Living Clay: A Sinking Auction

By Maxime Ostroverhy

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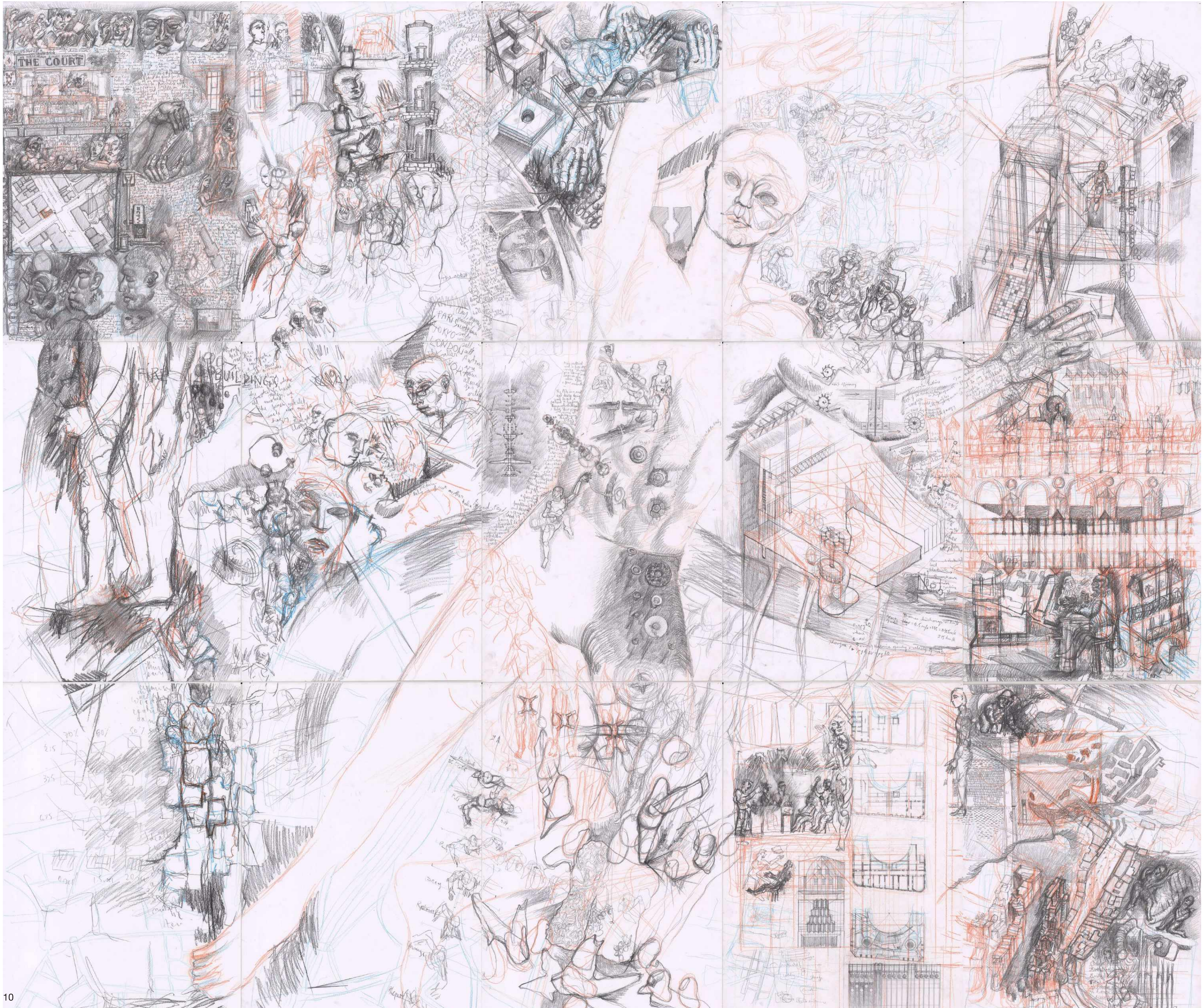
Contents

CAUTION!

Chapters do not have to be read chronologically.
Go to Section 15 to see the final proposal.

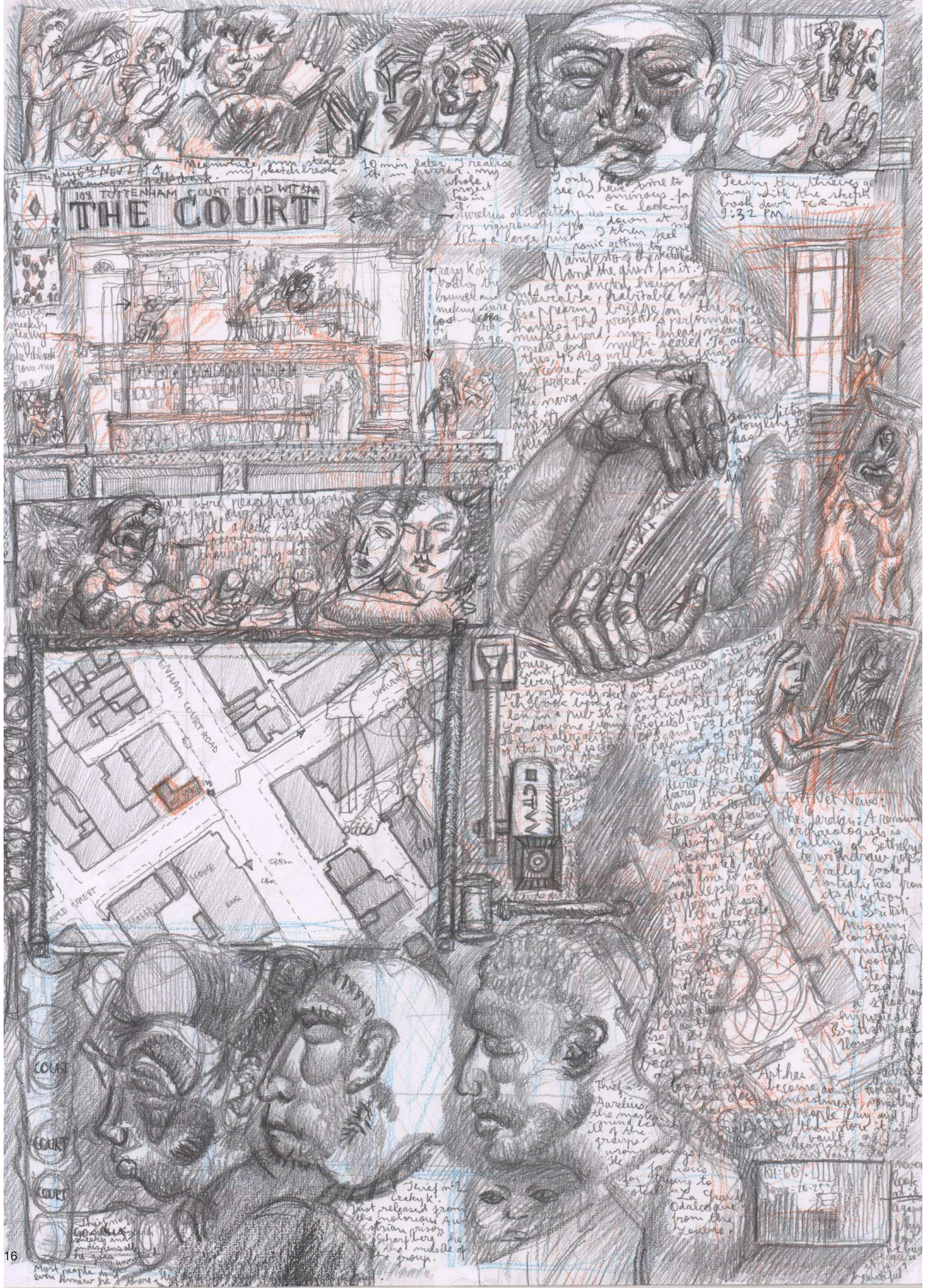
8th June 2023 London, UK
Maxime Ostroverhy



Introduction

Manifesto

This project is an auction house that sits on the Thames near Tower Bridge. It tries to highlight the imbalances and inequalities in the art world. Too often the artist is overshadowed by the dealer and then the artwork is not put into worth by being stored in a vault. It also points out the legitimacy of artworks, as they can often be stolen and then sold at an auction. In the floating bridge, the art market is brought back to the people. The symbolic bridging of the inequalities is portrayed by bringing together the north bank of the river that is historically wealthier and has the business district, with the south bank that is more industrial. The material aspect of this endeavour evolves around London clay, found on the shores of the Thames. Its properties as a building material are explored in a rigorous manner, and its therapeutic “muddying” properties are explored in a more hypothetical manner.



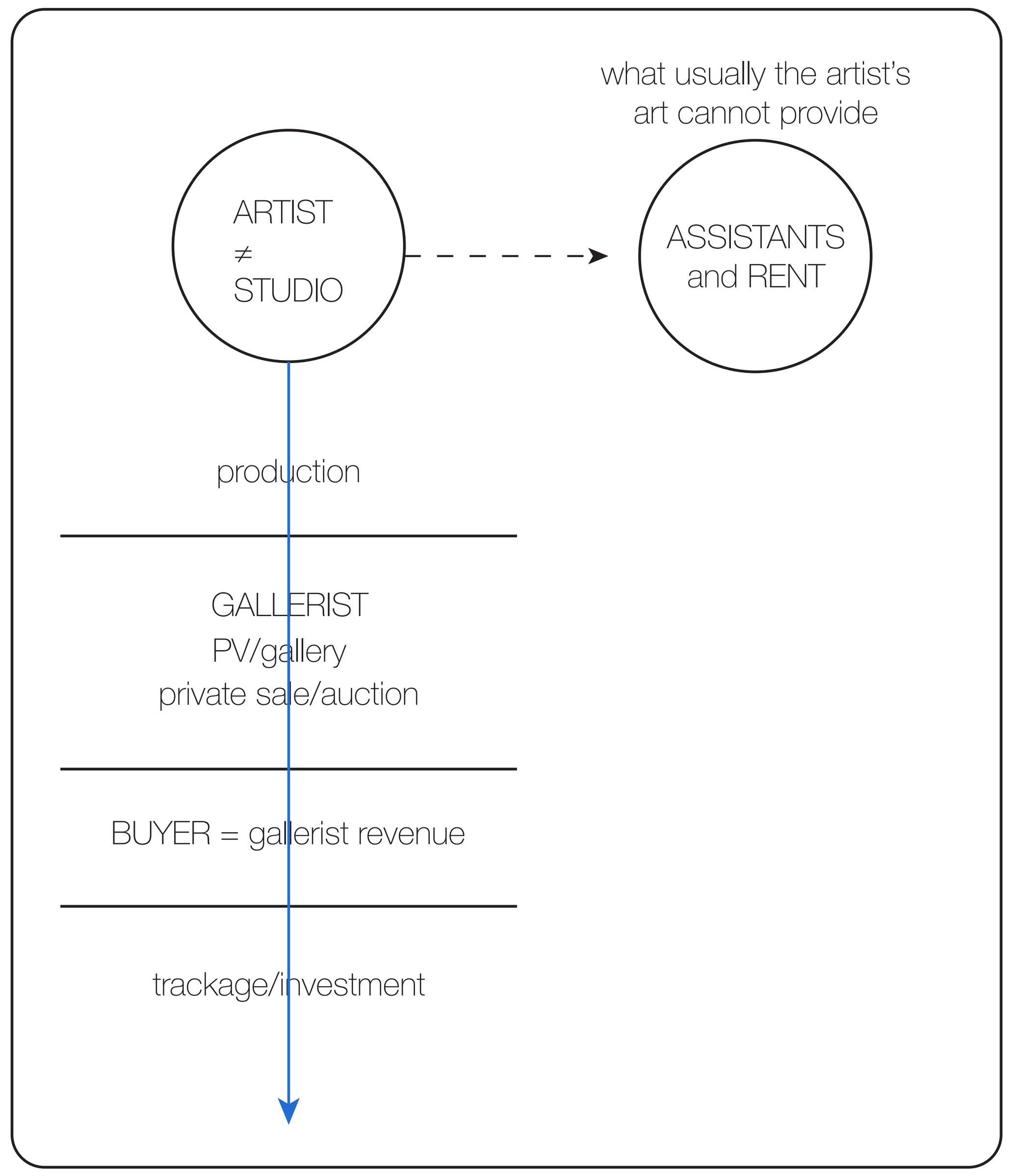
Section 1. Design Topic: Narrative

The idea of the art industry, and artworks cycle emerged when I got my sketchbook stolen with my bag in a pub on Totthenham Court Rd. Buying an artwork just as an investment can be seen as "stealing" from humanity's right to appreciate beauty. Oftentimes the artist is left out of this economy and is underpaid too.

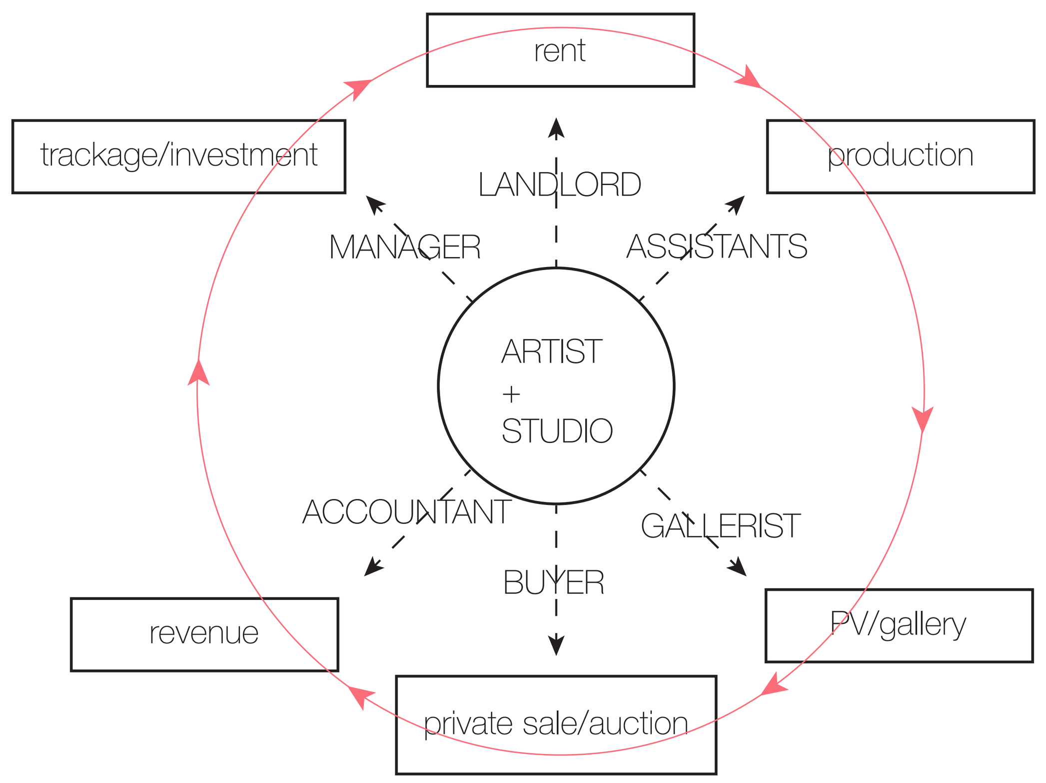
In a rapidly changing world becoming increasingly more volatile, bringing light onto the artist and the creative individual was something I hoped to emphasise. It is a message of reconciliation. The auction house serves its purpose in shedding light on the financial injustice revolving around artists, who are vulnerable to financial exploitation by dealers. These same people who, often in an auction, misuse their artworks for their own financial interests. In creating an auction house that is neither south nor north, yet both, I had the idea that a bridge, reminiscent of the medieval residential bridges that used to be prevalent in cities like London and Paris, with lingering traces still to be found in modern-day Bath, would bring about a symbolic message of unity.
The auction house reflects a unity that aims to emphasise reconciliation between the traditionally richer north bank and the more industrial and poorer south bank. The floating bridge takes on the world with a new purpose, to reduce inequalities, unite people and bring back art to the people. The auction house is a revolutionary idea, in which an art auction is no longer sold off in exclusive art salons. These same saloons that are generally not so easily accessible to the public suddenly become the new hub for people to gather. Art can be created in private, but once finished its aim is to be displayed to the world, and not sold off and locked into a vault for no prying eyes to see. Art has the potential to change people and artists should display their thoughts on current affairs, or have people ponder over issues that artists think are prevalent. The auction house embodies this movement, in which the artist hands art over for the people, in which people of all backgrounds, symbolically represented in the geographic location of the Thames, neither north or south, are able to exchange ideas.

Position

STANDARD
AUCTION HOUSE:
Artist's struggle for being underpaid and left out of the global art market



PROPOSED
PROGRAMME:
Sinking Auction on the Thames



Hypothesis


artnet news

Art World Market Opinion Style Multimedia Artnet News Pro Buyer's Guide

Law

What the Story of a Botched $1 Million Auction Reveals About the Clash Between New Anti-Money Laundering Laws and Client Confidentiality

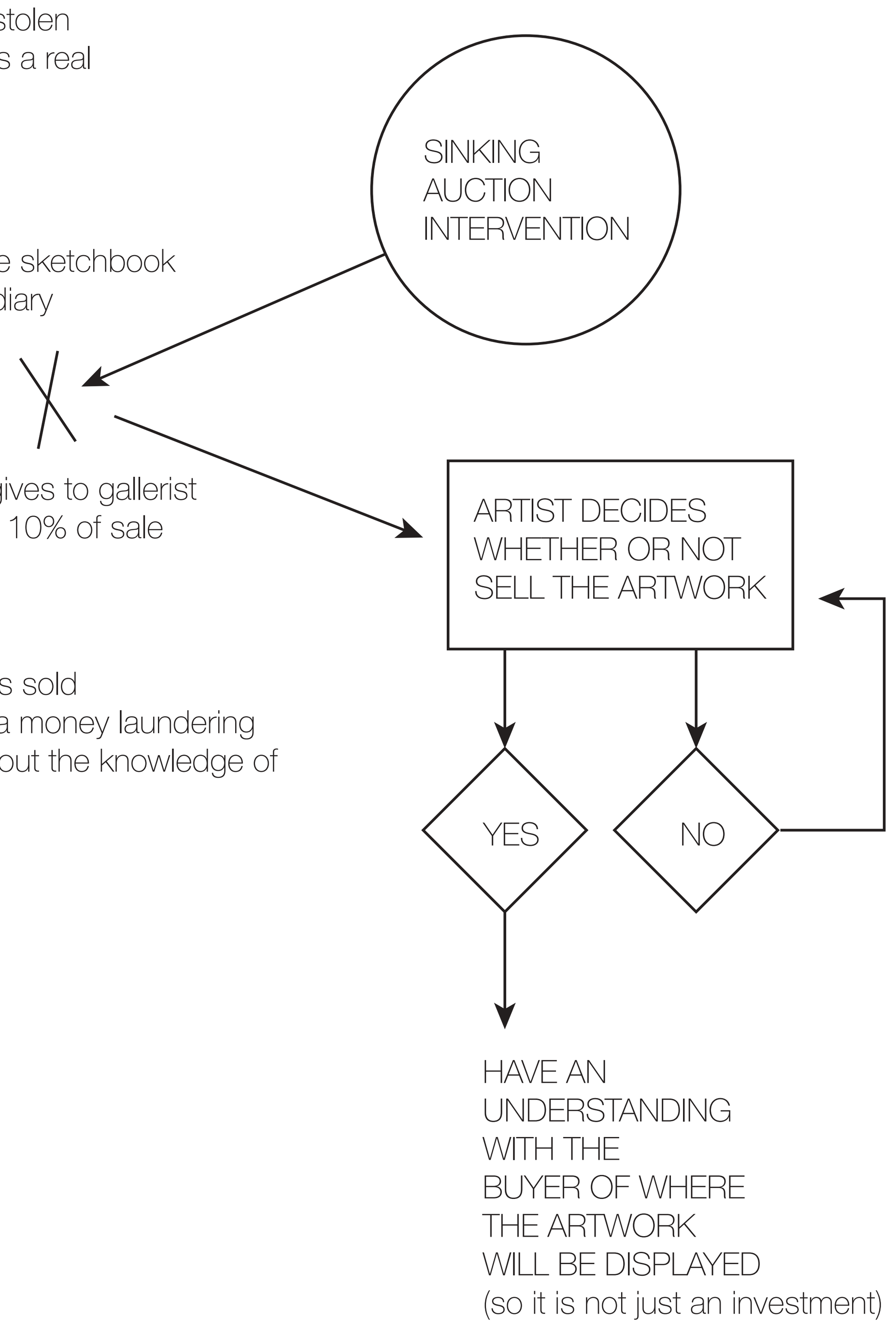
Patrick Matthiesen sought more information about a painting he bought at auction, but immediately hit a wall.

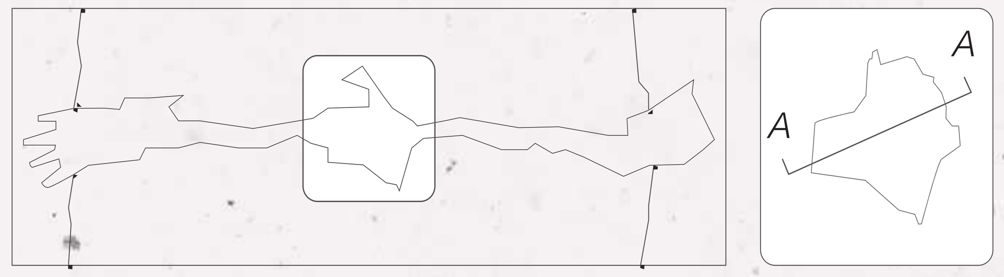
1. sketchbook stolen at the pub (as a real life eg)

2. thiefs give the sketchbook to an intermidiary

3. intermidiary gives to gallerist and receives 10% of sale

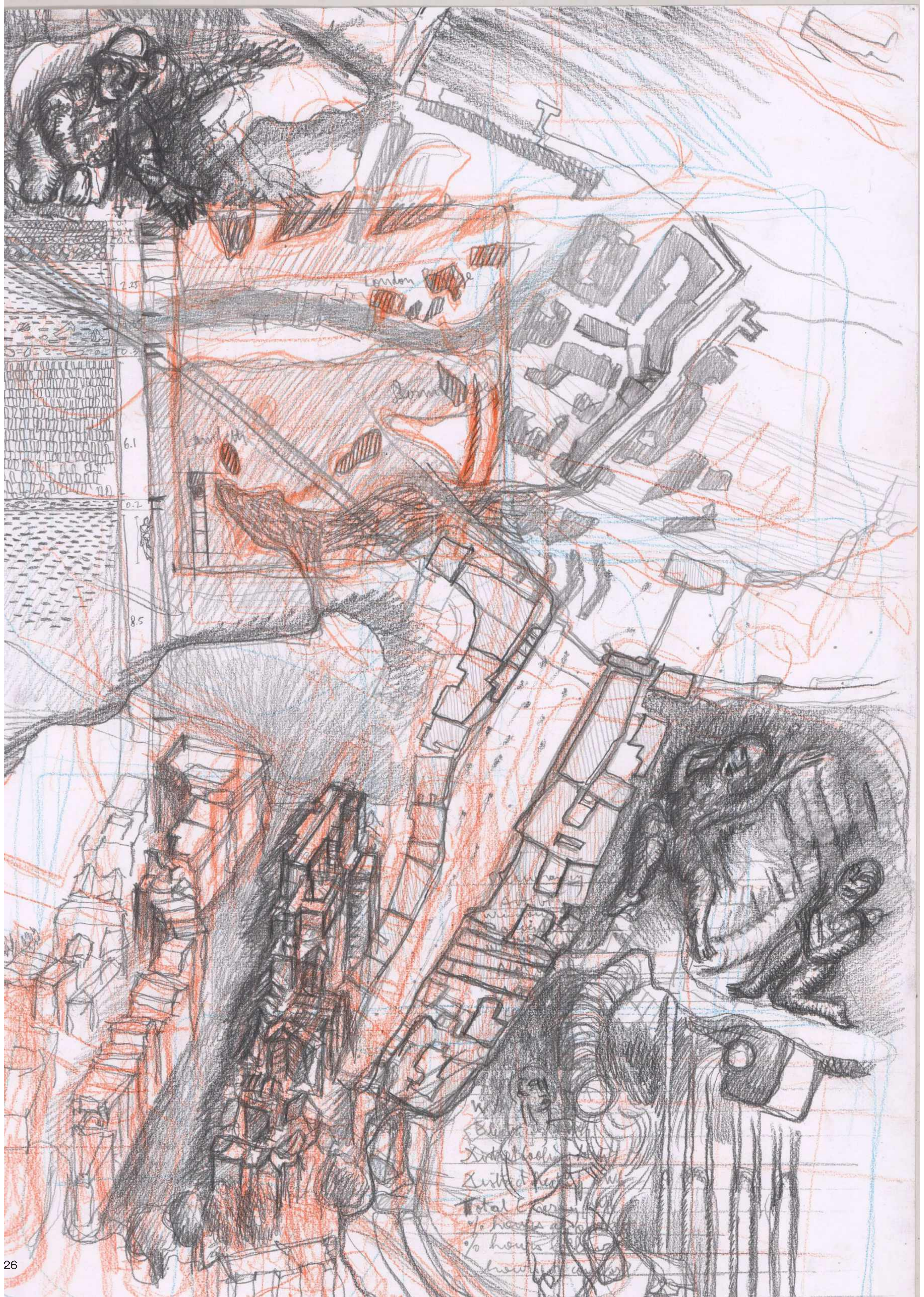
4. sketchbook is sold and is art of a money laundering scheme without the knowledge of the artist





1. display of artworks
2. artists peeping in auction of their artworks
3. businessmen from business district
4. auctioneer (a partial figure)
5. artists breathing in Thames breeze
6. private sale
7. artists grotto with listening device to private sale
8. two artists discussing the latest auction

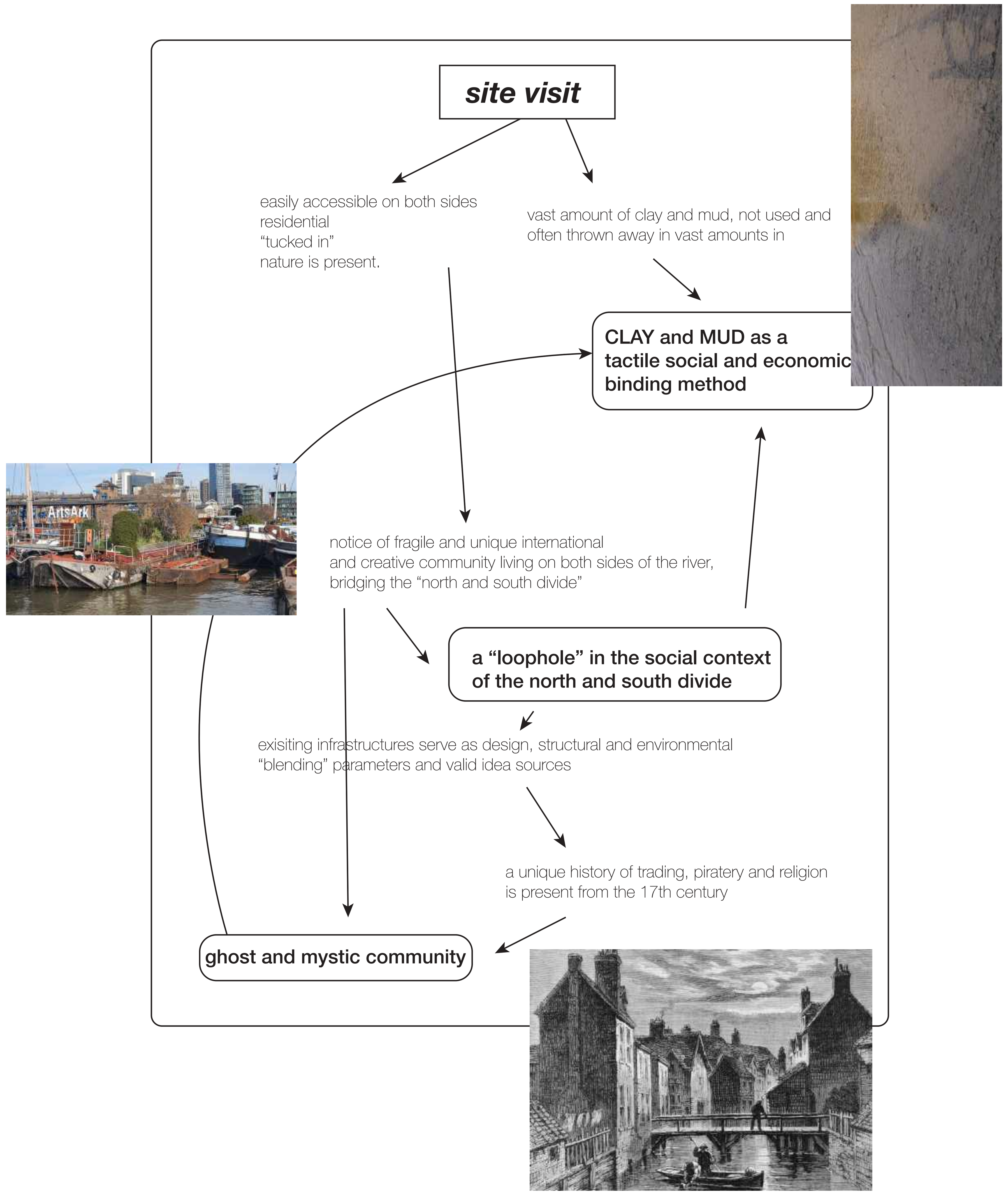
1:50 on A1 *4m*



Section 2. Pre-Design Research Site Analysis

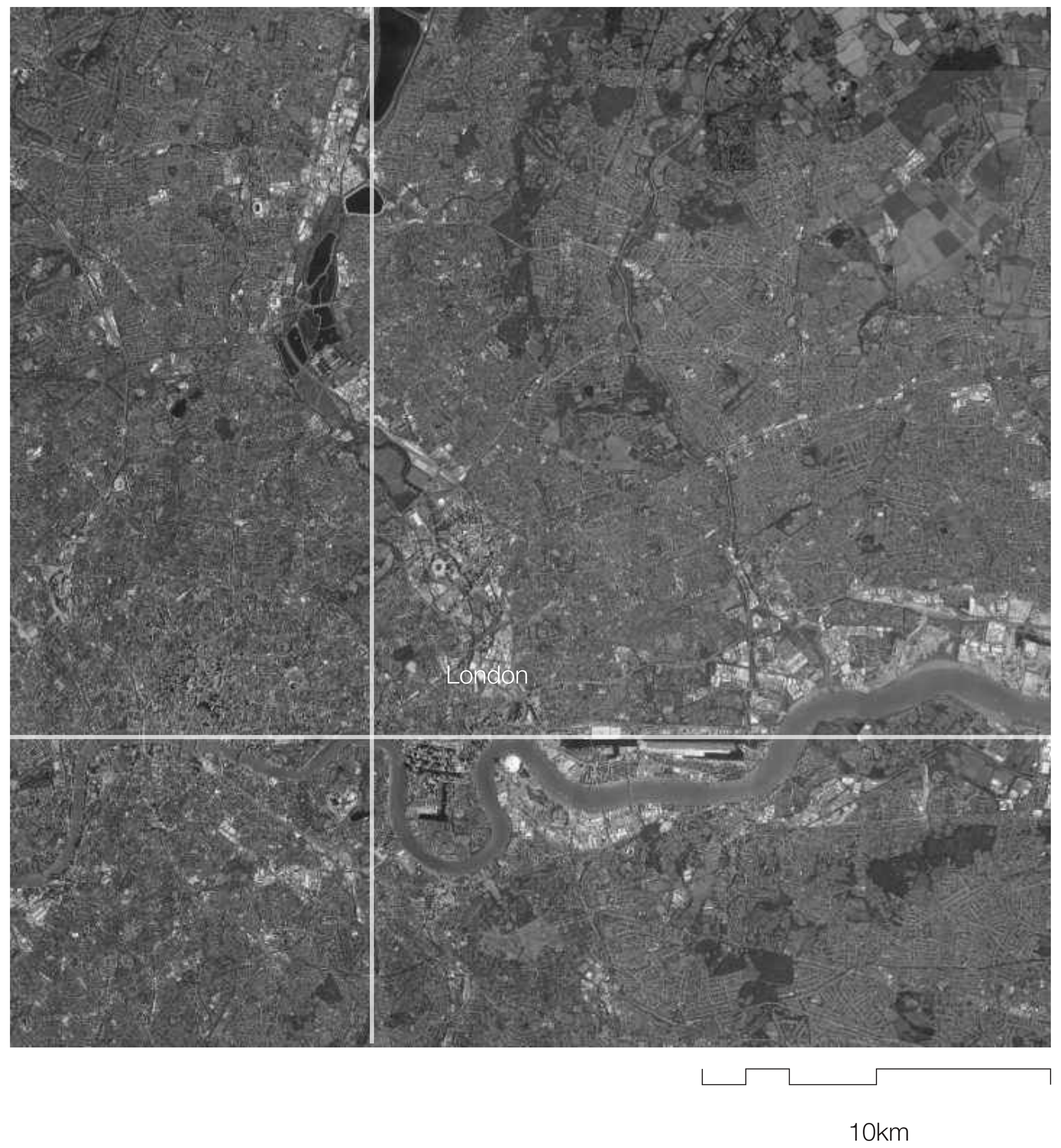
In order to make the auction house into a realistic and hypothetically feasible project to be created, it was important to research about the site in which the auction house would be situated. A floating bridge in the heart of London can only be created when it is qualified to be built if it conforms to local and national legislative laws. A bridge has to be safe for its people, something that is very important especially when innovative and almost experimental materials, such as clay, will be used. My preliminary steps for research was to look at the buildings surrounding the site, whether they are grade-listed and whether the bridge will pose any hindrances to its environment. The local natural environment was researched, particularly the Thames river. As a constantly flowing and changing aspect of nature, the Thames river can be both the subject of utility and of destruction. Therefore, researching about wind direction, waves, and local geological conditions (even just through visal means such as photographs) to the site made me understand what steps had to be made to ensure that this building would be both safe and feasible.

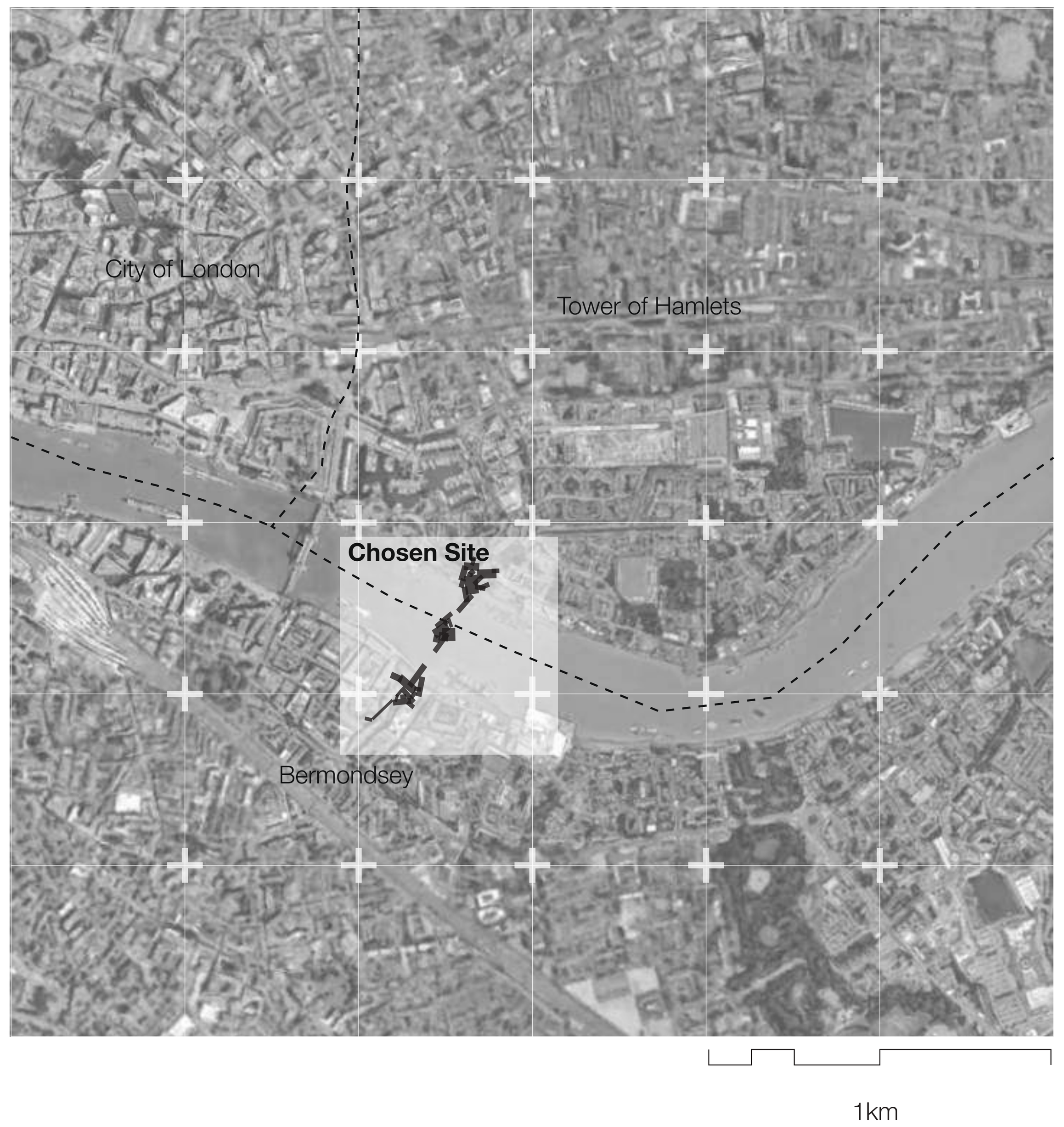
Site Survey Outcomes

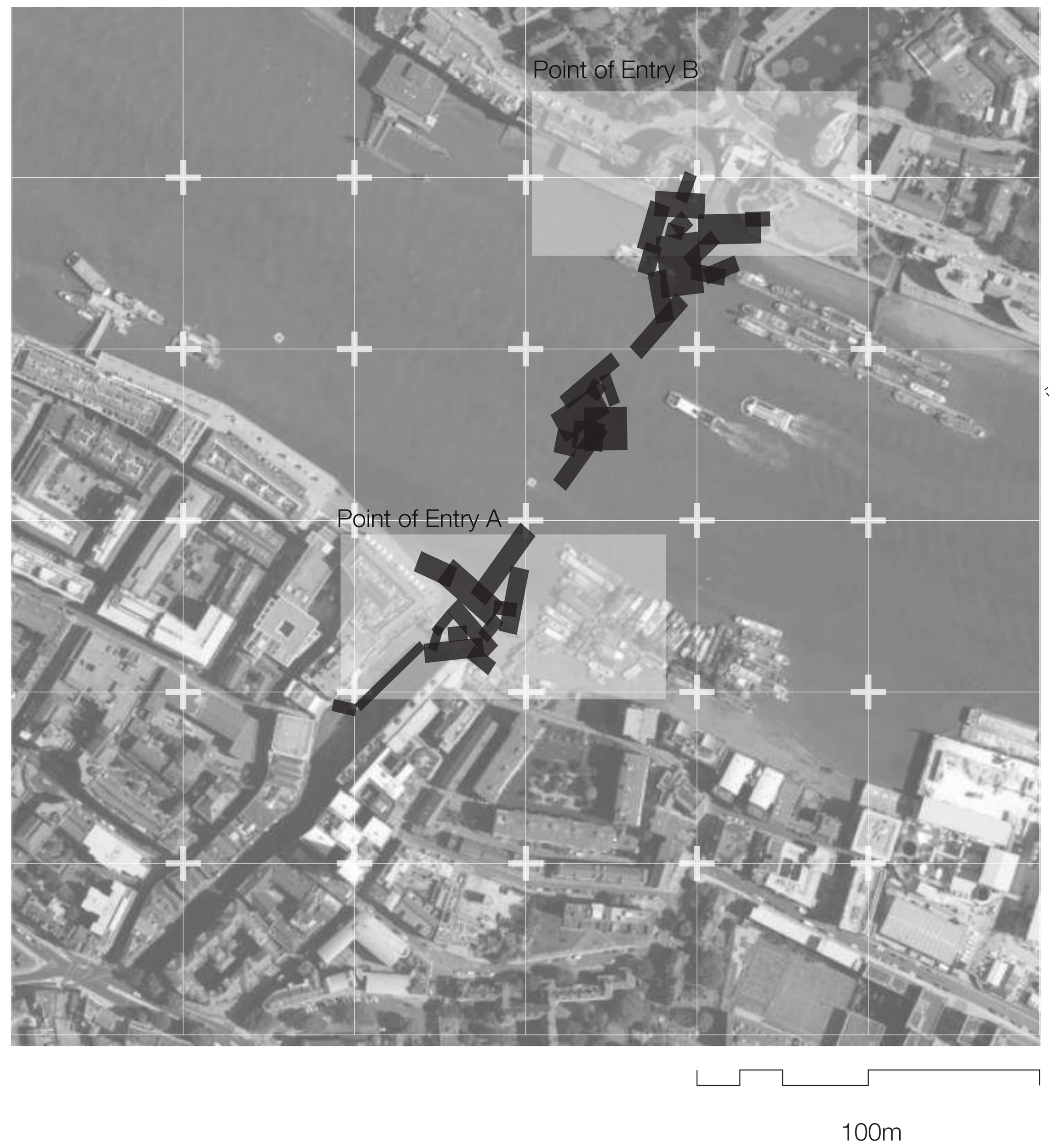


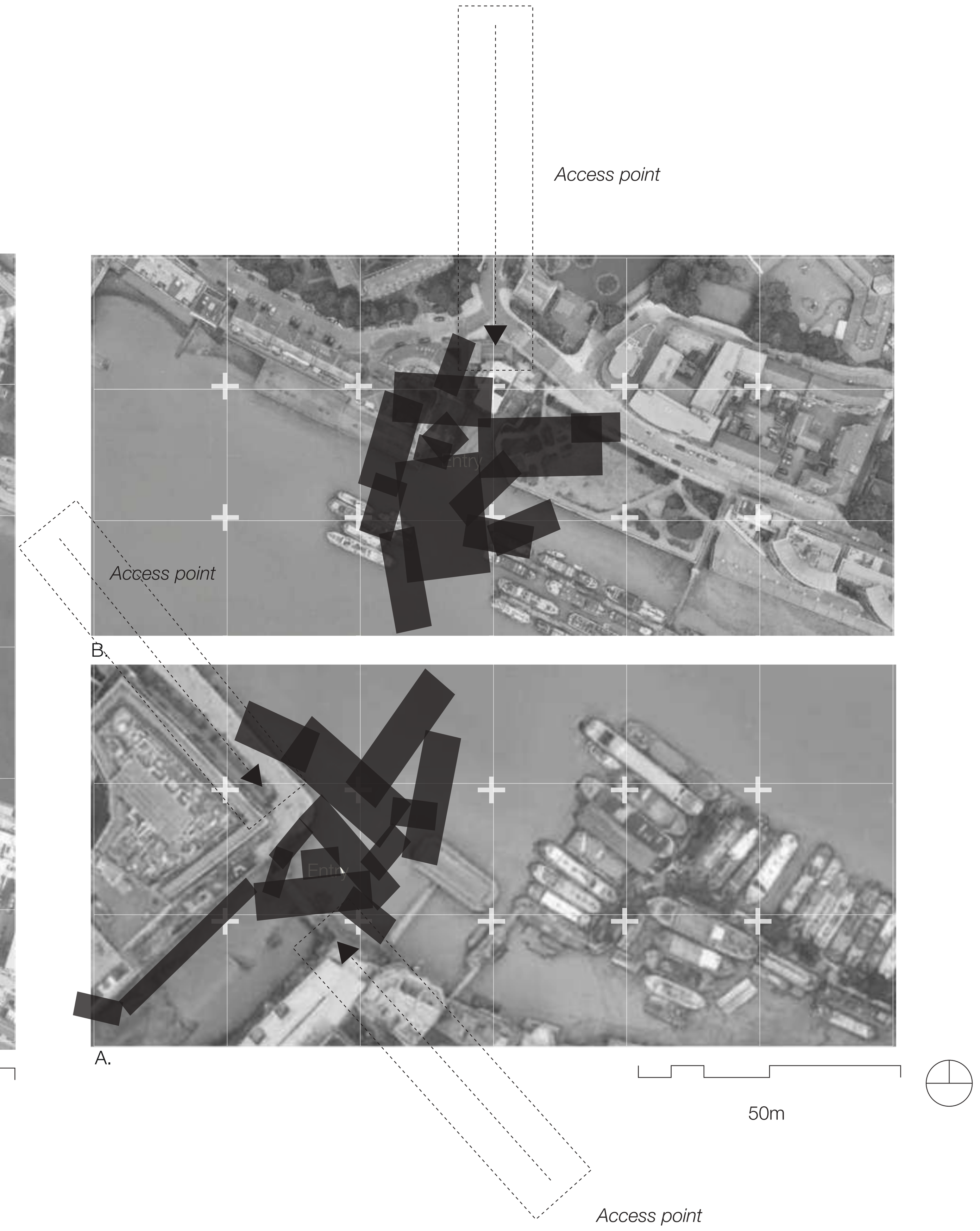

ArtsArk
THE HA

Macro: 1:2000, Meso: 1:200, Micro: 1:20





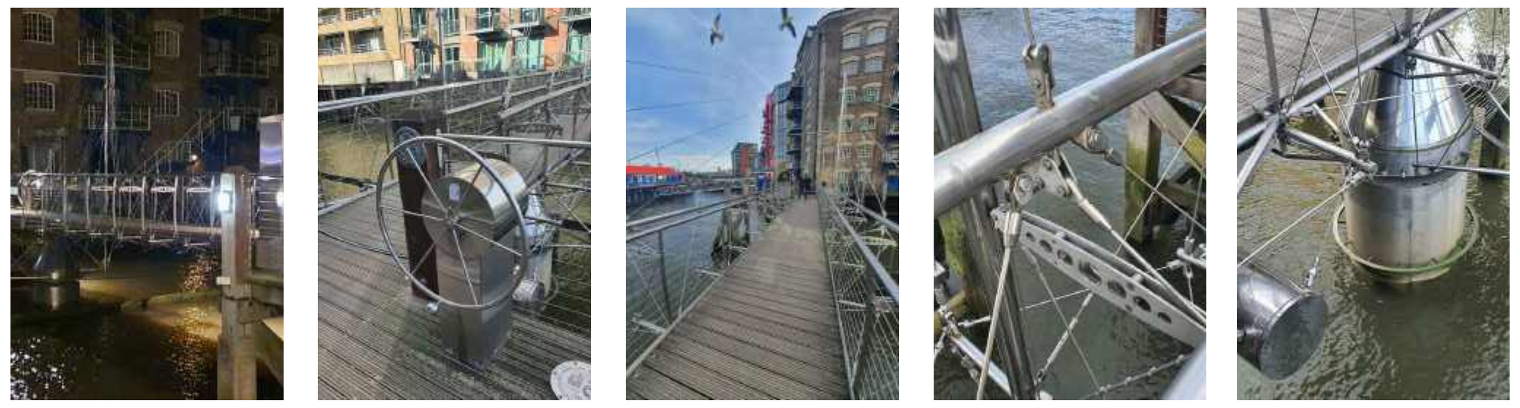




Social, Programmatic and Tyopological Context

1.Mud

2.Piers



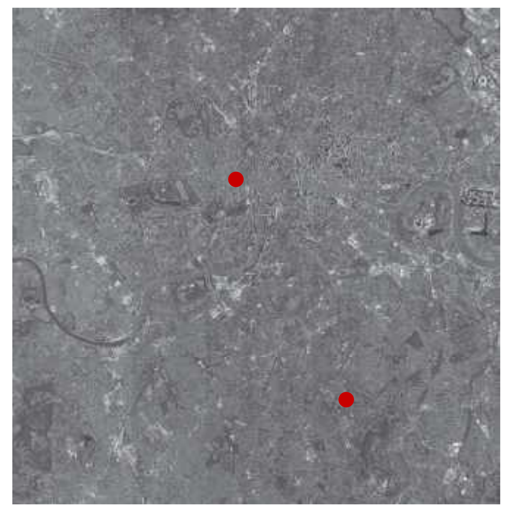
3.Existing structures

4.Living boats

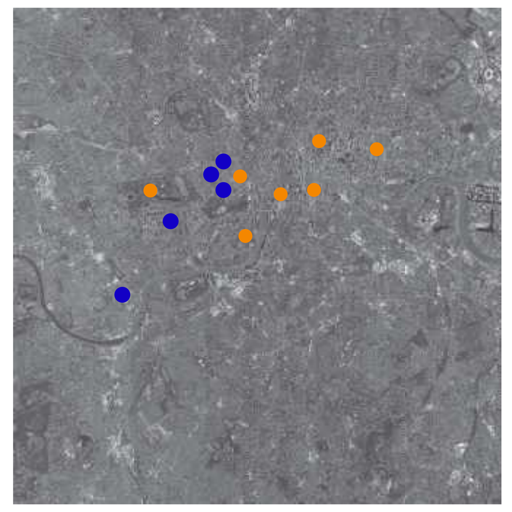
5.Cranes

6.Tides

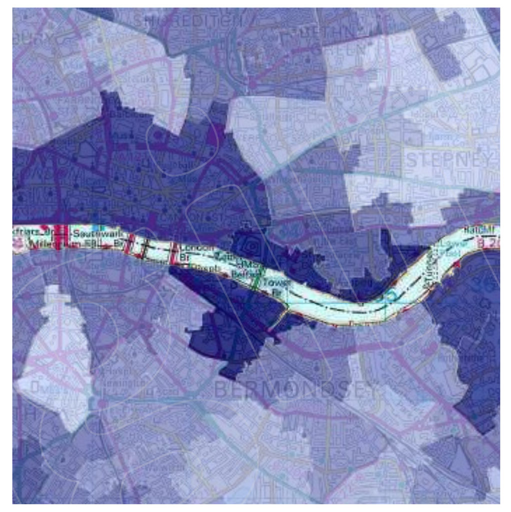
Overlayed base map 1:100



Notorious Art thefts London 1:50 000

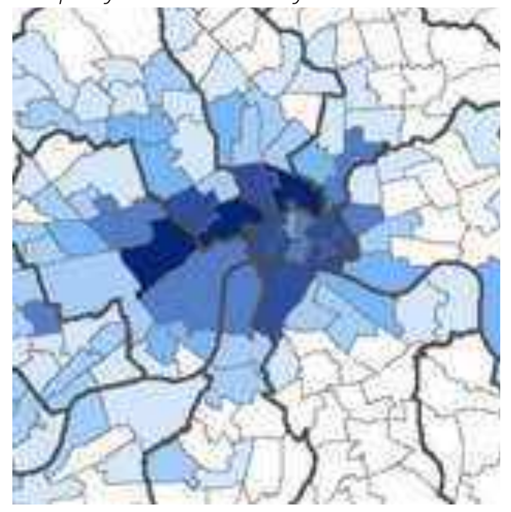


Auction houses, galleries nearby 1:50 000

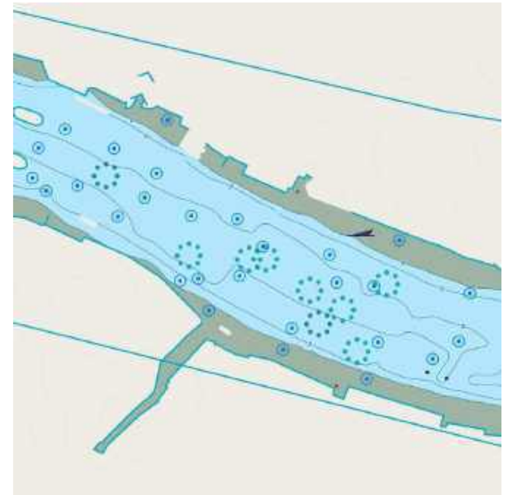


Employment density 1:10 000

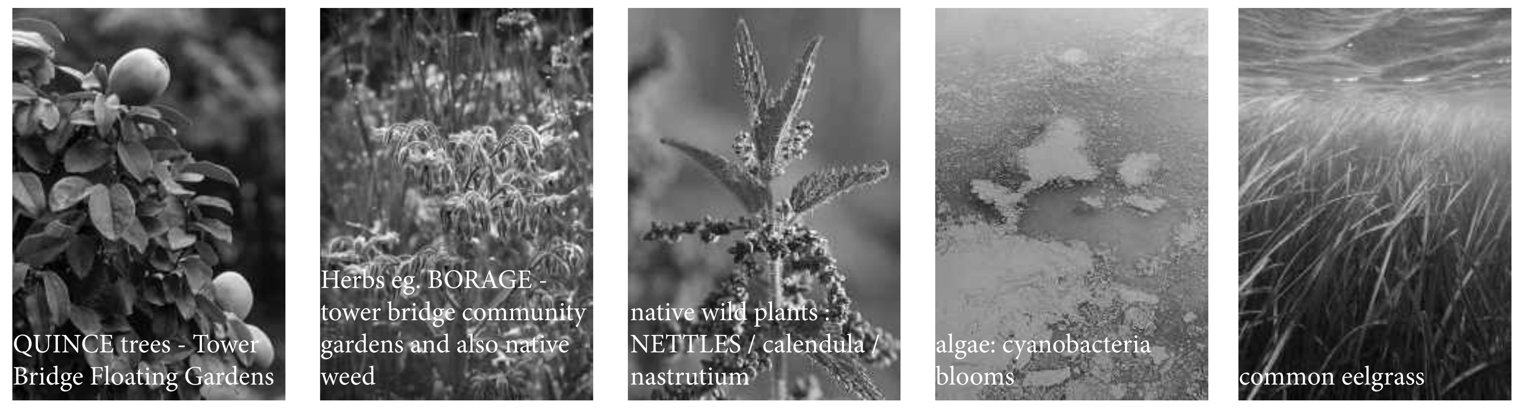
Population density 1:10 000



Creative industries 1:10 000



Marine features 1 1:100



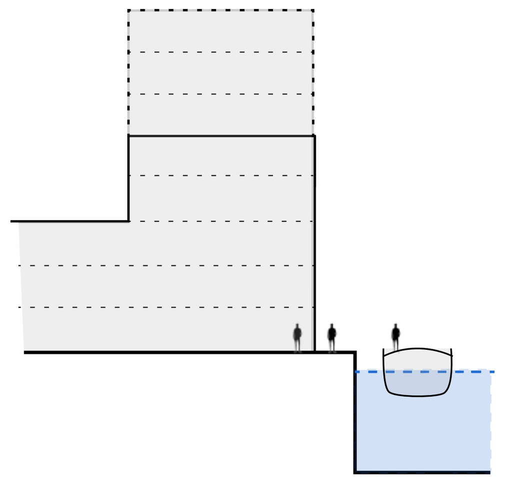
7. Nature

8. Animals

9.Buildings


GOOLE

Practical, Methodological and Legislatives Constraints



Typical dockland elevations

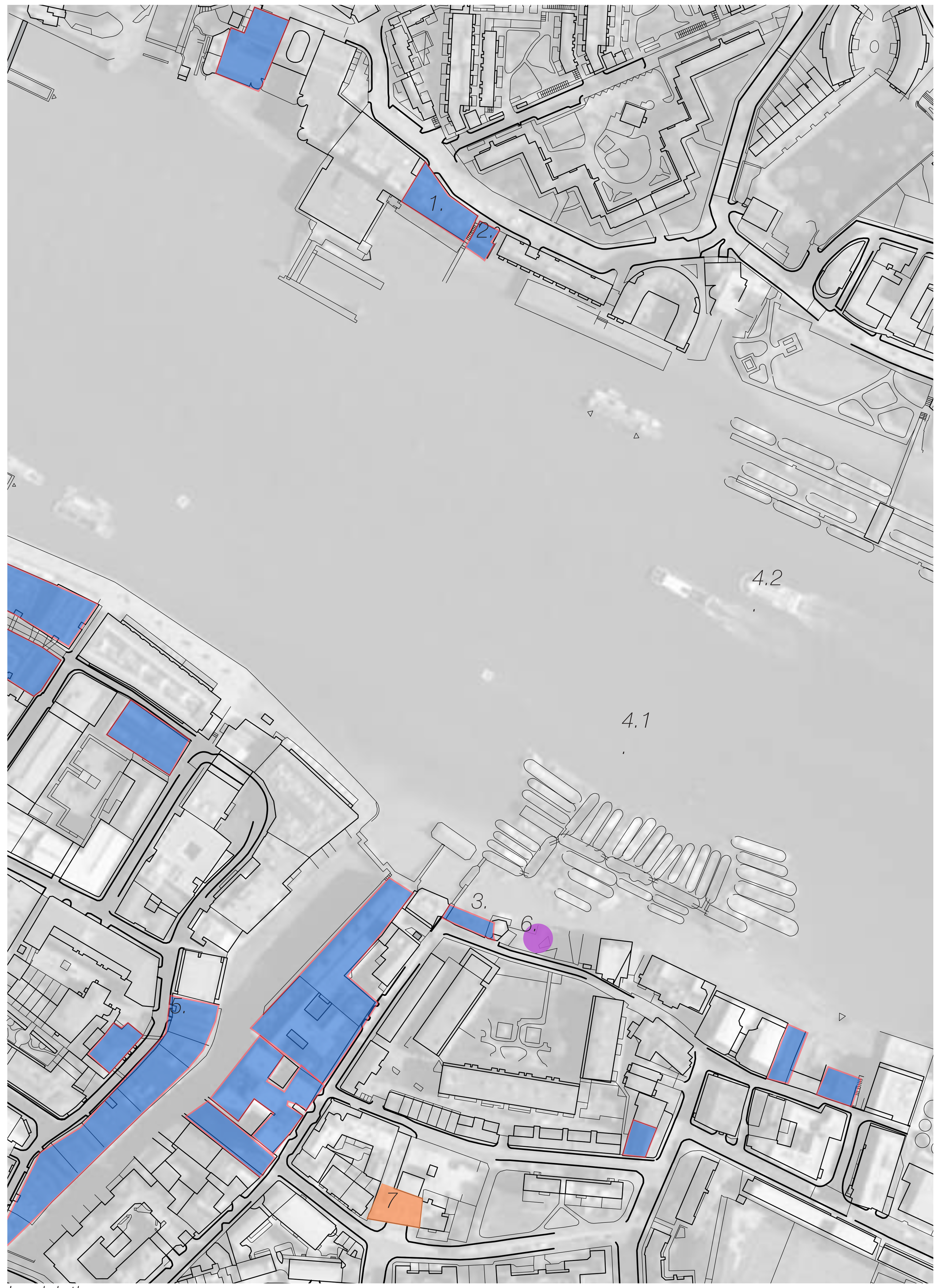
The dockland elevations are usually a minimum of 3 storeys, with the water-facing side 5-8 storeys. Generally buildings have "blocky" masses facades are flat .

Legend
listed buildings
fire station
street art

1. British and Foreign Wharves

2. Alderman Stairs and Gate Piers

3. China Wharf



Legislations map
1:100

5. Java Wharf

6. Banksy's Boy Fishing

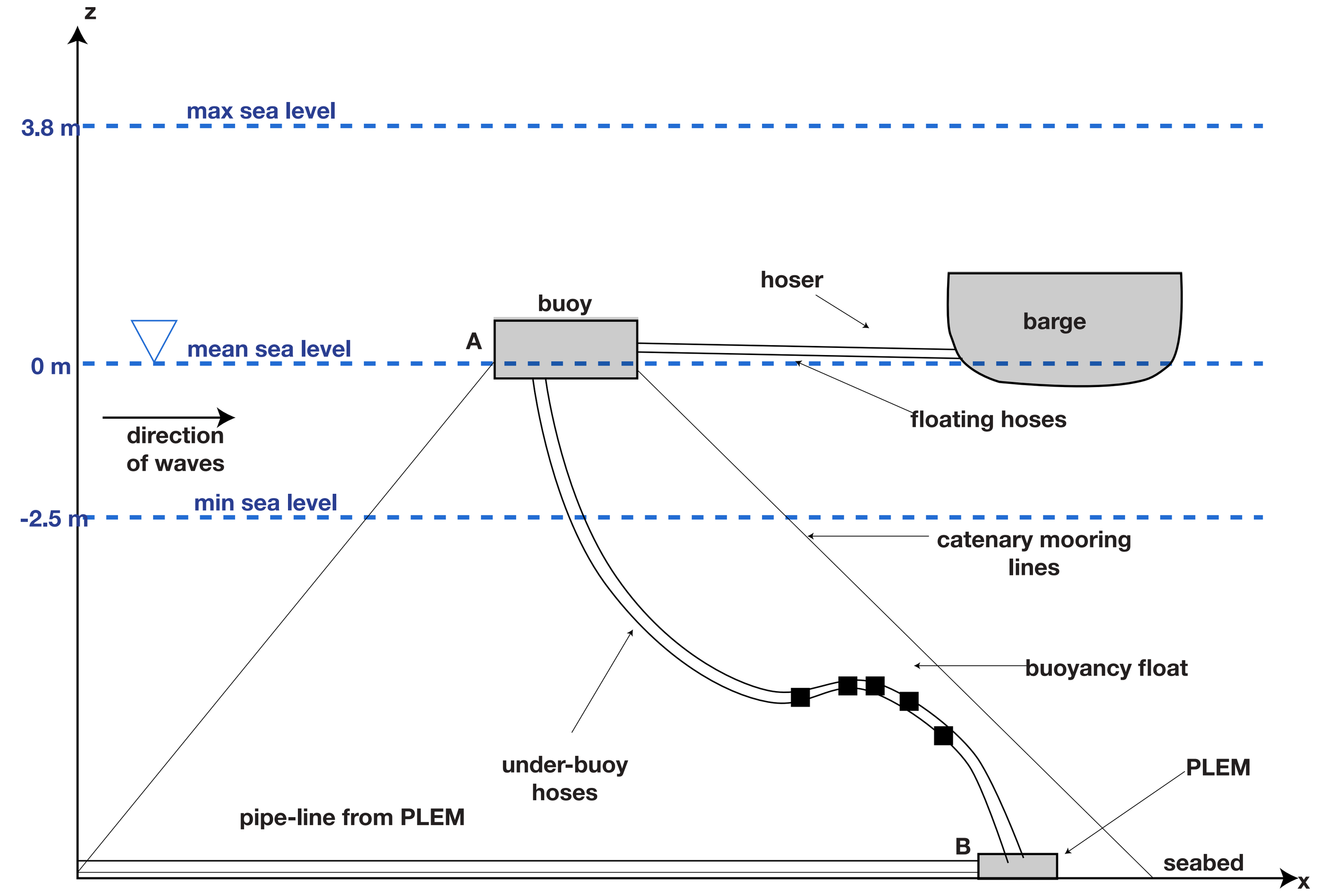
7. Dockhead Fire station

4.1. Tower Bridge Moorings
4.2. Hermitage Community Moorings

1. Saint saviour's dock footbridge

In 1995, an foodbridge was constructed connecting teh two side of Saint Savfiour's dock. However, due to several mechanical, structural and operational issues, the bridge had to be fixed in the closed position. This blocked the passage of large boats in the dock.

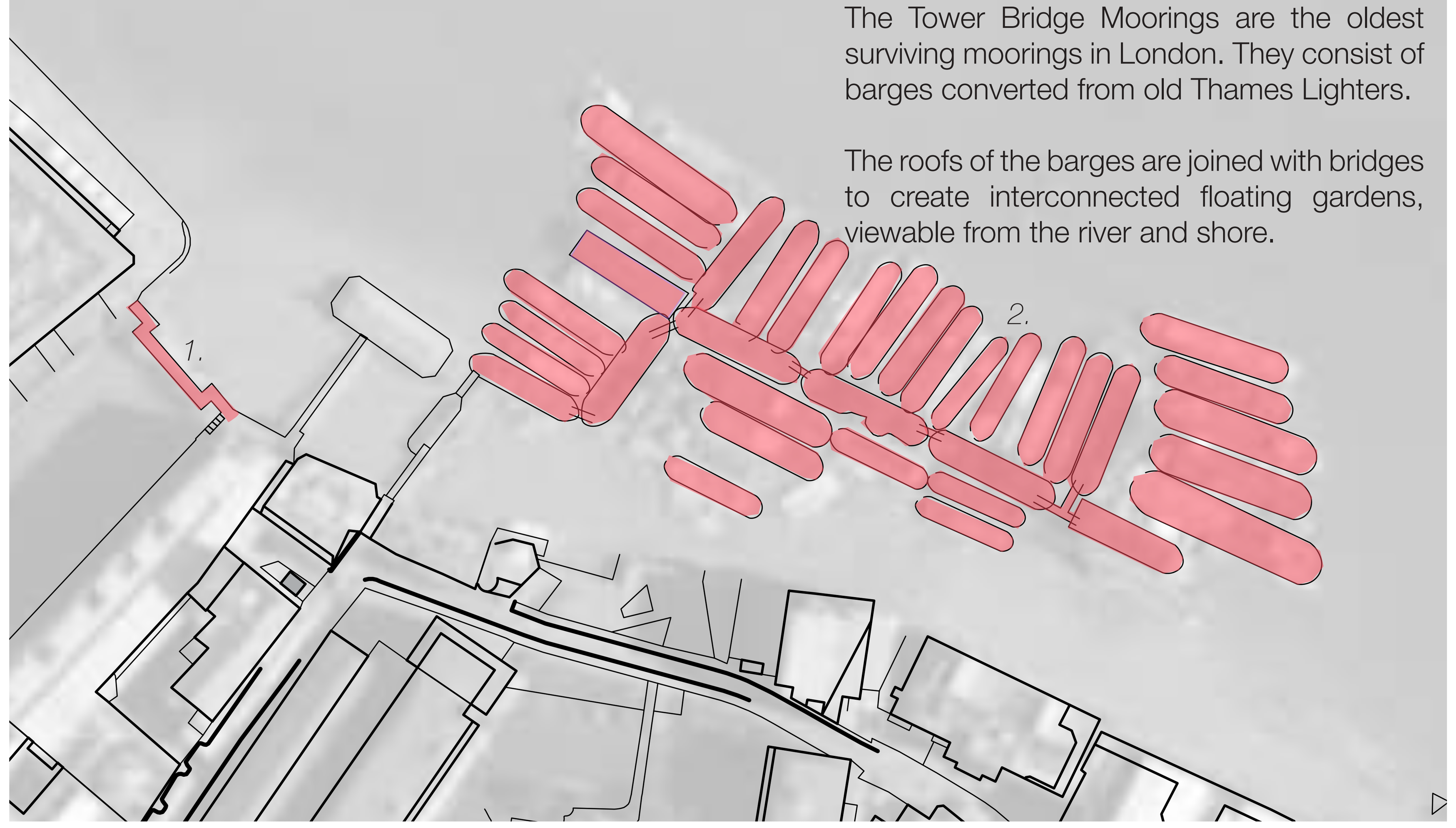
Now, the bridge is undergoing a refurbishment by CONWAY AECOM, in order to reopen the passage of boats, renew the sailbaot rigging anfd repair the hydraulic swing system.



2. Tower Bridge Moorings & Floating Gardens

The Tower Bridge Moorings are the oldest surviving moorings in London. They consist of barges converted from old Thames Lighters.

The roofs of the barges are joined with bridges to create interconnected floating gardens, viewable from the river and shore.



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Floating Gardens

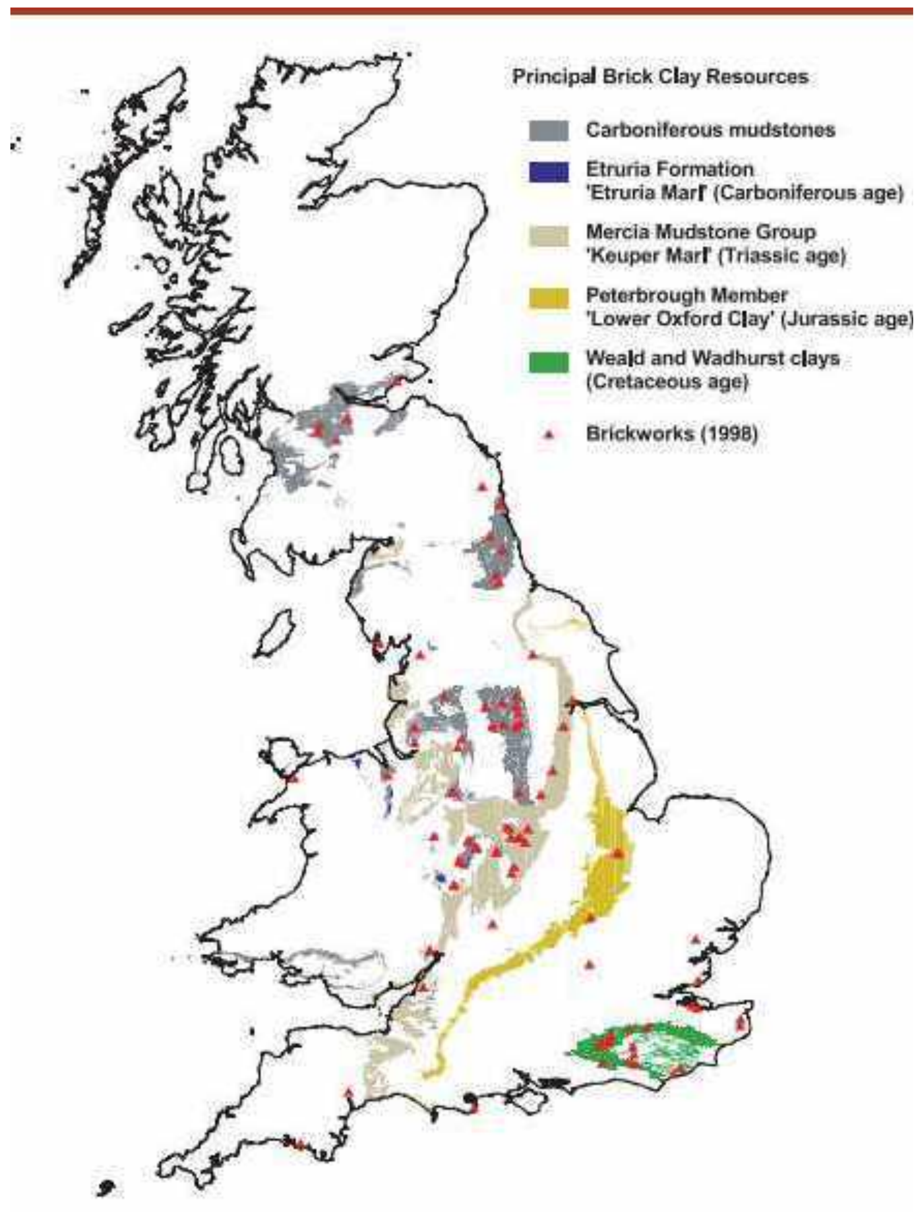
During the mid 1990s, one of the old lighters had started to develop its own ecology: a duck's next was growing in some silt at the bottom of the barge. This inspired the beginning of the floating gardens.

In 2003, the Southwark Council threatened to evict the barges for having no planning permission but the case was appealed and won with a large number of the public arguing for the "valuable contribution to views down river" that they provided.

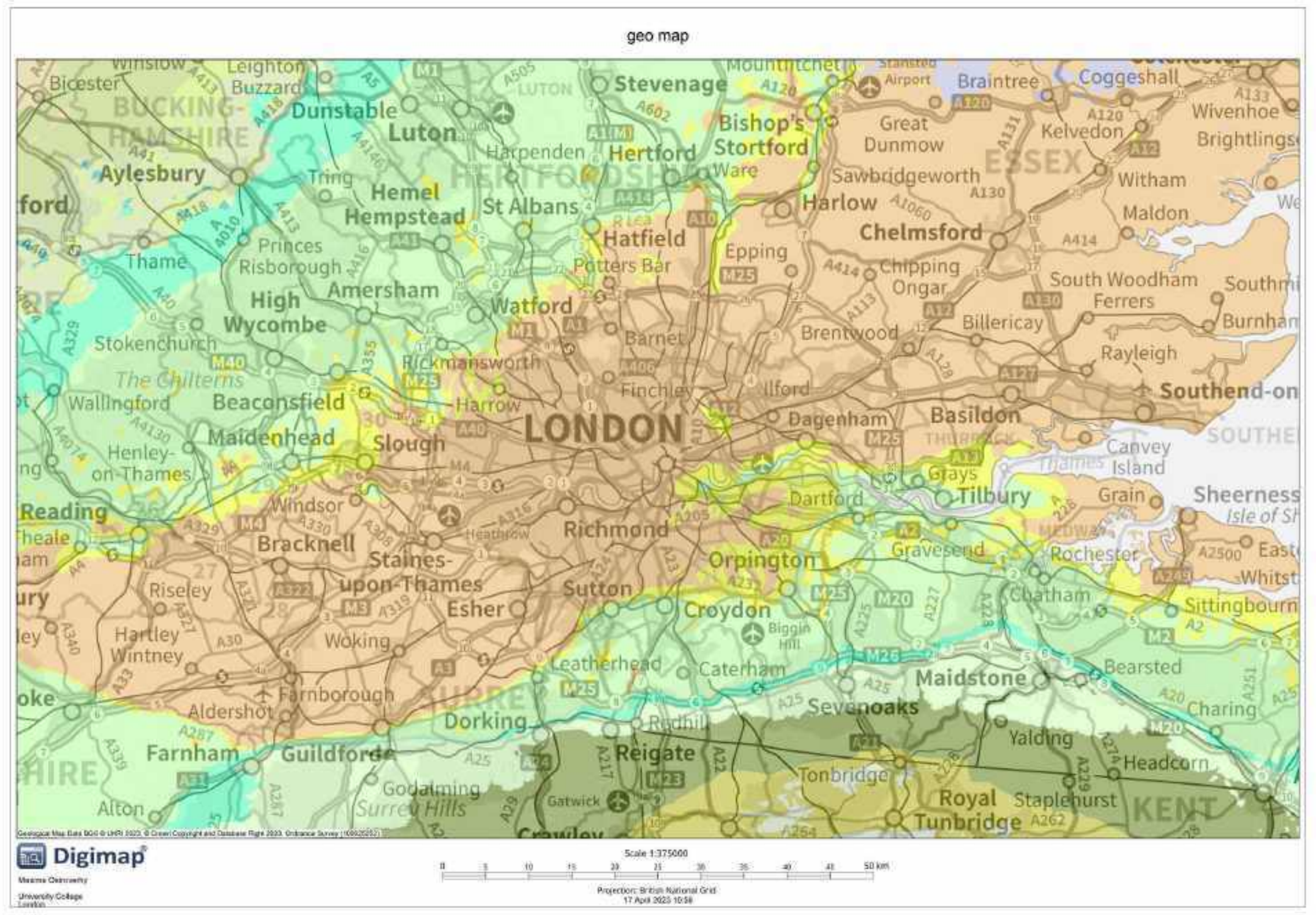
The Moorings used to be home to a communal barge event space called 'ArtsArk' which held many events such as film screenings, poetry evenings and bonfire parties.

Today, ArtsArk has dissolved but the barge is still used for communal events.

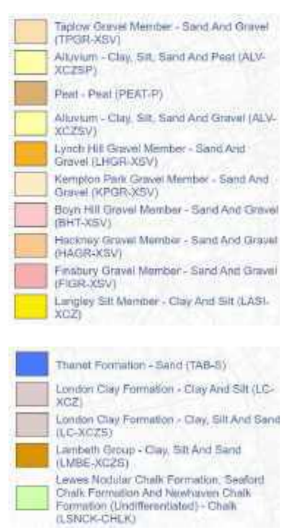

Topographic, Natural and Geological Conditions



Principal brick clay resources

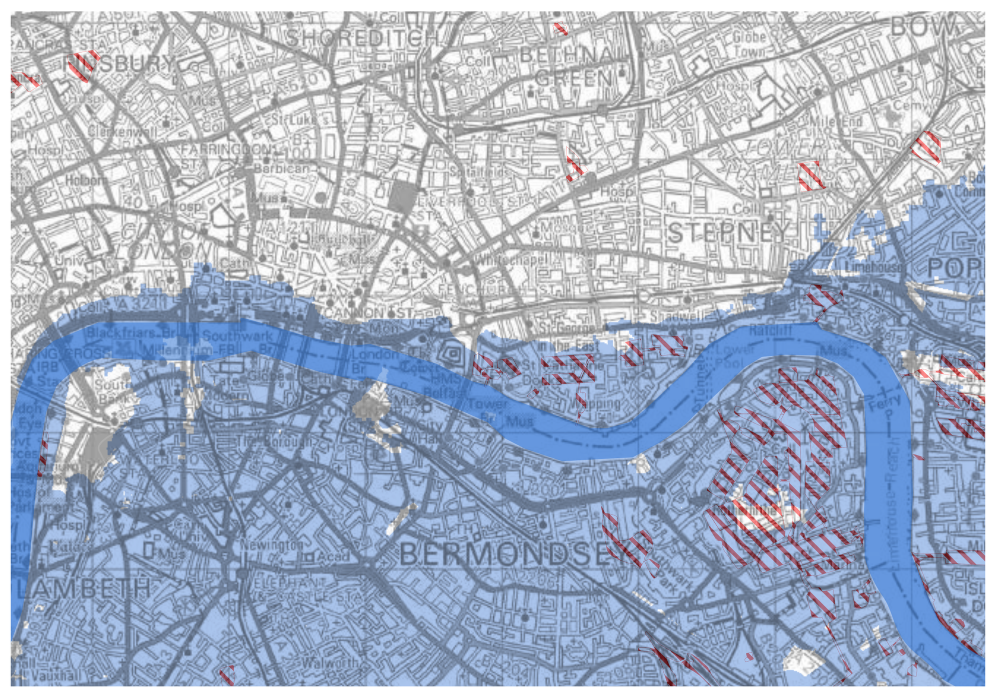


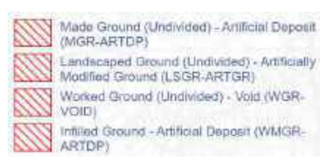
Bedrock map 1 1:375 000



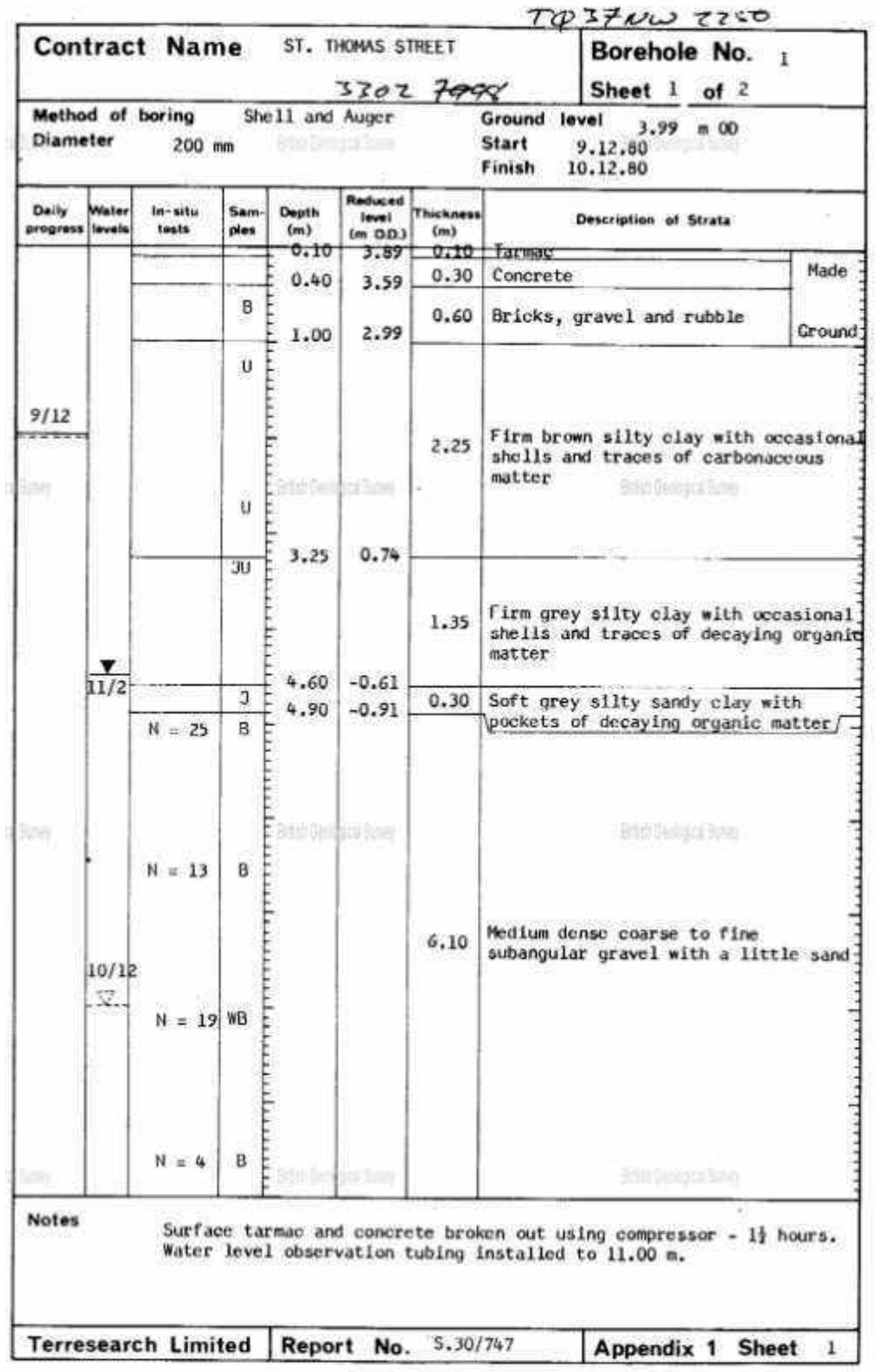
Bedrock and superficial deposits 1 1:20 000

Sea level rise 1:200 000





Artificial ground and sea level rise in 50 years 1:40 000



TQ37NW 2250

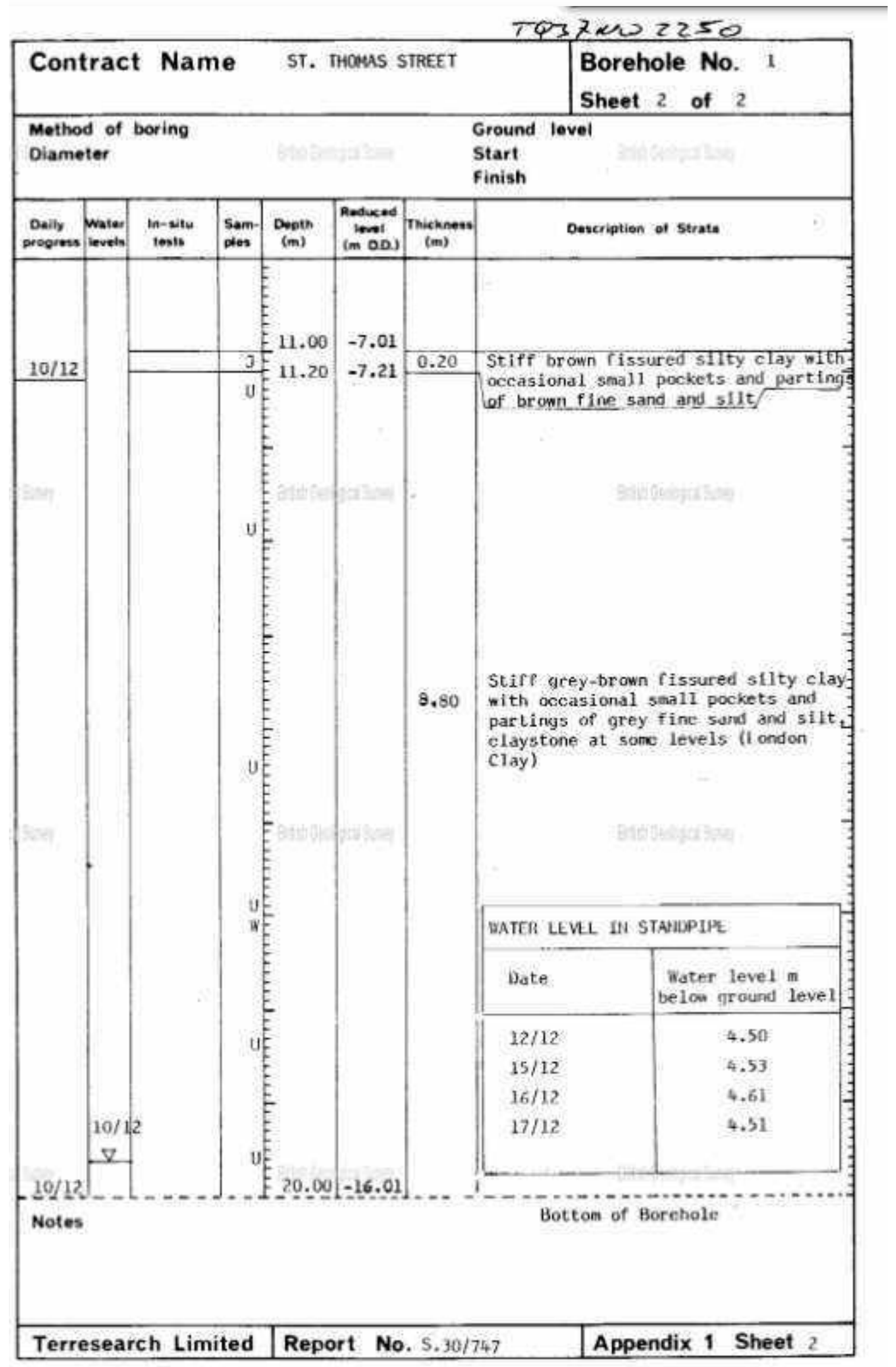
Contract Name ST. THOMAS STREET 3302 7998 — **Borehole No.** 1 — **Sheet** 1 **of** 2

Method of boring Shell and Auger — **Diameter** 200 mm — **Ground level** 3.99 m OD — **Start** 9.12.80 — **Finish** 10.12.80

Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata
				0.10	3.89	0.10	Tarmac (Made Ground)
				0.40	3.59	0.30	Concrete (Made Ground)
			B	1.00	2.99	0.60	Bricks, gravel and rubble (Made Ground)
9/12			U, U	3.25	0.74	2.25	Firm brown silty clay with occasional shells and traces of carbonaceous matter
	11/2		JU	4.60	-0.61	1.35	Firm grey silty clay with occasional shells and traces of decaying organic matter
			J	4.90	-0.91	0.30	Soft grey silty sandy clay with pockets of decaying organic matter
	10/12	N = 25, N = 13, N = 19, N = 4	B, B, WB, B			6.10	Medium dense coarse to fine subangular gravel with a little sand

Notes Surface tarmac and concrete broken out using compressor - 1½ hours. Water level observation tubing installed to 11.00 m.

Terresearch Limited — **Report No.** S.30/747 — **Appendix 1 Sheet** 1



TQ37NW 2250

Contract Name ST. THOMAS STREET — **Borehole No.** 1 — **Sheet** 2 **of** 2

Method of boring — **Diameter** — **Ground level** — **Start** — **Finish**

Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata
10/12			J	11.00	-7.01		
			U	11.20	-7.21	0.20	Stiff brown fissured silty clay with occasional small pockets and partings of brown fine sand and silt
10/12	10/12		U, U, U, U W, U, U	20.00	-16.01	8.80	Stiff grey-brown fissured silty clay with occasional small pockets and partings of grey fine sand and silt, claystone at some levels (London Clay)

WATER LEVEL IN STANDPIPE

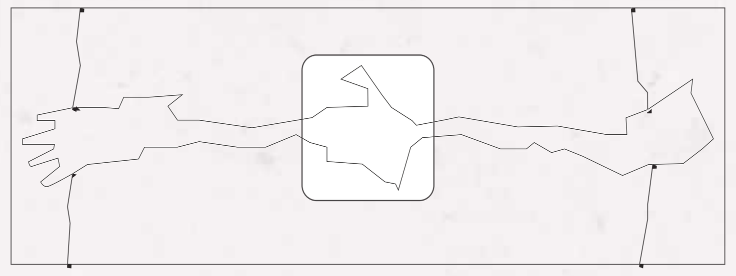
Date	Water level m below ground level
12/12	4.50
15/12	4.53
16/12	4.61
17/12	4.51

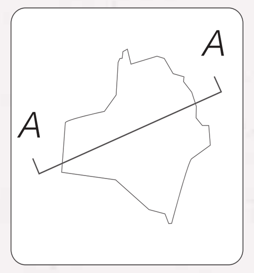
Bottom of Borehole

Notes

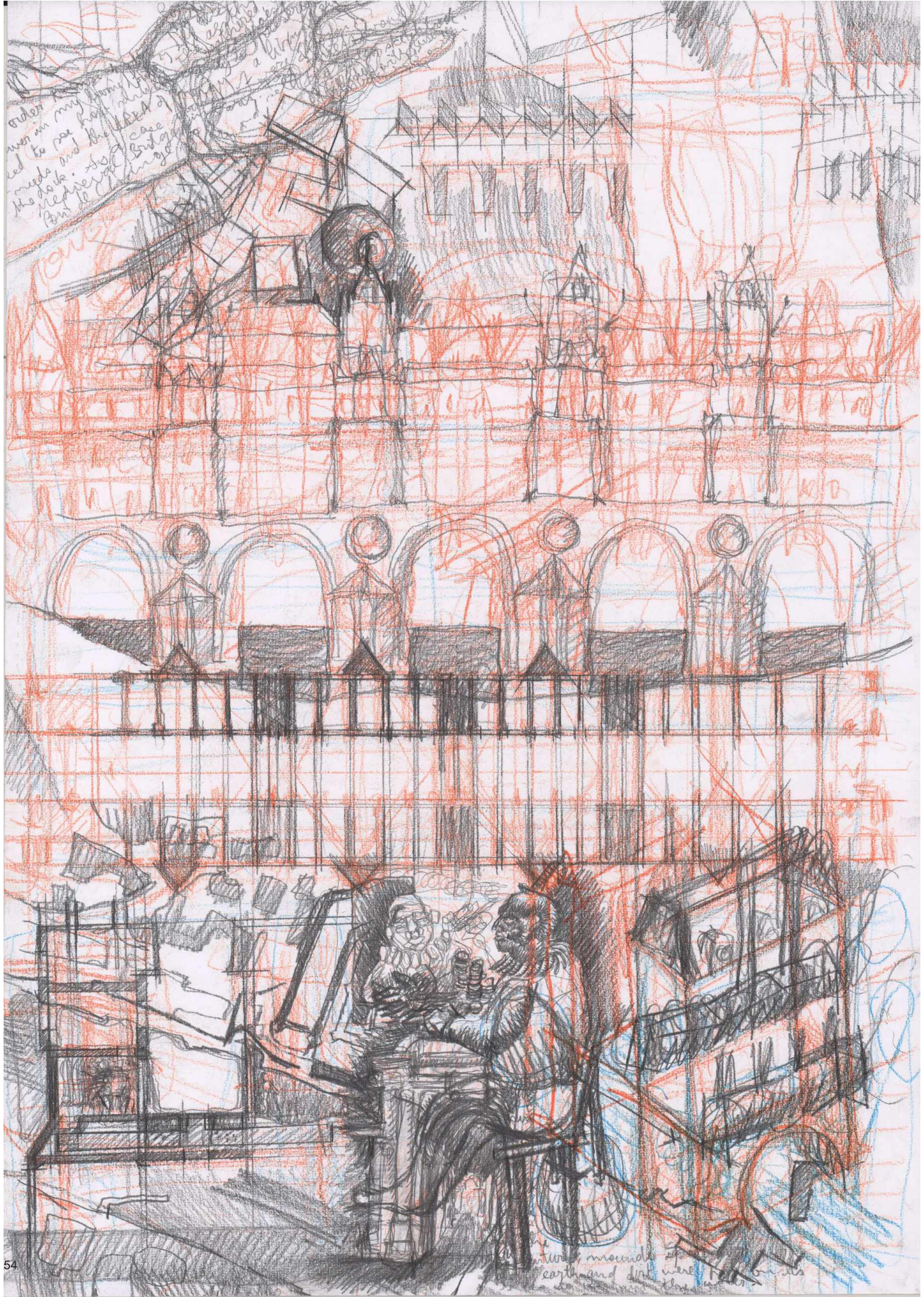
Terresearch Limited — **Report No.** S.30/747 — **Appendix 1 Sheet** 2

Borehole on site




A
A

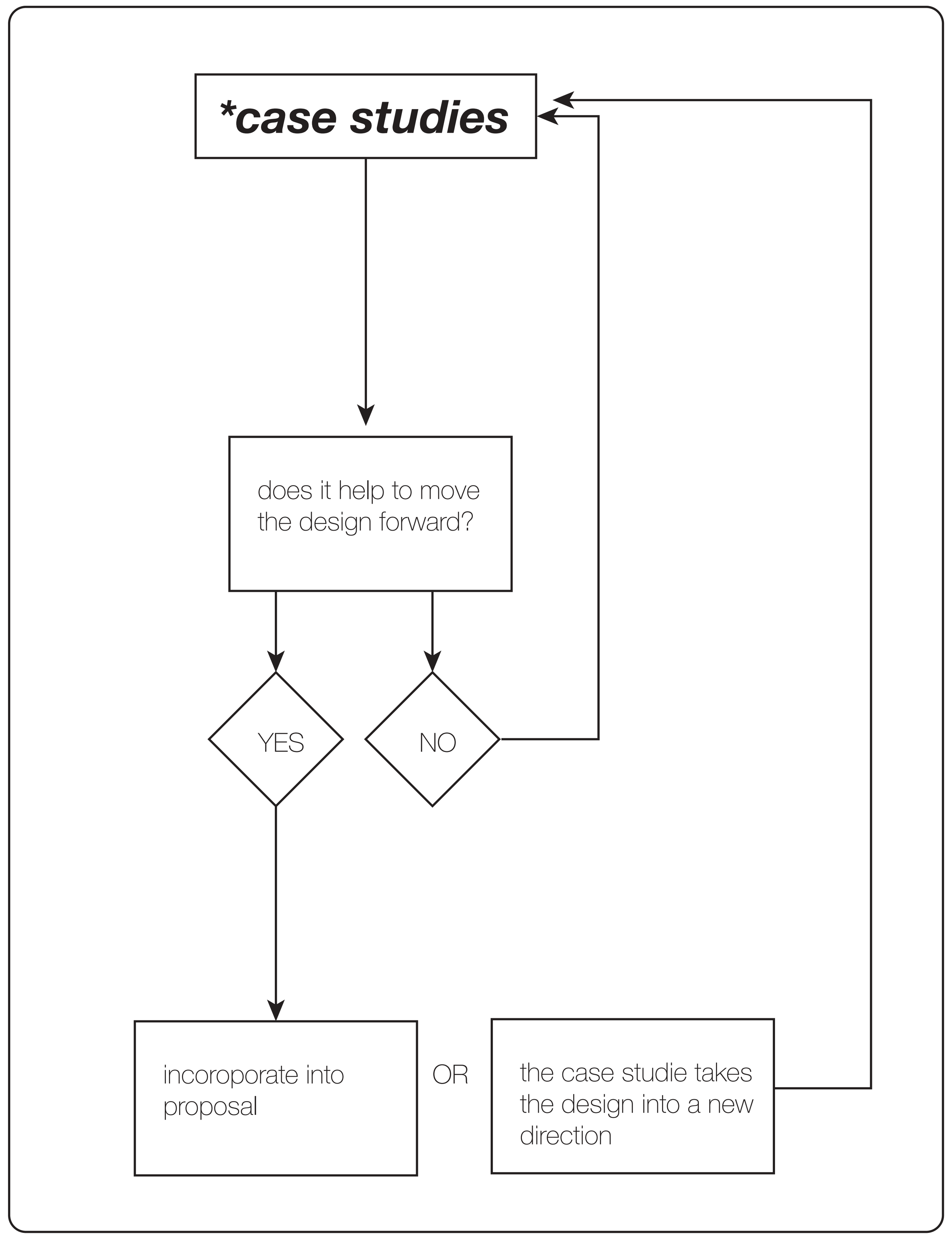

Year Tide Levels
Gauge (m)
10.00
5.00
0.00
-5.00
Jan 2022
Apr
Jul
Oct
Jan 2023
WeeklyTide Levels
Gauge (m)
4.00
2.00
0.00
-2.00
Mon 00:00
Tue 00L00
Wed 0:00
Thu 0:00
Fri 00:00
Sat 00:00
Sun 00:00
Daily TideLevels
Gauge (m)
4.00
2.00
0.00
-2.00
0:00
06:00
12:00
18:00
0:00
-0m
-1m
-2m
-3m
-4m
-5m
-6m
1:50 on A1
4m



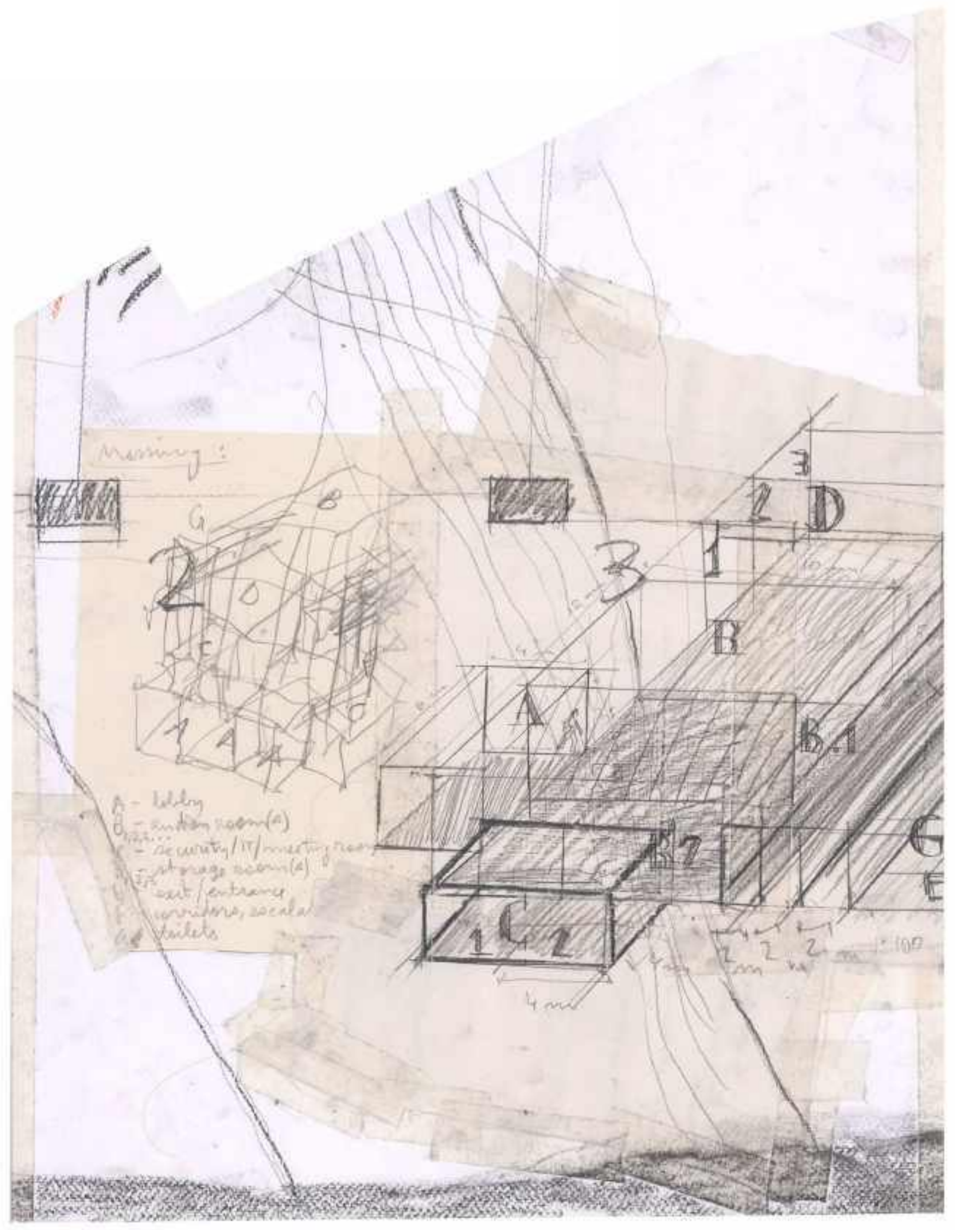
Section 3. Collaborative Urban Investigation Living Bridges

In designing a bridge that would serve as an auction house, I found it absolutely vital to research on past examples of bridges that have buildings for residential and business use. Looking at past examples of bridges that were created influenced me in my design and it is always helpful to look at problems I might not have thought of before. It was delightful to be able to link my hometown Paris into this overall project, especially my fondness over Parisian architecture. Specifically the architecture that was before Haussmann and that was destroyed, such as the Pont au Change, to which its history is quite fascinating, specifically how one of the main driving forces for the creation of this residential houses over the river were created to avoid land taxes. Of course, one of the most famous references that I used was the Ponte Vecchio in Italy, which I felt obliged to include for both its iconic look and to have certain people understand that the idea of constructing a floating bridge is not as crazy as it sounds. There have been past examples, and thus this bridge is taking inspiration from both past traditional examples whilst looking at innovating it and fitting it within the contemporary world.

It is important to highlight that I drew inspiration from both historic landmarks – Ponte Vecchio, Maidenhead Railway Bridge – and current landmarks the likes of Tokyo Gate Bridge. I was particularly inspired by the artist Christo whose temporary art installation 'The Floating Piers' managed to shock, amaze and make people stop a little with their busy lives and ponder. Despite the fact that 'The Floating Piers' was a temporary landmark – and mine is designed to be permanent – the way the materials were industrially recycled is very important to me. It links to my idea that we should raise the level of sustainability in a world that is trying to cope with such pressing matters like climate change.

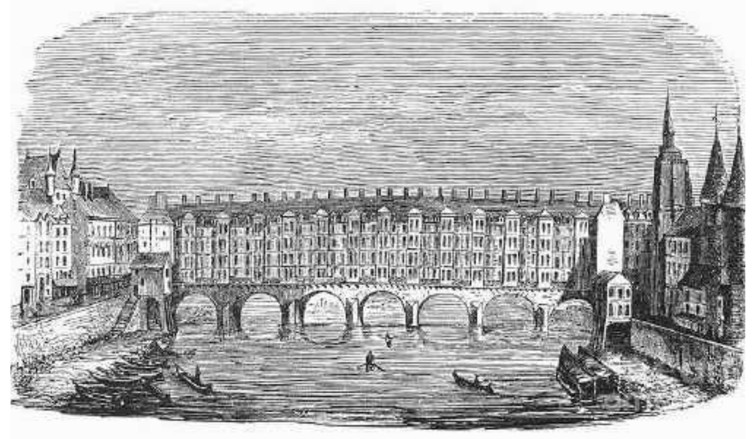


*even though it was done at the start, and was more of a formality to the brief, it helped to ground the project



Living Bridges and Infrastructures Case Studies

Case study 1: Pont au Change



Main feature: living

This bridge got its name from the money changers who built their houses and shops there in the 12th century. Although no houses exist now, it was common to have buildings on bridges in medieval Paris for two main reasons: to avoid land taxes and increase the stability.

Bridges might become a more viable living option in the future with rising sea levels and housing shortages. I could take inspiration from medieval Paris to increase the stability of my bridge.

Case study 2: Festa del Redentore Bridge

Main feature: floating

This bridge is temporarily constructed once a year for the Festa del Redentore during July which celebrates the end of the 16th century Plague in from 1577 and the construction of Palladio's church. It is a 330m long floating pontoon bridge which creates a walkway to the church which is usually only accessible by boat.

The floating mechanism could be inspiration for a pedestrian walkway feature of my bridge design, incase the Thames water level rises in the next 50 years.

Case study 3: West India Quay Bridge AL_A

Main feature: floating

his footbridge was built in 1996 over Canary Wharf, it is 94m long. It is built with X-shaped tubular steel struts bolted to pontoon floats, which are filled with polystyrene. The bridge also has wheels at either end, so in theory is fully moveable.

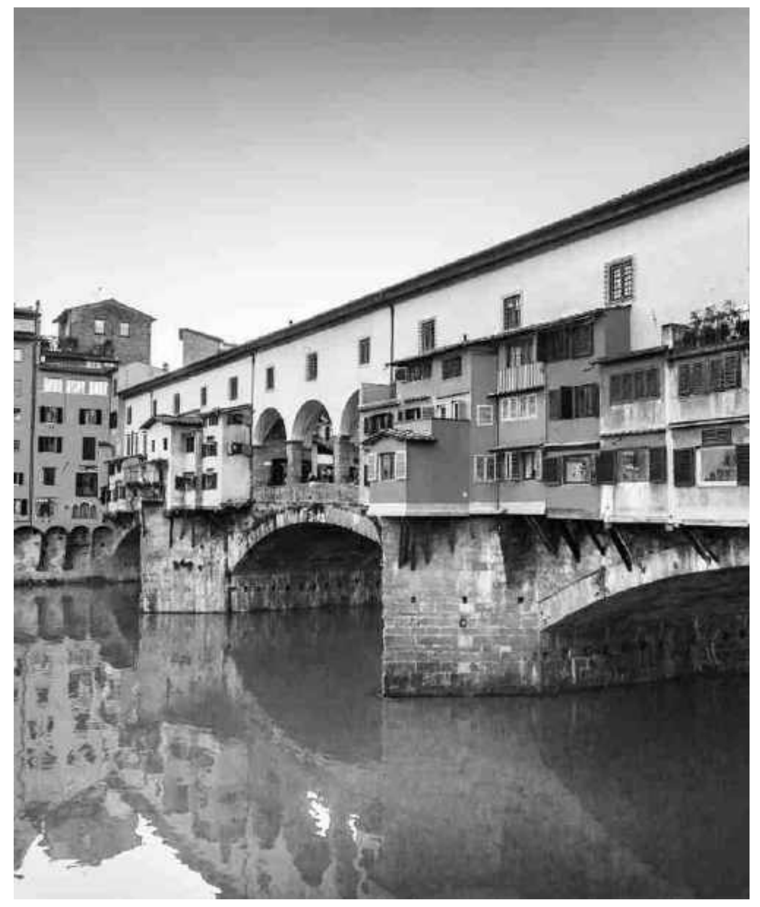
The floating structure could be inspiration for my bridge design to allow adaptablity to the Thames water level rise.

Case study 4: Ponte Vecchio Bridge

Main feature: living

This was believed to have been built in the Roman times, but notably recorded from medieval times. It was common place to build shops on bridges in Florence then. It wasv originally full of butchers, tanners and farmers but in 1595 they were excluded and replaced with mostly jewellers. Today, these prevail along with art dealers and souvenir shops. An important feature of the bridge is the large piazza at the center.

It's rich inhabited history attracts many tourists and artists to the bridge, which could inspire the living art community of my bridge.

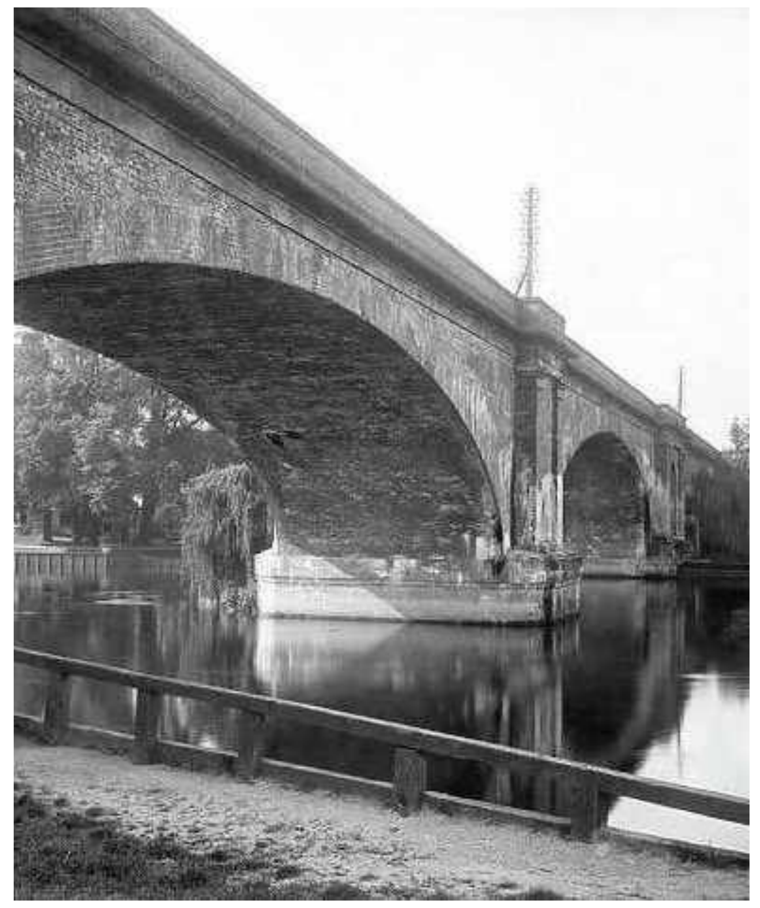


Case study 5: Maidenhead Railway Bridge

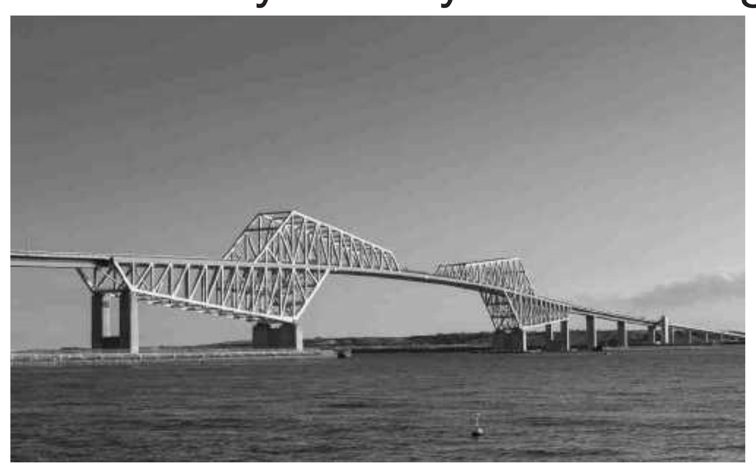
Main feature: masonry

Masonry bvridges are extremely durable and can last for a thousand years. This bridge was designed by Brunel and opened in 1839 for the Great Werstern Railway line to connect London to Bristol. It was the flattest and widest brick arch in the world at the time. Many didn't believe that the shallow arch could withstand the load but they were proved wrong.

Masonry bridge structures feature a main supporting arch so in order to use ceramics structurally, the form will be quite restricting. However, ceramics can be– used more for environmental qualities



Case study 6: Tokyo Gate Bridge

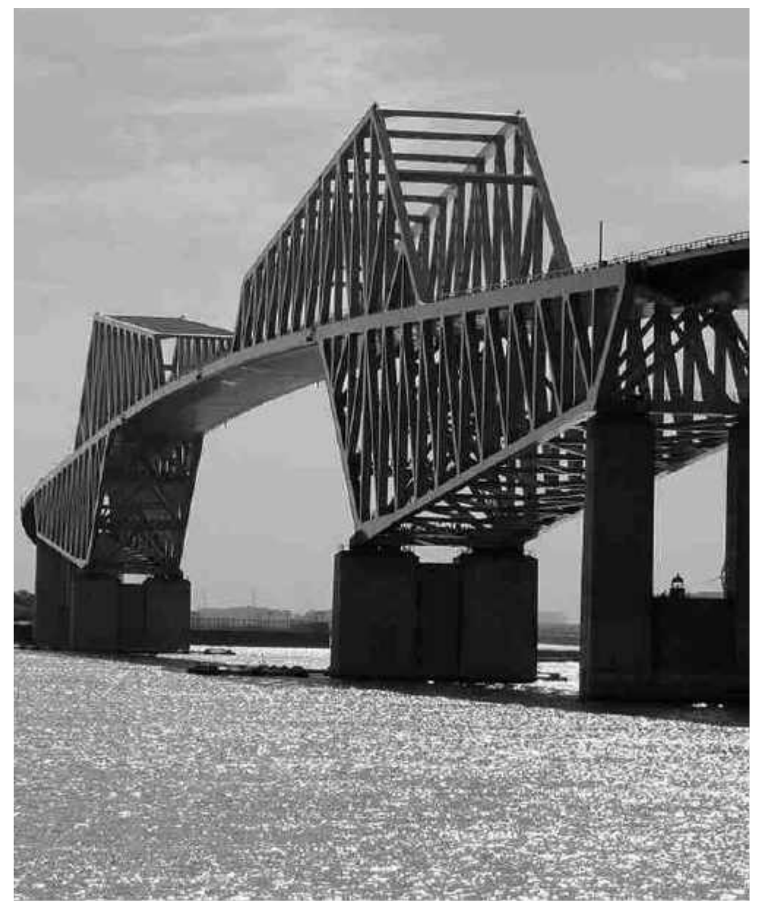


Main feature: cantilever

This bridge was built in 2012 to carry a heavy flow of traffic across East Tokyo. It had height restrictions due to air traffic and vessel crossings so the structural solution used was a steel truss cantilever system. It has an overal length of 2,618m.

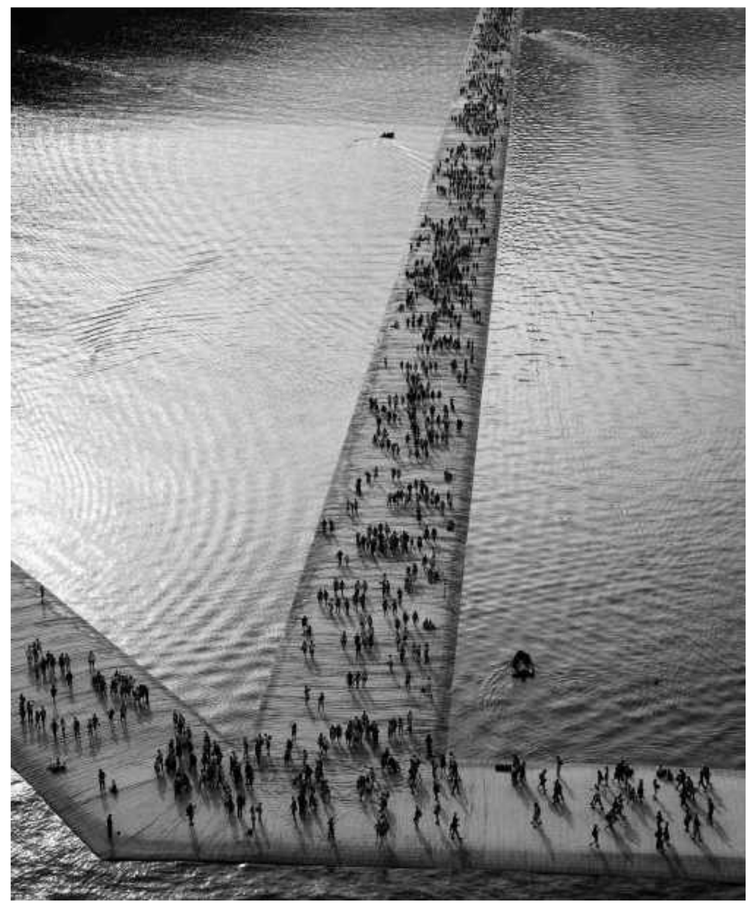
It is also a leading example of the application of Internet of Things technology in Japan where over 50 sensors across the bridge are used to collect and analyse environmental data in order to mitigate future climate crisises, eg. earthquakes

The cantilever system of the bridge could be used to inspire the structure of my bridge....



UNCHECKED
It is likely that not all case studies were relevant.
June 2023 London, UK

Case study 7: The Floating Piers by Christo

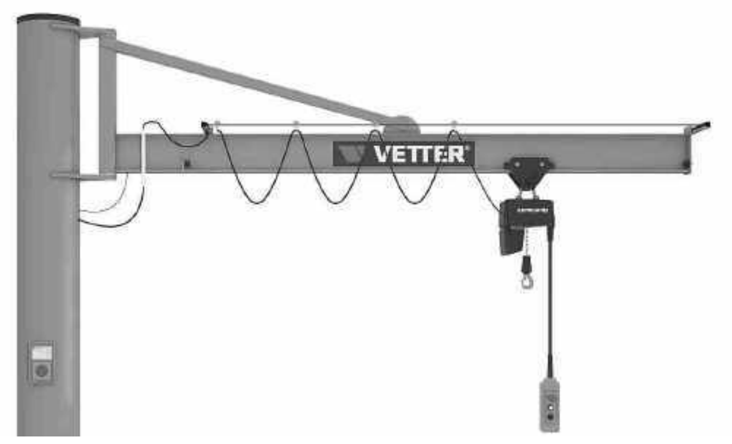


Main feature: floating

This floating walkway was temporarily installed in Lake Iseo, Italy, from June to July 2016, it was constructed using a modular floating dock system of polyethylene cubes (shown above). It was covered in 100,000 swuare meters of bright yellow fabric. The piers were 16 meters wide and 3 km long. After the 16 day installation, all parts were taken downa nd industrially recycled.

The temporary nature could inspire my project - to create walkways that go through the living spaces but can adapt and move to moving water levels.

Case study 8: JIB crane system



Main feature: pulley system

JIB cranes are one of the most simple types of cranes used. They consist of 3 main components: an arm/ boom/jib, a trolley and a lifting device. Floor-mounted jib cranes have a verticle column to support the arm. The lifting device could use an electric chain hoist, a pneumatic chain hoist or a manual chain hoist. The jib arm can rotate up to 300 degrees or be positioned as stationary.

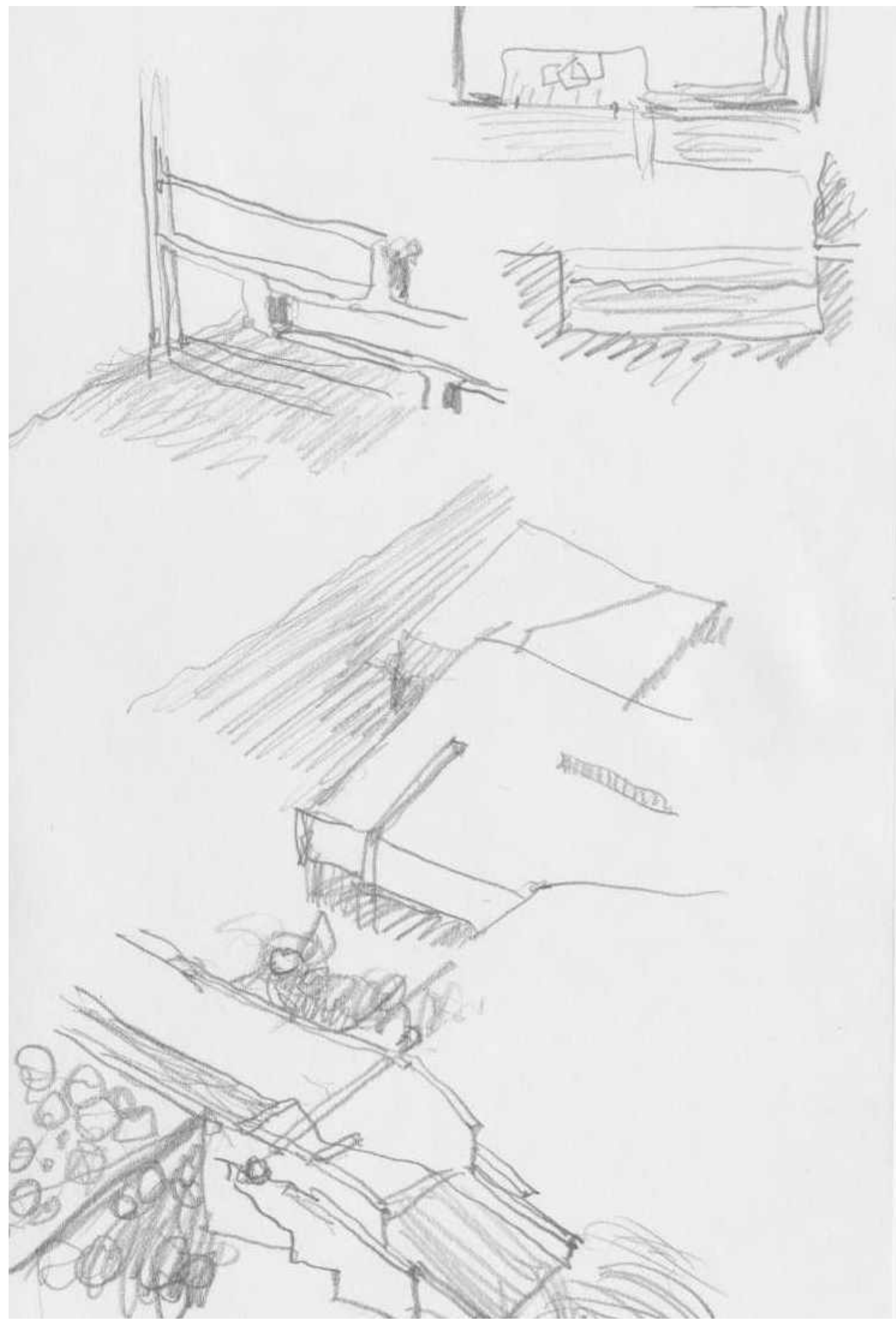
Case study 9: Barge boat

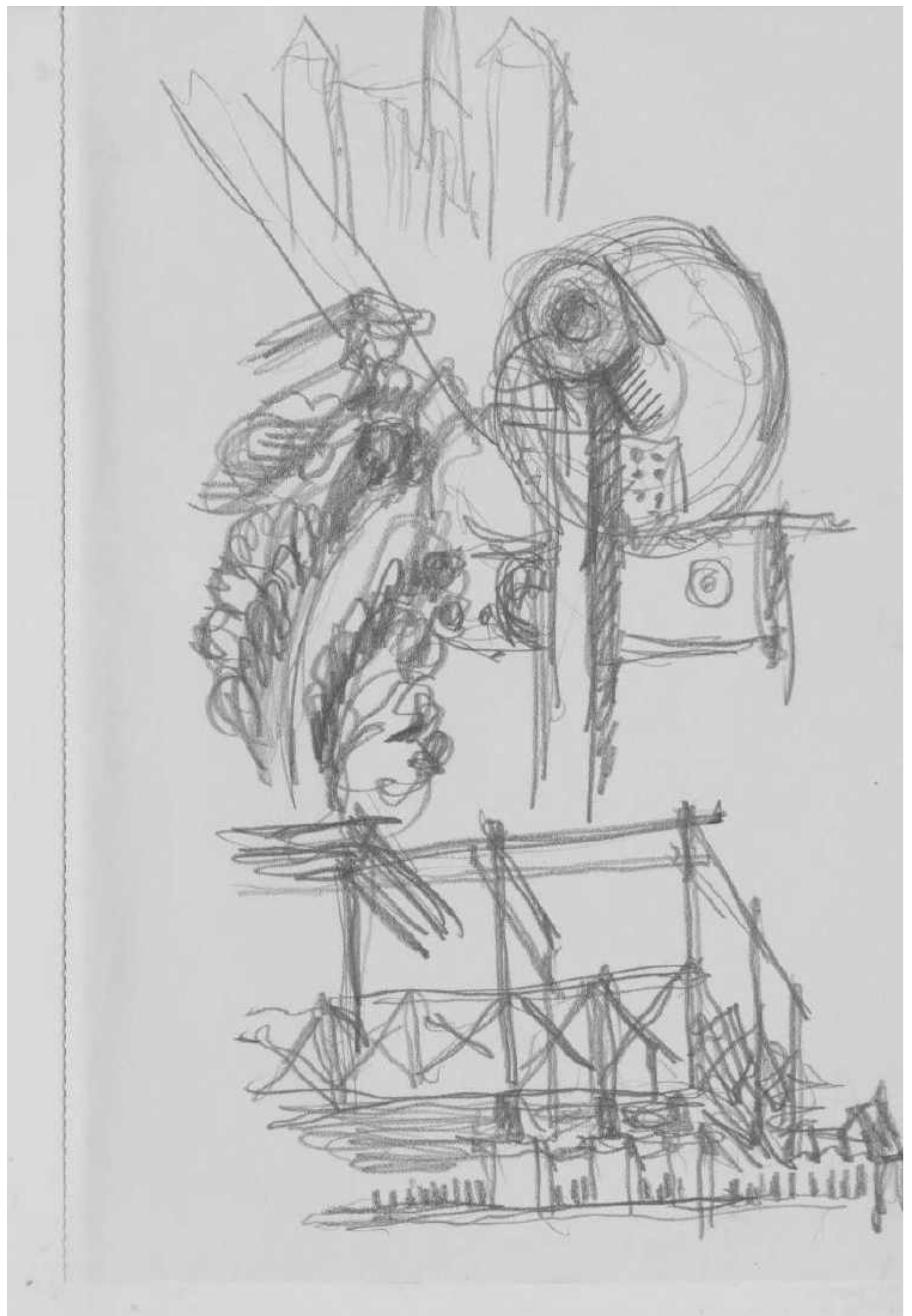
Main feature: floating

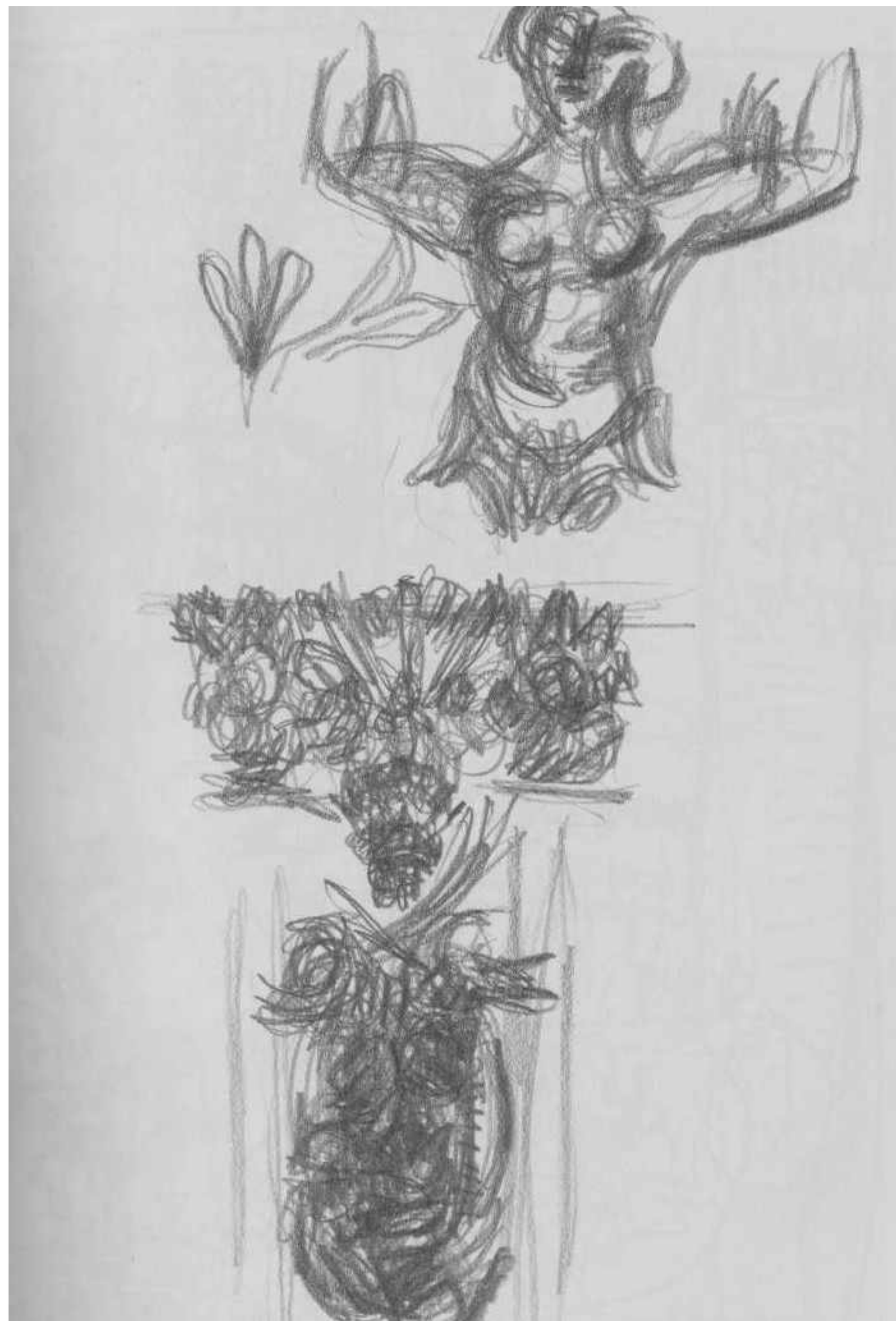
The narrow barge boat surround the entrances of the site and host a thriving artistic community.

