REVIVING TRADITIONS THROUGH SUSTAINABLE ARCHITECTURE


Al-Tahla Floating Islands Wetlands

312

مقابلة مع
جاسم الأسدي
منظمة طبيعة العراق، مكتب الجبايش
المدير العام

شارك الأسدي منذ طفولته في الحركة الكشفية في الأهوار. لقد ولد وترعرع في بيئة غنية بالتنوع البيولوجي والثقافة المحلية الموروثة ، وشارك بعد ذلك في إدارة الموارد المائية لأكثر من ربع قرن كمهندس. شهد إستنزاف هذه البيئة الفريدة في التسعينات. وبعد عام 2003 ، سعى للعمل مع منظمة طبيعة العراق لإستعادة أهوار بلاد ما بين النهرين ، وتسهيل عودة المهاجرين ، وتعزيز الحفاظ على التنوع البيولوجي والثقافة الشفاهية ، وإيجاد حلول للأنظمة الهيدروليكية ، ودعم السكان المحليين للتغلب على ندرة المياه في السنوات الجافة كما حدث في عامي 2009 و 2015 . وهو مدير مكتب منظمة طبيعة العراق في منطقة الأهوار ، شارك في أكثر من عشرة مشاريع تتعلق بدراسات الأثر البيئي والإجتماعي والإقتصادي. نشر الأسدي عشرات المقالات والتقارير الصحفية و التلفزيونية للتوعية بقضايا الأهوار. وهو يمثل منظمات المجتمع المدني في العراق في إتفاقية رامسار كعضو في لجنة الأتصال والتعليم والمشاركة والتوعية

TECHNICAL EXPLORATION OF SUSTAINABLE ARCHITECTURAL MATERIALS

MALAK HAMID [W1926580]

CHAPTER 1 - TECHNICAL AMBITIONS STATEMENT

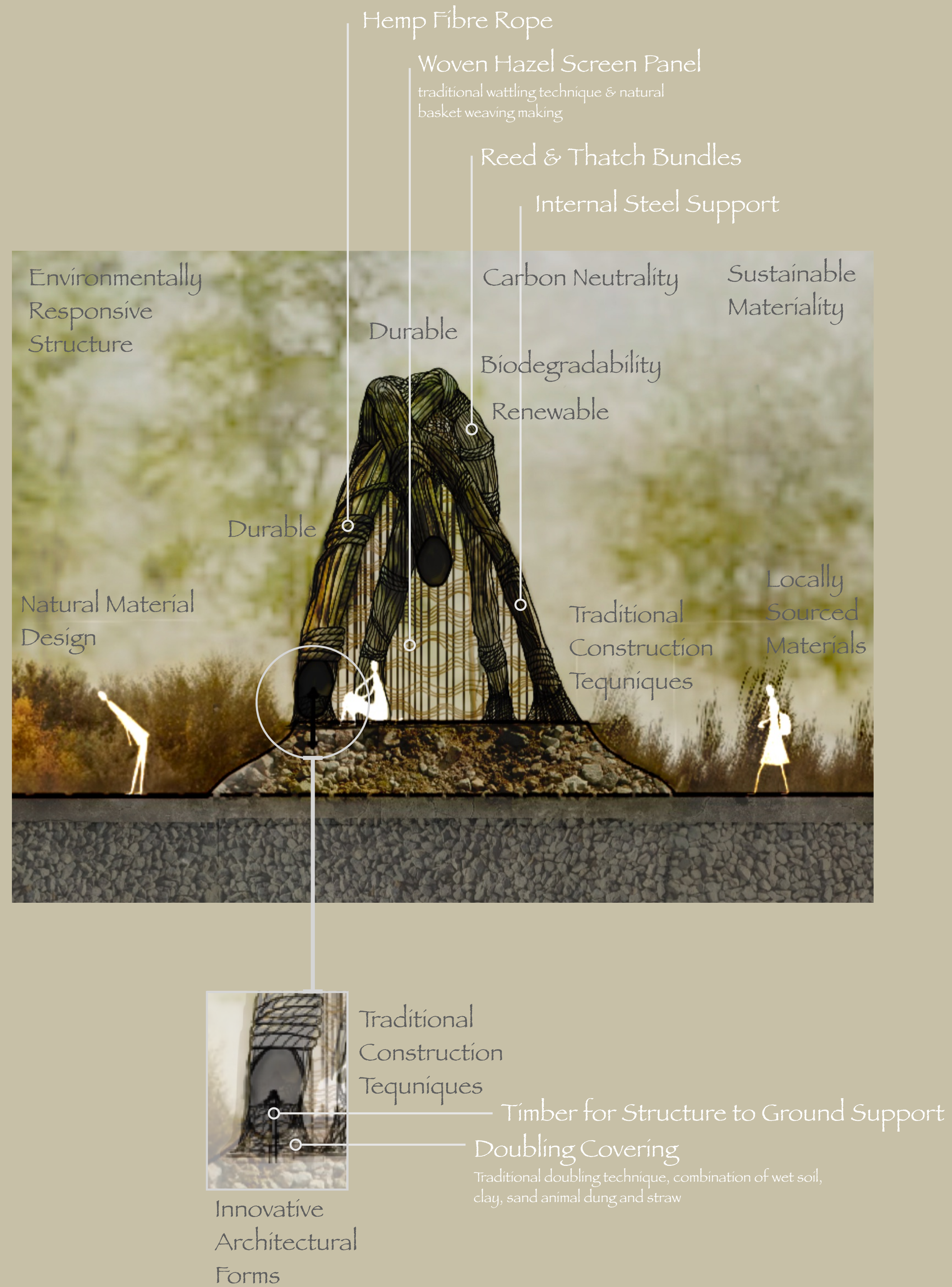
SOURCEBOOK AIMS AND AMBITIONS

This sourcebook investigates the integration of sustainable, locally sourced materials into innovative architectural forms, addressing contemporary challenges such as global warming and the urgent need for sustainability in construction. The focus is on the use of reeds, thatch, hazel, and hemp, materials that embody renewable, low-carbon, and biodegradable characteristics, with applications inspired by generational traditional knowledge and transitional construction methods.

Through research and experimentation, this study seeks to explore how traditional building techniques—rooted in the use of locally available resources and climate-adaptive practices—can inform modern architectural design. By examining weaving, bundling, and daubing methods passed down through generations, it aims to bridge ancestral wisdom with contemporary architectural ambitions to create environmentally responsive structures.

Additionally, this sourcebook explores innovative climate control strategies using natural materials. These include optimising thermal insulation with thatch, improving ventilation through woven hazel panels, and leveraging the inherent properties of reeds for waterproofing and shading. Through material testing, technical analysis, and design development, this work pushes the boundaries of natural material applications to propose solutions for sustainable, climate-conscious architecture.

This sourcebook not only explores sustainable material applications but also investigates how these materials enhance climate control within architectural designs. Reeds, thatch, and wattle panels naturally provide shading, ventilation, and thermal comfort. By leveraging these properties, the project aims to reduce reliance on artificial heating, cooling, and energy-intensive materials. Passive design strategies, such as orienting structures for optimal solar gain in winter and shading in summer, are integral to the ambition of achieving a low-carbon, comfortable building envelope.



2. MATERIAL ANALYSIS

Introduction to Materials:

- Overview of reeds, thatch, hazel, and hemp rope as renewable materials.
- Why these materials fit my design: local sourcing, ecological benefits, and traditional use.
- Characteristics like durability, biodegradability, and cultural significance.
- Examples where materials are used, traditional construction history

SECTION 1: REEDS

Properties:

- Flexibility: Reeds can be bent and shaped, making them suitable for creating curves in structures.
- Water-Resistance: Naturally resistant to water, reeds are ideal for roofing materials.
- Lightweight: Their low density makes reeds easy to handle and reduces structural load.

Applications:

- Roofing: Reeds have been traditionally used in thatched roofs, providing effective waterproofing and insulation.
- Wall Panels: Used in wattle and daub construction, reeds form the woven lattice that supports the daub.

Traditional Information:

- Reed thatching is a centuries-old practice in various cultures, notably in the UK and parts of Europe. Traditional thatched roofs often utilised water reeds, which were valued for their durability and insulating properties.

Cost Considerations:

- Material Cost: Reeds are generally affordable, especially when locally sourced. However, the cost can increase if transportation from distant locations is required.
- Labor Cost: Thatching with reeds is labor-intensive and requires skilled craftsmen, which can elevate installation expenses.

By-Products:

- Chaff/Dust: Generated during harvesting and cutting. It can be composted or used as mulch.
- Stalk Ends: Small, unusable reed ends can be shredded for biomass energy or animal bedding.
- Reed Ash: If reeds are burned, the ash is a rich source of minerals and can be used as a soil conditioner.

SECTION 2: THATCH

Properties:

- Thermal Insulation: Thatch provides excellent insulation, keeping interiors warm in winter and cool in summer.
- Aesthetic Texture: Offers a rustic and traditional appearance, enhancing the visual appeal of structures.

Applications:

- Roof Cladding: Thatch is predominantly used for roofing, creating a weather-resistant barrier.
- Wall Coverings: In some traditional constructions, thatch is applied to walls for additional insulation and protection.

Traditional Information:

- Thatching techniques vary by region, with materials including straw, reeds, and heather. In Scotland, for example, diverse thatching traditions have been documented, demonstrating the use of various materials and methods.

Cost Considerations:

- Material Cost: The cost of thatching materials varies depending on type and availability. Water reed is often more expensive than straw but may offer greater longevity.
- Labor Cost: Thatching is a specialised skill; thus, labor costs can be significant due to the expertise required.

By-Products:

- Straw Waste: Smaller pieces left during thatching can be used for animal bedding, composting, or biofuel.
- Old Thatch: Removed thatch from renovations can be repurposed as mulch or insulation material.
- Dust/Residue: Often created during processing; can be composted or used in bioenergy production.

SECTION 3: HAZEL

Properties:

- Elasticity: Hazel's flexibility makes it suitable for weaving into various shapes.
- Strength: Despite its pliability, hazel provides robust structural support.
- Renewability: Hazel is a fast-growing, sustainable resource when managed properly.

Applications:

- Wattle Panels: Hazel rods are traditionally woven to create wattle panels, which serve as a framework for daub in wall construction.
- Thatching Pins: Hazel is used to make spars or pins that secure thatch to roofs.

Traditional Information:

- Hazel has been utilised in wattle and daub construction for centuries, forming the woven lattice that supports the daub. This technique has been integral to traditional building methods in various cultures.

Cost Considerations:

- Material Cost: Locally sourced hazel is cost-effective, but prices can rise if transportation is necessary.
- Labor Cost: Weaving hazel requires skill, and labor costs will reflect the craftsmanship involved.

By-Products:

- Twigs and Offcuts: Small branches and twigs can be used for kindling, fencing, or creating smaller wattle structures.
- Sawdust: Created during cutting; can be used as mulch or in composting.
- Bark Peelings: Sometimes removed during processing; useful for animal bedding or as mulch.

SECTION 4: HEMP ROPE

Properties:

- Tensile Strength: Hemp rope is strong and capable of bearing significant loads.
- Biodegradability: As a natural fibre, hemp is environmentally friendly and decomposes without harming the ecosystem.

Applications:

- Binding Materials: Hemp rope is traditionally used to bind reed bundles and secure thatch in place.
- Structural Ties: It serves as a tying material for various structural elements in construction.

Traditional Information:

- In historical thatching practices, especially in regions lacking suitable wood, roofs were secured using ropes made from materials like straw, heather, or hemp. These ropes held thatched roofs firmly in place, demonstrating the versatility and importance of hemp in traditional construction.

Cost Considerations:

- Material Cost: Hemp rope is moderately priced, with costs varying based on thickness and quality.
- Labor Cost: Using hemp rope in construction is relatively straightforward, potentially reducing labor expenses compared to more complex materials.

By-Products:

- Fibre Waste: Short fibres or dust during rope production can be used for textiles, paper, or insulation.
- Seed Oil: Extracted from hemp seeds; used in cooking, cosmetics, or biodiesel.
- Hemp Hurds: Woody core leftover from hemp stalks; used for animal bedding, biofuel, or hempcrete.

Did you know?

Over time, reedbeds of Common reed will naturally be encroached by scrub and succeed to woodland if they are left alone. However, for many years they have been cut and managed to produce reeds for thatching buildings. Continuing this form of management keeps the habitat intact, providing a home for specialist wildlife. https://www.wildlifetrusts.org/wildlife-explorer/grasses-sedges-and-rushes/common-reed

Material Provenance and Reuse:

Reeds:

- Provenance: Locally sourced from wetland areas. Harvested annually, reeds regrow without harming ecosystems.
- Reuse: Removed reeds can be composted or used as mulch.

Thatch:

- Provenance: Thatch is often a by-product of cereal crops (e.g., wheat or rye) and can be locally harvested.
- Reuse: Old thatch is biodegradable and enriches soil as compost.

Hazel:

- Provenance: Coppiced hazel rods from sustainably managed woodlands. Coppicing promotes continuous regrowth.
- Reuse: Offcuts and old rods can be repurposed as kindling or mulch.

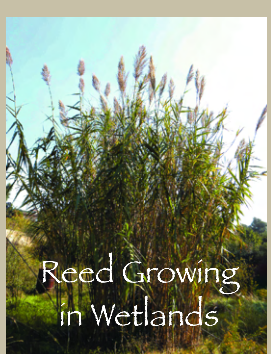
Table 1: Material Analysis Summary Table

Material	By-Products	Alternatives	Advantages	Limitations
Reeds	Chaff, stalk ends, reed ash	Bamboo, palm leaves, rattan	Renewable, lightweight, durable	Climate-specific growth
Thatch	Straw waste, old thatch, dust	Straw, wood shingles, coconut fronds	Excellent insulation, biodegradable	Requires maintenance
Hazel	Twigs, sawdust, bark peelings	Willow, chestnut, alder	Flexible, durable, easily sourced	Heavy labour required for processing
Hemp Rope	Fiber waste, seed oil, hurds	Jute, coir, sisal, flax	Biodegradable, strong, versatile	Costlier than other natural fibres

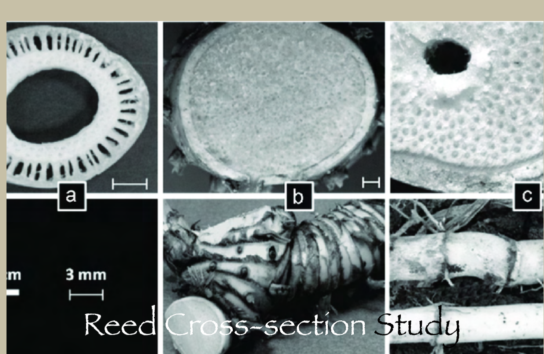
Table 2: Financial Cost Table

Material	Cost (£/kg)	Provenance	Reuse Potential
Reeds	~ £0.50 - £1.00	Wetlands, local UK	Compostable, mulch
Thatch	~ £0.30 - £0.70	Agricultural waste	Compostable, mulch
Hazel	~ £1.50 - £2.50	Coppiced woodlands	Reusable in fences, compostable
Hemp Rope	~ £2.00 - £3.50	Agricultural hemp	Reusable in binding, compostable

SECTION 1: REEDS


Reed Growing in Wetlands

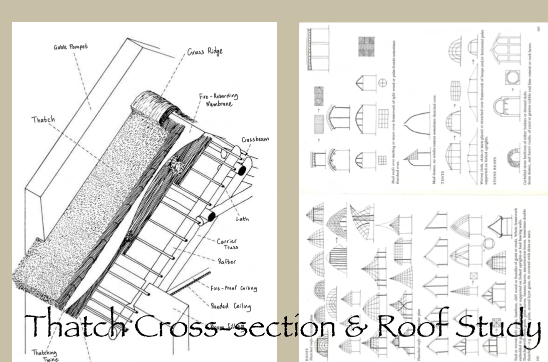

Reed Bundle


Reed Cross-section Study

SECTION 2: THATCH


Thatch Roof Structure

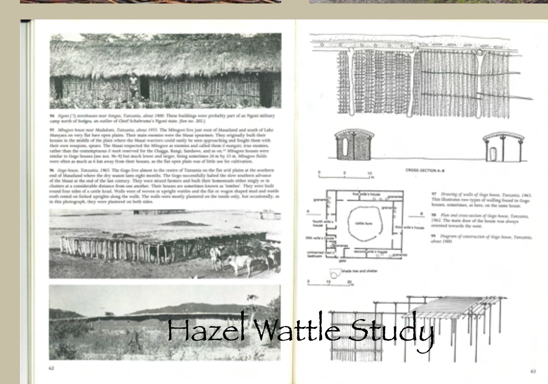

Thatch Roof Bundle


Thatch Cross-section & Roof Study

SECTION 3: HAZEL


Hazel Wattle Weaving

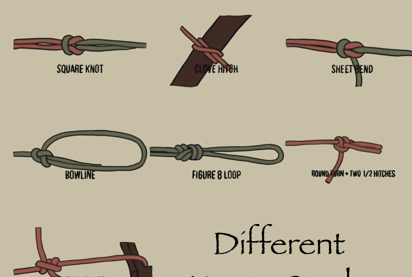

Hazel Wattle Walls Building


Hazel Wattle Study

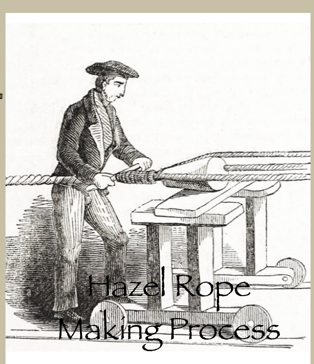
SECTION 4: HEMP ROPE


Rope Making Process


Knot Traditional Case Study



Different Knots Study


Hazel Rope Making Process

3. PRECEDENTS & INSPIRATION

1. Jingkieng Dieng Jri Living Root Bridges of The Khasis in India

Location: Meghalaya, India
Description:

- These living root bridges are grown using the aerial roots of Ficus elastica (rubber trees), which are trained and intertwined to create durable, flexible walkways.
- The bridges take 15-20 years to mature and are strengthened over time as the roots grow thicker.

