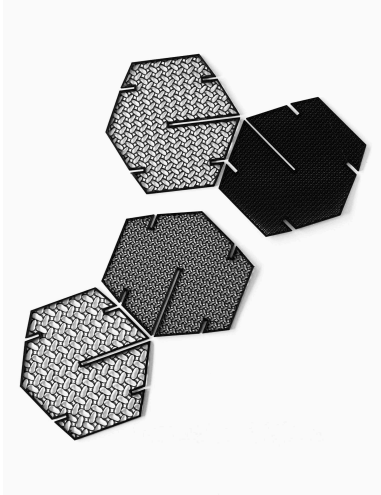
4. The ash samples and ash filament were tested for heavy metals by Seth John and Josh West, Professor of Earth Sciences & Environmental Studies at the University of Southern California.

They used an Olympus Vanta handheld XRF analyzer (sometimes called a portable XRF analyzer or pXRF) in benchtop mode. The nominal detection limit (LOD) for Pb in CLEAN samples is 20 ppm. They said, “We do sometimes get values lower than this, as in the case of your disc 1 sample, but the uncertainty on those values is high. The California state screening level for soils is 80 ppm, and the EPA level is 200 ppm. We find about 50% of soils in the Altadena area are above 80 ppm. All of your samples are well below these levels. Generally the technique we used is best suited to identifying samples with high Pb contents (like in the range of 100 ppm), and it is less accurate at the (low) levels of lead in your samples. So uncertainty on the values reported below could be as 50%, but even then, none of your samples would fall in the range that would be above the state screening level. The highest lead content in your samples was from the Altadena ash, which is consistent with our findings that Altadena is an area with some higher Pb contents in soils. Overall, though, I think what these tests show is that there is not much lead in your materials.”

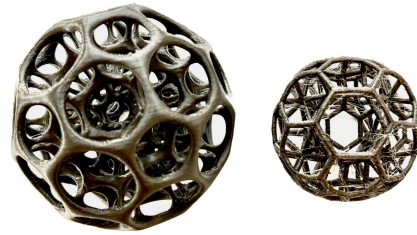
Sample	Pb (ppm)
Lightning Complex Ash	26
Altadena Ash	35
Filament Analysis 1	<LOD
Filament Analysis 2	<LOD
disc 1	11
disc 2	<LOD
disc 3	<LOD
disc 4	<LOD
disc 5	<LOD

5. Design and fabricate proof of concept, small scale pieces.

Both 3D printed tiles and beads were fabricated.

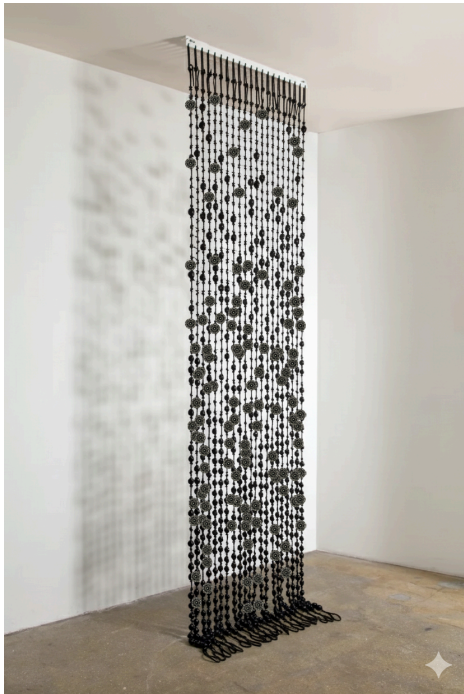


Tiles: (3" x 3" x 1/4")



