ARCH998 Design Thesis

Shipwreck Preservation Laboratory
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An Architectural System For Shipwreck Preservation Articulating Shipwreck Autonomy

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A thesis submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Architecture (Professional) (March(Prof)

02/21/2025

Attestation of Authorship Statement

“I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.”

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Abstract:

This thesis is a non-human-centric design project that seeks to relate to the ship's otherness by 'speaking for it.' It explores the question: Beyond human's domination of shipwreck preservation as heritage celebration and a resource for human history education, what architectural language can a ship preservation laboratory adopt to relate the shipwreck's autonomy?

I investigate the 'face' of the shipwreck after its service or sinking event, drawing on ontological and conservation theories, particularly Levinas' theory on otherness and Christopher Alexander's concept of the 'degree of life.' These frameworks help to understand the 'partial being' of a vessel.

Shipwrecks and wreck sites are analyzed, drawn, and modelled, while underwater archaeological preservation processes are studied. Alternative archaeological preservation principles are proposed to maintain the ambiguity of a wreck's liminal condition. Various media, including embodied image reading, narrative, parametric tools, and hand drawing are applied both intuitively and logically for iterative design development.

A series of preservation laboratories are proposed, including:
1. Excavation Laboratory
2. Stabilization Laboratory
3. Structural Assembly Laboratory
4. Re-Treatment (Re-Stabilization) Laboratory
5. Dispatch & Display Building

Together, these form a 'holobiont living system' for shipwreck preservation. Among them, the Re-Treatment (Re-Stabilization) Laboratory (No. 4) is discussed as a Phase 1 test design case, while the Dispatch & Display Building (No. 5) serves as the final design of this thesis. Through this building, I aim to translate the abstract concept of Cordelia's silence into an architectural language that relates to the wrecked vessel's 'partial being.'

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Chapter 0

[0.1] Acknowledgements:

I would like to express my deep appreciation to my parents for your unwavering love and support over the years.

I would also like to thank my supervisor, Charles. Throughout this year, you have given me an immense amount of freedom and personal space, helping me relieve the burden of an overly rationalized way of thinking. Your guidance has been invaluable.

[0.2] Positionality Statement:

A few years ago, during my bachelor's degree in architecture, I was introduced to a project involving the design of a ship recovery center. The objective of the brief was to create an architectural facility that educates the public about the Scottish shipbuilding era, in response to London's Maritime Museum and the Vasa Museum.

During the site visit, I was deeply moved by the sight of several shipwrecks lying in the quiet bay, while cargo ships passed along the River Clyde. At that moment, I felt that something was missing from the brief. The scene did not evoke a sense of pride in history, but rather a subdued beauty filled with sadness. I struggled to fully translate these emotions into architectural design, yet I felt there was so much more to consider.

At the same time, I became increasingly interested in the ideas of diaspora and belonging. I wanted to explore the potential of architecture and develop an entirely unique architectural language. For me, ships are a different kind of architecture, offering a refreshing perspective. These experiences became the motivation behind my thesis project.

[0.3] Glossary

Cordelia's Silence: A form of feminine subversive complicity, in which a silence appears to conform to the patriarchal idealization, yet it undermines the imposed dictates (Hamamra, 2019).

Conservation (in Archaeology): Measures and actions carried out to protect tangible cultural heritage of artifact while ensuring its accessibility to both present and future generations. Conservation includes preventive conservation, remedial conservation, and restoration(Nardi, 2020, p2655).

Degree of life: Christopher Alexander(2002) introduces a broader understanding of life beyond biological reproduction. According to Alexander, life is a quality inherent in all objects and spaces, though it exists in varying degrees.

Heterotopia: A type of 'counter-site' where a real, physical place is simultaneously represented, contested, and inverted (Foucault, 1986). The Heterotopia in this thesis explores the spatial configuration and formal qualities, resists conventional order and embodies a state of in-betweenness apart from Cartesian order and formless nature.

Holobiont: A living system carrying a myriad of organisms (Rich, 2021). The holobiont architecture in this thesis represents embody design elements with their own degree of life independent from the entity while sharing cooperative relationship. Holobiont Living System addressing material relationships, environmental integration, and the coexistence of shipwrecks and preservation systems.

Otherness: An alterity of a person, object or species that cannot be reduced to sameness (Levinas, 1998).

Preservation (in Archaeology): The process of protecting, conserving, and maintaining archaeological materials, sites, and artifacts to prevent deterioration and ensure their longevity for future study and interpretation (Cronyn, 1990).

Restoration (in Archaeology): Measures applied to artifact to facilitate its appreciation, understanding and use. The actions of restoration are taken when the item has lost part of its significance or function through past alteration or deterioration. They are based on respect for the original material. Such actions modify the appearance of object (Nardi, 2020, p2655).

Chapter 1 : Introduction

1.1 Background and Context:
A Paradigm Shift: From Heritage Celebration to Acknowledging the Shipwreck's Own Otherness

Ships and vessels, often referred to as "Naval Architecture," share similarities with architecture but possess a distinctive architectural language. Today, Earth's oceans are estimated to contain over 3,000,000 shipwrecks. Underwater or nautical archaeology emerged after World War II, when advancements in scuba technology enabled the general public to explore underwater environments. As a ship moves across the ocean, it functions as a self-contained microcosm of its culture, isolated from society at a specific moment in history. From the perspectives of anthropologists and historians, shipwreck preservation provides valuable insights into historical events and human activities. Conventional nautical archaeology has historically focused solely on humanistic perspectives (Hamilton, 1999). Notable shipwrecks, such as the Vasa and Mary Rose, have been institutionalized as national heritage, celebrated by both governments and the public. However, during the 20th century, scholars such as Foucault, Heidegger, and Lévinas explored the otherness and heterotopic nature of ships and shipwrecks, questioning their autonomy beyond human narratives. Only recently have archaeologists begun to engage with these ideas, reconsidering the shipwreck's own agency rather than viewing it merely as an artifact for human interpretation. Some scholars suggest that preservation efforts should maintain a 'proper distance', recognizing that shipwrecks exist in a liminal state, oscillating between the artificial and the natural (Rich, 2021).

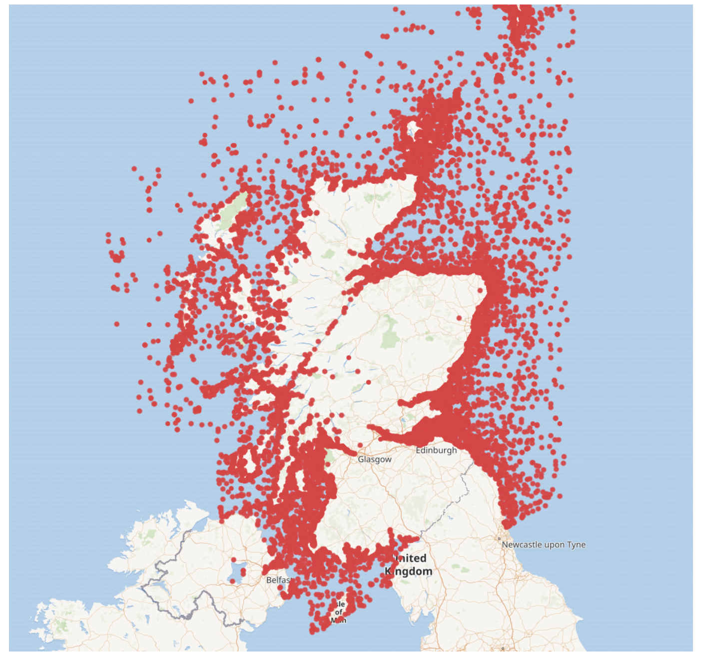


Figure 1: The Location Of Shipwrecks From Canmore in Scotland Territorial Waters (Code The City, 2020)

1.2 Research Question, Aims and Objectives:
Architectural System of Preservation Laboratories: Acknowledging Shipwrecks' Autonomy

Architecturally, ship preservation laboratories are rarely discussed beyond their functional requirements, with most research conducted by archaeologists and engineers. Shipwreck preservation, as a field within underwater archaeology, is typically approached from an archaeological perspective, focusing on artifact integrity and their significance as remnants of history. Preservation efforts primarily aim to protect artifacts from adverse environmental conditions—reinforcing the imposed order of nature.

This thesis explores the question: Beyond the human-centric approach of shipwreck preservation as heritage celebration and a resource for historical education, what architectural language can a ship preservation laboratory adopt to acknowledge the autonomy of the shipwreck itself?

The aim of this thesis is to propose an architectural system for ship preservation laboratories that shifts the focus toward shipwreck autonomy, integrating with and evolving from existing preservation practices.

1.3 Scope and Limitations:

Given the complexity of shipwreck preservation, achieving a fully integrated systemic architectural solution within the laboratory may not be entirely realistic or feasible. Instead, this thesis primarily presents recommendations for alternative treatment principles aimed at maintaining the authentic state of shipwrecks, which are discussed in written form rather than fully realized in design.

Of the five proposed preservation laboratory buildings, only one has been developed in greater detail, encompassing an architectural area of over 12,000 square meters. Additionally, a site visit to Svalbard was not possible due to budget constraints, limiting direct engagement with the local environmental and contextual conditions.

Figure 2 & 3: Cyclical (Seasonal) & Non-Cyclical (Meteorological) Event of Natural Flooding That Bury And Expose Wrecks in the Southern Coast of Brazil (Torres, 2012, p6)

Chapter 2: Research Methodology

2.1 Research Design Methodology

2.1 Research Design Methodology:

This thesis employs a design-led research approach, exploring how architectural forms can embody "Cordelia's silence" through iterative spatial experiments rather than solely through theoretical discourse. Design-led research, also known as Constructive Design Research (CDR), as defined by Jonas Löwgren and Erik Stolterman (Koskinen, 2011), is an approach in which design itself drives the research process. This method prioritizes making, prototyping, and iteration as ways of generating architectural knowledge. Additionally, a Field-Based Research Approach (Koskinen, 2011) is applied to analyze and engage with political and cultural history, landscape conditions, and the infrastructural context of the site.This thesis design functions beyond a purely functional institution, acting as a critical architectural statement. For example, my use of Braque's bird analogy as a spatial division is not merely an aesthetic choice, it critiques how shipwrecks are 'caged' by heritage institutions. Furthermore, this bird-like form is partially transformed into a 'wounded opening' within the preservation laboratory, governed by a grid system, reinforcing the proposition of "Cordelia's silence" as an architectural expression.

Case Study: Shipwreck Sites and Vessels
Data on shipwreck sites, including the landscapes in which they have been abandoned and the condition of the wreckage, will be documented through photographs, drawings, and 3D reconstructions. The embodied image of these wrecks will be analyzed in depth.

Quantitative Data Gathering
The ship preservation process, along with the technical devices required for treatment, will be catalogued into process diagrams. The necessary environmental conditions for the preservation laboratory are outlined in the appendix.

Iterative Process
The design iterations progress from a cartesian program-based approach to one inspired by landscape forms, allowing a loose design process to reshape my thinking. The rigid program-based approach is a functionally driven method, assisting in program organization and establishing a sense of scale for this complex project.The second design phase adopts an intuitive approach, allowing discoveries to emerge through the process of making rather than being predefined by cartesian spatial criteria.

Qualitative Embodied Image Analysis and Interpretation
'I do not doubt interior, have their interiors... eyesight has another eyesight, and the hearing another hearing, and the voice another voice'.
Walt Whitman, 'Faith Poem' from Leaves of Grass, 1856
Embodied images evoke emotions and condition human perception. Space can never be neutral. The poetic image, as explored by Andrei Tarkovsky, relates to reality through an awareness of the world. Similarly, Cornelius Castoriadis describes poetic architectural images as creatures with unique, singular identities. Embodied images create a tension between physical reality and mental suggestion. Unlike functioning vessels or architectural structures, which convey the image of perfection and closure, abandoned or deteriorated shipwrecks reveal disturbances that escape human control. These disturbances invite us to contemplate both their past and their uncertain future. According to Pallasmaa (2011), profound architectural experiences do not rely on intellectualized, formally refined structures but instead emerge from a "weak structure" with discontinuous narratives, creating spaces that are less definite and more open to interpretation. In this thesis, qualitative embodied image evaluation and cross-cultural references are applied to orient the architectural proposition toward a critical discourse.

Degree of life as Design Measure
Christopher Alexander introduces a broader understanding of life beyond biological reproduction. According to Alexander, life is a quality inherent in all objects and spaces, though it exists in varying degrees. For instance, a turbulent ocean appears more "alive" than a swimming pool filled with sanitizers, algaecides, and chlorine. To assess the degree of life in architectural design, this thesis applies Alexander's fifteen principles (Alexander, 2002):

1.Levels of Scale (smooth transition between small and large spaces/details)
2.Strong Centers (each space has its own focal point and sense of wholeness)
3.Boundaries (clear but permeable edges)
4.Alternating Repetition (not merely mechanical repetition)
5.Positive Space (spaces shaped by their surroundings)
6.Good Shape (aesthetic and functional clarity in forms)
7.Local Symmetries (subtle, balanced asymmetries that enhance vitality)
8.Deep Interlock and Ambiguity (spatial relationships that allow layered experiences)
9.Contrast (oppositions that create energy and dynamism)
10.Gradients (transitions in form, light, and spatial experience)
11.Roughness (imperfections that add character and authenticity)
12.Echoes (repetitive yet unique spatial elements)
13.The Void (intentional emptiness that enhances meaning)
14.Simplicity and Inner Calm (a sense of peace and clarity)
15.Not-Separateness (spaces that interlock and relate seamlessly)

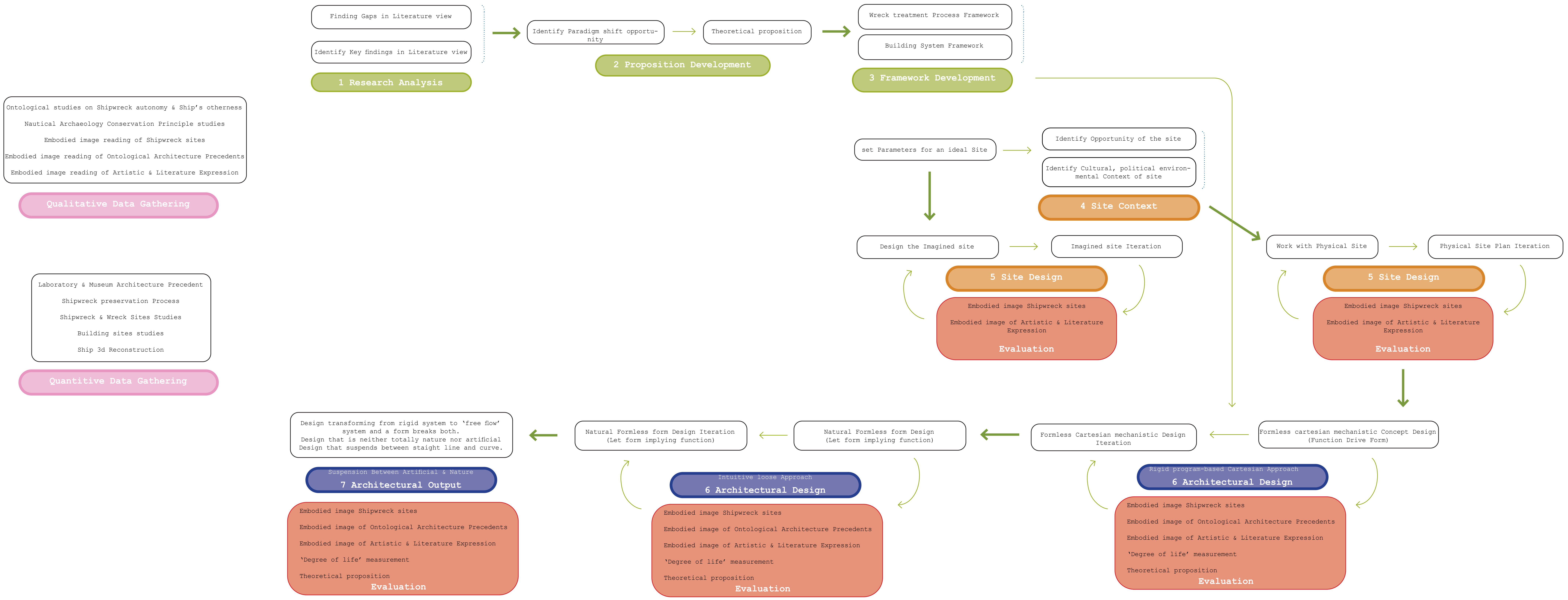
By integrating some of these fifteen principles, the thesis aims to develop an architectural language that acknowledges the autonomy of shipwrecks, rather than imposing a human-centric heritage framework onto them.

Chapter 2: Research Methodology

2.1 Research Design Methodology

Research Design Methodology Diagram

(Figure 4)



Chapter 3: Literature Review

3.1 Identification of Gaps in the Literature:

a.Heritage and Conventional Mindset of Conservation in Nautical Archaeology: Ontological Position

3.2 Theoretical Framework

a: The Face of Shipwreck, Its Degree of Life, Autonomy, and Otherness (Ontological Position)

3.1 Identification of Gaps in the Literature:
a.Heritage and Conventional Mindset of Conservation in Nautical Archaeology: Ontological Position

To anthropologists and historians, the value of a shipwreck lies in the human activities and cultural insights it offers, such as shipbuilding, monetary systems, trade, and class structures. Once set on the sea, a ship is a self-contained microcosm of its society, a miniature of culture isolated from the external world. In the case of sailing ships, the crew, officers, passengers, and even animals each inhabit distinct living areas, all carrying their belongings. The sudden event of a wreck forms a time capsule, deposited on the seabed (Hamilton, 1999). The principle of artifact preservation in traditional nautical archaeology aims to stabilize valuable historical data to become 'natural looking', often presenting the object with a 'humanistic' appearance that is pleasant to the eye. This process allows artifacts to be stored, displayed, and examined for archaeological study. Restoration, typically associated with damaged objects, requires replacing missing parts (Comer, 2020). In this context, the conservation of shipwrecks and their contents is primarily concerned with the integrity of objects as remnants of history. Preservation seeks to protect artifacts from adverse environmental reactions, essentially against the 'order of nature.'

The issue with this agenda lies in its inherent 'severing' of humanity from the wreckage. Efforts to reverse the ruin back into an anthropocentric framework ultimately reinforce a specific humanistic heritage. The concepts of orderliness and utilitarianism often construct a rationale for preservation that is human-centered, and then enforced upon the wreck. Preservationist narratives designate shipwrecks as heritage 'resources' for future generations, often framed in the language of capitalism (Rich, 2021; Nardi, 2020).

Shipwrecks displaced from their original context, meticulously cleaned, and infused with polished inorganic materials, lose the authentic 'intangible' qualities of the ruin while selectively preserving only the utilitarian aspects. This extravagant return to the public sphere creates a false sense of intimacy and obliterates the ambiguity inherent in the wreck (Rich, 2021). The nature of a preserved wreck, post-calamity, is locked in a state of non-becoming. It is neither a functional object nor an art piece; it is a utilitarian vessel that has been transformed into a visual artifact. From this point onward, the wreck ceases to decay, frozen in a condition approaching lifelessness. (The natural shipwreck, in contrast, is more alive than its preserved counterpart.) Ultimately, it becomes un-nature.

3.2 Theoretical Framework:
a: Design Proposition: The Face of Shipwreck, Its Degree of Life, Autonomy, and Otherness

In our encounter with the face of other, there is no known or difference that can be reducible into 'I'. Instead, a uniqueness overflows our categorization and rational simplification. The other is an alterity that cannot be reduced to sameness (Levinas, 1998). Heidegger depicts relating subject to the object as like place the object under the light, where light is a non-object but a horizon. An 'openness' that attempts to understand the being of otherness. (Heidegger, 1962) As to Levinas, the relation with a being (e.g., another person) is an invocation of a face and an 'already speech' (e.g. the expression of greeting). Such relation is characterized by depth rather than a 'horizon'. The 'horizon' considered by Levinas is being in general towards the other from the first person's stand. But 'depth' underlines a gap in the horizon. It is through the 'depth',that the naked face of other can mean by itself (Levinas, 1998).

A rational activity of conceiving other assimilates one's being. Under such rationality, the being of other are reduced and power are imposed upon him/her. To address the other is to 'already' speak to him/her. The language is not applied as subordinate to one's mind forming proximity of the other such as Through naming. Rather language is a medium through which conscious is in presence to the other. This exceeds the boundary of active contemplation, involves the sympathy (Levinas, 1998).

'Handling' is considered as a rational understanding towards object. In this relation, knowledge is justified beyond the known object through the involvement like grasping. However, such action contains a duality, portraying possession and consumption of the object, different from the relation with the other (human) being. When tools or objects reveal their Zuhandenheit (being ready-to-hand), they are used effortlessly and thus often forgotten due to their seamless integration into our activities. They are taken for granted because their functionality allows them to recede from our conscious awareness. However, Vorhandenheit (being present-at-hand) becomes evident when a sudden event, such as a wave crashing over a ship, brings our attention to their potential to fail. This state of precariousness makes us acutely aware of the object's presence and the risk of it breaking. Unzuhandenheit (unreadiness-at-hand) refers to the autonomy that an object gains through its brokenness (Heidegger, 1962). A broken object deviates from its creator's intentions, does not turn to 'dead'. Instead, they continue sharing their knowledge and presence, while transforming into another phase of becoming.

Shipwrecks, both physically and metaphysically, are isolated and withdrawn from human accessibility. Our perspective of the eeriness shipwreck is based on forces which govern mundane reality. For Shipwrecks, they are ordinarily obscured, offering us a pathway to spaces beyond mundane reality altogether. When ships sink and breakdown into pieces at the seafloor, their dynamic essence persists (Fisher, 2016 & Muckelroy, 1978). They are having lives of their own in the disorderliness. The encounter with the shipwreck contains the fact that, regardless of the human's domination and its submission, we do not possess it. Vessel does not totally belong to the opening of our being or our stand. We understand it in terms of its history, its materiality, its function. However, what departs from understanding it, is its 'partial other being', its autonomy, its world that letting us enter, both the familiar part and the part that is the alien to us.

Chapter 3: Literature Review

3.2 Theoretical Framework

b. Design Proposition - Cordelia's Silence

3.2 Theoretical Framework:

b. Design Narrative - Cordelia's Silence (Temperament)

'Cordelia's silence' serves as the guiding principle for the architectural language, shipwreck preservation methods, site selection, and the way of living, working, and visiting the proposed shipwreck preservation laboratory. Cordelia's silence, as depicted in King Lear, represents a form of feminine subversive complicity. Her silence appears to conform to the patriarchal idealization, yet it undermines the imposed dictates (Hamamra, 2019). In the context of shipwreck preservation, the 'patriarchal idealization' refers to efforts to reverse the shipwreck, restoring it to a state of orderliness, transforming it from organic to inorganic, and ultimately making it everlasting.

'Cordelia's silence' functions as the evaluative endpoint for the project, branching into two sub-concepts:
a) The Suspension of Order and Proper Distance
b) Heterotopia

A: The Suspension of Order and Proper Distance
'The suspension of order' and 'proper distance' suggest a sense of 'hesitation' towards the conventional mindset of shipwreck preservation and static exhibition. Within this gap shipwrecks are given space to release part of her autonomy. The suspension of order allows for the partial display of both the 'intangible' aspects of the ruin and the 'tangible' humanistic elements across both spatial and temporal dimensions. This idea resonates with the shipwreck ontology, which is considered elusive with spatial and temporal ambiguities (Rich, 2021). Shipwrecks are liminal objects that are in-between past and present, visible and absent, nature and culture, sacred and secular, bygone and enduring.
Roger Silverstone's concept of 'proper distance' explores the necessary balance in our relationship with the other to maintain a moral life. Among this 'nomadic universe', the sense of place is fragmented, and everyone simultaneously appears as a neighbour and a stranger. He emphasizes the paradoxical nature of connection and separation that defines contemporary existence and stresses the importance of positioning one's morality in the asymmetrical social relations. 'Proper distance' by Silverstone (2003) represents a 'pause' to reflect on technological and human limitations, in our efforts to understand and control the world.

c. Design Narrative - Ship & Shipwreck as Ultimate Heterotopia (Native Attributes)

Much like the concept of female otherness in relation to males, a ship represents a heterotopia in relation to human society on land. In Michel Foucault's essay (1986) "Des Espaces Autres" ("Of Other Spaces"), he defines a heterotopia as a type of 'counter-site' where a real, physical place is simultaneously represented, contested, and inverted. Among various heterotopias such as cemeteries and markets, Foucault considers the ship to be the quintessential example.

The ship is a holobiont, carrying a myriad of organisms. Ships are complex assemblage of diverse species displaced from their native environments: rats, horses, cockroaches, forest trees, mold, bacteria, gulls, barnacles, and shipworms. The holobiontic nature of a ship becomes more pronounced when it becomes a wreck. These fragmented objects remind us of mortality while signalling a new collective transition. They act almost like sanctuary cities, refashioned by extra-human architects as their home (Rich, 2021).
A ship is a migratory space, a place in a non-place by itself. Its passengers are often in a state of crisis, exile, military or in transit. Ships mimic land with towering tree-masts, castles fore and aft, and the underworld of bilges. Yet, no one would mistake a ship for land as it creaks and groans while the water tosses it. During long voyages, the perpetual motion results in a cessation or dissolution of time, blending with changes in wind, currents, storms, and temperature. Ships are both open and closed, isolated and penetrable. They are exposed to nature's entropic forces yet sealed off from terrestrial culture. Lives onboard are rigorously hold by the captain, and everyone is equally vulnerable to overpowering forces (Foucault & Miskowiec,1986).

Foucault's principles of heterotopia will be applied to measure the design organization in this project, so as to relating the autonomy and otherness of shipwrecks:
1:Heterotopia of Crisis and Deviation: Wrecks are deviant of man-made objects whose social function are been revoked.

2: Change In Social Function Over Time: shipwreck is dislocated from the social centre and becoming a 'microcosm' on the seafloor, undergoing a social hierarchical shift.

3: Juxtaposition and Incompatibility: The submersion of terrestrial elements to the seafloor creates a microcosm of land under beneath the water, evoking a sense of being out of place.

4: Heterochrony: A break with traditional time. The ship's quasi-eternity is characterized by its ongoing dissolution and disappearance. The disintegrated shipwrecks accumulate on the seafloor is similar to corpses in graveyards.

5: Ambiguity in Accessibility: The heterotopia is both open and closed, isolated and penetrable. Wreck sites are subjected to nature's entropic forces but are sealed off from the terrestrial human sphere.

6: Creation of a Space of Illusion or Perfection: Shipwrecks are binary spaces. They represent chaos, while resembles an illusion of terrestrial bias. Their disorderliness seems wait for re-measurement, re-labelling, and cataloguing, while different order also exists.

Chapter 3: Literature Review

3.2 Theoretical Framework

c. Shipwreck Preservation Laboratory As An Architectural Holobiont System With Life

3.2 Theoretical Framework:

d. Design Narrative - Preservation Laboratory As An Architectural Holobiont System With Life

A living holobiont Architectural system encompasses six stages:
I. Field Excavation
II. Physical Cleaning,
III. Laboratory Treatment,
IV. Supporting Structure Assembly,
V. Re-Treatment,
VI. Dispatch & Display,

These stages are integral to the shipwreck preservation laboratory, establishing it as a specialized building typology. An interconnected architectural cluster will be introduced, where each building and its interior spaces will maintain their own degree of life and character, while collectively forming a larger 'living body.'

(2) Retain the 'Brokenness' of Object During Stabilization:
Cutting down humanistic oriented over-treatment.The aim is to maintain a balance between humanistic and natural approaches, respecting the liminal nature of shipwrecks that exist between culture and nature. Ease Anthropocene's human-centred control over shipwreck, showing empathy and an ethic of care, promoting the autonomy of shipwreck and the sense of co-existence. Such system thinking connecting knowledge domains of Nautical archaeological preservation, architectural system, ship & shipwreck ontology which are disjunctive among conventional laboratories and ship museums.

(3) Regenerative Design Principles:
In addition, regenerative design principles will be applied to the project. These include:
Reducing treatment energy consumption
Sensitive water collection and recycling
Integrated lighting design
Indoor moisture control
Quality building envelopes
Given the complexity of this mega-project, these aspects will be briefly mentioned to support the specialized architectural system, ensuring that the laboratory not only preserves the shipwrecks but also embraces sustainable and regenerative practices.

e. Design Narrative - Three Moirai (Journey)

Three sisters of fate assign the span of life. Clotho, the spinner of the birth; Lachesis, the drawer of lots; Atropos, terminates the inevitable end (Doja,2005). Sometime controlled by human or other times free from our interference, Ship's entire life journey, remains autonomous and other to us.

These aspects of shipwreck autonomy are what I am looking into throughout the design thesis.

Figure 5: The Three Moirai, The Triumph Of Death, Flemish Tapestry(Unknown, ca. 1520)

Chapter 3: Literature Review

3.2 Theoretical Framework

d. Shipwreck Preservation Procedure

3.2 Theoretical Framework:

d. Shipwreck Preservation Procedure

Proposed below is the synthesised and organized preservation procedure for waterlogged shipwreck. It should be noted, this table is not an entirely linear process. For instance, under financial or physical constrains, shipwreck may only undergo in-situ preservation without been moving into laboratory for further treatment. In this case the laboratory oversees manufacturing in-situ preservation infrastructure for wreck site. Meanwhile, documentation is crucial across all stages, so object's original location, treatment history, morphological attributes, Relative Amounts of Components, Molecular Level changes should be traceable (High & Penkman 2020).

I Field Excavation:
1. Identification
2. Field Lab Setting
3. In-situ Observations
4. Excavation
5. Transportation
6. In-situ Management/Preservation

II Lab Initial Cleaning:
1. Initial Documentation
2. Intact Encrustation Storage
3. Mechanical Cleaning (Encrustation removal)
4. Pre-treatment Storage (thin encrustation layer remains)

III Lab Preservation:
1. Conservation Process Evaluation
2. Treatment to Stabilize
3. Restoration
4. Post Treatment to Protect

IV Structure Assembly:
1. Structure Evaluation
2. Support Structure Design
3. Hull Assembly/ Parts Replacement

V Re-Treatment & Storage:
1. Evaluation of Previously Treated Object
2. Re-treatment
3. Post-treatment Storage
4. Periodic Inspection

VI Temporary Display / Dispatch:
1. Archive & Package
2. Temporary Display
3. Dispatch

I Field Excavation:

1. Identification
Project planning and evaluation. Identify and surveying wreck site, Diagnose and classify breakdown, corrosion and degradation level to determine the Excavation material. Form a plan for a full-scale or partial excavation. (Brunning et al.,2010 & Hamilton, 1999)

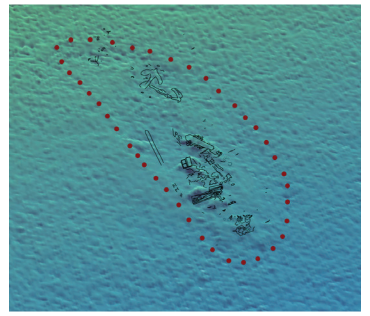


Figure 6: Bathymetry Seafloor Depression Image Indicating Mardi Gras Shipwreck site (Horrell & Borgens, 2017, p444)

Figure 7: Mardi Gras Shipwreck 1220m Under Sea Bed Site Pre-Disturbance Mosaic in 2007 (Ford et al, 2008, p264)

2. Field Lab Setting
Set up field laboratory near the excavation site with supported facility for temporary storage. The field lab could also be set in a Oceanographic Research Vessel (Hamilton, 1999).
3. In-situ observations
Records Morphological Changes and preliminary components on the objects, by Visual Scoring systems, X-ray imaging, Computed microtomography, Ultrasonic test, etc. Plot and number disintegrated objects, seeds, insects, orientation of encrustation and wreck fragment before raising them from the sea floor (High & Penkman, 2020 & Hamilton, 1999).

4. Excavation
This step includes hull and artefact rising. For sunken ships, a form-fit caisson will be placed over the hull and inserted into the sediment. Then steel tubes were weave through the caisson bottom to fix the hull for extraction. For Medium condition artefact, Metal Cage is vertically inserted into seafloor, with a metal baffle underneath. the object is then raised out by tied rope on frame. Bandage wrapping method & carbon fibers/epoxy wrapping could be applied for fragile organic items (Chen, X et al.,2022).

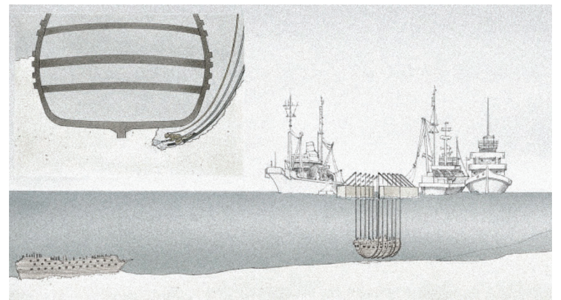


Figure 8: Vasa Raising process (Kvarning, 1993, p86-87)

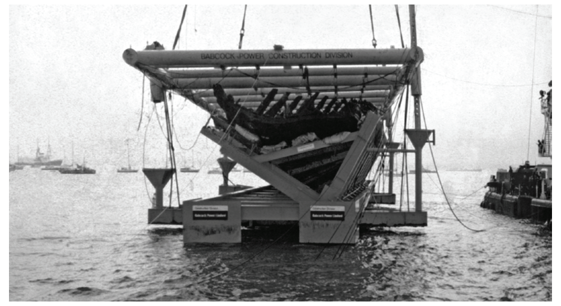


Figure 9: The Salvage of the Mary Rose wreck in 1982 (The Mary Rose Trust, 2020)

Chapter 3: Literature Review

3.2 Theoretical Framework

d. Shipwreck Preservation Procedure

5. Transportation
All items should be kept wet by sea water or sodium hydroxide freshwater solution to minimize further corrosion. The storage vats should be caped to avoid light exposure and inhibit algae growth (Hamilton, 1999).

6. In-situ Management/Preservation
Nautical archaeology in comparison to terrestrial archaeology is more technologically and finically challenging. Funds and human resources are inadequate in many situations. (Rich, 2021). In-situ management/preservation enables a prolonged ongoing excavation as well as the protection of underwater wrecks. Meanwhile the autonomous state of semi-natural, semi artificial shipwreck is maintained. A combination of quick and budget approaches is listed, facilitate periodic surveys and monitoring (Beltrame & Danilovic, 2014).
a. Reburial:
Bury exposed wreck with seafloor sediment to protect from aerobic deterioration.Feasibility assessment is needed. Fine sand could be carried away by currents. Large gravels may damage the wreck.
b. Sandbags:
sandbags attached to Metal mesh immobilize the archaeological item. It is however insufficient to provide hermetic anaerobic environment. synthetic materials or fine granulation sand could be applied to avoid microorganisms.
c. Geotextile:
Synthetic erram® T4000 revealed fibres wrapping around wreck with substrate inhibits erosion, which is not effective on preventing microorganisms.
d. Artificial Sea Grass:
It protects wreck site against the transportation of sediments carried by current.
e. Metal mesh:
Placing protective metal netting riveted to seafloor with gravel blocks. It is also act as coordinates for mapping artefact and fragment on site. Metal mesh combined with geotextile, sandbags and seafloor sediment could achieve permanent protection (Beltrame & Danilovic, 2014).

Figure 10 & 11: The Perry Triton XLS-17 ROV & Large Artifact Retrieval Tool (Irion, 2017, p332 & p335)

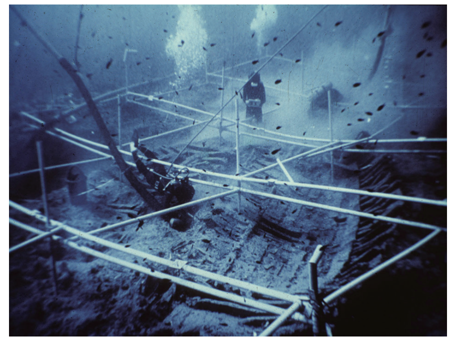


Figure 12: Metal Mesh Set up at the Kyrenia Wreck Site (Duivenvoorde, n.d.)

II Lab Initial Cleaning:

1. Initial Documentation
Apply analytical technologies on specimen, such as SEM-EDS / SEM-EDX, X-ray radiation, OM, OES to determining the content of encrustations, disintegration levels and material components. Documentation is kept parallel to artefact study and treatment. This Include detailed description, radiographs, digital images, etc. Physical data should be stored in cool, dry, dark cabinet. (High & Penkman, 2020 & Hamilton, 1999)

2. Intact Encrustation Storage
Adhering encrustation and corrosion layers over the objects are left untouched. These items are submerged in tap water with the addition of an inhibitor minimize further corrosion. (Hamilton, 1999)

3. Mechanical Cleaning (Encrustation removal)
Objects are extracted from the encrustation assisted by X rays. Well-directed hammer, assorted chisels, small pneumatic tools, Larger pneumatic weld-flux chisels and Sander are used (Hamilton, 1999).

4. Pre-treatment Storage (thin encrustation layer remains)
Pre-treatment storage of objects in various types of solutions or condition according to material classification. View specific pre-treatment storage requirement under the Appendix of [4-2] Underwater Artefact Treatment based on Material category.

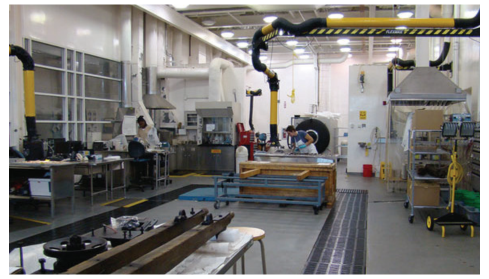


Figure 13: Maryland Archaeological Conservation Laboratory St Leonard Maryland, USA. (Mardikian & Chemello, 2020, p2650)

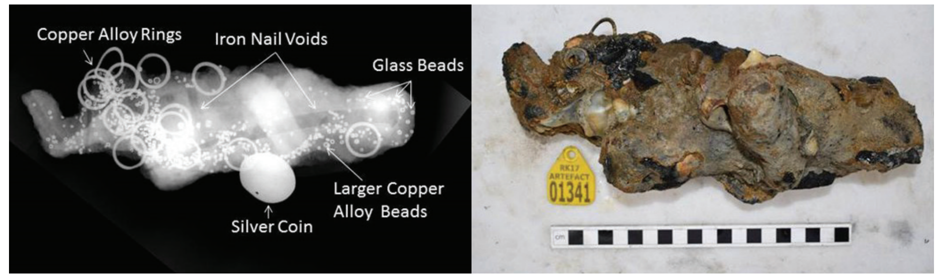


Figure 14 & 15: One Of The Encrustations With Its Corresponding X-Ray (Paynter, 2023, P68)

III Lab Preservation:

1. Conservation Process Evaluation
Ascertain object condition, based on their morphological attributes, Relative Amounts Of Components and Molecular Level. Discuss options for treatment based on cost, time, desired outcome and environmental impact before a course of action (Hamilton, 1999).

2. Treatment to Stabilize
Conservator each with individual experience and preference may take different approaches. The goal proposed by this thesis is to stabilize items while maintain its native microstructure attributes close to the point of its excavation. Oversee the application of adhesives and consolidates and ensure proper disposal of any waste generated. View specific storage requirement under the Appendix of [4-1] Underwater Artefact Treatment based on Material category (Hamilton, 1999).

Chapter 3: Literature Review

3.2 Theoretical Framework

d. Shipwreck Preservation Procedure

3. Restoration
This step is associated with the repair of damaged specimen and the replacement of missing parts with distinguishable material from original fabric. One common example is Mould making with Synthetic resins (Thermoplastic resins/Thermosetting resins) from encrustation for replica casting (Comer, 2020). Restoration is less rerecommended under the theoretical framework of this thesis.

4. Post Treatment to Protect
Steps included could be post treatment cleaning, drying, sterilization and sealant layer for surface protection (Hamilton, 1999).

IV Structure Assembly:

1. Structure Evaluation
Ship was not built to carry its own weight but the water around it. Without aqueous condition, swollen timber will eventually deform in gravity. Under the sea wood cellulose was disintegrated and Lignin network are filled with water. The PEG replacement of water molecular although offset the original weight of wood ship, keel still have tendency to slide off and leading to starboard collapse. The wreck deformation, wood cellulose hydrolysis condition, absorbed excessive water content in relationship to its original manufacture need to be assessed (Fix, 2015).

2. Support Structure Design
Rigid system that integrating multiple point load supports across the hull remains is the optimum option. However, in this scenario the structure of preserved shipwreck still undergoes deformation. Over the period the point load of support structure needs to be re-adjusted. Fastening internal shipwreck structure should also be incorporated (Fix, 2015).

3. Hull Assembly/ Parts Replacement
Ship hull treatment may undergo two paths. Firstly, dissemble shipwreck into small pieces for Individual treatment and re-assemble afterwards. Secondly entire hull treatment and then assemble it with other non-hull elements. Some parts may undergo for restoration for the overall structural integrity (Fix, 2015).

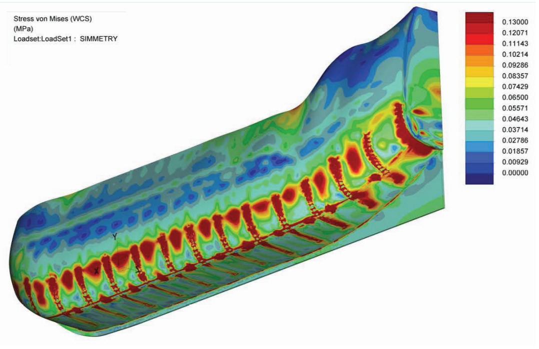


Figure 16: Vasa Structural Critical Area On The Hull (Marina & Carlos, 2014, P65)

Figure 17: Eight Sails Found During the Excavation Took Conservation More Than a Decade. (GetArchive, 2023)

V Re-Treatment & Storage:

1. Evaluation of Previously Treated Object
Retrieve original treatment data from the object, assess the original treatment failure, planning treatment process for reverse the treatment and propose re-treatment options (Hamilton, 1999).

2. Re-treatment
Reverse the previous treatment and perform specimen re-treatment. In this step, new treatment technology and test for new treatment are often applied. Objective of artifact preservation is to delay the inevitable re-treatment (Hamilton, 1999).

3. Post-treatment Storage
Treatment enables artefact and shipwreck to maintain at a relative inert status in the indoor environment. Object of given category of material require specific indoor climate. View specific post treatment storage requirement under the Appendix of [4-2] Underwater shipwreck & Artefact Treatment based on Material category (Hamilton, 1999).

4. Periodic Inspection
In a climate-controlled building, ubiquitous atmospheric pollutants, Sulfur dioxide, hydrogen Sulfide, sodium chloride, dust, could be detrimental for artefacts. These factors together with more common measurements, UV level, natural light exposure, relative humidity and temperature need to be Monitored. Treated objects ought to be inspected in a regular basis (Hamilton, 1999).

VI Temporary Display / Dispatch:

1. Archive & Packaging
Collection category for Archive (Hamilton, 1999):
(1). Components of structures features (mounds)
(2). Artifacts of human manufacture
(3). Natural objects used by humans
(4). By-products, waste products or debris
(5). Organic remains
(6). Human remains
(7). Petroglyphs, pictographs, intaglios
(8). Components of shipwrecks
(9). Environmental & chronometric specimens

2. Temporary Display
Condition Requirement follows Post-treatment Storage.

3. Dispatch
After treatment, the shipwrecks will be packaged as whole with support structure, or in other scenario undergone disassemble process, which is then carried by cargo ship to a static museum in another country.

Chapter 3: Literature Review

3.2 Theoretical Framework

e. Propositions on Underwater Archaeological Specimen Preservation

Material Types requiring specific treatment methods:

I: Organic
1: Seeds and Plant Material
2: Bone, ivory, Teeth and Antler
3: Leather
4: Textile

II: Timber
5: Wood

III: Inorganic
6: Pottery, Stone
7: Glass
8: Encrustation Removal
9: Encrustation Mold Casting

IV: Metal
10: Iron
11: Cupreous (Copper, Bronze, Brass)
12: Silver
13: Lead, Tin, Pewter and Lead Alloys
14: Gold & Gold Alloy

The specific treatment technologies applied for objects are arranged in Appendix. The revised treatment principles based on theoretical framework proposed in thesis are:

Principle 1: Stains and salts that neither inhibit further degradation of material nor cause human harm in the indoor environment should be kept from excessive treatment to retain the semi-natural and semi-artificial state of object. This will also save the treatment resource and reduce treatment time. For instance, the reduction of certain corroded while stable oxidized metal back to metallic state could be unnecessary. In addition, conservation should focus on applying treatment to passivate less stable oxidized metal object.

Principle 2: Mechanical cleaning will be the preferred option over chemical cleaning such as nitric acid to minimize environmental impact.

Principle 3: Reservoir of toilet can be used to remove soluble Salts on object like glass or pottery. These objects could be placed in Mesh bags. Such method encourages water reuse.

principle 4: Although with flex limitation, waterlogged wood treated by dammar resin & colophony rosin as natural material is environment positive in comparison with PEG and Sucrose method. Due to the high cost this method remains less practical. However, the future research for preservation material should align with an environmental positive principle.

Principle 5: Dedicate operatable facades or Open-air floor with maximized natural ventilation for items that can be air dried to reduce mechanic air conditioning/filtering energy cost. Such space could be allocated for Acetone-Rosin or Camphor-Alcohol treated wood.

Principle 6: When water is the acceptable solution for treatment, it should be kept as preferred choice over alcohol or other types to reduce environmental impact. The environmental impact has high priority over treatment speed.

Principle 7: When applicable Freeze drying, air drying or oven heating should be preferred choice over alcohol or other types of solution drying, as the later ones could have greater environmental impact.

Principle 8: Encrustation signifies nature's influence on man-made ships. This process reflects how tools, once serving human needs, break free and grow into something new. The liminality of the semi-natural and semi-artificial state of the object should be preserved to acknowledge the autonomy and authenticity of the wrecked artifact. To retrieve the humanistic value of the artifact, a limited portion of the encrustation may be removed so the public can barely recognize it. However, most of the encrustation should be retained as it is, if the object remains relatively stable in an indoor environment.

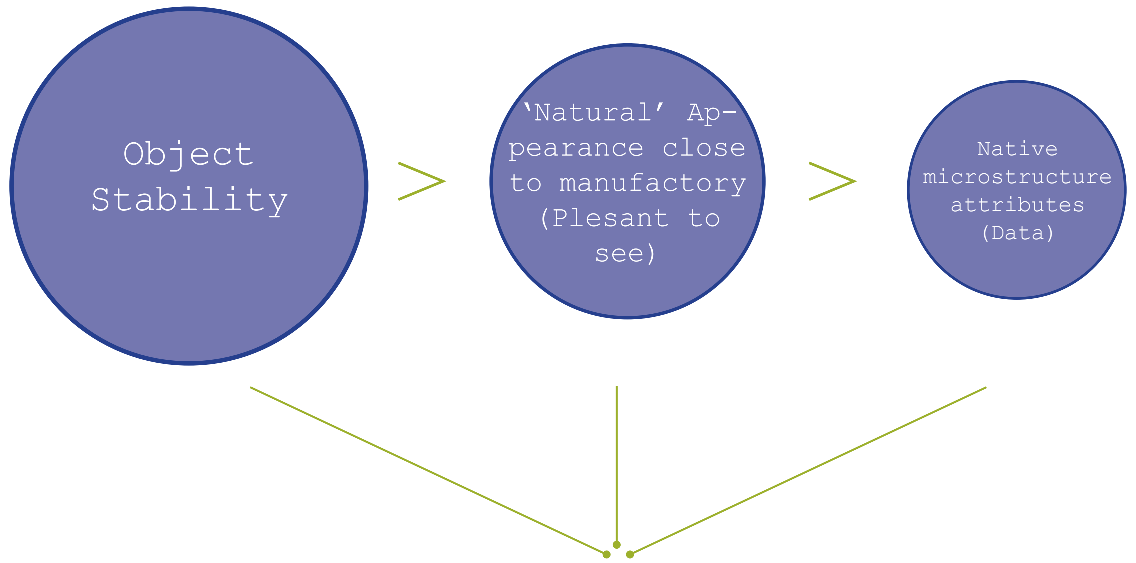
Principle 9: Mold casting, when used solely to create a formal replica of the original object, is often imprudent, especially considering the additional time and resources required (A drawing could be enough of them to communicate). However, for objects that have completely corroded away, their imprint remains in the encrustation. This ghost-like presence, akin to contrails left by an aircraft, captures the essence of the object in that specific space and time.

Chapter 3: Literature Review

3.2 Theoretical Framework

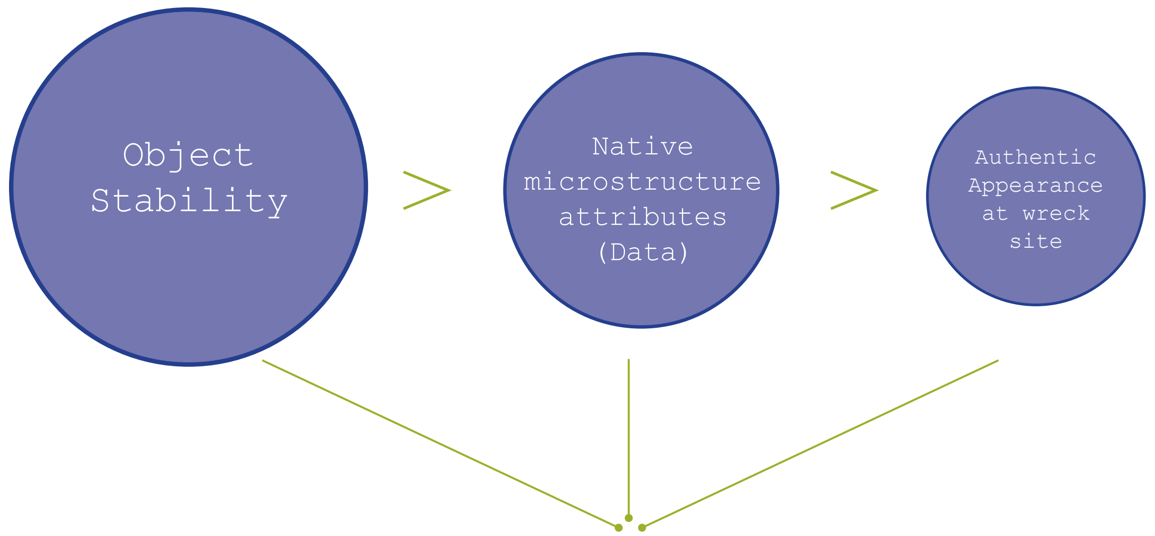
e. Propositions on Underwater Archaeological Specimen Preservation

Figure 18: Diagram of Key Factors In Conventional Archaeological Conservation & Hierarch Of Importance



Objective:
Human Heritage Celebration & Historical Studies: Recover original appearance of artefact back to the time when it was been used.

Figure 19: Diagram of Key Factors In Proposed Archaeological Preservation & Hierarch Of Importance



Objective:
Acknowledge the autonomy of shipwreck (semi-artificial and semi-natural state) & History studies: Establish 'a proper distance' maintain a stable wrecked liminal appearance.

Figure 20: Encrusted Iron Blade (TAMU Nautical Archaeology Program, n.d.)

Figure 21: Encrustation Removed from Iron Blade (TAMU Nautical Archaeology Program, n.d.)

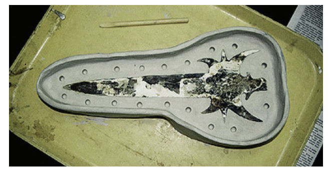


Figure 22: Part Metal/ Metal Oxide with Epoxy Partisan (TAMU Nautical Archaeology Program, n.d.)

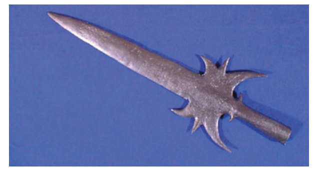


Figure 23: Iron Blade Replica Casting (TAMU Nautical Archaeology Program, n.d.)