Cultural Significance:

- A testament to the Khasi tribe's deep connection with nature and their sustainable practices of working with the environment rather than against it.
- Bridges are often maintained through community efforts, reflecting the integration of cultural heritage and ecological wisdom.

Technical Lessons:

- Weaving Technique: Demonstrates how interweaving natural elements over time creates strength and flexibility.
- Biodegradability: Unlike conventional bridges, these structures naturally decompose when abandoned, leaving no waste.
- Long Lifespan: Some root bridges are over 500 years old, showcasing the durability of this method.

Environmental Impact:

- Zero embodied carbon.
- Supports the local ecosystem by allowing plant growth and water flow underneath.

The evolution of a root bridge over time.

Root bridge highlighting the weaving, knotting and growth process.

2. Totora Reed Floating Islands of the Uros in Peru

Location: Lake Titicaca, Peru and Bolivia
Description:

- The Uros people construct floating islands using dried totora reeds, layering them to create a buoyant and habitable surface.
- Houses, boats, and furniture on the islands are also made of reeds.

Cultural Significance:

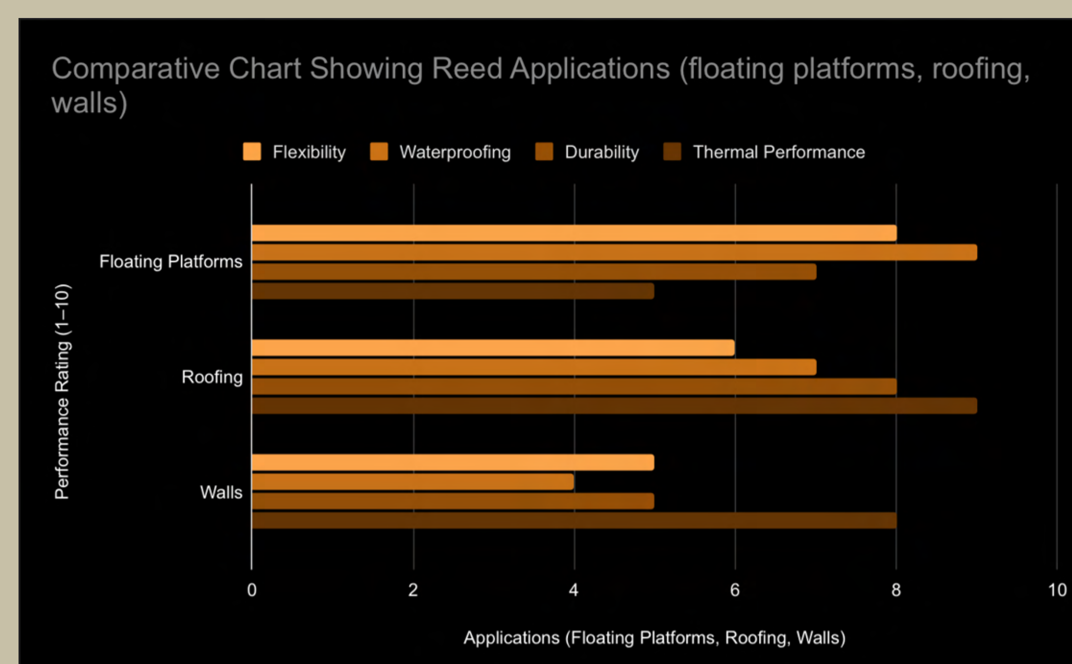
- Represents centuries of adaptation to the lake environment, where the Uros chose mobility over fixed settlements.
- Symbolizes ingenuity in utilizing abundant natural resources.

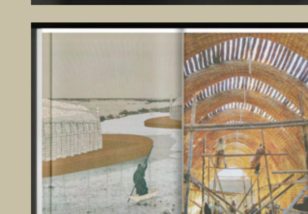
Technical Lessons:

- Layering Technique: Reeds are continuously added to replace decomposed layers, demonstrating a dynamic maintenance process.
- Structural Adaptability: The islands can be dismantled and moved, allowing for flexibility in response to changing water levels.
- Thermal Properties: Reeds provide insulation, keeping the structures cool during the day and warm at night.

Environmental Impact:

- Fully biodegradable.
- Sustainable use of local resources without depleting the ecosystem.





3. Thomas Heather-wick's Woven Screens

Location: Guy's Hospital, London, UK
Description:

- Contemporary façade screens inspired by basket weaving techniques.
- Constructed using aluminium strips, these screens provide shading, ventilation, and aesthetic texture.

Cultural Significance:

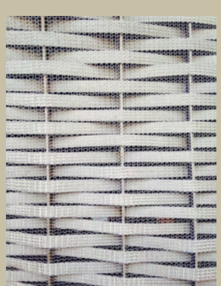
- A modern reinterpretation of traditional weaving techniques used in global architecture.
- Demonstrates how ancestral craftsmanship can inspire modern applications.

Technical Lessons:

- Ventilation and Light Control: The woven screens regulate sunlight and airflow, reducing energy use.
- Modular Design: Prefabricated panels allow for efficient assembly and customisation.
- Durability: Aluminium replaces traditional natural materials to meet the demands of an urban environment.

Environmental Impact:

- Aluminium's high embodied carbon is a drawback, but the screens contribute to operational energy savings by reducing cooling demands.




The pattern and shading effects of the woven screens



Traditional basket-weaving patterns (Bee-hives from United Kingdom & Natural material woven baskets, hats, crafts from Uganda.

Traditional hazel fences made from weaving, Living fences semi-cut and Weaved over each other

4. Kengo Kuma's Weaving Techniques

Location: Various Projects (e.g., GC Prostho Museum Research Centre, Japan)
Description:

- Kuma uses natural materials like bamboo and timber in woven patterns to create lightweight, breathable structures.
- His work emphasises harmony with nature and the tactile quality of materials.

Cultural Significance:

- Reconnects contemporary design with traditional Japanese craftsmanship.
- Reflects the philosophy of "ma" (space), which focuses on balance and interconnectivity.

Technical Lessons:

- Tensile Strength: Woven bamboo demonstrates excellent load distribution.
- Aesthetic and Functional Integration: The woven patterns enhance ventilation while creating dynamic visual interest.

Environmental Impact:

- Use of locally sourced, renewable materials minimises environmental footprint..






Table 3: Comparative Chart - Material Applications Across Cultures

Precedent	Material	Tequnique	Applications	Environmental Impact
Living Root Bridges	Rubber tree roots	Weaving and training growth	Bridges, walkways	Zero embodied carbon, supports ecosystems
Uros Floating Islands	Totora reeds	Layering	Floating islands, boats, housing	Fully biodegradable, renewable
Heatherwick Screens	Aluminium strips	Basket-weaving inspiration	Facades, shading	High embodied carbon, but operational savings
Kengo Kuma Structures	Bamboo, timber	Weaving	Walls, screens, roofs	Renewable, low embodied carbon

Additional precedents and sources of inspiration (site visits):

Kings castle Uganda, CTC conservation Uganda, Arts and crafts village Uganda, Weald & Downland Living Museum United Kingdom (original photographs in gallery at the end of sourcebook)

1. Thatch and Reed Curves

Detailed Process:

- Reeds are naturally flexible and can be bundled and bent into structural curves. The process involves:
    1. Selecting evenly sized reed bundles for uniform strength.
    2. Binding bundles tightly with hemp rope at intervals to create curved tensioned forms.
    3. Applying gradual force to bend reeds into desired shapes while ensuring the bundles maintain structural integrity.
- Hemp rope is essential for tensile strength and provides a biodegradable, low-carbon binding method.

Load Distribution and Bending Tolerances:

- Load Distribution: Reed bundles distribute loads evenly due to their dense, overlapping structure. This minimises weak points, making them suitable for arches and roofs.
- Bending Tolerances: Reeds can bend up to 45–60 degrees without splitting, depending on moisture content. Pre-soaking reeds improves flexibility and prevents cracking during bending.

Environmental Impact:

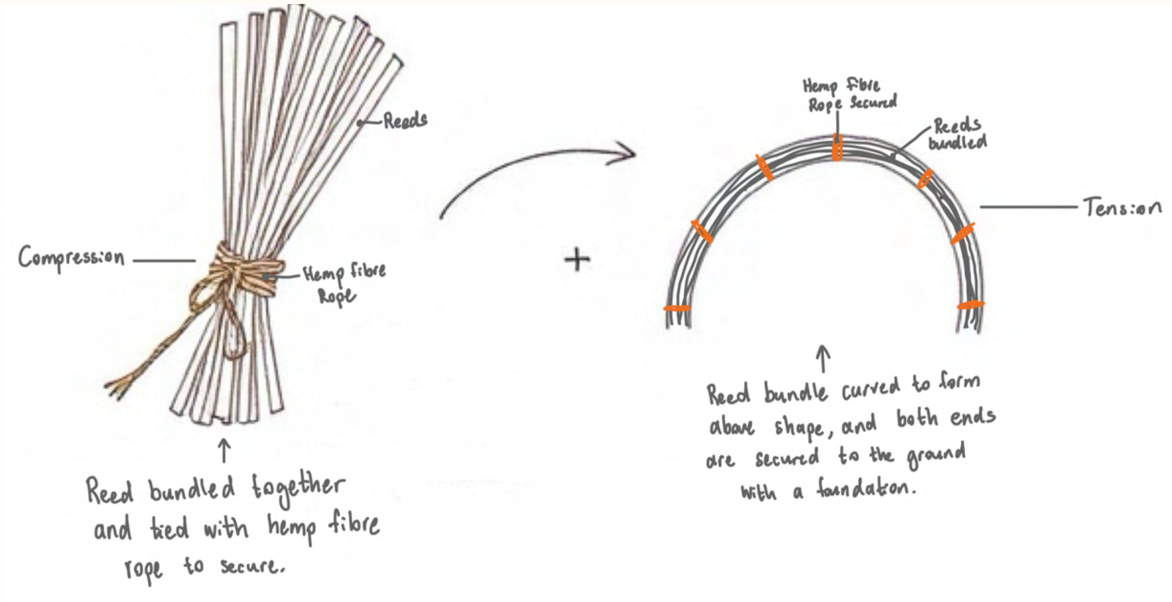
- Reeds and hemp rope are 100% biodegradable.
- Minimal embodied carbon compared to steel or concrete structures.
- Supports circular construction systems by decomposing naturally after the structure's lifecycle.

References:

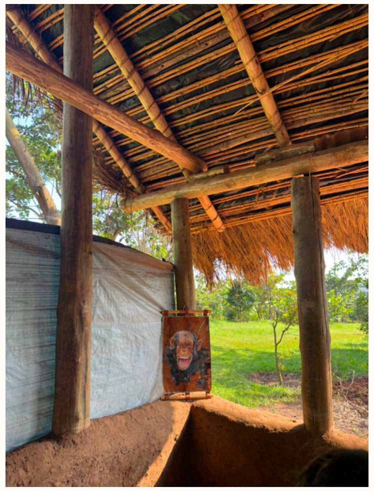
- Thomas Heatherwick: His woven screens demonstrate how bundling and tension create functional yet visually dynamic curves.
- Kengo Kuma: His bamboo weaving techniques showcase how natural fibres can form lightweight, strong structural systems that respond to environmental forces.

4. STRUCTURAL SYSTEMS

Step-by-step sketch showing reed bundling, tying with hemp rope, and bending into a curved form.



Reed structure supporting a thatched roof, with layered thatch for insulation and waterproofing.



2. Foundation Systems

Options:

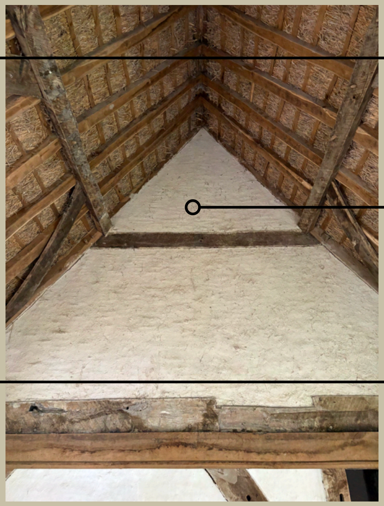
- Timber Foundations:
  - Renewable, locally sourced material with low embodied carbon.
  - Suitable for temporary structures or sites where environmental disruption must be minimised.
  - Vulnerable to decay without treatment, especially in moist environments.
- Steel Foundations:
  - High strength and long-lasting durability, suitable for permanent structures.
  - High embodied carbon due to energy-intensive production processes.
  - Resistant to moisture and insects, requiring less maintenance than timber.

Connection Methods:

- Timber:
  - Reeds are bundled and secured into pre-drilled holes or tied to wooden posts using hemp rope.
  - Connection points are elevated slightly off the ground to prevent moisture exposure.
- Steel:
  - Use prefabricated steel brackets or clamps to hold reed bundles securely.
  - Bolted connections provide stability, especially for high-load-bearing curves.