First Bridge Concept

Venice Sketches of Bridge Details





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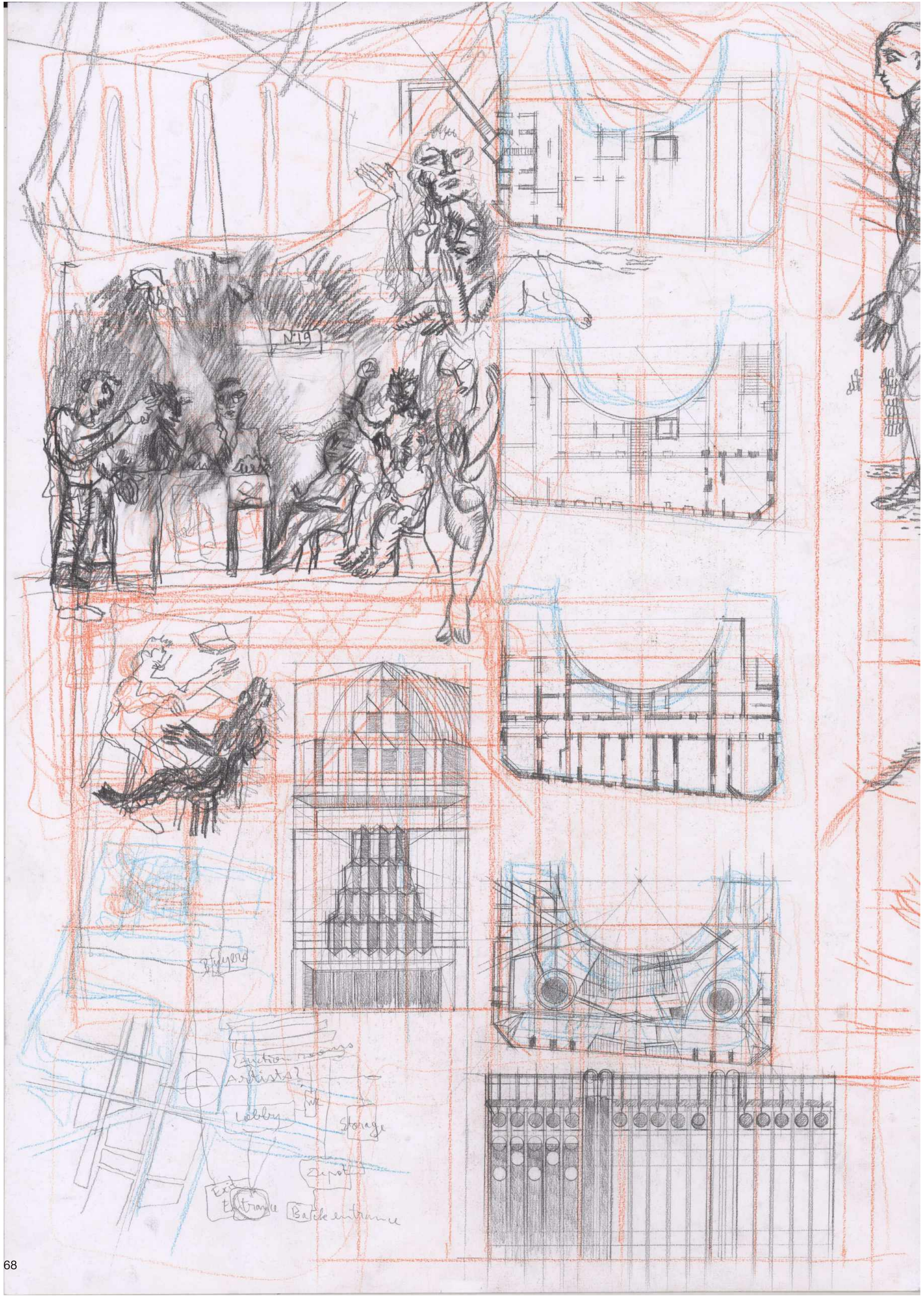


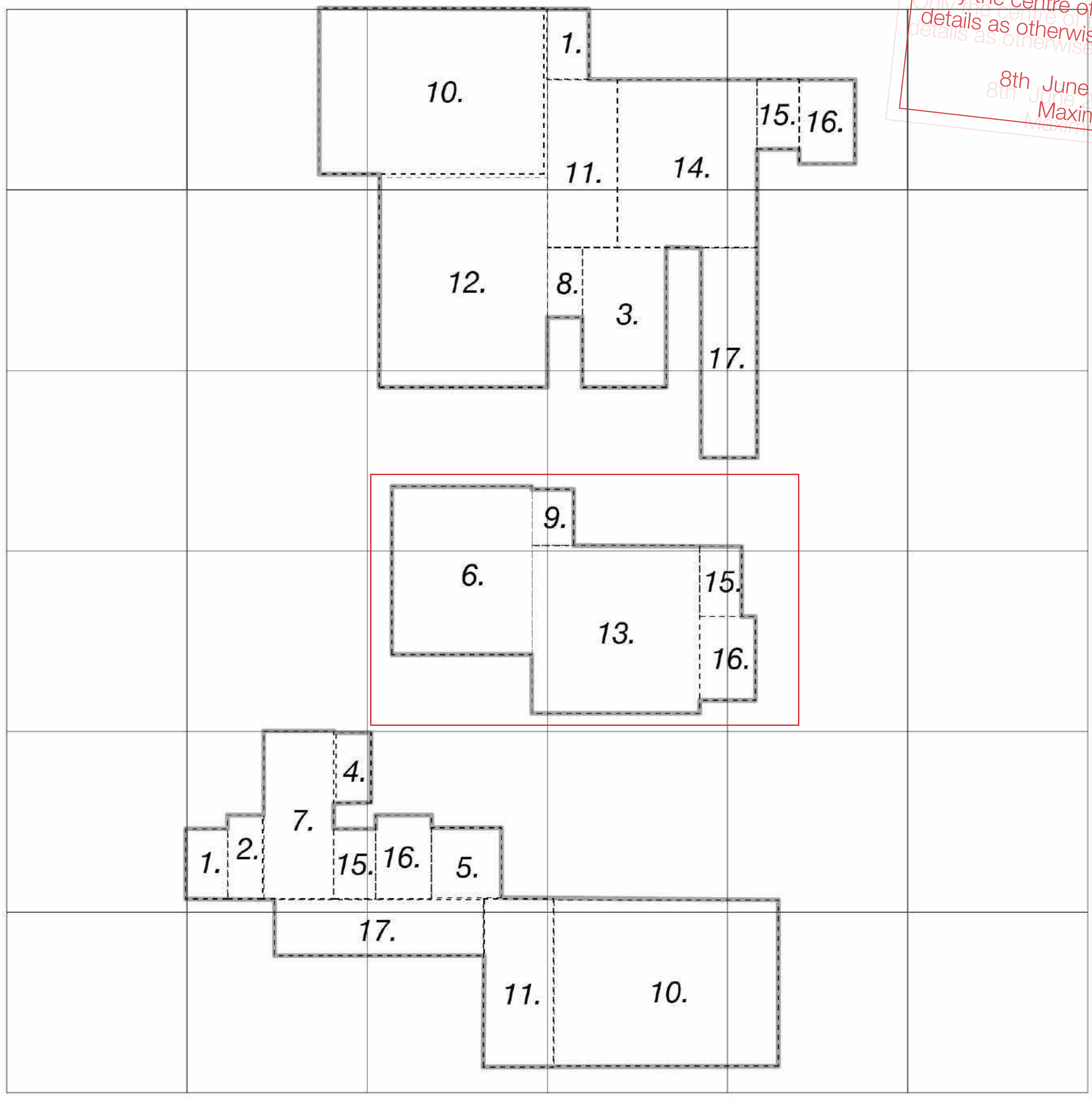
Section 4. Organisation of Adjacencies: Programme

In order to create an auction house, it must function as an auction house. In order for that to be achieved, I looked at already existing auction houses in the world – Drouot – as well as taking inspiration from art spaces, specifically those that I have personally visited, such as the White Cube Museum in Bermondsey, London, and private art studios in Paris.

In the process I have made a diagram to reiterate the central message of this work, through creating a visual understanding of the way the art business world functions. In understanding this system, we can then start to think about possibilities to foster a healthy, balanced and fair relationship between the artist, the dealer and the buyer. The diagram put down two examples, two ways in which we could live. One is within a buyer-dominated market, and the other is an artist-dominated market. I am inspired by the Cubitt Art Co-op in London which seeks to create a market in which the artist has a fairer say in what happens to his artwork which he, after all, remains the art's creator. All of this was key in influencing me for the overall architectural design of the auction house on the floating bridge. Through a series of initial sketches (see Appendix), an intuitive approach was taken to create a paper model of the bridge.I have sought to create a thought-provoking, feasible and beautiful building which would reflect the central ethos that the auction house is trying to emulate: a place where the artist's work is sold with fairness as artists and curators get a fair share of the business and the art spaces.

The uneven shapes, reflects on the decomposing piers on the river banks, the rusted metal chains and boat frangments.

ADJACENCY DIAGRAM



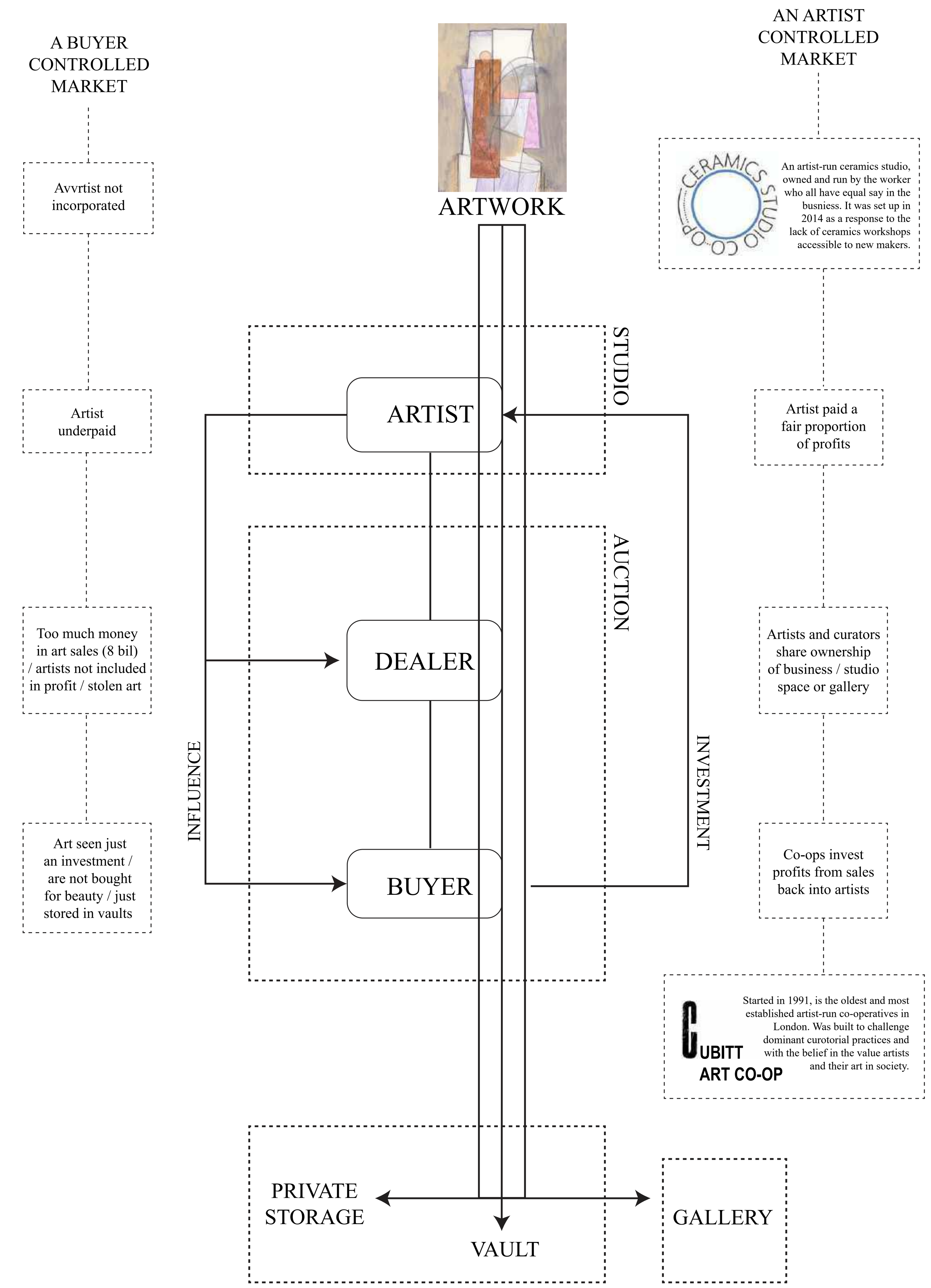
CURRATOR'S NOTE

Only the centre of the bridge was designed in details as otherwise the proposal was too big.

8th June 2023 London, UK
Maxime Ostroverhy

1-entrance
2-bookshop
3-north galleries
4-auditorium
5-south galleries
6-central gallery
7-viewing rooms
8-archive
9-meeting room
10-offices
11-boat entry
12-storage
13-AUCTION ROOM
14-art restauration
15-toilets
16-boiler room
17-maintenance
18-dam for hydropower

Users and Clients



Typology Study and Analysis

Drouot, Paris

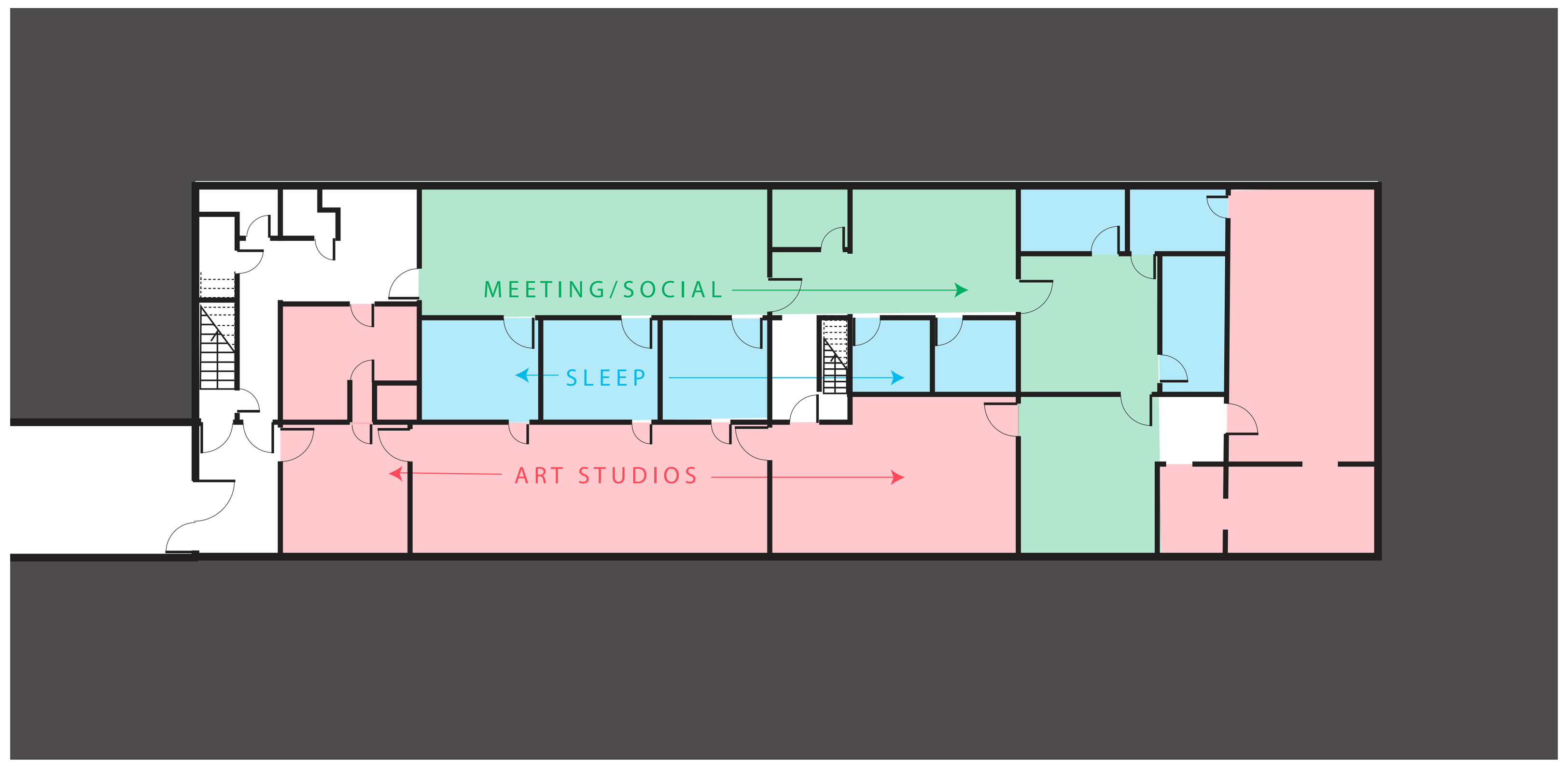
Drouot auctiopn house was established in 1852 as part of the hotel, it is one of the oldest and biggest public auction houses that exists today. It houses 18 salerooms which hold auctions of pieces from a wide range of disciplines including archeology, islamic art and wines. These are always accessible to everyone.





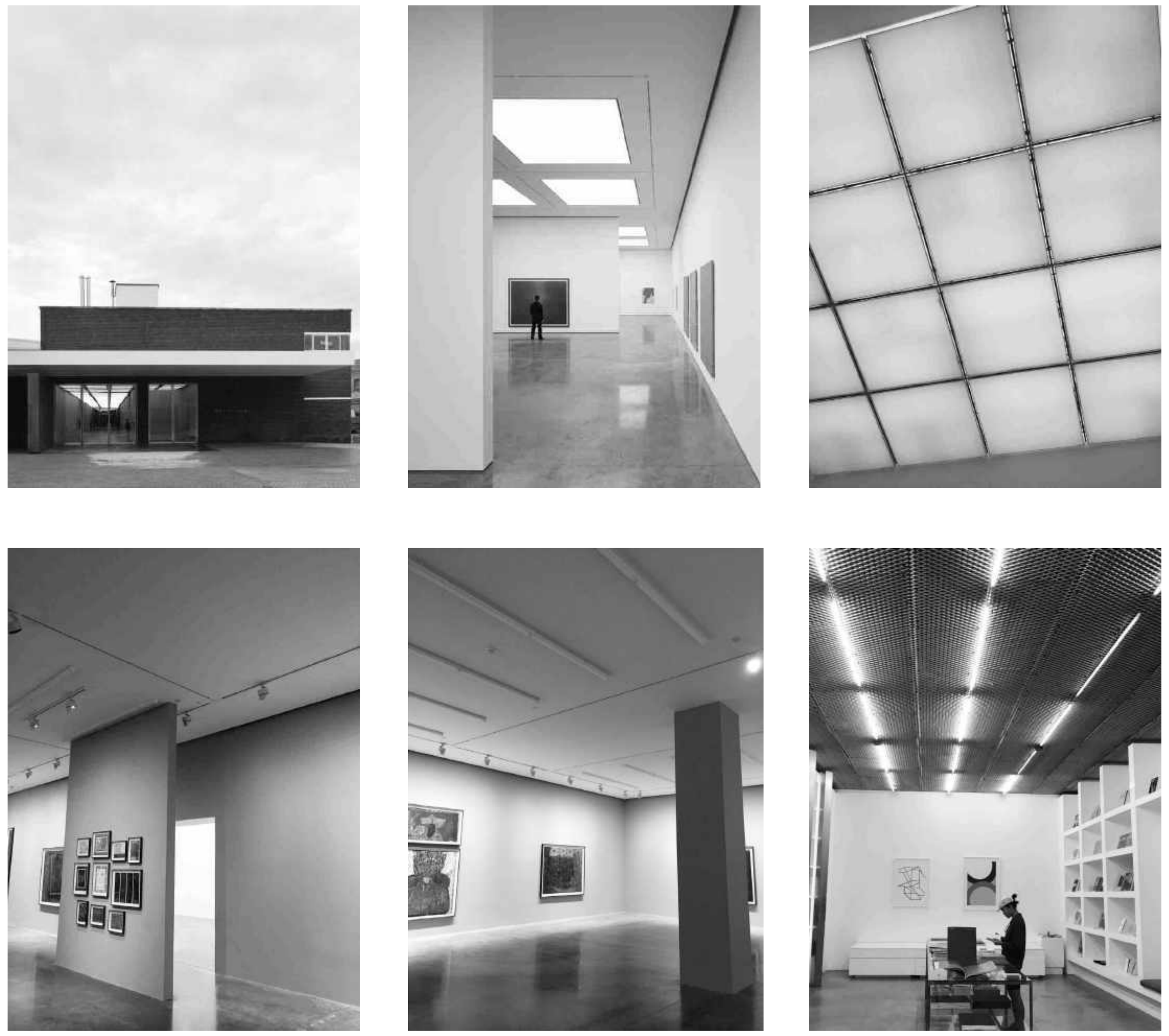

The Territory, Paris

This is an art community space in the south of Paris, where art assistants can co-live in exchange for help on various projects. There are various flexible art studio and gallery spaces, with shared equipment and amenities which the residents can use for many different creative projects. It was built into a courtyard surrounded by Haussemanian appartment buildings, so relies on the polycarbonate roof for its sunlight.



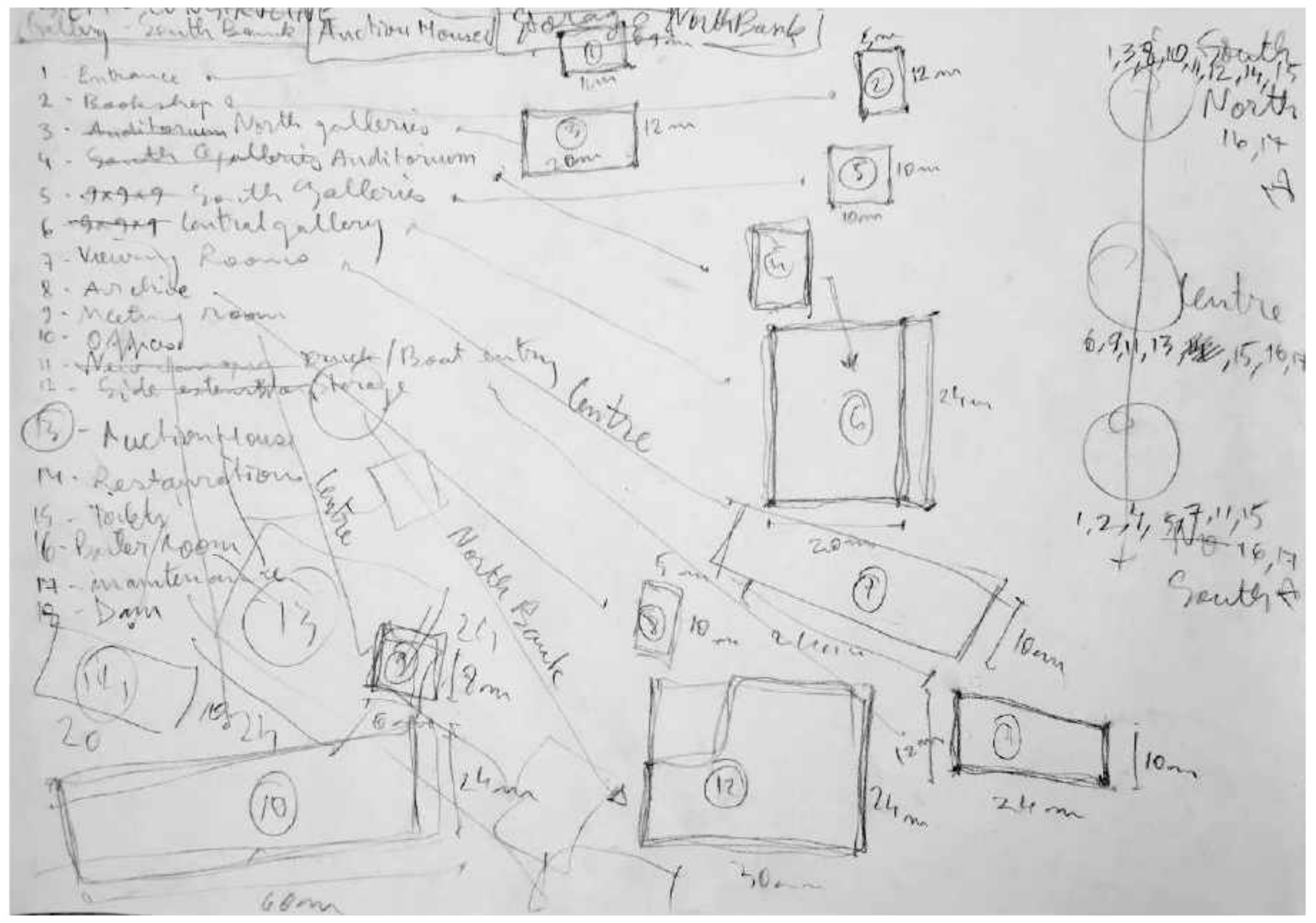
White Cube, Bermondsey

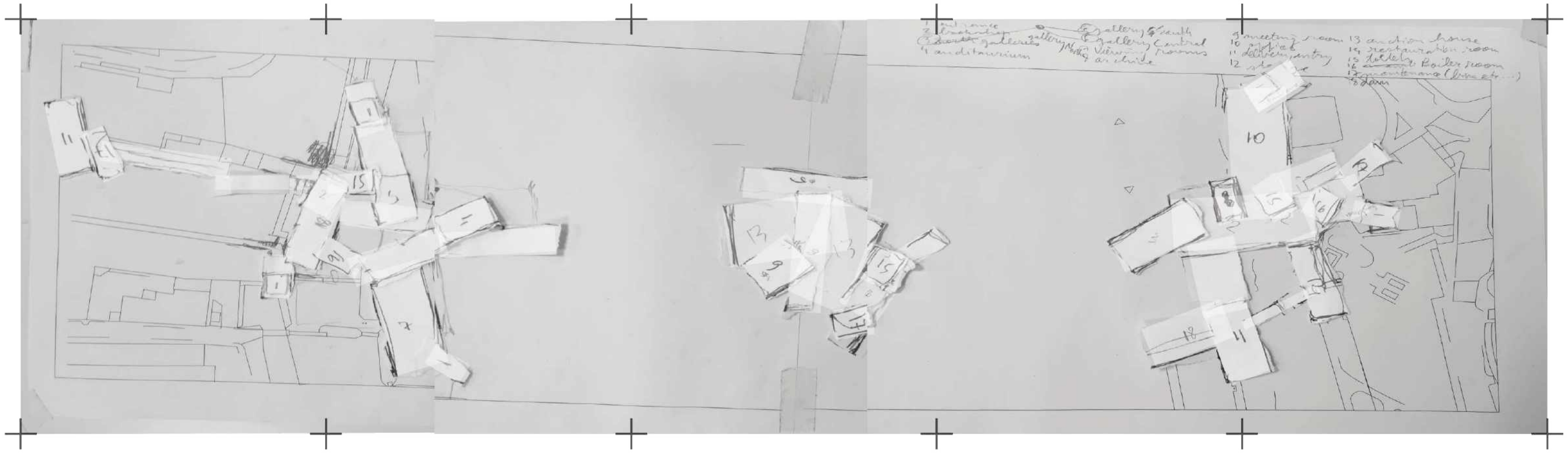
The White Cube in Bermondsey was opened in 2011, sitting inside a former 1970s warehouse. At the time it was Europe's largest commercial art gallery, since then it has provided an early exhibition venue for many now internationaly acclaimed artists, such as Tracey Emin, Gilbert & George and Antony Gormley. It holds multiple exhibition spaces, a warehouse, private viewing rooms, a bookshop and auditorium. The industrial character of the building was enhanced and maintained by retaining the existing structure and with the use of concrete and steel.

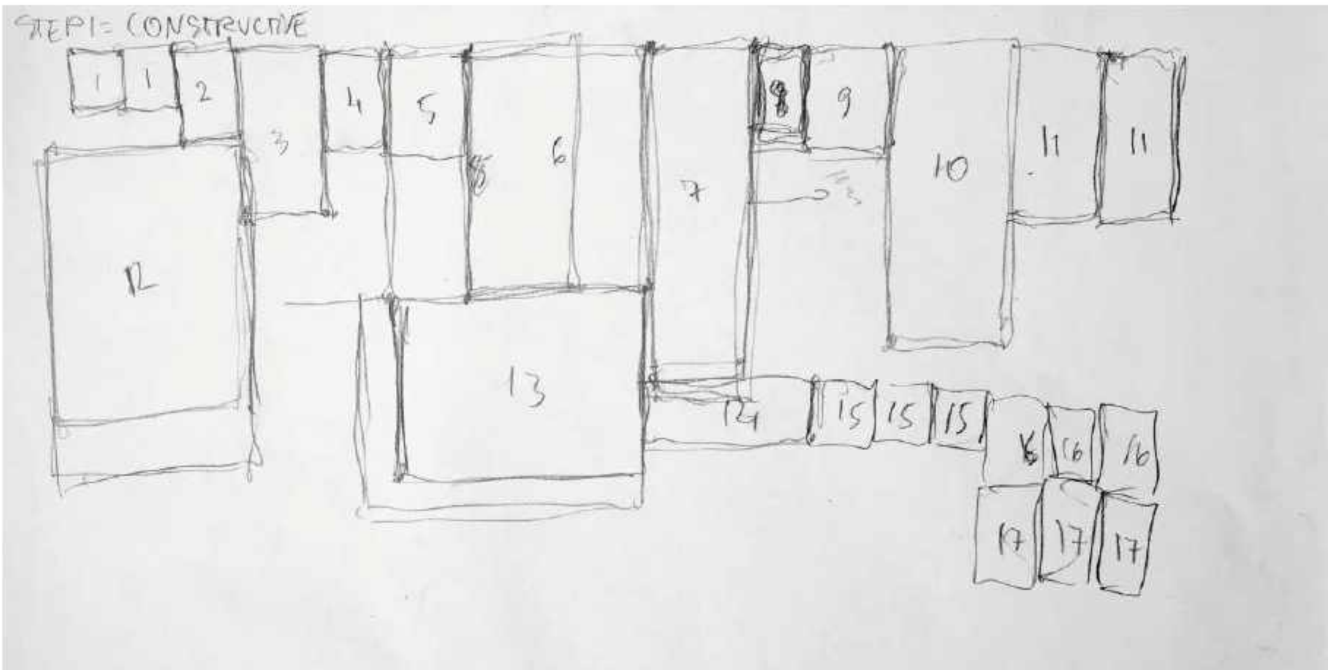


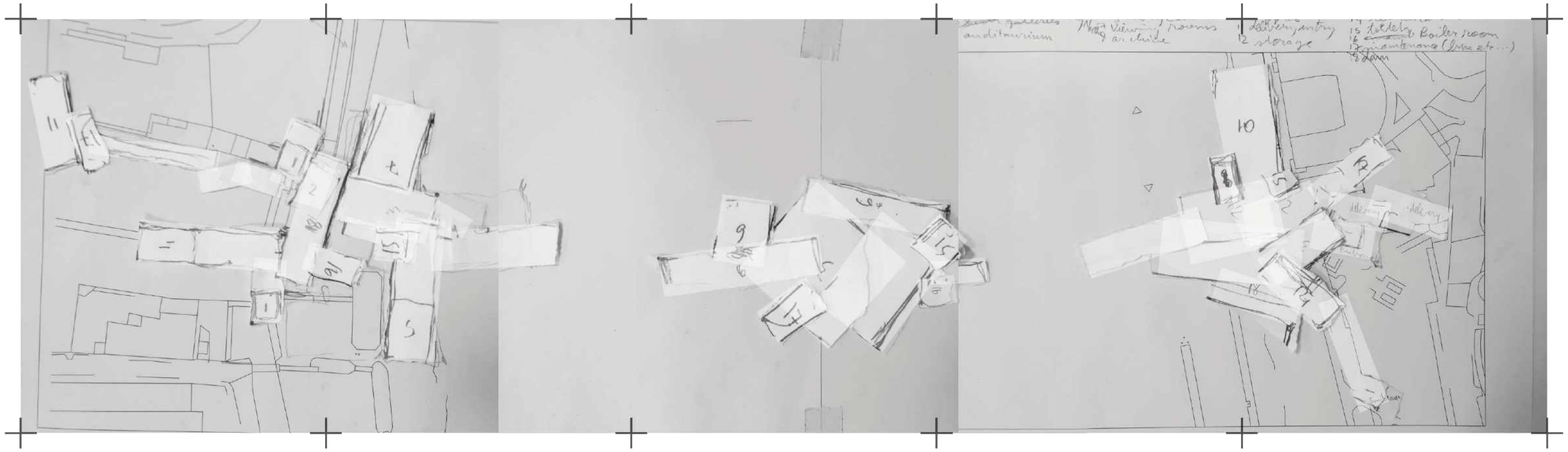

Sotheby's
730
CHRISTIE'S

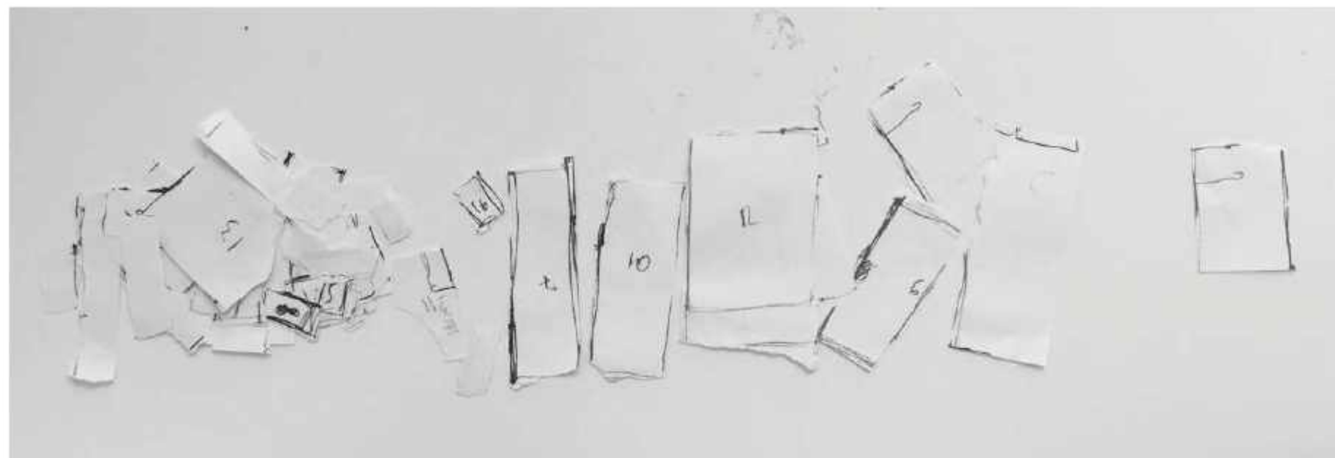
Massing

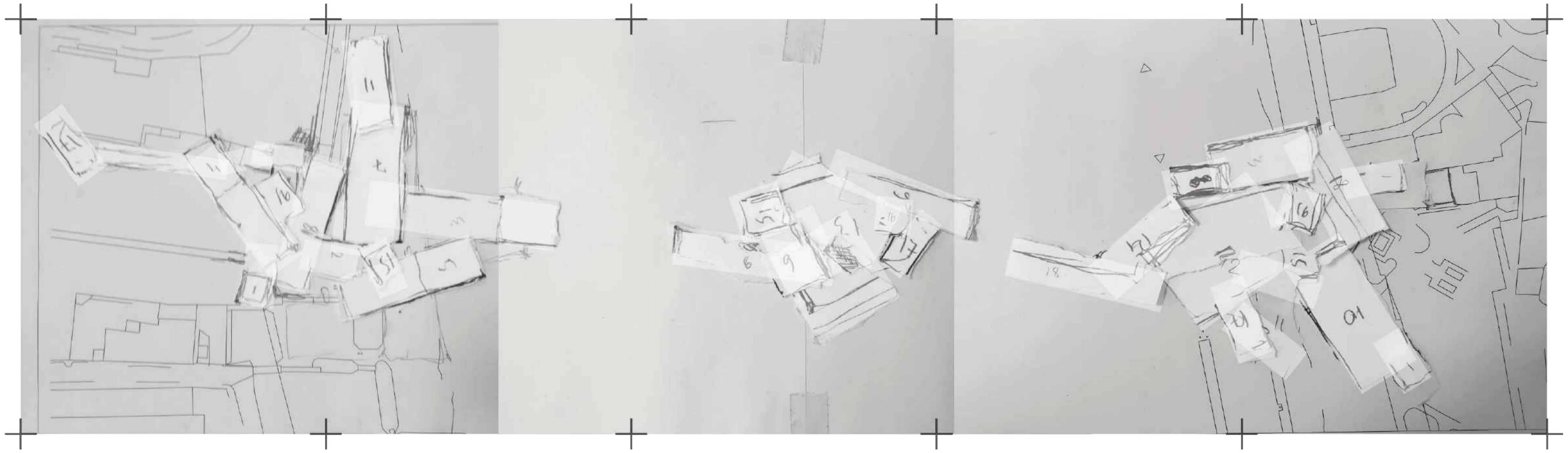


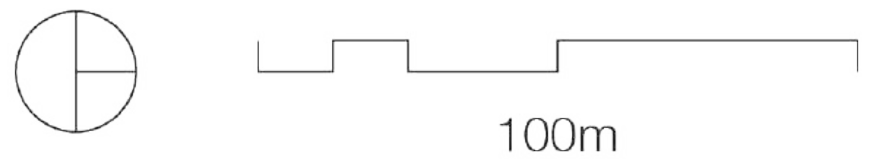




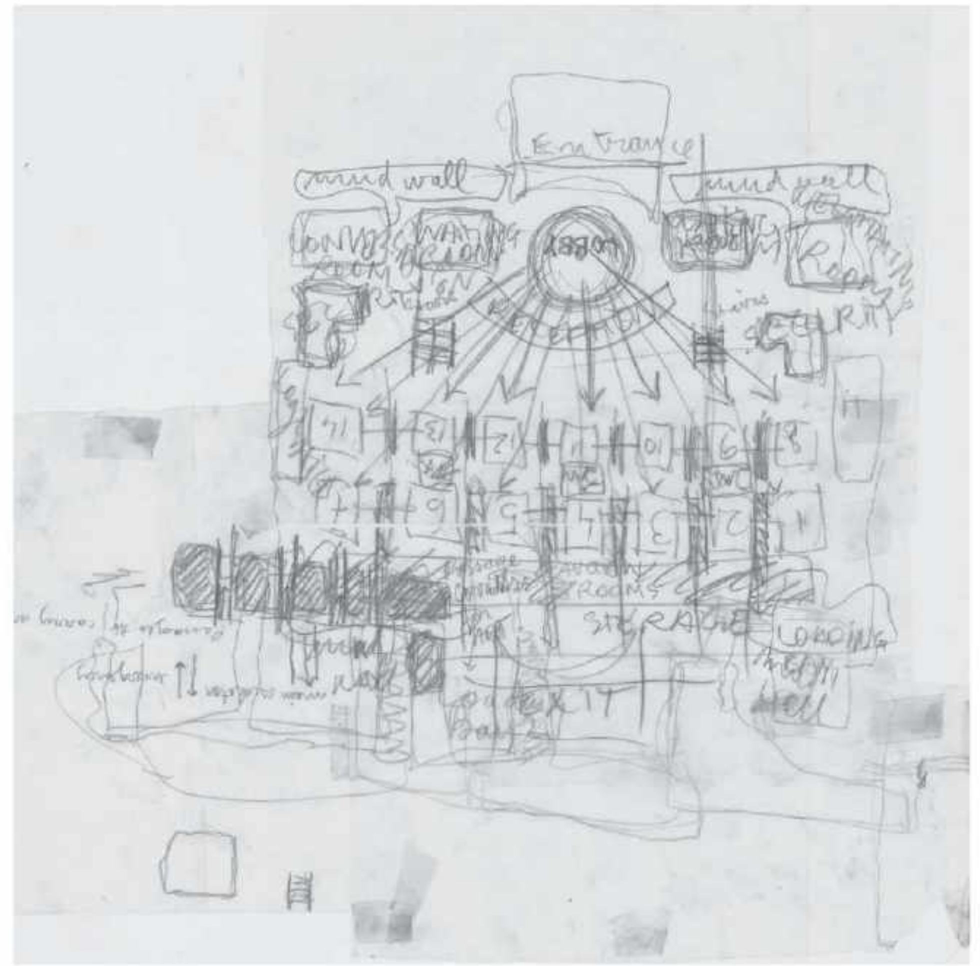


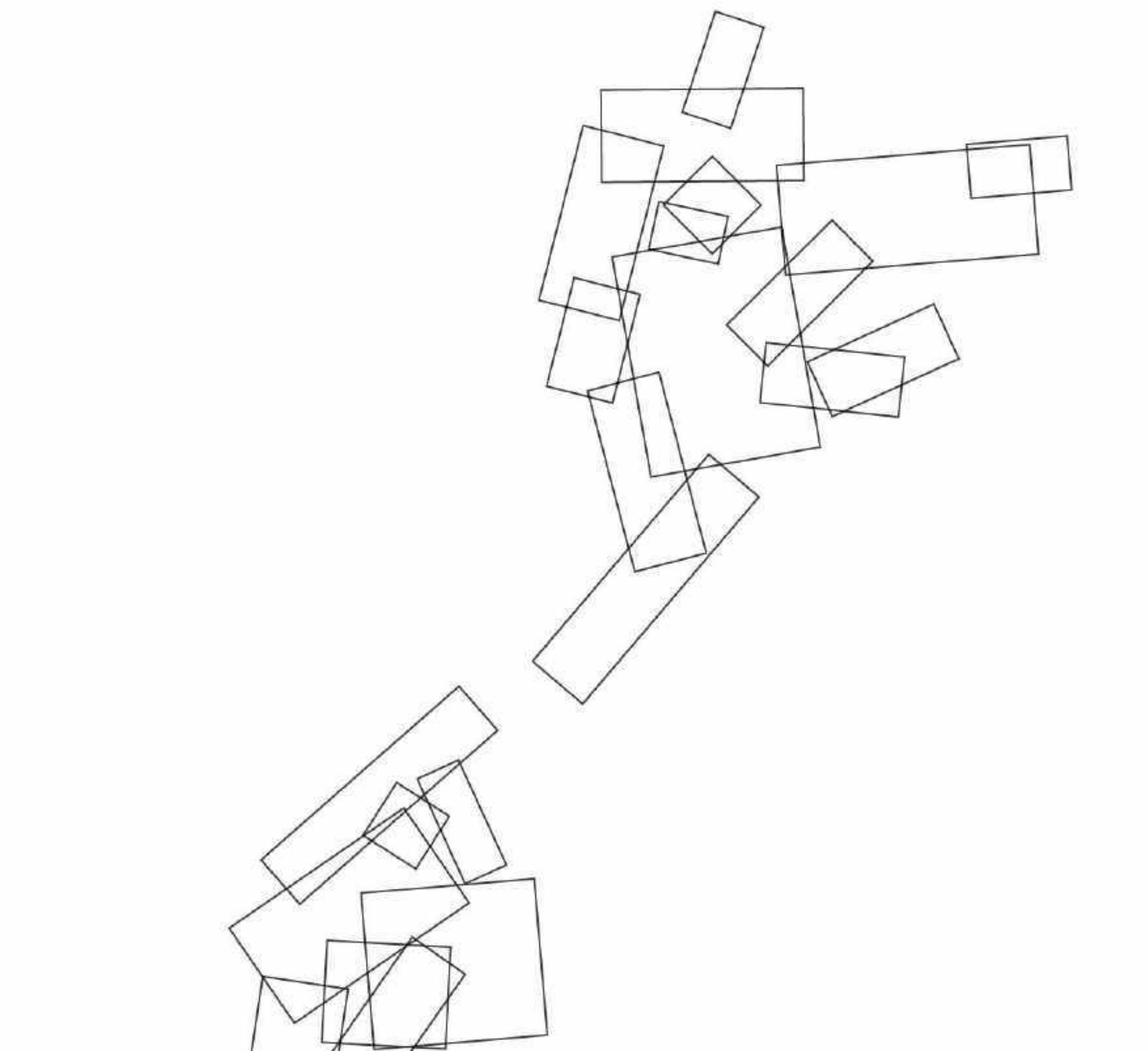


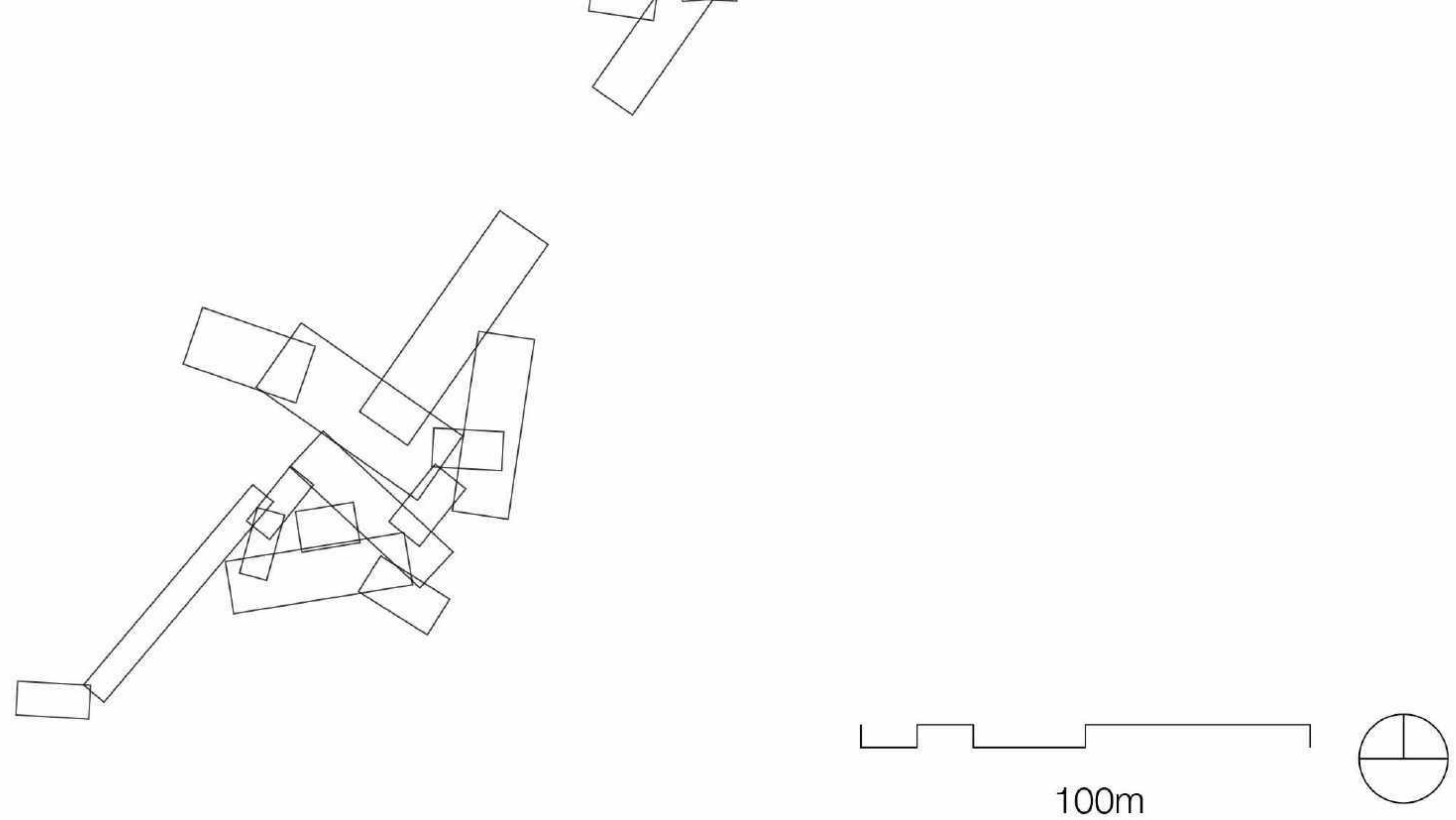




Adjacency diagram







1-entrance
2-bookshop
3-north galleries
4-auditorium
5-south galleries
6-central gallery
7-viewing rooms
8-archive
9-meeting room

10-offices
11-boat entry
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13-AUCTION ROOM
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15-toilets
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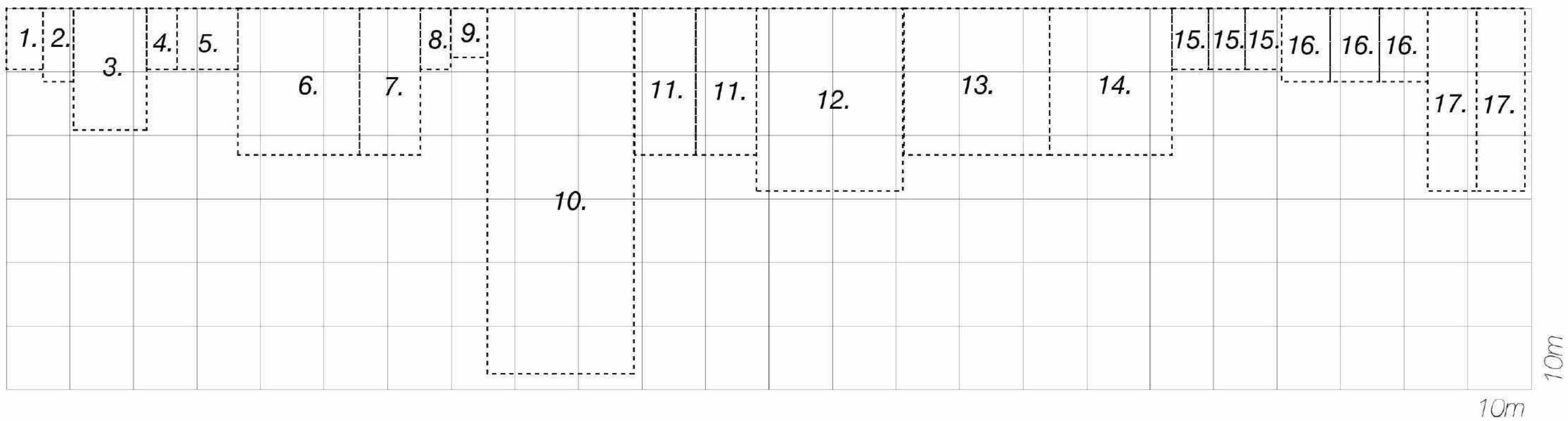
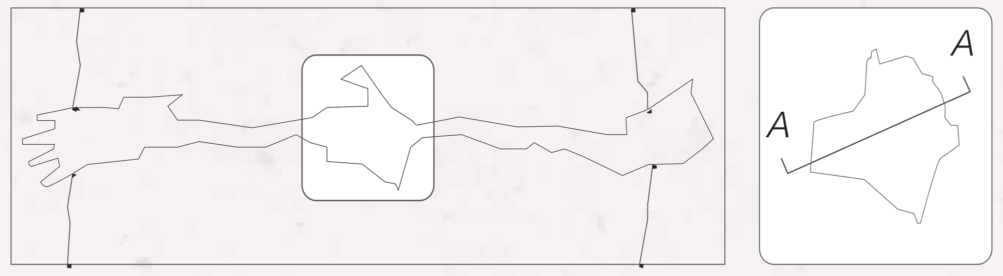
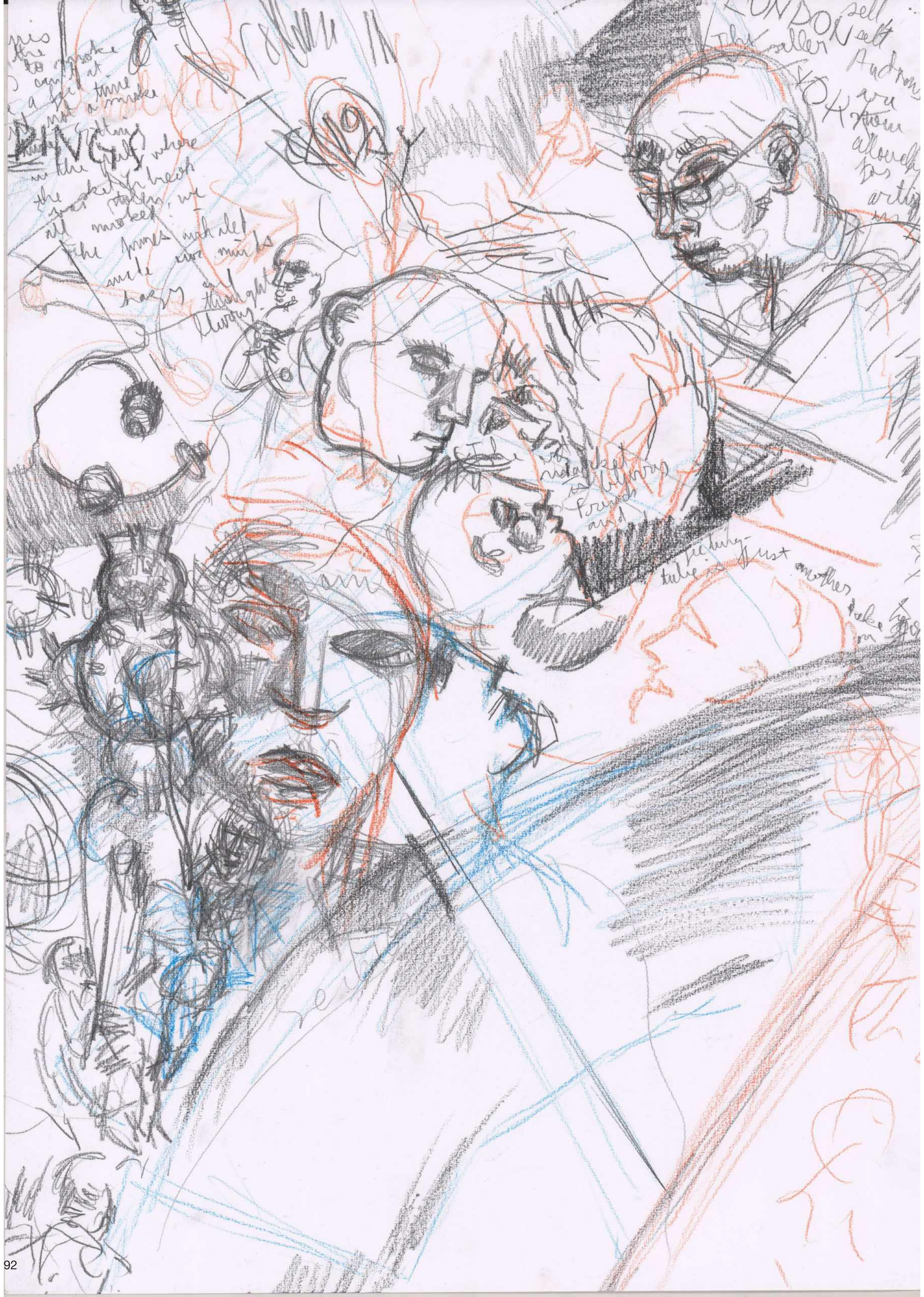
18-dam for hydropower



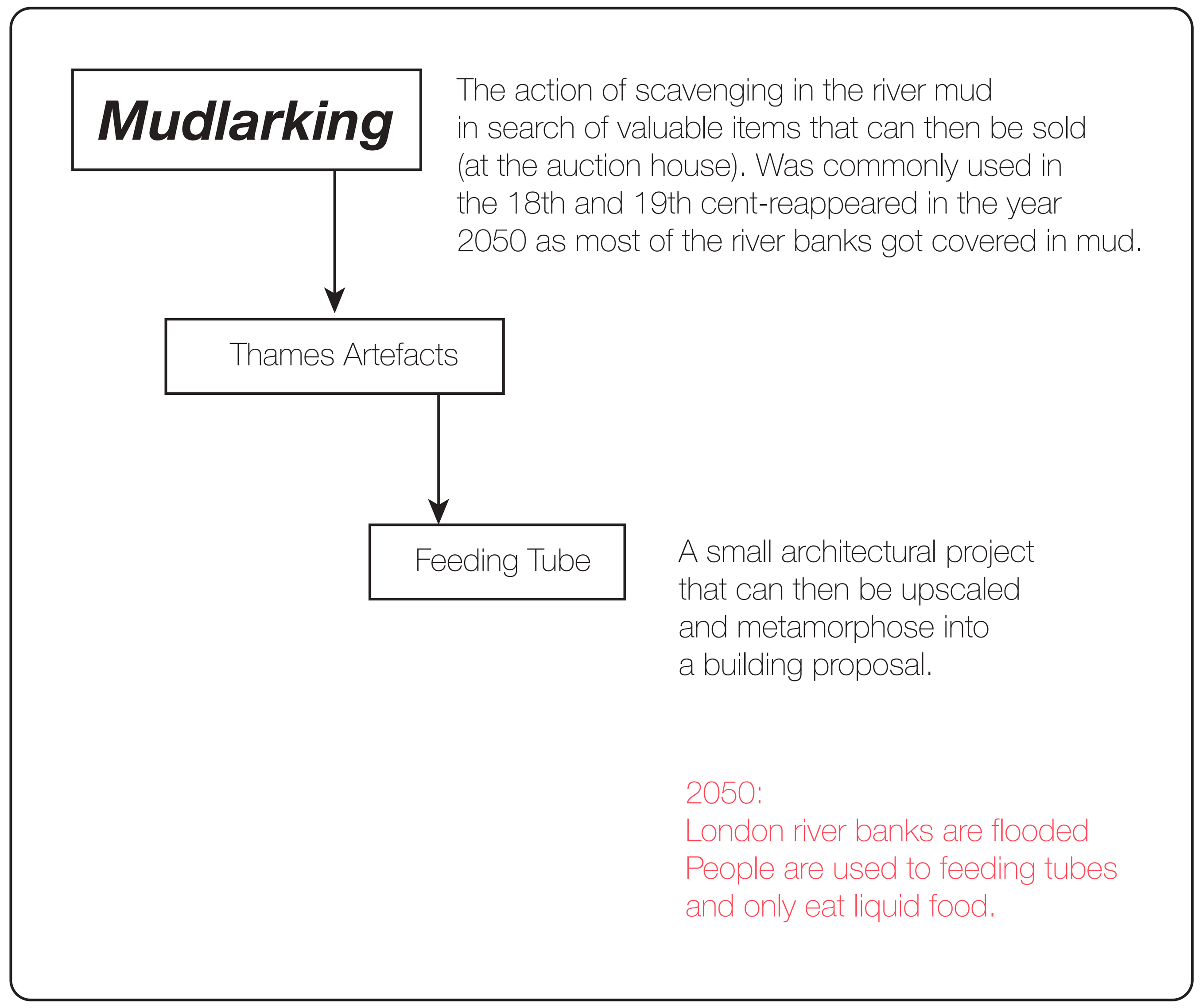

A
A

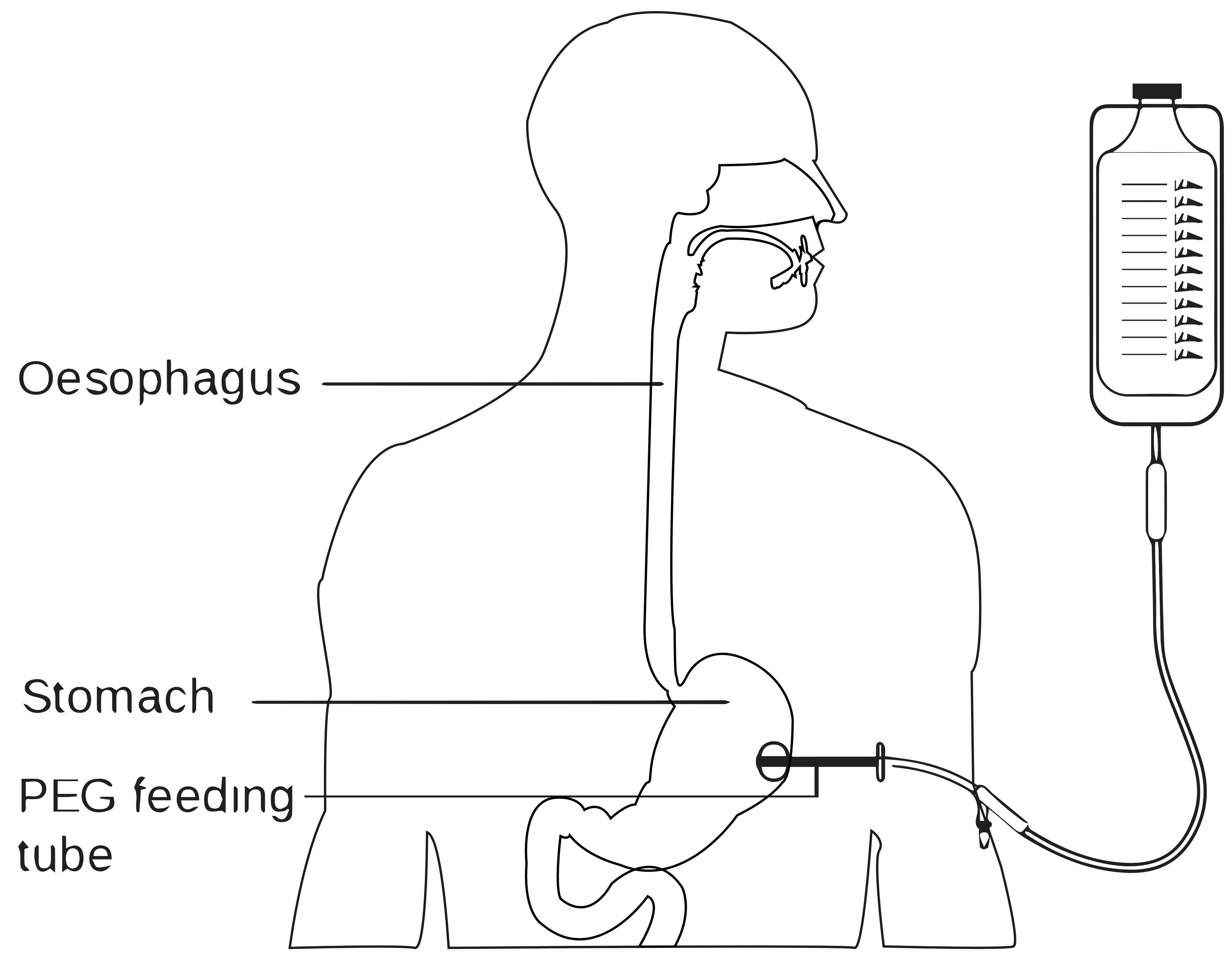

Artwork.
Buyers are shocked with the apparition from the water pulled by crane.
Auctioneer is ready to auction.
Artists are well aware of the element of surprise, and enjoy having their artworks displayed in a spectaculous manner-it becomes a performance like the banksy self destructive artwork- when does an artwork becomes valuable?
Art is carried in a submarine to have the sales done in a very fast and efficient way.
1:50 on A1
4m



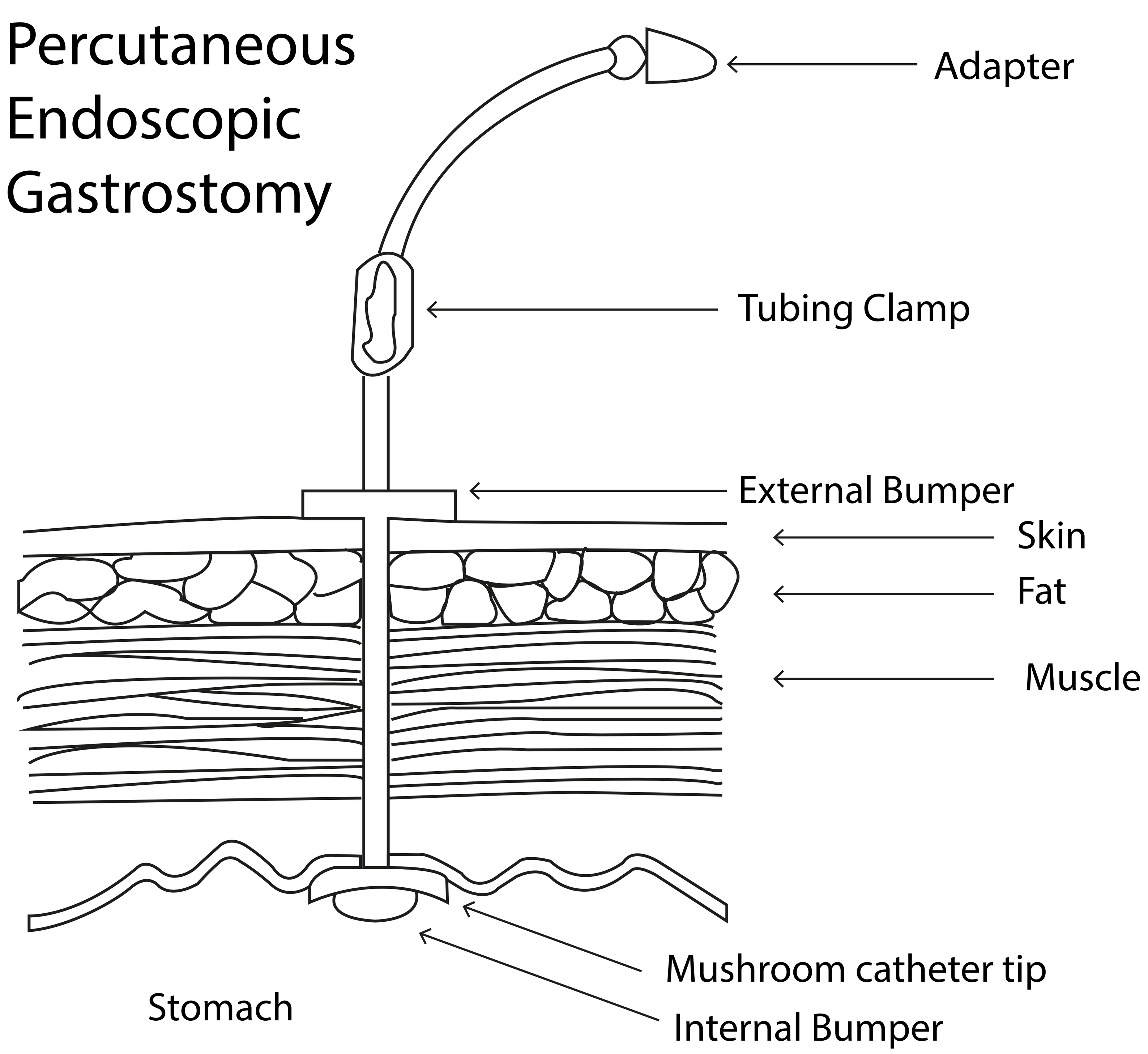
Section 5. Obsessive Exploration: PEG Research

I cannot stress enough how important it was for me to research materials to be used for the auction house. Its aesthetics, the way it can be built, its reliability, how much it can endure, the dangers of its contact with water – if any – all of these I was thinking about and had to use other means than brainstorm moodboards drawings from my imagination. Mud, where does it start and where does it end served as an initial jumping point that was investigated on the shores of the thames with Mudlarking. Still, I felt that it was important that this project was multi-disciplinary. I feel that in researching other things that may not have as strong a connection as other sections, in the end it adds on to the auction house. I looked at feeding tubes in particular as well as ancient jewellery and the aim was partially to see how we could make feeding tubes into something that becomes the body, is permanent yet change with time. Percutaneous Endoscopic Gastrostomy – abbreviated as PEG – which was an admixture of art, scientific, and the relationship between human and robot was the starting design point for the direction of the academic year.


Mudlarking
The action of scavenging in the river mud in search of valuable items that can then be sold (at the auction house). Was commonly used in the 18th and 19th cent-reappeared in the year 2050 as most of the river banks got covered in mud.
Thames Artefacts
Feeding Tube
A small architectural project that can then be upscaled and metamorphose into a building proposal.
2050:
London river banks are flooded
People are used to feeding tubes
and only eat liquid food.



The PEG tube bypasses the oesophagus by inserting directly into the stomach.



The PEG tube needs to have both external and internal bumpers to secure the tube in place.

Indications

PEG feeding tubes are recommended for patients who have difficulty swallowing. This could be as a result of:
head and neck cancer
neurological disorders
stroke

It is also sometimes used for those who are severely malnourished.

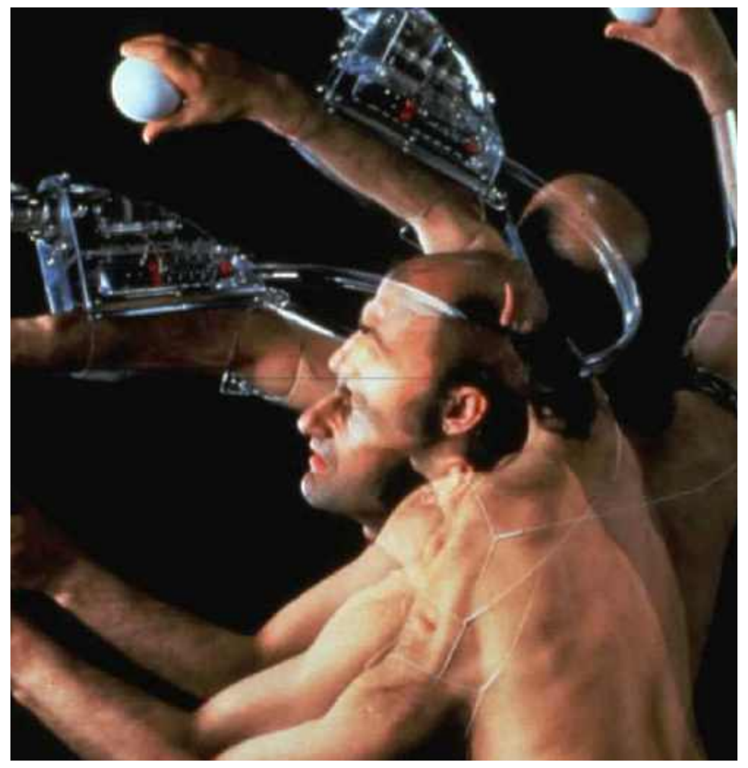
Procedure

A surgeon or gastroenterologist inserts a endoscope through the mouth down to the stomach. The surgeon than makes a small incision in the abdominal wall at the appropriate location, and threads a guidewire through the endoscope and out of the incision. The endoscope is carefully removed, and then the internal portion of the PEG tube is threaded over the guidewire. The guidewire is removed and the PEG tube is externally fixed.

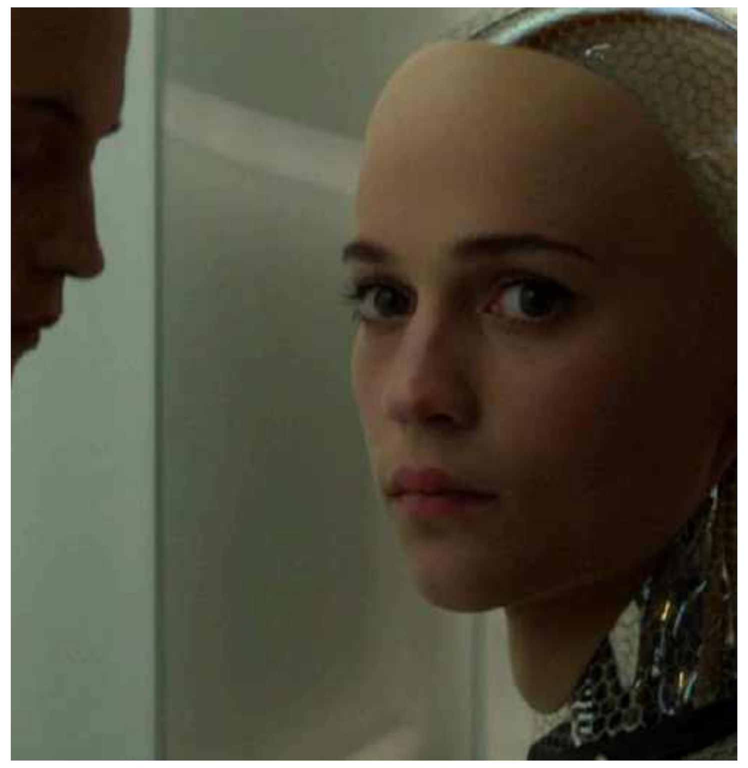
Benefits

As compared with other types of feeding tubes, the PEG feeding tube is more comfortable for the patient, reduces the risk of aspriation pneumonia, and allows for greater mobility. Though the tube must be replaced every year, it can be a long-term solution for those who cannot feed orally.

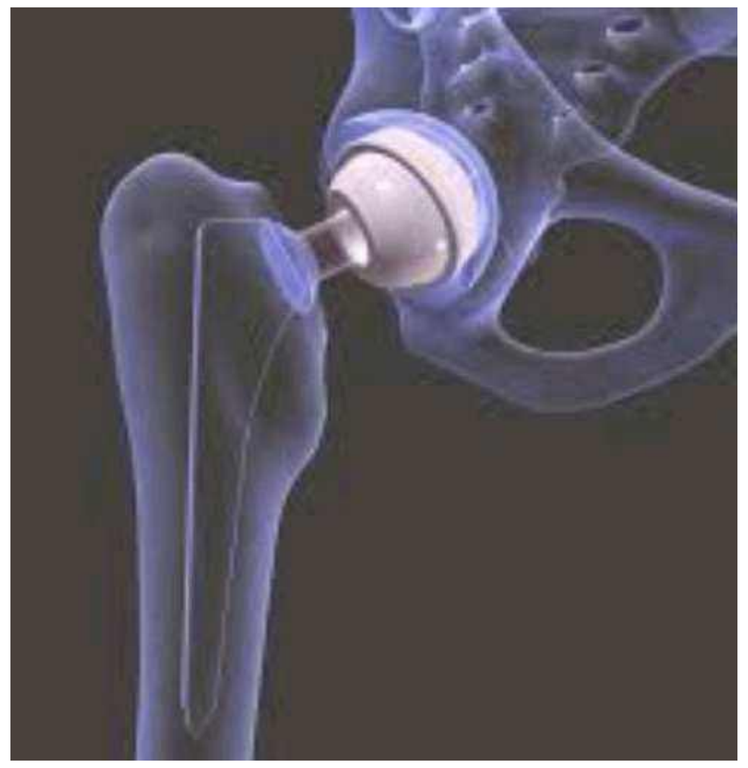
Pre columbian gold jewlery



Sterlac body and machine



Ex-Machina



Joint ceramics transplant

Bio ceramics

Roman bronze amulet

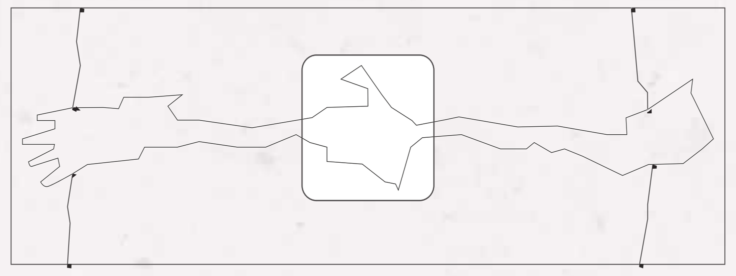
Mudlarking: Thames Artefacts

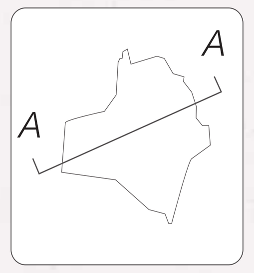
1-clay pipe

2-ceramic broken pieces

3-glass medicine bottle

4-Steel coin

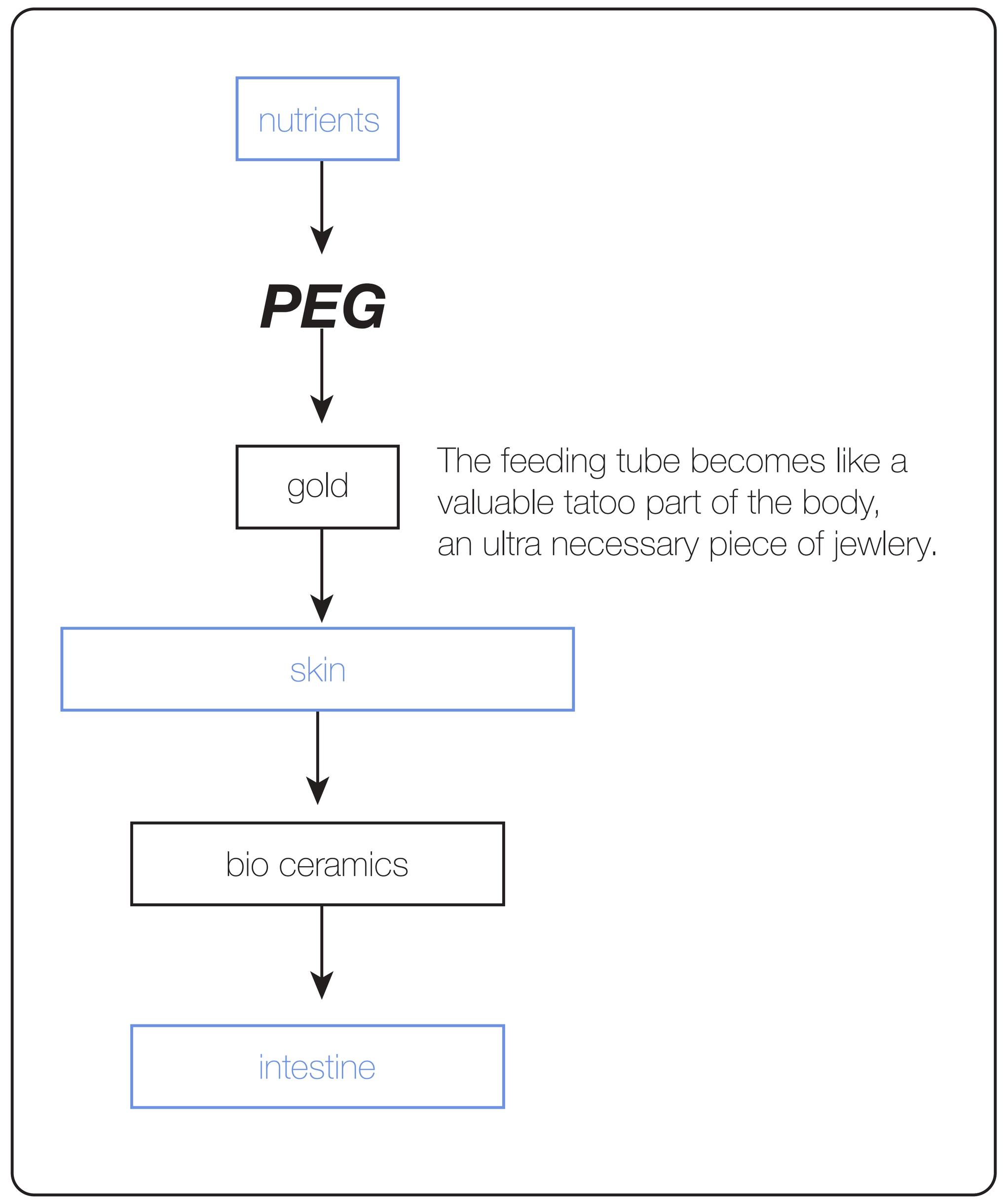


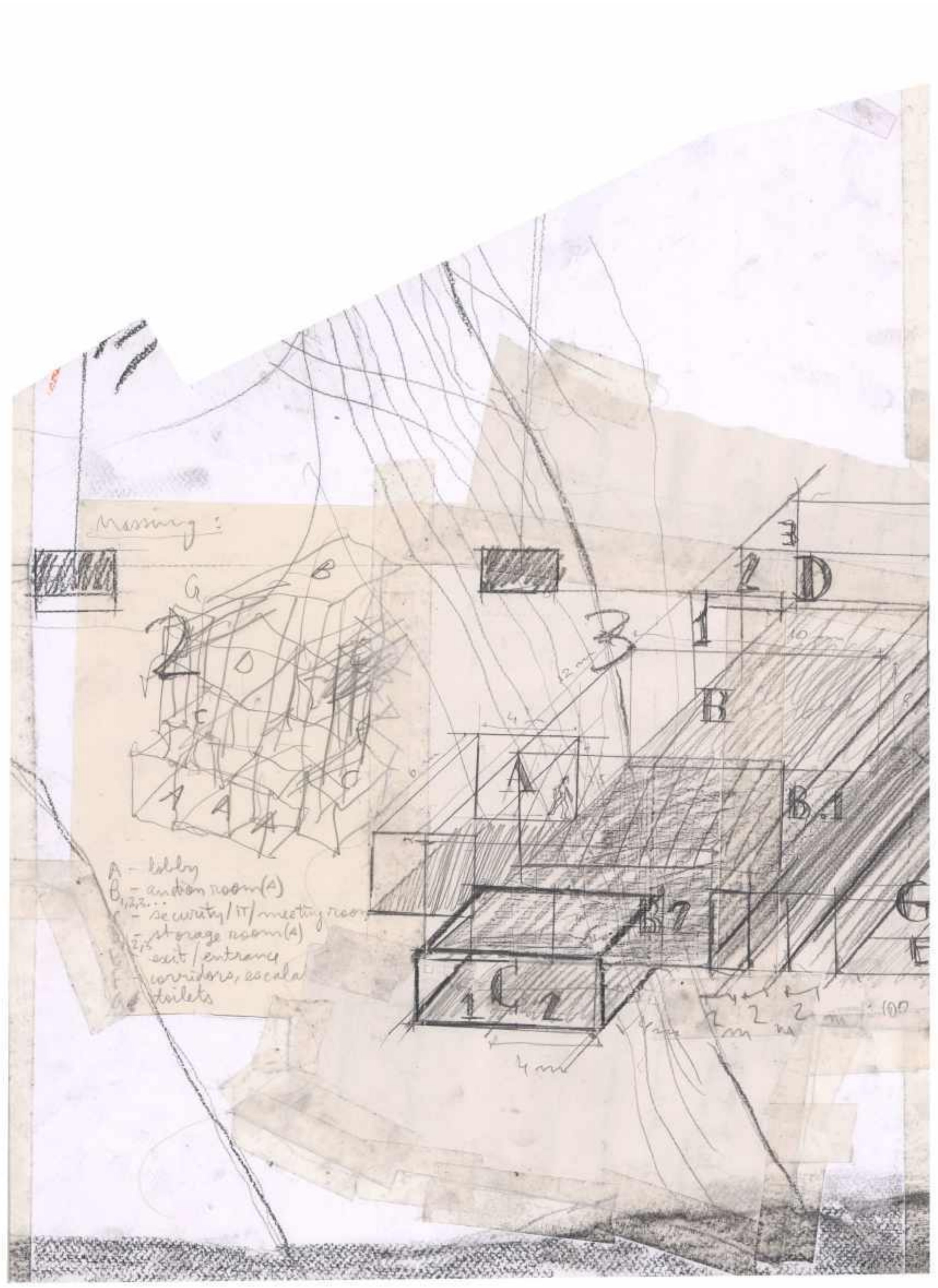


Art curator found a ceramics PEG in the Thames, mudlarking. It's year 2050, humans are only fed by tubes with protein powder containing all nutrients necessary. The ceramics PEG is a relic of the old age, before the Thames Barier broke. The curator examines it.

Section 6. Experiment and Concept Design: PEG

I had a lot of experiments with the design of PEG, and kept looking for different ways to make the design both practical and aesthetical. The goal remained the same, how to transform a medical device such as PEG into something beautiful and desirable. A design created to be solely practical can make us forget that sometimes humans desire a comforting touch that can be best bought by looking at the beautiful. In a world that is increasingly becoming more technological, it is vital that we do not lose ourselves and that we are able to retain our identities. Inspired by my upbringing within the Steiner education which aimed at students developing a creative self through a variety of disciplinary subjects – such as gardening, dancing, singing, drawing and wood-sculpting – I have remained attached to the idea that we should have beautiful designs. Beauty appeases worries, and in transforming a medical device into something that fosters reassurance, and not fear, it can help appease a patient's fear.


nutrients
PEG
gold
The feeding tube becomes like a valuable tatoo part of the body, an ultra necessary piece of jewlery.
skin
bio ceramics
intestine

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foundation in wa

PEG Design

ABDOMINAL AREA V2 with FEEDING TUBE

PEG Analysis and Redesign

STANDARD PEG VERSION

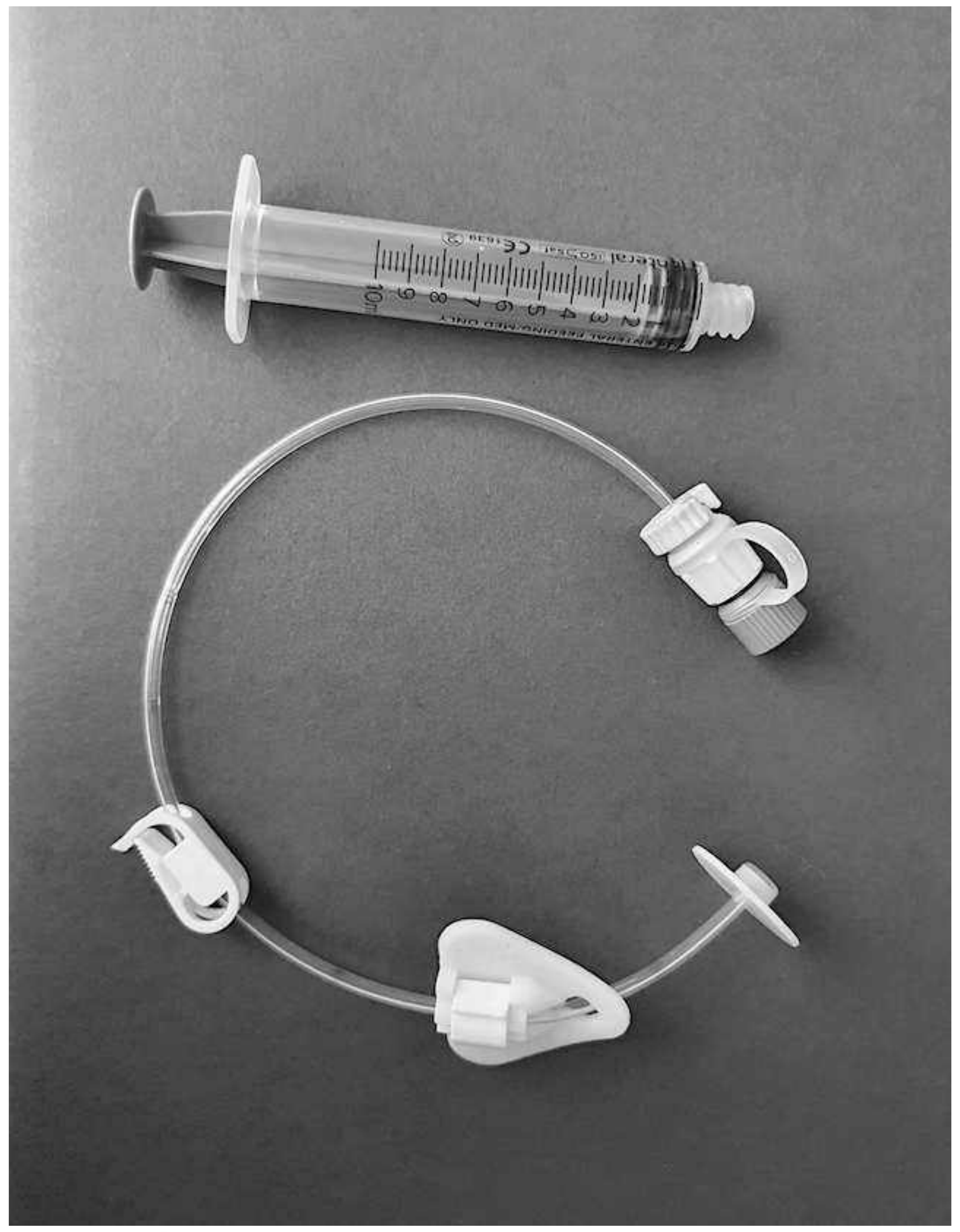
Material Sustainability

Standard PEG tubes are produced using a mix of medical-grade polyurethane (PU) and silicone. The extraction and the processing of petroleum used to manufacture PU is both carbon-intensive and can lead to habitat destruction. Similiarly, silicon needs to be extracted from sand deposits and processed into silicone via energy-intensive chemical reactions. These environmental effects are compounded by the fact that PEG tubes have to be replaced every 6-12 months. It is difficult to recycle medical-grade PU and silicone because of contamination risks.

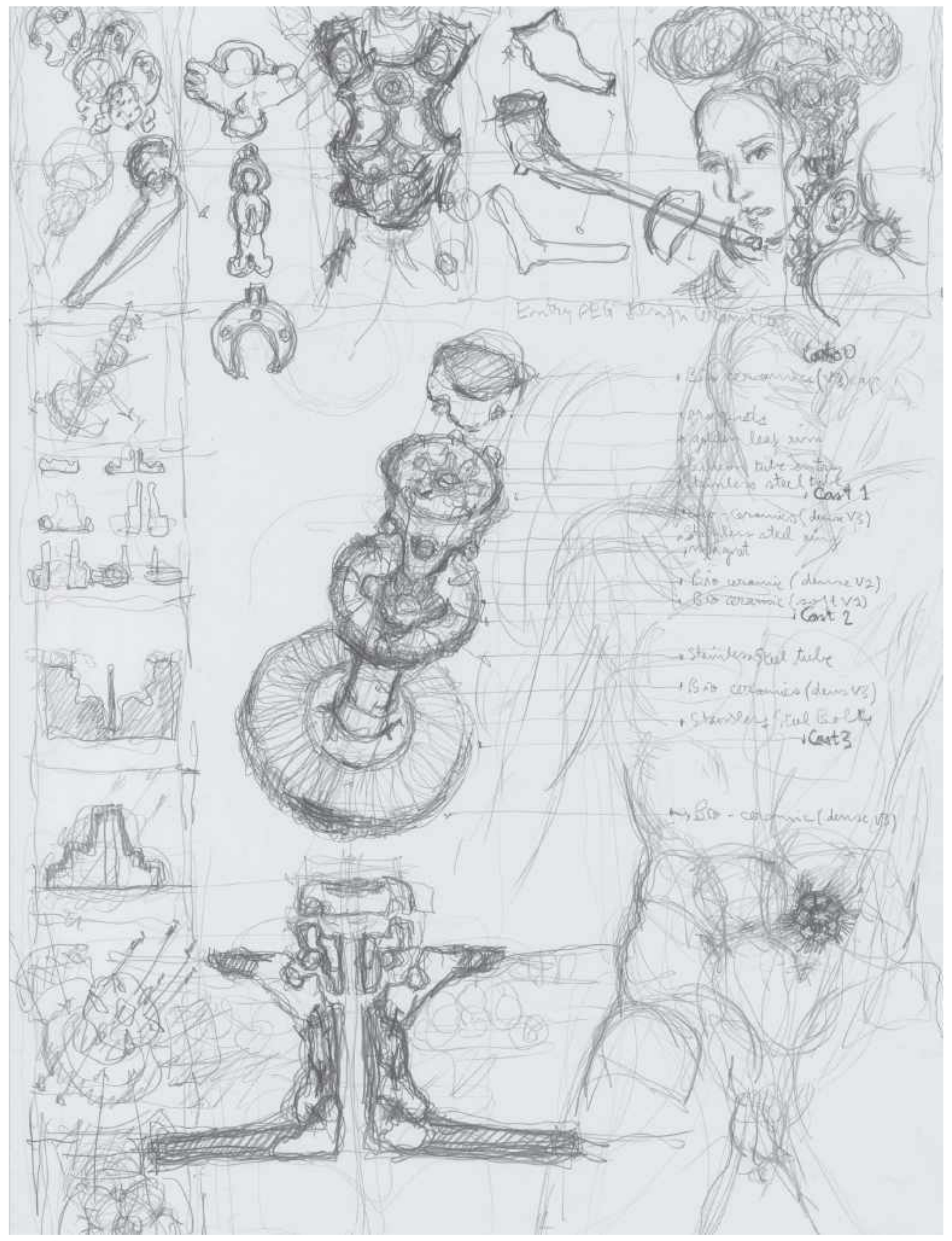
Aesthetics

"The truth is a feeding tube makes you self-conscious when you go out."
- Tayarra Smith, via feedingtubeaware.com.au

Many who wear feeding tubes face psychological distress from external judgement. Unfortunately, tube feeding in public continues to be viewed with emotions ranging from curiosity to disgust by observers.



Previous PEG design, using polyurethane and silicone.



PEG redesign, using ceramics

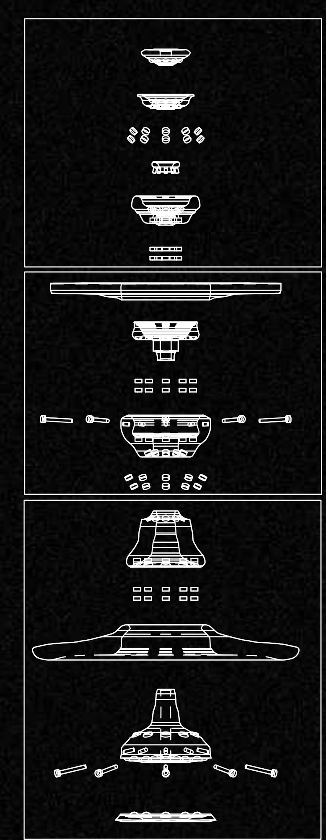
SUSTAINABLE PEG VERSION

Material Sustainability

Bio-ceramics were selected as a sustainable alternative to the use of petroleum-based products like polyurethane. Materials used in the PEG tube must be bio-compatible and easily sterilizable. Fortunately, bio-ceramics are stable in tissue and pose a low risk of infection. They are already widely used in dentistry, tissue engineering, and drug delivery. Some forms of bio-ceramics, such as alumina and zirconia are non-resorbable and can remain in the body for years. At the end of their life-time, bio-ceramics can be ground, milled, and processed for use as a powder in industrial applications.

Aesthetics

Bio-ceramics can be aesthetically customized to the preference of the patient. For example, the external fixations of the PEG tube can be matched to skin tone -- or alternatively created with specific color to provide joy to the patient. These additions could reinvent the feeding tube as a natural extension of the body, and provide patients with agency that help them to gain confidence with their feeding tube.



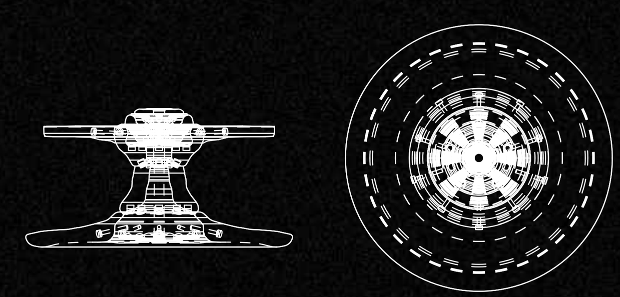
1-silicon replacable entry point

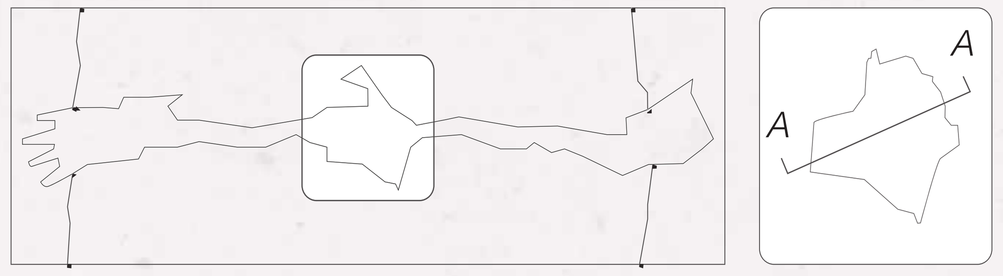
2-hardened bio ceramics

3-stainless steel joints

4-gold (antioxidant)

5-bio ceramics



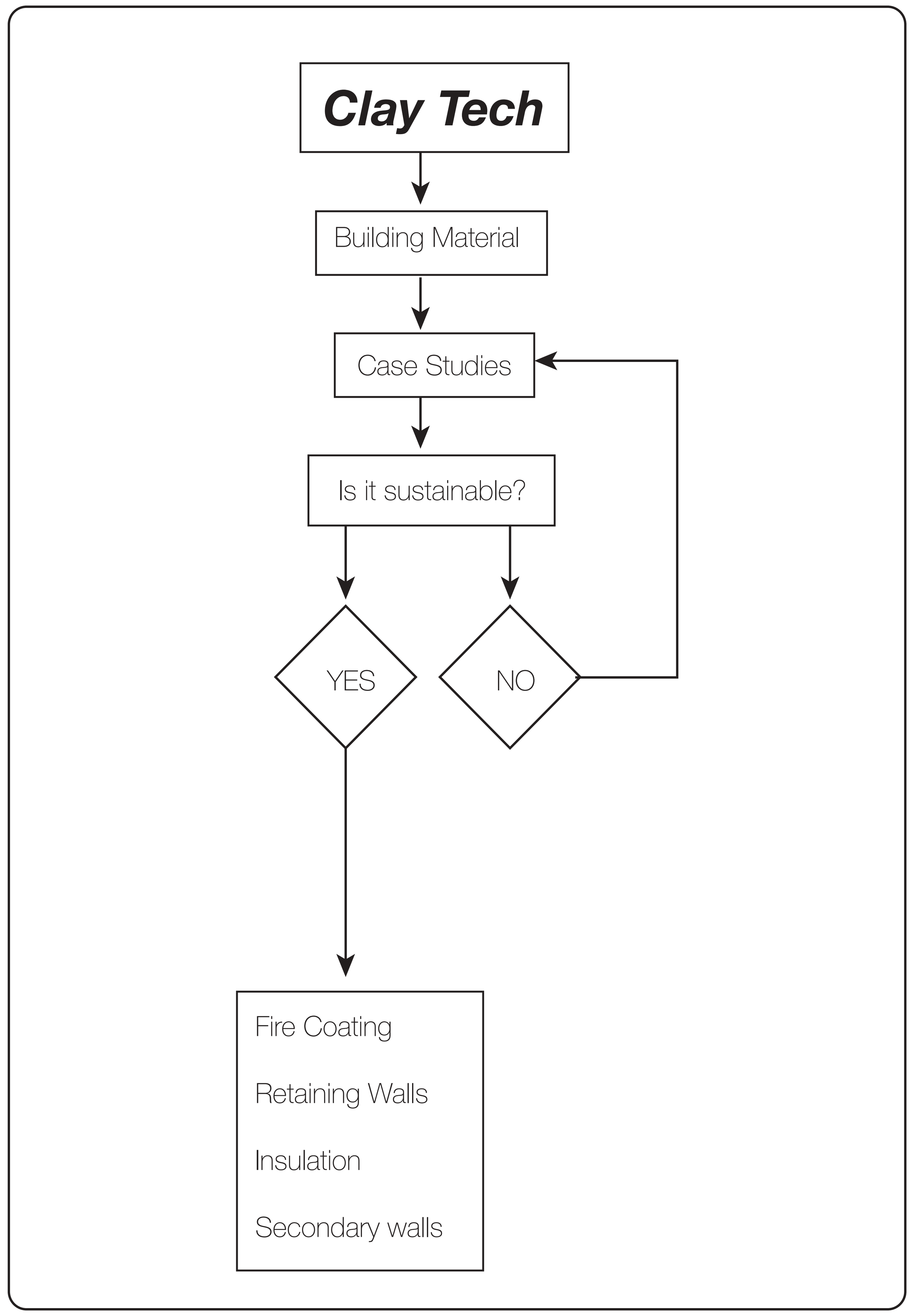



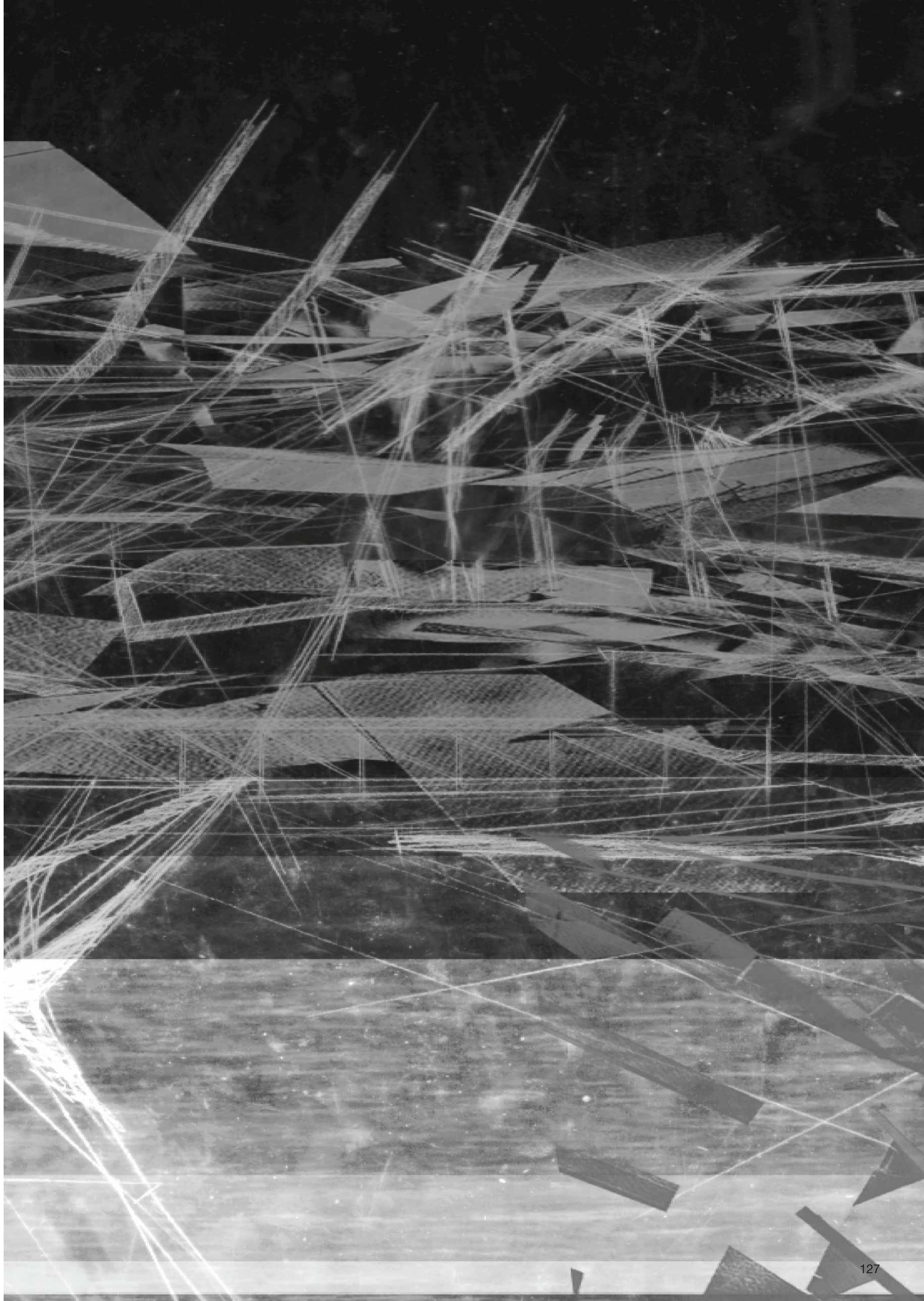
The curator gives the PEG to the business man and artist, and he is now trying to see if the PEG can be sold at the next auction

1:50 on A1 *4m*

Section 7. Technical Investigation: Clay Tech

Naturally, when I wanted the building to use a significant amount of clay to build the auction house, the effusive term ‘clay’ does not suffice. One must be specific, which is what I have strived to do in section 7, carrying out a technical investigation on clay. I researched on the different types of clay that could be used in pottery, construction and real-life instances where clay was applied as a material used for the creation of an architectural building. The university trip to Venice inspired me in this process as I photographed walls that used clay as a sacrificial layer, something that caught my eye.
Again, I have been quite fascinated by how we can use traditional materials, such as clay, to create modern constructions, re-adapting traditional architecture and learning from its techniques to create an innovative, new design. Clay as a building material has the capacity to be practical, beautiful and sustainable, something I think is very important for the success of an architectural building.


Clay Tech
Building Material
Case Studies
Is it sustainable?
YES
NO
Fire Coating
Retaining Walls
Insulation
Secondary walls



Clay as a Building Material

Pottery

The process to form pottery clay from natural clay is relatively consistent: the clay is harvested, screened to remove impurities, mixed with water to form a slurry or slip, and kneaded to evenly distribute clay particles. Once the mix settles, impurities are removed from the bottom and the water drains. The clay is then wedged to remove air bubbles.

Earthenware

From sedimentary rock and fired at low termperatures. Easy to work with and cheap, but porous, less durable, and not suitable for food.

Porcelain

Mined from kaolin deposits and fired at high temperatures. Very pure and water-resistant, but expensive and low workability.

Stoneware

Mined from weathered granite (which has fewer impurities) and fired at high temperatures. Durable and water-resistant, but less workability.

Terracotta

Contains iron-oxide which leads to the characteristic reddish-orange color. Grog (ground-up fired clay) is mixed in to provide workability. Inexpensive and low-firing, but fragle and porous.

Clay Powder

To form clay powder, natural clay is mined, cleaned, ground, and sieved to achieve constant particle size. This powder is then packaged for use in a variety of industries, including ceramics, construction and cosmetics. It often functions as a binder or absorbent. Some common clay powders are kaolin clay, bentonite clay, red clay, and stoneware clay.

Glazes

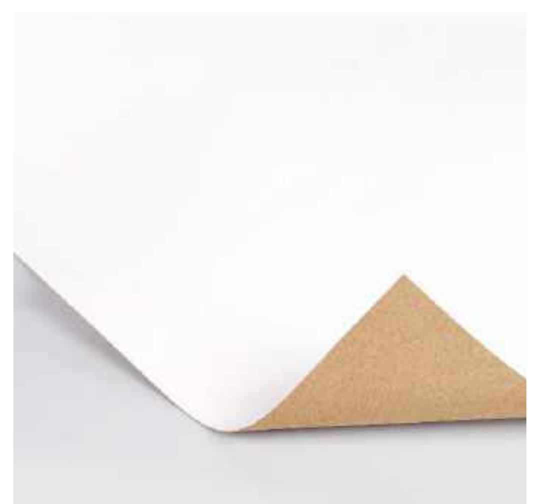
A clay powder is combined in a slurry of fluxes and mixes in order to improve surface adhesion and add color to an ojbect.

Cosmetic Facial Masks

Clay powder is mixed withwater and other extracts to form a paste. The clay pozder helps to absorb and remove impurities and excess oil from the skin.

Cat Litter

Clay powder is treated with doedorizers and clumping agents. The powder helps to make the litter absorbent and easy to clean.

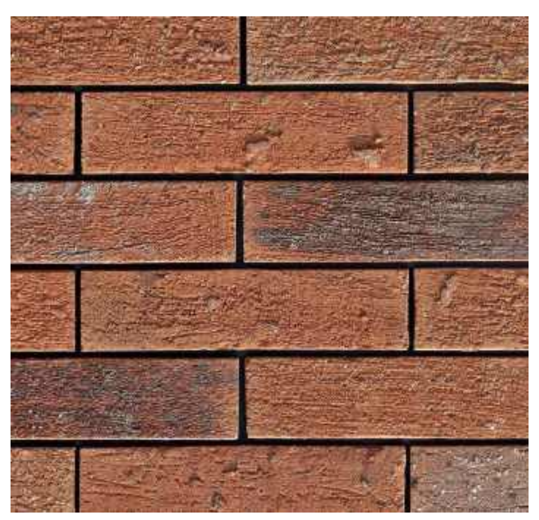


Paper

Clay powder is mixed with pigment and fillers, then applied to the surface of the paper to to create a smooth surface. This helps with printing quality and improves strength and durability.

Construction

Clay's durability, sustainability, and insulation properties have made it a natural construction material for millenial. For construction, clay is usually ground and mixed with other materials (sand, straw, etc.) to lower its density and provide additional structure.



Bricks

Clay is crushed into small pieces and mixed with water and sand for texture and consistency. This mixture is then extruded to mold it into its final form.

Tiles

Clay is usually mined from a quarry and then is ground into a fine powder. This powder is mixed with feldspar, silica, and talc to improve its strength and durability. Different molding techniaues produce complex shapes.

Clay Plaster

The plaster consists of a mixture of sand and water. Sometimes straw or other natural fiber is added to improve strength and texture. The plaster is applied in layers to interior walls and ceilings.

Cob Construction

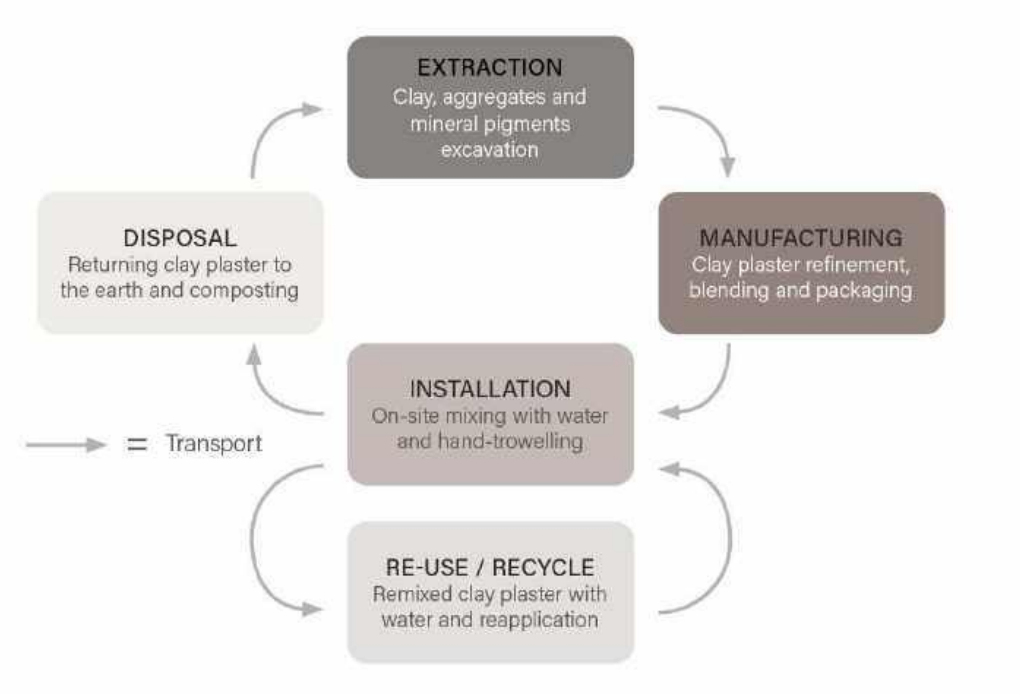
Traditional building material. 3-4 parts sand and 1 part natural clay is mixed by foot, and straw is added. The resulting mixture creates incredibly thick, durable walls.

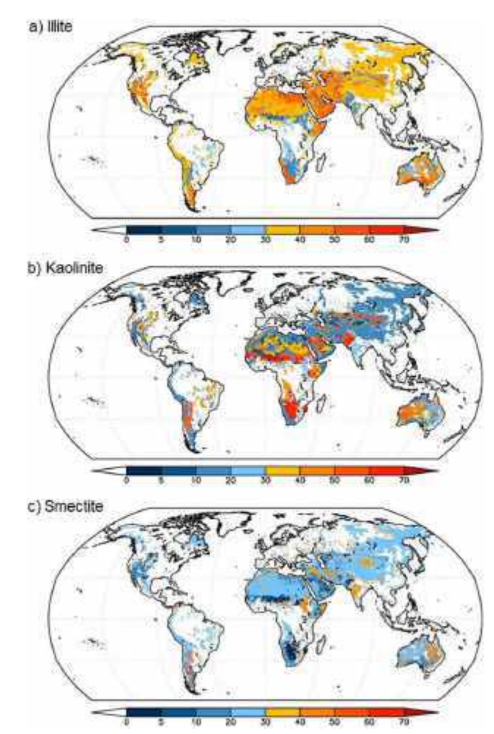
Clay Sustainability

Advantages

Clay is a highly abundant natural occurring mineral. It is non-toxic and non-polluting. Clay has a low thermal conductivity, making it a very energy efficient building material. It is incredibly durable and long-lasting, and can be easly recycled when needed.

Compared to many other materials, clay produces relatively low emissions. Clay bricks, for example; emit 0.5 kg CO2 per kg of material, lower than both steel (1.7 kg CO2) and cement (0.9 kg CO2).



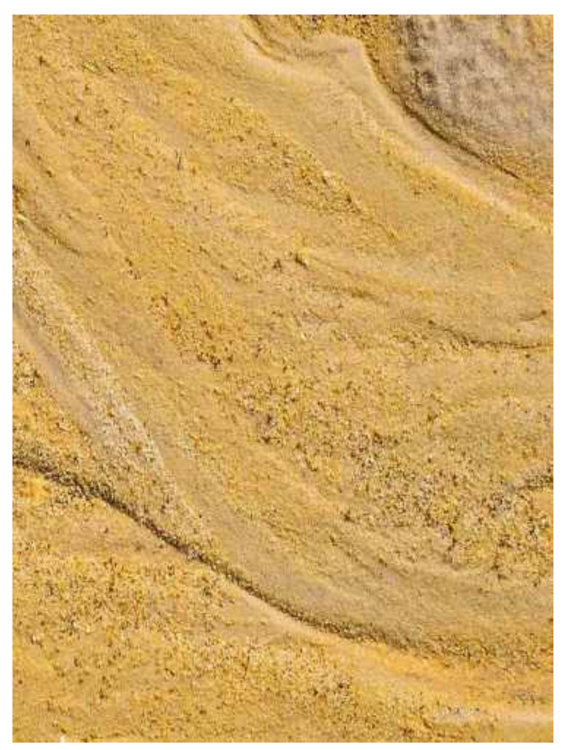


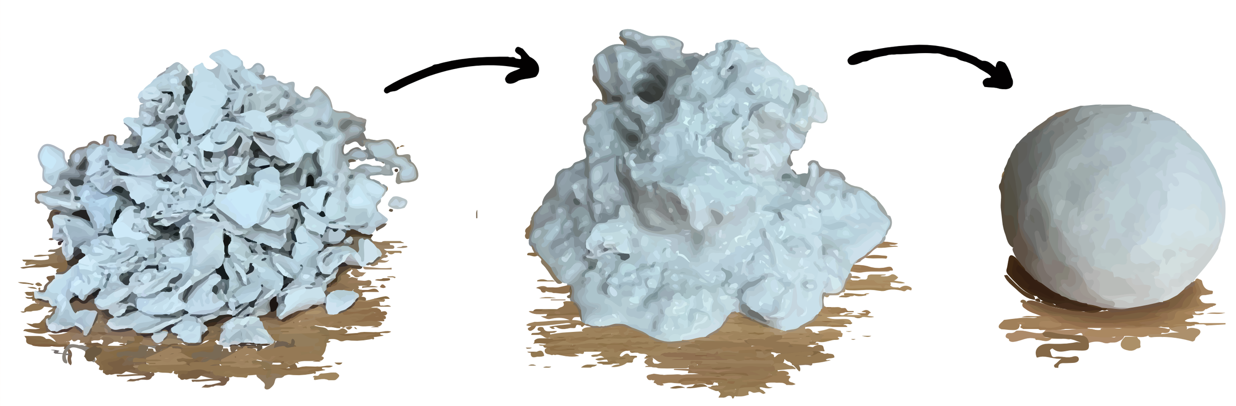
Disadvantages

Most of the environmental impacts of clay processing arise from mining emissions and firing emissions (covered in another section). Mining clay deposits leads to soil erosion and generates large amounts of waste. These tailings are the rocks, minerals, and other material extracted from the deposit but not needed for natural clay. These waste products are often toxic as a result of heavy metals, and can contaminate water and soil. Though mining clay consumes significantly less water and energy than other forms of mining, it still drains around 100-1000 gal/min of water.

Improvements

Several steps can be taken to reduce emissions from clay. During mining, better waste management practices can be employed to decrease the environmental destruction caused by tailings. Energy efficient mining eauipment (e.g. powered by renewables) can help to decrease energy use. To bypass mining emissions completely, it is important to reduce teh need for need clay as much as possible by reducing the density of clay and by recycling existing clay.





Summary

Overall, clay is a sustainable building material. Though clay mining can consume lots of water and energy and wreak environmental destruction, it is a durable, recyclable, and naturally-occurring material. Its emissions are significantly lozer than many other building materials. However, this doesn't mean that we shouldn't improve its environmental impact by increasing recycling and decreasing mining waste and energy use.

Case Studies in Clay

Casa Terracota

Clay, Sand, Straw, Bamboo

Located in Villa de Leyva, Colombia, this structure was the result of a collaboration between local artisans, architects, and builders to demonstrate sustainable, traditional building techniques. The 5400 square foot home is built exclusively with local clay, and formed over 15 years. Each layer was successively baked using the sun.



Arg-e Bam

Clay soil, palm tree trunks

Located in present-day Iran, this ancient citadel was constructed from 224-637 AD to support the trade of garments along the Silk Road. Underground water canals, watch towers, and thick walls protected a population of more than 12,000 people. About half of the citadel was destroyed in an earthquake in 2003, though most destruction ocurred in buildings that had been previously restored. This has been hailed as a testament to the durability and longevity of this adobe structure.



Toru Kurokawa

Silver-black ceramic

Kurokawa draws on the inspiration of mathematical formulae to create scultpures that seem to deny physics. He coil-builds hollow-core sculpture into shapes that balance "existence and non-existence." Many of his sculptures are inspried by organic forms, like coral. Korukawa`s ceramics demonstrate the ability to build and balance using clay by takign advantage of the laws of physics.



Natural Insulation

Clay, Straw

In this form of natural insulation, clay is used as both a binder and a preservative. 90-95% straw (or other form of stiff vegetal waste) is coated with a 5-10% clay slurry. As the clay dries, it binds together the straw while leaving air pockets that decrease teh thermal conductivity. The R-factor of this insulation can reach 3 per inch, and has been shown to zithstand decay over a period of 700 years.

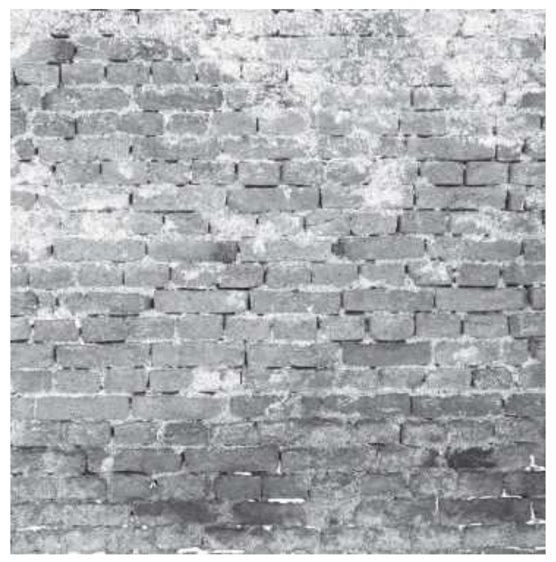


Sacrificial Layer (Venice)

Various (Clay plaster, clay, etc.)

In locations that suffer repeated water damage, a sacrificial layer of clay can be added to the exterior to prevent foundational damage. This layer is slowly eroded with time, leaving the structural integrity of the building underneath intact. The time it takes to erode can be controlled as a function of the thickness of the sacrificial layer.



