

LOUIS BROUWER

**OPUS SIGNIUM
INNOVATUM**



**SUPERGREEN
IDE 24/25**





CONTENTS

5.
MANIFESTO

6.
CHAPTER I
MATERIAL EXPLORATION

12.
CHAPTER II
STRUCTURES AND IDEATION

16.
CHAPTER III
DEVELOPMENT AND FINISHING

A PRAGMATIC CASE FOR THE REVIVAL OF OPUS SIGNIUM

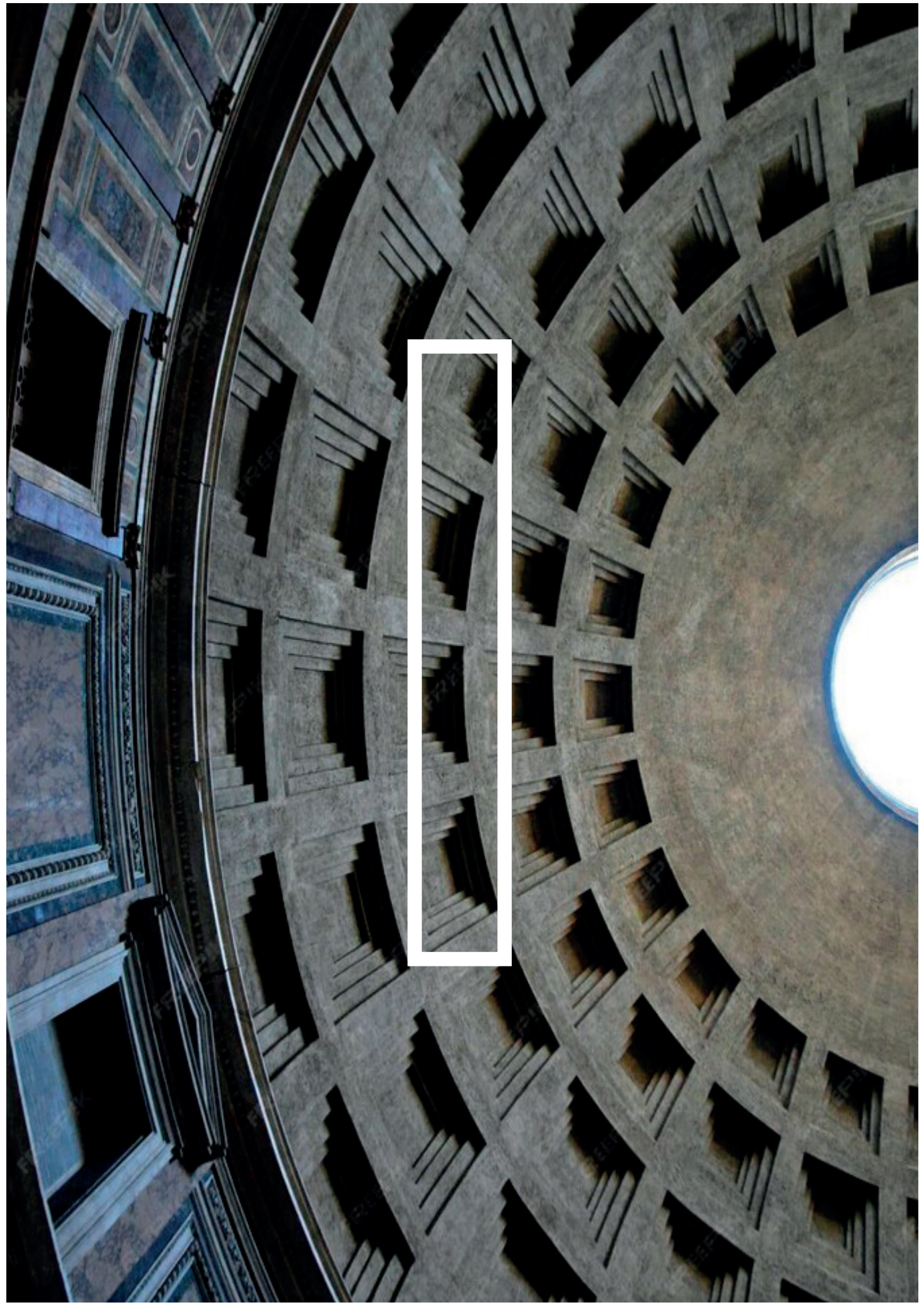
Climate change and consumerism can both be seen as consequences of the unchecked expansion of capitalism—one accelerating environmental degradation, the other fostering a culture of disposability. This project seeks to address both, exploring a material that challenges prevailing notions of efficiency and value in construction.