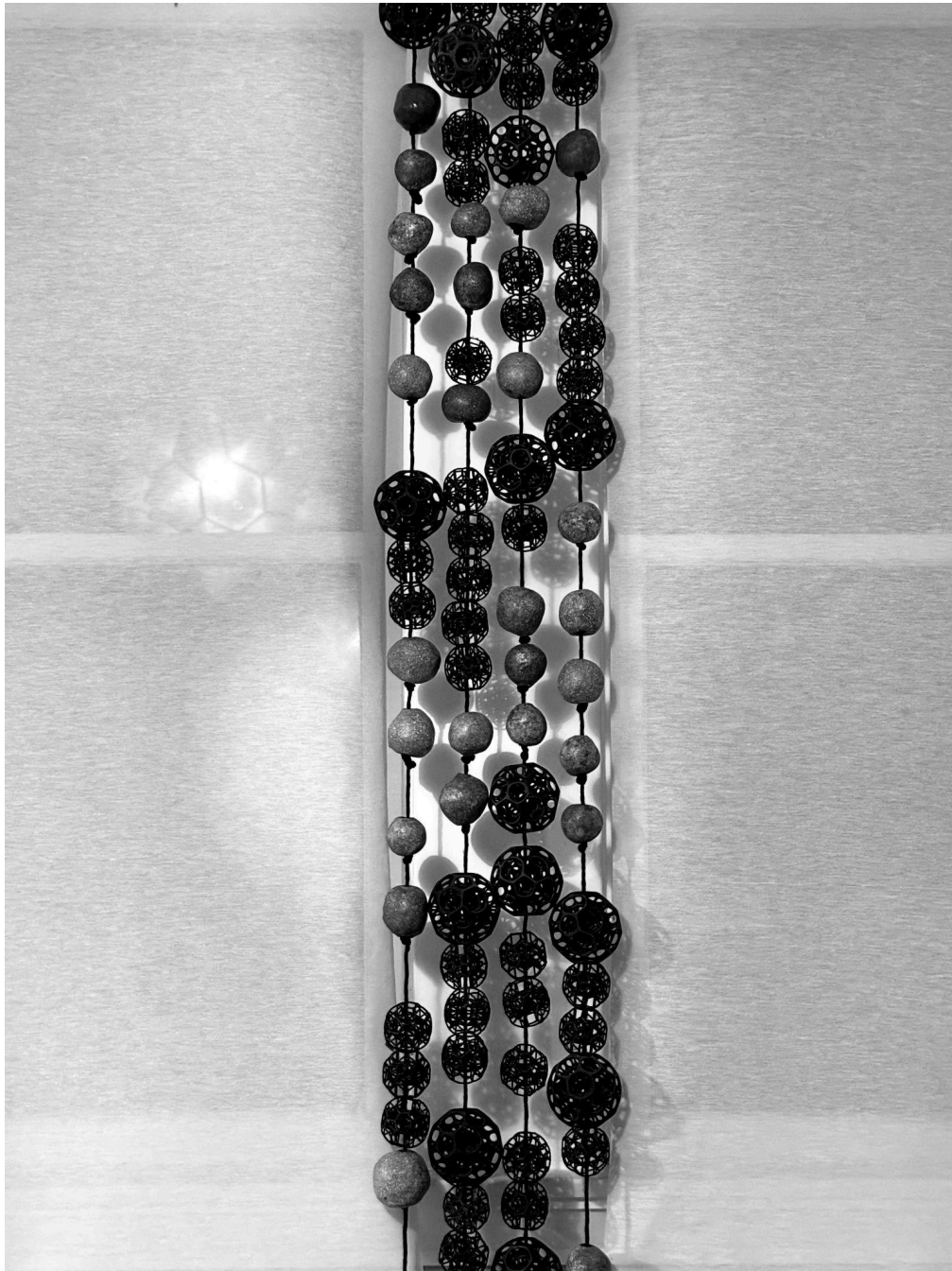
Beads: (3" dia.) (1.5")

6. Design a modular 3D printable element that can be aggregated to make a large screen, curtain or textile.





7. Fabricate a portion of the textile for exhibition.



Beaded Tapestry Prototype: 84" tall X 12' wide x 1.5" deep.

Material: 3D printed wildfire ash and black porcelain beads.

The Smoke Screen Tapestry is designed to be a durable and permanent piece. The design is composed of 3D-printed ash beads and handmade clay beads, instead of tiles (as originally proposed). The new design is 22 feet long by eight feet tall. Each printed unit takes between one hour and two hours and 20 minutes to 3D print, and each clay bead takes about 3 minutes to make, but 2 weeks to dry and fire. We calculate we will need 2500 units, half of which will be 3D printed with the wildfire ash filament and half of which will be hand-made using high fire ceramic (fire resistant) coated in mica (also fire resistant). At the time of this report, we have fabricated 500 units and assembled 150 of them into the full-scale prototype (shown above) to confirm the strength and viability of the installation.