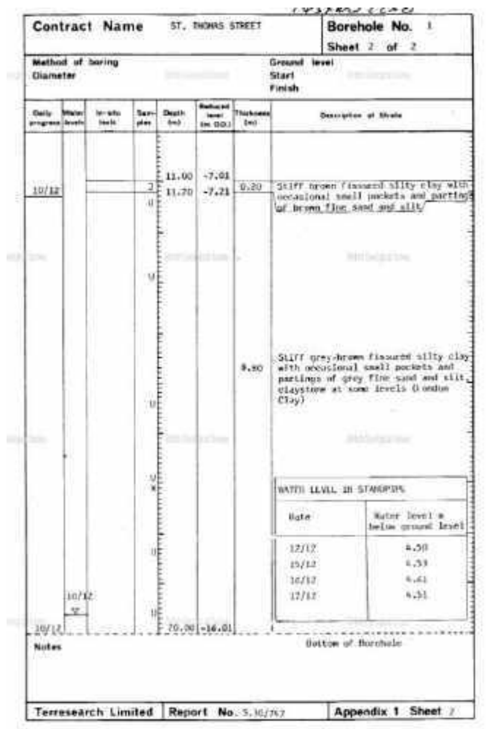
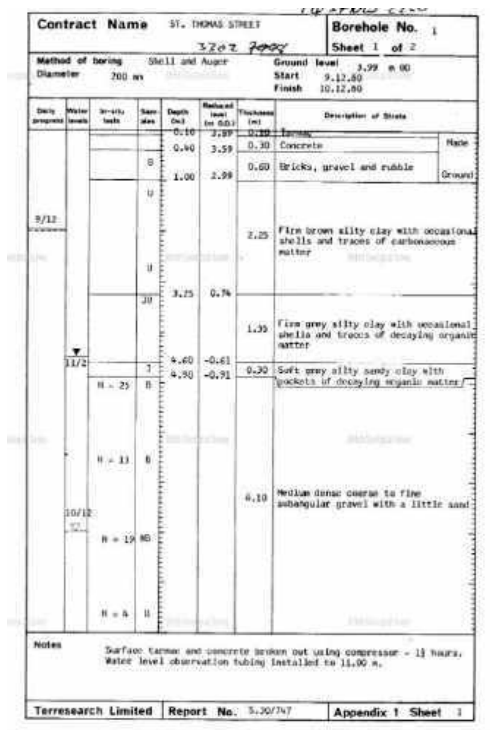


Research and Experiment Sequence

Extraction of Clay from Borehole on Site


Extraction from borehole


Borehole Site

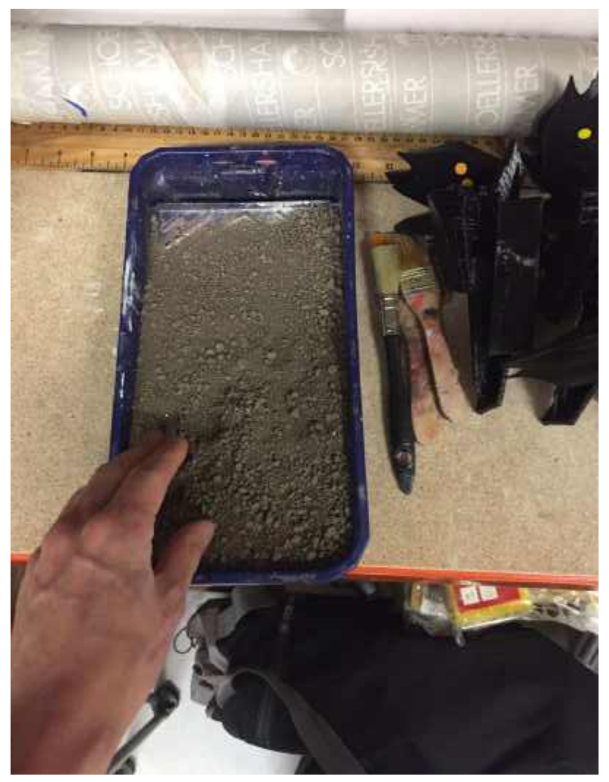


Site borehole data

Making of Clay


1. Letting it dry for a week


2. Grounding it down


3. Siving it.


4. Letting it dry FOR 48H


5. Pouring water in with a bit of sand (sand:clay = 1:4) for consistence, and stopping until texture feels right


6. Ball of clay

Tools

1-bucket

2-big siv

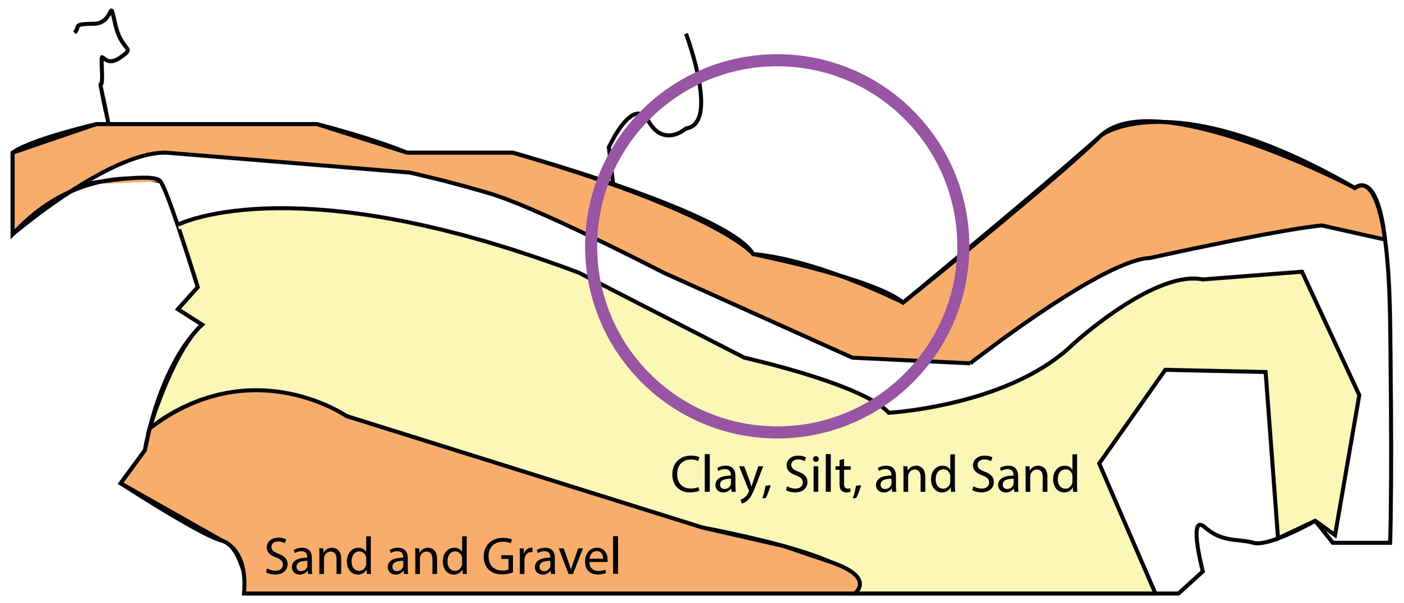
3-raw clay

4-steel hammer

5-rubber hammer

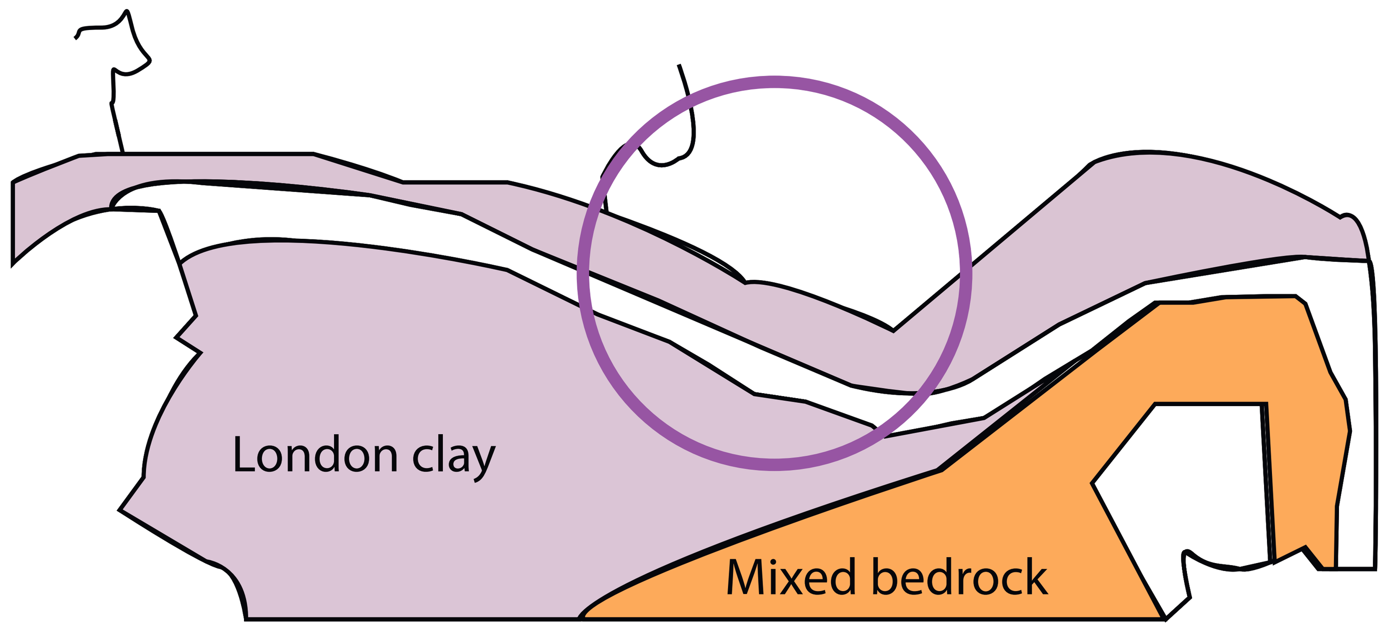
6-small siv

Specific Adaptations to Site Conditions



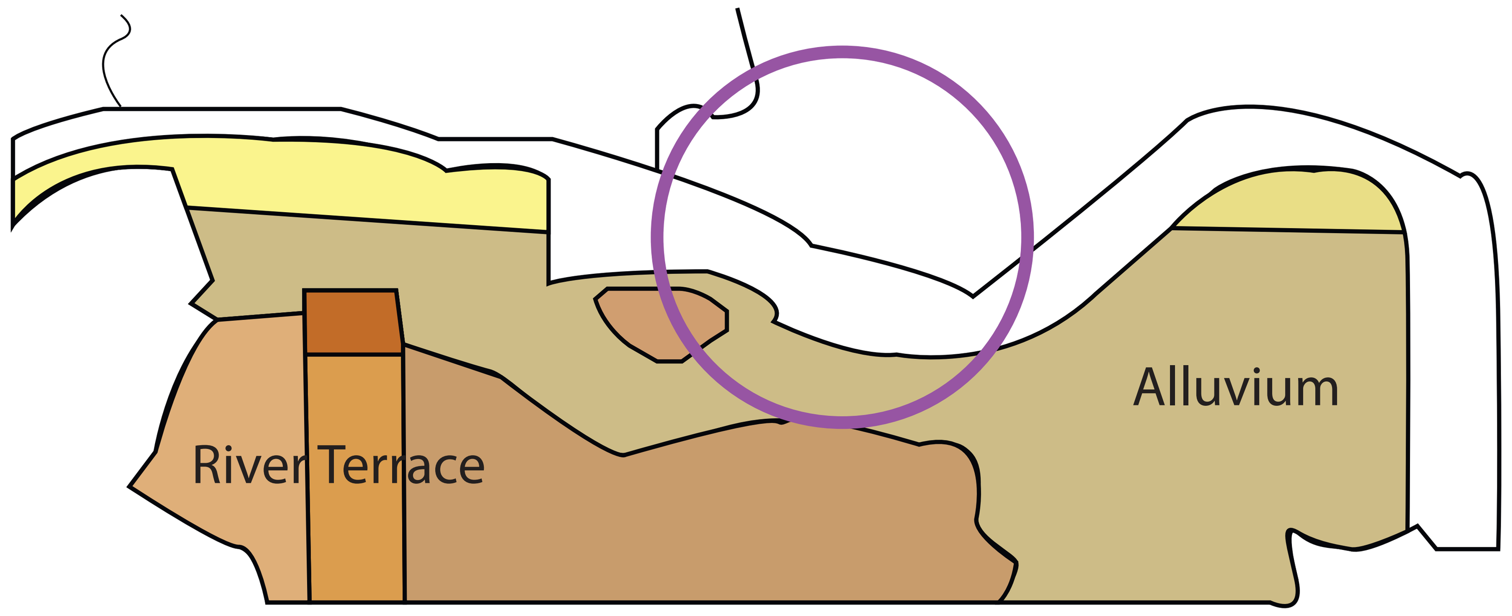
Sand and Gravel Composition

This map indicates the soil composition along the section of the River Thames that includes our site. The pink circle indicates the exact site. As demonstrated, our site consists primarily of clay, silt, sand, and gravel.



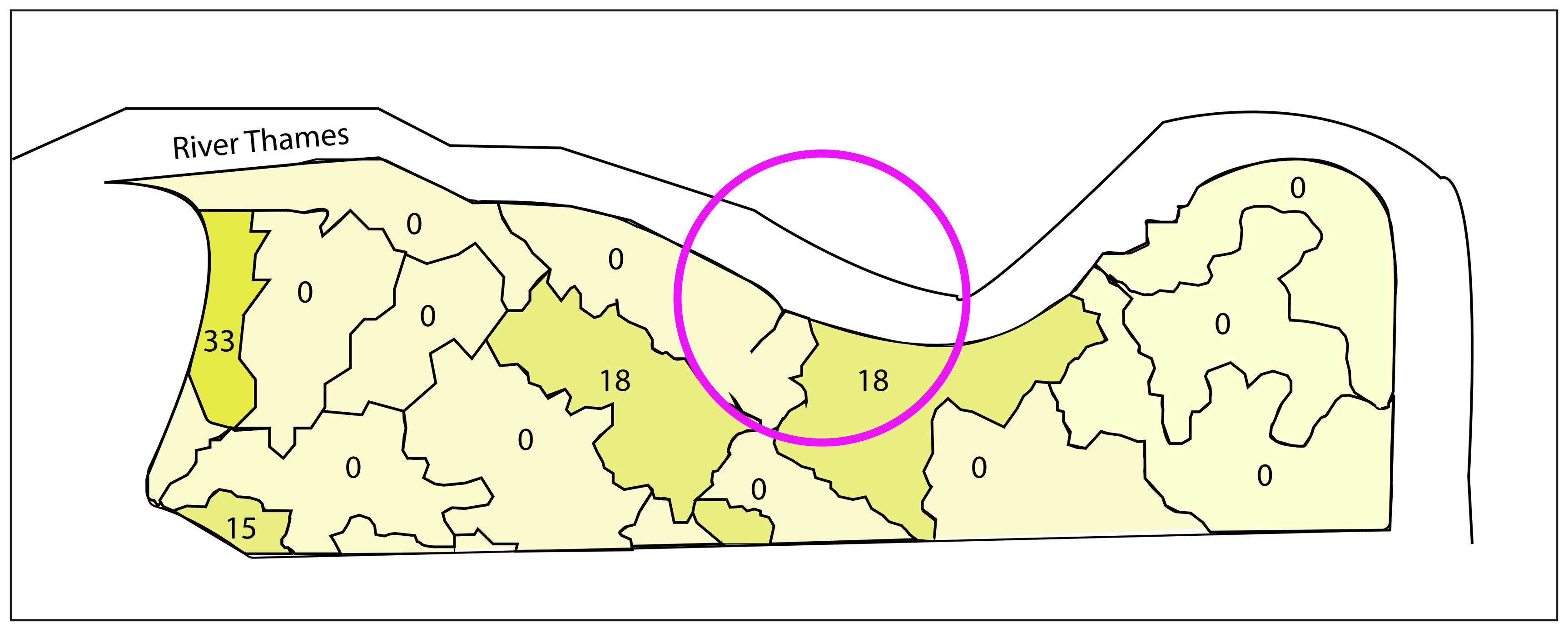
Clay Mapping

This map shows the clay availability surrounding our site. As demonstrated here, there is an abundance of london clay located along the River Thames. This clay is stiff and becomes brownish with oxidation. It is silty, sandy, and contains pyrite.



Alluvium Deposits

Soil deposits by river beds are known as alluvial. This combination of clay, silt, and sand leads to fertile, but typically looser, soil. This soil can also have poorer drainage. The foundations of our design will take into account these characteristics.



Soil Average Plasticity Index

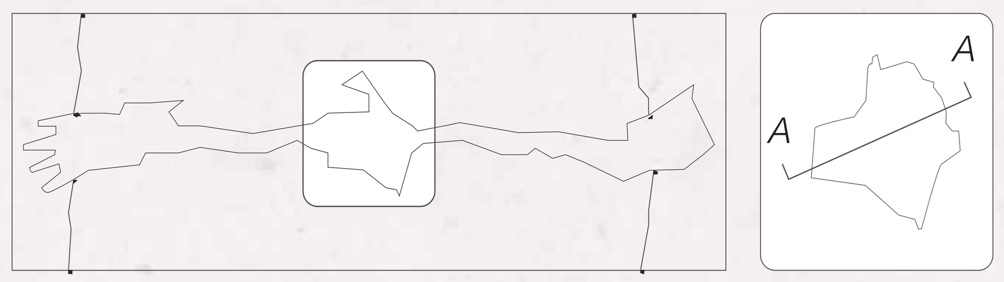
Map showing the plasticity index (PI) of soil surrounding the site. This measurement indicates the range of water contents where the oil exhibits plastic properties. It can be correlated with workability and shrinkage. In this map, a PI of 0 could indicate either a lack of plasticity or a lack of data for that specific region.

Outcomes

Car sculpting with clay.

Replacing fire coating insulation with clay instead of concrete.

Sacrificial layer.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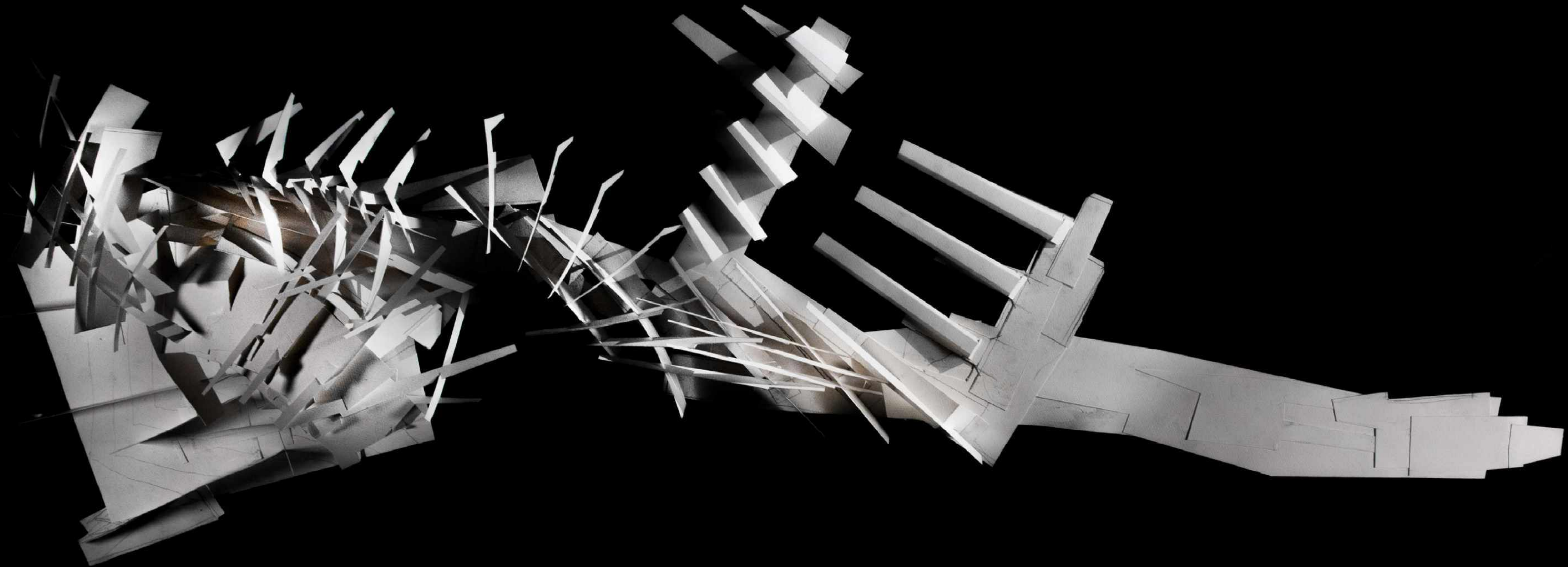
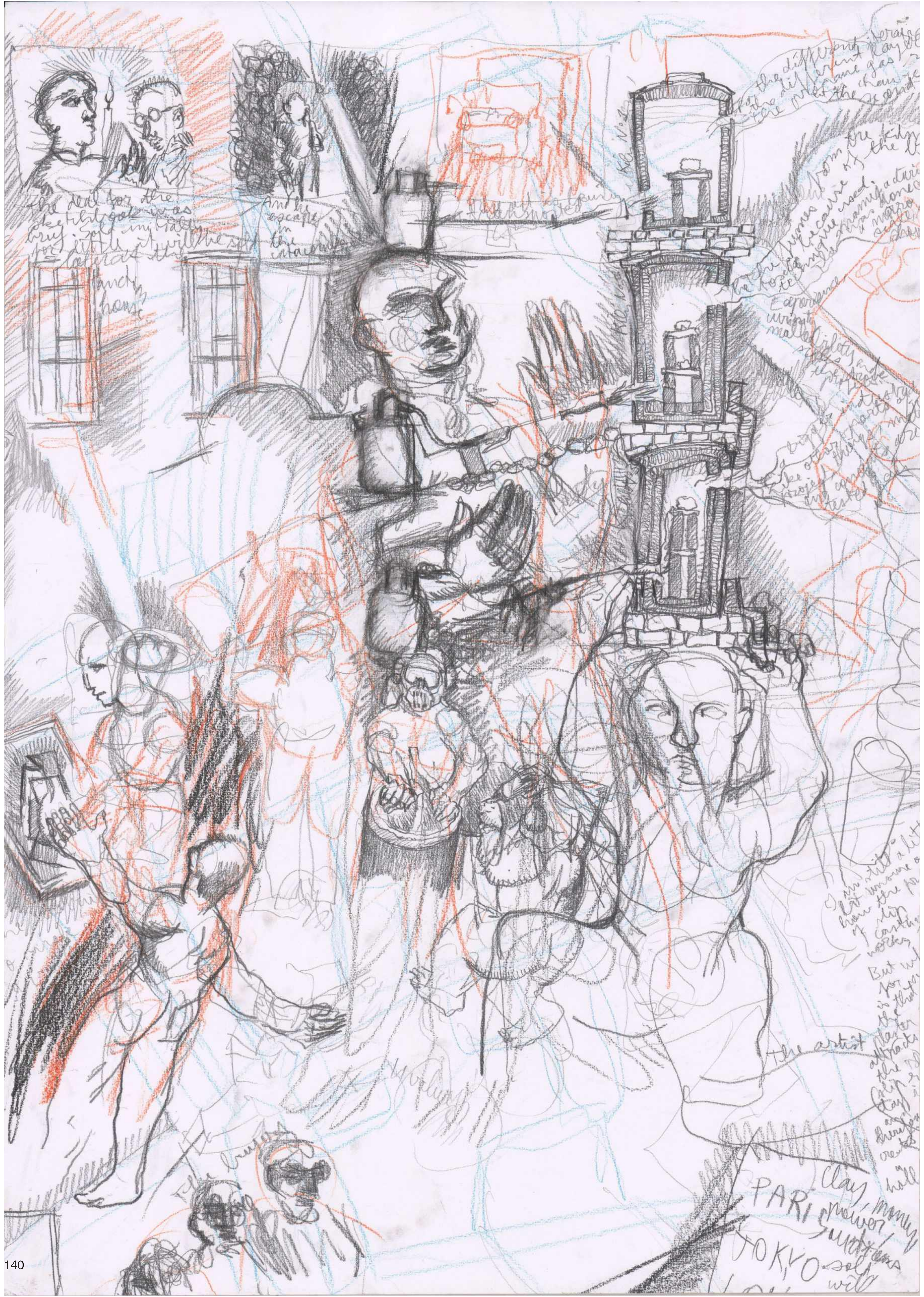
2.
2.
1.
1.
1-inner fire proof clay coating on steel members
2-sacrifical layer against water
1:50 on A1
4m

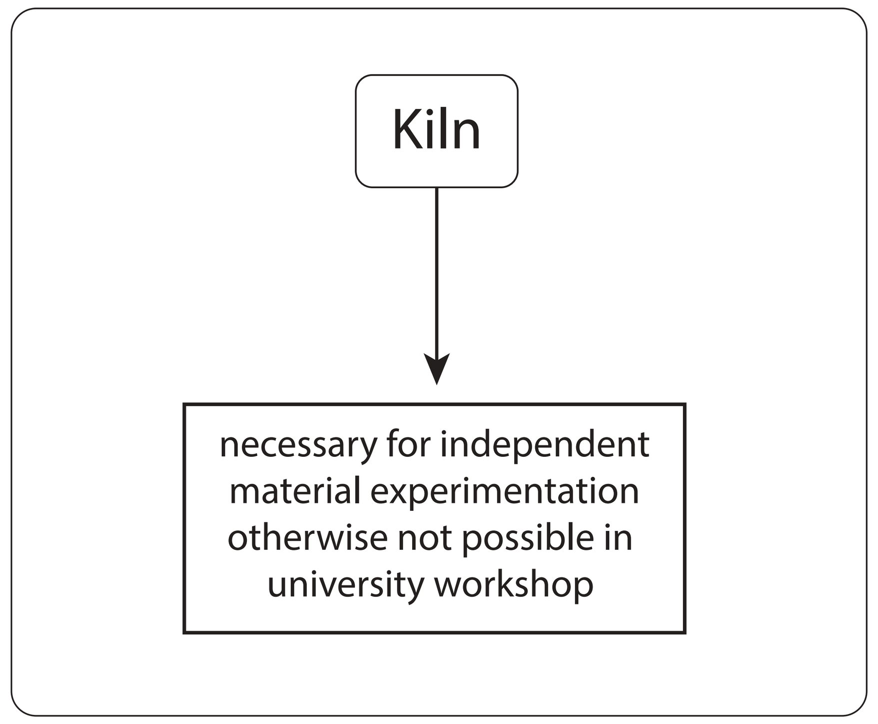


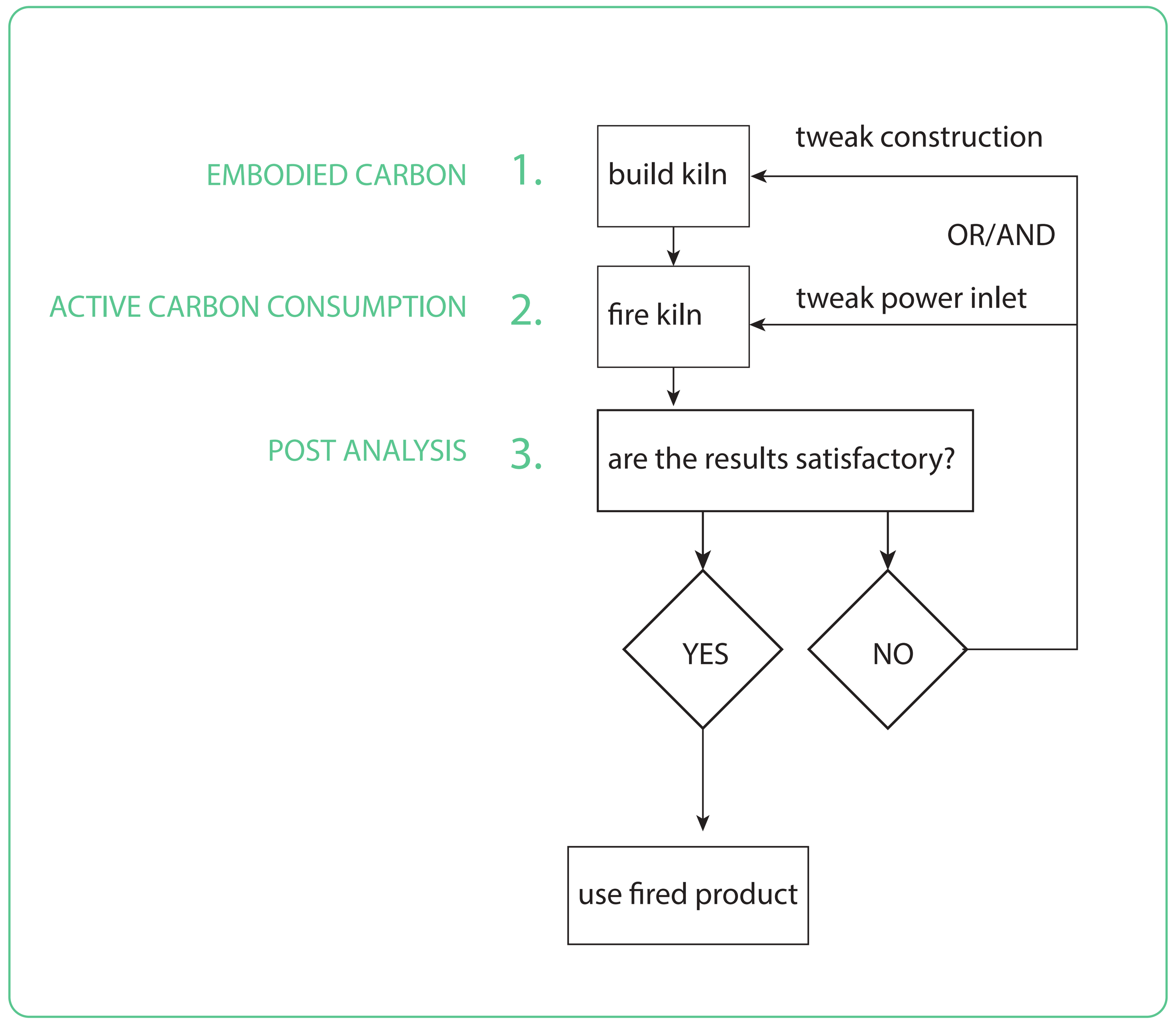


Section 8. Re-Use, Construction and Deconstruction Logic: Kiln

We cannot have the auction house be constructed in such a way that the result will be a grand fiasco. This is why the process of its construction is important, and I created digital images for the viewer to visualise how the construction process of the auction house on the Thames River will look like. The production of clay within kilns was something that had to be researched because without any data on clay there would be no construction of an auction house. The fabrication processes had to be figured out, and the re-use of materials was deeply important as part of a general effort to reach a certain level of sustainability. The kiln became an academic project in itself, and what was learned with it then informed the building. The kiln was always working throughout the year, and parallel to other research, it kep producing new outcomes. The transportation of materials that would be carried out for the auction house construction will have to involve water transports which will be much harder to be carried out than an auction house that would have been constructed on land. A general consensus on the methodology to be used with the construction had to be reached, and this was attained with help of visual images, such as the creation of digital images on how the construction of the auction house would look like.

Kiln Understanding





Making a kiln

1-90L steel bin, drill and J-saw to cut openings.

2-Protection clothes with tape around wrists.

3-Ceramic insulation is toxic due to its dust particles.

4-Extract fan is on and cut insulation.

5-Holes are made for fire resistant wires.

6-The wires are put through to hold the fire blanket.

7-Leave some extra insulation on the sides.

8-Make openings for inlet and outlet.

9-Take fire bricks for flooring and shelves.

10-Coat kiln shelve.

11-Install shelves inside.

12-Plug in propane gas with weed burner.

1) weed burner
2) propane gas
3) inlet
4) outlet
5) welding gloves
6) fire bricks flooring
7) fire bricks holds
8) ceramic insulation floor
9) gravel
10) kiln

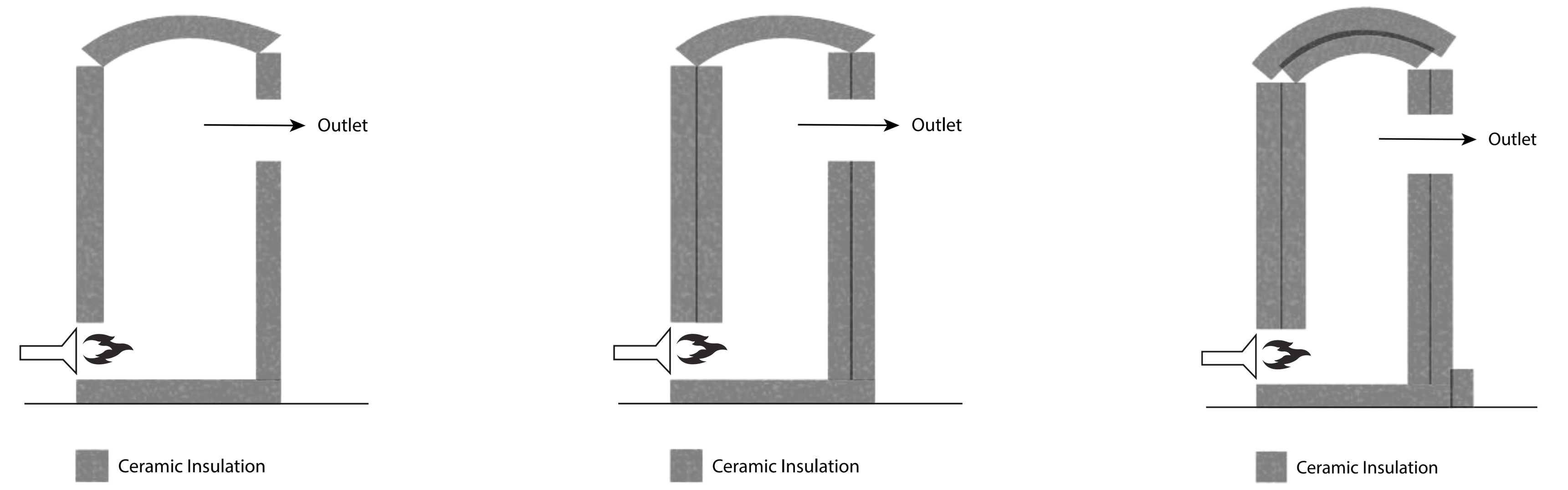
Value and Energy Testing

Kiln Energy Use

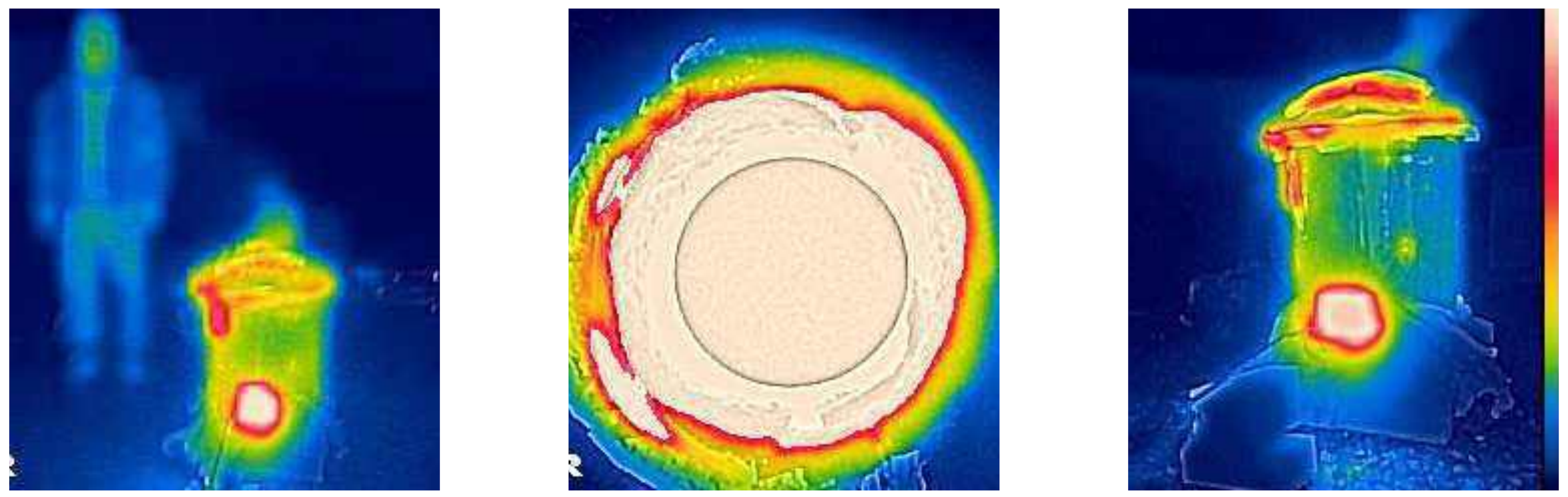
An experiment was conducted to determine energy use and the optimal role of insulation. Insulation was successively added to the kiln in three configurations. For each of these configurations, firing time and propane use was carefully measured. Using this information, the kWh and kW rating has been calculated, where 1kg of propane is 14.19kWh (per FloGas).

1st Firing, ceramic insulation at minimum	*2nd Firing, 2nd layer of ceramic insulation*	*3rd Firing, 2nd layer of ceramic insulation and insulation on top*
Time = 4 hours	Time = 2 hours	Time = 2.5 hours
Propane use = 1kg	Propane Use = 1.8kg	Propane use = 2.1kg
Energy Use = 14.2 kWh	Energy Use = 25.54 kWh	Energy Use = 29.8 kWh
3.55 kW rating	12.77 kW	11.92 kW rating

Insulation levels



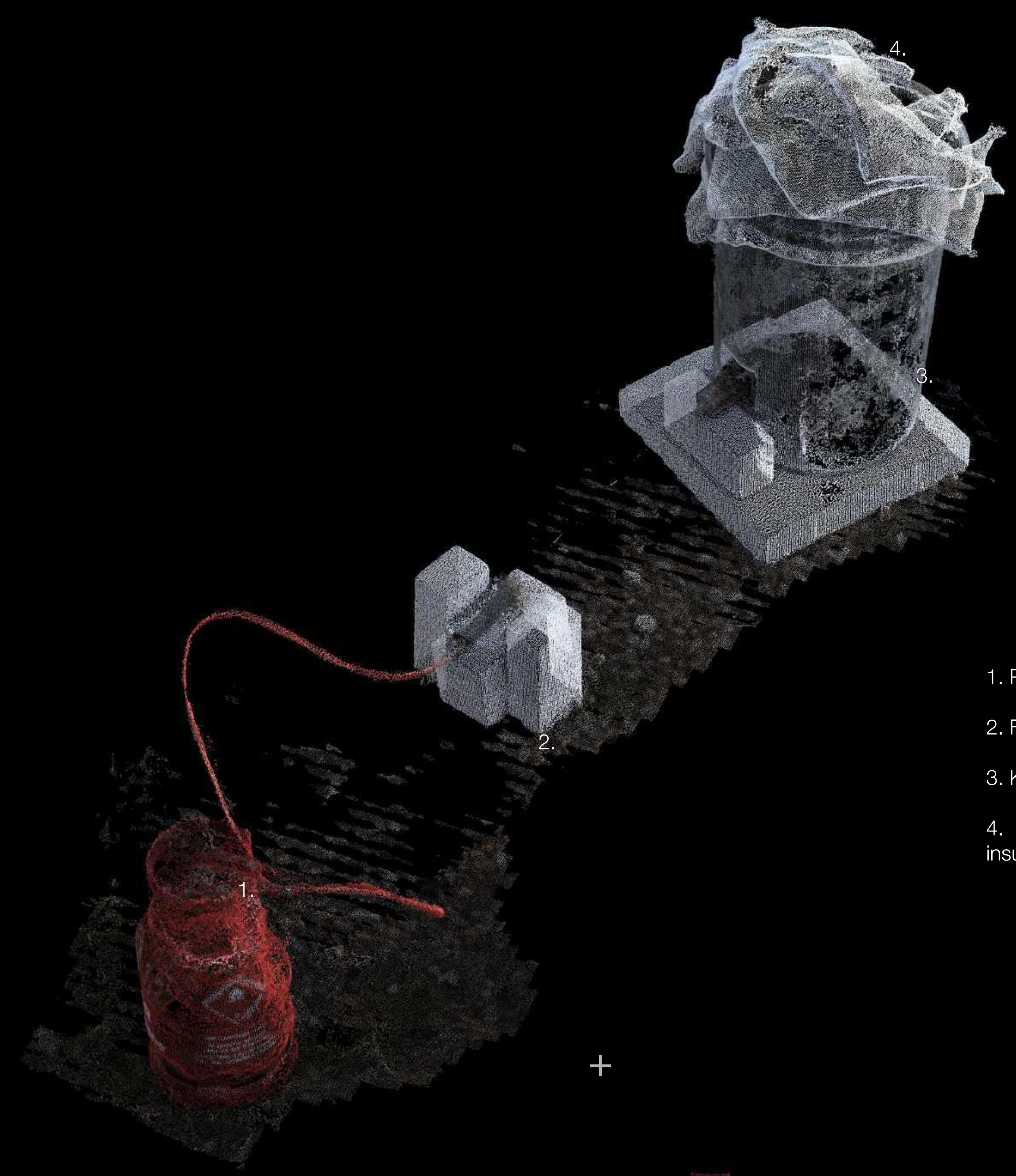
Thermal photos



In use

Summary

Small kilns draw between 1.5-1.8 kW, while medium-sized kilns draw between 5-8kW. The ceramic kiln design therefore falls well below the energy usage of a typical kiln. The ceramic kiln is additionally sustainable because it is constructed entirely using a sustainable material (clay) rather than employing a steel frame.

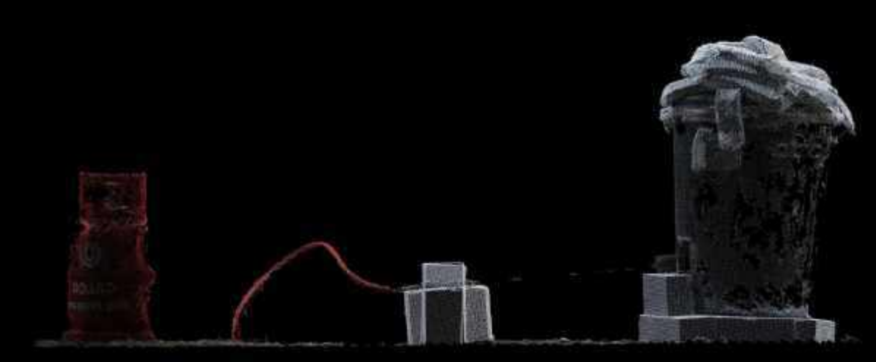


1. Propane gas

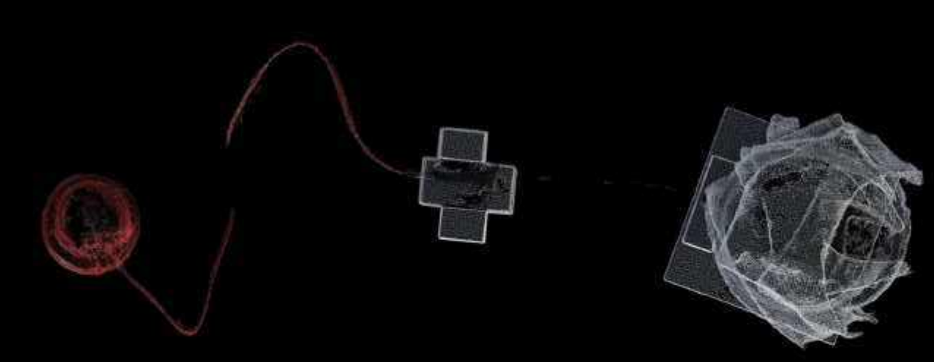
2. Fireproof bricks

3. Kiln

4. Ceramic insulation

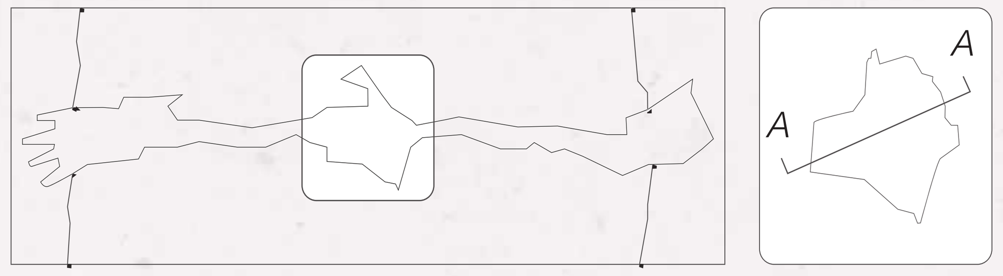


section



plan

KILN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smoking
fumer
1:50 on A1
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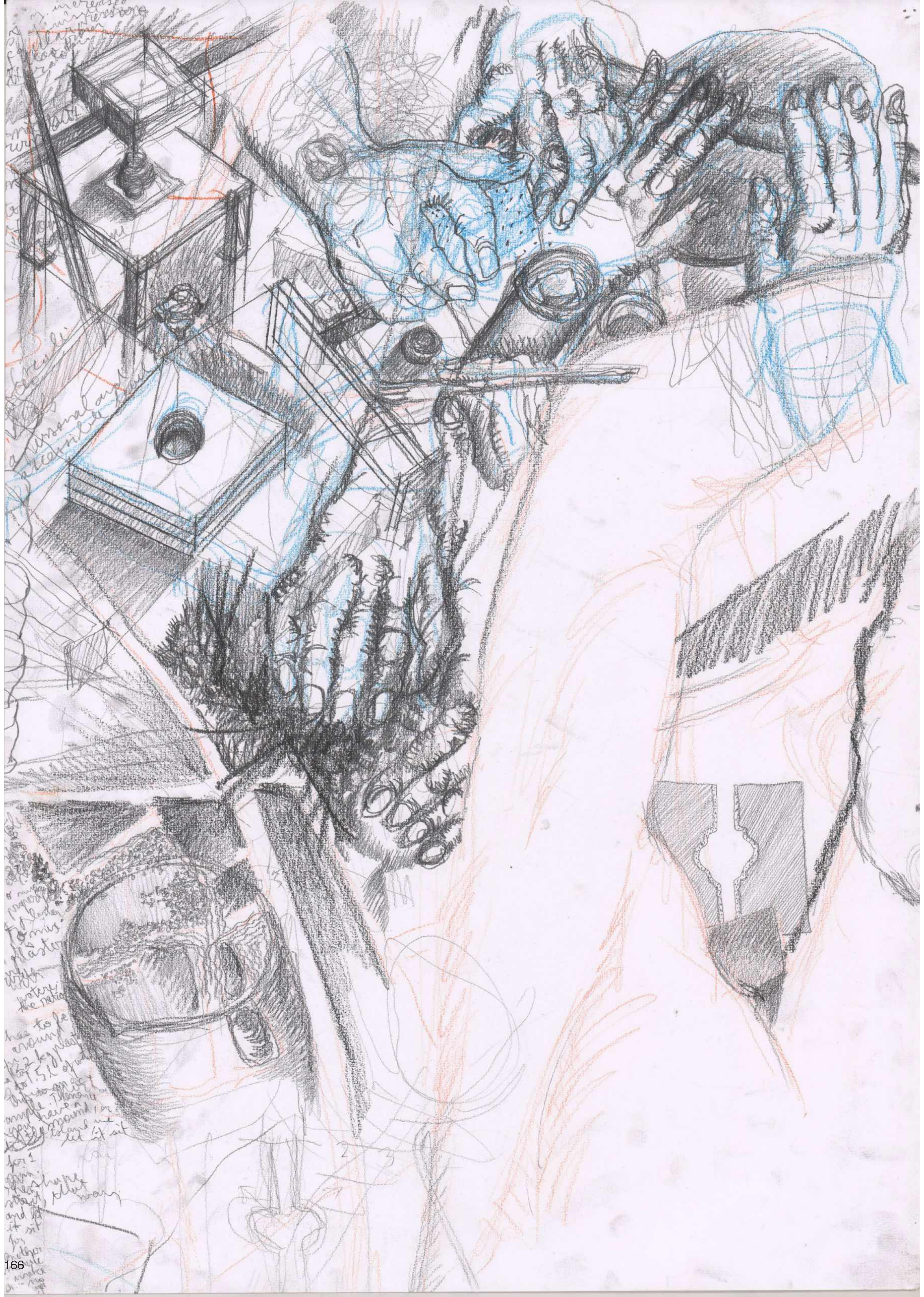
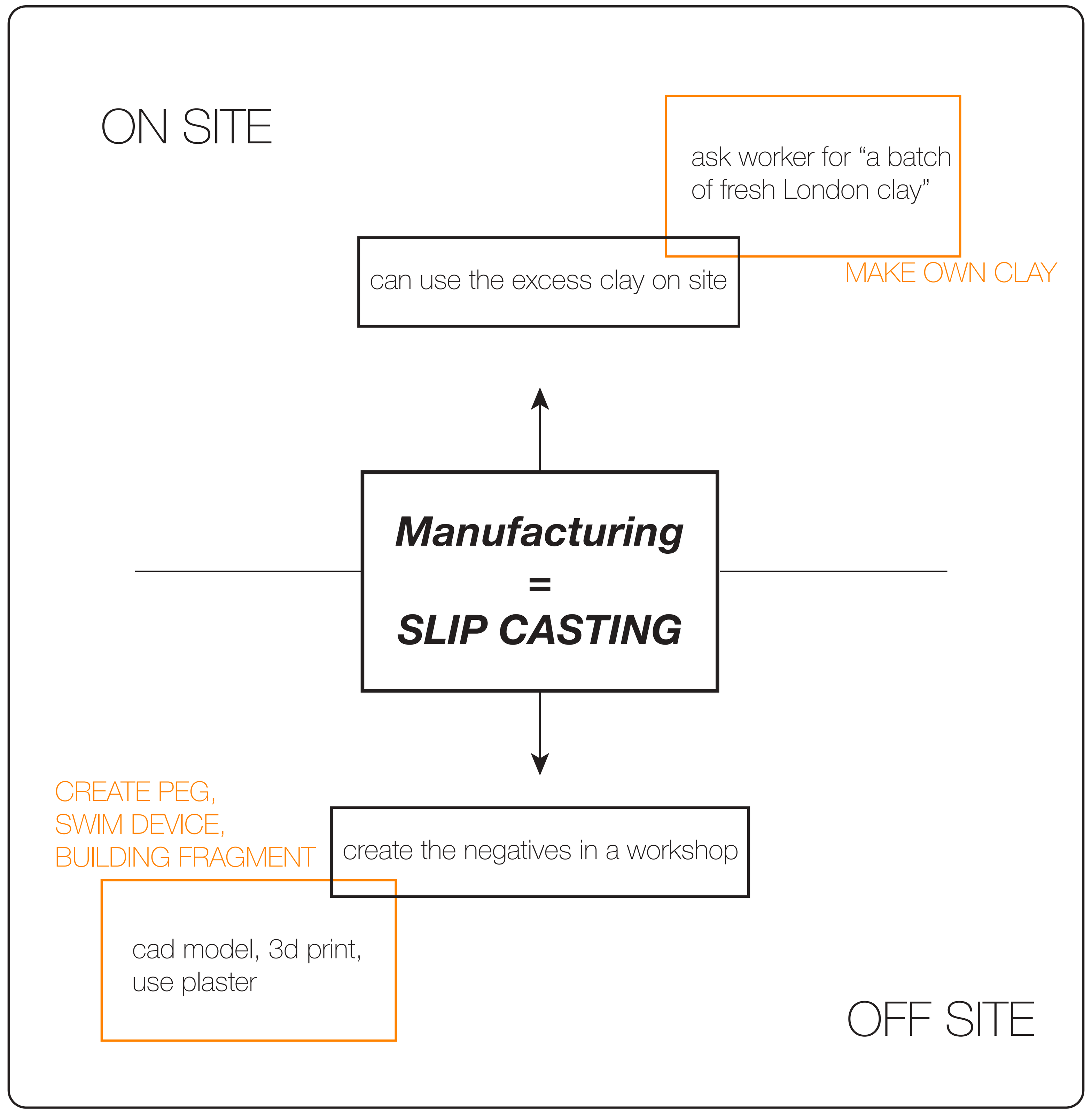
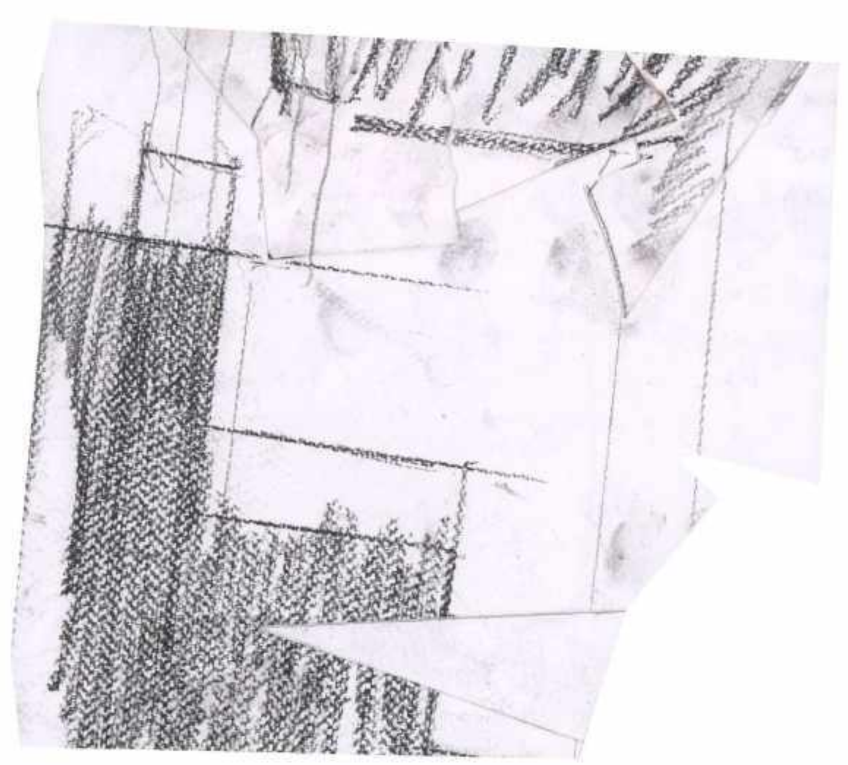


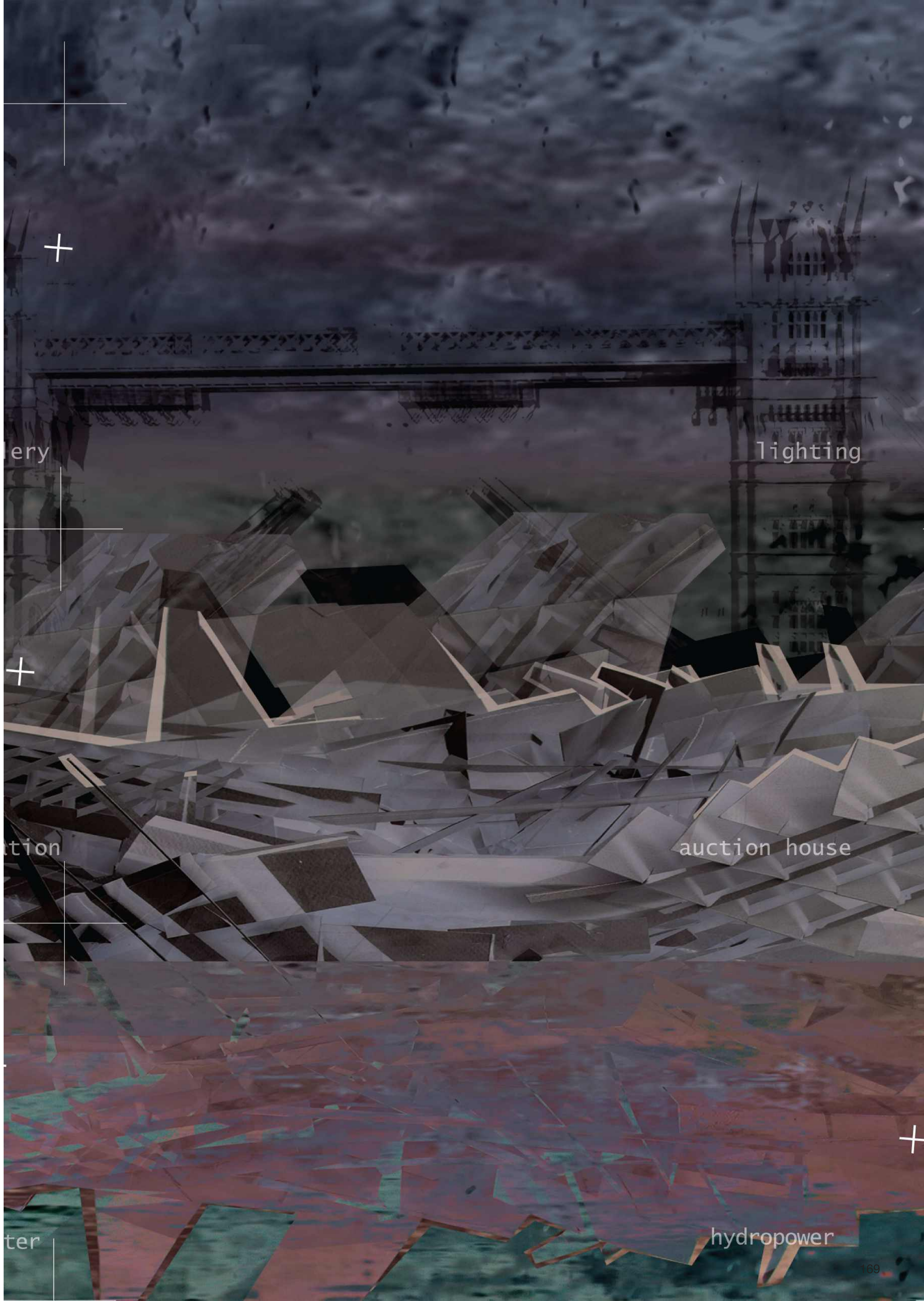
Section 9. Individual Material System: Manufacturing

For section 9, it was necessary to highlight the construction constraints that would be faced as well as a general assessment of specialist equipment to be used. As such, manufacturing slip casting was explored as a manufacturing mean for clay. This material can be used to create homeware pieces. It can also produce complex clay tiles in large quantities. It was absolutely vital to see what sort of method can be used in relation to the creation of clay as well as having a method related to art. My research into slip casting was helpful, and I related it to my experiment and concept design PEG. For this project, PEG would be manufactured using the technique of slip casting. I decided that in theory, the pull buoy could also be created out of slip casting, as well as the building fragment. It created an exponential scaling that naturally took form later on in a building proposal.

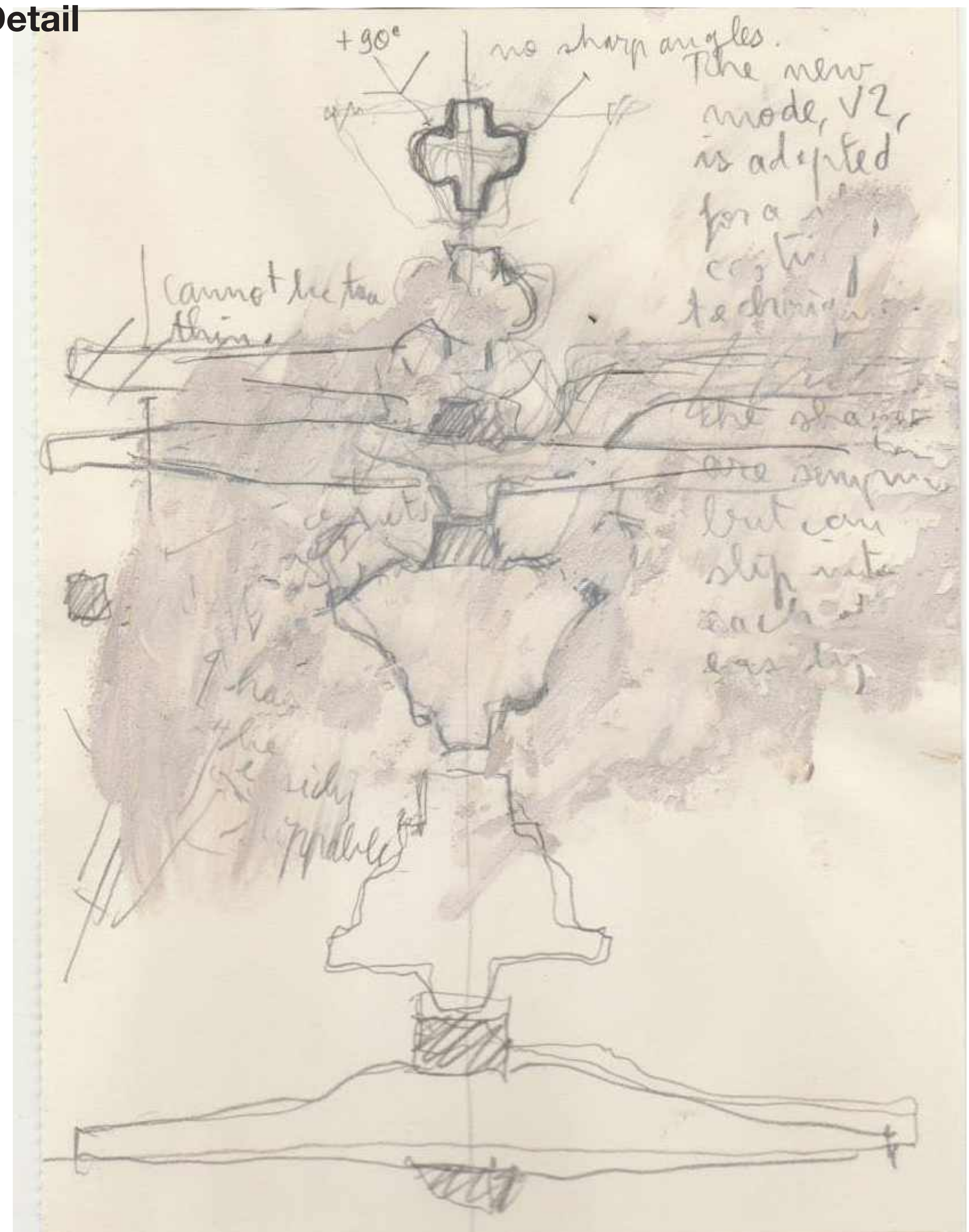
Processus


ON SITE
ask worker for "a batch of fresh London clay"
can use the excess clay on site
MAKE OWN CLAY
Manufacturing = SLIP CASTING
CREATE PEG, SWIM DEVICE, BUILDING FRAGMENT
create the negatives in a workshop
cad model, 3d print, use plaster
OFF SITE

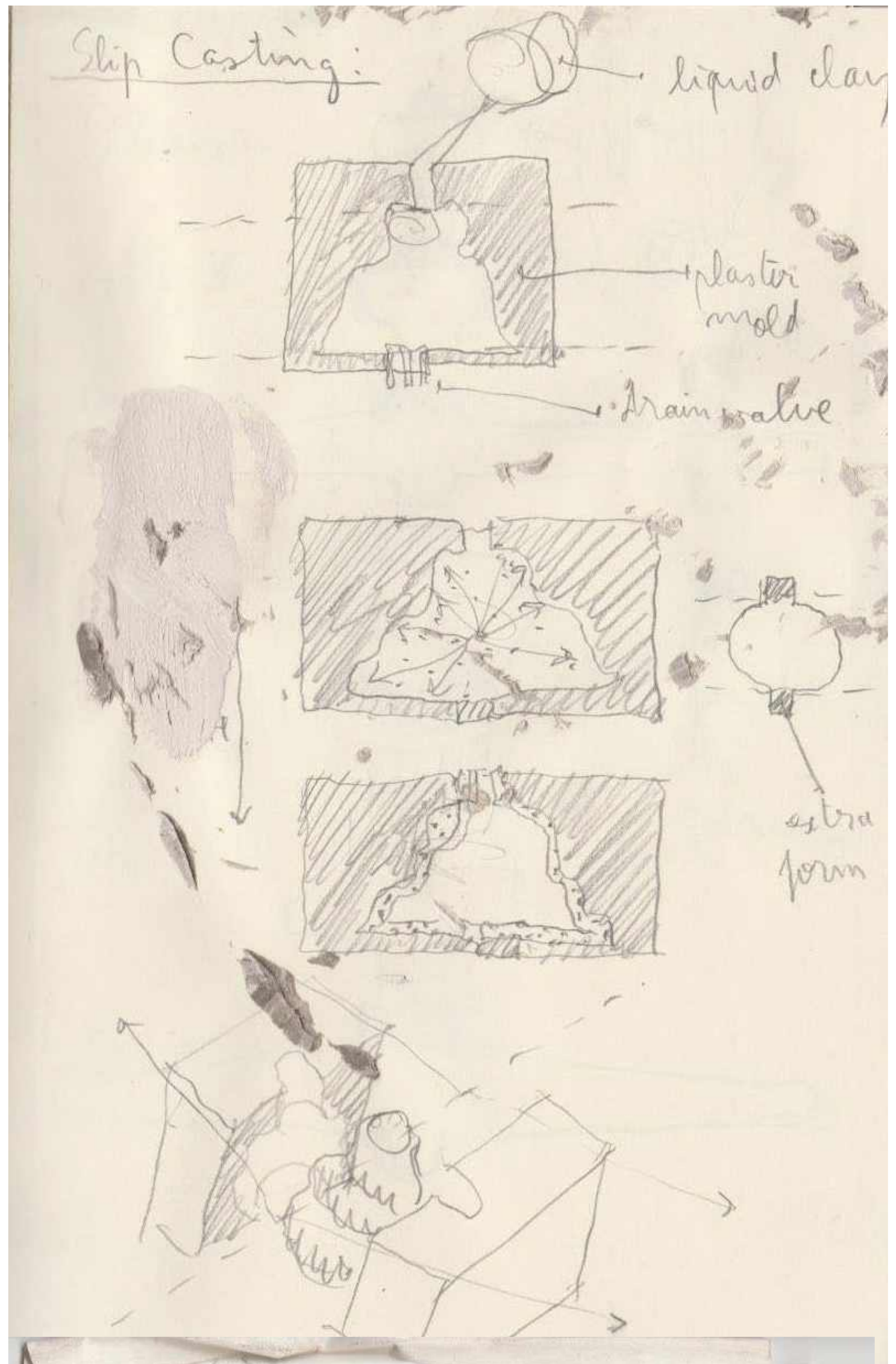


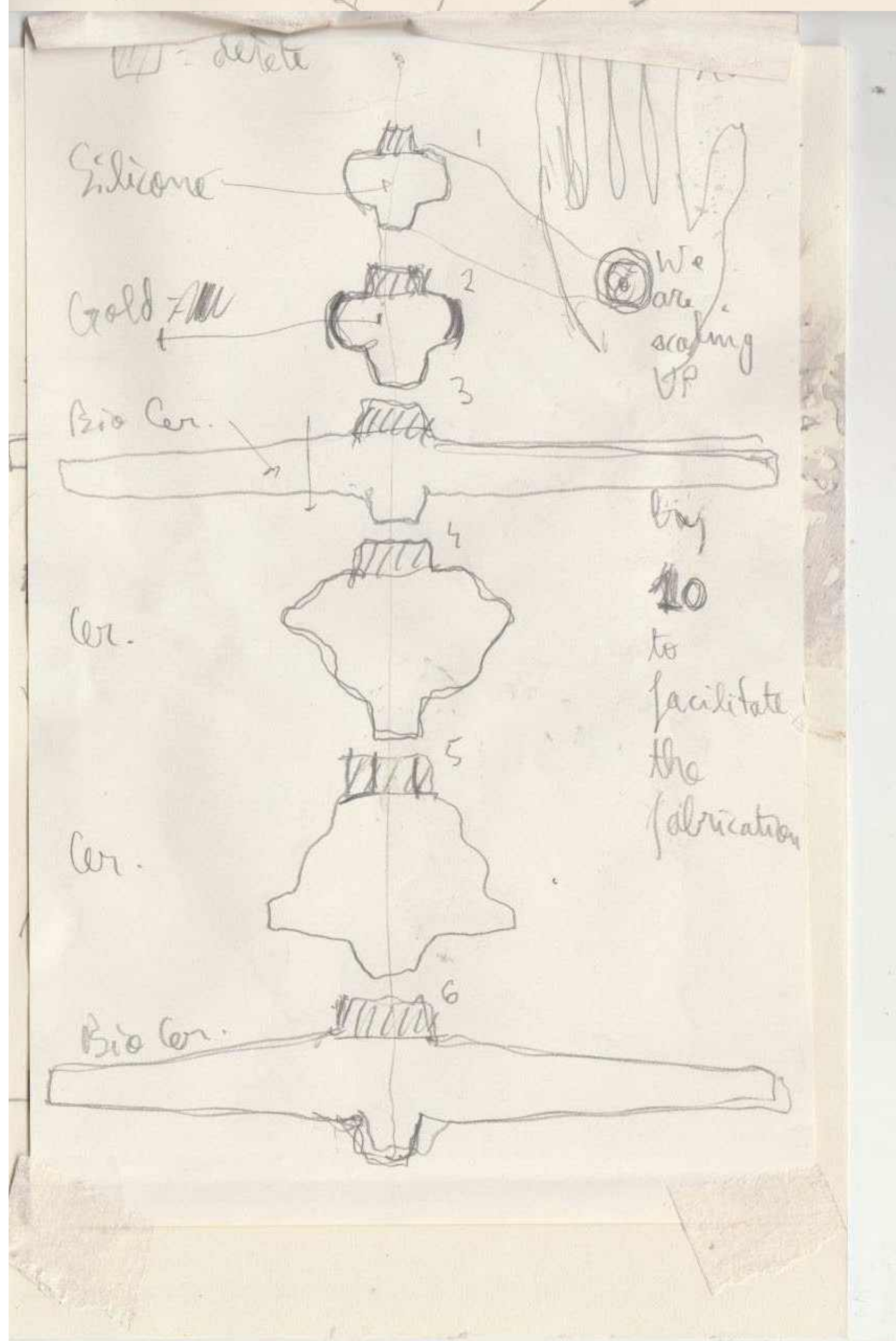

lighting
auction house
hydropower

Slip Castin Feeding Tube and Facade Detail



Gold leaf glazed slip casted geometries





Slip casting was the main technique used to fabricated the different clay geometries. Later on burn out technique was applied onto the geoemtries that created irregular forms within conventional shapes.

Different glazes were applied, including leafed gold for the bacterial free properties it has when in contact with the skin (for the feeding tube).

Slip Casting Detail


1-3d print detail, put clay and soap on it


2-cover half of the mold with plaster


3-cover the other half with plaster


4-make sure it s dry enough


5-molds


6-put rubber bands and peg


7-ready to pour slip

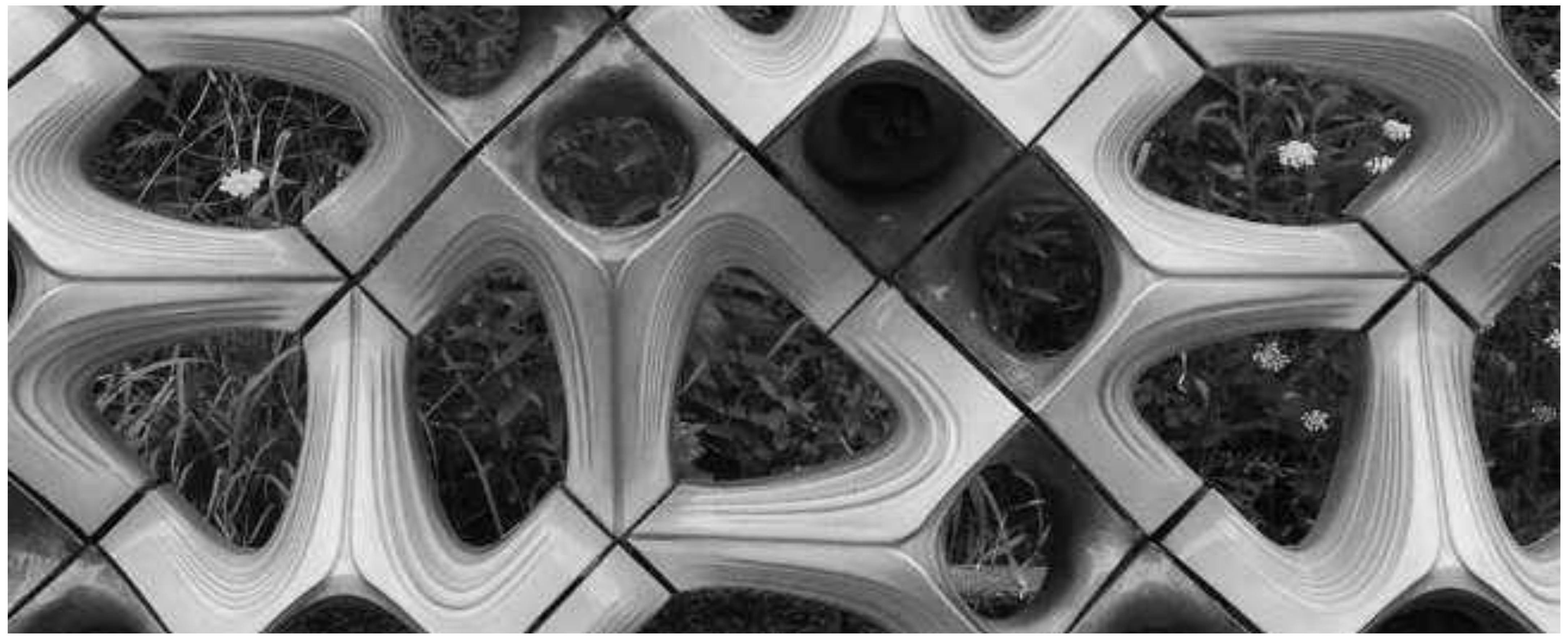

8-prepare slip


9-pour slip in mold


10-pour extra slip out

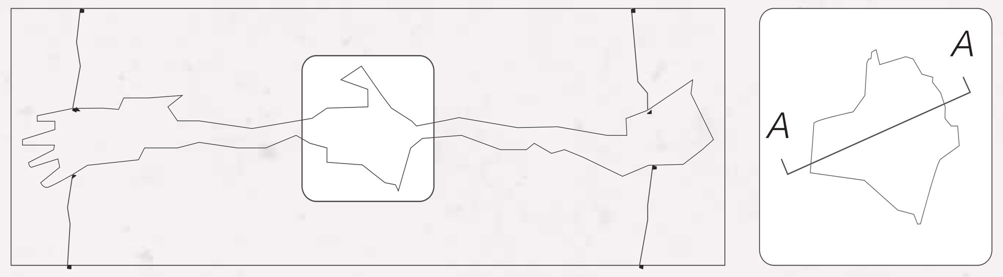
11-let it dry for 2 days before firing

Industrial Slip Casting


Buro Happold facade system for urban rewilding.

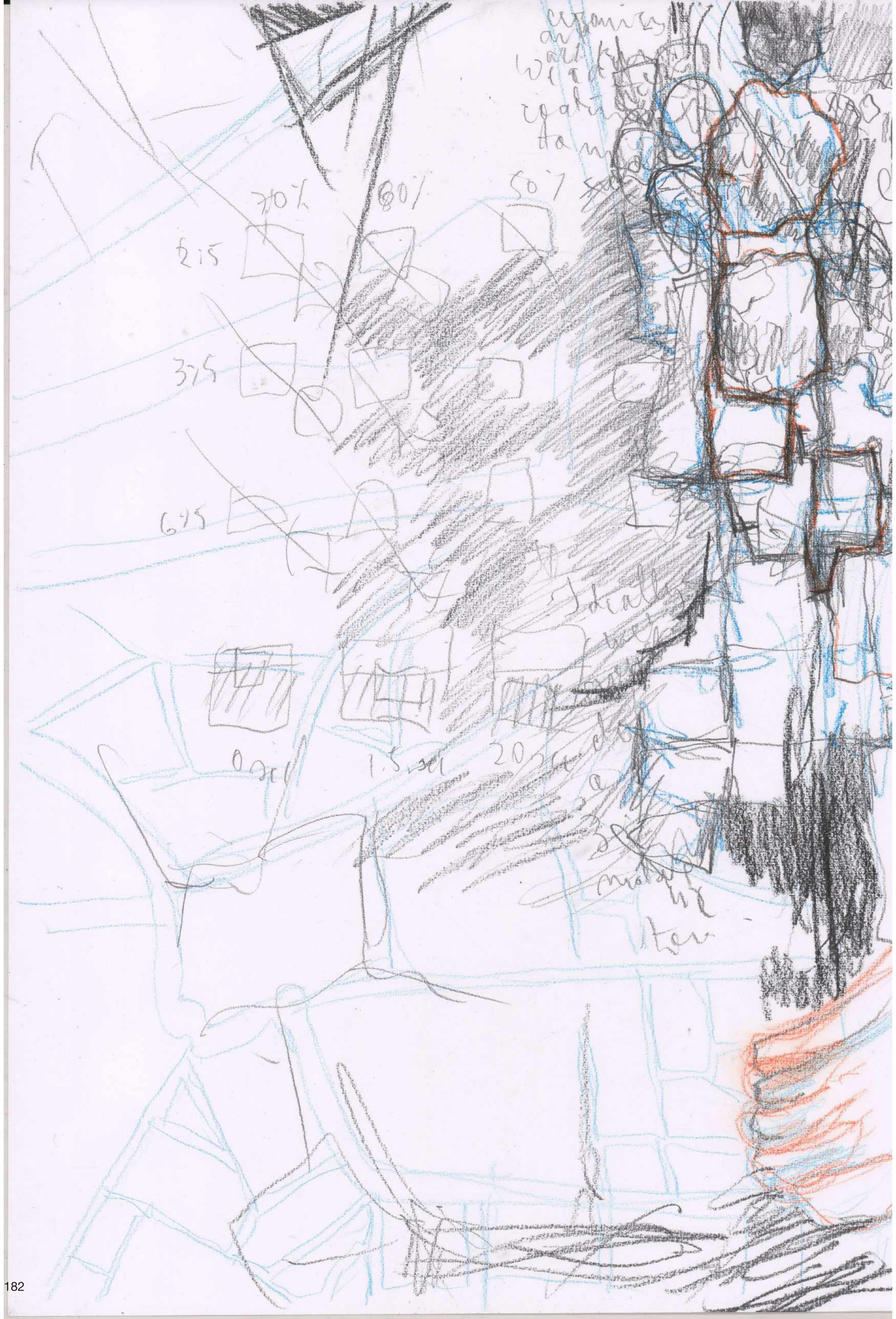

Architectural decorative detail


Toilets



1:50 on A1

4m

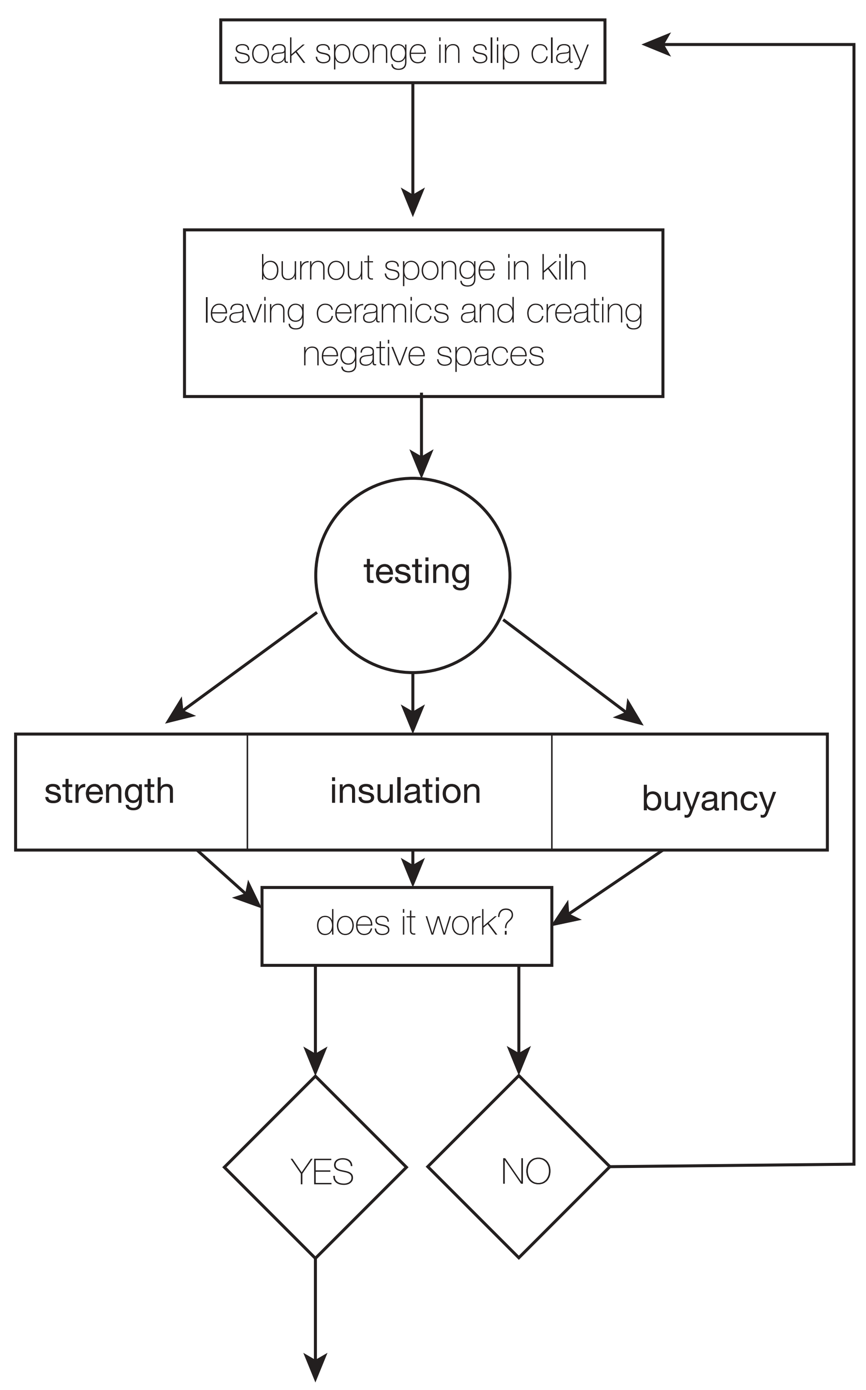


Section 10. Strain Test: Foam Ceramics

Concerning ceramics and the project as a whole, I can state that foam ceramics was the part in which I studied extensively. It was researched rigorously and was very much in depth. I decided to research first on the material typology, such as clay, concrete and foamed concrete, as well as a classified and up to date comparative table of different kinds of foam ceramic processes. These included starch consolidation, direct foaming, replication, gel-casting and lost material aeration. I had to see which methods were more industrially used, more convenient, its cost, which one was most efficient, as well as the positives and negatives of each. At the heart of this strain test on foam ceramics was sustainability. Each aeration method was also judged for its sustainability, which remains a very important element within this project. There were strength, buoyancy and insulation tests that were done , and the self made kiln was allowed to do different burn out experiments, being independent of B-made. The fabrication primarily served as a material exploration, but it was also an aesthetic means to create intricate materials that looked like corals. The aesthetic element was certainly not forgotten. After being finished with the experiments, the materials could theoretically be put to practical use.

ON HOLD
The use of fire as a mean to create negative spaces is of interest. Future works will be done in this field, not covered in the project.
8th June 2023, London UK
Maxime Ostrovehry

foam ceramics



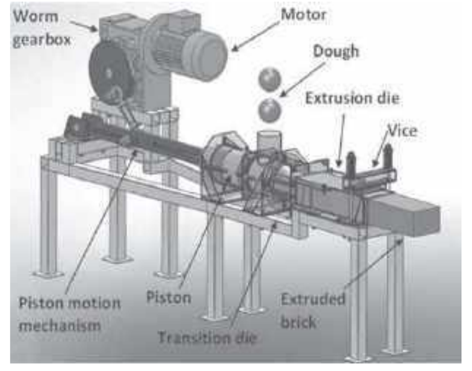
APPLICATION (upscaling):
-PEG
-Pull buoy
-Building pantoons and enveloppe of main space

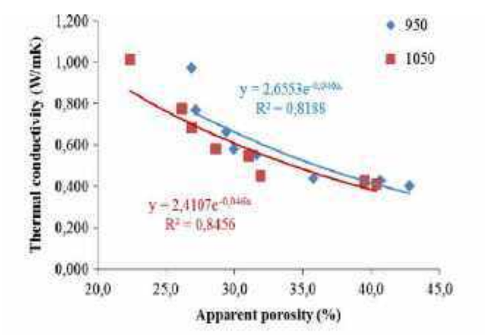
Material Typology

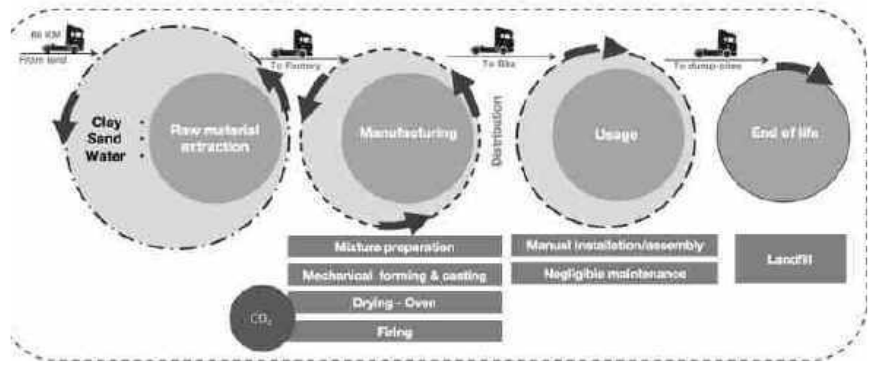
Clay (Brick)

Ground clay in bricks is usually comprised of alumina, silicia, lime and iron oxide. It is mixed with 10-15% water, extruded through a die to remove air bubbles, and cut into the final shape. These bricks are then dried and fired. The process takes between 10 and 40 hours.

Main Uses: Construction (Facades, driveways, etc)







Bulk Density: 1800-2000 kg/m3
Porosity: 30-40%

Compressive Strength: 12-40 MPa
Thermal conductivity: 0.5-1.0 W/mK

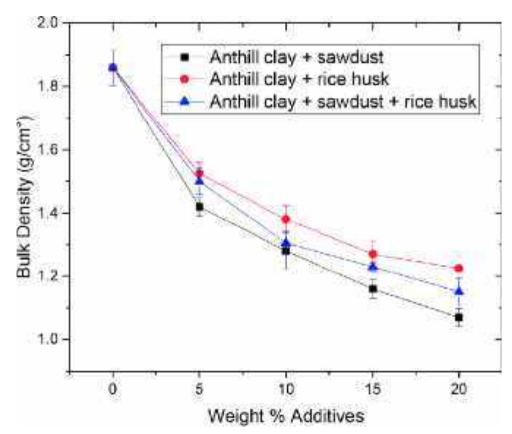
Sustainability. Considered a green building material. Consists of naturally abundant raw material and very durable. Emissions vary based upon firing technique, though coal is the most common (.81 kg CO2 per brick)

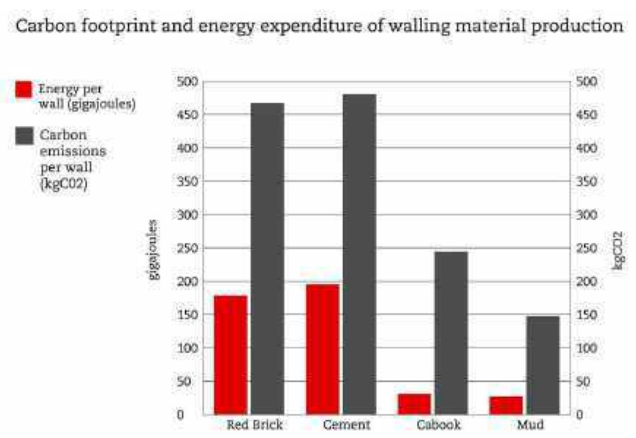
Mud and Natural Additive

The practice of adding additive to earth has been in practice since antiquity, when mud was mixed with straw and vegetable matter and dried by the sun. It is now employed widely in low-income settings and by DIYers to cheaply and simply decrease density while improving insulation. Additives commonly include straw, vegetable fiber, and animal fiber. The brick usually dries via the sun, though sometimes is sintered to remove the additive.
Main uses: construction, infill

Brick samples (Clay + % Additive)	Bulk Density ρ (g/cm³) Trial 1	Trial 2	Trial 3
Reference Value	1.85	1.80	1.73
Clay + Typha 1%	1.73	1.81	1.71
Clay + Typha 3%	1.65	1.62	1.77
Clay + Typha 7%	1.60	1.64	1.68
Clay + Typha 15%	1.48	1.49	1.62
Clay + Typha 20%	1.44	1.49	1.59

[a] Coefficient of variation = 100*(ρsample/...





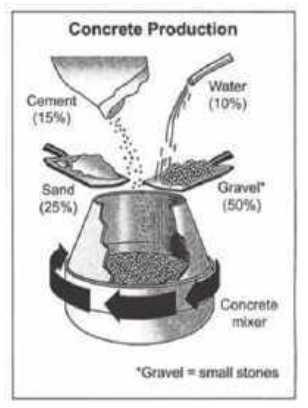
Bulk Density: 1000-2000 kg/m3
Porosity: Varies widely.

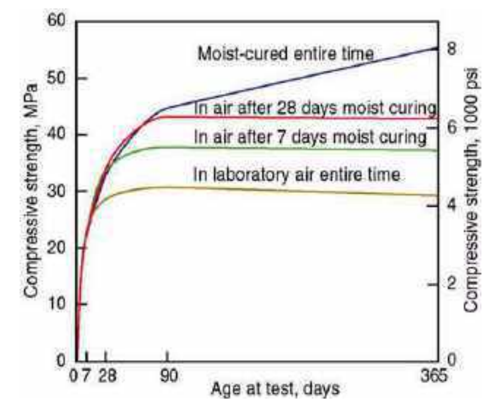
Compressive Strength: 3 -17 MPa
Thermal conductivity: 0.3 - 0.9 W/mK

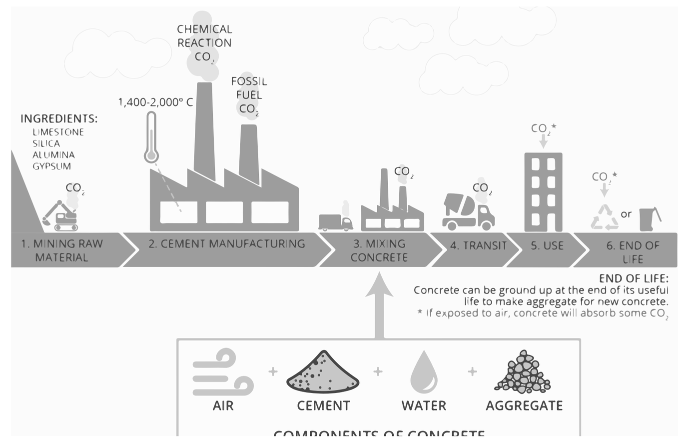
Sustainability. Considered a green building material. Consists of naturally abundant raw materials and incorporates waste. Often doesn't include a firing process. However, not very durable.

Concrete

Concrete is created by combining 10-15% portland cement (primarily lime, silica, and alumina) with 10-15% water and 65-75% aggregate. Steel fiber may also be added to the mix to create reinforced concrete. The water hydrates the cement causing it to solidify. Before the concrete hardens, it is placed and compressed to remove air bubbles. While the concrete cures, its moisture must be carefully regulated to control strength and avoid cracking.
Main uses: construction, transportation, and insulation.







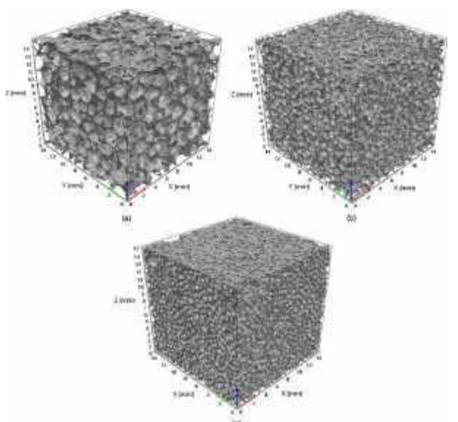
Bulk Density: 1900-2400 kg/m3
Porosity: 9-10%

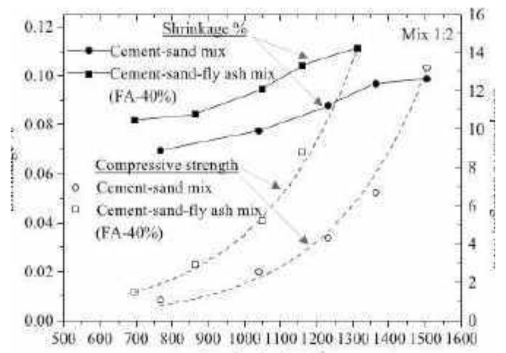
Compressive Strength: 17-40 MPa
Thermal conductivity: 0.6-3.3 W/mK

Sustainability. Cement production is the 3rd largest producer of CO2 globally (largely from calcining lime). Quarrying generates air pollution and is reponsible for 10% of industrial water use.

Foamed Concrete

Cement and water (sometimes in combination with fly ash and sand) are mixed together with an aerated foam. In order to be classified as foamed, the mix must be at least 20% foam by volume. In the pre-foam method, pre-prepared foam is added to the cement. In the inline method, the foaming agent is added directly into the base material.
Main uses: insulation, bridge approaches, void fill.





FC-12.5 composition	Percentage breakdown by components of mass, %	Percentage breakdown by CO_2 emissions in impact category GWP, %
Portland cements CEM I 42.5 N	46.1	94.07
Sand, fraction 0/1 mm	26.3	0.72
Water	21.4	0.02
Polypropylene fibres EUROFIBER REF 512	0.2	0.88
Metakaolin	3.3	2.4
Silica fume (Elkem 971Dens)	2.1	0.01
Plasticizer (polycarboxylate)	0.3	1.05
Plant power	–	0.85

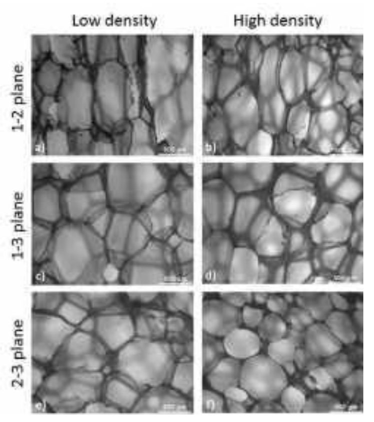
Bulk Density: 300-1600kg/m3
Porosity: 30-70%

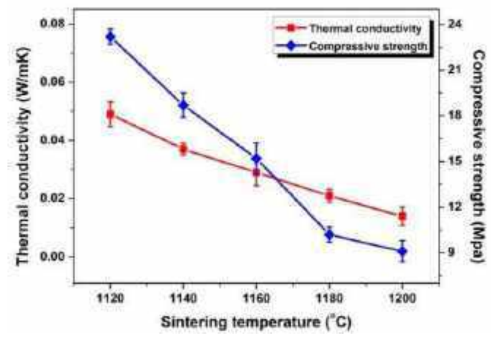
Compressive Strength: 0.2-18 MPa
Thermal conductivity: 0.1-0.7 W/mK

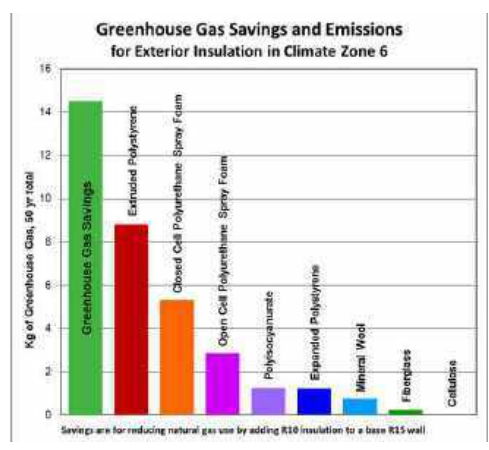
Sustainability. Lower thermal conductivity results in better insulation for buildings. However, uses more cement than normal concrete -- resulting in water use and C02 emissions.

Foamed Ceramic

Several different manufacturing processes (outlined 10.1) can be used to produce foam ceramics. In industrial applications, the most commonly used ceramic foams are silicon carbide (SiC), alumina (Al2O3), and Zirconia (ZrO2). Of these, alumina ceramics produced using the replication method are the most popular.
Main uses: Insulation, noise control, pollution control, filtration.







Bulk Density: 300-600 kg/m3
Porosity: 70-90%

Compressive Strength: 0.1-40 MPa
Thermal conductivity: 0.05-0.7 W/m/K

Sustainability. Though raw minerals are naturally occuring and non-toxic, the extraction process accounts is carbon-intensive and water intensive. Carbon emissions also depend on the firing process.

Conclusion: Foamed materials can lower the thermal conductivity by decreaing the density -- effectively replacing the solid with pores of gas of a lower thermal conductivity. Of the foamed materials, foamed ceramic is the most sustainable because it foregoes the use of cement.

Foam Ceramic Processes

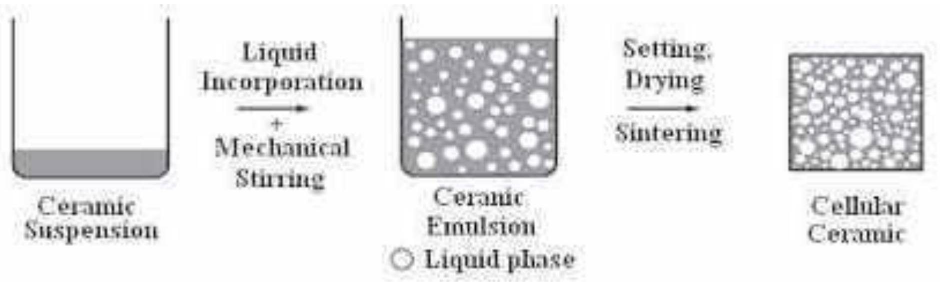
A comparison of the methods and advantages of different aeration methods.

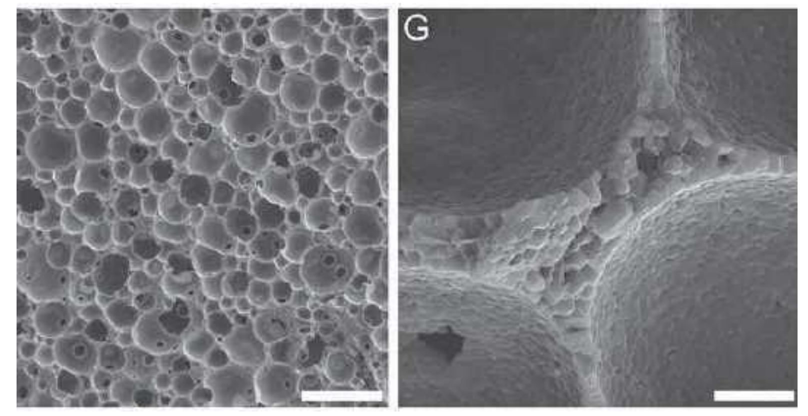
There are two overarching classifications of foams: open-cell and closed-cell. Open-cell foams have interconnected pores and typically lower density, while closed cell foams have fully enclosed pores which have on average higher compressive strength.

Direct Foaming

A gas or liquid is mixed into a ceramic suspension, which is then dried and sintered at high temperatures. Direct foaming leads to high mechanical strength and can be done with very low emissions. However, pore size and porosity can be difficult to control. Porosity is roughly equivalent to the amount of gas or liquid introduced, while pore size is proportional to the amount of stirring done in the mixing process.

Sustainability: Very low waste gases and liquids. Emissions affected by stirring method.

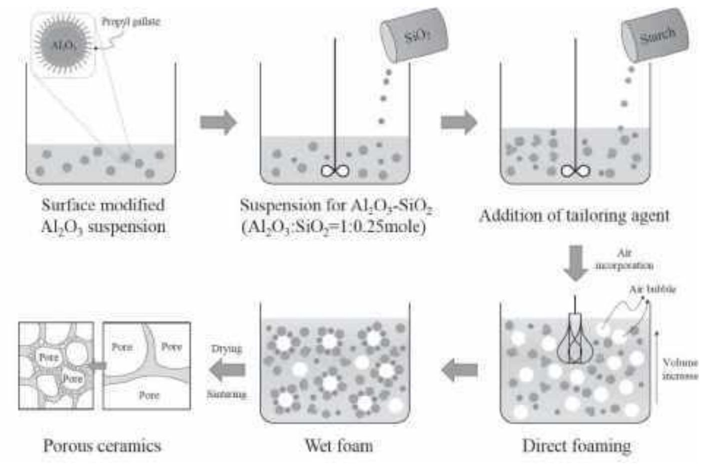


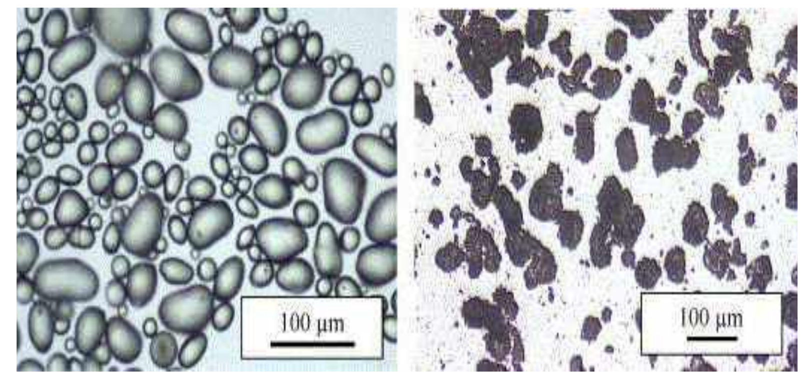


Starch Consolidation

Starch and ceramic powder are suspended within distilled water. The starch is then burned out during sintering. The pore size achieved can be controlled by the amount and type of starch introduced. Starch consolidation is often combined with other foaming methods to control pore size. It is cheap, non-toxic, and environmentally friendly.

Sustainability: Starches can be naturally occuring and are often non-toxic. Emissions affected by stirring method.

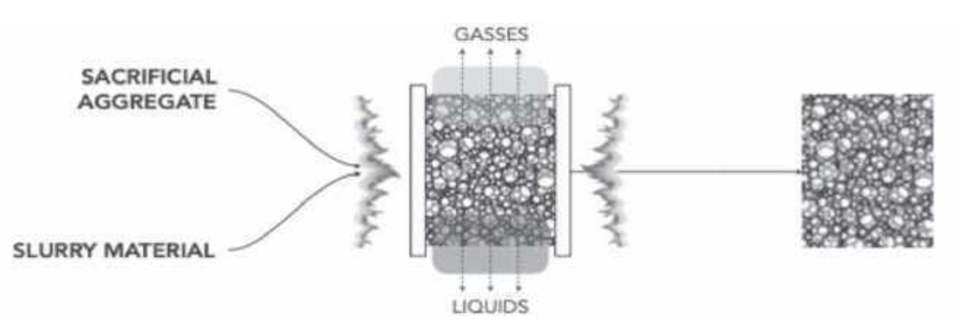


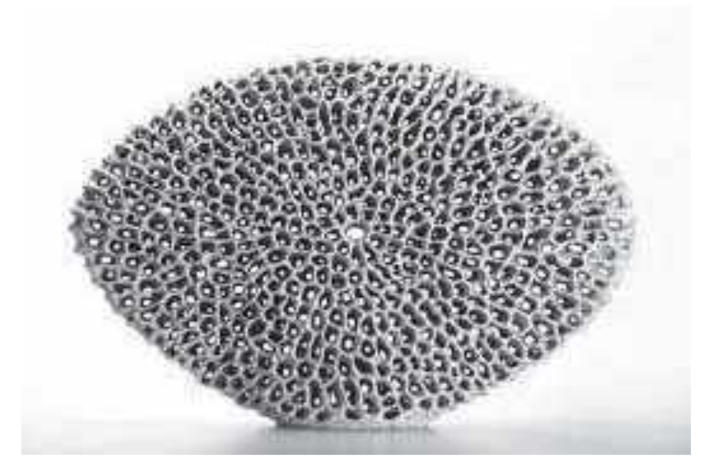


Burnout / Lost Material Aeration

Aggregate (such as gravel, sand, and crushed rock) is mixed into the slip and then dissolved. In ceramics, polyurethane (PU) is mixed into the slip and then burnt out after drying. This technique is common in industrial applications due to its relative simplicity and high thermal insulation.

Sustainability: Aggregate used is often waste material. PU is a plastic derived from crude oil, but is recyclable.

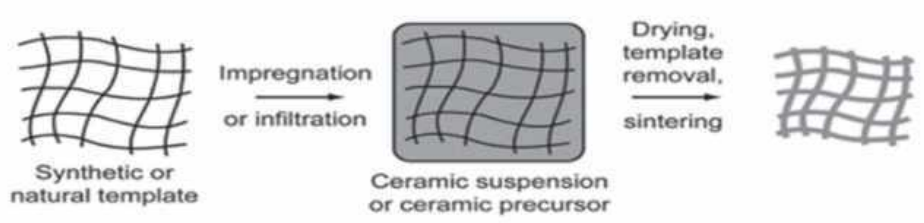


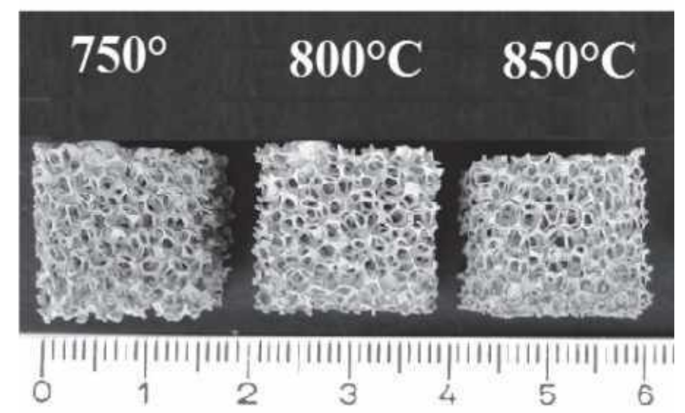


Replication

Replication utilizes a polymeric foam (often polyurethane) as a template, which is then dipped into ceramic slurry. After the coated template is dried and sintered, a replica of the original template remains. It is therefore a form of the burnout techniaue. The replication method's higher permeability comes at the cost of lower mechanical strength.

Sustainability: PU is a plastic derived from crude oil, but is recyclable.

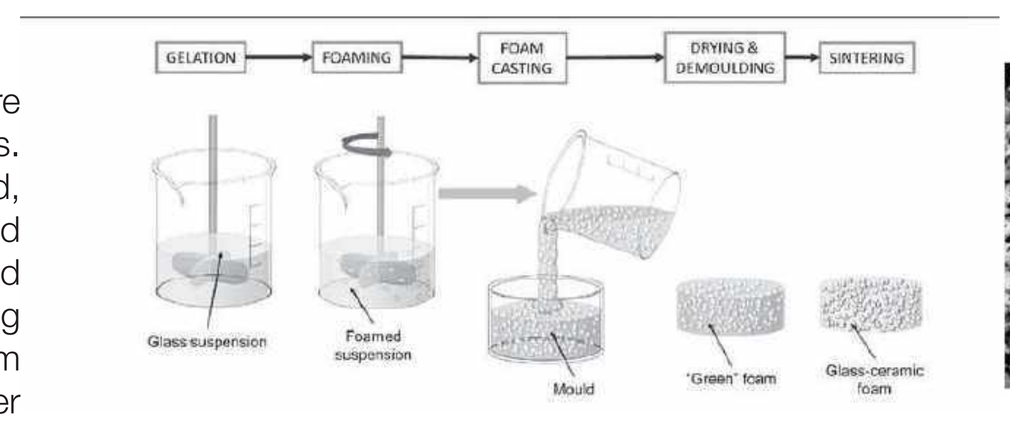


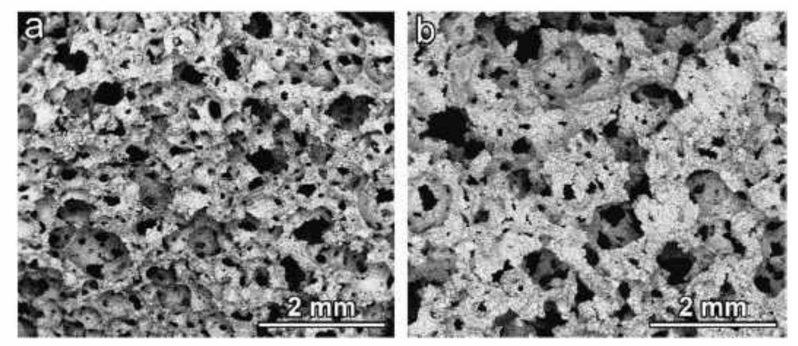


Gel-Casting

Ceramic powder and organic monomers are suspended with solvents and dispersants. This mixture is poured into a nonporous mold, at which point the monomers polymerize and a gel forms. This "green foam" is removed from the mold to dry and sinter. Gel-casting can use organic materials to produce foam ceramics with high homogeneity, fewer geometry limitations, and shorter burnout times.

Sustainability: Recently, lower toxicity gels have been developed to decrease enviornmental impacts.





1-Make sludge around 50-50 water to clay ratio.

2-Take sponge.

3-Dip sponge in.

4-Leave it to dry for a week.

Case Studies in Composite Structures

Drawing inspiration from existing forms.

SkelETHon

Steel Fiber-reinforced Concrete + Waterproof Concrete

This fully functional, 114 kilogram canoe uses a unique Free Formwork skeleton to minimize material and maximize stiffness. In this design, a 2-3mm waterproof concrete skin covers a 1mm fiber-reinforced concrete skeleton. High-resolution surface texture increases contact area between the two.



SS Atlantus

Ferrocement + Steel

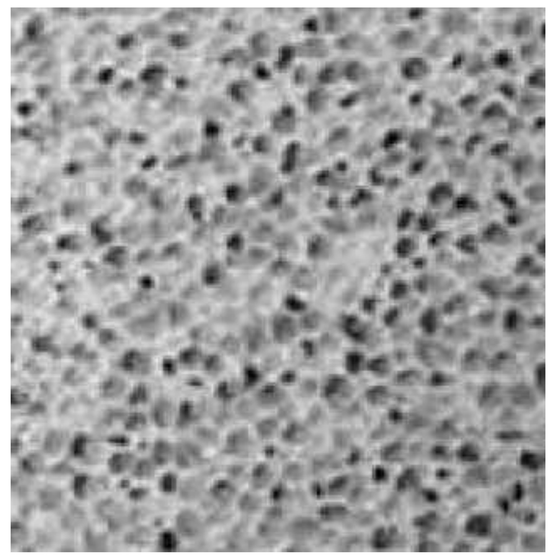
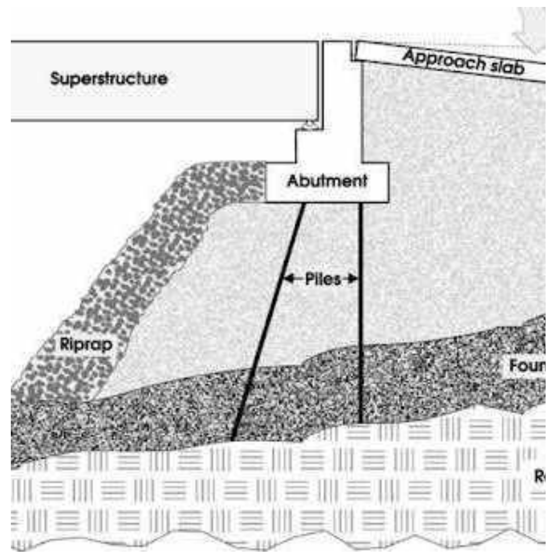
This concrete ship is the most famous in a series produced during World War I, as concrete was easier to acquire and less expensive than steel. A ferrocement hull layers wire mesh with mortar for high durability. This hull is then reinforced with steel bars. Concrete ships were removed from the navy because their thick hulls compromised hydrodynamics and cargo space.



Bridge Approach

Foamed Concrete

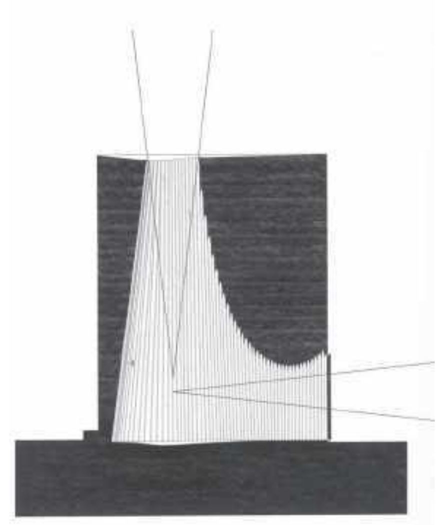
Recently, fiber-glass reinforced foam concrete has been used in railway bridge approaches. This technique has been shown to improve performance by decreasing effects of settlement and displacement on the railway.

Burder Klaus Field Chapel

Concrete, Lead, Linden Wood, Crystal Glass Marbles

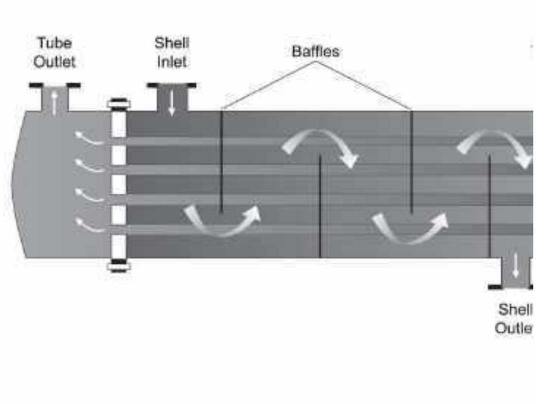
Architect Peter Zumthor poured 24 layers of concrete around a teardrop-shaped wigwam frame of 112 tree trunks. Once the concrete had set, the trunks were slowly burnt out for three weeks, leaving behind a ridged and blackened interior. The cavern is open to the sky and the floor is composed of lead.

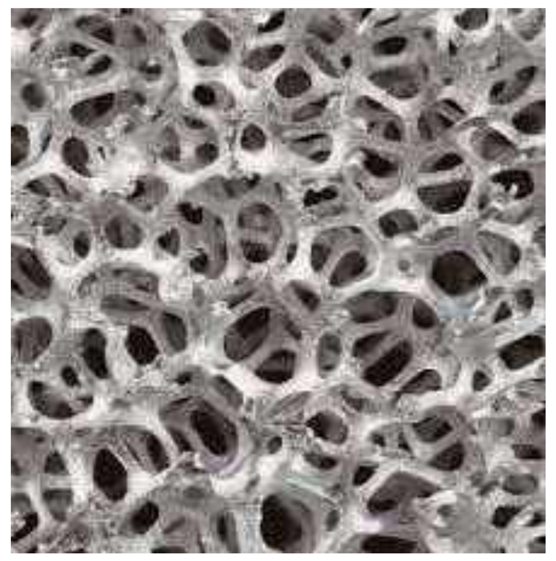


Duocel Heat Exchanger

Silicon carbide (ceramic) foam

A typical heat exchanger passes two fluids through a series of pipes or fins to transfer heat from one to the other without transferring liquid: A Duocel foam heat exchanger replaces these pipes fins with Duocel ceramic foam to increase surface area and turbulent flow. The ceramic foam's high thermal conductivity also allows for efficient heat transfer.



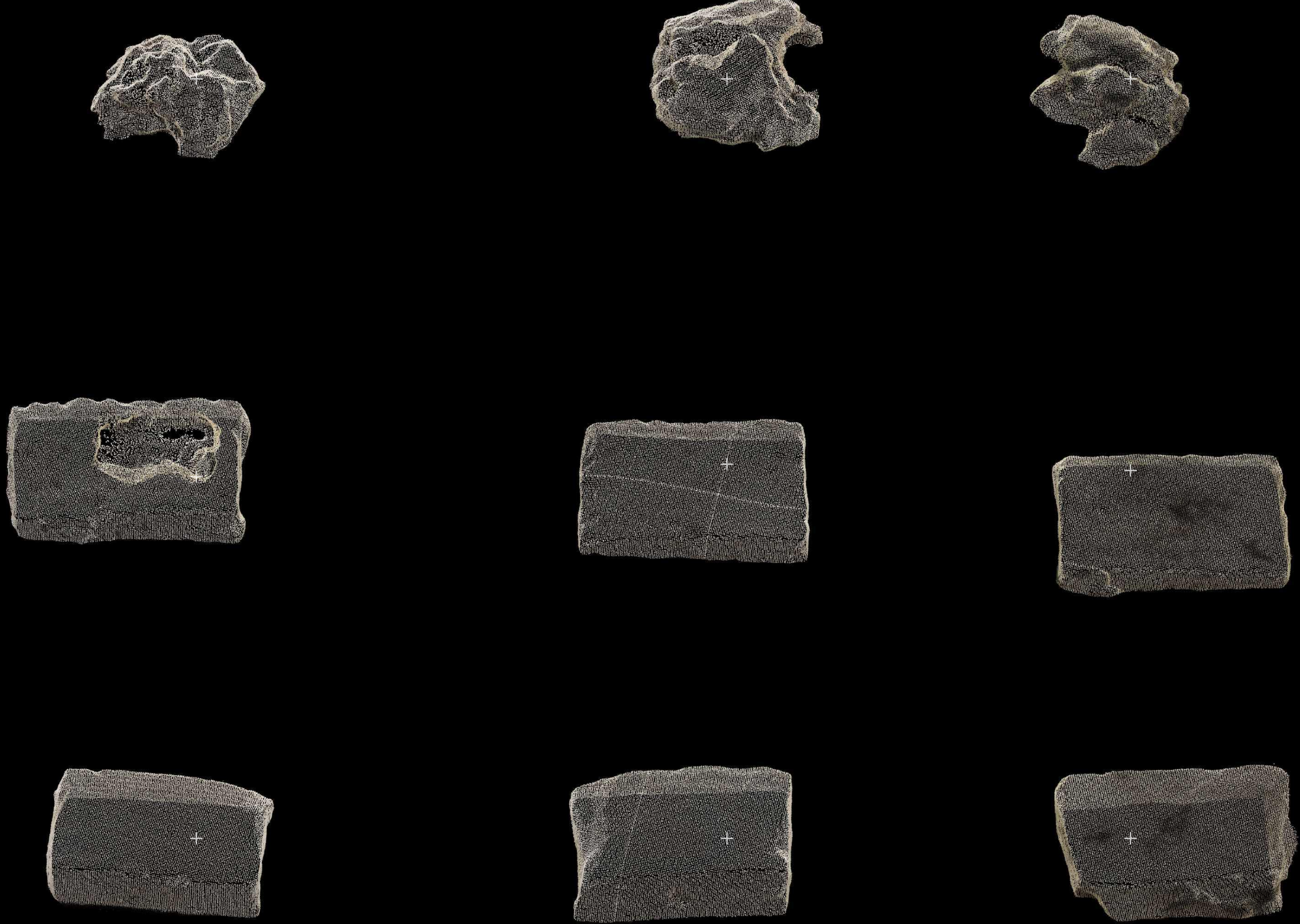



NO COATING | ACRYLIC COATING | BIO PLASTIC COATING

POROSITY 60%

POROSITY 50%

POROSITY 40%

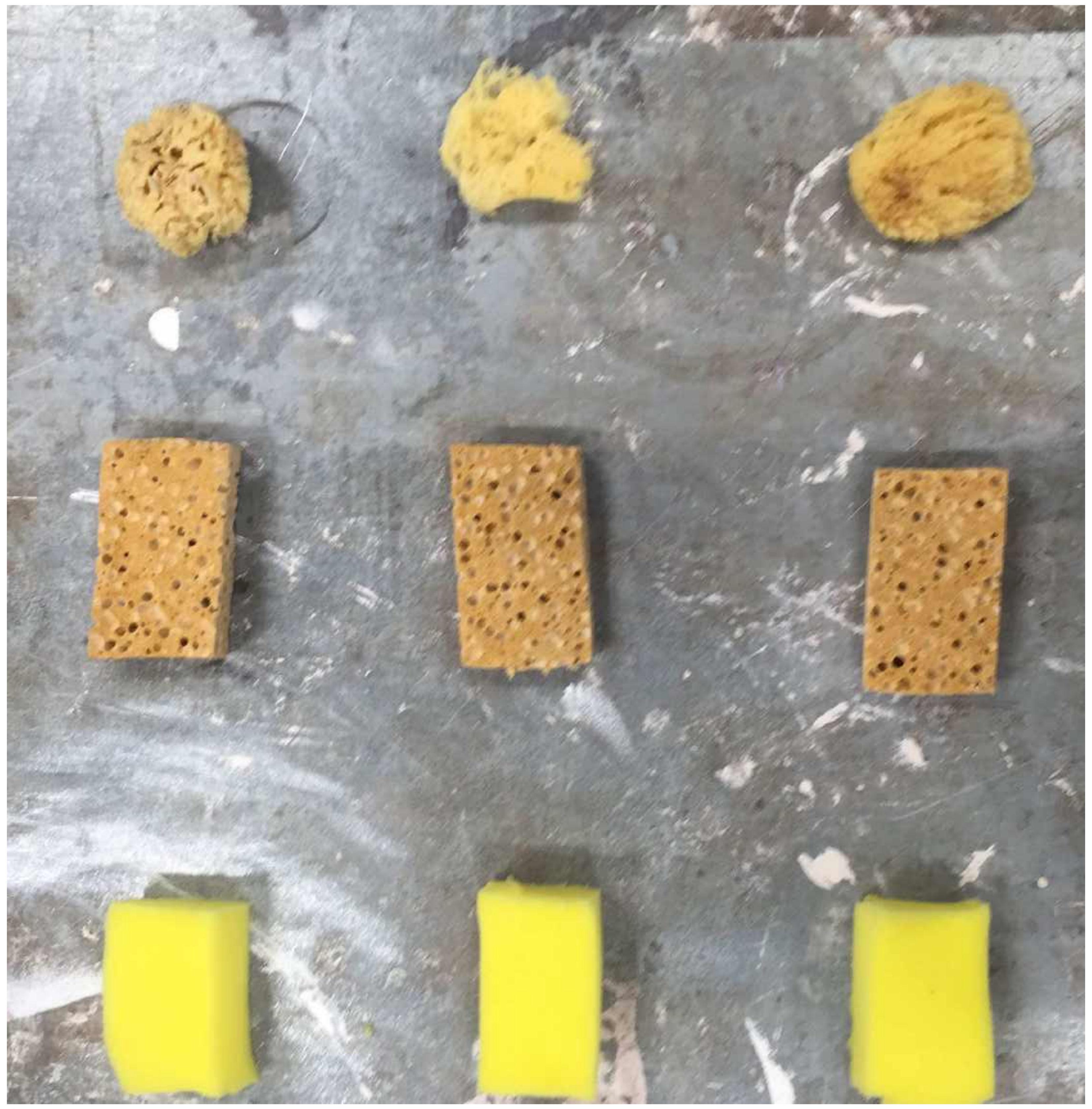


COATED FOAM CERAMICS SAMPLES

Manufactured Prototypes

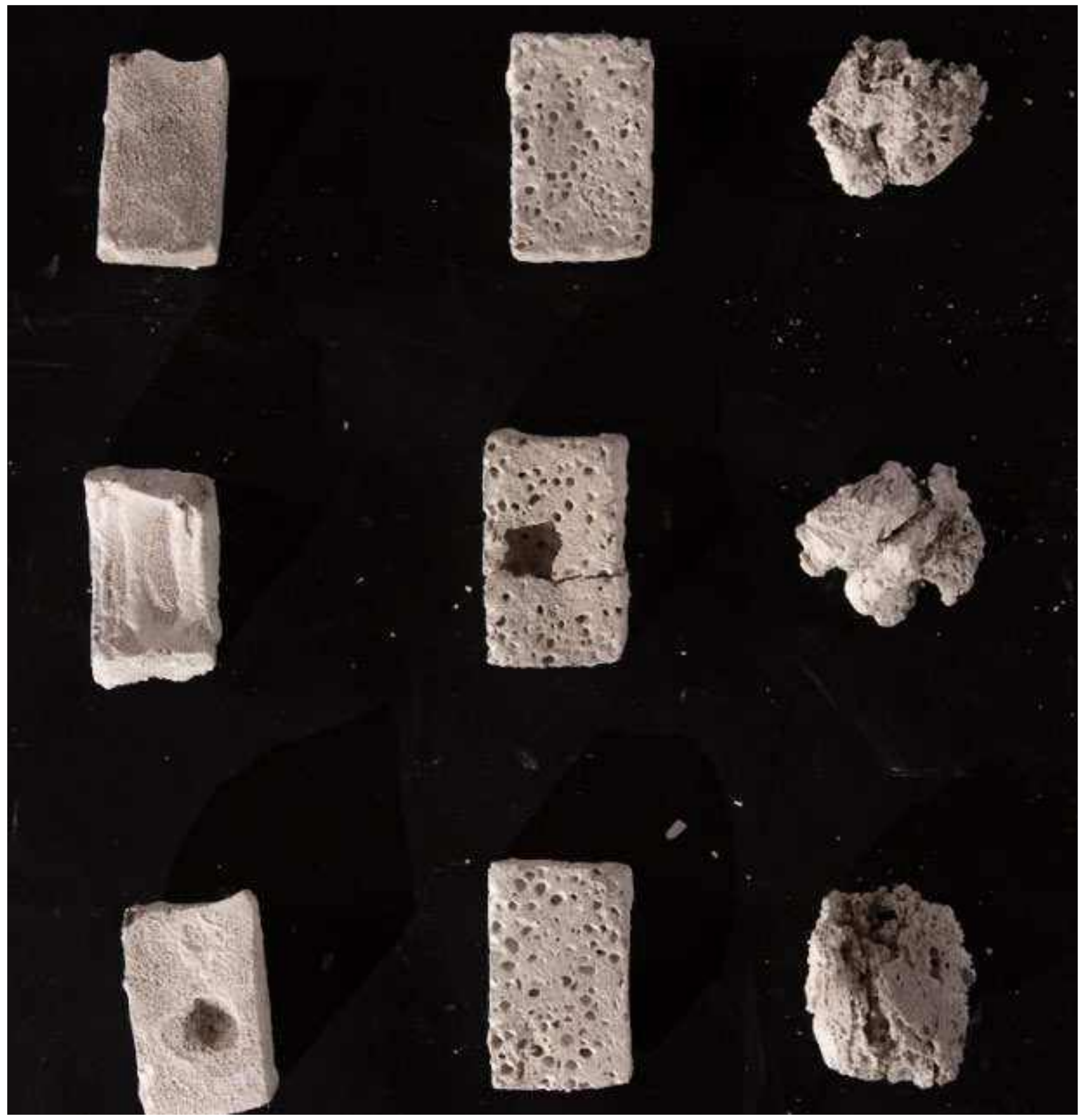
Slip Making and Dipping

Sample Manufacturing



Sponges chosen with different porosities.