As industries worldwide grapple with the urgent need to reduce carbon emissions, the built environment remains a significant contributor to the crisis. This project investigates an alternative building material—one that is not only sustainable and regenerative but also possesses an intrinsic aesthetic appeal. Unlike many eco-friendly solutions that depend on goodwill, regulation, or subsidies to gain traction, this material offers a compelling reason to be chosen beyond its sustainability: its beauty.

However, it does not pretend to be a perfect substitute for modern concrete. It is weaker, takes longer to set, and is more expensive. By conventional standards of construction efficiency, it falls short. Yet, what it lacks in raw performance, it makes up for in its visual and textural qualities, offering a poetic response to the rigid functionality of contemporary building materials.

At its core, this project is an exploration of a modern interpretation of Roman concrete—a lime-based material that sustained the architecture of the ancient world. By revisiting this lost knowledge and adapting it for today's needs, the aim is to question whether durability and beauty can hold more value than brute efficiency in the spaces we inhabit.

MANI - FESTO



C H A P T E R O N E

MATERIAL EXPLORATION

MATERIAL EXPLORATION

The ancient Romans mastered the art of durable and resilient construction materials, with their most renowned invention being Roman concrete, or *opus caementicium*. Unlike modern Portland cement, which relies on high-energy production processes, Roman concrete utilized volcanic ash and lime, forming a remarkably durable and environmentally resilient material. A significant feature of Roman concrete was its self-healing properties, attributed to the presence of unreacted lime clasts that, upon exposure to moisture, could recrystallize and mend microcracks over time. Recent research, including groundbreaking studies from MIT, has highlighted the role of "hot mixing" in enhancing these properties. By rapidly combining quicklime with water at high temperatures, the Romans inadvertently created highly reactive lime inclusions, which contributed to the material's long-term durability and self-repairing capabilities

Cocciopesto, a derivative of Roman concrete, was widely used for flooring, waterproof coatings, and decorative surfaces. It replaced volcanic ash with ground ceramic or crushed brick, maintaining

pozzolanic reactivity while offering a rich, warm aesthetic. This historical formulation inspired the direction of this project, which seeks not only to explore cocciopesto's potential as a contemporary building material but also to push its structural capabilities beyond its traditional role as a surface treatment.

"There is also a kind of powder from which nature causes produce astonishing results. This substance, when mixed with lime and rubble, not only lends strength to buildings of other kinds, but even when piers of it are constructed in the sea, they set hard under water."

— Vitruvius, *De Architectura*, Book II, Chapter 6

Testing and Material Selection

Although this project ideally would have included comprehensive mechanical testing of the materials produced—including three-point bending and compression tests—access to advanced



[ABOVE]
A RANGE OF THE TESTED SAMPLES

lab equipment was not feasible. As a result, testing was conducted using workshop equipment, allowing for a more empirical approach based on observable strength, workability, and aesthetic qualities.

Initially, the project explored the use of volcanic ash, following traditional Roman concrete formulations. However, due to limited access to pumice and natural pozzolanic volcanic materials, the focus shifted toward cocciopesto, which offered greater accessibility and superior aesthetic properties. Fly ash was available as an alternative pozzolan, but preliminary tests revealed that even minimal quantities (>2%) dramatically altered the color of the mix, leading to a loss of the material's characteristic warm hues. Consequently, only a limited number of samples incorporated fly ash, while the primary pozzolanic material used was metakaolin clay, known for its strong reactivity and compatibility with lime-based binders.