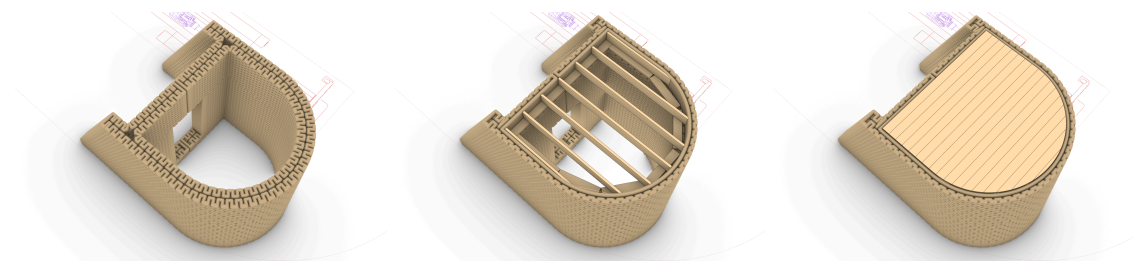
### **3. Student Engagement:**

We have identified 3 groups of art and design students at SJSU with whom Prof. San Fratello will be conducting public engagement workshops this winter to share in this creative process. This will be a co-creating knowledge event. The student groups (total 90 students) will be engaged in working with her to create ceramic beads for the final San Jose installation, while simultaneously learning about the design process, the history of wildfires in the region, the process of converting ash into filament, and the opportunities for utilizing this material (and other customizable materials for 3D printing) in the future. The workshops will take place on Friday, Feb. 6.

## **3D Printed Adobe as a study of Thermal Mass Building Enclosure: *La Cas' 'e la Pompa***



**One foot thick—among the most substantial adobe walls ever produced through 3D printing—this prototype marks a deliberate shift in emphasis.** Rather than focusing on expressive form, surface articulation, or novel robotic toolpaths, the project turns toward something more fundamental: the environmental intelligence of earth itself. In an era dominated by lightweight assemblies and mechanical dependence, *La Cas' 'e la Pompa* (The Pump House) asks a quieter but more consequential question—what can architecture achieve when material, mass, and climate are allowed to work together?



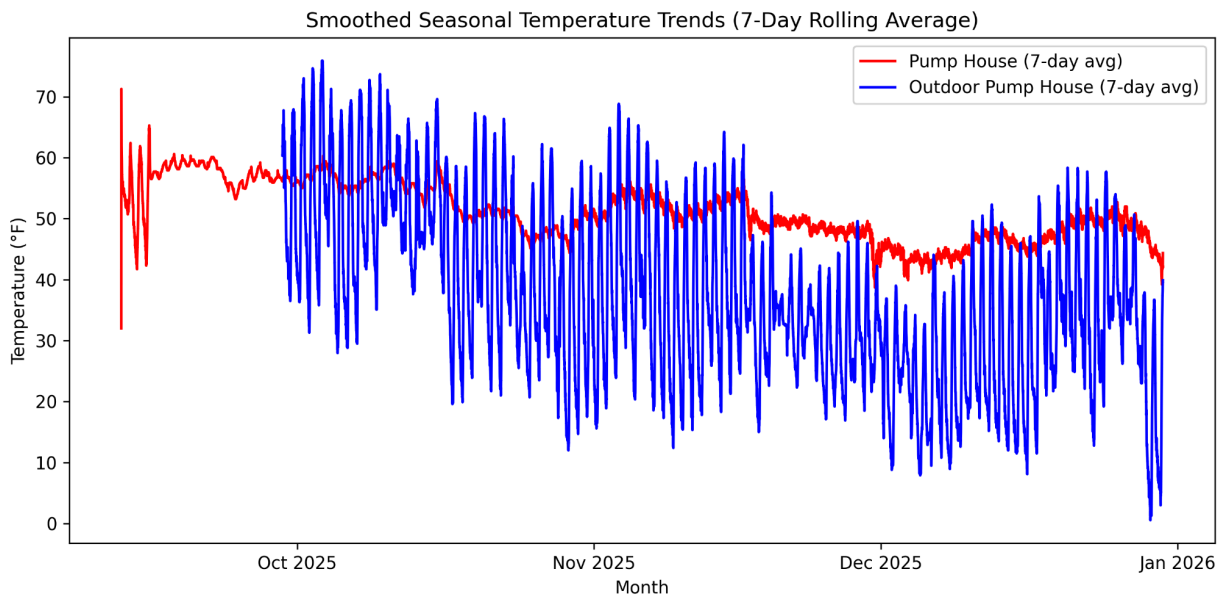
The structure is conceived as a complete thermal envelope rooted in regional building traditions. A wood-framed roof, insulated and capped with soil, draws from local vernacular strategies while completing the enclosure above the massive earthen walls. Together, roof and walls operate as a unified system, balancing heat gain and loss through mass, insulation, and delayed thermal transfer. Paired sensors placed inside and outside the building record temperature and humidity continuously, allowing the project to be evaluated not as an aesthetic object, but as a living environmental instrument.