Dipped into slip clay.



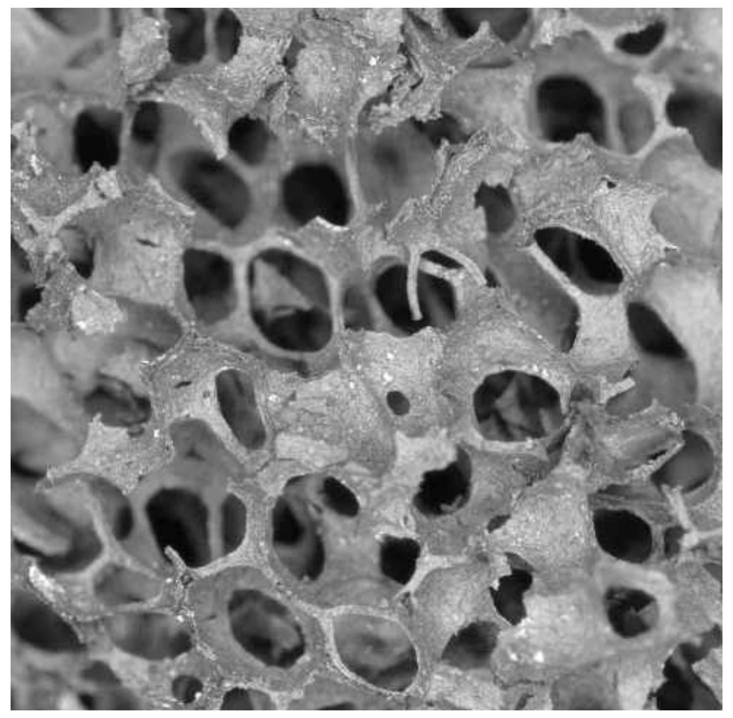
5+ hours of bisque firing.

Failed 1st sample

Propane nozzle did not have enough pressure.
It resulted in low temperatures.

Successful Results

AFTER (under microscope)

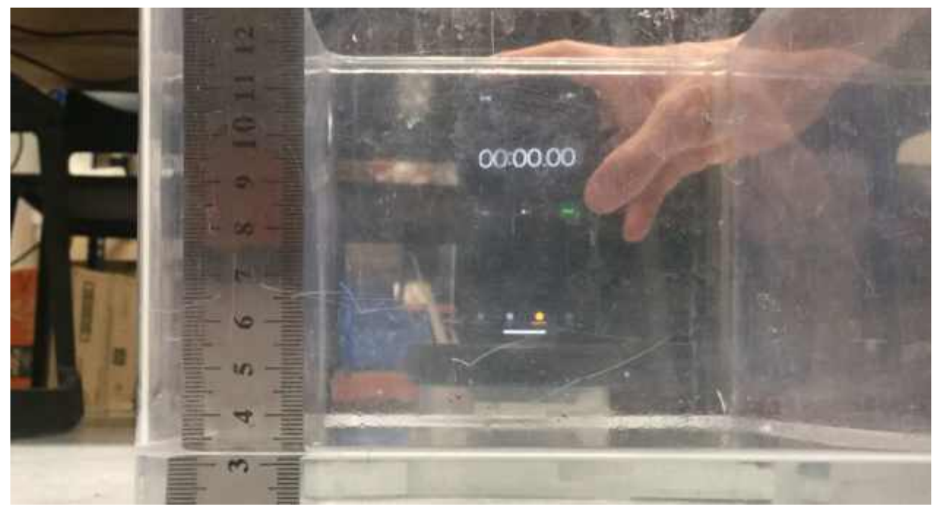


BEFORE (under microscope)

Conclusion

The burn out technique worked well, now we can test and see what use we can have from these materials.

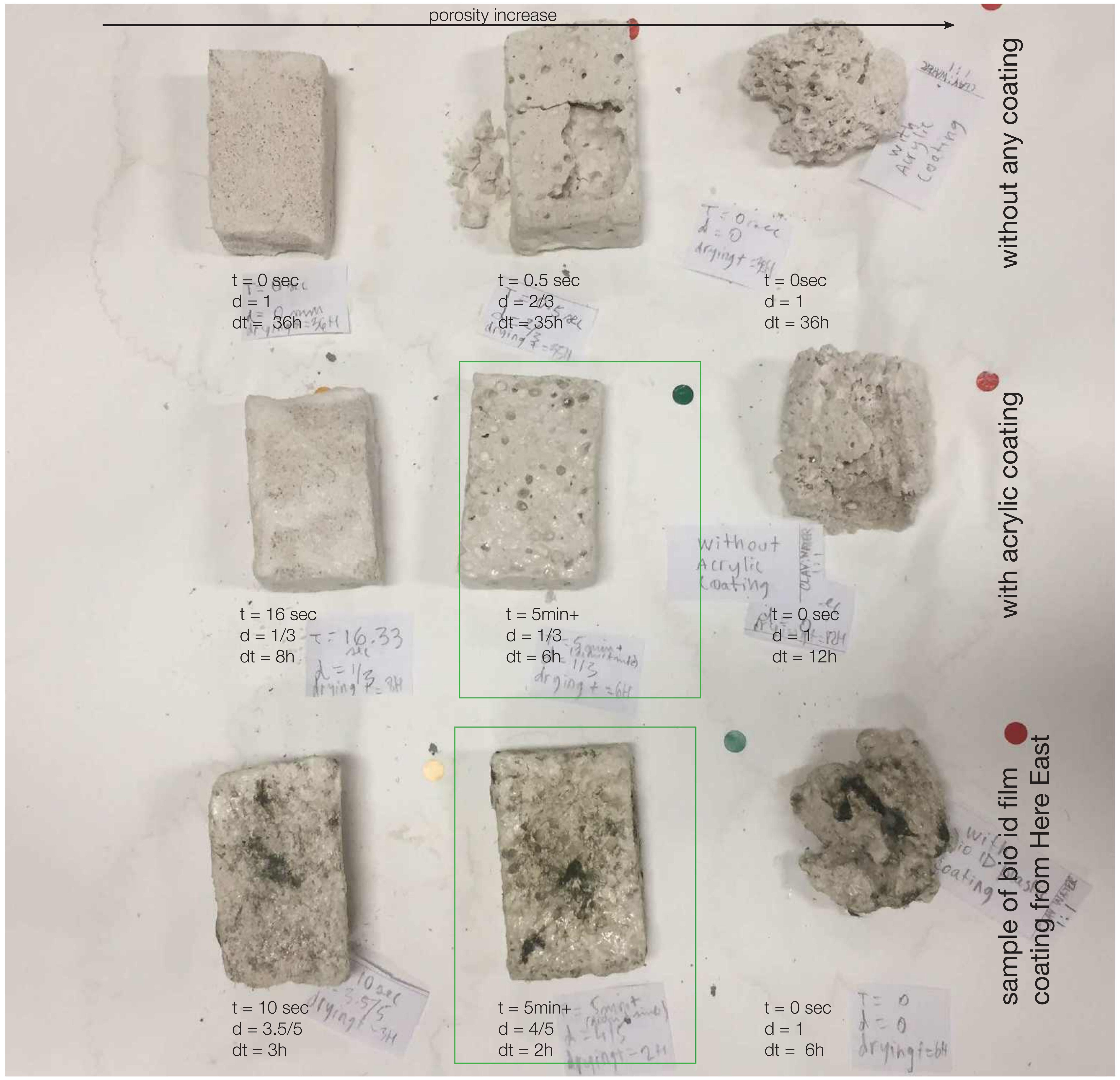
Buoyancy Experiment



The experiment went well for two samples, which will therefore be later used to create a pull buoy and maybe pantoons on inbetween spaces on the bridge.

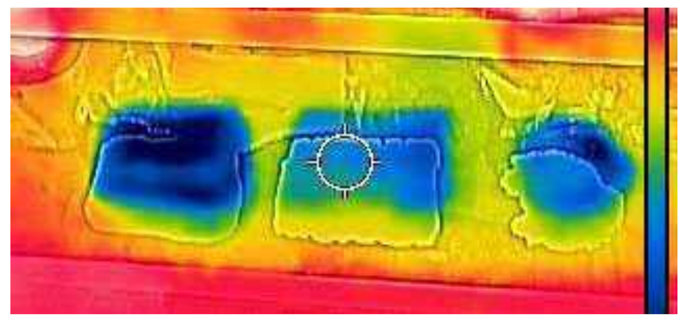
LEGENDS:

t = time afloat
d = depth of sample beneath surface of water
dt = drying time

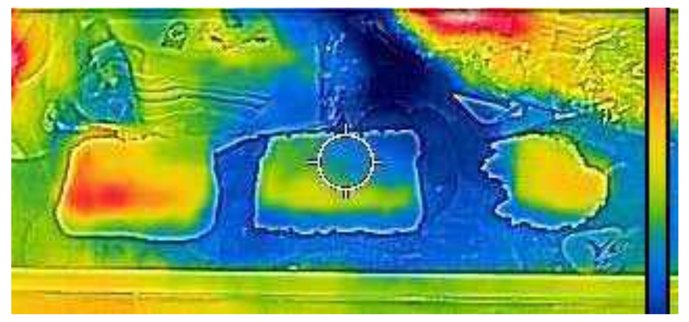


Insulation Experiment

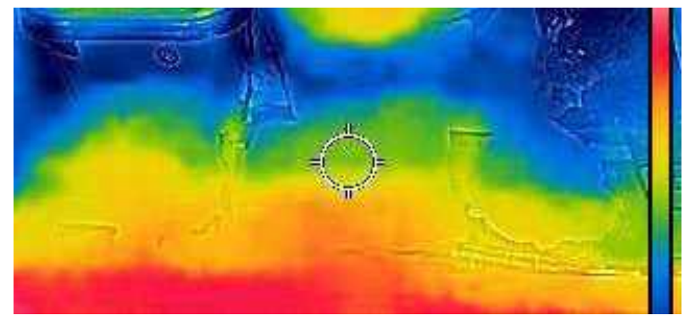
foam ceramics



After 15 min

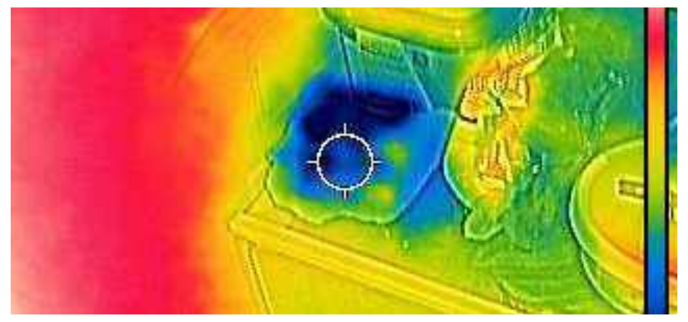


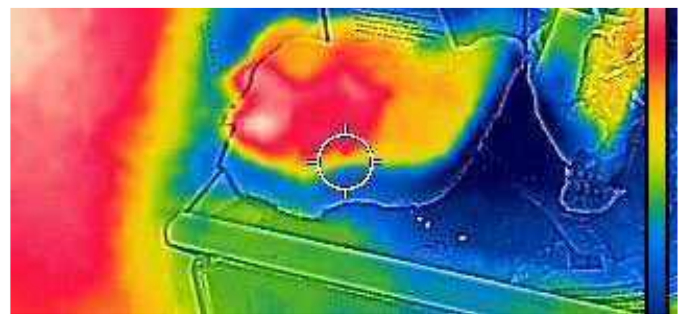
After 30 min

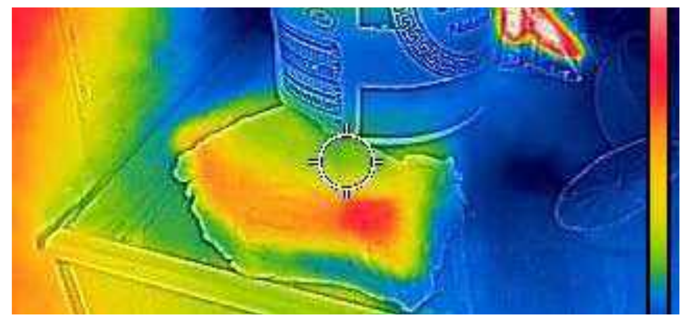


After 1h

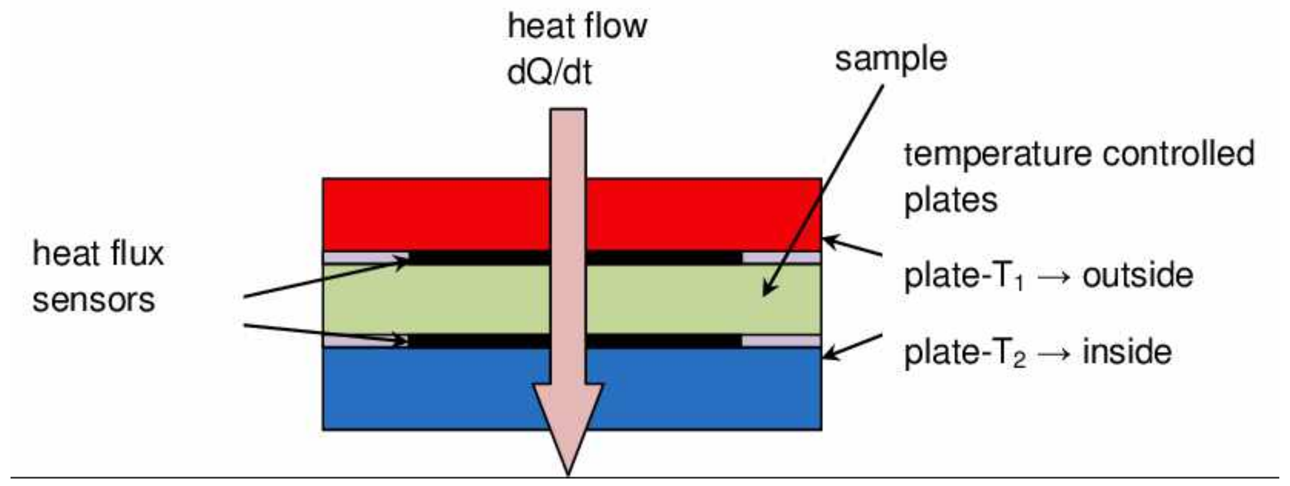
standard insulation







All 4 samples were put in the freezer to reach a stable temperature. Then they were all put in the fridge to see how fast they let heat in. The foam ceramics reached the fridge temperature much faster than the standard insulation which was predictable.
It can be used but will need to be much thicker than standard, or can help out to be put in cracks and stay there for longer than standard insulation.



freezer

Fridge

Loading Experiment

Coating

All the samples are extremely brittle, and can withstand a force only with a coating.

Shape Building

Having defined the material, the shape can be changed and manufactured. Bits of sponge were pushed into a slip casting mold. Two techniques were tried, where one was break the sponge first and the other push it in.

Technique 1 (2 steps)

Technique 2 (1 step)

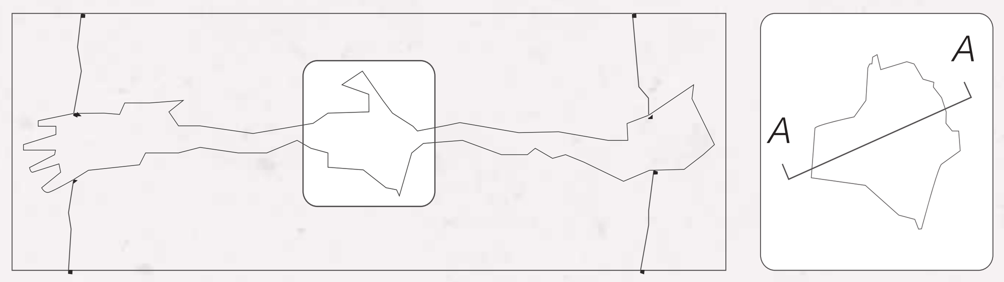
shape 1 pre fire

shape 2 pre fire

shape 2 post fire

shape 2 post fire

In conclusion the mold burn out shaping worked well, and next time the consistency of the sponge to slip ratio will need to be more carefuly monitored.



1-inner foam ceramics insulating membrane

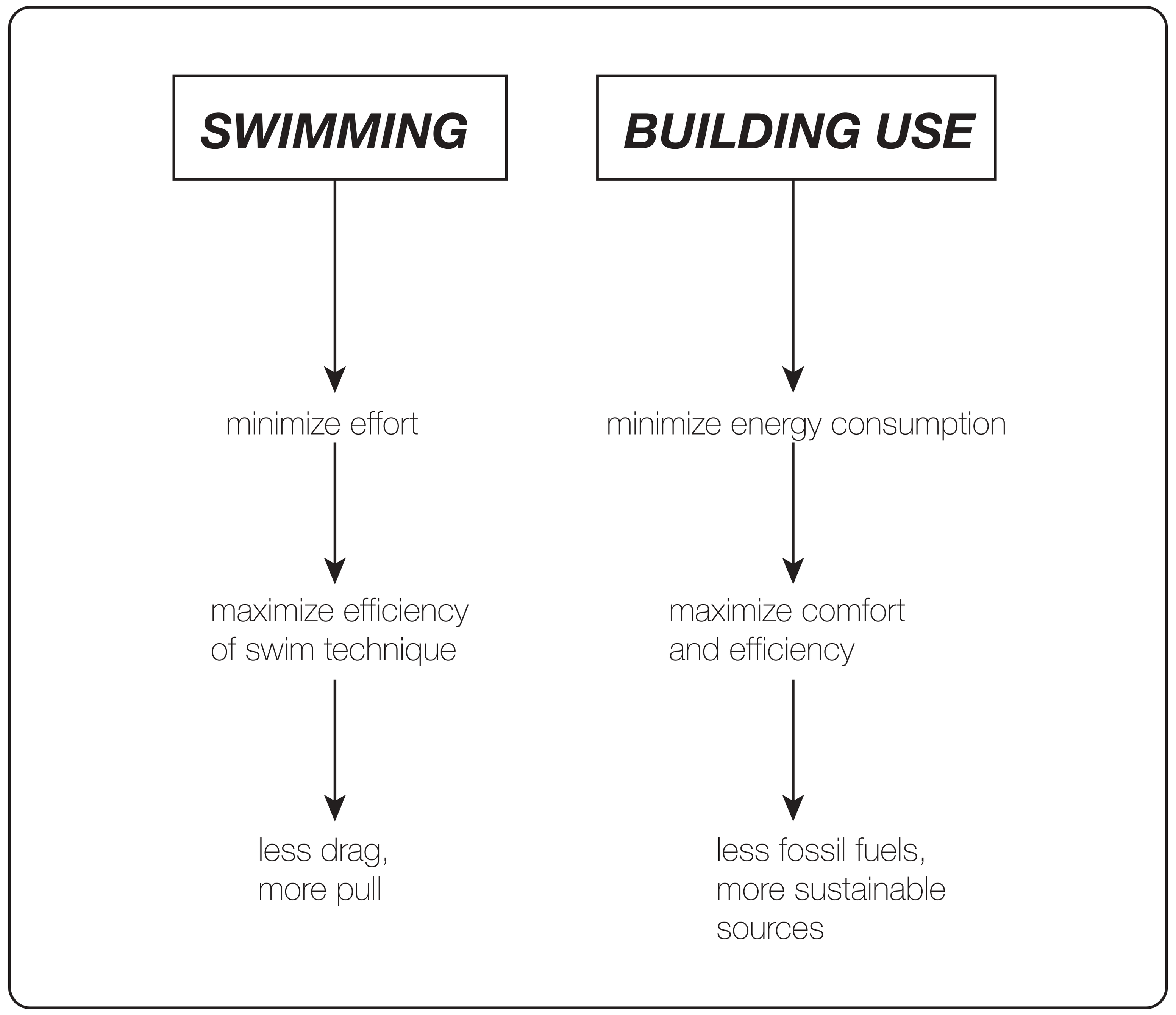
2-floating ceramics for balance and arrival and departures

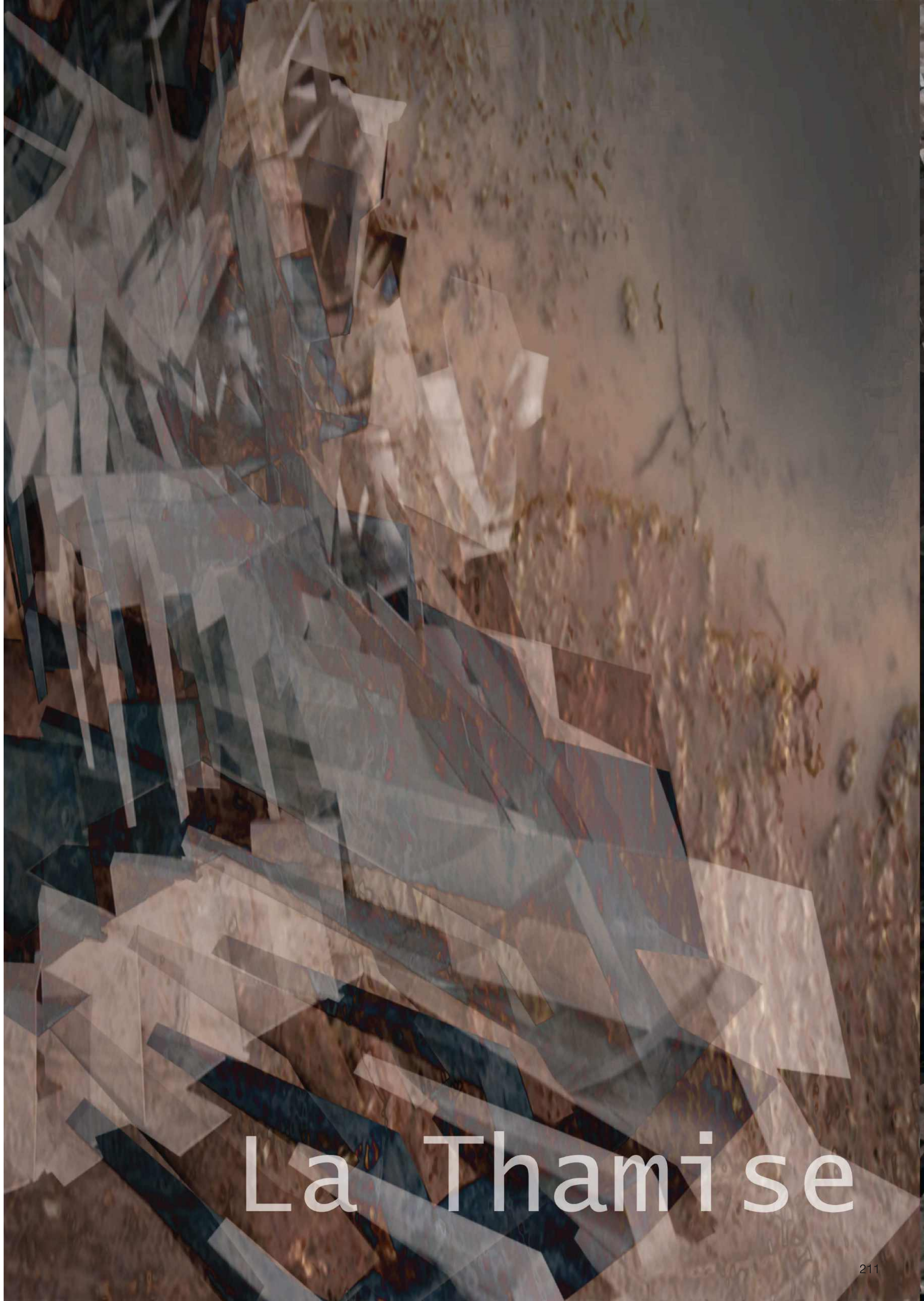
1:50 on A1 *4m*

Section 11. Passive Measures: Swimming

Despite its incomplete nature, this section is necessary for the project and its overall picture as a whole. Swimming was looked into as an activity for both the body and the soul: its main driving factor is that the person swims by maximising the power and minimising the effort. This was mainly to be used as an analogy to passive environmental measures. Unfortunately, it was only carried out in depth on a three dimensional scanning aspect: the body – which was me – was scanned using photogrammetry and a handheld scanner, it became a project in itself. It is something that I would call an architectural scanning folie, or folly.

Minimizing Energy and Maximizing Pull



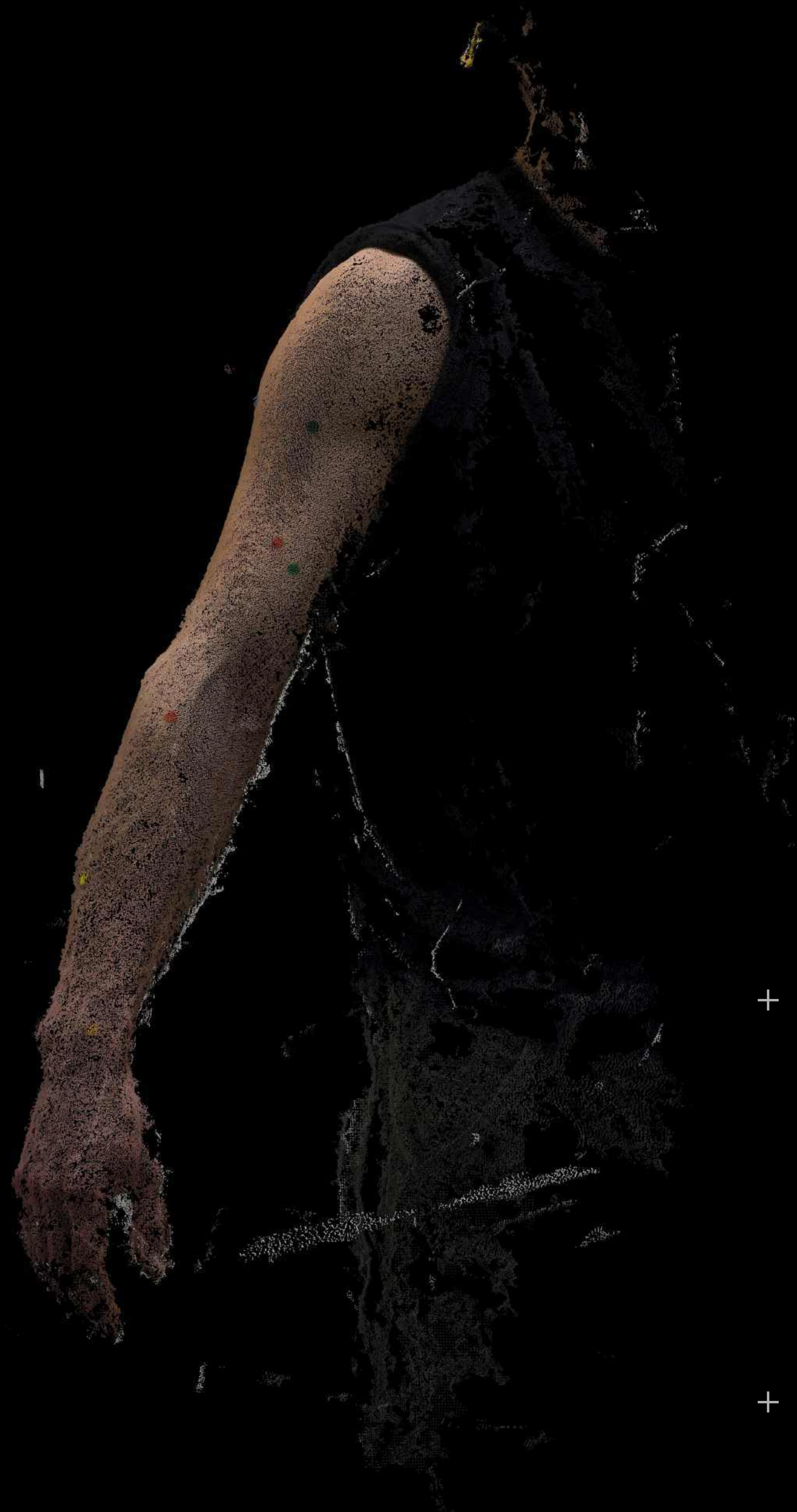


3D Scanning

BODY

front

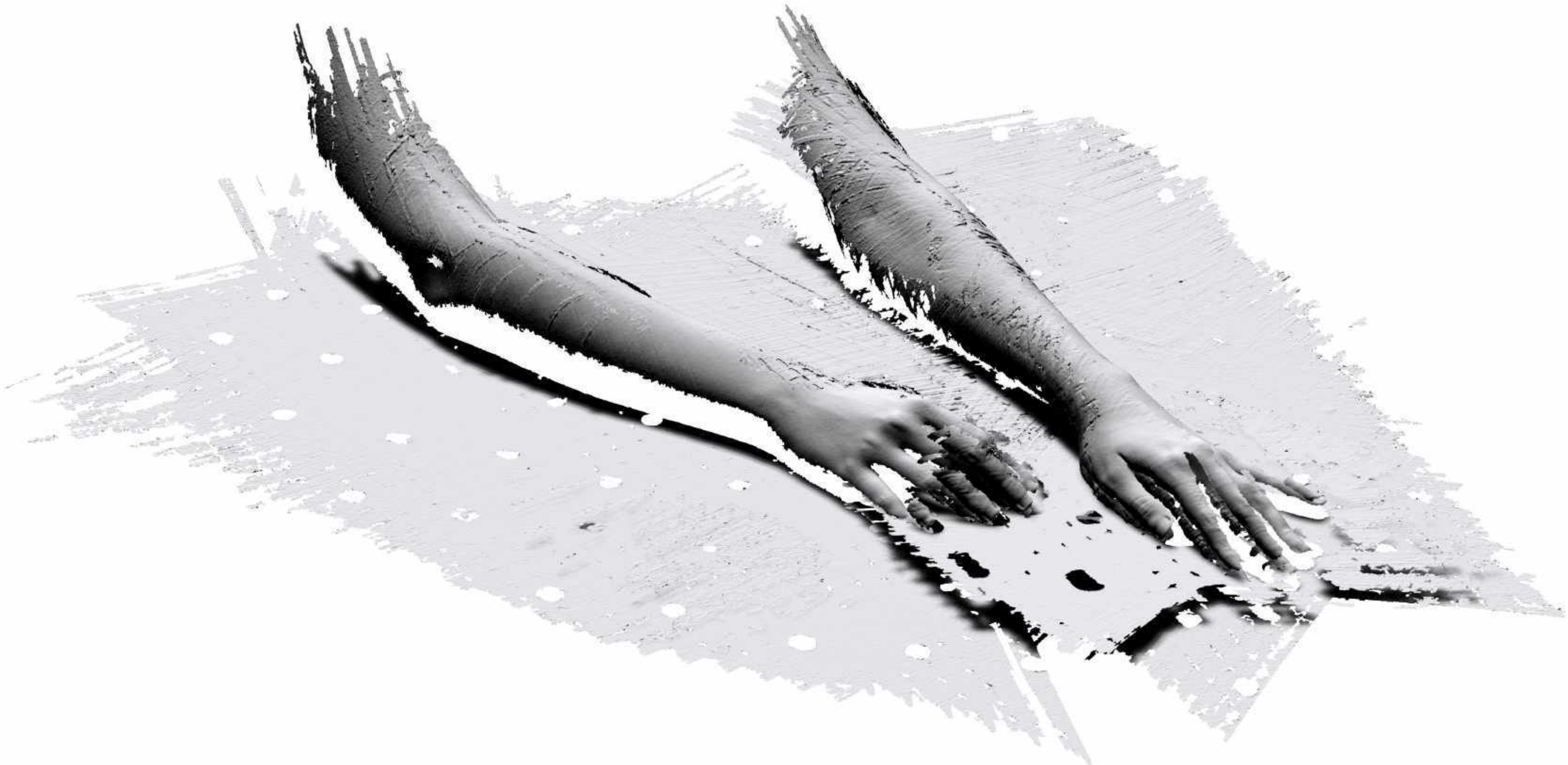
top



ARM

front

top



right

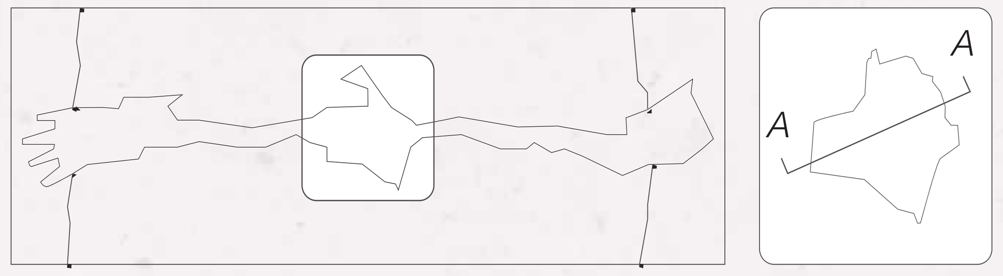
top

TWO ARMS

right

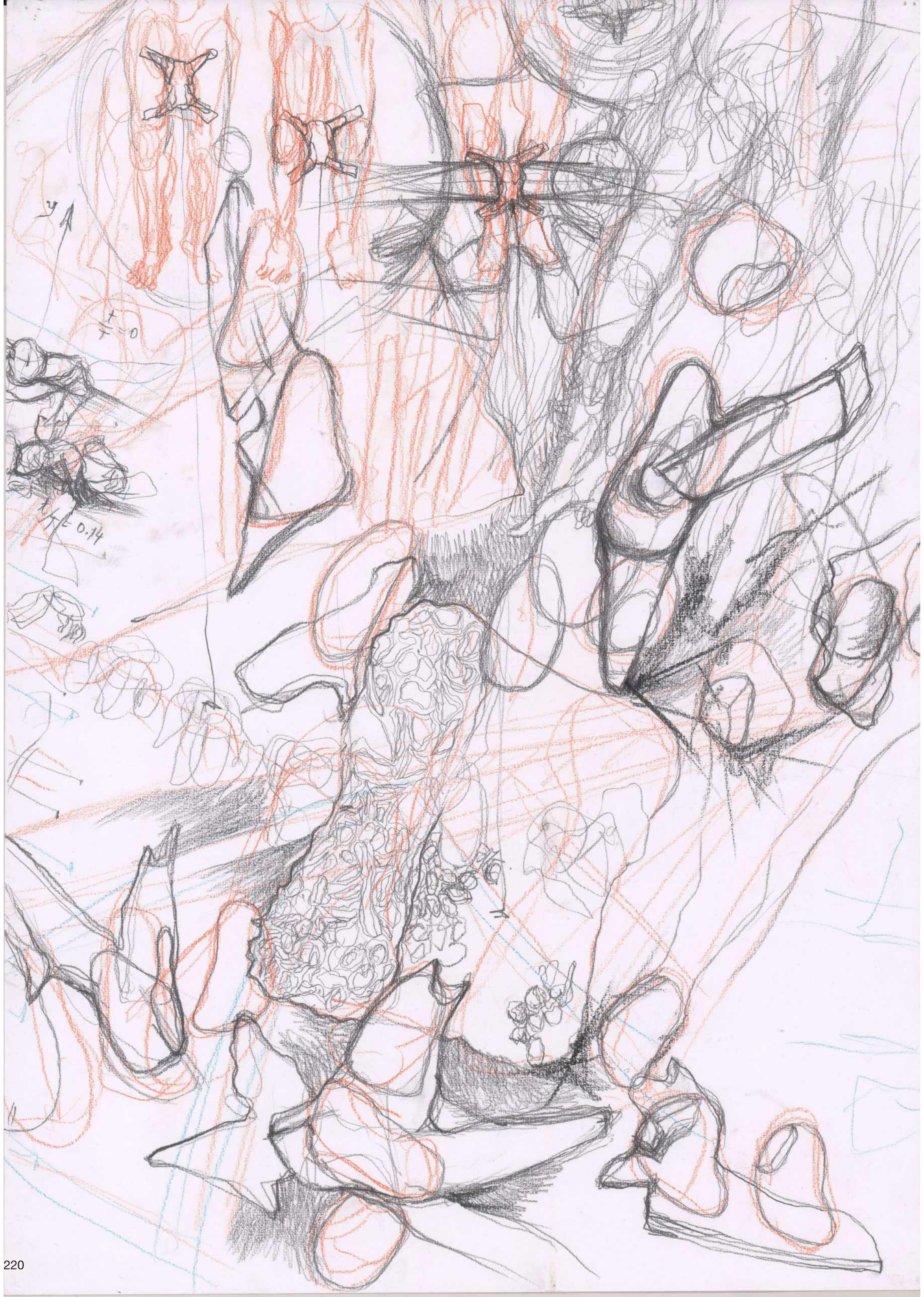
top

LEG



1. Delivering the art through swimming

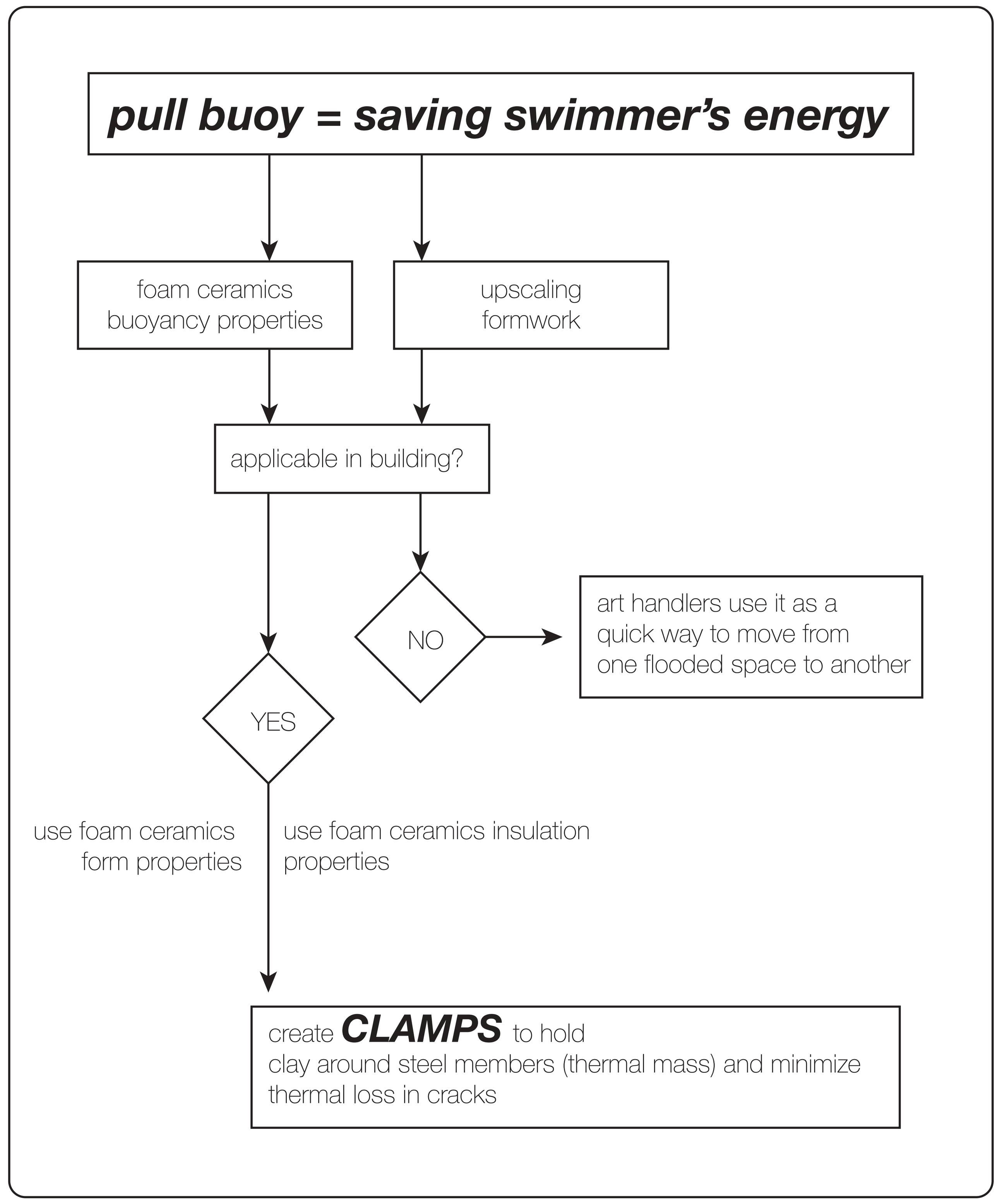
1:50 on A1 4m



Section 12. Fragment Design: Device

Continuing with swimming, the fragment design was based on a device that was linked to swimming. A device that would help people in the water as it contained the elements of buoyancy and relating to section 10, the swimming device would be created with the foam ceramics that would be upscaled. Then there would be a building fragment, a clamp to hold the clay coatings surrounding the metal. One of the techniques used would be the burnout technique in accordance with slip casting, which would non-conformist geometries that are still produced in a controlled manner. I found it very important that it related to the strain test, and the swimming device can be looked as another project within a project, closely interlinked with section 11, passive measures: swimming, as well as section 10 concerning foam ceramics.

Device to Building Detail



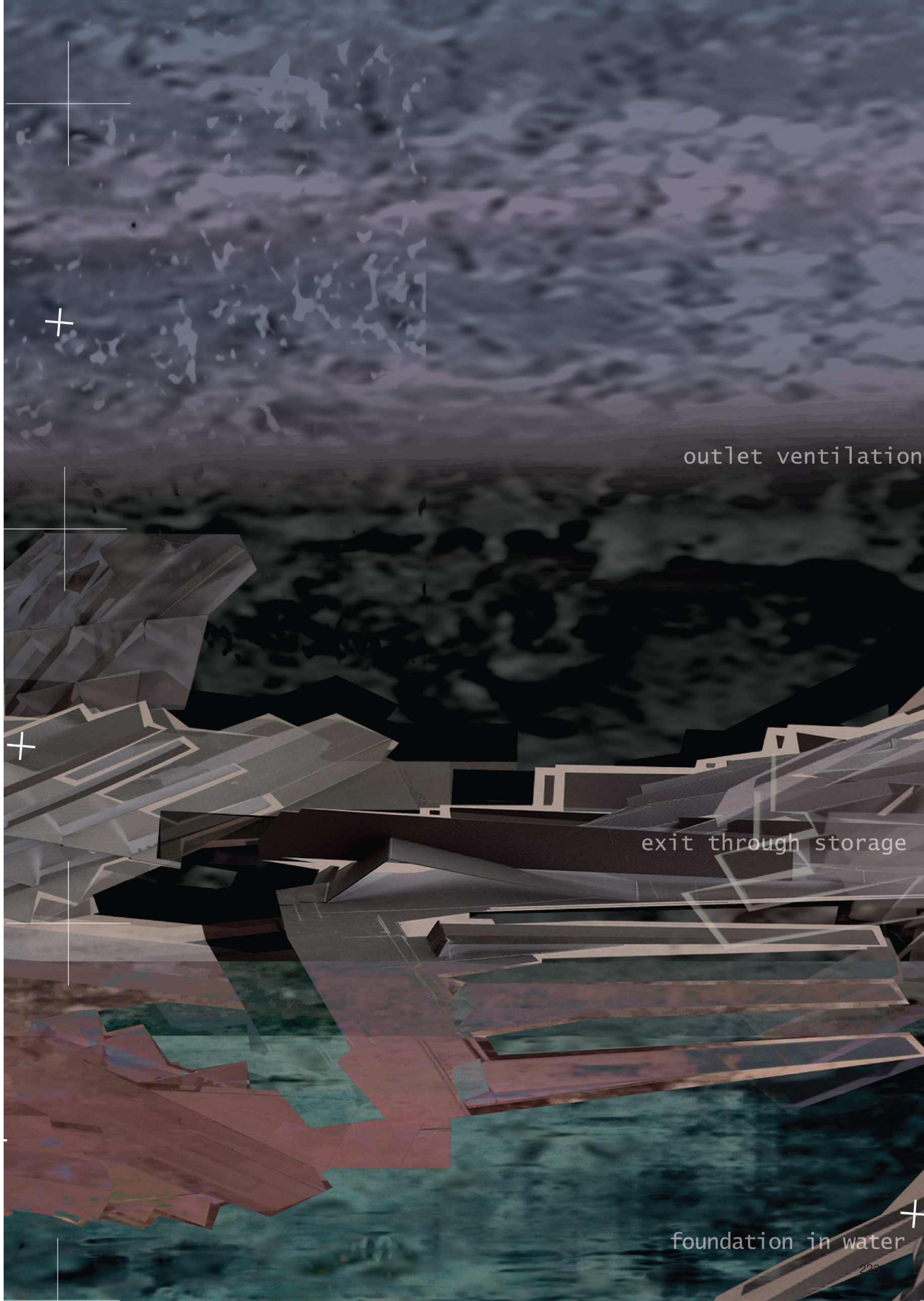


Figure 12.1

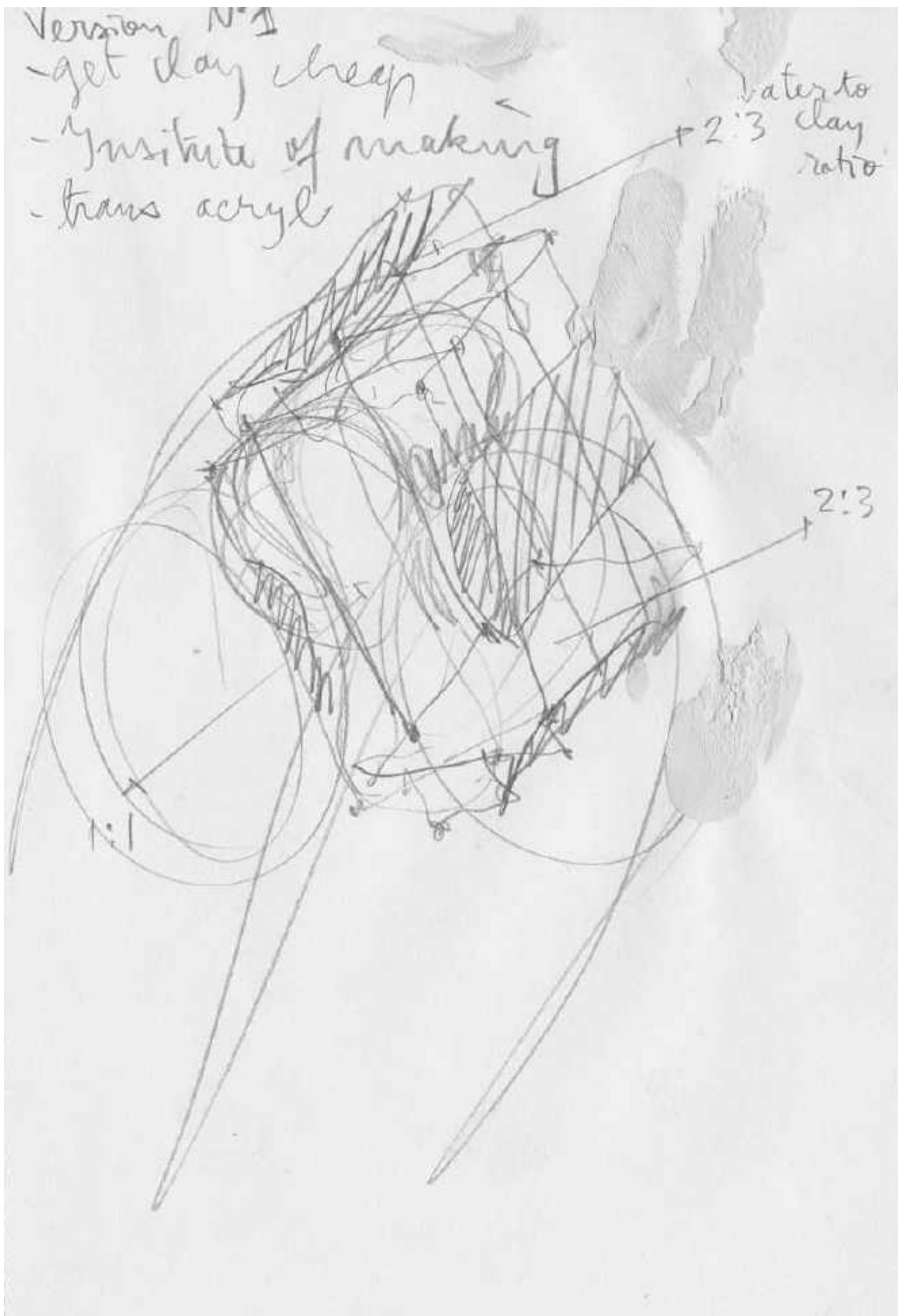


Figure 12.2

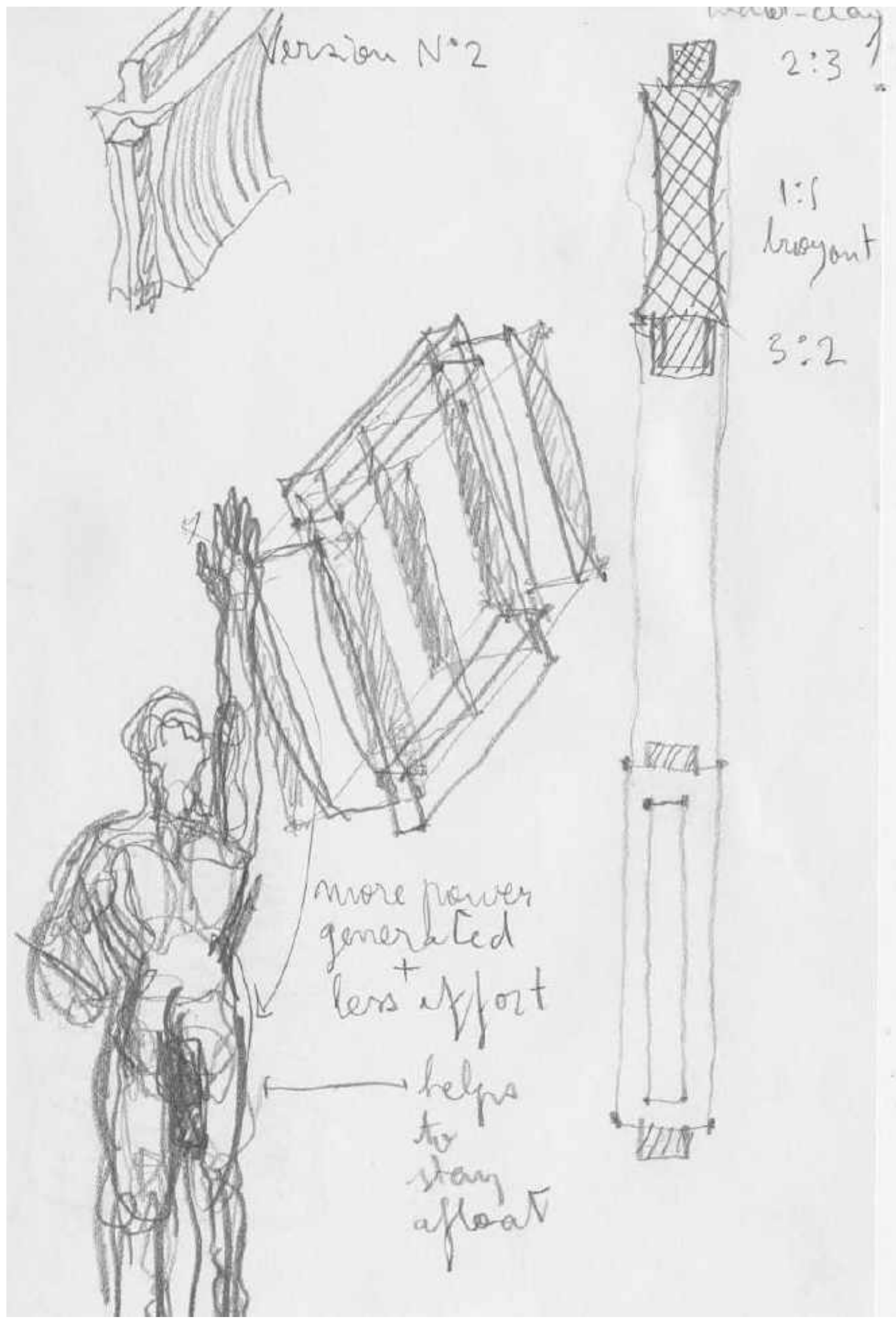


Figure 12.3

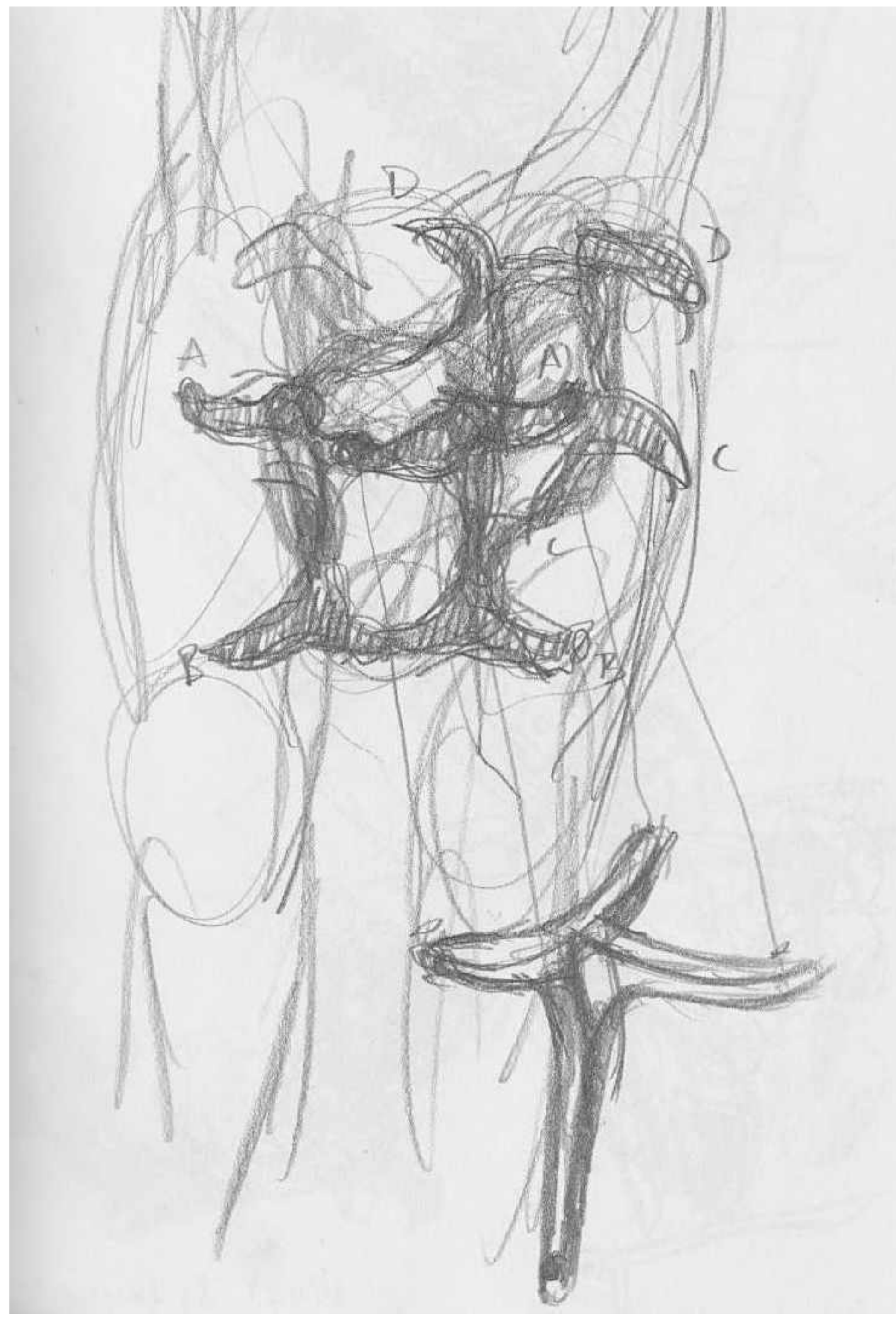


Figure 12.4

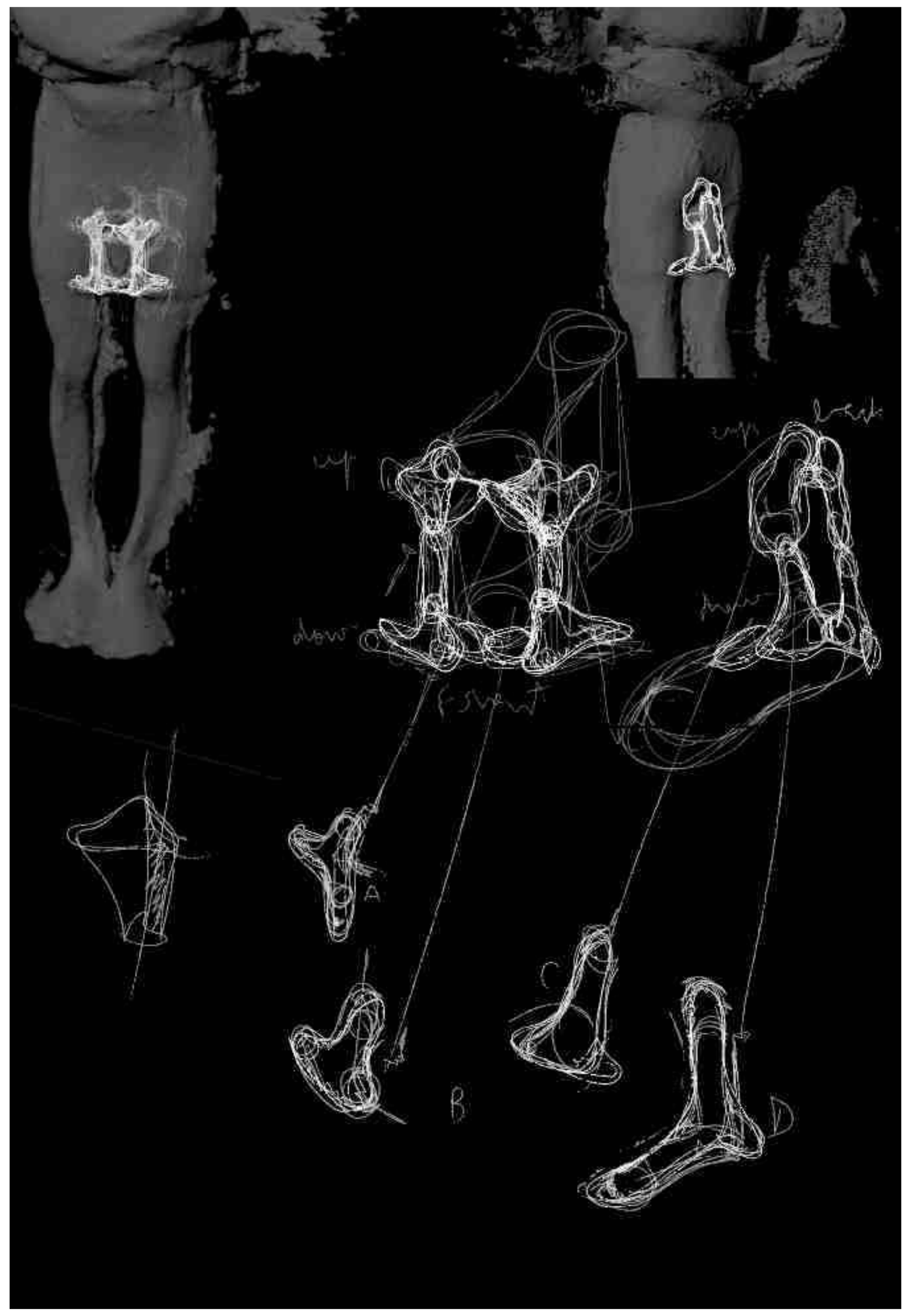
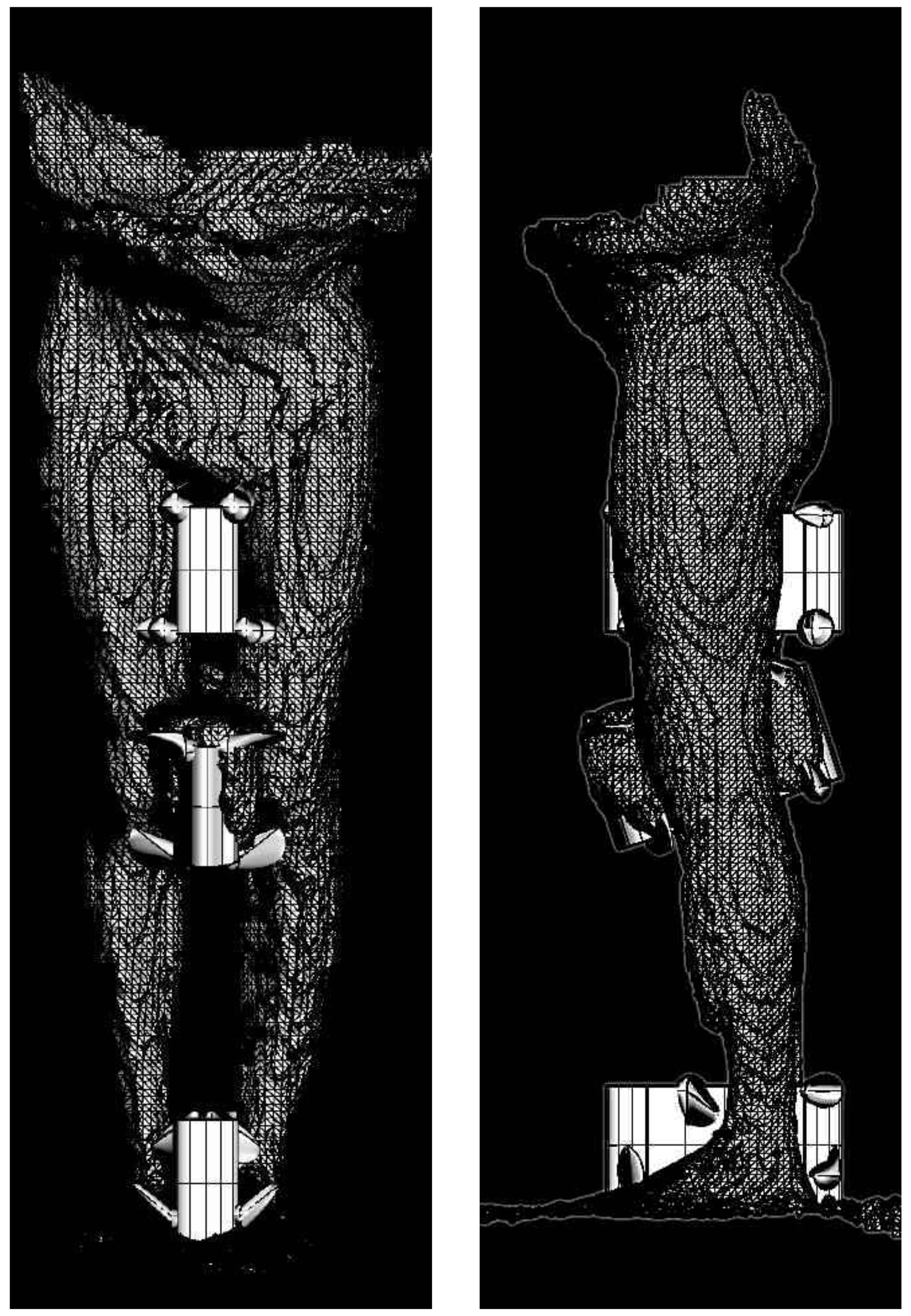


Figure 12.5



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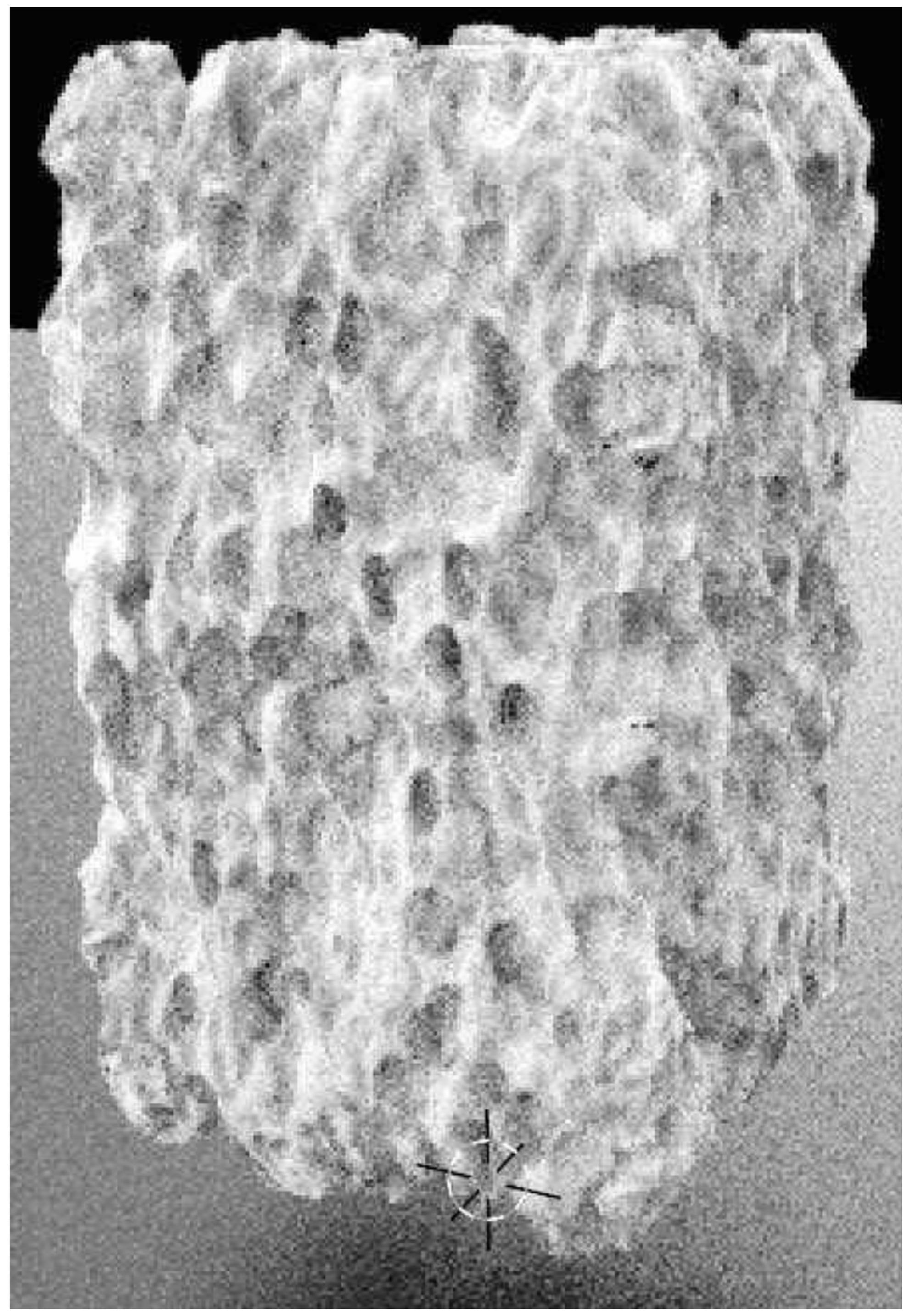


Figure 12.7

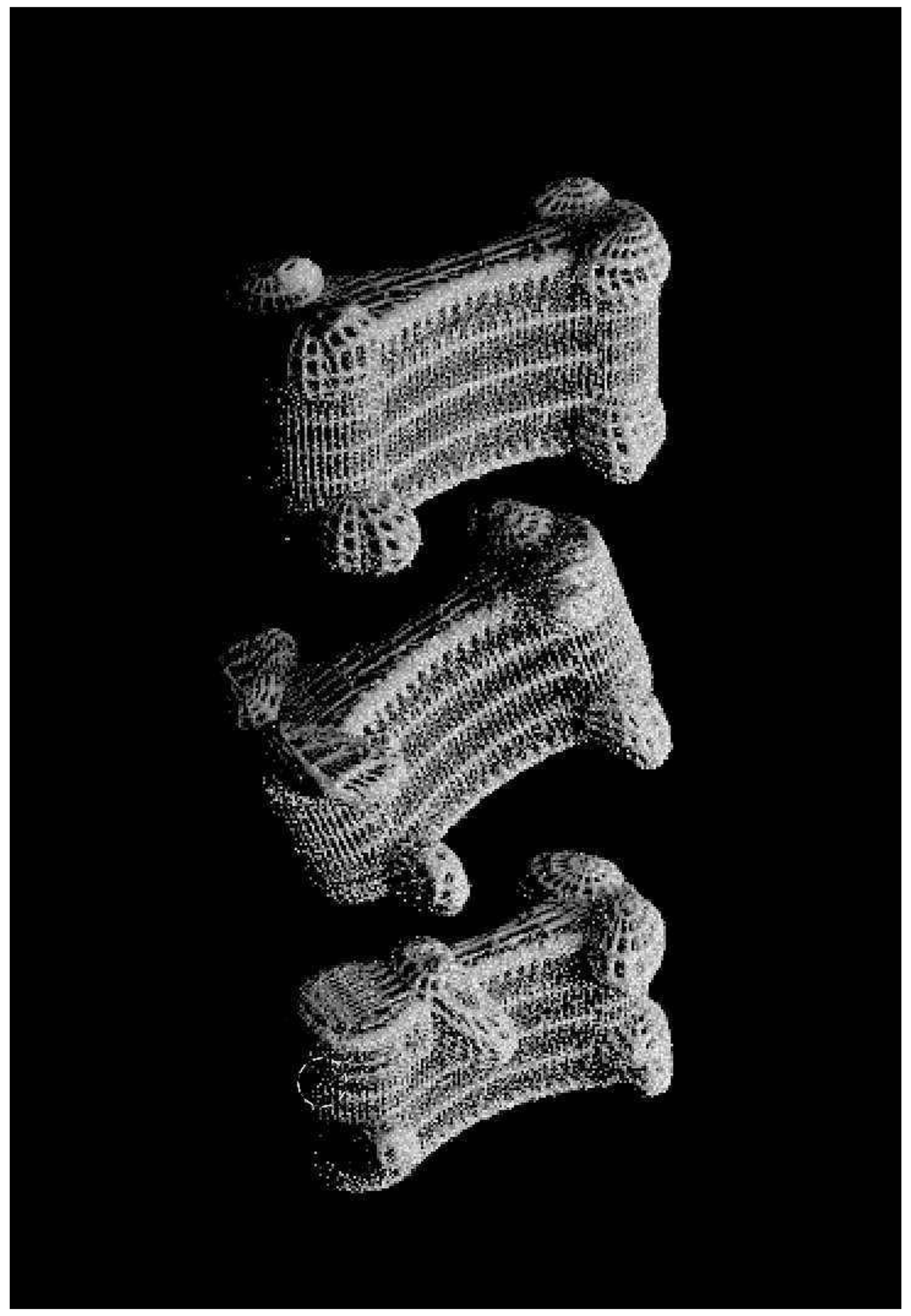
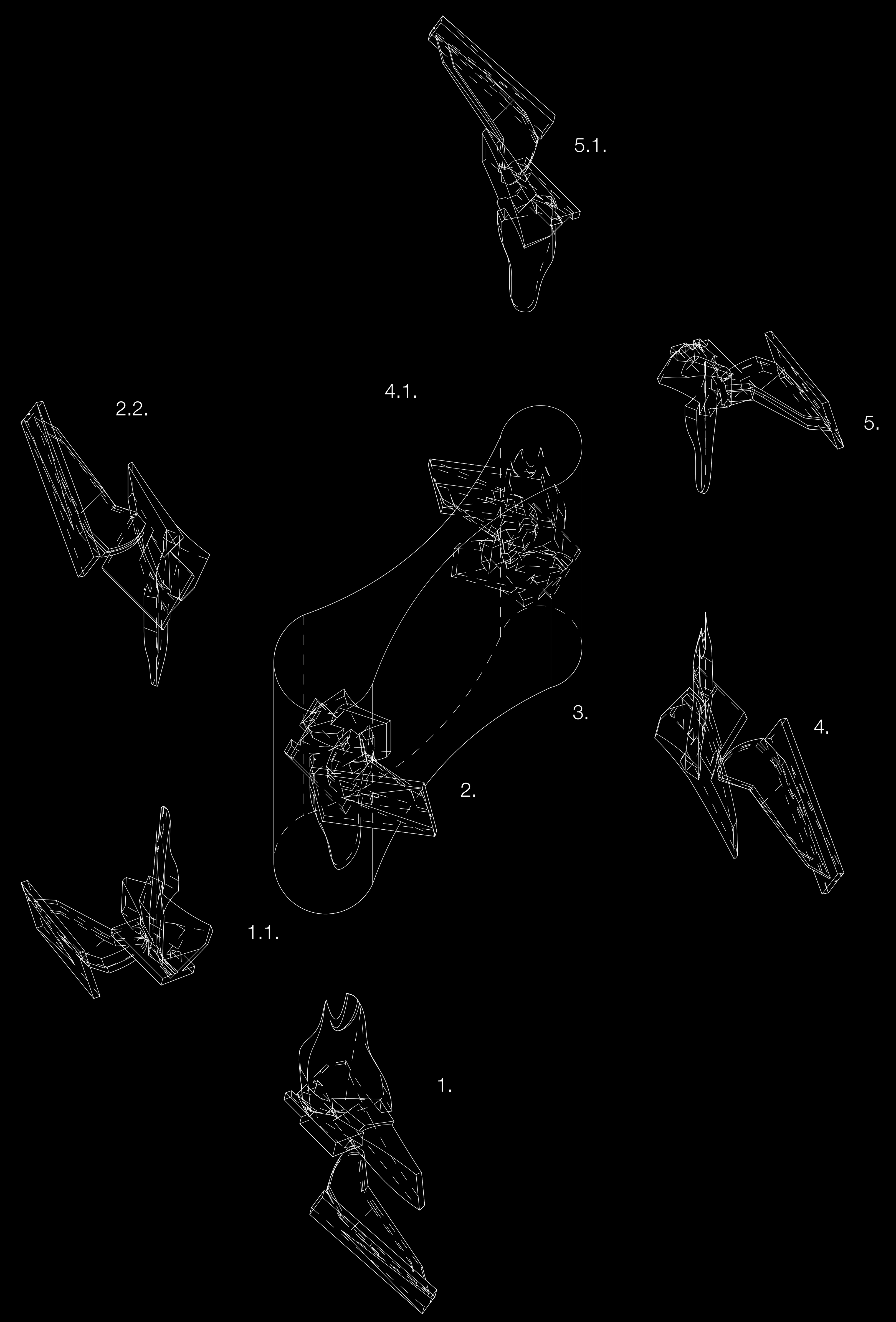


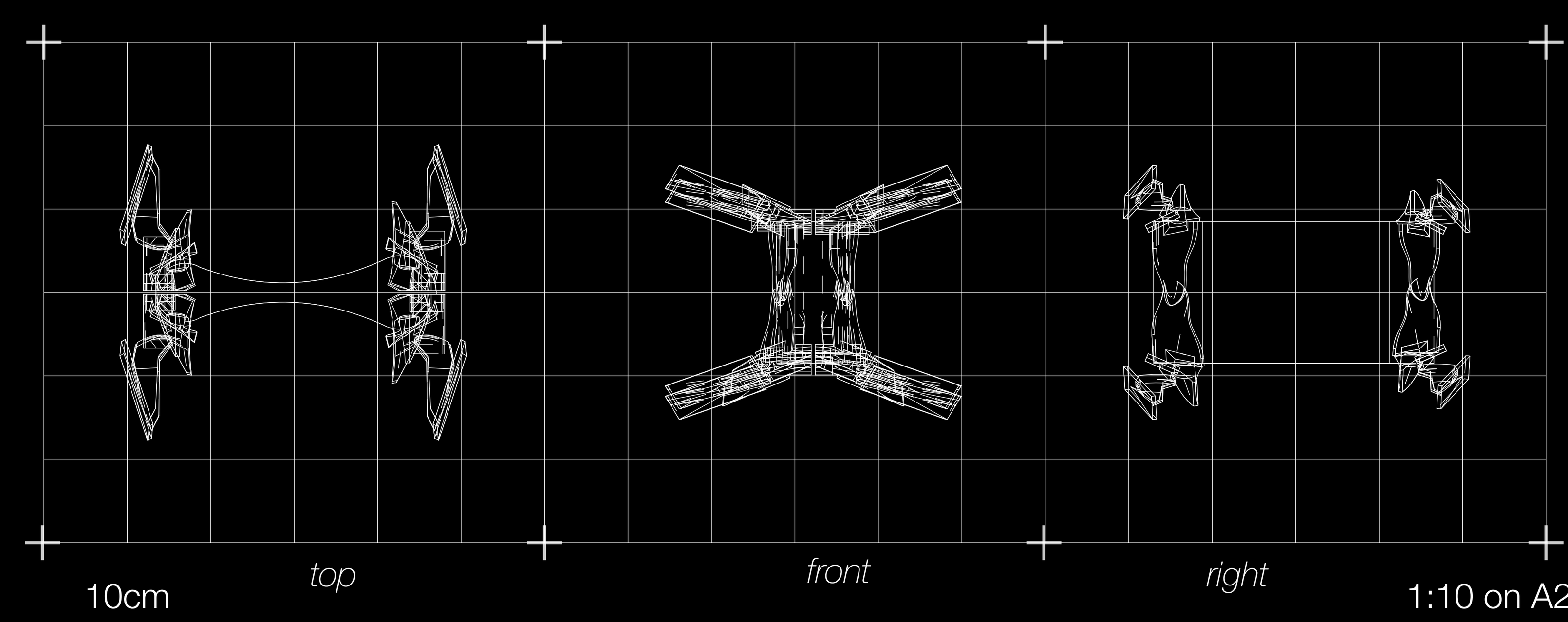
Figure 12.8

After doing preliminary sketches (fig.1 to 4), I was able to model versions of a personalized pull buoy that would fit my legs in different positions using an ipad scan of my legs (fig. 5 and 6).

To model the desired foam clay, Blender was used as well as Voronoy texxtures (fig.7 and 8). It was a way to visualise the design before manufacturing it.

Upscaling



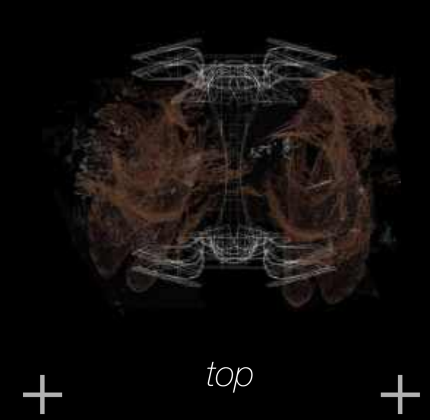


1. Top front adjusters
2. Bottom front adjusters
3. Pull buoy
4. Bottom back adjusters
5. Top back adjusters

1:2 on A2


LEGS and SWIMMING DEVICE

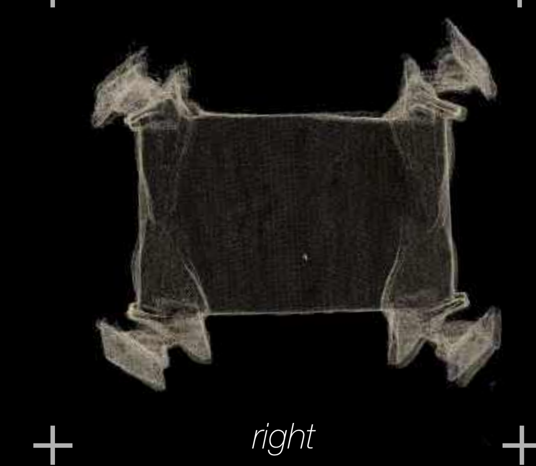
front



top

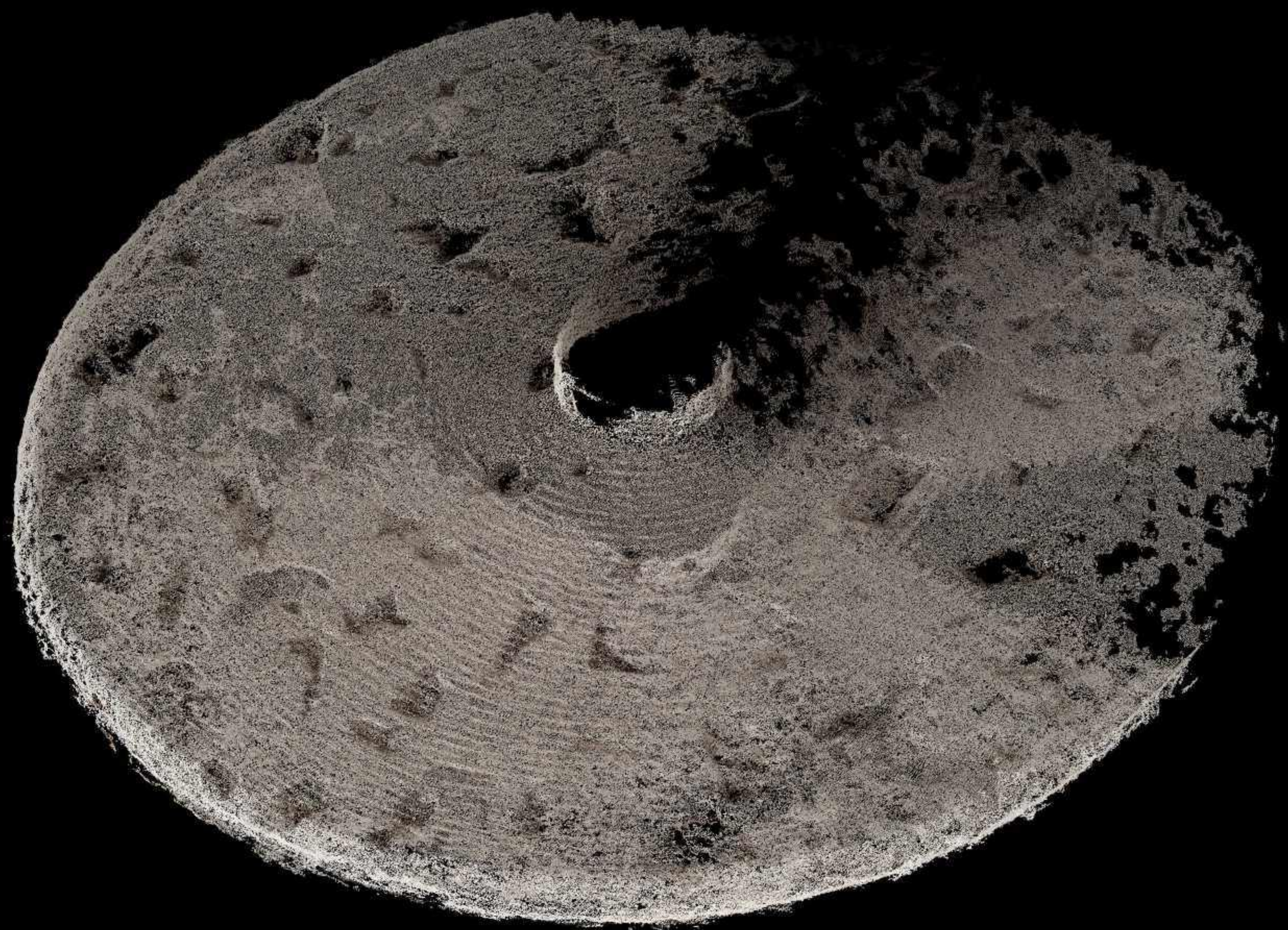
SWIMMING DEVICE

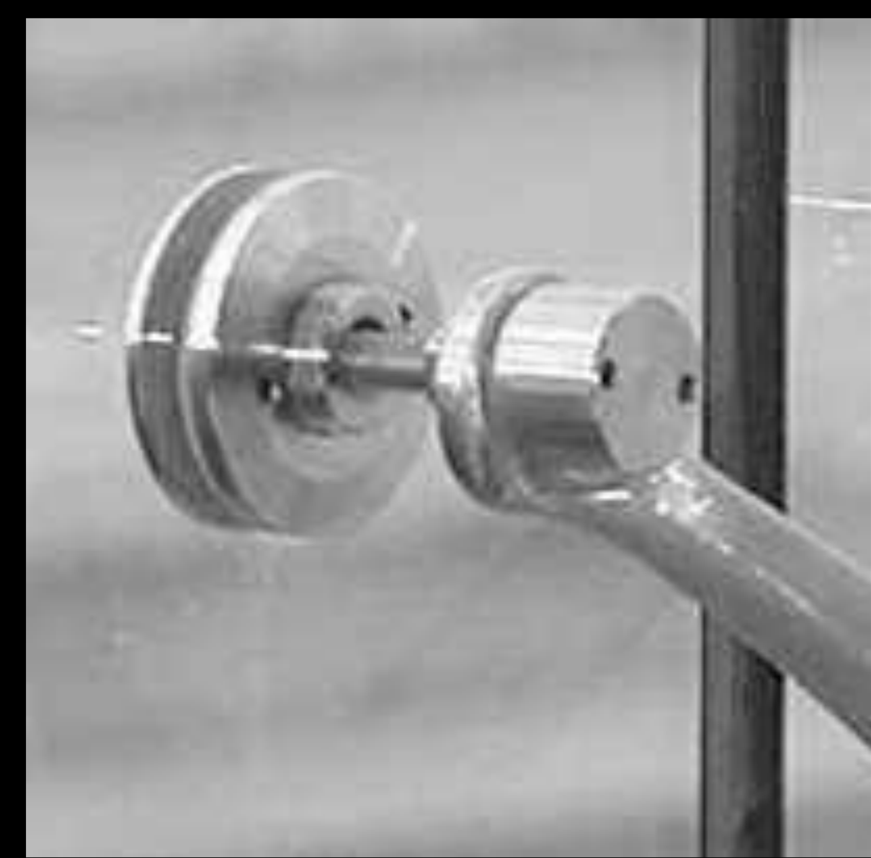
top

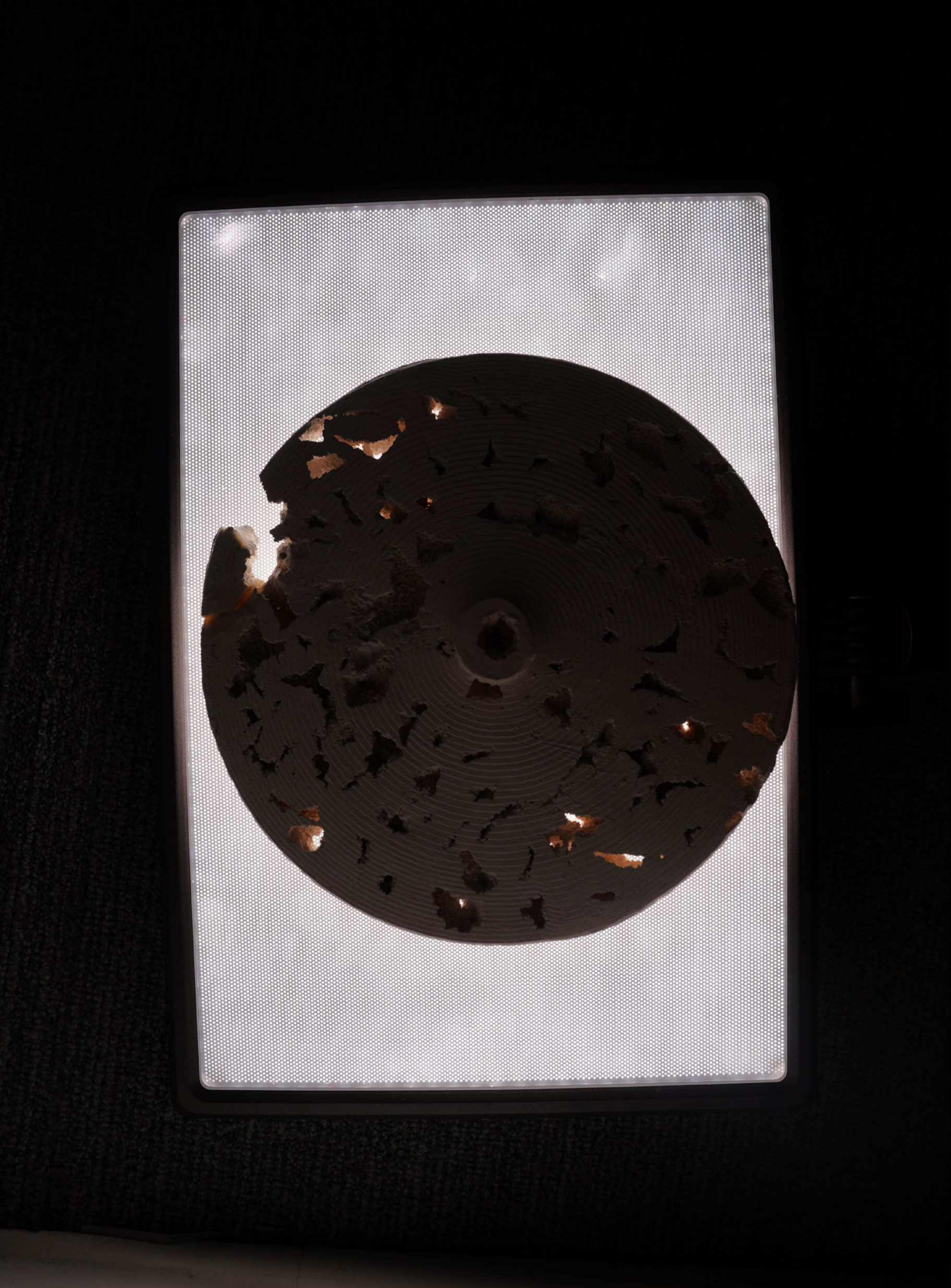


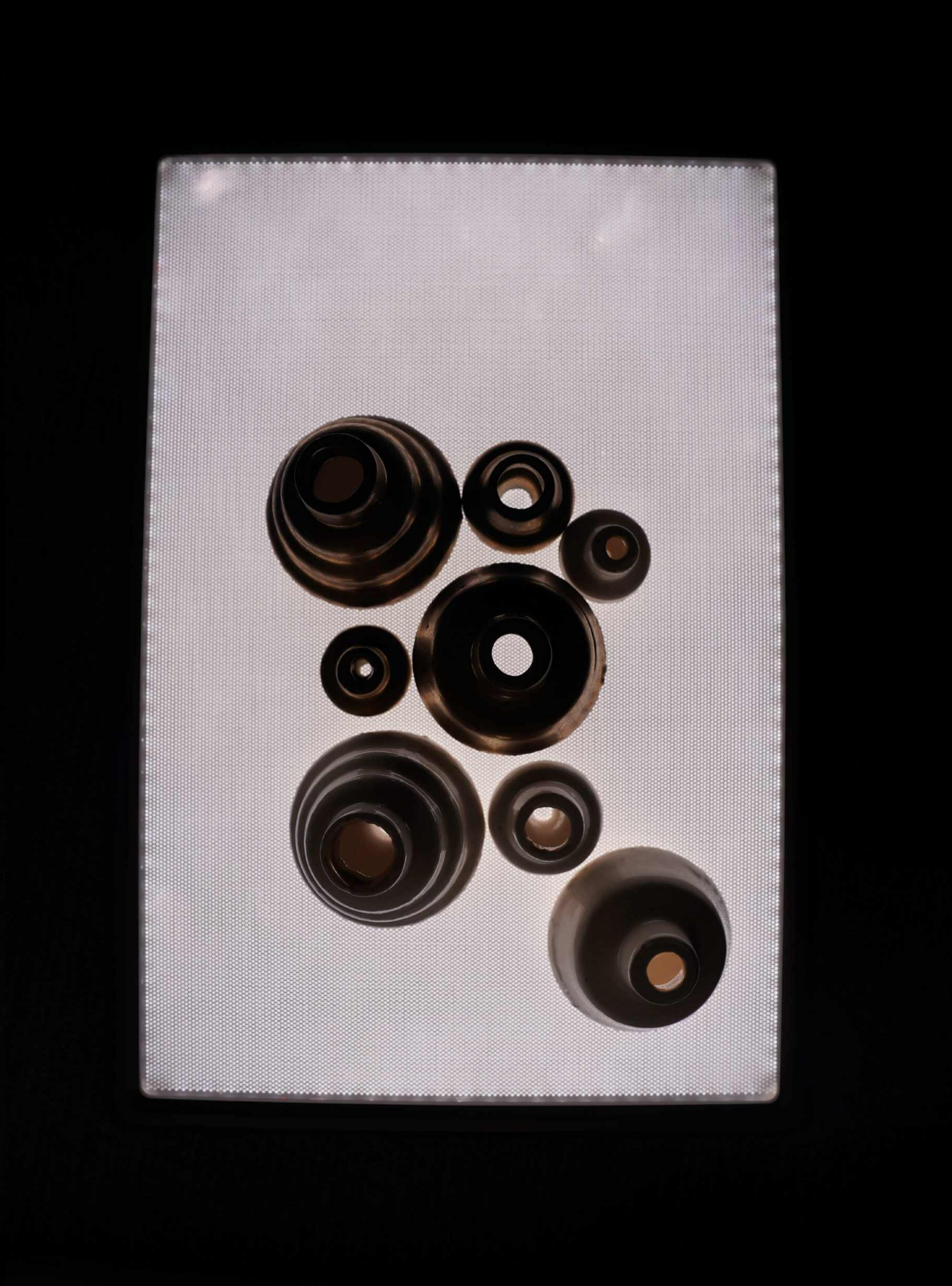
right

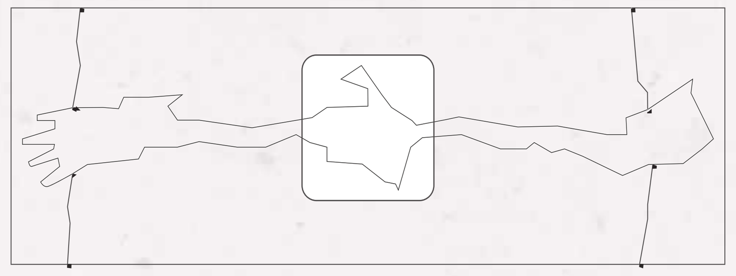
Fragment: Clamp for Clay

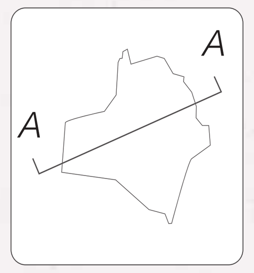








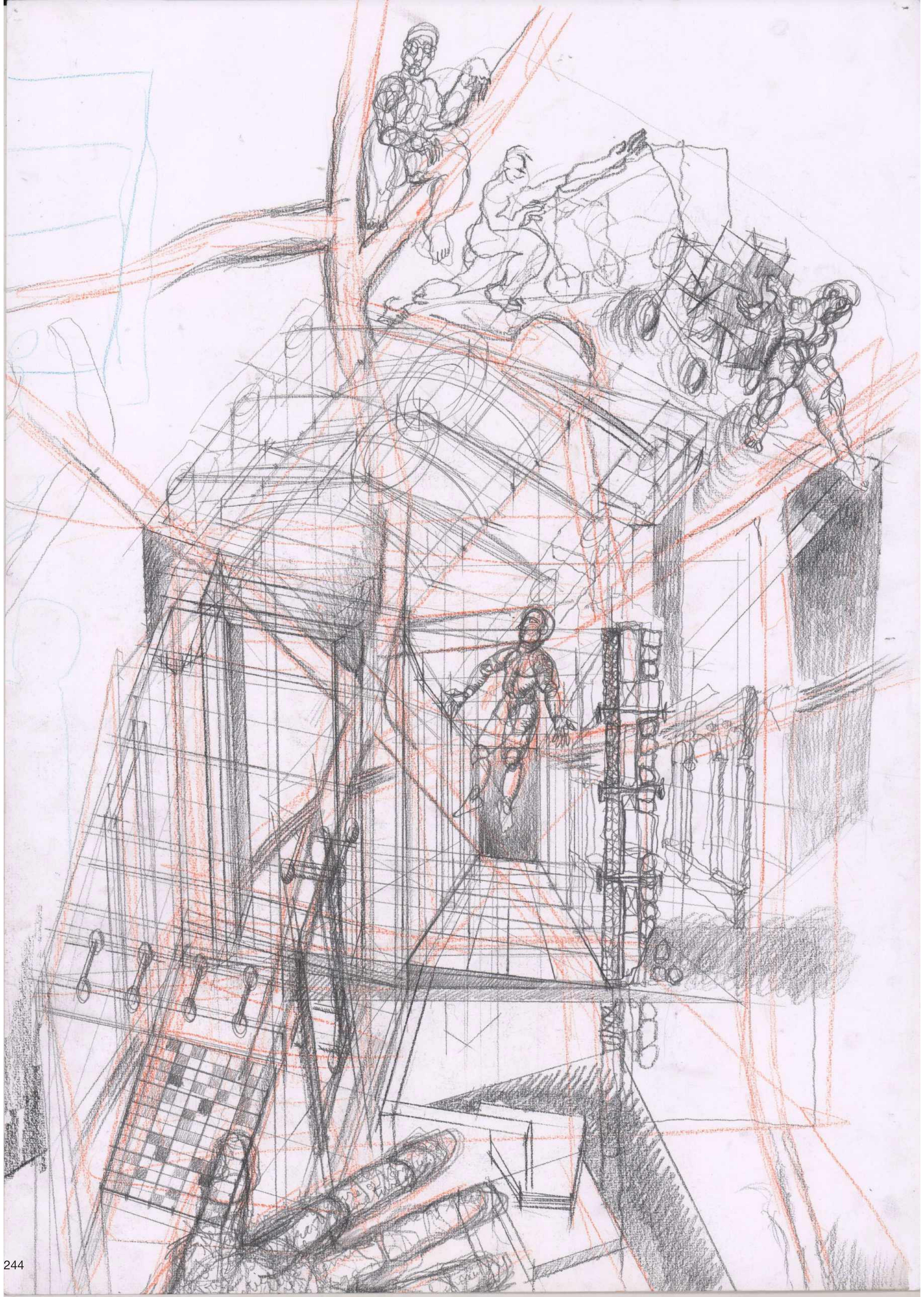




1. clamps holding foam ceramics insulation

2. foam ceramics pull buoy

1:50 on A1 *4m*



Section 13. Abstraction: Ramps

This section mainly focuses on the project's structural aspect. The building remains an ever sinking auction house and thus poses a huge structural challenge. The ever tilting aspect of the bridge makes it a huge ramp and the calculations contain some structural challenges that have to be dealt with accordingly. I was inspired by my trip to Venice, the sinking city, and photographed some of the ramps that were there. I looked extensively at the roof design, floors and foundation, sizing cable and braces, the main columns, and other aspects that had to be considered from a structural point of view. Concerning the cantilever system, I was inspired by the West Ham stadium system and researched how that worked so as to be able to apply some of its design to the auction house.

Loadings

DEAD LOADS

construction	material/element	unit load (kN/m2)
roof	snow/wind uplift	0.8
	kingspan steel roof panels	0.8
	services	0.1
	clay tiles finishes	0.1
	TOTAL_roof	1.8

construction	material/element	unit load (kN/m2)
exterior walls	glass windows	0.15
	insulation	0.05
	secondary columns	0.5
	clay tiles finishes	0.1
	TOTAL_walls	0.8

construction	material/element	unit load (kN/m2)
floor	partitions	0.1
	composite slab	1.2
	asphalt waterproofing	0.45
	celing and services	0.15
	TOTAL_floor	1.9

LIVE LOADS

construction	use	unit load (kN/m2)
floor 1	storage/private sale (type A)	2
floor 2	auction (type C)	3
floor 3	gallery (type B)	2

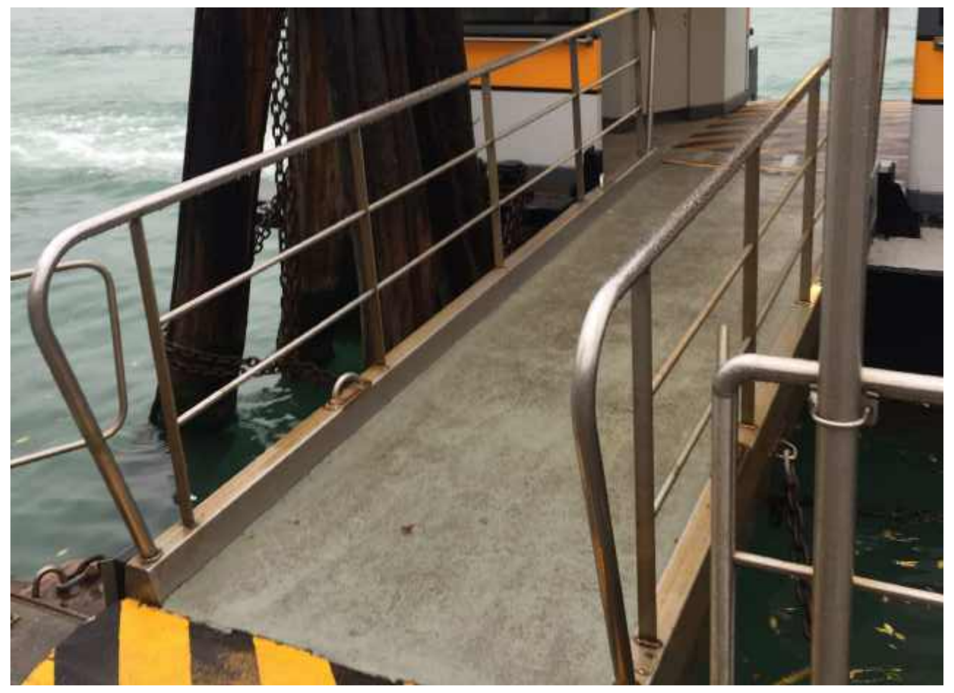
TOTALS

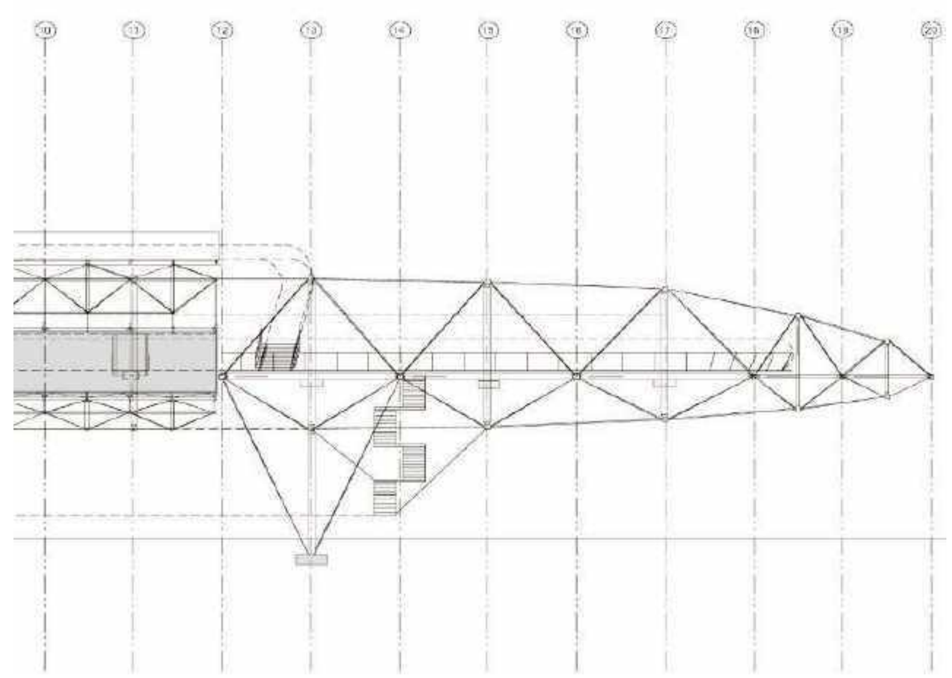
	unit load (kN/m2)	tributary area (w*l = m2)
total roof	1.8	160
total floor 1	4.7	60
total floor 2	5.7	60
total floor 3	4.7	60
total floors	15.1	180
total all	16.9	340

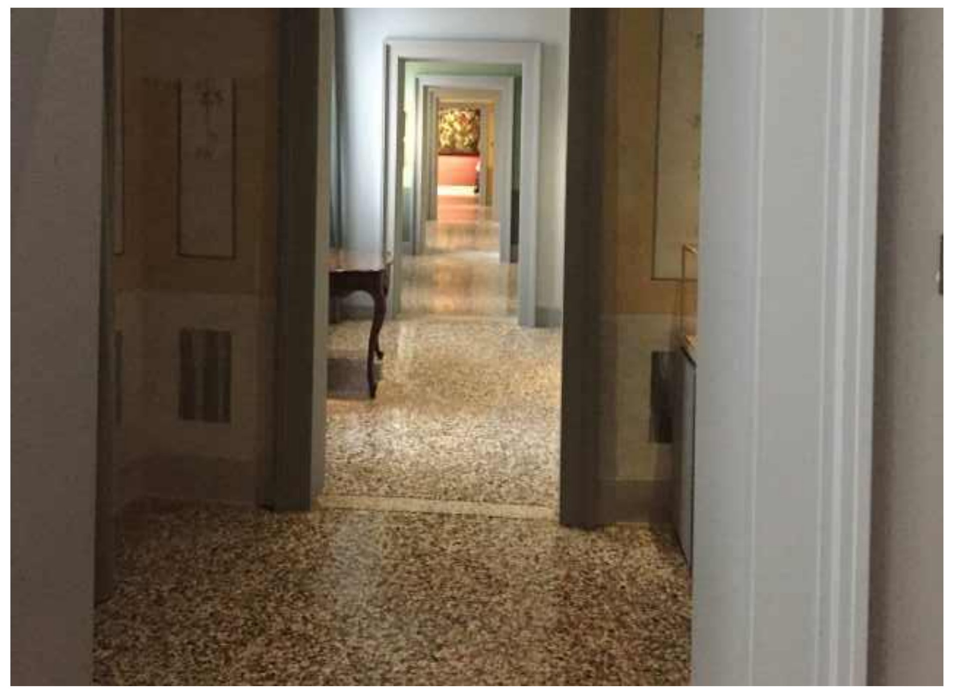
Structural Considerations

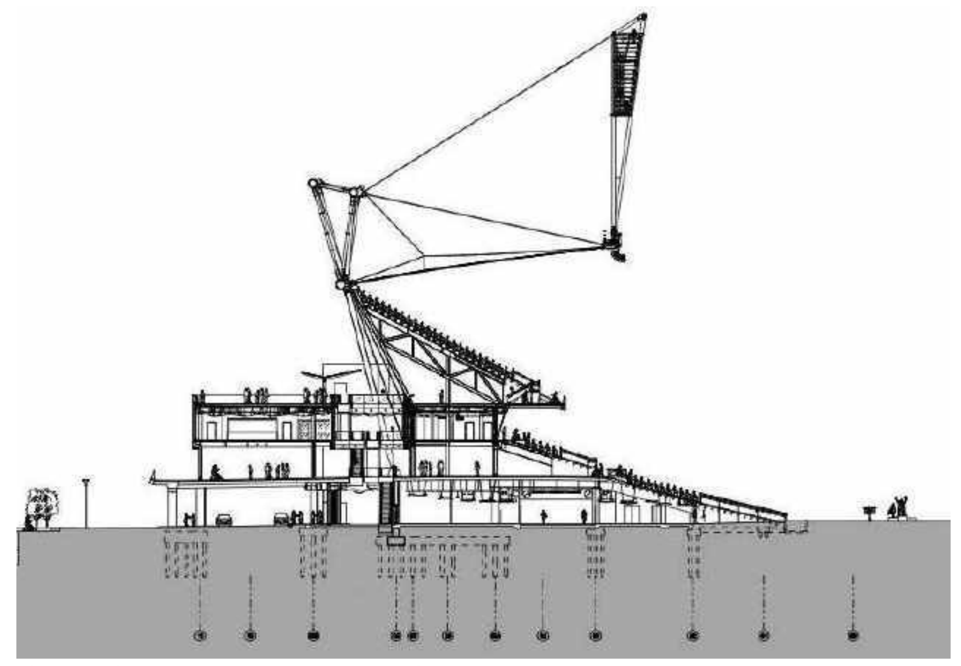
The concept of ramps, sinking cities (Venice), and tilting floors are taken as an insipiration to design cantilever systems, truss systems and members in tension and compression.

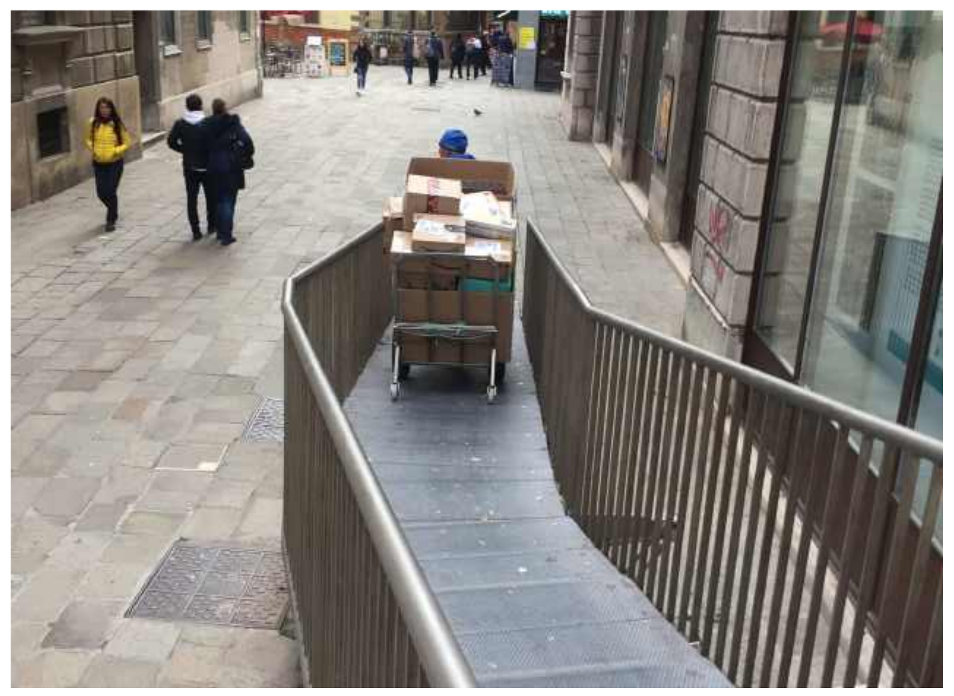

Venice Ramp 1


Venice Ramp 2


Case Study 1: Smoke Pavilion


Venice Ramp 3

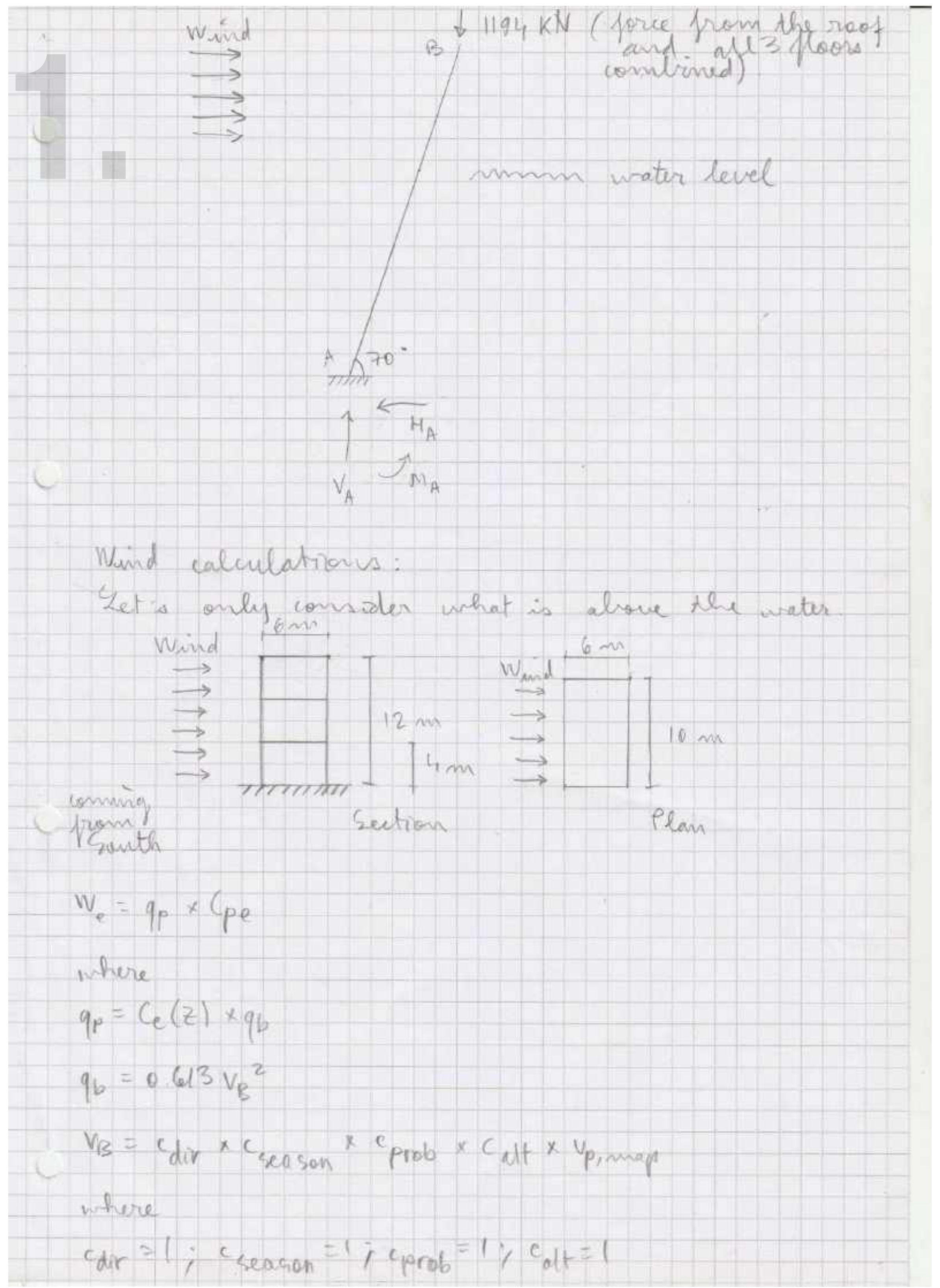

Case Study 2: West Ham Stadium


Venice Ramp 4


Case Study 3: Oil Rigs

Main Columns Design

1.



