



# Beyond Waste

*Uncovering the Hidden Potential of  
Coal Ash*

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**Beyond Waste**

Uncovering the Hidden Potential of Coal Ash

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Thesis submitted to the faculty of the  
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in

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**Abstract.**

The thesis lies at the intersection of the concepts of “beyond” meaning surpassing and “waste” referring to the materials and resources that are often discarded or overlooked, are the focus of this project. Overall, the project represents a commitment to surpassing conventional limits and transforming waste into a valuable resource.

This project also proposes a new ethical architectural practice that seeks to challenge traditional design approaches by exploring the potential of waste as a valuable input in building design. By deviating from conventional methods and proposing new ideas, the study aims to rethink traditional practices and create a new view toward the incorporation of waste in architecture. By adopting the principles outlined in the book “Cradle to Cradle” the project embraces the 4 R’s of recycling, reducing, reusing, and recovering, demonstrating how waste can be transformed into a valuable input in building design.

This ethical framework emphasizes the reuse, recycling, repurposing, and recovery of waste in architecture. Through this project, the aim is to challenge the current ways in which architecture is designed, with a view toward promoting sustainable practices and a more responsible approach to architectural design. Ultimately, this thesis offers a new ethical perspective on how waste can participate in the way we design buildings, and presents a potential pathway towards a more sustainable future for the field of architecture.



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## 1. Macro\_Territory



Fig 1: Quicker than Coal Ash: Photographer Will Warasila

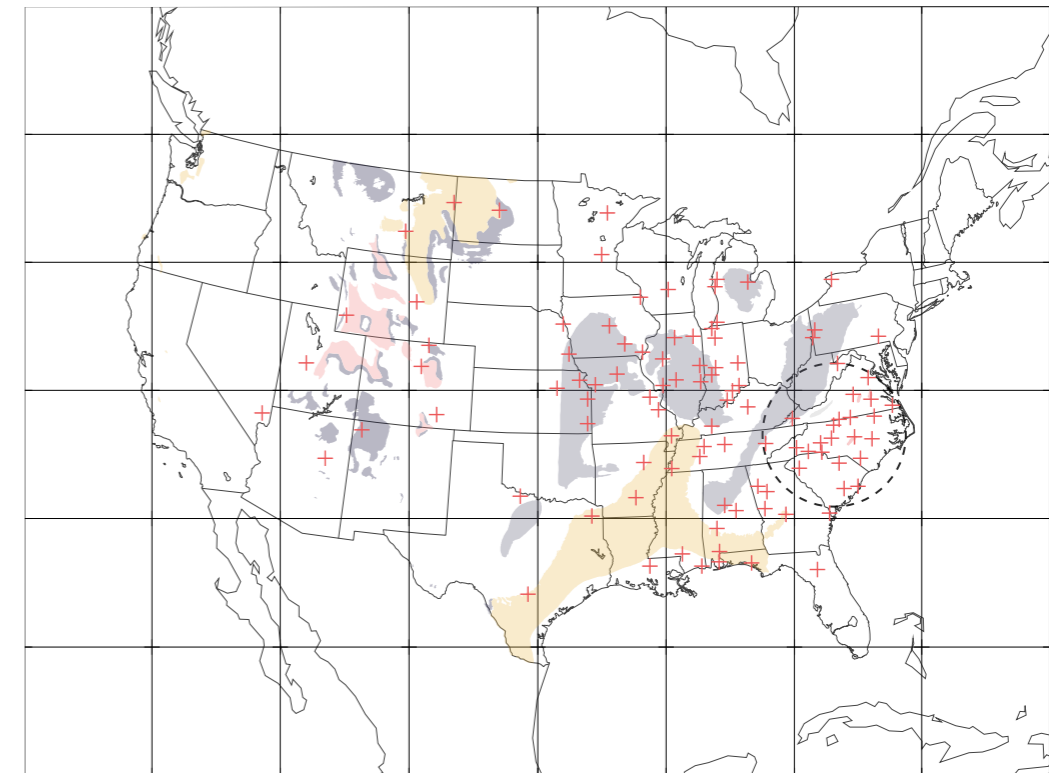
## 1. Macro\_Territory

### 1.1. Introduction

Around seven years after the EPA (U.S. Environmental Protection Agency) initially implemented federal regulations mandating the cleanup of coal ash waste sites, only approximately 50 percent of power plants responsible for polluting groundwater recognize the necessity of a cleanup, and 96 percent of these plants are not proposing any measures to treat the groundwater. In fact, only one of the 292 plants surveyed is intending to perform a thorough cleanup.

The majority of power companies failing to comply with the 2015 Coal Ash Rule is significantly detrimental to environmental safety, water quality, and public health. According to monitoring data, 91 percent of coal-fired plants in the United States possess ash landfills or waste ponds that are releasing hazardous amounts of metals such as arsenic, lead, mercury, and selenium into groundwater, often placing streams, rivers, and drinking water aquifers at risk.

The research is primarily centered around investigating the power plant sites that are powered by coal mining activities in the Appalachian region of the United States, which has been identified as the major source of environmental hazards and concerns.



#### Coal Ash Waste Sites

Based on [americangeosciences.org](http://americangeosciences.org)

+ Coal-Fired Power Plants (with no plan of action)

☐ Focus of the Research

#### Geological Region: Primary Coal Basins

■ Anthracite, semi-anthracite, and meta-anthracite

■ Subbituminous

■ Low-volatile bituminous

■ Lignite

■ Medium and high-volatile bituminous

## 1. Macro\_Territory

### 1.2. Site Selection

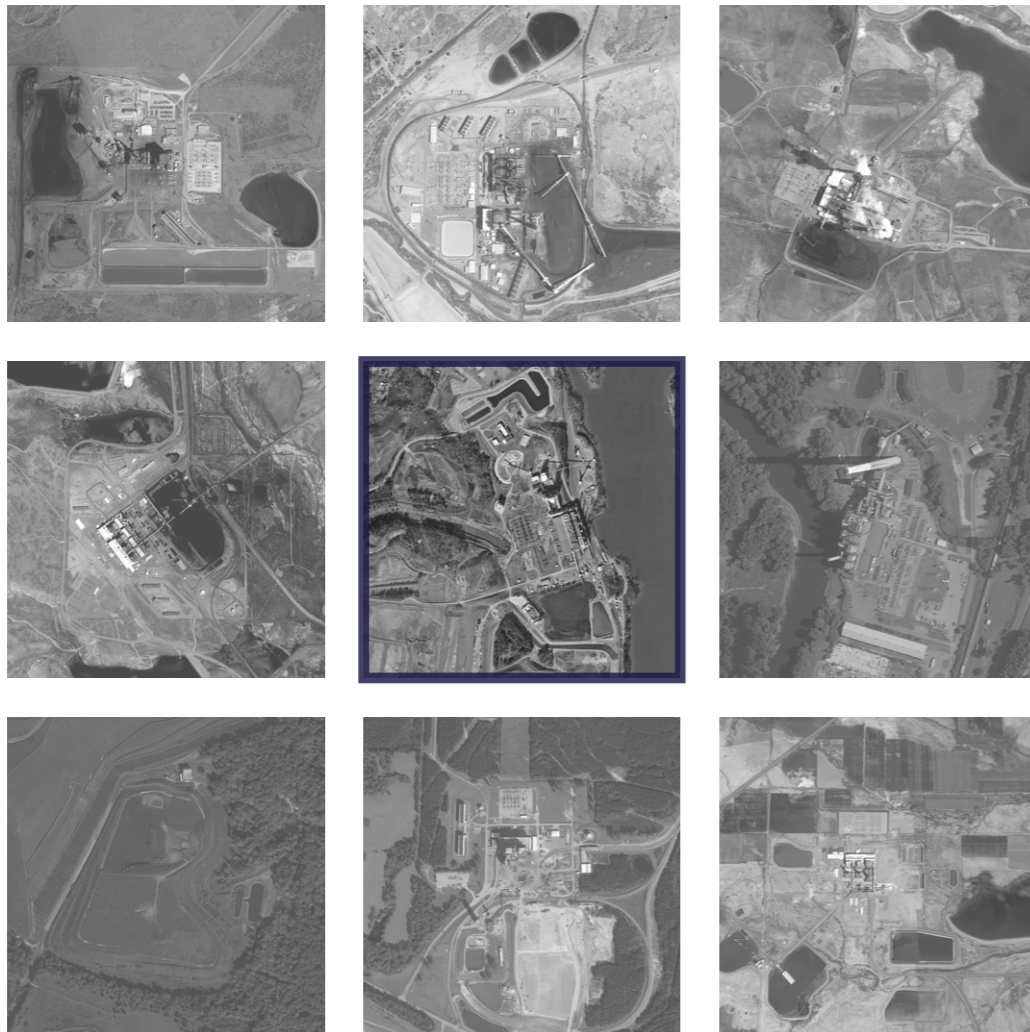
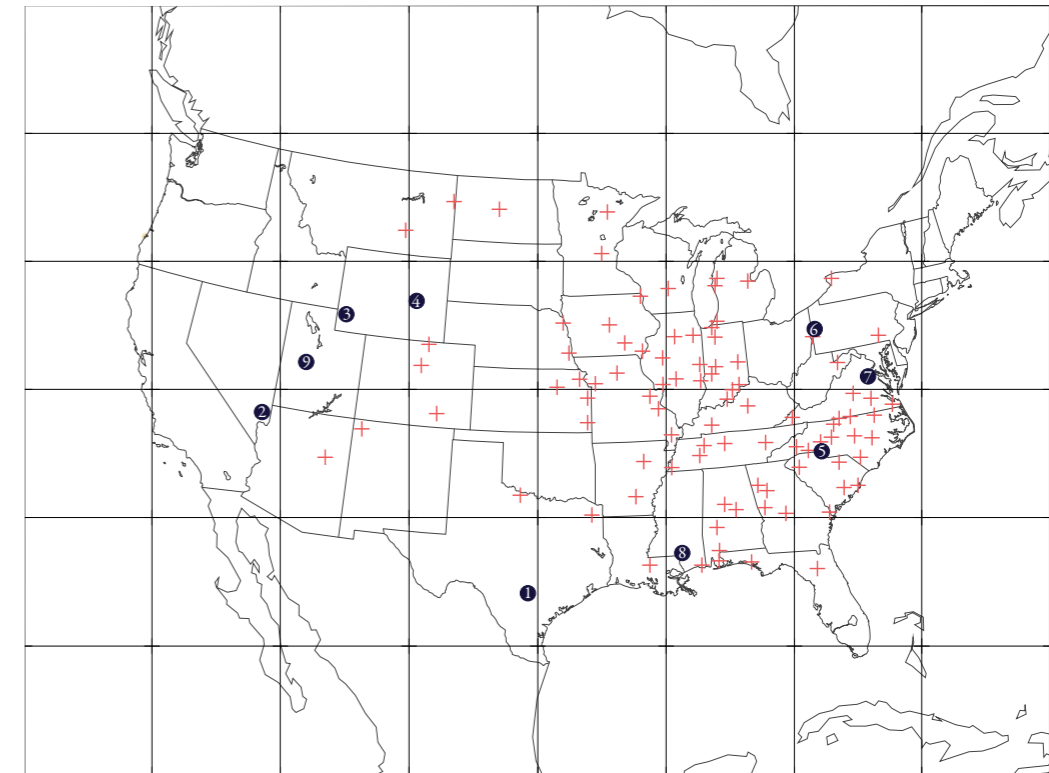


Fig 2: Coal ash polluted sites, Satellite view

There is one thing in common between the power plants above, that is tons of coal ash buried/non buried and created a wasteland. While narrowing down the site selection for this research, environmental and human health factors are elaborated.