Composition and Processing

A key consideration in this project was the utilization of waste streams to create a viable construction material. Traditionally, cocciopesto relies on crushed terracotta or low-fired ceramics to provide pozzolanic activity. This project aimed to extend that concept by using crushed red brick as the primary pozzolanic ingredient, enabling the repurposing of construction waste. However, a major limitation was that only low-temperature-fired bricks maintain the necessary pozzolanic reactivity, and most modern bricks do not meet this criterion due to their high-temperature firing processes. The final composition of the material was refined through multiple iterations, balancing strength, workability, and aesthetics. The optimized mix consisted of:

- Metakaolin clay (as the primary pozzolan, due to its high reactivity)
- Crushed brick and brick dust (providing additional pozzolanic material and texture)
- Quicklime (the binder, crucial for long-term strength development and self-healing properties)
- By using a combination of these materials, the goal was to create a modernized version of cocciopesto that maintained the aesthetic richness of traditional formulations while enhancing its structural performance.

[BELOW]
COCCIOPESTO FLOORING

[2ND BELOW]
AN EXCERPT FROM THE TESTING TABLES OF
THE VARIETY OF SAMPLE COMPOSITIONS



Sample no	Quicklime	Metakaolin	Fly ash	Crush brick (fine)	Crush brick (coarse)
1	50%	30%	20%	0%	0%
2	50%	40%	10%	0%	0%
3	50%	45%	5%	0%	0%
4	50%	35%	5%	0%	10%
5	50%	27%	3%	0%	20%
6	50%	8%	2%	10%	30%
7	20%	28%	2%	10%	40%
8	10%	30%	1%	10%	50%
9	10%	20%	0%	20%	50%
10	12%	18%	0%	20%	50%
11	14%	16%	0%	20%	50%
12	16%	14%	0%	20%	50%
13	18%	12%	0%	20%	50%
14	20%	10%	0%	20%	50%
15	8%	22%	0%	20%	50%
16	6%	24%	0%	20%	50%
17	4%	41%	0%	5%	50%
18	10%	35%	0%	5%	50%
19	10%	75%	0%	5%	10%
20	20%	65%	0%	5%	10%
21	20%	65%	0%	5%	10%
22	20%	65%	0%	5%	10%
23	20%	65%	0%	5%	10%
24	20%	65%	0%	5%	10%
25	30%	55%	0%	5%	10%
26	30%	45%	0%	15%	10%
27	10%	25%	0%	15%	50%
28	8%	27%	0%	15%	50%
29	12%	23%	0%	15%	50%
30	14%	21%	0%	15%	50%



C H A P T E R T W O

STRUCTURES AND IDEATION

STRUCTURES AND IDEATION

The process of mixing and testing materials is valuable, but true innovation in construction demands more than experimentation—it requires structural integrity. My goal for this project was to develop a material that could serve as a viable structural component, capable of withstanding both compressive and tensile forces. While the samples I produced exhibited satisfactory compressive strength, they fell short in tensile performance, limiting their application in more complex geometries such as curved or cantilevered forms.

To address this limitation, I experimented with reinforcing the mix using polypropylene fibers and, later, glass fibers. While both significantly improved tensile strength, the increased cost and greater susceptibility of glass fibers to environmental degradation rendered them impractical for this application. The trade-off between performance and longevity was a critical factor in material selection, as the goal was to create a durable, low-maintenance material suited for architectural and structural applications.

Structures

To substantiate the potential of this material, it was essential to construct a piece that could adequately demonstrate its strength. Initially, I considered fabricating a large, flat slab—such as a dining table or countertop—given the clear demand for such materials in architectural and interior design applications. However, the project brief required a more dynamic and functional object, leading to the decision to create a chair or stool.

A logical approach was to replicate an existing iconic design to

[BELOW]
CLASSIC ROMAN CURULE CHAIR (REPLICA)



[ABOVE]
VENTURI STOOL BY ASSA STUDIOS

highlight the material's capabilities. Ideal candidates included the Panton Chair and the Venturi Stool, both renowned for their sculptural forms and structural ingenuity. The latter, designed by Assa Studios, also provided a direct connection to my course, and I sought to collaborate by using their mold. Despite multiple attempts to reach out across various platforms, I received no response—an unfortunate but common obstacle in design collaborations. Faced with this challenge, I pivoted toward designing my own form.