Doubling Covering

- Traditional doubling technique, combination of wet soil, clay, sand animal dung and straw, then adding a lime plaster wash overlay

Reed & Thatch Bundle

Internal Steel Support

Hemp Fibre Rope

Doubling Covering

Timber or Steel for Structure to Ground Support

Reeds and Thatch in Structure

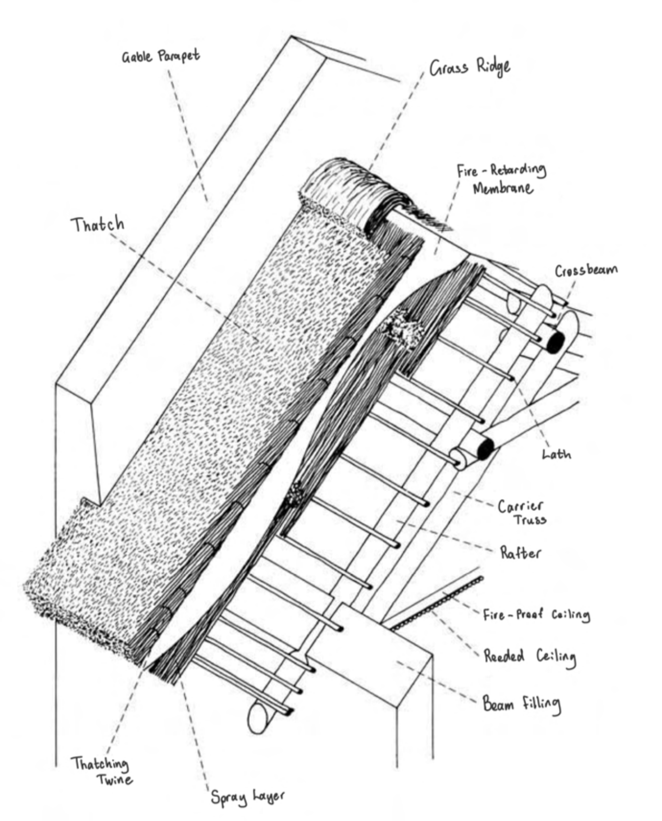
Material Analysis

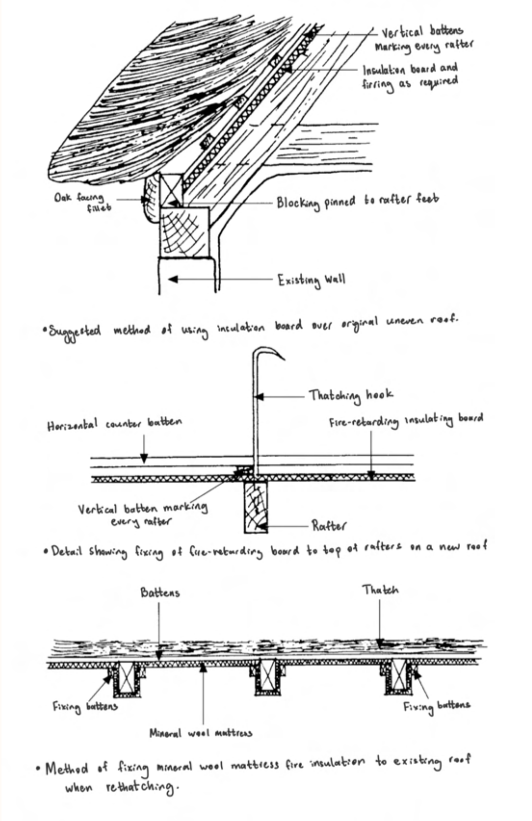
- Reeds:
  - Properties: Flexible, lightweight, naturally water-resistant.
  - Advantages: Renewable, low carbon, locally sourced.
  - Challenges: Requires maintenance to avoid decomposition in damp conditions.
- Thatch:
  - Properties: Durable, high thermal insulation, aesthetically appealing.
  - Advantages: Biodegradable, excellent for regulating interior temperatures.
  - Challenges: Prone to rot or insect damage without proper care.

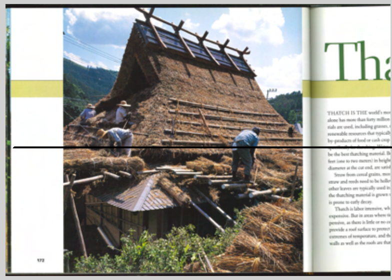
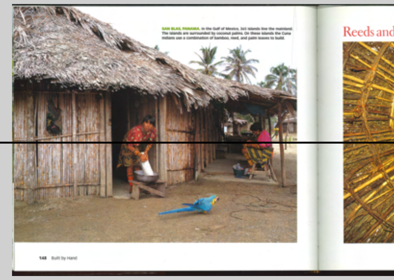
Structural Applications

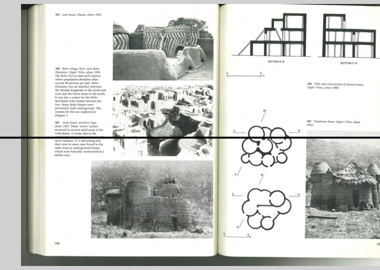
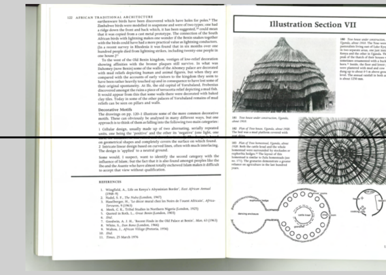
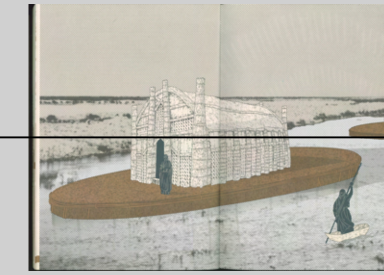
1. Reeds:
   - Bundled reeds are tied with hemp rope to form arches and curved frames.
   - Curves distribute loads effectively, minimising weak points.
   - Reference: Southwark countryside reed thatching demonstrates the traditional process of preparing and bundling reeds.
2. Thatch:
   - Applied in layers:
     - Base Layer: Provides insulation and a substrate for upper layers.
     - Outer Layer: Protects against weather, designed to shed water effectively.
   - Layering methods mimic fish scales to maximise water runoff and longevity.


Layering of thatch and reeds on a roof





References

Environmental Highlights

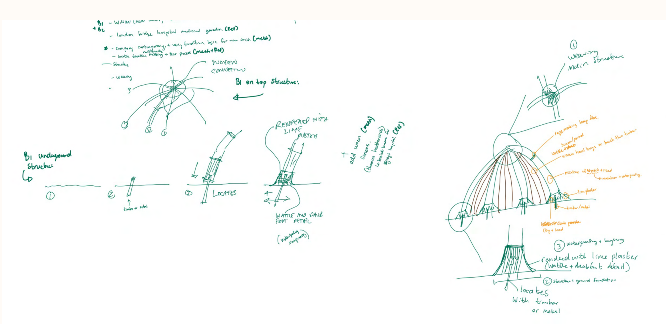
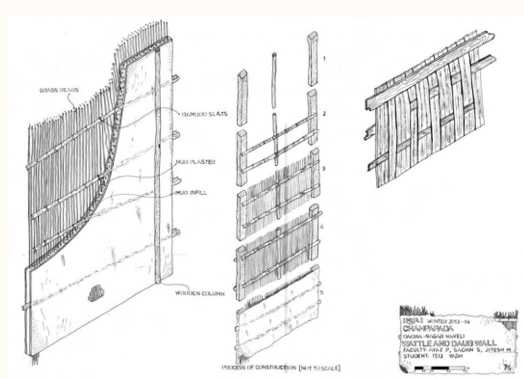
- Biodegradability:
  - Both reeds and thatch decompose naturally, enriching the soil.
  - Hemp rope ensures all components remain non-toxic after deconstruction.
- Embodied Carbon:
  - Reeds and thatch have significantly lower embodied carbon compared to concrete, steel, or synthetic insulation materials.
  - Use of local materials reduces transport emissions.

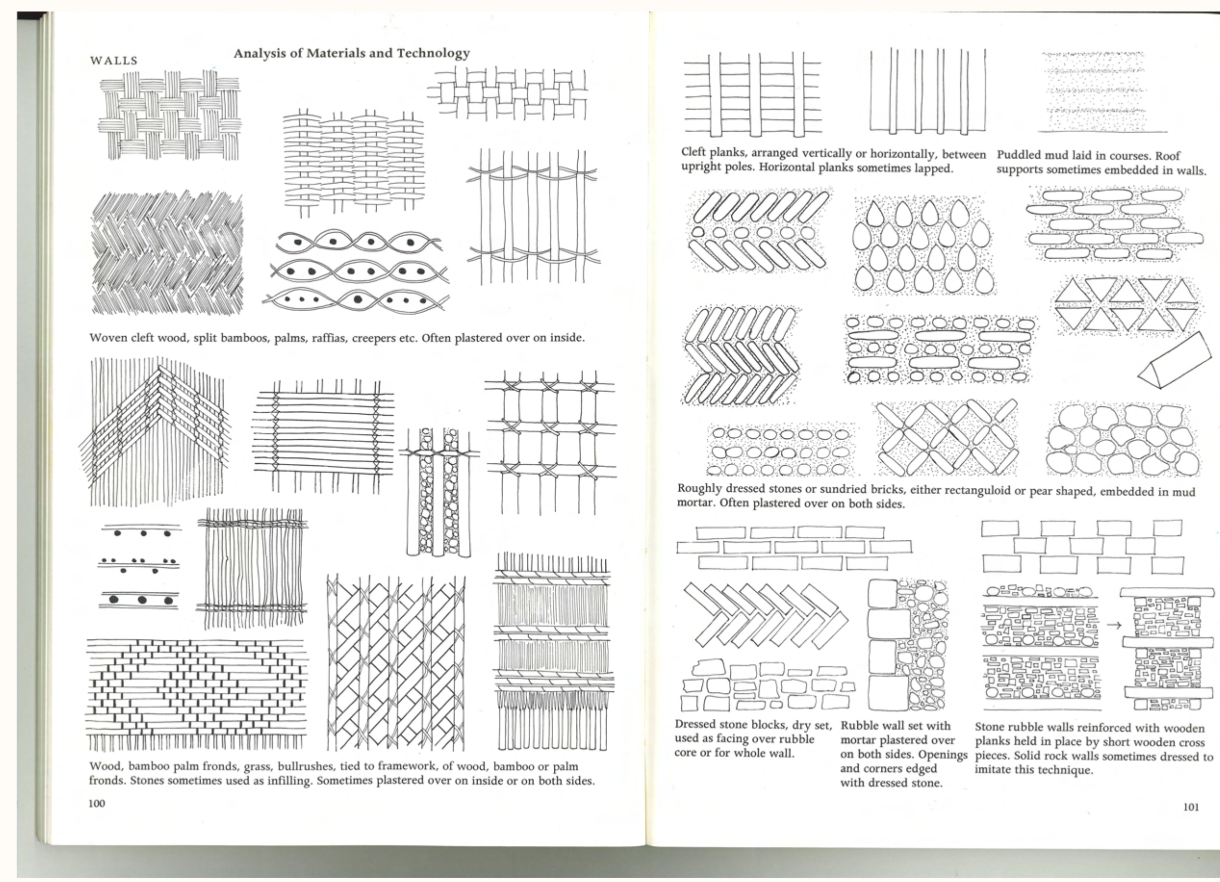


Prefabrication Techniques:

To enhance efficiency and reduce construction time, elements of wattle and daub and reed structures can be prefabricated:

1. Wattle Panels: Hazel rods can be woven into modular panels off-site, allowing for quick on-site assembly.
2. Reed Bundles: Pre-bundling reeds with hemp rope ensures uniformity and reduces on-site labor.
3. Daub Panels: Prefabricated daub-coated panels can be cured and transported to the site, minimising drying times.


WALLS

Analysis of Materials and Technology

Woven cleft wood, split bamboos, palms, raffias, creepers etc. Often plastered over on inside.

Wood, bamboo palm fronds, grass, bullrushes, tied to framework, of wood, bamboo or palm fronds. Stones sometimes used as infilling. Sometimes plastered over on inside or on both sides.

100

Cleft planks, arranged vertically or horizontally, between upright poles. Horizontal planks sometimes lapped.

Puddled mud laid in courses. Roof supports sometimes embedded in walls.

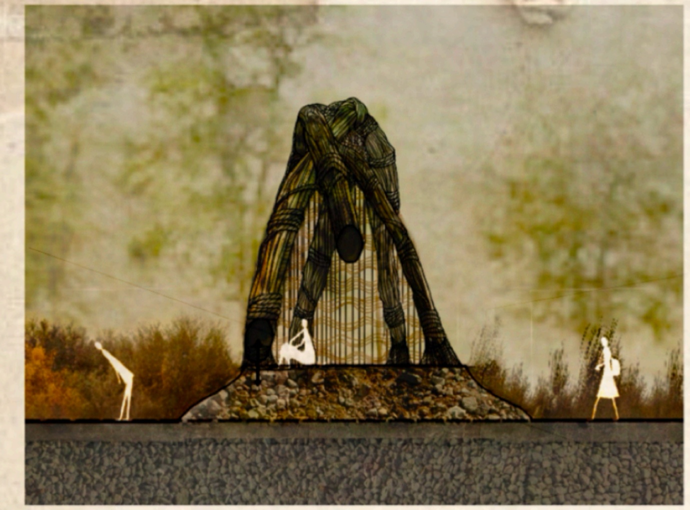
Roughly dressed stones or sundried bricks, either rectangluoid or pear shaped, embedded in mud mortar. Often plastered over on both sides.

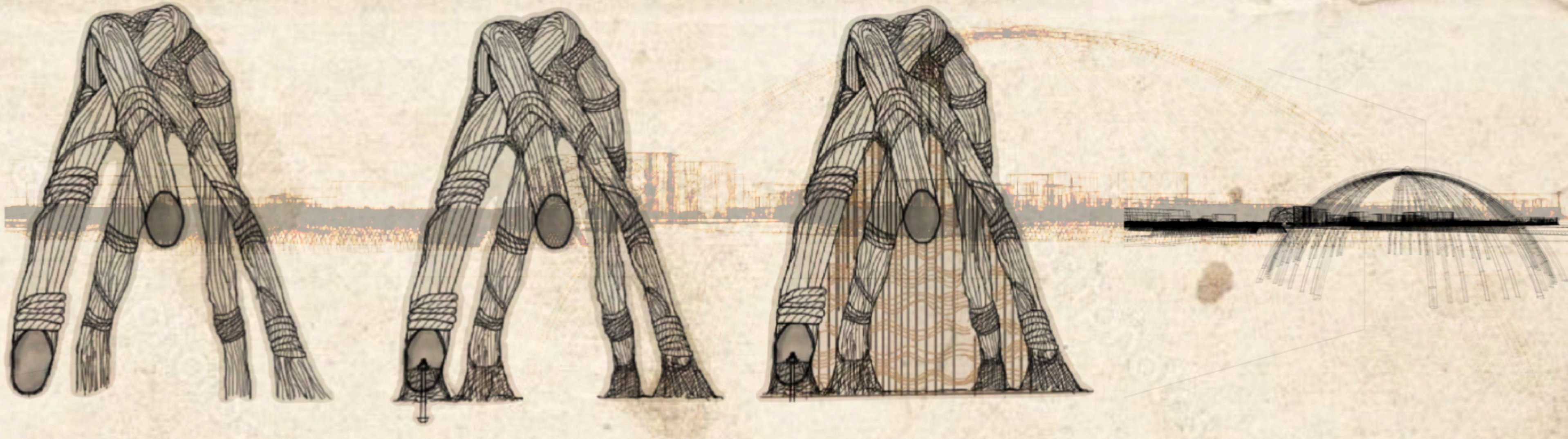
Dressed stone blocks, dry set, used as facing over rubble core or for whole wall.

Rubble wall set with mortar plastered over on both sides. Openings and corners edged with dressed stone.

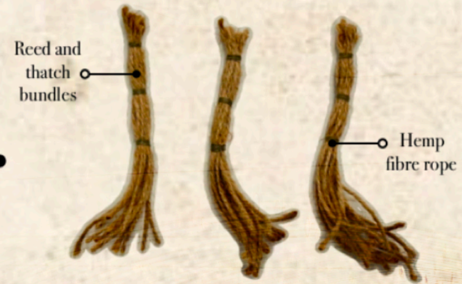
Stone rubble walls reinforced with wooden planks held in place by short wooden cross pieces. Solid rock walls sometimes dressed to imitate this technique.

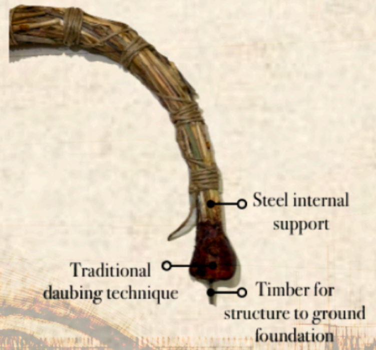
101

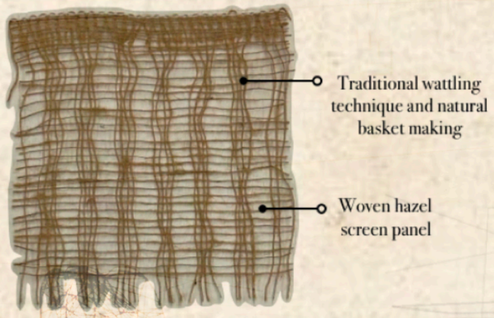




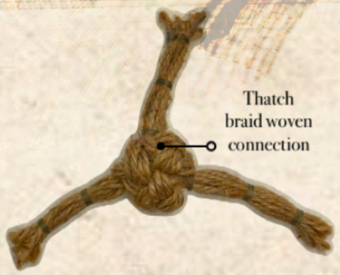
Technical concepts modelled





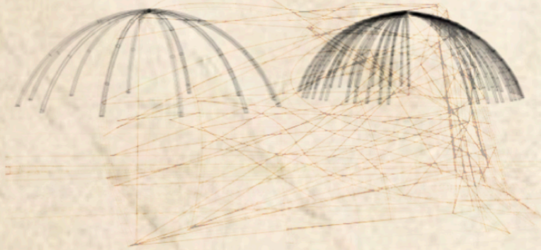


Ancestral techniques for methodology implementation

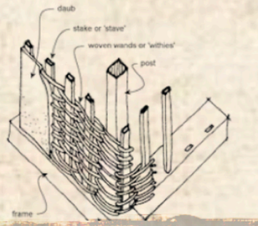



Traditional wattle and daub construction


Ancient natural material woven basket




Traditional hemp fibre rope production process


Wattle and daub technical construction process breakdown


Wattle fence traditional construction

TECHNICAL BREAKDOWN, CLADDING STRUCTURES AND CONCEPTUAL UNDERSTANDING

Foraged planets production building construction.