Therefore, Duke Energy's Allen Steam Station is selected as it is the only urban power plant that has less than a mile to the closest residential area. The coal ash dumps were built beneath the water table and are leaking cobalt (which causes thyroid damage) into soil and groundwater at concentrations more than 500 times above safe levels, along with unsafe levels of eight other pollutants.



### Top Utilities Fail to Clean Up Coal Ash Pollution

Based on earthjustice.org

1. San Miguel Electric Cooperative's San Miguel Plant, TX
2. NV Energy's Reid Gardner Station, NV
3. PacifiCorp's Naughton Power Plant, WY
4. PacifiCorp's Jim Bridger Power Plant, WY
5. Duke Energy's Allen Steam Station, NC
6. GenOn's New Castle Generating Plant, PA
7. GenOn's Brandywine Coal Ash Landfill, MD
8. Cooperative Energy's R.D. Morrow Power Plant, MS
9. PacifiCorp's Hunter Power Plant, UT

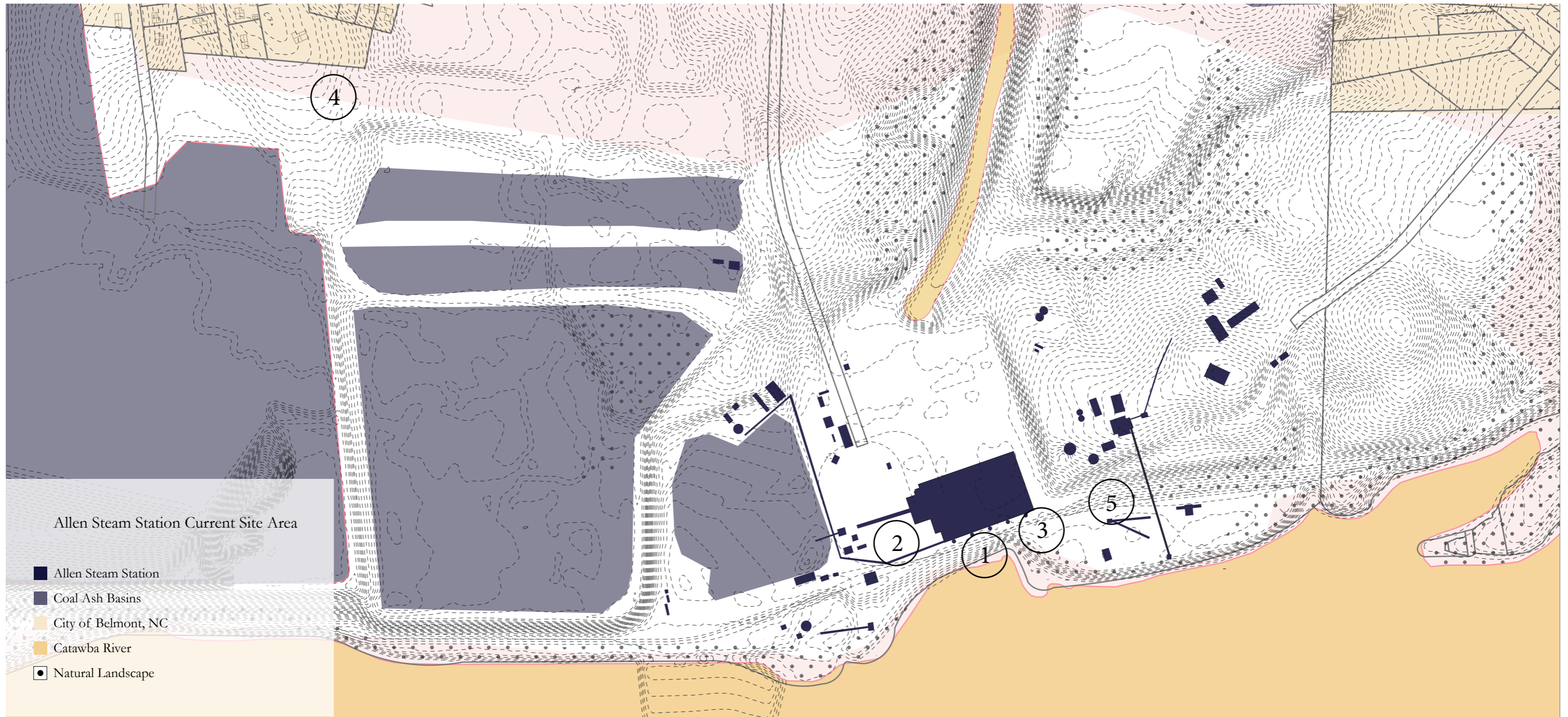


Fig 3, 4, 5: Allen Steam Station: Photographer Unknown

## 1. Macro\_Territory

### 1.3. Position

By incorporating the principles of Reduce, Reuse, Recycle, and Regulate, this research project paves the way for a more sustainable future. Instead of simply burying the coal ash and perpetuating the problem, the approach outlined in this study focuses on revitalizing the wasteland and establishing a sustainable cycle for coal ash, an otherwise neglected waste material. By considering the potential negative impacts on the environment, such as soil contamination, the research aims to address these concerns through sustainable and responsible practices.

Through the repurposing of the decommissioned power plant into a facility for reusing coal ash, this study showcases the potential of environmentally responsive solutions. It emphasizes the importance of looking beyond traditional waste management approaches and reimagining how resources can be utilized. By doing so, positive outcomes can be achieved for both the environment and the economy.

In the larger context of waste management and sustainable development, the findings of this research try to contribute to the existing body of knowledge. It sheds light on the importance of adopting environmentally responsive approaches and provides insights into how future practices can be shaped to create a more sustainable and resilient world.

## R e d u c e



Burying coal ash only masks the problem. Start reducing the presence of coal ash from wastelands, therefore the environmental problems.

## R e u s e



Explore and promote the use of coal ash as a substitute for traditional construction materials. This reduces the demand for virgin materials and provides a valuable application for coal ash.

## R e c y c l e



Develop and promote technologies that can process coal ash into valuable products. Also, invest in research and development to explore new recycling methods and technologies for coal ash.

## R e g u l a t e



Enforce strict regulations on coal ash disposal to prevent environmental contamination. Establish monitoring systems to track the generation, handling, and disposal of coal ash.

## 2. Meso\_Site Area

## 1. Meso\_Site Area

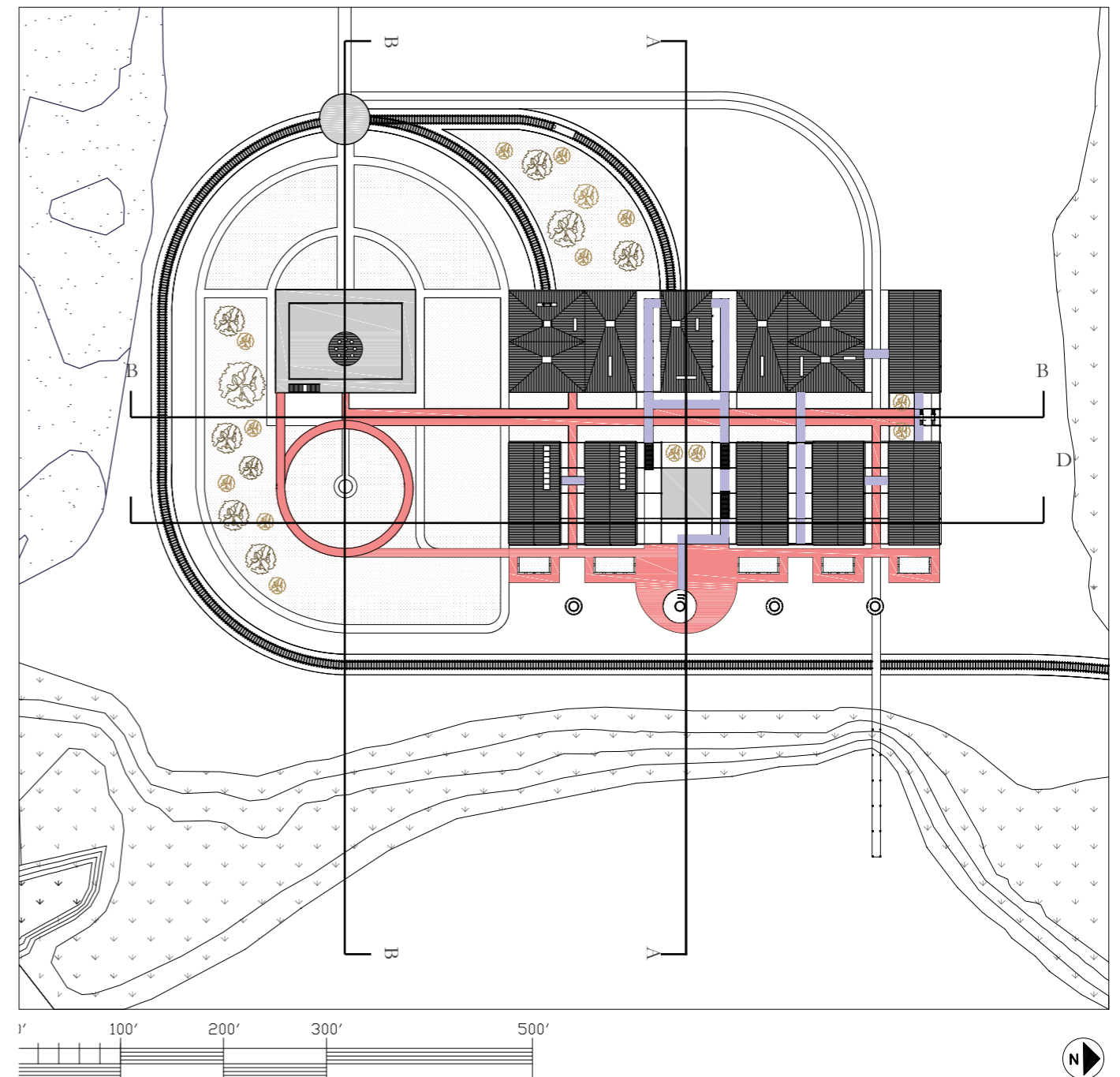
### 1.1. Program

The transformation of a decommissioned coal-fired power plant into a production, exploration, and exhibition facility for reclaiming coal ash represents an opportunity for innovation, sustainability, and community engagement. By upcycling the byproduct, coal ash, and preserving the industrial relics that once dominated the building, a new generation interaction point that celebrates the constant motion of an architectural product is created. By repurposing a building that was once seen as a symbol of pollution and environmental degradation, it is shown that with circular vision and technology, the built environment can be transformed into a force for good. This project is an example for how a more sustainable, equitable, and inspiring future can be created for ourselves and for future generations.