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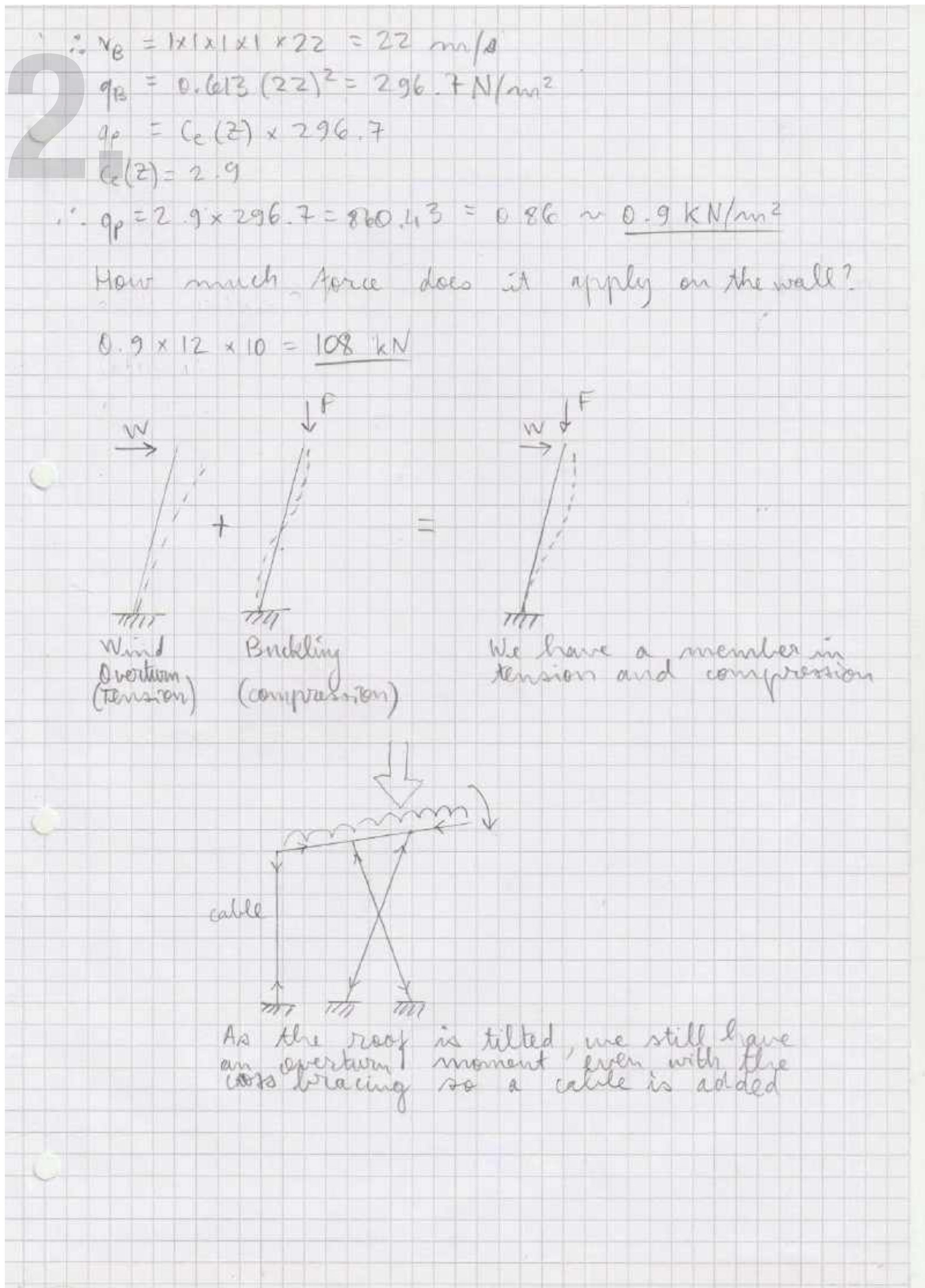

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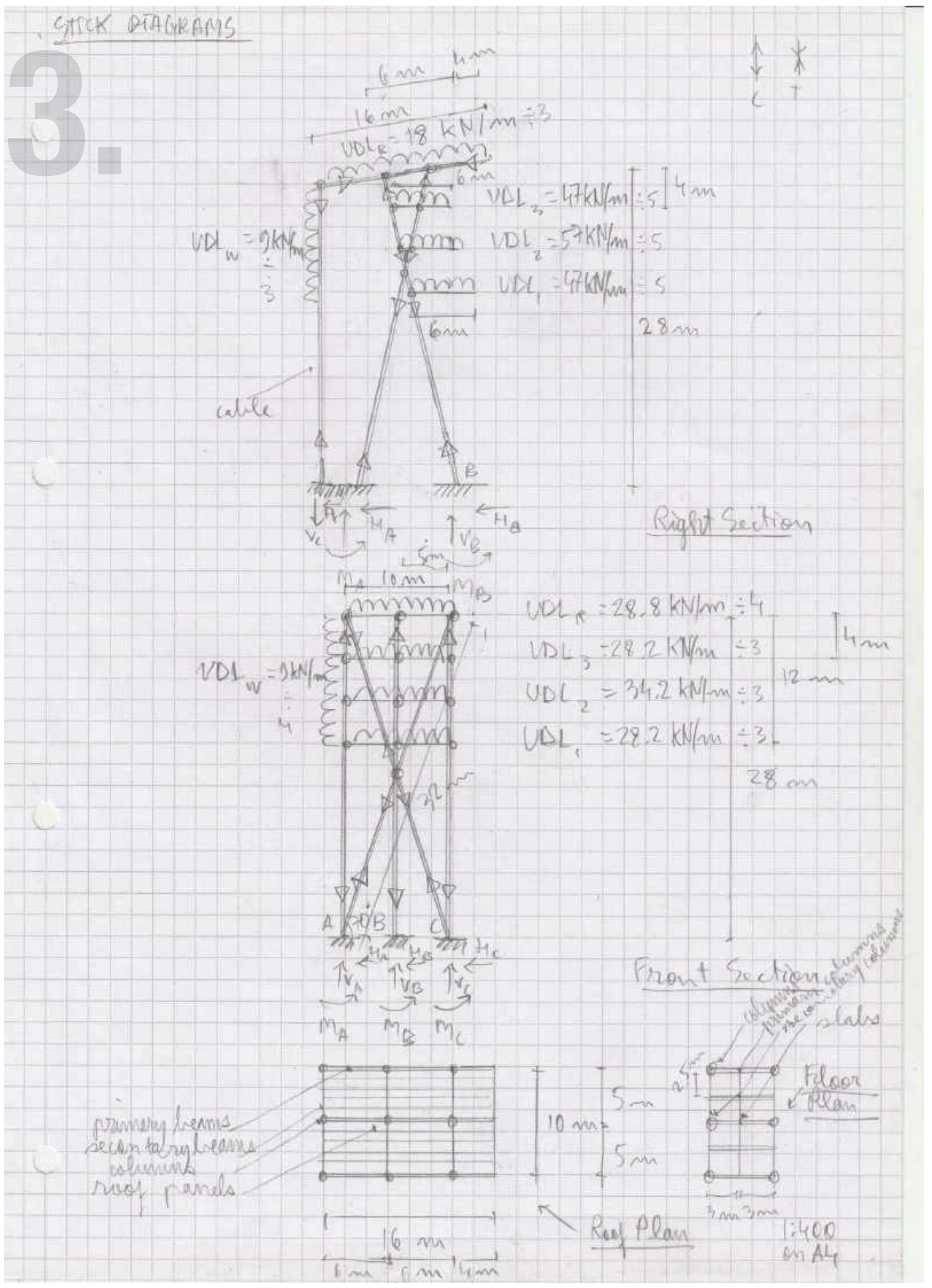

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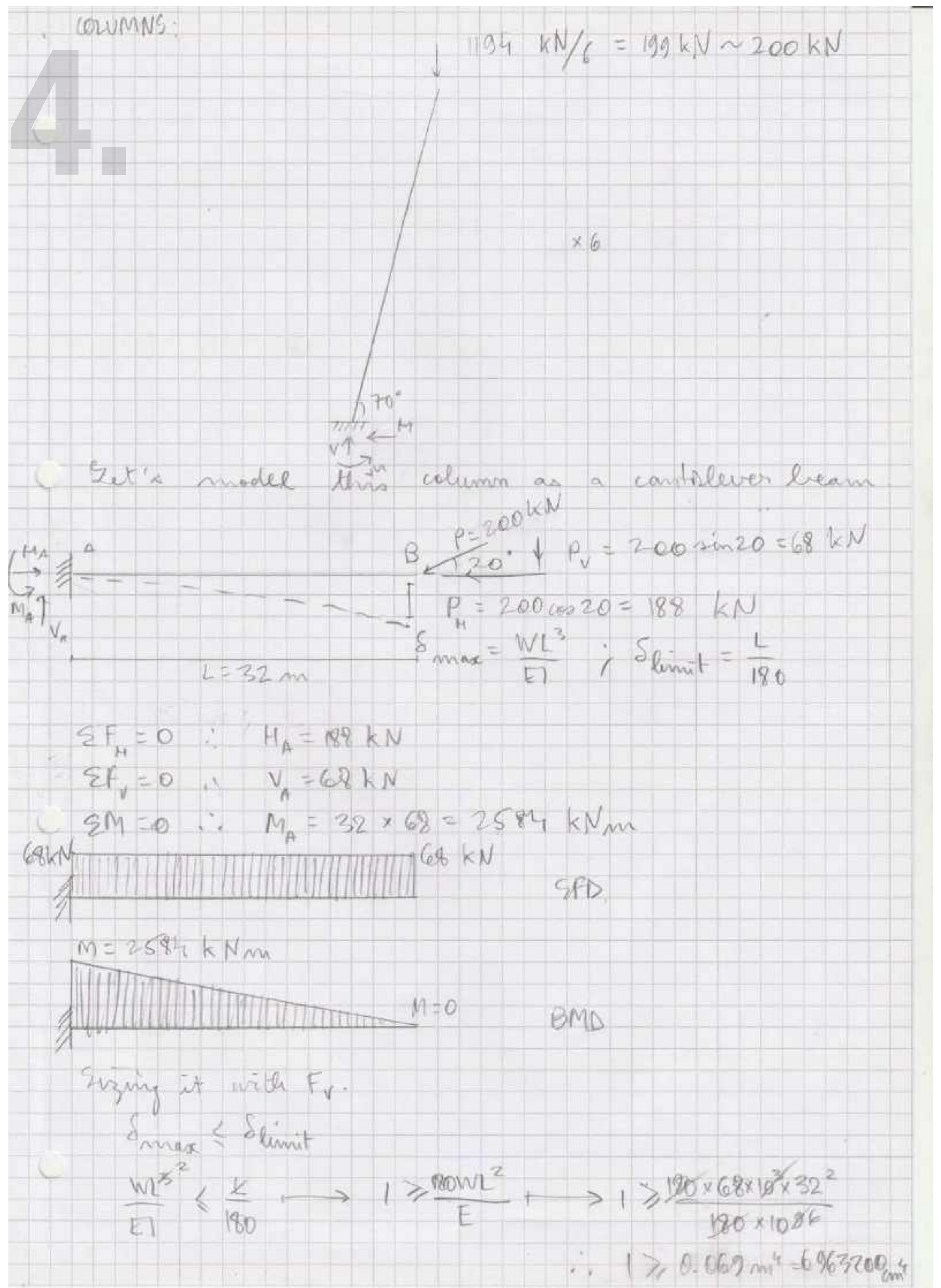

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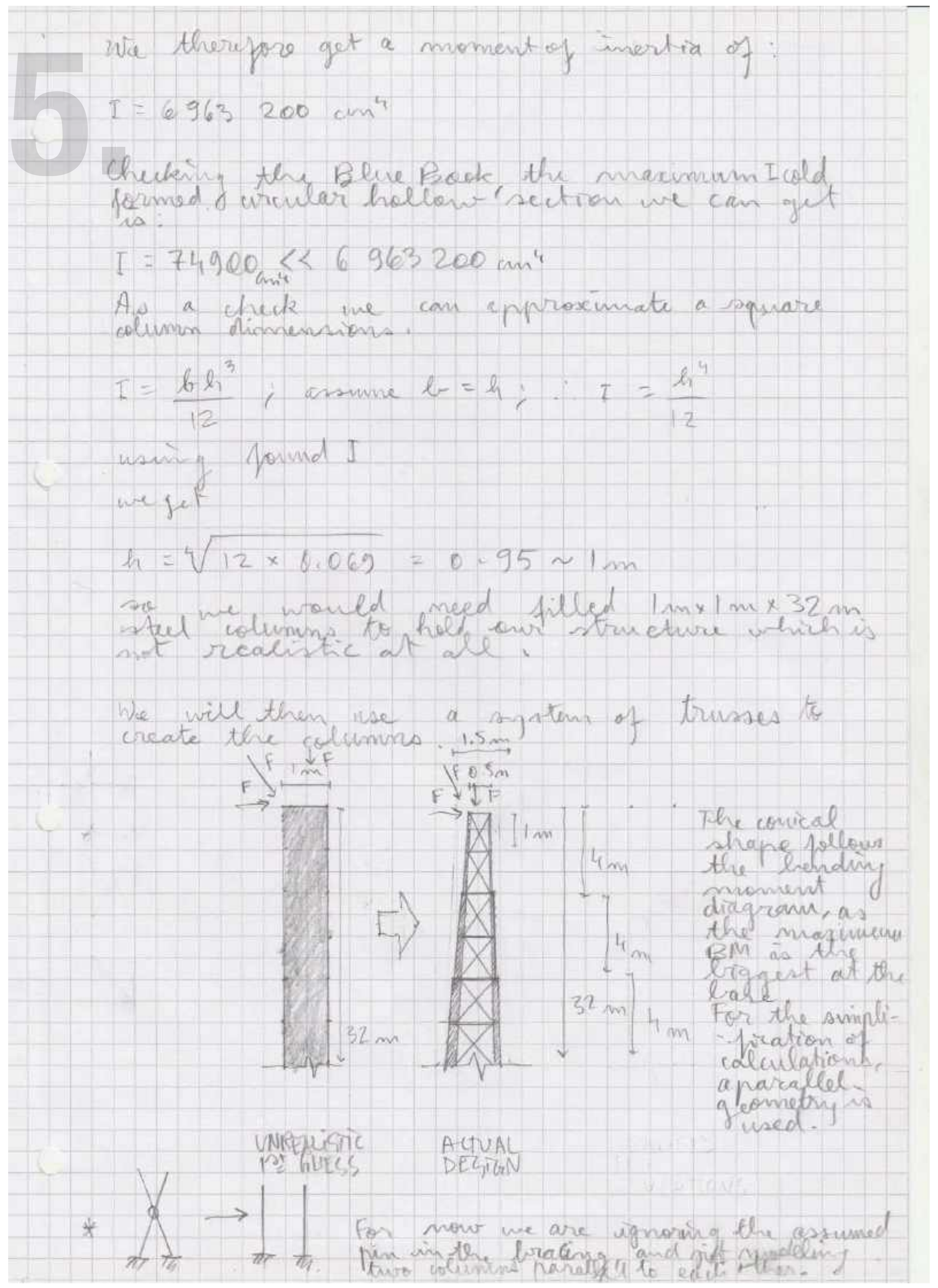

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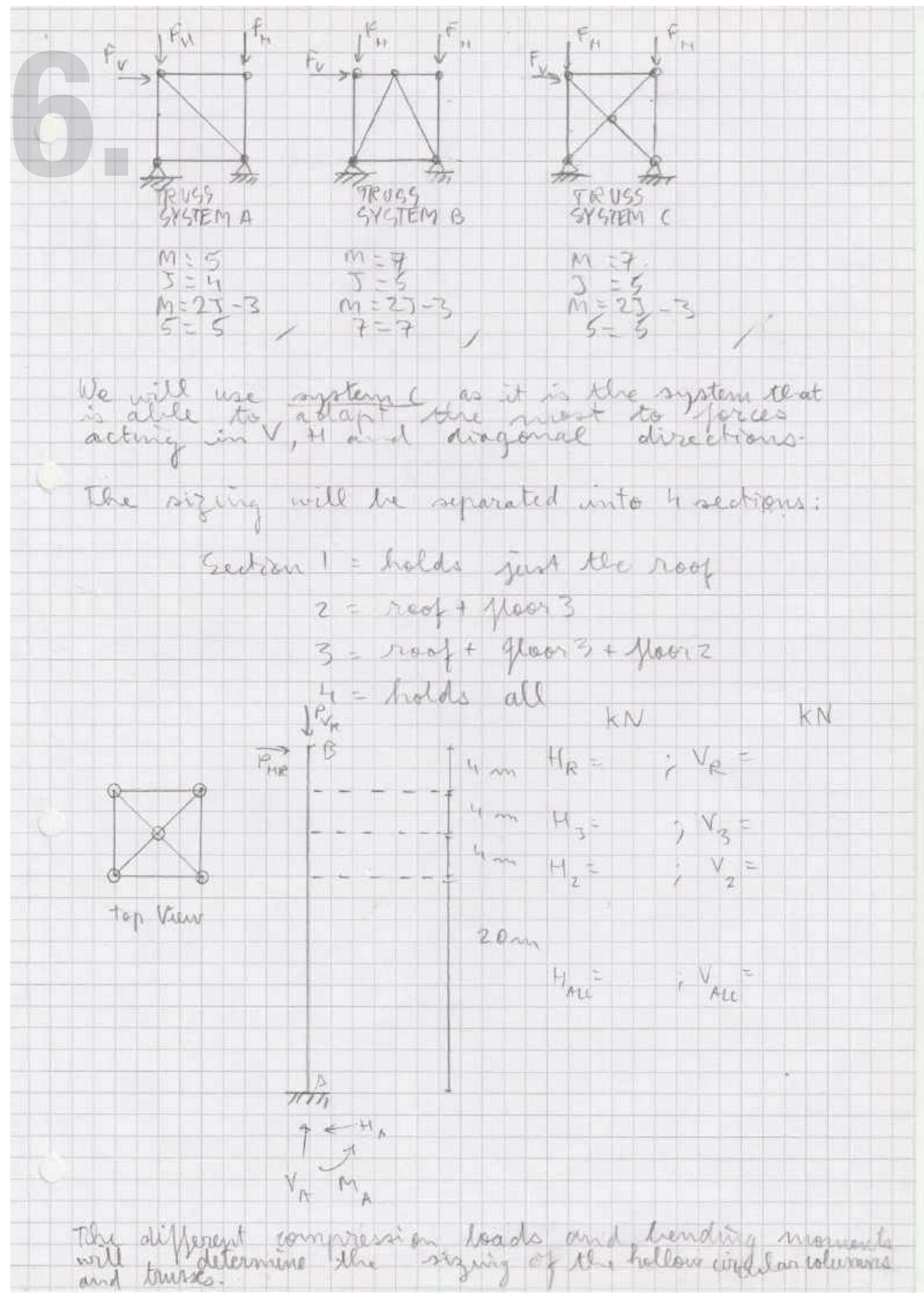

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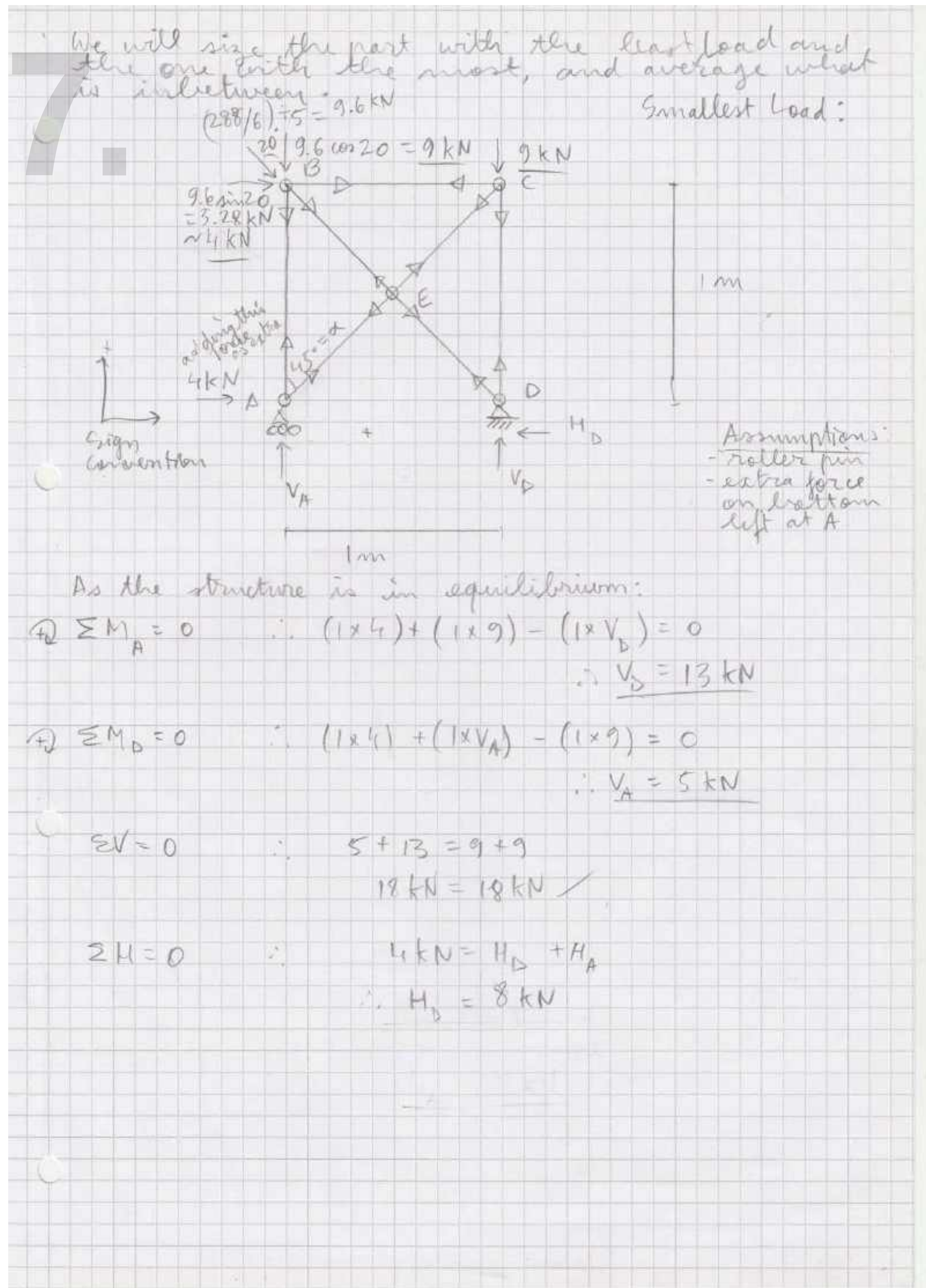
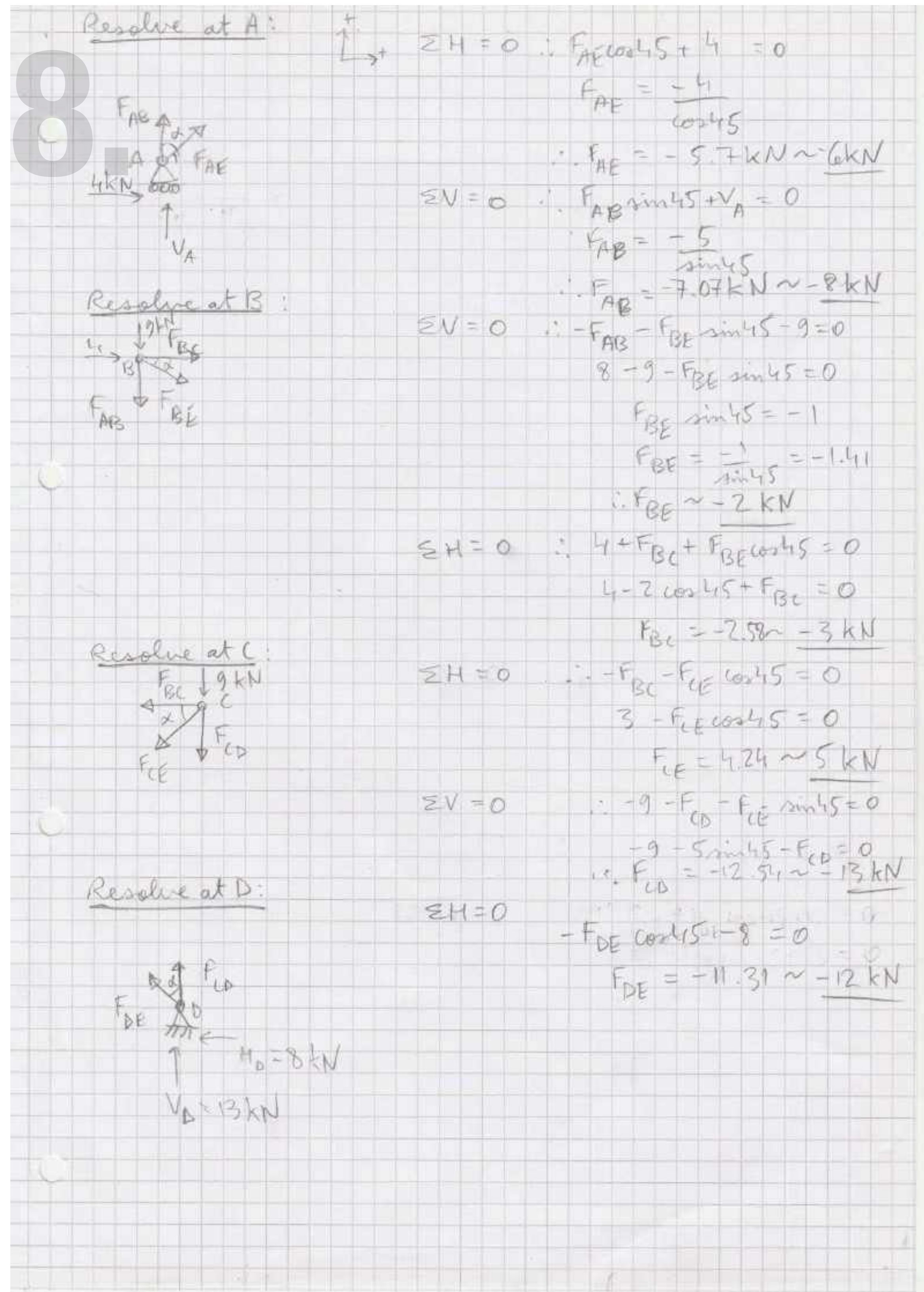
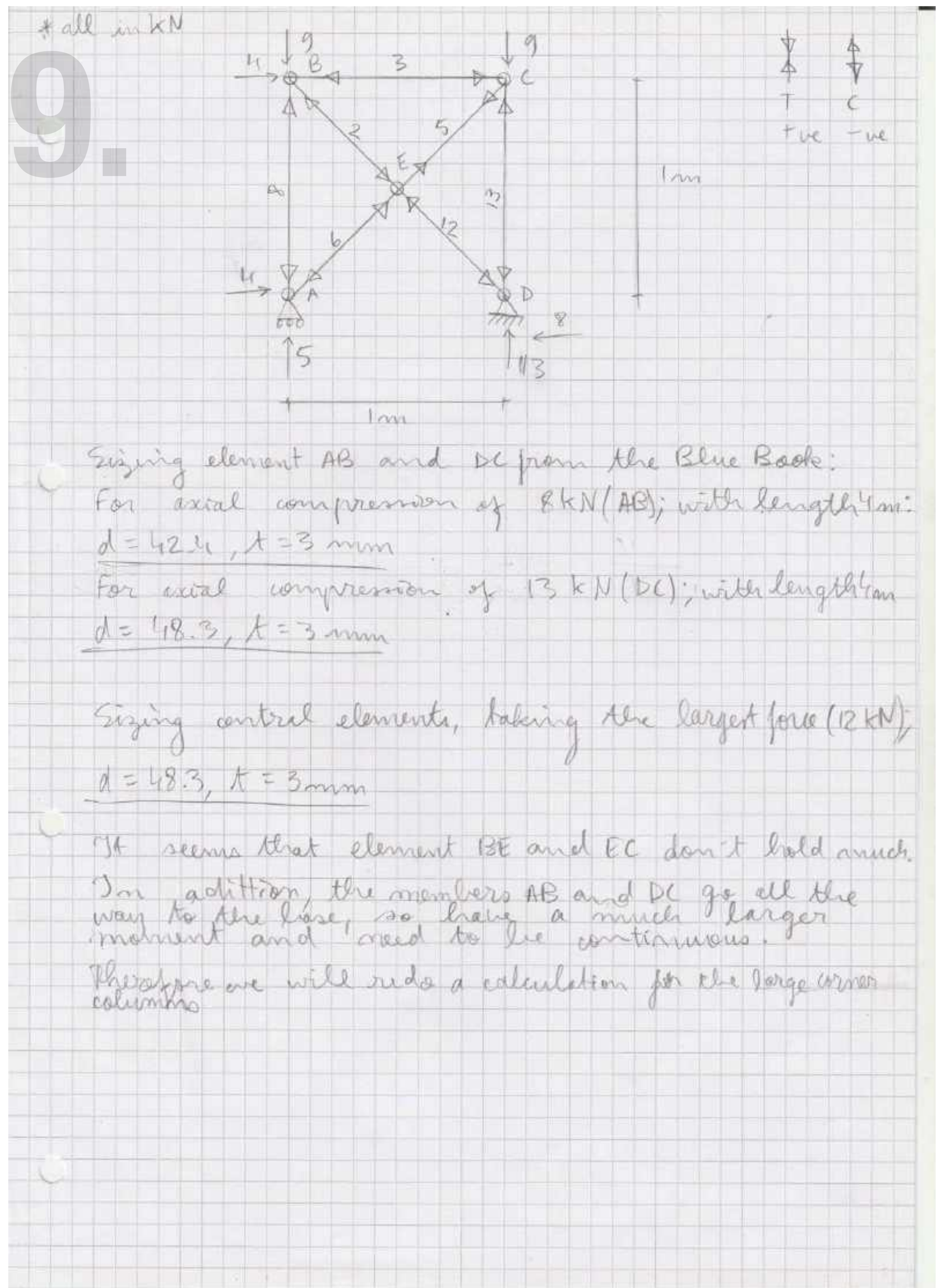


8.

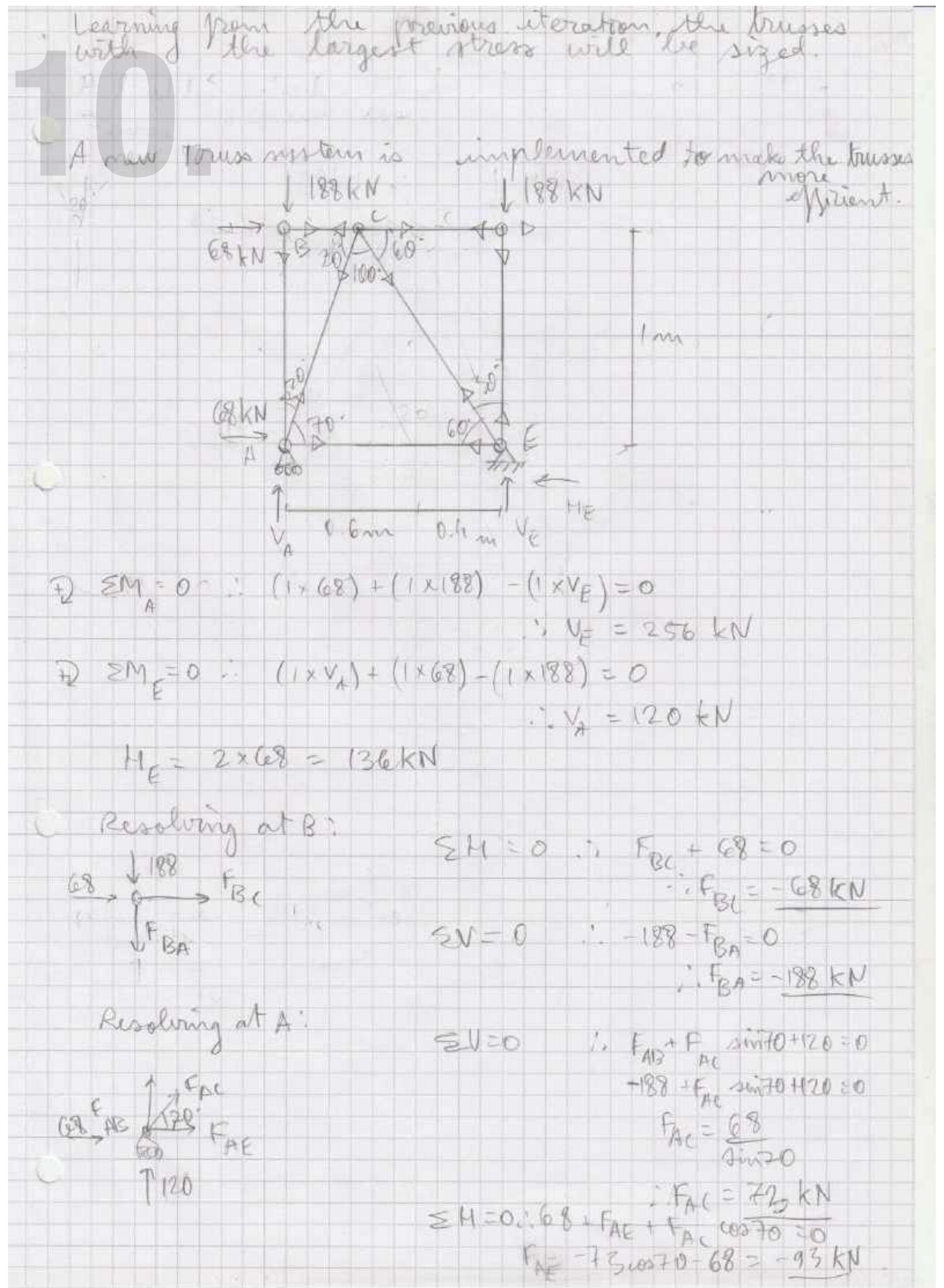


Solving Cantilever System

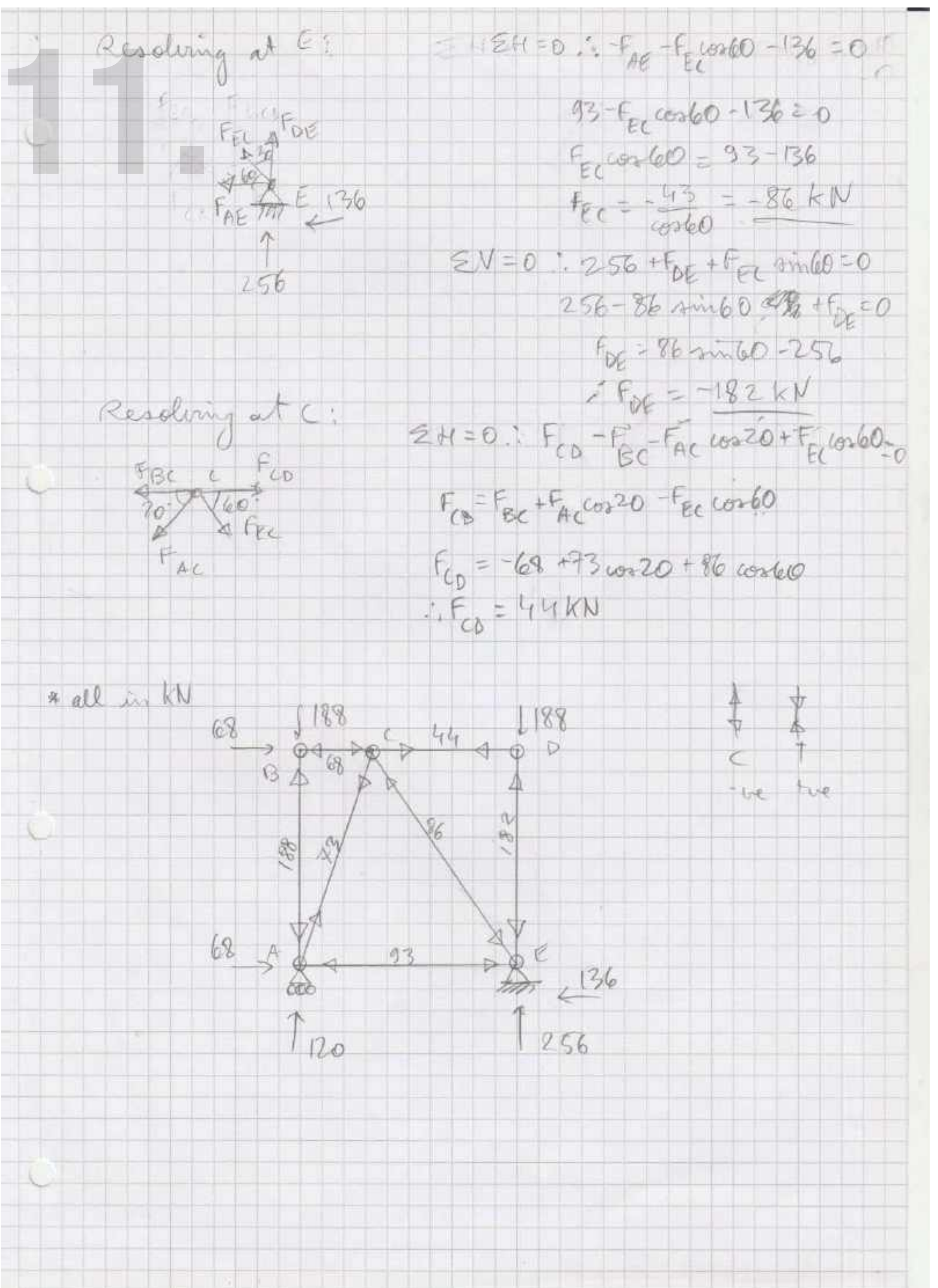
9.



10.



11.



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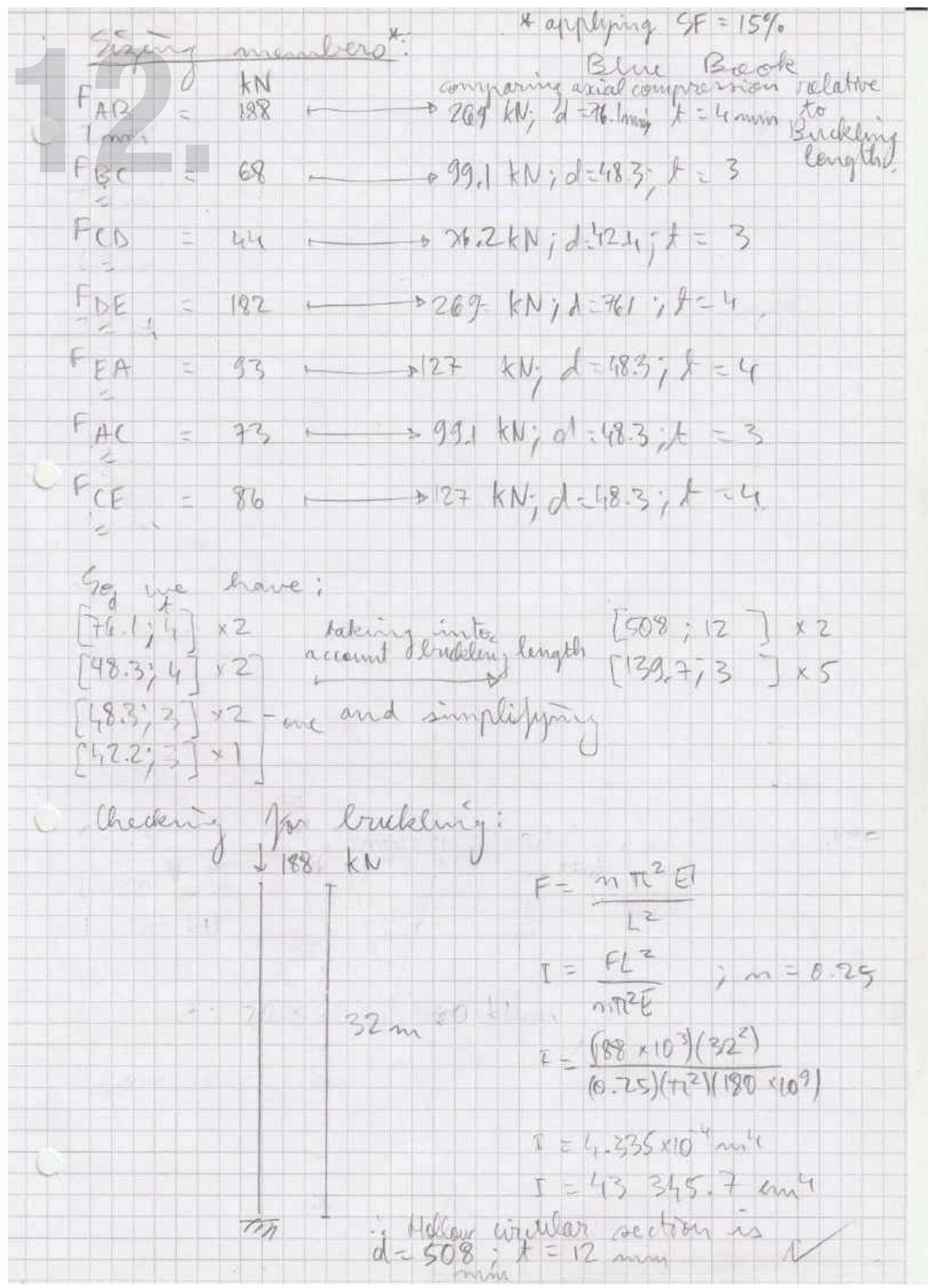

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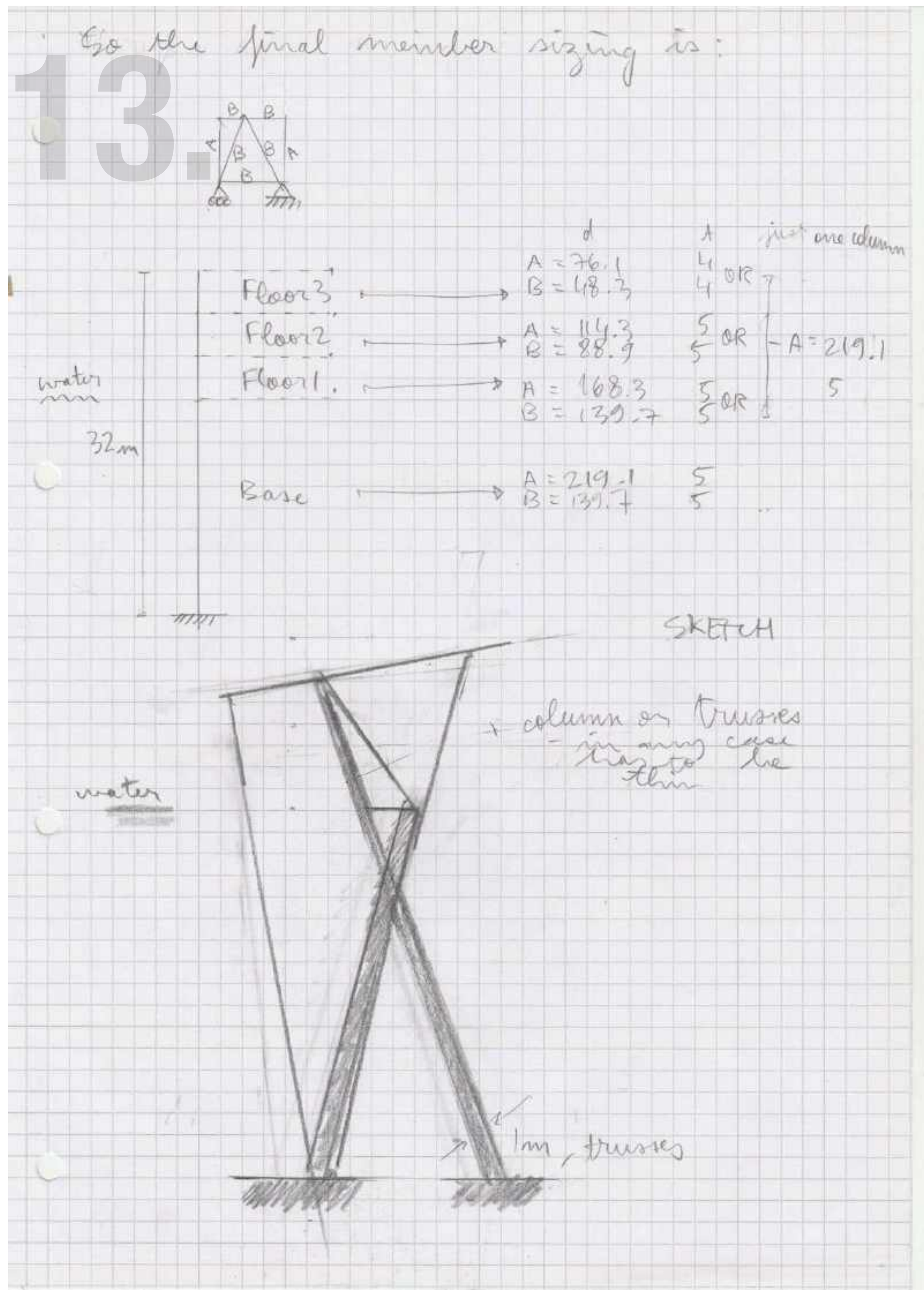

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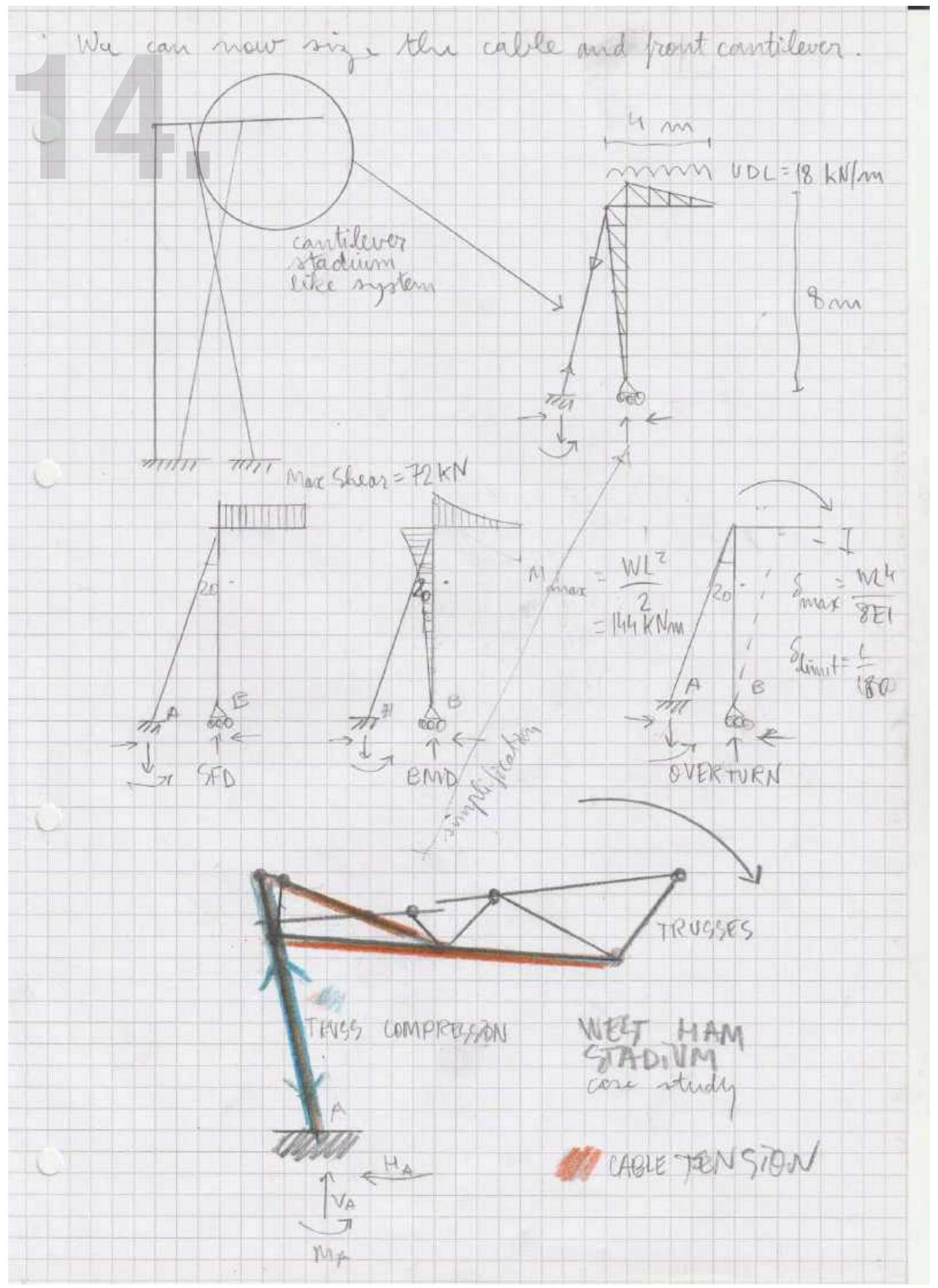

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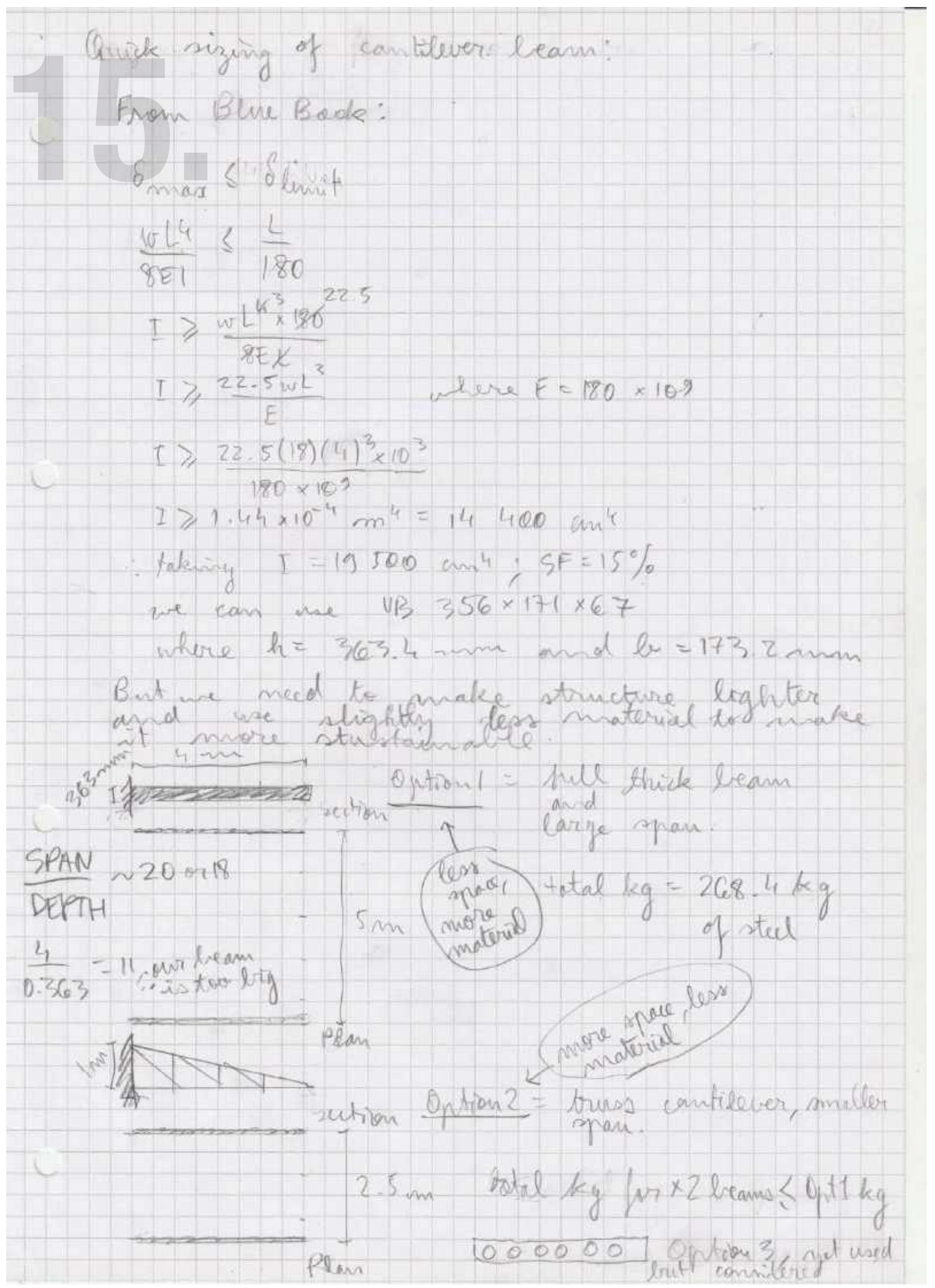

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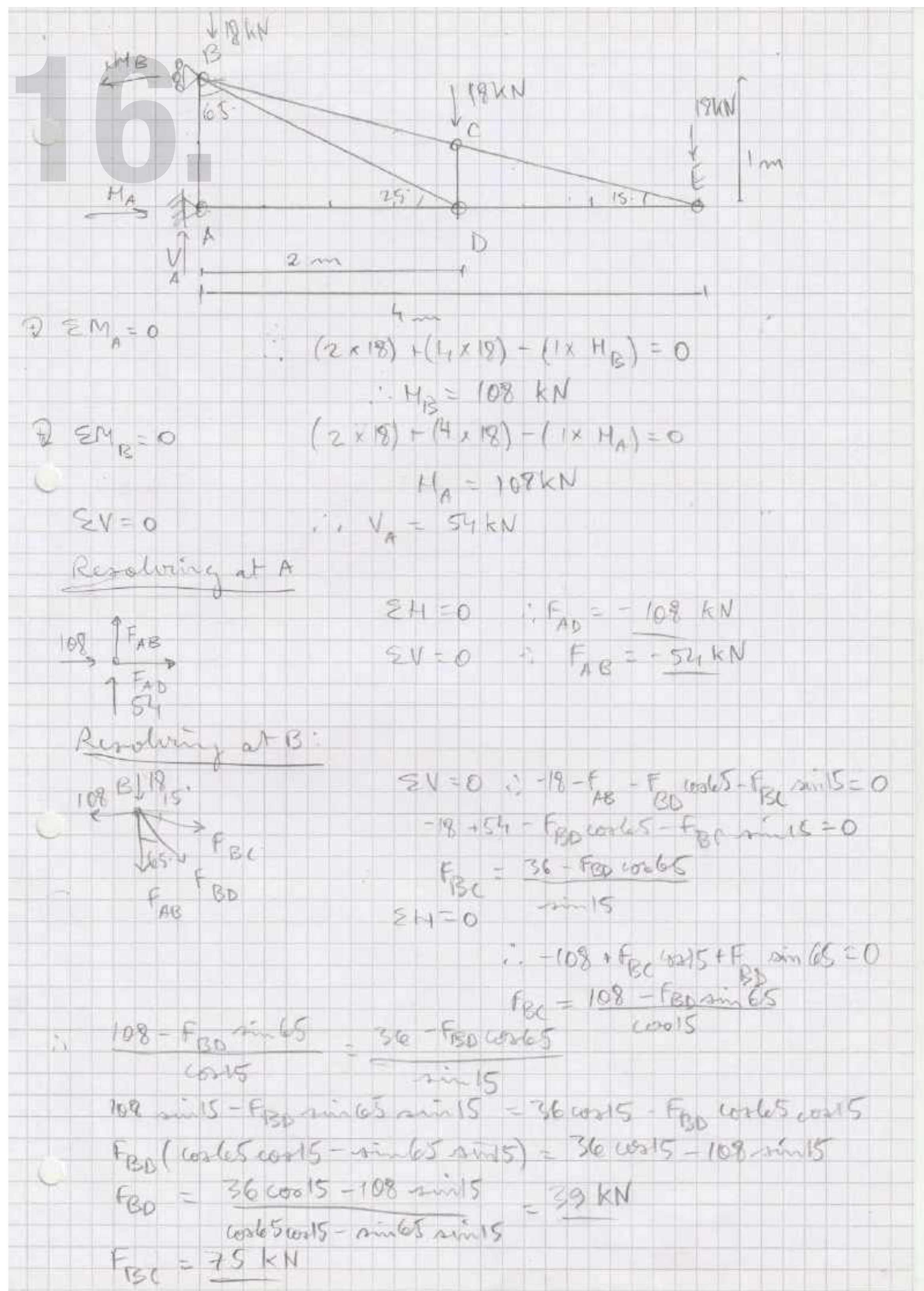
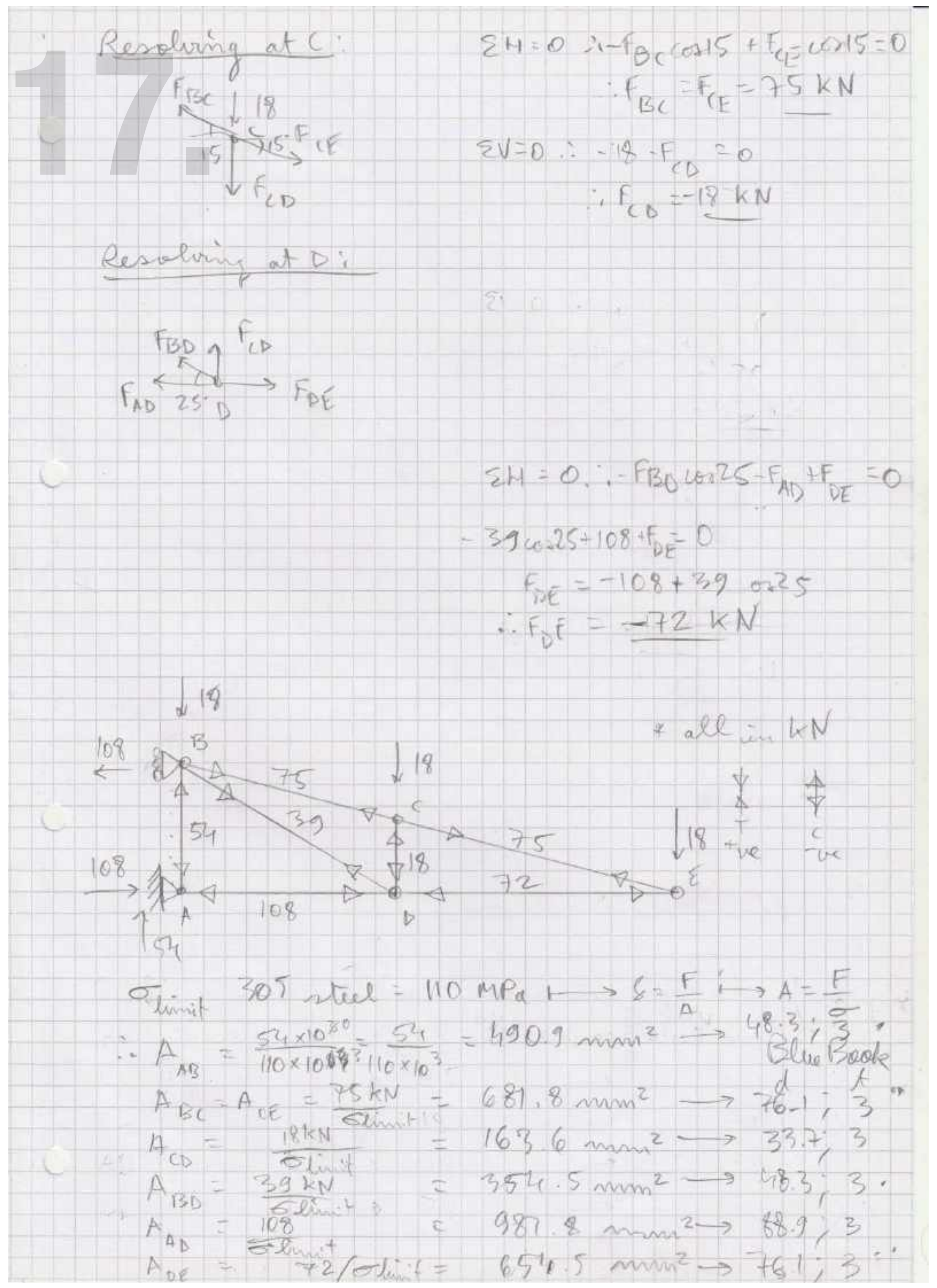
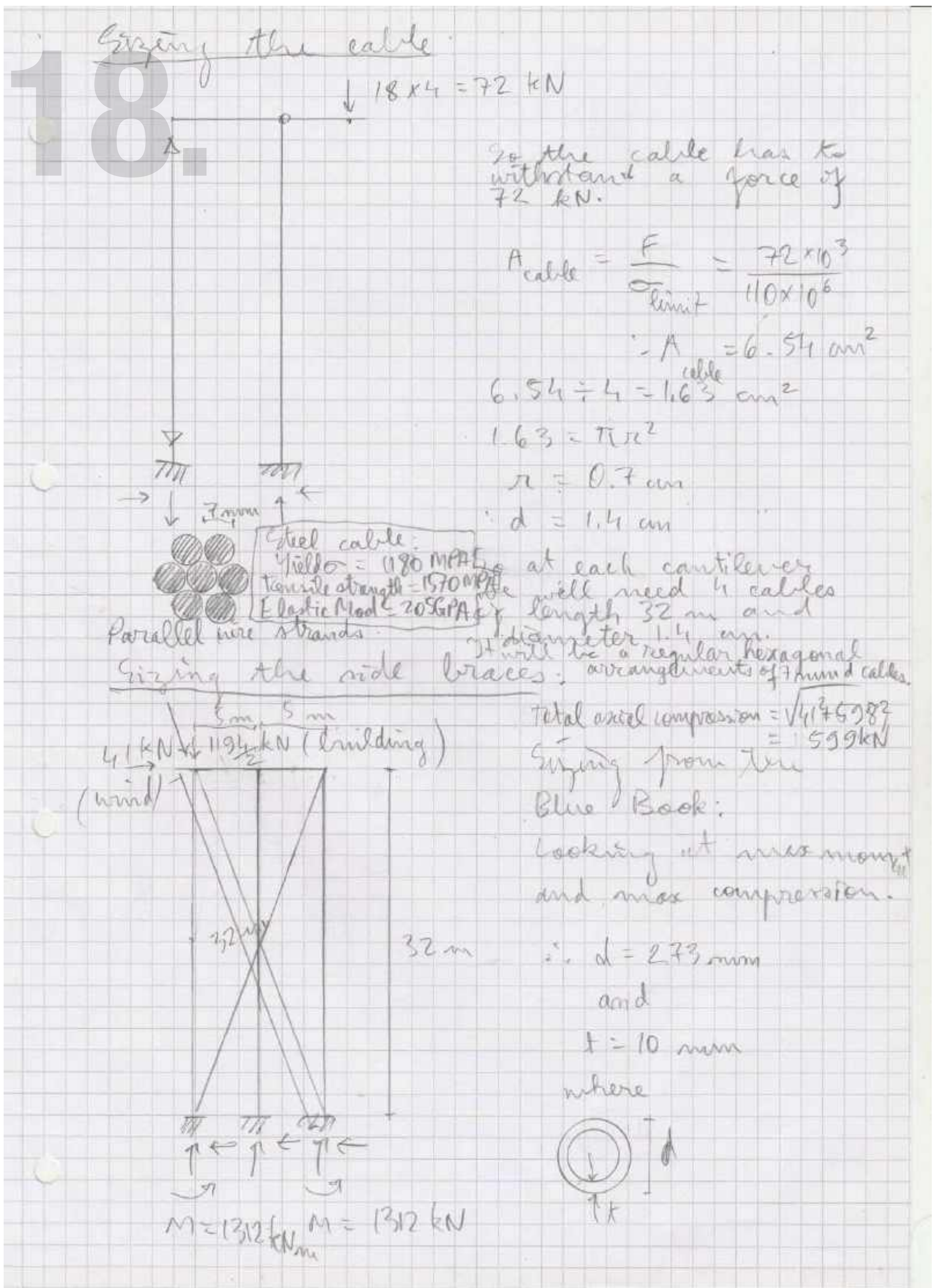
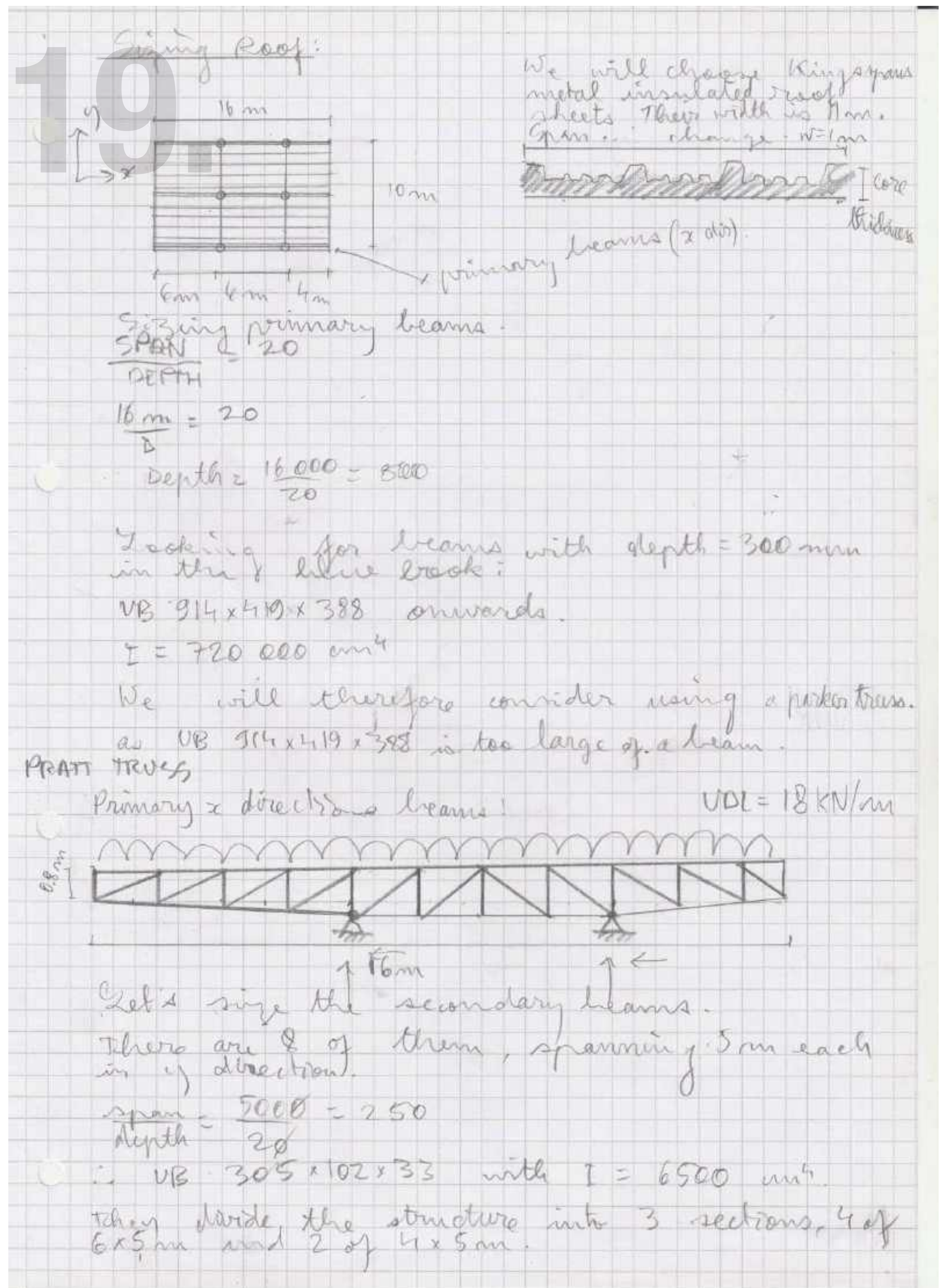


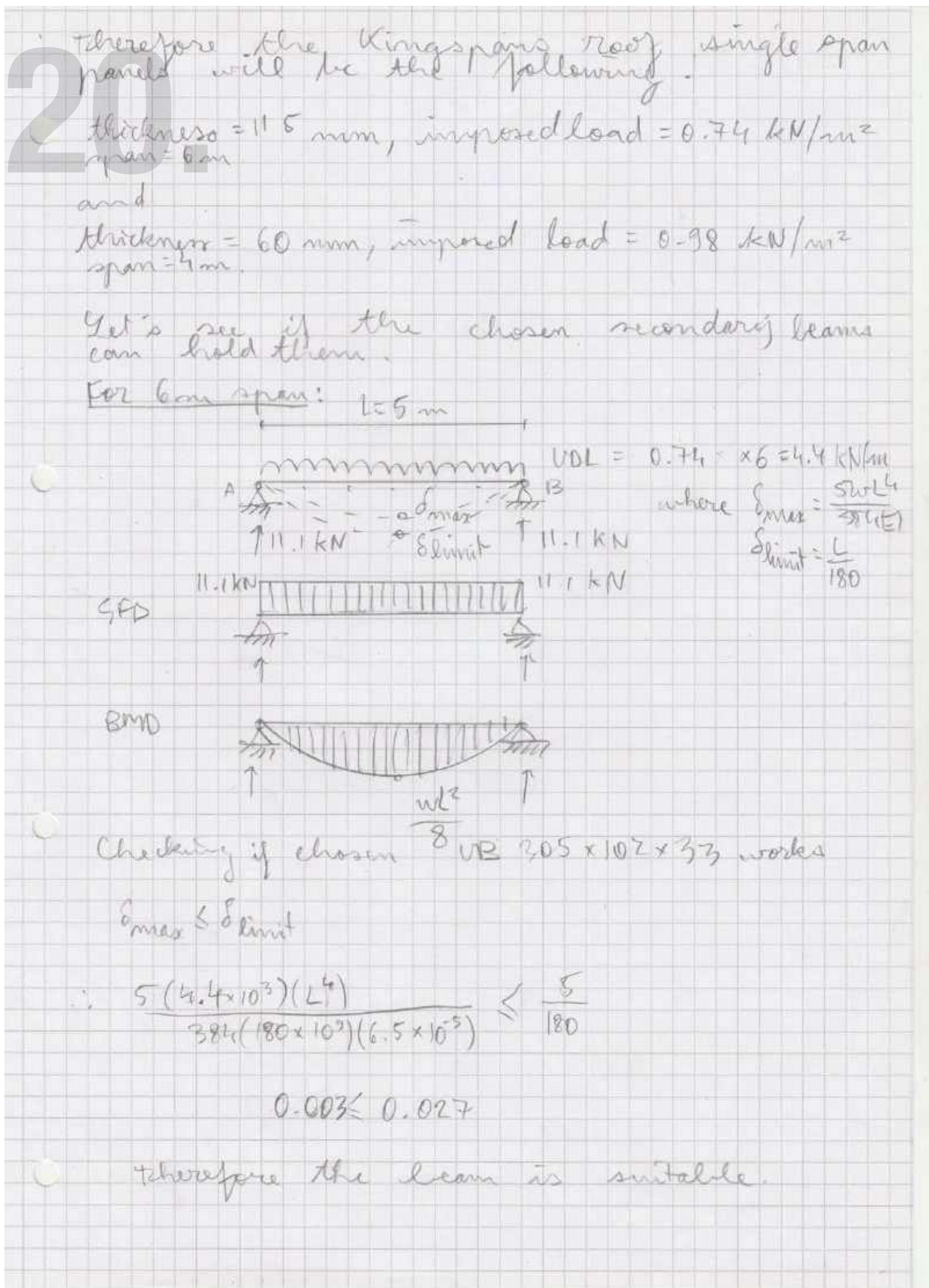
Sizing Cable and Braces

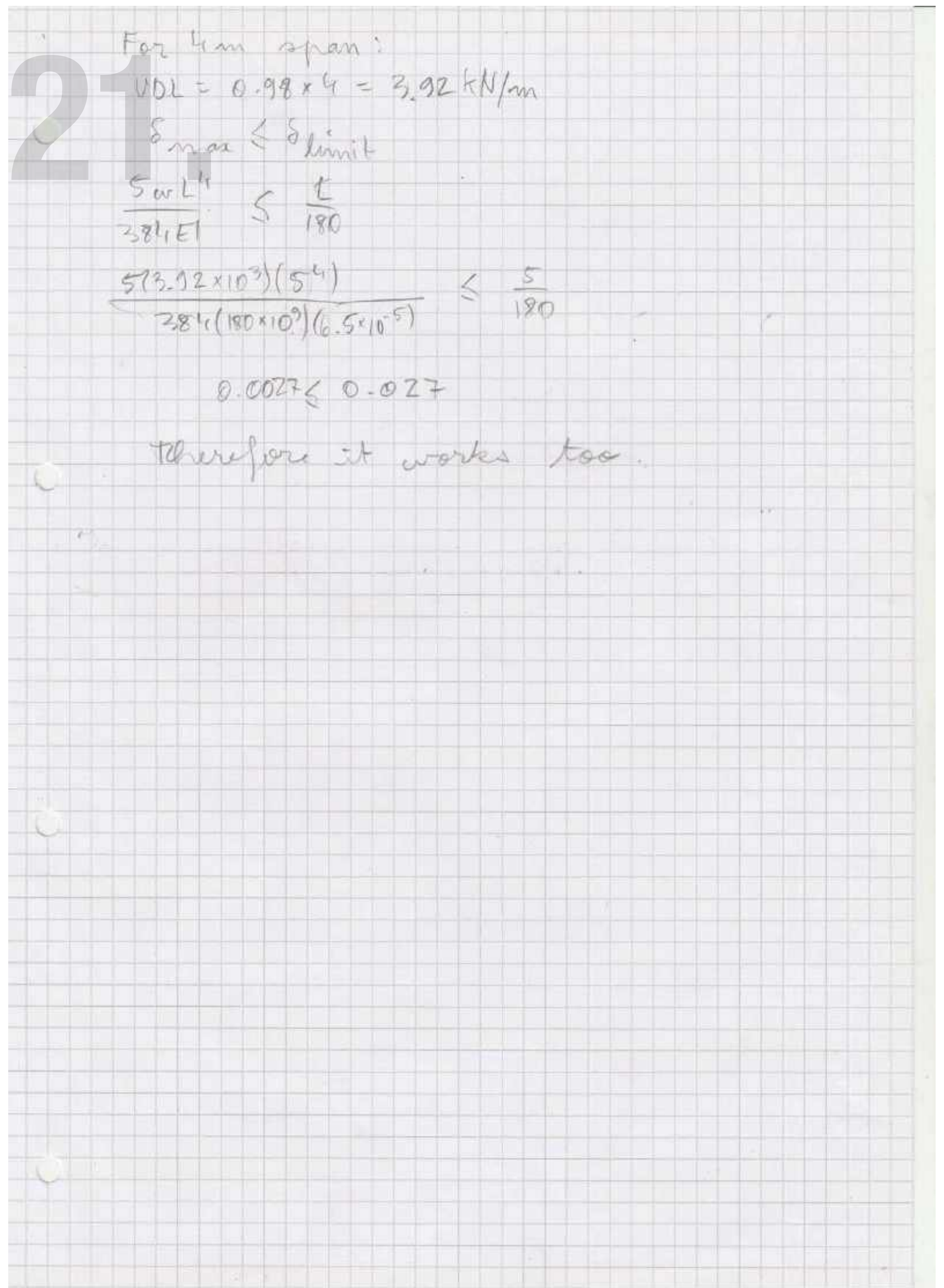




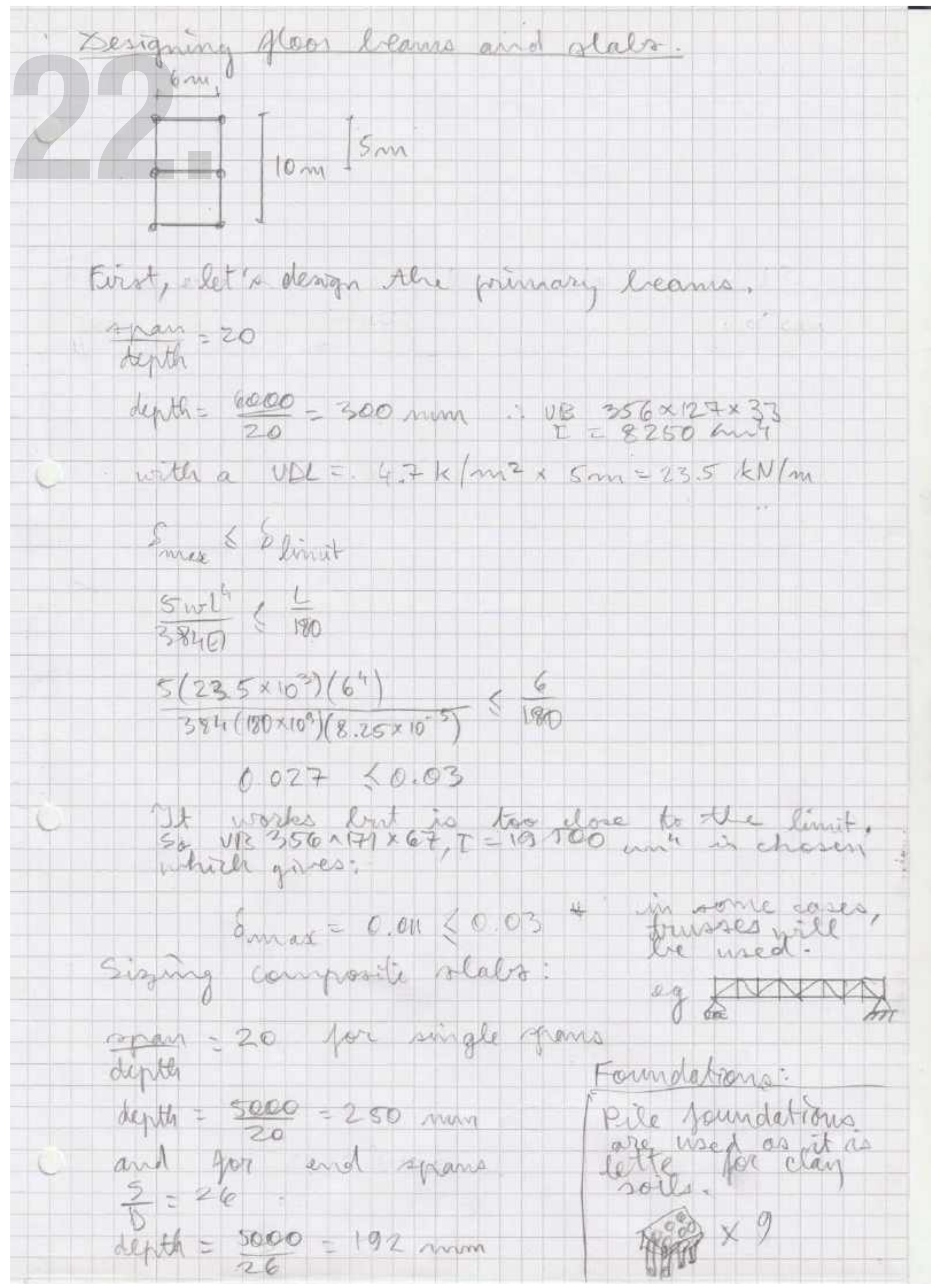
Roof Design







Floors and Foundations



CURATOR'S NOTE:

Go to Appendix to see the Blue Notes to see the full scope of the back of the envelope calculations.

8th June 2023 London, UK
Maxime Ostroverhy

1:20 CLAY EXTRUSIONS THAT ARE SIZED BASED ON CALCULATIONS

trusses in columns:
1- d = 508mm, t = 12mm
2 -d = 219.1mm, t = 5mm
3 -d = 76.1mm, t = 4mm

cable :
4 -d = 14mm, x7

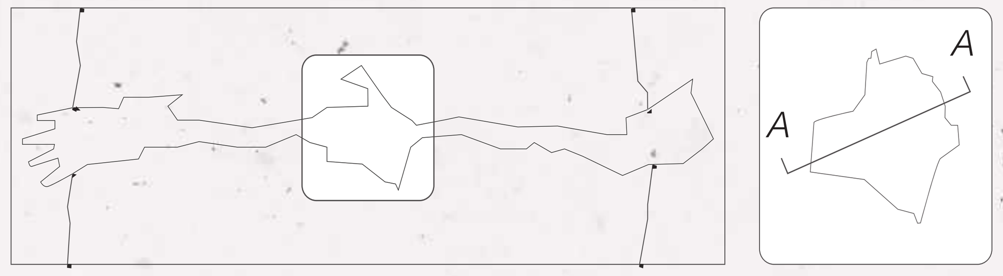
roof panels:
5 -core = 120mm, width = 1m, span = 5 or 6m

primary beams roof:
6 -UB 914 x 419 x 388

secondary beams roof:
7 -UB 305 x 102 x 33

Secondary beams floor:
8 -UB 356 x 127 x 33

floor slabs:
9 -20cm x 1m x 5m or 6m



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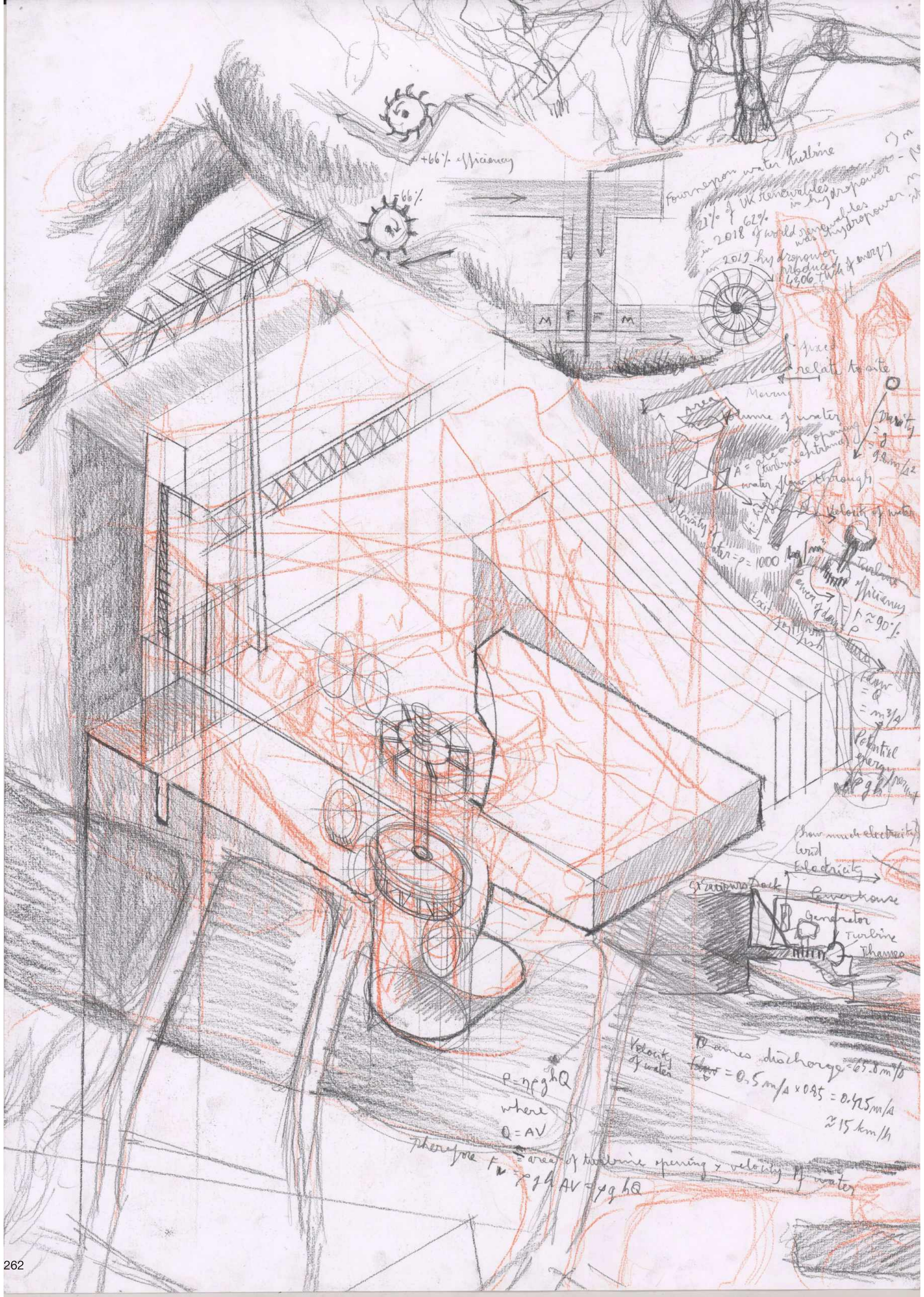
9 -20cm x 1m x 5m or 6m

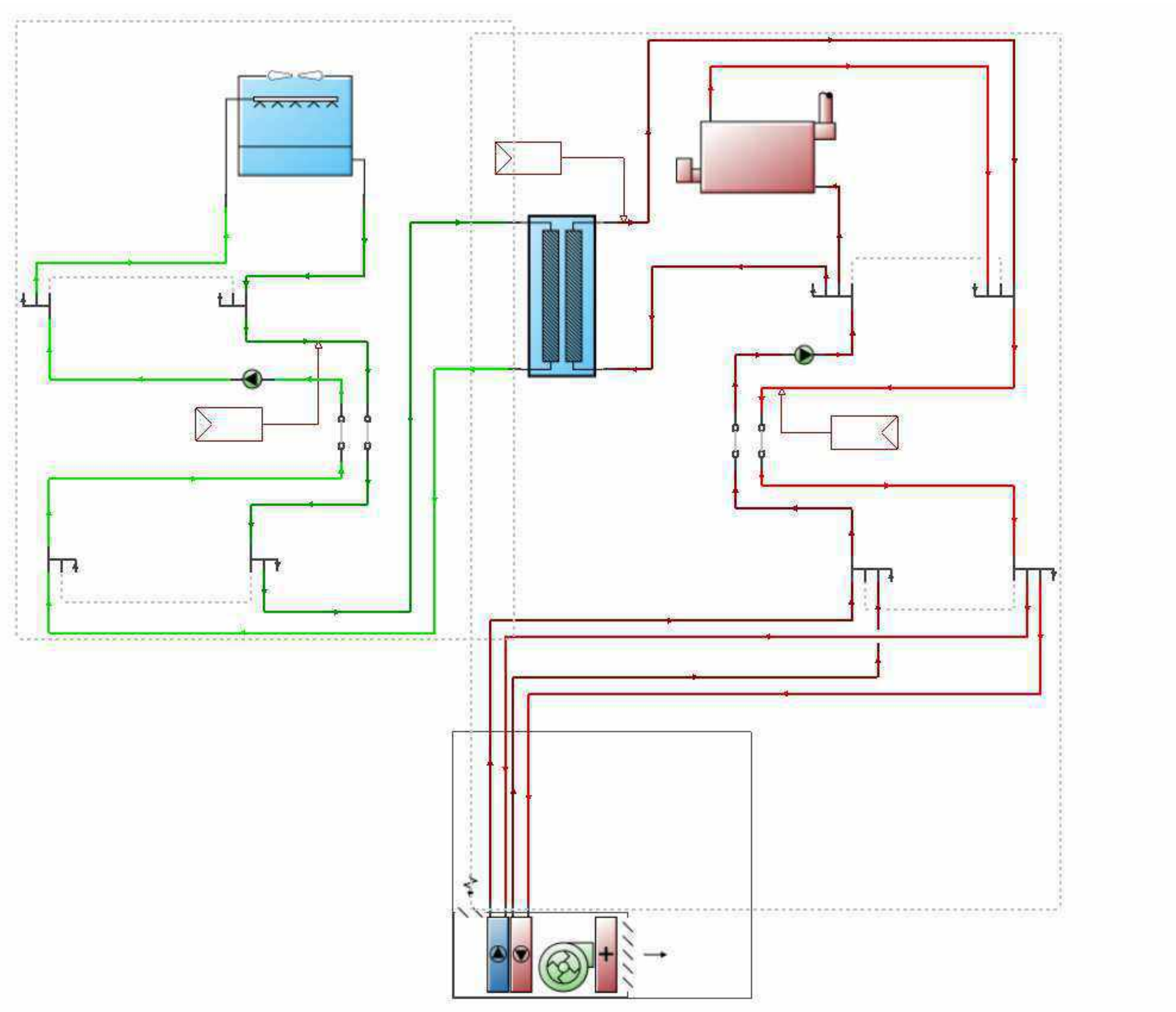
1:50 on A1 *4m*



Section 14. Environmental Design Strategy: Hydropower

The main environmental renewable is hydropower, which helps the building to reach net carbon zero. Sustainability remains very important. The auction house is over the River Thames, and therefore hydropower would be the most convenient and sustainable source of energy for the building to be able to function properly. As such, whenever a building is created, its environment had to be studied in order to determine which course of action would best. A detailed HVAC and relevant collected data concerning everything that is needed to create an energy design for the auction house had to be completed with meticulous care and attention. Overall, the result was satisfactory and I remain confident that the environmental design strategy would work if it is ever to be applied. The building must strive to be sustainable and the best way to do that is to see which renewable energy is best for the auction house through a matrix of iterations using Design Builder.

Detailed HVAC



Detailed HVAC iteration 51: GSHP

Environmental Site Analysis

Introduction:

Site coordinates:
51.5021° N, 0.0714° W (St Saviours Dock)
Closest data taken was:
54.9756° N, 1.6217° W (St James Park)

Wind

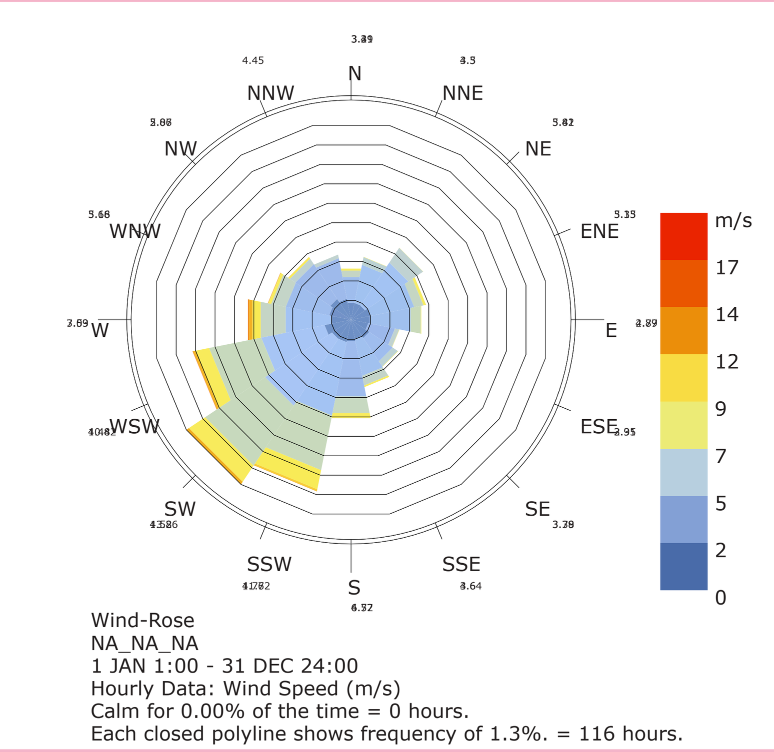
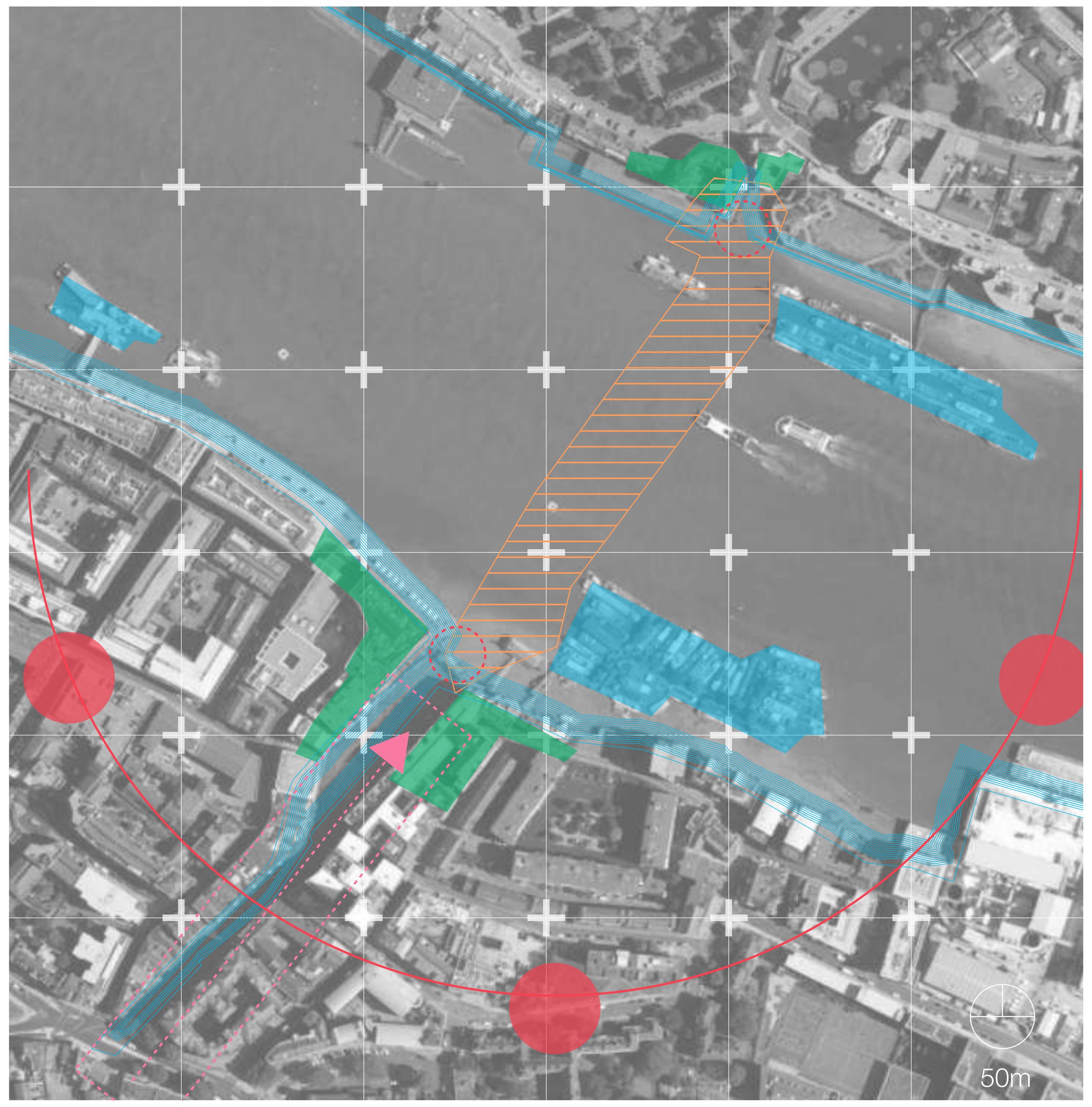


Figure 2.1.



Tides

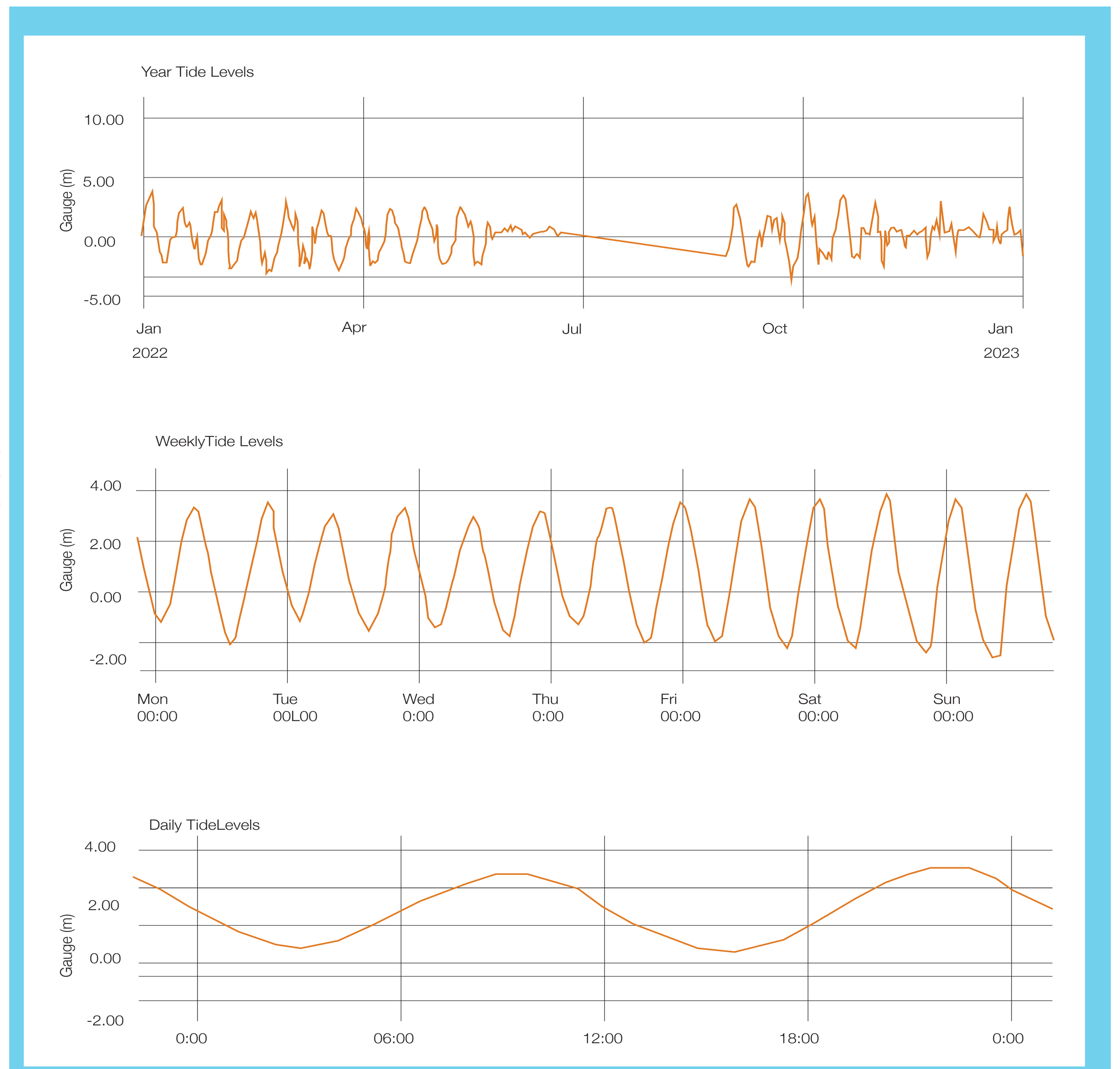


Figure 2.2.: Tides

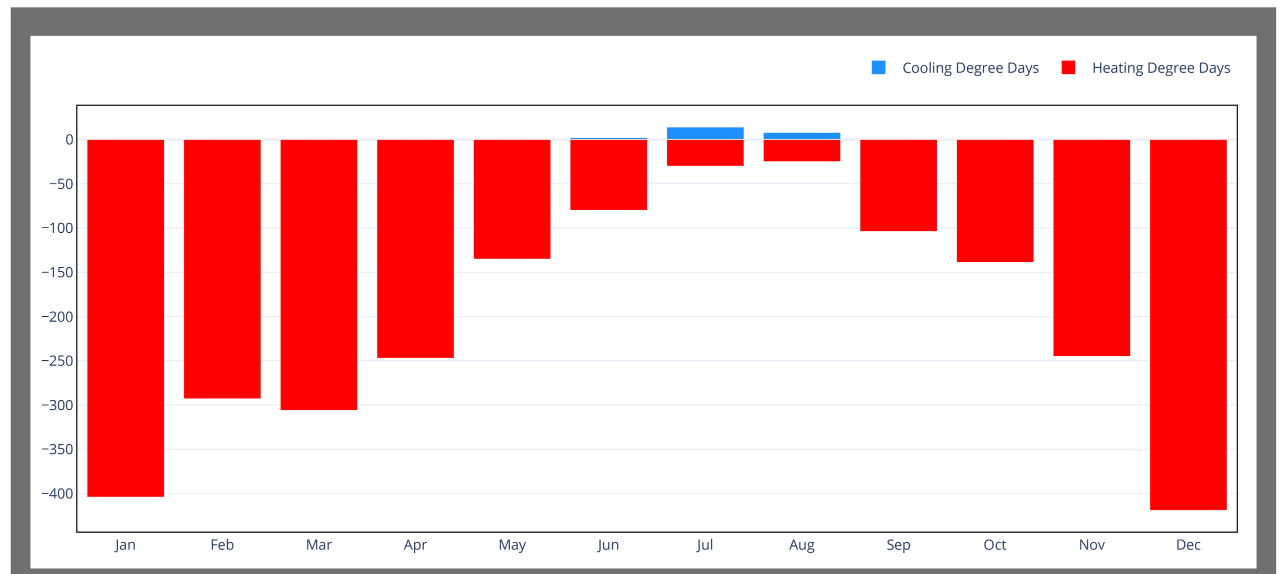


Figure 2.3.: Heating and cooling days

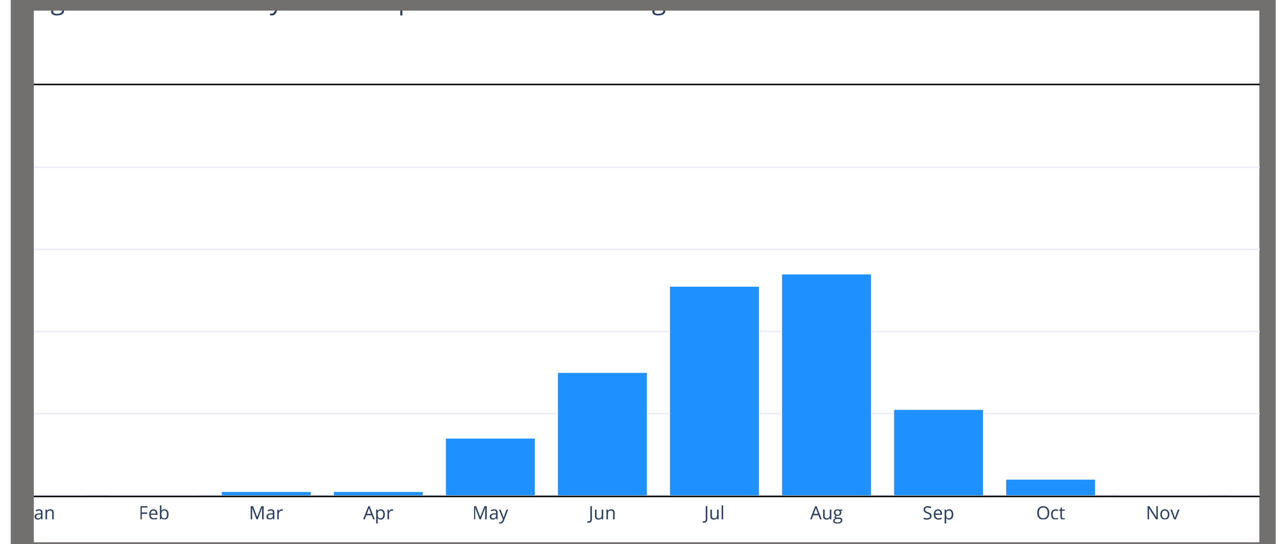


Figure 2.4.: Percentage of hours the drybulb temperature is in the range 18 to 25

Comfort

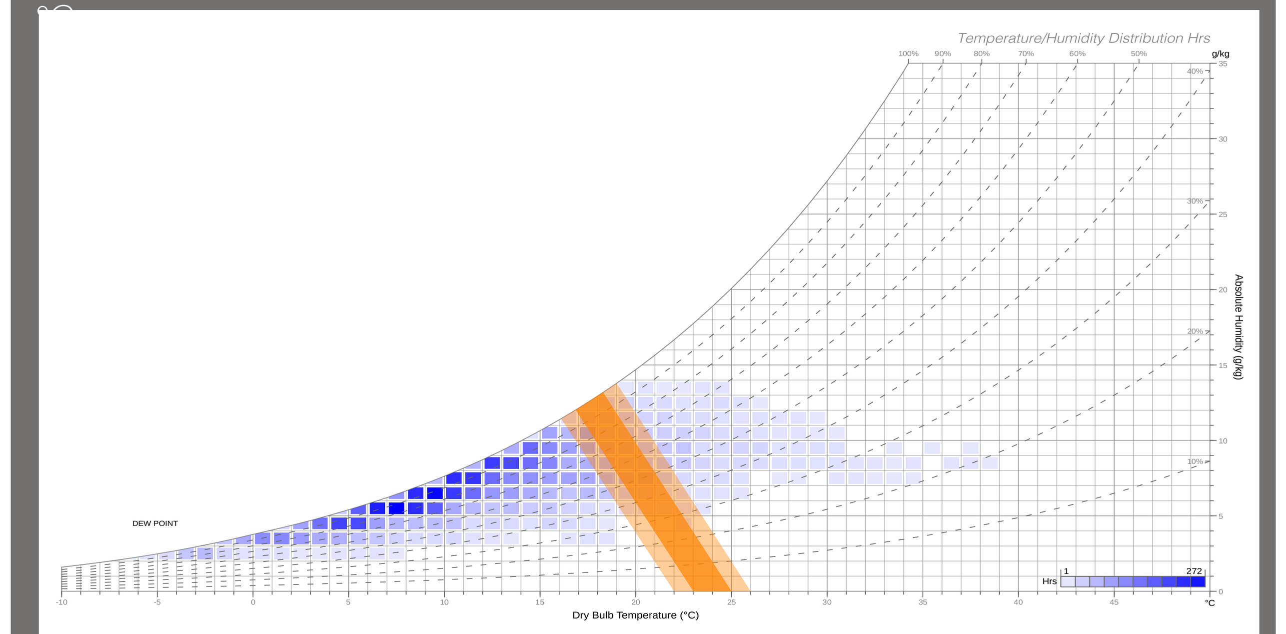


Figure 2.5. Heating Season comfort as per ASHRAE 55-2017

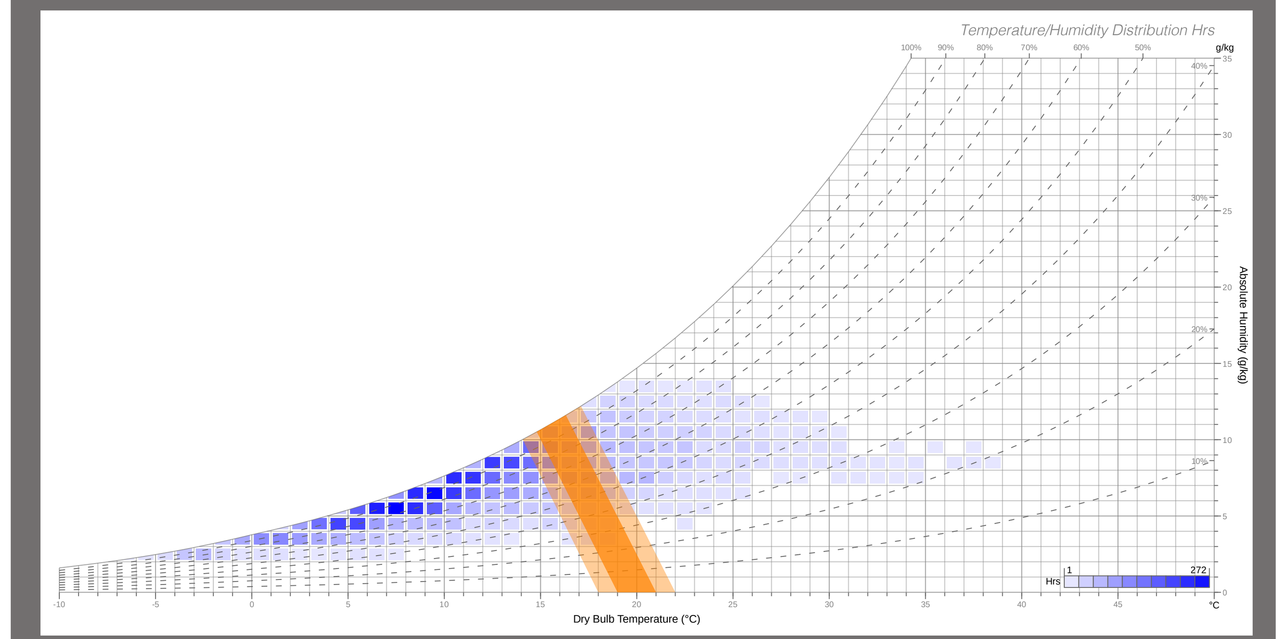


Figure 2.6. Cooling Season comfort as per ASHRAE 55-2017

Relative humidity

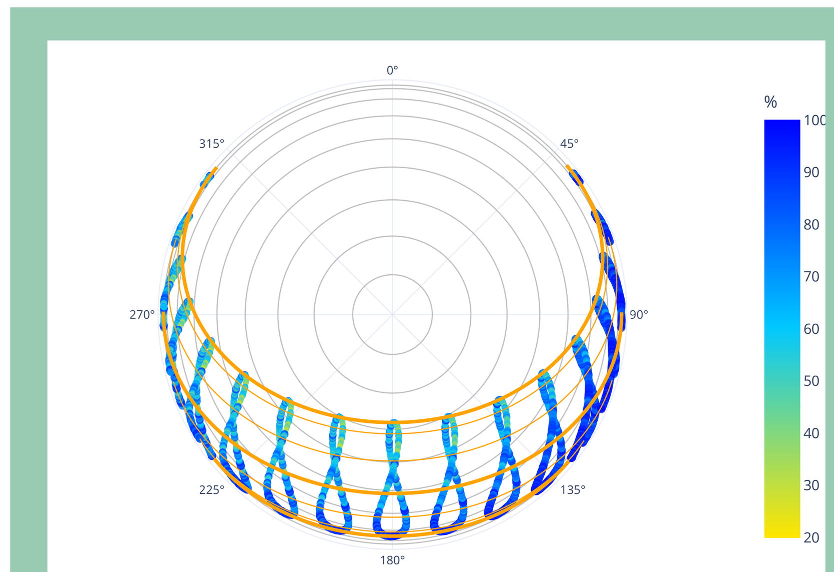


Figure 2.7.

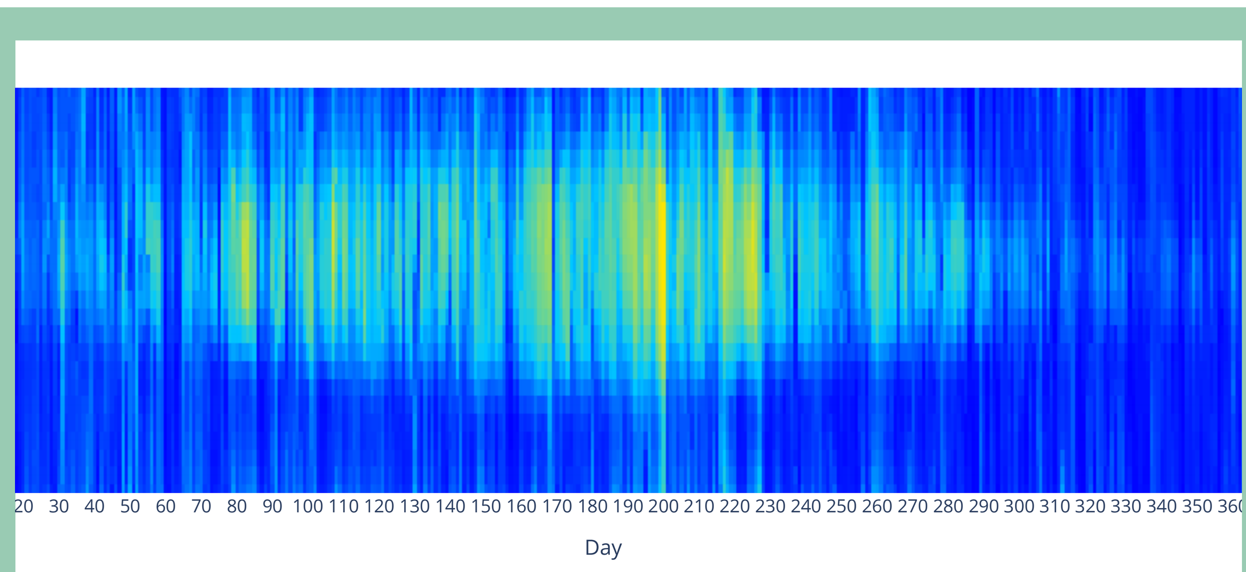


Figure 2.8.

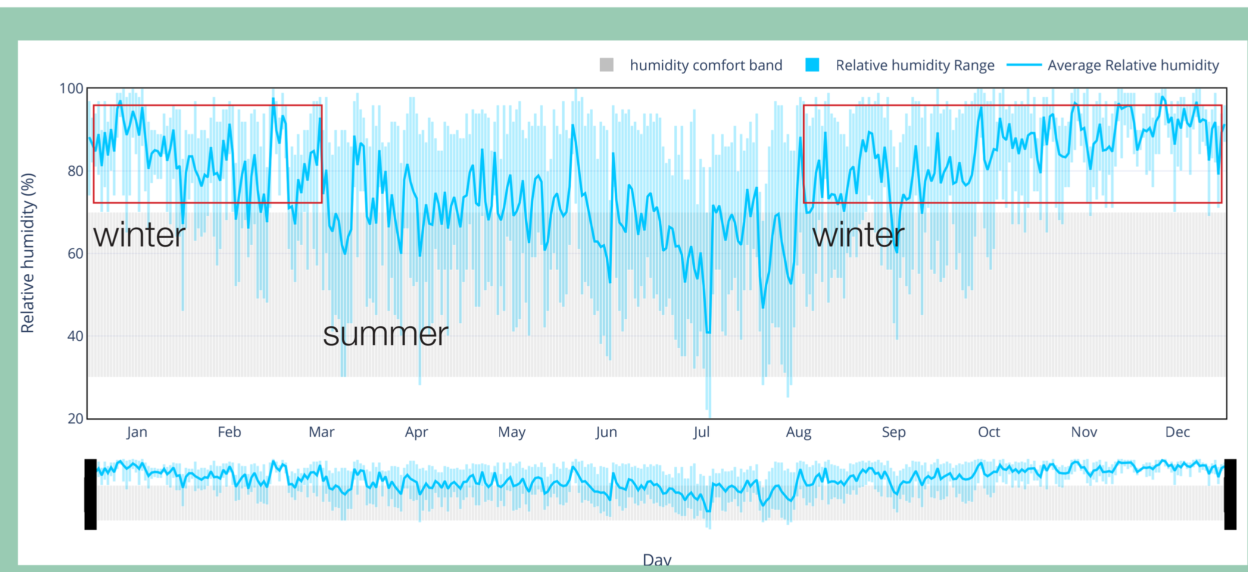


Figure 2.9.

Dry bulb temperature

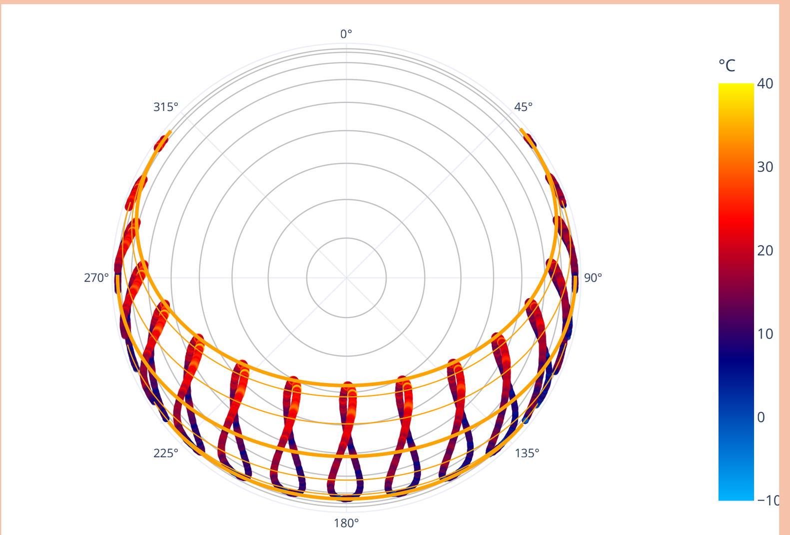


Figure 2.8.

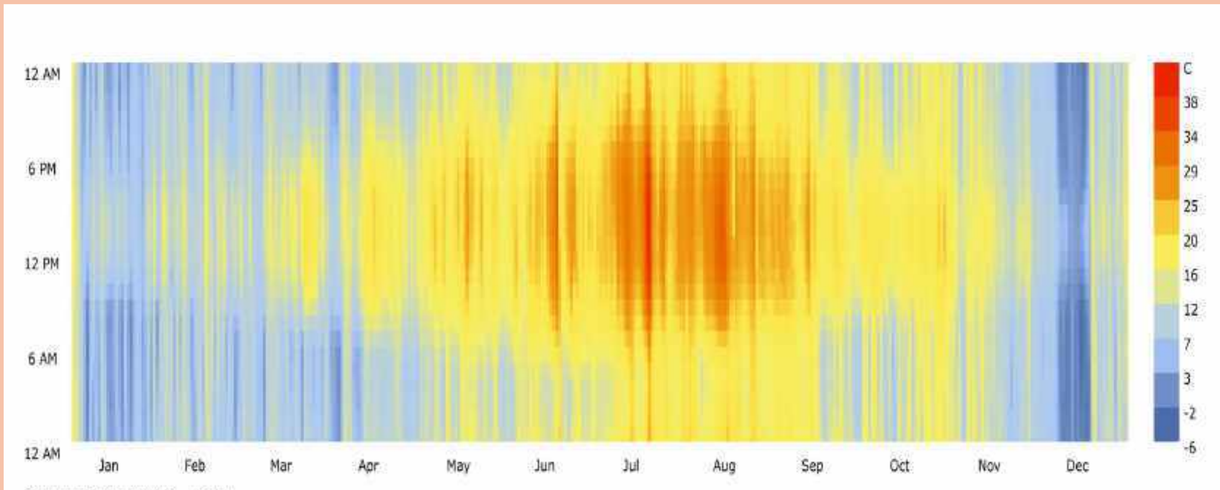


Figure 2.9.

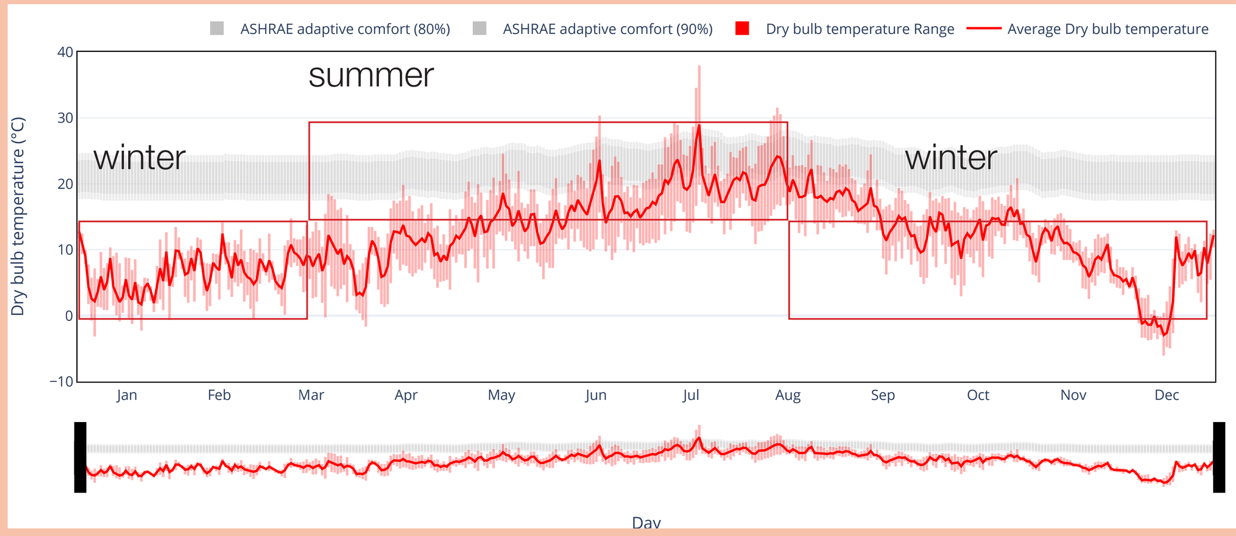


Figure 2.10.

Direct normal radiation

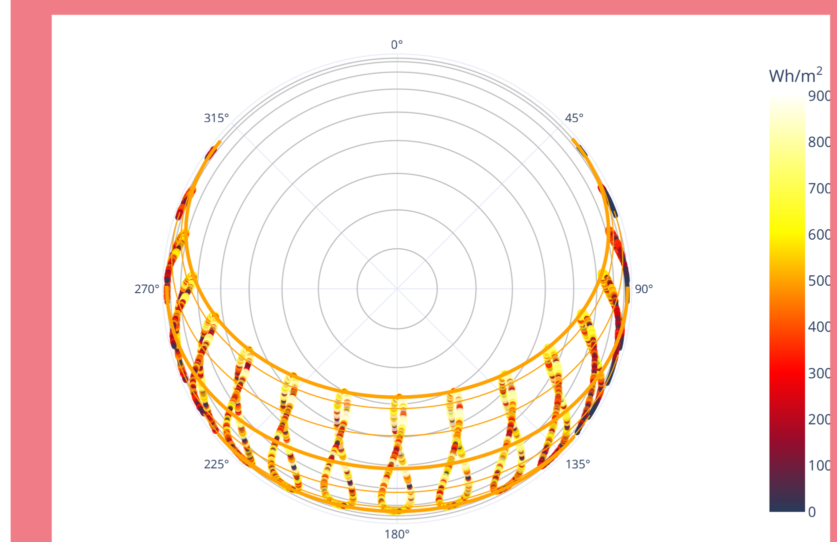


Figure 2.11.

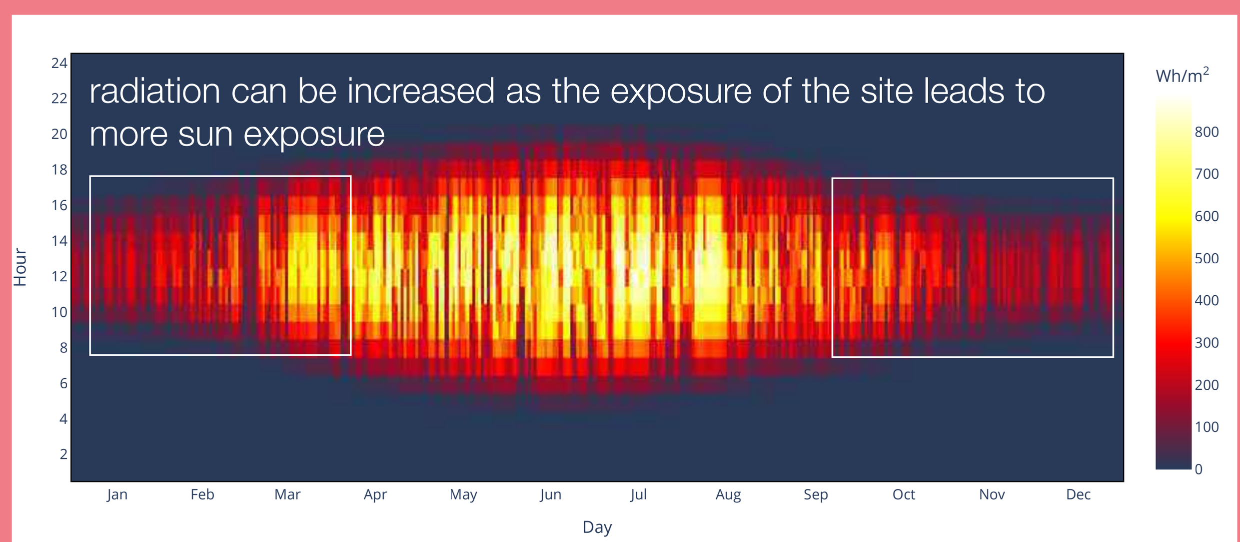


Figure 2.12.

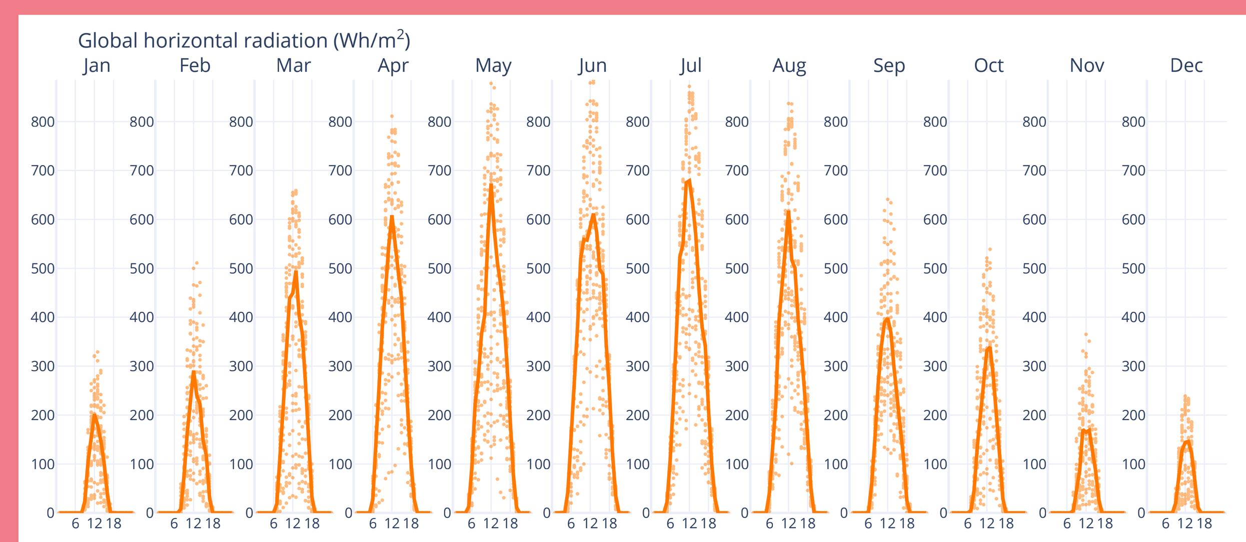


Figure 2.13.

Conclusion:

Wind:
A wind tunnel is created with the adjacent buildings and prevalent winds coming from the south (fig.2.1.). Potential opportunity for wind powered energy source.

Comfort:
It is clear from fig.2.3. as well as 2.5. and 2.6. that the building requires much more heating strategies than cooling strategies. However, some storage room require a more stable temperature so slightly more cooling might be necessary.

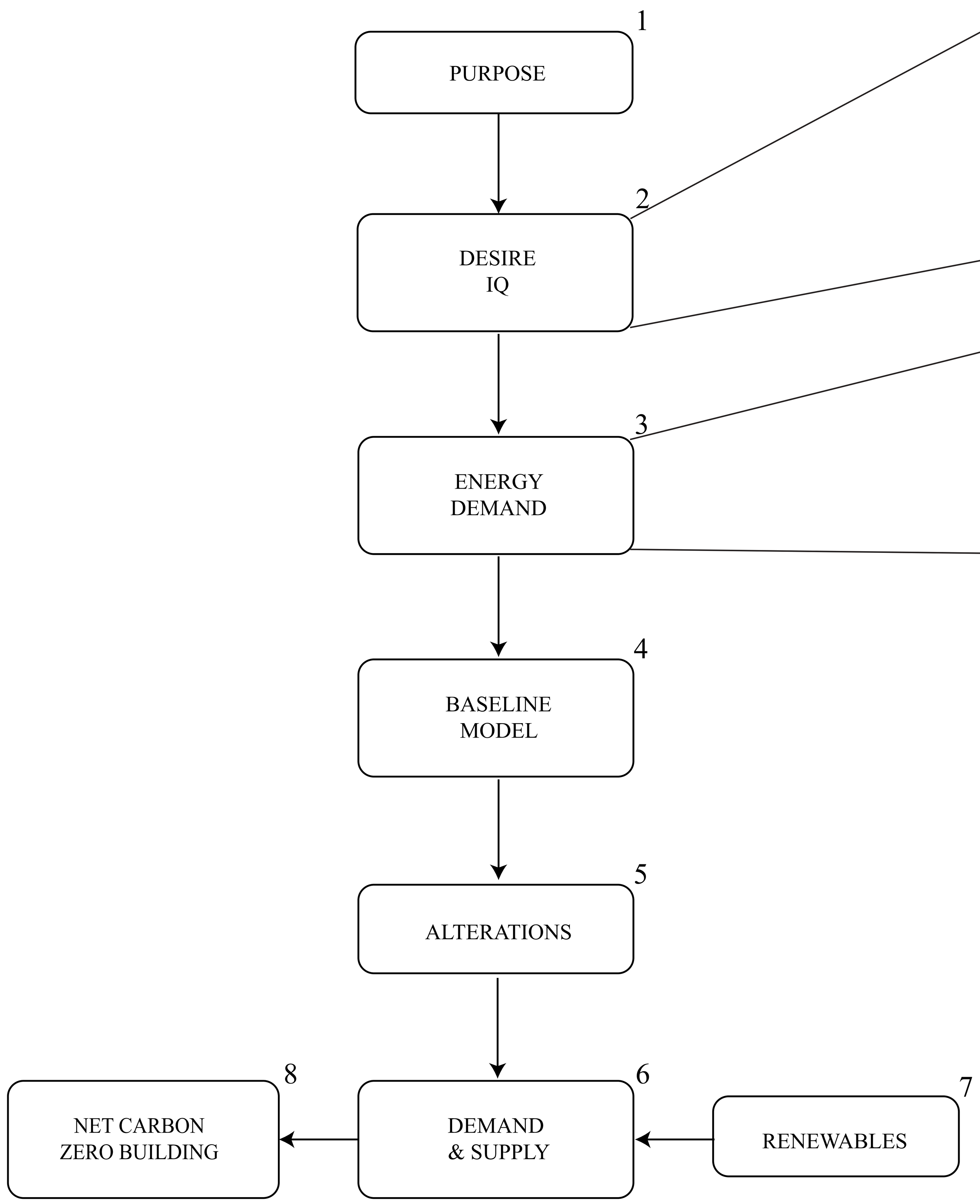
Tides:
Highlighted on the map are the communities affected by the tide, they live with the tide. It is a great opportunity for hydropower, and dam designs that can be filled up up to twice per day (fig. 2.3.).

Relative Humidity:
The site being on water, nearby buildings can be taken into account in terms of how they deal with high humdity.

Dry bulb temperature:
Fig. 2.8., 2.9. and 2.0. do not show high temperatures, and it seems that extremely low temperatures are not very common either. There is a tendency for the site to be in the range of being in the range of 12 to 16 degrees.

Direct Solar Radiation:
The site being on the Thames it is constantly exposed to solar radiation, so the graphs could be changed and thus radiation increased by 10%. No need for shadow and radiance analysis, as the center of the river is constantly exposed to sun. So for air drying clay, vessels can be sent onto the Thames for it to dry on the roof.