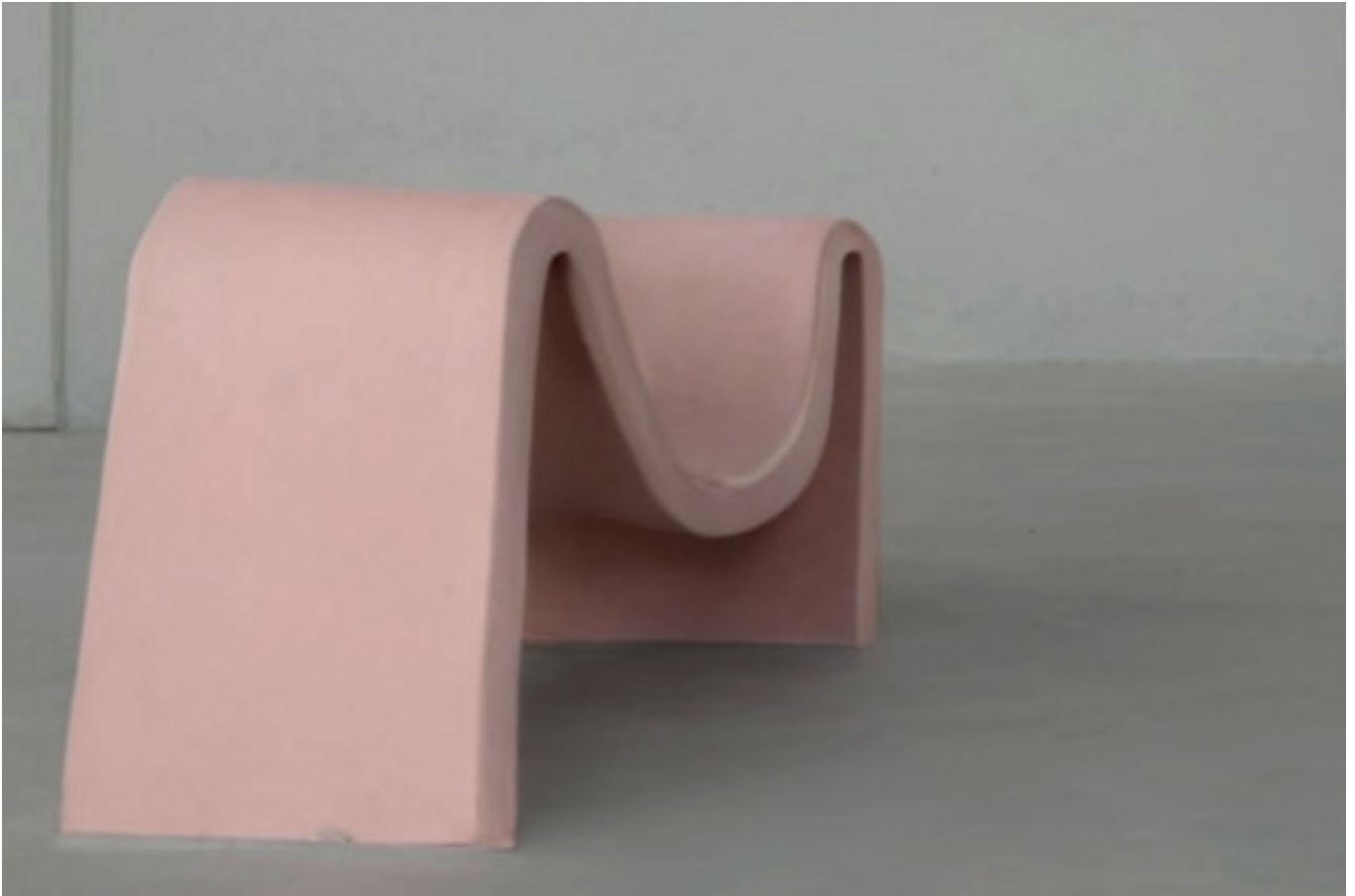
Design Inspiration and Layup Considerations

I drew inspiration from ancient Roman furniture, integrating elements of their structural logic with a contemporary fabrication approach. However, the material's layup process required careful consideration, particularly given its layered composition. The final design consists of two primary layers:

A structural base incorporating large brick fragments, providing compressive strength and a visually striking texture.

A fiberglass-reinforced layer, enhancing durability while complementing the raw aesthetic of the crushed brick.