It is more than just a physical transformation of a building; it is a statement of commitment to creating a more sustainable future. By reclaiming coal ash, waste from landfills is diverted and turned into a valuable resource for the construction industry. This reduces the need for virgin materials and lowers carbon emissions, contributing to a circular economy that prioritizes resource efficiency and waste reduction.

This project is also an opportunity for education and community engagement. The public is invited to see the potential of a decommissioned power plant, the process of reclaiming coal ash, and the importance of sustainable practices. Through the motto of 'Produce, Explore, Exhibit!', it is hoped to inspire visitors to think critically about their own impact on the environment and to take action to reduce waste and conserve resources.

This project has the commitment to preserve the history and character of an industrial site while creating a functional and sustainable space that serves the needs of the community and the planet to create an inspiring future for all.



Designing for

Produce + Explore + Exhibit

Beginning and the end of the cycle

Exposing the possibility

Stored beauty of temporality, public display for public

Further research and development

Enriched training and practising experience with finer batches

Last stage of economical circularity for smaller market

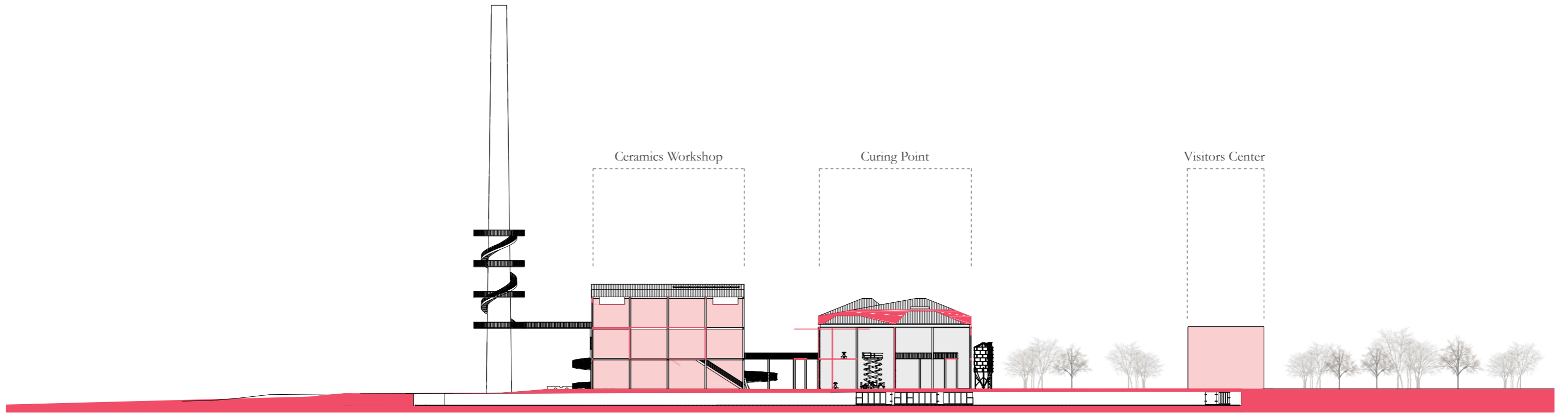
Self suited environment for comfortable practices and residences

Creating public engagement with healed environment

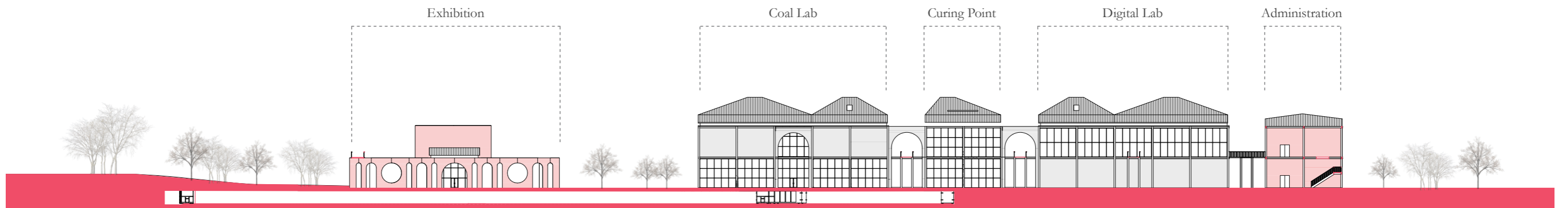
Generating multidimensional users

Middle ground for cultural users and producers to come together

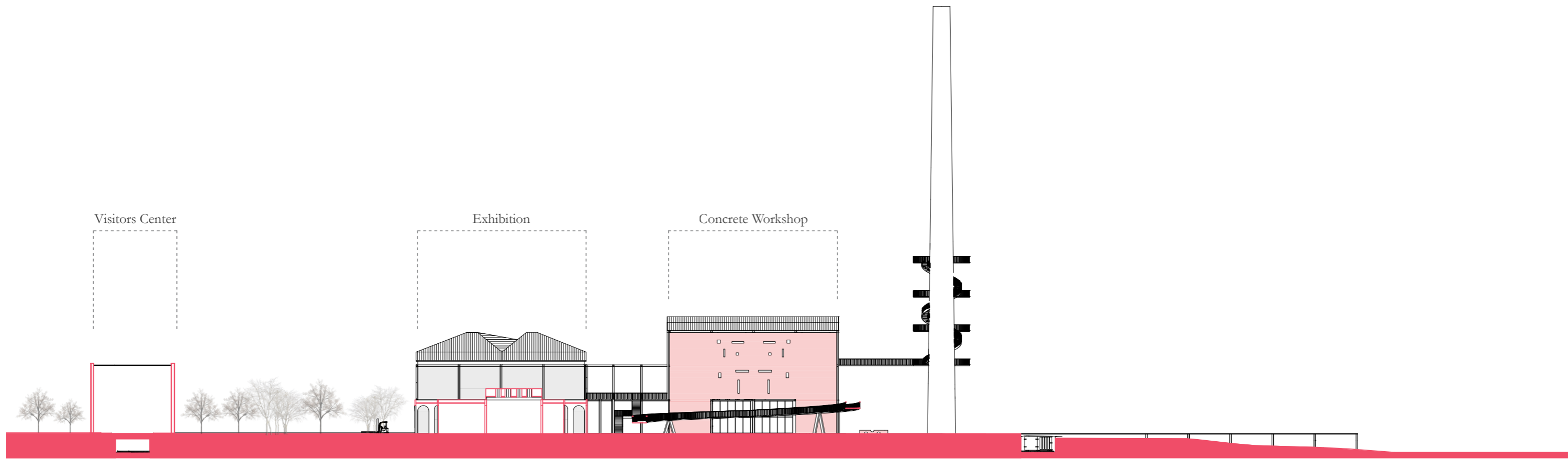
Exposing the last stage of material circularity of coal ash