Environmental Design Goals



KEYSPACES NEEDS and DEMANDS

	total building area = 182m^2	zone 1	zone 2	zone 3	zone 4	zone 5	zone 6	zone 7
	ROOM TYPE	**AUCTION ROOM**	**BOILER ROOM**	**CORRIDOR**	**GALLERY**	**PRIVATE SALE ROOM**	**STORAGE ROOM**	**TOILETS**
	floor area (m2)	81	1.2	28	67	14	17	2.5
	people	97.2	1	3	10	2	4	2
	occupancy (people/m2)	1.2	0.833	0.107	0.149	0.143	0.235	0.800
heating season	**temp (°C)**	21-23	19-21	19-21	19-21	21-23	19-21	19-21
	RH (%)	40-60	40-60	40-60	40-60	40-60	40-60	40-60
	activity (met)	1.2	n/a	1.4	1.4	1.4	1.4	n/a
	clothing (clo)	0.9	n/a	1	1	1	1	n/a
cooling season	**temp (°C)**	22-25	21-25	21-25	21-25	21-25	21-25	21-25
	RH (%)	40-60	40-60	40-60	40-60	40-60	40-60	40-60
	activity (met)	1.1	n/a	1.3	1.3	1.3	1.3	n/a
	clothing (clo)	0.6	n/a	0.6	0.6	0.6	0.6	n/a
	suggested air supply rate (L·s^-1 per person)	11.5	11.5	11.5	11.5	11.5	11.5	11.5
	maintained illuminance (lux)	200	100	100	200	200	50	100
	noise criterion (NR)	30	n/a	40	35	30-35	30-35	n/a
	noise criterion (dBA)	35	n/a	45	40	35-40	35-40	n/a
	noise criterion (dBC)	60	n/a	70	65	60-65	60-65	n/a

GOALS AND BENCHMARKS

	zone 1	zone 2	zone 3	zone 4	zone 5	zone 6	zone 7			
ROOM TYPE	**AUCTION ROOM**	**BOILER ROOM**	**CORRIDOR**	**GALLERY**	**PRIVATE SALE ROOM**	**STORAGE ROOM**	**TOILETS**	**TOTAL**		**PASSIV HAUS**
electricity good practice benchmark (kWh/m2/yr)	52	n/a	39	39	39	37	n/a	41		24
electricity typical benchmark (kWh/m2/yr)	60	n/a	55	55	55	39	n/a	52.8		24
fossil thermal good practice benchmark (kWh/m2/yr)	125	n/a	79	79	79	283	n/a	129		15
fossil thermal thypical benchmark (kWh/m2/yr)	190	n/a	121	121	121	311	n/a	172.8		15
total electricity (kWh/yr)	4212	0	1092	2613	546	629	0	9092		

On Site Renewables and Storage

Table 1

	explanation		Auction house on a fairly busy day, modelling all with one occupancy.	On a busy day.	On a very busy day.	Auction takes over the whole building.	Quiet day at the auction house with no auction.	Private viewing in the whole building.	Changing orientation.	Changing orientation.	Changing orientation.	Changing WWR.
	simulation	updated baseline V1	iteration 1	iteration 2	iteration 3	iteration 4	iteration 5	iteration 6	iteration 7	iteration 8	iteration 9	iteration 10
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	0.5	2	3	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	all auction	all storage	all gallery	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	south	east	45 towards west	north
PASSIVE MEASURES	WtoW ratio (%)	30	30	30	30	30	30	30	30	30	30	60
	solar shading (m)	off	no	no	no	no	no	no	no	no	no	no
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	283	283	283	283	283	283
	window u-value (W/m2-K)	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
	external walls u-value (W/m2-K)	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351
	roof u-value (W/m2-K)	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346
	skylight (porcelain roof) (m2 or WtoR ration %)	off	no	no	no	no	no	no	no	no	no	no
	natural ventilation	on	off	off	off	off	off	off	off	off	off	off
	mechanical ventilation	off	off	off	off	off	off	off	off	off	off	off
HVAC	heating	on	on	on	on	on	on	on	on	on	on	on
	cooling	off	off	off	off	off	off	off	off	off	off	off
	HVAC type	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller
	Humidity control	off	off	off	off	off	off	off	off	off	off	off
detailed HVAC	Heat pumps	off	no	no	no	no	no	no	no	no	no	no
	Hydropower	off	no	no	no	no	no	no	no	no	no	no
RENEWABLES	Solar panels (roof coverage %)	off	no	no	no	no	no	no	no	no	no	no
	Geothermal energy	off	no	no	no	no	no	no	no	no	no	no
	site energy per m2 ((kWh/m2/year)	87	73	63	61	87	53	94	86	87	85	88
	cooling load (kWh/m2/year)	0	0	0	0	0	0	0	0	0	0	0
	heating load (kWh/m2/year)	40	25	15	13	43	45	40	38	39	37	40
	electricity-interior lighting (kWh/m2/year)	36	36	36	36	36	6	40	36	36	36	36
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

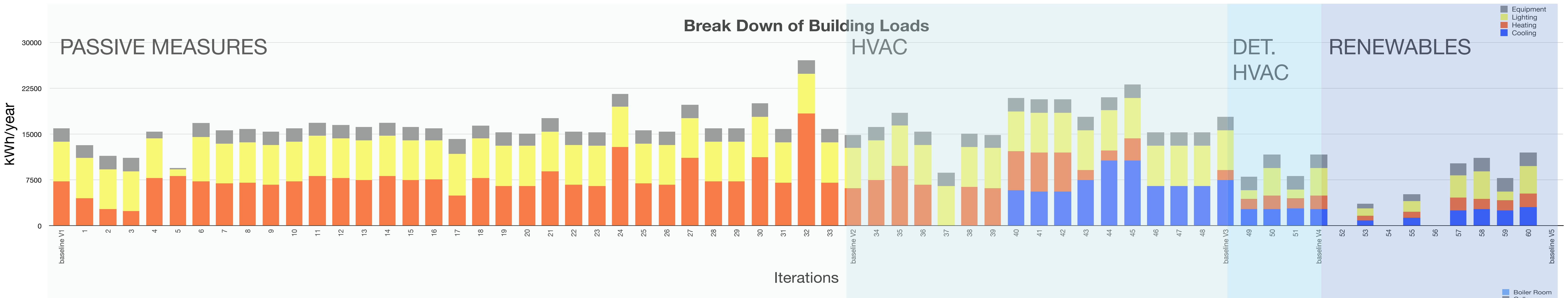
	explanation	Very high WWR (unrealistic scenario).	Very low WWR (unrealistic scenario).	Implementing shading.	Trying unrealistic shading.	Putting louvres as a better design solution.	Increasing thermal mass.	Extremely thick walls for an increase in thermal mass.	Thin walls for a low thermal mass (unrealistic scenario).	Lower window U value.	State of the art window U value.	What happens to the energy consumption when there is a high window U value?
	simulation	iteration 11	iteration 12	iteration 13	iteration 14	iteration 15	iteration 16	iteration 17	iteration 18	iteration 19	iteration 20	iteration 21
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	north	north	north	north
PASSIVE MEASURES	WtoW ratio (%)	90	10	30	30	30	30	30	30	30	30	30
	solar shading (m)	no	no	0.5 overhang	2 overhang	0.5 louvres	off	off	off	off	off	off
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	500	2000	100	283	283	283
	window u-value (W/m2-K)	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.4	0.8	3
	external walls u-value (W/m2-K)	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351
	roof u-value (W/m2-K)	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346
	skylight (porcelain roof) (m2 or WtoR ration %)	no	no	no	no	no	off	off	off	off	off	off
	natural ventilation	off	off	off	off	off	on	on	on	on	on	on
	mechanical ventilation	off	off	off	off	off	off	off	off	off	off	off
HVAC	heating	on	on	on	on	on	on	on	on	on	on	on
	cooling	off	off	off	off	off	off	off	off	off	off	off
	HVAC type	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller
	Humidity control	off	off	off	off	off	off	off	off	off	off	off
detailed HVAC	Heat pumps	no	no	no	no	no	off	off	off	off	off	off
	Hydropower	no	no	no	no	no	off	off	off	off	off	off
RENEWABLES	Solar panels (roof coverage %)	no	no	no	no	no	off	off	off	off	off	off
	Geothermal energy	no	no	no	no	no	off	off	off	off	off	off
	site energy per m2 ((kWh/m2/year)	93	90	89	93	89	89	78	91	84	83	97
	cooling load (kWh/m2/year)	0	0	0	0	0	0	0	0	0	0	0
	heating load (kWh/m2/year)	45	43	41	45	41	42	27	43	36	36	49
	electricity-interior lighting (kWh/m2/year)	36	36	36	36	36	35	38	36	36	36	36
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

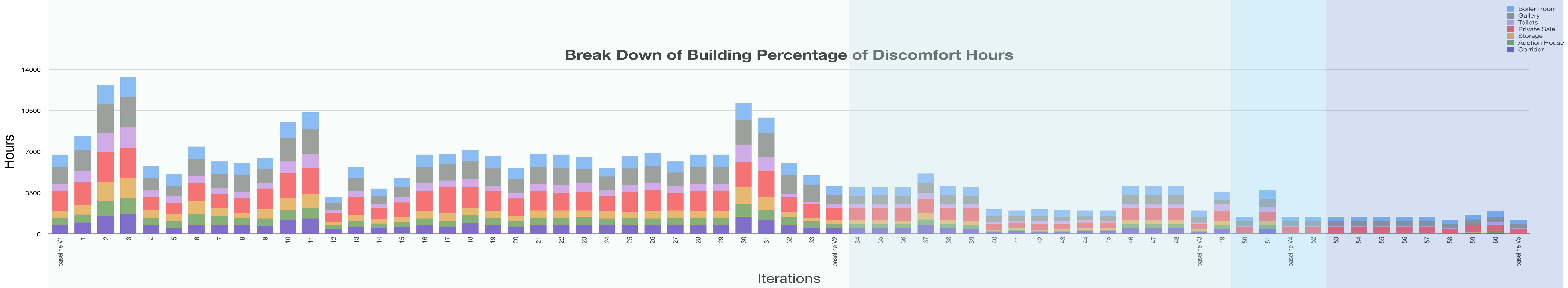
	explanation	Lower wall U value.	State of the art wall U value.	What happens to the energy consumption when there is a high wall U value?	Lower roof U value.	State of the art roof U value.	What happens to the energy consumption when there is a high roof U value?	Putting reasonable roof openings.	Putting bigger roof openings.	Trying unreasonable skylight where the roof become a huge window.	Seeing what happens when there is no natural ventilation.	Putting on exclusively mechanical ventilation.
	simulation	iteration 22	iteration 23	iteration 24	iteration 25	iteration 26	iteration 27	iteration 28	iteration 29	iteration 30	iteration 31	iteration 32
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	north	north	north	north
PASSIVE MEASURES	WtoW ratio (%)	30	30	30	30	30	30	30	30	30	30	30
	solar shading (m)	off	off	off	off	off	off	off	off	off	off	off
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	283	283	283	283	283	283
	window u-value (W/m2-K)	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
	external walls u-value (W/m2-K)	0.26	0.22	1.5	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351
	roof u-value (W/m2-K)	0.346	0.346	0.346	0.3	0.22	1.5	0.346	0.346	0.346	0.346	0.346
	skylight (porcelain roof) (m2 or WtoR ration %)	off	off	off	off	off	off	fixed roof window 1mx0.5m	fixed roof window 1mx1.5m	100	off	off
	natural ventilation	on	on	on	on	on	on	on	on	on	off	mechanical
	mechanical ventilation	off	off	off	off	off	off	off	off	off	off	off
HVAC	heating	on	on	on	on	on	on	on	on	on	on	on
	cooling	off	off	off	off	off	off	off	off	off	off	off
	HVAC type	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller
	Humidity control	off	off	off	off	off	off	off	off	off	off	off
detailed HVAC	Heat pumps	off	off	off	off	off	off	off	off	off	off	off
	Hydropower	off	off	off	off	off	off	off	off	off	off	off
RENEWABLES	Solar panels (roof coverage %)	off	off	off	off	off	off	off	off	off	off	off
	Geothermal energy	off	off	off	off	off	off	off	off	off	off	off
	site energy per m2 ((kWh/m2/year)	85	84	119	86	85	108	87	89	110.15	87	148
	cooling load (kWh/m2/year)	0	0	0	0	0	0	0	0	0	0	0
	heating load (kWh/m2/year)	37	36	71	38	37	61	40	40	62	39	101
	electricity-interior lighting (kWh/m2/year)	36	36	36	36	36	36	36	36	36	36	36
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

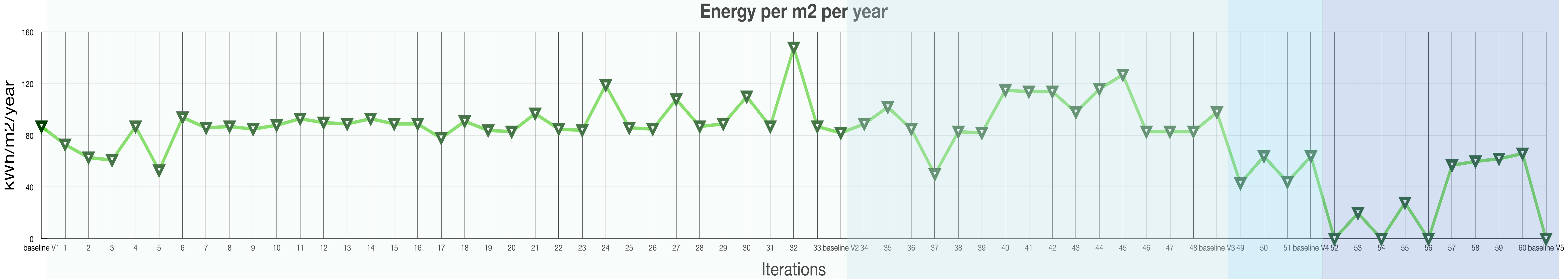
	explanation	Trying a mixed ventilation system.	Implementing the best passive energy measures, mainly to lower discomfort hours.	Putting HR in mechanical ventilation on.	Putting economiser in mechanical ventilation on.	Putting HR and economiser in mechanical ventilation on.	Switching off the heating.	Trying out fossil fuels as a worst case scenario.	Taking into account natural ventilation load.	Switching on cooling with an air cooled system.	Trying cooled beams, so that the art underneath is untouched.	Trying chilled ceilings, so that the art underneath is untouched.
	simulation	iteration 33	updated baseline V2	iteration 34	iteration 35	iteration 36	iteration 37	iteration 38	iteration 39	iteration 40	iteration 41	iteration 42
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	north	north	north	north
PASSIVE MEASURES	WtoW ratio (%)	30	20	20	20	20	20	20	20	20	20	20
	solar shading (m)	off	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	283	283	283	283	283	283
	window u-value (W/m2-K)	1.96	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	external walls u-value (W/m2-K)	0.351	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	roof u-value (W/m2-K)	0.346	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	skylight (porcelain roof) (m2 or WtoR ration %)	off	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m
	natural ventilation	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed
	mechanical ventilation	off	off	heat recovery	economiser	HR + economiser	off	off	off	off	off	off
HVAC	heating	on	on	on	on	on	off	natural gas	natural ventilation load	on	on	on
	cooling	off	off	off	off	off	off	off	off	air cooled	cooled beams	chilled ceiling
	HVAC type	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller
	Humidity control	off	off	off	off	off	off	off	off	off	off	off
detailed HVAC	Heat pumps	off	no	no	no	no	no	no	no	no	no	no
	Hydropower	off	no	no	no	no	no	no	no	no	no	no
RENEWABLES	Solar panels (roof coverage %)	off	no	no	no	no	no	no	no	no	no	no
	Geothermal energy	off	no	no	no	no	no	no	no	no	no	no
	site energy per m2 ((kWh/m2/year)	87	82	89	102	85	50	83	82	115	114	114
	cooling load (kWh/m2/year)	0	0	0	0	0	0	0	0	32	31	31
	heating load (kWh/m2/year)	39	34	41	54	37	0	35	34	35	35	35
	electricity-interior lighting (kWh/m2/year)	36	36	36	36	36	36	36	36	36	36	36
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

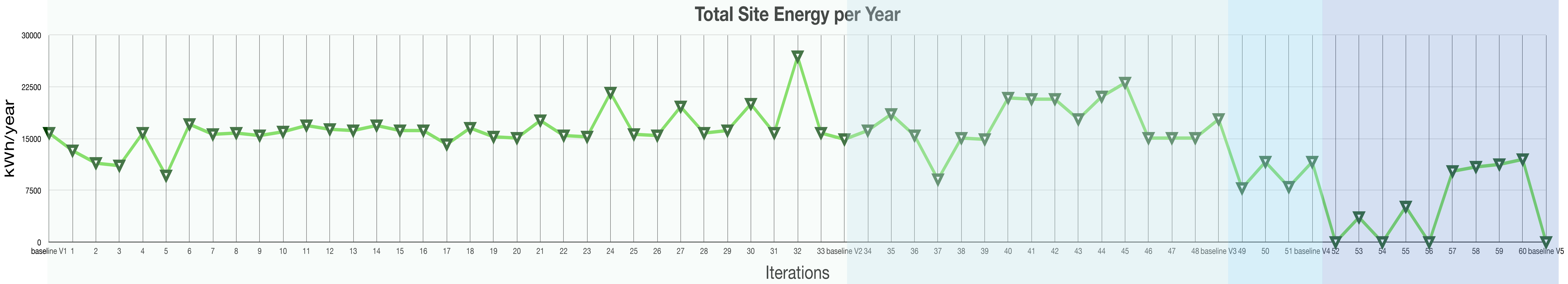
	explanation	Putting on VAV, and in theory it should be the best system.	Putting on CAV to see if it underperforms VAV.	Putting on VRF as a third option.	It is likely that the space can become too humid due to the river so humidification is put on.	Humidification is tried, but is likely not needed.	Even though HUM+DEHUM is not needed to see if it affects anything.	The loads are at the highest, but this is due to the switching on of cooling. Discomfort hours are down.	Trying ASHP.	Trying GSHP.	Trying water to air heat pump.	Lowering down energy consumption while having a low discomfort hours percentage.
	simulation	iteration 43	iteration 44	iteration 45	iteration 46	iteration 47	iteration 48	updated baseline V3	iteration 49	iteration 50	iteration 51	updated baseline V4
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	north	north	north	north
PASSIVE MEASURES	WtoW ratio (%)	20	20	20	20	20	20	20	20	20	20	20
	solar shading (m)	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	283	283	283	283	283	283
	window u-value (W/m2-K)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	external walls u-value (W/m2-K)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	roof u-value (W/m2-K)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	skylight (porcelain roof) (m2 or WtoR ration %)	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m
	natural ventilation	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed
	mechanical ventilation	off	off	off	off	off	off	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser
HVAC	heating	on	on	on	on	on	on	on	on	on	on	on
	cooling	off	off	off	off	off	off	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams
	HVAC type	VAV	CAV	VRF	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	fan coil uni, air cooled chiller	VAV	VAV	VAV	VAV	VAV
	Humidity control	off	off	off	dehumidification	humidification	HUM+DEHUM	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification
detailed HVAC	Heat pumps	no	no	no	no	no	no	no	ASHP, air to water Heat Pump, Suplementary Boiler, Water Convector	GSHP (vertical, 40 boreholes), water to water HP, heated floor, chilled Beams	Zone water to air heat pump, supplied by cooling tower and boiler dual setpoints	GSHP, water to water HP, heated floor, chilled Beams
	Hydropower	no	no	no	no	no	no	no	no	no	no	no
RENEWABLES	Solar panels (roof coverage %)	no	no	no	no	no	no	no	no	no	no	no
	Geothermal energy	no	no	no	no	no	no	no	no	no	no	no
	site energy per m2 ((kWh/m2/year)	98	116	127	83	83	83	98	43	64	44	64
	cooling load (kWh/m2/year)	41	59	59	36	36	36	41	15	15	16	15
	heating load (kWh/m2/year)	9	9	20	0	0	0	9	9	12	9	12
	electricity-interior lighting (kWh/m2/year)	36	36	36	36	36	36	36	8	25	8	25
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	explanation	Putting a dam on the south bank.	Putting a dam on the north bank.	Putting a dam on the north and south bank.	Half of the roof is covered with solar panels.	All of the roof is covered with solar panels, but it might be costly.	Trying a very low solar panel coverage.	Close to the surface means bigger variation in temperatures but can get higher values.	Digging deep means more stable but lower temperatures.	Longer pipes near the surface means more frequent energy input.	The final baseline is net carbon zero and has a very low discomfort hours percentage.
	simulation	iteration 52	iteration 53	iteration 54	iteration 55	iteration 56	iteration 57	iteration 58	iteration 59	iteration 60	updated baseline V5
	occupancy (people/m2)	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.8	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.9	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.10	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.11	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.12	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.13	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.14	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.15	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.16	zone 1: 1.2 zone 2: 0.833 zone 3: 0.107 zone 4: 0.149 zone 5: 0.143 zone 6: 0.235 zone 7: 0.16
	activity	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets	zone 1: auction room zone 2: boiler room zone 3: corridor zone 4: gallery zone 5: private sale room zone 6: art storage room zone 7: toilets
	building orientation	north	north	north	north	north	north	north	north	north	north
PASSIVE MEASURES	WtoW ratio (%)	20	21	22	23	24	25	26	27	28	28
	solar shading (m)	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres	0.5 louvres
	walls thickness (increase thermal mass) (mm)	283	283	283	283	283	283	283	283	283	283
	window u-value (W/m2-K)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	external walls u-value (W/m2-K)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	roof u-value (W/m2-K)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	skylight (porcelain roof) (m2 or WtoR ration %)	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m	fixed roof window 1mx1.5m
	natural ventilation	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed	mixed
	mechanical ventilation	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser	heat recovery + economiser
HVAC	heating	on	on	on	on	on	on	on	on	on	on
	cooling	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams	cooled beams
	HVAC type	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV
	Humidity control	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification	dehumidification
detailed HVAC	Heat pumps	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams	GSHP, water to water HP, heated floor, chilled Beams
	Hydropower	south dam	north dam	north and south dam	no	no	no	no	no	no	north and south dam
RENEWABLES	Solar panels (roof coverage %)	no	no	no	50%	100%	10%	no	no	no	50%
	Geothermal energy	no	no	no	no	no	no	closed loop horizontal, 270 boreholes, 70m	closed loop vertical	closed loop pond lake	closed loop horizontal, 40 boreholes, 70m
	site energy per m2 ((kWh/m2/year)	0	20	0	28	0	57	60	62	66	0
	cooling load (kWh/m2/year)	0	5	0	7	0	14	15	14	17	0
	heating load (kWh/m2/year)	0	3	0	4	0	9	9	9	12	0
	electricity-interior lighting (kWh/m2/year)	0	8	0	12	0	24	25	8	25	0
	electricity-interior equipment (kWh/m2/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total site energy (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	cooling load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	heating load (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior lighting (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	electricity-interior equipment (kWh/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE CORRIDOR ZONE 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE AUCTIONHOUSE ZONE 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE STORAGE ZONE 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE PRIVATESALE ZONE 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE TOILETS ZONE 7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE GALLERY ZONE 4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PEOPLE BOILERROOM ZONE 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	total time at discomfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	time at comfort level (h/year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at discomfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	percentage at comfort level (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]









BASELINE V1

The basline has already some good parameters implemented. However, its energy consumption are way to high and discomfort hours too large too.

updated BASELINE V2

Mainly the discomfort hours have gone down in that iteration, from 41% to 25%, according to ASHRAE standard 55-2007, with a 90% acceptability limit. This is achieved just using passive measures. There is also a small decrease in heating loads, which could be due to the mixed ventilation.

updated BASELINE V3

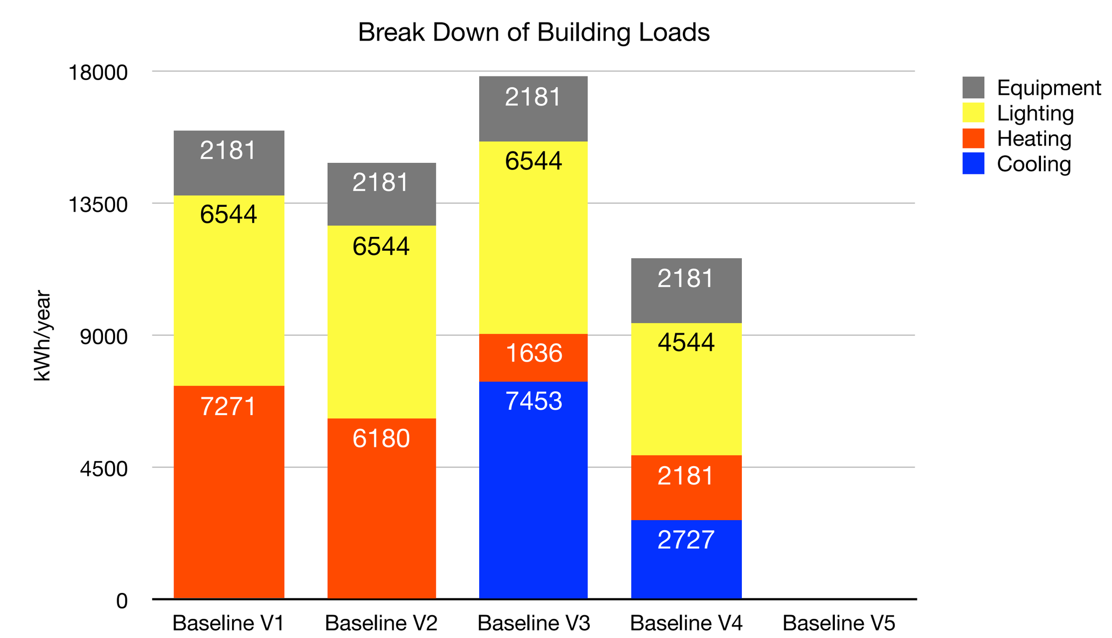
The added cooling significantly decreases the discomfort hours (from 25 to 12%), and the HVAC system significantly decreased the heating loads by 74%. The lighting and equipment stays the same in terms of loads. It is still not enough to reach net carbon zero or the desired occupant comfort range.

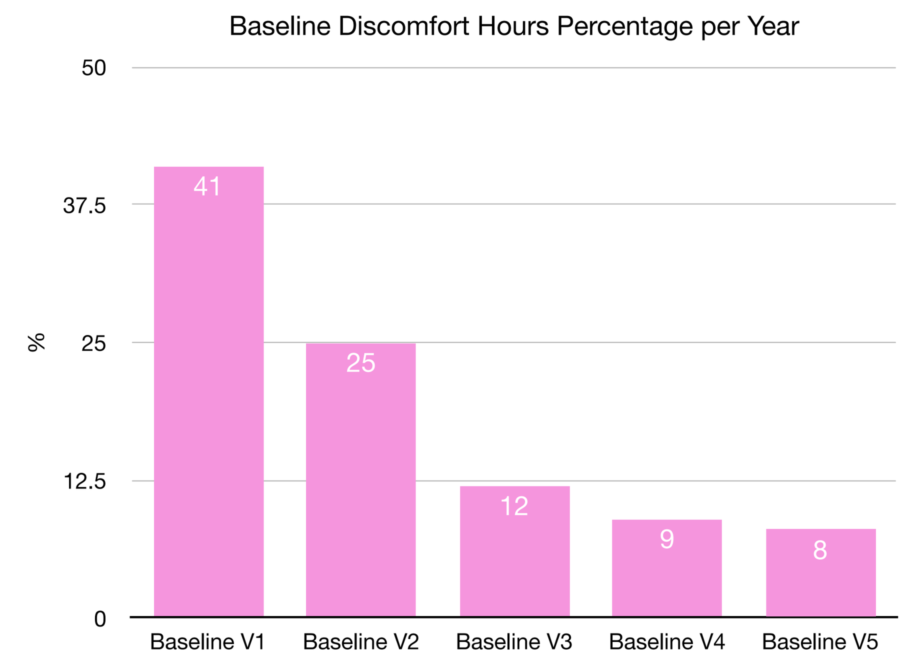
updated BASELINE V4

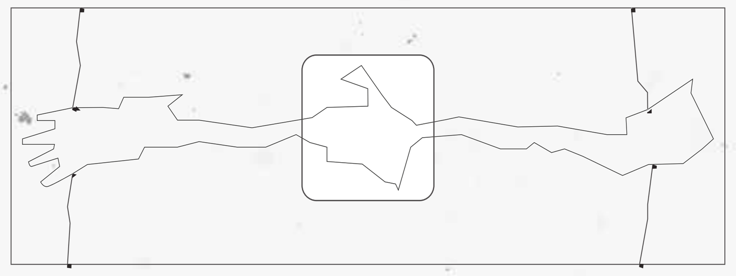
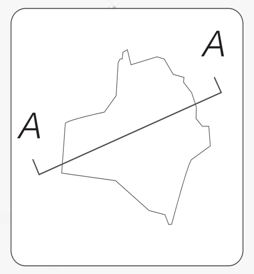
There is a compromise made where the heating load increases in the GSHP by 33% but the cooling load is reduced by 63%. The 9092kWh/year CIBSE benchmark is still not reached (having only achieved 11 633 kWh/year), but the discomfort hours are reduced to 9% which is good for a space with a programme that varies so much (from very occupied auction house to private sale).

updated and final BASELINE V5

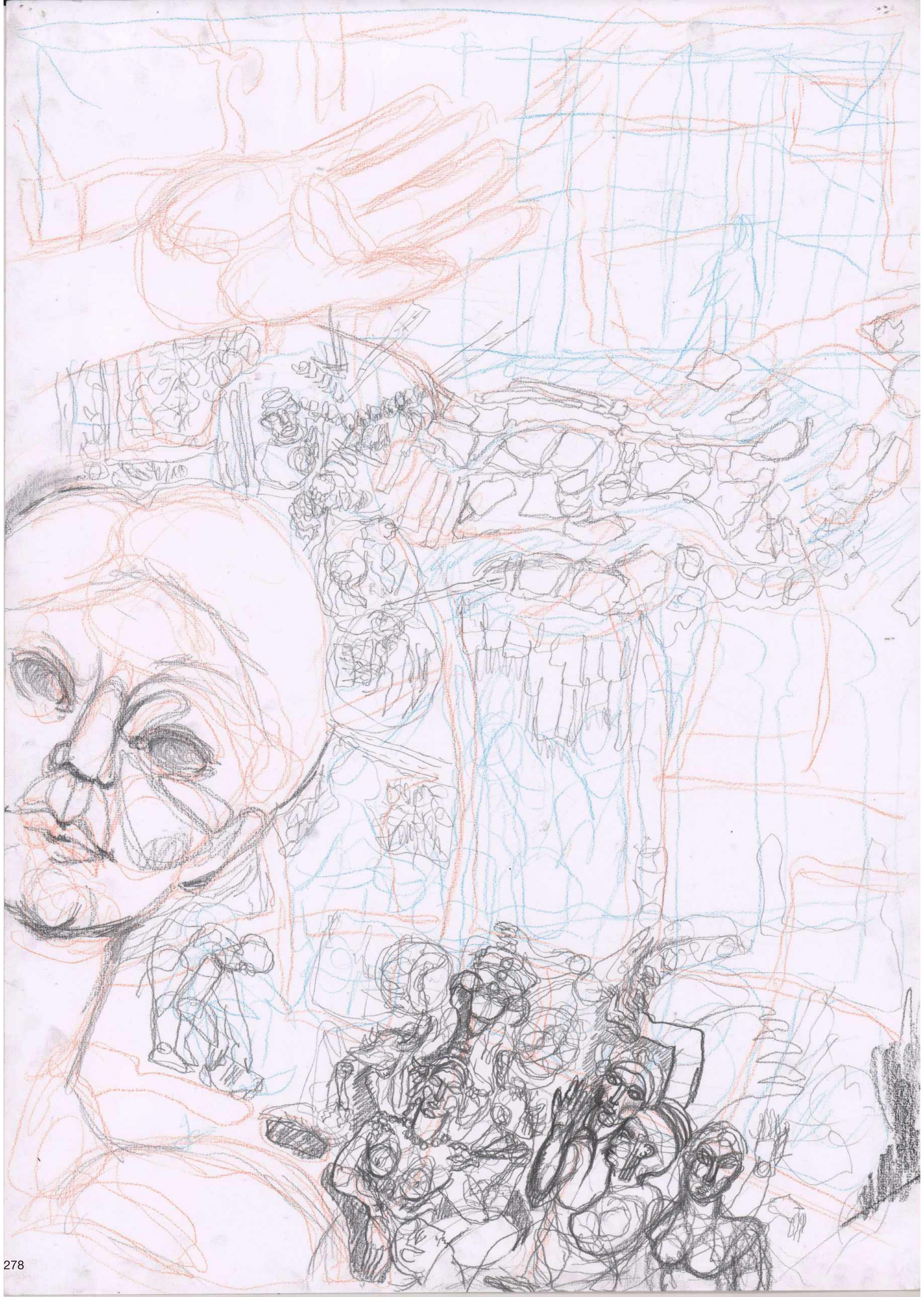
The renewables implemented, mainly solar power panels and dams, reduce the energy usage to net zero carbon. It is the desired goal, and even though the discomfort hours are still 8%, it is good enough for an auction house where people do not live.





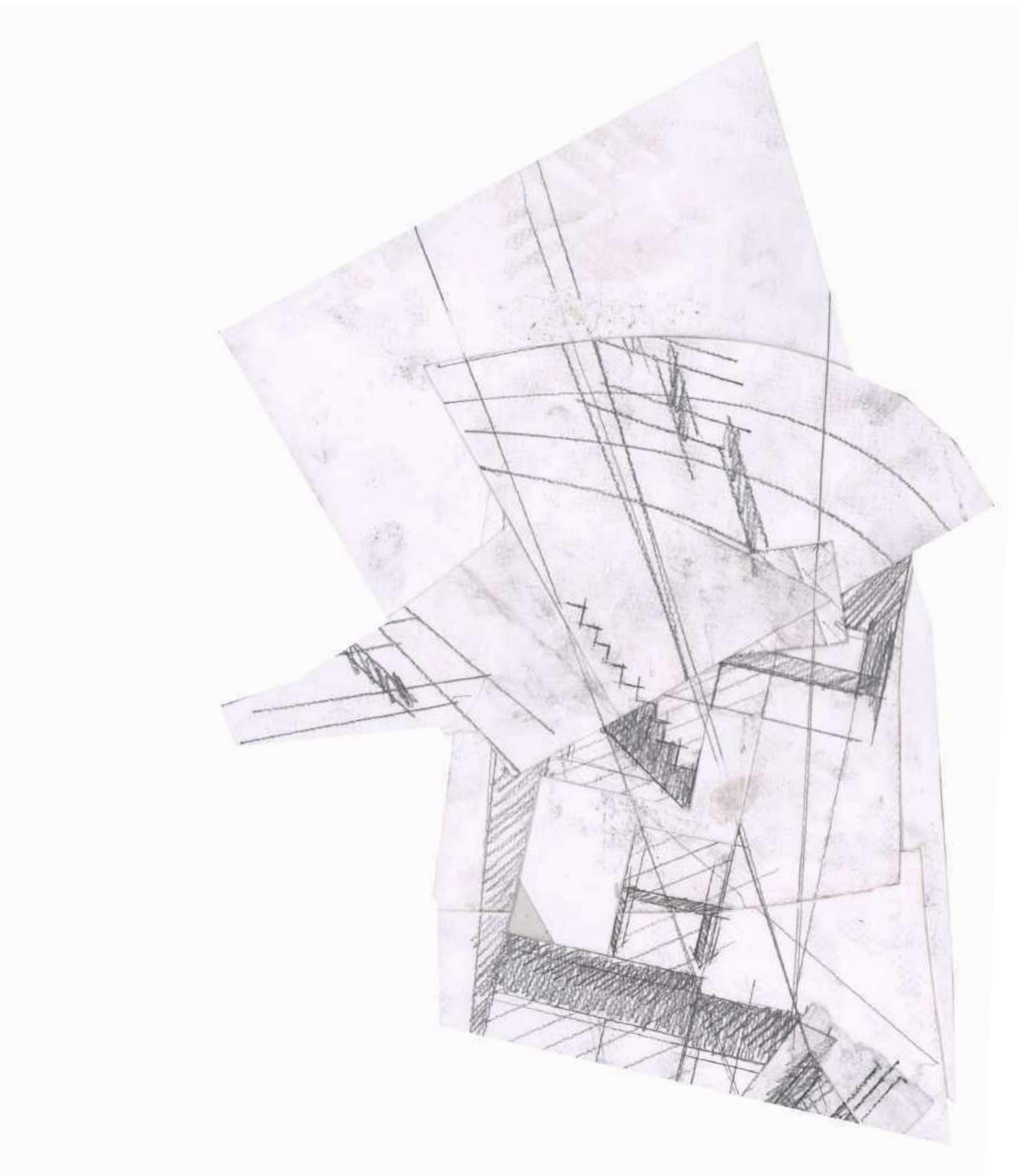


A
A

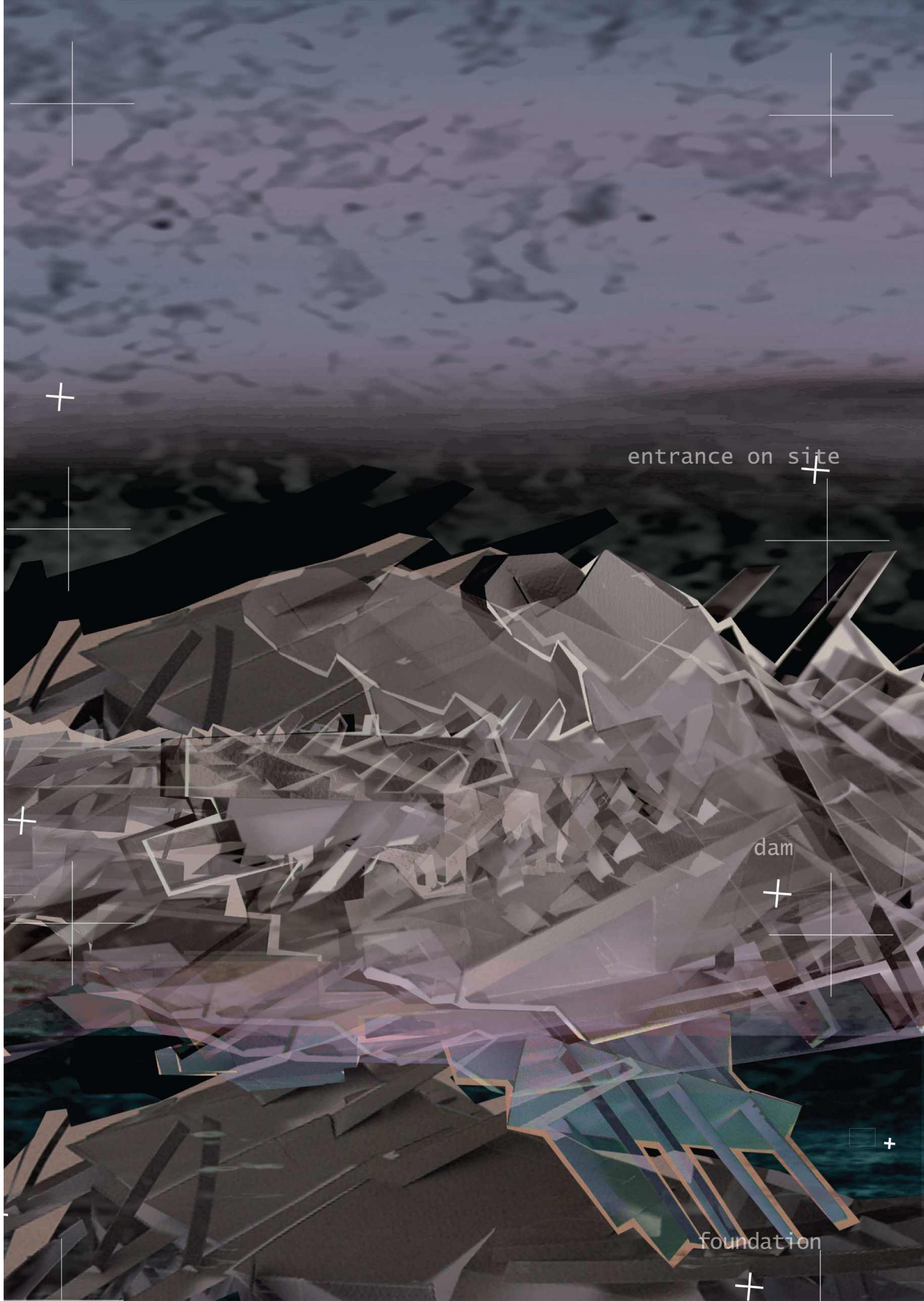
6.
7.
9.
8.
10.
11.
5.
4.
3.
2.
1.
1- GSHP
2- electrical grid
3-water sewage
4-toilets
5-underfloor heating
6-solar panels
7-VAV
8-CO2 sensors
9-lights
10-switches
11-electrical sockets
1:50 on A1
4m



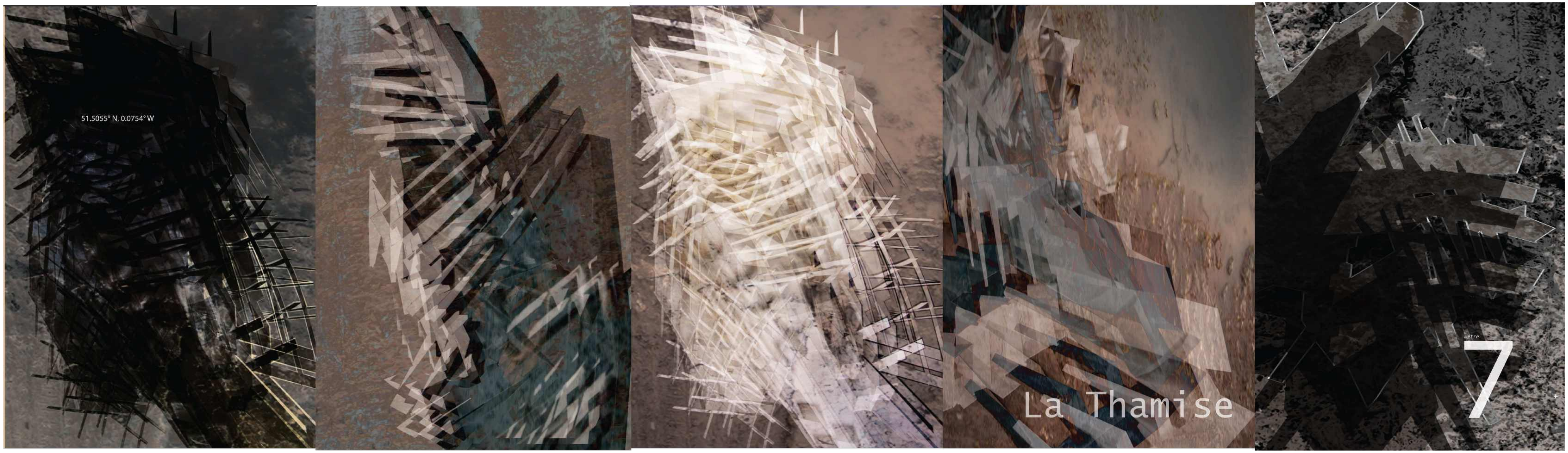
Section 15. Final Drawings: Venice

The outcome of the project, is like clay, malleable. Malleable in the sense that it is not completely finished, yet accomplished in its own right. The drawings vary from being concrete to abstract, and inbetween the collages-that sit somewhere inbetween art, illustrations and architecture, is my vision of my future practice as a creator. The renders took form of ceramic glazed fragments, that lie on tables, floors and rivers just like the Thames artefacts: lost, forgoten and scavanged. The building is one that can last or be destroyed, one that exists and does not at the same time. If one agrees to see it, it will appear, like a sinking ship in St Saviour's dock, with its rusted beams, muddy stairs and algae wettened rails.

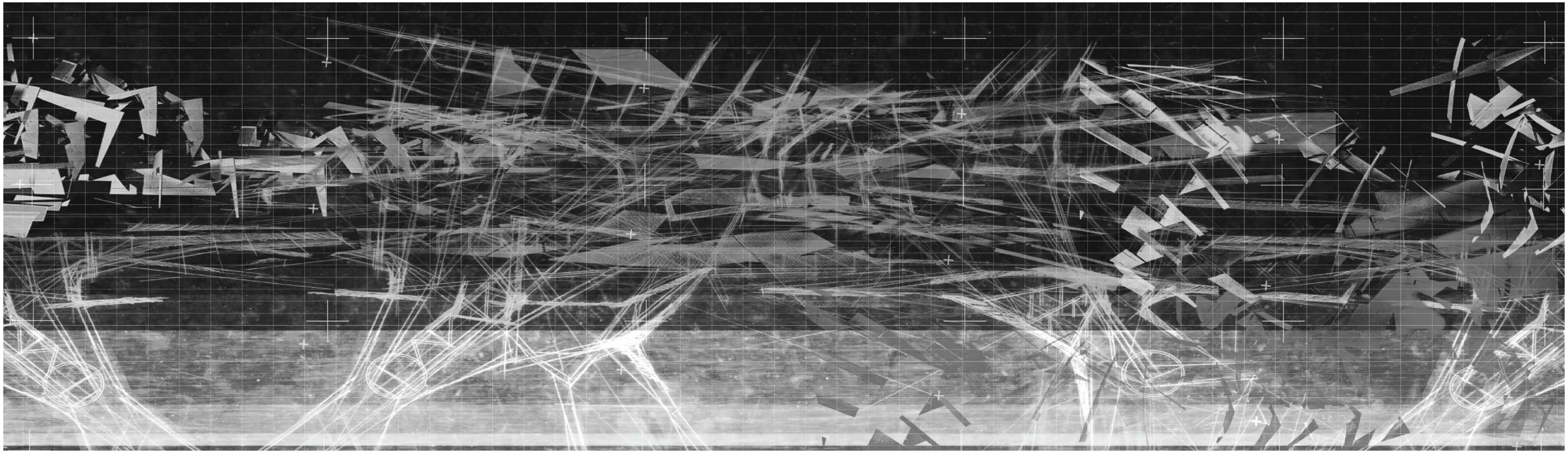



entrance on site
dam
foundation

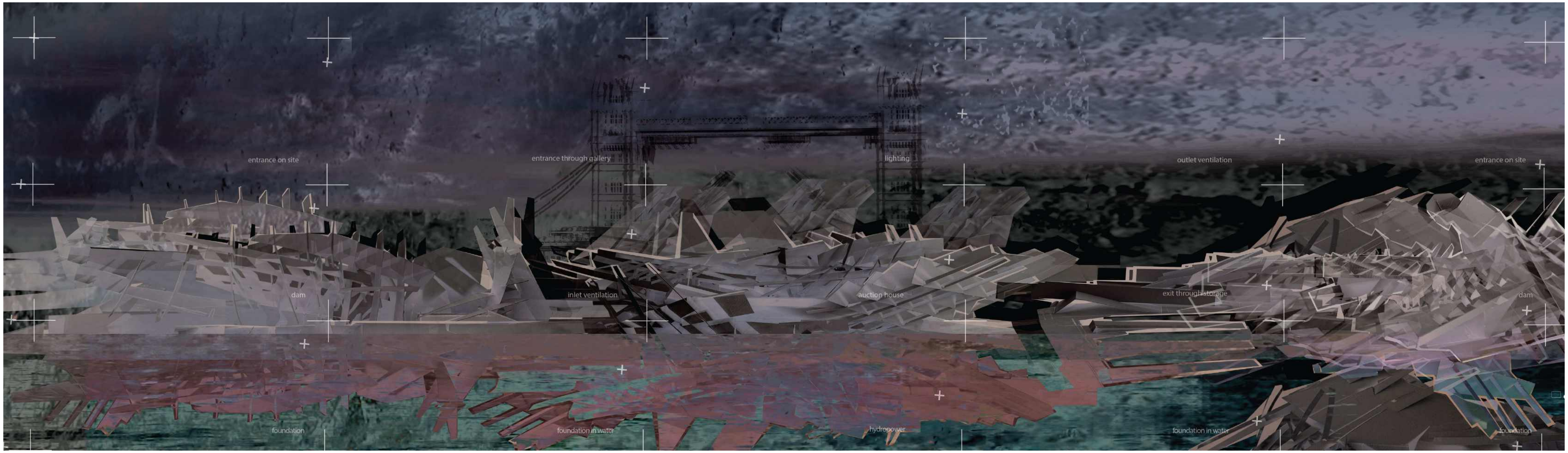
Front Cover



Long Section 1:200



Elevations 1:200



Aerial Photo-Montage

Site Plan 1:5000

Floor Plan of center of bridge 1:50

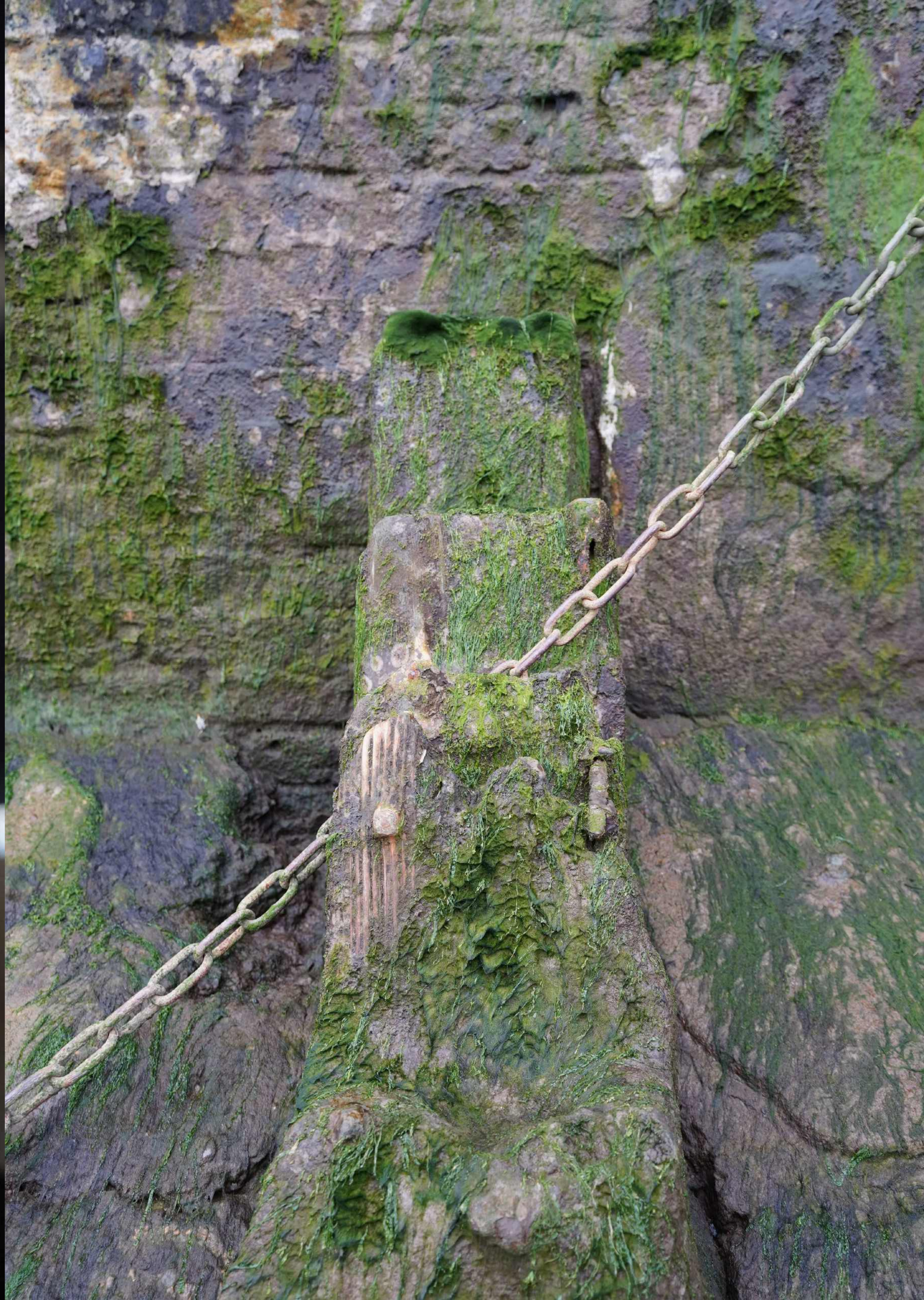
1-auction space
2-peeping room
3-private sale room
4-gallery
5-main entrance
6-disabled entrance
7-toilets
8-back door entrance
9-cargo entrance
10-artists entrance
11-auctioneer's stand
12-trap door

1:50 on A1   *4m*

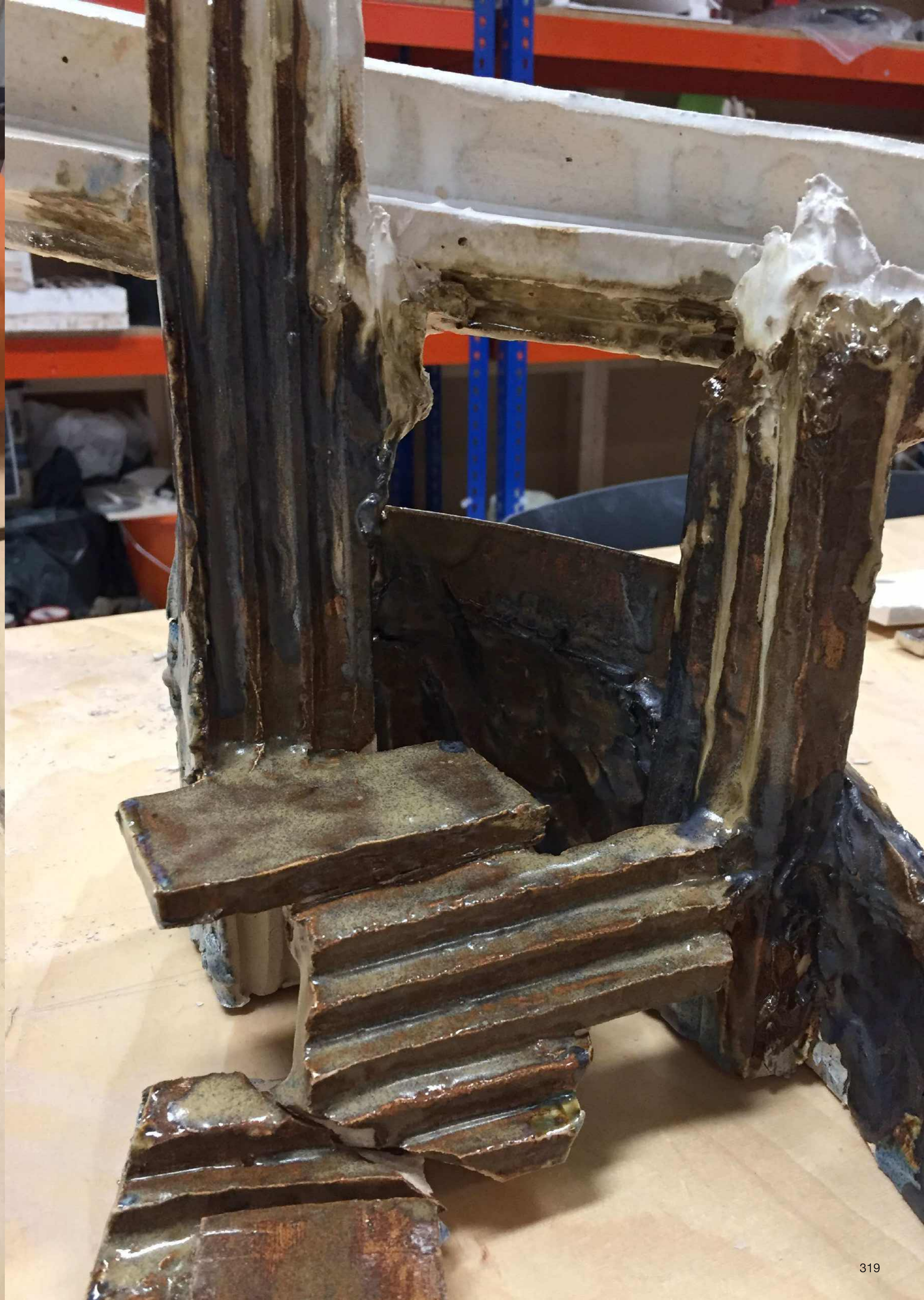
Sections of Center of Bridge 1:50

1:20 Ceramics Fragement



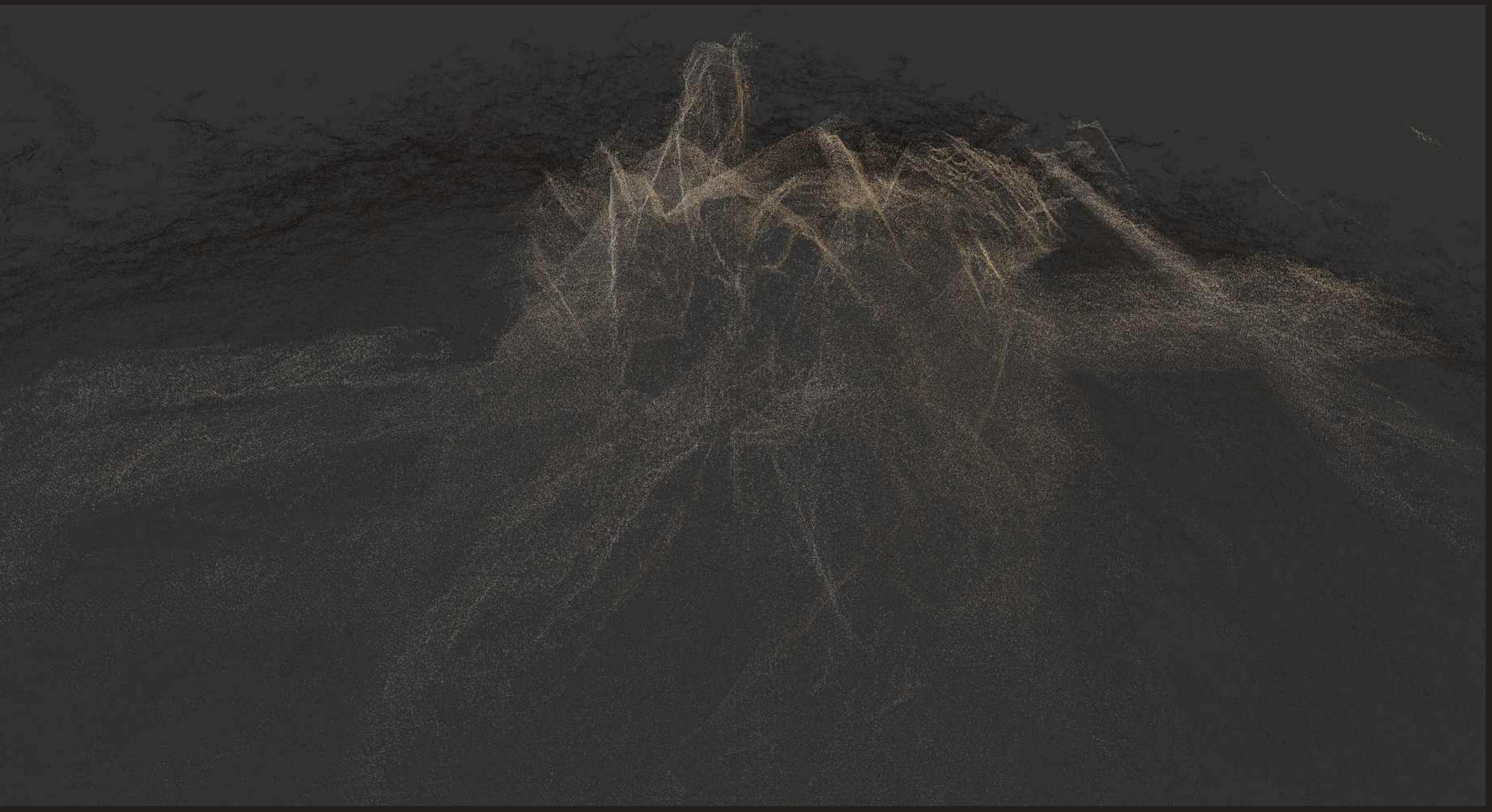




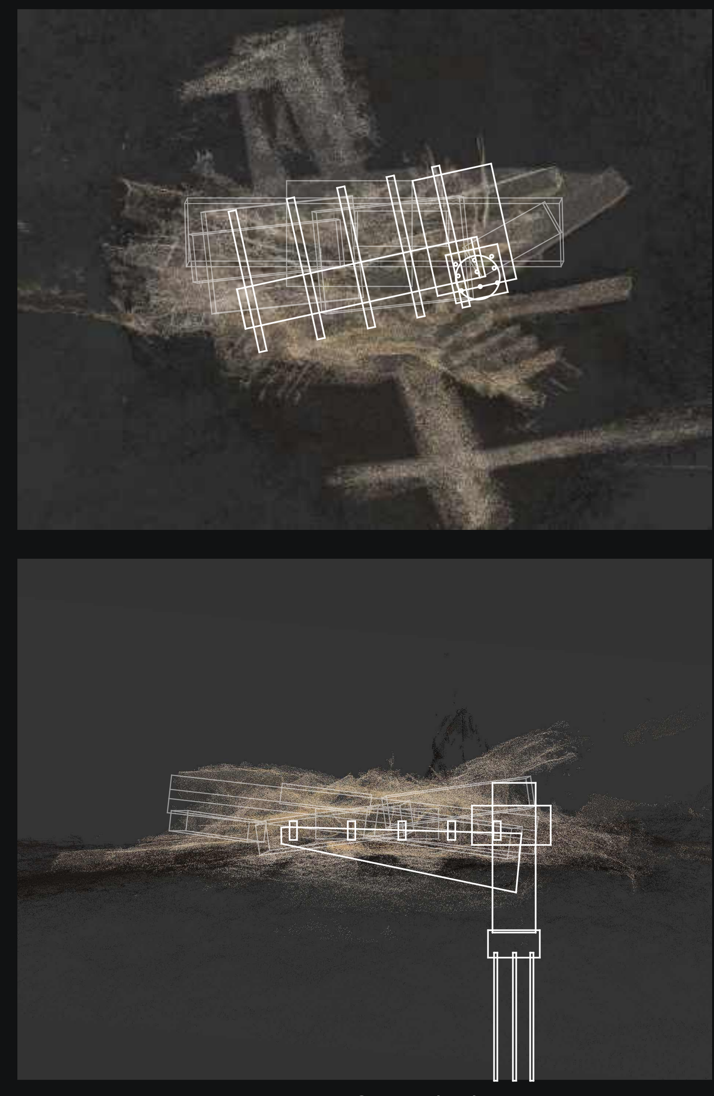




Ultimaker 2+
19
2.85mm

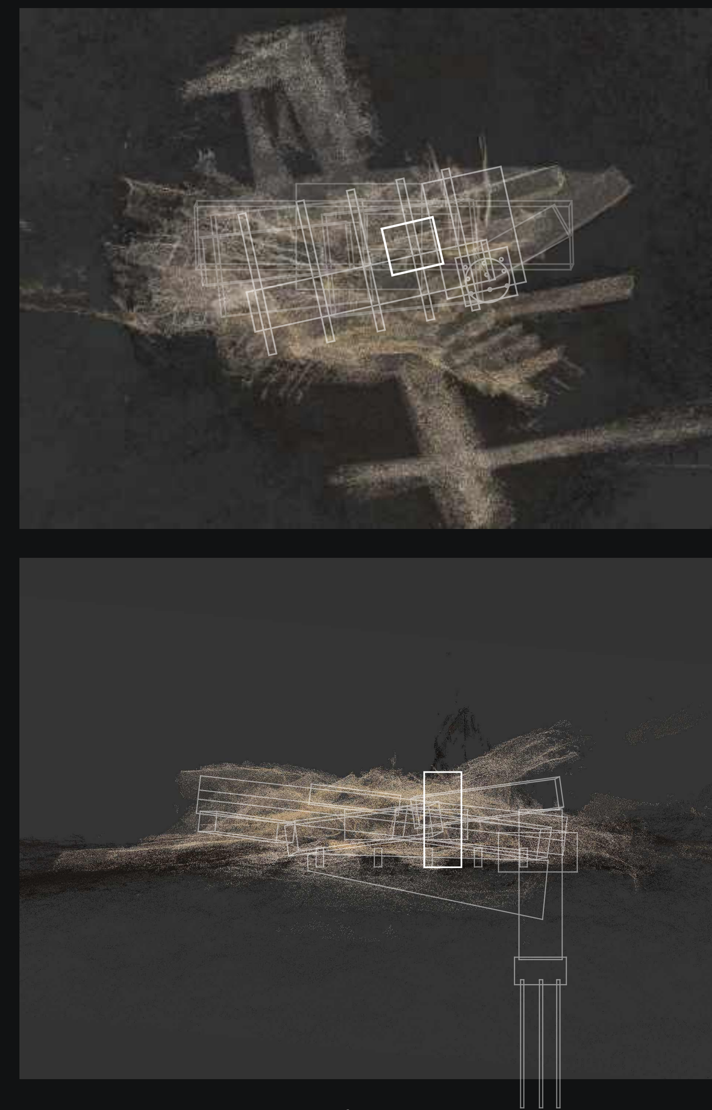
Appendix



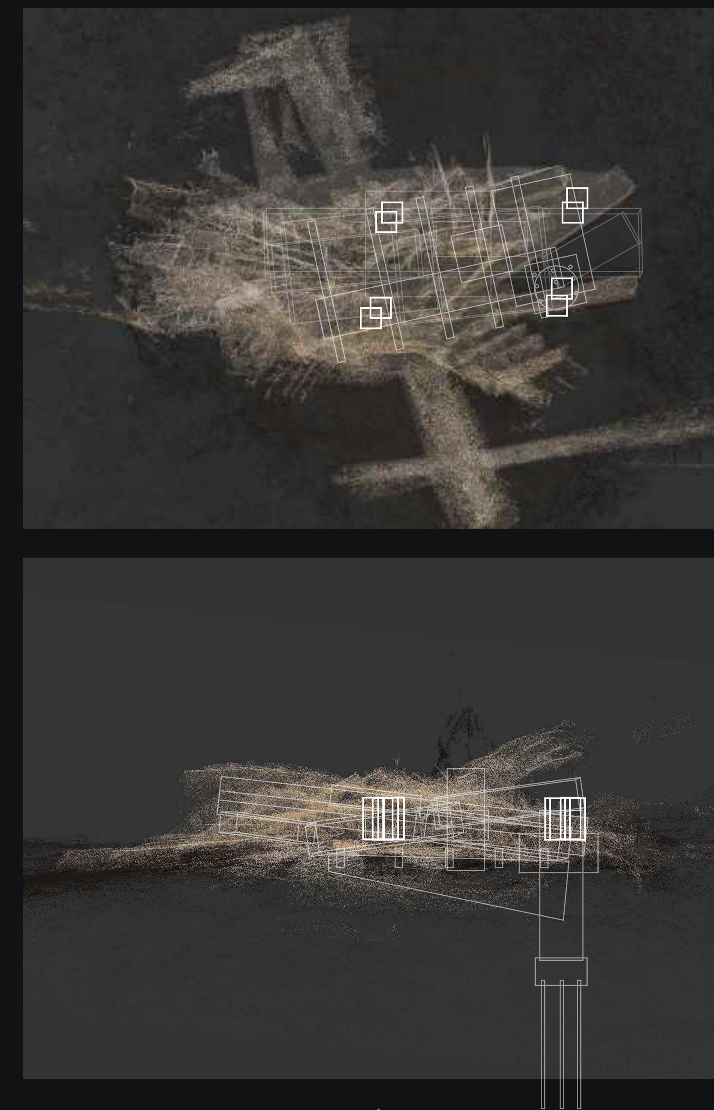
massing



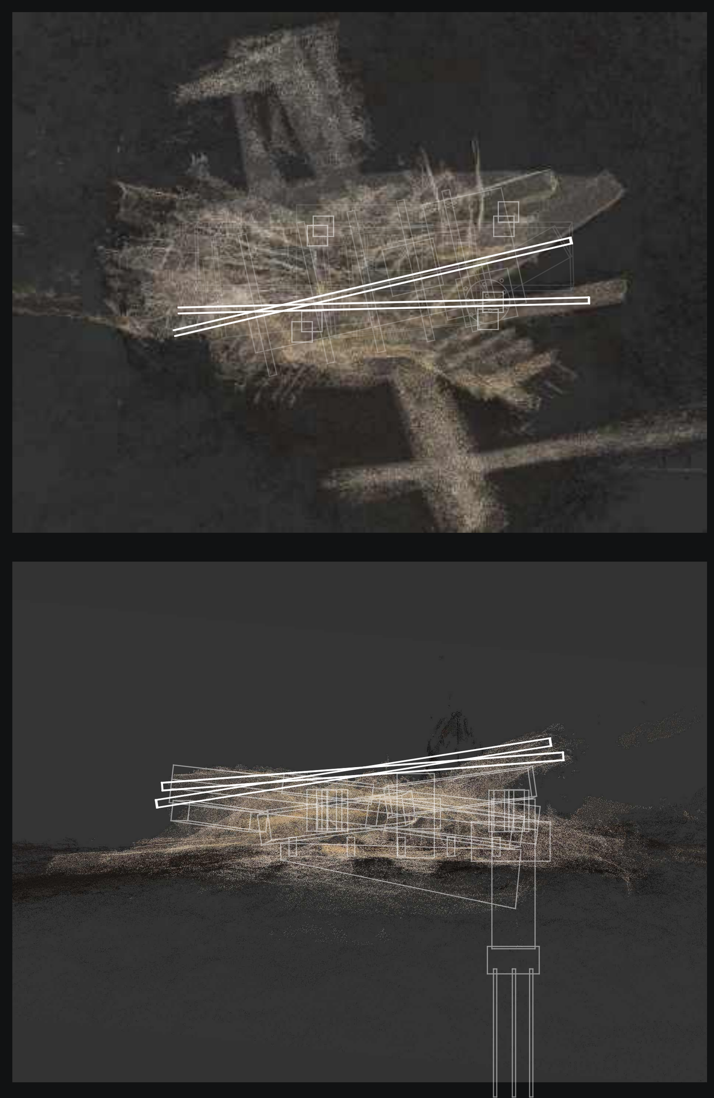
foundations



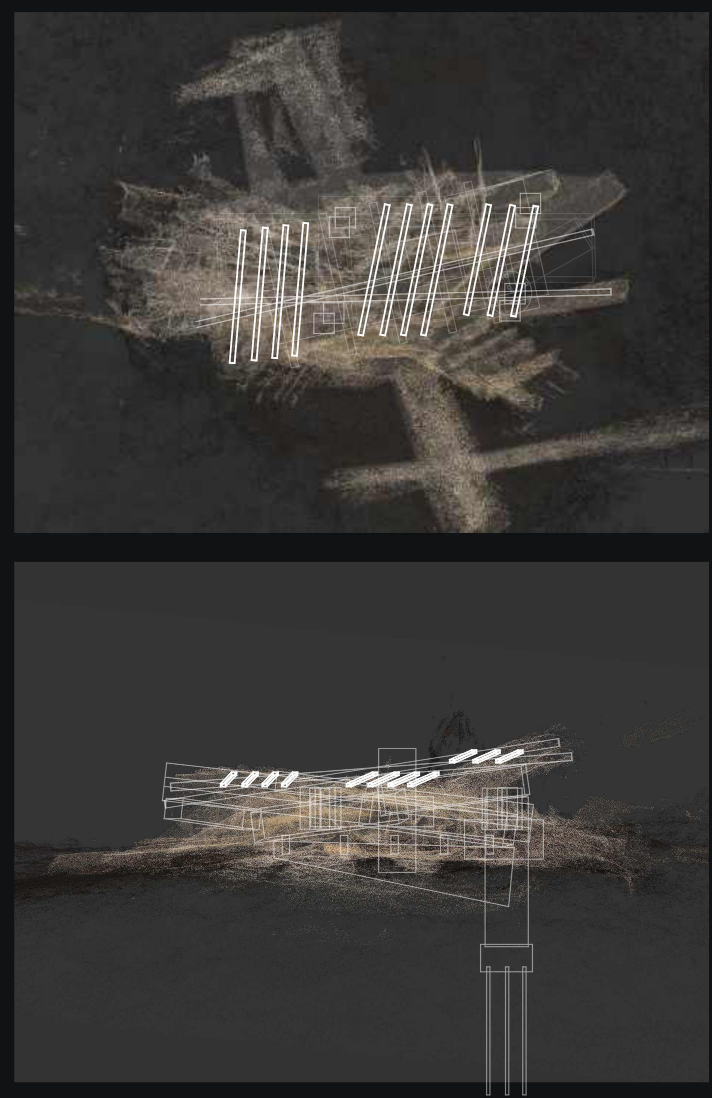
services



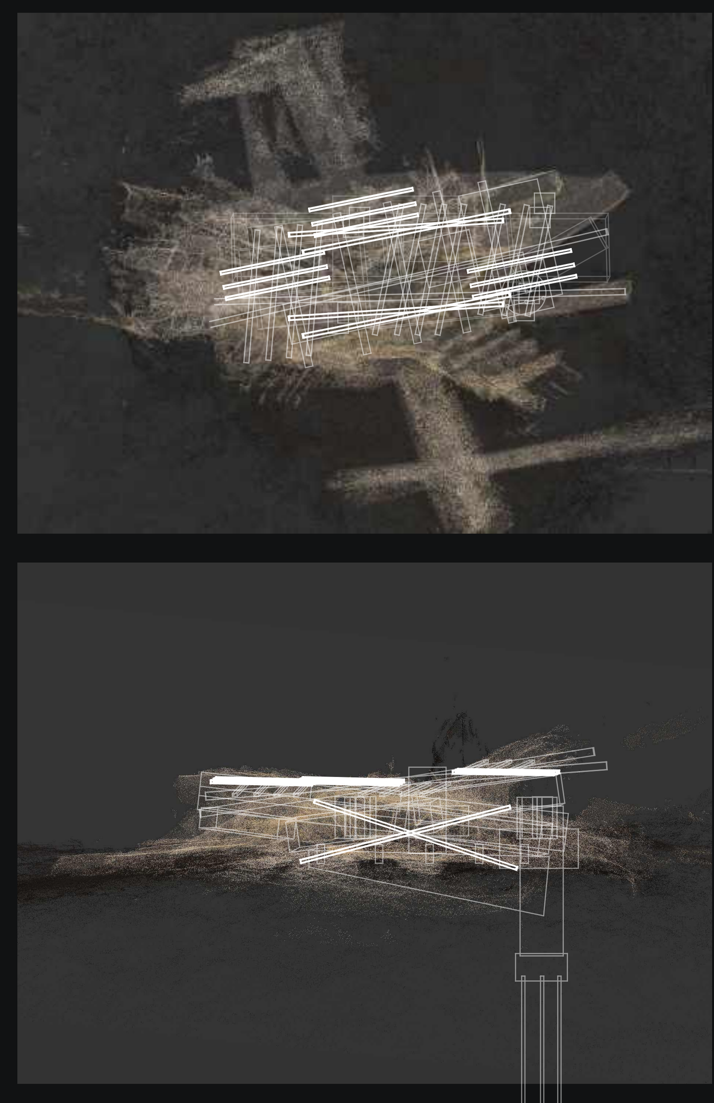
primary columns



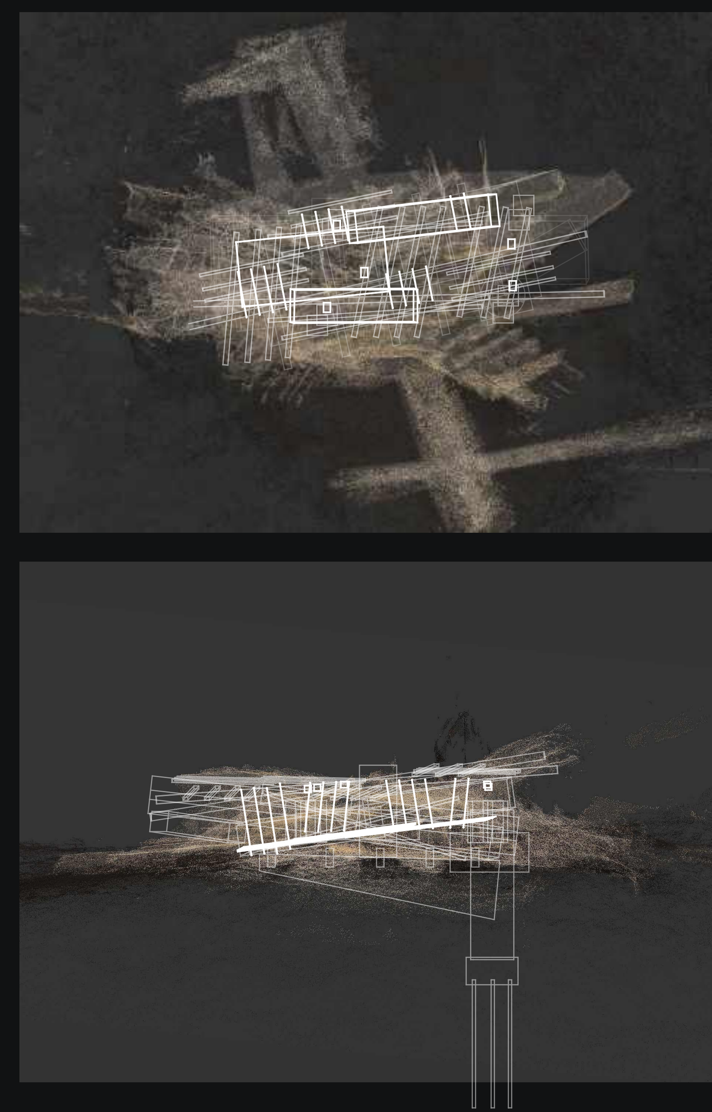
primary beams



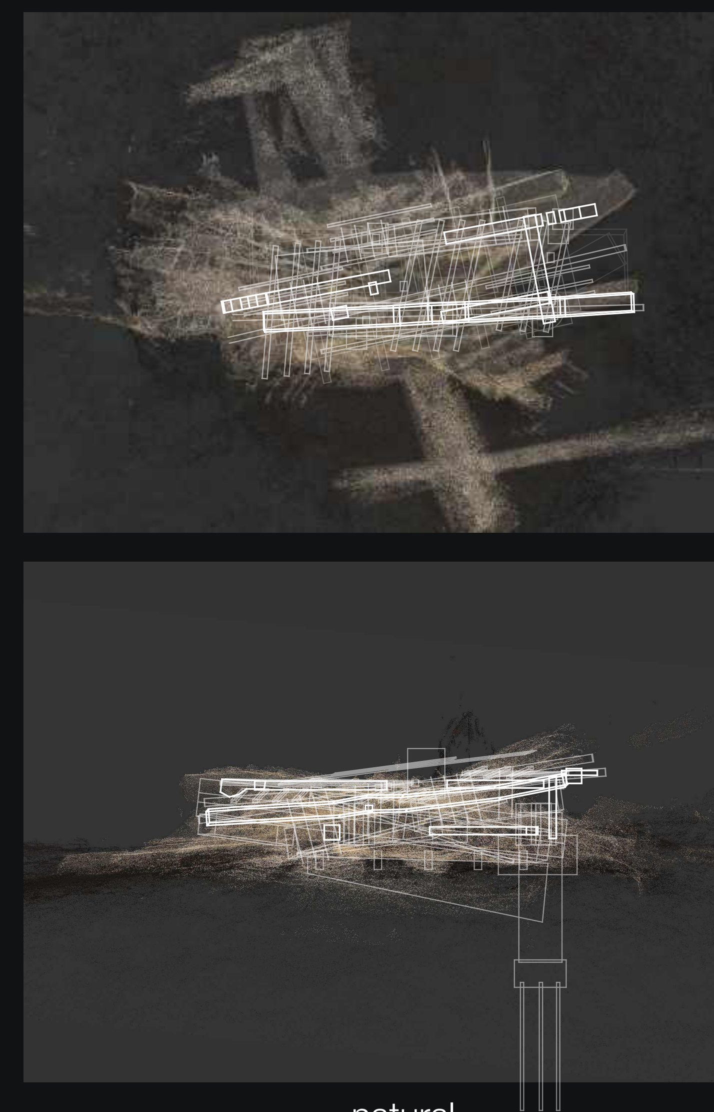
secondary beams



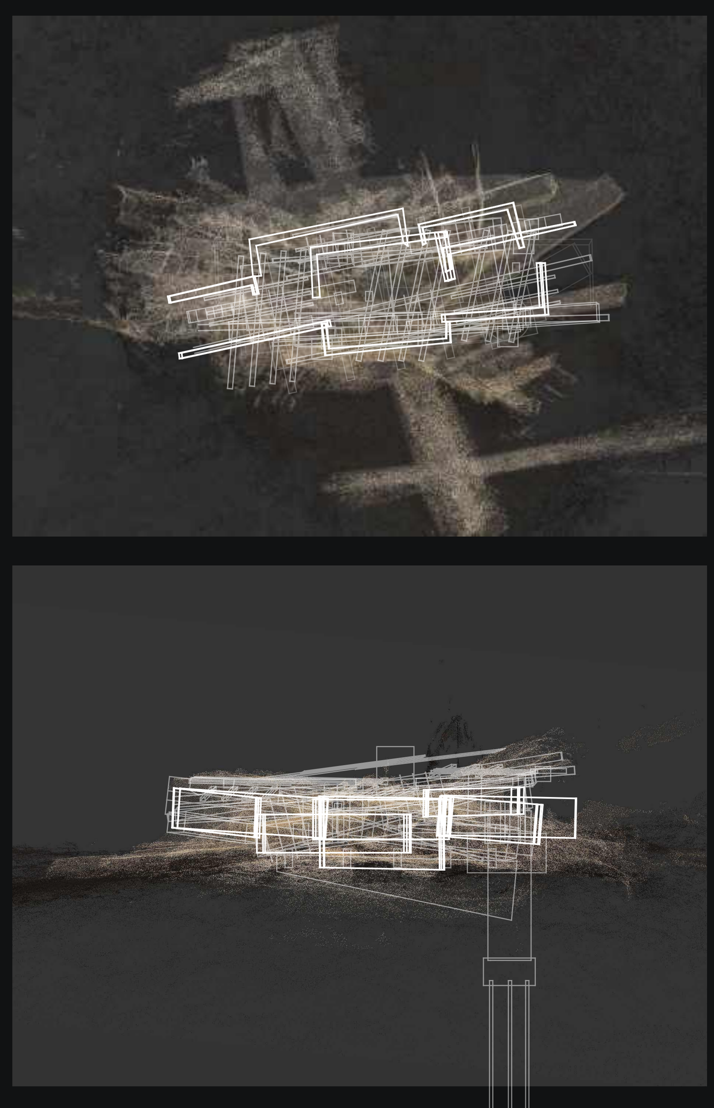
third degree beams and bracing



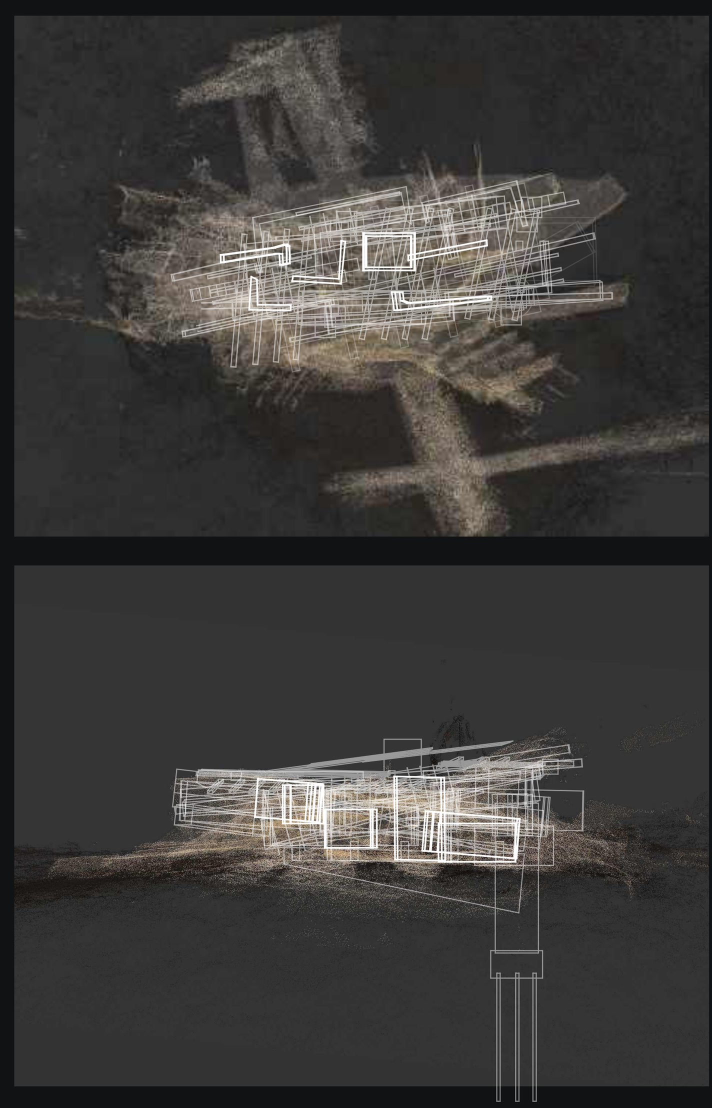
joints, cables and ramps



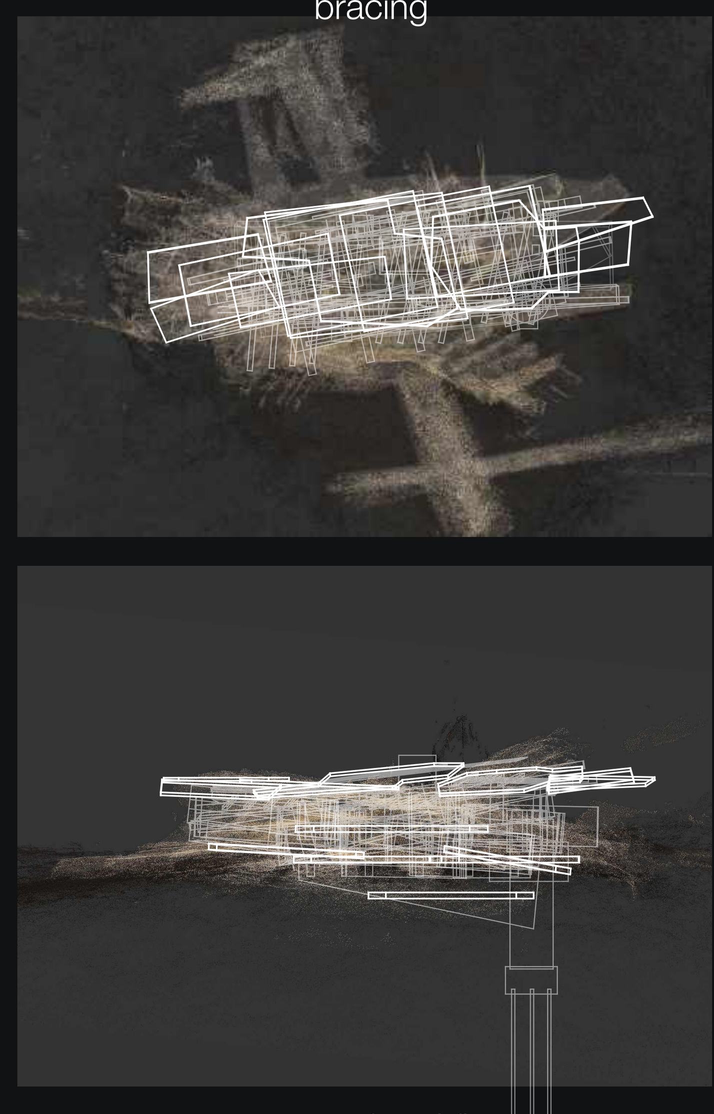
natural ventilation and HVAC



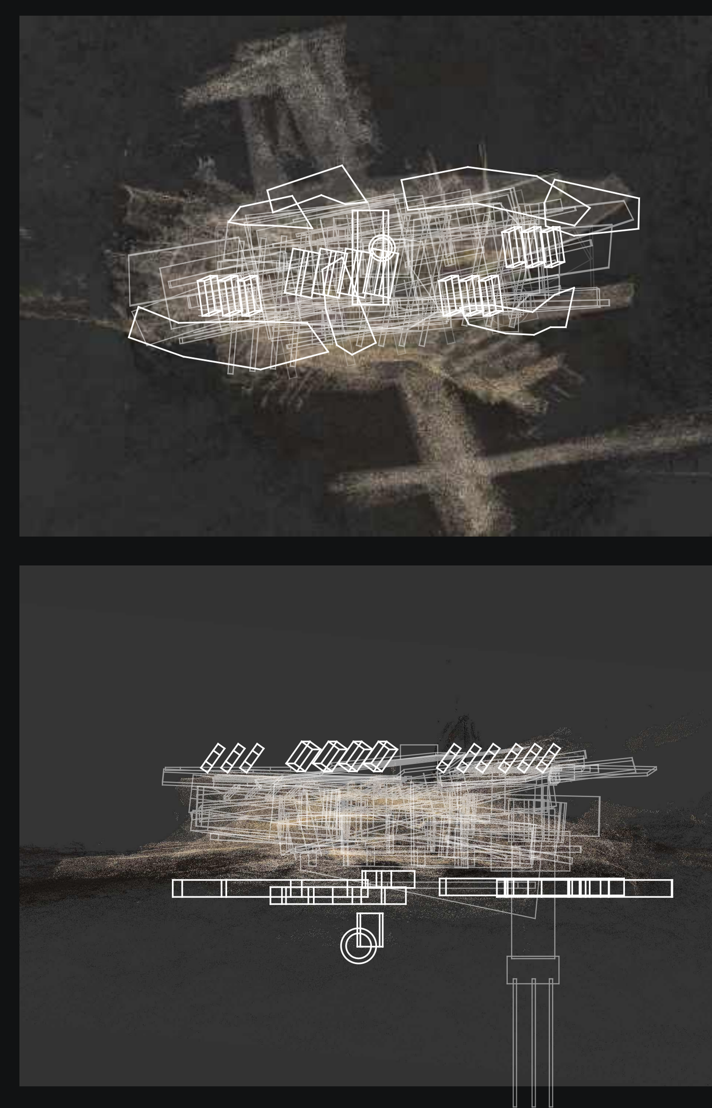
load supporting walls



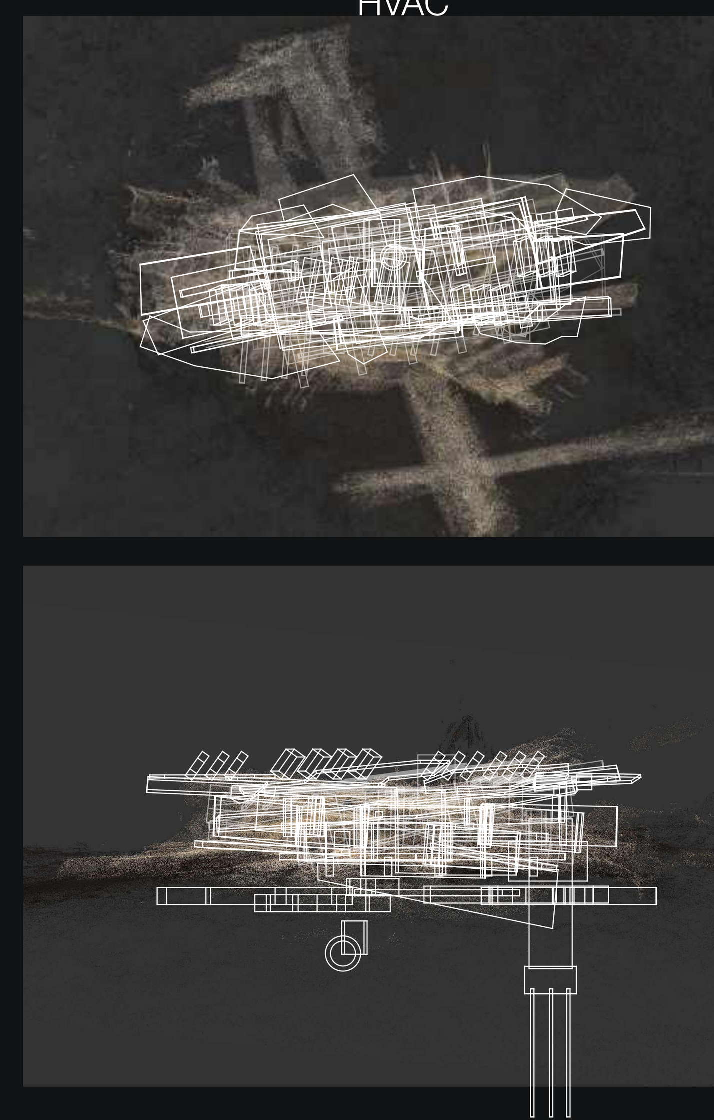
internal partitions



roof and floors



louvres, floaters and hydropower

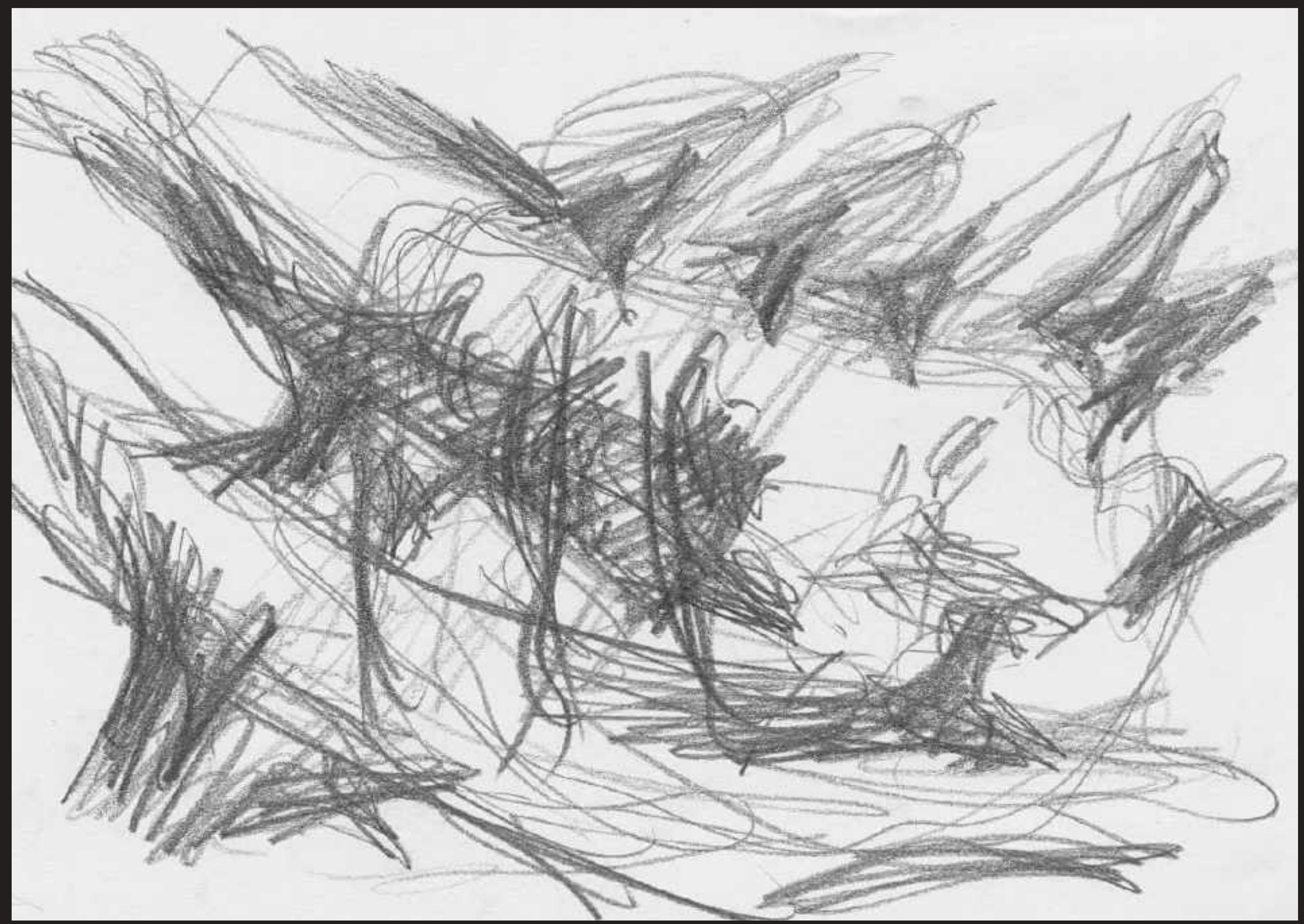
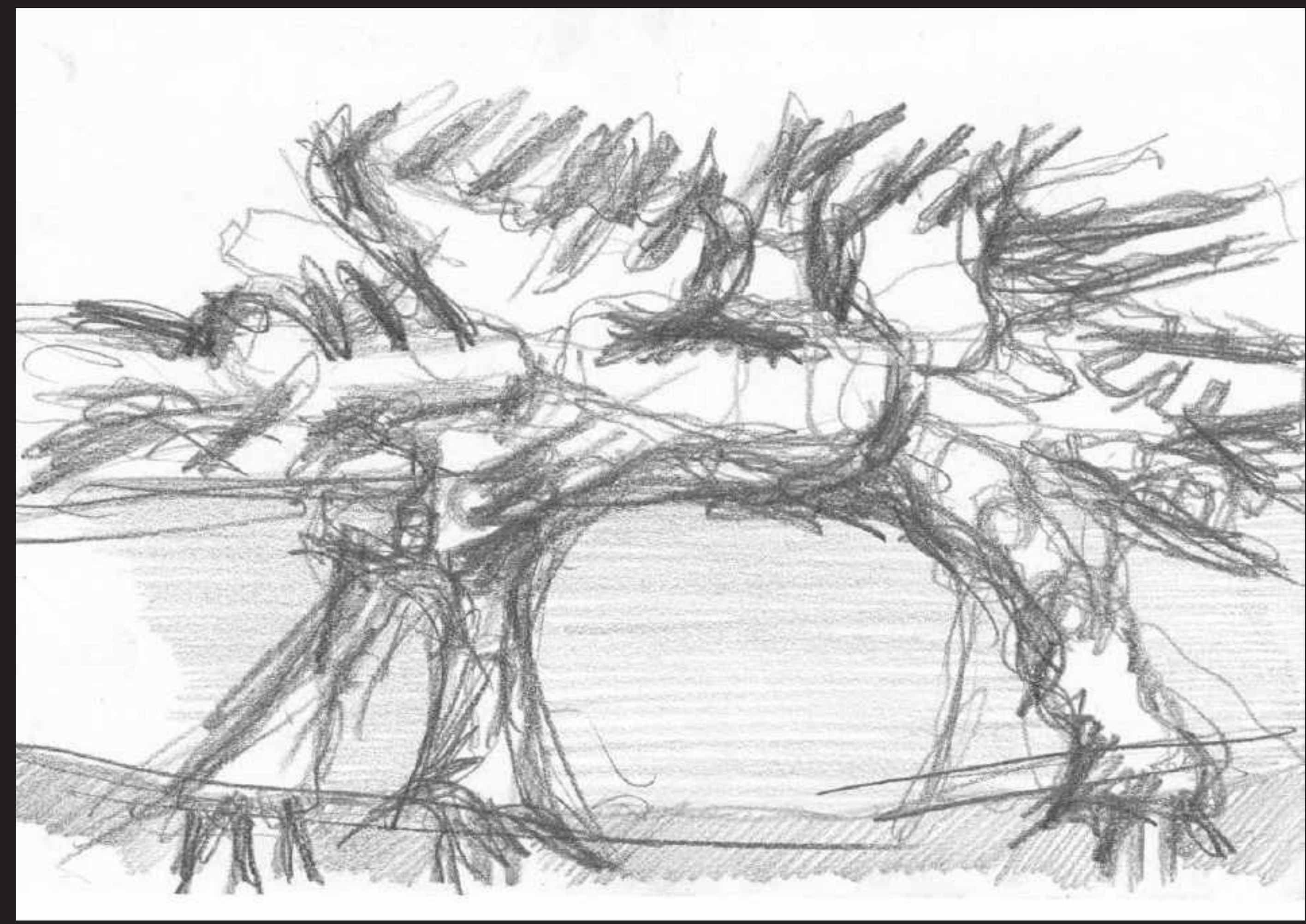
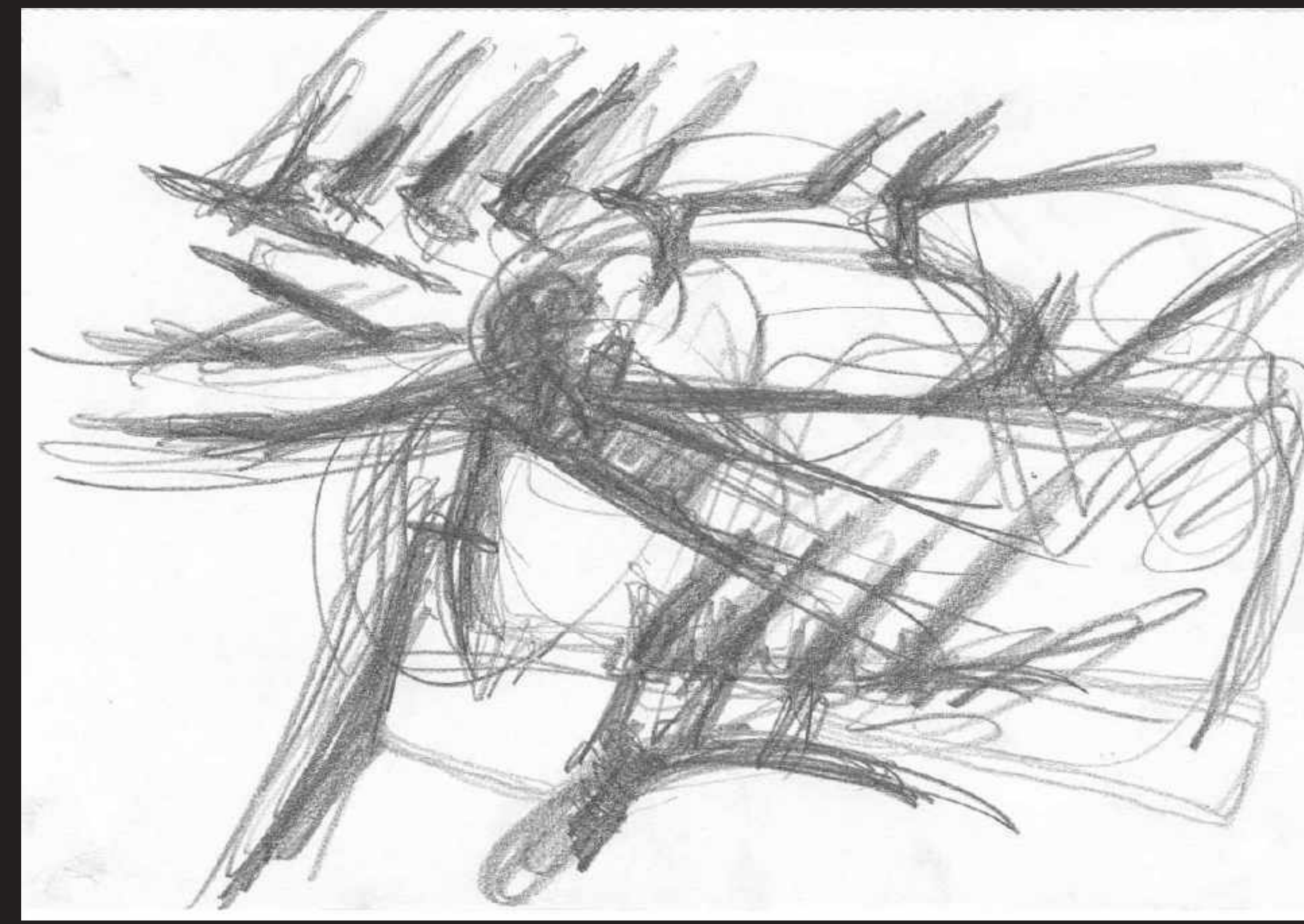
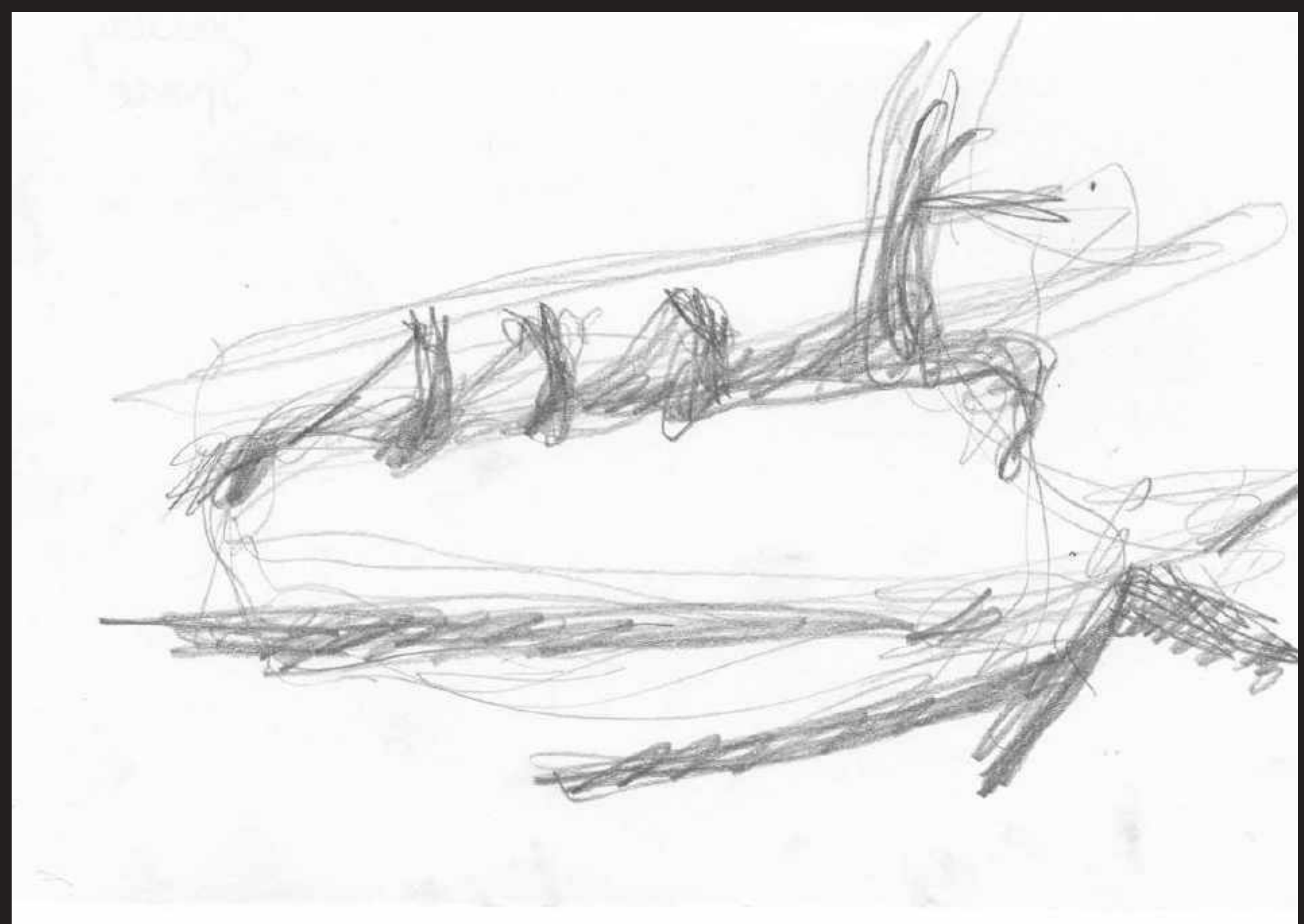
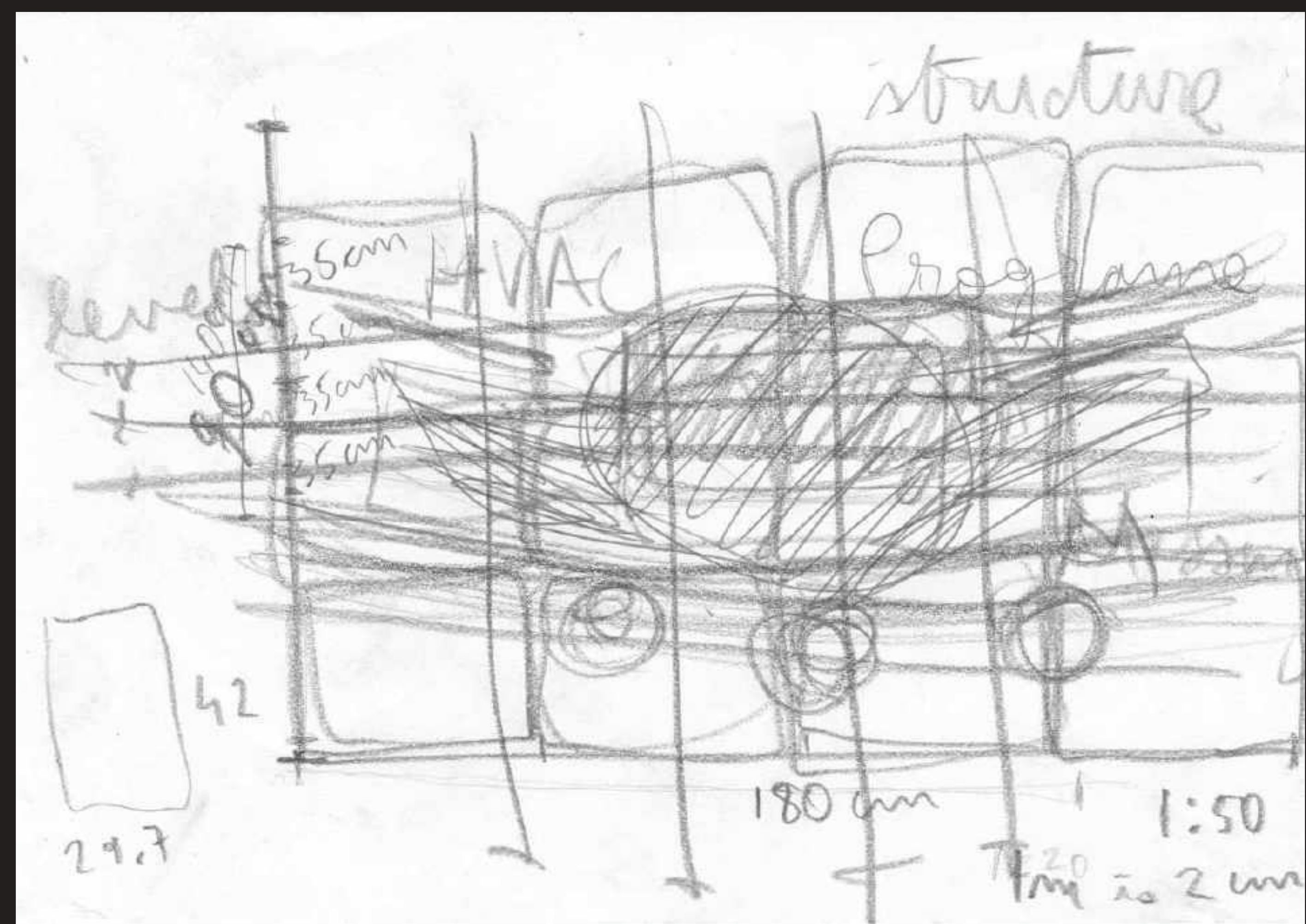
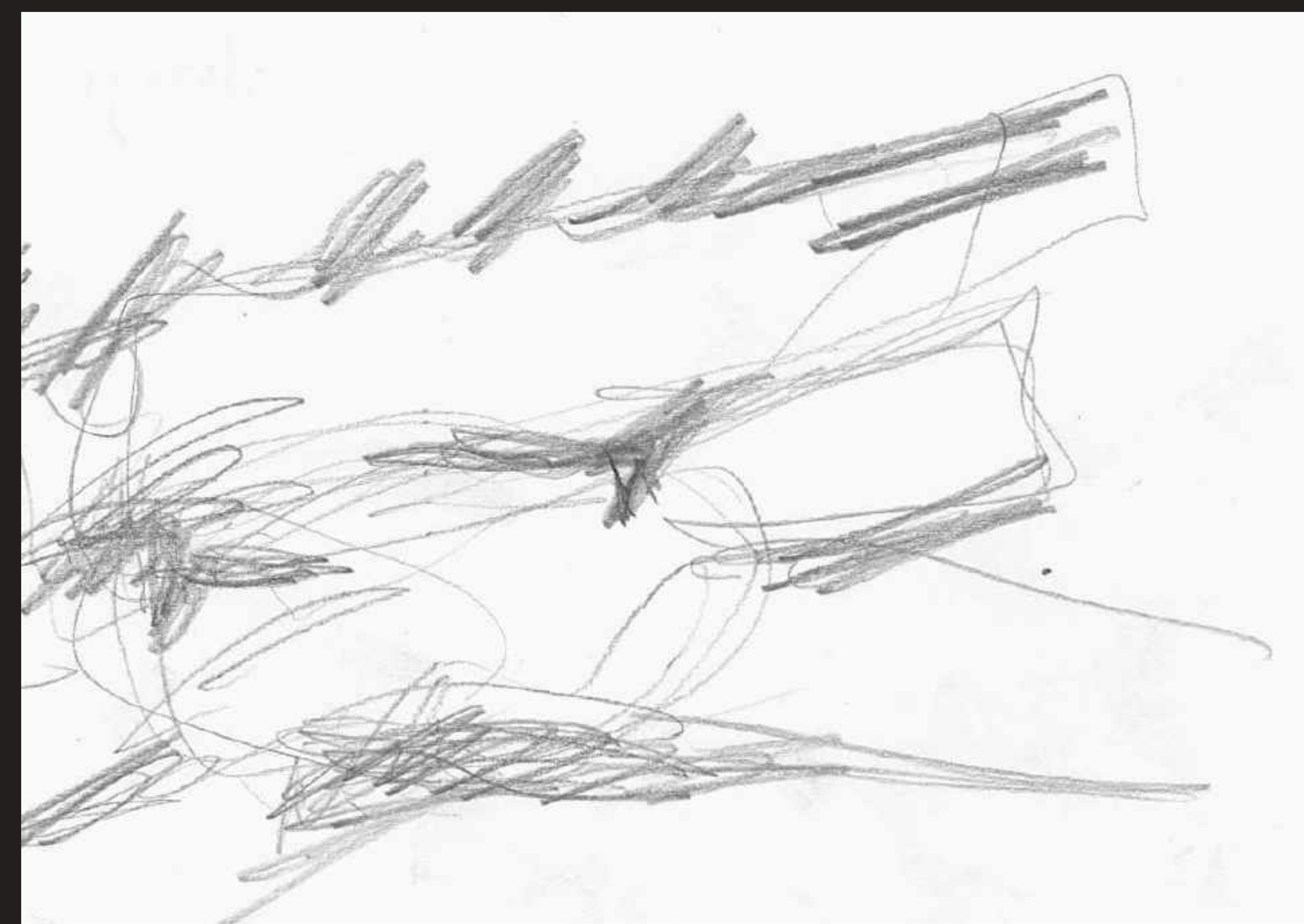


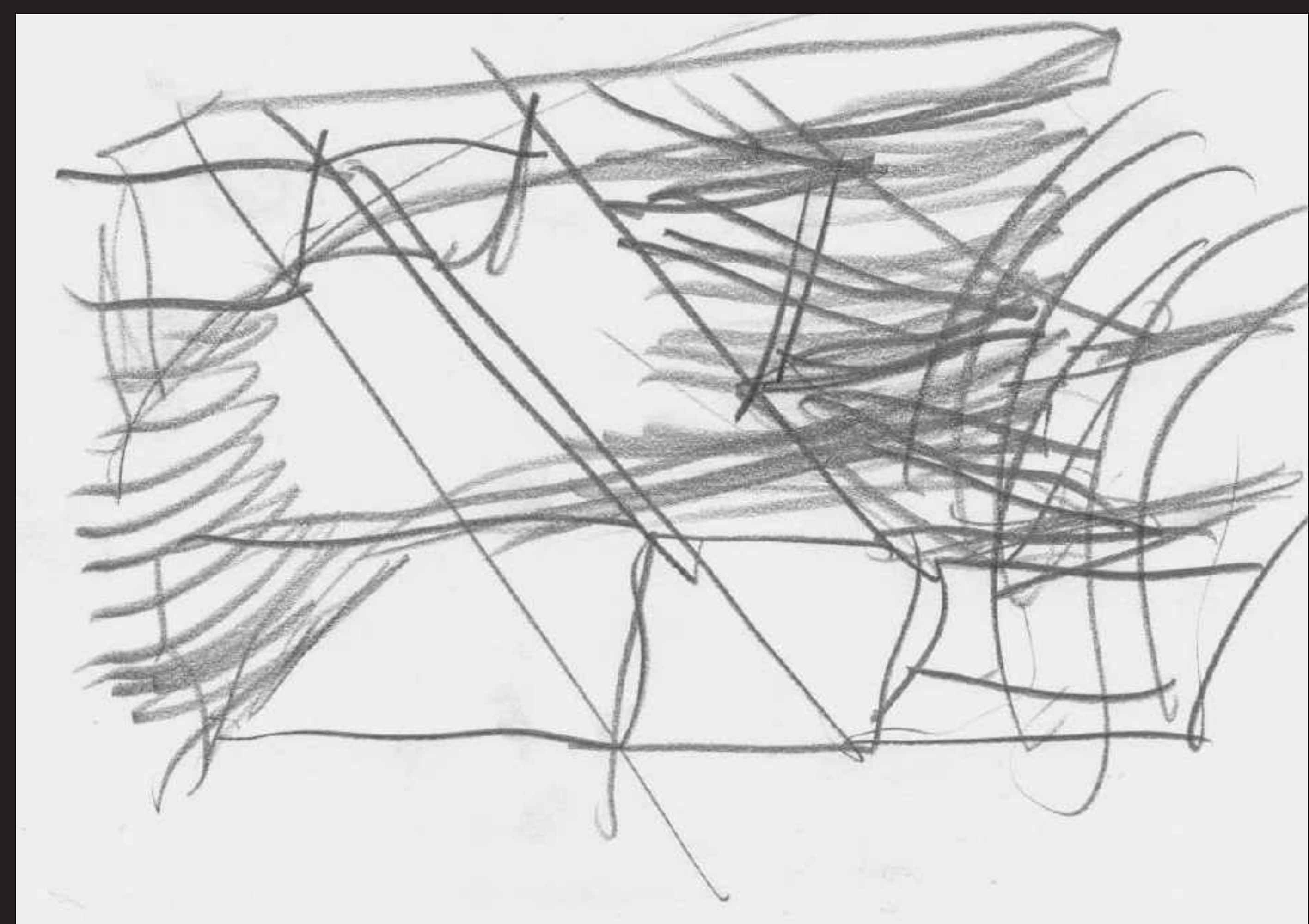
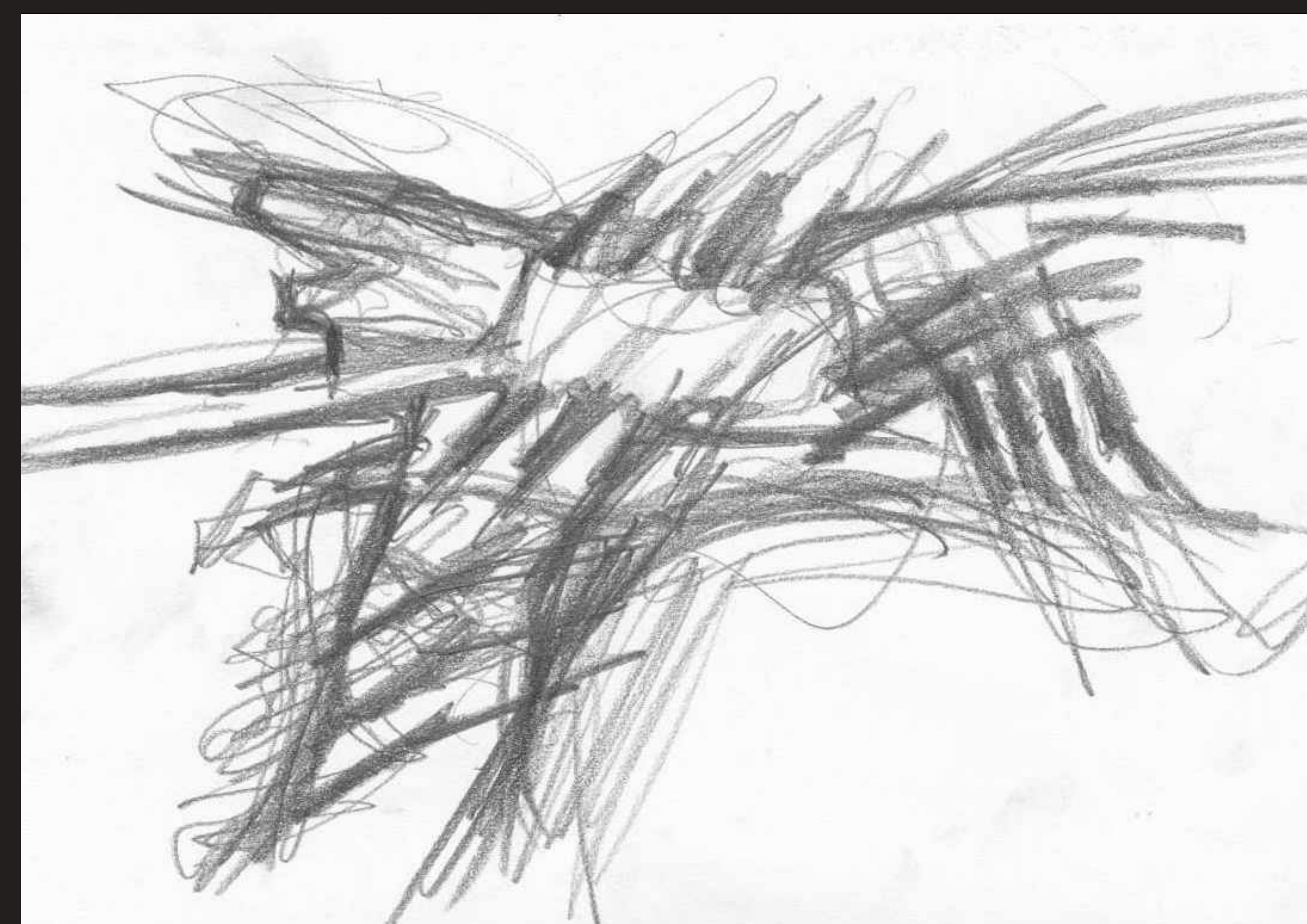
1:200 on A1