Step 1: Creating thatch and reed structural curves; hemp fibre rope bundling. Then weaving main structural bundles together on the top of the structure to make a woven connection.

Step 2: Locating structure to the ground foundation with timber or steel. Daub technique utilisation on the structures bace and rendering for waterproofing, bug saving, and thermal insulation.

Step 3: Wattle only technique for a woven screen panel around with hazel to enclose and clad the structure.

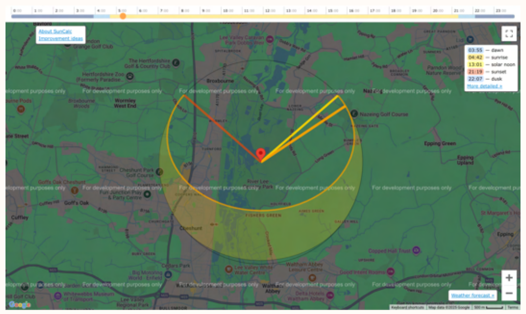
5. ENVIRONMENTAL STRATEGIES

1. Climate Considerations

Content:

Sun-Path Analysis:

- Summer: The structure is designed with overhanging thatch and angled reed curves that provide shade to interior spaces, reducing solar heat gain during the hottest months.
- Winter: Openings are oriented to the south (in the Northern Hemisphere) to capture low-angle sunlight, naturally heating the interior.
- The use of wattle panels with adjustable woven designs allows light control based on seasonal needs.

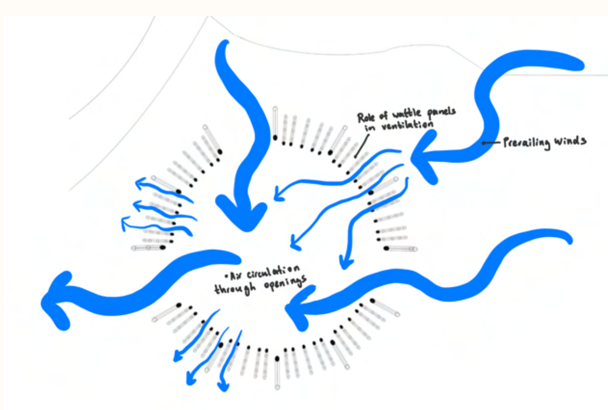


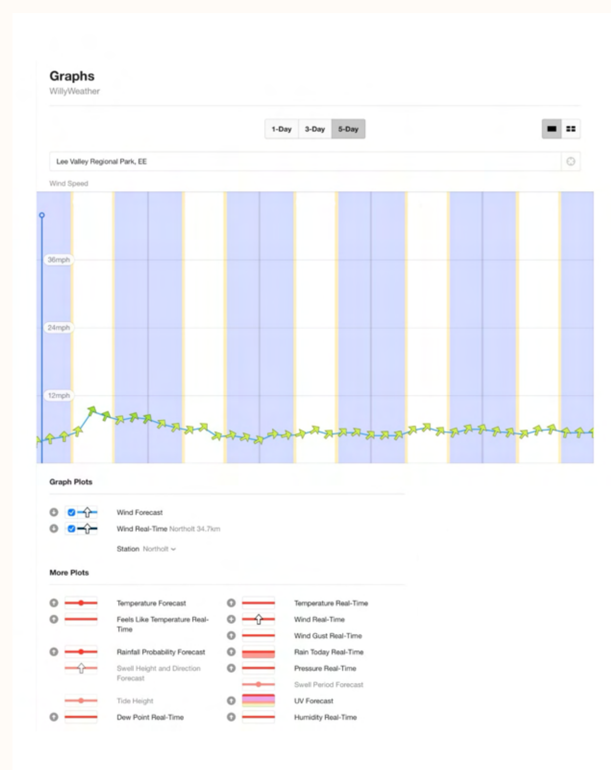
Summer Sun Path

Winter Sun Path

2. Wind Flow:

- Wattle panels are strategically placed to allow natural cross-ventilation. The weaving patterns in hazel wattle screens diffuse strong winds, providing comfort in summer.
- The reed curves themselves enhance air circulation by channeling breezes through the structure.





Environmental Site Investigations:

Sun-Path Modelling:
A sun-path analysis was conducted for the proposed site, identifying optimal solar orientations.

- Summer: Overhanging reed and thatch elements provide shade to minimise overheating.
- Winter: The south-facing orientation ensures low-angle sunlight penetrates deep into the interior for natural heating.

Wind Mapping:

Wattle panels are positioned to optimise ventilation by channeling prevailing summer breezes through openings while diffusing strong winter winds. This ensures thermal comfort and reduces reliance on mechanical ventilation systems.

Biodiversity and Air Quality Mapping:

Local biodiversity influences the sourcing of hazel, reeds, and clay, ensuring minimal ecological disruption. Air quality is enhanced through the use of breathable materials like reed and thatch, which allow natural airflow and filter particulates.

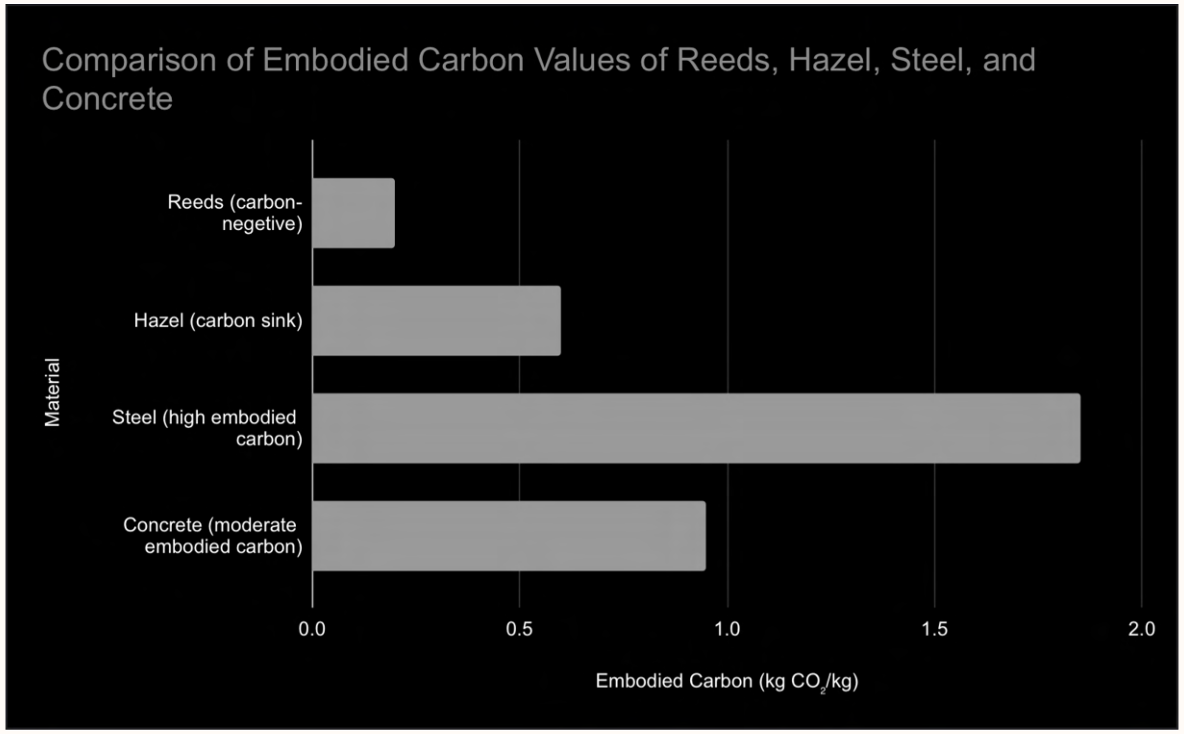
3. Material Lifecycle

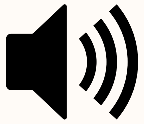
Content:

1. Lifecycle Stages:
    - Growth: Reeds and hazel are fast-growing, renewable resources. Reeds can be harvested annually, and hazel can be coppiced every 7–10 years.
    - Construction: Minimal processing is required. Both materials can be cut, bundled, and shaped on-site, reducing transport and energy costs.
    - Biodegradation: At the end of their lifecycle, reeds and hazel naturally decompose, enriching the soil with nutrients. Hemp rope and daub are also biodegradable.

Circular Diagram:
Lifecycle of reeds & hazel.

2. Carbon Analysis:
    - Reeds are a carbon-negative material: They absorb more carbon during growth than is emitted during harvesting and processing.
    - Hazel, when coppiced sustainably, acts as a long-term carbon sink, continuously sequestering carbon.
    - Comparative embodied carbon analysis:
        - Reeds: ~0.2 kg CO_2 per kg (carbon-negative).
        - Hazel: ~0.6 kg CO_2 per kg.
        - Steel: ~1.85 kg CO_2 per kg.
        - Concrete: ~0.95 kg CO_2 per kg.



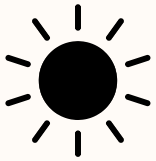


Acoustic Benefits:

The porous structure of reeds and thatch provides natural sound insulation, absorbing ambient noise and creating quieter interior spaces. This is especially beneficial in rural or urban-fringe settings where wind noise or nearby activity can be mitigated.

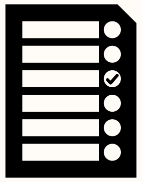
Fire Safety Considerations:

While reeds and thatch are flammable, modern treatment methods can enhance fire resistance. A borax-based solution can be applied to reeds and thatch to slow ignition and reduce the spread of flames. Hazel wattle panels, when coated with lime-rich daub, also improve fire safety by acting as a barrier to flames.



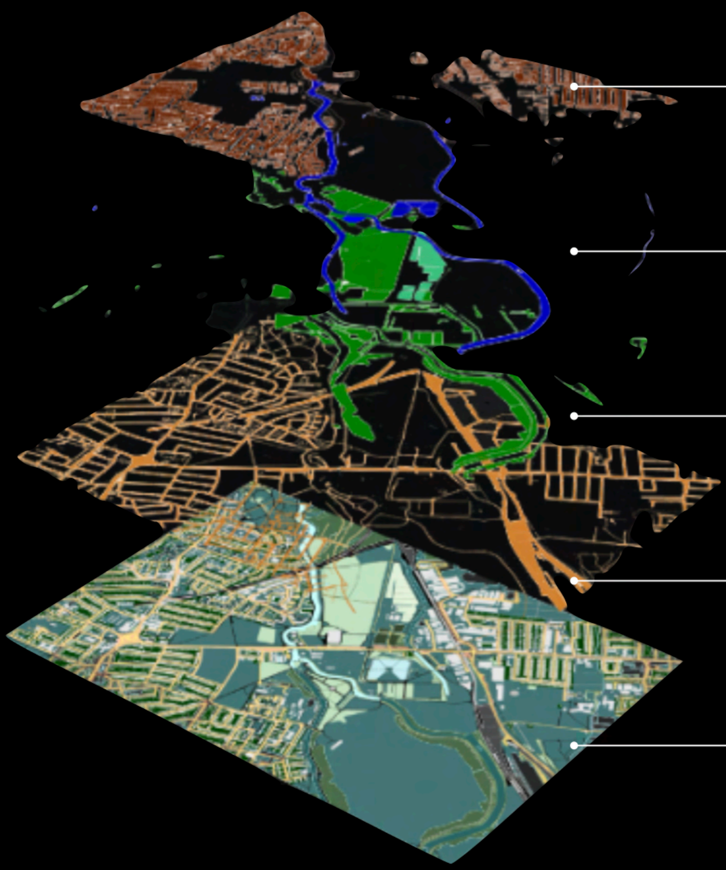
Daylighting Strategies:

Reed and wattle panels can be designed with intentional gaps or translucent layers to allow diffused natural light. This reduces the need for artificial lighting during the day while maintaining privacy and thermal performance.



Integration with Site Microclimates

- The structure's design responds to site-specific conditions, ensuring minimal energy use:
    - Orientation for passive solar heating.
    - Material use for natural insulation and ventilation.
    - Adaptability to local wind and precipitation patterns.



Existing Buildings

- Lea Bridge Library
- Ice Rink and Leisure Centre
- Nearby residential buildings
- Industrial units along the canal

Water Bodies

- River Lea (also known as River Lee)
- Canalised sections of the River Lea
- Marshland ponds and wetlands

Vegetation and Greenery

- Extensive grasslands (Hackney Marshes)
- Woodland areas (e.g., native trees like oaks, willows, and birches)
- Wildflower meadows
- Riparian vegetation along waterways

Pathways

- Towpaths along the Lee Navigation
- Cycling routes and footpaths connecting marshlands and urban areas
- Pedestrian bridges over the River Lea
- Recreational trails across Hackney Marshes

Complete map of all elements visible in Lea Valley in Hackney Marsh, London, UK

LEA VALLEY

INTRODUCTION TO THE SITE

The main site Lee Valley is located in the Hackney borough London UK with the focal point on the specific site being located near Lee Bridge Road.

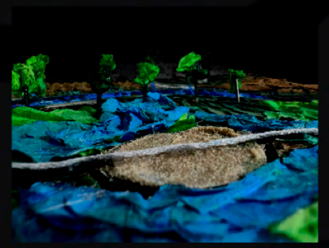
The sides consists of vegetation and contains a diverse network of pathways leading towards it. The Lee valley River runs through it which feeds the greenery and vegetation varying from marshland ponds, scrubs, wetlands, grassland fields and thick woodland.

Since the early 1700s, the area has originally had water works and filter beds. Due to multiple cholera epidemics in the 1830s, they were constructed in the 1860s to provide London homes with clean drinking water but now providing to nature.

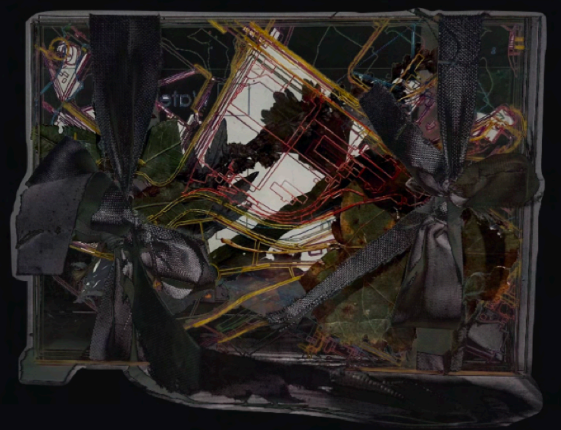
Over time, new habitats were created and species returned once the filter beds were closed in the 1970s and human activity ceased. While nature soon gained traction, different habitats and species took many years to develop into what they are presently.

Mapping Lea Valley

Transect Walk Mapping



Site Photography



Compressed Vegetation & Site Dissection Exploration

6. WATTLE & DAUB DETAILING

1. Construction Process

1.1 Wattle Weaving

- Step-by-Step Technique:

  A. Framework Setup: Vertical hazel rods are inserted into timber or steel frames at regular intervals.

  B. Weaving Patterns:
     - Traditional: Alternating horizontal hazel rods around the verticals to create a sturdy lattice.
     - Modern Adaptations: Diamond or spiral weaves for increased load distribution and aesthetic variety.

  C. Tightening and Finishing: Ensure rods are tightly woven to minimise gaps, enhancing stability and support for daub application.