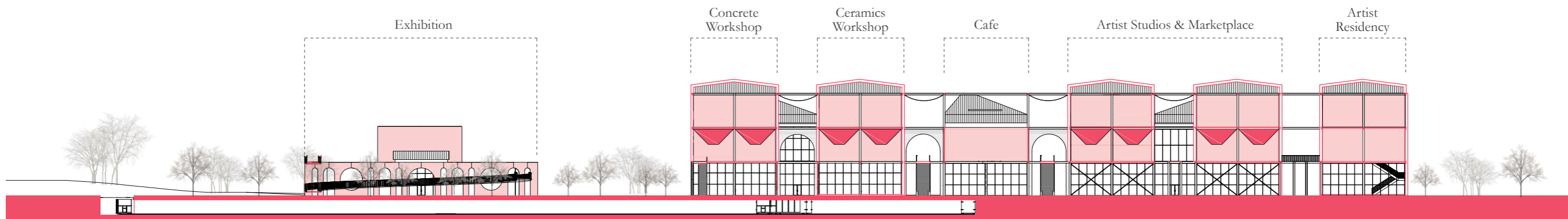
Section A-A



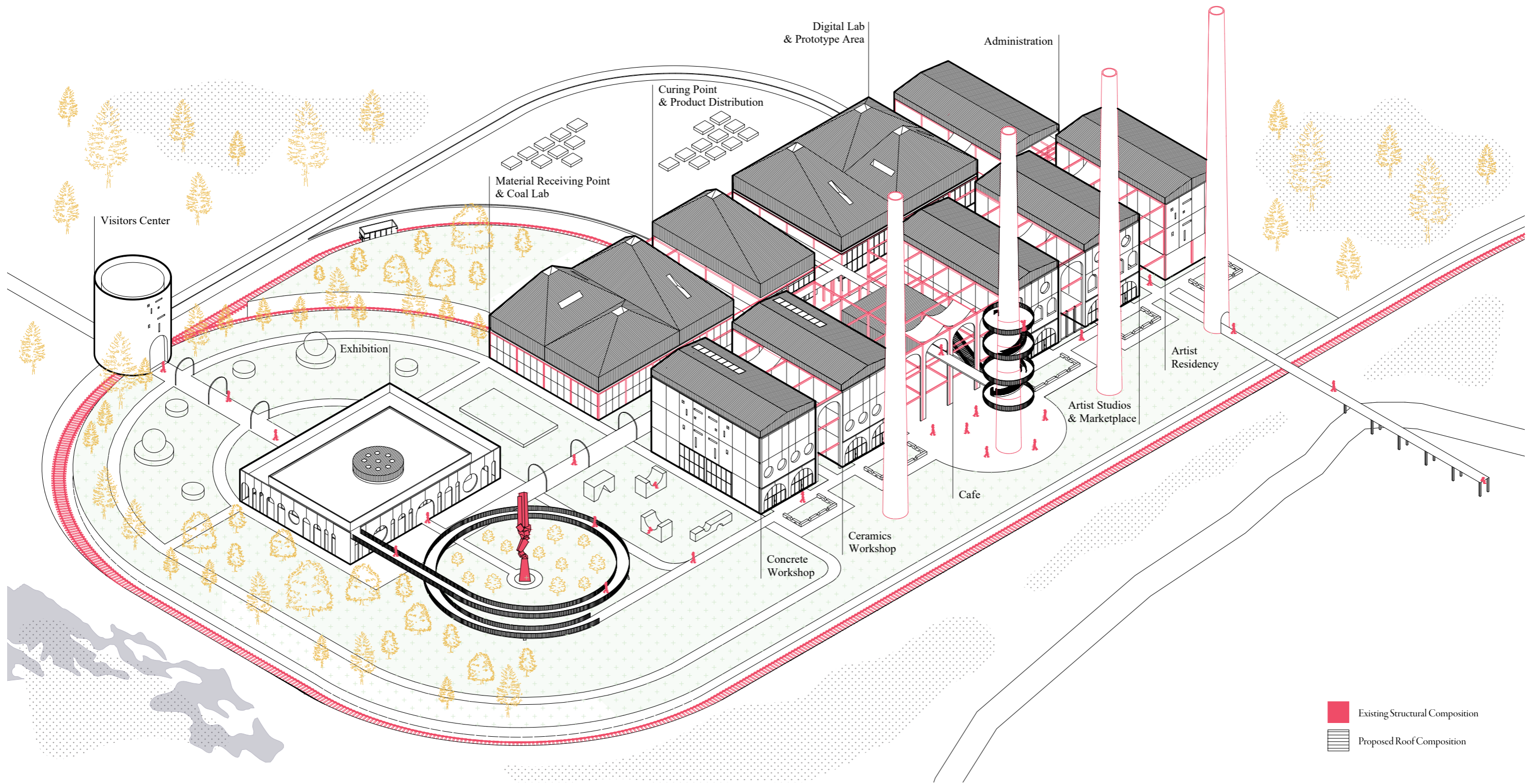
Section B-B



Section C-C



Section D-D

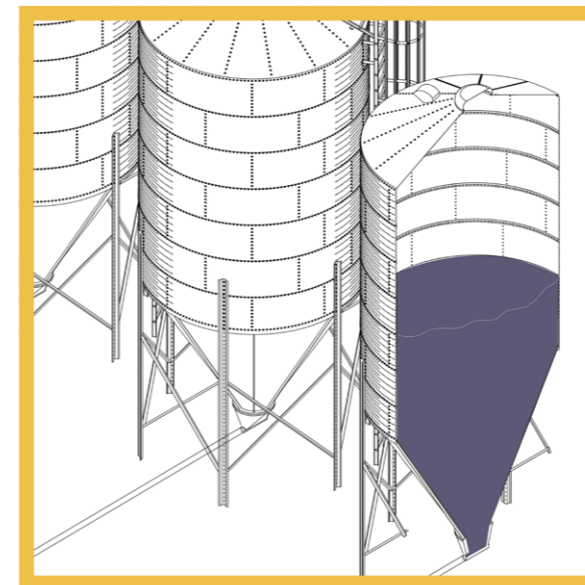
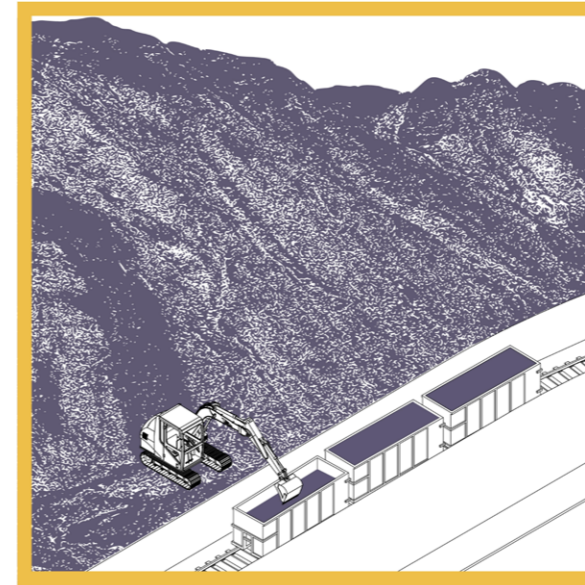


## 1. Meso\_Site Area

### 1.1. Wasteland

In this project, the innovative use of coal ash as a building material becomes an example of upcycling, reflecting both the culture and design ethos of the endeavor. By repurposing this industrial byproduct, the project is not only addressing practical concerns of waste management but also embodying a broader ethical question: What is our role as architects in responding to societal and cultural influences?

By consciously integrating coal ash into the design, the project demonstrates a commitment to sustainable practices and a responsibility to engage with the pressing environmental and social issues of our time. This approach tries to create a challenge between the conventional notions of materiality, sparking a dialogue about the potential for transformative design interventions that reconcile industrial remnants with human needs and aspirations. By embracing coal ash, 'Beyond Waste' invites us to reflect on the ethical implications of our built environment and consider how architecture can meaningfully respond to and shape the cultural and societal landscapes we inhabit.

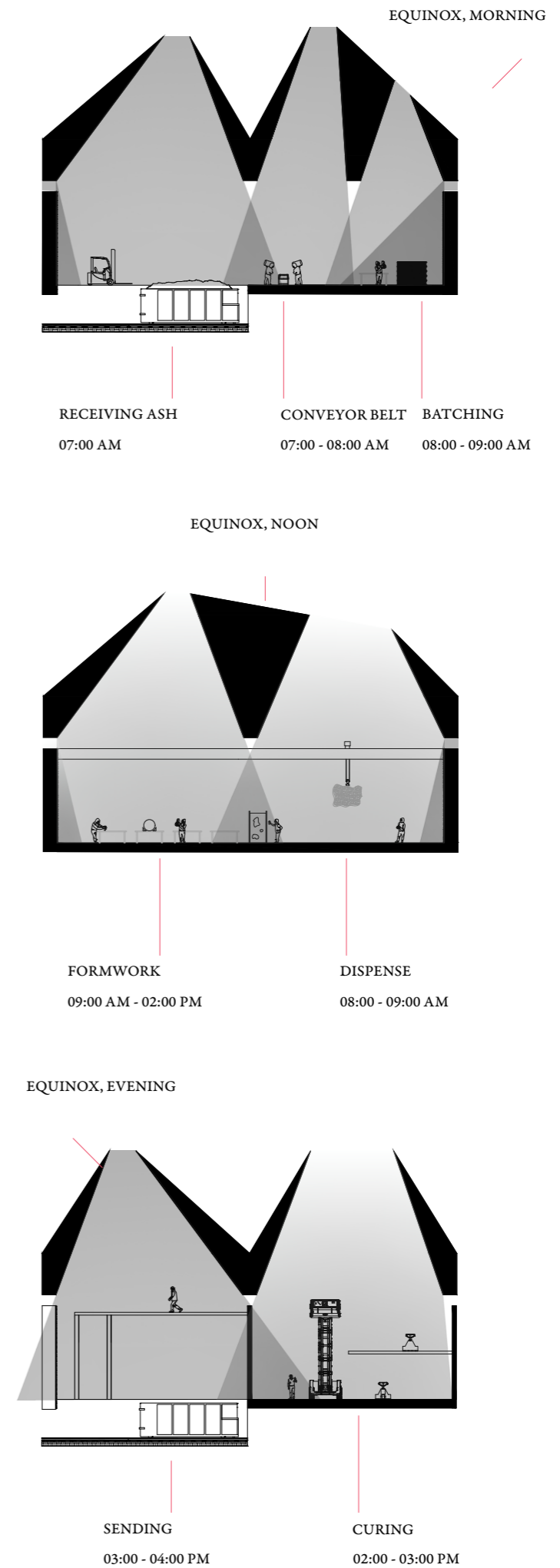


1. Excavator starts loading tons of coal ash to the wagon train
2. Wagon train arrives, the coal ash is being carried over the conveyor belt to be stored in the silos
3. Coal ash is dispensed from silos whenever needed

### **3. Micro\_Core Hub**

### 3. Micro\_Core Hub

When all the spatial elements are brought together, they create a cohesive and engaging environment. The skylighted concrete roof, rough textured tabby geopolymer walls, and terrazzo floor tile work together to create a dynamic interplay of light and shadow throughout the space. The contrasting textures of the walls and floor add visual interest and depth to the environment, while the skylights create a sense of openness and invitation. Overall, the combination of these spatial values creates a visually interesting and engaging space that is both functional and aesthetically pleasing.



### 3. Micro\_Core Hub

#### Roof

The roof of the space has a significant impact on the overall spatial value of the environment. A skylighted concrete roof provides a smooth and modern contrast to the rough, textured walls made from tabby geopolymer. The skylights allow natural light to filter into the space from all angles, creating a dynamic interplay of light and shadow on the walls and floor. This helps to create a sense of depth and dimensionality, thanks to the existing height of the space, making it feel more open and inviting.

#### Wall

The rough textured tabby geopolymer walls provide a tactile and visually interesting backdrop for the production areas. The use of tabby geopolymer gives the space an industrial and utilitarian feel, which is complemented by the smooth and modern appearance of the skylighted concrete roof while the time and spatial sequence of light adds a sense of drama and energy to the environment. Depending on the time of day and the angle of the sun, the light creates a constantly changing pattern of highlights and shadows on the walls, emphasizing the texture of the tabby geopolymer.