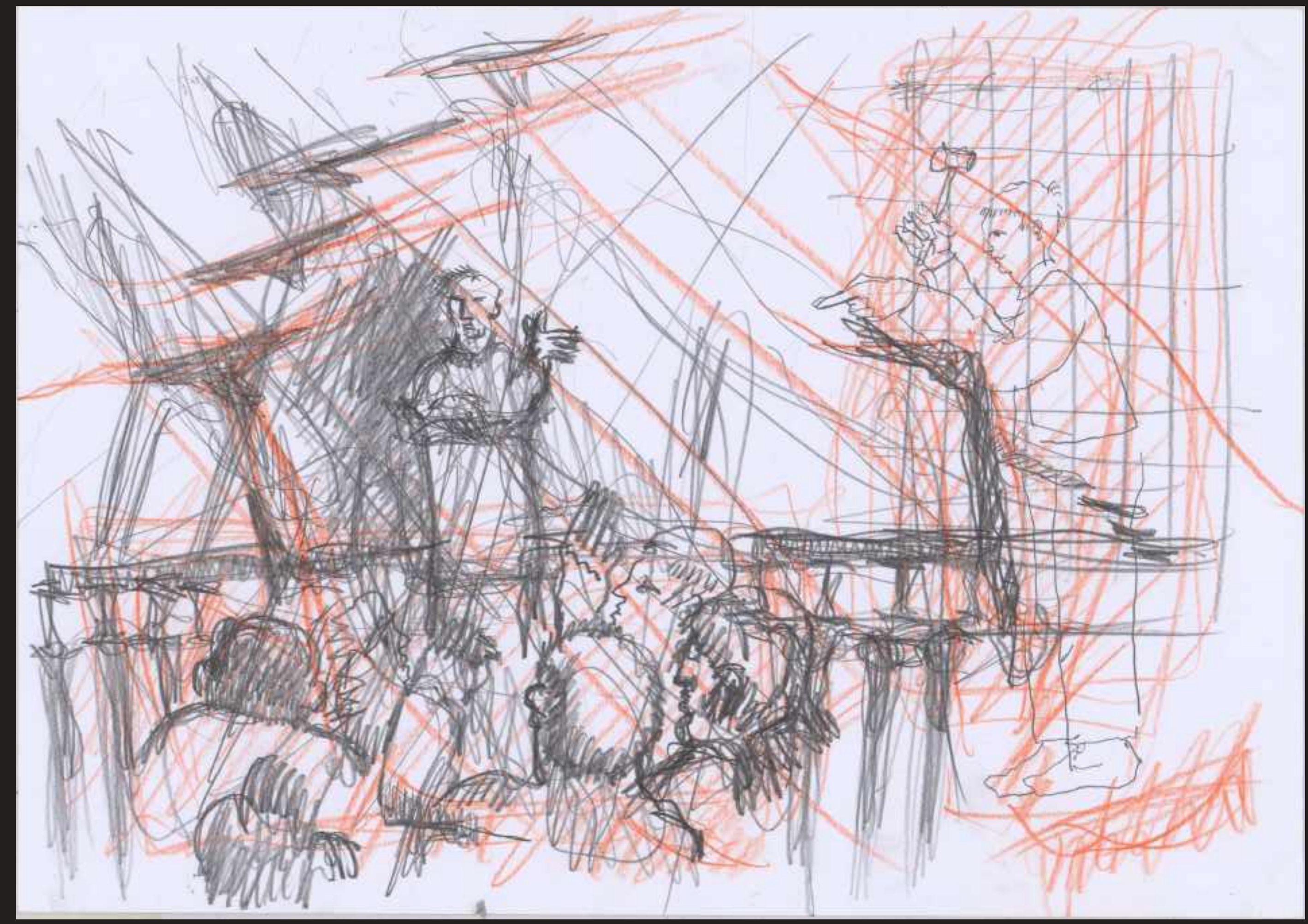
section

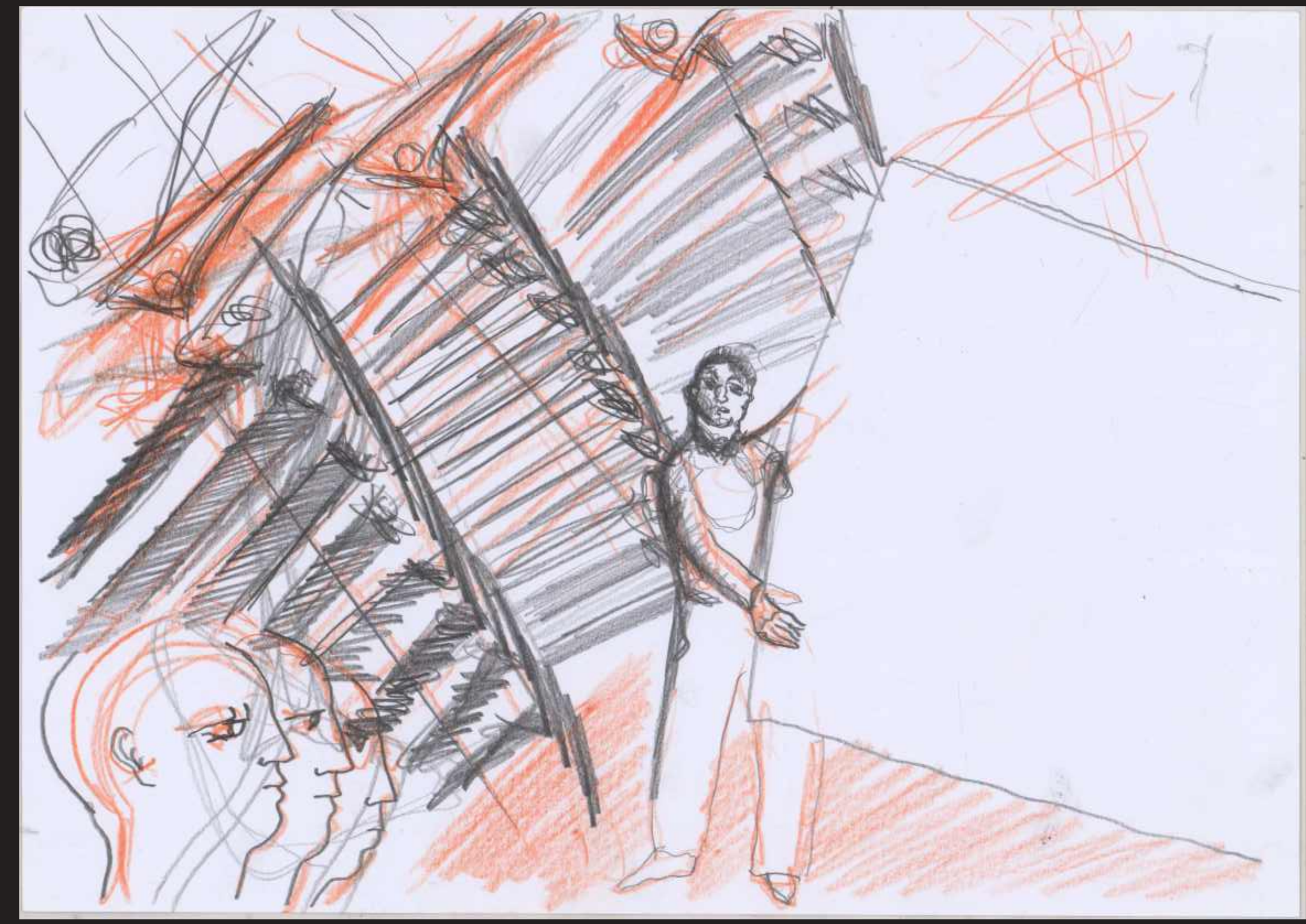
plan

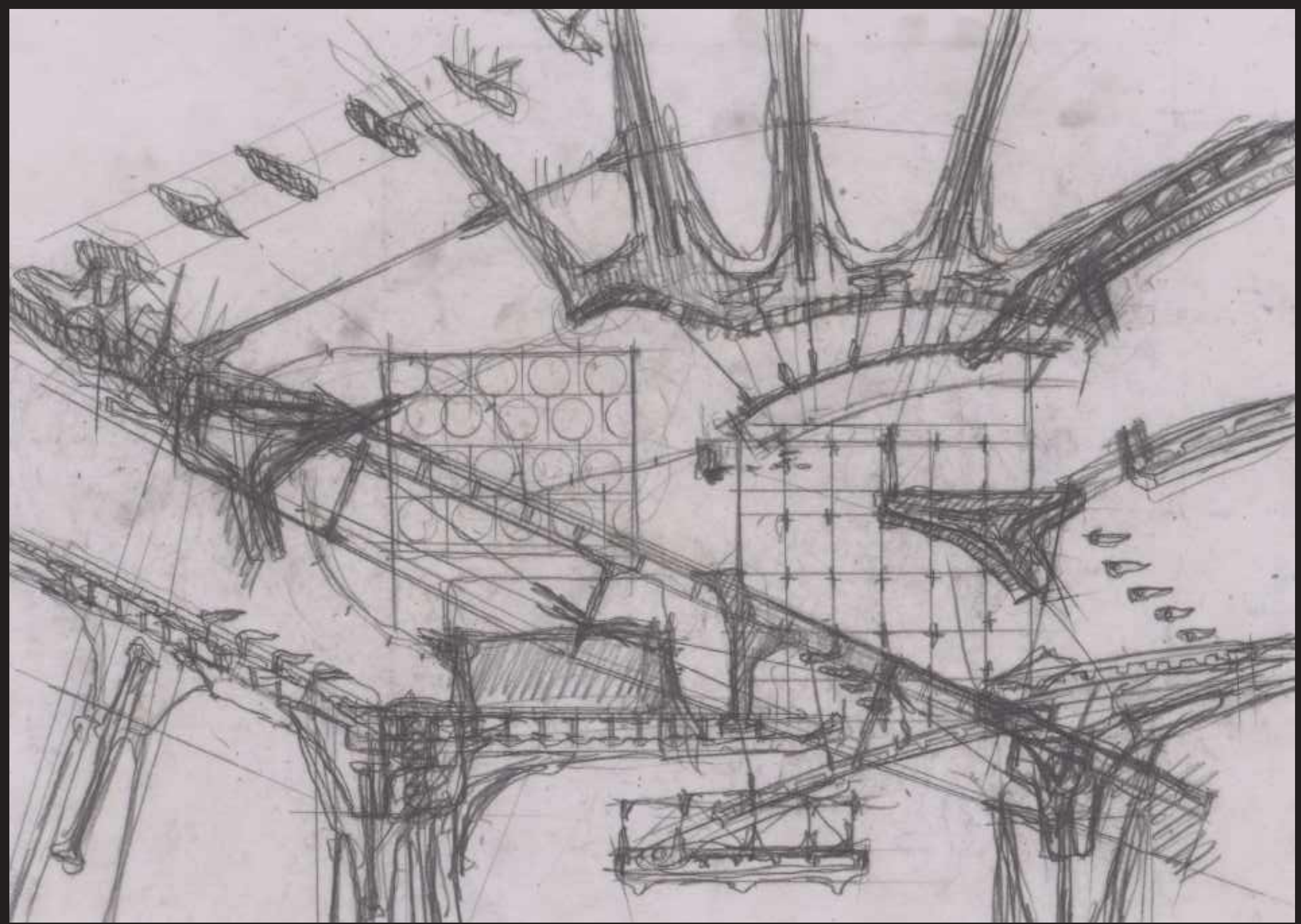
PAPER MODEL SCAN

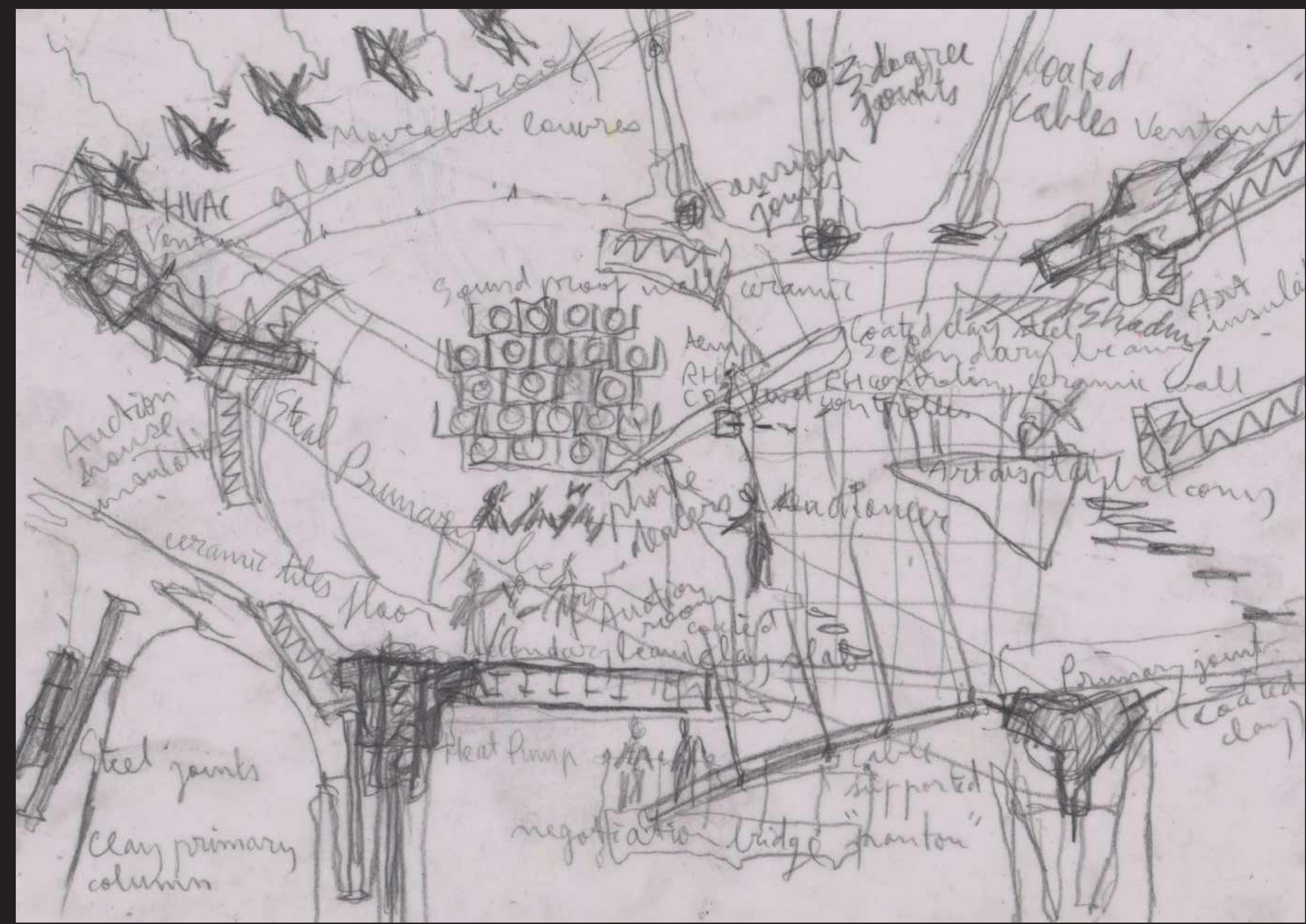





structure
HVAC
Programme
42
29,7
180 cm
1:50


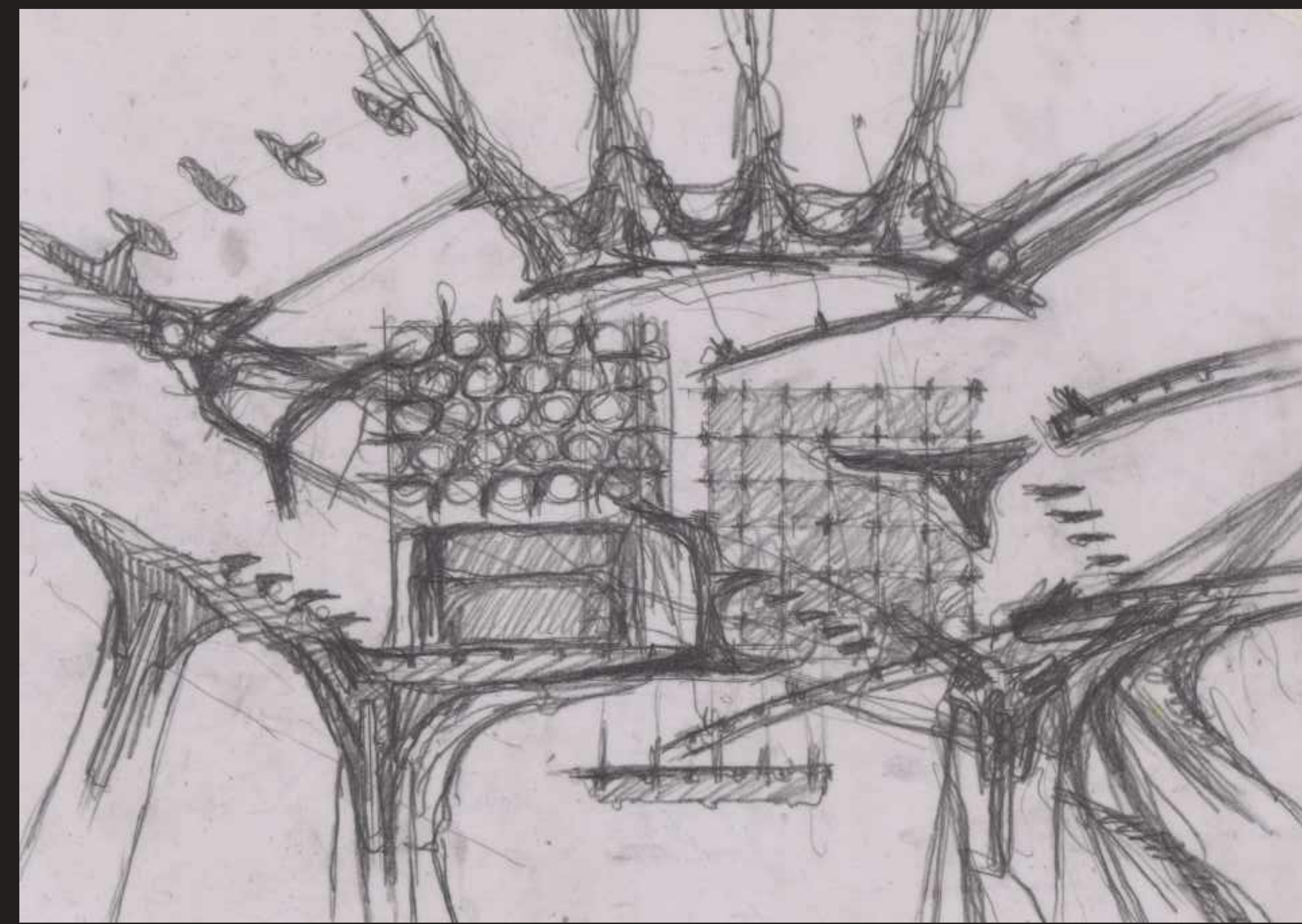



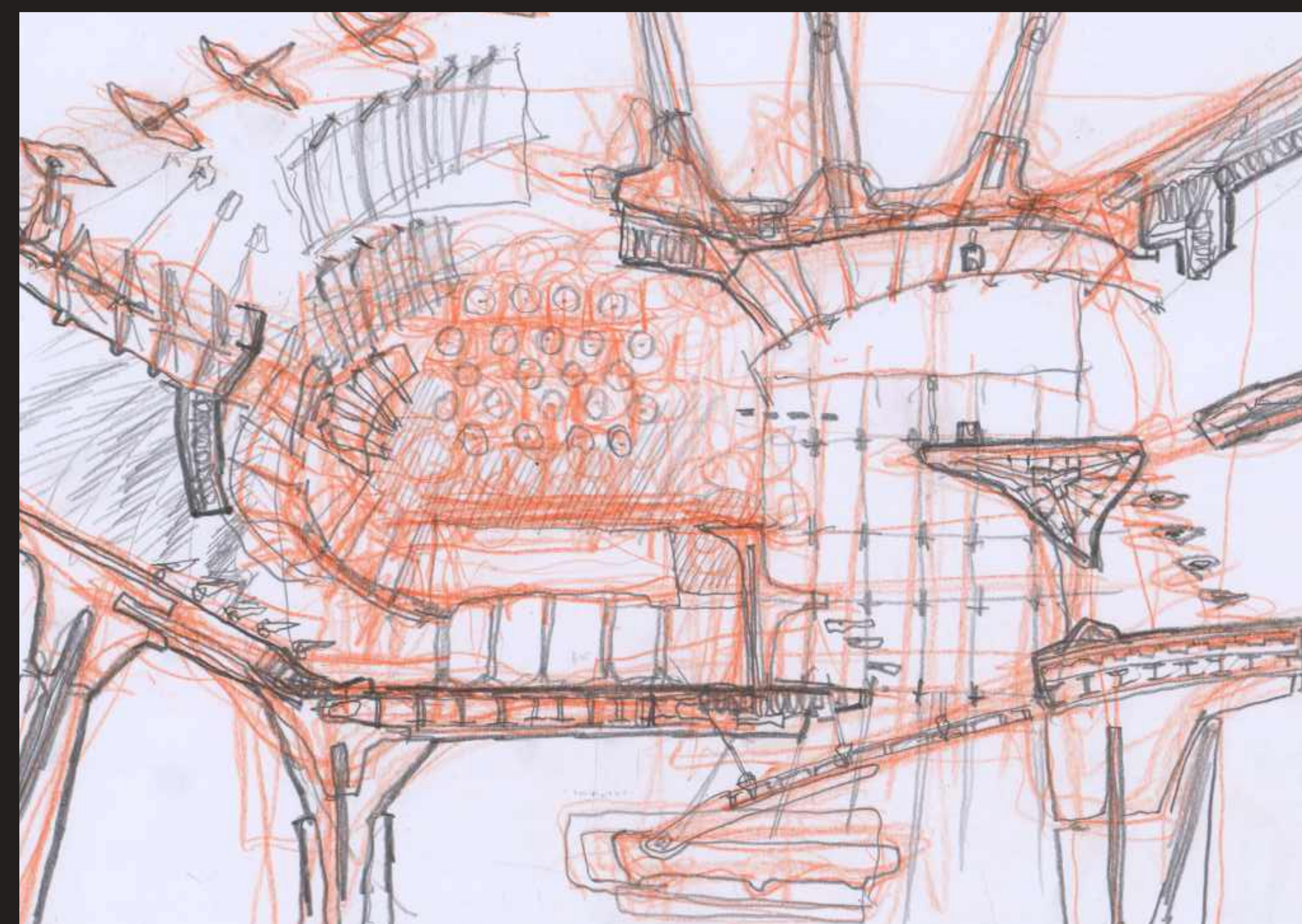


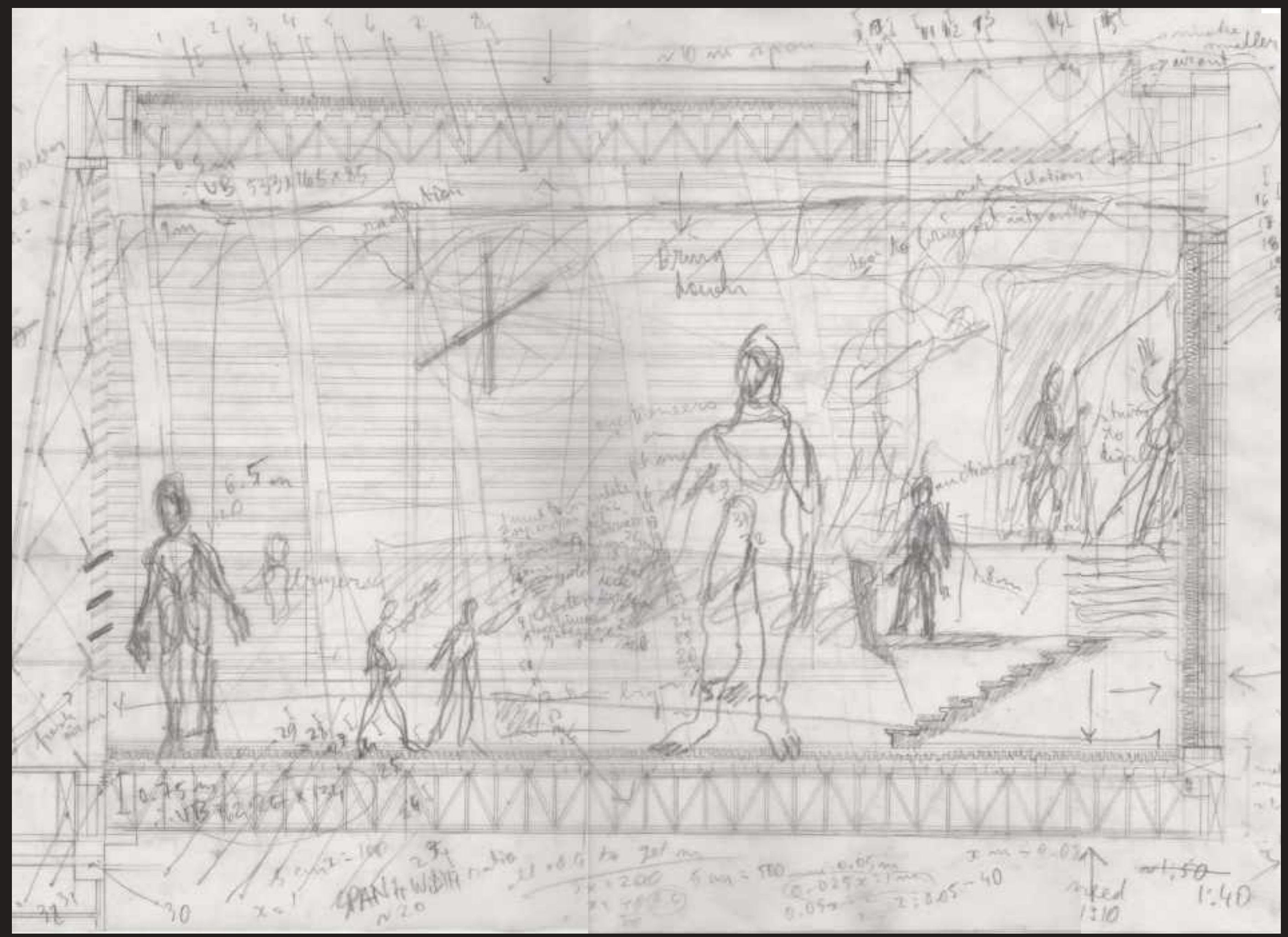


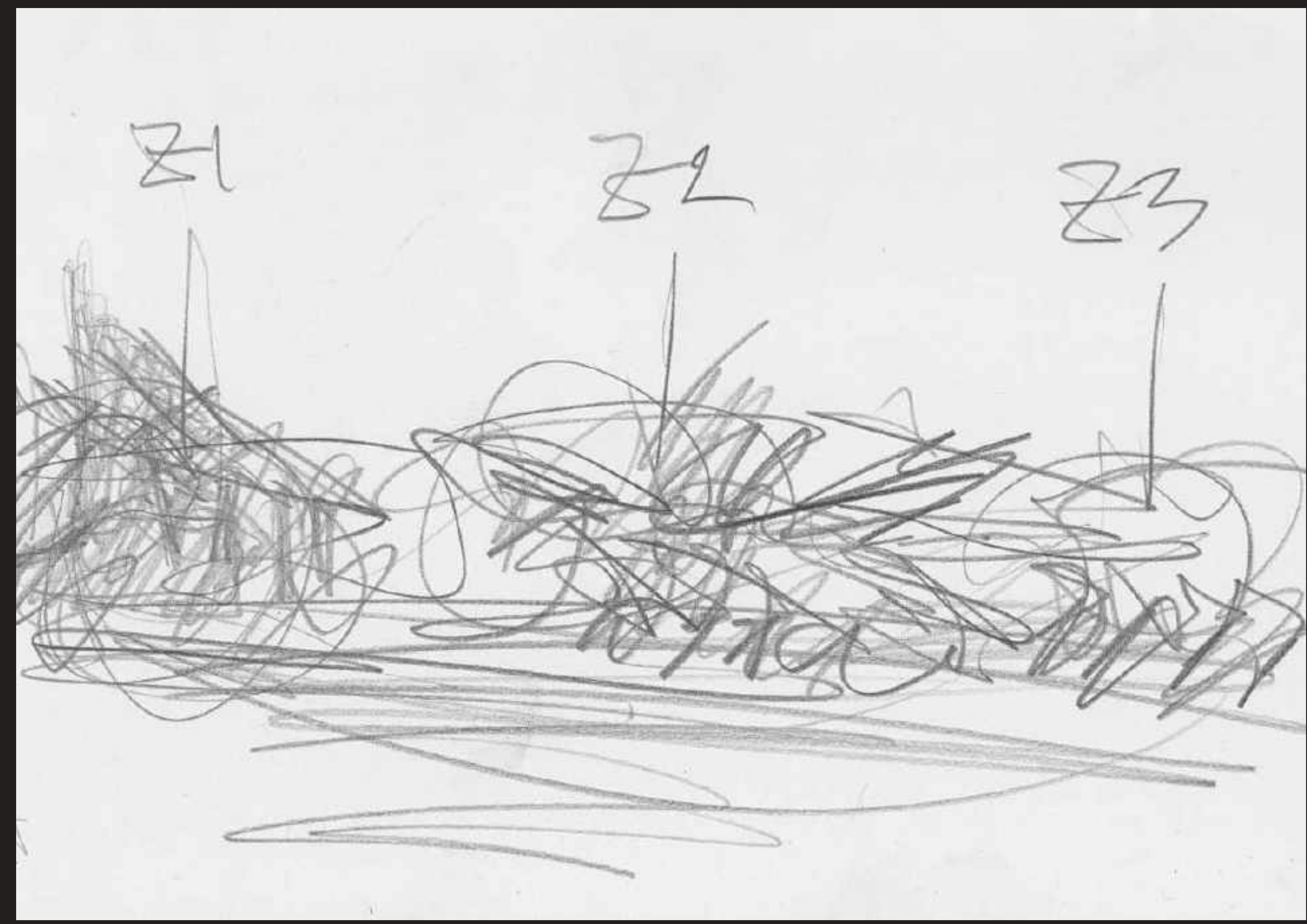


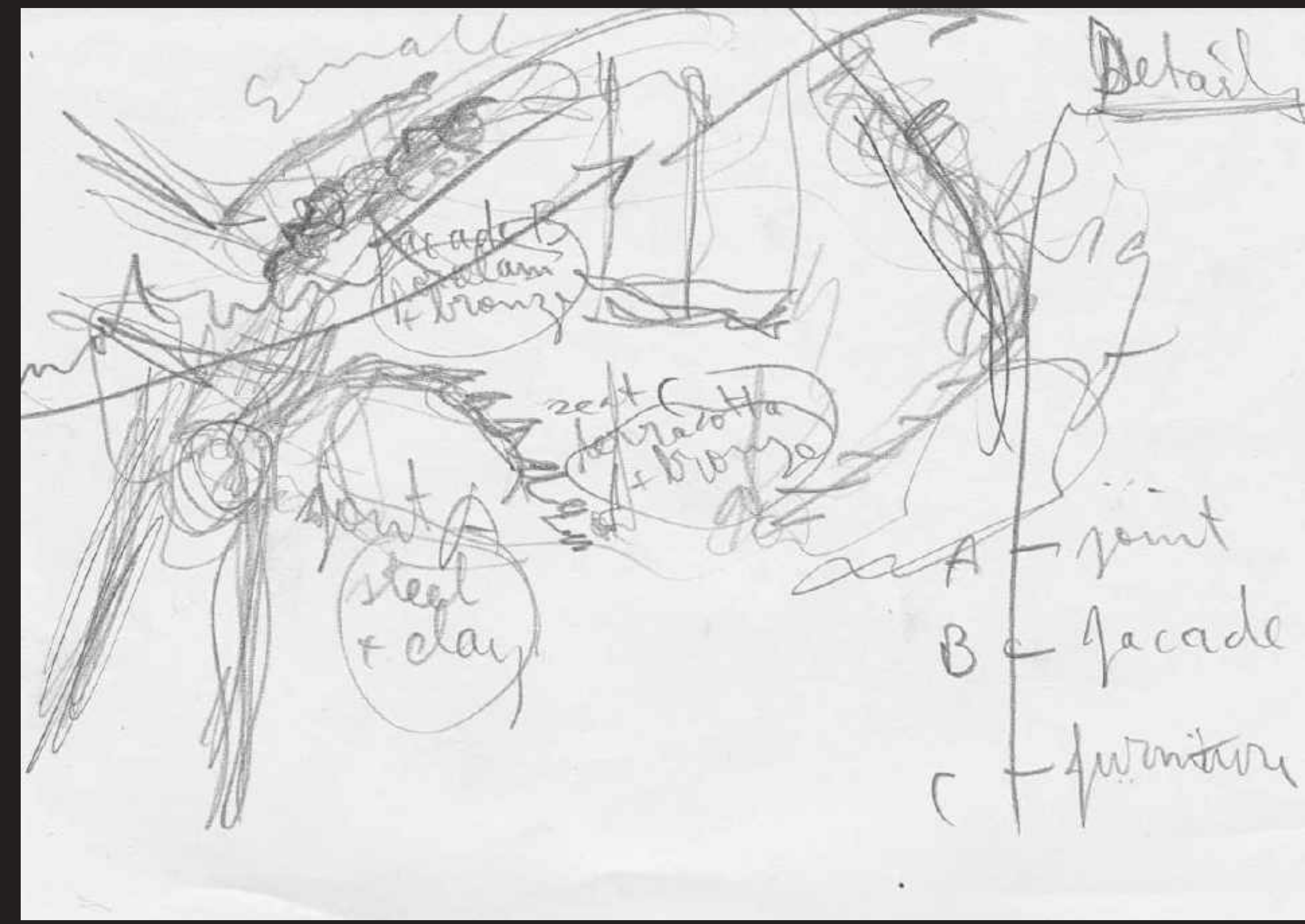

movable louvres
glass
HVAC
floated cables
sound proof wall
ceramic
Art display balcony
Audience
ceramic tiles floor
Steel joints
Clay primary column
Heat Pump
cable supported
negotiation bridge
Primary joint (coated clay)

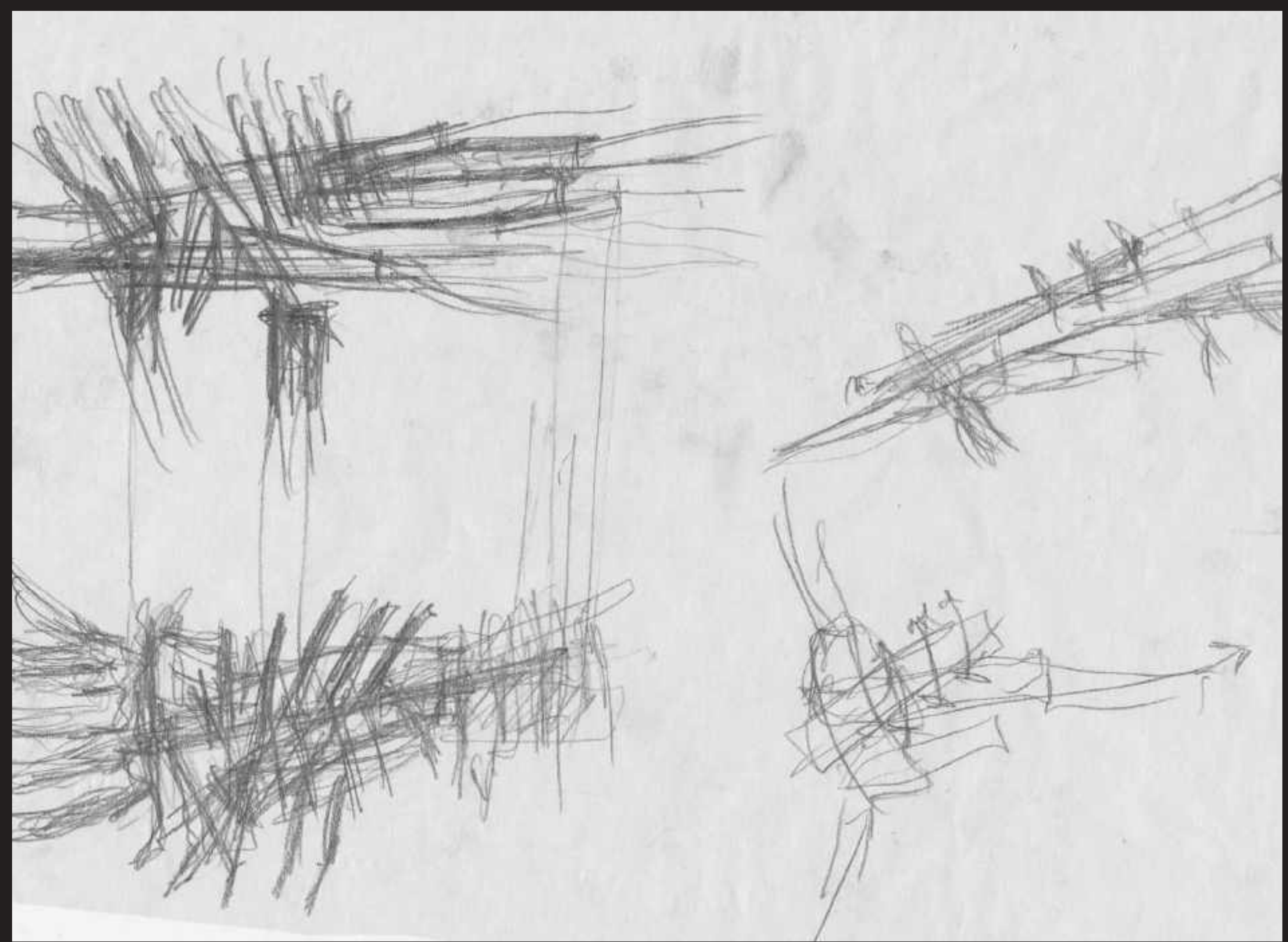


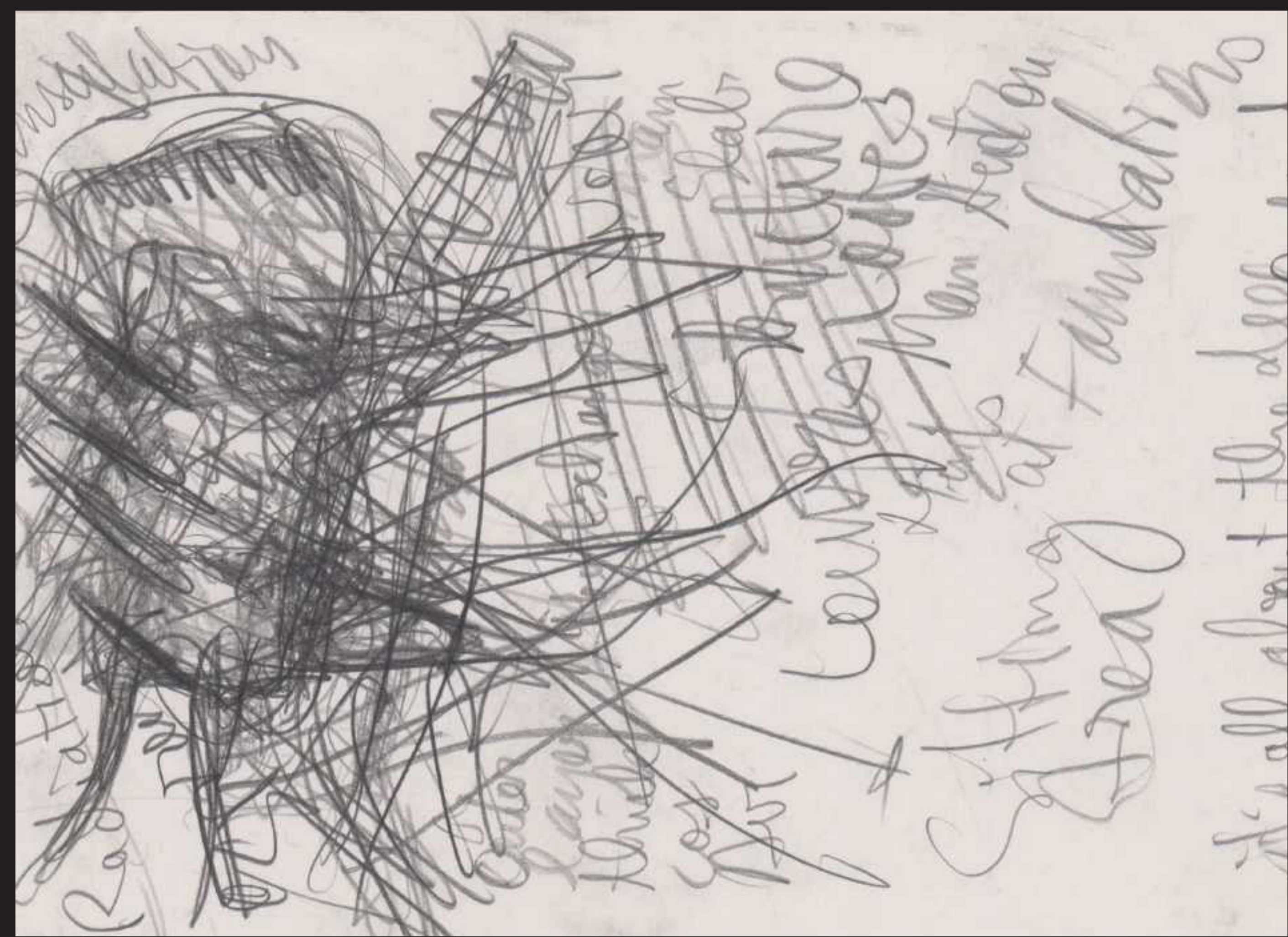


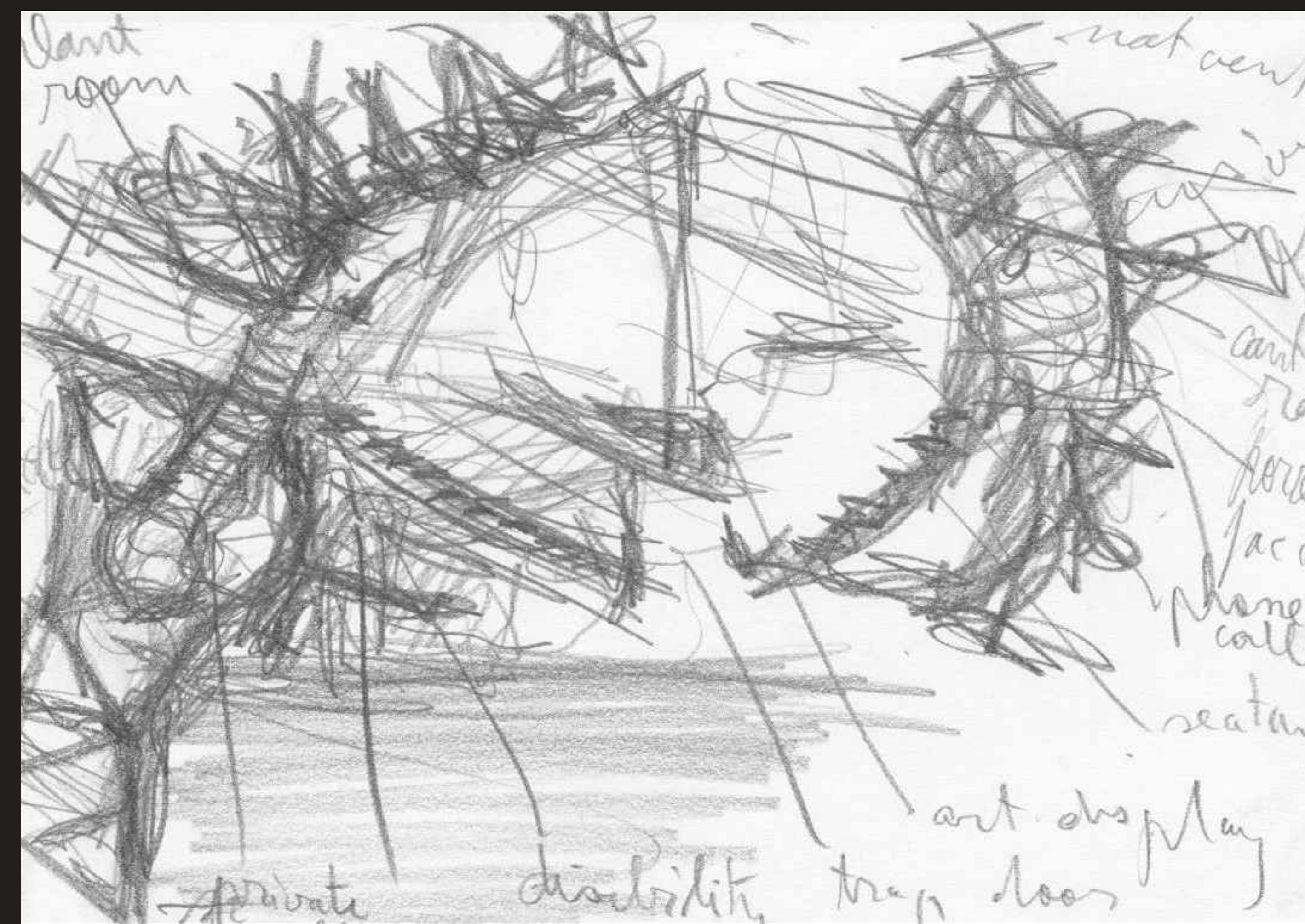


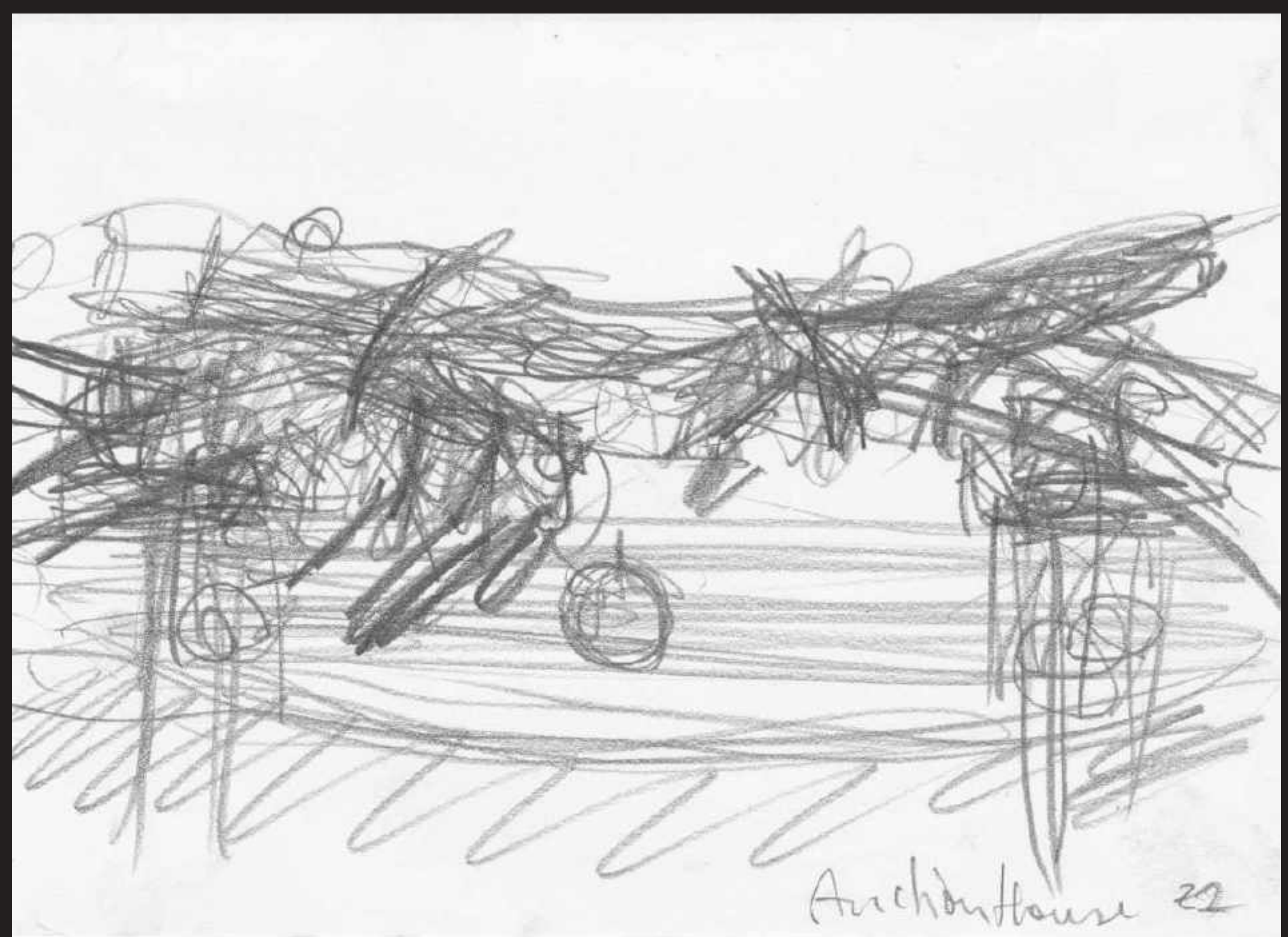

Z1
Z2
Z3

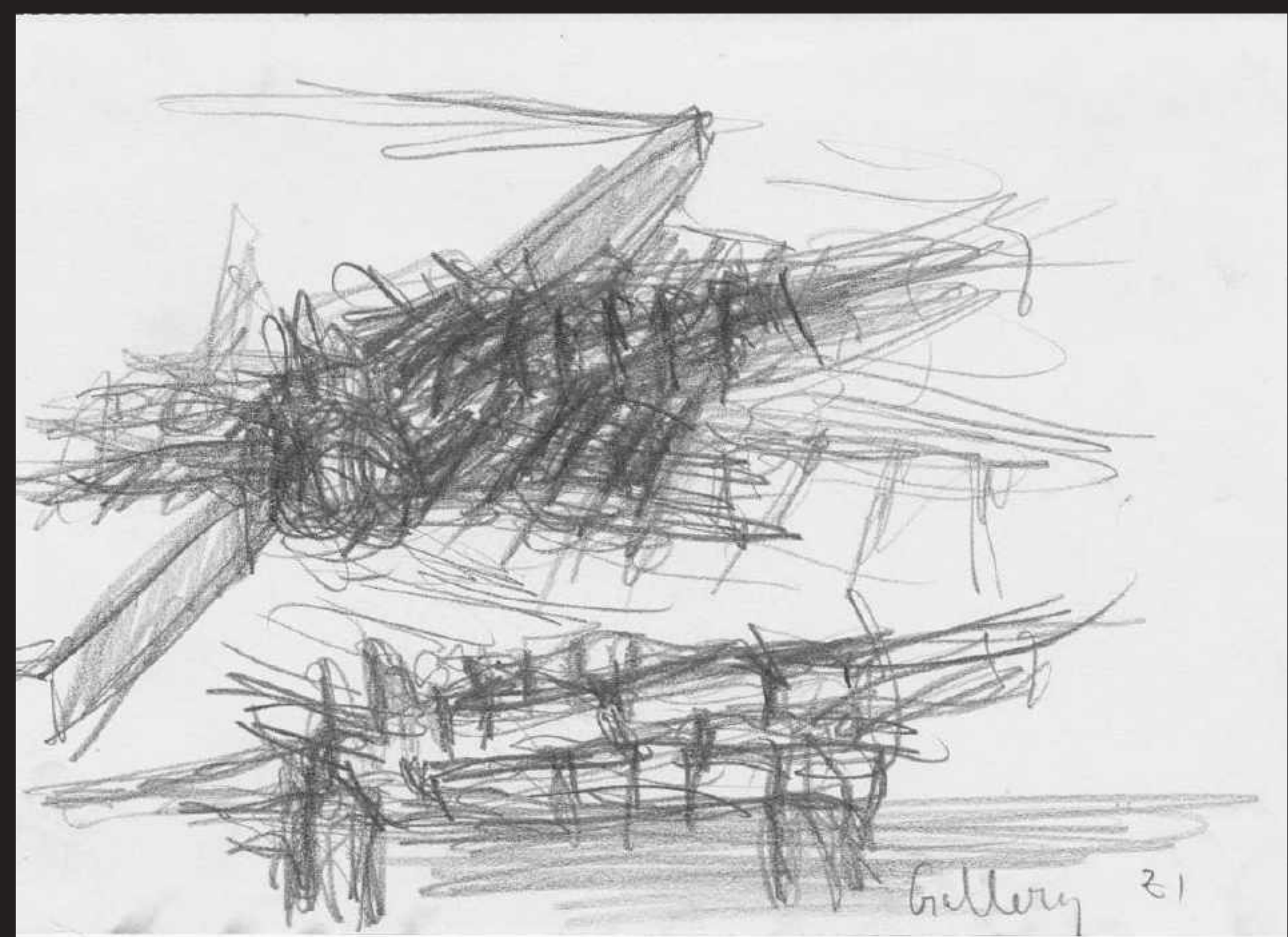

Detail
steel + clay
A joint
B facade
C furniture



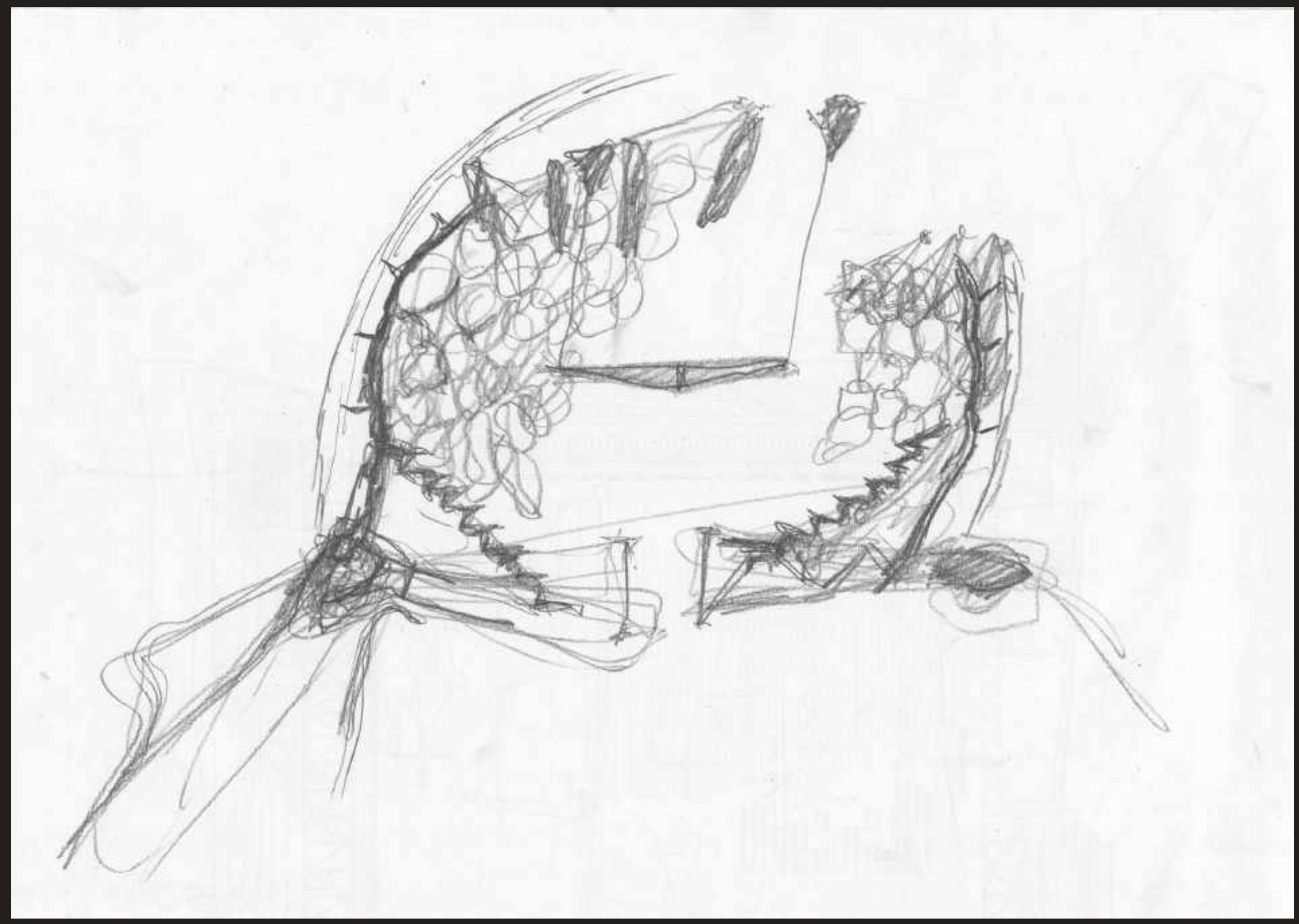
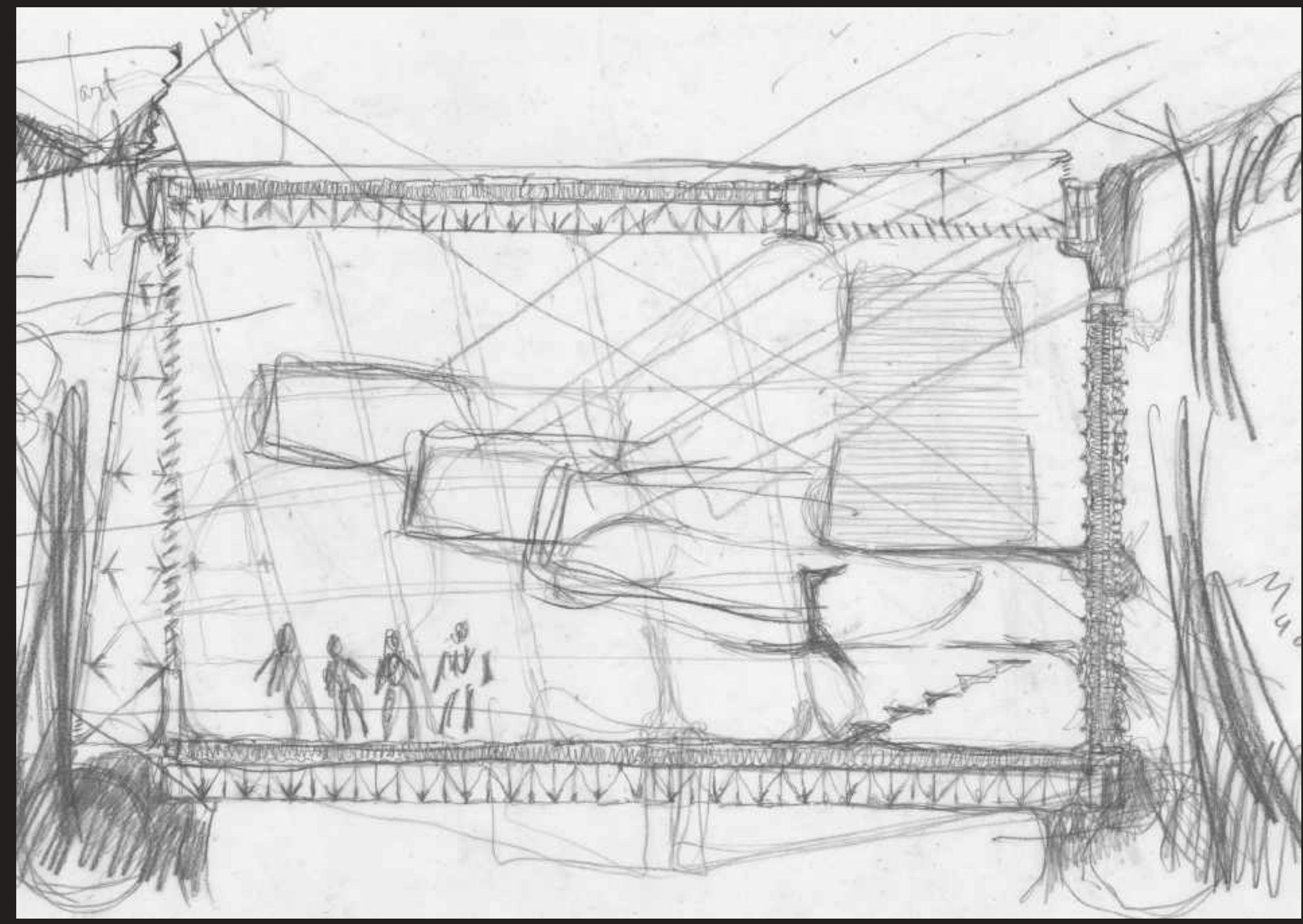
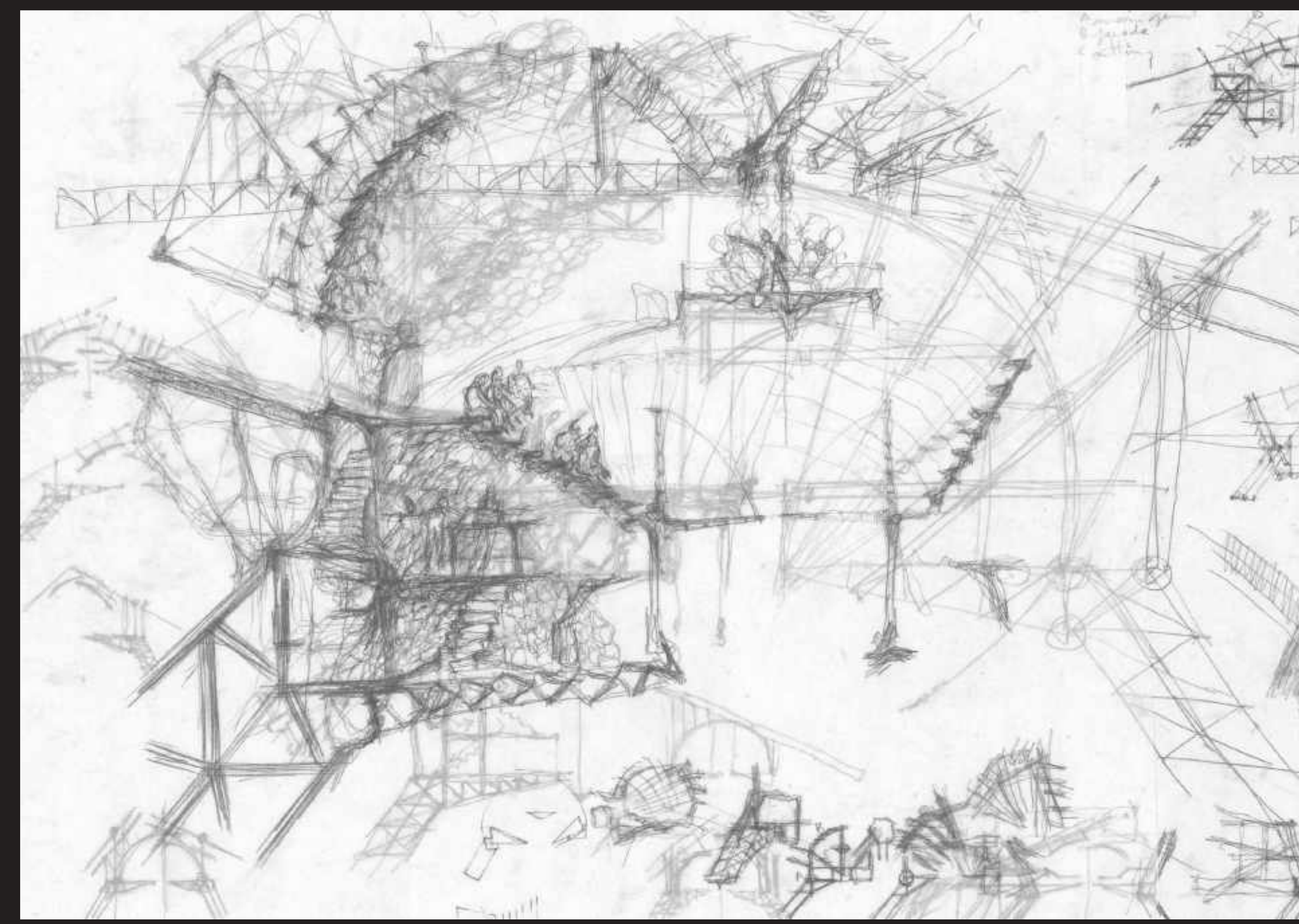
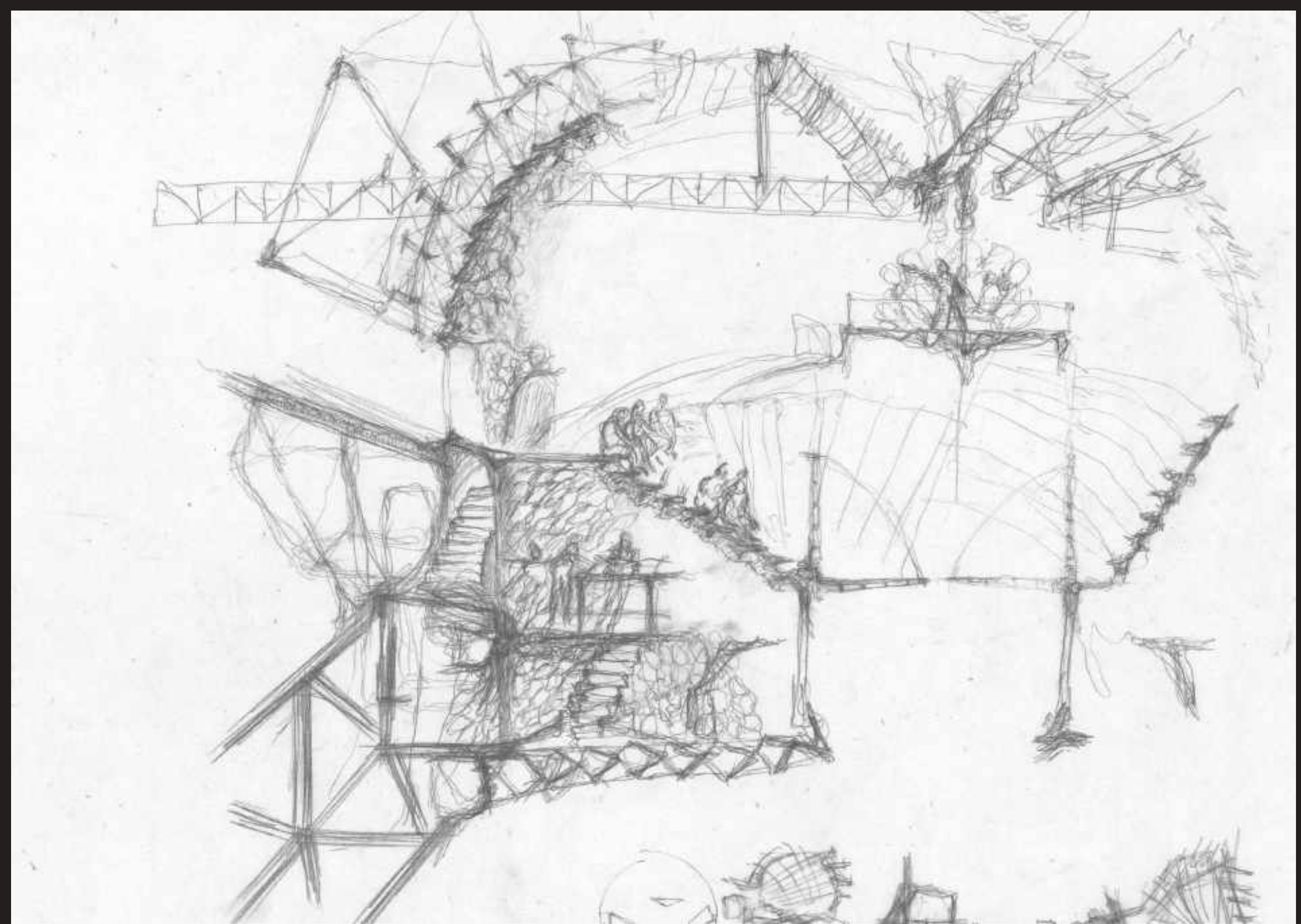
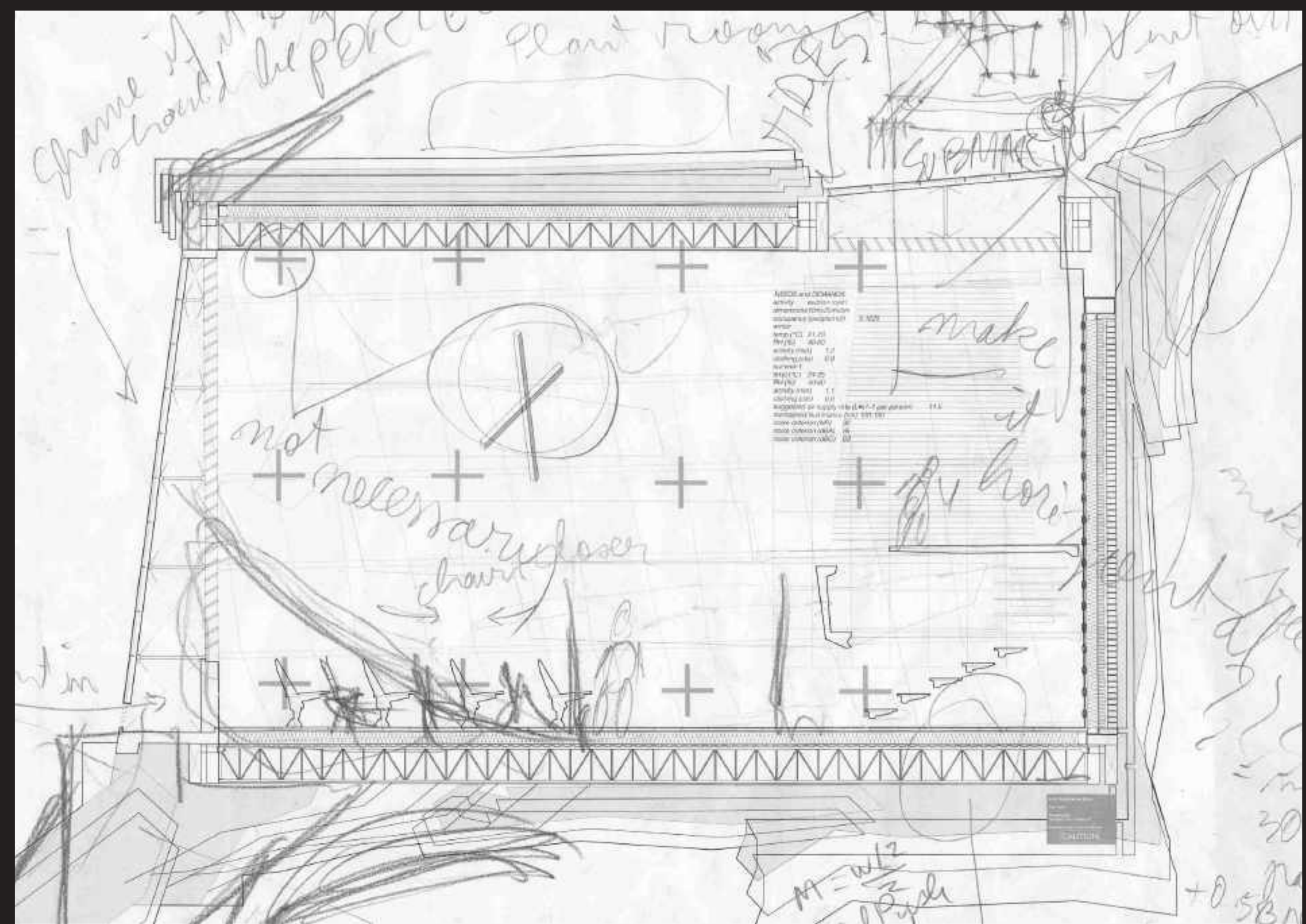
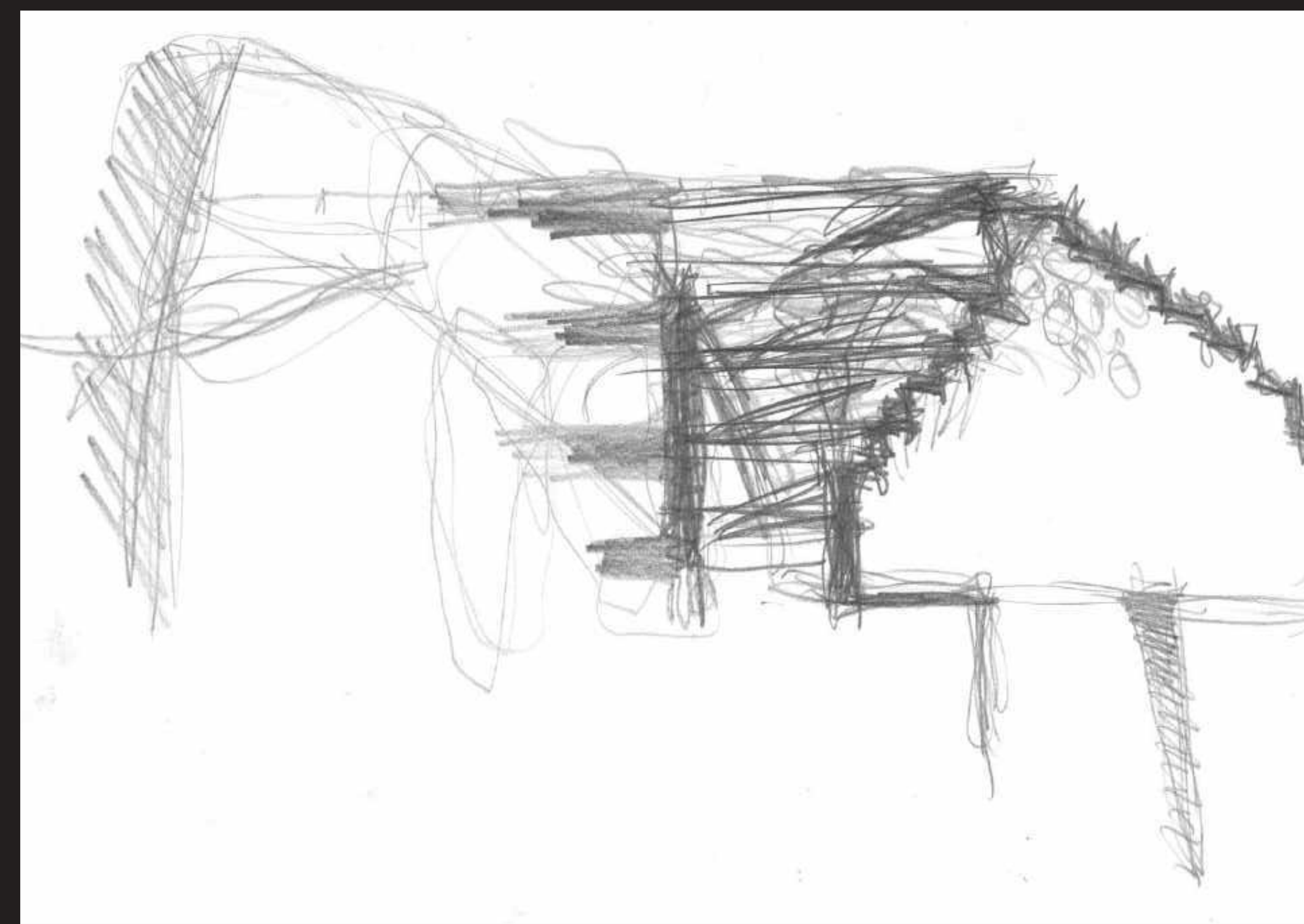
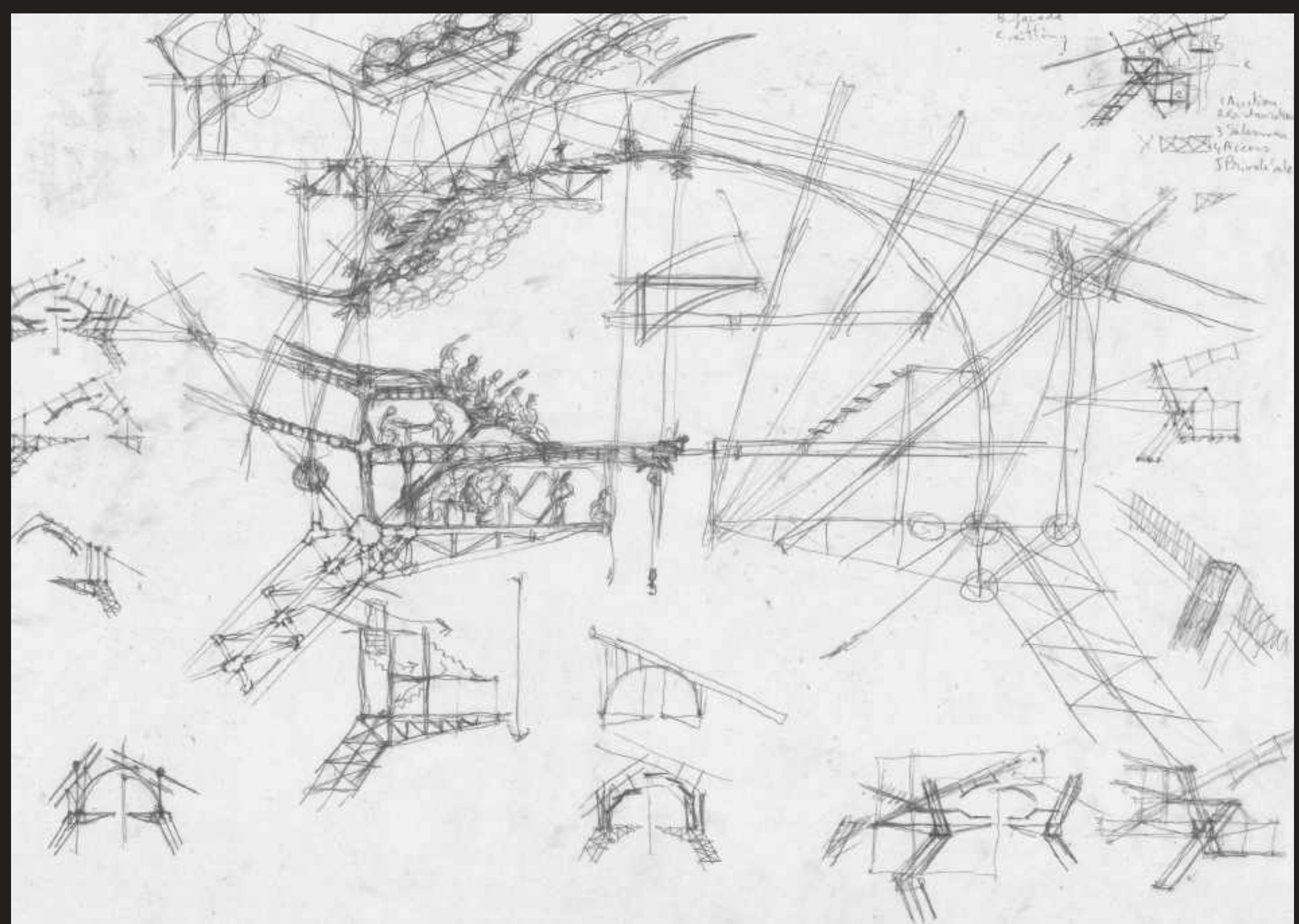
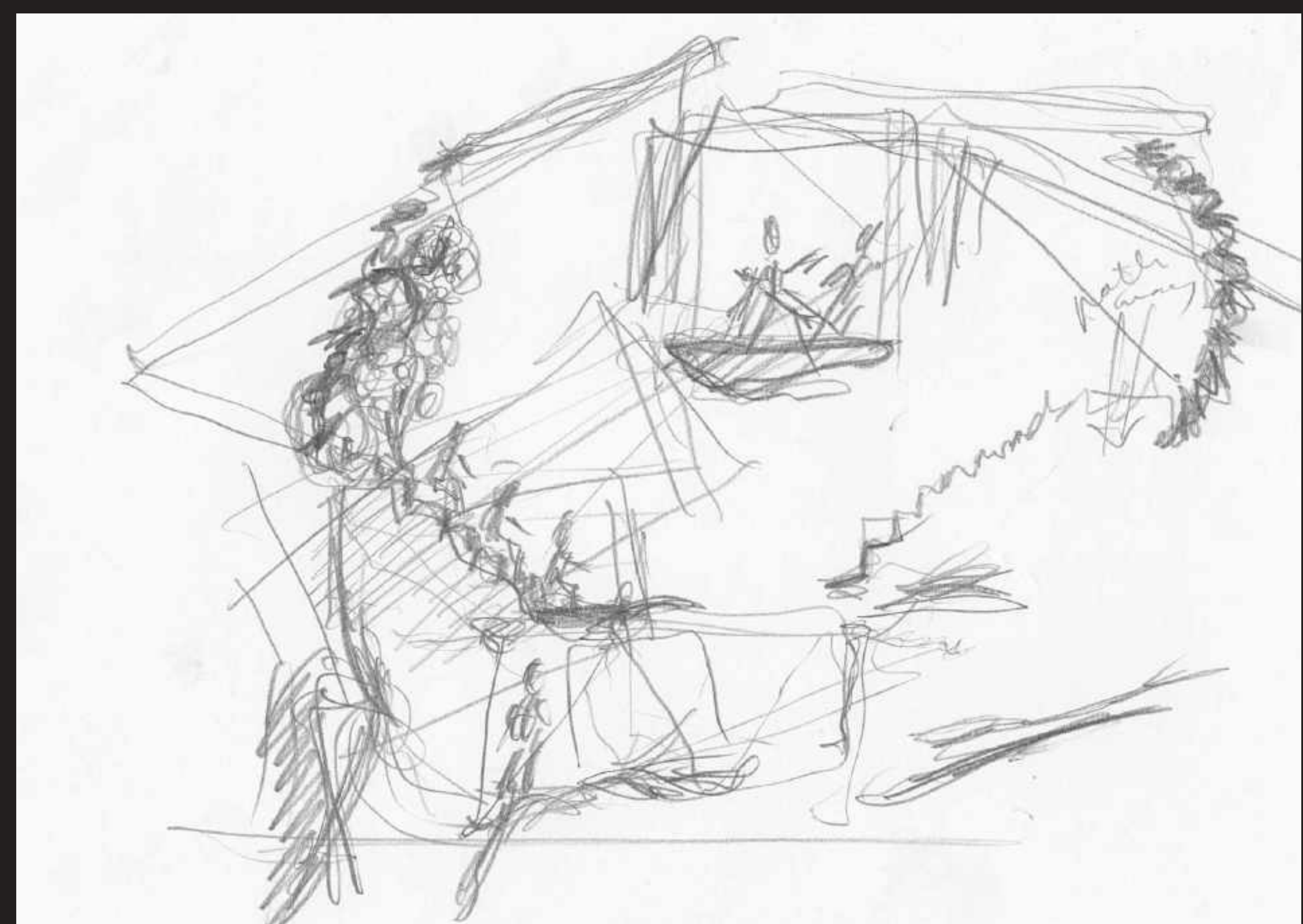
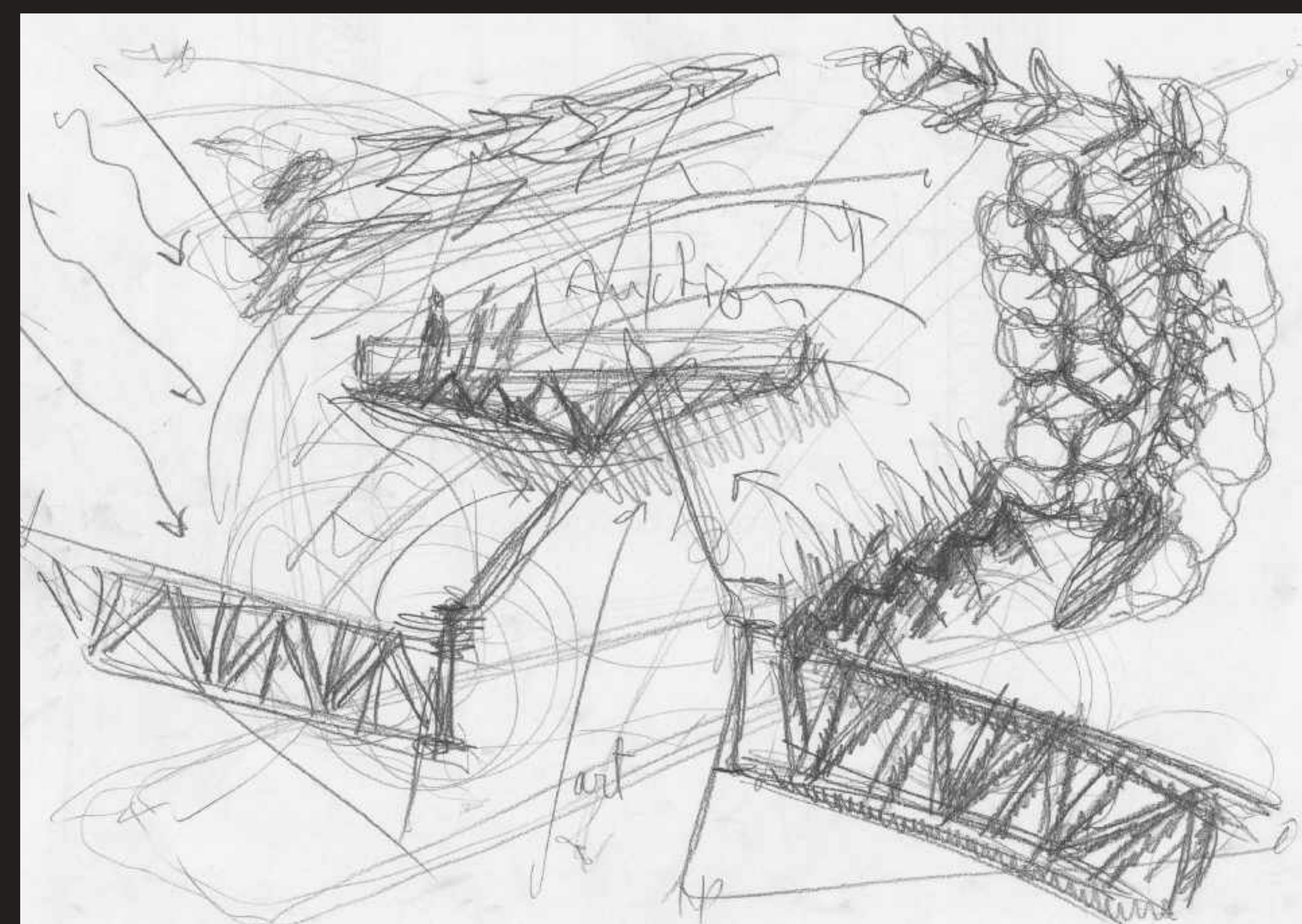