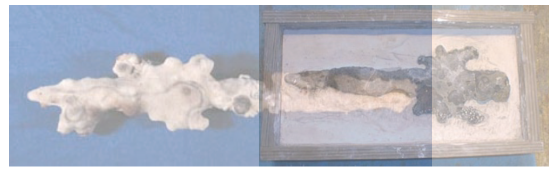


Figure 24: Proposed Treatment Philosophy - Preserve the ArtIfact Appearance in a Partially Encrusted Condition While Maintaining Material's Stability

Figure 25: Porcelain Fragment Comes from the V.O.C. White Lion Ship before 1613 (Anoniem, n.d.)

'Recovered from the sea, the corrosion products of objects of lead, tin, pewter are stable. Clean for aesthetic reasons is the main objective.' (Hamilton, 1999, p. 85)

This porcelain fragment from Rijksmuseum shares a balance between the humanistic value and the authentic broken state.
Other objects similar to this condition could be less pleasant to see or even grotesque. But such grotesqueness is suggesting a sense of 'less accessible', this is what 'a proper distance' stands for.

Chapter 3: Literature Review

3.3 Precedent Studies:

a. Vasa Shipwreck Excavation and Vasa Museum Studies

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a. Vasa Shipwreck Excavation and Vasa Museum Studies

Vasa Excavation & Its Temporary Structure Construction:
When been discovered, Vasa was essentially intact. It was lying at the depth of 32m, and only 120m away from the shore in Stockholm harbour. Despite the fact, the initial survey and the entire excavation phase lasted for 7 years, from 1959-1967. Water jets were used to blast six tunnels beneath the wreck sediments. Six steel cables were then threaded through these tunnels, and each three were secured to two submerged pontoons at shipwreck's both sides. This taut support system resembles a cradle holding the hull. As water pumped out of the pontoons, the wreck could raise up. During the process of transportation, the shipwreck would stay submerged beneath the water surface until landing (Kvarning, 1993). The temporary museum/treatment Lab for Vasa "Wasavarvet" was built, mooring at the dockyard. Hull was sat on a pontoon with prefabricated beams of pretensioned concrete. The wall was made of aluminium sheets with 10mm of rockwool insulation in between. During excavation two rows of props were used for hull support in 1961 which was replaced with the anti-corrosive steel cradle filled with wedge units (Håfors, 2010).
The subsequent conservation phase was also costive and time consuming. To illustrate, the water-soluble PEG spray treatment over hull and its following air drying took 28 years in total, from 1961-1988. Inside the ship more than 40,000 objects were found. In 1988, Vasa with a special encasement was sent to the permanent Vasa Museum by pontoon. The conservation and re-treatment remain an ongoing process until now (Hocker, 2010).

Museum Design and Display:
Since the opening in 1990, Vasa Museum, built to house the sunken Swedish warship remains as the most visited maritime museum in the world. The Vasa Museum was designed with an internal volume of 105,000 m3 and ceiling height of 36.5 meters where ship is located. Nordic architects Göran Månsson and Marianne Dahlbäck designed the museum. Consideration is given on environmental characteristics to communicate with the shipwreck. Irregularly shaped concrete structure space containing platforms at six height levels makes it possible to view the Vasa from all directions (Hocker, 2010). Windows are scarce to minimize direct daylight. Natural rock stones, untreated pine wood and stone walls from original dry dock was applied among different parts of the museum, giving a sense of archaeological layering.

Storage System Management & Upgrade:
Despite the well-claimed exhibition design, the collection management is a failure. The storage facilities and conservation laboratory were lacking. In the original design, 330 square meters is dedicated for storage under 6 cubic cells on basement. Portions of objects were stacked on top of one another. Bottom items were bearing heavy loads. Other items were compactly placed together. Air circulation was poor and work-injury risk was high. To illustrate, due to humidity variation, salt precipitated from sulphur absorbed by wood in the seabed lead to human health, indoor environment safety and object integrity issues. Since 2001, the problem of storage of object found in ship became unmanageable inside the Museum. The storage was not only subjected to store the not displayed object, but documentation, damage assessment and photo recordings (Lindblom, 2003).
To address this, new arrangement was made inside the museum, where work-transit room replaced the auditoriums for temporary object placement under documentation, damage assessment, and photography. An external 600 square meters storage warehouse was registered for 500 over sized objects such as deck planks. They were in total weight of 10 tons (Lindblom, 2003).

Shipwreck Support Structure Upgrade:
The ship was supported by 'I' shaped steel Stanchions. The point load on structurally weakened wooden wedges due to sea water impregnation required a new fasten & support system with area contact. So periodic ship deformation could be minimized. This whole process was intended to be operated inside the museum (Hocker, 2010).

Indoor Climate Control System Upgrade:
The new climate control system introduced in 2004, maintained the year-round temperature of 18.5C +/- 1.5c and relative humidity of 53 +/-2%, accommodate 1500 people (1440 visitors). A reserve power supply was also added during the retrofitting. 30% fresh air was included in circulation with airflow regulated at 11.6 m3/h. Double air locks were updated from exterior and single air locks were updated from the offices and restaurant. CA01 drum-shaped air outlets (1 meter interval) were installed underneath the ship to function as an air curtain. Together with six conditioned air columns, a climate canopy was formed. The waste air was removed through the east wall into the basement plant. CA02 Plant, distributed air through wall slits on higher floors (visitor galleries). And auxiliary plant CA03, delivered air through the south wall high ducts at the location of the ship stern, where visitor concentrated. In addition, 42 cordless sensors were installed on the ship, and 15 inside the building to monitor the RH, temperature as well as sub-stances released from Vasa (Hocker, 2010).


Figure 26: Vasa Under PEG Spray, 1962 (Vasamuseet, 2019)


Figure 27: Structure for Temporary Museum, the Pontoon with the Concrete Beams Leaving the Dry Dock (Håfors, 2010, p23)


Figure 28: Vasa - Towed into the New Museum 1988 (Vasamuseet, 2020)


Figure 29: Climatized air duct heads within the ship (Hocker, 2010, p6)


Figure 30: Auxiliary Plant CA03 (Vasamuseet,2024)

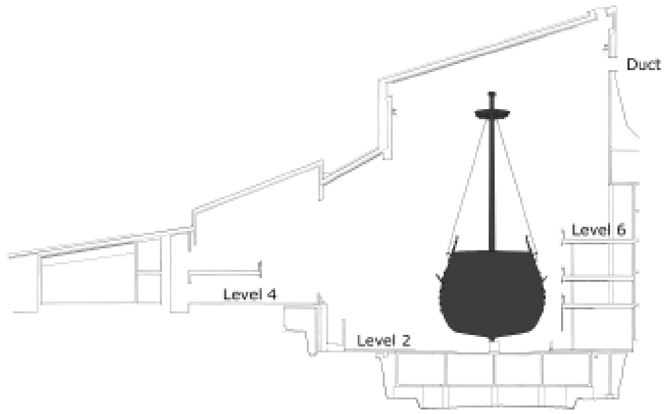


Figure 31: VASA Museum North-south Section (Hocker, 2010, p4)

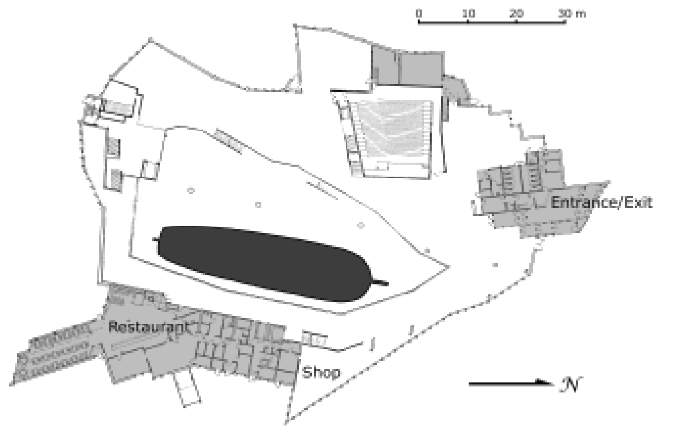


Figure 32: VASA Museum Building Plan (Hocker, 2010, p4)

Chapter 3: Literature Review

3.3 Precedent Studies:

b. H. L. Hunley wreck and Warren Lasch Conservation Centre Studies

3.3 Precedent Studies:
b. H. L. Hunley wreck and Warren Lasch Conservation Centre Studies

The Hunley Wreck Treated in Warren Lasch Conservation Centre:
H. L. Hunley is a 12.2m long, 1.3m high, with a breadth of 1.1m cast iron submarine wrecked in 1864. Since the excavation in 2001, its treatment had proceeded to the de-concretion stage in 2017 (Scafuri, 2017). This project was taken place in a controlled environment in Warren Lasch conservation laboratory. Submarine was treated in a 340 m3(93m2 * 3.7m) freshwater vat equipped with impressed current protection system. Electrochemical Reduction method was applied. On top of the vat, hollow plastic sphere (as 'blanket') were placed to reduce temperature loss. A 100-m2 mezzanine attached with a scissor lift was constructed adjacent to assist work. Above the space, two 20t top-running double-girder crones were installed to enable heavy lifting, x-ray tube and Cyrax Scanning. The vat water was exchanged everyday automatically. Externally, six 57 cubic meters fibreglass-mixing tanks stored treatment water and neutralization chemicals waste before discharge (water discharge rate 95L/min). The human, animal, and other organic materials are given with additional lab space for examination, treatment. This includes large walk-in cold storage (morgue), freeze dryers, as well as filtrated baths. Glass capable of filtering ultra-violet light and excessive visible light were incorporated to reduce artificial lighting uses (Michael, 2004).

Additional Design Guidelines for Marine Conservation Lab:
The lab compartment is divided into 'wet & clean ', 'wet & dirty ', 'clean' areas. The desalination of artifacts and encrustation removal is regarded as 'wet & dirty ', where building temperature could be as low as 0-10 degree with less insulation requirement. All service facility such as electrical cables, water, and compressed air hoses should be attached to the walls or ceilings with retractable reels for flexible indoor and outdoor uses. Workshop space with Grinding and abrasive equipment can be set in separate space to minimize noise impact. Stationary as well as portable fume, dust, and particle extraction units in a high ceiling space should be planned to encourage ventilation. Public visit areas should be refrain from lab activities prevent disturbance such as large bay window. Rainwater collected should be stored in cool(10°C) dark place avoid algae growth. Wide and shallow sinks made of 316 stainless steels should be connected with hot/cold tap water and deionized water. Modular furniture (task-specific lighting and locking casters tables) and storage should be designed to enable diverse conservation tasks. Dedicate space for crones or forklifts for heavy lifting (Mardikian & Chemello, 2020).

Discussion Based on Theorical Framework:
The divided process between treatment and display distorts the interpretive message of 'being-like' shipwreck and inhibits the sense of discovery for visitors. In Vasa Museum, the environment is designed with less focus on potential re-treatment, where shipwreck is present in static and seems lifeless. On the other hand, in the conservation laboratory, daily visit open to public is limited, where shipwreck is still 'moving' (undergoing transformation) having a higher 'degree of life'. However, the laboratory space do not 'speak' with the shipwreck architecturally. The shipwreck preservation laboratory proposed in this thesis aim to merge these divided stages, sharing the prolonged life transformation process of shipwreck to visitors and conservators.

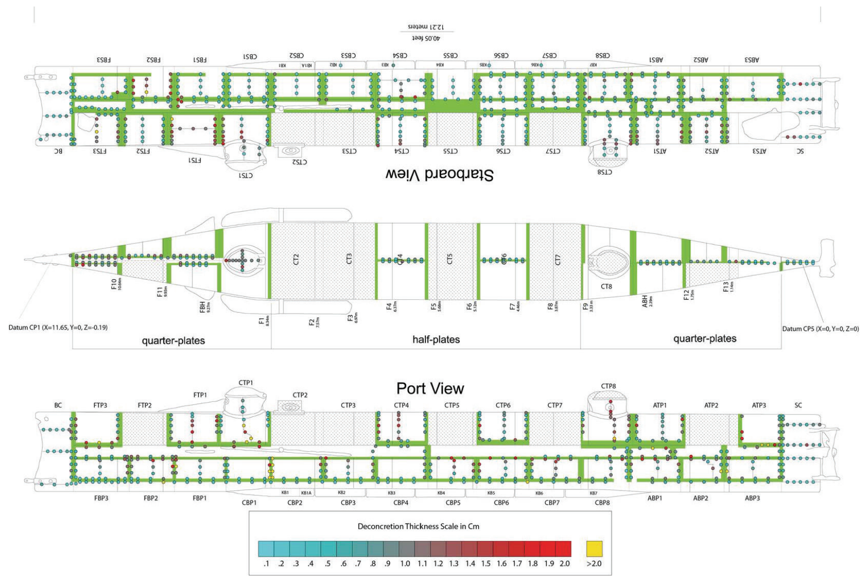


Figure 33: Scaled Visualization of the Concretion Thicknesses over the Length of the Hull (Scafuri, 2017, p309)

Figure 34: Six Mixing Tanks Located Outside the Building (Michael, 2004, p142)

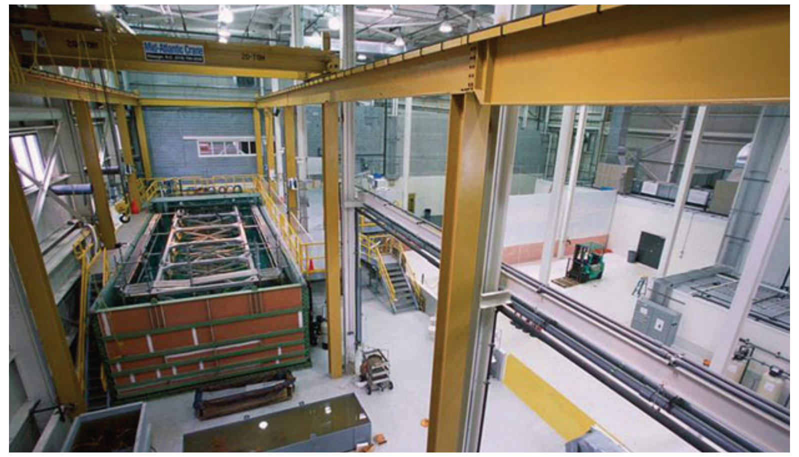


Figure 35: Warren Lasch Conservation Center in Charleston, South Carolina, USA (with 1864 American Civil War era submarine H.L. Hunley in a 340 m3 tank containing refrigerated fresh water) (Mardikian & Chemello, 2020, p2651)

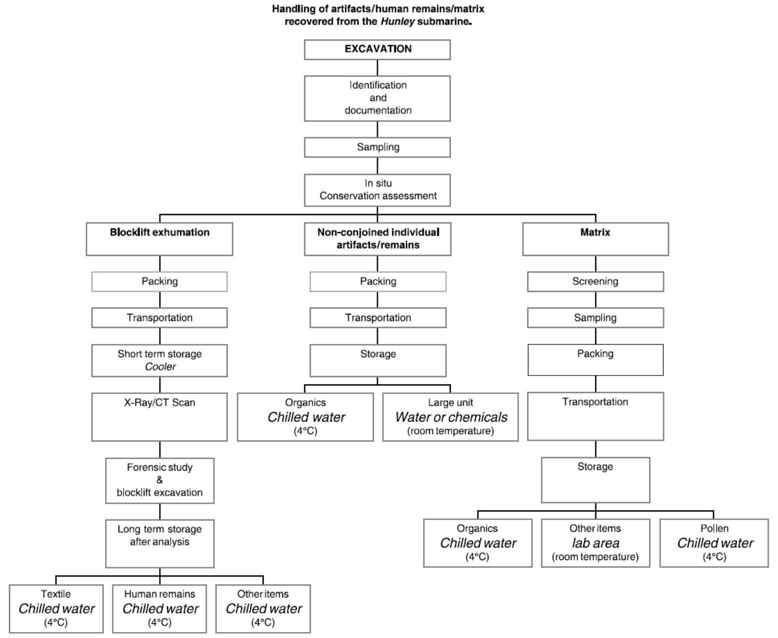


Figure 36: Handling and Storage Procedures on Hunley Project (Michael, 2004, p143)

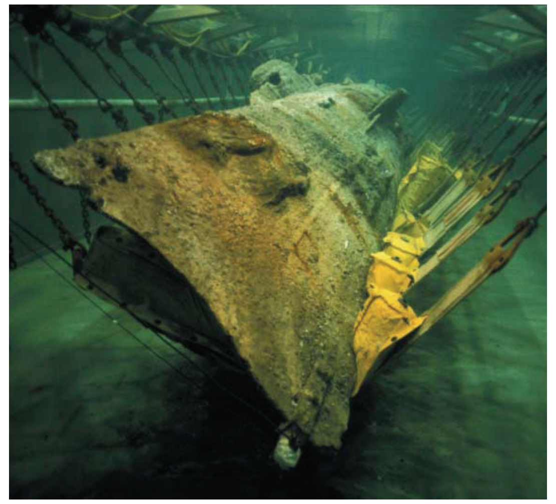


Figure 37: Hunley Resting in Its Tank with Anodes in The White Perforated Pipes at Warren Lasch Conservation Center (Michael, 2004, p140)

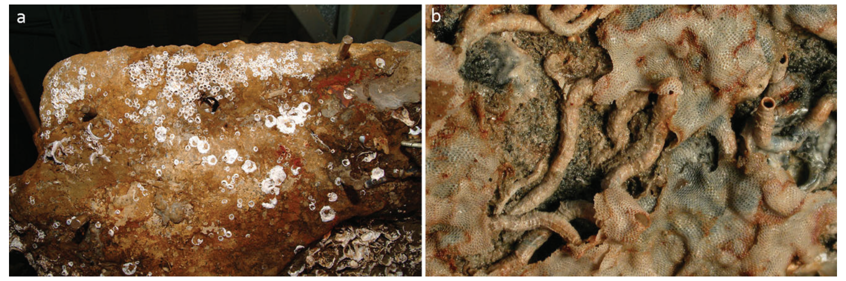


Figure 38 & 39: (Left) Concretion Covering the Starboard Stern, (Right) Macrofaunal Remains on the Concretion (Scafuri, 2017, p305)

Theoretical Framework Diagram

(Figure 40)

Shipwreck Preservation Laboratory

How & Principles

Introduced Revised 9 Conservation Principles acknowledge the autonomy of shipwreck
Refer to [4-2]

1)
2)
3)
.... 9) principle

Treatment process is kept minimum focusing on stabilize the native microstructure attributes (Data), Other than reduce object back to 'natural' manufactory appearance. This will render the wrecks & object 'less accessible', maintaining the 'proper distance', out of our grasp.

Ontological Proposition

1) Otherness (partial being) of shipwreck
2) Zuhandenheit (being ready-to-hand), Unzuhandenheit (unreadiness-at-hand) & 'handling'
3) Heterotopia

How & Principles

Maintain the sense of 'brokenness' of Shipwreck through preservation, rather than reestablish the readiness of seemingly perfect usable project.

1) 'Suspension of order'
2) A 'proper distance'
3) Heteropia

Conceptual Framework:

Cordelia's Silence as proposition, demonstrating autonomy & building 'proper distance' of semi-natural semi-artificial shipwrecks through ship preservation Laboratory

Conservation:

1) Reduce treatment process that erases nature's impact on object, deviating from the conventional preservation process

2) Identify technical requirement and shipwreck Preservation Procedure

I Field Excavation:
1. Identification
2. Field Lab setting
3. In-situ observations
4. Excavation
5. Transportation
6. In-situ management/preservation

II Lab Initial Cleaning:
1. Initial documentation
2. Intact encrustation storage
3. Mechanical cleaning (Encrustation removal)
4. Pre-treatment storage (thin encrustation layer remains)

III Lab Preservation:
1. Conservation process Evaluation
2. Treatment to stabilize
3. Restoration
4. Post treatment to protect

IV Structure Assembly:
1. Structure evaluation
2. Support structure design
3. Hull assembly/ parts replacement

V Re-Treatment & Storage:
1. Evaluation of previously treated Object
2. Re-treatment
3. post-treatment Storage
4. Periodic inspection

VI Temporary Display / Dispatch:
1. Archive & Package
2. Temporary Display
3. Dispatch

Building System:

Unify architecture programs into a 'Holobiont living system'.

Arrange architecture program based on identified technical requirement of shipwreck preservation procedure.

How & Principles

A Building Typology Manual

Building No. 1 Excavation
Burial Site for freshwater in-situ preservation
Building No. 2 Satblization
Building No. 3 Assembly
Building No. 4 Re-Stabilization
Building No. 5 Dispatch & Display

Architecture of preservation centre as a 'holobiont living system', other than a static museum. Here shipwrecks that undergoing slow pace, but more ecologically friendly treatment facilitate on-going visitation & education experience. Spaciously hall design enables mobility of preserved ship, showing awareness of its 'life '.

1. Low-impact pile foundation: Ensures the architecture remains independent from the site, minimizing disruption to the natural environment.
2. Controlled indirect natural light access: Protects the shipwreck hull by preventing exposure to direct sunlight.
3. Operable open-air floor: Reduces carbon and energy consumption for objects requiring electrolytic reduction cleaning and temporary storage.
4. Water collection and reuse system: Categorizes and manages tap water, rainwater, deionized water, and distilled water for efficient use.
5. Toxic waste neutralization: Implements systems to safely process and neutralize hazardous materials.
6. Support facility for fieldwork and excavation: Provides infrastructure to aid in on-site research and excavation processes.
7. Freshwater in-situ preservation: Establishes a stable burial environment for shipwrecks near the proposed architecture.
8. Facility for in-situ preservation at the wreck site: Supports preservation efforts directly at the shipwreck location.
9. UV- and visible-light-filtering glass: Prevents damage from harmful ultraviolet and excessive visible light exposure.
10. Energy-efficient climate control: Utilizes localized moisture controls, such as airlocks, air outlets, and air columns, to create a stable climate canopy for large objects.
11. Integrated natural and artificial lighting: Balances daylight and artificial sources for optimal visibility and preservation conditions.

Museum & Laboratory Precedent:

Precedent 1:
VASA shipwreck Excavation and VASA Museum studies
Precedent 2:
H. L. Hunley wreck and Warren Lasch Conservation Center studies

Architectural Experience Based on Proposition:

1) Suspension of order
2) 'proper distance'
3) Heteropia

Way of living/work/visitation:

1) Heterochrony as temporal experience

Ontological precident:

Precedent 1: Villa Madama - Completion from Incompletion
Precedent 2: Bridge fragment of Lange Brücke (The long bridge) at Forst

How & Principles

1) Use form that is neither with Cartesian order nor entirely formless.
2) Loosely connect the functional treatment building with interlude by the breath of landscape.
3) Structural elements demonstrates both the functional requirement and the sense of less orderliness and derivation, etc.
For more principles refer to Part Three [1]

Chapter 4: Site Analysis

4.1 Introduction

4.2 Site Location and Context

a. Site No.1 Mardi Gras Wreck Site - 'The Heavenly Gutter'

'Though the years vanish as swiftly as ever, sorrow, and life coming to an end make time seem too long. They spend entire days observing nature, the gradually calming of nature: at such times their shape become vague, undecided ... their gazes wander over the sand, rock and the water all around ... and somehow places they were not familiar become their friends... as though a faint recollection were telling them that they'd lived here - or in the water long ago - though the exact trace of that time has been erased in them...'

- Texts Modified (in red) from The Water Status (Jeaggy, 2021, p3)

4.1 Introduction

This chapter covers four sites. The first two are shipwreck sites: one located on the ocean floor, which has been researched, and another onshore, which I studied through site visits and drawing analysis. The other two sites are potential locations for the preservation laboratory. The first is an imagined site developed during the early design phase to establish ideal parameters for the project's location. The second is the final chosen site where the architectural design will be implemented.

4.2 Site Location and Context:

a. Site No.1 Mardi Gras Wreck Site - 'The Heavenly Gutter'

Ships operating in the American region during the colonial period (1715-1765) had an average lifespan of 4.7 years, with only 9.4% surviving longer than 10 years (Bauer, 1988: 32-33). It is likely that the Mardi Gras was built within a decade before its sinking.

Resting 1,220 meters below the sea, 64 kilometers off the coast, the wreck is gradually being scattered by underwater currents and marine activity, its remains settling into the soft flocculent silt. The site is both ethereal and fragile—soft and light, yet at the same time deep and dark.

Wreckage Date: 1808-1820 (hypothetical)
Construction Date: 1798-1815 (hypothetical)
Built Nationality: Uncertain (Great Britain, France, Mexico, or the United States)
Wreckage Location: Mardi Gras Shipwreck Site (16GM01), 1,220m below sea level, 64km off the coast of Louisiana, US
Excavation Institutions: Okeanos Gas Gathering Company; Texas A&M University, Department of Oceanography; Texas A&M Research Foundation; Center for Maritime Archaeology and Conservation, College Station, Texas

Excavation Status: Identified (2001-2002), artifact recovery and exposed remains recorded (2004-2009); the shipwreck was not fully excavated.
Excavation Tools: Remotely operated vehicle (ROV), autonomous underwater vehicle (AUV), 4-meter (13-ft) line spacing sonar, heavy lifter with Rig Master manipulator, excavation dredge and screening system, suction pickers, scoops, rake, pneumatic chainsaw, Large Artifact Retrieval Tool, lifting basket, site recording tracker.

Vessel Type: Lightly framed armed schooner with an uncertain purpose (armed merchant vessel, privateer, or slave ship).
Wreckage Cause: Unknown (foul weather, structural failure, burning, or other violent events).
Wreck Condition: Deteriorated hull.
Estimated Measurements: 40-65 tons, 17.1m in length, 5.8m beam, 2.04m depth of hold.

Material Composition: Approximately 604 objects were excavated, including:
Intact artifacts: Sand glasses, ceramics.
Corroded metals: Ferrous materials, cast iron.
Other materials: Lead, copper alloys ("cupreous" materials), wood (Aster, Alder, Amaranthus, Oak, Hickory, Wax Myrtle, Pine, Willow, Elm), stone, leather, bone, seeds, rope, and composite materials.

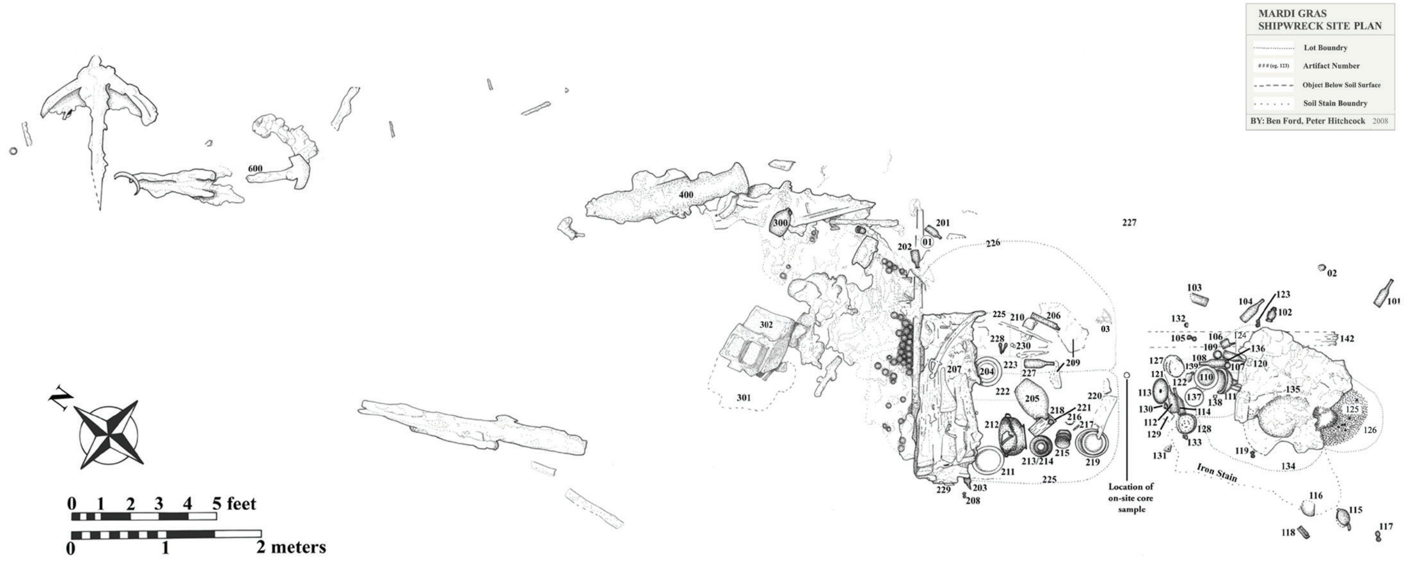


Figure 41: Mardi Gras Shipwreck 1220m Undersea Bed Site Drawing Pre-Disturbance Mosaic in 2007 (Ford et al, 2008, p268)

Figure 7: Mardi Gras Shipwreck 1220m Undersea Bed Site Pre-Disturbance Mosaic in 2007 (Ford et al, 2008, p264)

Chapter 4: Site Analysis

4.2 Site Location and Context

b. Site No.2 Shipwreck Harbour in Bowling, Glasgow - Yarn Of the Abandoned Ships

Yarn of the Abandoned Ships
Mapping of Artificial Streams Formed by Abandoned Ships During Tide Shifting
(Figure 43)

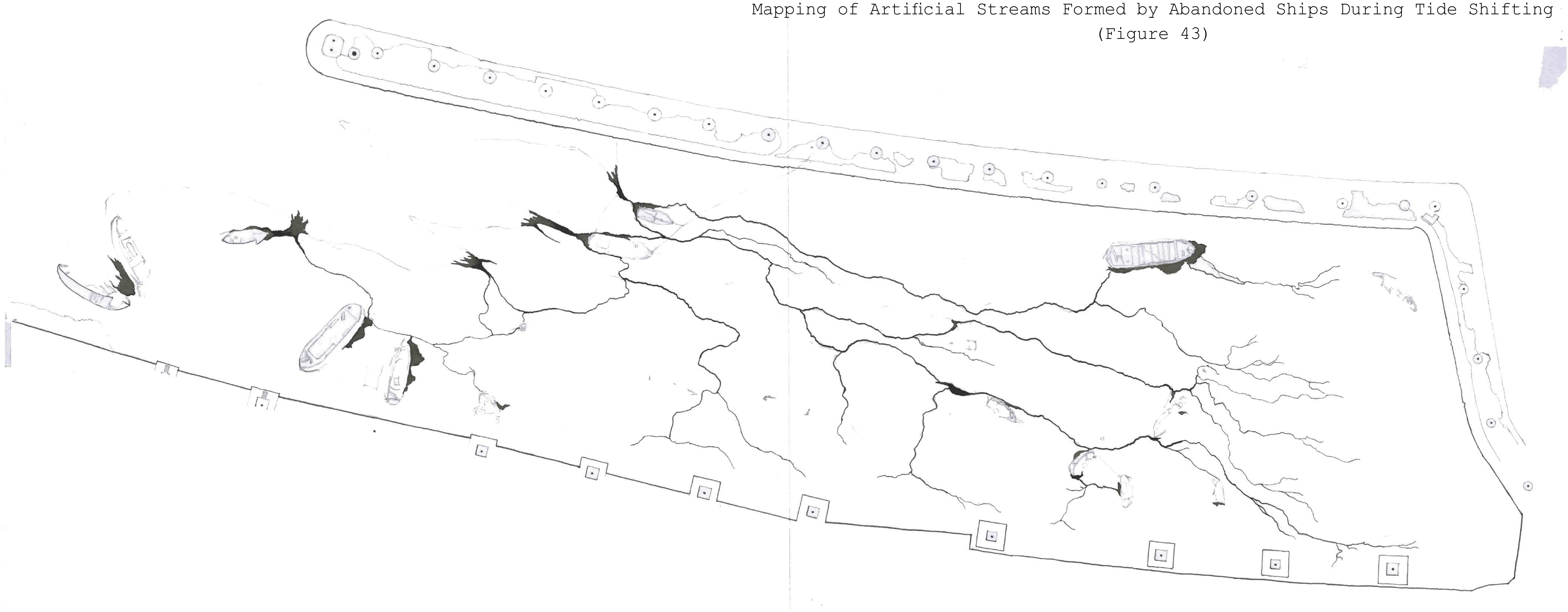


Figure 44: Panorama View of Bowling Harbour at Low Tide

4.2 Site Location and Context:

b. Site No.2 Shipwreck Harbour in Bowling, Glasgow - Yarn of the Abandoned Ships

During my first visit to the shipwreck harbour in Bowling, Glasgow, the tide was low, revealing the abandoned ships in greater detail. With the water receded, minor streams emerged on the riverbed, intertwining to form a network of streams - a kind of river. Around the wrecks, a series of lagoons appeared, accompanied by the soft sound of water draping over decayed hulls.

The ships felt almost human—gasping, struggling, as if drowning in the lingering water trapped inside them. Their ‘coughs’ shaped the lagoons, feeding the streams on the exposed waterbed. These wrecks cannot take a proper breath before the tide rises again.

The weight of waterlogged wrecks presses into the soft shore bed, which is unable to support their burden. Some ships have nearly vanished into the earth, with only their bows protruding. Those that lack historical significance and thus remain unrestored will eventually become part of the landscape.

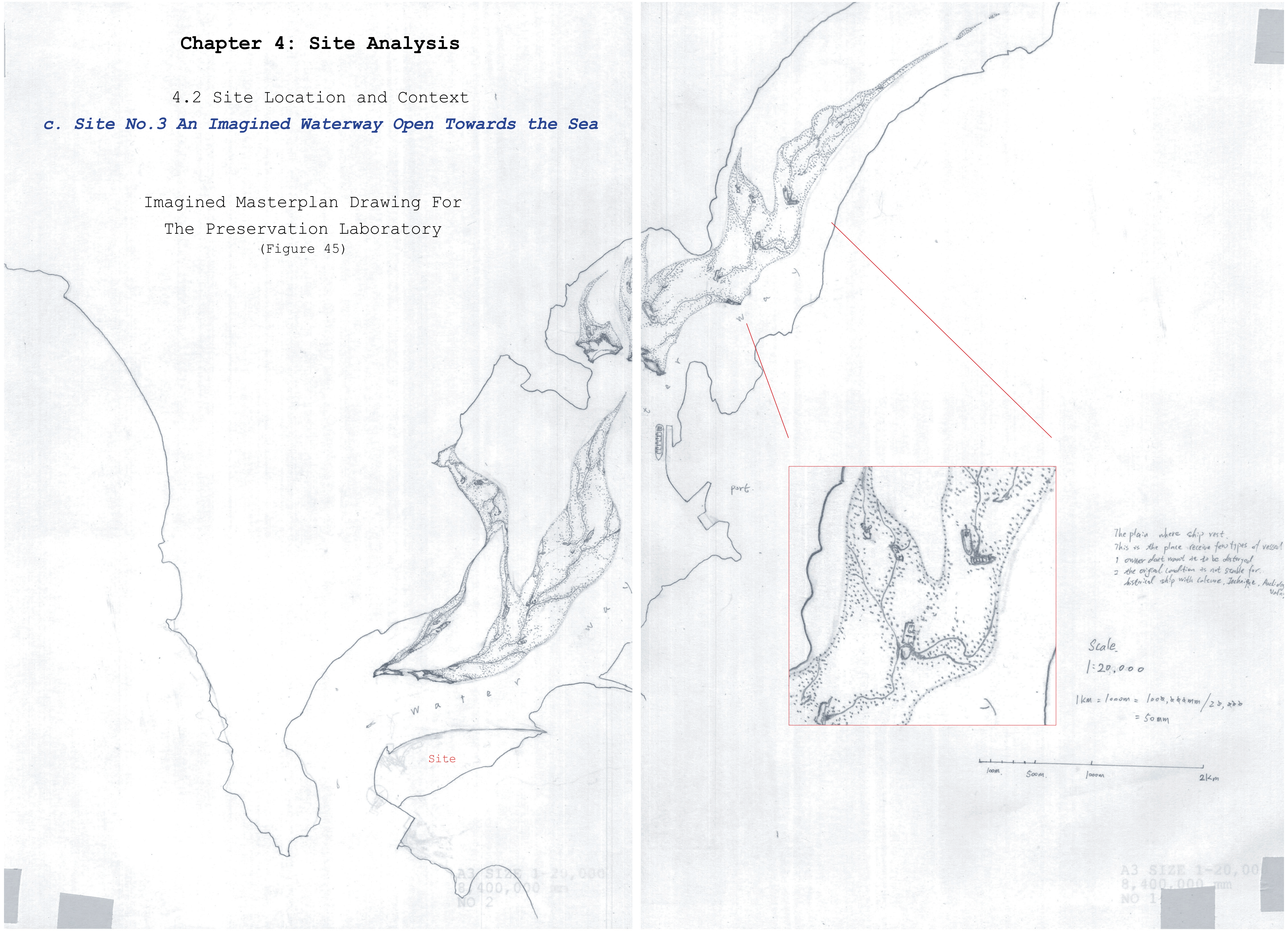
Figure 42: Bowling Harbour at Low Tide with Abandoned Ships Revealed

Chapter 4: Site Analysis

4.2 Site Location and Context

c. Site No.3 An Imagined Waterway Open Towards the Sea

Imagined Masterplan Drawing For
The Preservation Laboratory
(Figure 45)



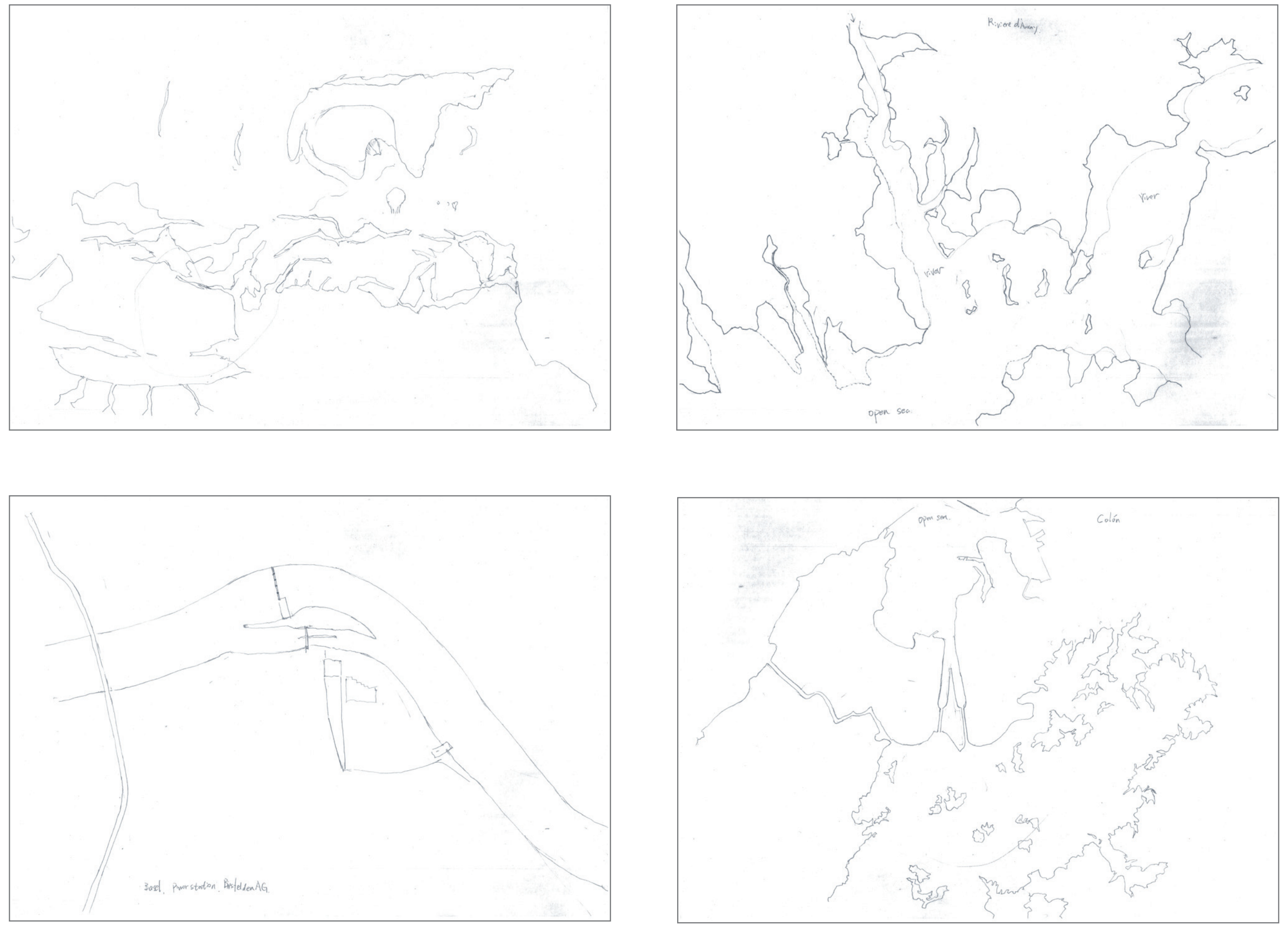
4.2 Site Location and Context:

c. Site No.3 An Imagined Waterway Open Towards the Sea

My ideal location for Laboratory is a site claimed by no one yet accessible to everyone which a certain distance away from civilization. Much like the state of a vessel's wreck, many of these are beyond human reach, yet still retain traces of human creation. They are simultaneously accessible (open to visitation) and inaccessible (physically challenging to reach). My original research focused on lands that are not owned by any entity, such as Antarctica, Bir Tawil, and Liberland, but these proved unsuitable for the project due to the lack of harbour infrastructure. As a result, this imagined site was conceived during the initial stages of design.

This imagined area defuses associations with national identity and cultural heritage, providing a neutral typological institution of preservation that serves the needs of multiple countries. It is a place where ships are given a certain degree of autonomy within a constructed, reflective landscape.

The waterways in this imagined site are protected by small isles, and the alluvial plain of the inland shore cradles natural shipwrecks, gradually sinking into the earth and decaying over time. The site lies at the terminus (or perhaps the beginning?) of the waterway. The drawing attempts to evoke a sense of drift and indecisiveness, mirroring the disorienting and fragmented nature of the shipwrecks.



Imagined Masterplan Drawing Iterations For The Preservation Laboratory
(Figure 46-49)

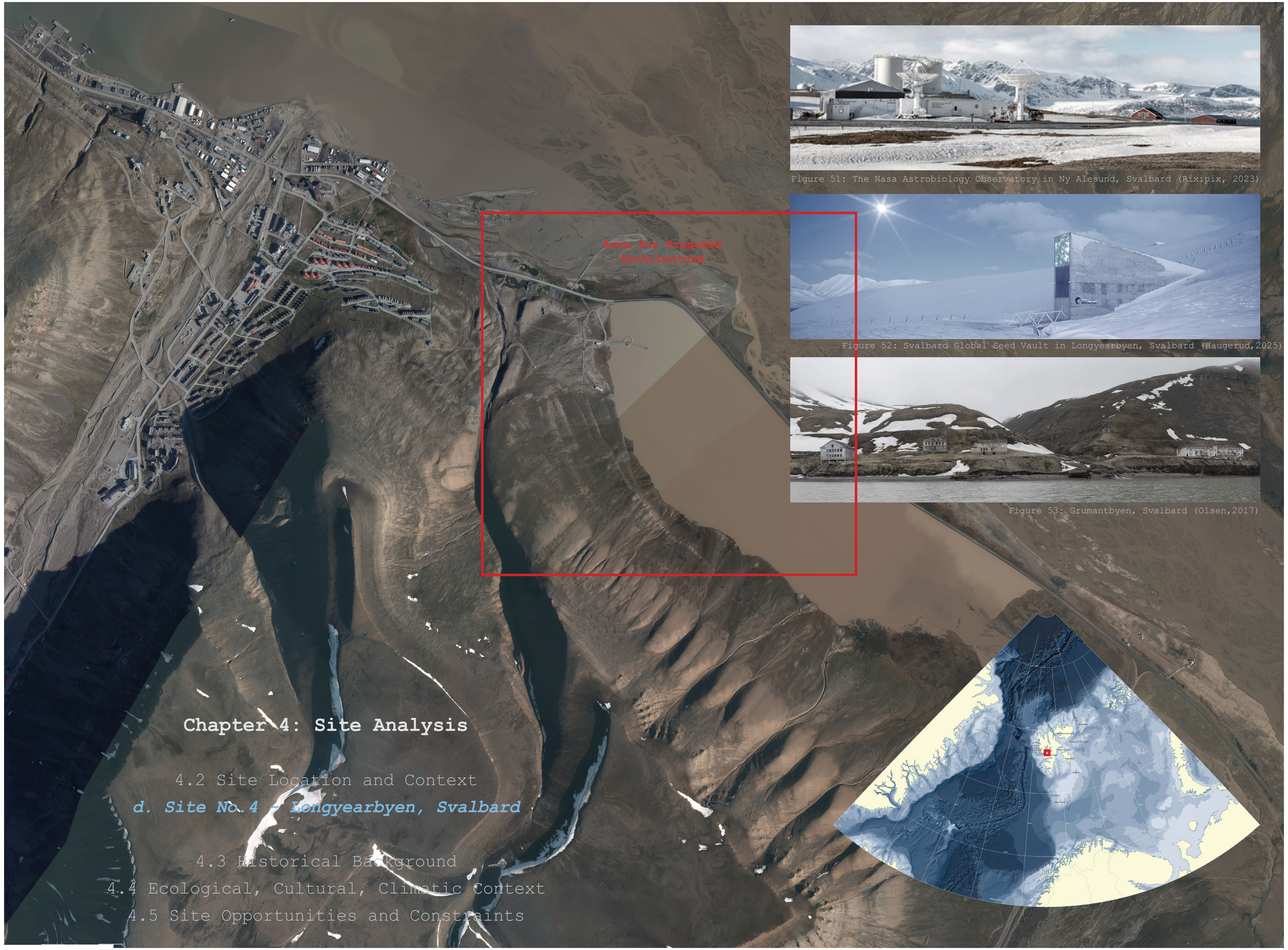


Figure 51: The Nasa Astrobiology Observatory in Ny Alesund, Svalbard (Rixipix, 2023)

Figure 52: Svalbard Global Seed Vault in Longyearbyen, Svalbard (Haugerud,2025)

Figure 53: Grumantbyen, Svalbard (Olsen,2017)

Figure 50: Longyearbyen Aerial Imagery Stitched by Author (TopoSvalbard, n.d.)

4.2 Site Location and Context:

d. Site No.4 - Longyearbyen, Svalbard

The high Arctic site of Longyearbyen (78°13′N 15°38′E), located on Spitsbergen Island in Svalbard, has been chosen as the site for the project.

4.3 Historical Background:

Dating back to the 17th century, people from various nations have travelled to Svalbard for trapping, research, mining, and tourism, without claiming ownership of the archipelago. Svalbard belonged to any countries and no country. In 1920, the Svalbard Treaty was officially signed by multiple nations, granting Norwegian sovereignty over the islands. However, it remains a demilitarized, non-discriminatory, and entirely visa-free zone where anyone may live and work, and exercise property ownership—including mineral rights—regardless of their country of citizenship (Jensen, 2020).

4.4 Ecological, Cultural, Climatic Context:

The spirit of Svalbard has evolved through its unique agreement, which is exemplified by projects such as the Svalbard Global Seed Vault. Longyearbyen, the administrative center with 2,400 residents from nearly 53 different countries, is inhabited by nature enthusiasts, scientists, tourists, and residents living under the High Arctic wilderness. It is renowned for its hospitality, Arctic education, and research stemming from its mining industry (Visit Svalbard, 2024).

4.5 Site Opportunities and Constraints:

The proposed preservation laboratory in Svalbard is a place-based decision aimed at serving the historical shipwreck preservation needs of multiple countries. This will also enhance the autonomy of the shipwrecks, free from national heritage labels. The high Arctic climate (ranging from 10°C to -27°C between July 2023 and July 2024) helps limit physical erosion and bio-chemical corrosion rates. The UV index throughout the year ranges from 0 to 2, which is ideal for UV-sensitive artifacts and allows for indirect natural light access to the architecture. Additionally, the availability of infrastructure, such as the Svalbard University Center and Longyearbyen Harbor, gives the site great potential for shipwreck preservation. The proposal embraces the unique geopolitical value of the location and will contribute to regenerative change in Svalbard.