#### Floor

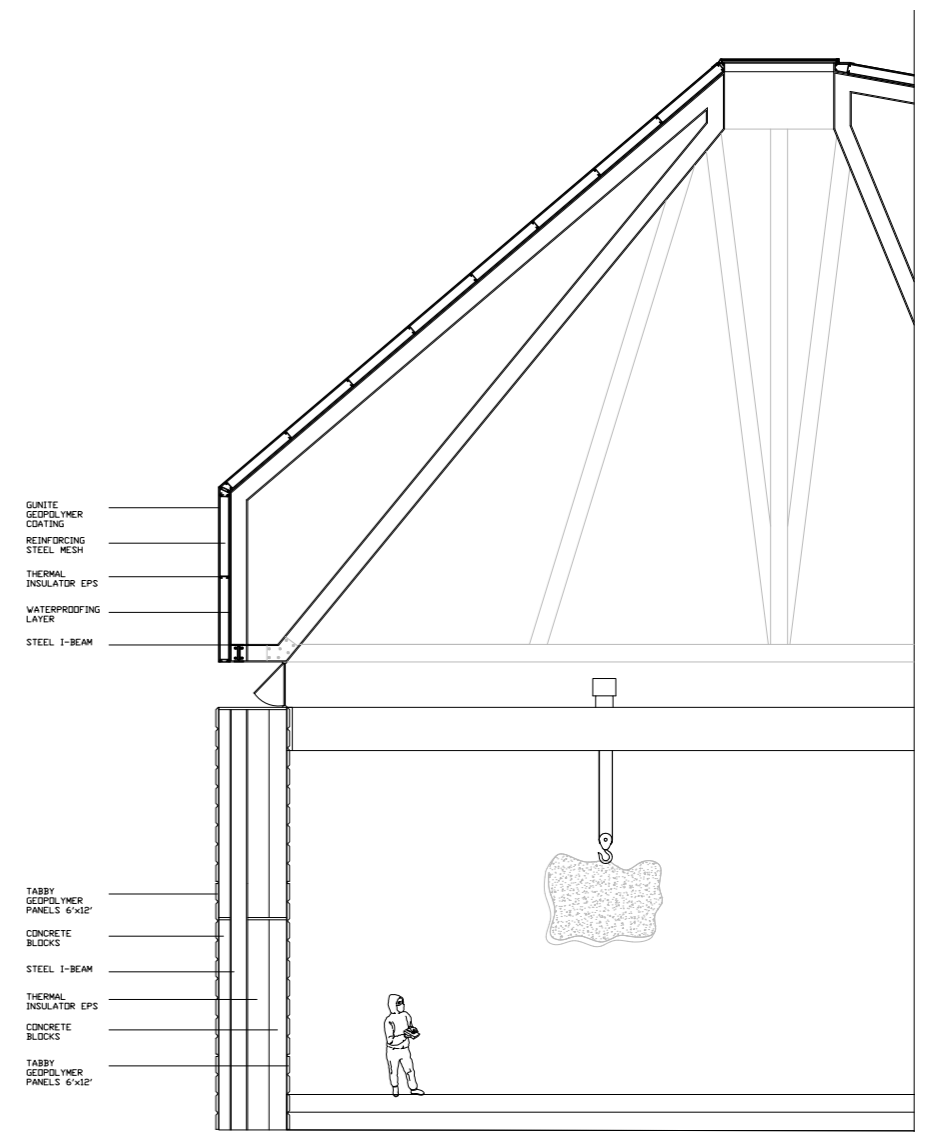
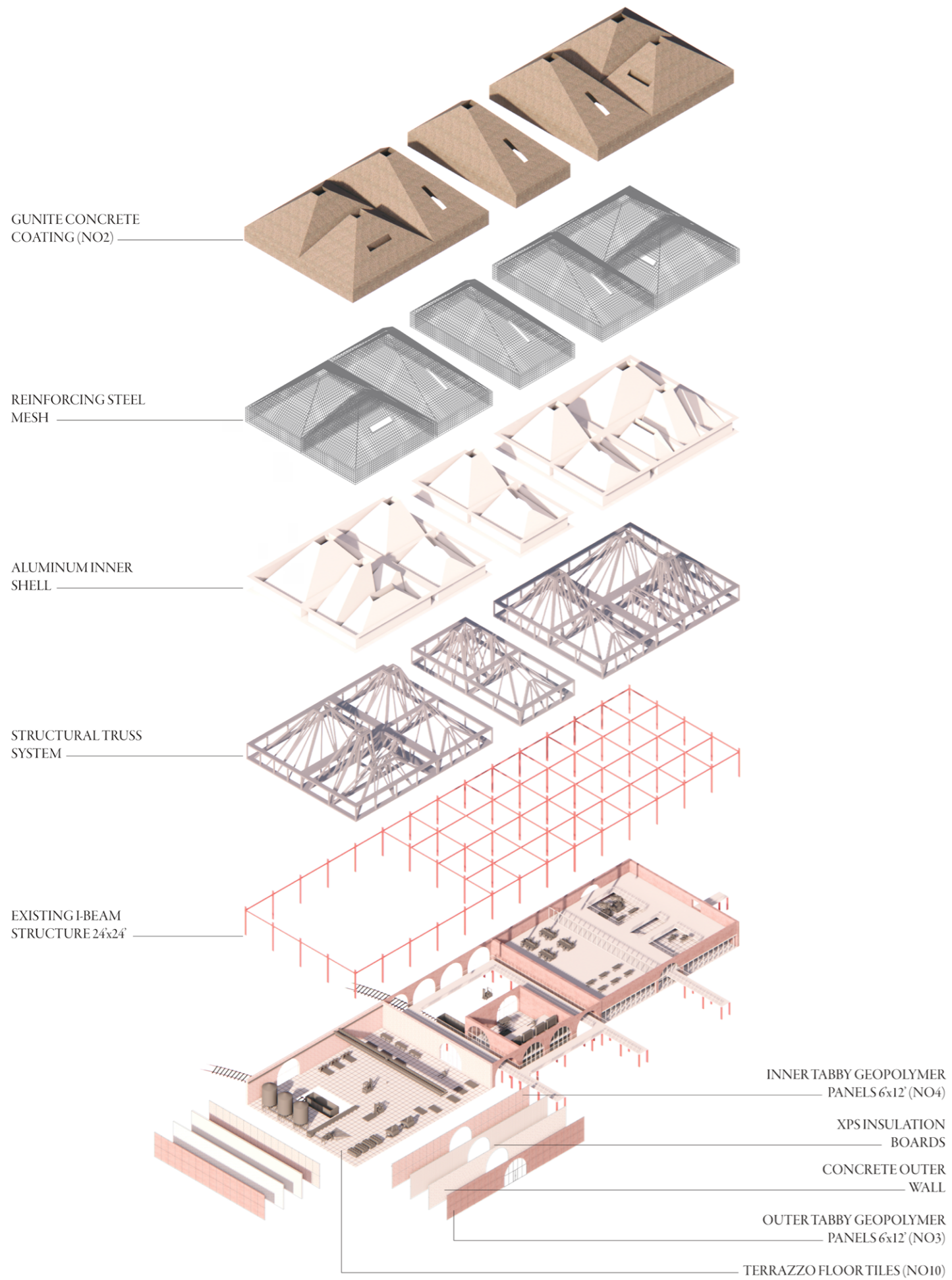
A terrazzo floor tile provides a smooth and sophisticated look in contrast to the rough texture of the tabby geopolymer walls. The speckled appearance of the terrazzo complements the natural patterns of light and shadow created by the skylights, helping to create a cohesive and visually interesting space.



Latitudinal Section through Coal Lab

#### Reflection of Ambiance

When all these spatial elements are brought together, they create a cohesive and engaging environment. The skylighted concrete roof, rough textured tabby geopolymer walls, and terrazzo floor tile work together to create a dynamic interplay of light and shadow throughout the space. The contrasting textures of the walls and floor add visual interest and depth to the environment, while the skylights create a sense of openness and invitation. Overall, the combination of these spatial values creates a visually interesting and engaging space that is both functional and aesthetically pleasing.



Latitudinal Detail Section through Coal Lab

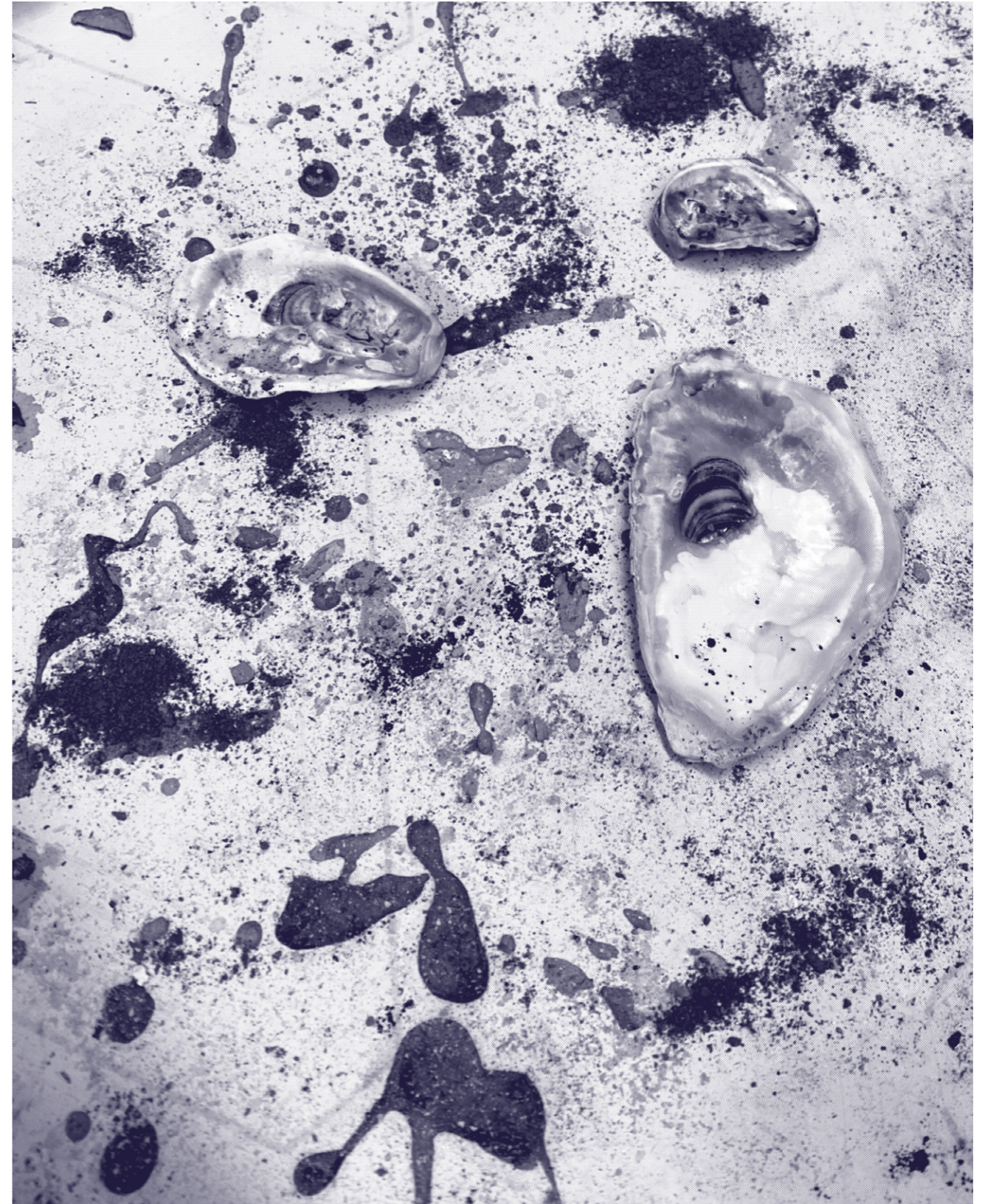


## **4. Craft and Technique**

#### 4. Craft and Technique

Craft and technique have always played a vital role in architecture, shaping the way buildings are conceived, constructed, and experienced. In his influential book “Studies in Tectonic Culture”, Kenneth Frampton explores the intricate relationship between construction techniques, cultural context, and architectural design. By drawing inspiration from local craft traditions and employing meticulous techniques, critical regionalism seeks to create buildings that not only respond to the unique conditions of a region but also capture the essence of its culture and identity.