Even in its earliest days, the performance has been striking. During the first monitored night, while exterior temperatures dropped to **37.8°F (3.2°C)**, the interior remained at a steady **57.6°F (14.2°C)**—without any active heating system. This difference is not incidental; it is the direct result of twelve-inch-thick adobe walls that absorb heat during warmer periods and release it slowly as temperatures fall. The building responds to climatic change with delay rather than immediacy, transforming sharp desert fluctuations into a calm, inhabitable interior condition.

What emerges in this humble structure is the reactivation of an ancient science. Adobe's thermal mass and vapor permeability work together to regulate temperature and moisture with remarkable precision. Rather than sealing out the environment, the walls negotiate with it—storing, releasing, and breathing in response to daily and seasonal cycles. The pump house becomes less a machine and more a mediator, quietly demonstrating how architecture once operated before energy was outsourced to mechanical systems.

*La Cas' 'e la Pompa* ultimately suggests that innovation need not abandon tradition. By combining advanced robotic fabrication with one of humanity's oldest building materials, the project points toward an architecture that is both technologically forward and materially

grounded. It reminds us that sustainable comfort does not always require more complexity, but rather a deeper attentiveness to the intelligence already embedded in earth. In listening to that intelligence, the project offers a vision of resilience—one rooted in the past, yet urgently relevant to the future.



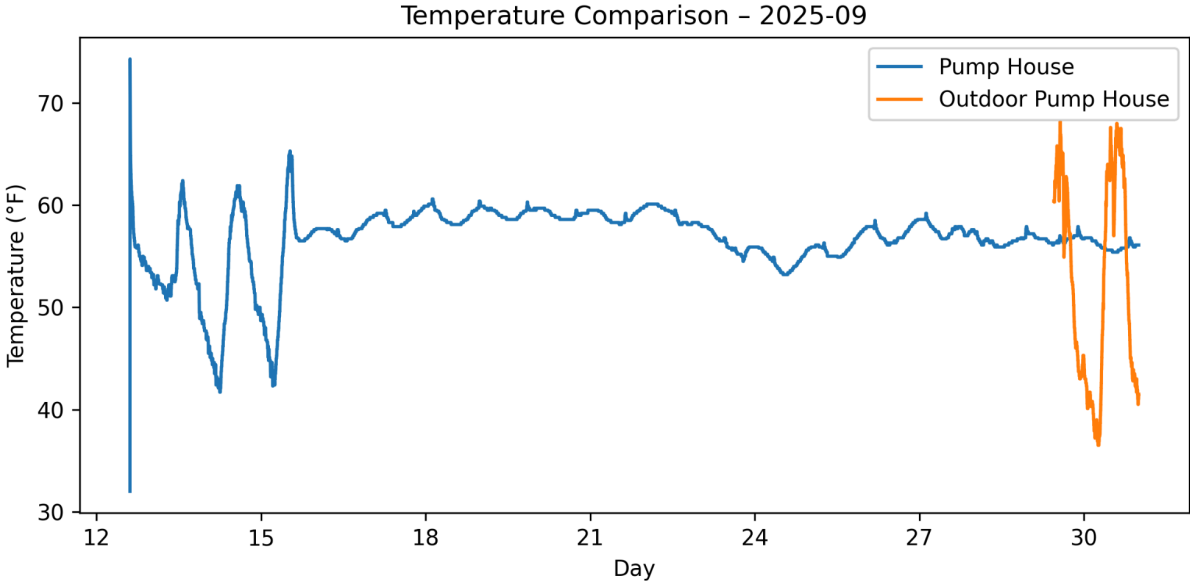
The temperature data reveal a striking contrast between the interior of the 3D-printed adobe pump house and the surrounding desert environment. Over the monitored period, outdoor temperatures fluctuate dramatically, ranging from near-freezing lows of approximately **0°F** to daytime highs exceeding **76°F**. These extreme swings—often occurring within a single 24-hour cycle—are characteristic of high-desert climates, where clear skies, low humidity, and intense solar radiation drive rapid heating during the day and equally rapid heat loss at night.