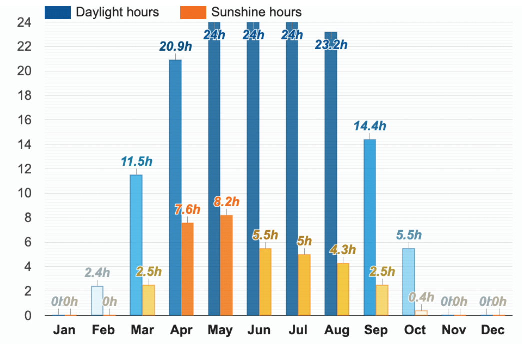


Figure 54: Daylight/Sunshine Hours - Longyearbyen, Svalbard And Jan Mayen (Weather Atlas, 2024)

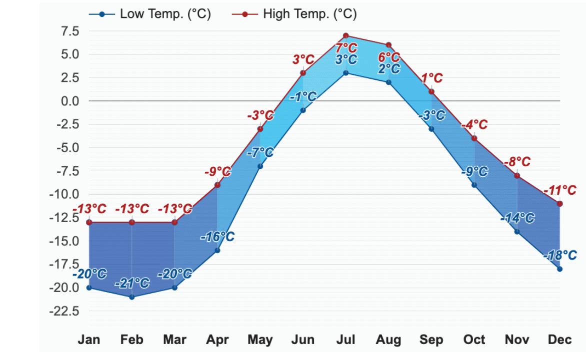
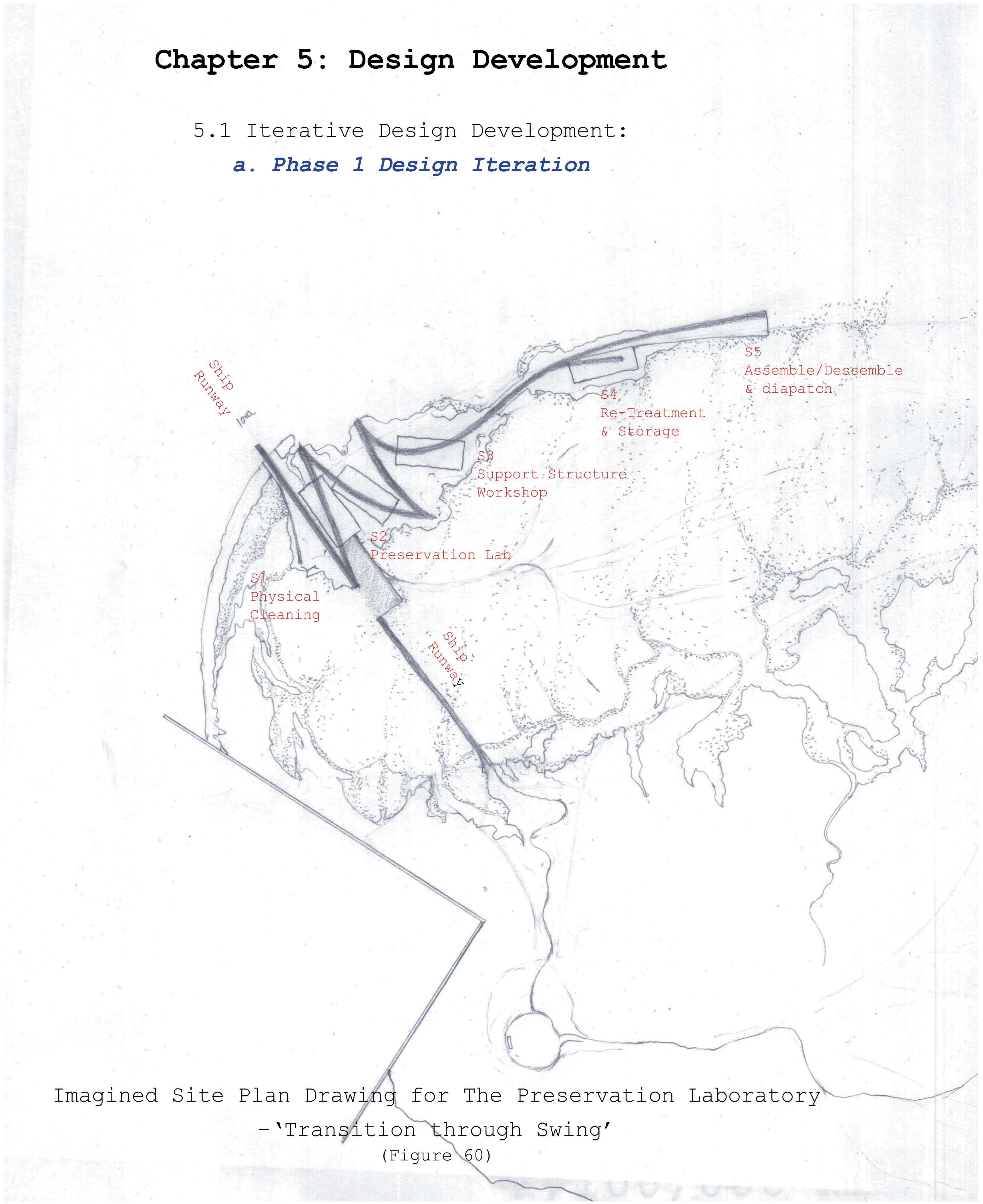


Figure 55: Temperature - Longyearbyen, Svalbard and Jan Mayen (Weather Atlas, 2024)

Chapter 5: Design Development

5.1 Iterative Design Development:

a. Phase 1 Design Iteration



Imagined Site Plan Drawing for The Preservation Laboratory
-'Transition through Swing'
(Figure 60)

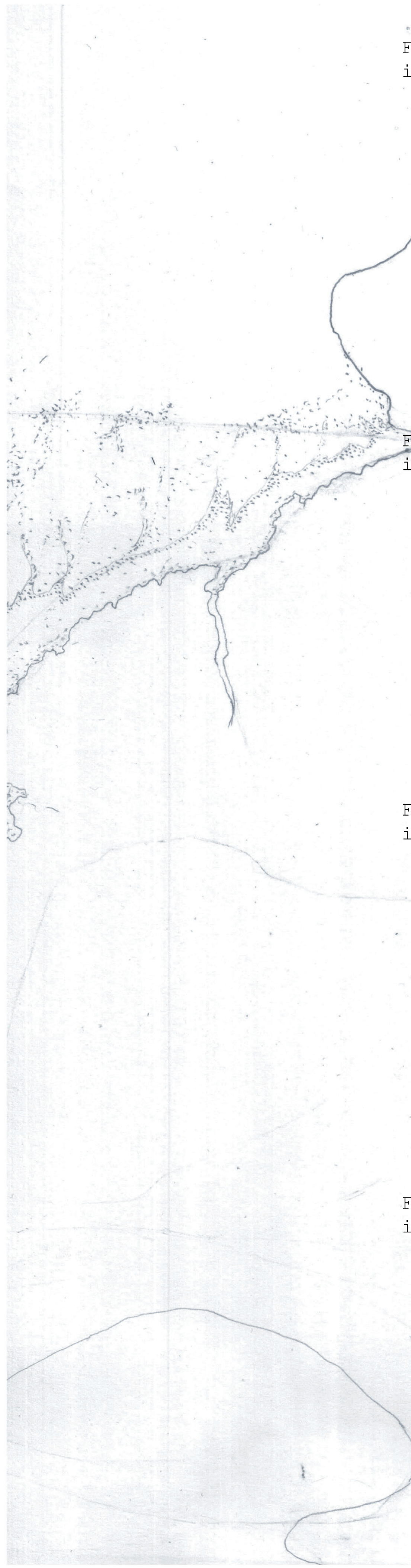


Figure 56: Test 1 - Perpendicular Building Transition from Short Side

Figure 57: Test 2 -Perpendicular Building Transition from Long Side

Figure 58: Test 3 - Perpendicular Building Transition Through Quarter Circle

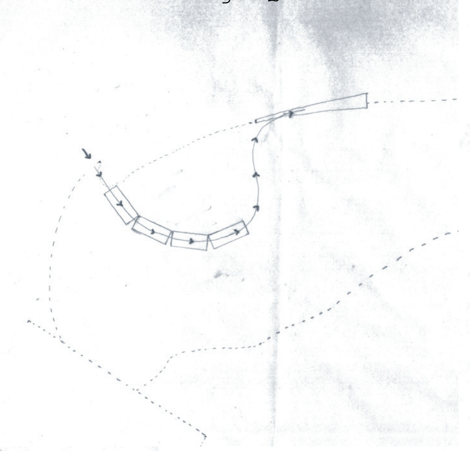
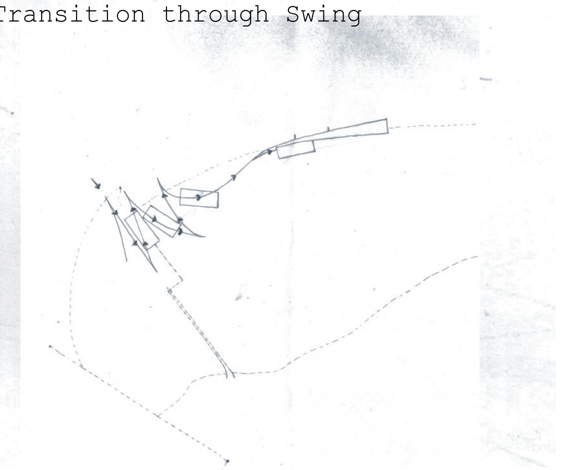


Figure 59: Test 4 - Perpendicular Building Transition through Swing



S1(Stage 1): **Field Excavation & Initial Physical Cleaning** (Cold room, Partially semi-open air space)

S2 (Stage 2): **Preservation Lab** (climate control room, Isolation Gown Usage)

S3 (Stage 3): Support Structure Workshop, wreck **Structure restoration & replacement**(Climate controlled)

S4 (Stage 4): **Re-Treatment** (Climate controlled, Isolation Gown Usage)

S5 (Stage 5): Temporary Display, **Assembly/Disassembly & Diapatch** (Climate controlled)

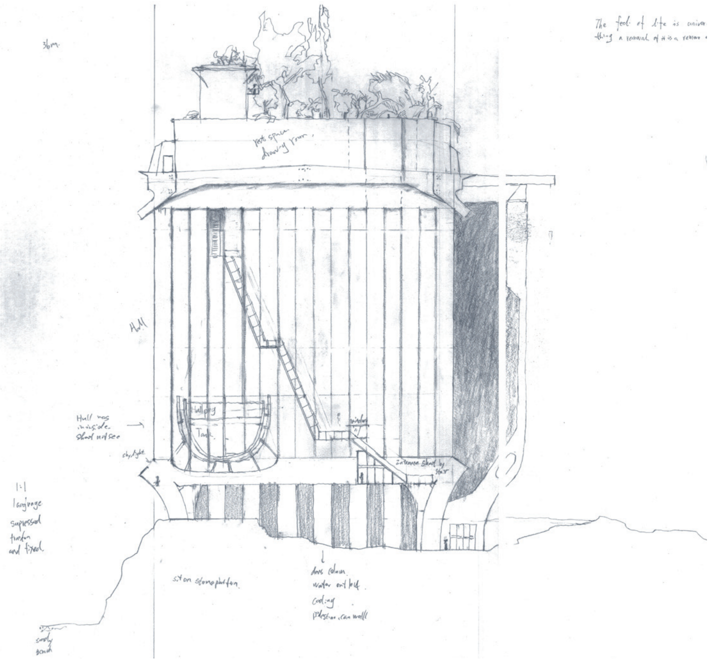


Figure 61: Initial Sketch (Elevation) of Preservation Architecture

Phase 1 Master Plan & Building Arrangement

Zooming into the southwest corner of the imagined master plan from the previous page, the building site is situated on an alluvial plain at the outlet of the waterway leading to the sea. The preservation lab is Divided into five separate buildings, with four arrangements tested. As shipwrecks under treatment are considered to be in a transitional phase between wrecked and exhibited conditions, the architectural representation of this transition is reflected in the buildings' orientations. Shipwrecks in a wrecked state are scattered in random orientations on the beach or in the water, while ships in service are always parallel to the water. In contrast, the transitional phase is represented by buildings oriented perpendicularly, cutting across both the waterway and the shore, distinguishing this phase from other statuses where the shipwrecks' fates are determined.

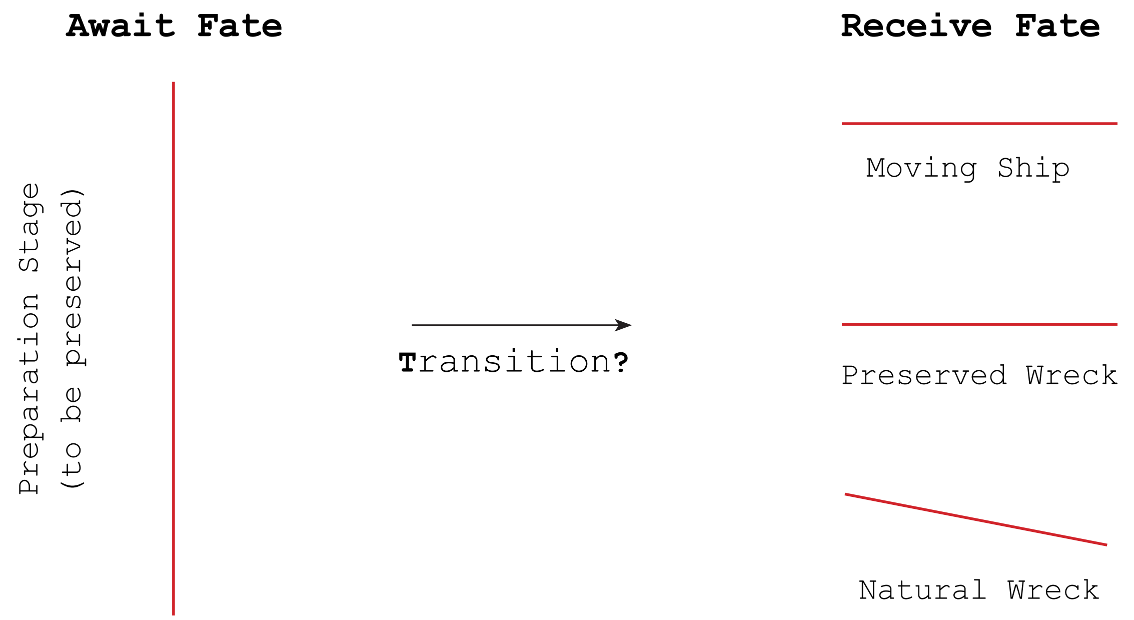
Four building arrangements are tested to demonstrate the transformation from the perpendicular to the parallel orientation. Among these, the 'Transition through Swing' is selected, as it evokes a sense of drifting shipwrecks and the indecisiveness of their upcoming fate. The black stroke represents a 10-meter-wide movement track for shipwrecks during the treatment process. The shipwrecks will move from one building to another, and once preservation is complete, their orientation will return to the 'normal' parallel alignment with the waterways.

Chapter 5: Design Development

5.1 Iterative Design Development:

a. Phase 1 Design Iteration

Figure 62: Articulated Transition of Status Under an Undecided Fate



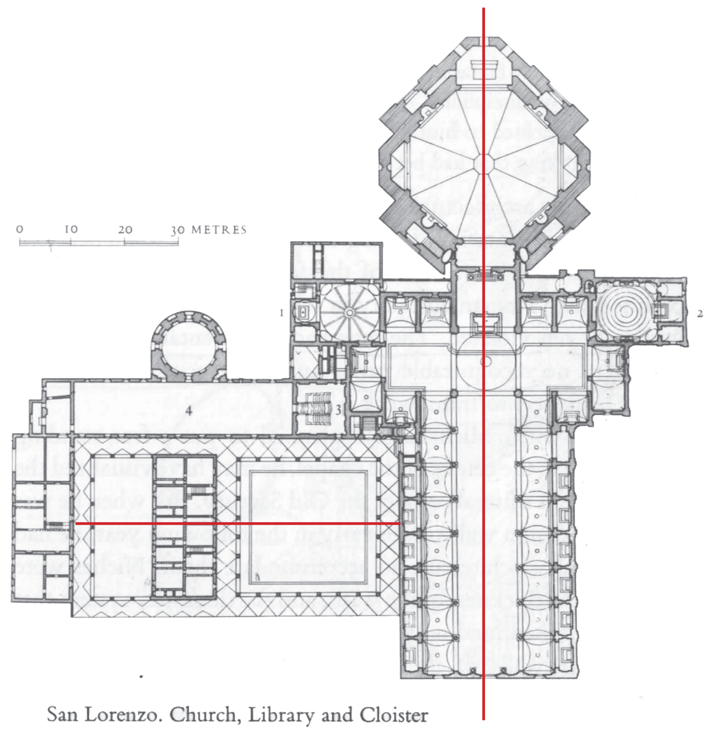
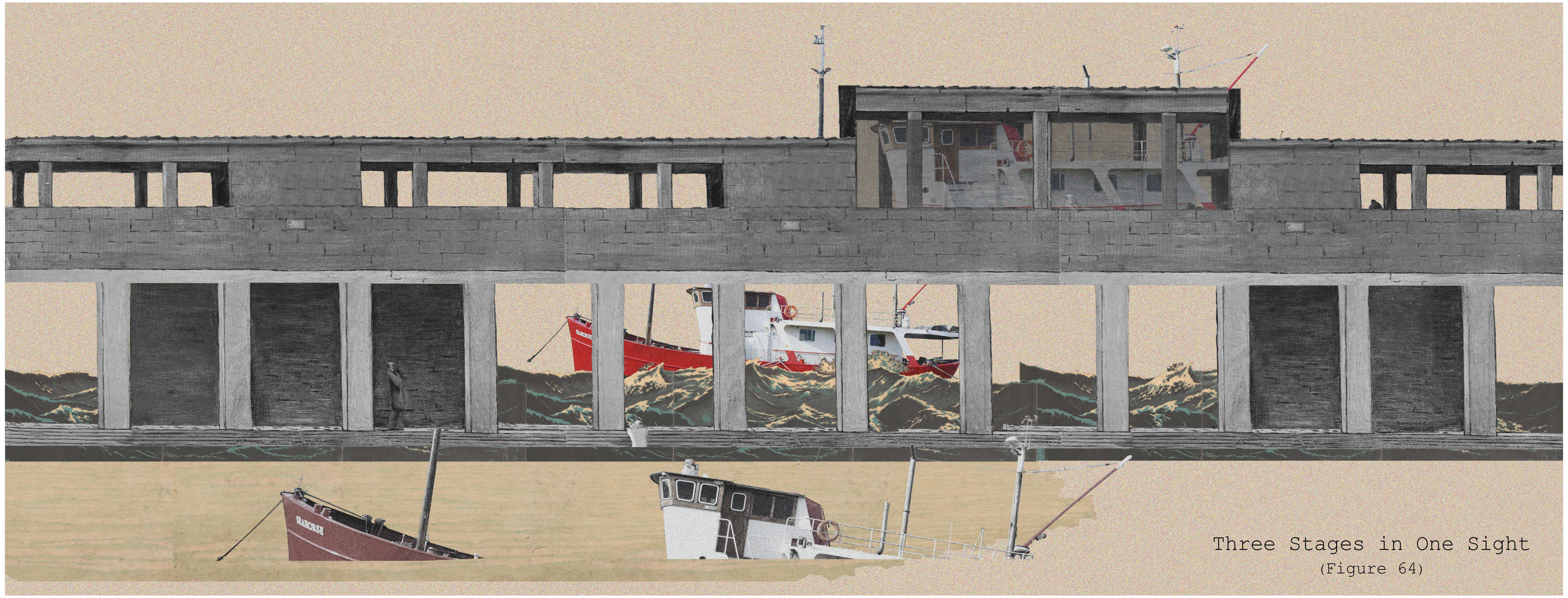


Figure 63: Addressing Transition & Conflict in Architecture though Orientation (Cooper, 2011, p50)



Three Stages in One Sight
(Figure 64)

Interpretating Shipwreck's Liminal Condition in Transitional Phase

Three Stages in One Sight

Living boat vs. decaying ship,
Quiet shore vs. weaving water,
With the preserved dead in between, as a thin Layer of ceremony

Here, the guests' vision is perpendicular to this scene, witnessing the three destinies of the vessel in one image, before entering the space. So guest can decide whether they still wish to proceed at the very beginning of their visit.
Here, the Vessels are made aware of their futures, so they will not feel surprised anymore.
Here, conservators work over decades to impose the orderliness of humanity.

Paintings can bend reality, compressing three time spans into a single image. This technique, employed by painters such as Edvard Munch and Sano di Pietro, offers the viewer an 'omniscient perspective.' In classical architecture, orientation serves as a means of translating messages of conflict. For instance, in the cloister of the San Lorenzo Church, where the monks reside, the space orientation is perpendicular to the chapel, where God dwells. The design metaphorically addresses the idea that humans are exiled on earth by God, with a place to dwell with God on earth being forbidden. This building arrangement resolves the conflict, placing them on two distinct places.

This metaphysical compression of stages into one image, alongside the perpendicular architectural arrangement, is also applied in my design iteration. It implies that the chosen shipwrecks, now under human control after being abandoned, are in a similar situation to Cordelia subjected to King Lear.

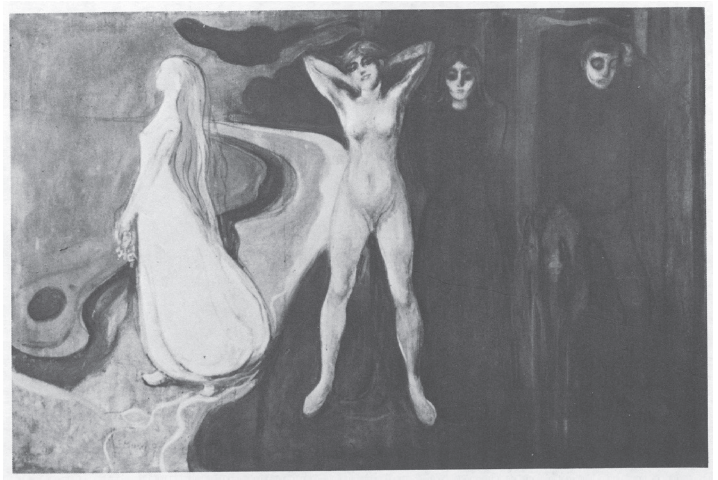


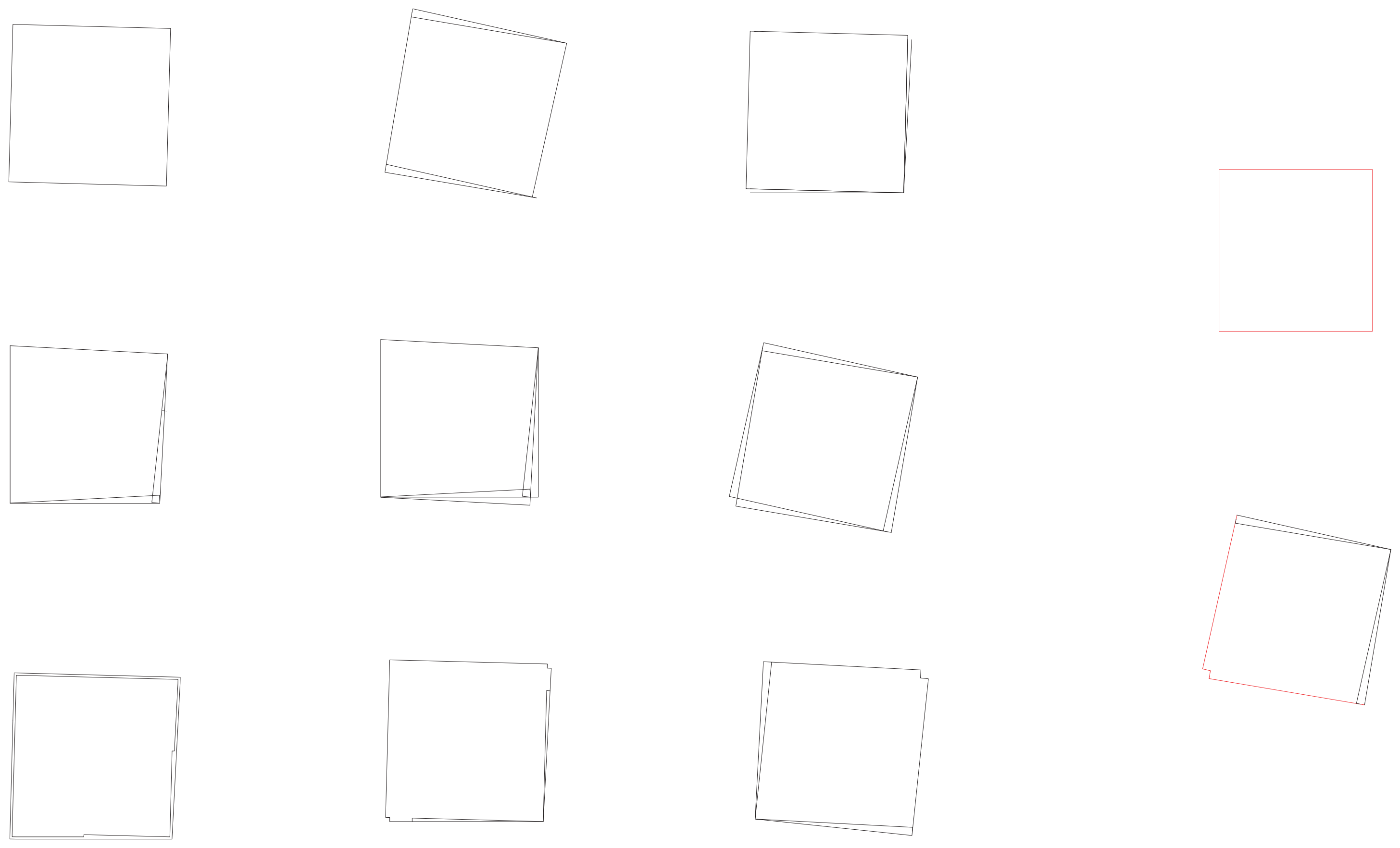
Figure 65: Edvard Munch - The Woman in Three Stages 1894 (Wilson, 1980, p492)

Figure 66: The Meeting of Saint Anthony and Saint Paul (Master of the Osservanza, 1430/1435)

Chapter 5: Design Development

5.1 Iterative Design Development:

a. Phase 1 Design Iteration



Strabismus form Iterations on Square
(Figure 67)

3 degree shift of square which
generate an additional corner
at the boundary.

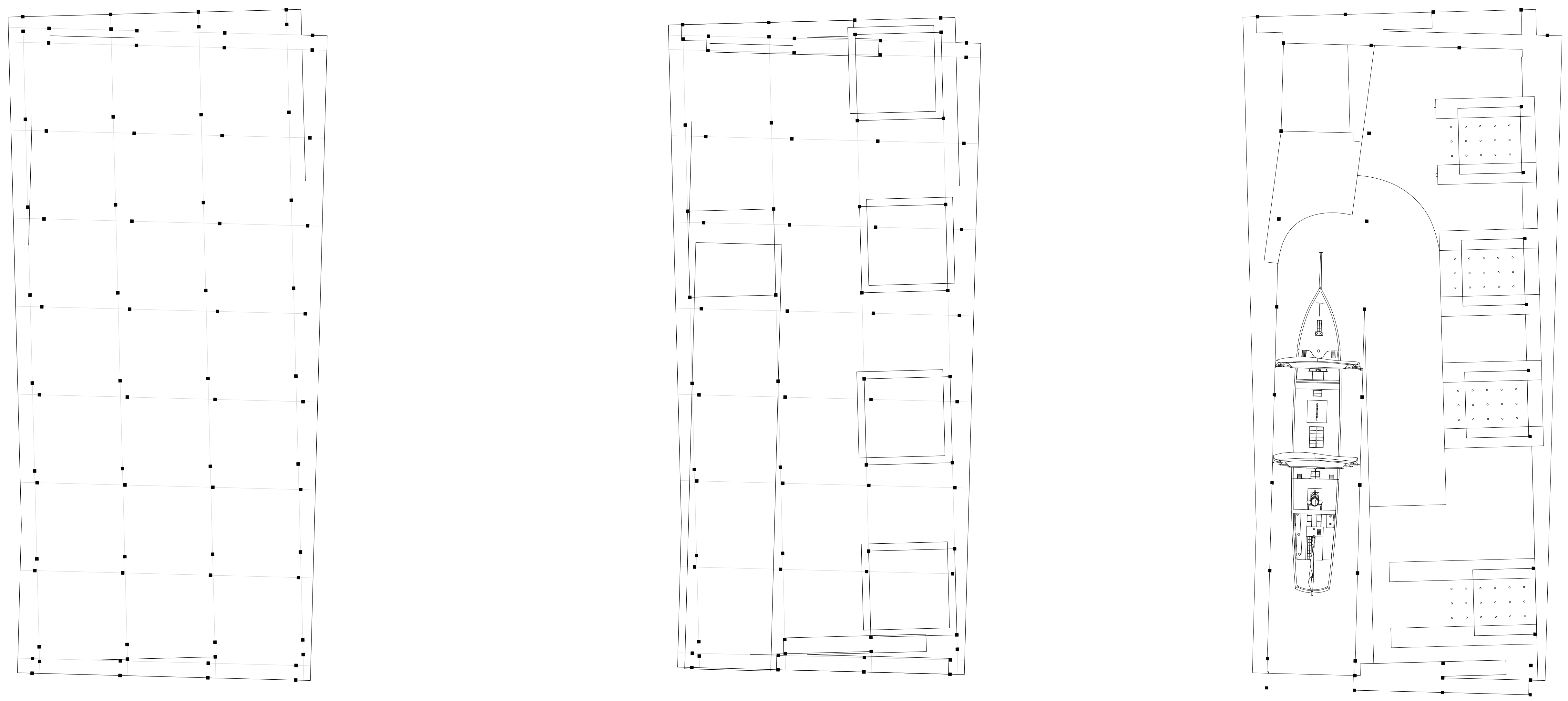
Phase 1 Design Test: No. IV Re-Treatment Building

The Phase 1 test utilizes a Cartesian mechanical approach to organize the architectural system, incorporating the movement of large items and establishing ship runways within the building. These runways Divide the 'cold & wet' spaces from the 'clean, warm' spaces. In this phase, the concept of 'suspension of order' is demonstrated through a 3-degree shift in the juxtaposed double columns, which interfere with the rectilinear arrangement, generating an additional corner within the rigid grid system.

Strabismus Eye Illness
(Figure 68)

Testing Suspension of Order Through Strabismus

Strabismus is a condition in which the eyes do not properly align when focusing on an object. In the context of the ship recovery project, it attempts to evoke the feeling of an ordinary industrial building, but with something subtly off. In the detailed structural design, the displaced steel columns are set 3 degrees off from the main columns. This off-ness suggests an altitude of Ships, which might not be interested in paying attention towards or unable to focus its destinies, the functioning one, the abandoned one and the preserved one. The architecture aims to evoke a sense of 'powerless retaliation' against the shipwrecks' fixed destinies.



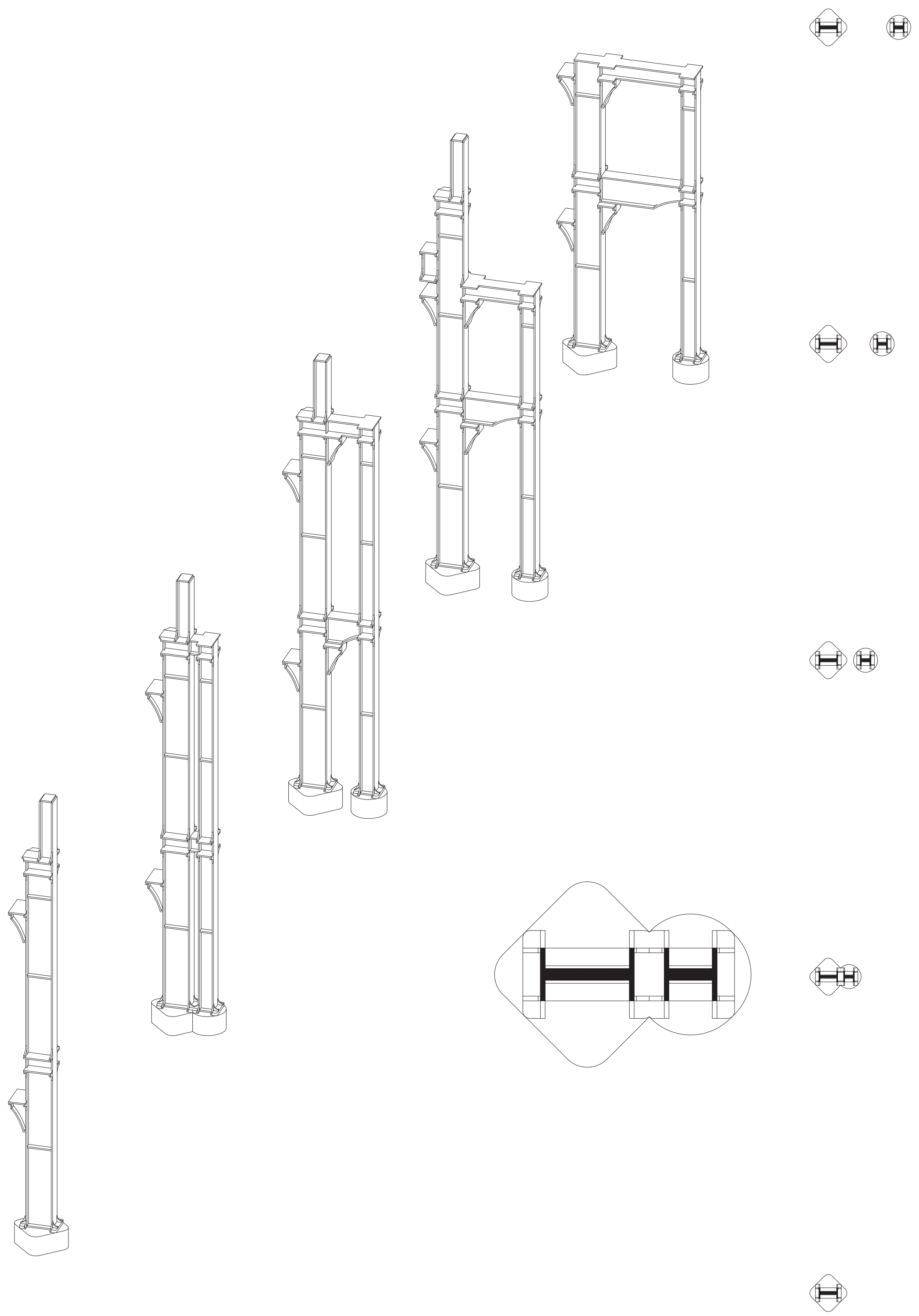
Plan Development on No. IV Re-Treatment Building
(Figure 69-71)

A 14.4m span Grid system is arranged in the build of
110m in length * 52m in width * 42m in height

Chapter 5: Design Development

5.1 Iterative Design Development:

a. Phase 1 Design Iteration



3 Degree De-coupled Steel Columns
(Figure 72)

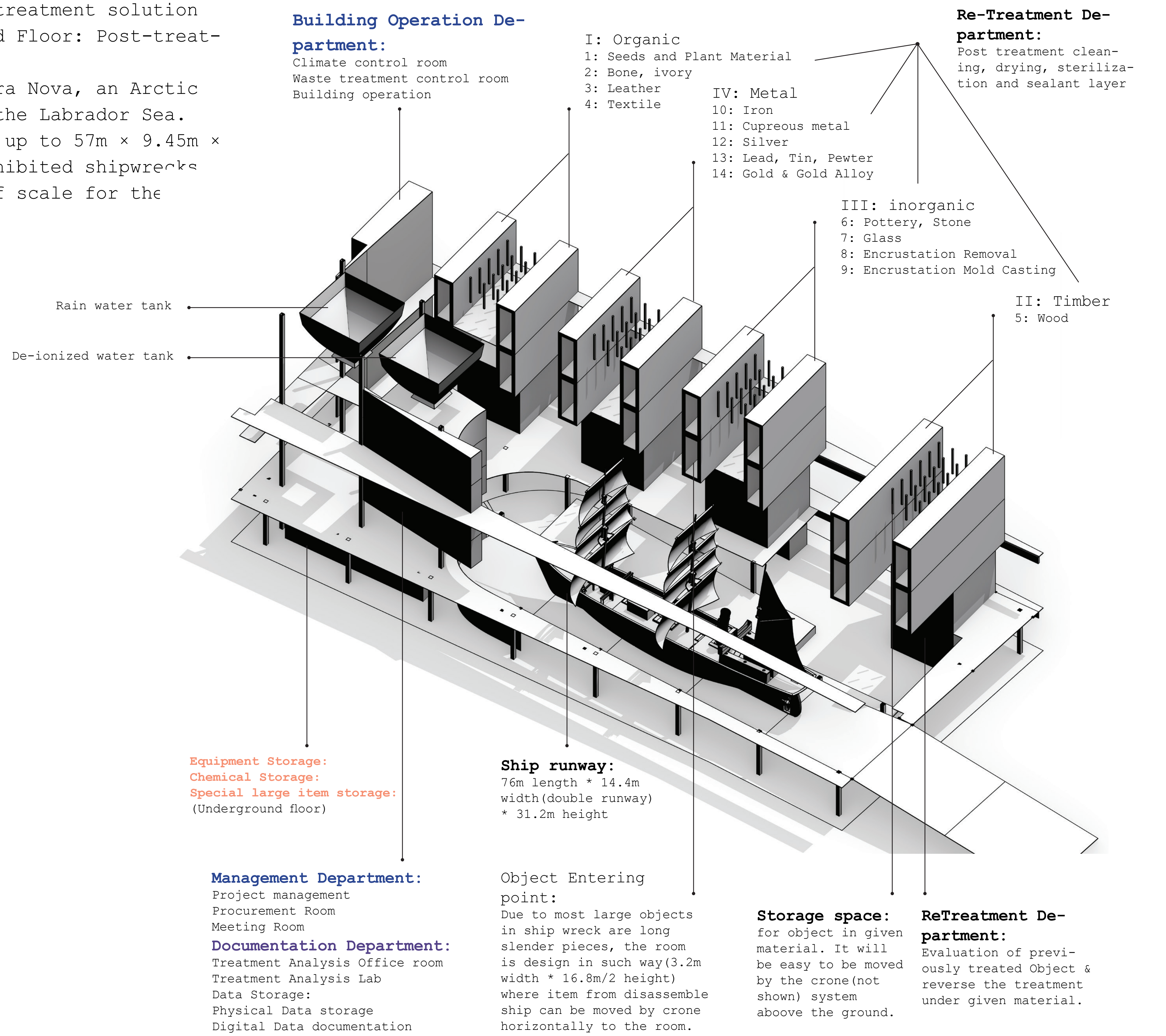
De-coupled structural steel columns suggest a sense of departure.

Phase 1 Design Test: No. IV Re-Treatment Building

The Phase 1 design test is conducted on the No. IV Re-Treatment Building, where a rectilinear Cartesian approach is examined. The ship runway is set at a 3-degree shift relative to the treatment department, introducing a subtle disruption to the otherwise rigid alignment.
The building consists of four treatment department blocks, each dedicated to a major material category: Organic, Metal, Inorganic, and Wood. Each block is structured into three levels. G Floor: Impregnation treatment solution tank; 1st Floor: Sterilization and sealant layering; 2nd Floor: Post-treatment drying.
The ship model used for scale reference is based on Terra Nova, an Arctic sealing and polar exploration relief ship that sank in the Labrador Sea.
The building is designed to accommodate ships measuring up to 57m × 9.45m × 5.8m, a size comparable to the largest preserved and exhibited shipwrecks
This Cartesian approach helps establish a clear sense of scale for the ject.

Phase 1 Design Test:
No. IV Re-Treatment Building
(Figure 73)

(NB: The building envelope is not included in this building.)



Chapter 5: Design Development

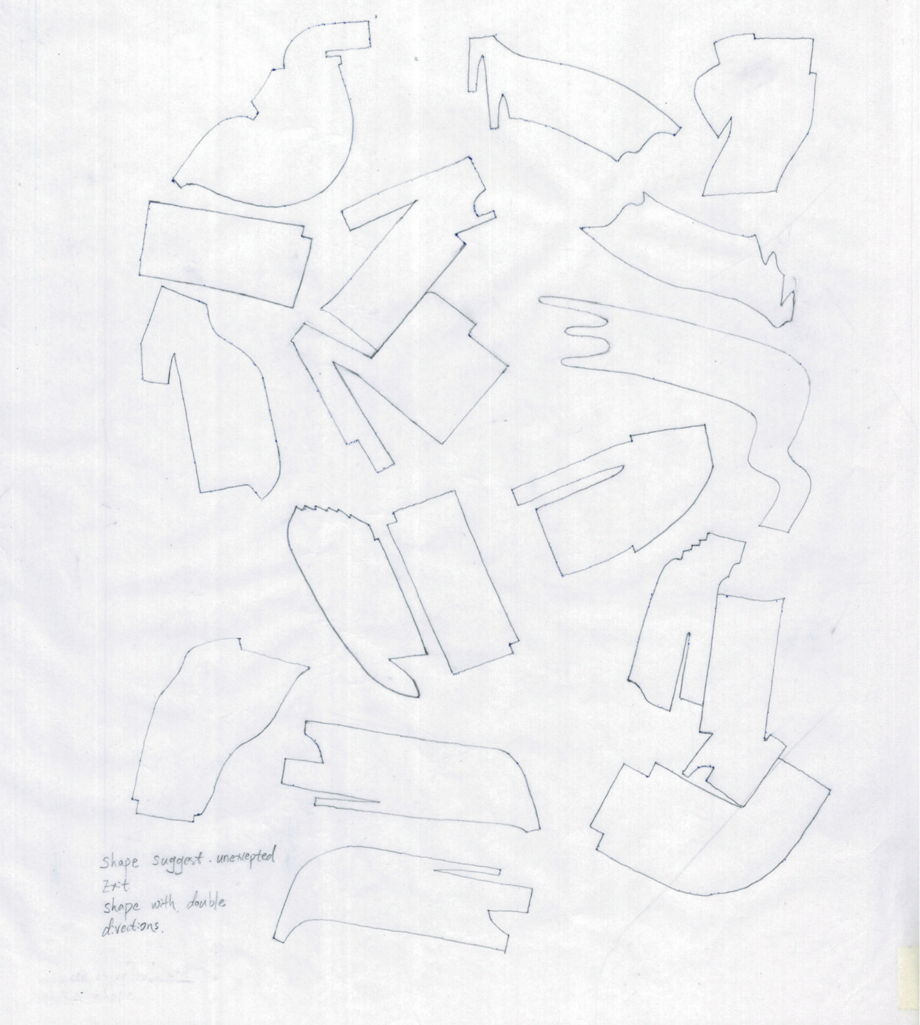
5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration

Heterotopia Form

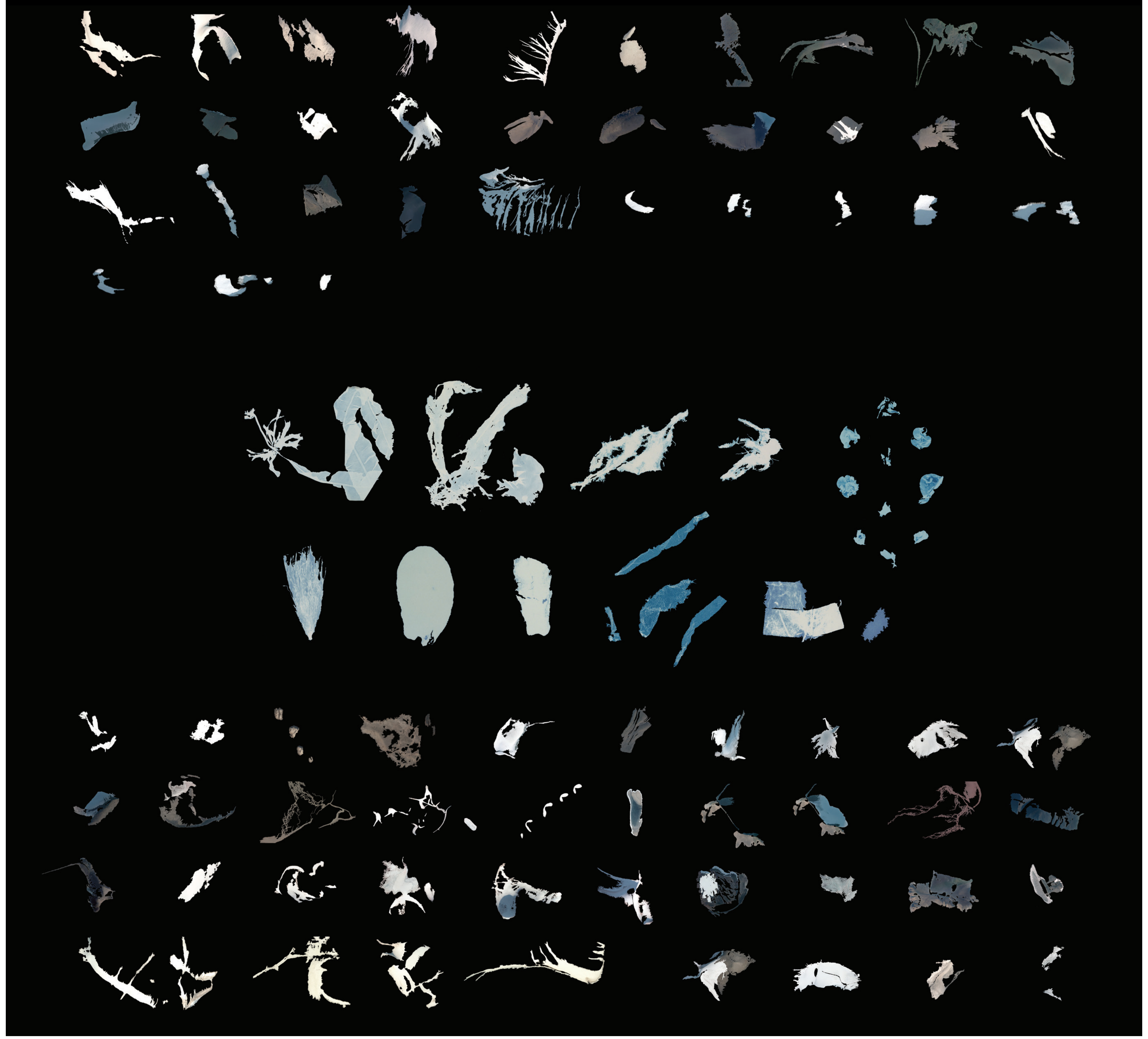
Generation & Selection

(Figure 74)



Natural Fragments Taken in Svalbard

(Figure 75)



5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration

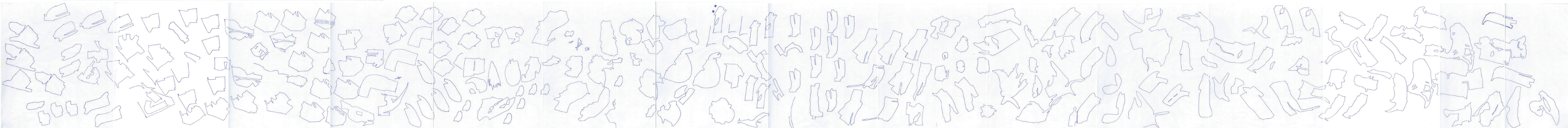
Heterotopia: Form Generation & Selection

There are two ways of understanding formlessness in architecture. One is the rectilinear Cartesian form. Shapes such as squares, rectangles, and circles that are universally accepted and rarely questioned due to their universal human usage. The other is the formless shape of nature, which defies explanation through human language and logic. Unlike Cartesian forms, reader is unable to question or explain these shape intellectually. There is no vocabulary to describe these exact shapes. They emerge outside the boundaries of human intent and function. Christopher Alexander (2002) suggests that both types of forms contain an underlying order. The former is explicit and part of architectural convention, while the latter is implicit, deeply personal and unique in its formation story. These natural forms possess an autonomy that renders them fundamentally "other."

In understanding otherness, Levinas argues that we should not impose our language and logic onto it. To truly acknowledge the other, we must remove the self. Our only appropriate response is to greet it, rather than to define it.

This second design phase begins from a position of openness, embracing the shapes of 'other cultures' without pre-imposed consciousness or pre-defined logic. The essence of shipwrecks is deeply other; they cannot be told, only encountered. This does not mean I have abandoned the previous Cartesian framework. I have carried those ideas with me for an extended period. They have been digested and embodied in my thinking. As I move deeper into this alternative approach, I trust that these ideas will return in a new form, reshaped by the process rather than by intention.

Due to physical constraints, I was unable to visit the site in person. Instead, I gathered as many raw natural fragments as possible from aerial images of the area. I traced these shapes repeatedly, studying their flows and contours. Through this process, I gradually developed my own personalized iterations, a transformation where raw natural forms, shaped by human hand, became semi-ordered yet unconventional. These forms are neither entirely natural nor entirely artificial. They embody a semi-human, semi-artificial quality that informs inhabitation, shaping an architecture that resists convention. In this way, the design reconnects to the idea of heterotopia a place that exists both within and beyond human order.



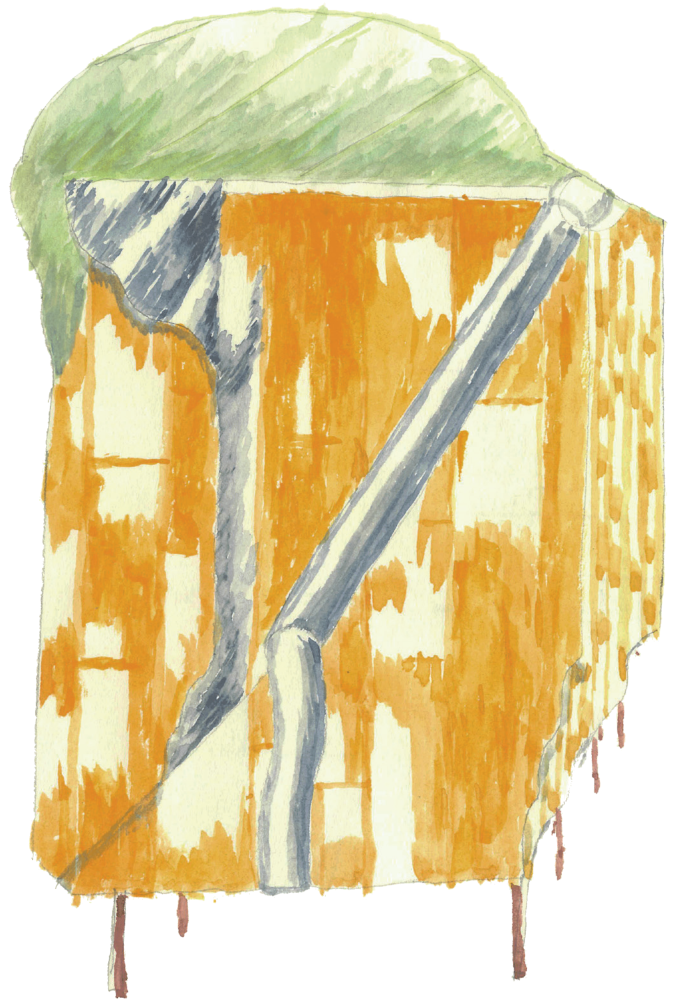
Personalized Iterations Transforming Aerial Natural Fragments

(Figure 76)

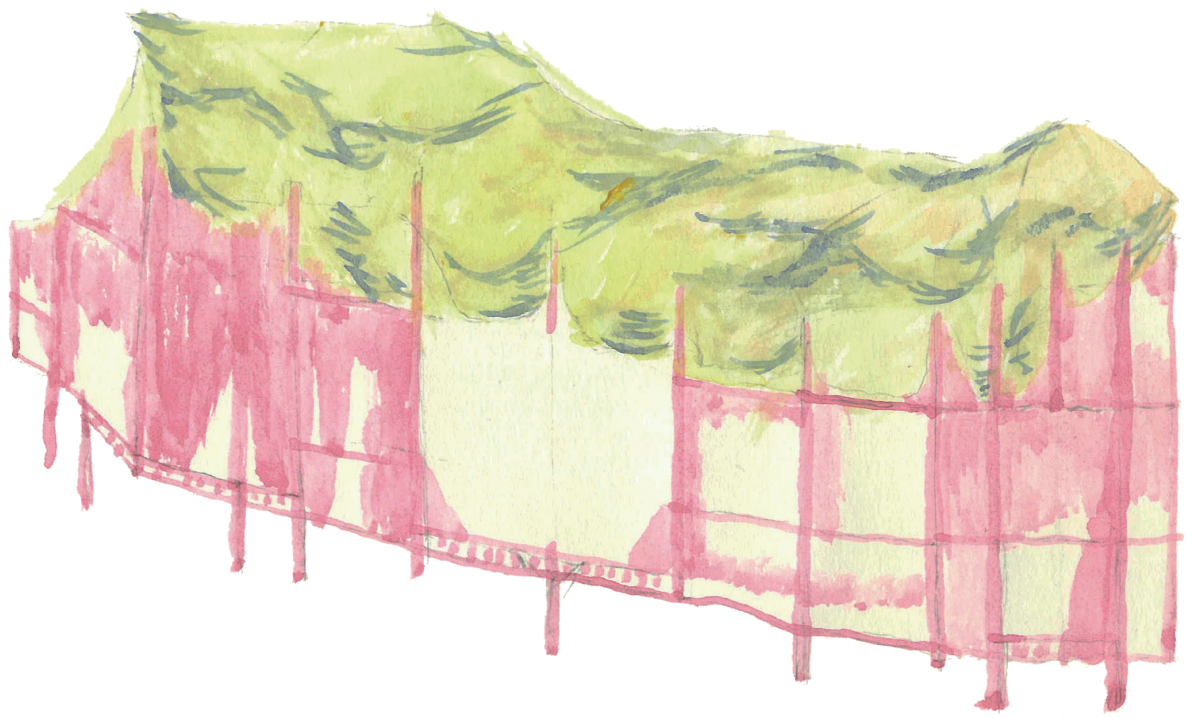
Chapter 5: Design Development

5.2 Iterative Design Development:

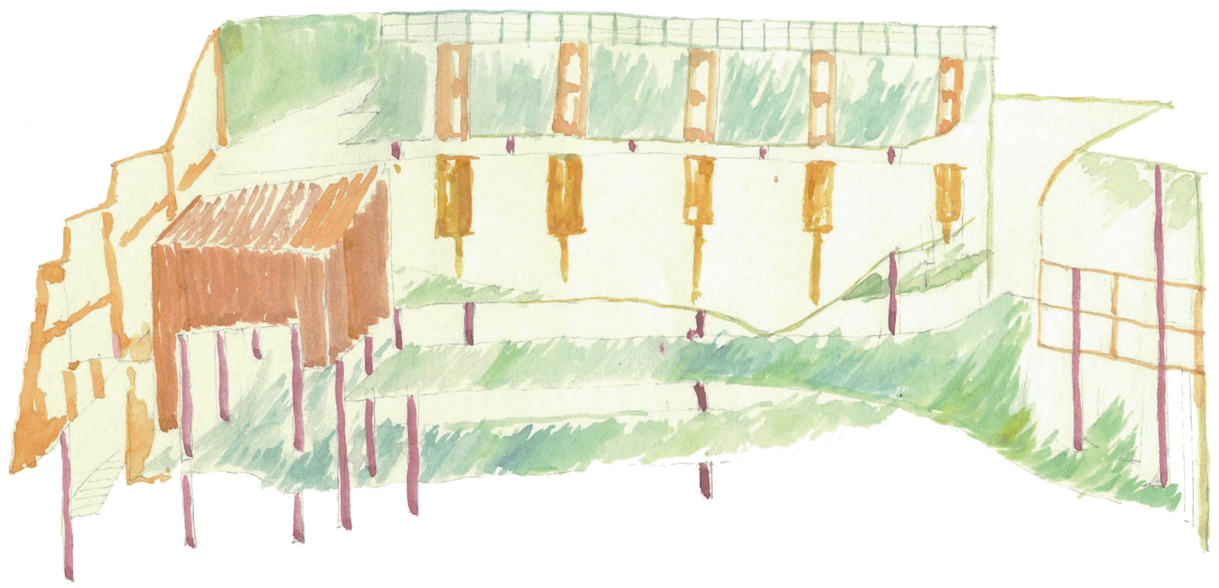
b. Phase 2 Final Design Iteration



Drawing Of A Facade Where Functional Elements Is Diffused
(Figure 77)



Grid Body and Ethereal Roof
(Figure 78)



Weaved Interior Floor
(Figure 79)

5.2 Iterative Design Development:
b. Phase 2 Final Design Iteration

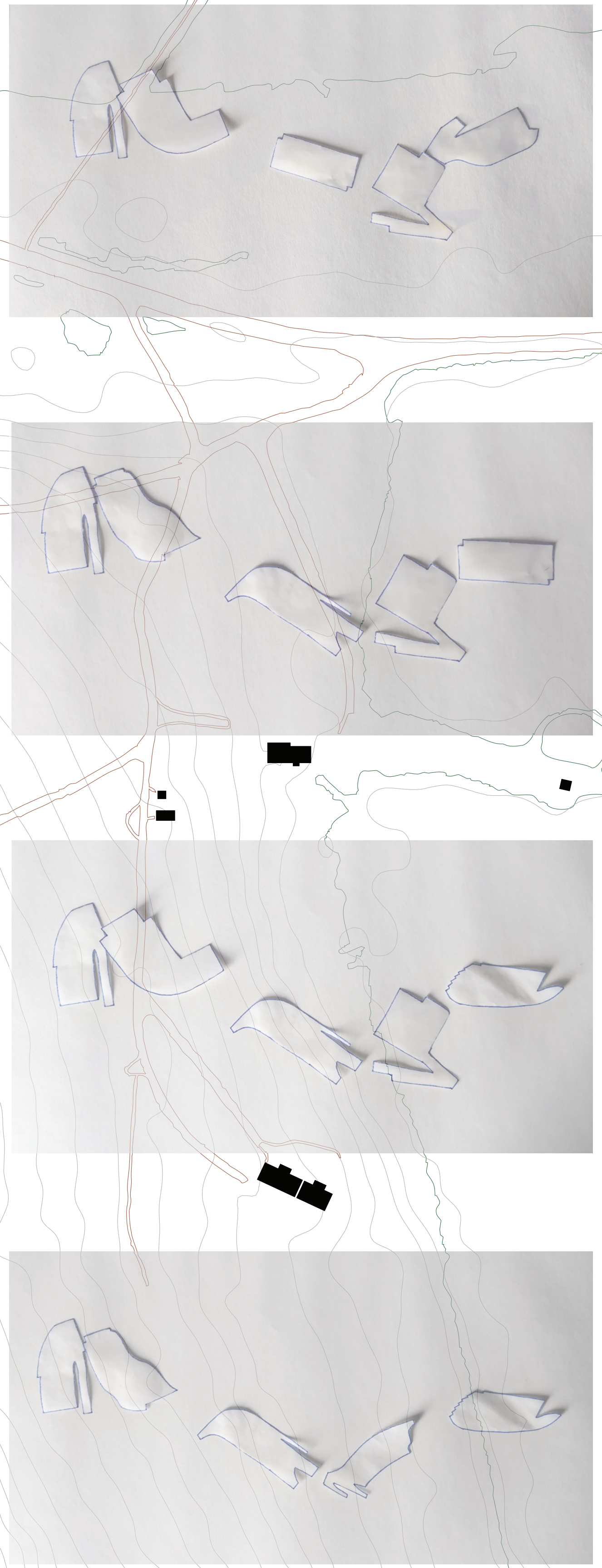
Mental Image Drawing:
The first sketch attempts to capture a split condition between a systematically rigid main structure and an ethereal roof which is light, airy, reminiscent of reeds growing along the shore. Together, they express the suspension of order.