In this regard, this thesis study sets the stage for an exploration of how craft and technique can contribute to the poetics and authenticity of architecture, transcending mere functionalism and resonating with the aspirations of individuals and communities alike.



#### 4. Craft and Technique

The interplay between craft, technique, and regional identity that can be found in the architecture of North Carolina is explored, where the use of oyster shells has been a traditional method for centuries. This local craft tradition, rooted in the region's rich coastal heritage, embodies the essence of critical regionalism. By employing meticulous techniques and drawing inspiration from this indigenous material, this project not only responds to the unique coastal environment but also captures the cultural identity and sense of place.

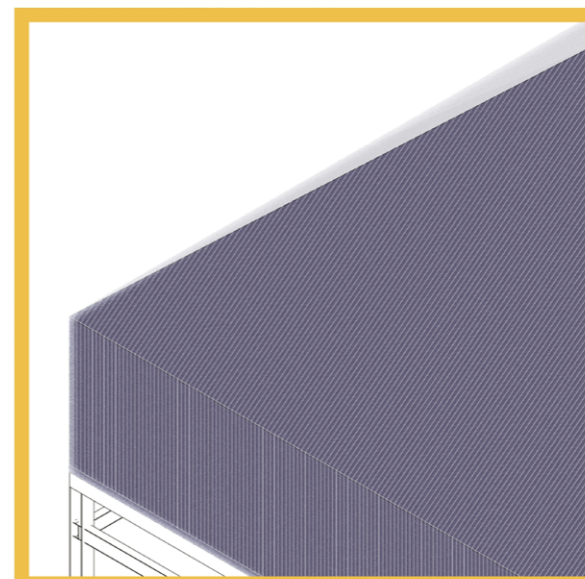
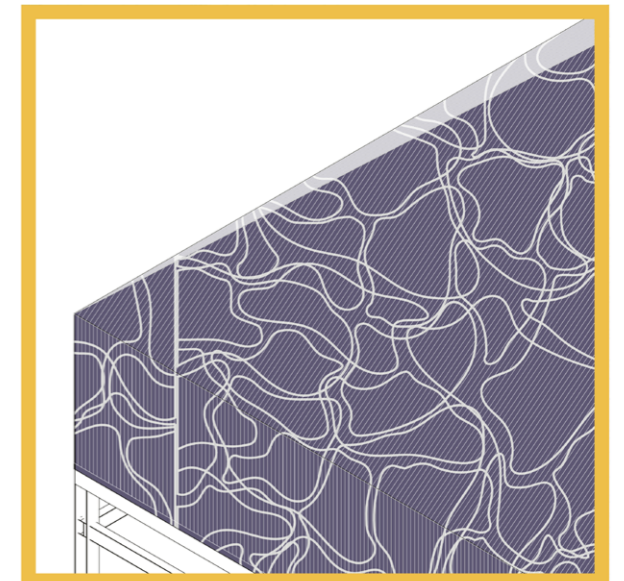
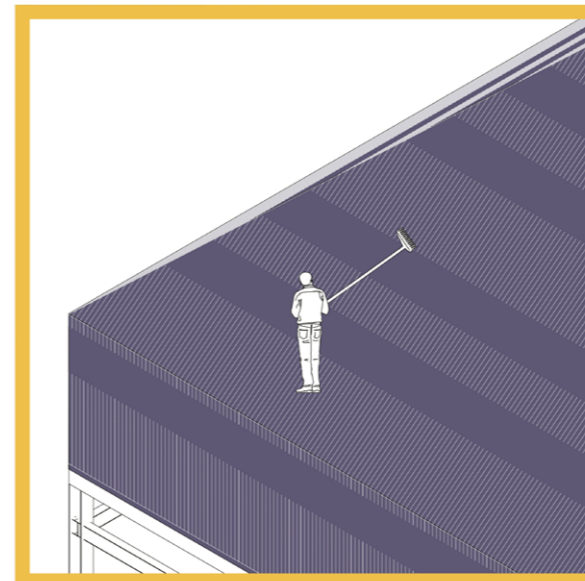
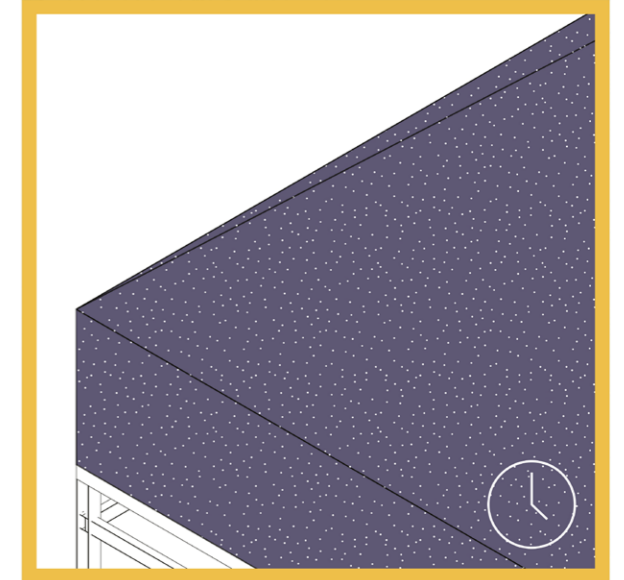
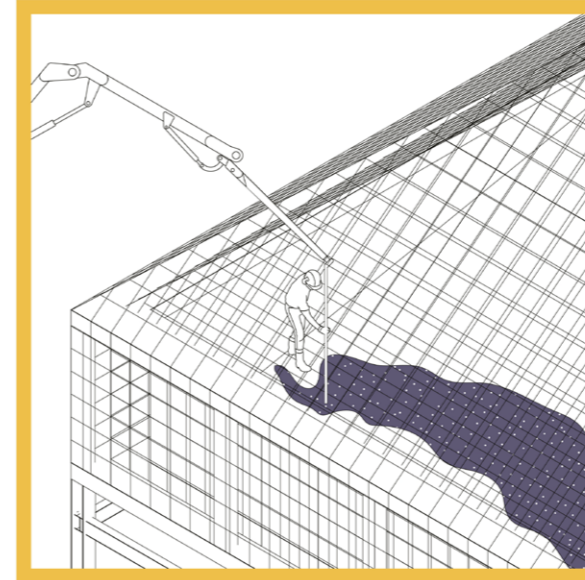


## 4. Craft and Technique

### 4.1. Processing of Architectural Elements

#### 4.1.1. Roof

The use of coal ash in gunitite can provide environmental benefits by reducing the amount of waste produced by coal-fired power plants. It can also increase the durability and strength of concrete as well as workability by reducing the amount of water needed for production. The roof structure made of gunitite concrete including coal ash allows the creation of a lightweight and flexible roof for Allen Steam Station.



1. Pre-mixed wet gunitite is applied using a nozzle that combines compressed air and water to the steel mesh onto the surface with force
2. Allow to partially set and apply the gunitite as following layers
3. Brush the surface of the concrete to create a textured finish
4. Cure the concrete by wetting it from time to time
5. Apply the waterproof coating once it's cured