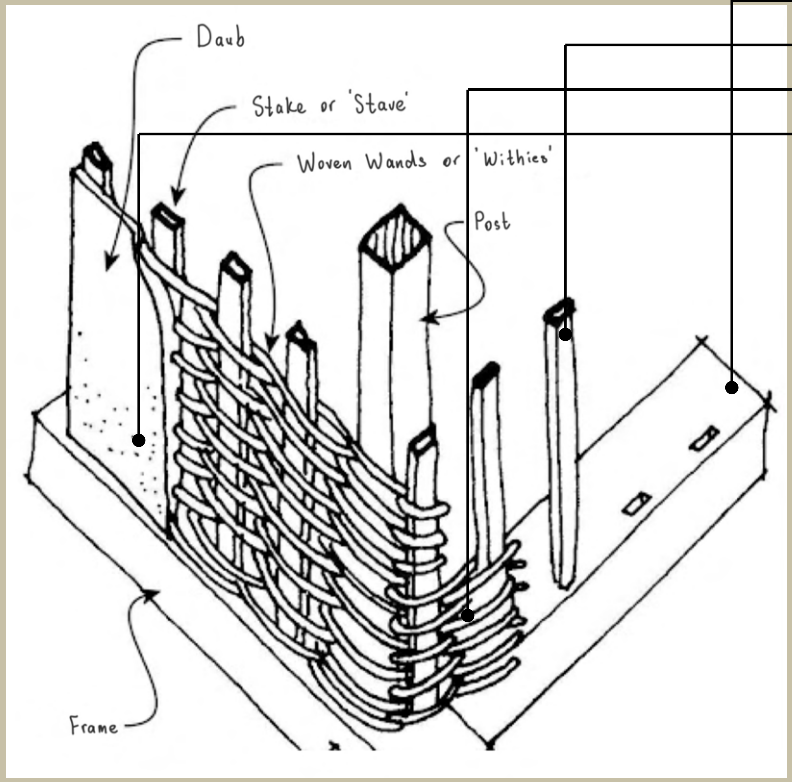
1.2 Daub Application

- Layering Process:

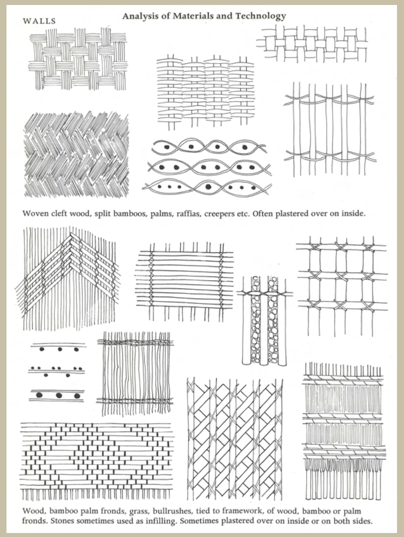
  A. Base Coat:
     - A mix of clay, sand, straw, and water is applied to the wattle lattice for structural adhesion.
     - Optional additives (e.g., lime or hemp fibres) improve flexibility and reduce cracking.

  B. Intermediate Coat:
     - Applied once the base dries; thicker consistency for insulation.
     - Thermal performance can be enhanced using cob-bauge techniques, incorporating clay and straw for high insulation.

  C. Finish Coat:
     - Smooth, waterproof clay-lime plaster for a weather-resistant exterior.
     - Modern mixes may include carbon-reducing additives (e.g., pozzolans) for sustainability.



Exploded Axonometric Drawing: Showing the construction of a wattle and daub panel from the foundation to the finished surface.



Traditional weaving patterns (diamond, square).

Textural details of the daub surface. (rough, smooth).

2. Environmental Benefits

- Local Sourcing:
  - Hazel and clay are widely available in many regions, reducing transport emissions.
  - The use of natural materials eliminates the carbon footprint associated with synthetic insulation and cladding.
- Compostable End-of-Life Cycle:
  - At the end of its life, wattle and daub panels naturally decompose, enriching the soil without producing waste.

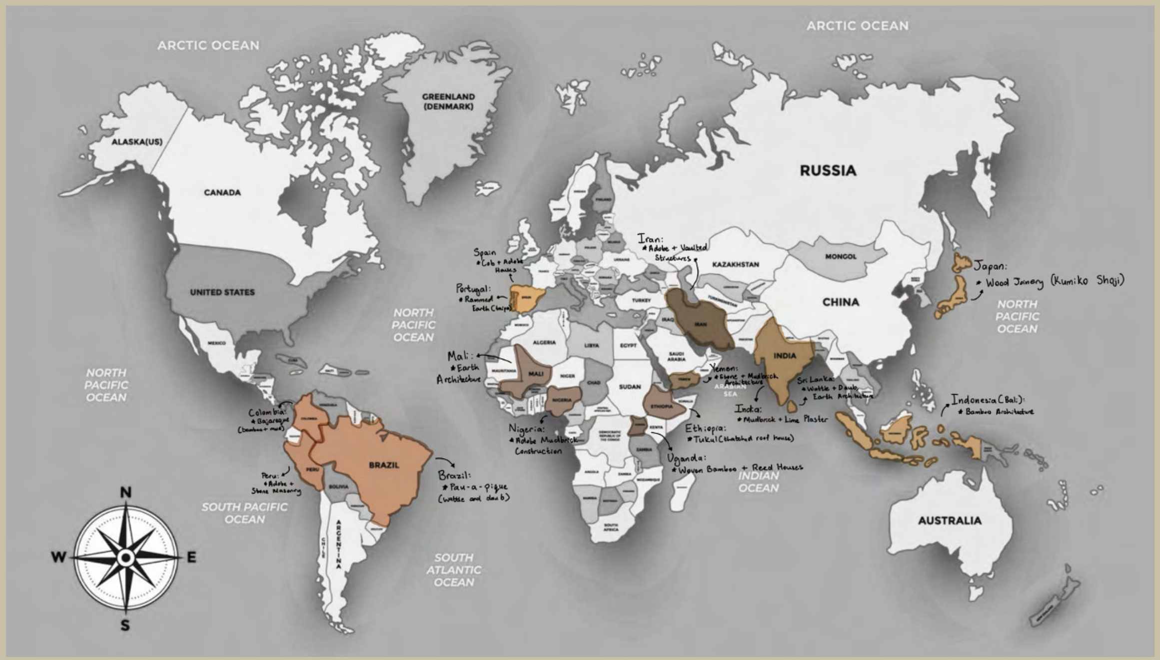
3. Material Analysis

Hazel:

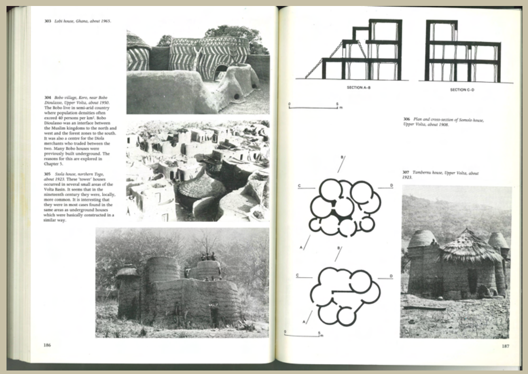
- Properties:
  - Flexibility: Essential for weaving panels that can absorb loads without breaking.
  - Strength: Provides a durable framework for daub application.
  - Renewability: Hazel can be coppiced every 7–10 years, ensuring a sustainable supply.
- Applications:
  - Traditional wattle screens for walls and partitions.
  - Modern adaptations for lightweight, ventilated cladding.

Daub:

- Properties:
  - Thermal Insulation: Effective in reducing heat transfer.
  - Waterproofing: Enhanced by lime or clay-rich mixtures.
  - Sustainability: All-natural components, often locally sourced.
- Thermal Performance:
  - U-Value: Traditional daub systems can achieve U-values of ~0.4–0.6 W/m²K. When combined with cob insulation, U-values can drop below 0.3 W/m²K, approaching Passive House standards (~0.15 W/m²K).
  - Thatch and Reed Comparison: Thatch roofs can achieve U-values as low as 0.2–0.3 W/m²K, making them highly competitive for sustainable construction.

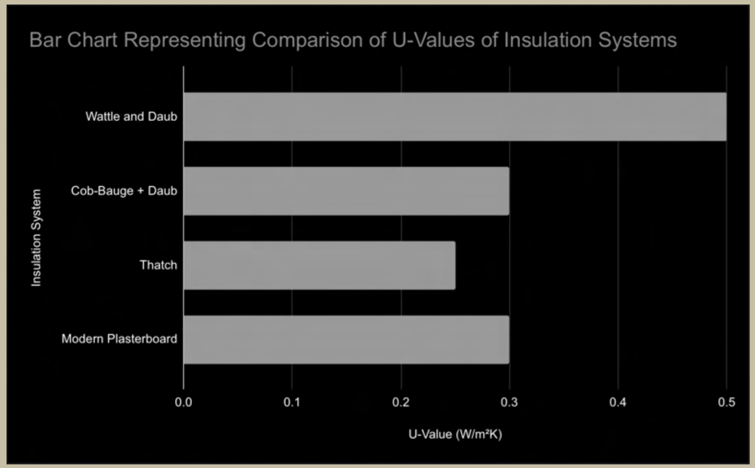


A map showing regions where traditional construction methods are commonly used around the world.



Traditional Daubing Reference .

Traditional Bamboo Weaving Reference .



Comparing U-values of wattle and daub with other insulation systems (e.g., cob-bauge, thatch, modern plasterboard).

Traditional Daubing Reference .

4. Foundations and Grounding

Timber Foundations:

- Advantages:
  - Renewable, biodegradable, and easy to source.
  - Best suited for temporary or lightweight structures.
- Disadvantages:
  - Vulnerable to decay and insect damage in wet environments.

Steel Foundations:

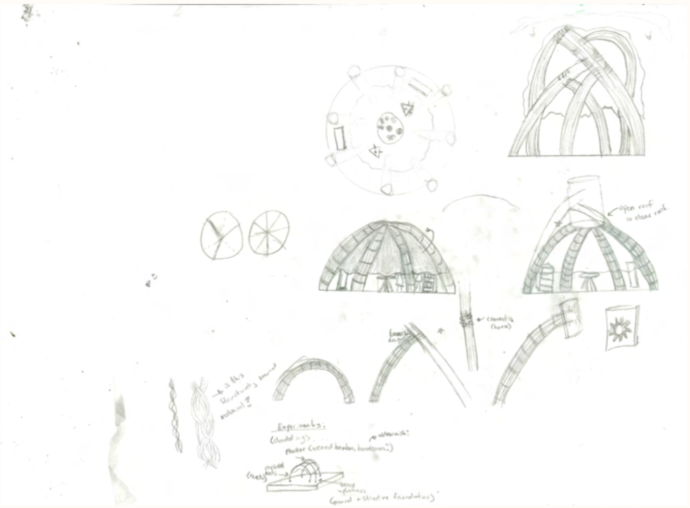
- Advantages:
  - Long-lasting and resistant to environmental degradation.
  - Suitable for permanent, high-load structures.
- Disadvantages:
  - High embodied carbon due to energy-intensive manufacturing.
  - Difficult to recycle compared to timber.

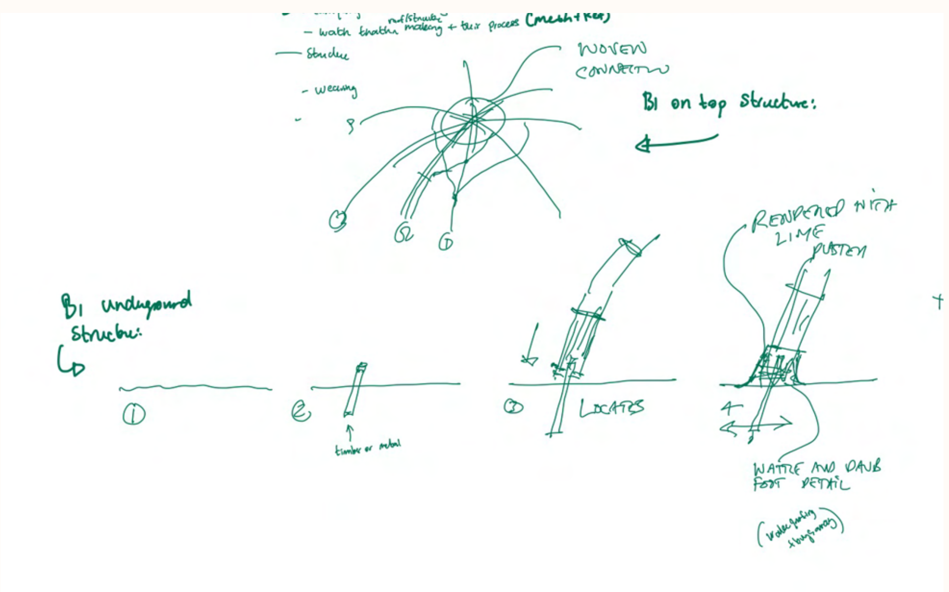
Environmental Considerations:

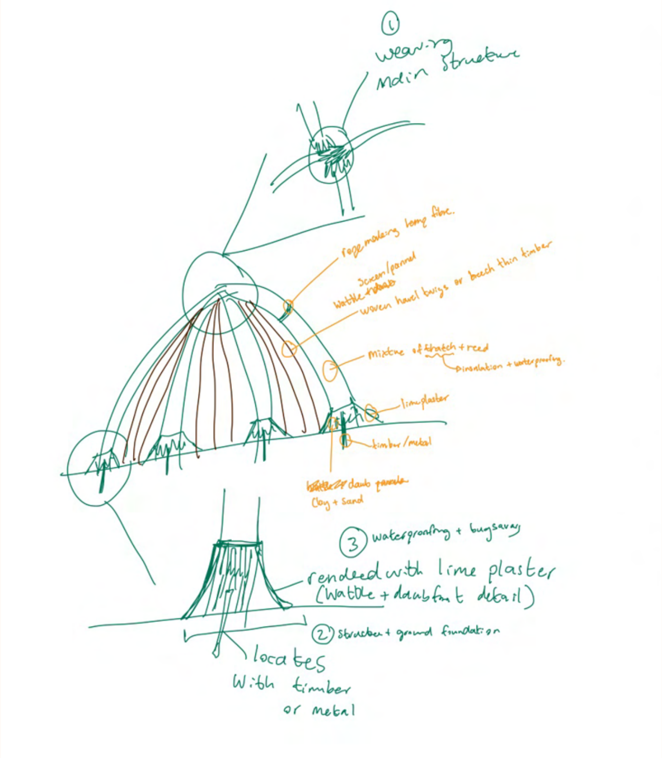
- Hazel panels on timber frames have minimal embodied carbon.
- Steel frames, while durable, significantly increase the carbon footprint of the structure.

5. Thermal Performance of Wattle and Daub

- Cob-Bauge Reference:
  - Cob-bauge construction, as highlighted by the Construction History Society, combines rammed earth and cob for structural stability and insulation.
  - Modern cob achieves excellent insulation performance while maintaining the breathable qualities of natural materials.
- Passive House Relevance:
  - The airtight yet breathable nature of reed and thatch can meet Passive House standards when paired with properly insulated wattle and daub walls.
  - Materials like lime or hemp additives in daub enhance performance.







7. EXPERIMENTS & TESTING

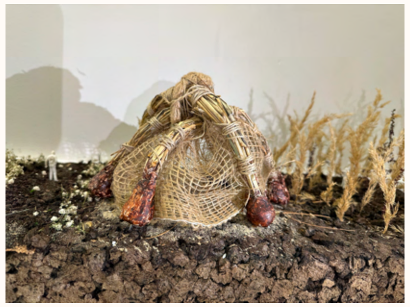
1. Reed Bundling

Experiment:

- Objective: Test the structural integrity and flexibility of reed bundles when tied with ropes and fibres.
- Process:
    1. Collected reed samples from a local park.
    2. Tested different bundling methods using rope and reed grass fibres harvested from the same park.
    3. Gradually applied tension to evaluate how tightly the bundles could be secured without cracking or splitting the reeds.
    4. Included a bendable steel rod in the centre of the reed bundle, then slowly begun bending the reed bundles to create curved arch shaped reed bundles.

Findings:

- Successes:
    - Bundling with rope provided tensile strength and flexibility.
    - Bendable steel rod allowed for reed bundle to be shaped and remain in the given curved shape without straightening again; resulting in low tension bundled curve.
- Failures:
    - Reeds became brittle when dried too quickly, leading to cracking under tension.
- Adaptations:
    - Pre-soaking reeds in water for 12–24 hours improved flexibility during bundling.
    - Combining reed grass fibres with rope enhanced the overall structural stability of the bundle.