The second sketch is inspired by the artist Miyoko Ito, seeking to diffuse the building's defined functional elements. For instance, a grey air duct tube extends across the facade, partially covering windows, disrupting the conventional hierarchy between service elements and served spaces.

Chapter 5: Design Development

5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration



Heterotopia: Master Plan Iterations
(Figure 80-83)

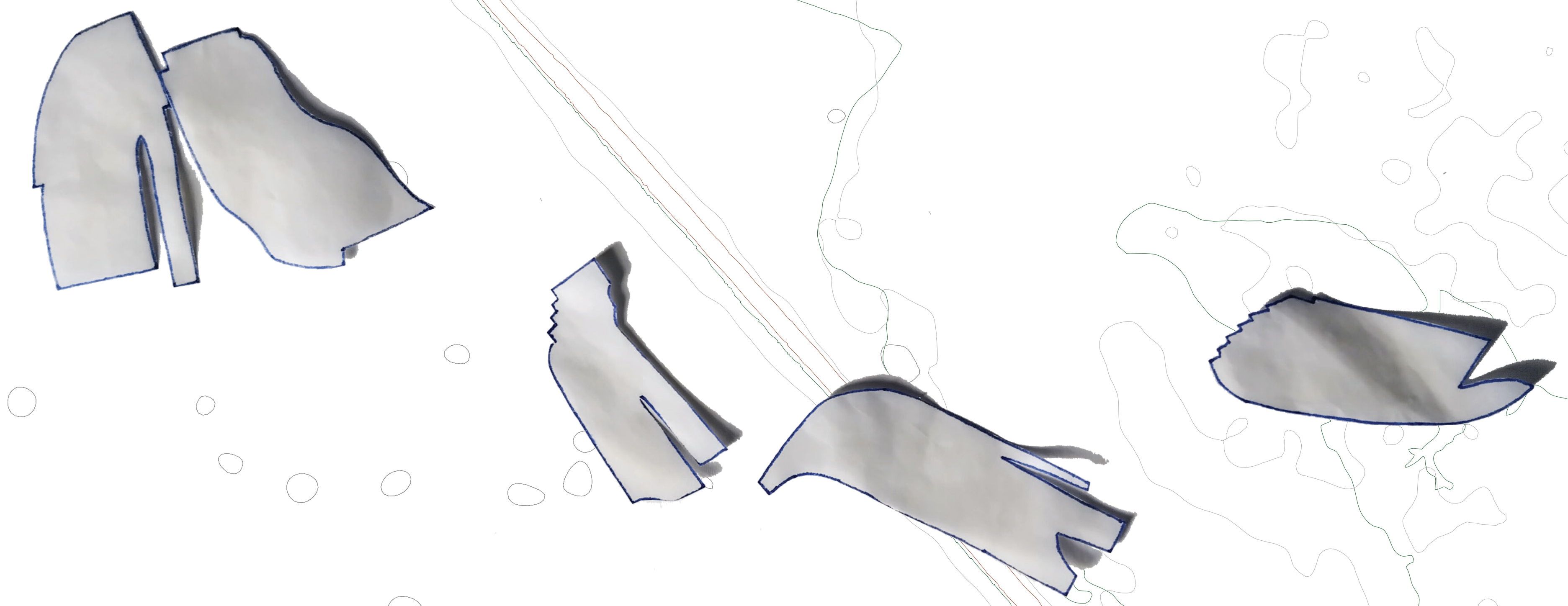


Figure 86: Heterotopia: Master Plan Iterations
(Selected)

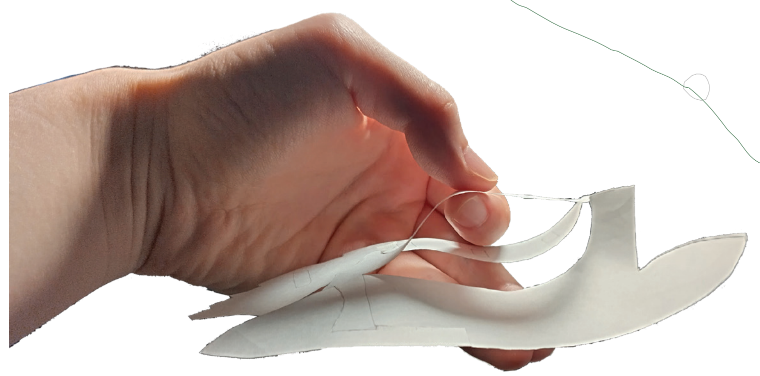


Figure 84: Heterotopia - Model Iteration

Heterotopia: Master Plan
In this phase, the previously designed master plan, “Transition through Swing,” originally set in an imagined landscape, is further developed in the real physical site of Svalbard. The plan of ‘Transition through swing‘ is still governed by a singular, too-obvious logic. In contrast, the Mardi Gras Shipwreck’s fragmented dispersal across the seafloor and the artificial stream formations mapped in Bowling reveal a far more complex interplay of forces. These elements evoke a sense of drift and indecisiveness, qualities intrinsic to shipwrecks themselves.

For the Heterotopia Master Plan, more fragmented, multi-dimensional arrangements are tested. The initial swinging transition is now less overt. Each building is oriented with its geometry split into two or three tail-like extensions at the eastern end, while maintaining a more intact, singular form at the western front. Here the plan configuration expresses a sense of dispersal, drifting along with the landscape.
To the west, the townscape of Longyearbyen follows an (sort of) organic spatial arrangement (as shown in Chapter 6). However, the Heterotopia Master Plan deliberately sets itself apart. Its buildings extend across inland lagoons, roadways, and scattered islets at the ocean’s edge. They interfere with the landscape and existing human infrastructure in an almost careless manner. Yes, they are embedded within the landscape. Yes, they appear subjugated by natural forces. At the same time, they seem to pay little attention to their surroundings. They are strabismus.

Figure 85: Heterotopia - Model Iteration

Chapter 5: Design Development

5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration

Heterotopia: Space Division Iterations
(Figure 87-102)

5.2 Iterative Design Development:
b. Phase 2 Final Design Iteration

Cordelia's Silence Represented Through a Bird Trapped in an Interior as Key Architectural Spatial Element:

Over time, I have become more confident in my ability to adopt and personalize other artistic expressions within this design proposal. I began to realize that every form, whether it grows spontaneously or is derived from another architecture or artist, is like a piece of a word. What I am doing is selecting, iterating, and sometimes inventing a few words myself, so they can piece together into a new sentence or paragraph with its own narrative. Weaving together, these forms become self-explanatory.

In this phase, I decided to use this selected shape to design the final building: Stage V Temporary Display/Dispatch. While working on developing the internal organization in an unexpected, "other" way, Georges Braque's later works come into my sight. Particularly his obsession of birds flying within interiors. The framed flight evokes a sense of poignancy, as the interior becomes a space of morte (Hejduk & Shkapich, 1985). While Braque's expression is symbolic, his portrayal of birds is soft, relaxed through simple geometry. I find them very 'Cordelia'.

As a result, I chose to literally draw my own bird, as another foreign shape with life, to interfere with the architectural boundary. Cordelia is subjugated to the forces of King Lear, she has little choice but to obey. Yet, her personality shines through Shakespeare's play. Similarly, shipwreck never totally belongs to our being. In this architectural heterotopia, each space and form may share an inherent incompatibility, yet also enhance each other's independent life.

Heterotopia: Space Division (Selected)
(Figure 103)

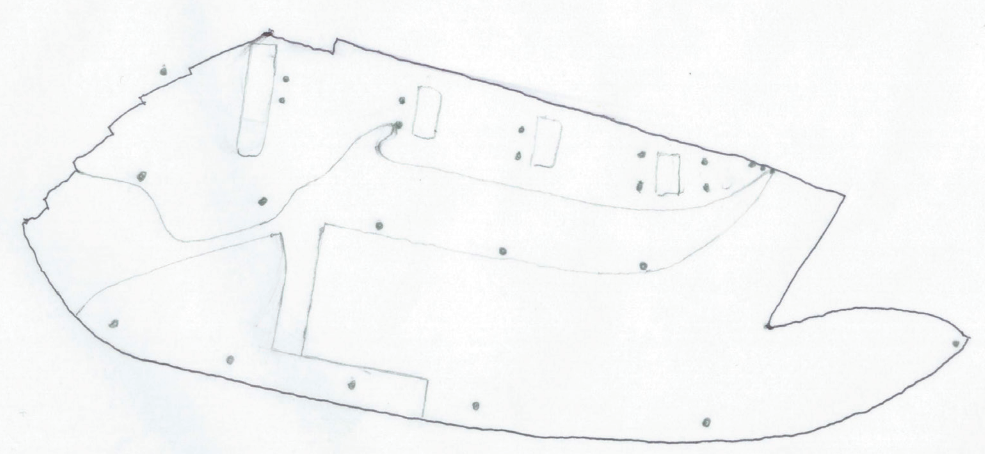
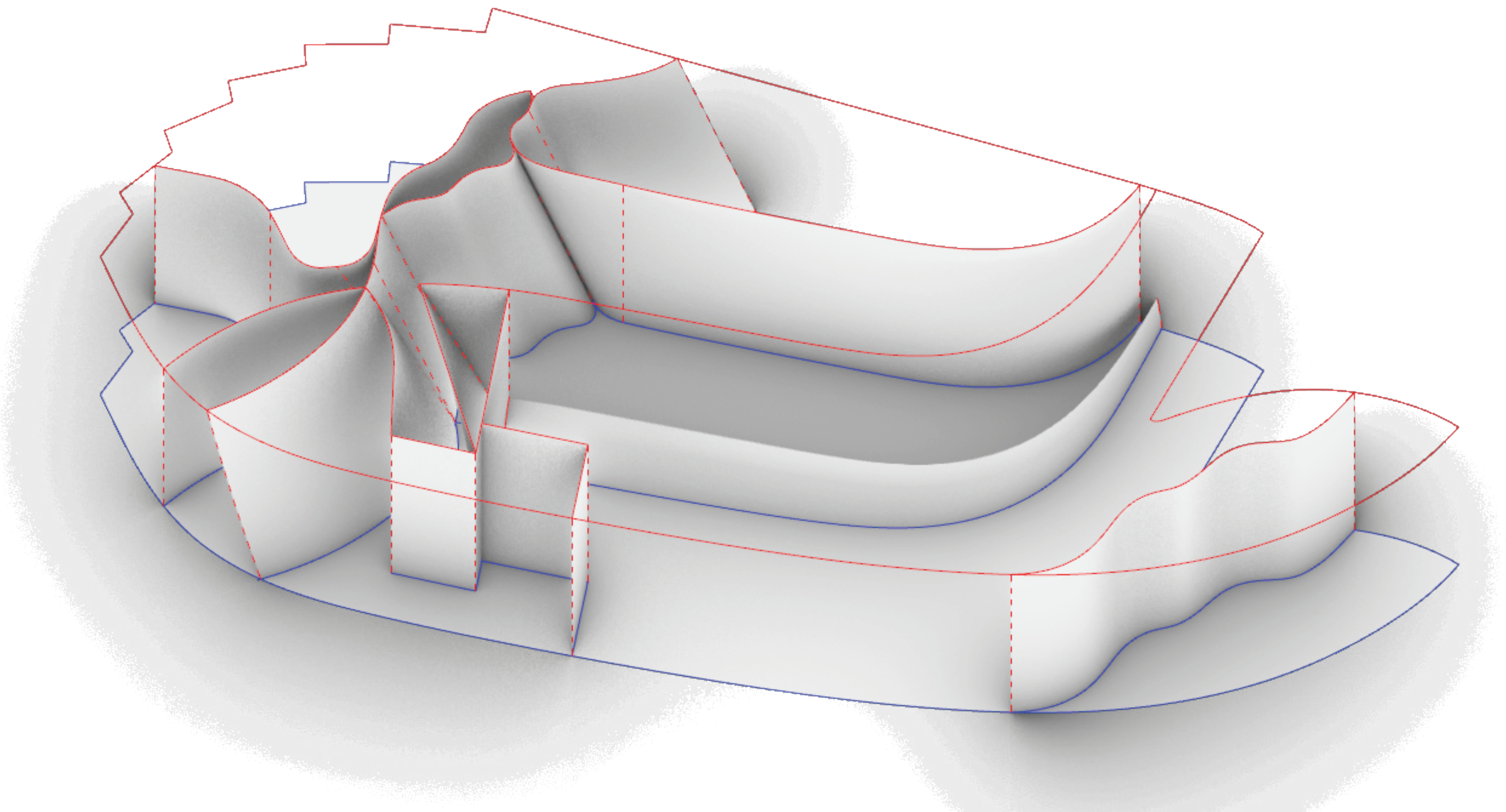


Figure 104: Untitled Painting of Georges Braque for the Poem: If I Should Die Over There (Si je mourais Là-Bas). This peom is recorded in Guillaume Apollinaire's book - Calligrammes: Poems of Peace and War (Calligrammes: Poèmes de la paix et de la guerre) (Braque, 1962, p39)

5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration



Axonometric Diagram Illustrate the Plan Transformation
(From 0.0 m to 47.1m)
(Figure 105)

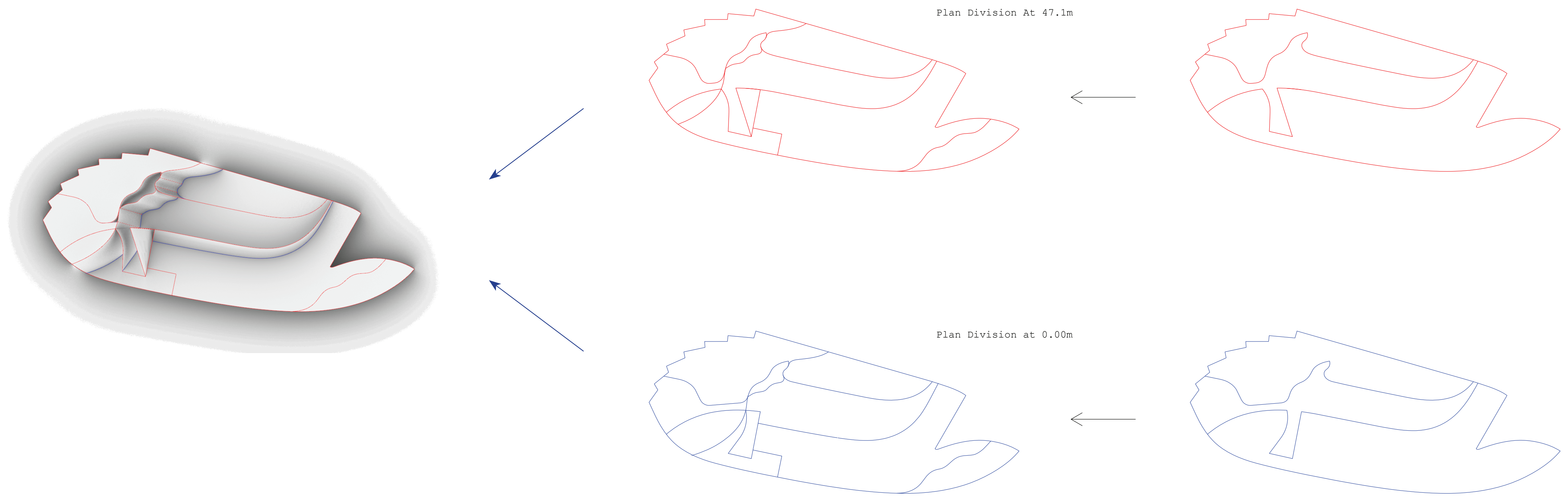


Diagram Illustrate the Plan Transformation (From 0.0 m to 47.1m)
(Figure 106)

5.2 Iterative Design Development:
b. Phase 2 Final Design Iteration

Cordelia's Silence Represented Though a Bird Trapped in an Interior:

To animate space, a simple extrusion from planar space division would contradict the intention of creating an unpredictable relationship between each design decision. The design choice reflects the principles of juxtaposition and incompatibility in Foucault's heterotopia, as well as Alexander's notion of "contrast" (2002), to enhance the 'degree of life'. In this context, contrast refers to the visible differences between things, such as the front door differing from the back door, allowing each element to take its proper place. The implementation will be discussed with more detail in the developed design chapter.

The bird-like shape functions as a traffic spine, weaving through all spaces for both visitors and staff. Through various adjustments, the dual bird-like plan is overlapped at two different heights. The blue plan represents the division organization at ground level, with the bird shape resting in the center. The red plan shows the division at the roof level, where the bird's centroid slightly shifts westward, as if the bird is about to flap its wings, implying a subtle internal struggle.

The vertical walls are generated from these two plans, causing the floor plans to change gradually. The "head" of the bird shape becomes a light tunnel opening to the sky, with a slight tilt. From an aerial view, the shape appears somewhat "wound-like." The bird shape is abstract so that visitors and users are not immediately aware of its form. Instead, they will perceive how its parts affect the contrast between spaces, making the spatial logic more complex and less comprehensible at the micro-human scale.

Heterotopia Form Drafting on
Building No.5 Dispatch & Display
(Figure 107)

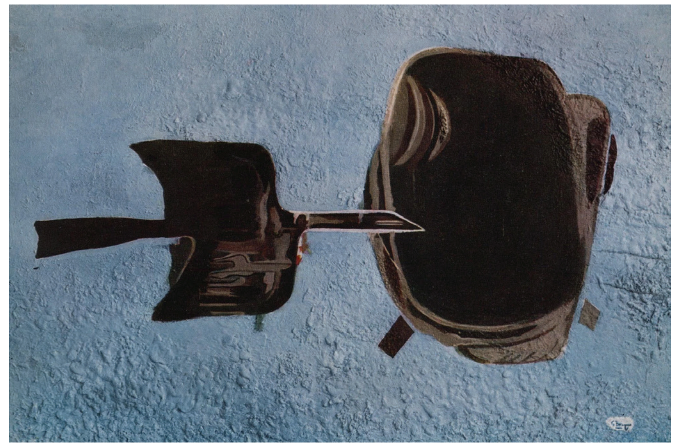
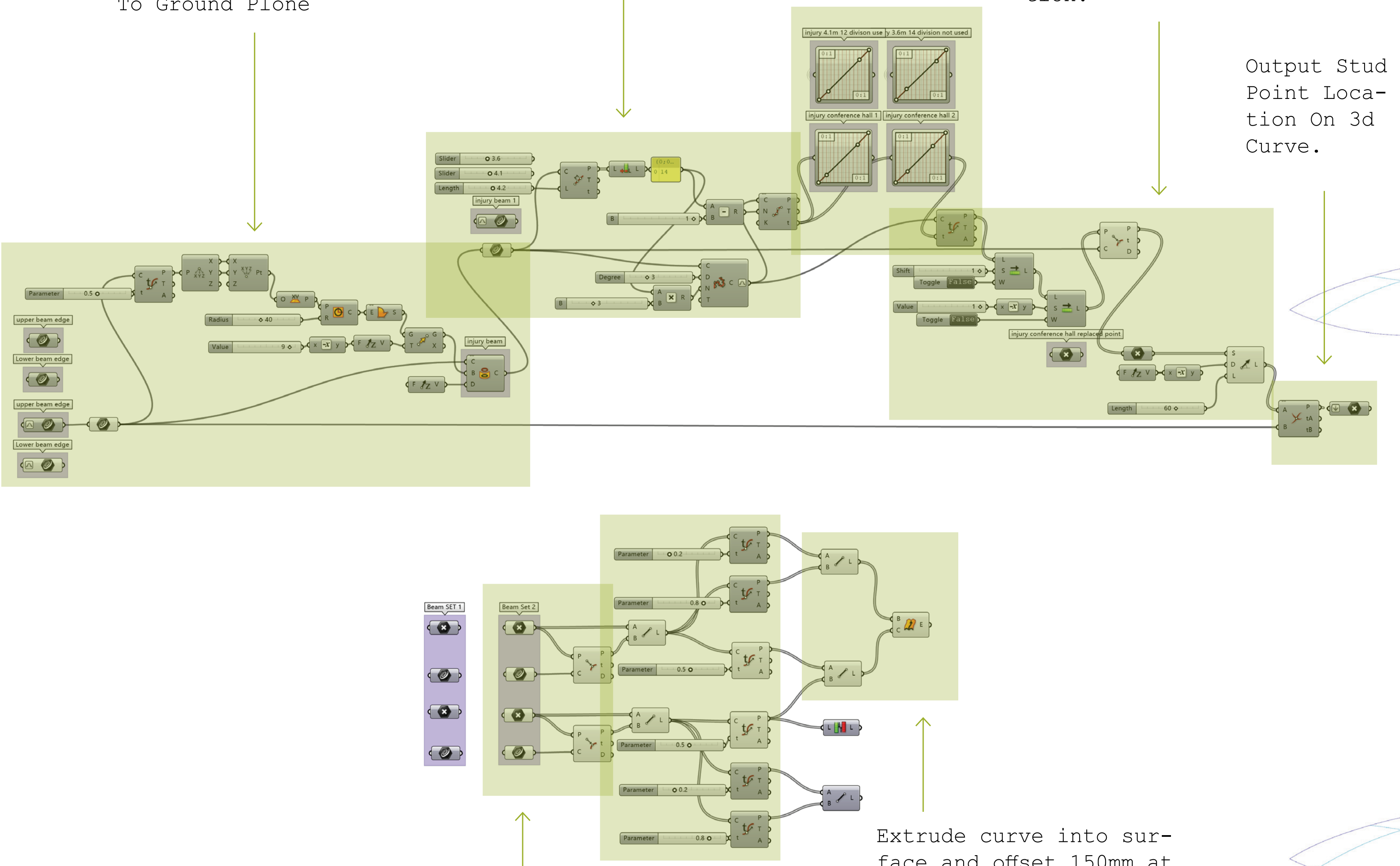


Figure 108: Swiftly - A Tire D'aile
(Georges, 1956-61)

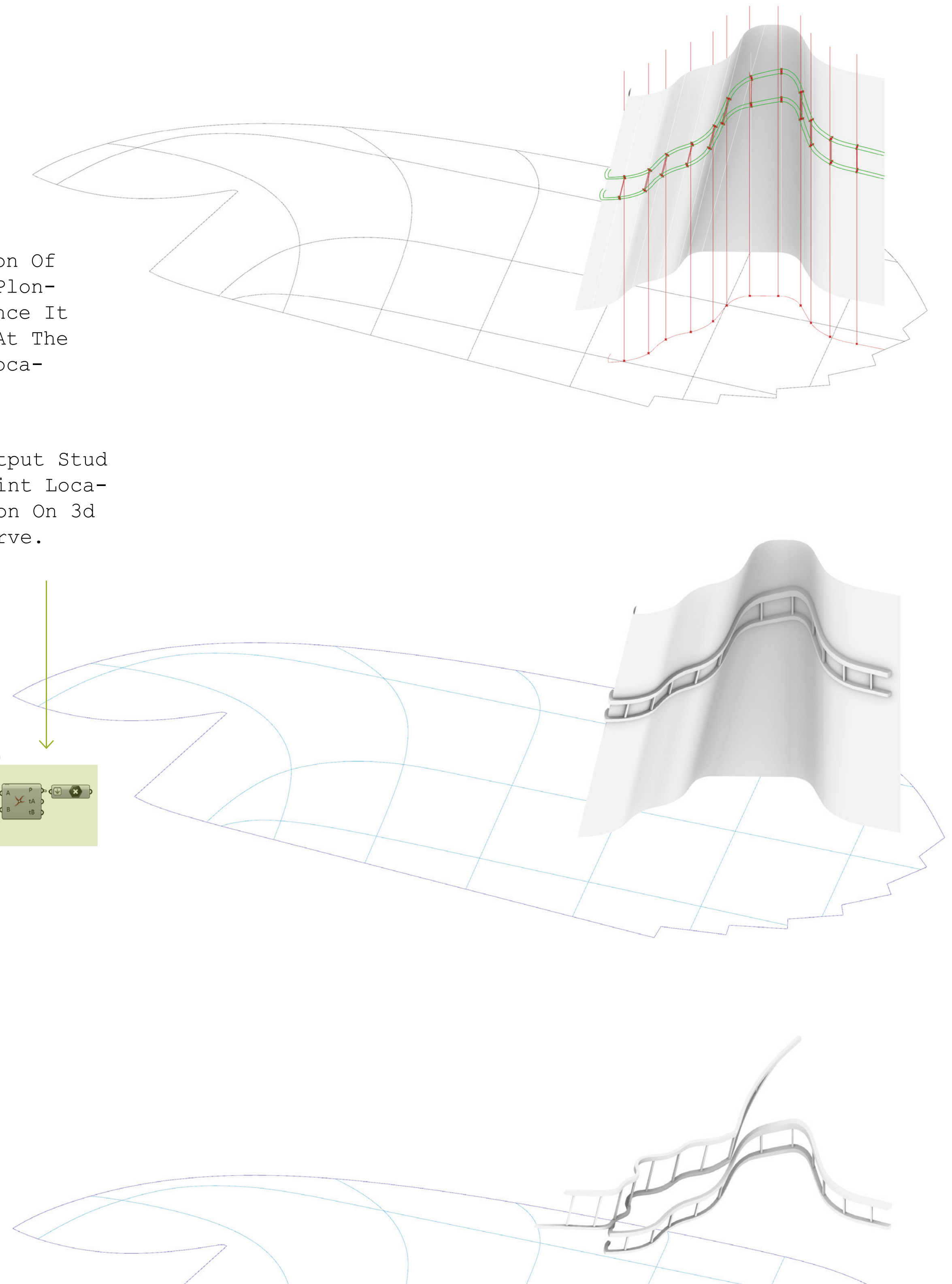
Chapter 5: Design Development

5.2 Iterative Design Development:

b. Phase 2 Final Design Iteration



Grasshopper Definition on Injury Beam Development
(Figure 109)



Injury Beam Development in Building No.5 Dispatch & Display
(Figure 110-112)

5.2 Iterative Design Development:

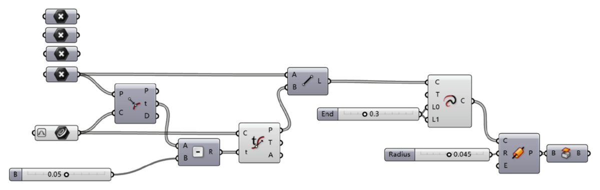
b. Phase 2 Final Design Iteration

Computational Aided Design (CAD):
During the digital design process, I developed several Grasshopper definitions to assist in drafting the digital model. These definitions include: transitioning from a rigid, rectilinear grid system to an organic one, designing curved ramps and staircases, editing double-curvature geometry, creating the ship support structure, designing diamond-shaped roof window patterns on curved facades, partitioning the structural system, creating zigzag building elevation, and demonstrating in-situ shipwreck preservation with “Artificial Sea Grass” at the seafloor.

The final design emerged through a multi-media layering approach. I intentionally avoided relying on a single way of thinking or tool to dominate the design process, as I believe this adds depth to the thesis’ final outcome.

An example of this approach is the double-curved primary steel structure beam, assisted by parametric tools. The goal was to evenly distribute the studs along the beam while aligning with the 18-meter primary grid system indicated on the floor structure plan. Together, there are two special structures form the “wounded” light tunnel that cuts through the building.

Figure 113: Shipwreck Support Structure Definition



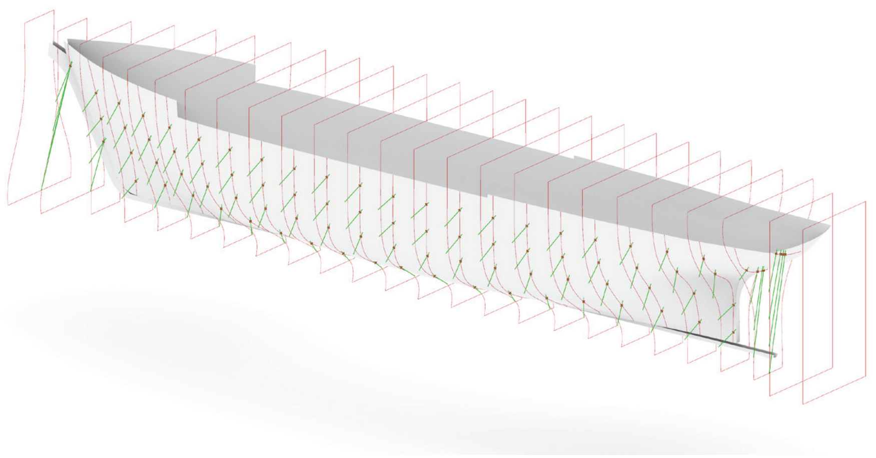
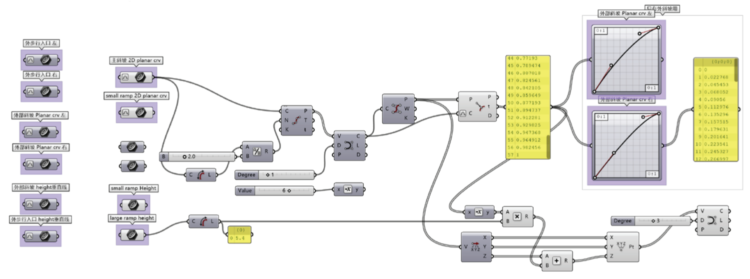


Figure 114: Shipwreck Runway Ramp Definition



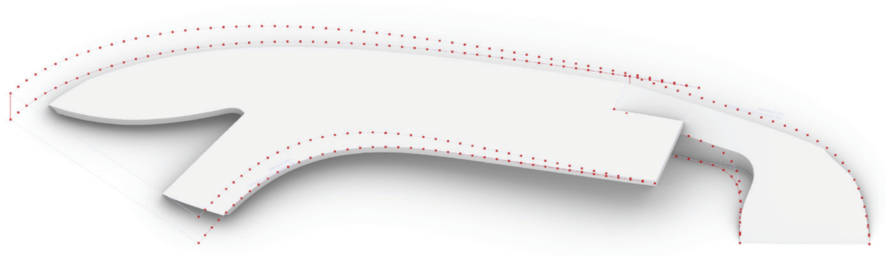
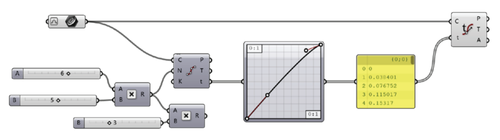


Figure 115: Primary Grid Transition Coordinates

***Original subdivied for further joist division [Final]



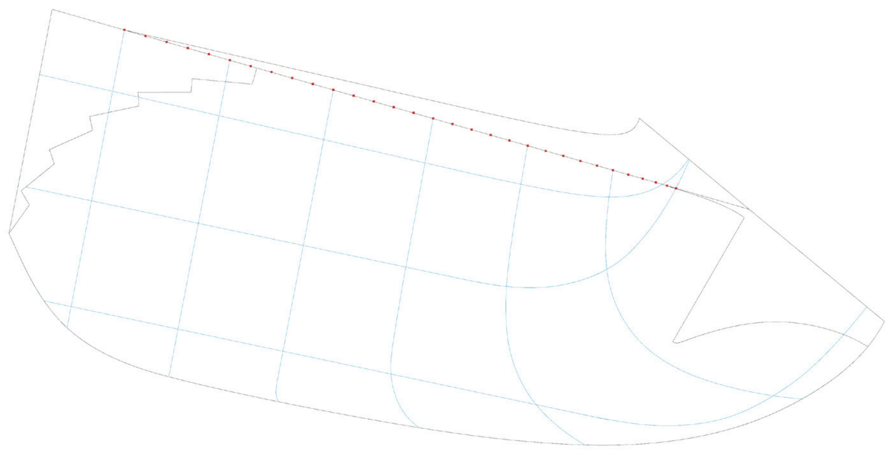
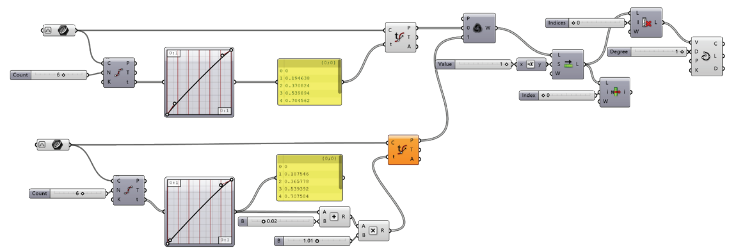


Figure 116: West Facade Zig-zag Definition



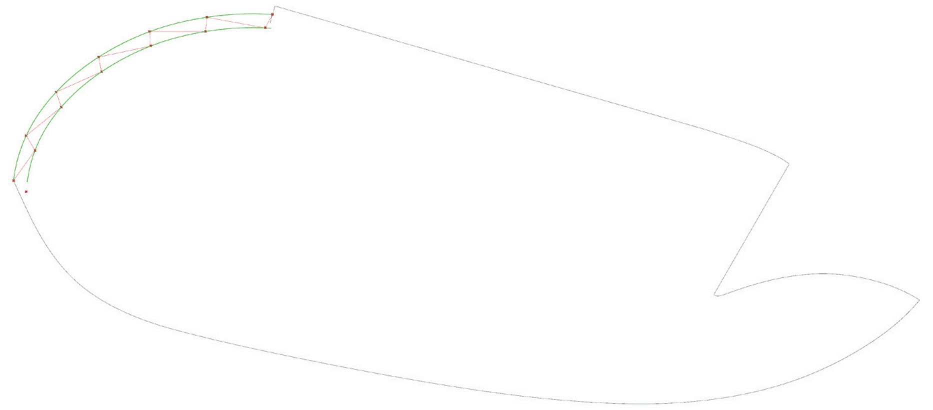
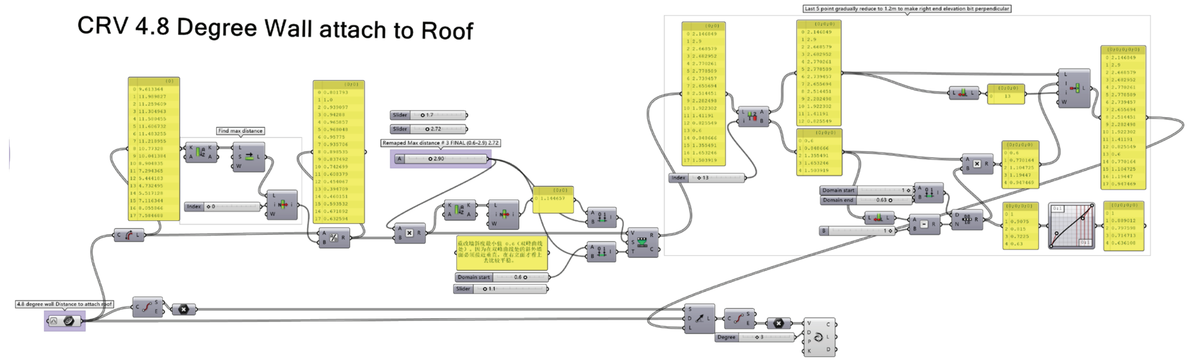


Figure 117: South Facade Coordinates for Double-Curvature Surface

CRV 4.8 Degree Wall attach to Roof



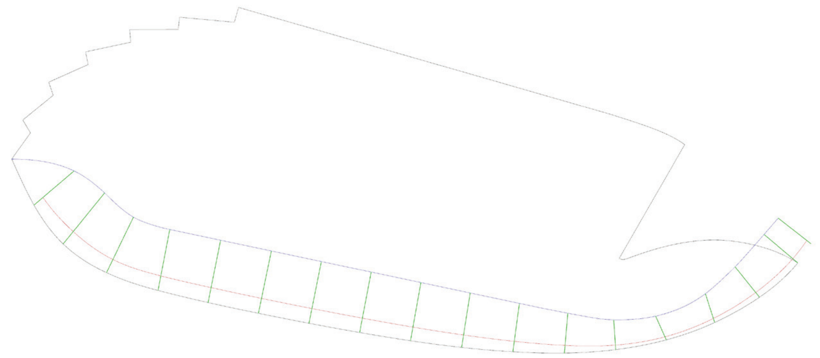
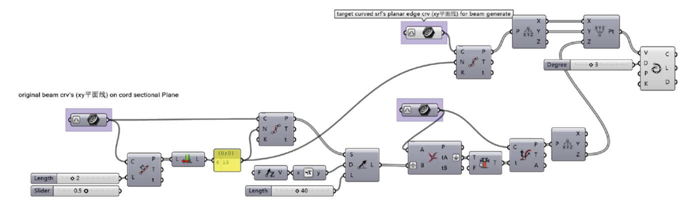


Figure 118: Arrangement of Curved structure from planar drawings



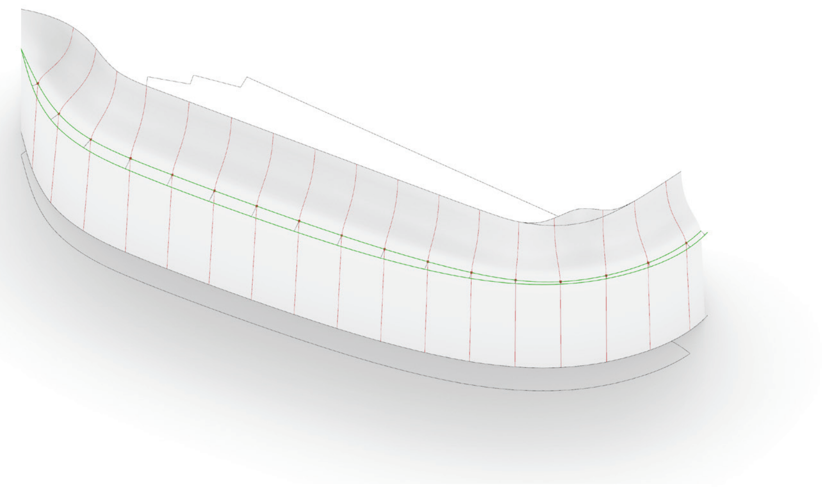
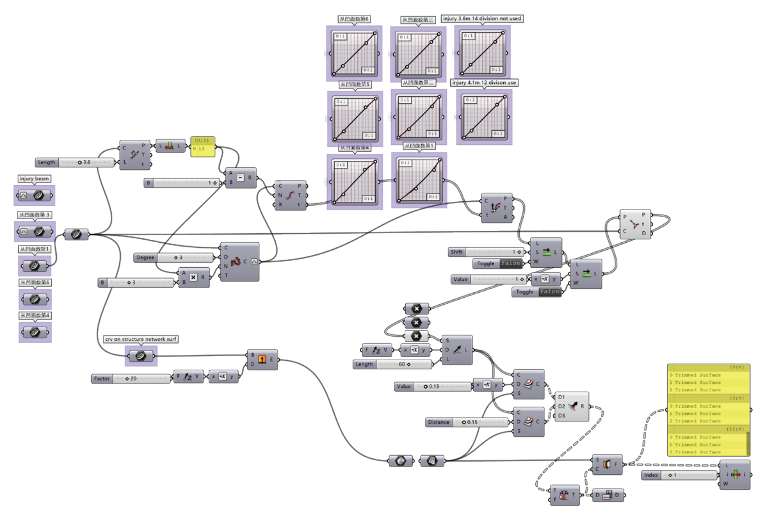


Figure 119: Arrangement of Joist location on Curved structure



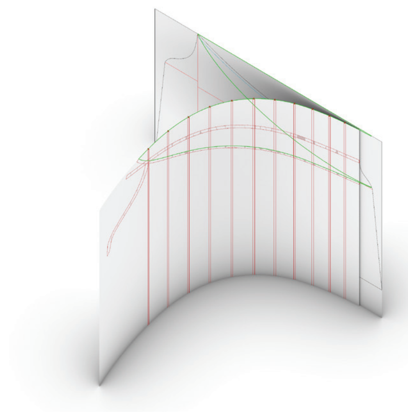
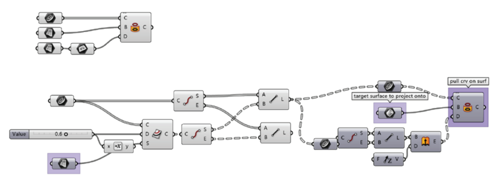
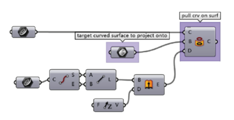


Figure 120: Beams & Joists Series Generation with thickness

滑斜双柱 与 横梁 offset on planar or curved surface
后半部分没用



滑斜双柱（offset之后的）
简单投射



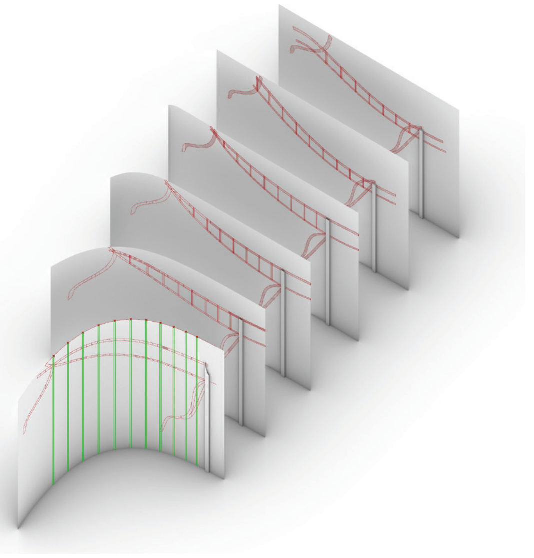


Figure 121: Sub-column Aligning to Grid Under Runway Ramp

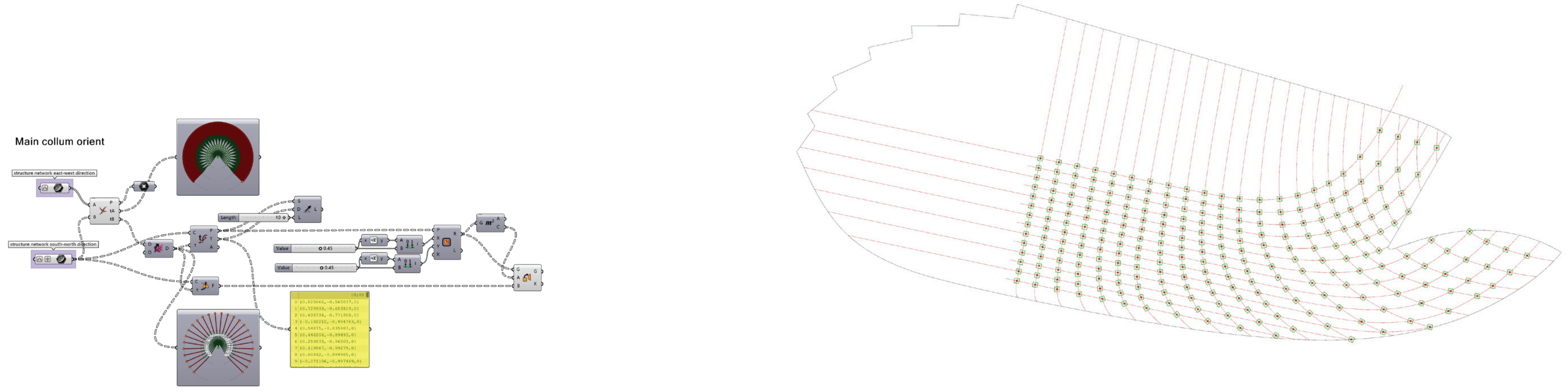
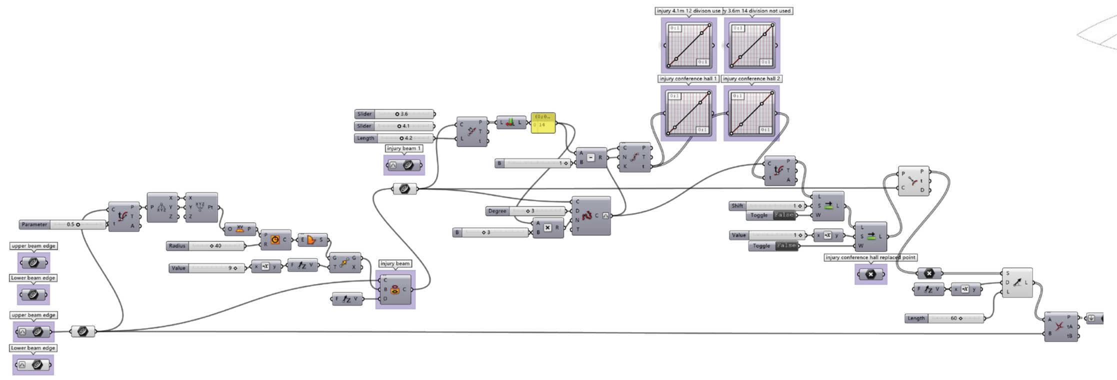


Figure 122: Curved Staircase with Irregular Division

Figure 123: Injury Beam/hoist Coordinates Definition



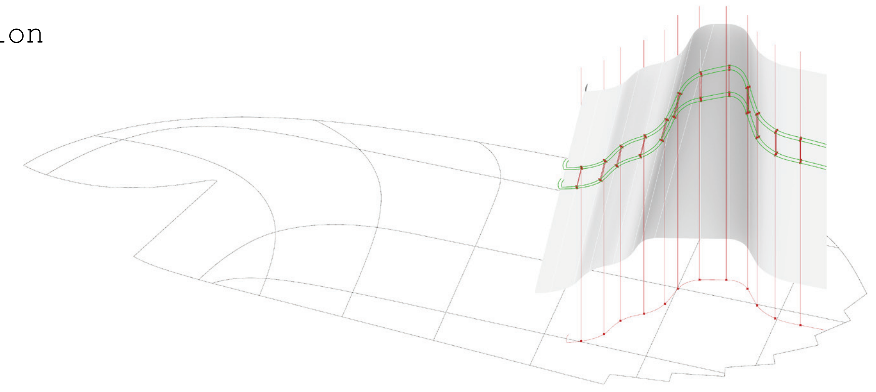
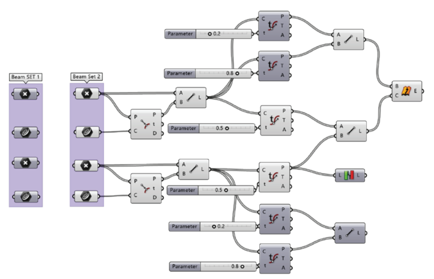


Figure 124: Injury Beam/joist with Thickness



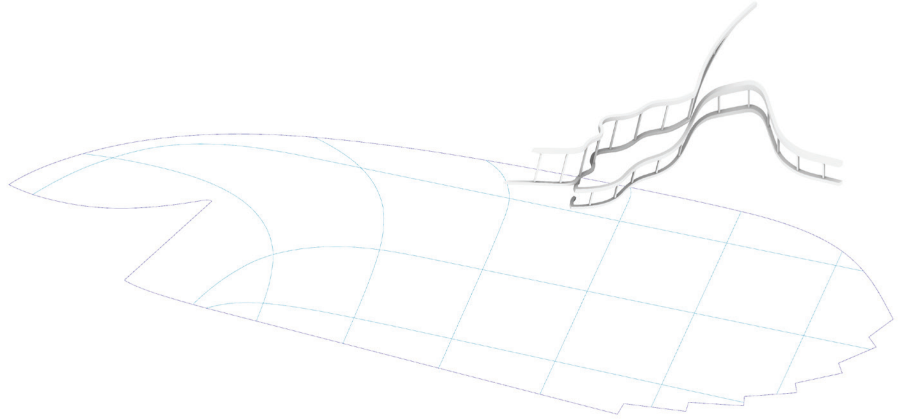


Figure 125: West & East Facade Further Division For Stud & Opening

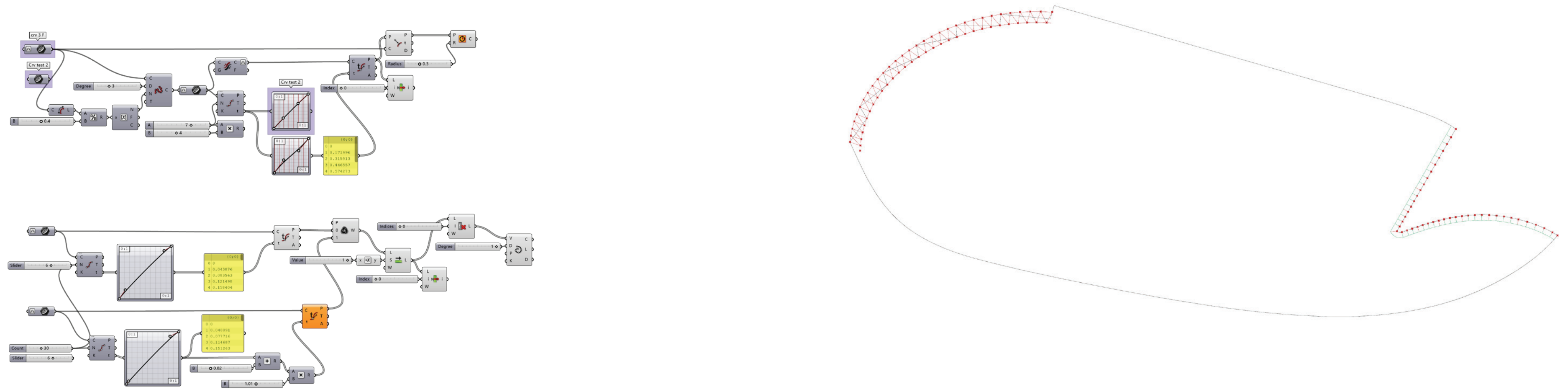
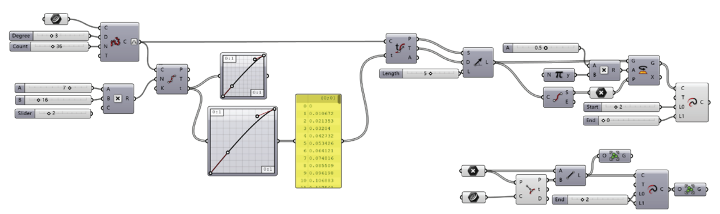