The result is a piece that fuses classical Roman influences with a modern brutalist aesthetic, intended primarily for outdoor use. Notably, the exposure to natural elements—particularly rain—serves a functional purpose beyond aesthetics. The self-healing properties of the material, derived from the inclusion of reactive lime, allow small cracks to mend over time as water activates the recrystallization process. This aligns with the broader philosophy of sustainable and enduring material innovation.



[ABOVE]
VIZCOM RENDER OF THE SIDE PROFILE
OF THE STOOL

[BELOW]
VIZCOM RENDER OF THE FRONT PROFILE
OF THE STOOL



Surface Exploration and Material Aesthetics

Throughout the fabrication process, I experimented with various gradations of crushed brick to achieve an ideal surface finish. My initial goal was to create a terrazzo-like appearance, where the embedded brick fragments would be polished to reveal a rich, varied texture. However, a significant challenge arose due to the density difference between brick and the lime matrix—the lighter brick particles tended to float to the surface, disrupting the intended finish and necessitating extensive surface grinding to expose them. This was a process I sought to avoid due to its labor-intensive nature and potential to alter the material's structural properties.

To explore an alternative approach, I conducted a deliberate surface variation experiment on a section of the final mold. In this

test, I loosely packed certain areas with crushed brick, allowing them to settle naturally before casting. The result was a surface that exhibited a rough, exposed-brick texture in certain areas, contrasting sharply with the smoother, more uniform finish of the surrounding material. This juxtaposition not only enhanced the authenticity of the material but also introduced a compelling visual tension—mirroring the interplay between natural imperfection and refined craftsmanship.

Beyond its aesthetic merits, this design choice subtly reinforces the Roman architectural theme present throughout the project. The exposed cavities in the surface bear a resemblance to archaeological excavations, where layers of ancient structures emerge through timeworn erosion. This connection between material, history, and process strengthens the conceptual foundation of the work, transforming a structural experiment into





[LEFT PREVIOUS PAGE]
THE POROUS NATURE OF THE SAMPLE ALLOWS
WATER TO SEEP IN AND HEAL THE MATERIAL

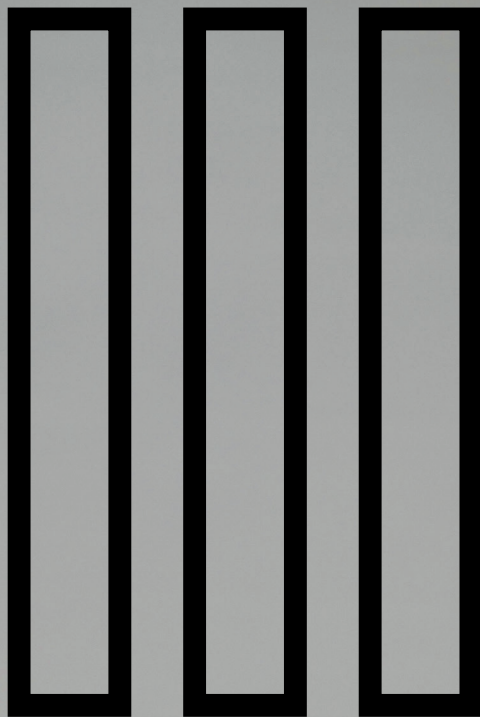
[ABOVE]
EXPOSED CRUSHED BRICK IS A NOD TO THE NATURE
OF THE MATERIAL, DISCOVERED IN THE DUST

[BELOW]
IN THE RAIN OR DAMP THE TONE OF THE
STOOL REACHES A HIGHER SATURATION



C H A P T E R T H R E E

**DEVELOPMENT
AND FINISHING**



DEVELOPMENT AND FINISHING

Casting was an entirely novel process for me—an exciting opportunity to explore a new method of working with material at scale. However, it quickly became apparent that casting is an extremely time-consuming, physically demanding, and messy process, particularly when handling over 150 kg of material. The complex geometry of the mold introduced additional challenges, particularly in achieving a stable layering process between the surface layer and the structural layer. The primary issue was slumping, where the fresh material would shift before setting properly, resulting in uneven distribution. Ensuring that the layers were packed without voids required significant effort, and a more rigid secondary form would have helped provide greater structural stability, particularly for the underside of the stool, which lacked the refinement I had hoped for.