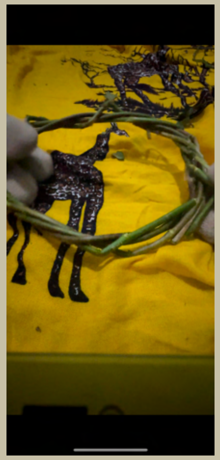
2. Wattle Weaving & Rope Making

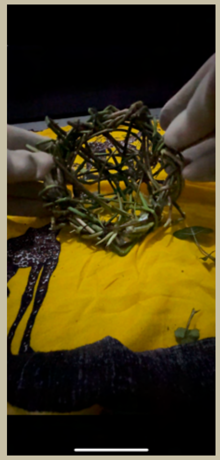
Experiments:

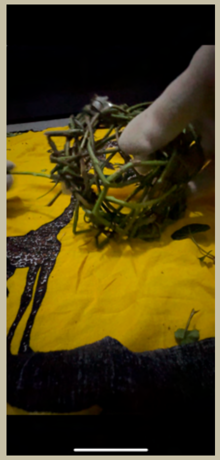
- Objective: Assess different weaving patterns (square, diamond, spiral) using textile fabrics (resembles flax fibre), and Ivey plant stems, & learn about flax plant processing into linen fabric and ropes.
- Process:
  1. Prepared fabric into vertical separate lines as the base framework, then tested different weaving patterns:
     - Square weave: Traditional, simple interlacing.
     - Diamond weave: Complex pattern, better load distribution.
     - Spiral weave: Decorative, but less rigid.
  2. Experimented traditional basket making; hand made from natural foraged ivy through ancestral traditional techniques of removing leaves, creating circular bace to start, weaving branches to circular base to create a basket curved structure, continue weaving branches to create full basket.
  3. Visited Weald & Downland Living Museum in Chichester, and learned the process of harvesting flax plants, cleaning off seeds, processing stems for plant wall breakdown and easy fibre extraction, drying and creating finer fibres through processing stems by hand and with different equipment, then using spinner to create rope from flax plant fibres.

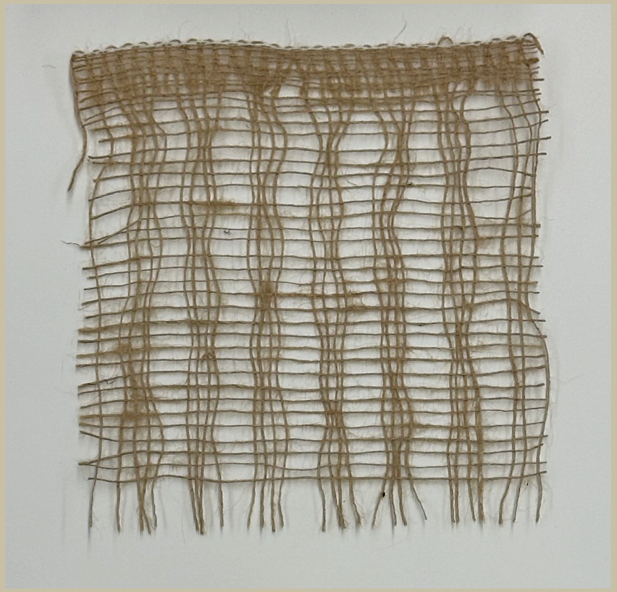
Findings: For Weaving Patterns

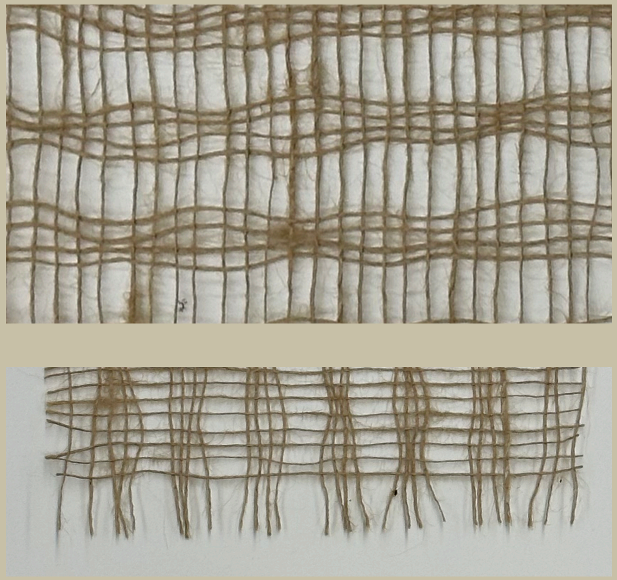
- Successes:
  - The diamond weave provided the highest load distribution and rigidity, making it suitable for structural wall panels.
  - Square weave was easier and quicker to execute, ideal for non-load-bearing partitions.
- Failures:
  - Spiral weave lacked structural stability and was prone to warping under pressure.
- Adaptations:
  - Added horizontal reinforcement rods in the middle of the diamond weave for greater stability.
  - Combined square and diamond patterns for specific applications (e.g., diamond in load zones, square in decorative areas).











3. Daub Insulation Properties

Experiment:

- Objective: Experiment daub mixes, and the mixes' possible insulation and waterproofing properties.
- Process:
  1. Prepared daub sample with clay, sand, straw, horsehair (by-product) for insulation and tensile strength, and used hemp fibres for improved flexibility and carbon sequestration.
  2. Applied sample to bace of a reed bundle, wrapping and securing together the ends of reeds, ensuring to leave 'structure to ground' support central foundation out.

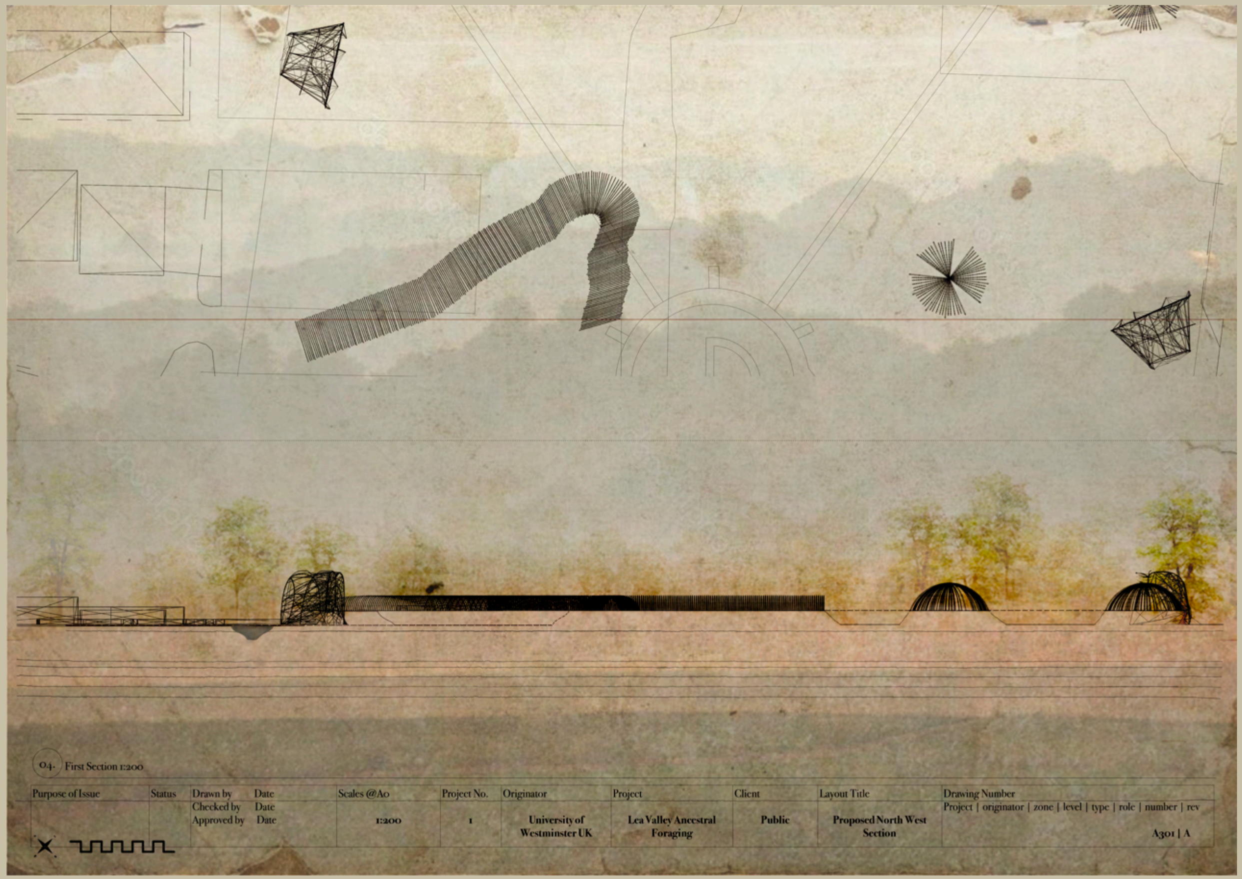
Findings:

- Successes:
  - Reed bundle secured properly, enclosing the end of the curve bundle and fixing it to foundation bace. No cracking wash showed even under pressure from internal reed sticks pushing outwards, remained secure.
- Failures:
  - Securing daubed reed bundle to bace was difficult as central foundation support was not thick enough.
- Adaptations:
  - Incorporated horsehair for added tensile strength.

4. Reflections on Design Decisions

- Reed Bundling:
  - Resulted in a better understanding of how pre-soaking reeds enhances flexibility, informing the structural curves in the design.
- Wattle Weaving:
  - Inspired the use of a hybrid square-diamond pattern for load-bearing panels in the structure.
- Daub Insulation:
  - The final mix combines hemp fibres, and horsehair for optimal insulation and durability.

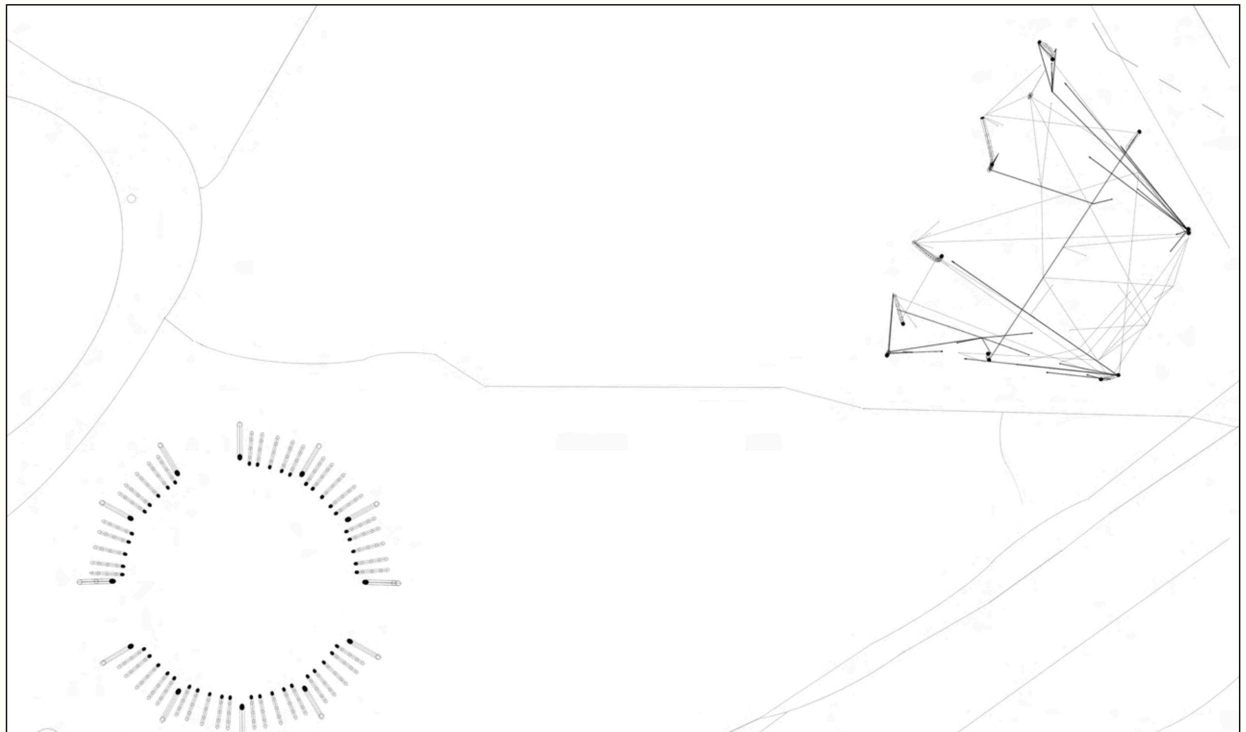
8. TECHNICAL DESIGN STATEMENT



The buildings materiality and structural concepts are inspired mainly from Jingkieng Dieng Jri Living Root Bridges of The Khasis in India, Totora Reed Floatinf Islands of the Uros in Peru, and Al-Tahala Floating Islands of the Ma'dan in Iraq, along with the places visited as site visits for further educational knowledge and traditional heritage experiences.

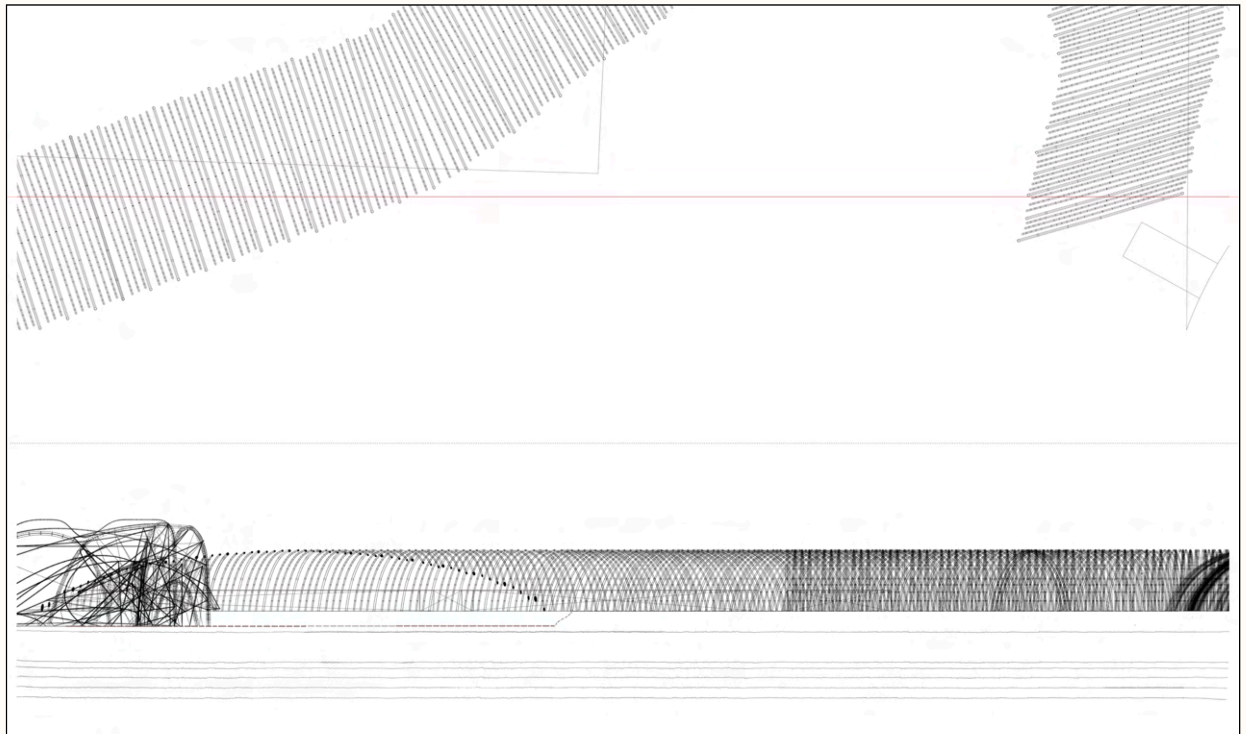
The choices of structure cladding and materiality was explored with the focus of using sustainable materials that can be grown on the site, for example reeds or hazel, and will be able to give back to nature in the future through the process of decay, decomposition or natural succession. The techniques used in construction selected are traditional and honour ancestral practices like the foraging ritual (part of the brief and programme theme of design) does; through methods of hand building and intertwining what has been provided for by nature to create a structure for human inhabitation. It is further a celebration of the past and its traditions, and a way to learn from the generational traditional knowledge and implement their techniques and materiality for contemporary sustainable architecture.