In contrast, the interior of the pump house remains remarkably stable. Despite exposure to these harsh exterior conditions, interior temperatures are maintained within a much narrower band, ranging roughly between **32°F and 74°F**, with far fewer abrupt changes. Even when outdoor temperatures plunge toward freezing, the interior resists rapid cooling, and during periods of intense heat, peak temperatures inside are significantly dampened. The data show a clear thermal lag: interior temperatures respond slowly and smoothly to exterior conditions rather than mirroring their volatility.

This performance is directly attributable to the **12-inch-thick 3D-printed adobe walls**, which provide substantial thermal mass and a small heater that will turn on at **44°F** to prevent potential freezing. Adobe’s density allows it to absorb large amounts of heat during the day, storing that energy within the wall assembly rather than transmitting it immediately to the interior. As outdoor temperatures drop—often precipitously after sunset in desert environments—that stored heat is gradually released back into the interior, preventing sharp temperature declines. The walls effectively act as a thermal buffer, flattening peaks and filling valleys in the temperature curve.

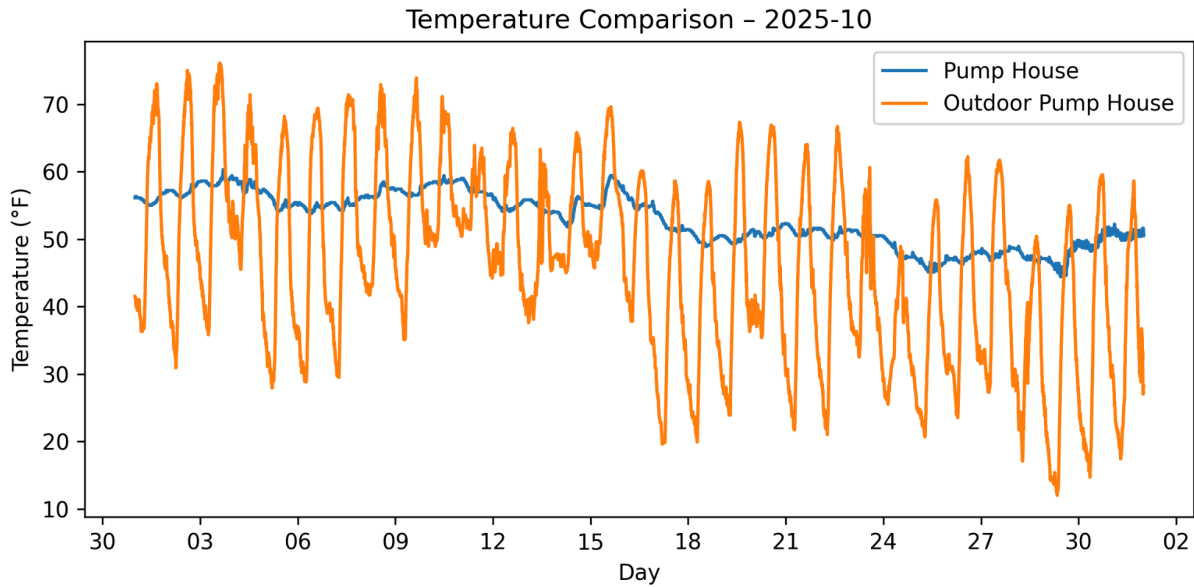
Taken together, the data illustrate how thick earthen construction can withstand extreme desert temperature fluctuations without mechanical intervention. The pump house operates as a passive thermal regulator, transforming daily temperature extremes into slow, moderated interior shifts. This confirms the effectiveness of high-mass, 3D-printed adobe construction as both an infrastructural and climatic strategy—one that draws on deep material intelligence to create resilient architecture in environments defined by thermal extremes.