Figure 126: North Facade Further Division For Stud & Opening



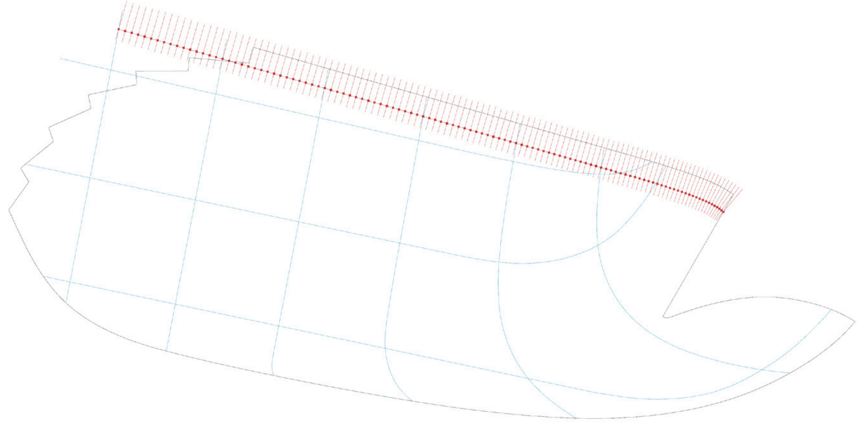
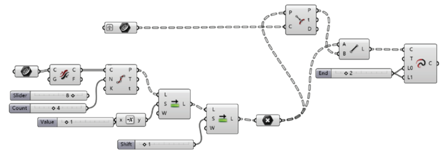


Figure 127: Facade Further Division For Stud and Opening I



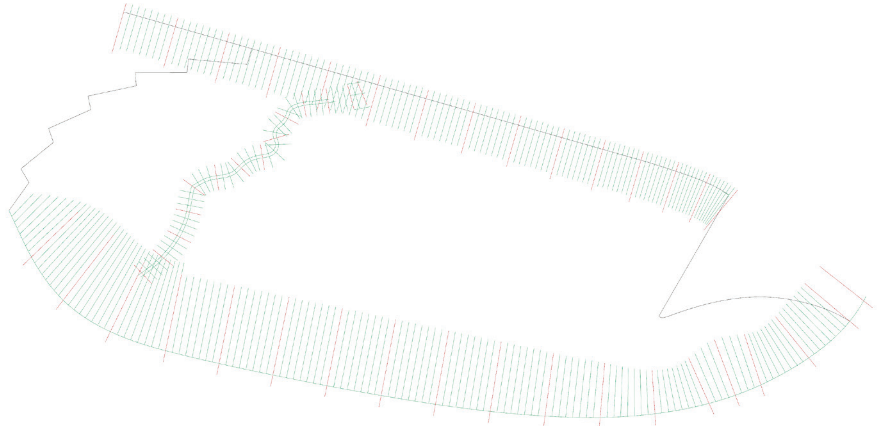
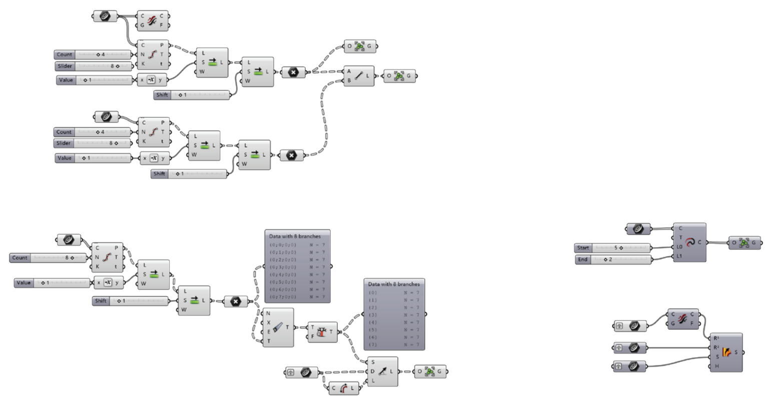
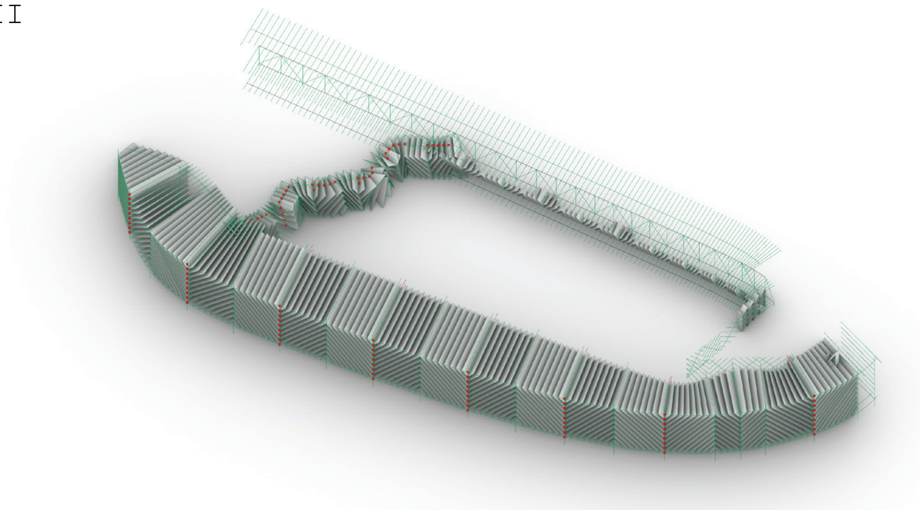


Figure 128: Facade Further Division For Stud and Opening II



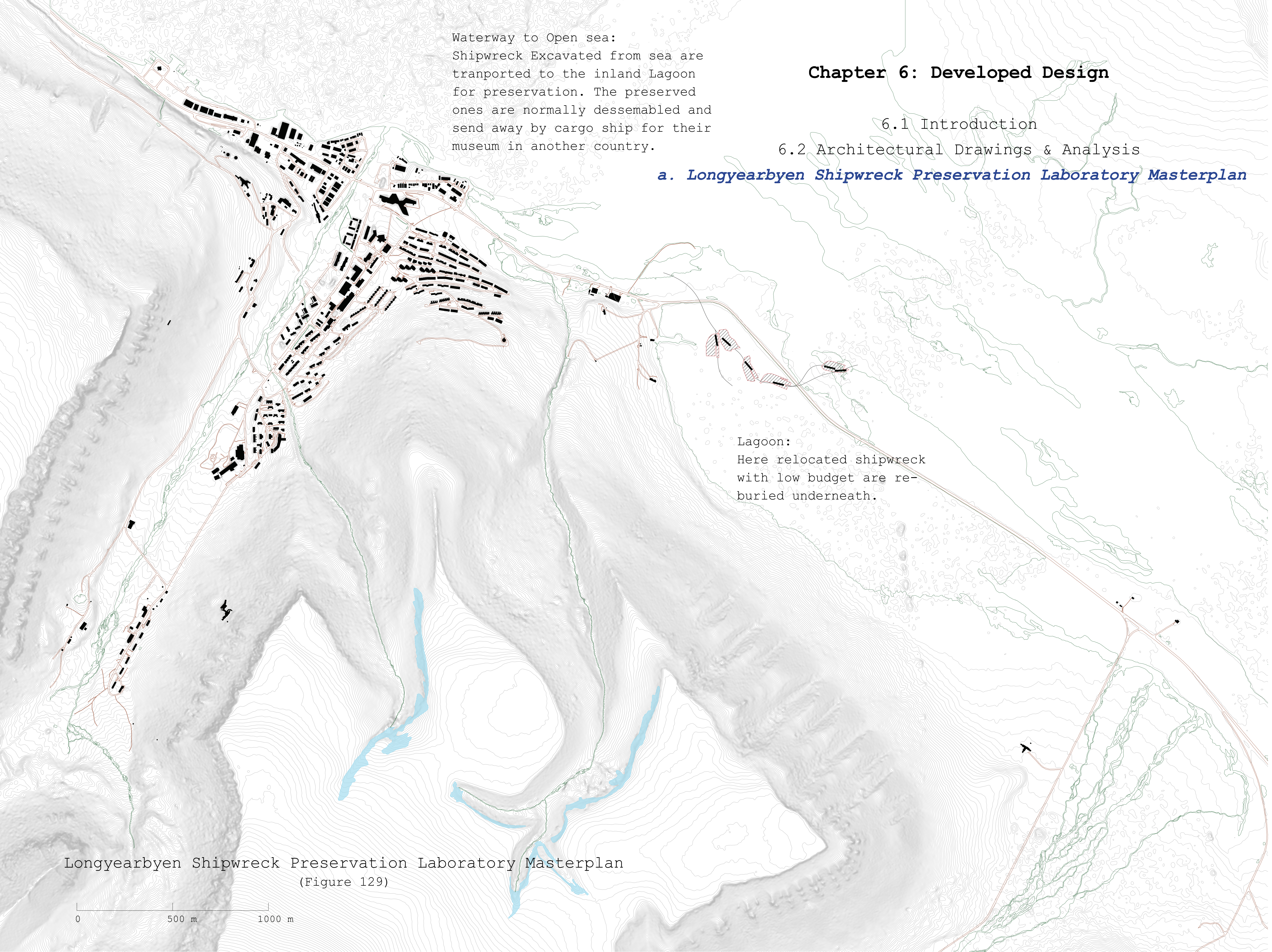


Chapter 6: Developed Design

6.1 Introduction

6.2 Architectural Drawings & Analysis

a. Longyearbyen Shipwreck Preservation Laboratory Masterplan



Longyearbyen Shipwreck Preservation Laboratory Masterplan
(Figure 129)

6.1 Introduction

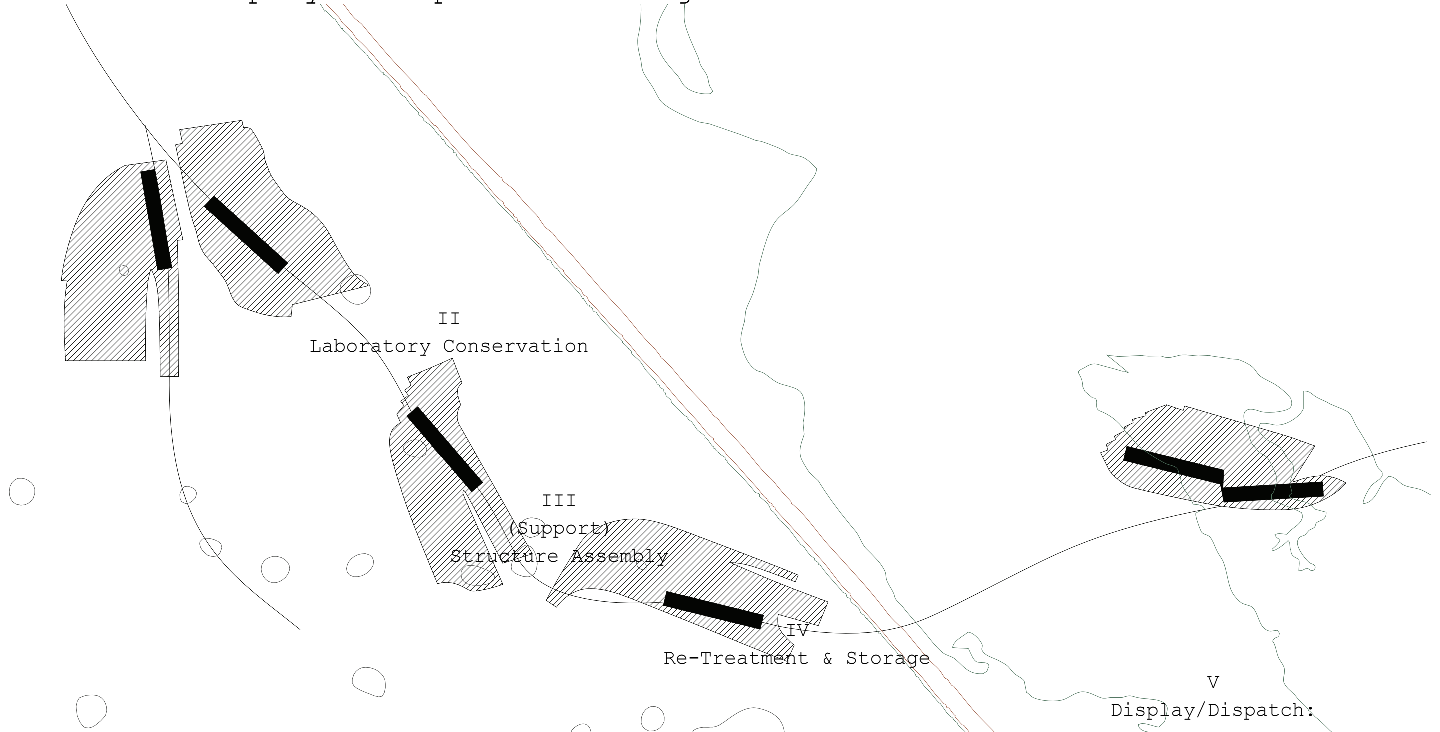
The ship preservation laboratories are situated on free-to-access land of Svalbard, where shipwrecks are transported, undergo preservation treatments, and are eventually dispatched to museums claimed by various nations. These shipwrecks, once abandoned, now find their destinies determined once more under human control. Through our imposed order, they are transformed into tools of heritage celebration. However, even with humanity's agenda of resurrecting them for our service, these shipwrecks can never be fully assimilated. Their sense of withdrawal persists.

To Levinas, the invocation of a face deeply relates to the being of the other. This invocation can simply be presented through a greeting. The architectural design embodies a submission to this greeting toward the vessel. This gesture of greeting takes the form of a heterotopia architecture, relating the autonomous shipwreck. The gesture of greeting take form of an architecture with face in responding to the face of shipwreck. The gesture of greeting taken form of an architecture that seems neither artificial nor nature, relating the liminal state of shipwreck which is simultaneously semi-artificial and semi-natural. The gesture of greeting also manifests in the open, loose design process, which mirrors the openness of the shipwreck, far removed from civilization yet still accessible to us.

6.2 Architectural Drawings & Analysis

a. Longyearbyen Shipwreck Preservation Laboratory Masterplan

In the master plan, five preservation labs are loosely connected, interfering with the landscape in a seemingly careless manner. These giant structures maintain an 'proper distance' from Longyearbyen town. Among them, the No. 5 Display & Dispatch building is realized in this thesis.



Ship Preservation Laboratory Site Plan
(Figure 130)
Site location: Longyearbyen ('the Longyear town'), Svalbard

Chapter 6: Developed Design

6.2 Architectural Drawings & Analysis

b. Heterotopia Forms of Architectural Boundary

Development Diagram of Selected Heterotopia Fragment into Architecture Form (Figure 131)

Formless shapes in the Svalbard landscape are recorded. Among which, these with slight memorable character, and positive shape to hold the ship are picked. The positive shape stands for a form with most part of inside space swells outward (Alexander, 2002).

↓

Memorable fragments are displaced from the original location for close scrutiny.

↓

Accurate digital trace along the cutouts boundary.

↓

Hand drawing as the way to understand the flow of these shapes.

↓

Further manipulations make them neither totally natural nor purely artificial (Cartesian order). Allow Each of them maintain their own memorable character, i.e. the autonomy.

↓

Each shape self is a transitional shape, a turning point with single starting point at one end, but derivation to alternative departures on the other end. This gives a sense of drift, i.e. the suspension of order.

c. Diagram of Building Program Based on Preservation Process

(Figure 132)

Stage I
Field Excavation:
1. Identification
2. Field Lab setting
3. In situ observations
4. Excavation
5. Transportation
6. In-situ management/preservation

Stage II
Initial Cleaning:
1. Initial documentation
2. Intact encrustation storage
3. Mechanical cleaning (Encrustation removal)
4. Pre-treatment storage (thin encrustation layer remains)

Building No. 1 Excavation →

Management Department:

Office room Political:
Fund raising/ Business Contract
Funding & Contract Archive
Procurement Room
Office room Cooperation:
Project Planning Room
Jointed External party office Room
Office room Operation:
Building operation
Climate control room
Waste treatment control room
Project Conference:
Conference Theater

Documentation Department:

Office/Lab room:
Initial Physical documentation
Initial analysis
Data Storage:
Physical Data storage
Digital Data documentation
(In-situ & Ecavation)

Field Department:

Field Lab Equipment Storage:
Field environemnt recoding
Photographic equipment
digital recording equipment
insuit-preservation equipment
(Wreck Rebury)

Field Lab Camp Workshop:
Workshop space for camp build
Field camp Dispatch

Office/Lab room:
In-situ preservation Monitoring
(Pre/Post) excavation Site recording

Excavation Department:

Excavation Hull (Temporal treatment & storage):
Hull Hall
Hull Excavation Shell

Mechanical Cleaning:
Components mech-Cleaning room
Encrustation mec-Cleaning Room
Mechanical cleaning waste & washing plain (underground)

Encrustation Storage:
Encrustation Shell
I,II,III,IV storage
Equipment Storage:
Initial treatment material
Artefact packaging
Chemical Storage:
Treatment Material storage

Stage III
Lab Preservation:
1. Conservation process Evaluation
2. Treatment to stabilize
3. Restoration
4. Post treatment to protect

Building No. 2 Satblization →

Management Department:

Office room Political:
Project management
Procurement Room
Office room Operation:
Building operation
Climate control room
Waste treatment control room
Project Conference:
Meeting Room

Documentation Department:

Damage level classification
Conservation process Evaluation

Data Storage:
Physical Data storage
Digital Data documentation

Stablization Department:

Office room:
Conservation Meeting

Artefact Treatment Labs:
(preservation & restoration)

Stablization MAIN Room:
Hull Hall
I: Organic
1: Seeds and Plant Material
2: Bone, ivory, Teeth and Antler
3: Leather
4: Textile
II: Timber
5: Wood
III: inorganic
6: Pottery, Stone
7: Glass
8: Encrustation Removal
9: Encrustation Mold Casting
IV: Metal
10: Iron
11: Cupreous
12: Silver
13: Lead, Tin, Pewter
14: Gold & Gold Alloy

Restoration Department:

A B C D room
material replacement
structural replacement(<50cm items)
Casting

Post-treatment protective layer Lab:
A B C D room

Drying Lab:
Artefact drying compartment
Ship component drying

Artefact Storage(next to labs)
Chemical Storage:
Treatment Material storage
Equipment Storage:

Stage IV
Structure Assembly:
1. Structure Evaluation
2. Support structure design
3. Hull Assembly/ structure replacement

Building No. 3 Assembly →

Management Department:

Office room Political:
Project management
Procurement Room
Office room Operation:
Building operation
Climate control room
Waste treatment control room
Project Conference:
Meeting Room

Documentation Department:

Wreck Structural Analysis Lab
(Support/transportation/In-situ preservation)
Replica Scale Model testing Lab

Data Storage:
Physical Data storage
Digital Data documentation

Structural Department:

Office room a:
Structural Analysis Room
Structural Design room

Project Conference:
Meeting room

Support Structural Assemble Workshop:

Assemble MAIN Room:
Hull hall

Structural Workshop:
(Field Excavation Support structure/Transportation structure/ Long-term support structure for display)

Storage:
Material Storage
Equipment Storage:

Stage V
Re-Treatment & Storage:
1. Re-treatment
2. Periodic inspection
3. Storage

In the re-treatment sector, storage occupies more space than lab. Here items undergo perodic inspection and low frequency treatment.

Building No. 4 Re-Stabilization →

Management Department:

Office room Political:
Project management
Procurement Room
Office room Operation:
Building operation
Climate control room
Waste treatment control room
Project Conference:
Meeting Room

Documentation Department:

Treatment Analysis Office room
Treatment Analysis Lab

Data Storage:
Physical Data storage
Digital Data documentation

ReTreatment Department:
(New technology coservation & restoration)

Office room:
Conservation Meeting

Stablization MAIN Room:
Hull Hall

I: Organic
1: Seeds and Plant Material
2: Bone, ivory, Teeth and Antler
3: Leather
4: Textile
II: Timber
5: Wood
III: inorganic
6: Pottery, Stone
7: Glass
8: Encrustation Removal
9: Encrustation Mold Casting
IV: Metal
10: Iron
11: Cupreous
12: Silver
13: Lead, Tin, Pewter
14: Gold & Gold Alloy
Artefact storage(next to labs)

Alternative & new-tech department:

New tech Stablization Lab:
A B C D room

Protective layer Renew Lab:
A B C D room
Replacement/adding

Drying Lab:
Artefact drying compartment
Ship component drying

Equipment Storage:
Chemical Storage:
Treatment Material storage

Stage VI
Temporary Display/ Dispatch:
1. Archive & Packaging
2. Display
3. Dessamble
4. Dispatch

Building No. 5 Dispatch & Display

Management Department:

Office room Political:
Project management
Procurement Room
Office room Operation:
Building operation
Climate control room
Waste treatment control room
Project Conference:
Conference Theater

Documentation Department:

Data Storage:
Project Physical Data storage
Project Digital Data documentation

Public/Edu Visitation:

Visiting Center
Educational room
Conference hall
Library
(Historical; academic; material; Archive)
Clinc

Dispatch Department:

Dispatch Port

Office room:
Dispatch Meeting
Dispatch assemble manual

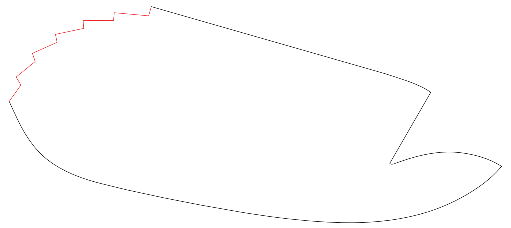
Display/Dessemble Hall:
Runway ramp
Artefact display

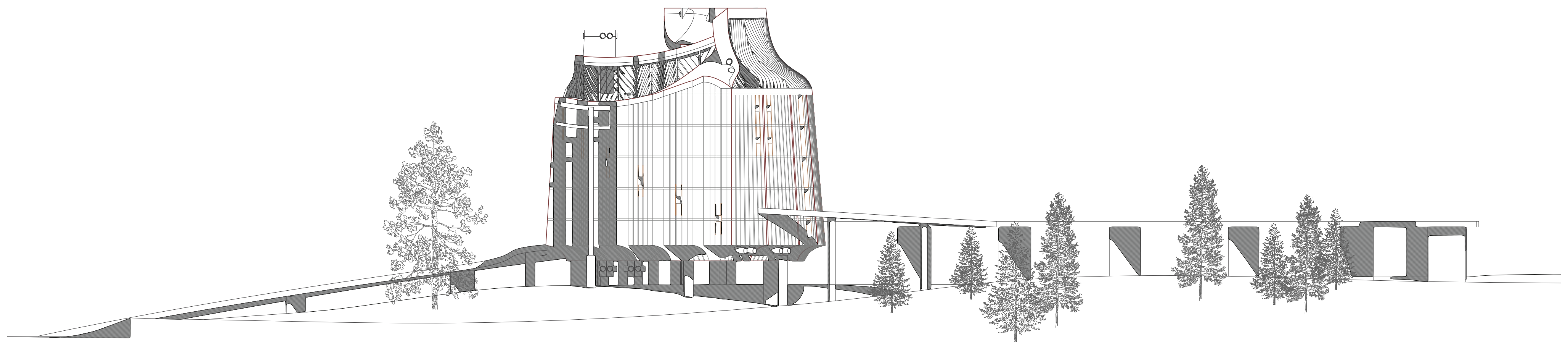
Archive:
1. Components of structures features (mounds);
2. Artifacts of human manufacture
3. Natural objects used by humans
4. By-products, waste products or debris
5. Organic remains
6. Human remains
7. Petroglyphs, pictographs, intaglios
8. Components of shipwrecks
9. Environmental & chronometric specimens
Equipment Storage:

Chapter 6: Developed Design

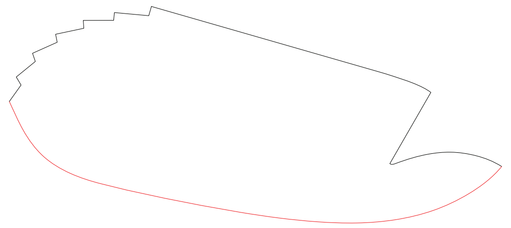
6.2 Architectural Drawings & Analysis

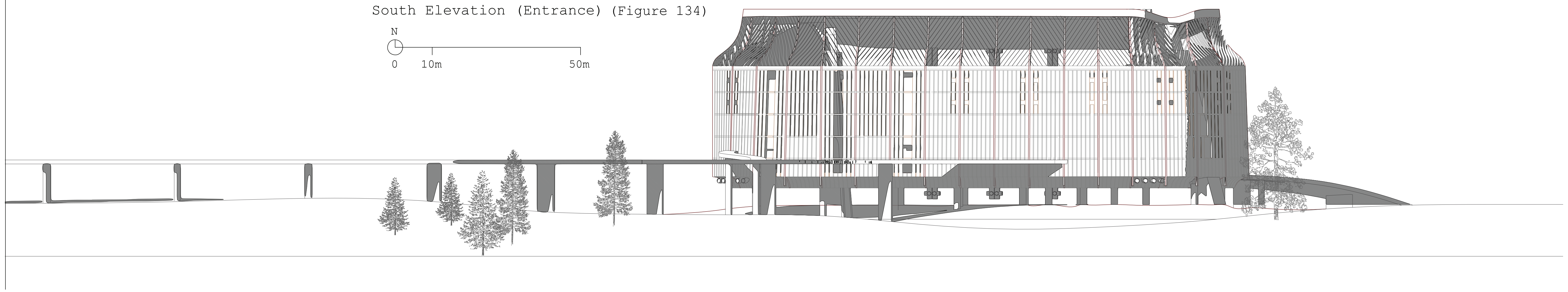
d. Architectural Elevation of No. 5 Dispatch & Display - The Construction of the 'Face'



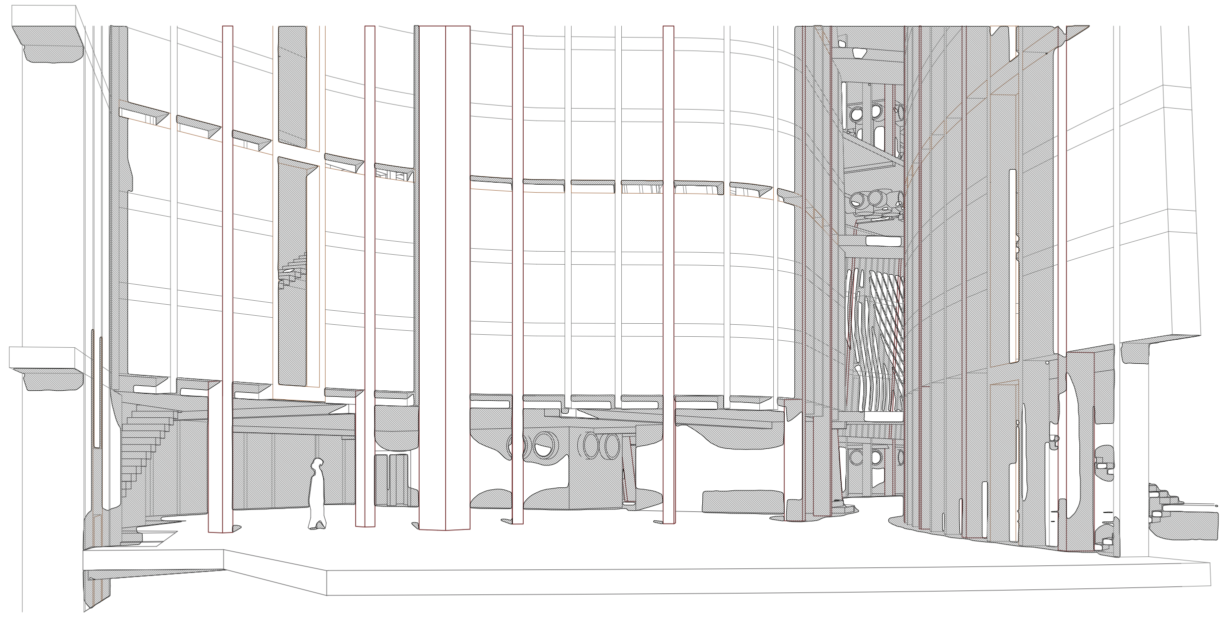


West Elevation (Figure 133)





South Elevation (Entrance) (Figure 134)



Perspective on Functional Space
[Guest Entrance Hall Way]

(Figure 135)

6.2 Architectural Drawings & Analysis

The Construction of the 'Face'

To put it simply, I would say otherness is basically an object or one's being with life and self, that is alien to perceiver's rational activity of conceiving. Through the 'face' one present the life of oneself towards other.

When isolate human face into four sides, you got one front side and one back head which are two entirely distinctive images. The left and right sides on the other hand is extremely similar, except that they are mirror image to each other. The fact that left and right can never overlap together in the reality is deeply uncanny. Finally transition of shapes from person's front face, to one's side and all the ways to the back is nothing short of surprise. Whereas, on a cube, cuboid, cylinder, sphere, cone, or many parametric forms, a linear rationality can be drawn and the transition between elevations is very much predictable.

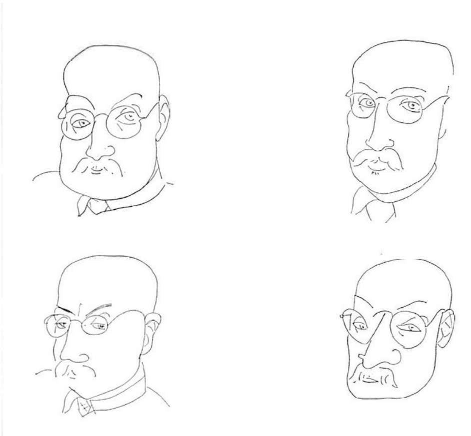
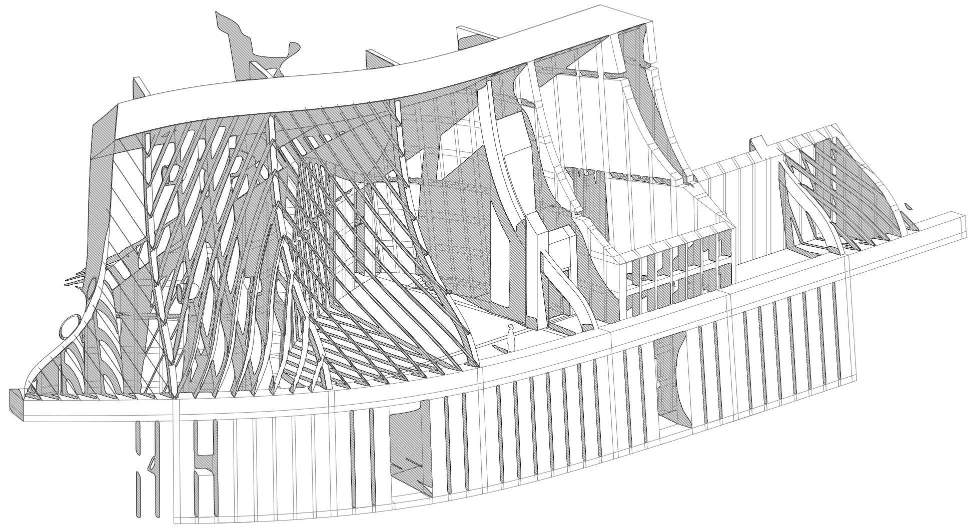


Figure 136: Human face is something which is deep in the person. Self-portraits of Matisse. (Alexander, 2002, p97)

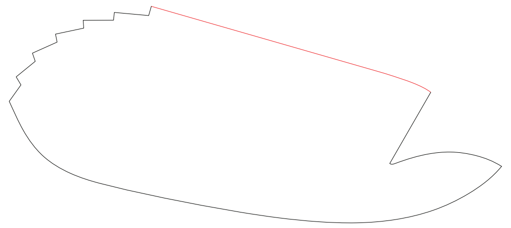
Chapter 6: Developed Design

6.2 Architectural Drawings & Analysis

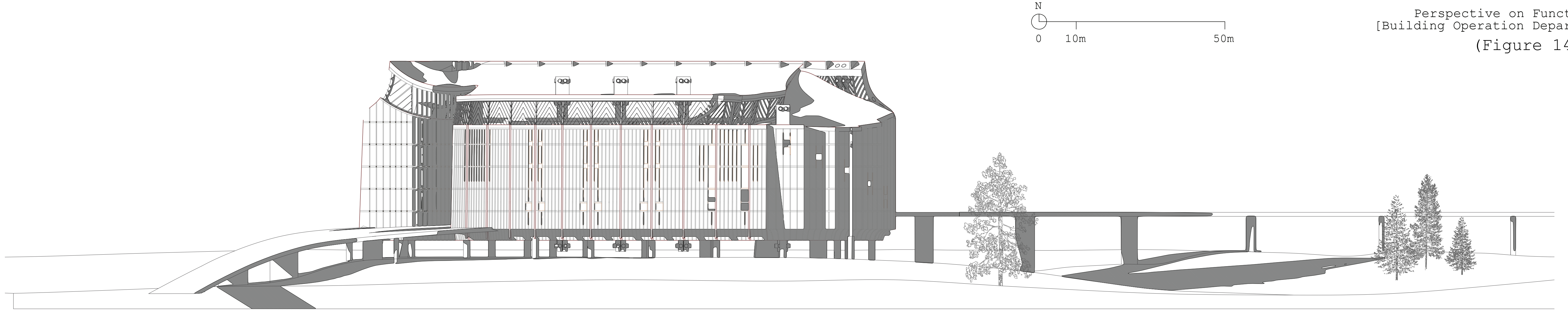
d. Architectural Elevation of No. 5 Dispatch & Display - The Construction of the 'Face'

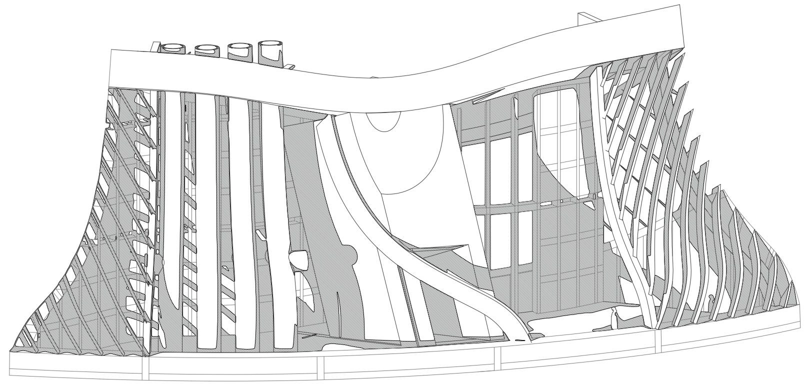


Perspective on Functional Space
[Project Management Department]
(Figure 139)



North Elevation (Figure 137)



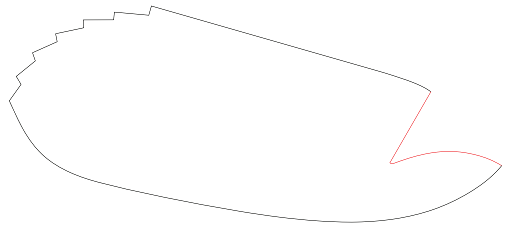


Perspective on Functional Space
[Building Operation Department Air/Water]
(Figure 140)

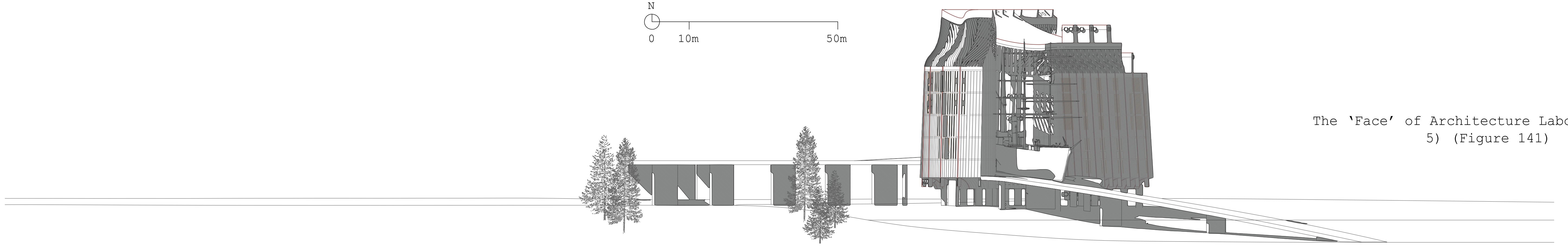
6.2 Architectural Drawings & Analysis

The Construction of 'Face' (Continue)

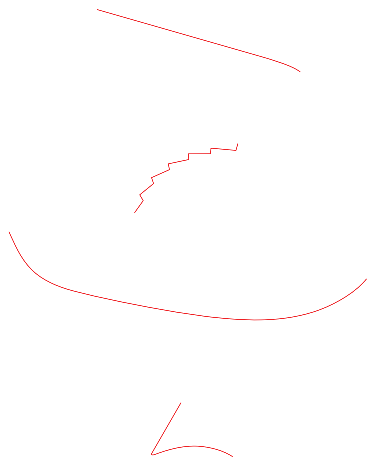
In the making of Building No.5 Dispatch & Display, I maintained an open state of my mind, allowing the architecture to develop its own face. The four sides are independent to each other and maintain memorable character when isolated into Individual pieces. One asymmetrical sweeping curve, giv-ing south facades an almost perfectly balanced look. One Zigzag shaped front face connects two longer sides. The shape on north side is a straight line, ending in an uneven fillet. Lastly, one 'concave' like poly-curve, which nest a convex shape in itself. Together, they form the architectural boundary, that is neither purely nature nor artificial, neither totally organic nor rigid. The 'Holobiont living system' here, means there are 'lives' within the 'life'.



East Elevation (Exit) (Figure 138)



The 'Face' of Architecture Laboratory (No. 5) (Figure 141)



Straight line with an uneven fillet tail

Zigzag Transition

Nearly balanced long curve

An convex shape within 'concave' like poly-curve

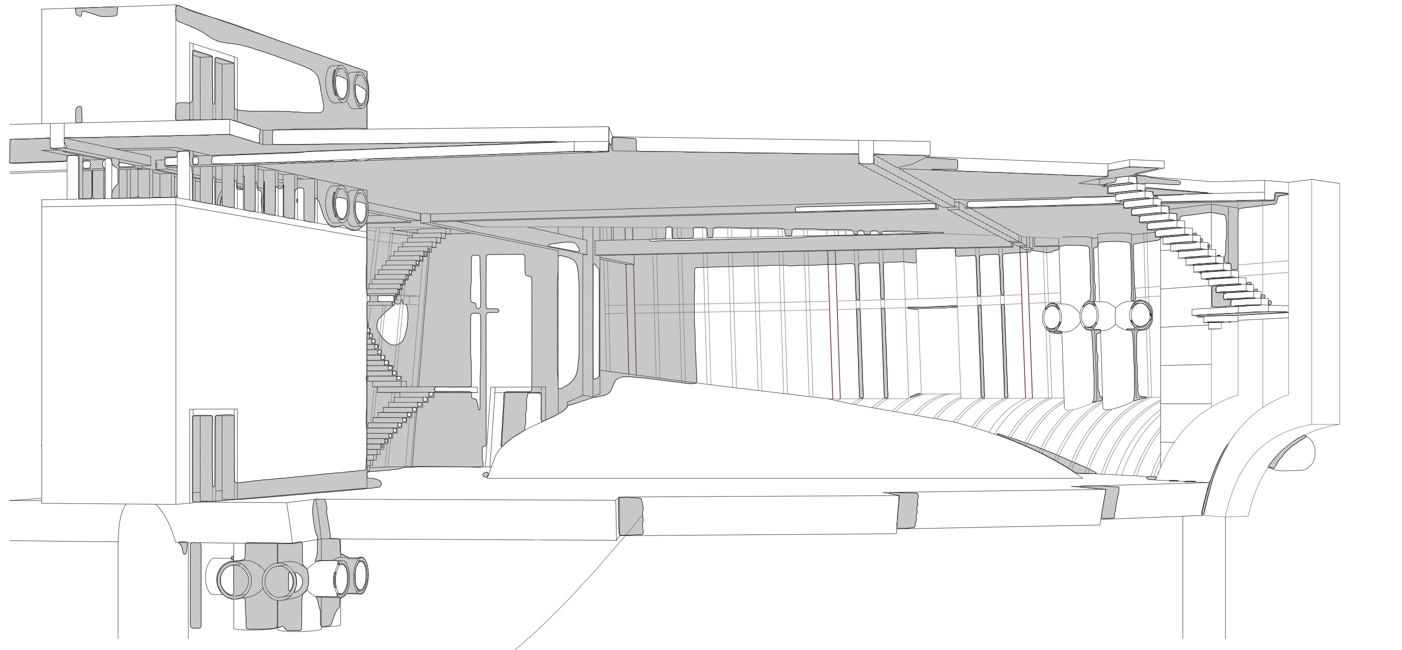
Chapter 6: Developed Design

6.2 Architectural Drawings & Analysis

e. Architectural Plan Organization of No.5 Dispatch & Display

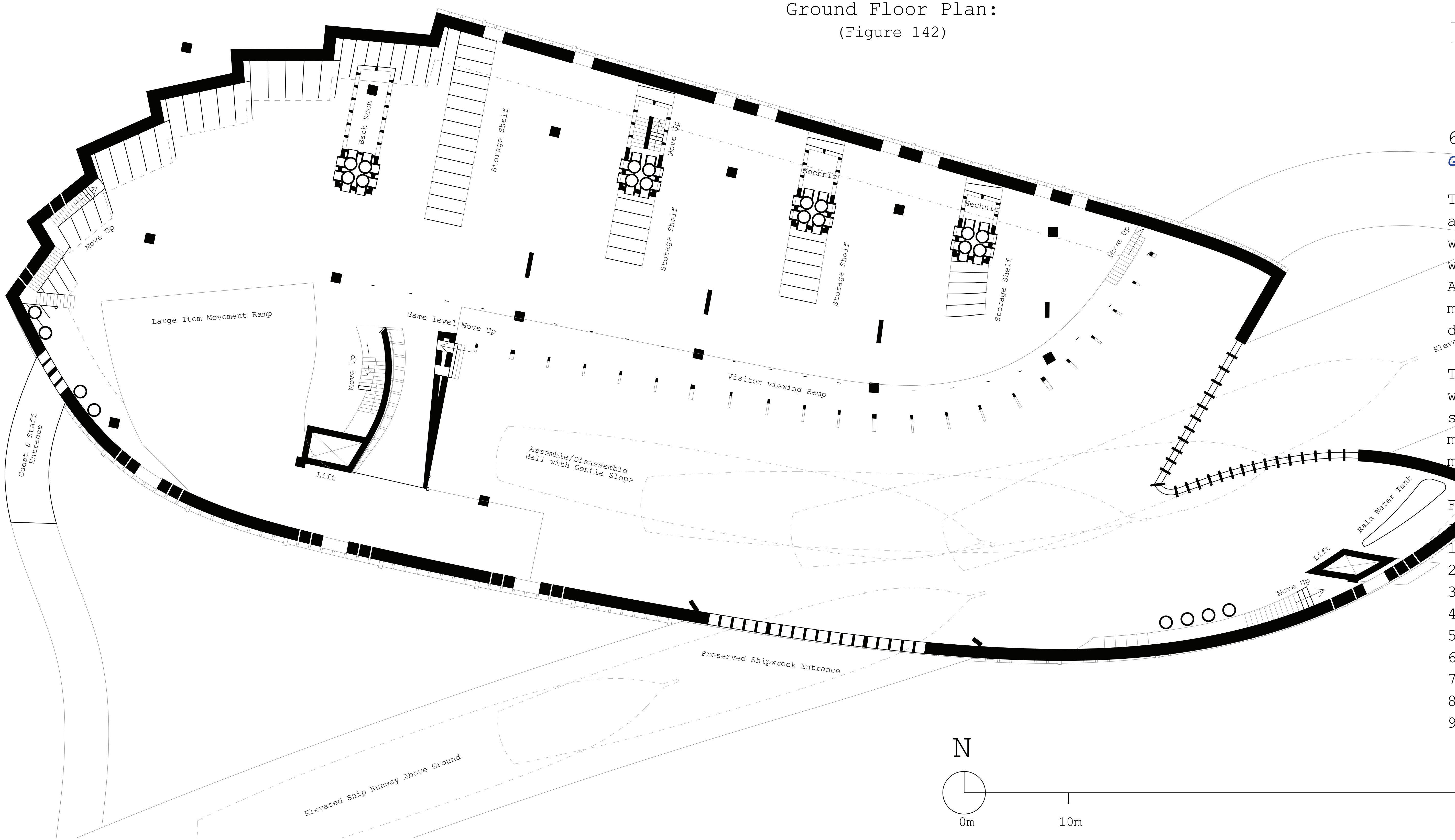
Perspective on Functional Space
[Large Item Movement Ramp]

(Figure 143)



Ground Floor Plan:

(Figure 142)



6 Architectural Drawing's & Analysis

Ground Floor Organization:

The ground storage floor has a height of 9.9 meters, with this plan cut at 8.16 meters. The Transportational ramp spans a width of 6.6m to 20.4m, with a angle of 7.3 degrees, allowing for the movement of medium to large wreck components or structural support elements to the ground floor. A 21-meter-wide ramp, with a gentle 1.9-degree incline, serves as the main workspace for shipwrecks to be assembled for temporary display or disassembled for dispatch to other museums via large cargo ships.

The external elevated shipwreck runway measures 11.6 meters in width, with a 20.1-meter-wide entrance and a 13.6-meter-wide exit. The final design accommodates shipwrecks with dimensions up to 60 meters in length, 9 meters in hull width, and 36 meters in height. During entry or exit, the mast and sails will be dismantled.

Five rows of shelves are provided for storing wreck objects, categorized as follows:

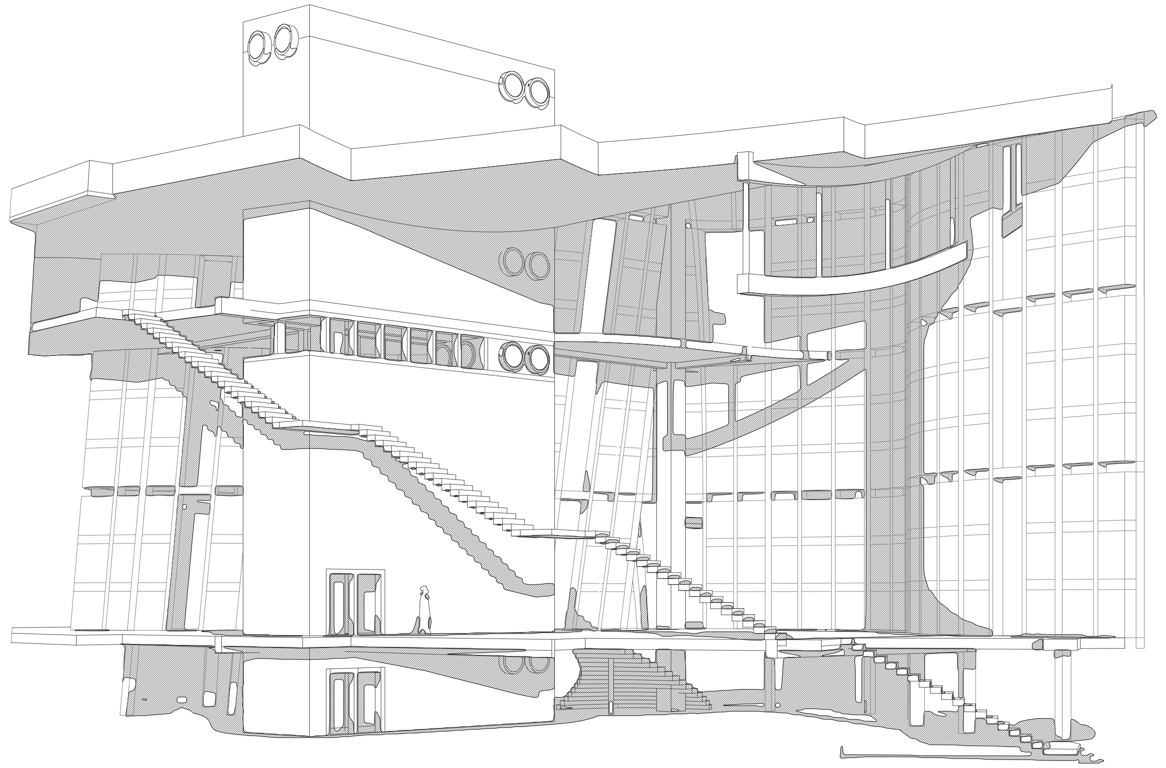
1. Components of structures features (mounds)
2. Artifacts of human manufacture
3. Natural objects used by humans
4. By-products, waste products or debris
5. Organic remains
6. Human remains
7. Petroglyphs, pictographs, intaglios
8. Components of shipwrecks
9. Environmental & chronometric specimens

Chapter 6: Developed Design

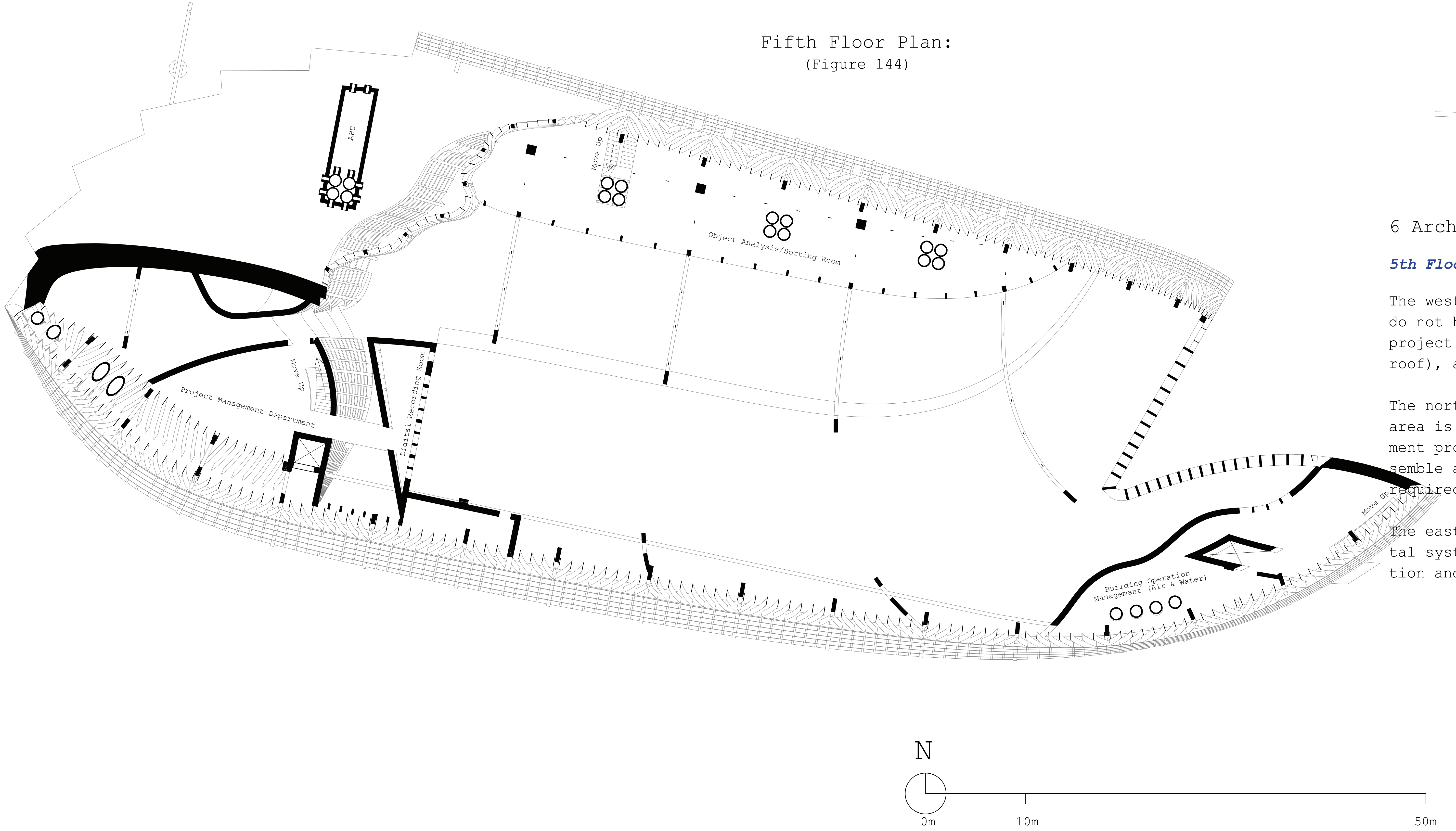
6.2 Architectural Drawings & Analysis

e. Architectural Plan Organization of No.5 Dispatch & Display

Perspective on Functional Space
[Conference Hall]
(Figure 145)



Fifth Floor Plan:
(Figure 144)



6 Architectural Drawing's & Analysis

5th Floor Plan Organization:

The west side of the floor is designated for management offices, where staff do not have direct contact with the wreck objects. This area includes project management/planning offices, a conference hall (semi-covered by the roof), and a digital/photo studio.