A significant takeaway from this project was a shift in my approach to material aesthetics. Instead of chasing perfection, I found it far

more effective to embrace the natural irregularities of the material. Forcing an inherently imperfect and organic substance into a mold that demands absolute precision is often counterproductive. This realization guided my surface finishing approach, which evolved as a result of material exploration rather than predefined intent. The textured, irregular finish that emerged was not originally planned but became an essential stylistic feature—one that reflects the unpredictable nature of the casting process and the inherent beauty of material-driven design.

Demolding Issues

One of the most critical and frustrating moments in the project was removing the stool from the mold. Due to time constraints and impatience, I attempted to demold the piece before it had fully set, resulting in a large crack. Ideally, the stool should have been left for at least five additional days to allow proper curing, significantly reducing the risk of damage. This was a clear lesson in patience and process discipline—one that could have



[ABOVE]
A RANGE OF THE TESTED SAMPLES

prevented an avoidable structural flaw. However, given the time available, this was a limitation I had to work within, reinforcing the need for better time management and contingency planning in future projects.

Structural Limitations and Weight Challenges

The final stool weighed approximately 75 kilograms, making it impractically heavy for everyday use. While the visual and sculptural qualities of the design were successful, the sheer bulk of the material highlighted the need for a more refined structural approach. A thinner primary section combined with selective reinforcement only where necessary—particularly in curved regions—would have significantly reduced weight without compromising aesthetics.

One potential improvement would be the introduction of a flange, which would preserve the bold, monolithic appearance of brutalist design while strategically minimizing material usage in non-structural areas. In professional Glass Fiber Reinforced Concrete (GFRC) fabrication, the facing layer is typically sprayed, allowing for a thicker reinforcement layer while keeping weight to a minimum. Due to limited access to GFRC spraying equipment, I had to hand lay up the face layer, resulting in a significantly thinner reinforcement section, likely contributing to structural weakness.

Final Reflections: A Balance Between Art and Engineering

Despite its practical limitations, I am satisfied with the overall outcome of this project. The experience provided invaluable stylistic and technical insights, particularly regarding material behavior, structural considerations, and fabrication constraints. The design process reaffirmed the importance of working with materials rather than against them, allowing their inherent qualities to shape the final outcome rather than forcing them into rigid expectations. That said, one of the biggest drawbacks of this project was the lack of quantitative material testing. While the aesthetic and conceptual goals were met, true validation of the material's structural potential would require formalized strength testing and material certification. This would be a long and resource-intensive process, and at this stage, I remain uncertain whether it is worth pursuing further.

Nevertheless, this project has reinforced my belief that material-driven design is not just about function and strength, but also about understanding and embracing materiality as a key part of the creative process.

[BELOW]
SAMPLE PIECE WITH A HIGHLY REFLECTIVE MIRROR FINISH

[2ND BELOW]
REDESIGNED VERSION INCORPORATING THE FLANGE EDGES TO REDUCE WEIGHT



THE ERGONOMICS OF THE STOOL
ACCOUNT FROM THE 5TH TO 95TH
PERCENTILE





THE ERGONOMICS OF THE STOOL
ACCOUNT FROM THE 5TH TO 95TH
PERCENTILE

THE AFOREMENTIONED CRACK
PURTRUDING ALL THE WAY THROUGH
THE ARMREST





EXPOSED BRICKWORK AND CRUSHED
FINE BRICK DUST PRODUCE THE PINK
TINT

OPUS SIGNIUM INNOVATUM

Louis Brouwer is an Engineer and Sculptor, Designer and Maker. His latest work is a stylistic demonstration of Opus Signium Innovatum—a material that revives and modernizes the ancient wisdom of Roman concrete. This project challenges the efficiency-driven mindset of contemporary construction by showcasing a furniture piece that is both functional and eternal. Utilising the self-healing properties of Roman concrete, it resists decay over time, strengthening with exposure to moisture rather than deteriorating. Its stylistic qualities outweigh any minor practical trade-offs, making it ideal for structural applications where aesthetics and longevity are paramount. This is furniture designed to last forever.

IDE 24/25