A month-by-month reading of the temperature data reveals how the 3D-printed adobe pump house consistently moderates desert temperature fluctuations while the outdoor environment undergoes sharp daily and seasonal swings.

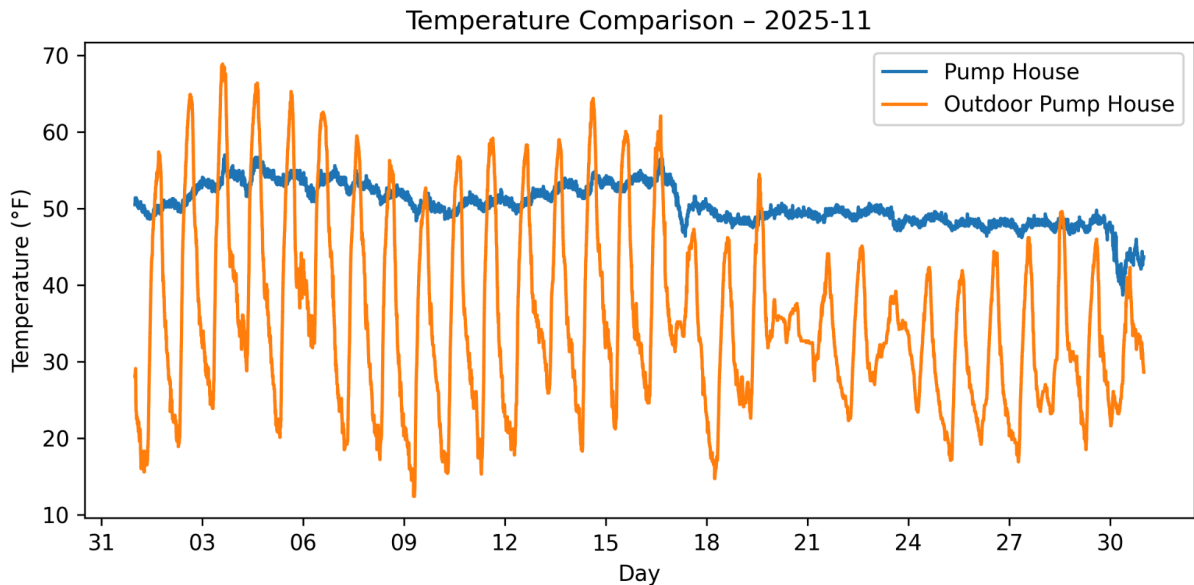


**September** shows the strongest contrast between interior and exterior conditions. Outdoor temperatures still reflect late-summer desert heat, with warm daytime peaks and rapid nighttime cooling. These daily swings are pronounced, producing large temperature amplitudes over short periods. Inside the pump house, however, temperatures rise and fall gradually. Peak heat is delayed and reduced, and nighttime lows remain noticeably warmer

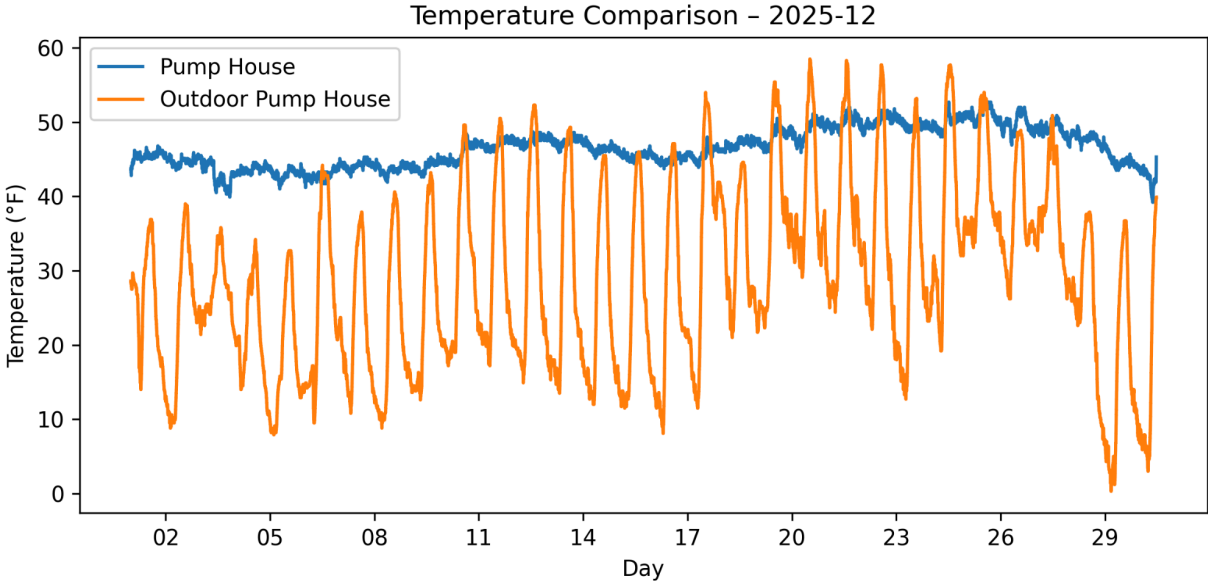
than outdoors. The interior curve appears smoothed and phase-shifted, indicating that heat absorbed by the adobe walls during the day is released slowly overnight.