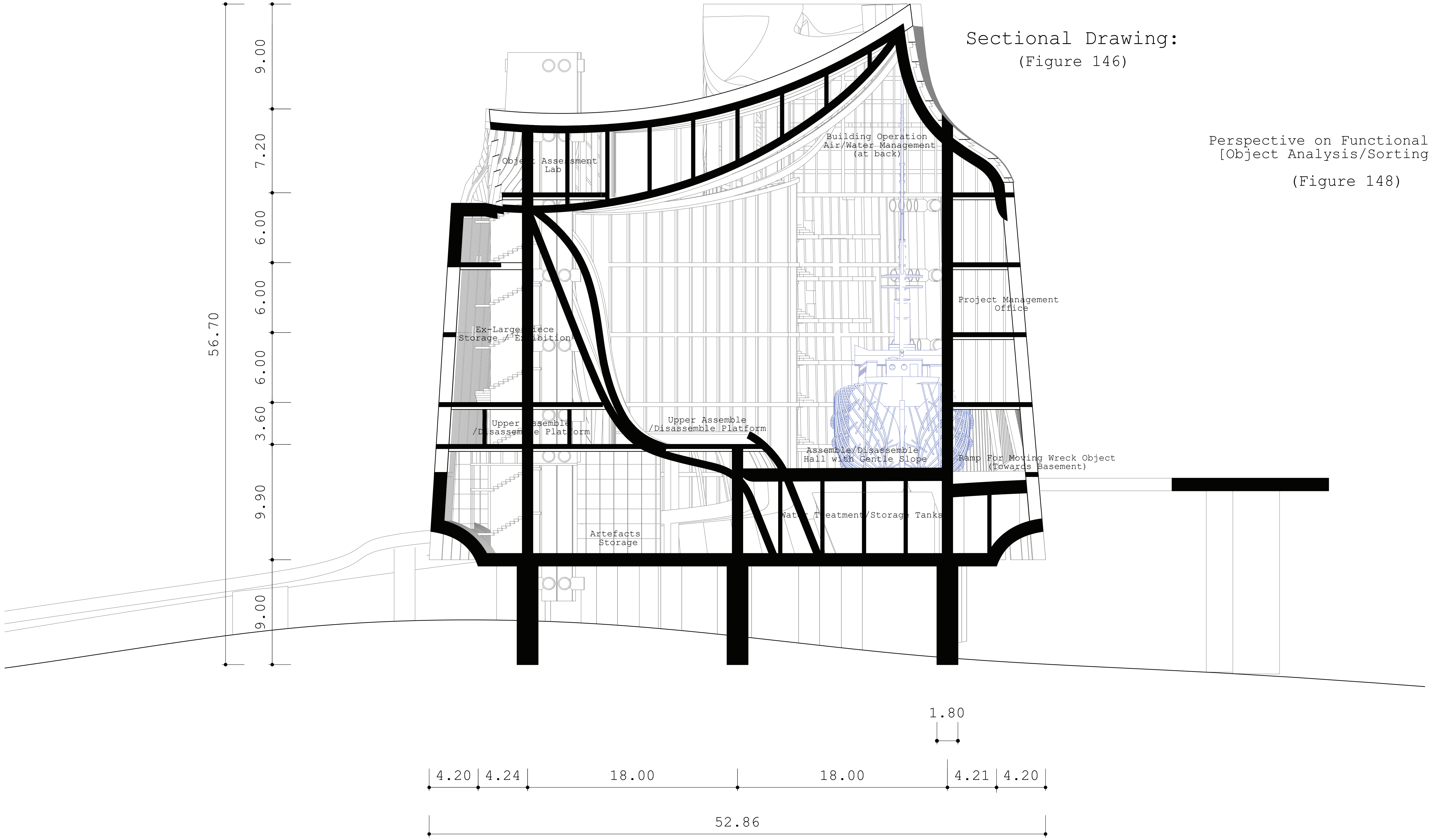
The north wing is where staff engage directly with the wreck items. This area is dedicated to sample recording, assessment, and mild-level treatment processes. Since the primary function of this building is to disassemble and dispatch preserved shipwrecks, a large treatment area is not required.

The east end of the floor focuses on monitoring the building's environmental systems, including air conditioning, solar access, and water collection and usage.

Chapter 6: Developed Design

6.2 Architectural Drawings & Analysis

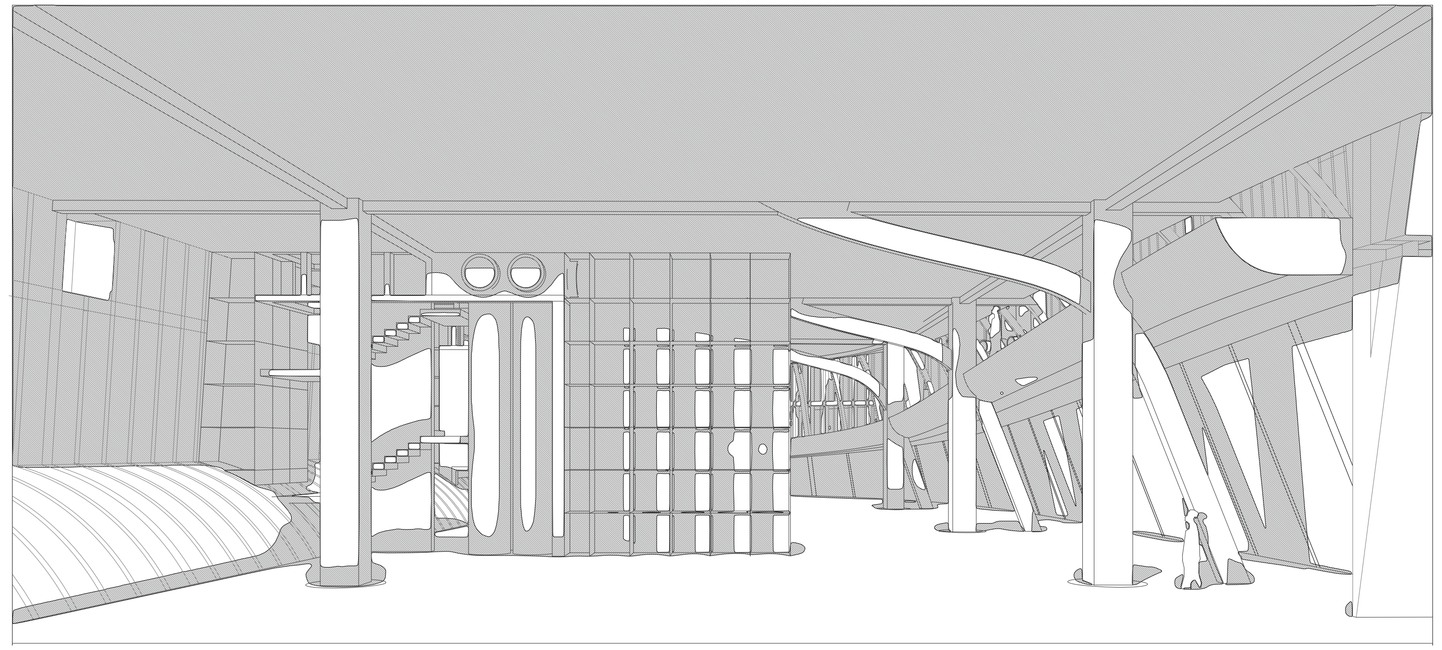
f. Architectural Sectional Organization of No.5 Dispatch & Display



Sectional Drawing:
(Figure 146)

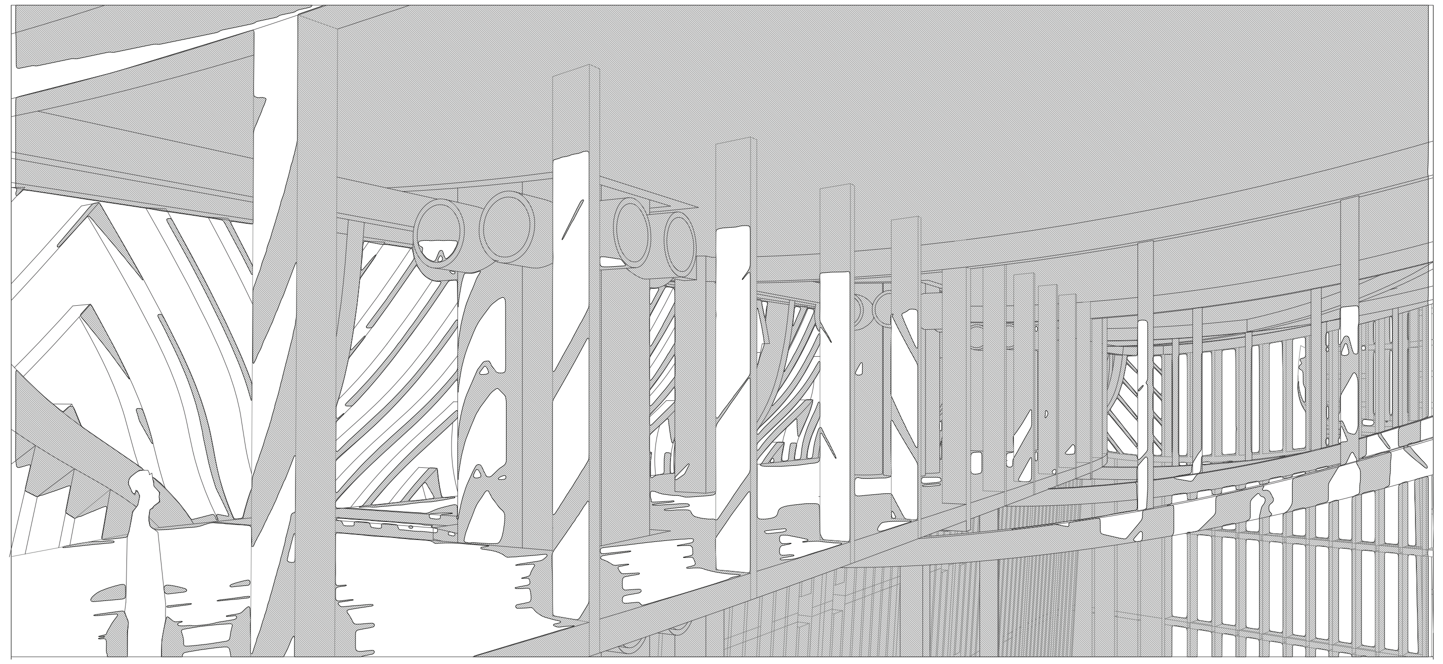
Perspective on Functional Space
[Storage Basement]

(Figure 147)



Perspective on Functional Space
[Object Analysis/Sorting Lab]

(Figure 148)



6 Architectural Drawing's & Analysis

Section Analysis:

Roof slope:

The roof is tilted at a 14-degree angle. The main curved single roof becomes steeper in the middle section to facilitate rainwater collection. During the cold winter months, the building requires staff to clear snow accumulation to maintain functionality.

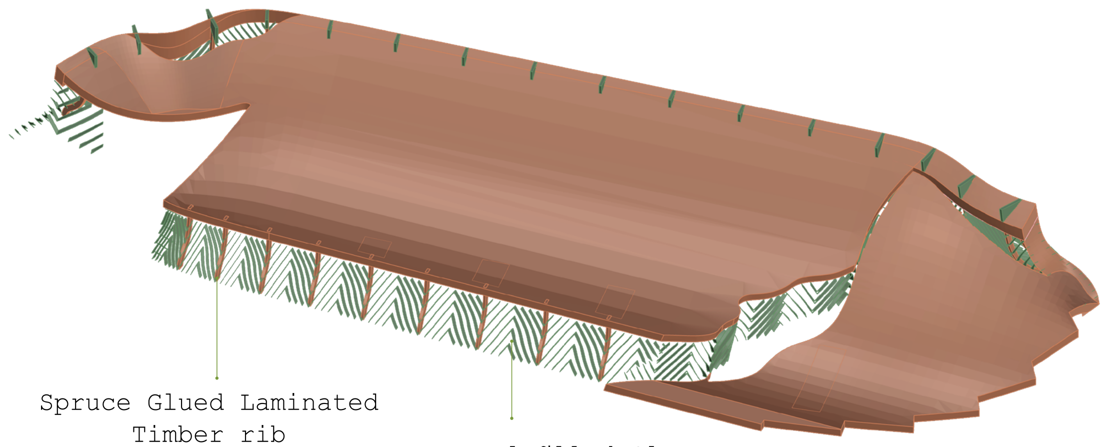
Foundation:

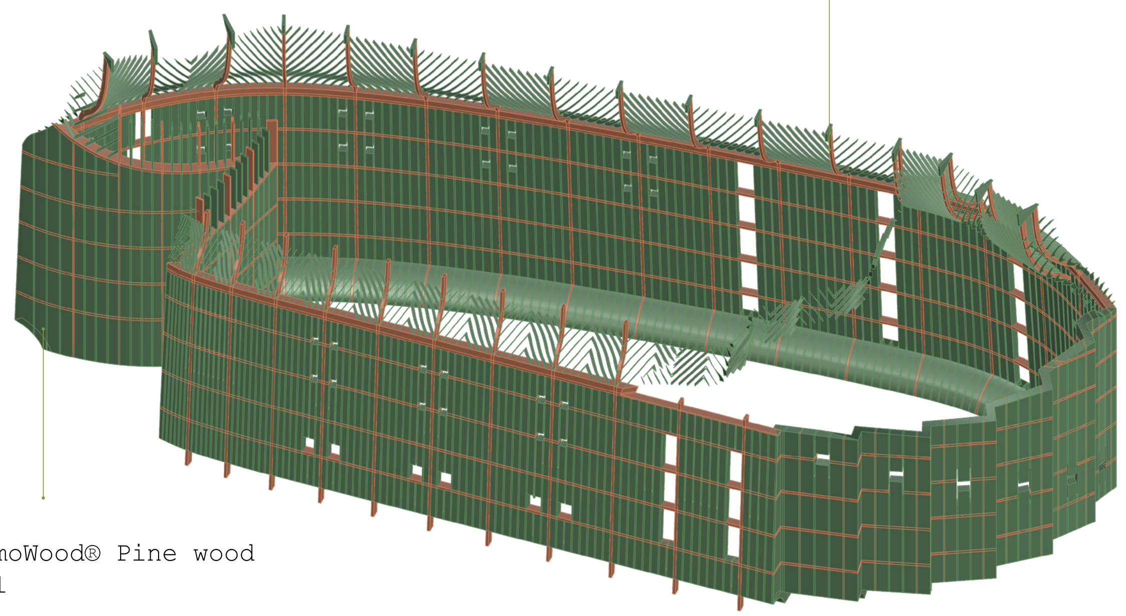
To meet the architectural requirement of making the building independent from the surrounding landscape, a series of 1.80m diameter Permafrost-Compatible Steel Pipe pile foundations are used. The piles are set in place with cementitious or thermally conductive grout, forming an ice-locked connection with the permafrost. The deep penetration of these piles into the permafrost provides a high load-bearing capacity. Additionally, aerogel-based coatings will be applied for insulation (Dourado et al., 2024).

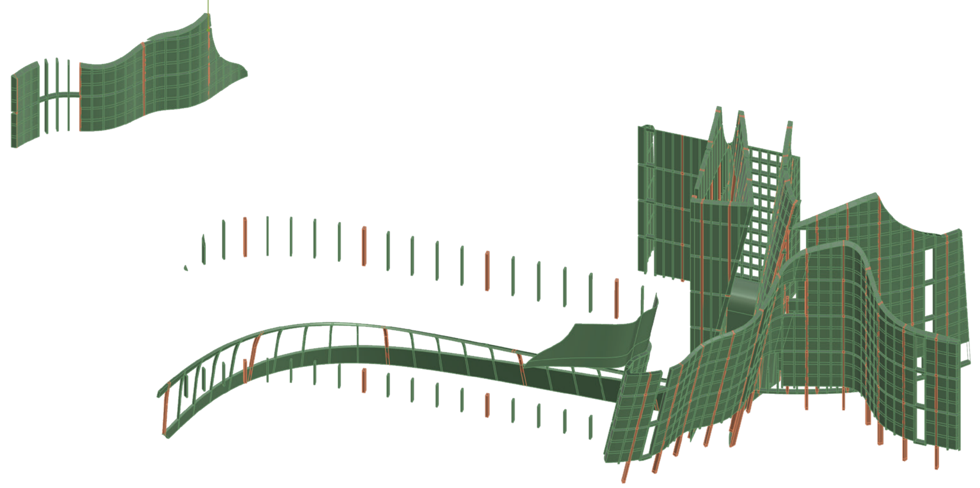
Chapter 6: Developed Design

6.3 Design analysis: Construction, Structure, Materiality

a. Building System & Materiality







Solar Access and UV Filtering (Figure 149):

The external walls on top floor are constructed with Spruce Glued Laminated Timber ribs, integrated with glass panels. The Pilkington Profilit™ glass, paired with Lumira® aerogel, features a UV-blocking, Low-E laminated layer. This combination provides soft, even light dispersion while minimizing glare. The glass panels are filled with aerogel, an insulation material known for its surreal, otherworldly translucency (Riffat & Qiu, 2012). The open design on the 5th floor directs diffused natural light into the shipwreck main hall. This helps avoid direct sunlight exposure, which can be harmful to the shipwrecks, and reduces UV light impact on sensitive objects. Additionally, the design reduces reliance on artificial lighting while safeguarding the preservation of delicate artifacts.

External Facades (Figure 150):

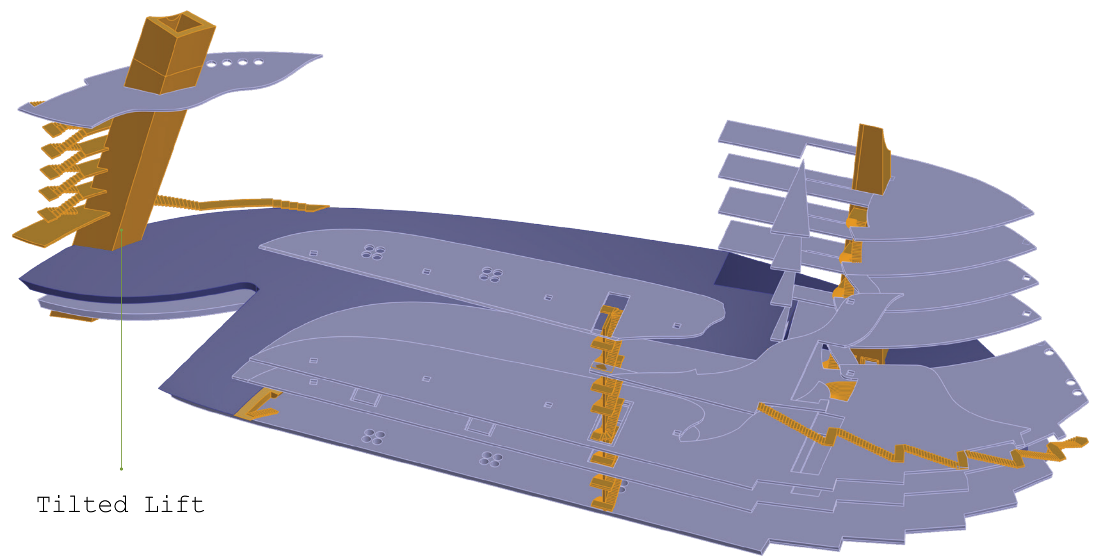
The secondary structure system of the building is composed of a Spruce Glued Laminated Timber framework. For the timber façade panels, ThermoWood® (thermally modified) Pine wood, a softwood material is selected. The interior side of the panels is equipped with cellulose insulation. The external timber panel has a rustic appearance and provides moisture resistance, and weatherproof properties, making it durable for the high Arctic climate.

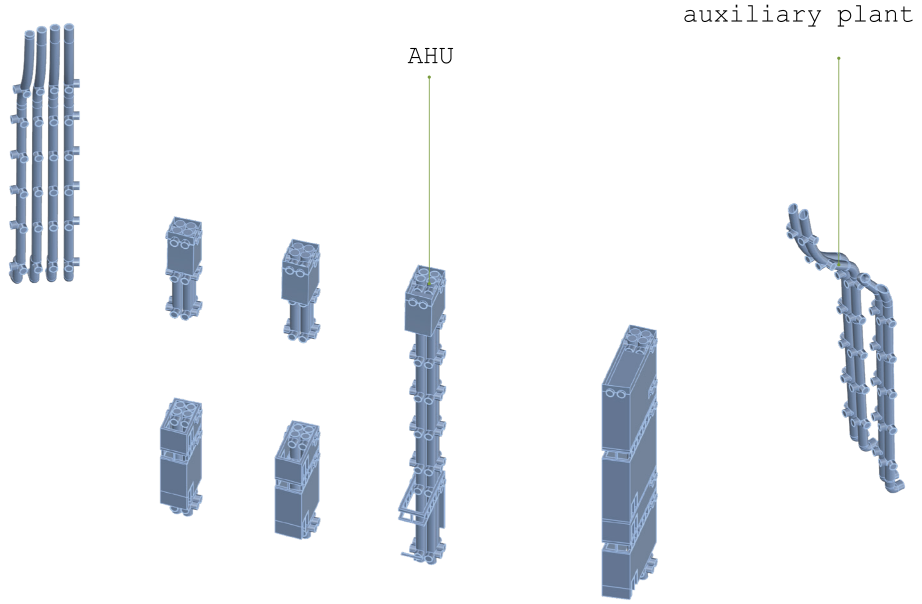
Internal Walls (Figure 151):

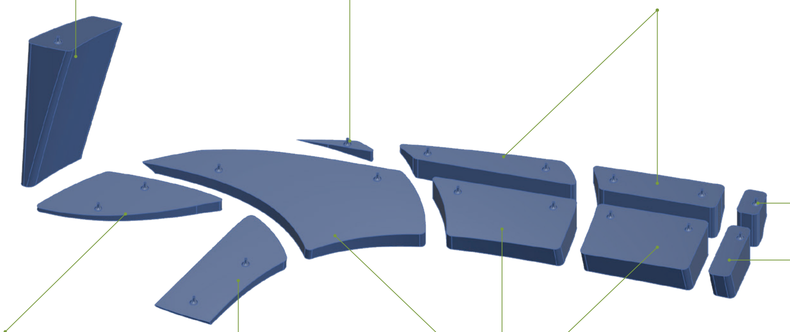
Spruce Glued Laminated Timber framework is paired with Pine wood (Softwood) facade panel.

6.3 Design analysis: Construction, Structure, Materiality

a. Building System & Materiality







Circulation (Figure 152):

A system of four staircases has been designed to enhance circulation efficiency and meet emergency evacuation requirements. The maximum distance a person must travel to access a staircase from any part of the building is approximately 42 meters. Three lifts are incorporated to accommodate vertical transportation of both people and small to medium-sized objects. The lift dimensions (clearance) are as follows:
2.60m × 3.30m
2.50m × 4.00m
2.88m × 3.00m

Mechanical Services and Airflow System (Figure 153):

Six sets of auxiliary plant units (CA03) are distributed across the space, each connected to its own external air handling unit located at both the roof level and beneath the building. The indoor temperature is maintained at 18.5°C ± 1.5°C, with a relative humidity of 53% ± 2%. The mechanical service spaces are designed to accommodate over 1,000 people during peak periods while ensuring the protection of ship hulls. Waste air will be discharged through a plant in the basement underneath the building.
In terms of airflow, the fresh air is directed from the south-central side of the building, flowing through the shipwreck and into all other spaces with high human activity. Locally provided fresh air in the human-use spaces will be directed outward from the south shipwreck location. Steel columns and the secondary timber structure adjacent to the ship hull will be fitted with CA03 drum-shaped air outlets, creating an air canopy around the ship hull (Hocker, 2010).

Water Collection & Treatment (Figure 154):

Rainwater or snowmelt from the gently sloped roof is directed to the Building Operation Water Management area. The water collection system is situated directly beneath this department floor. From here, the collected water is transferred to the ground floor, where it undergoes a filtration process to ensure it is suitable for specific uses. Separate water tanks will hold tap water, rainwater, de-ionized water, and distilled water (Hamilton, 1999).

6.3 Design analysis: Construction, Structure, Materiality

b. Construction Detailing

Design Strategy:

Concrete Pile foundation is applied to reduce environmental damage of river bed. Cofferdam is constructed before the foundation construction which stops river water flowing into construction site. Concrete slab is insulated externally to reduce cold bridging. Thermal continuity is Minimized with offset studs and counter battens in wall. The timber joist and columns are underneath the insulated roof and floor. Both wall and roof have the well insulated U values of 0.083 Wm2/K. The airtight membrane is attached behind the interi-or planks. Many junctions also contain inter-locking wood blocks and boards to reduce air leakage.

External Wall Construction: The glulam beams connected to steel structure are bolted with cladding studs. Then counter battens are stamped onto studs. One layer of waterproof plywood boards and one layer of Douglas fir batten are stamped to the counter batten. Finally Oak boardings are screwed to fir battens. Waterproof plywood is the outside layer next to insulation, on which waterproof membrane is stamped.

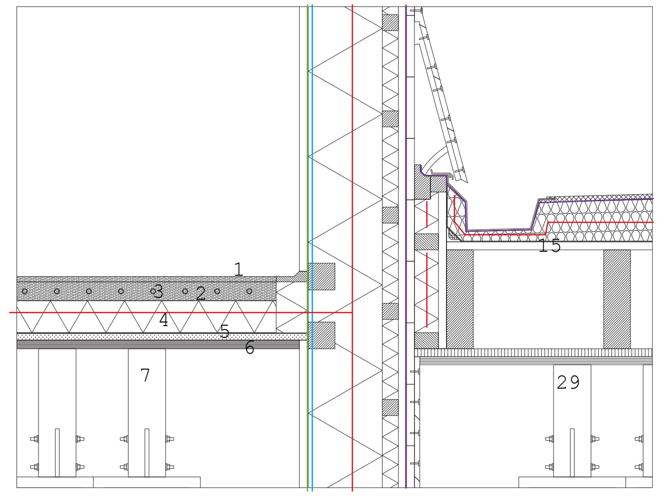


Figure 155: Roof & Wall Junction Construction
1:20
1. 20 mm magnesite composite screed
2. 70 mm cement and sand screed around
3. underfloor heating on polythene sheeting
4. 120 mm mineral-fibre thermal insulation
5. 25 mm loose fill on building paper
6. 30mm white planks
7. 480/140 mm Glulam timber beam
15. 30mm waterproof plywood board
29. 430mm/100 Glulam timber beam attachend roof of Hall

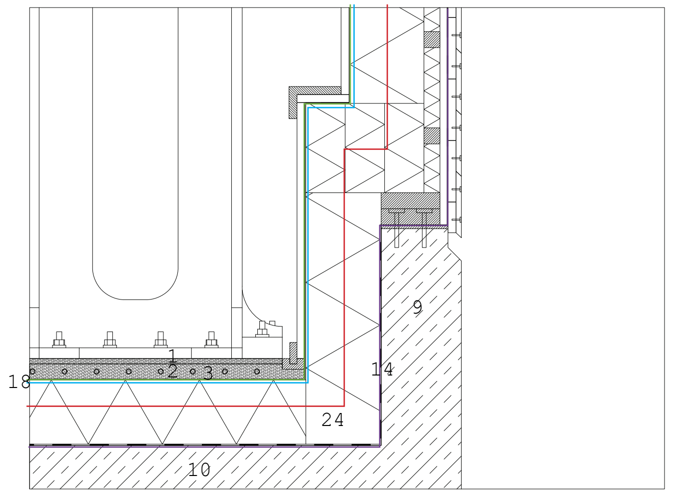


Figure 156: Ground Floor construction
1:20
1. 20 mm magnesite composite screed
2. 60 mm cement and sand screed around
3. underfloor heating on polythene sheeting
18. vapour-retarding layer
8. 240 mm mineral-fibre thermal insulation
14. water-proof membrane
9. 300 mm thickness 480mm height concrete wall
10. 1000mm to 1300mm concrete slab

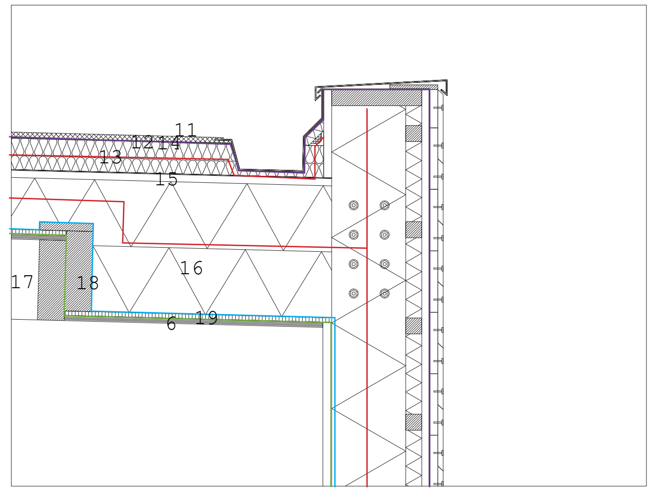


Figure 157: Roof construction
1:20
11. 20 mm asphalt roofing
12. neoprene sealing layer
13. 120 mm polyurethane rigid-foam thermal insulation
14. water-proof membrane
15. 30 mm waterproof plywood
16. 200/500 mm cellulose thermal insulation in gaps of Glulam timber rafters
17. 100/530 mm laminated timber rafters
18. vapour-retarding layer
19. 16mm moisture-diffusing composite wood board
6. 20mm white planks

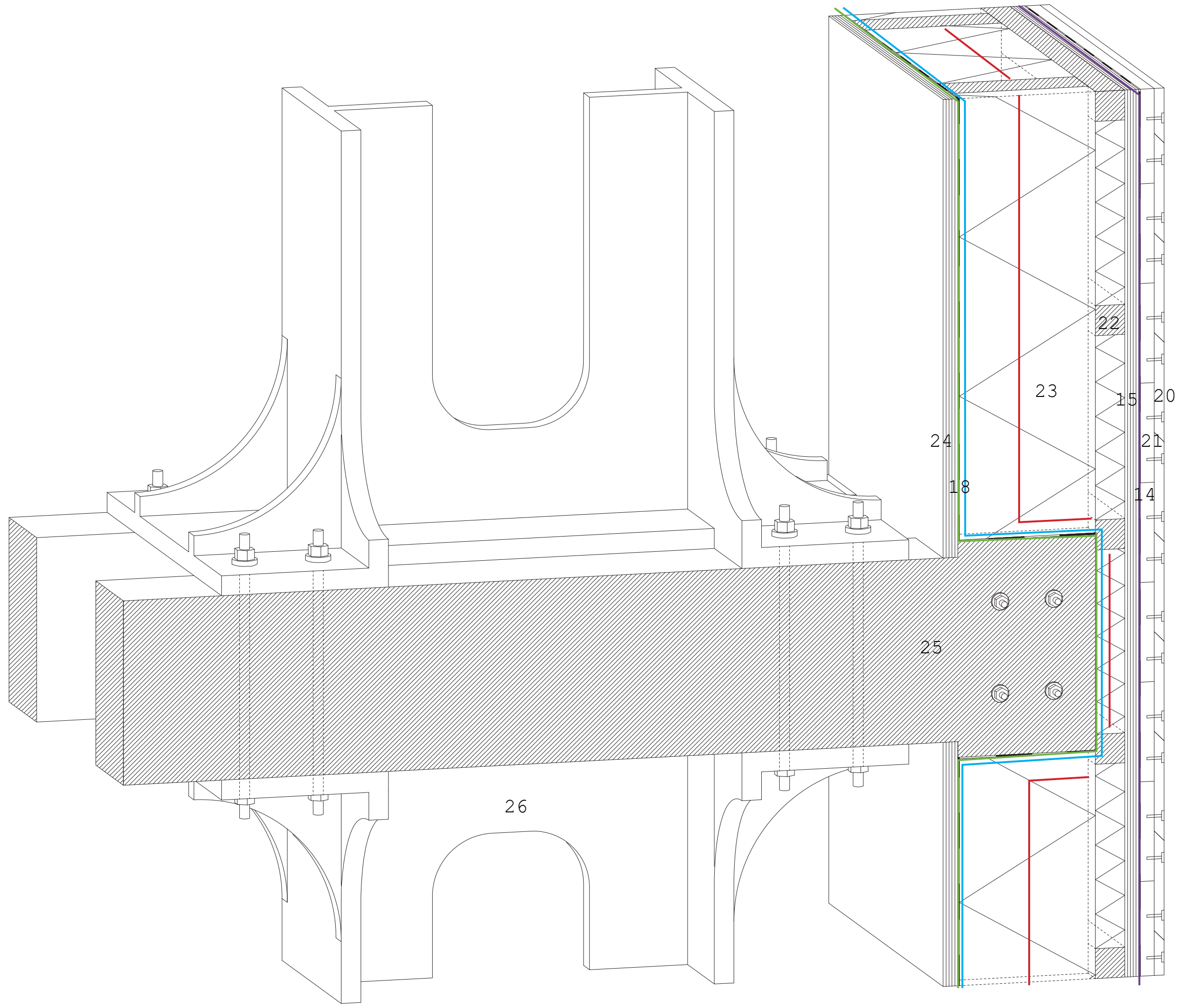
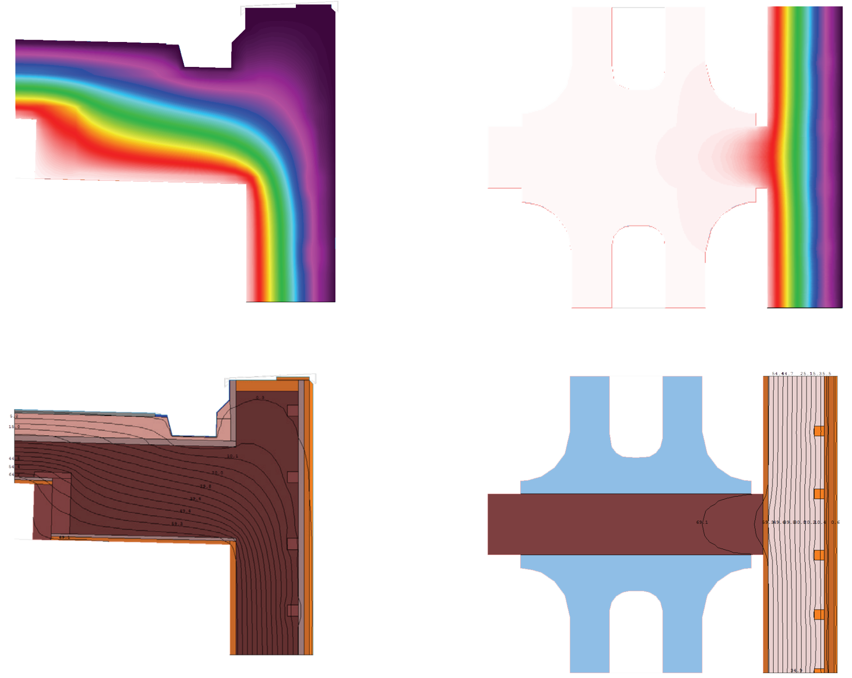


Figure 158: External Wall Construction
1:10
20. 20mm oak Boarding fixed with stainless steel screw to
21. 30/230mm Douglas fir battens
14. water-proof membrane
15. 30mm waterproof plywood board
22. 60/60 counter battens (with 60mm rock wool mineral insulation in gaps)
23. 280/100mm Studs (with 280 mm rock wool mineral insulation in gaps)
18. vapour barrier, glued air-tight
24. 20mm silver fir boarding
25. 370/210mm Glulam beam screwed to
26. 800/450mm I section steel structure with 40mm thickness, supporting ground floor wall, first floor, roof as well as crone.

Figure 159: Therm Analysis Program for Insulation Study



Roof U Value calculation:
External surface resist-ance
R=0.4 K m2/W

Asphalt 20mm
Conductivity 0.75 W/m K
R=0.02/ 0.75=0.027K m2/W

Polyurethone Rigid insu-lation 120mm
Conductivity 0.023 W/m K
R=0.12/ 0.023=5.22 K m2/W

Waterproof plywood board 30mm
Conductivity 0.13 W/m K
R=0.03/ 0.13=0.23 K m2/W

Cellulose insulation 200mm
Conductivity 0.035 W/m K
R=0.2/ 0.035=5.7 K m2/W

Plywood board 16mm
Conductivity 0.13 W/m K
R=0.016/ 0.13=0.12 K m2/W

Pine Plank 20mm
Conductivity 0.13 W/m K
R=0.02/ 0.13=0.17 K m2/W

Interior surface resist-ance
R=0.13 K m2/W

Total R: 0.4+0.027+5.22+0.23+5.7+0.12+0.17+0.13=12 K m2/W
U=1/R=0.083 Wm2/K

Wall U value calculation:
External surface resistance
R=0.4 K m2/W

Oak wood 20mm
Conductivity 0.12 W/m K
R=0.02/0.12=0.17 K m2/W

Douglas fir batten 30mm
Conductivity 0.13 W/m K
R=0.03/0.13=0.23 K m2/W

Waterproof plywood 30mm
Conductivity 0.13 W/m K
R=0.03/0.13=0.23 K m2/W

insulation rock mineral wool 340mm
Conductivity 0.032 W/m K
R=0.34/0.032=10.6 K m2/W

Silver fir boarding 30mm
Conductivity 0.13 W/m K
R=0.03/0.13=0.23 K m2/W

Interior surface resistance
R=0.13 K m2/W

Total R: 0.4+0.17+0.23+0.23+10.6+0.23+0.13=12 K m2/W
U=1/R=0.083 Wm2/K

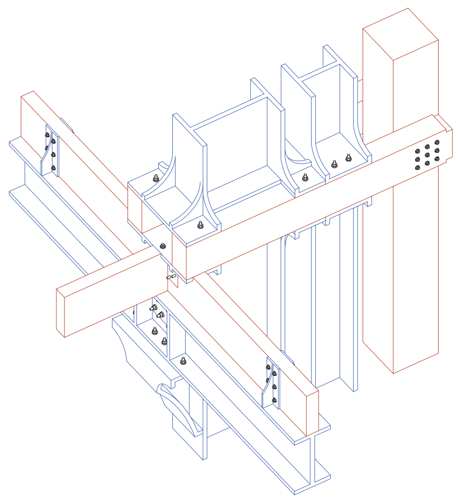
Air tight membrane
Vapour-retarding layer
Thermal contunity
Waterproof membrane

Chapter 6: Developed Design

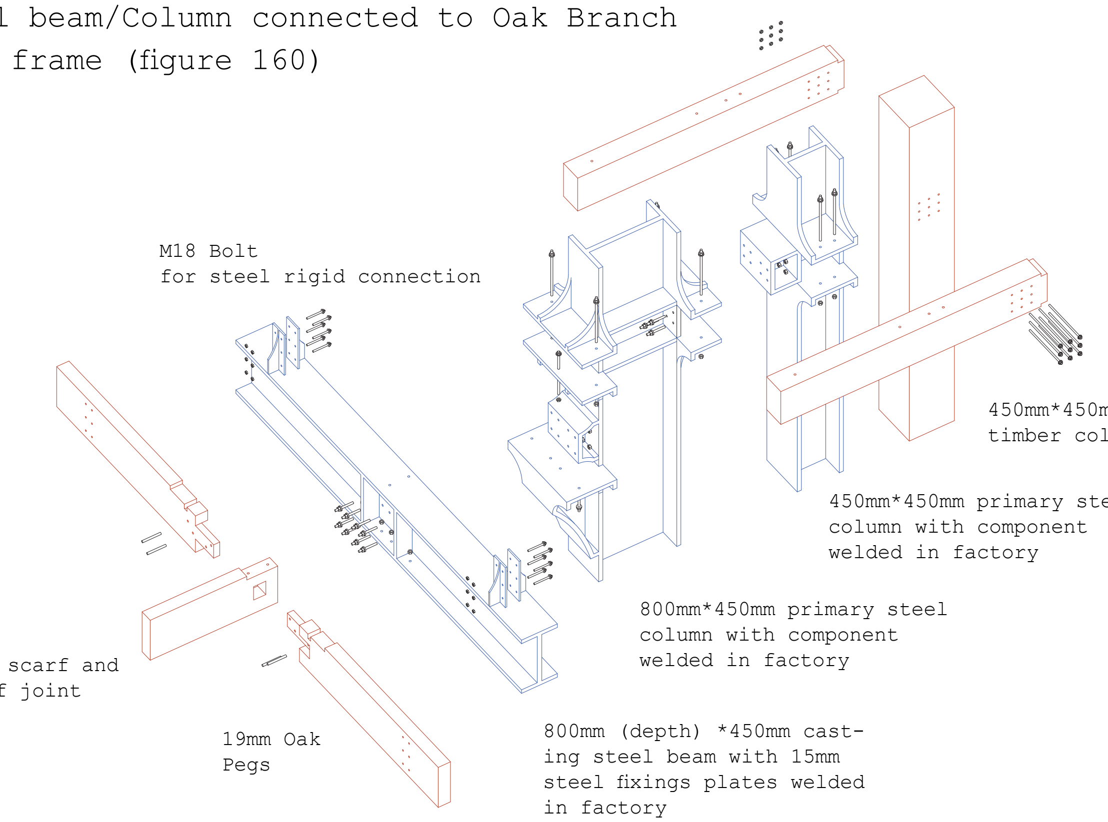
6.3 Design analysis: Construction, Structure, Materiality

b.Structural Detailing

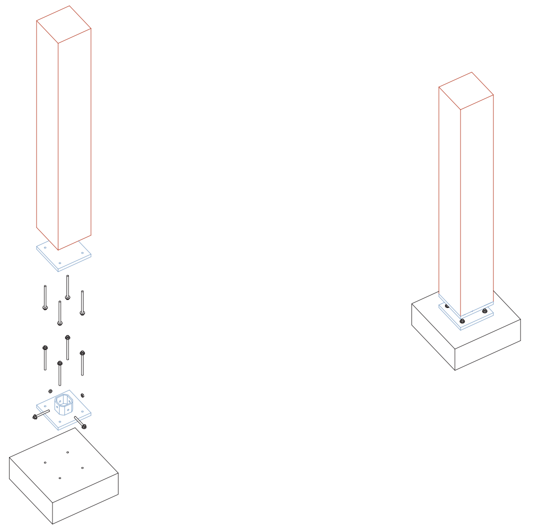
The cold bridge is minimized through applying the steel super structure inside the preservation laboratory without touching roof and wall. The Glued laminated timber beams and columns are sub structures grafting from the steel structure holding the roof, floor and walls made of wood.
N.B. Due to the complexity of architectural design, the structural detailing idea is represented through straight wall & floor junction.