INHABITED TRANSECT MODEL @1:50 SCALE



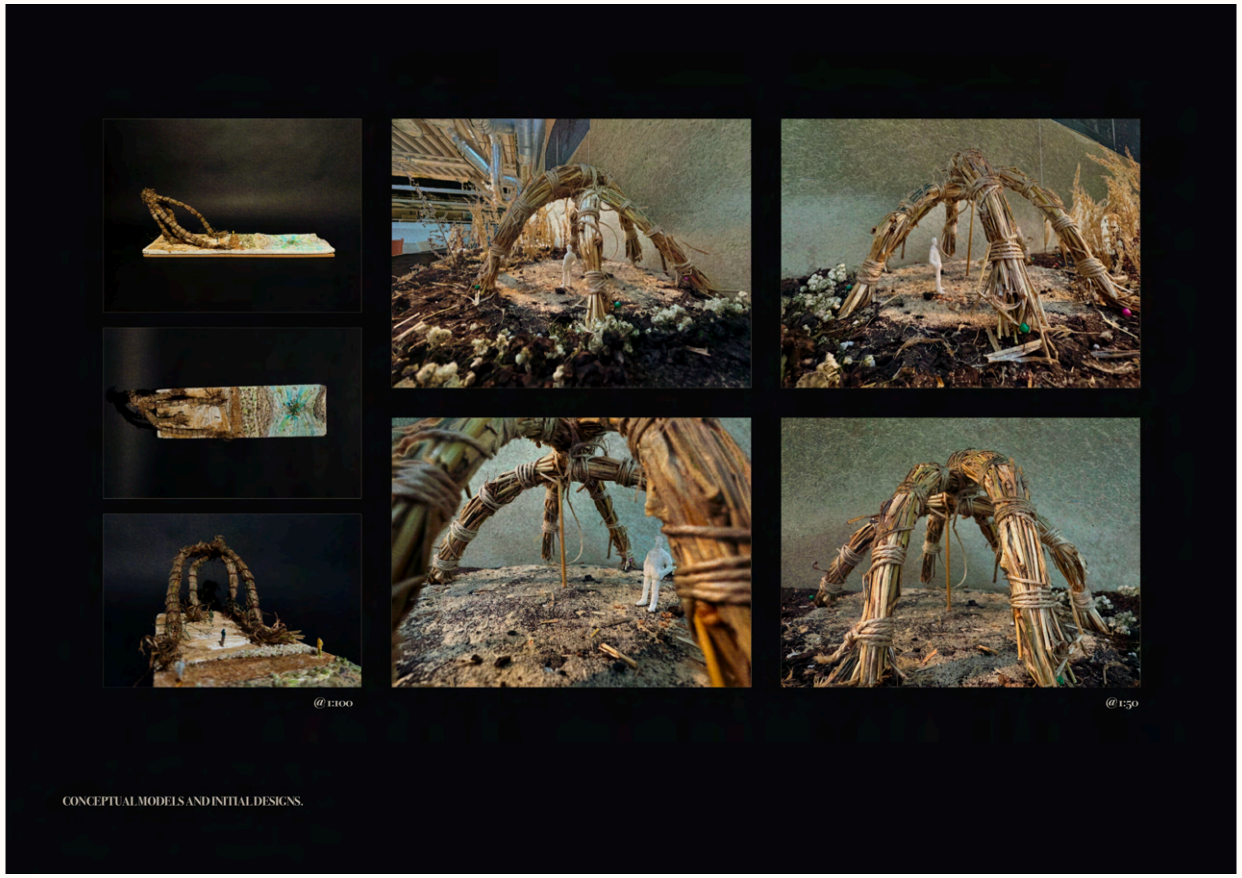
03. Ground Floor Plan 1:50

Purpose of Issue	Status	Drawn by Date Checked by Date Approved by Date	Scales @A0	Project No.	Originator	Project	Client	Layout Title	Drawing Number Project | originator | zone | level | type | role | number | rev
			1:50	1	**University of Westminster UK**	**Lea Valley Ancestral Foraging**	**Public**	**Proposed Ground Floor Plan**	**A101 | A**



05. Second Section 1:50

Purpose of Issue	Status	Drawn by Date Checked by Date Approved by Date	Scales @A0	Project No.	Originator	Project	Client	Layout Title	Drawing Number Project | originator | zone | level | type | role | number | rev
			1:50	1	**University of Westminster UK**	**Lea Valley Ancestral Foraging**	**Public**	**Proposed North West Section**	**A302 | A**



9. REFLECTIVE LOG

1. Key Findings and Decisions

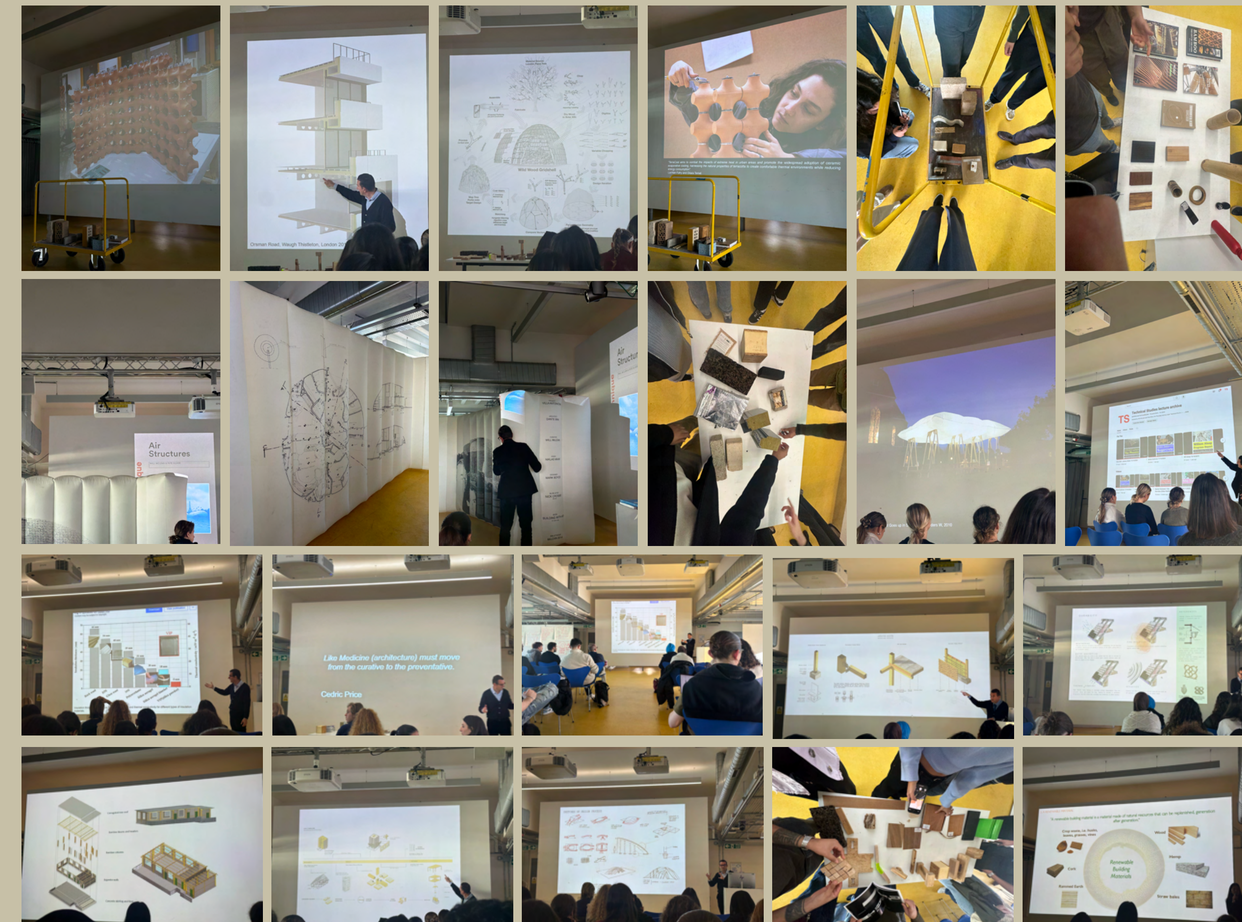
Summary of Findings:

- Material Properties:
    - Reeds and hazel are flexible, breathable, and biodegradable materials. These qualities make them ideal for creating dynamic, moisture-regulating, and low-energy structures.
    - Hemp rope enhances the tensile strength of reed bundles while aligning with low-carbon goals.
    - Daub combines natural clay, straw, and lime, providing thermal insulation and reducing embodied energy.
- Environmental Benefits:
    - Reeds are carbon-negative: they sequester carbon during growth, require minimal energy for processing, and decompose naturally.
    - Hazel coppicing contributes to a circular economy by promoting regrowth every 7–10 years.
    - Thatch provides excellent thermal insulation with U-values approaching 0.2–0.3 W/m^2K, rivalling Passive House standards.
- Construction Techniques:
    - Combining traditional weaving patterns (square and diamond) with prefabrication methods can save energy and labor.
    - Layering daub with hemp fibres or lime improves thermal and moisture performance.
- Sustainability Decisions:
    - Opted for timber foundations for temporary structures to reduce embodied carbon compared to steel.
    - Used wattle panels for natural ventilation and passive cooling.

2. Impact of Lectures and Site Visits

Site Visit Insights:

- Observations from local reed thatching workshops:
    - Understanding how reeds are harvested and bundled influenced the decision to use pre-soaked reeds for structural curves.
- Exploring hazel wattle patterns in East England:
    - Inspired the integration of square and diamond weaves to balance aesthetics with load-bearing needs.
- Overall Ugandan Site Visits and UK Site Visits:
    - Site visits gave the opportunity to experience firsthand, different traditional techniques and materials that could lead to sustainable contemporary architecture. Allowed for the opportunity to touch the materials, enter the different spaces and communicate with specialists in the fields for further educational experience and knowledge.



Lecture Insights:

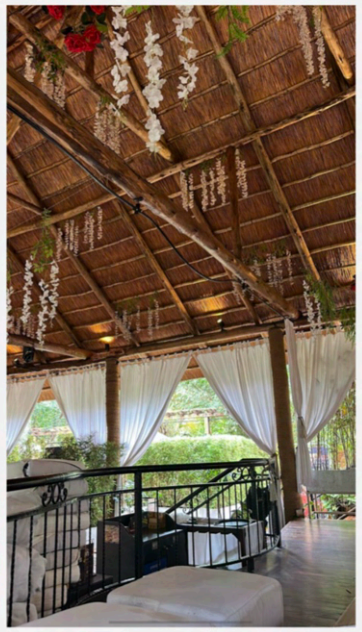
1. Passive House Lecture by Megan Ancliff (YouTube):
    - Emphasised the importance of airtight but breathable materials to achieve low U-values and reduce heat loss.
    - Inspired the focus on thermal insulation using thatch and daub, as well as incorporating passive shading with reed curves.
2. Technical Study Classes (University of Westminster):
    - Highlighted how natural materials, like bamboo and reeds, absorb carbon during growth and require minimal energy for processing.
    - Reinforced the idea of combining vernacular techniques (e.g., weaving, bundling) with modern sustainability goals.
    - Opportunities to be exposed to various materials, their applications to building designs, and to be able to comprehend them to a great extent

Next Steps for Refinement and Application: (if structure was to be built in real life)

1. Material Testing:
    - Conduct U-value tests for reed and daub panels to compare thermal performance under varying conditions.
2. Scaling Up Prefabrication:
    - Develop modular reed and wattle panels to optimise on-site assembly.
3. Carbon Tracking:
    - Incorporate lifecycle assessment tools to track embodied and operational carbon over the structure's lifespan.

GALLERY FROM SITE VISITS

Banana Bistro - Kampala, Uganda (original photographs)

Original photographs of a Thatch style roof in Banana Bistro, Kampala, Uganda.

Lubiri in Mengo - The Kabaka's Palace Tourist Shop - Buganda Kingdom Heritage, Kampala, Uganda (original photographs)

Traditional Hut Building Made from Natural Materials Of Thatch, Reed, and Mud

Zoom in to Traditional Hut Building

Mud on Reed Structure Wall, Ugandan Form of Bajareque

CTC Conservation Centre, Lukalu Uganda (original photographs)

Traditional Hut with a Woven Bridge made from Natural Materials of Thatch and Wood

Zoom in to Traditional Hut

Animal Shelter made from Natural Materials of Thatch and Wooded Trunks

Interior View of Natural Animal Shelter

Bamboo School Project - San Pablo La Laguna, Guatemala

Images from the presentation of bamboo architecture and construction by Jan Balbaligo which represents the collaborative work of local construction workers and international architects, the bajareke ancient Mayan technique of building, and bamboo weaving.

National Arts and Cultural Crafts Village, Kampala Uganda (original photographs)

Earrings made from natural wood, recycled paper materials and bead/thread work

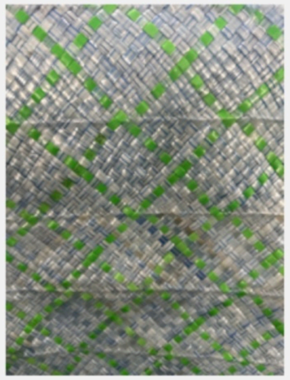
Carved decorative sculptures made from different natural woods

Furniture made from Natural wood and skin

Crafted football made from wrapped banana leaves

Cooking Equipment made from carved and treated wood

Crafting in progress, using recycled fabric, paper clips and candle wax to be interweaved



Recycled Plastic Straw Weaved Mat

Creative construction of toy vehicles, made from soda bottle caps and recycled metal

Diverse types of weaving patterns and natural plant materials utilised

Bowl made from treated waterproofed Recycled paper

Bags made from different natural materials and traditional methods

Weaved purse made from naturally sourced plant materials

Tight weaving design of baskets made from twisted strengthened natural materials

Woven baskets using traditional tequniques

Diverse Woven Styles

Various woven basket styles, and the different outcomes of bags, coasters, mats, baskets, etc.