## 4. Craft and Technique

### 4.1. Processing of Architectural Elements

#### 4.1.1. Wall

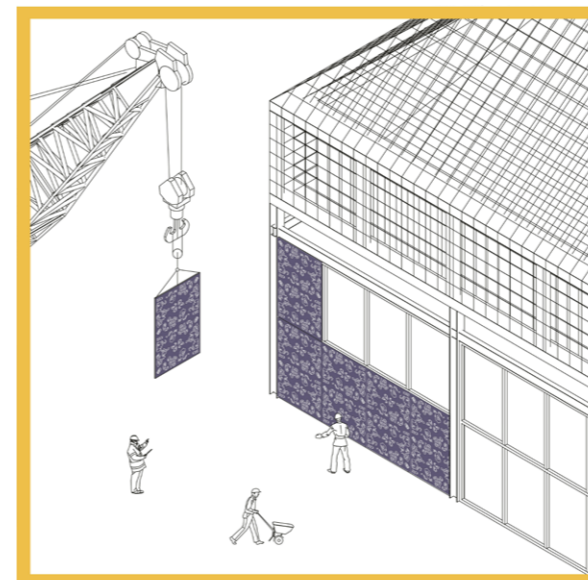
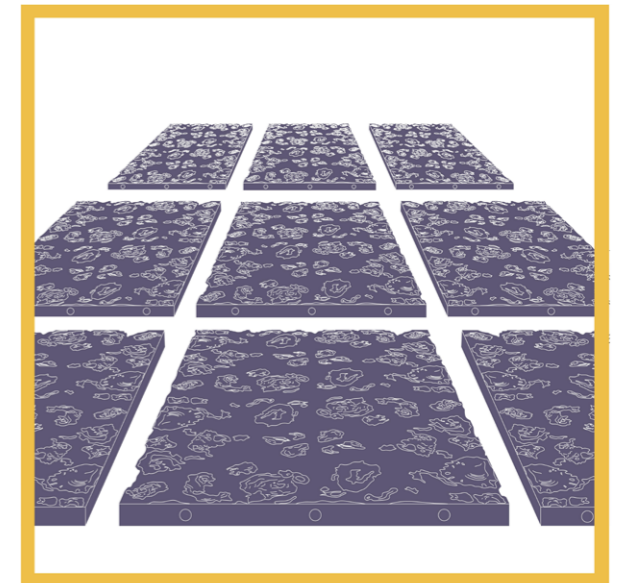
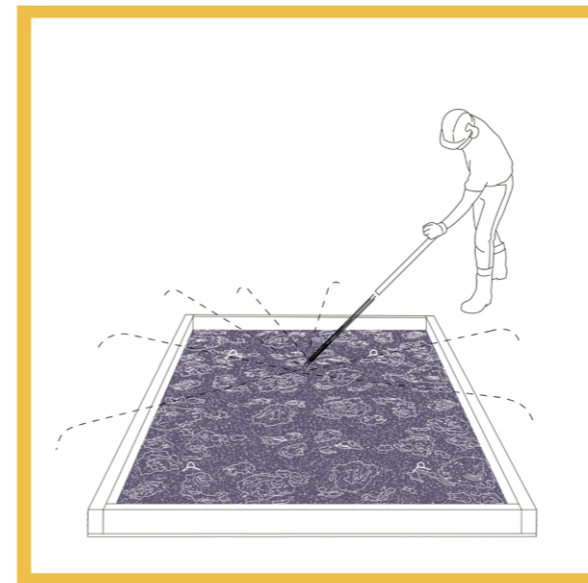
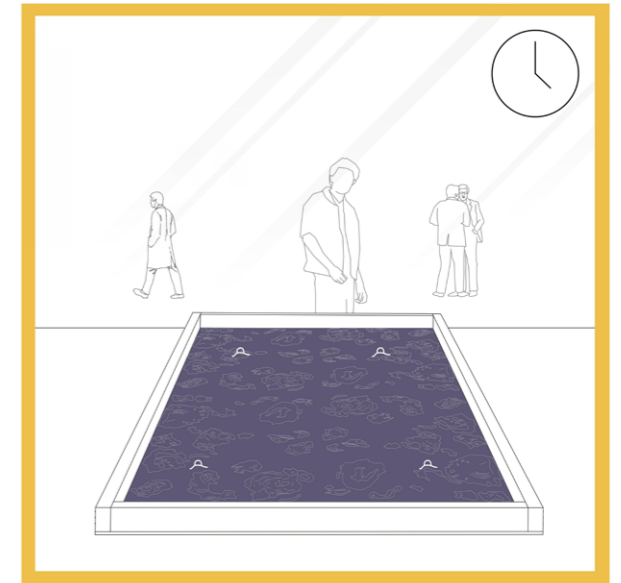
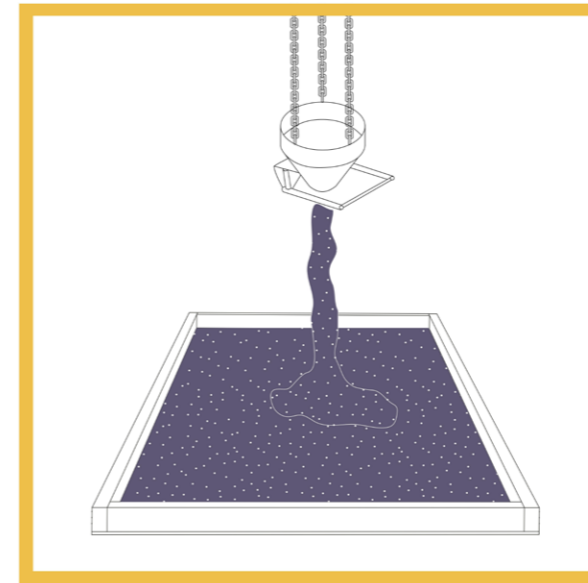
Combining tabby and geopolymer concrete into a single material can create a sustainable building product that is environmentally friendly and sustainable by minimizing the impact on the planet.

Tabby concrete is an important architectural heritage in the coastal regions of the US. It was widely used historically, is readily available, and is affordable as a building material in North Carolina.

Locally obtained crushed seashells (from Catawba River by the power plant) are mixed with geopolymer concrete to utilize the waste, and coal ash material while reducing the high carbon footprint by reducing the need for portland cement.

Tabby concrete also has a unique texture that is prized for its aesthetic value in this project. By combining this with the strength and durability of geopolymer technology, a tabby geopolymer brick could offer both beauty and function.

The best example of tabby concrete is the façade of Cowgill Hall, Virginia Tech.



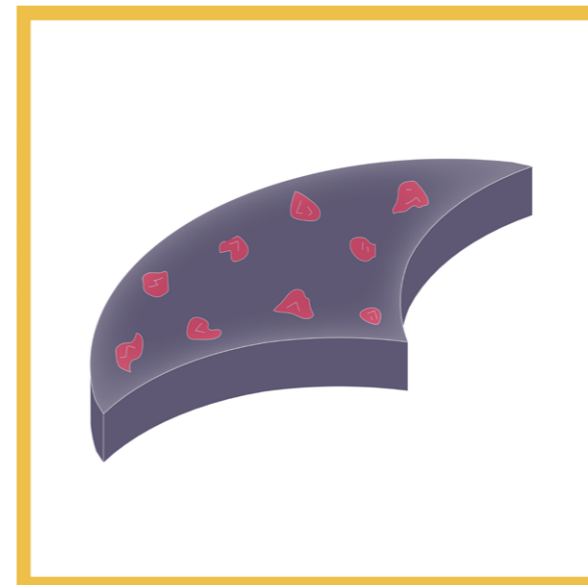
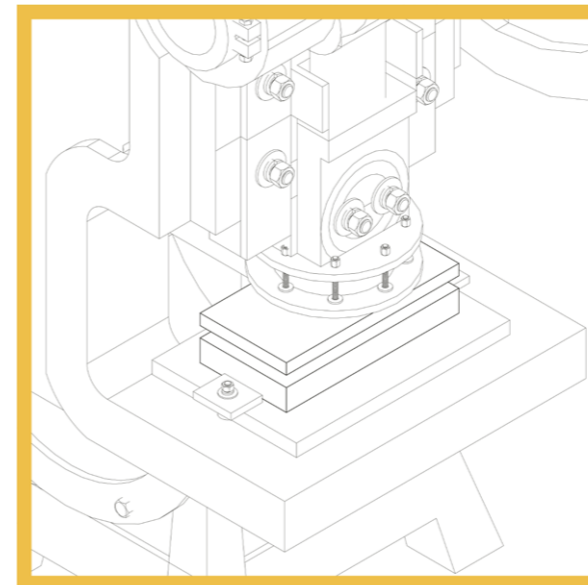
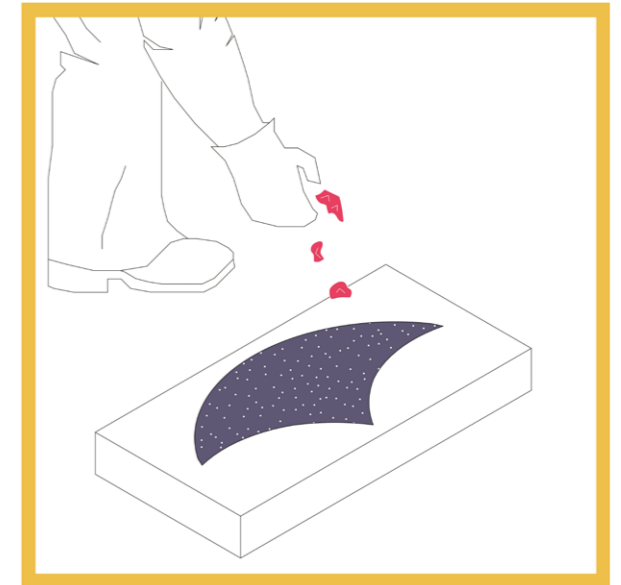
1. Pour the compound inside the 6' by 12' wood-based formwork
2. Include the lifting inserts and leave to cure the concrete in the display section for the necessary amount of time
3. Treat the surface to expose aggregates by washing away the top layer of cement
4. Seal the panel and remove the formwork
5. Carry the pre-cast piece to the site of construction with a crane

## 4. Craft and Technique

### 4.1. Processing of Architectural Elements

#### 4.1.1. Floor

Terrazzo tiles made with gypsum, ash, and coal insertions are a perfect flooring choice for production facilities. The combination of gypsum and ash creates a strong binder, ensuring durability. The coal insertions provide a distinctive look while keeping the tiles lightweight. These tiles offer natural resistance to wear and tear, making them ideal for high-traffic areas. They are also easy to clean and maintain, making them a practical and visually appealing option for industrial environments.