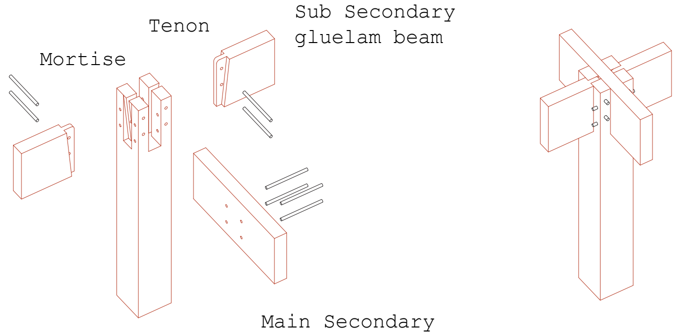
A: Steel beam/Column connected to Oak Branch & Floor frame (figure 160)



C: Plug-in steel Column joint (figure 162)

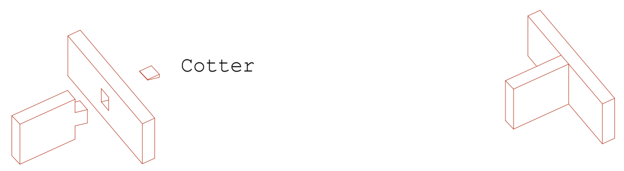


D: Bevelled-shoulder tenon joint (figure 163)

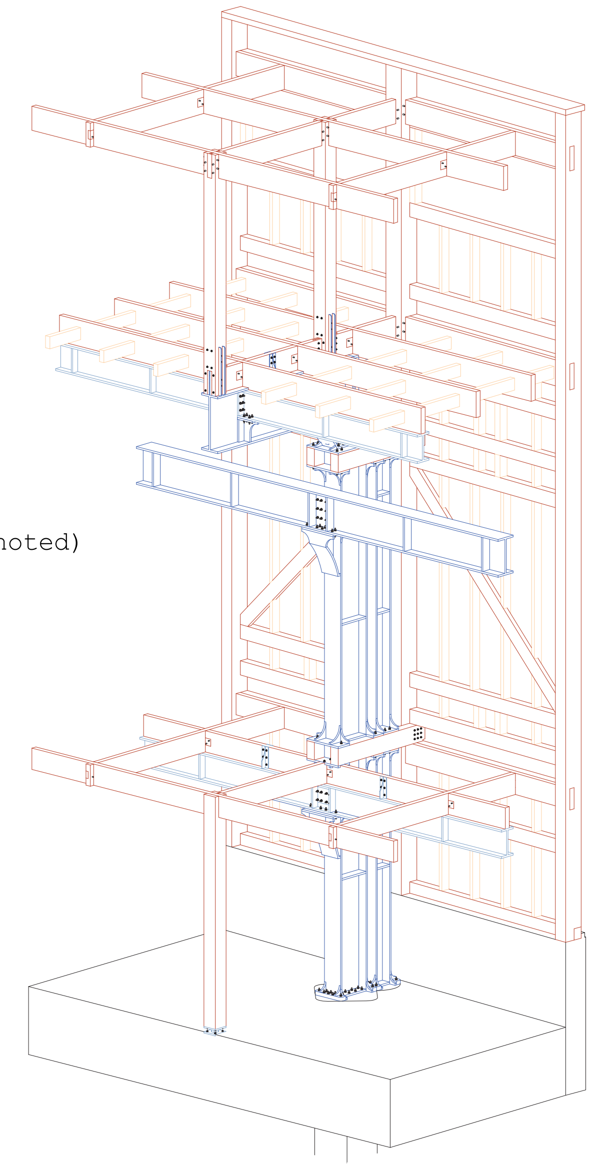


E: Face halved scarf and bladed scarf joint (figure 164)

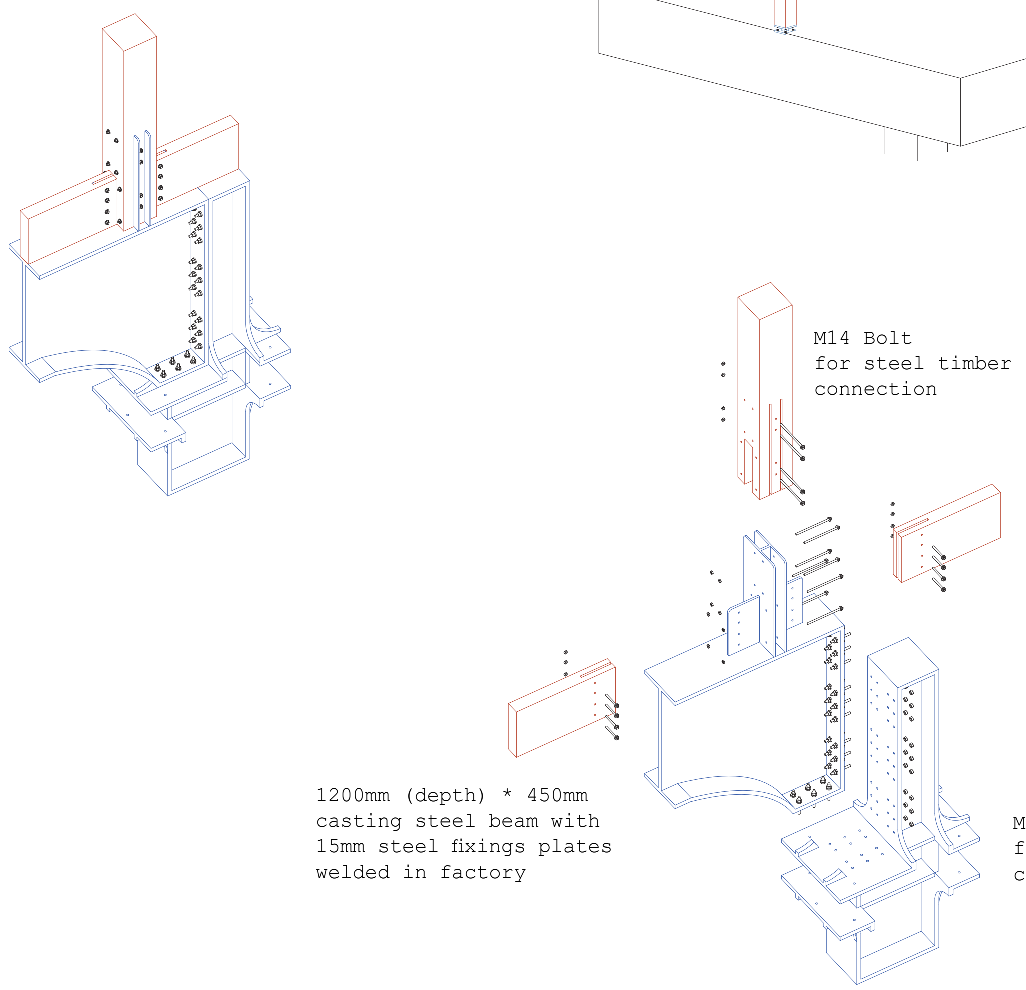
F: Dovetail Tenon joint (figure 165)



- Primary structure Casting Steel
- Sub-Primary structure Casting Steel
- Secondary structure Column Glulam (not always noted)
- Secondary structure Timber Glulam
- Sub-secondary structure Timber strand board



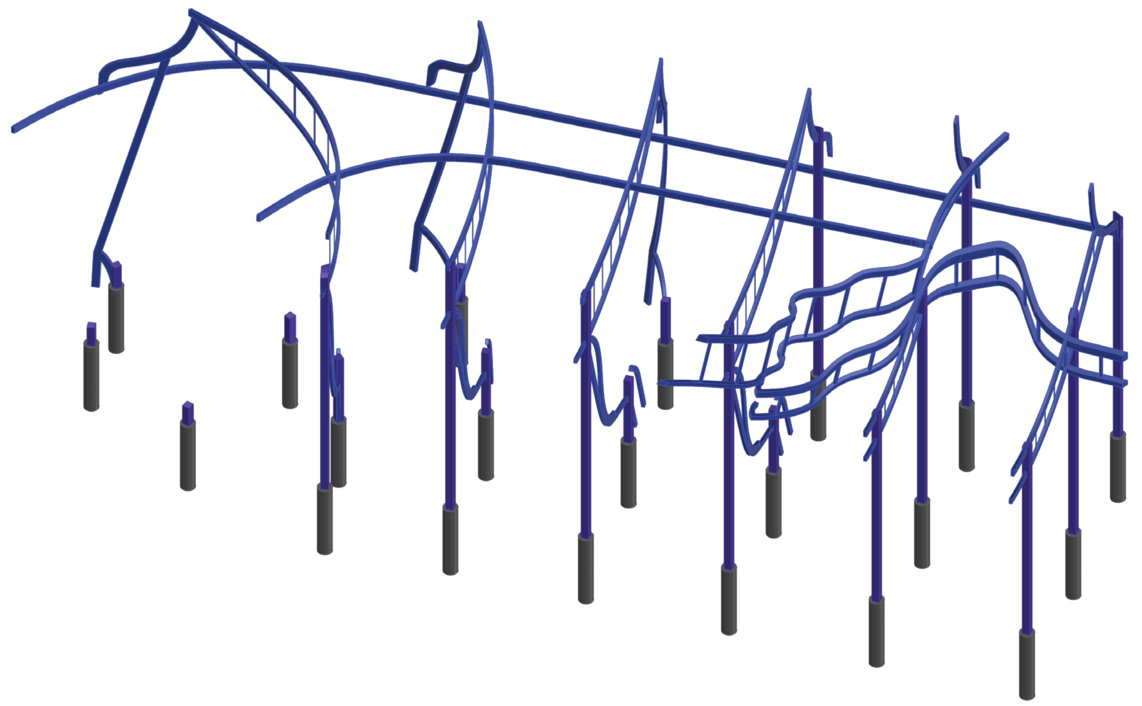
B: Steel beam/Column connected to Oak Column & Floor frame (figure 161)



Chapter 6: Developed Design

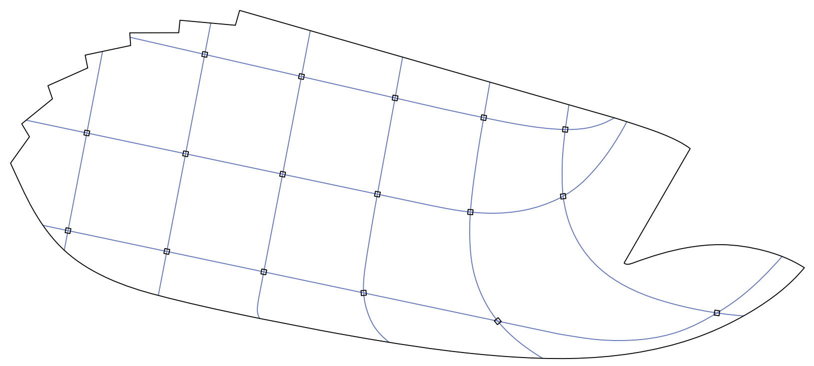
6.3 Design analysis: Construction, Structure, Materiality

c.Suspension Of Order Realized Through Structural System Design

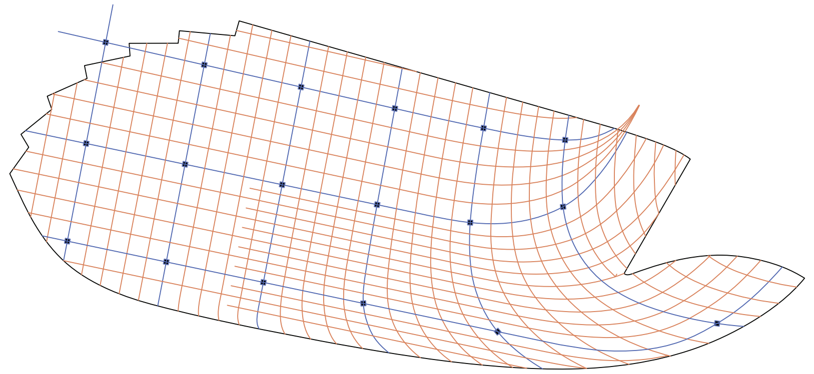


Axonometric Diagram on Primary Structural System
(Figure 166)

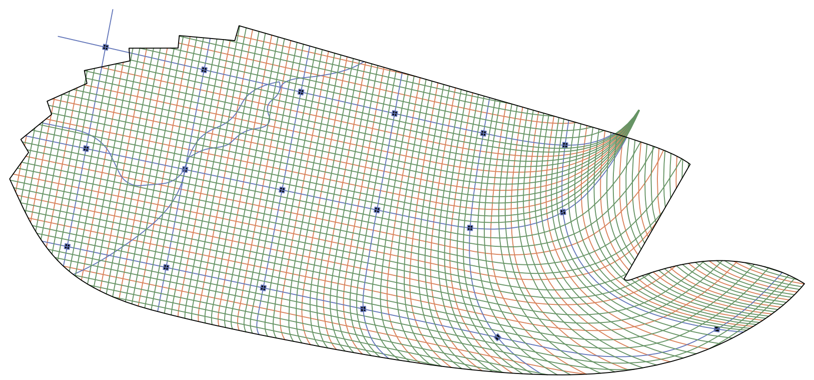
Primary Steel Structural System
(Figure 167)



Secondary Timber Structural System
(Figure 168)



Tertiary Division System for Interior Panels and Two Injury Steel Beam
(Figure 169)



b. Suspension Of Order Realized Through Structural System Design

Repetition is one of the most common features in architecture. During the Renaissance, repetition symbolized a utopian idea of infinity. Early modern architecture used it as a language of timelessness. These utopian ideas of divine order elevated architecture into something perfect and everlasting. But today, what do architects do with repetition? I question whether most view it simply as a convenient method to fill space. Infinity and timelessness can also be lifeless.

My position is not to criticize repetition, but rather to consider it as a process of accumulation. By leading repetition toward a conclusion, a story forms. There is a bittersweetness in watching things come to an end. As human beings, we often struggle to appreciate things ending. Perhaps we should be grateful for what has been created and then leave it behind.

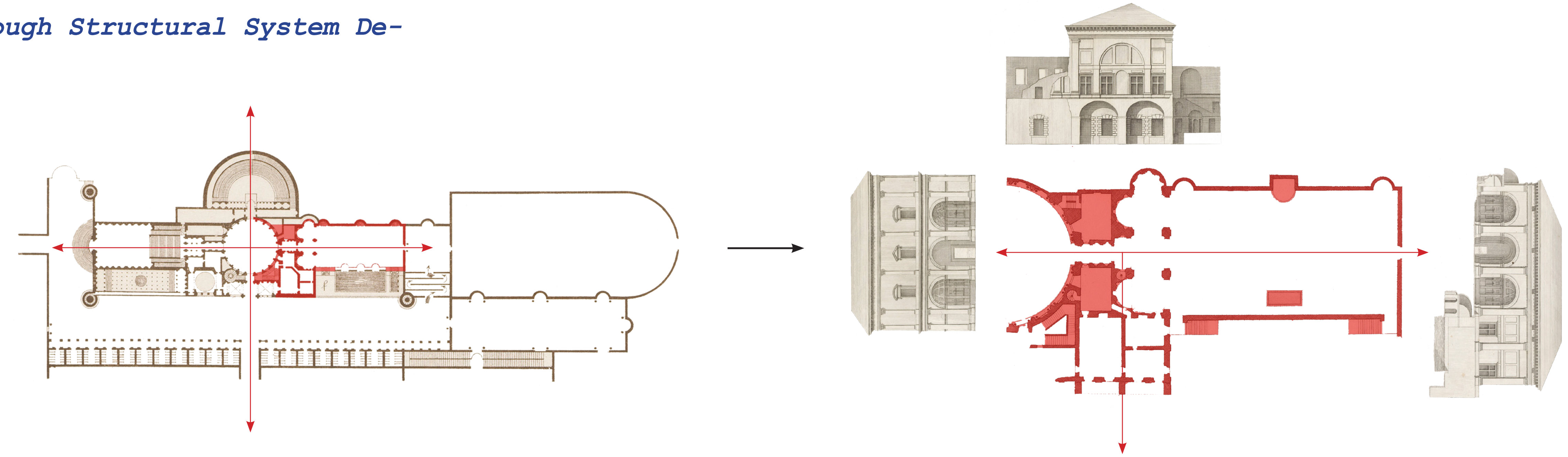
Heidegger (1962) suggests that an object gains autonomy through its brokenness, or Unzuhandenheit (unreadiness-at-hand). Such occurrences allow an object to deviate from its creator's intentions. In Japanese Zen philosophy, Wabi-sabi reminds us that life is fragile and momentary. Life itself is damaged, and nothing perfect can truly be alive.

To give life is to end repetition. From the west side, the building plan begins with a perfect square grid. As it extends toward the east, where the shipwreck's movement interferes, the middle part of the grid expands, while the sides compress, creating a workspace for the shipwreck less obstructed by columns. The rigid repetition transforms into a more natural flow. Two special beams further interrupt this arrangement, deviating from the previous structural system. They tear open a rift in the building, forming an injury-like opening. The conclusion is made.

Chapter 6: Developed Design

6.3 Design analysis: Construction, Structure, Materiality

c.Suspension Of Order Realized Through Structural System Design



Planned Villa Madama

Completed Villa Madama

Villa Madama Building Axis Shift from Original Plan to Completion (Figure 170)

Ontological Precedent:
Villa Madama - Completion from Incompletion

Villa Madama underwent the hands of several architects and sculptors over decades of construction, destruction, and modification. Key figures involved in its development include: Raphael (1518-1520) as the initial planner, Antonio da Sangallo the Younger (a disciple of Raphael), Giulio Romano (decorations & architect), Baldassare Peruzzi (decorations & architect), Giovanni da Udine (sculptor), Giovan Francesco Penni, and Baccio Bandinelli (sculptor) (Coffin, 1967). In 1527, parts of the structure were pillaged, and much of it was ravaged by fire. The villa was never fully realized, yet it stands as a finished project of incompleteness.

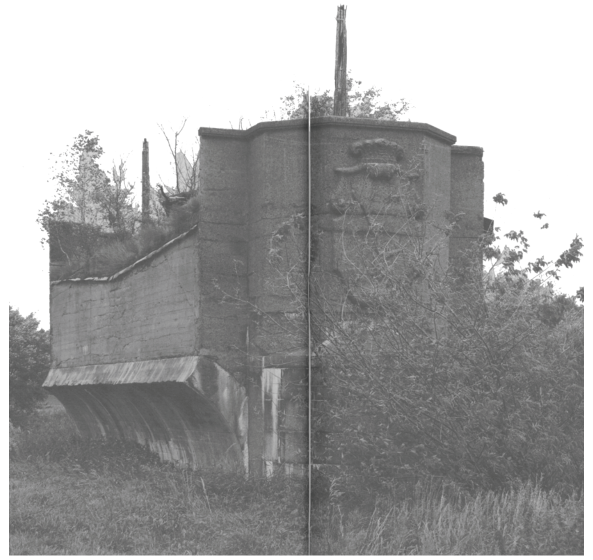


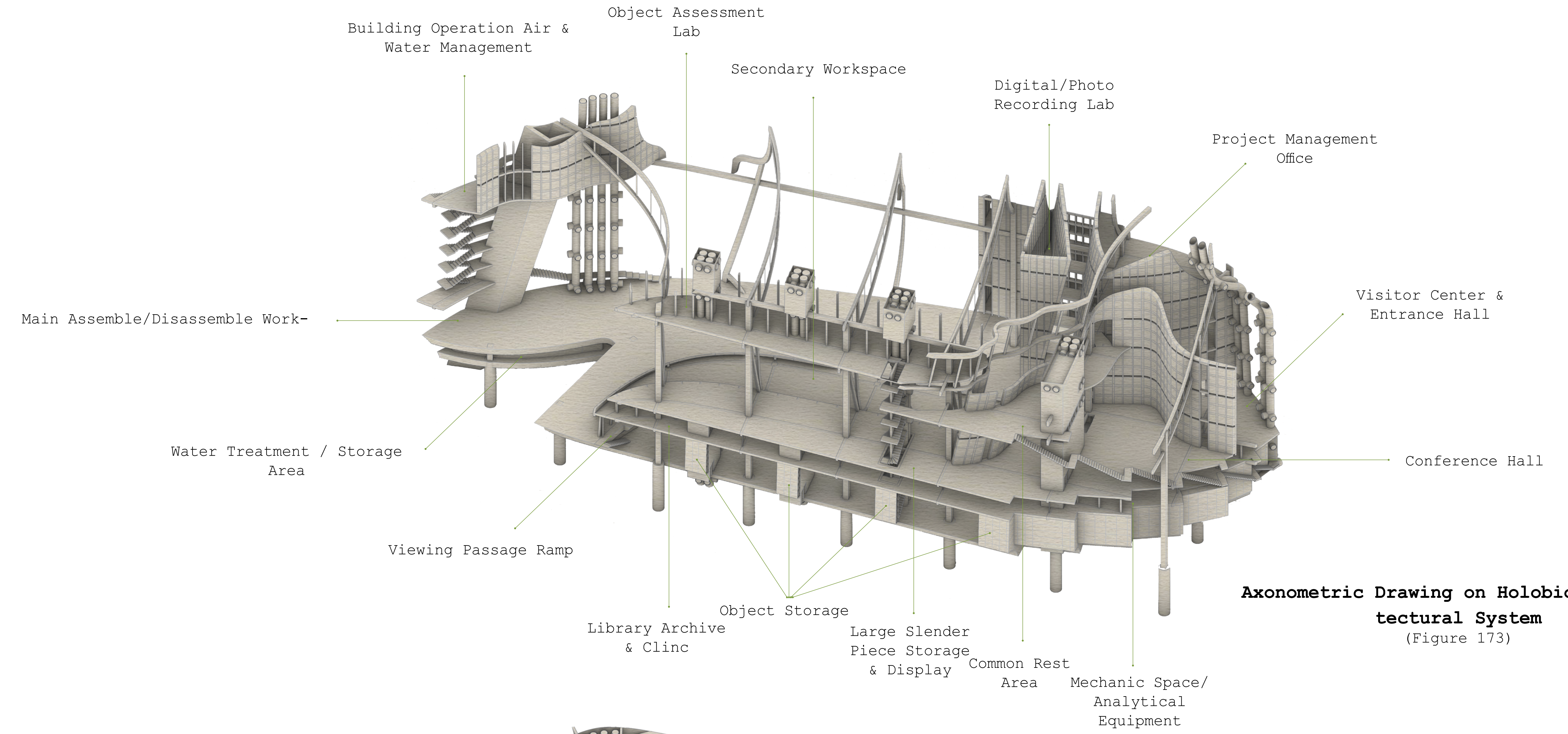
Figure 171: Bridge Fragment of Lange Brücke (The long bridge) at Forst (Studio Tom Emerson, 2012, p55)

Figure 172: Sketch on Original Lange Brücke

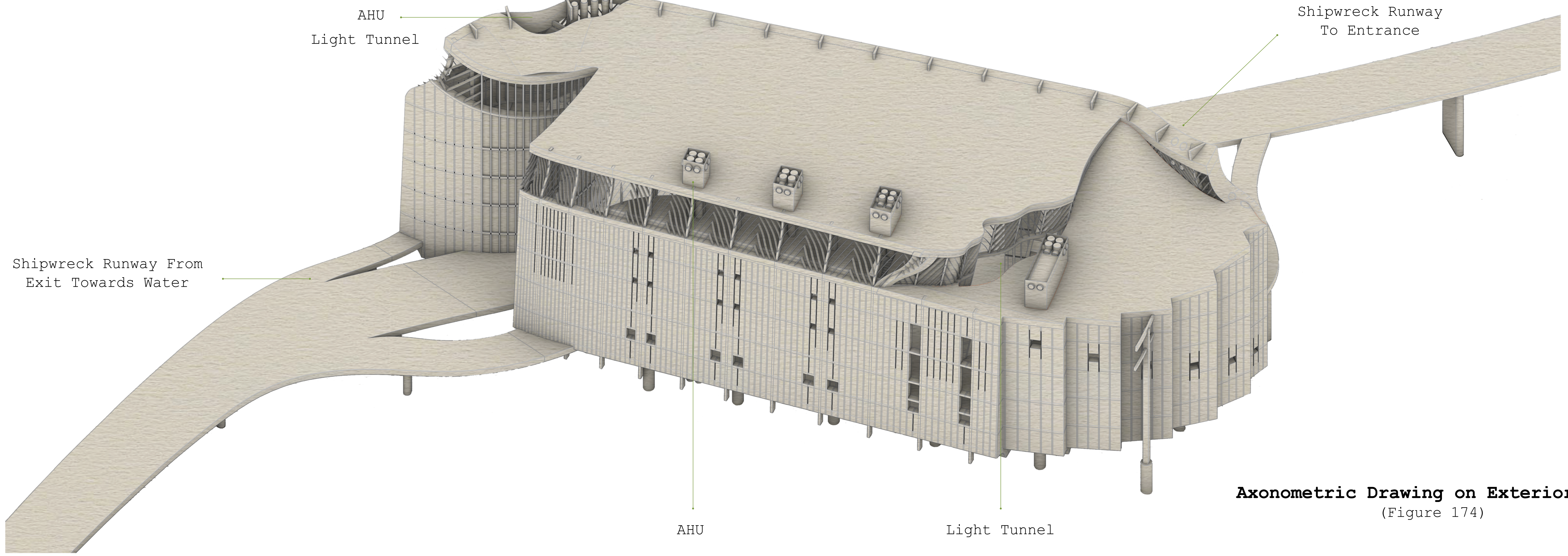
Ontological Precedent:
Broken Object That Breaks Free into Autonomy

To create parts with a new presence after breaking from the original wholeness, these parts must possess autonomy, character, or a life of their own. After breaking away from the original function, the bridge fragment of Lange Brücke (The Long Bridge) at Forst becomes something entirely independent.

In contrast, modern architecture, with its rectilinear order and generic shapes, fails to achieve such autonomy once it falls apart. The lack of Individual life renders these structures lifeless after their breakdown.



Axonometric Drawing on Holobiont Archi-tectural System
(Figure 173)



Axonometric Drawing on Exterior View
(Figure 174)

6.2 Architectural Drawings & Analysis

g. Architectural Program & Measurements

Building Dimension:
The entire building is 144.80m in length, 53.70m in width and 56.70m in height. The single floor area is 5711.0 sqm. The main assembly/disassembly workspace for shipwreck is 2063.4 sqm. Overall, there are six floors.

Building Program & Measurements:
Object storage & water treatment/storage area (ground floor):
Floor area: 4253.79 Sqm, floor height: 1.36~9.90m (various)
Main Assemble/disassemble workspace (1st floor):
Floor area: 2063.40 Sqm, floor height 29.21 ~ 42.10m (various)
Viewing passage ramp (1st floor):
Floor area: 170.71 Sqm, floor height 1.80 ~ 6.74 M (various)
Secondary workspace (2nd floor):
Floor area: 698.75sqm, floor height 27.45m - 30.07m (angled roof)
Visitor & staff entrance hall, passage & light tunnel (2nd floor):
Floor area: 585.08 Sqm, floor height: 21.81m ~ 35.93m (angled roof)
Library archive/clinic/mechanic space (reserve power supply)/analytical equipment (2nd floor):
Floor area: 1309.93 Sqm, floor height 3.6m
Guest viewing deck/ staff monitoring deck (2nd floor):
Floor area: 8.31 Sqm, floor height: 6m
Project management office (2nd, 3rd, 4th, 5th floor):
Floor area: 380.18 Sqm +350.19 Sqm +320.34 Sqm +290.61 Sqm = 1341.30 sqm, floor height: 6m or 2.63m ~ 15.00m (angled roof)
Digital/photo recording lab (3rd, 4th, 5th floor):
Floor area: 17.73 Sqm 27.72 Sqm + 37.92 Sqm = 83.37 Sqm, floor height: 6m or 9.03 ~ 15.00 M (angled roof)
Conference hall (3rd floor):
Floor area: 627.25 Sqm, floor height 12.00m ~ 23.65m (angled roof)
Extra-large/slender piece storage & display area (3rd floor):
Floor area: 612.06 Sqm, floor height: 12.00m Or 18.00m
Building operation air/water management (5th floor):
Floor area: 262.72 Sqm, floor height: 11.98~12.89m (angled roof)
Object assessment lab (5th floor):
Floor area: 539.82 Sqm, floor height: 5.73 ~ 5.86m (angled roof)
Common rest area tea & coffee (5th floor):
Floor area: 284.43 Sqm, floor height: 6.00~11.17m (angled roof)

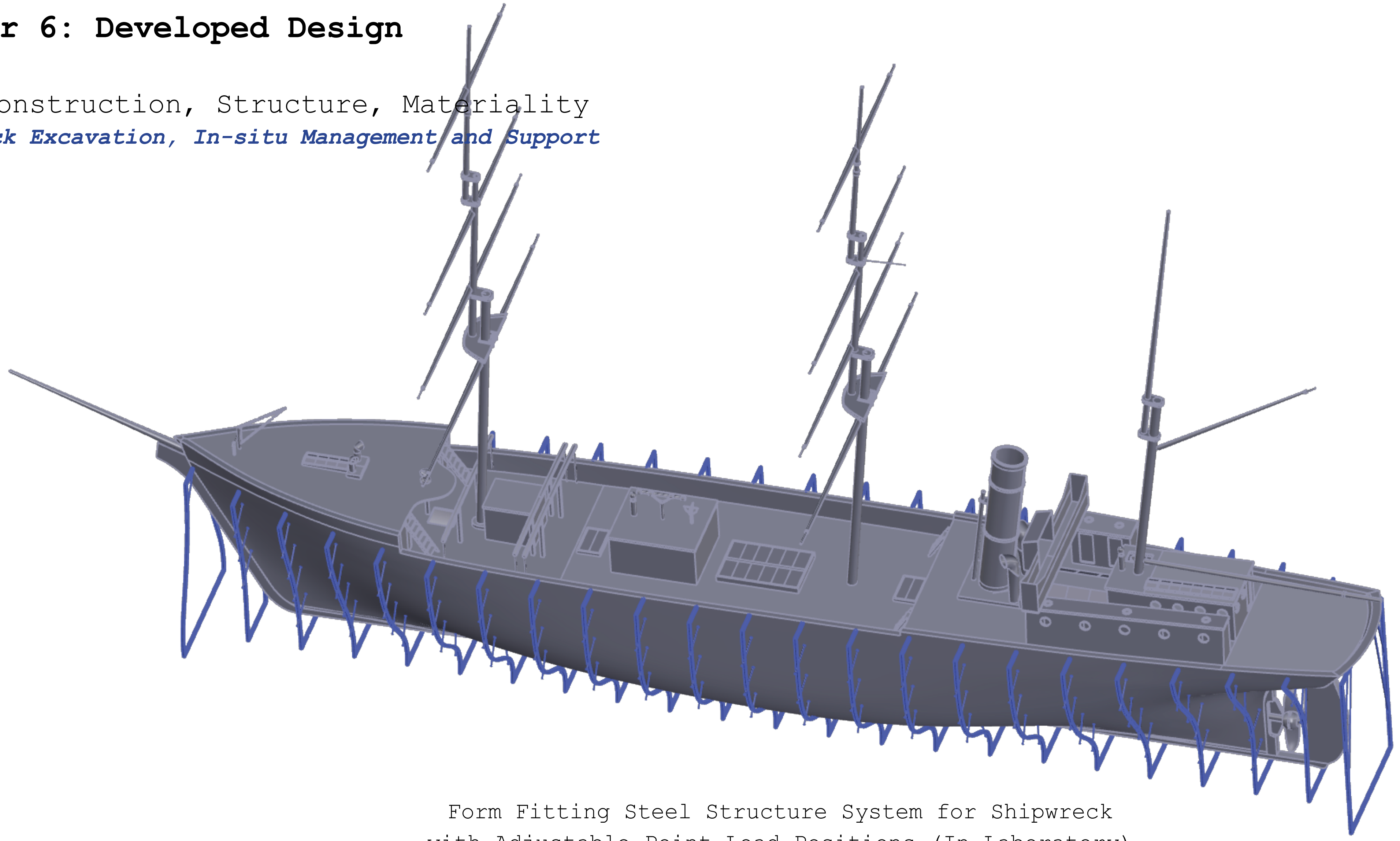
Roof:
Roof area: 1003.29 + 136.11 + 2999.13 sqm = 4138.53 sqm
Tilted Wall/ Roof:
Area: 2543.16 sqm + 512.45 sqm = 3055.61 sqm

Total Architectural Area (excluding staircase & roof area):
12840.92 sqm

Chapter 6: Developed Design

6.3 Design analysis: Construction, Structure, Materiality

d. Demonstration on Shipwreck Excavation, In-situ Management and Support Structure



Form Fitting Steel Structure System for Shipwreck
with Adjustable Point Load Positions (In Laboratory)
(Figure 175)

c. Demonstration on Shipwreck Excavation, In-situ Management and Support Structure

1 Ship Wreckage:

1) Waterlogged shipwrecks undergo two main types of corrosion:
Anaerobic corrosion: Affects parts buried under sediment or covered in encrustation.
Aerobic corrosion: Affects parts exposed to the saltwater environment.

2 In-situ Management/Preservation:

1) Shipwreck Coverage: Shipwreck remains are covered with sediment and wrapped in Synthetic Erram® T4000 geotextile for protection.
2) Artificial Seagrass: Installed to reduce sediment transport and stabilize the wreck site.
3) Metal Mesh Grid: A netting system riveted to the seafloor with gravel blocks to secure the ship-wreck in place. Also serves as a coordinate reference for mapping artifacts and ship fragments on site.

3 Excavation: Prepare For the Rising

1) Clearing Sediment: Sediments surrounding the shipwreck are carefully excavated to create work-space tunnels.
2) Steel Cable Weaving: Strong steel cables are threaded beneath the wreck to form a supporting structure.
3) Caisson Placement: Form-fitting caisson parts are positioned on either side of the wreck and connected by steel cables.

4 Excavation: Rising the Shipwreck

1) Connecting Caisson Parts: Steel cables are tightened to secure the caissons. Another caisson component is installed as a cap.
2) Airbag Inflation: (Indicated by green curves in drawings) Steel airbags are positioned beneath the shipwreck. Air is gradually introduced, replacing water to increase buoyancy.
3) Lifting the Shipwreck: The shipwreck is lifted to the water's surface using the buoyant force of the airbags and the steel cable system.

Diagram of Shipwreck Excavation Process:

Figure 176: 1 Ship wreckage

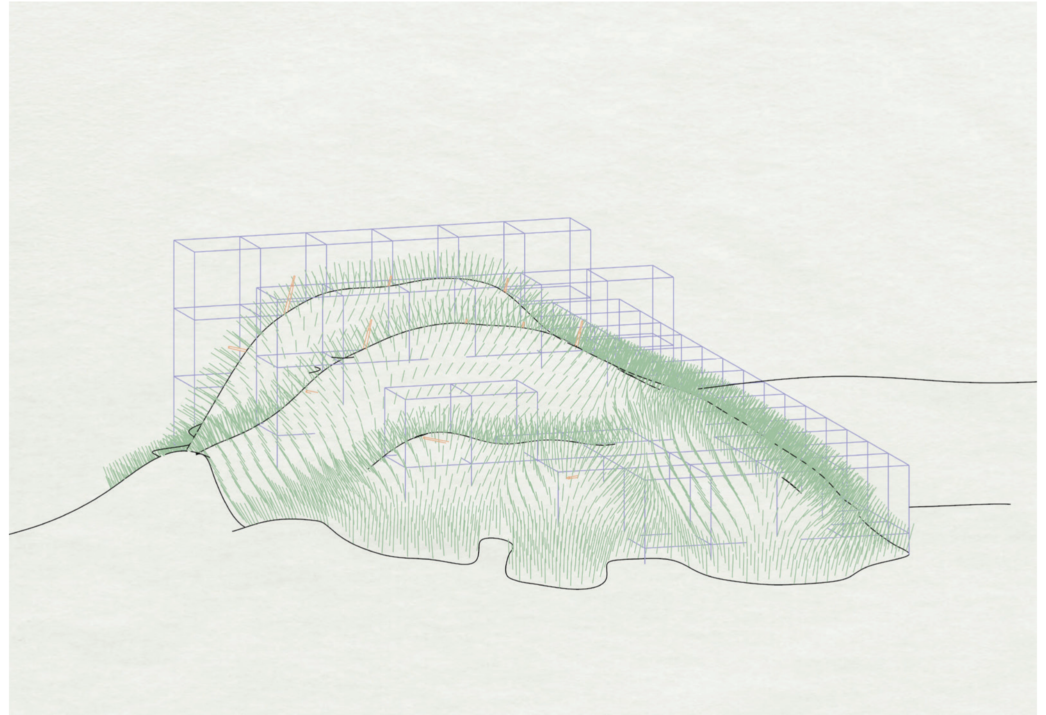


Figure 177: 2 In-situ Management/Preservation

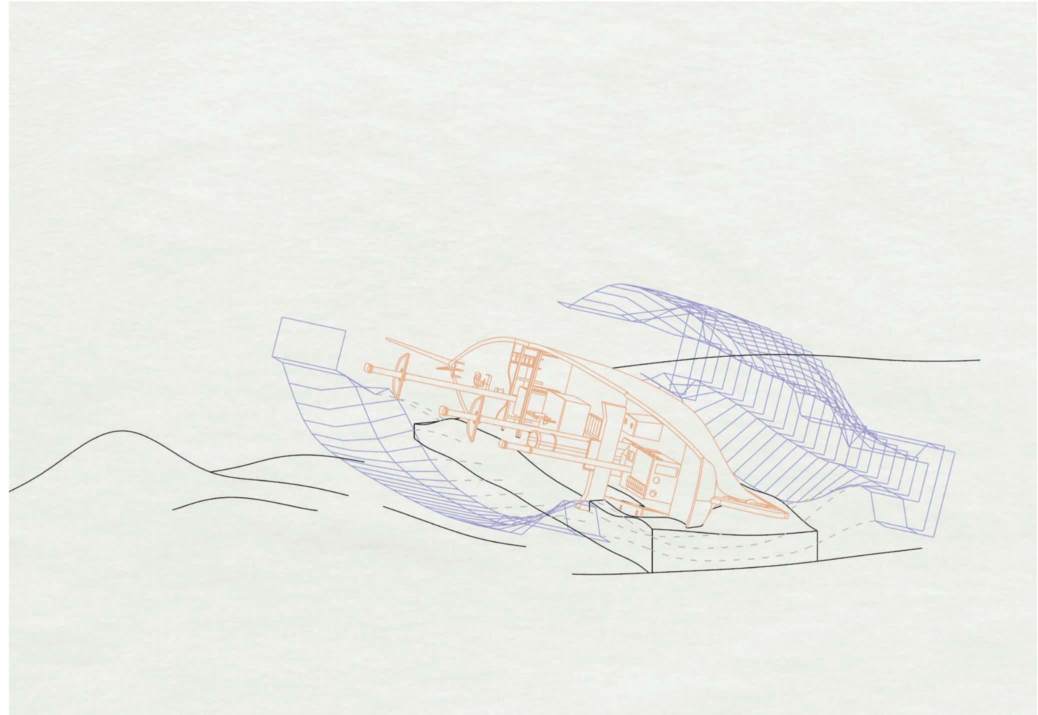


Figure 178: 3 Excavation - Prepare For The Rising

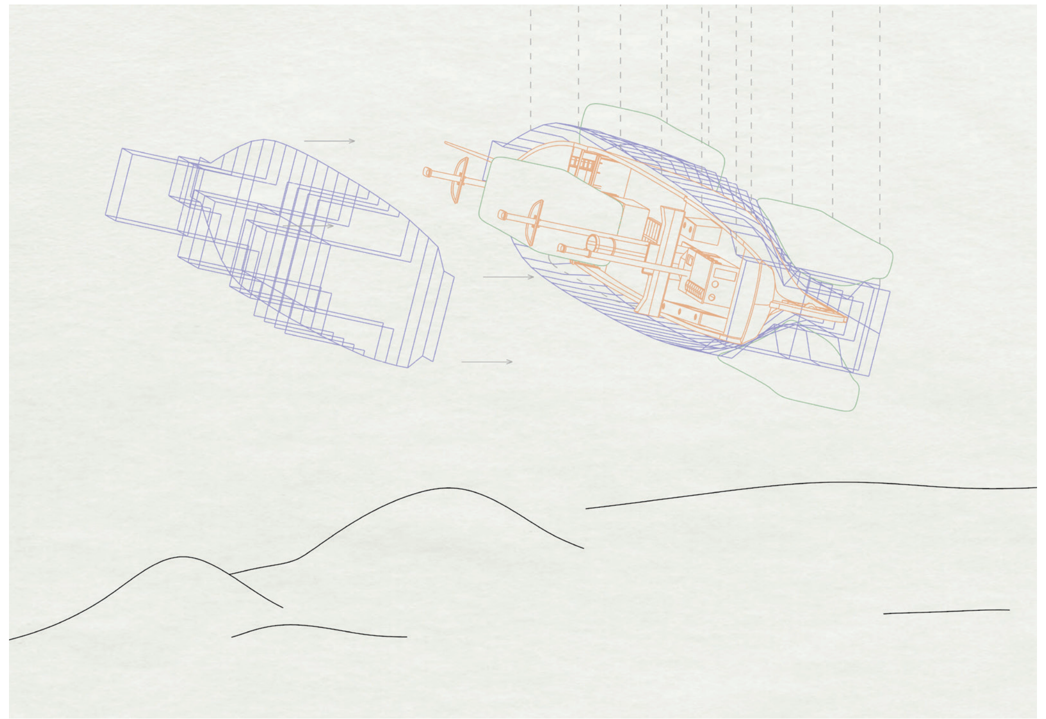


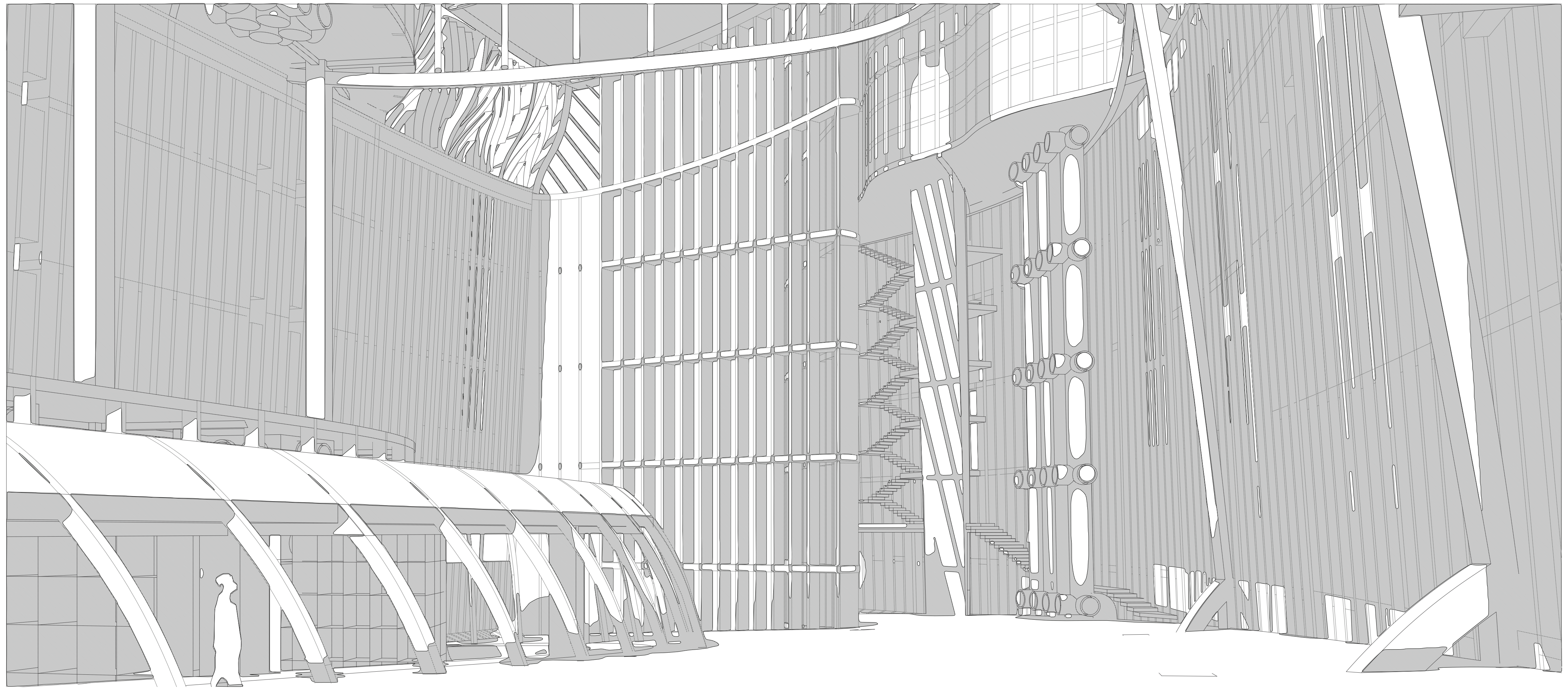
Figure 179: 4 Excavation - Rising The Shipwreck

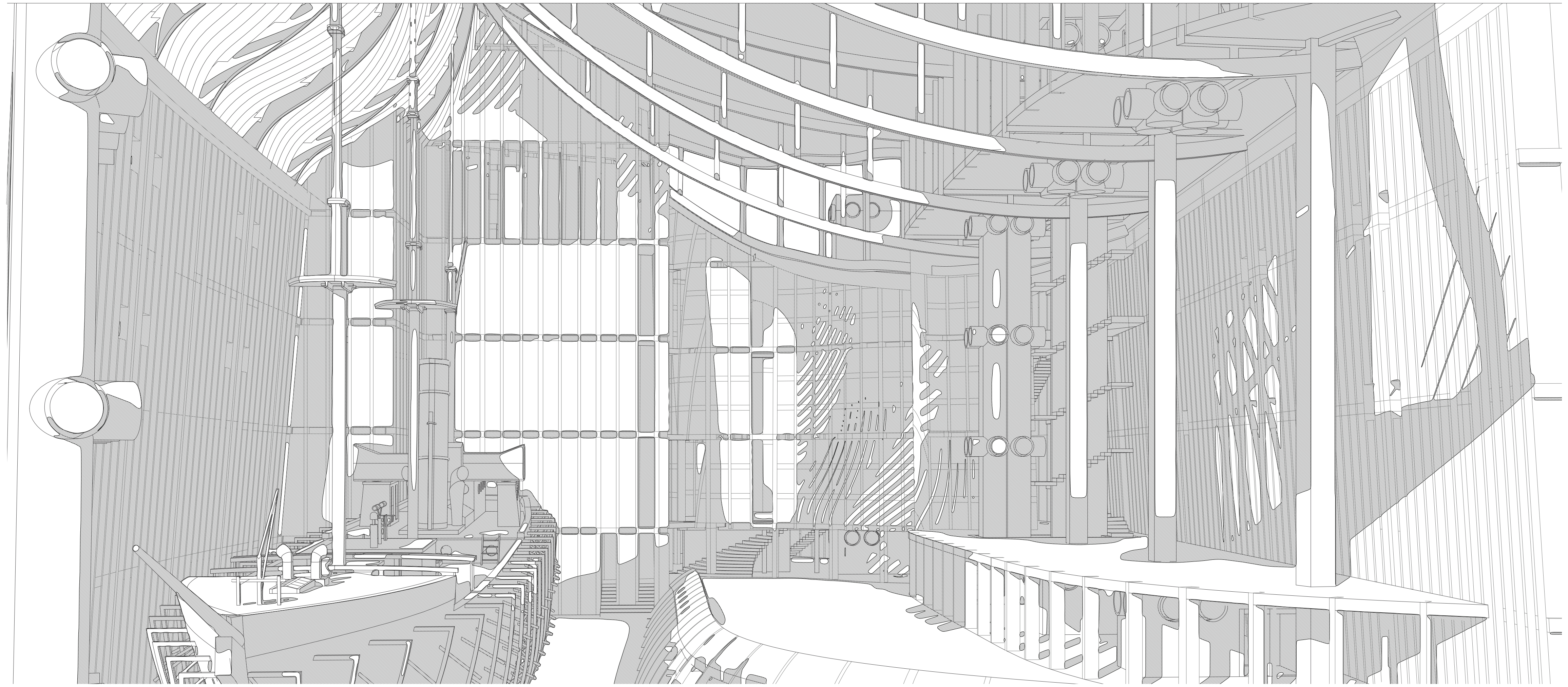
Chapter 6: Developed Design

6.4 Perspective Images

Perspective Functional Space
[Visitor Viewing passage & Assemble/
Dissemble Hall]

(East Facing)
(Figure 180)





Perspective Functional Space
[Shipwreck Assemble/Dissemble Hall]

(West Facing)
(Figure 181)

Three Stages in One Sight

Living boat vs. decaying ship,
Quiet shore vs. weaving water,
With the preserved dead in between, as a thin Layer of ceremony

Here, the guests’ vision is perpendicular to this scene, witnessing the three destinies of the vessel in one image, before entering the space. So guest can decide whether they still wish to proceed at the very beginning of their visit.
Here, the Vessels are made aware of their futures, so they will not feel surprised anymore.
Here, conservators work over decades to impose the orderliness of humanity.

(Figure 182)

6.4 Perspective Images

The Three Moirai

Ship In Voyage Receives Clotho (The Spinner)
(Figure 183)

Chapter 6: Developed Design

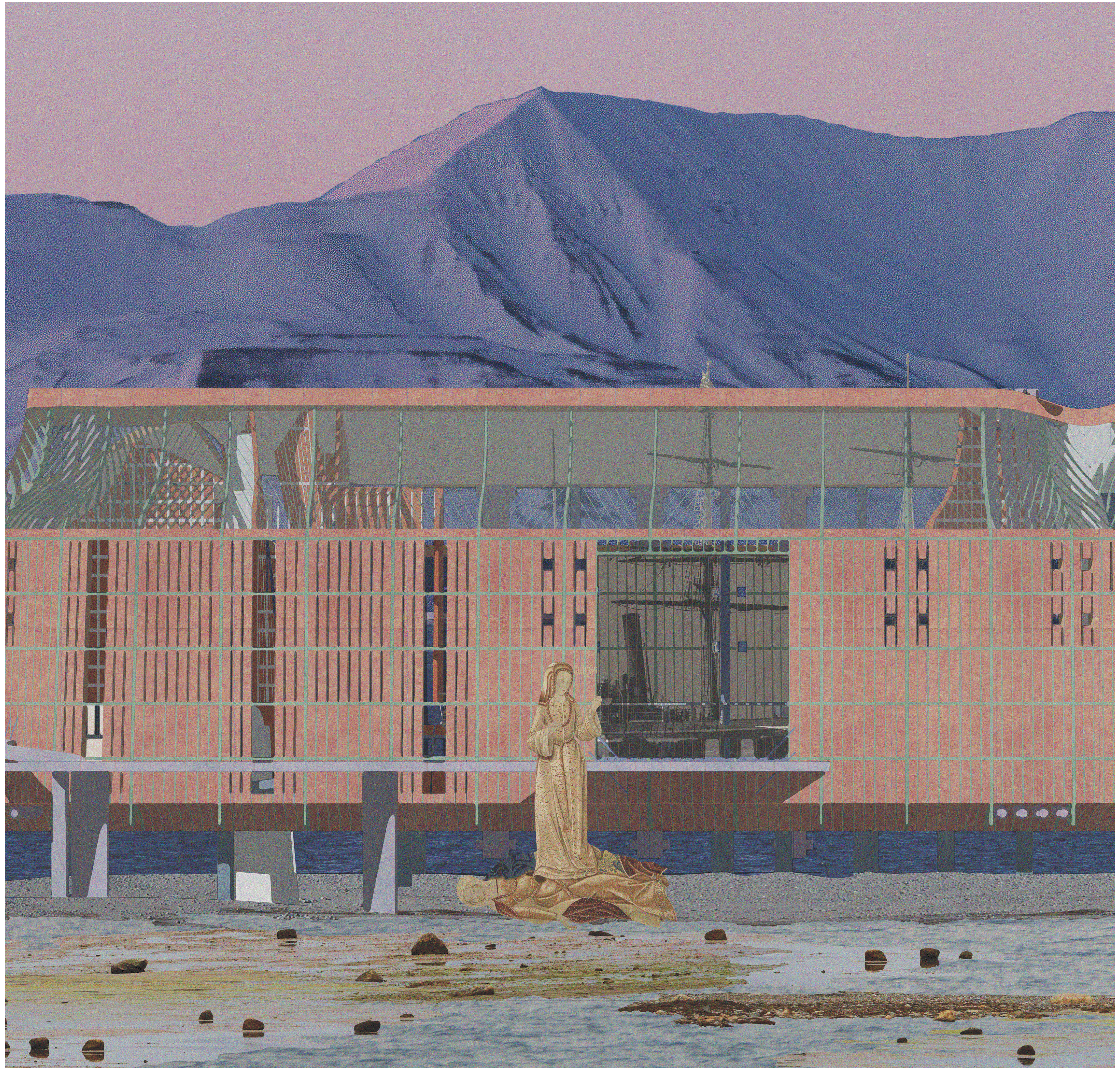
6.4 Perspective Images

The three Moirai

Preserved Shipwreck Receives Lachesis

(The Allotter)

(Figure 184)



Chapter 6: Developed Design

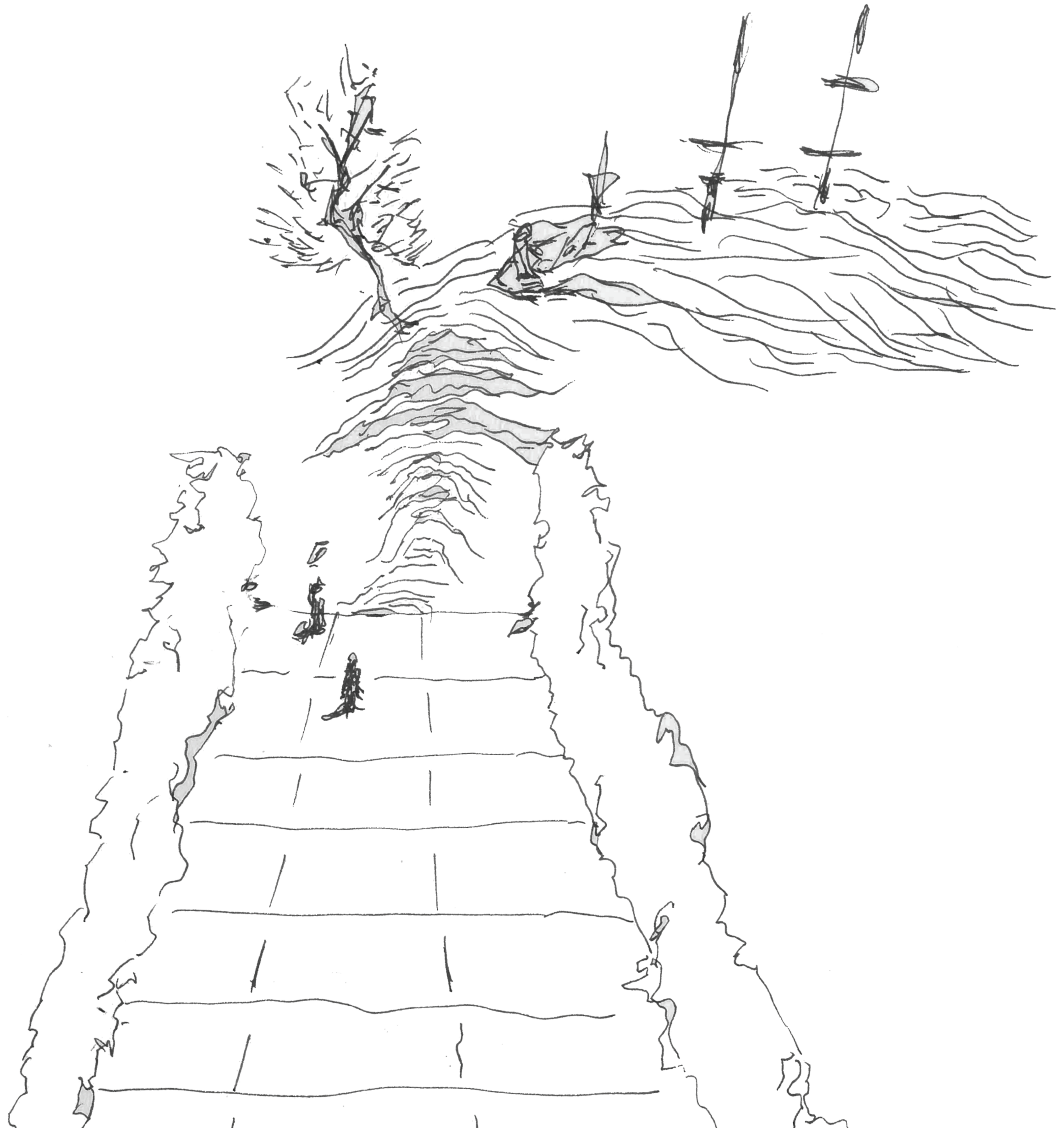
6.4 Perspective Images

The Three Moirai

Decaying Shipwreck Receives Atropos

(The Inevitable

(Figure 185)



Chapter 7: Results, Discussion, Reflection

7.1 Critical Reflection

Chapter 8: Conclusion

Chapter 7: Results, Discussion, Reflection
7.1 Critical Reflection

Challenges in Systematically Integrating Cutting-Edge Preservation Technology into Design

In shipwreck preservation, treatment approaches for waterlogged artifacts face significant challenges, including potential molecular alterations and the question of treatment reversibility. Many treated artifacts cannot be practically preserved (Hamilton, 1999). Additionally, a large number of shipwrecks lie thousands of meters below the sea, beyond human reach, where current excavation methods remain impractical.
The preservation facilities proposed in this thesis are primarily based on technologies developed around the year 2000. Over time, many of these approaches have revealed flaws. For example, the formation of sulfur compounds on PEG-treated wood surfaces. Today, this field serves as a testing ground for new preservation technologies, materials, and equipment, which opens further possibilities for architectural integration.
Given the technological complexity and the multidisciplinary expertise required in this field, it is unrealistic for this thesis to comprehensively establish a systematic architectural design manual. Instead, many of these aspects are discussed conceptually, leaving room for further architectural refinement and development.

Interdisciplinary Research Opportunities

The integration of marine archaeology and conservation with architecture has been an eye-opening and intellectually stimulating process. However, gaining access to maritime museums and shipwreck preservation laboratories with detailed architectural documentation has proven difficult. In the future, direct involvement in excavation and preservation projects—collaborating closely with experts—would enhance the credibility and depth of research in this area, which remains a limitation of this thesis. Nevertheless, I consider this work as one of the first into bring the paradigm shift from an architectural design viewpoint in academia.