In **October**, as overall outdoor temperatures begin to decline, the desert climate becomes more volatile, with cooler nights and moderate daytime warmth. Outdoor temperatures fluctuate sharply from day to night, but the pump house interior continues to maintain a compressed range. Interior temperatures decrease over the course of the month, yet they do so steadily rather than abruptly. The thermal mass of the 12-inch adobe walls dampens the increasing diurnal variability, maintaining interior stability even as exterior conditions become less predictable.



By **November**, desert temperature swings intensify further, with colder nighttime lows approaching freezing and mild daytime recovery. Outdoor conditions exhibit pronounced oscillations, often spanning tens of degrees within a single day. The pump house responds with a slower, buffered pattern: nighttime temperatures inside remain elevated relative to outdoors, and daytime warming is moderated. The interior environment effectively resists the sharp thermal shocks experienced outside, demonstrating strong thermal inertia as the walls continue to store and release heat over longer cycles.



In **December**, the desert reaches its most extreme condition in the dataset, with outdoor temperatures dropping to near **0°F** during cold nights while still warming significantly during the day under clear skies. These extremes produce the largest temperature ranges of the year outdoors. Inside the pump house, however, temperatures remain comparatively stable, hovering near freezing at their coldest and avoiding the rapid drops seen outside. The interior temperature curve becomes especially smooth in this month, clearly illustrating the role of adobe as a thermal battery—absorbing limited daytime warmth and releasing it slowly to protect the interior from severe cold.

Across all months, the data show that while outdoor temperatures respond immediately to solar radiation and nighttime heat loss, the pump house interior responds on a delayed, moderated timeline. This consistent behavior underscores the effectiveness of thick, high-mass, 3D-printed adobe walls in transforming extreme desert temperature fluctuations into a stable interior environment, reinforcing the value of earthen construction as a passive and resilient climatic strategy.



In its quiet performance, *La Cas' 'e la Pompa* demonstrates that the future of robotic construction need not be defined by novelty alone, but by a deeper alignment between technology, material intelligence, and climate. The project shows how 3D printing can move beyond formal experimentation to rediscover architecture's environmental agency—using mass, thickness, and time as design tools rather than liabilities. By pairing advanced robotic fabrication with earthen materials that have regulated human comfort for millennia, this pump house offers a compelling model for resilient construction in an era of climatic uncertainty. It suggests a future in which robots do not replace tradition, but extend it—enabling thick, high-performance earthen architectures that are low-energy, place-responsive, and grounded in the enduring wisdom of the ground itself.

## YBCA Proposed Public Engagement

A portion of the "*Smoke Screen Tapestry*" will be installed at the Yerba Buena Center for the Arts (YBCA) in San Francisco from Sept. 25, 2026 -Jan. 25, 2027 as part of the Rael San Fratello: Sanctuary exhibit (working title) and a large earthen structure, that builds on the *Cas' 'e la Pompa* and other Rael San Fratello earthen works will be built for the exhibition.

A portion of the "*Smoke Screen Tapestry*" will be installed at the Yerba Buena Center for the Arts (YBCA) as part of the "*Taxonomy Table*". The table will be approximately 50' long x 4' wide and will include many of the different 3D printed material experiments conducted by Emerging Objects over the past 15 years.