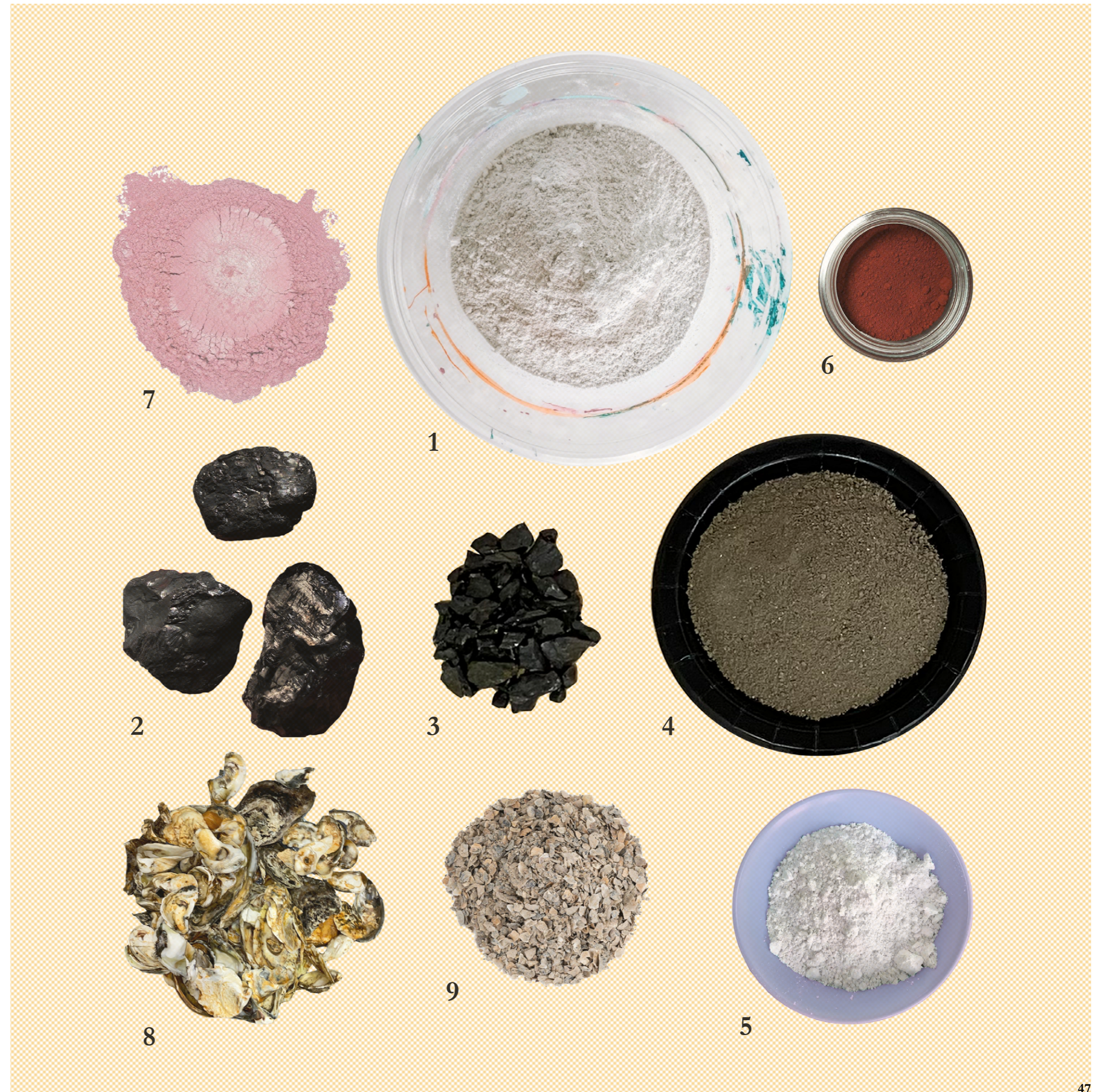


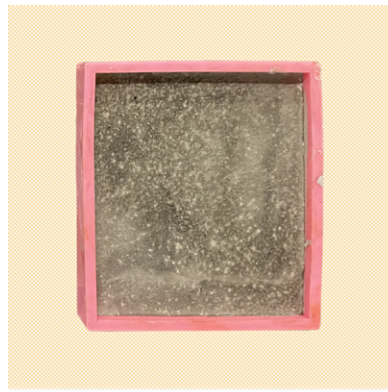
1. Apply the thin layer of terrazzo matrix to the 3' by 1.5' fishscale tiles
2. Embed the coal chunks on top of the mix for the necessary amount of time
3. Use the press machine for 2-3 minutes
4. Cure the matrix for some time
5. Take the forming tile out and apply the sealer to resist staining

#### 4. Craft and Technique

##### 4.3. Material Board

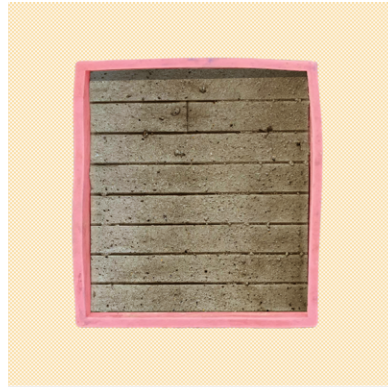
- 1 Concrete Mix
- 2 Coal Chunks
- 3 Coal Lumps
- 4 Coal Ash
- 5 Gypsum Powder
- 6 Brick Dust
- 7 Iron Oxide Pigment
- 8 Oyster Shells
- 9 Crushed Oyster Shells





### № 1 Spray Geopolymer Concrete

1. Create sustainable concrete by blending concrete mix, coal ash, and water.
2. Incorporate 10-30% coal ash into the mix for added strength and durability.
3. Gradually add water to achieve desired consistency.
4. Pour into mold, and leave for the cure.



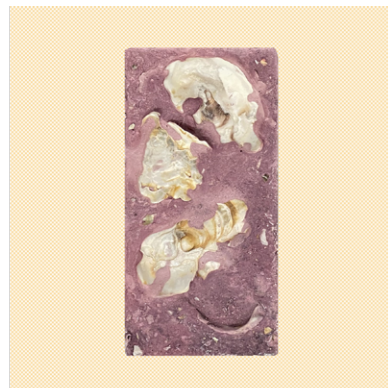
### № 2 Spray Geopolymer Concrete

1. Create sustainable concrete by blending concrete mix, coal ash, and water.
2. Incorporate 10-30% coal ash into the mix for added strength and durability.
3. Gradually add water to achieve desired consistency.
4. Pour the mixture into the mold, rake, and brush till you have a rough finish.
5. Leave for the cure.



### № 3 Tabby Geopolymer Panel

1. Combine concrete mix, coal ash, and iron oxide pigment (one table spoon).
2. Mix the ingredients thoroughly to ensure a uniform blend.
3. Pour the mixture into a panel mold and spread it evenly.
4. Sprinkle crushed oyster shells on the surface of the poured mixture.
5. Allow the panel to cure.



### № 4 Tabby Geopolymer Panel

1. Combine concrete mix, coal ash, and iron oxide pigment (as desired).
2. Mix the ingredients thoroughly to ensure a uniform blend.
3. Pour the mixture into a panel mold and spread it evenly.
4. Press oyster shells onto the surface of the poured mixture.
5. Allow the panel to cure.



### № 5 Tabby Geopolymer Panel

1. Combine concrete mix, coal ash, and red brick dust (one table spoon).
2. Mix the ingredients thoroughly to ensure a uniform blend.
3. Pour the mixture into a panel mold and spread it evenly.
4. Sprinkle crushed oyster shells on the surface of the poured mixture.
5. Allow the panel to cure.



### № 6 Geopolymer Brick

1. Add 1:1 concrete mix to the coal ash and add gravel.
2. Combine ingredients thoroughly until a homogeneous mixture is formed.
3. Pour the mixture into a brick mold, ensuring even distribution.
4. Allow the bricks to cure and harden for 12 hours.



### № 7 Geopolymer Brick

1. Pour a mixture of 1:8 coal ash into the concrete mix, and add water.
  2. Ensure thorough mixing to achieve a consistent paste.
  3. Compact the mixture in the mold, pressing the coal chunks into place.
  4. Allow the brick to cure and harden for 12 hours.
- (It needs a protective finish to use. This is only a result of an investigation.)



### № 8 Terrazzo Floor Tile

1. Mix the coal lumps with gypsum, add water to form a workable paste.
  2. Ensure thorough blending of the ingredients.
  3. Pour the mixture into tile molds and allow it to dry and harden.
- (Once cured, the terrazzo tile can be polished to reveal the distinctive patterns and textures created by the coal lumps)



### № 9 Terrazzo Floor Tile

1. Use gypsum, brick dust, coal ash, and water.
  2. Mix equal parts of the ingredients, adding water until a thick paste forms.
  3. Pour into a tile mold, level the surface, and let it dry.
- (Optionally, sand and polish for a smooth finish)



### № 10 Terrazzo Floor Tile

1. Mix the concrete with water until it reaches a workable consistency.
2. Pour the mixture into the tile mold, then insert coal lumps into the mixture.
3. Level the surface and let the tiles cure and dry completely.
4. Once cured, remove the tile from the mold and sand them to expose the aggregate. (Seal the tiles for protection)

## 4. Craft and Technique

### 4.1. Material Analysis

When these spatial elements harmonize, they form a cohesive and captivating environment. The dramatic gunite concrete roof, rough-textured tabby geopolymer walls, and ribbed terrazzo floor tiles seamlessly blend to create a dynamic interplay of light and shadow throughout the space.

The contrasting textures of the walls and floor enhance visual interest and depth, while the skylighted roof fosters a sense of openness and invitation. Overall, the combination of products № 2, № 4, and № 10 allows us to shape spatial values and craft an engaging and visually striking space that is both functional and aesthetically pleasing.

	SPRAY GEOPOLYMER CONCRETE FOR ROOF		TABBY GEOPOLYMER WALL PANELS			GEOPOLYMER WALL BRICK (ONLY INVESTIGATION)		TERRAZZO FLOOR TILES		
	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	№ 7	№ 8	№ 9	№ 10
COLOR -HUE	GREY	GREY	BLUSH ROSE	ROSE	RED ROSE	GREY	LIGHT GREY	WHITE	BRICK RED	GREY
TEXTURE	MATTE	ROUGH / MATTE	MATTE	ROUGH	MATTE	MATTE	SHINY	MATTE	MATTE	ROUGH / MATTE
REFLECTION	DIFFUSE	DIFFUSE	DIFFUSE	SPREAD/DIFFUSE	DIFFUSE	DIFFUSE	SPECULAR/SPREAD	DIFFUSE	DIFFUSE	DIFFUSE
VISUAL ASSESMENT	NO DISTINCTIVE CHARACTERISTICS	THE TEXTURE OF THE ROOF CREATES DEPTH IN 45/135 DEGREES ANGLE	LOOKS VERY SIMILAR TO TERRAZZO FLOOR	ROUGH, UNDER LIGHT ANGLE IT SHOWS ITS IRREGULARITIES	DARK COLOR LOOKS OFF	MATERIAL LOOKS IRREGULAR	MATERIAL LOOKS UNUSUAL	NO DISTINCTIVE CHARACTERISTICS	COLOR CHANGES SLIGHTLY OF APPEARANCE	MATERIAL CHANGES SLIGHTLY OF APPEARANCE IN TEXTURE
COMBINATION OF LIGHT AND MATERIAL	NOTHING SIGNIFICANT	EMPHASIZES TEXTURE	EMPHASIZES TEXTURE	EMPHASIZES TEXTURE	EMPHASIZES TEXTURE	NOTHING SIGNIFICANT	EMPHASIZES INSERTS	COLD	WARM	COLD
INDIVIDUAL EXPERIENCE	FORMAL	RELAXED	AESTHETICALLY PLEASING	DRAWS ATTENTION	AESTHETICALLY PLEASING	AESTHETICALLY UNPLEASING	INCREDIBLY LIGHT-WEIGHT	FORMAL	UNFORMAL	DRAWS ATTENTION

## 5. Reflection

## 5. Reflection

As architects, we bear an ethical responsibility to approach our role beyond mere design and construction. It is incumbent upon us to consider the broader societal and cultural influences in our practice, particularly when it comes to addressing environmental concerns. One crucial aspect of this responsibility is the thoughtful utilization of waste materials like coal ash, imbuing them with purpose and meaning.

By combining waste materials with conventional elements like oyster shells in this project, we create a unique synthesis that reflects the principles of sustainable design and cultural authenticity. Through this ethical lens of waste recycling, the design process takes on a new dimension, resulting in architecture, as a cultural artifact, that challenges the status quo. This transformative approach not only contributes to environmental sustainability but also promotes a broader cultural shift by showcasing the beauty and potential of these reclaimed materials.

As architects, we have the power to shape the built environment in a way that transcends functionality and resonates with deeper cultural values, leaving a lasting impact on society and inspiring a reimagining of what can be achieved through responsible design practices.



Fig 6: A New Concept for Good Architecture

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## 7. Image Citations

Fig 1: Quicker than Coal Ash: Photographer Will Warasila  
Retrieved from <https://atmos.earth/quicker-than-coal-ash-will-warasila-walnut-cove/>

Fig 2: Coal ash polluted sites, Satellite view (Google Earth)

Fig 3, 4, 5: Allen Steam Station: Photographer Unknown  
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Fig 6: A New Concept for Good Architecture  
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