Autonomous Architecture as a Form of Critical Knowledge

This thesis uses the "otherness" of shipwrecks as a way to provoke a discussion on the "otherness" of architecture. Contemporary architecture is overwhelmingly focused on serving human needs and fulfilling sustainability agendas. Architects frequently design buildings as "frames", stating 'we are building platforms, so community character can grow, or so that inhabitants could develop their own content.' What's even worse? The frames that are being produced are constantly taking other frames as reference, making our built environment and ourselves, hollow inside.
I argue that architecture's "otherness" lies in its capacity for self-generative force. its ability to exist as absolute architecture beyond mere function. The autonomous architecture makes architecture critical.
Some critiques of this thesis suggest that heterotopia has been extensively explored in postmodernist discourse. However, my intention is not to reaffirm these theories from a postmodernist perspective. Rather, I use this as a way to appreciate the independent life of shipwrecks and their "partial being." The appearance of Laboratory No. 5, may resemble the form of ship for some readers. However, this design is not a literal mimicry of a ship or a shipwreck ruin. It is a form of wish to accompany the journey of shipwreck's further to its absolute otherness, a 'complete life' with face.

Chapter 8: Conclusion

This thesis explores an architectural form of 'greeting' toward the shipwreck, seeking to engage with its otherness. The proposed architectural work translates the abstract proposition of Cordelia's silence into an architectural language. Spaces are imagined and crafted through the ideas of heterotopia, 'degrees of life', and 'face,' resonating with the shipwreck's authentic, semi-natural, semi-artificial state. The architectural design intends to reflect a paradigm shift—from an anthropocentric approach to heritage reclamation and historical education to a humbler contemplation of the shipwreck's intangible existence between the artificial and the natural.

Secondly, a holobiont architectural system is introduced to add a practical dimension, integrating shipwreck preservation processes, material relationships, and environmental considerations into the design. The proposed artifact treatment principles challenge the traditional philosophy of restoring artifacts to their original, manufactured state, instead striking a priority of maintaining the shipwreck's natural state over highlighting its cultural significance. Technically, the treatment procedures are suggested to be simplified, shifting away from intensive reduction processes and promoting a slower, more environmentally conscious preservation method with reduced chemical reliance.

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Appendices

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

I: Organic
1: Seeds and Plant Material
2: Bone, ivory, Teeth and Antler

Underwater Archaeology Preservation Techniques Based on Material Types:

Material list for treatment includes:

I: Organic
1: Seeds and Plant Material
2: Bone, ivory, Teeth and Antler
3: Leather
4: Textile

II: Timber
5: Wood

III: Inorganic
6: Pottery, Stone
7: Glass
8: Encrustation Removal
9: Encrustation Mold Casting

IV: Metal
10: Iron
11: Cupreous (Copper, Bronze, Brass)
12: Silver
13: Lead, Tin, Pewter and Lead Alloys
14: Gold & Gold Alloy

I: Organic
1: Seeds and Plant Material

Treatment method for seeds and plant material could be refered to bone (Hamilton, 1999). The extensive discussion of this category will not be covered in this essay.

I: Organic
2: Bone, ivory, Teeth and Antler

Bone and ivory are susceptible to warping from heat and moisture. In waterlogged environments, This group of material can degrade into a porous, sponge-like state. As ossein undergoes hydrolysis, the porous cell will be fill with silica and mineral salts, leading to fossilization.

[Pre-treatment Storage]:
Apply cool sea water for only short-term storage. This group material should be treated with (High urgency).

[Treatment Procedure]:
Step 1: Remove surface dirt by:
a. Wash with soap in water/alcohol
b. Apply brush or scrape gently with dental tools to remove stain.
c. Towel dry.

Step 2: remove Of soluble salts by:
Type A: While treating bone in good condition, use:
100 % sea water -> 75% sea water + 25% fresh water (local tap water) -> 50 % sea water + 25 % sea water -> fresh water -> deionized water.
Monitor soluble salts and chloride level.
Type B: While treating structurally unsound bone, use:
(1): solution of Acryloid B-72 and follow with rinse.
(2): ethanol, acetone or diethyl baths(from alcohol water mixture -> 100% alcohol)
(3): resin to strengthen weak structure.

Step 3: Remove Insoluble Salts & Stains:
Tools like picks is preferred over chemical method. Calcium carbonate stains are removed by hydrochloric acid or formic acid. Iron stains are treated by oxalic acid, ammonium citrate mixture. Sulfide stains are removed by hydrosulfite and hydrogen peroxide solution.
Step 4: Consolidation:
Apply diluted synthetic resin solution to strenghen material (Elmer's Glue All for large bone. PVA V7 or Acryloid B-72 for ivory, PVA V15 for object with low density). Brush coating and dry material for multiple times.

[Post treatment Storage]:
Cooled environment, Low RH and Low moisture (specific data for such material are not found)
Canadian Conservation Institute (CCI)'s Guidelines suggest a general indoor condition of: 18-22°C, RH levels at 45-55%, low light conditions under 50 lux, apply UV-filtered lighting and glass.

[Special Facility]:
Conductivity meter, vacuum environment for slution immersion, dental tools.
Silver nitrate, synthetic resin, hydrochloric acid, formic acid, oxalic acid, ammonium citrate, ethanol, acetone, hydrosulfite, hydrogen peroxide, tap water, deionized water.etc

Additional Comment Based On Theortical Framework:
principle 1

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

I: Organic
3: Leather Conservation
4: Textile

I: Organic
3: Leather Conservation

In waterloged anaerobic environments, the acidic byproducts and hydrogen sulfide produced by anaerobic bacteria can cause leather degradation. hydrolysis process occured on collargen weakens leather’s structure.

Books on underwater archaeology and conservation, such as “Conservation of Leather and Related Materials” by Marion Kite and Roy Thomson, provide detailed information on the preservation and deterioration processes of leather in marine environments

[Passive Storage Prior To Treatment]:
Storage waterlogged leather and organic material in fresh water with the ethanol addative. Glycerin and drops of formaldehyde are optional. (Medium urgency)

[Waterlogged Leather Treatment Process]:
1. Remove soluble salts (similar procedure as for bone and ceramics).
Remove Iron staining: ammonium citrate or disodium EDTA.
Remove Calcareous material: hydrochloric acid.
2. Remove ingrained dirt by mechanic rinse in aqueous soltion with non-ionic detergent or sodium hexametaphosphate and Calgon (water softener).
3. Clean the piece in running water and balance PH.
4. (Optional) Consolidate with PEG treatment
5. Drying: Freeze drying, solvent dehydration (such as acetone) or controlled air drying.
6. (Optional) Softening and Dressing: Apply lubricant (glycerin treatment) on brittle or desiccated leather in alcohol(faster) or water(slower) and manipulate the form. Drying with acetone bath or or with Bavon lubricant brush on surface.

[Drying method]:
1. Freeze drying
2. Solvent dehydration (such as methyl, ethyl, ketone or acetone)
3. Controlled air drying

[Indoor Treatment environment]:
From 53-55°C to 60°C humid thermostatically controlled oven, ventilated vat
-20 to -30°C freeze-drying chamber under vacuum

[Post treatment Storage]:
Store Leather and other waterlogged organic material at a RH of 45-60%, and never goes above 63%.

[Special facility]:
Soft brushes, water jets, ultrasonic cleoners, ultrasonic dental tools, freeze-drying vacuum chamber, humid thermostatically controlled oven, blotting paper, glass plates .etc

Water, formaldehyde, Dowicide (TM), glycerin, methyl, ethyl, ketone, acetone, anhydrous lanolin, beeswax, diethylether hexone, Bavon ASAK 5205, ethanol, Lissapol, castile soap .etc

Additional Comment Based On Theortical Framework:
principle **1,6,7**

I: Organic
4: Textile

In waterloged environments protein in Animal fibers, are generally more stable than cellulose in plant fibers. Flax and cotton are prone to bacterial attack in humid environment. Both animal and plant fibers suffers degeneration while exposed to light, insects, microorganisms, and air pollution, which reduce the textile strength and flexibility. Oxygen in atmosphere causes slow disintegration of these materials.

Main factors contribute to textile decay:
1. Organic factors: Attack by molds, insects and bacteria, damp heat, stagnant air, contact of plant matter.
2. Physical factors: desiccation and embrittlement resulted from excessive heat; tendering caused by exposure to ultra-violet light, degradation affect by susceptible dyes.
3. Chemical factors: noxious gases. etc

[Passive Storage Prior To Treatment]:
Limit Textile exposure to atmospheric pollutants & ultra-violet light; Storage of dark place. Store material in De-ionize water(situational) or organic solvents at a Tempreature of 10°C. (Medium-high urgency)

[Textile Treatment Procedure]:
1.Identify fiber’s composition including: physical tests, such as burning; microscopic and textile stain examination. etc Record pertinent the property of the fibers.
2. Cleaning
Remove soil, discoloration and stains: Rinsing in de-ionized water with ammonium hydroxide, non-ionic detergent and hydrogen peroxide.
Remove stubborn stains: Apply de-ionize water with sodium silicate, sodium carbonate and sodium hydroxide to remove mildew, mold, black sulfide stains, and organic stains.
Remove Copper Corrosion Stains: De-ionized water with ammonium hydroxide
Silver Corrosion Stains: De-ionized water with potassium cyanide, iodine, sodium thiosulfate.
Iron Rust Stains: De-ionized water with EDTA disodium or ammonium citrate (less damaging but slow) or hydrochloric acid, oxalic acid, hydrofluoric acid. etc (drastic but fast and effective)
4. Rinsing with de-ionized water
5. Organic Solvent Cleaning: Dry cleaning with organic solvents, like perchlorethylene, trichlorethylene or petroleum.
6. Reinforcing Fragile Textiles: Polyvinyl alcohol, Polyvinyl acetate (V7), Ethulose, Polymethacrylate or Acryloid B-72. Apply synthetic mesh of terylene or glass sheet mounting for fragile textiles. Iron (heat-sealed) mesh onto the textile. Weft affixed with consolidant drops on breaks in the threads.
7. Sterilization: Place textile in closed container with thymol crystals(crystals vaporize by placeing the container next to light bulb). Spray ethanol and de-ionized water mixture with lysol solution or carbon disulfide as fumigation agents on to the textile.

[Post treatment Storage]:
Limit exposure to atmospheric pollutants and ultra-violet light; Use moth balls to deter insects.Store item in dark place and avoid direct sunlight. Keep the Tempreature at 10°C and RH < 50% (A RH < 68% discourages mold growth).

[Special facility]:
heat-sealing iron, hot plates, closed container, operable light bulb, textile testing devices, Flat and shallow pans, plastic or glass sheets and racks. etc
De-ionize water,sodium silicate,sodium carbonate,sodium hydroxide, n-alkyl, n-ethyl morpholinium, ethyl sulfates. etc

[Health & safety]:
Precautions on the toxicity and flammability of chemicals.

Additional Comment Based On Theortical Framework:
principle **6:**

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

II: Timber
5: Wood

II: Timber
5: Wood

In aquatic sites, wood is often found to be stable but waterlogged. The primary cause of wood degradation in underwater environments is insect attack. In anaerobic, waterlogged conditions, wood experiences chemical alteration internally which reduce its strength. Over time, hydrolysis causes the cellulose in the cell walls to break down, leaving only the lignin network intact. The porous wood, filled with water in the remaining lignin cells, hold the shape of wood.
Class I: over 400% expansion of waterin in lignin network
Class II: 185-400% expansion of waterin in lignin network
Class III: less than 185% expansion of waterin in lignin network

[Wood Pre-treatment Storage]:
Fresh tap water for waterlogged wood with medium-low treatment urgency.

[Waterlogged Wood Treatment Process]:
1. Cleaning surface dirt
2. Removed large amount of soluble salts(white bloom leached out from treated wood destablizes iron components in it).
3. The injection of material(PEG or Sucrose) into the wood to give it strengthen while replacing the water.
4. Remove excess water to halt shrinkage or distortion (solvent dry or freeze-drying).

Type a. Polyethylene Glycol (PEG)(suitable for large or small items)
PEG stucked in cellular voids leads to intra-cellular damage, weaken the structural integrity. PEG is also corrosive to common metals, particularly iron.
1. cleoned by rinsing fresh water
2. (Optional) HCl pre-treatment to enhance the PEG penetration. However finished items could subject to checking and shrinkage.
3. Soak in alcohol (ethanol, methanol, isopropanol) to removes water while inflating the wood.
4. wiped off the excess wax.
5. Climated controled cooling.
6. Removed surplus wax on the surface by hot-air gun.

Type b. Sucrose (suitable for Large & small items, least expensive method)
Finished product looks dull muted, which has hair line cracks appeared on the surface.
1. Rinsine with fresh water to remove ingrained dirt as well as soluble salts.
2. Apply Refined pure sucrose solution.
3. Add Dowicide A as anti-microbial agent, which also imporves penetration and protection.
4. Insecticide additive to minimize insect and rodent attacks
5. Air drying under controlled high humidity envirronment.

Type c. Acetone-Rosin (suitable for hardwoods which impervious to the high molecular weight PEGs) Due to the high cost, such method is practical for small objects. Acetone-Rosin also has flex limitation for wood.
1. Rinses with fresh water.
2. (Optional) Use Hydrochloric acid pre-treatment to enhace the wood permeability for rosin. However finished items could subject to checking and shrinkage.
3. Dehydrate by acetone, Ethanol or isopropanol.
4, Soak object in acetone solution with saturated rosin in a sealed Vat. Warm up solution to 52°C.
5. Remove surplus rosin by acetone-moistened rags.

Type d. Alcohol-Ether Method
The high cost limits this method into small-scale object.
1. Clean with fresh water.
2. Consecutive alcohol baths (isopropanol or ethanol)to replace most water.
3, Apply acetone to replace all water.
4. Soak object in dimethyl ether to replace all the acetone.
5. Dissolve dammar resin or colophony rosin(natural tree resin) in ether, for consolidation in final bath
6, Drying. Placing object in vacuum environment to volatize the ether.

Type e. Camphor-Alcohol Method
It is economically impractical for large objects. The solution is flammable.
1. Rinse with fresh water to remove ingrained dirt as well as soluble salts.
2. Dehydrate in alcohol baths
3. Heat camphor solution to 52°C
4. Move object out, wait for the alcohol to evaporate.
5. Apply varnish such as wax, polyurethone, dammar resin, colophony or PVA to the wood surface to impede the camphor evaporation.

Type f. Silicone Oil Method
Stabilize object by sealing it off from moisture and air with silicone polymers. (Irreversible)
1. Bath item in ethanol under vacuum.
2. Bath item in acetone under vacuum.
3. Mix SFD-1 silicone oil with isobutyltrimethoxysilone under a low vacuum.
4. Pat dry wood with rag, to remove surplus silicone oil on surface before setting.
5. Place the wood in a sealed container with FASCAT Catalyst 4200, in a furnace under 52°C.

[Drying]:
Freeze Drying:
A vacuum environment is preferred.
1. Mixe Borax/boric acid or Dowicide 1 with PEG to prevent slime.
2. Soak the wood in a freeze dryer with acetone and dry ice (frozen CO_2) under -25°C to -40°C.

[Post treatment Storage]:
Store treated wood in a RH of 45-60%.
Store the Sucrose treated wood under 70% RH.

[Special facility]:
Heat resistance stainless steel or glass vats allowing the circulation of solution, PVC pipe for ethanol Solution, Vacuum and low vacuum environemt for artefact sized wood (Type f & d), furnace, Freeze Dryer, hot-air gun.etc
Fungicide, Dowicide 1 (ortho phenylphenol), HCl, PEG, ethanol, methanol, isopropanol, sucrose, rosin, acetone, dimethyl ether, wax, polyurethone, dammar resin, colophony, PVA camphor, silicone, isobutyltrimethoxysilone.etc

[Indoor treatment environment]:
In case of Sucrose and PEG method. Object in ventilated vat among a 53-55°C to 60°C humid thermostatically controlled oven(It is not mandatory to seal it from indoor environment).
Object that applying the rest methods should be suspended or supported above the solution.
A sealed container is required for Acetone-Rosin method, Camphor-Alcohol method and Silicone Oil method with a terperature of 52°C.

[Health & safety]
Flammability of chemicals such as asacetone and ether.

Additional Comment Based On Theortical Framework:
principle **1, 4, 5.**

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

III: Inorganic
6: preservation of Pottery & Stone
7: preservation of Glass

III: Inorganic
6: preservation of Pottery & Stone

Stoneware and porcelain are impermeable to water and soluble salts in aquatic environment. Long rinses is unnecessary. However, porcelain glazes, that undergoes extra firings process, could have salts accmulated underneath. These salts could lead to glazes layer peeling off. earthenware can absorb soluble salts and its surface may deposited insoluble salts like calcium carbonate and calcium sulfate.In the seawater, frequent dissolving and crystallization of soluble salts occuring in encrustations can cause the exfoliation of pottery's surface layer, where these two are in close range.

[Pre-treatment Storage]:
stored **Pottery & Stone** in tap water with medium-low treatment urgency.

[Treatment Procedure]:
Treatment method for pottery also applies to metamorphic and igneous rock. more diluted acid should be applid to sedimentary rocks.
Type A: Well-fired Non-salt Pottery
Use soft brush scrub object surfaces assisted with mild detergents. Pieces, friable surfaces, flaking surfaces and fugitive paints demand resin to consolidate.

Type B: pottery with Salts
1, Consolidate item with Acryloid B-72 and rinse afterwards.
2, placing item in tap water to remove Soluble Salts. Monitor water conductivity to determine rinse progress.
3, Remove insoluble salts. Apply nitric or hydrochloric acid for fsturdy pottery, and hydrochloric acid for Glazed, friable or carbonate-tempered surfaces. Rinse object afterwards to remove acid residue.
Remove iron oxide stains with oxalic acid or EDTA, followed with rinse.
Remove iron sulfide and organic stains by soaking in hydrogen peroxide.
Remove Calcareous Deposits with nitric acid,hydrochloric acid or EDTA.
Remove Calcium Sulfate by mechanical cleaning or nitric acid.
Remove Silicates by hydrofluoric acid (dangerous acid) or Mechanical cleaning.
Remove Black Metallic Sulfide & Organic Stains by hydrogen peroxide.
4. Strengthen the material in diluted PVA or Acryloid B-72 solution.
5, Repairing & Restoration: dissolve Alpha cyanoacrylate glues(super glues) in acetone for setting, then replace solution with toluene.

[Post treatment Storage]:
Specific data for such material are not found. Canadian Conservation Institute (CCI)'s Guidelines are followed here: 18-22°C, RH levels at 45-55%, low light conditions under 50 lux, apply UV-filtered lighting and glass.

[Special facility]:
Scalpel (for scraping), dental appliance, dental picks Dental burrs and pneumatic air chisels. Various sized vats.
Tap water, de-ionized water, acetone, ethanol, PVA, Acryloid B-72, hydrogen peroxide, hydrochloric acid, oxalic acid, nitric acid, EDTA .etc

Additional Comment Based On Theortical Framework:
principle **1,2,3**

III: inorganic
7: preservation of Glass

Glass is a stable archaeological material composed of 70-74% silica, 16-22% alkali (soda ash or potash derived from wood ash act as fluxes), and 5-10% lime (calcium oxide) acting as a stabilizer. However, glass objects made in 17th-century could disintegrate in aquatic environments. Archaeological glass often consists of soda-lime or potash-lime glass. When there is an excess of alkali and a deficiency of lime, the glass becomes vulnerable to moisture, leading to 'weeping glass.' This condition causes the glass to craze, crack, flake, and pit, resulting in a frosty surface. Over time, the surface of any glass becomes hydrated and eventually leading to devitrification, giving it a frosty, cloudy, or iridescent appearance. Glass corrosion products can not be eliminated by treatment. It is alkalinity cause the natural deterioration of glass.

[Pre-treatment Storage]
Store glass artefact in tap water with low treatment urgency.

[Treatment Procedure]:
Type A: 18th century Leaded glass:
1. It is impervious to salt contamination. Baisc rinsing to remove incidental stains, such as lead sulfide or calcareous deposits.
2.Deposits removal (view salt removal part below)
3. Leaded Glass in anaerobic marine environment is covered with dense black lead sulfide film. Apply hydrogen peroxide solution to removes sulfide stains (same goes to ceramics).
4. consolidate the glass with resin.
5. (optional) Apply epoxy, such as araldite glues fragments for (irreversible) restoration.

Type B Weeping Glass Treatment:
1. Wash glass with tap water, then immersed in distilled water.
2. Deposits removal (view salt removal part below)
3. Alcohol dry the glass to inhibit disintegration.
4. Apply organic lacquer (PVA or Acryloid B-72) to retard disintegration.
5. (optional) Apply An epoxy, such as araldite glues fragments for (irreversible) restoration.

Type C Devitrified Glass treatment:
1. Rinse glass with tap water, then immersedin distilled water.
2. Deposits removal (view salt removal part below)
3. coating with PVA or Acryloid B-72 to add strength and impede further devitrification.
4. (optional) Apply An epoxy, such as araldite glues fragments for (irreversible) restoration.

Salts Removal: (Similar to ceramics treatment)
Lead Oxides Removal: nitric acid.
Iron Oxide Removal: sulfuric acid solution to neutralize the alkalinity of glass.
Calcareous Deposits Removal: hydrochloric acid, or tetrasodium EDTA.
Iron Stains Removal: oxalic acid or disodium EDTA.

[Post treatment Storage]
Type A: Store Weeping Glass in a dry environment, RH 20-30% , and must < 40%.
Type B: Store treated incipient crizzled glass in a RH 40-55% environment (caused by partial dehydration from previously hydrated condition).

[Special facility]:
Similar to ceramics

Additional Comment Based On Theortical Framework:
principle **1,2,3**

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

III: Inorganic
8: Encrustation Removal
9: Encrustation Mold Casting

IV: Metal
10: Ferrous Metal

III: Inorganic
8: Encrustation Removal
9: Encrustation Mold Casting

Encrustation Formation:
The corrosion of metals alters the local pH, disturbing the balance between dissolved calcium carbonate and carbon dioxide in seawater. This imbalance leads to the formation of insoluble precipitates such as calcium carbonate and magnesium hydroxide. These precipitates combine with sand, marine organisms, and corrosion byproducts (notably ferrous hydroxide, ferrous sulfide, and magnetite) to create a crust or concretion around the metal. This encrustation acts like a mold around the object, effectively separating any metal pieces that are in contact.

[Pre-treatment Storage]:
Apply fresh seawater (same seawater from where encrustations are recovered) at a temperature of 4°C to slow down biological and chemical coorsions. Maintain a low-light conditions to impede the growth of algae as well as other organism. This group demands urgent treatment. (ctgpt)

[Encrustation Removal process]:
1. Initial documentation: Apply X-ray machines to identify the properities of specimens, their location and size in encrustation.
2. Remove encrustation: Mechanical clean encrustation assisted by Hammers and chisels for large pieces; Chicago Pneumatic Weld Flux chisels for small object; Chicago Pneumatic Air Scribes for precise control. Labortory custom-made delicate scribes and chisels for special situation.
3. (Optional, no preferred) Electrolysis and 'deganguing': During the Electrolysis process, the hydrogen bubbles evolve at the metal surface will loosen the encrustation. Metal objects can then be removed by hand. This method can be destructive when applying on concretion embeded with mheavily corroded items.
4, Apply tap water and followed with deionized water to remove any excess chemicals.
5, Air-drying (Chat gpt)

[Casting Procedure:]
Once a ship wrecks in an aquatic environment, an encasing crust begins to form almost immediately. This encrustation preserves the surface details of the metal and can provide valuable information even after the object has deteriorated. The stored encrustation mold can be used to create epoxy casts for fragile metals or those that have completely corroded away.
1. Apply x-ray for close observation. Draw and ocat Specimens that is unclear on the radiographs.
2. Acids or electrolysis should not be used while remove initial encrustation.
3. Apply Casting material: such as silicone rubber, Smooth-On polysulfide rubber, Surgident Neo-Plex Rubber, Permamold Latex, Hysol Epoxy, plaster of Paris or Coecal plaster.etc
4, Apply Lapidary Saw Cut casting procedure or X-Ray Air Chisel Cut casting procedure for item casting.

[Post treatment Storage]:
Store encrustation in Acid-free containers with polyethylene foam supports, Provide a indoor environment with temperature at 18-22°C, RH 45-55%, UV-filtered, Low-light-level lighting. (Chat gpt questionable)

[Special Facility]:
Industrial X-ray machines, Fine bristle brushes, pointed wooden sticks, latex peel, Lapidary Saw Cut, Air chisel, pneumatic tools with air compressors, tube drills, sander. Forklifts, chain hoists, large vats, etc

Additional Comment Based On Theortical Framework:
principle **8,9**

IV: Metal
10: Ferrous Metal

Electrochemical Corrosion
When submerged in marine environment, a shipwreck behaves like a large galvanic cell due to the electromotive properties of its metals. Metals with more negative electrode potentials are more active and tend to lose electrons, undergoes electrochemical reactions. Aerobic conditions result in the electrochemical oxidation of iron, producing ferrous and ferric corrosion products. The formation of encrustation on the outer layer impedes oxygen contact with the inner layers, where anaerobic corrosion persist within because of sulfate-reducing bacteria. This ongoing process contributes to a loss of density, physical strength, and deformation of the metal. Over time, iron objects can transform into various compounds, including ferrous sulfide, mineralized oxide, magnetite, granular oxide, ferro-hydroxide, and ferric oxide.

[Pre-treatment Storage]:
Once Ferrous metal excavated from the sea water, the corrosion process accelerates. Such group needs to be treat with medium-high urgency. Prepared distilled water(Cl^- < 1 mg/L) or de-ionized water (Cl^- = 0 mg/L) as storage solvent. Tap water should be electrolyted to reduce chloride before use. Rain water (Cl^- = 1~10 mg/L) is a provisional measure between tap water (Cl^- = 10~250 mg/L) and de-ionized water to reduce expenses.
Short term storage: Metal encrustations are kept out of light stored cool (~10°C)in chloride-free solutions with oxidizing agents or alkaline inhibitors. Apply Sodium hydroxide, sodium carbonate, and sodium sesquicarbonate to balance pH(at 8-13) and passivate the iron. (Michael P. Scafuri,2004)
Medium term storage: Solution with potassium chromate, potassium dichromate, sodium chromate form thin film passivate ferrous metal.

[Treatment Process]:
Condition A: mildly corroded Object:
Electrochemical and electrolytic reduction applies to metal objects with a considerable metal core and a consolidated surface. This approach reverse the oxidised metal to metallic state and consolidate its surface.

Method a, Electrolytic Reduction Cleaning:
Apply an electrochemical reaction device with adjustable electromotive force (EMF) or electric current.
1. Investigate corrosion layers with a magnet, a dental pick, and X rays. Record diagnosis.
2 Mechanically remove encrustation and clean the object.
3. Wiring up artifacts for electrolysis.
4. Electrolytes: Place artifact in a form-fiting electrolytic cell as the cathode in electrolyte
(Alkaline solutions of sodium carbonate or sodium hydroxide with Gluconic acid, sodium gluconate, or sodium glucoheptanate). Use Tap water as solvent for items with high chlorides level. Then replaced solvent with Distilled or de-ionized water for chloride-free items.
5. Adjust DC power for oxidation and reduction: Apply mild steel or Stainless steel as anode material where electrons discharges(oxygen is evolved). Place treated object at cathode where receives electrons (hydrogen is evolved).
5. Turn off power when high hydrogen evolves and oxidized crust appears. Begin mechanical clean.

Method b Hydrogen Plasma Reduction:
Place metal artifacts in a quartz discharge tube fill with hydrogen gas under low pressure. the high-frequency radio waves ionize hydrogen gas into plasma state. Magnetite and ferric oxide surface are converted to metallic iron. Temperature requirement: < 400°C. Metallic structure of object is maintained in this process. Very high cost.

Condition B: Severely corroded object with overall shape:
Apply aqueous solution of sodium sesquicarbonate to passivate the object by diffusing out the chlorides. Strengthen object with synthetic consolidants such as microcrystalline wax.
Method a, Alkaline Sulfite Reduction:
Treatment carried out in an heated air-tight container. Barium hydroxide is slightly poisonous, contact with the skin avoided.
1. Investigate corrosion layers with a magnet, a dental pick, and X rays. Record diagnosis.
2 Mechanically remove encrustation and clean the object.

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

IV: Metal
10: Ferrous Metal

3. Soak object in sodium hydroxide and sodium sulfite. Air tightening the container and place it in an oven with a temperature of 60°C to remove chlorides. Use tap water for initial baths, de-ionized water or distilled water in the final ones. Iron corrosions are converted to magnetite result in a black surface on finished product.
4 Bath object with deionized water. Then placed it into barium hydroxide solution.

Condition C: Severely oxidized object without overall shape:
Rather than further treatment whcih could disintegrate it, consolidation is the most feasiable option. Meanwhile, casting a replica from encrustation mold is adopted by conservator.

Mothod a: Water diffusion:
1. Investigate corrosion layers with a magnet, a dental pick, and X rays. Record diagnosis.
2 Mechanically remove encrustation and clean the object.
3. Apply aqueous solution of sodium sesquicarbonate, sodium carbonate, or sodium hydroxide as inhibitor, to halt object from rusting.
2. Immersed object in tap water until the chloride level approximates.
3. Alternate heating(50°C) and cooling cycle of de-ionized water to remove chlorides.
4. Rinse to remove insoluble oxide sludge, metallic powder, residual chlorides, and electrolyte. Mesaure chlorides level with nitric acid test.
5. Rinse and dry object by adding gluconic acid, sodium gluconate, sodium glucoheptanate or potassium chromate into the de-ionized water to halt rusting.

Mothod b: Clear Plastic Casting:
Embed transparent plastic material into untreatable object.(Irreversalble)

[Post Treatment Process]:
Post Treatment - Acid Cleaning and Surface Protection:
1. Use oxalic acid, citric acid, phosphoric acid or EDTA to clean non-chlorides object.
2-method a. Use Tannin acid to oxidize iron oxide into a ferrous tannate corrosion-resistant film.
2-method b. phosphoric acid solution impregnation to formed phosphate protective film in a vacuum.
2-method c. Apply Phosphoric acid and tannin solution mixture to form a coating.
3. Coat with an extra sealant, such as microcrystalline wax, onto tannate film. This acts as vapor barrier and adds strength to corrosion layer.

Post Treatment - Drying:
mothod a. Oven or infra-red lamp Heating
mothod b. Vacuum desiccation
mothod c. Water-miscible alcohol (ethanol, methanol, isopropanol) or acetone dehydration.It is prefered choice because of minimal oxygen contact.

Post Treatment - Sealant & Consolidation:
mothod a. Microcrystalline waxes (Cosmoloid 80H, Gulf 75 Micro-wax, Witco 180M) Place dried artifact in a container with microcrystalline wax heated to 175°C. Remove surplus wax with rags, a torch, a hot air gun, or a knife.
mothod b. Polyurethone-based paints are thermoplastic polymers. It is a ecnonmic choice on large object and suitable for out door displayment.
mothod c. Rustoleum, a fish-oil-based paint for indoors displayment.
mothod d. Clear-drying zinc phosphate-based primer coat with clear acrylic lacquer on top and Krylon Matte Spray finishing is stuiable for outdoors displayment.

[Post treatment Storage]:
Store Iron with chlorides at RH < 50%, chloride-free Iron and steel at RH 50-60%.
Iron artefacts are not chemically stable, that undergose mineralize process over time. Ideally this group should be stored at RH 12%-20% and temperature between 15°C-25°C in sealed containers with oxygen scavengers and VPIs.

[Treatment indoor/outdoor environment]:
Electrochemical Reduction generate irritating corrosive vapors and hydrogen gas. Well-ventilated room and sealed rooms with exhaust systems are required, irritating caustic gas should be filtered and potentially collected recyclying in treatment use if possible. The smaller artifacts should be treated in well-ventilated lab under fume hoods. Large Objects are treated in a ventilated room in a separate building. Safety showers are necessary.
Alternatively, open-to-air floor spaces could accmodate electrolytic vats where air exhaust systems is unrequired. Air-blown dirt or atmospheric pollutants are negligible. Regular solutions changed should be enabled. Hydrometers need to be set to monitor solution concentration due to natural parciptation. Power supplies should be sheltered from weather. Operatable facades could be designed so building can be sealed from outdoor environment when electrolytes are getting freezed in low temperated.

[Special facility]:
specialized DC and AC Power supplies, terminal wires and clips, anode materials such as mild steel or Stainless steel, heat oven, rags, torch, hot air gun, knife.etc
Vats: Polyvinyl chloride (PVC), polypropylene (PP), and polyethylene (PE) air-tight vats for Non-conductive alkali-resistant setups(Chemical reduction treatment). Glass and wooden vats for electrolytic setups. Conductive mild steel vats for electrolyte cleaning setups. Stainless steel or HDPE vacuum vats for Vacuum desiccation drying. Stainless Steel vats for Heat resistant for Sealant process in Oven. Form-fit'T'-shaped or cross shaped vats with the stem and opens end for large irregular anchor. Supplemental expandable mild steel sheets of suspend above anchor.
Safety equipment: gloves, eye shields, eye washes, Fume hoods.etc
Diphenylcarbazone-bromophenol, mercuri nitrate solution, Sulfuric acid, magnetic stirrer, Teflon-coated stirring bars, glasswares.etc

[Health, safety & Waste disposal]:
Disposal Of Hexavalent Chrome: Chromate solutions are toxic and flammable and its contact with organic material should be eliminated. The solution need to be neutralized before Disposal. Acidified chromate solution with sulfuric acid to Sodium metabisulfite. Followed with the addition of sodium hydroxide solution, the disposable chromium hydroxide precipitate are yield. The solution can be drained into the sewer line. Dispose solution down the drain. Gluconates solutions has strict disposal requirements.

Additional Comment Based On Theortical Framework:
principle 7,**8**,**9**

Storage Requirement Reference:
"Conservation of Marine Archaeological Objects" by Colin Pearson
"Conservation of Metal Objects from Underwater Sites: A Study in Methods" by Donald R. Binnie
"Marine Archaeology and Conservation: The Experience of the British Museum" by Jonet Ambers (Journal of the British Museum, 2010)

Appendices

Appendix A:
Underwater Archaeology Preservation Techniques Based on Material Types

IV: Metal
11: Cupreous Metal (Copper, Bronze, Brass) Conservation
12: Silver

IV: Metal
11: Cupreous Metal (Copper, Bronze, Brass) Conservation

Cupreous Metal corrosion in Waterloged environment:
The term "cupreous" refers to metals composed of copper or primarily copper alloys, such as bronze (copper and tin) and brass (copper, zinc and lead). The two most common marine corrosion products are cuprous chloride and cuprous sulfide. Cuprous chloride continually forms cupric chloride when exposed to moisture and oxygen. In anaerobic salt water site, sulfate-reducing bacteria produce cuprous (Cu_2S) and cupric sulfides(CuS). Upon exposure to oxygen, cuprous sulfides undergo further oxidation.

[Pre-treatment Storage]:
Copper and Copperous silver alloys are susceptible to oxidizing solutions and strong alkaline solutions. Copper-lead alloy and Copper-tin alloy are susceptible to alkaline solutions. Cupreous Metals are passivated in neutral PH solution or mild alkaline solution of sodium sesquicarbonate or sodium carbonate. This group have medium treatment urgency.

[Treatment Process]:
1. Investigate corrosion layers with dental pick and X rays. Record diagnosis.
2. Mechanically remove encrustation and clean the object.
3-condition A: mildly corroded specimen object: Apply citric acid with thiourea as inhibitor to dissolve cupric and cuprous adhering compounds.
3-condition B: Thin, fragile, delicate or almost mineralized object: Use sodium hexametaphosphate to convert the insoluble calcium and magnesium into soluble salts.
4-Method a Electrochemical Reduction:
Apply sodium hydroxide or sodium carbonate as electrolyte when mild steel is anode; formic acid as electrolyte when 316 stainless steel or platinized titanium is anode.
4-Method b Alkaline Dithionite Reduction:
Apply sodium hydroxide and sodium dithionite solution to remove the chlorides further when reduces corroded products back to metallic state. This method is destructive to cupreous patina surface.
4-Method c, Chemical Sodium Sesquicarbonate Treatment:
Use sodium sesquicarbonate to convert cuprous chlorides to cuprous oxide. Use tap water as initial solvent, then change to deionized water. Apply mercuric nitrate to monitor chlorides level. Corrosion layers is stable by itself.
4-Method d, Sodium Carbonate Treatment: Apply sodium carbonate with distilled water as solvent.

[Post Treatment Porcess]:
Cleaning, Sealant and drying:
1. Hot rinses object in de-ionized water.
2-a (Optional)Removes tarnish by polishing with a wet paste of sodium bicarbonate.
2-b Resined object with denatured ethanol.
~~3:~~ Benzotriazole (BTA) Surface Protection: Under a vacuum environment, BTA disolved in ethanol or water form a protective layer on cuprous chloride. wiped off residual with a rag.
4 Dehydrated object in acetone or a water-miscible alcohol.
5 Add a final coating of clear acrylic lacquer or microcrystalline wax.

[Post-treatment Storage]:
Specific data for such material are not found. Canadian Conservation Institute (CCI)'s Guidelines are followed here: Store product in a temperature between 18-22°C, RH between 35-55%. Minimize fluctuations in humidity. Keep illuminance below 50 lux and minimize object exposure to UV light.

[Special facility]:
Vacuum/Air tight vats. Refer to ferrous metal for more detail.
Tap water, Deionized water, distilled water, acrylic lacquer, BTA, sodium bicarbonate, denatured ethanol, Sodium Sesquicarbonate, Alkaline Dithionite, citric acid, sodium hexametaphosphate, sodium hydroxide, sodium carbonate.etc

[Health & safety, waste disposal]
BTA is a potential carcinogen, avoid skin contact or power inhalation.

Introduced Principles Based On Theortical Framework:
principle **1,8,9**

IV: Metal
12: Silver

Silver corrosion in Waterloged environment:
In the marine shipwreck site, silver is subjected to anaerobic corrosions. The hydrogen sulfide produced from Sulfate-reducing microorganism, converting silver to silver sulfide. Among corrosion products such as silver chloride ($AgCl$) and silver sulfide (Ag_2S), silver bromide ($AgBr$) is the most common one. Silver corrosion products are stable and do not participate in further reactions.

[Pre-treatment Storage]:
Silver corrosion products are with low treatment urgency, Which are stable in aqueous condition or in the atmosphere. Silver is inert with chlorides or PH fluctuation. Only chromate solutions could oxidize it.
Condition a. Stored dry.
Condition b. Apply sodium sesquicarbonate or sodium carbonate solution when iron is invoved.

[Treatment Process]:
1. Investigate corrosion layers with dental pick and X rays. Record diagnosis.
2. Mechanically remove encrustation, followed with cleaning. Use formic acid to assist remoeval.
3-method a. Electrolytic reduction: Apply platinized titanium as inert anodes in formic acid/sodium hydroxide electrolytes; or No. 316 stainless steel in formic acid ;or Mild steel in sodium hydroxide electrolytes. Chloride ions and sulfide ions are remove from $AgCl$ and Ag_2S. Corrosion product is reduced to silver.
3-method b: Alkaline Dithionite Reduction: Apply hydrochloric acid to remove encrustation. Add sodium hydroxide and sodium hydrosulfite in solution in air-tight vat for reduction.

[Post Treatment Process]:
1. Cleaning object in soapy water or rubbing with a polishing abrasive.
2. (Optional) Apply thiourea non-ionic detergent with distilled water to remove Tarnish (sulfur compounds)
3. (Optional) Apply ammonium thiosulfate in distilled water to dissolves silver chloride
4. (Optional) Apply formic acid in de-ionized water to dissolves copper compounds
5. (Optional) Apply silver nitrate solution to remove metallic copper films
6. Rinse object with de-ionized water
7. Dry object with hot air or acetone.
6-a.(Optional) Consolidate: Ag_2S and $AgCl$ are relatively stable. Consolidate item with PVA, butyl acetate, various polymethacrylates or wax in acetone.
6-b Coating with clear acrylic lacquer(Apply Krylon 1301 if Alkaline Dithionite method was used).

[treatment indoor/outdoor environment]:
Refer to ferrous metal for more detail.

[Post-treatment Storage]:
No specifical requirement.

[Special Facility]:
HDPE, Polypropylene(PP), or Glass-Lined Steel air-tight vat for chemical and electrolytic reduction. Non-ionic wetting agent. Refer to ferrous metal for more detail.

[Health & safety, waste disposal]
Disposal of alkaline dithionite solution: Left solution oxidized in air for several days to form sulfates from sulfites. Neutralize sulfites with hydrochloric acid. Drain the solution into the sewer line.

Introduced Principles Based On Theortical Framework:
principle **1**

Appendices

Appendix A:

Underwater Archaeology Preservation Techniques Based on Material Types

IV: Metal
13: Lead, Tin, Pewter and Lead Alloys
14: Gold & Gold Alloy Conservation

IV: Metal
13: Lead, Tin, Pewter and Lead Alloys

[Tin] Corrosions:
In sea water, intercrystalline oxidation prompted be sodium chloride convert tin into a series products stannous oxide (SnO), stannic oxide (SnO2) or gray powdery tin. Tin sulfide is also discovered with in anaerobic environment.
[Lead] Corrosions:
Lead weights, cannonballs, sheeting, and stripping are stable in neutral, alkaline aqueous solutions without oxidizing agents. Lead carbonate and lead oxides are corrosion-resistant layer. lead chloride (PbCl2), lead sulfide (PbS),lead sulfate (PbSO4), are also common.
[Pewter] Corrosions:
Historical Pewter is often consisting of tin and lead. Leaded pewter is more inert than lead-free ones due to protective lead sulfate (PbSO4) corrsion. In aerobic marine site, lead-free pewter suffers corrsion, which mineralize into stannic oxide (SnO2) and lead sulfide (PbS). Leaded and lead-free pewter with lead sulfide and tin sulfide films survive well in anaerobic condition.

[Pre-treatment Storage]:
Lead:
a. Stored dry.
b. Store in tap water by the addition of sodium sesquicarbonate(pH 8-10).
c. Store in sodium carbonate solution with a pH of 11.5.
Pewter:
a. Stored dry.
b. Store in tap water, by the addition of sodium sesquicarbonate(pH 8-10).
c. Store in sodium carbonate solution with a pH of 11.5.
d. Passivated in slight alkine soultion.
Tin:
a. Stored dry.
b. Store in tap water, by the addition of sodium sesquicarbonate(pH 8-10).
c. Passivated in mild alkine soultion.

[Treatment Process]:
1. Investigate corrosion layers with dental pick and X rays. Record diagnosis.
2. Mechanically remove encrustation, followed with cleaning.
3-condition a: Lead Chemical Treatment
Hydrochloric acid: remove adhering encrustation followed with rinse.
(optional) Ammonium acetate: Apply such method when lead dioxide is detected.
(optional) EDTA: Apply such method to remove all lead corrosions. Rinse object afterwards.
3-condition b: Electrolytic Reduction for Lead, Tin, Pewter:
Apply such method when artifact has considerable metal remaining.
Apply sodium hydroxide (aggressive) or sodium carbonate(gentle) as electrolyte, mild steel or stainless steel as anode. Use sulfuric acid to even out the alkalinity. Bath object with cold distilled water.

[Post Treatment Process]:
1. Dry object with hot air gun or in a water-miscible solvent.
2. Consolidate and protect product from atmospheric pollutants by soak in molten microcrystalline wax.

[Post Treatment Storage]:
Specific data for such material are not found. Canadian Conservation Institute (CCI)'s Guidelines are followed here: Store product in a temperature between 18-22°C, RH between 35-45%. Minimize fluctuations in humidity. Keep illuminance below 50 lux and minimize object exposure to UV light.
Storage in air tight containers or polyethylene bags. Lead is prone to organic acids, acetic acid, humic acid, tannic acid, oak cabinets.

[Special Facility]:
Tight containers, polyethylene bags, mild/stainless steel Refer to ferrous metal for more detail. Tap water, sodium sesquicarbonate, sodium carbonate, sodium hydroxide, Hydrochloric acid, Ammonium acetate, EDTA, microcrystalline wax.etc

Introduced Principles Based On Theortical Framework:
principle 1

IV: Metal
14: Gold & Gold Alloy Conservation

[Gold Corrosion]:
Gold is inert metal undergoes minimum corrosion.

[Gold Conservation]:
The copper and silver alloy with gold can be corroded. Conservation choices are made under those headings.

[Post-treatment Storage]:
No specifical requirement.

[Discussion on Post-treatment Stability]:
Conventional PEG method for wood conservation has a short life expectancy. Climite controlled environment only prolongS the inevatble retreatment. Water miscibility and chemical changes within this treated product cause its slow degeneration. The discovery of new method are having impacts on archaeological preservation. Reversibile treatment method enables new method to be updated on the previously finished product.

Reference for Preservation Techniques Based on Material Types:

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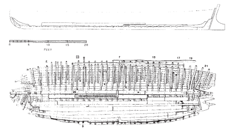
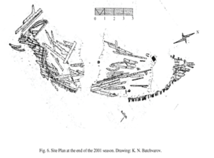
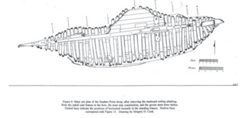
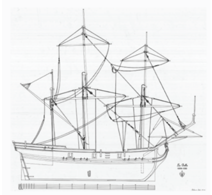
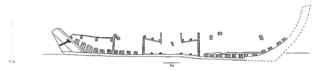
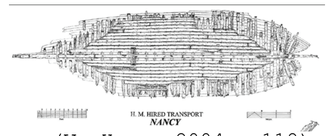
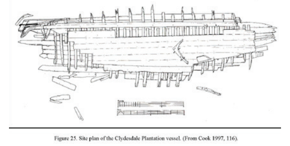
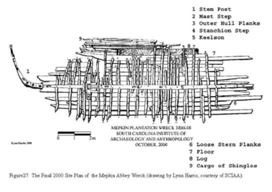
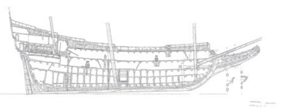
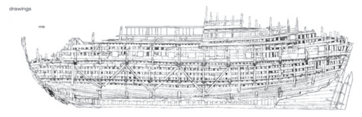
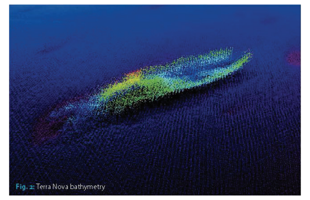
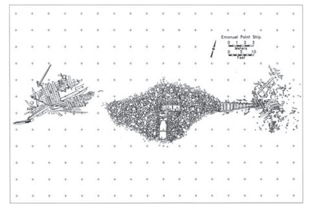
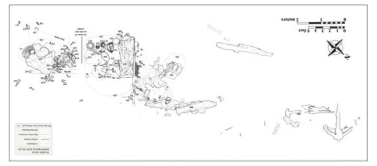
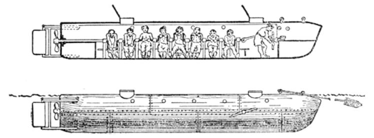
Appendices

Appendix B:
Archaeological Shipwrecks reviews - Size, Material & Fate

	Name	Function	Measurement Length, Beam, Depth	Stern largest piece	Tonnage	Material	Wreck Condition	Excavation status	Fate Wreckage cause
 (Amer,1986, p35)	# 1 Browns Bay vessel	Cargo carrier -> Gun Boat	16.5m * NA * NA (remain)	NA	NA	Timber,Iron,Copper	Hull remain	Hull Excavated	Abandon
 (Batchvarov, 2009, p22)	# 2 The Kitten	Merchantman	24-25m * 7-8m * NA (remain)	NA	160t	Timber, Bronze, ceramics, tin, copper, silver, leather, Ivory, Amber.	Hull remain	Hull & Artefacts Excavated	NA
 (Cook, 1997, p110)	# 3 St Ann's Bay Sloop	Colonial Merchant Sloop	18.24m * 5.49m * NA (Original)	NA	100t	Timber, Stone, ceramics, Glass, Leather, Iron, Botanical, Faunal.	Hull remains	Reburied	Abandon
 (Corder, 2007, p369)	# 4 La Belle	Colonial Merchant Sloop	14.63m * 4.88m * 2.44m (remain)		40-45 t	Timber, Textile, artifacts, iron, ,Brass,copper	Hull remains	Hull Reburied Artefacts & parts Excavated	A storm
 (Pedersen, 1991, p9)	# 5 Waterschip NZ42i	Fishing Watership	12.56m * 5.9m * 1.5m (remain)		NA	Timber, iron, Textile, Stone, ceramics, brick, copper, leather, Bone, peat.	Intact hull, detached elements	Partial repair	NA
 (VanHorn, 2004, p118)	# 6 Nancy Schooner	Trading vessel -> military service warship	20.7m * 6.7m * 2.3m (remain)		100-120t	Timber, iron	Hull remains	NA	burned down in the war
 (VanHorn, 2004, p124)	# 7 Clydesdale Plantation Vessel	Agricultural cargo sloop	13.4m * 4.7m * 1.9m (remain)		20-25t	Timber, iron	Hull remains	Reburied	Abandon
 (Vezeau, 2004 , p41)	# 8 Mepkin Abbey Baker	Costal perishable goods cargo	14.63m * 3.35m * 0.97m (remain)		24t	Timber, Stone, Glass, Ceramics, iron	hull remains	Stabilization	accidential sinking (assumption)
 (Marina & Carlos, 2014, p54)	# 9 VASA	Ruling house propaganda (war)ship	69m * 11.7m * NA (original)	45m(keel)	1200t	Timber, Faunal, Botanical, bodies, Iron, Bronze	largely intact	Conservation & partial restoration	A gust of wind

Appendices

Appendix B:
Archaeological Shipwrecks reviews - Size, Material & Fate

	Name	Function	Measurement Length, Beam, Depth (exclude bowsprit)	Stern largest piece	Tonnage	Material	Wreck Condition	Excavation status	Fate Wreckage cause
 (McElvogue, 2015, p7)	# 10 Mary Rose	Ruling house warship	40m * NA * 4.1m (Remain) 49.7m * NA * NA (original)	NA	518t	Timber, brick, Iron, ceramics, Copper, Glass, stone, bodies, Faunal, Botanical, Bone,Ivory, leather, Textiles, Gold, silver, Iron, brass, bronze, Tin, pewter,lead	Hull remain	full Excavation	Sink in the war
 (Täuber, 2019, p45)	# 11 Terra Nova	Artic sealing ship -> Polar exploration relief ship -> Wartime supplier	57m * 9.45m * 5.8m (original)	NA	858t (744t)	Steel, Iron, glass, Timber	Hull remain	Site Suvery	Strucked by ice
 (Smith, 2018, p244-245)	# 12 Emanuel Point Ship I	Colonial & merchants vessel	29.5m * 9.48m * 4.55 m (original)		417-502t	wood, ceramics, iron, wrought-iron, glass, stone, lead, copper, brass, bronze, Lead-Glazed Earthenwares, tin-glazed enamelware, Organic Debris, leather, bone & teeth ,insects, mollusks, plant textiles, food, silver, glass, Mercury	Scattered remains with recognizable parts	Arefacts Recovery + Insitu preservation	Strucked by hurricone wood-eaten worm
 (Ford et al, 2008, p268)	# 13 Mardi Gras	Light armed merchant vessel, privateer or slave ship(Assumption)	17.1m * 5.8m * 2.04m(Est)		40-65t	sand-glasses, ceramics, Ferrous materials, Cast-iron, lead, cupreous alloys, wood, stone, leather, bone, seed, plant textile, Composites	Deteriorated hull	Artefacts recovery + wreck parts excavation	unknown (Foul weather, structural failure, burning or other violence)
 (Wills, 2017)	# 14 Submarine H. L. Hunley	Submarine	12m * 1.17m * NA		6.8t	Rolled iron, Wrought Iron, human remains	intact vessel	Full Conservation	Crew members impacted by torpedo detonation wave

Appendices

Appendix B:
Archaeological Shipwrecks reviews - Size, Material & Fate

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