Weaved Hats made from natural materials

Wooden carved plane and recycled bottle cap and mettle cars, made as toys

Close up to bundling weaving patters

Woven hats bottom design

Coaster made from weaving natural banana leaves

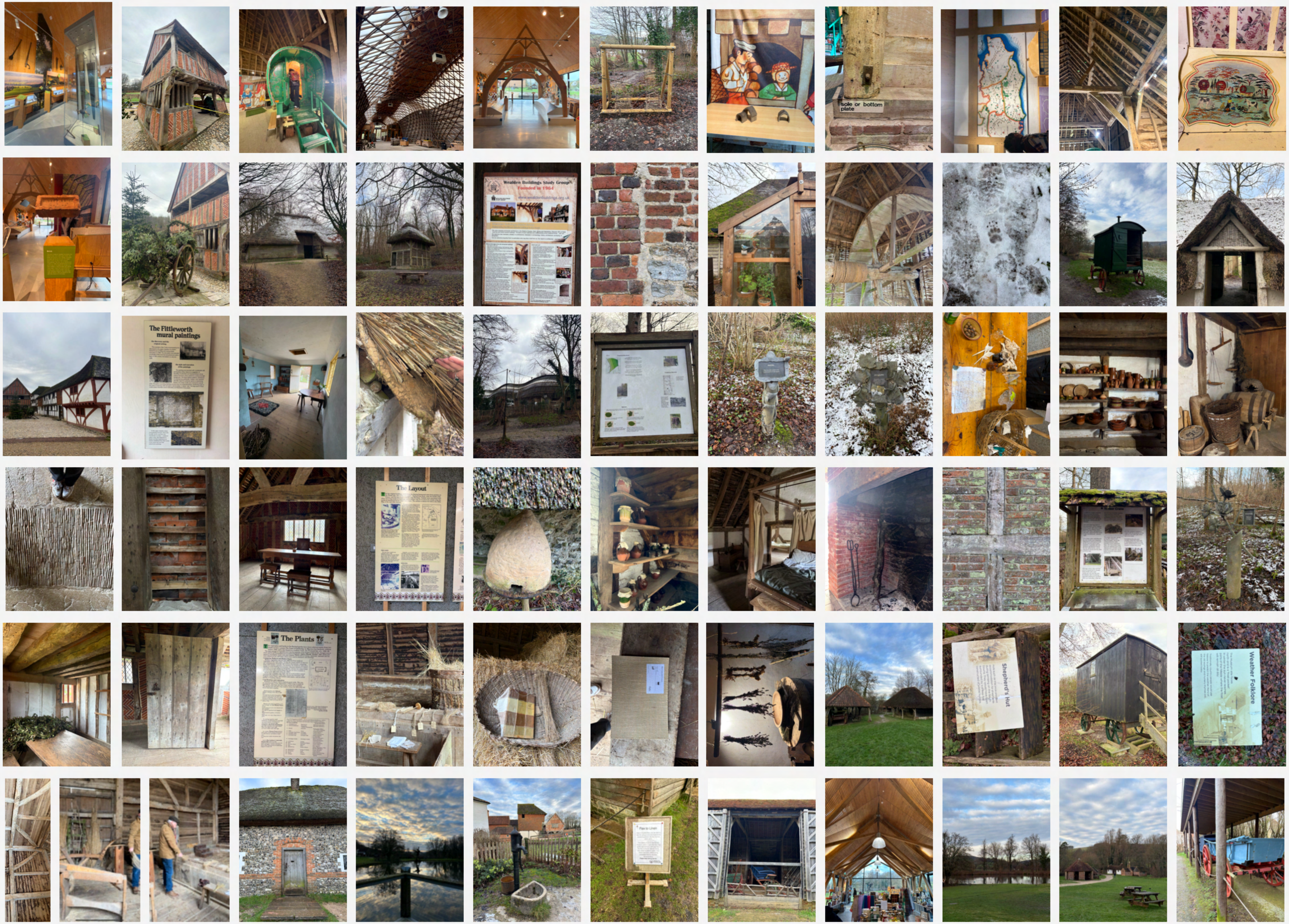
Front of a 'Kanteen' arts craftsman shop

Zoom in to the detail of weaved patters in crafted earrings

Woven hats top design

Weaved baskets and hats, and traditional mask wall decorations made from natural materials of various wood and long grass/leaves types

Weald & Downland Living Museum, United Kingdom (original photographs)



10. REFERENCES / BIBLIOGRAPHY

Books

- Heath, N., and Walker, P., *Building with Cob: A Step-by-Step Guide*, Totnes: Green Books, 2010.

- Johnson, T., *Woven Fences and Traditional Techniques: The Hazel Twig Legacy*, London: Green Craft Publications, 2017.

- Kuma, Kengo, *GC Prostho Museum Research Center: Architectural Design Philosophy and Techniques*, Tokyo: Kengo Kuma & Associates, 2010.

- Minke, G., *Building with Earth: Design and Technology of a Sustainable Architecture*, Basel: Birkhäuser, 2012.

- Oliver, P., *Encyclopedia of Vernacular Architecture of the World*, Cambridge: Cambridge University Press, 1997.

Articles and Reports

- Brown, R., 'Sustainable Building Materials in Rural and Urban Architecture', *EcoArchitecture Review*, vol. 12, no. 4, 2020, pp. 75–89.

- Hall, P., 'Tensile Strength and Structural Applications of Natural Materials', *Structural Design Quarterly*, vol. 20, no. 3, 2019, pp. 34–49.

- Hammond, G., and Jones, C., 'Inventory of Carbon & Energy (ICE), Version 2.0', University of Bath, 2011. Available at: https://www.circularecology.com/embodied-carbon-footprint-database.html [accessed 12 January 2025].

- Heatherwick, T., 'Basket Weaving and Modern Design', *Architectural Review*, vol. 141, no. 1, 2015, pp. 22–28.

- Kumar, K., 'Reinventing Bamboo and Reed Architecture: Insights from Kengo Kuma', *Journal of Sustainable Architecture*, vol. 18, no. 4, 2023, pp. 45–56.

- Lehmann, S., 'Sustainable Materials for Low Carbon Construction', in Newton, P. et al. (eds.), *Decarbonising the Built Environment*, London: Springer, 2021, pp. 145–165.

- Smith, J., 'Traditional Japanese Craftsmanship and Its Role in Contemporary Design', *Journal of Architectural Studies*, vol. 15, no. 2, 2018, pp. 102–117.

- Tanaka, H., 'Bamboo and Timber Weaving in Contemporary Japanese Design', *Materials and Design Journal*, vol. 18, no. 3, 2021, pp. 128–139.

- Yamamoto, A., 'The Concept of "Ma" in Japanese Architecture', *Asian Architectural Review*, vol. 9, no. 1, 2016, pp. 45–56.

- Lecture Notes - Sustainability and Passive Design Strategies in Bamboo and Reed Architecture, University of Westminster, 2024.

Websites

- British Ecological Society, 'Carbon Sequestration in Natural Building Materials'. Available at: https://www.britishecologicalsociety.org/ [accessed 12 December 2024].

- Bulk Hemp Warehouse, 'Video Shows Fascinating Process of Traditional Hemp Rope Making'. Available at: https://bulkhempwarehouse.com/how-to-make-rope-from-hemp [accessed 1 November 2024].

- Construction History Society, 'Homepage'. Available at: https://www.constructionhistory.co.uk/ [accessed 24 December 2024].

- Hartwell Fencing, 'Hazel Hurdle Fence Panel'. Available at: https://www.hartwellfencing.co.uk/ranges/fencing/wattle-hurdles/wattlehurdle [accessed 6 November 2024].

- Hartwell Fencing, 'Wattle Wall Made by Weaving Pliable Hazel Wood Around Uprights'. Available at: https://www.hartwellfencing.co.uk/ranges/fencing/wattle-hurdles/wattlehurdle [accessed 124 November 2024].

- Instructables, 'How to Tie Various Knots'. Available at: https://www.instructables.com/How-to-tie-various-knots [accessed 1 January 2025].

- Passive House Institute, 'Understanding U-Values: A Guide to Energy Efficiency'. Available at: https://passivehouse.com [accessed 3 January 2025].

- Softouch, 'Knots: The Complete Visual Guide'. Available at: https://www.softouch.on.ca/kb/data/Knots-The%20Complete%20Visual%20Guide.pdf [accessed 13 December 2024].

- Thatching Info, 'A Beginner's Guide'. Available at: https://thatchinginfo.com/beginners-guide [accessed 20 December 2024].

- Thatching Info, 'Roping Down: Fixing Thatch in a World Without Wood'. Available at: https://thatchinginfo.com/ [accessed 18 November 2024].

- UNESCO World Heritage Centre, 'The Living Root Bridges of Meghalaya'. Available at: https://whc.unesco.org [accessed 14 December 2024].

Videos and Visuals - YouTube, 'Making Hazel Spars for Thatching'. Available at: https://www.youtube.com/watch?v=K3TnwYDKhY0 [accessed 22 November 2024].

Case Studies and Precedents

- Jingkieng Dieng Jri Living Root Bridges, Meghalaya, India.

- Thomas Heatherwick's Woven Screens, Guy's Hospital, London, UK.

- Uros Floating Islands, Lake Titicaca, Peru.

- Kengo Kuma, GC Prostho Museum Research Center, Japan.

Technical Data

- Reeds: ~0.2 kg CO_2/kg (carbon-negative).

- Hazel: ~0.6 kg CO_2/kg.

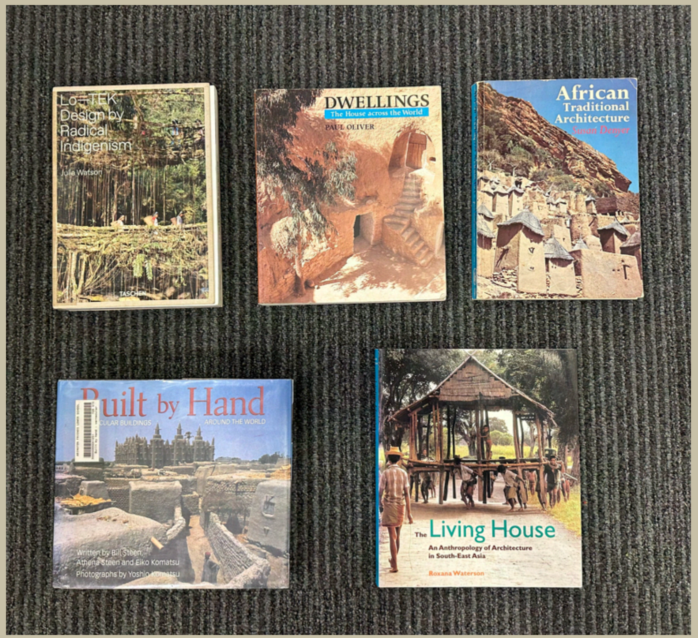
- Steel: ~1.85 kg CO_2/kg.

- Concrete: ~0.95 kg CO_2/kg.

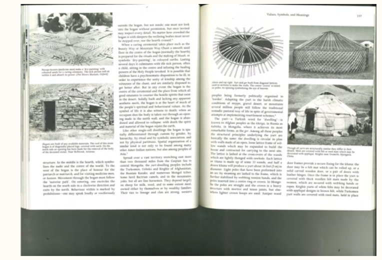
- U-Values for Materials:

  - Thatch: ~0.2–0.3 W/m²K.

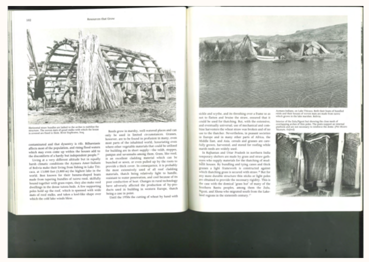
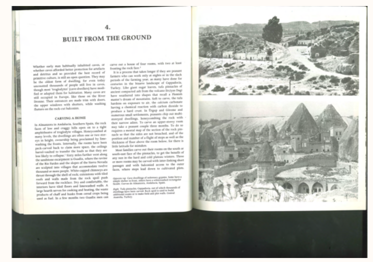
  - Daub Panels: ~0.4–0.6 W/m²K (with hemp or straw additives).



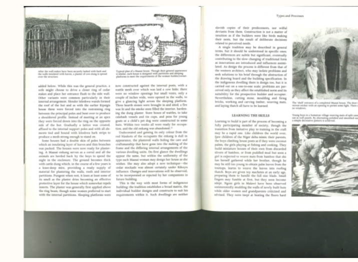
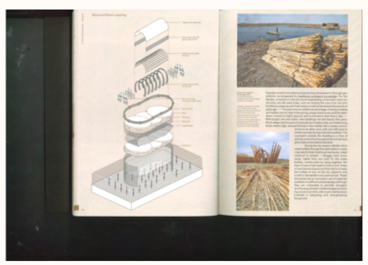
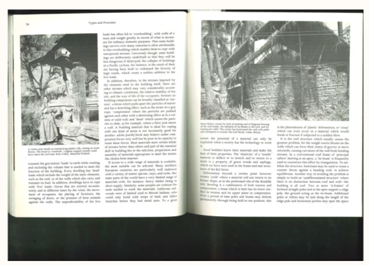
REFERENCES BOOK SCANS

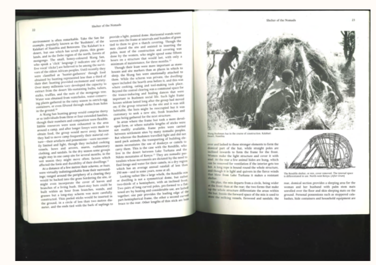



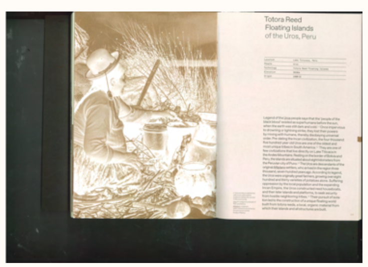


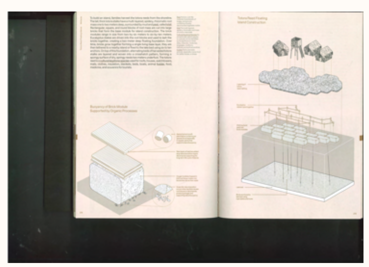
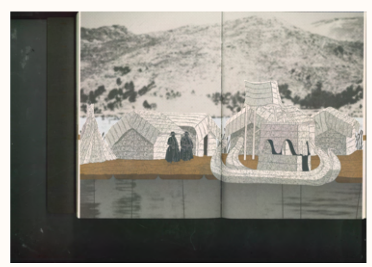
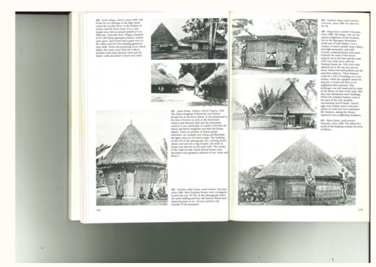
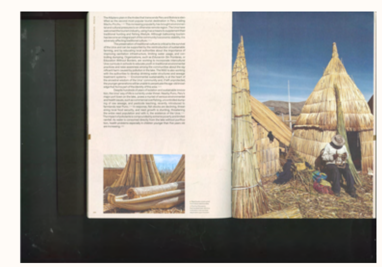
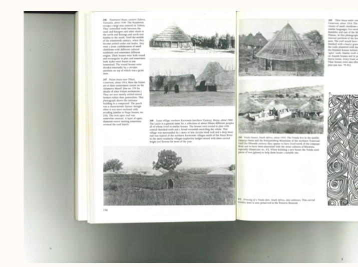
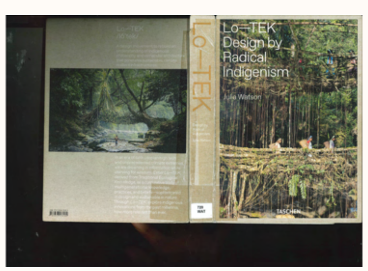



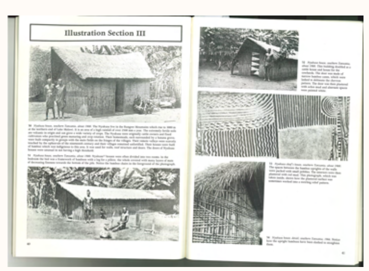


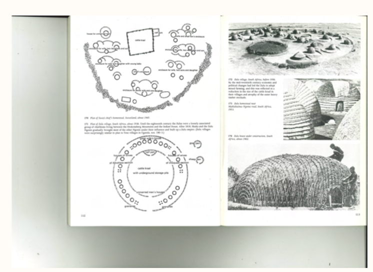
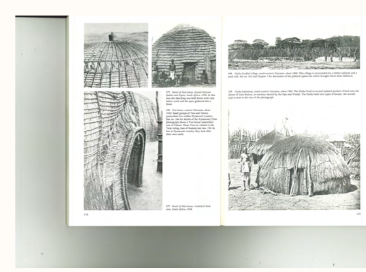
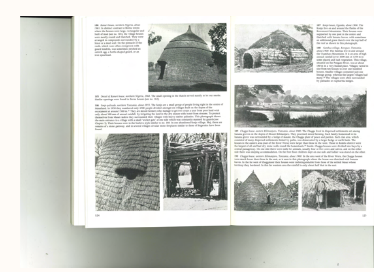
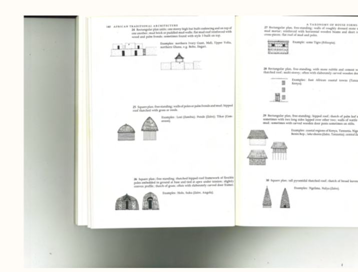
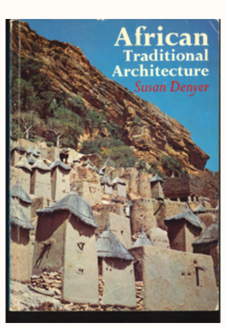




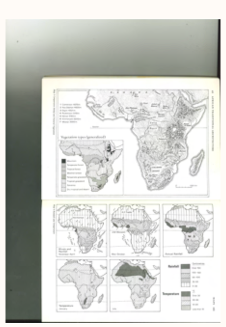
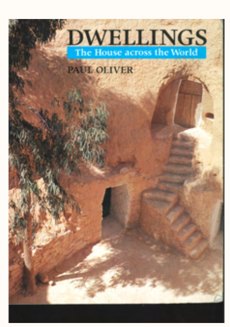










THE END.

THANK YOU.