*Visualization of "Taxonomy Table"*

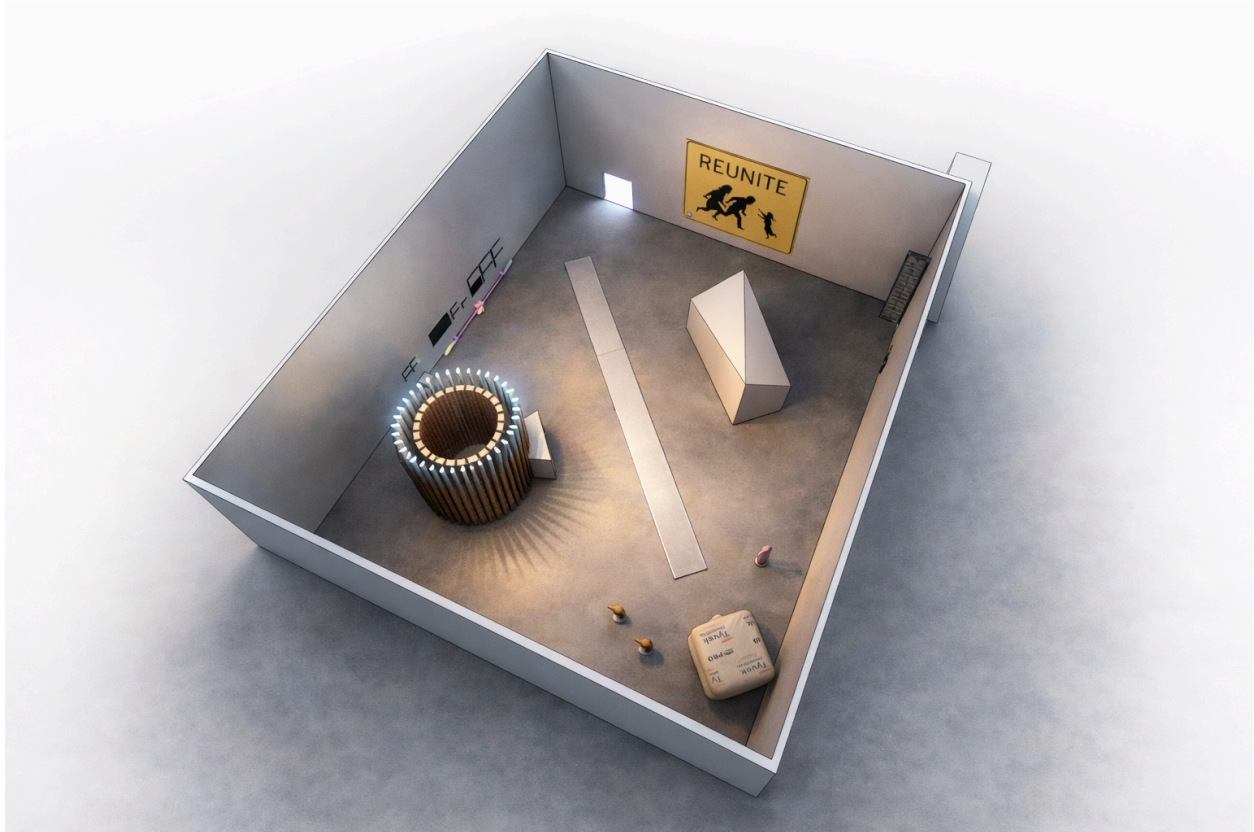
**Sanctuary** is a monumental adobe structure conceived as a vessel for light. Glass rods pierce the earthen cylinder, carrying illumination inward and transforming light into a spatial, almost spiritual presence.

The thick adobe walls act as a protective mass—absorbing, filtering, and quieting the world beyond. A simple plywood opening defines a threshold, marking the passage from the public gallery into an intimate, luminous interior. Sanctuary invites pause, enclosure, and retreat.



*Visualization of adobe "Sanctuary"*

The exhibit will also include existing pieces from the body of work by Rael San Fratello created over the last 15 years such as the Teeter Totter, NOWHERE, the Vac Pac, the R13 jackets, and the Reunite Banner.



*Birds Eye View of the entire exhibit*

Special thanks to **One Workplace** for their generous support of *Rael San Fratello: Sanctuary* through the ONEder grant.. Their commitment to design innovation and cultural engagement has helped make this exhibition at YBCA possible.