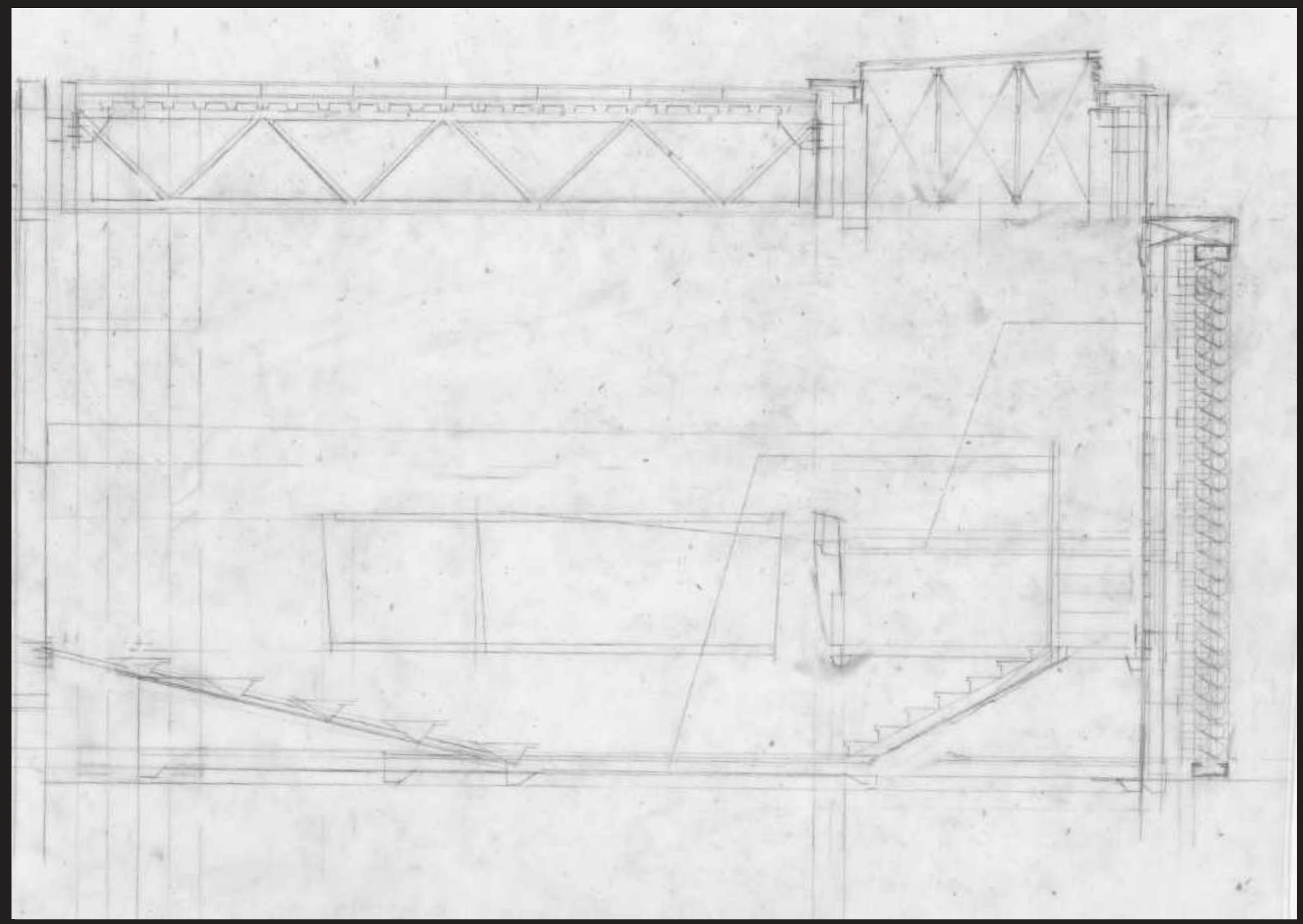

art display
trap doors

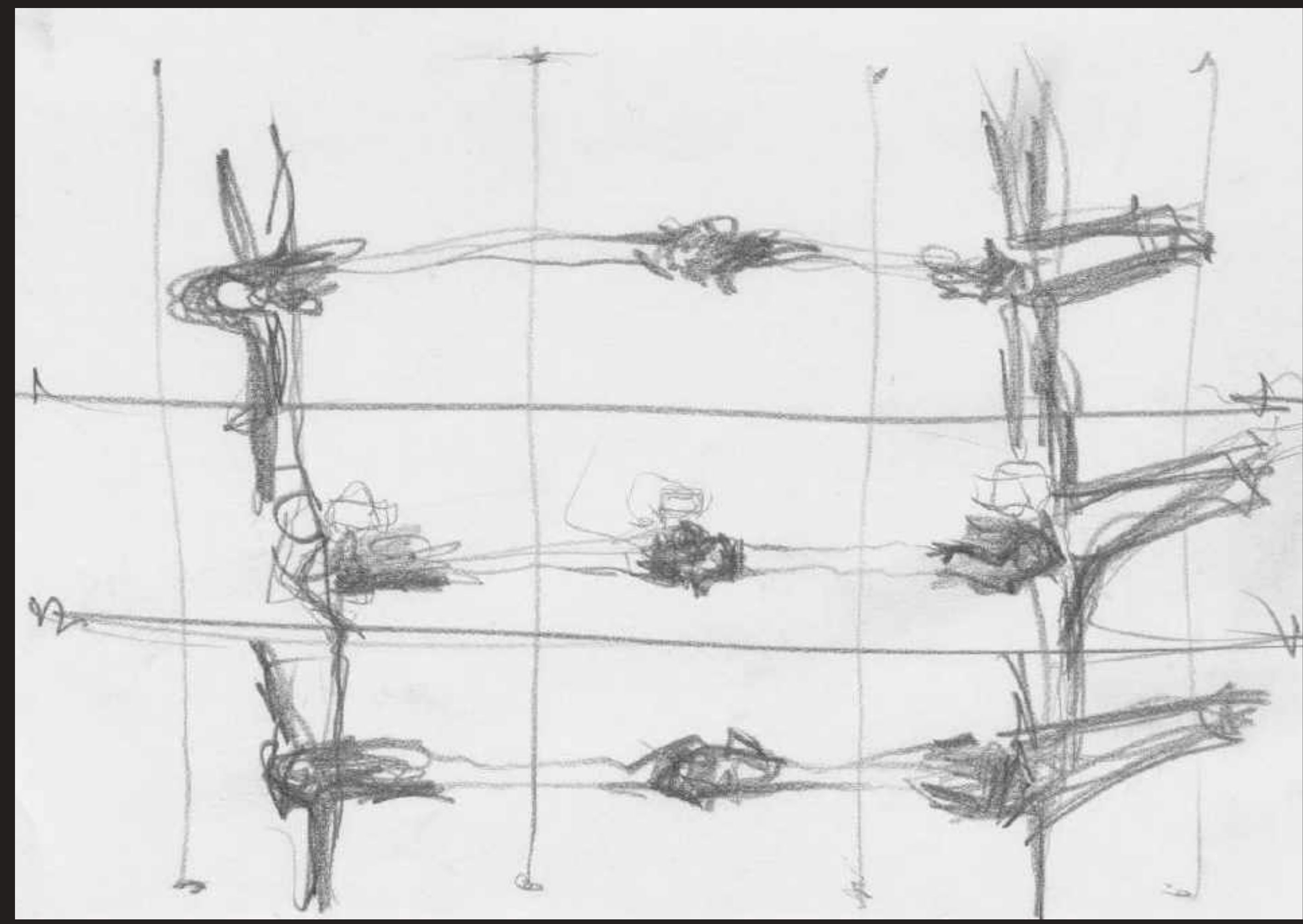

Z2

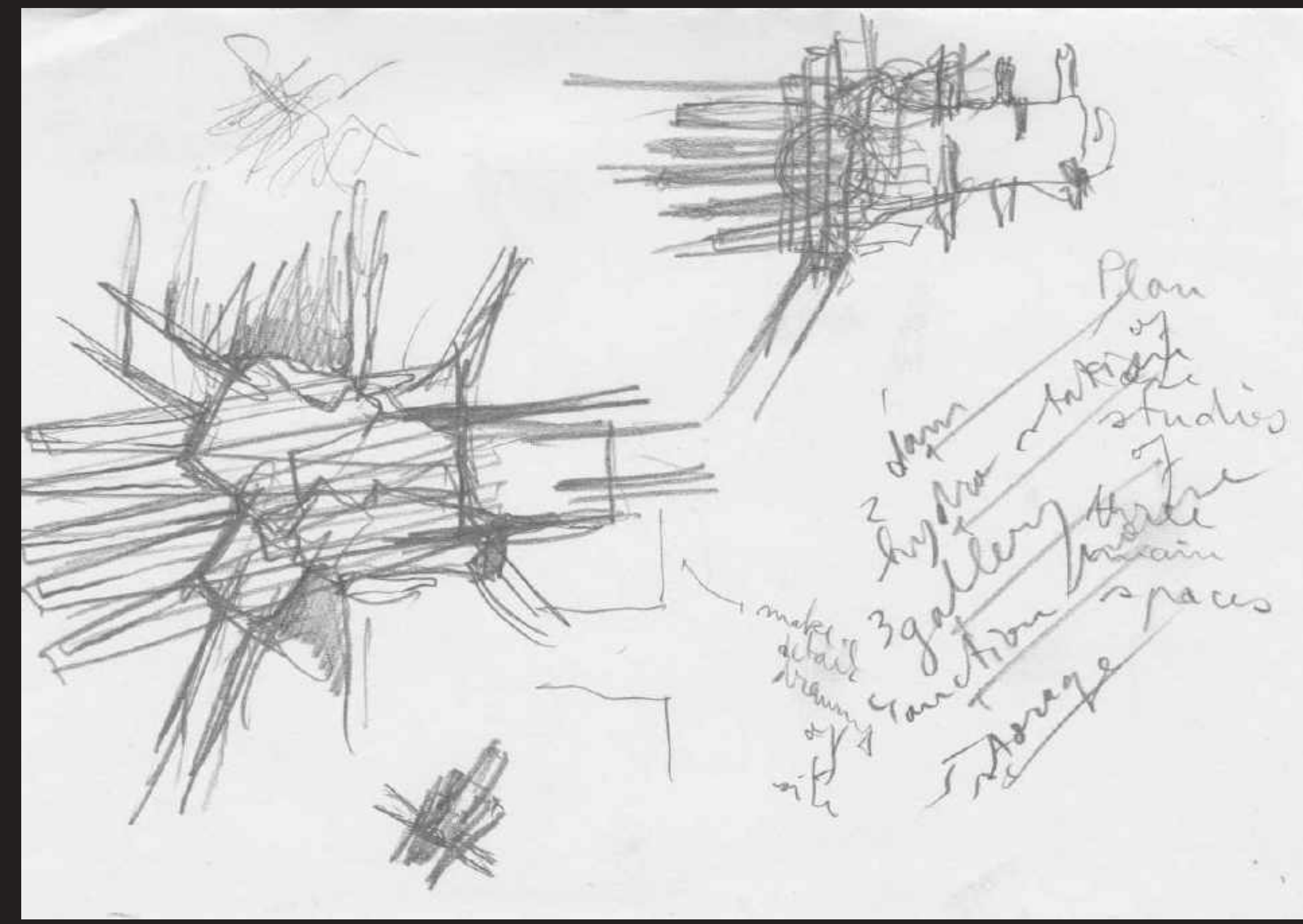

Gallery Z1

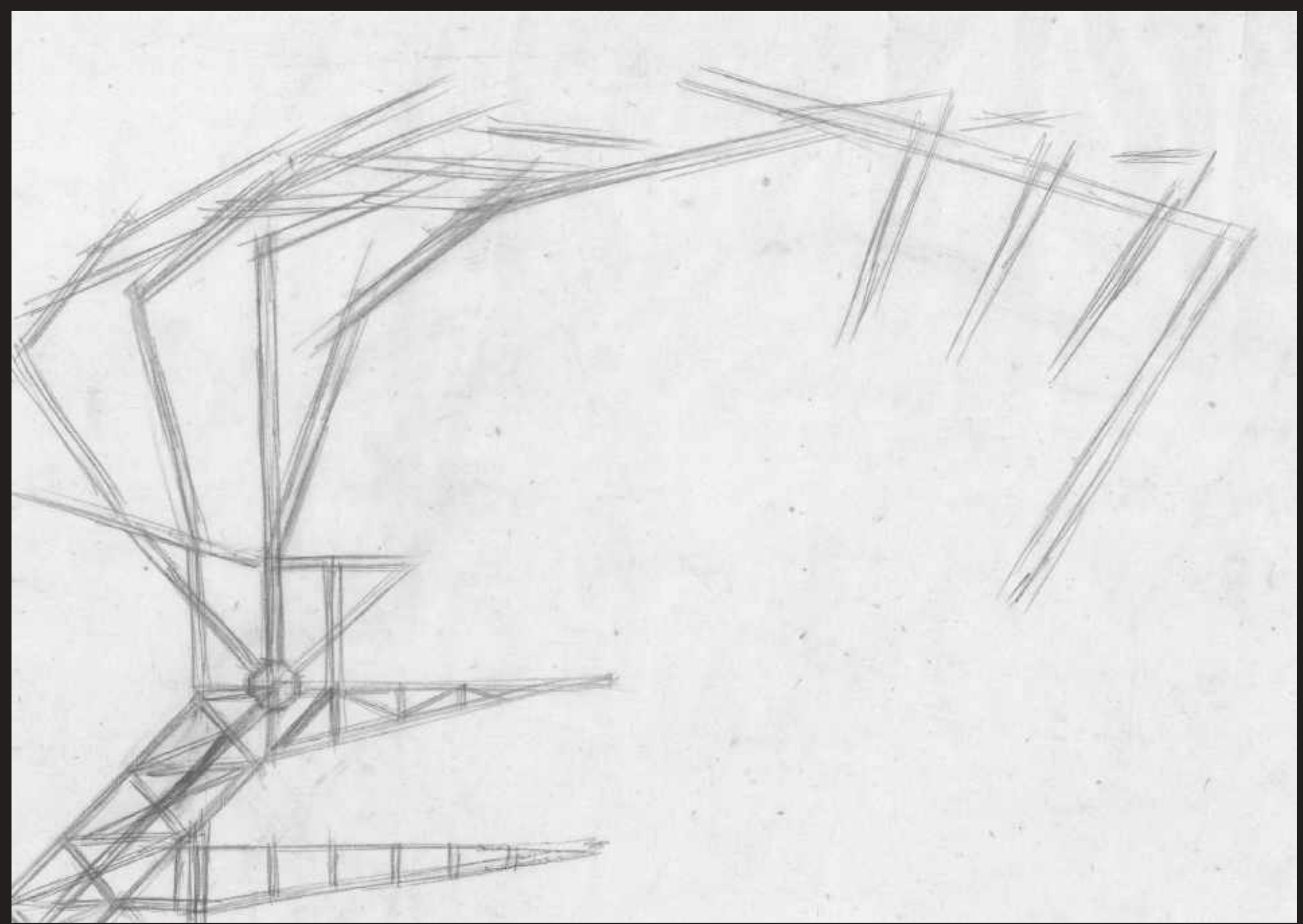

Storage Z3

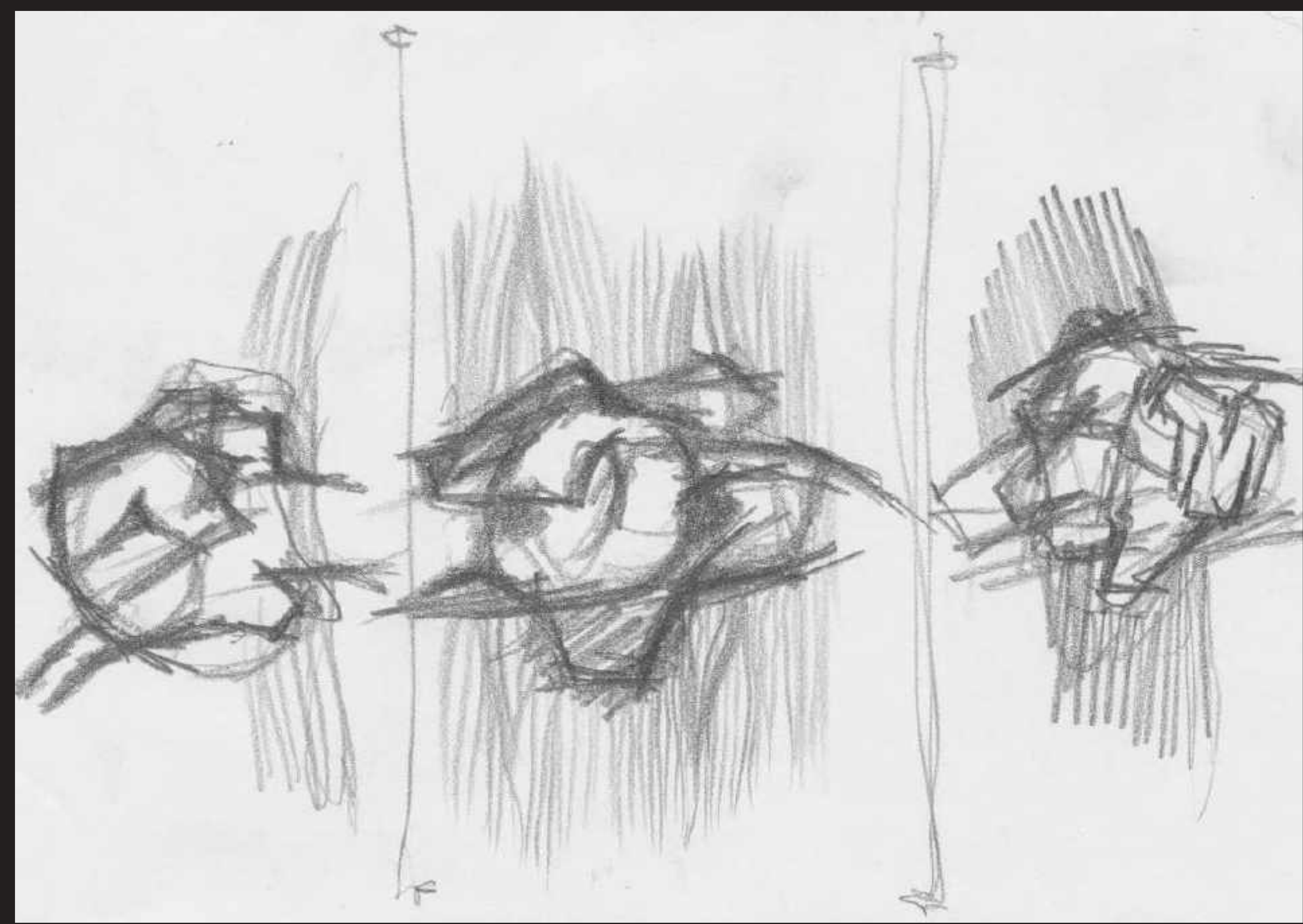










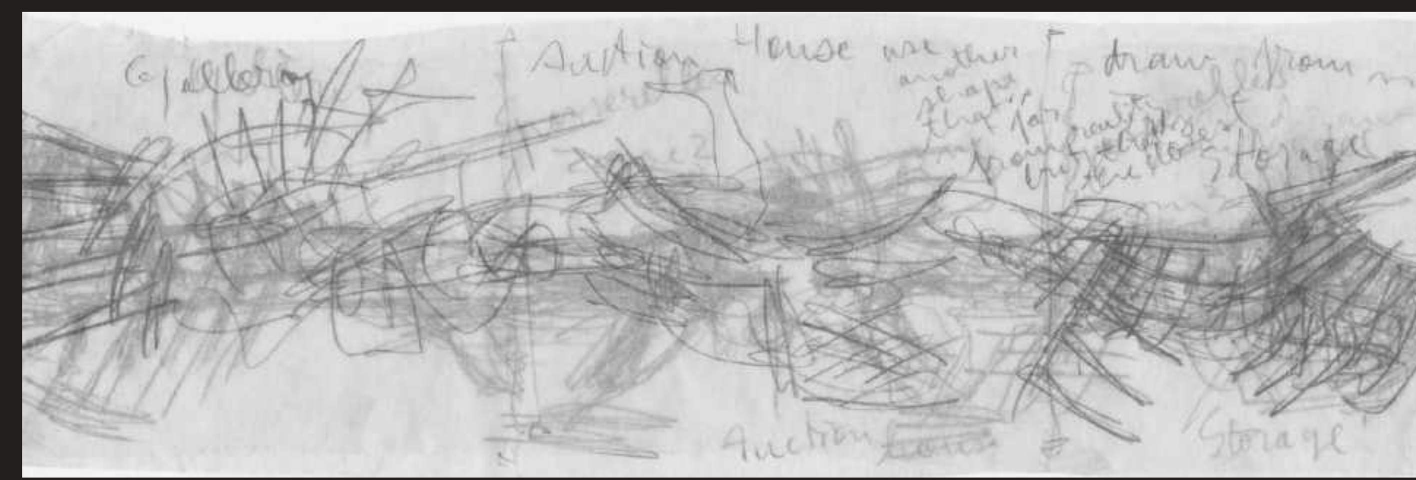


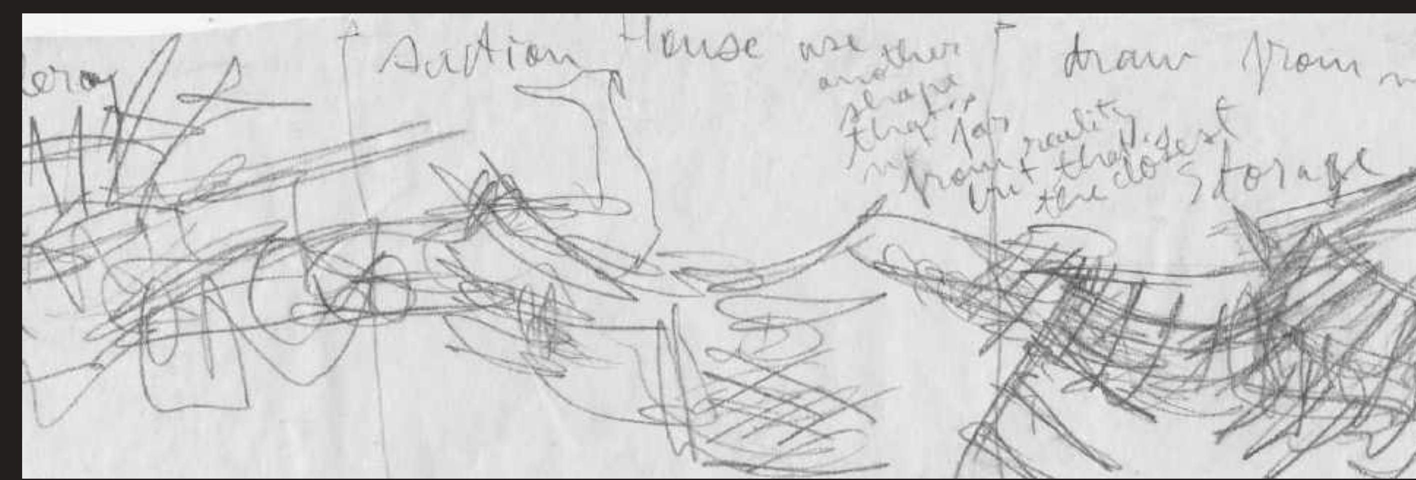


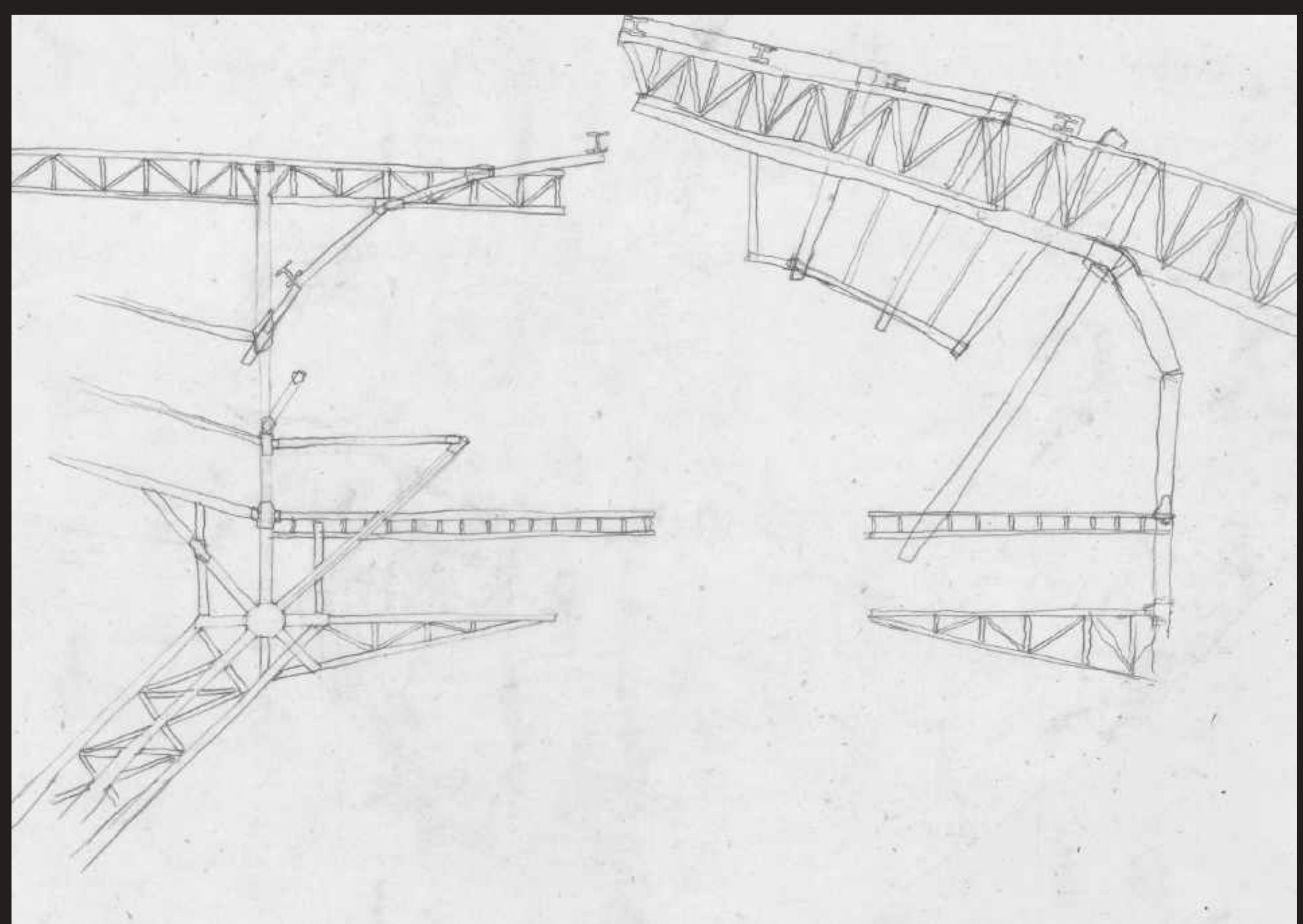

Plan
studios
gallery
storage

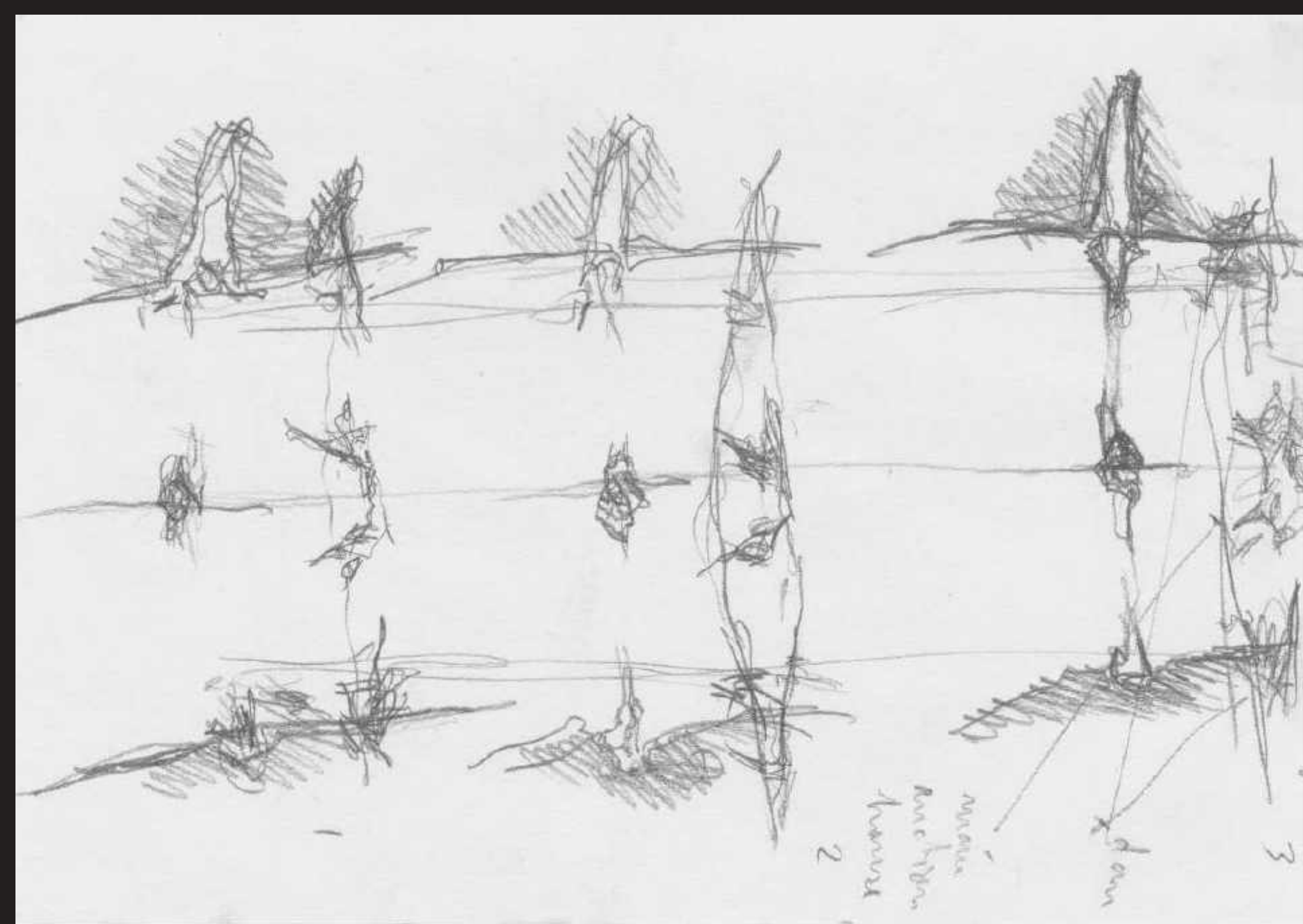




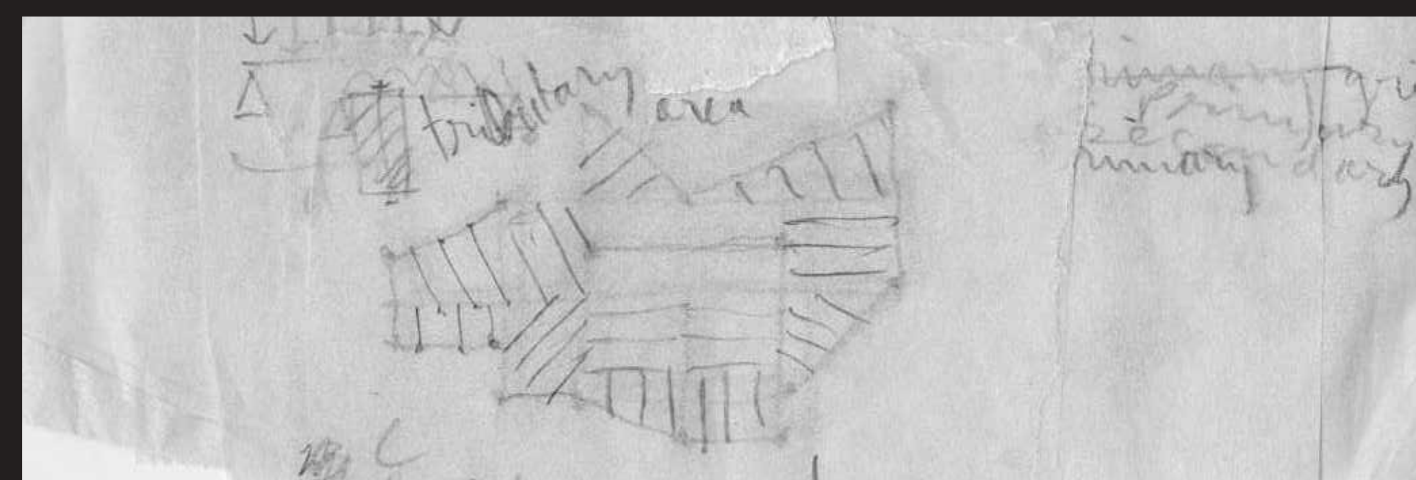

Gallery
Auction House
Storage


Auction House
draw from
Storage

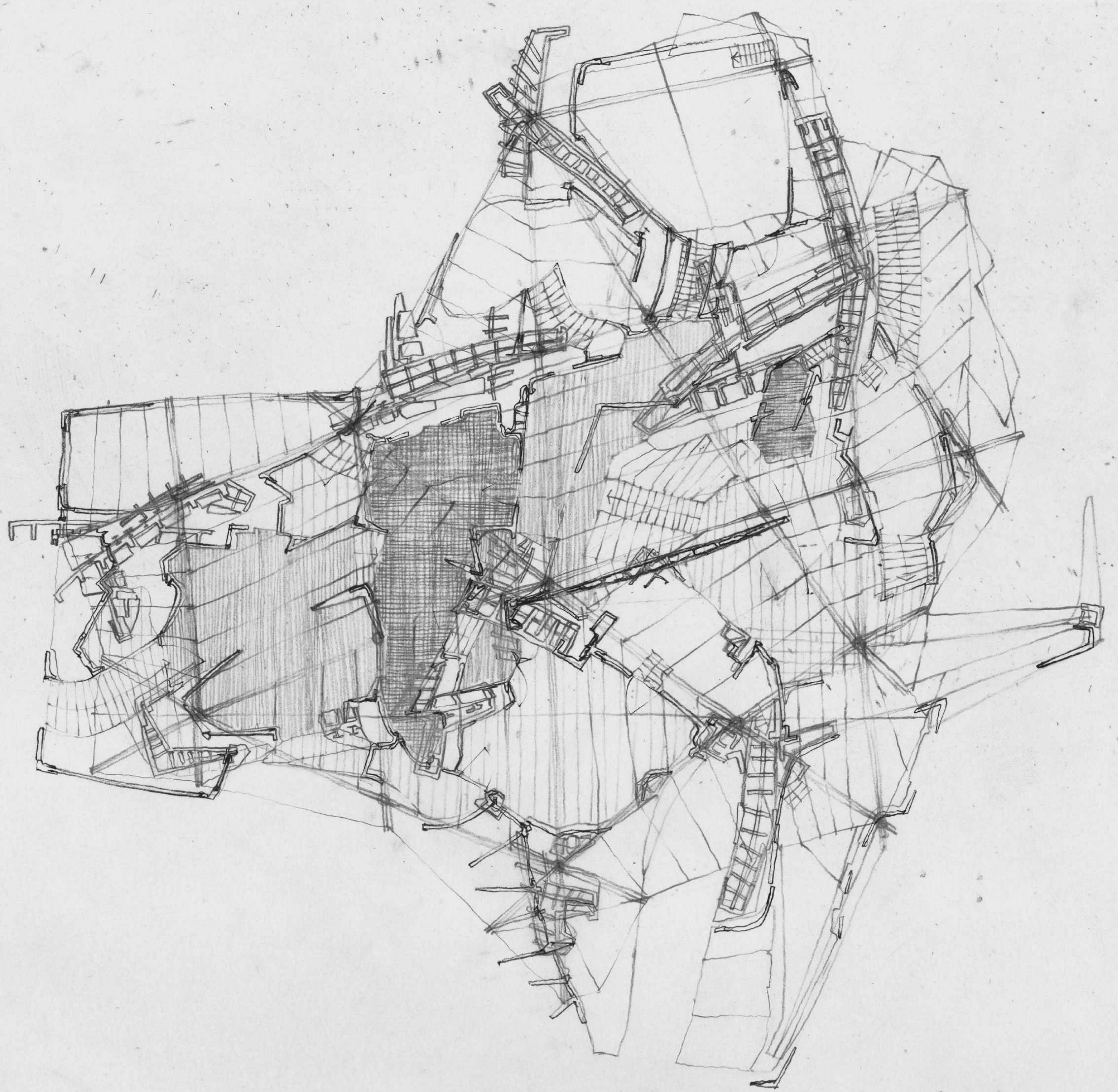





Gallery
passerelles
zone 2

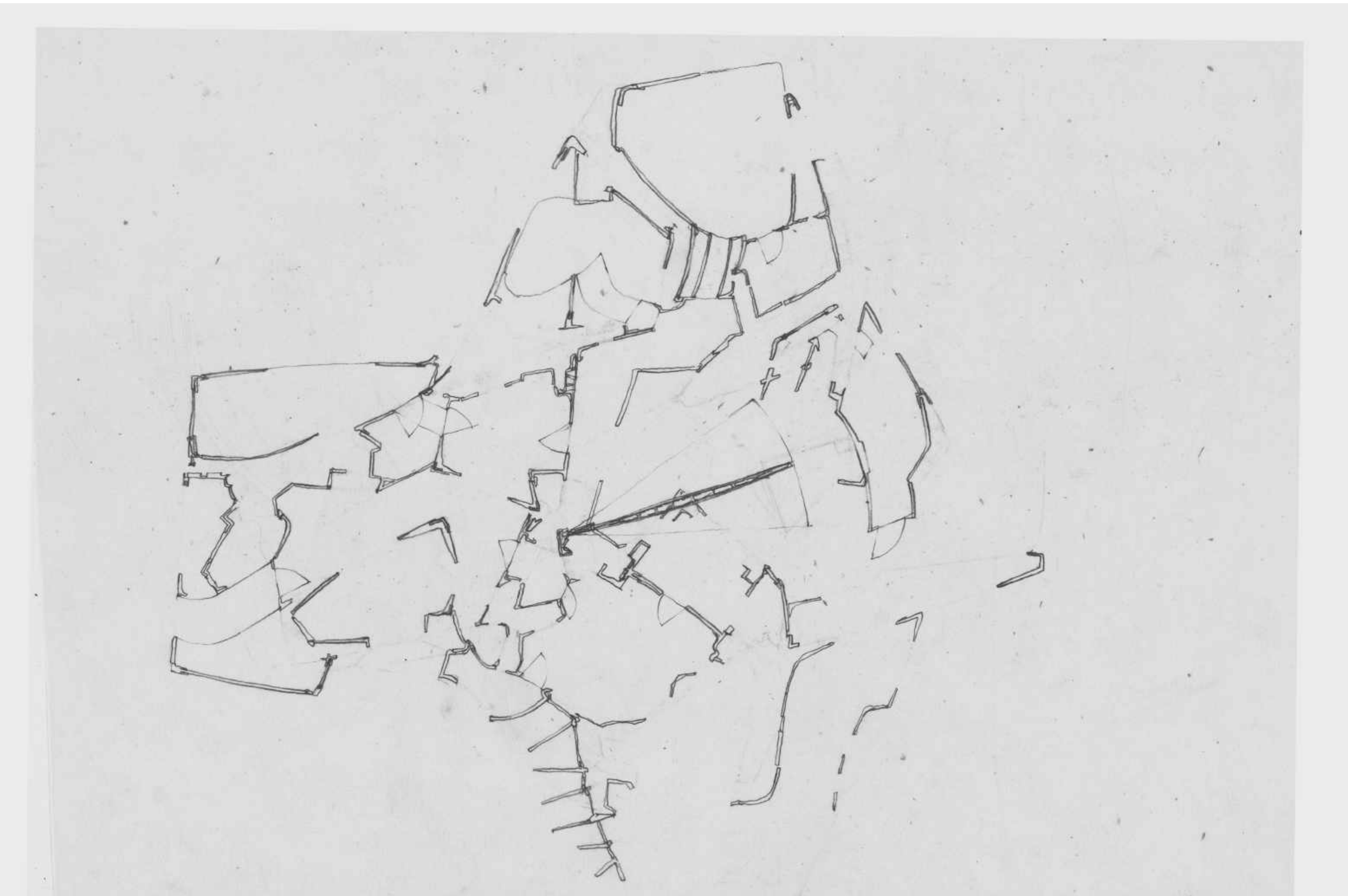


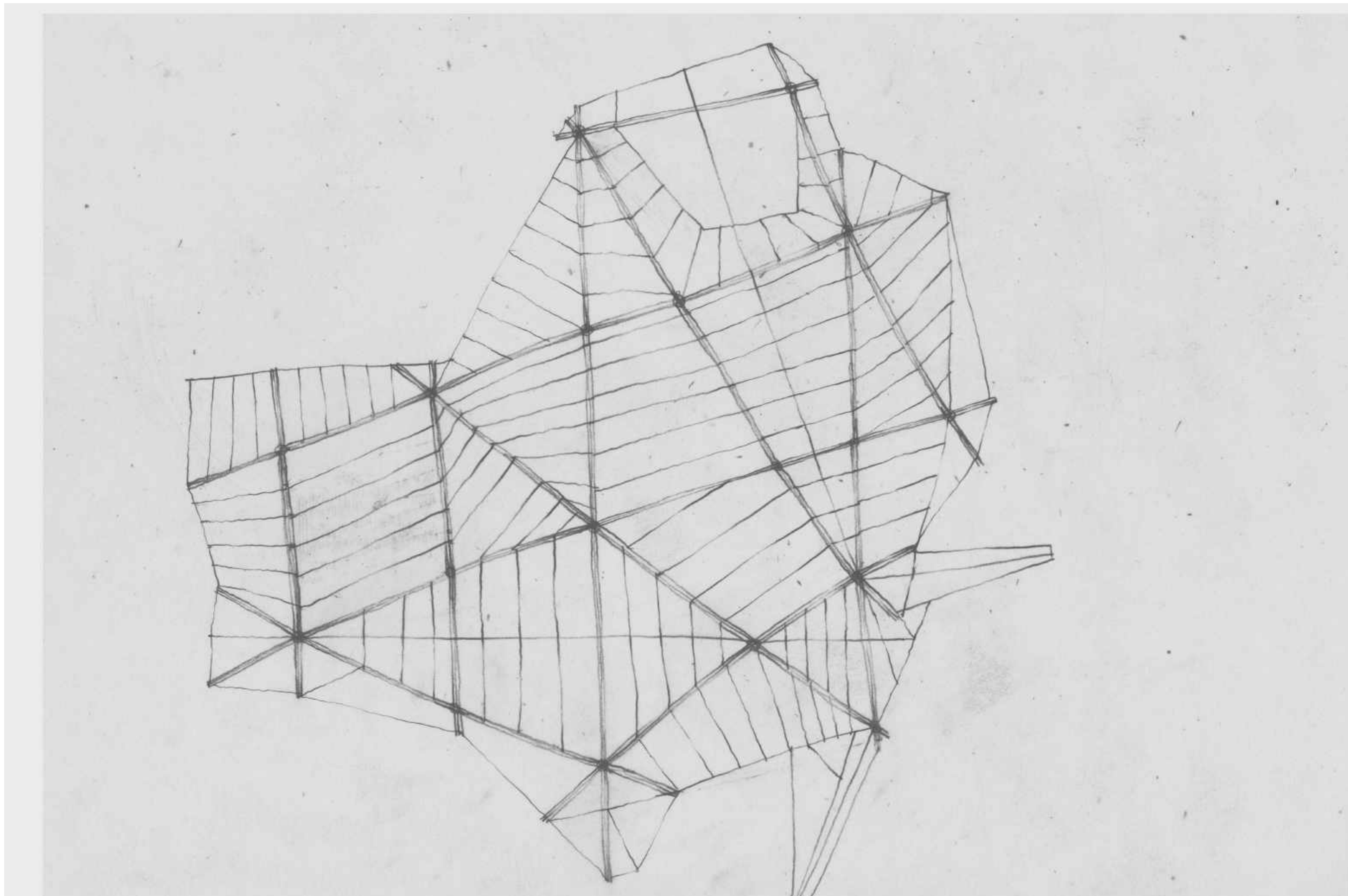
First Plan




flooring

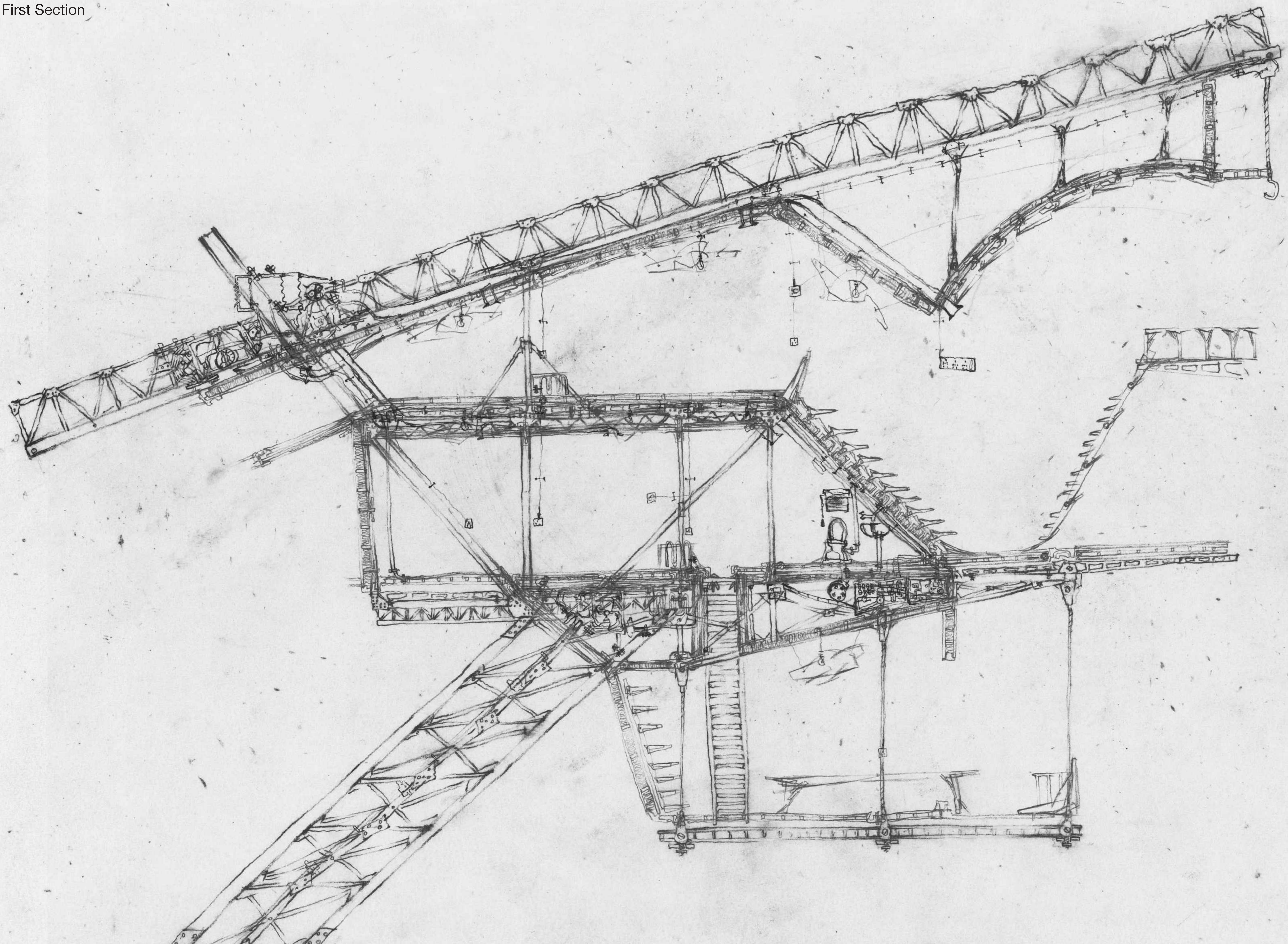

bearing walls

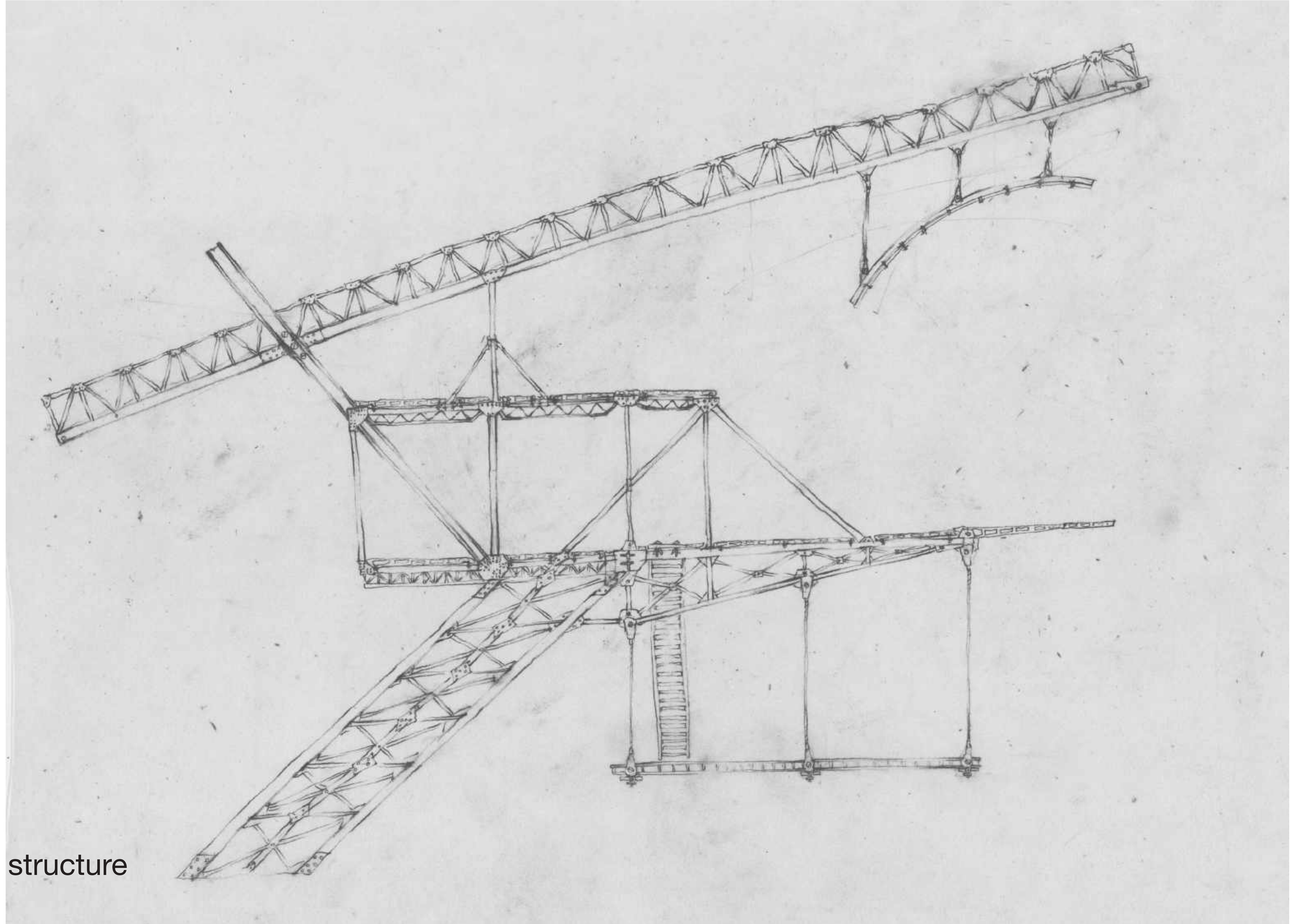

partitions

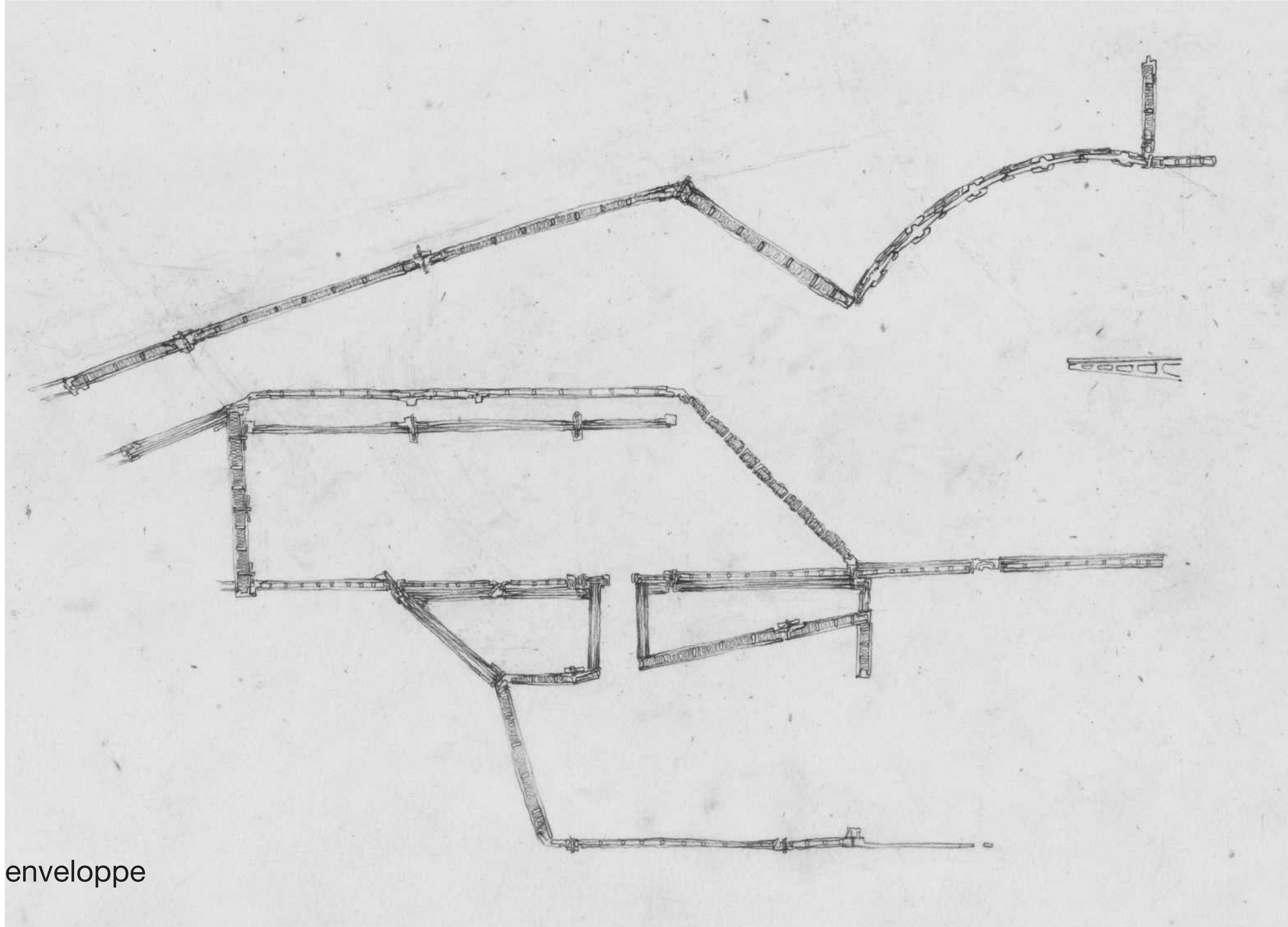

structural grid

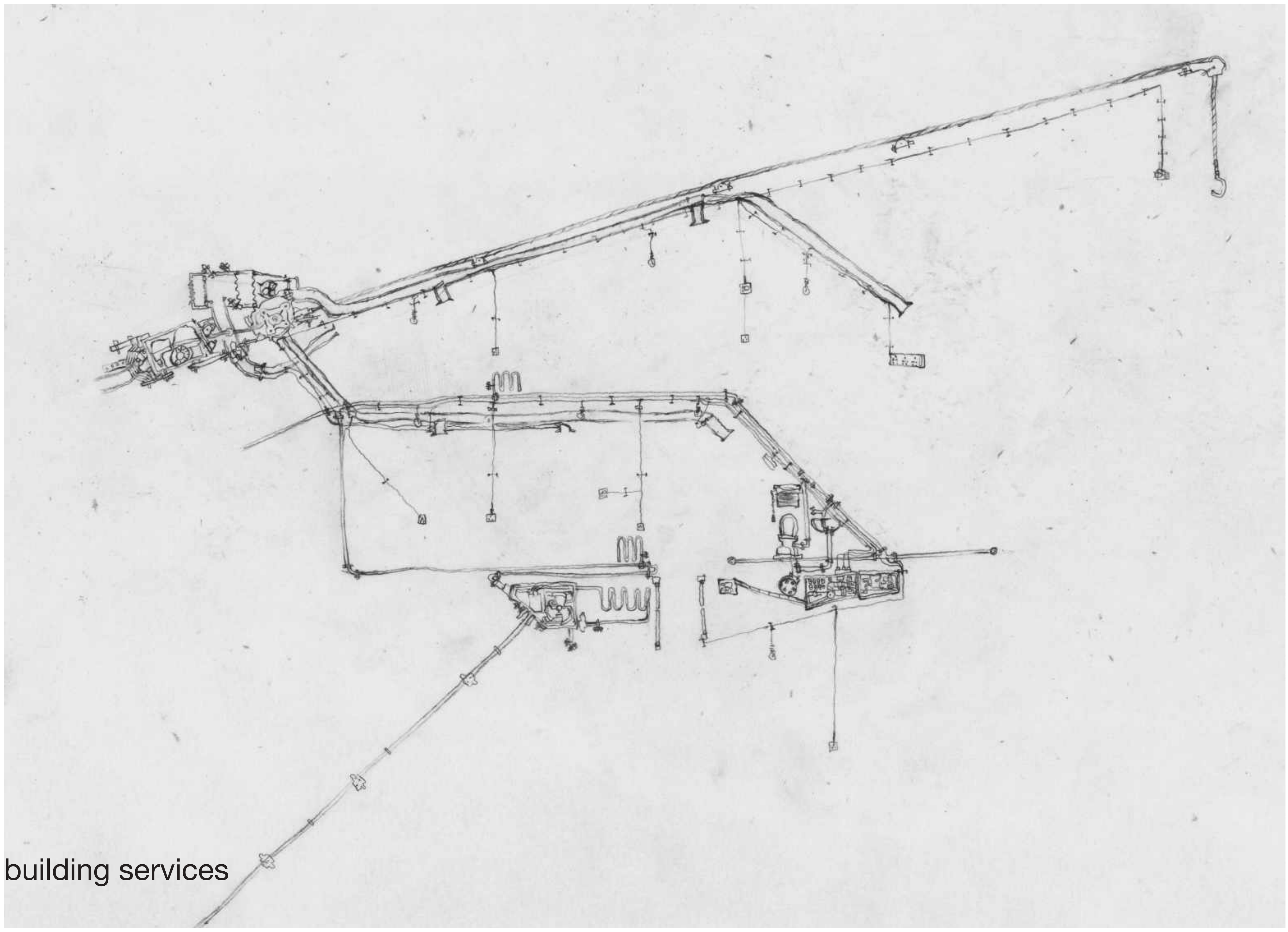
1:100 on A3

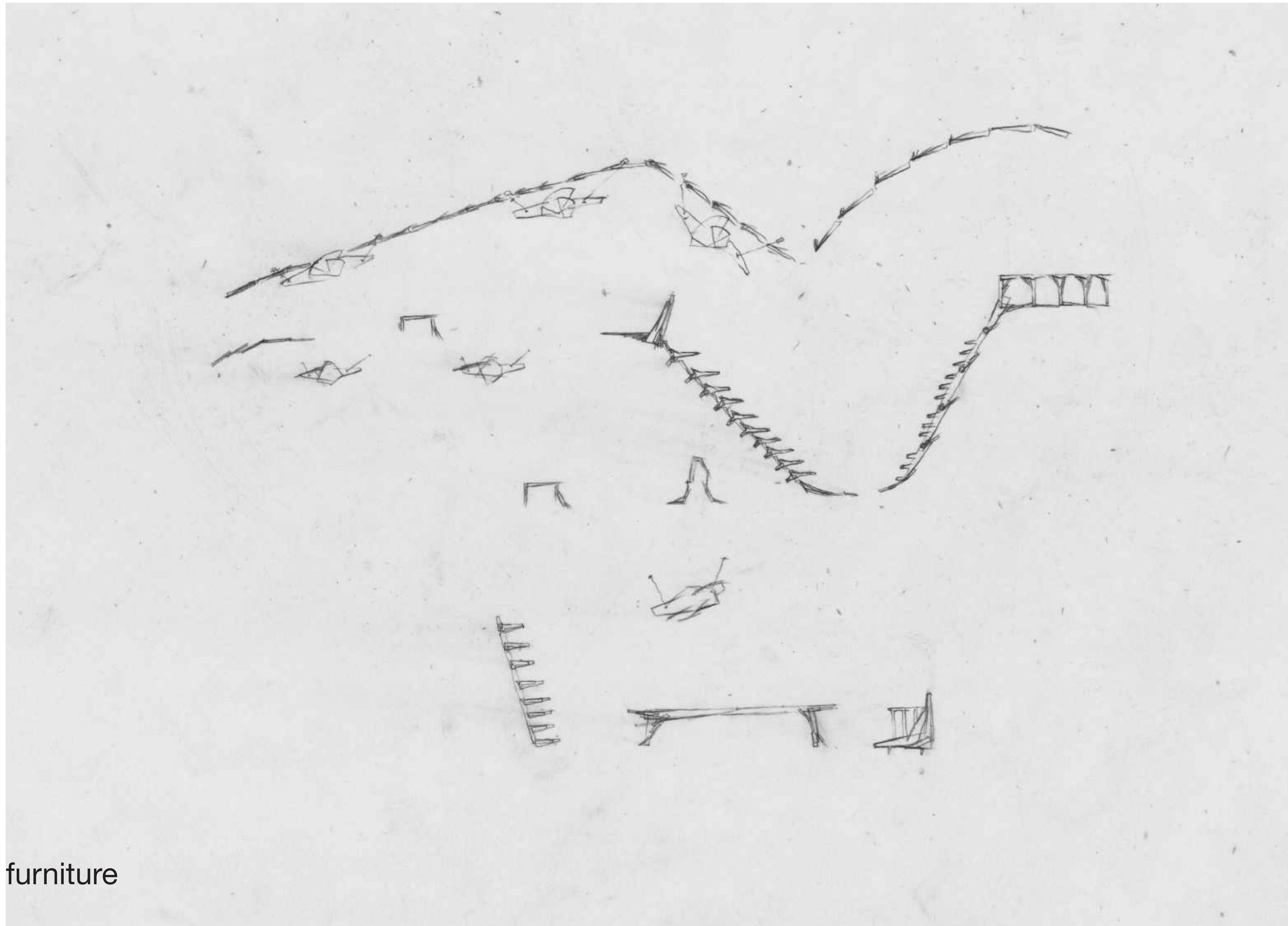
First Section




structure

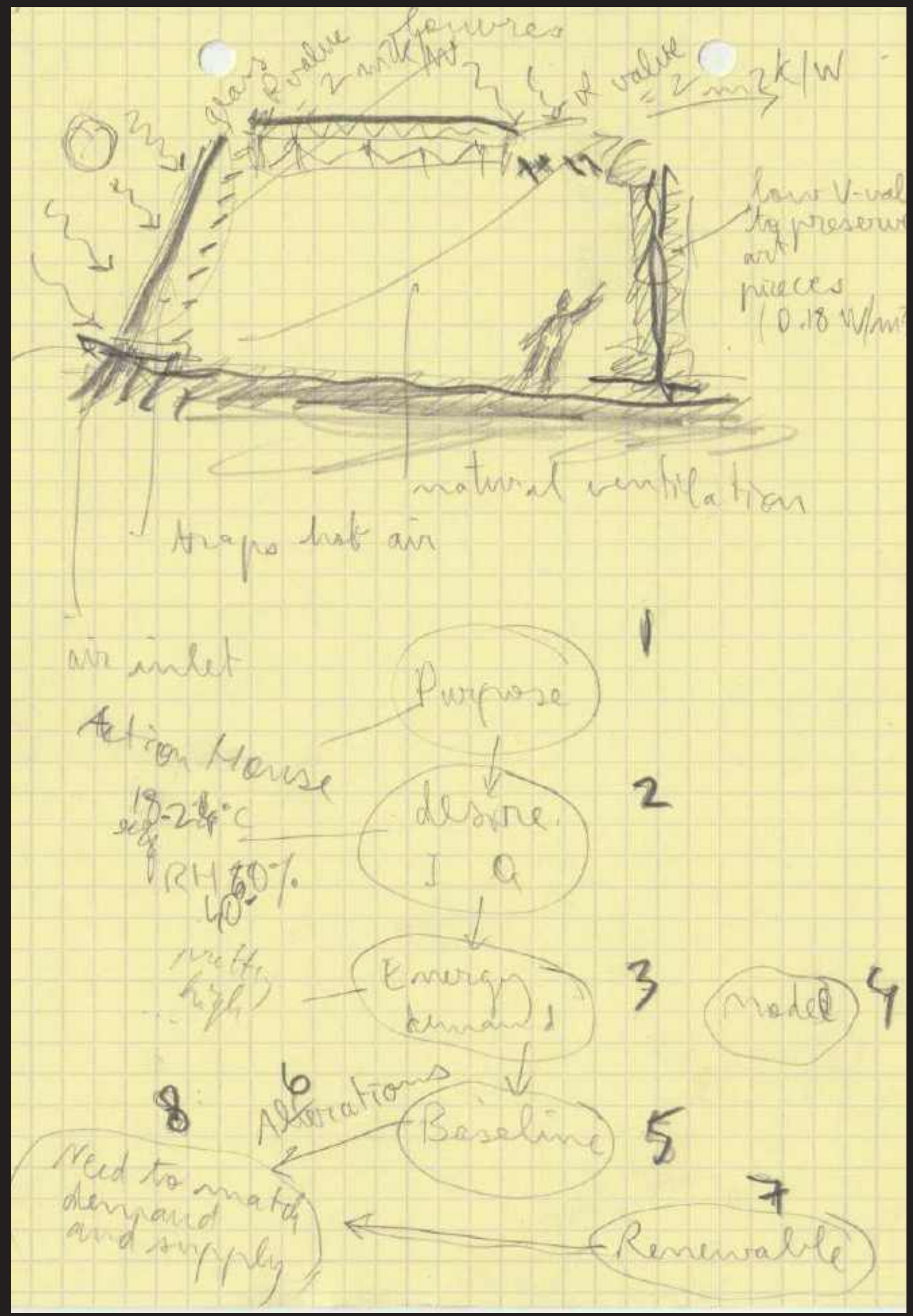

enveloppe

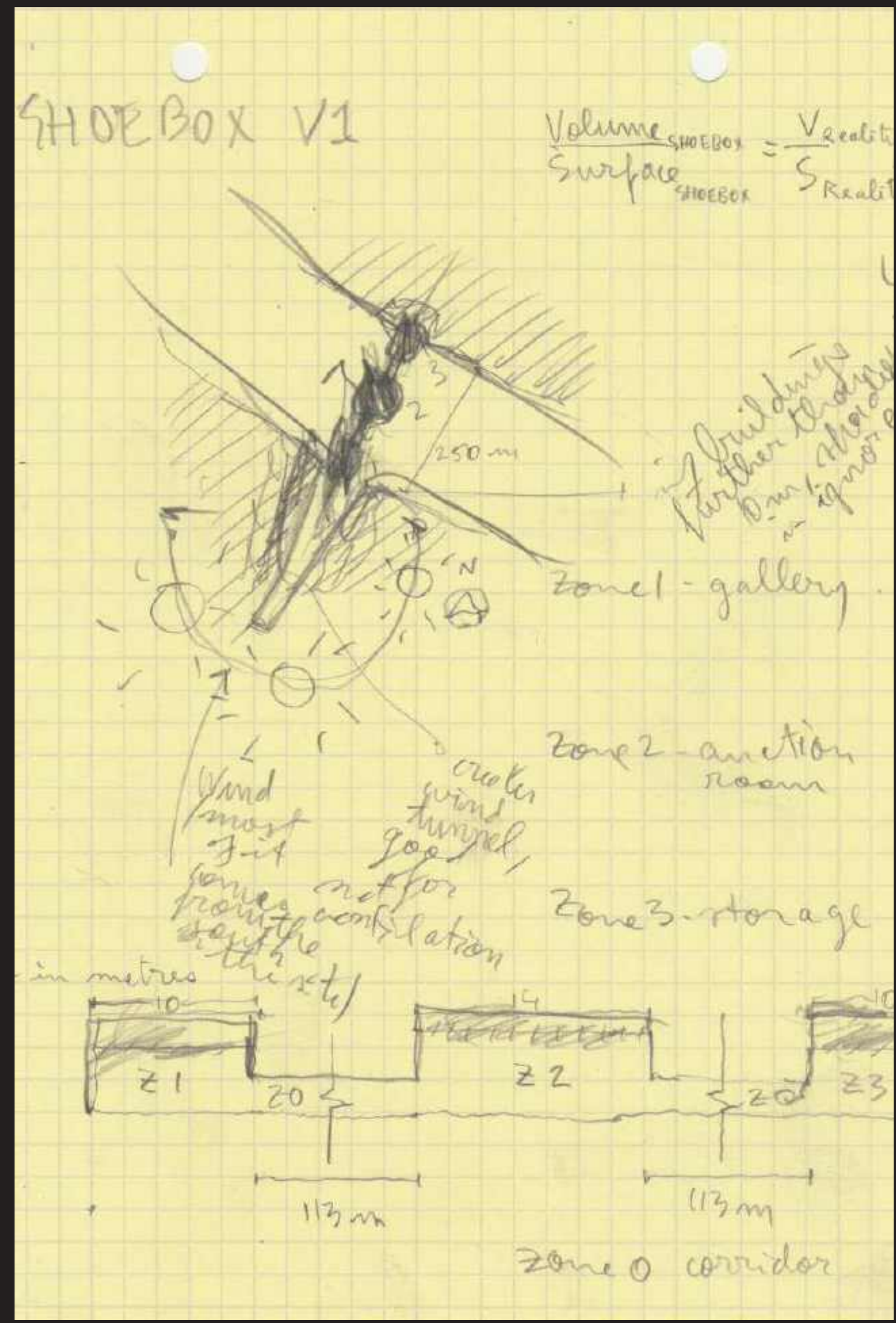

building services

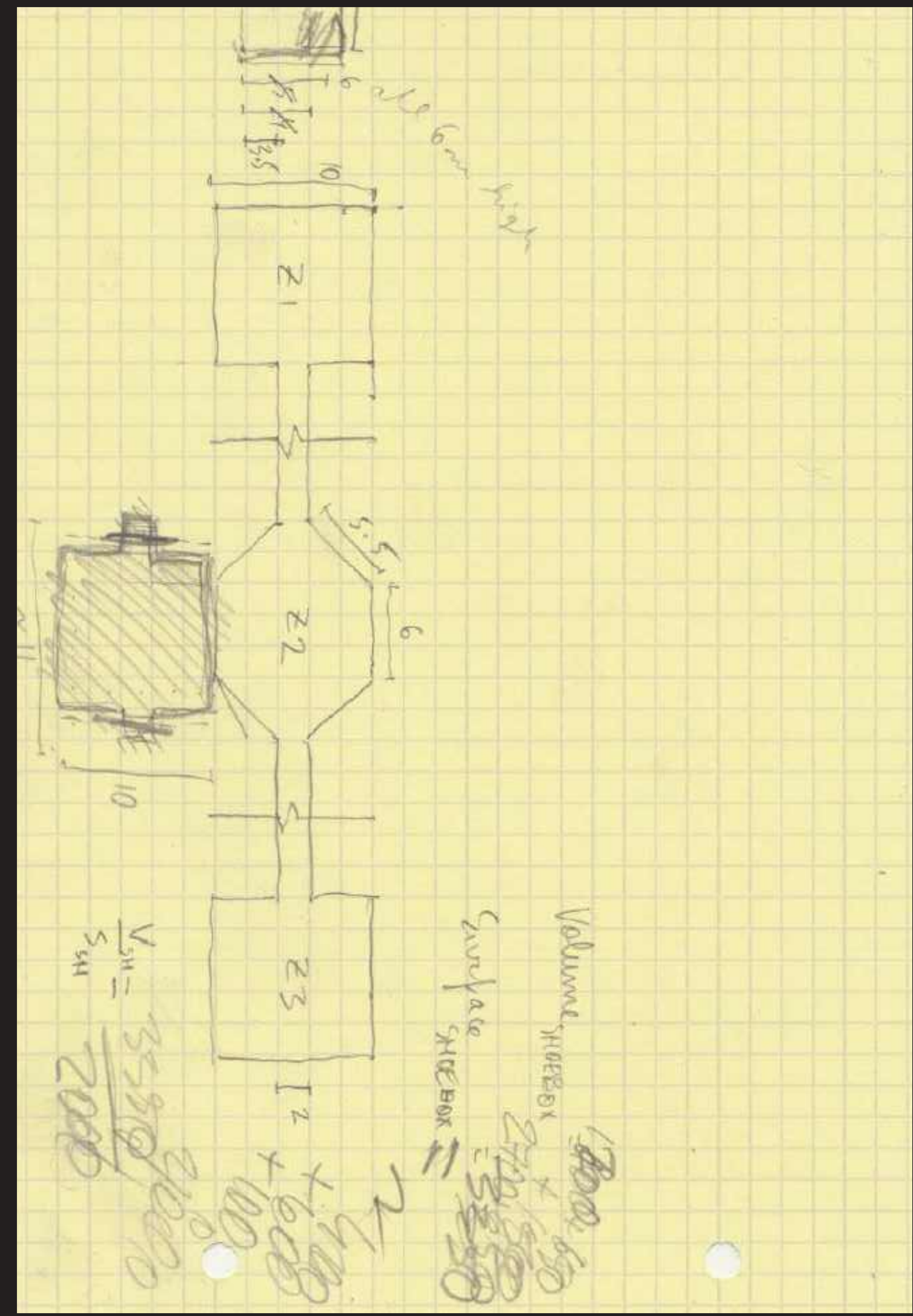

furniture

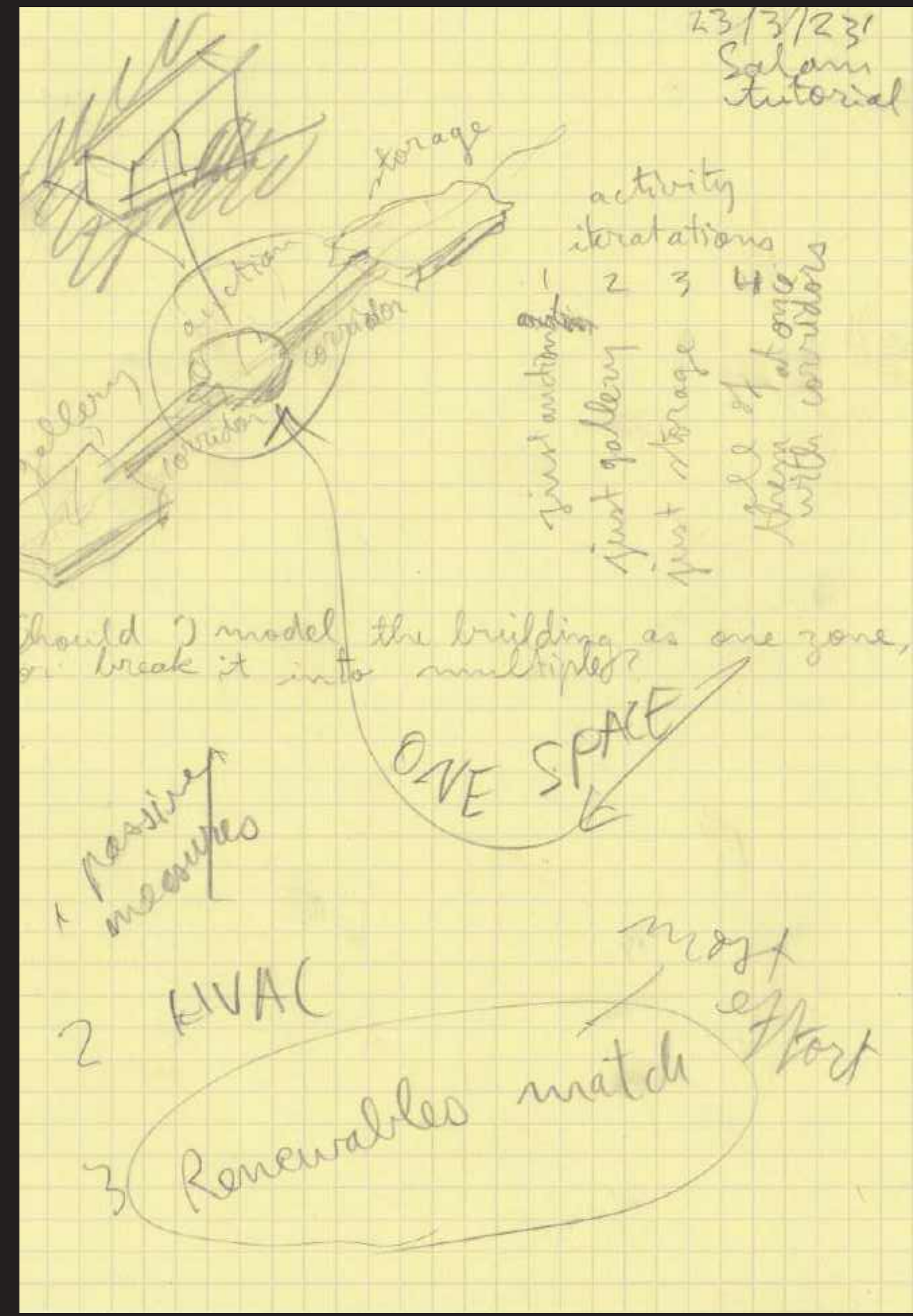
1:50 on A3

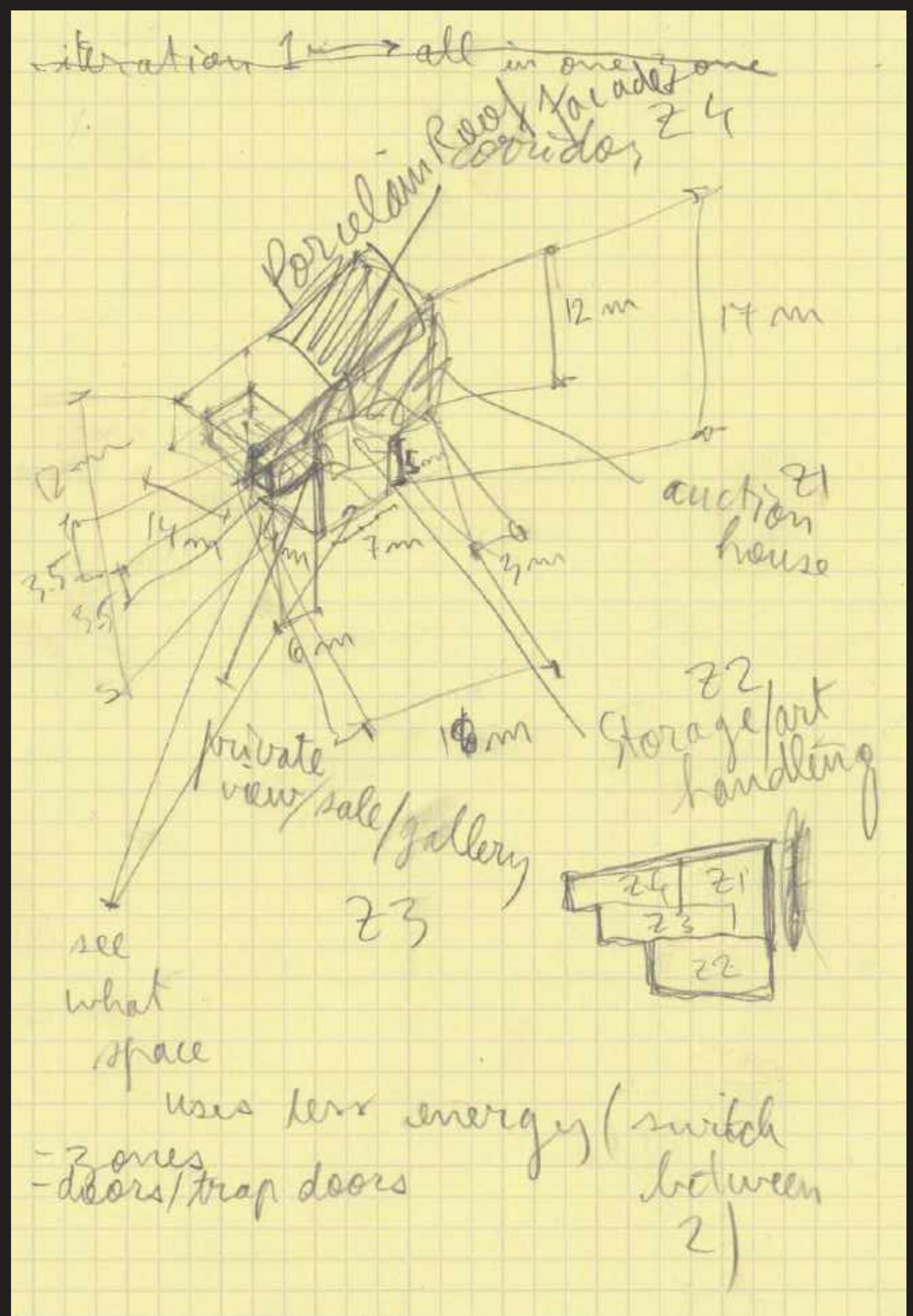
Environmental Calculations

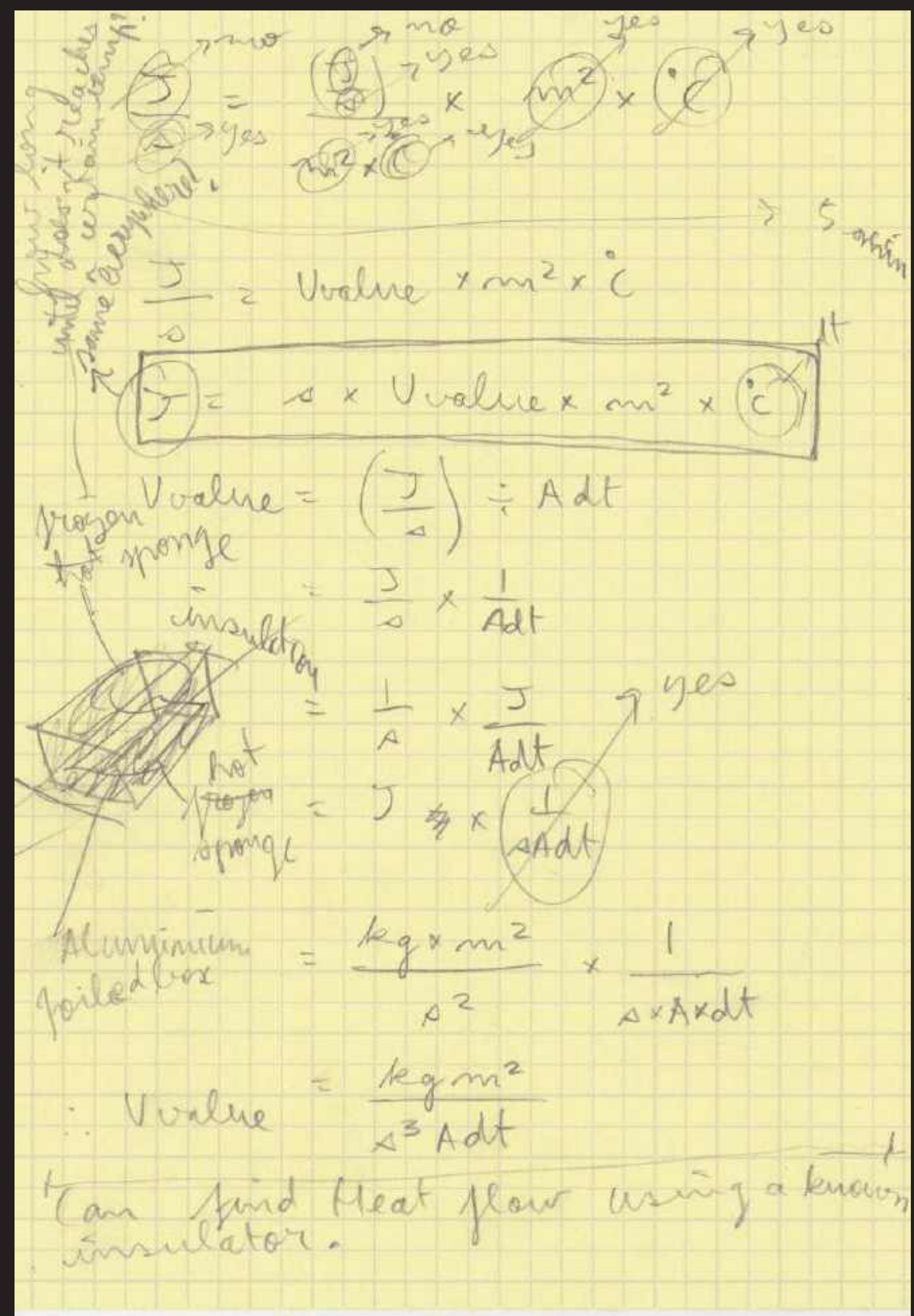


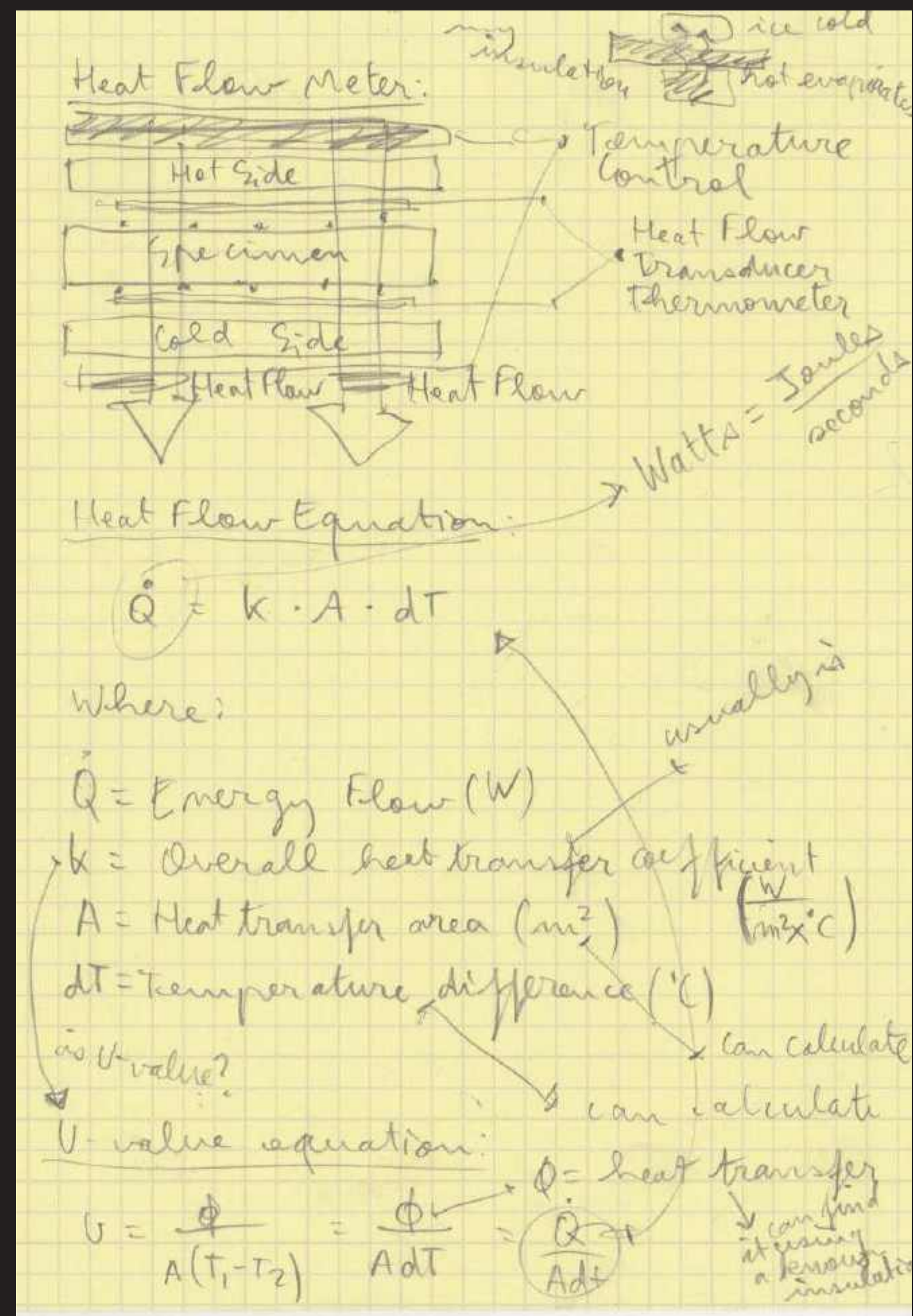


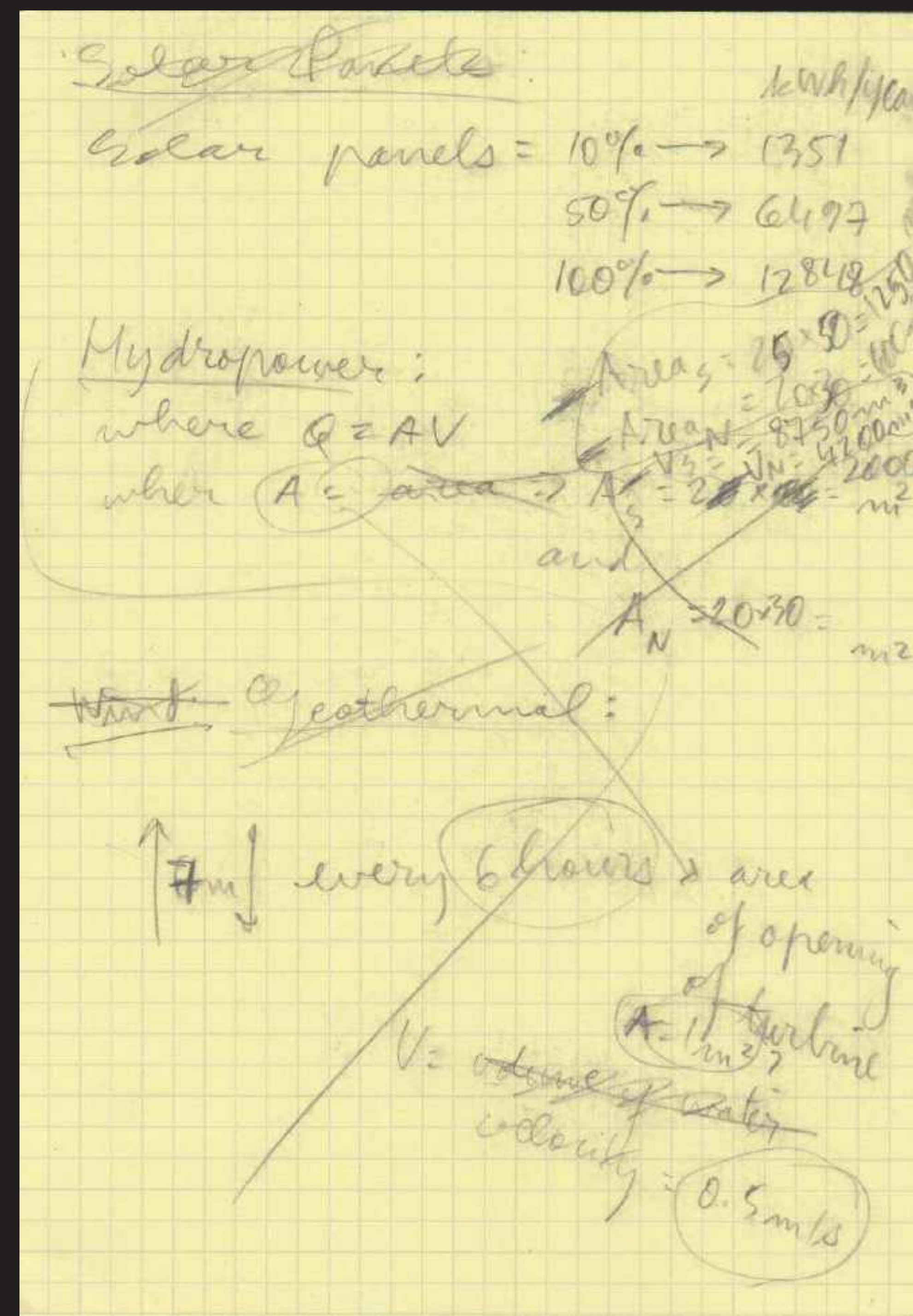


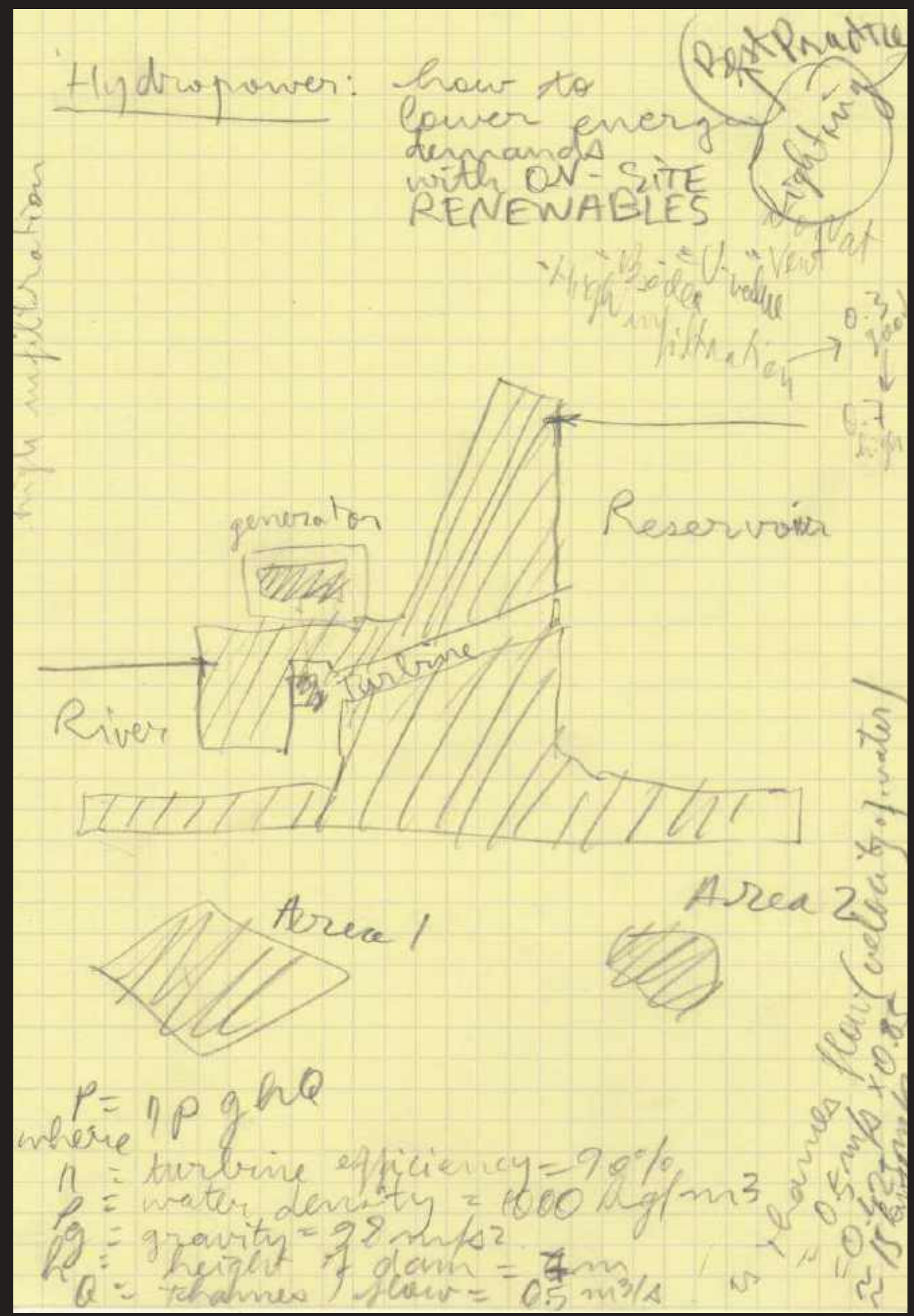
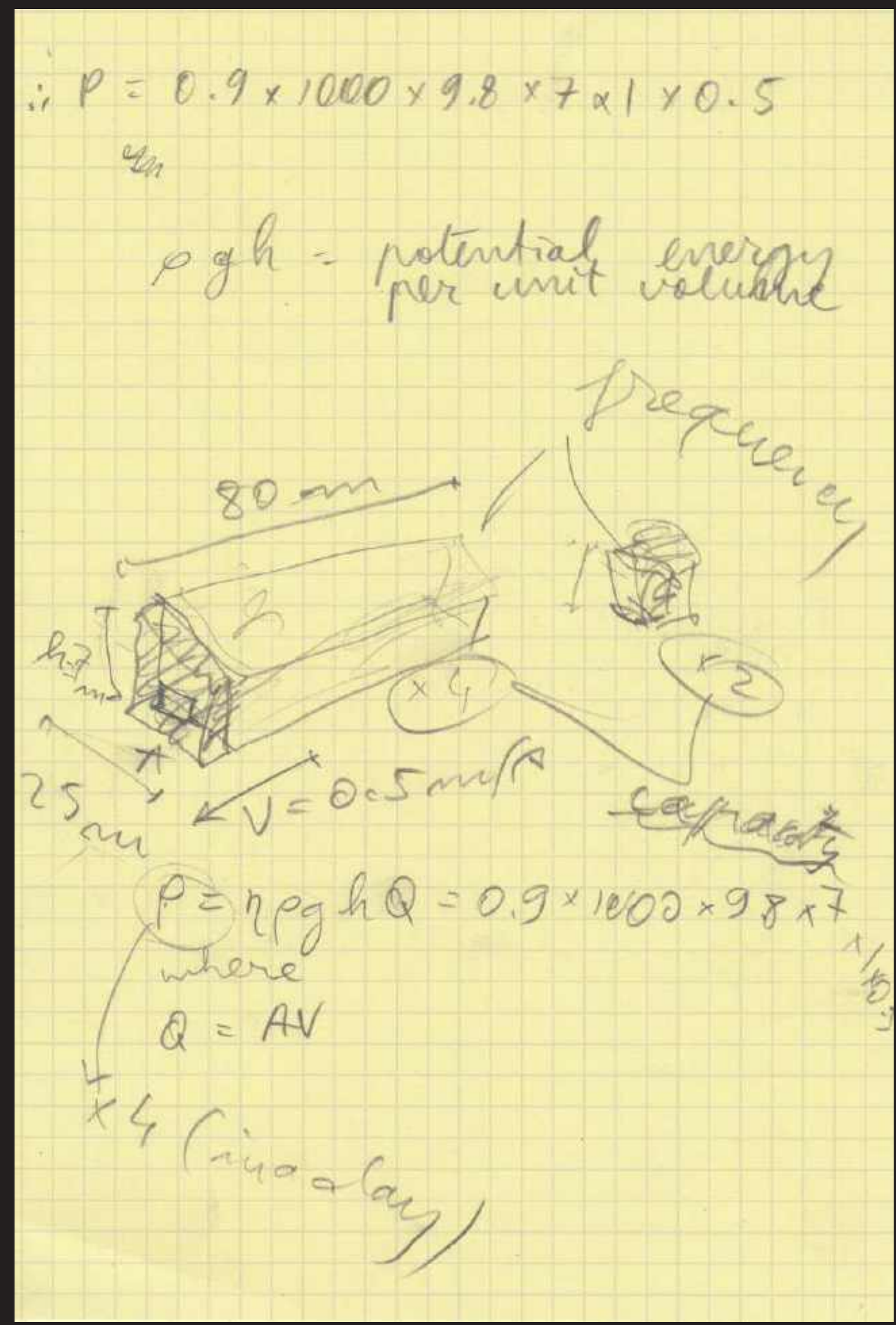
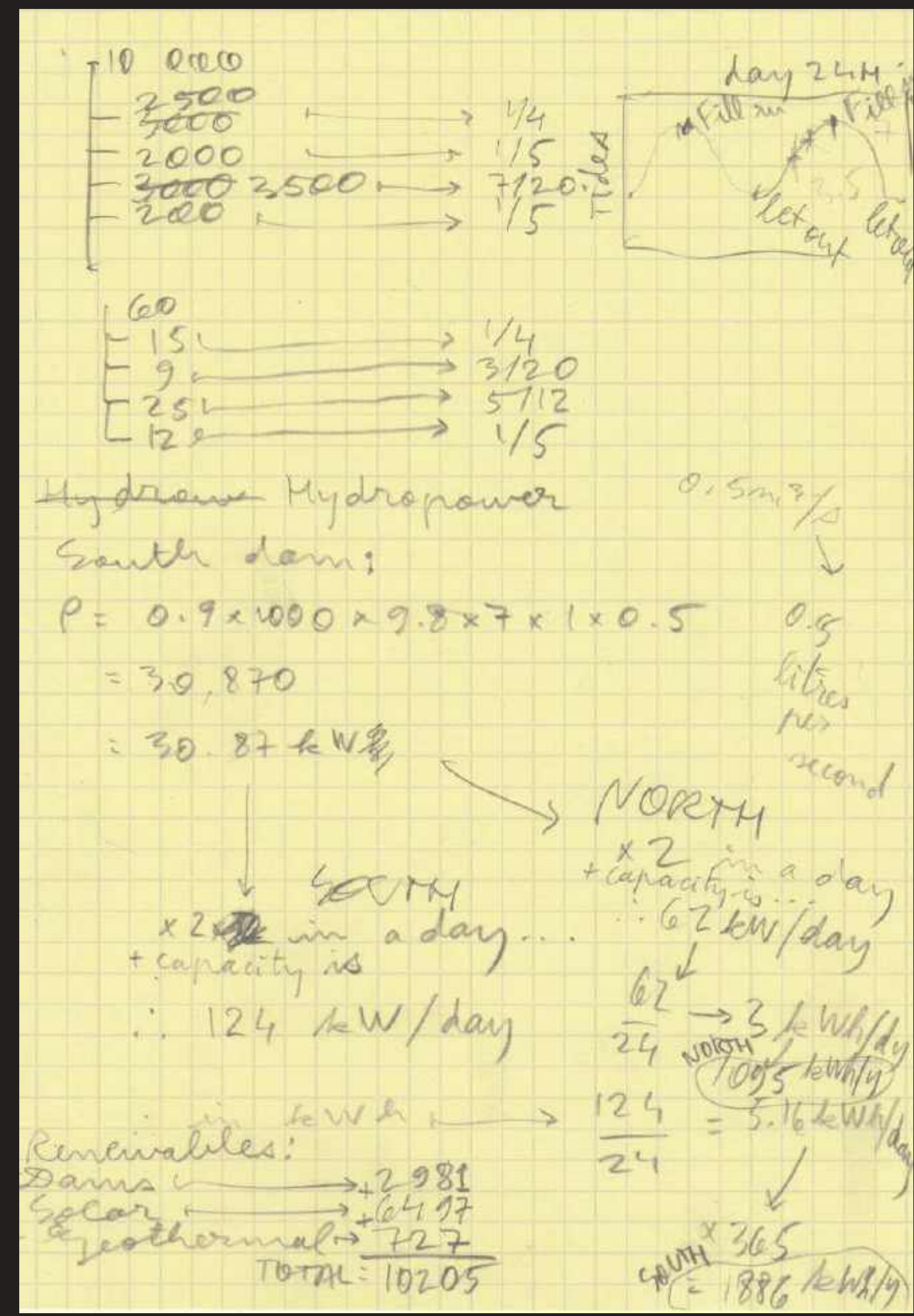
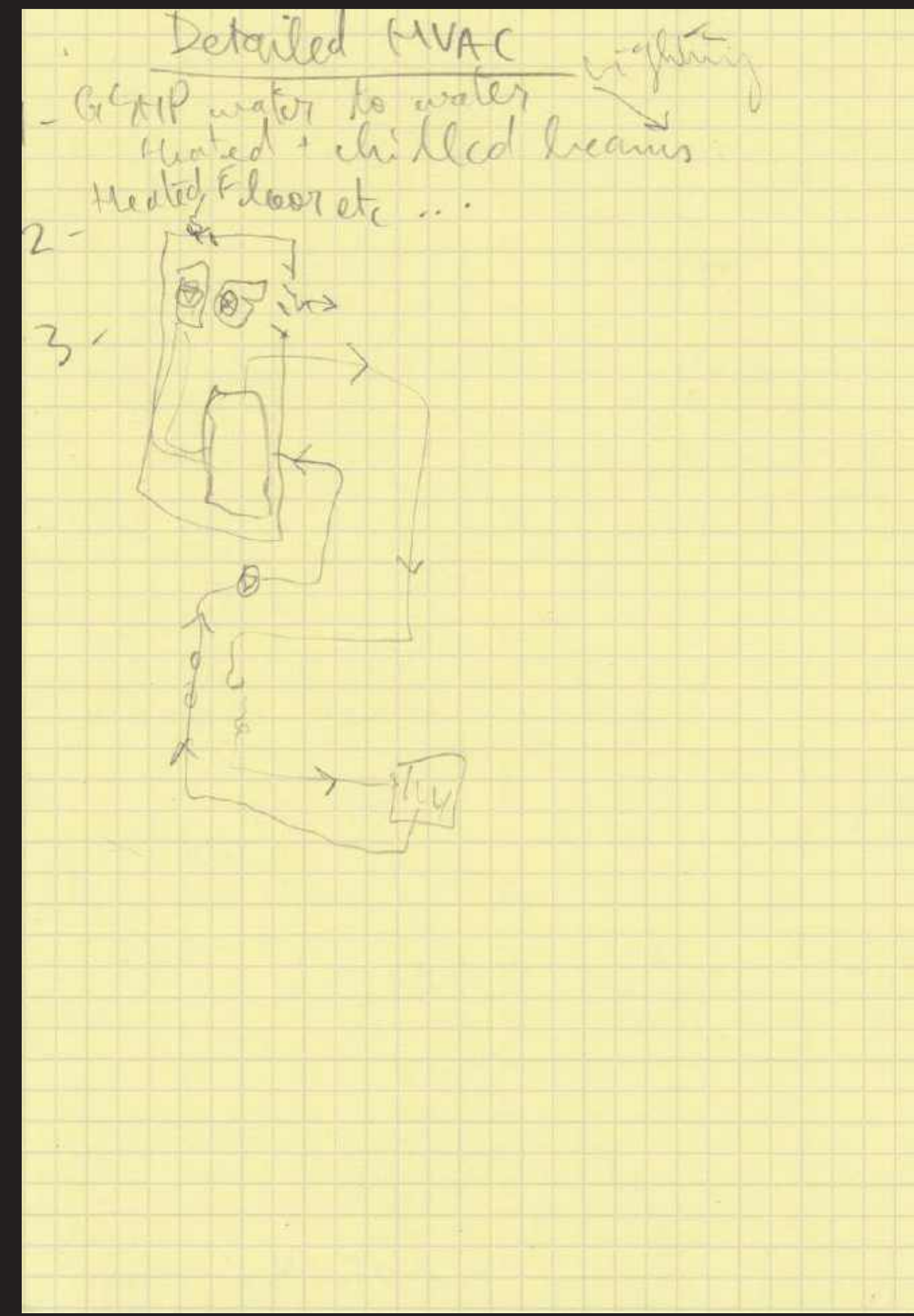
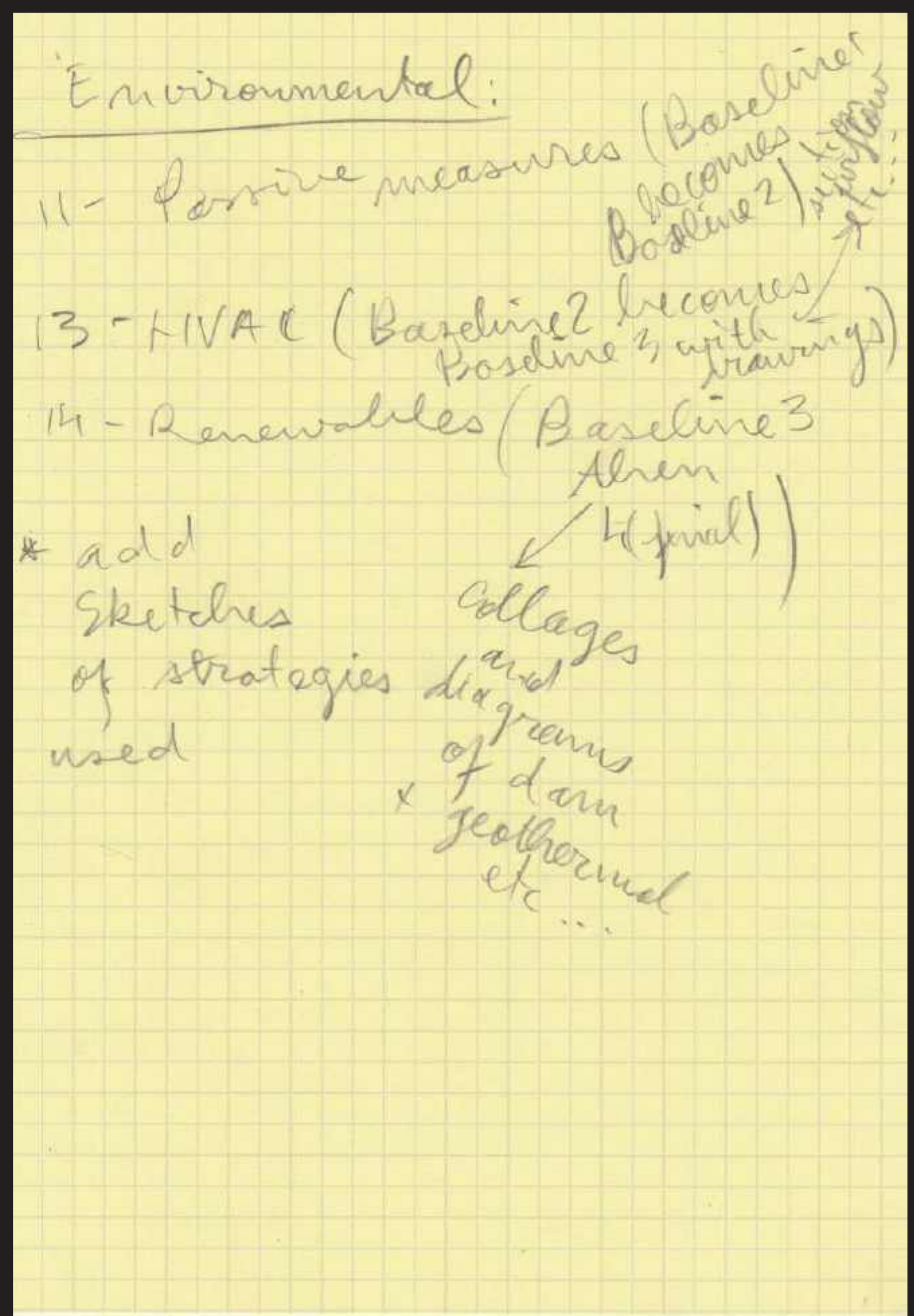
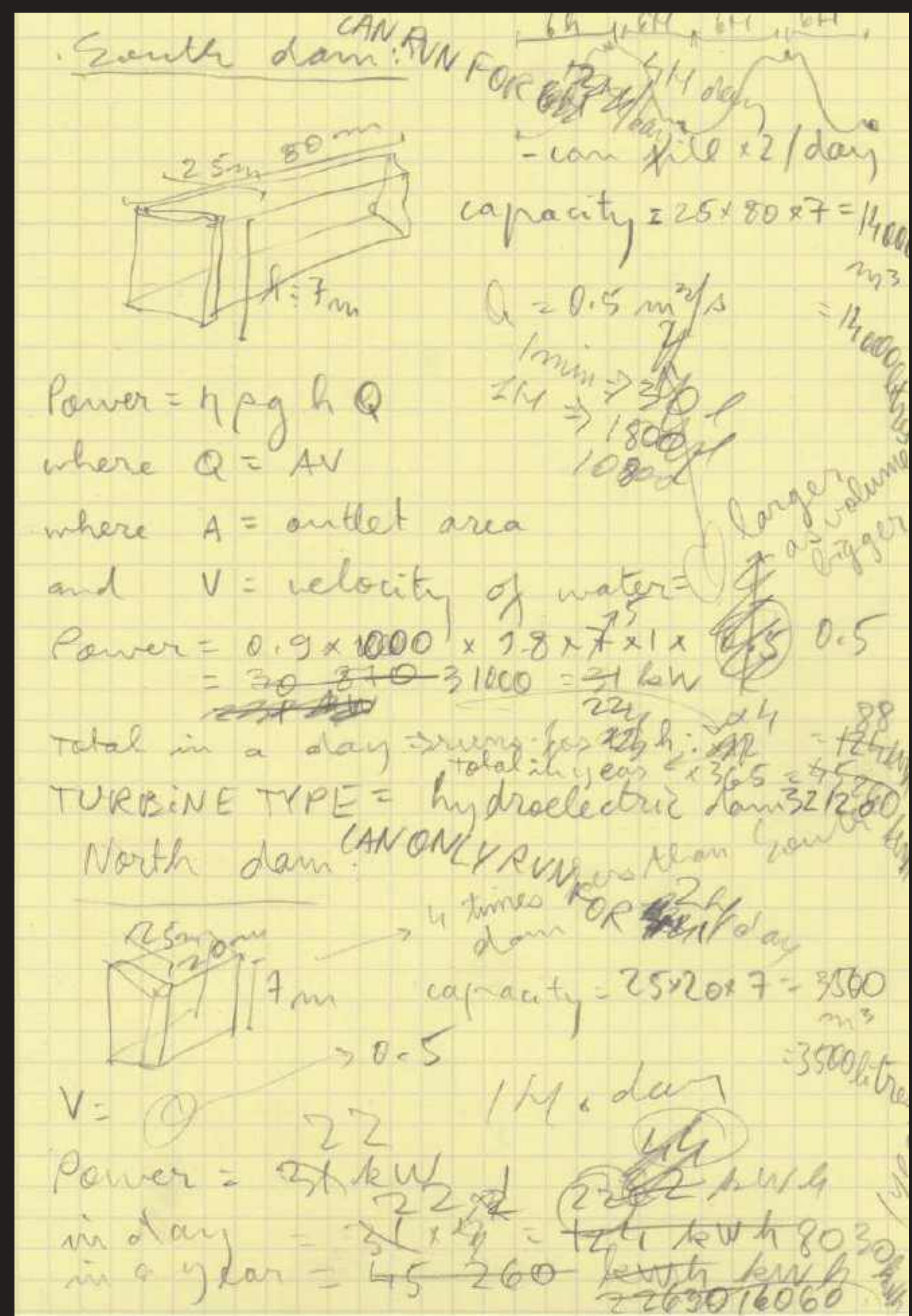
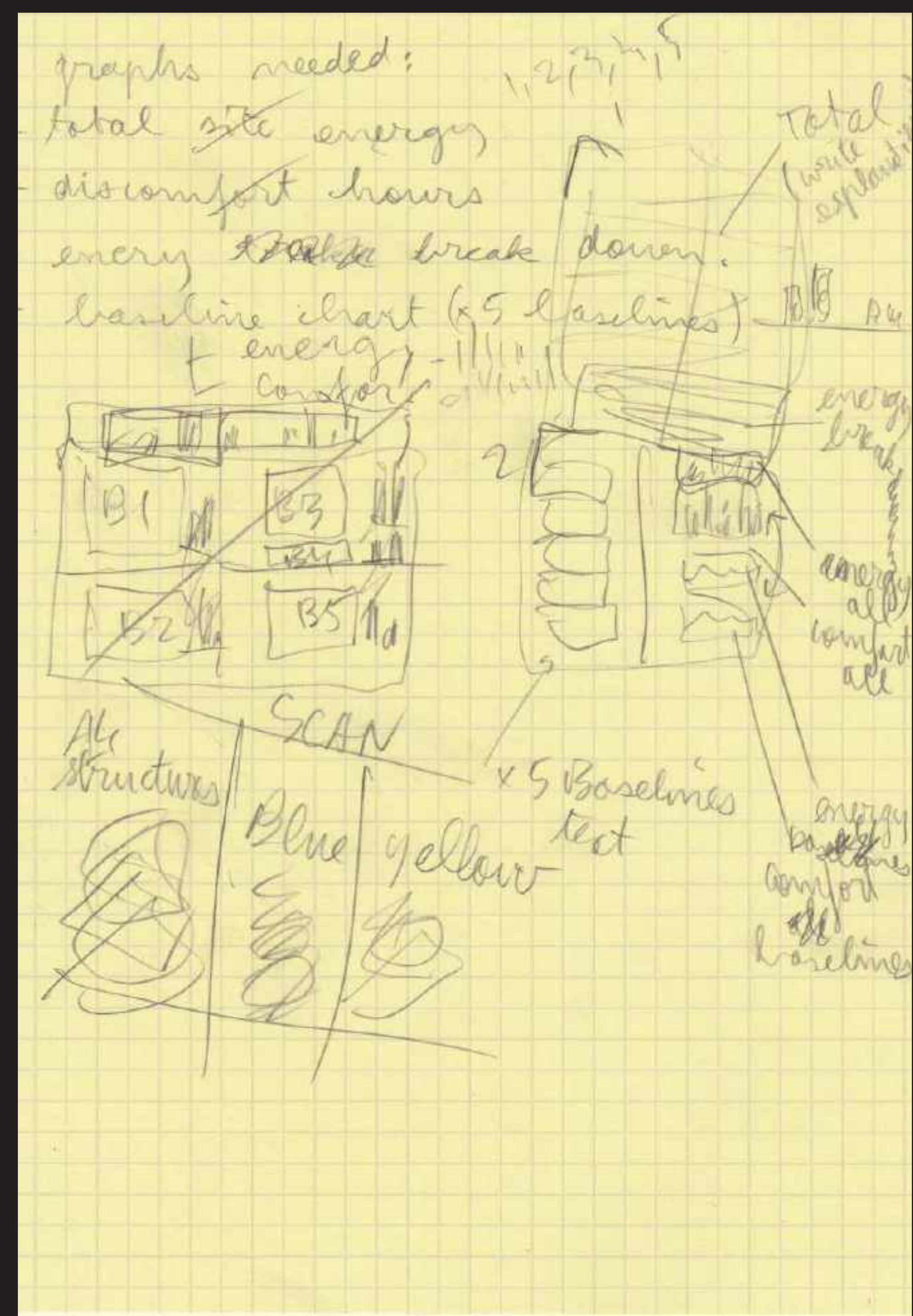











Hydropower: how to lower energy demands with ON-SITE RENEWABLES
generator
Reservoir
Turbine
River
Area 1
Area 2
P = ηρghQ
where
η = turbine efficiency = 90%
ρ = water density = 1000 kg/m3
g = gravity = 9.8 m/s2
h = height of dam = 7m
Q = volume of flow = 0.5 m3/s

∴ P = 0.9 x 1000 x 9.8 x 7 x 1 x 0.5
ρgh = potential energy per unit volume
80 m
frequency
25 m
V = 0.5 m/s
capacity
P = ηρghQ = 0.9 x 1000 x 9.8 x 7
where
Q = AV
x4 (in a day)

Hydropower
South dam:
P = 0.9 x 1000 x 9.8 x 7 x 1 x 0.5
= 30,870
= 30.87 kW
NORTH
x2
SOUTH
x2 in a day...
+ capacity is
∴ 124 kW/day
Renewables:
Dams
Solar
geothermal
TOTAL: 10205

Detailed HVAC
lighting
1 - GSHP water to water
Heated + chilled beams
Heated floor etc ...
2 -
3 -

Environmental:
11 - Passive measures (Baseline1 becomes Baseline2)
13 - HVAC (Baseline2 becomes Baseline3, with drawings)
14 - Renewables (Baseline3 Alren Hybrid)
* add Sketches of strategies used
collages and diagrams of dam geothermal etc...

South dam:
25m
80m
7m
capacity = 25 x 80 x 7 = 14000 m3
Q = 0.5 m3/s
Power = ηρghQ
where Q = AV
where A = outlet area
and V = velocity of water
Power = 0.9 x 1000 x 9.8 x 7 x 1 x 0.5
Total in a day
TURBINE TYPE = hydroelectric
North dam:
capacity = 25 x 20 x 7 = 3500 m3
Power =
in a day
in a year

graphs needed:
total site energy
discomfort hours
energy break down
baseline chart (x5 baselines)
+ energy + comfort
B1
B3
B2
B5
SCAN
All structures
Blue
yellow
x 5 Baselines text

Dam:

using the same water flow rate as the thames

V=	0.5m/s
with an outlet	
A=	1m2
and efficiency	
n=	0.9
rho=	1000kg/m3
g=	9.8m/s2
height of dam	
h=	5m

we get
P=n*rho*g*h*V*A=22050W=22kW
if the dam is filled twice a day
it can discharge water for 4h
as the south dam has a bigger reservoir, it can discharge for 2h at a time, 4h in day
and the north dam being 4 times smaller, can discharge for 1h a day

therefore the south dam generates

P_south=	22*4*365= 32120 kWh/year
P_north=	22*1*365= 8030kWh/year
in total it generates	
40150	kWh/year

Geothermal

three different types of loops were tried
it seemed that the closed loop horizontal was the best one

Solar Power:

https://www.fmb.org.uk/homepicks/solar-panels/best-solar-panels/
has good charts bout average kWh for angle and placement in uk

W rating * hours of sunlight per day * efficiency = kWh / day

- adds a lot of weight!! calculate weight
think about angle and position

calculating average sunlight in the UK:
https://britishbusinessenergy.co.uk/blog/sunshine-duration-the-sunniest-cities-in-the-uk-and-europe/
- average sunlight in UK = 4.1 hours/day
- average sunlight in london = 1410 hours/day = 3.8 hours/day

https://www.architecturaldigest.com/reviews/en-gb/solar-panels/sunpower-maxeon-3-solar-panels-review

SunPower Maxeon is popular in the UK
- 350 pounds (more expensive, but better warranties)
- 430W output
- 22.7% efficiency
- 98% output during the first year, than 0.25% degradation per year (lowest on th market)

- weight = 21.2 kg

- area = 1812 mm x 1046 mm = 1.90 m2

CALCULATIONS
W rating * hours of sunlight per day * efficiency = kWh / day

430W * 3.8 hours/day * 0.227 = 370.92 Wh/day/ panel

Our roof = 181 m2
area of one solar panel = 1.90 m2

one solar panel = 0.37kWh/day and this is 135 kWh/year
approximately, this is 0.185kWh/m2/day

10% of roof = 18.1 m2 = 10 solar panels = 3.70 kWh/day
- cost = (3500 pounds)
- weight = 212 kg
total kWh/year 1350.5

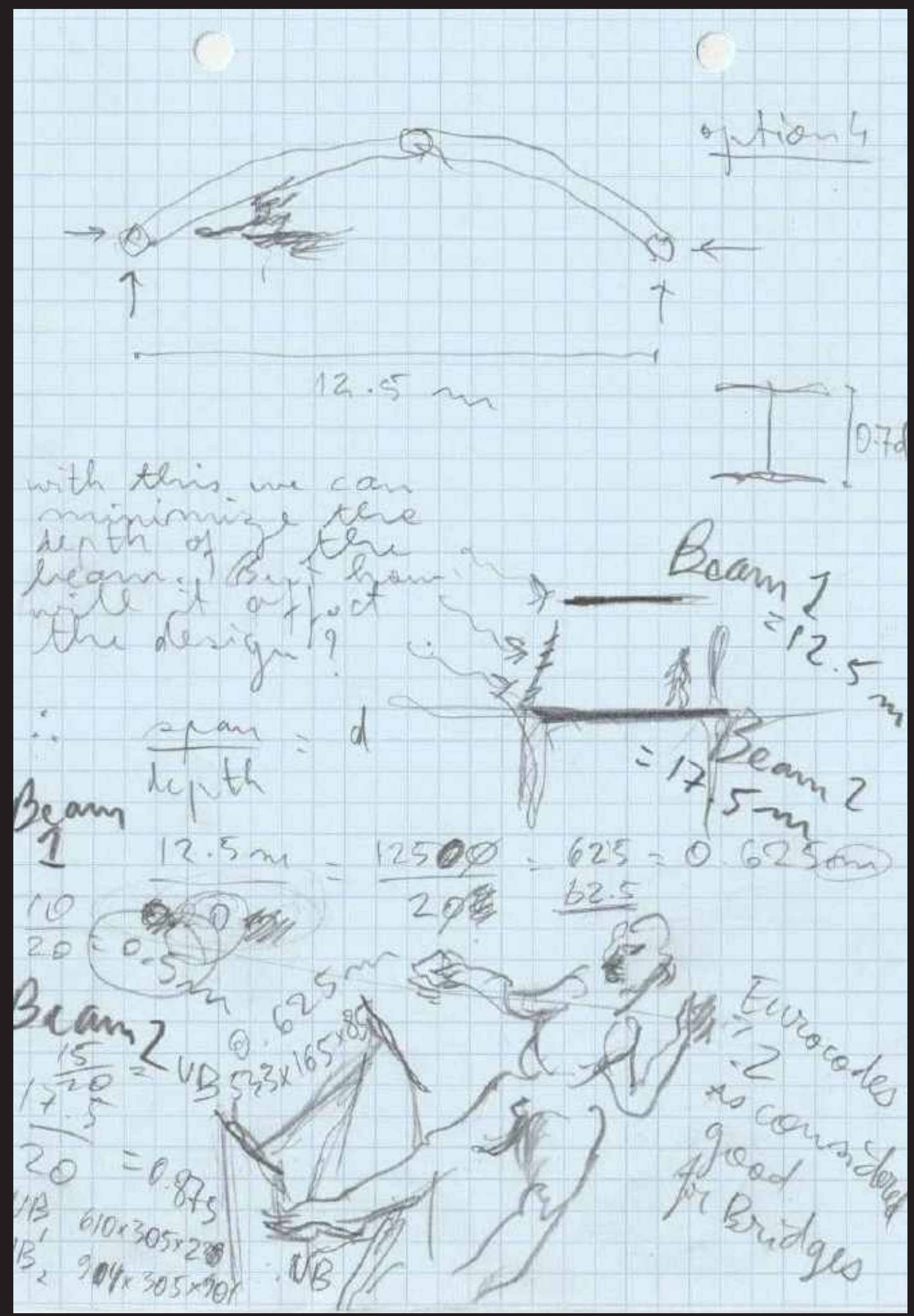
50% of roof = 90.5 m2 = 48 solar panels = 17.8 kWh/day
- cost = (16800 pounds)
- weight = 1,018 kg 6497

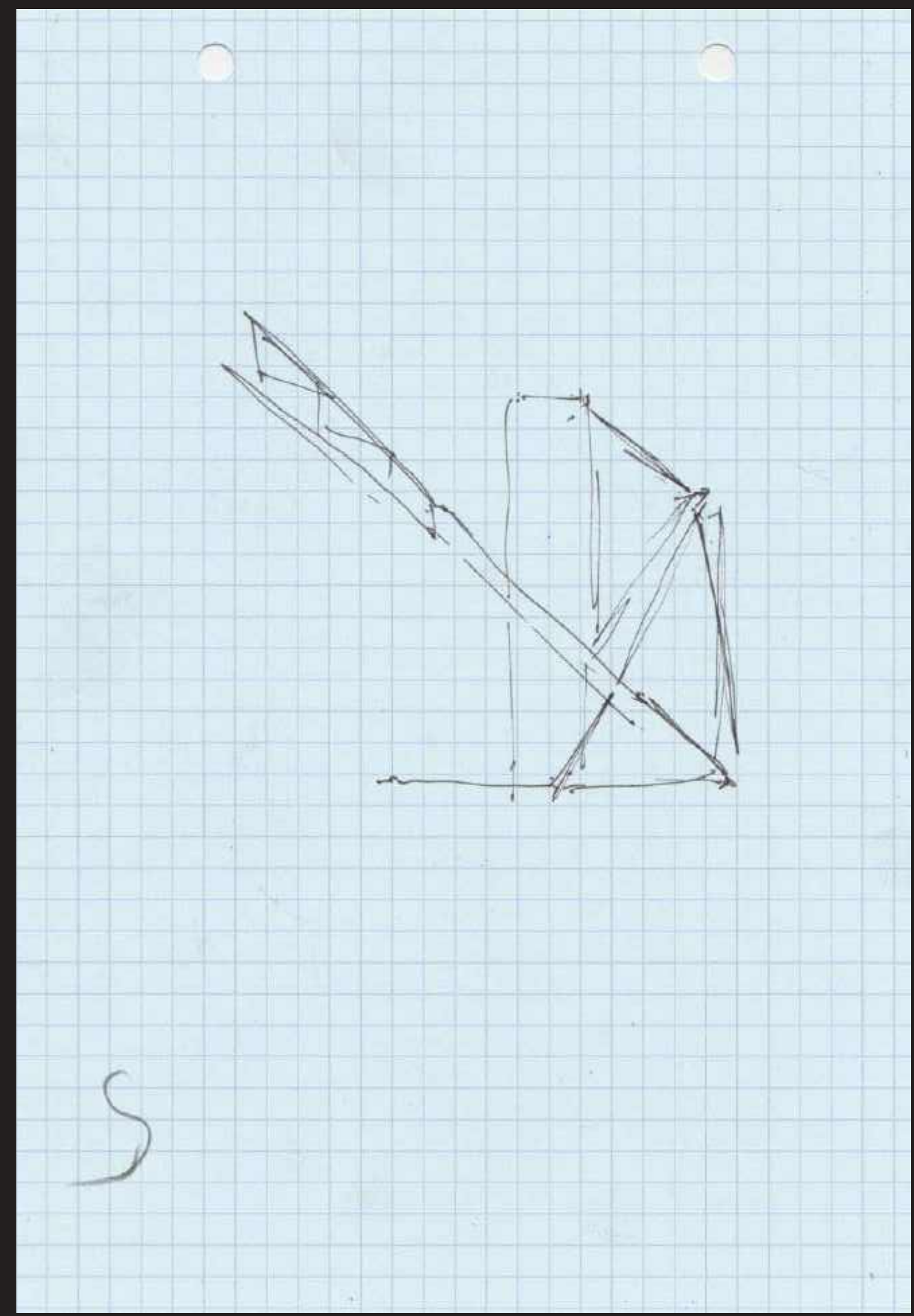
total kWh/year

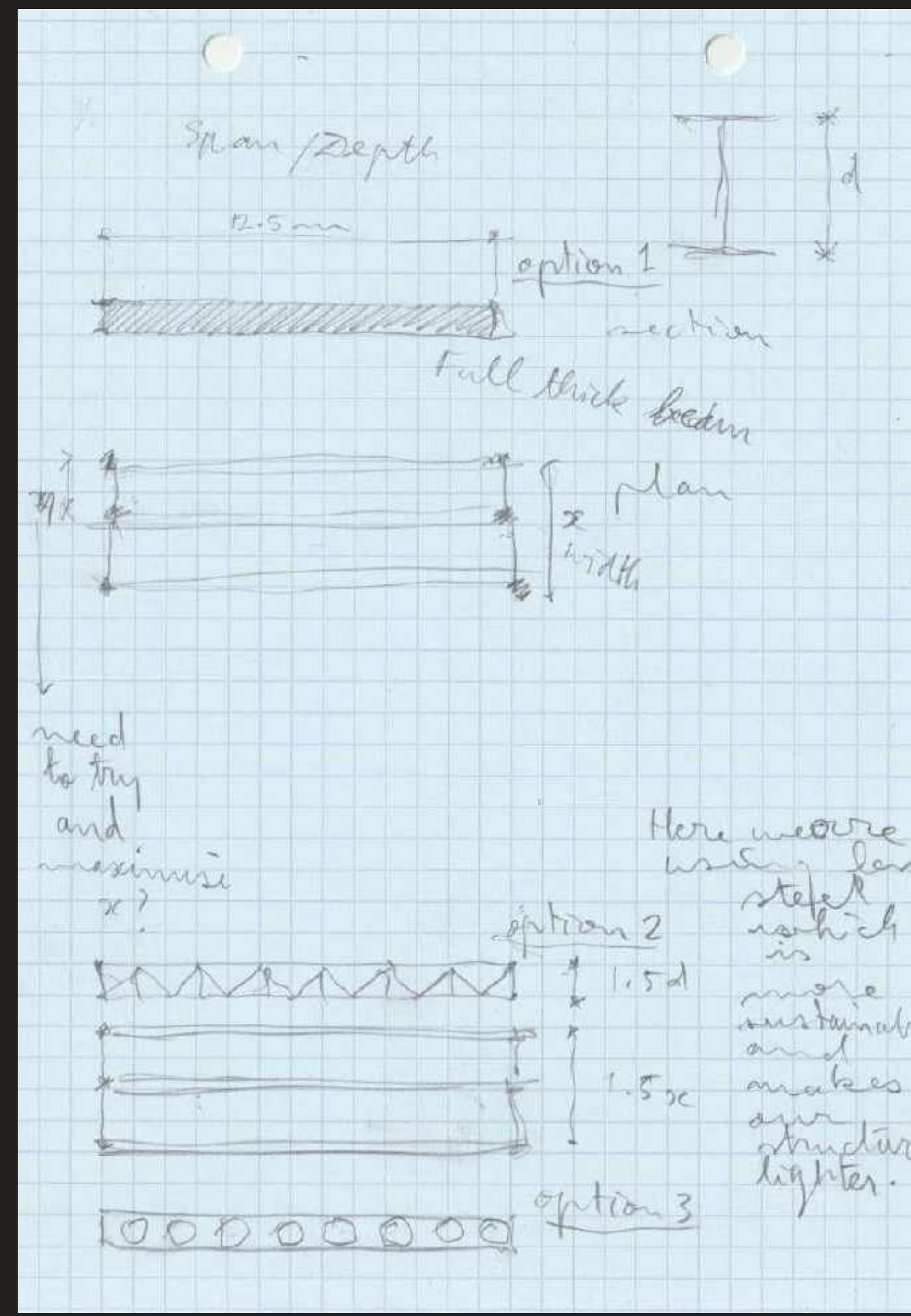
100% of roof = 95 solar panels = 35.2 kWh/day
- cost = (33,250 pounds)
weight = 2014
total kWh/year 12848

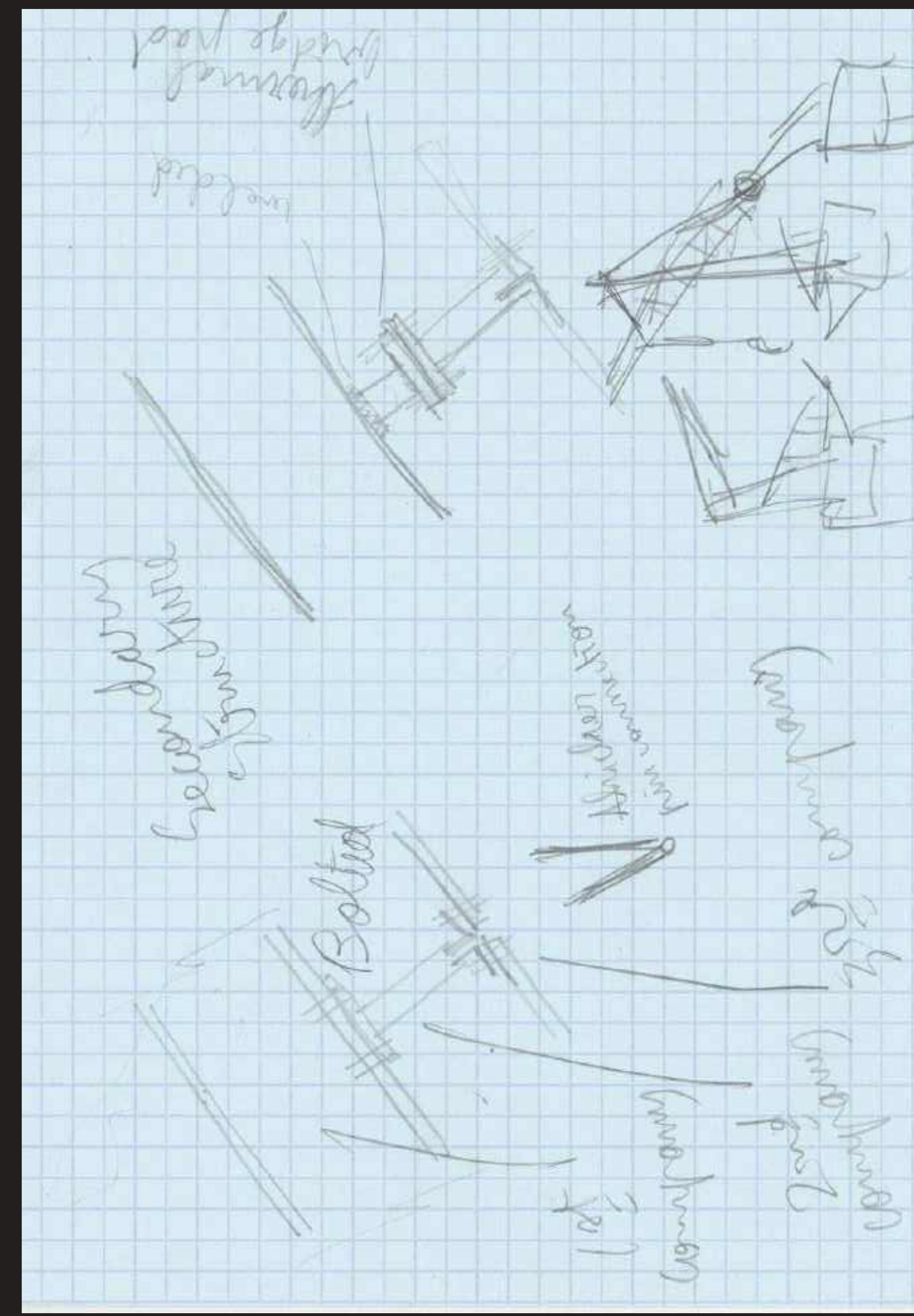
Remember this will decrease 0.25% per year.

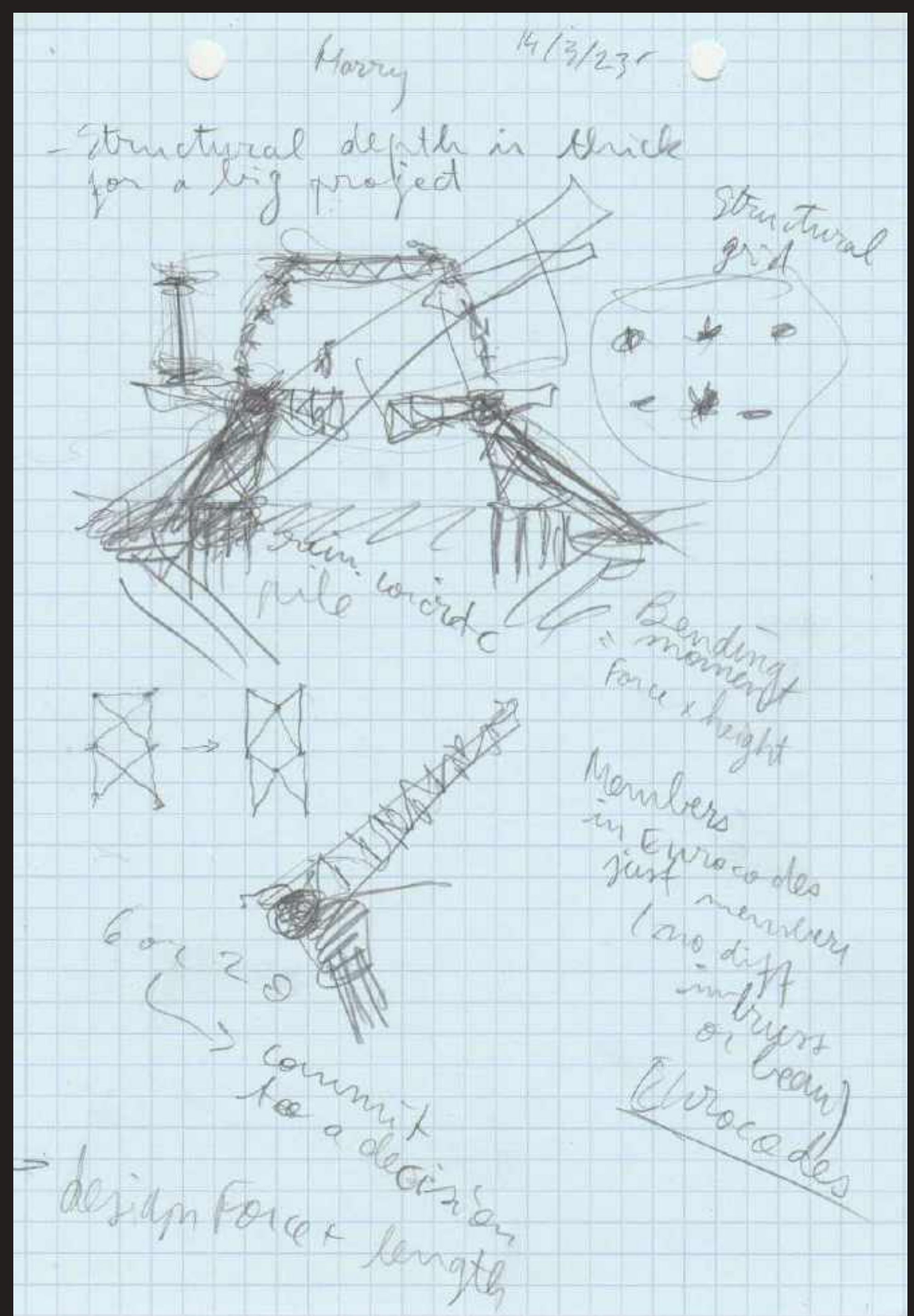
Structural Calculations

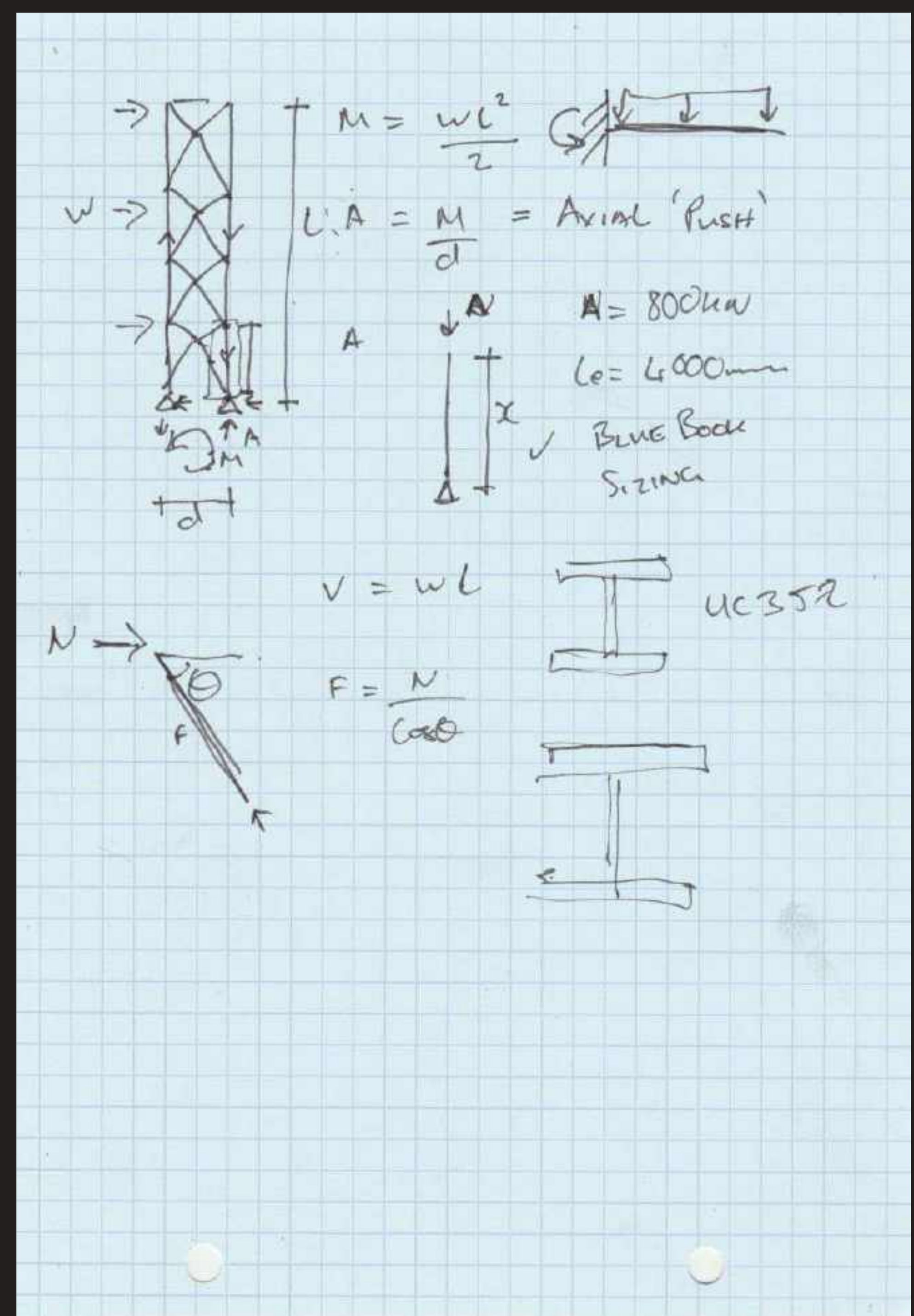


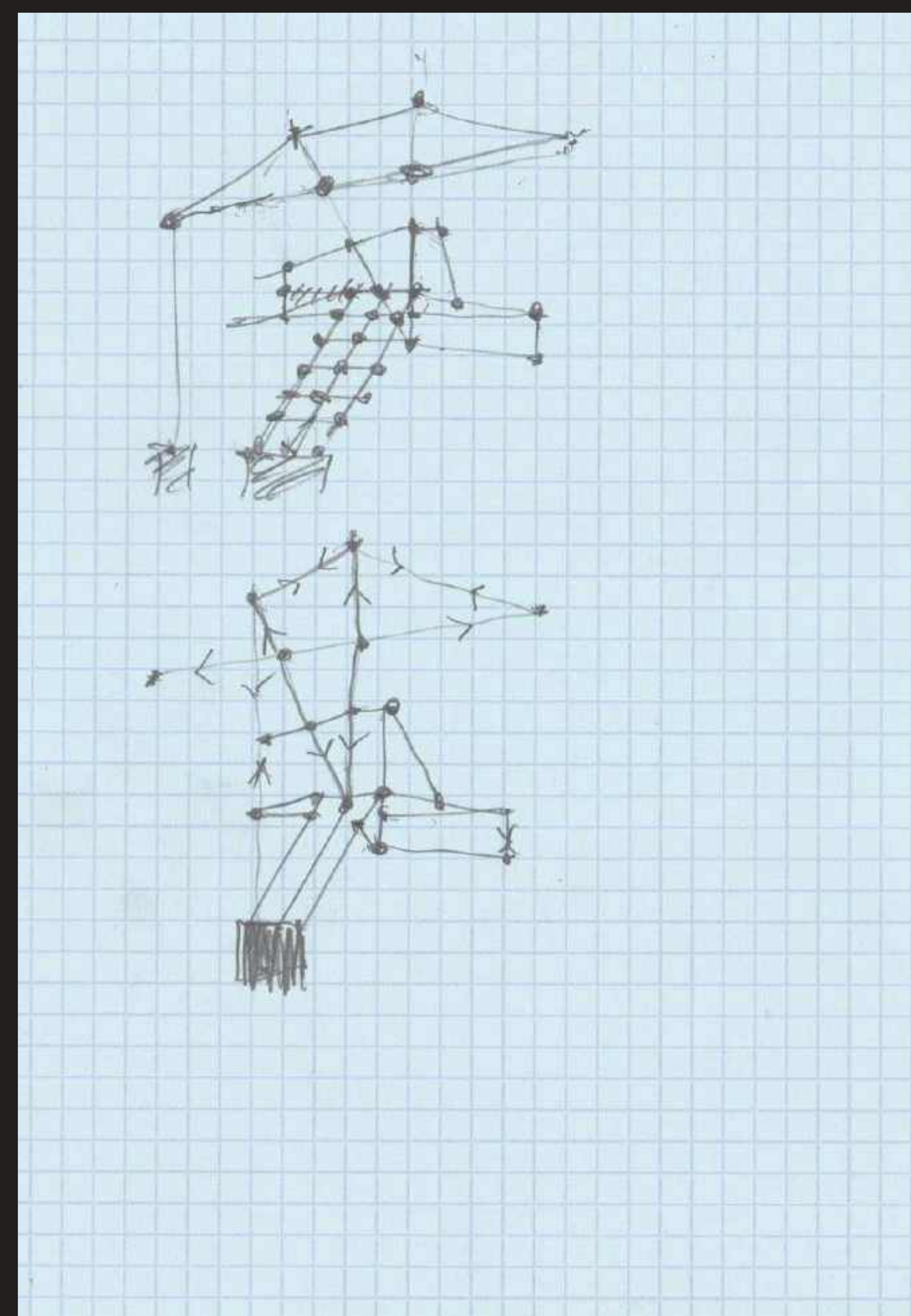


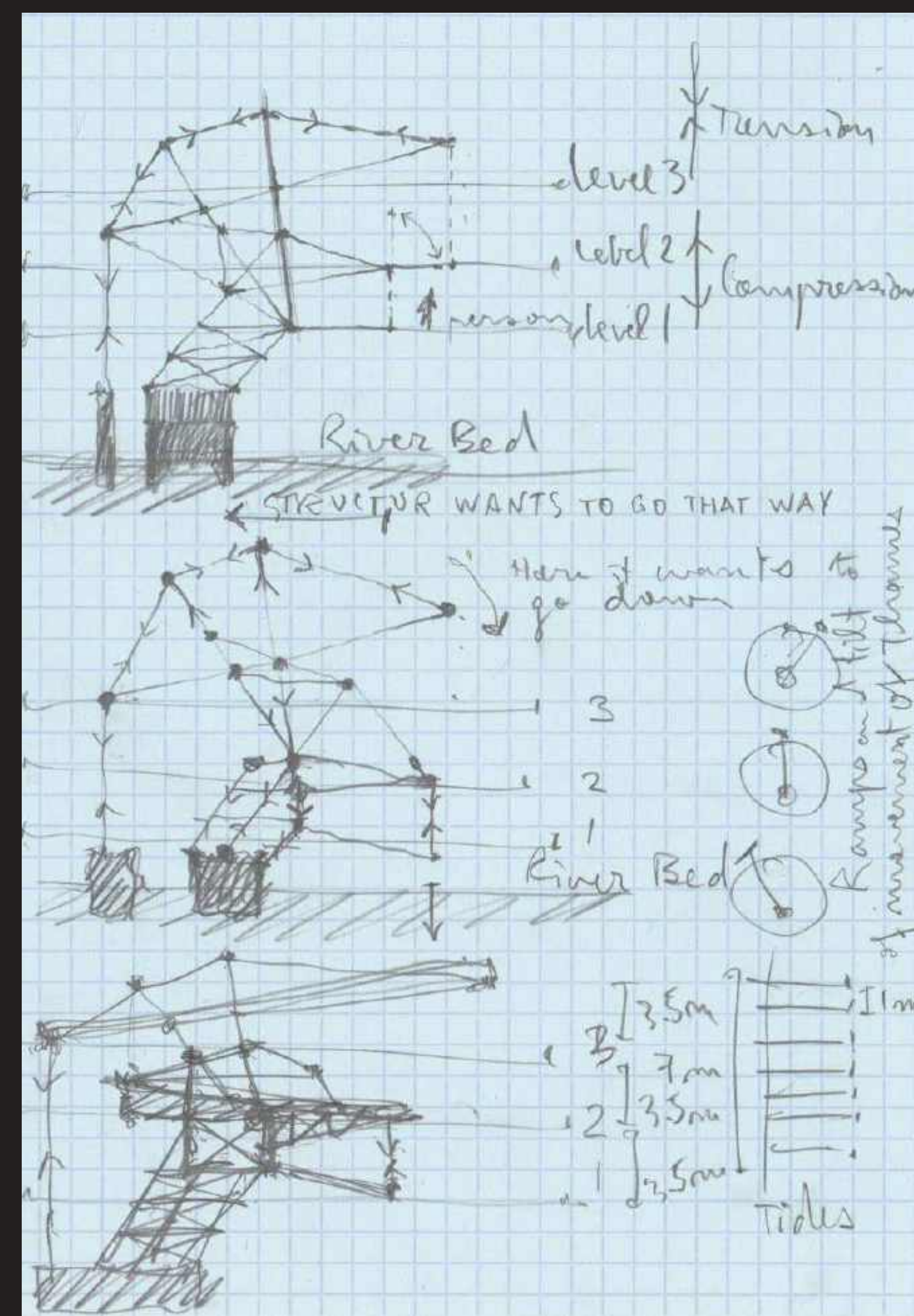


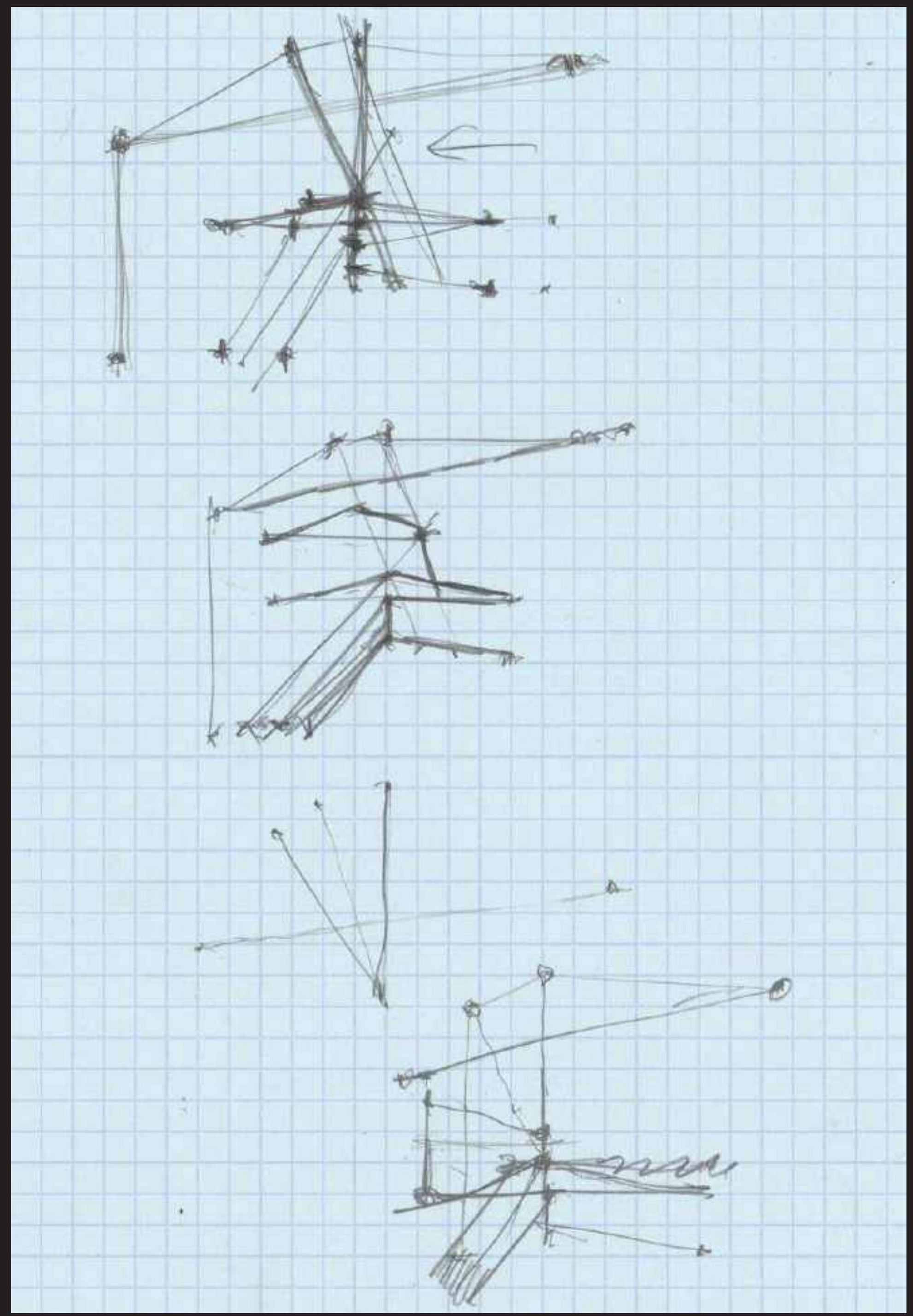


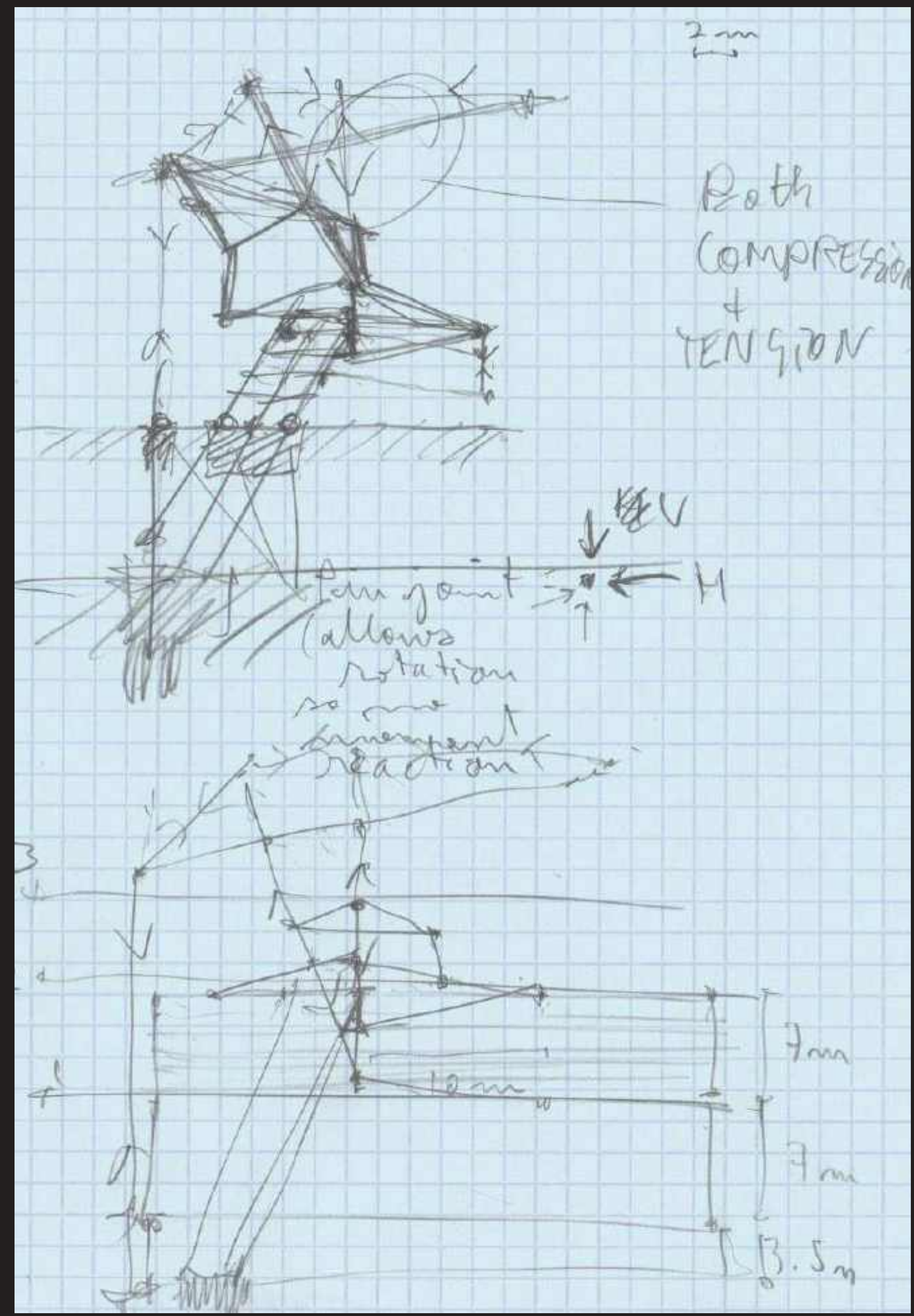


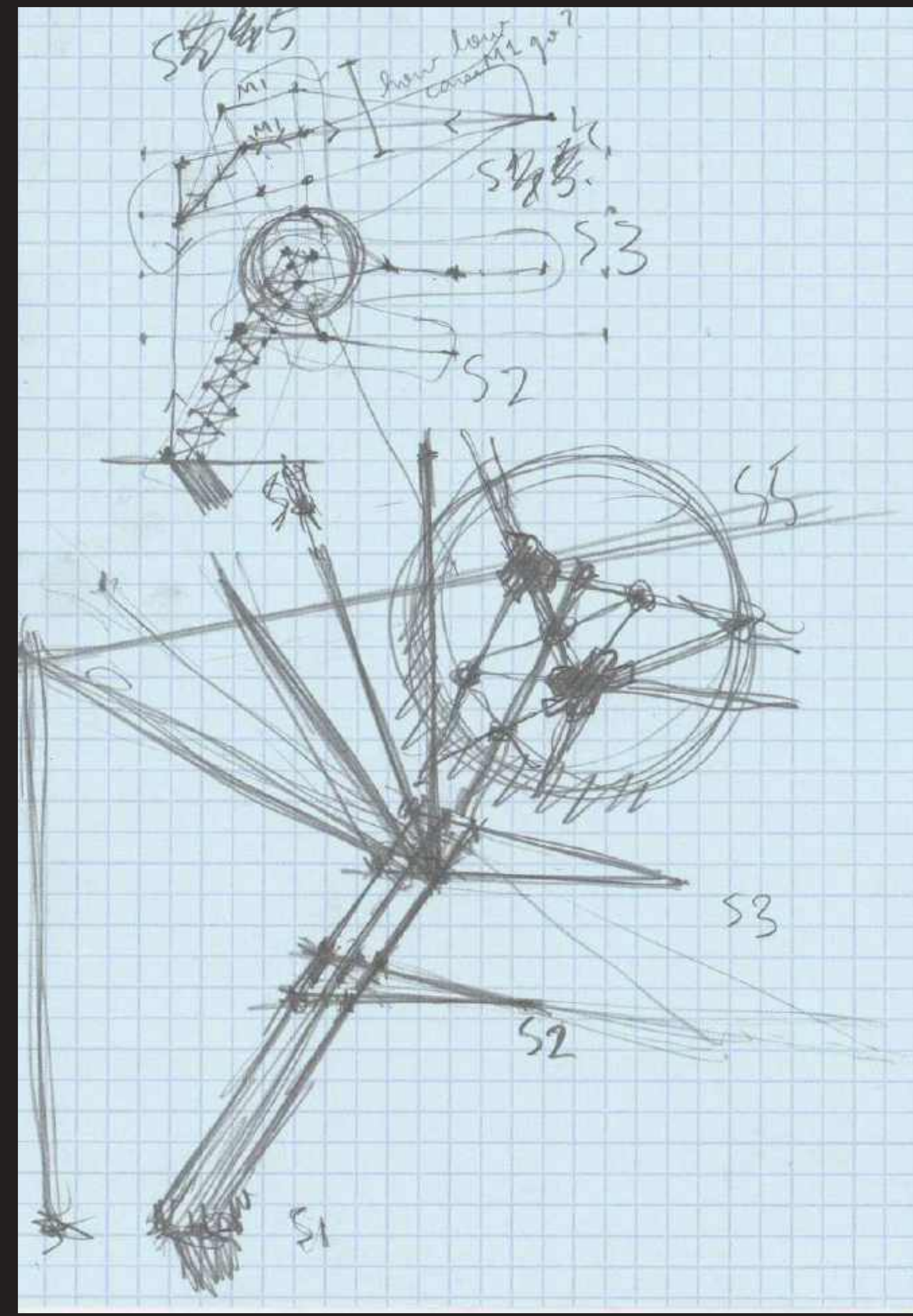


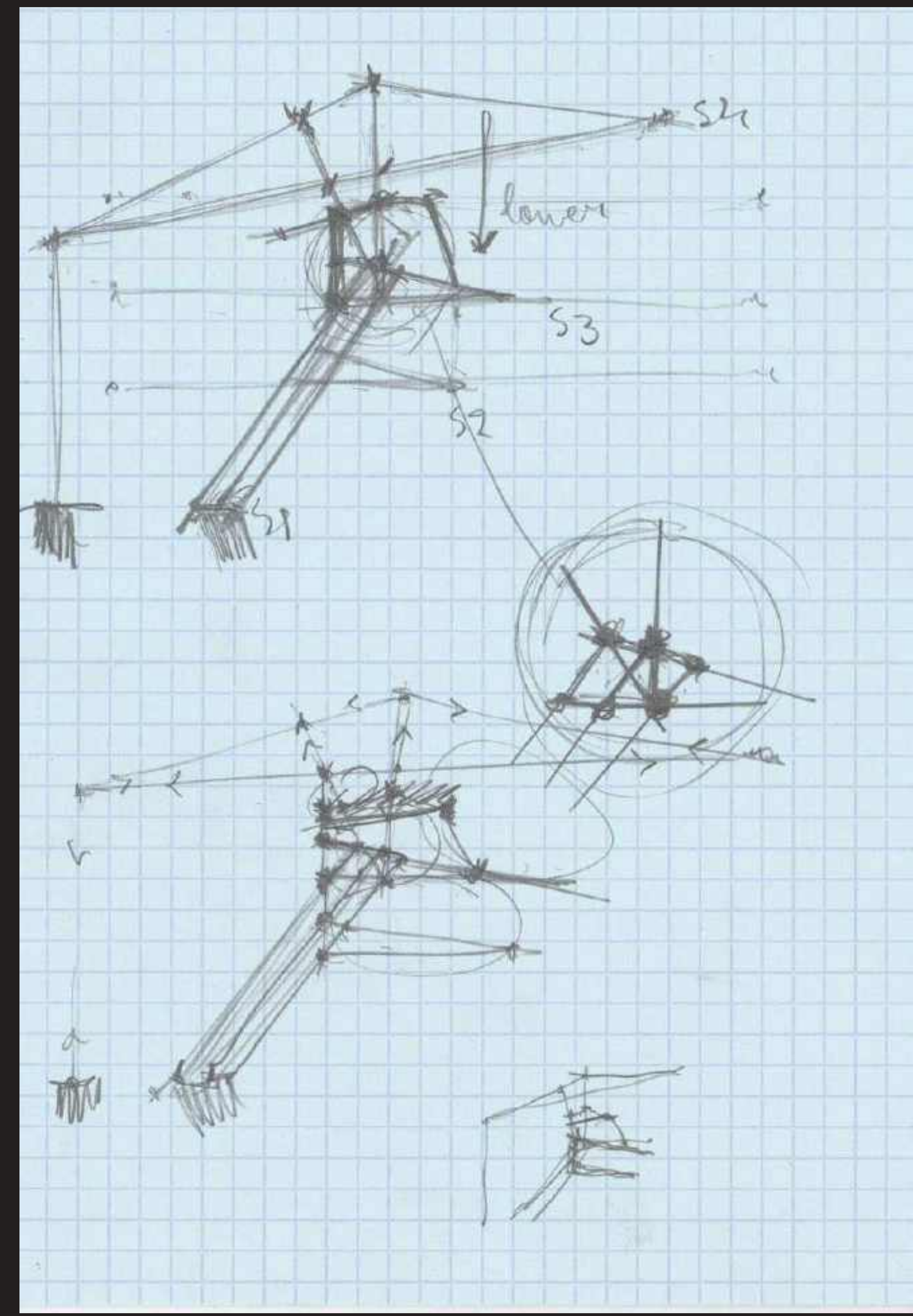


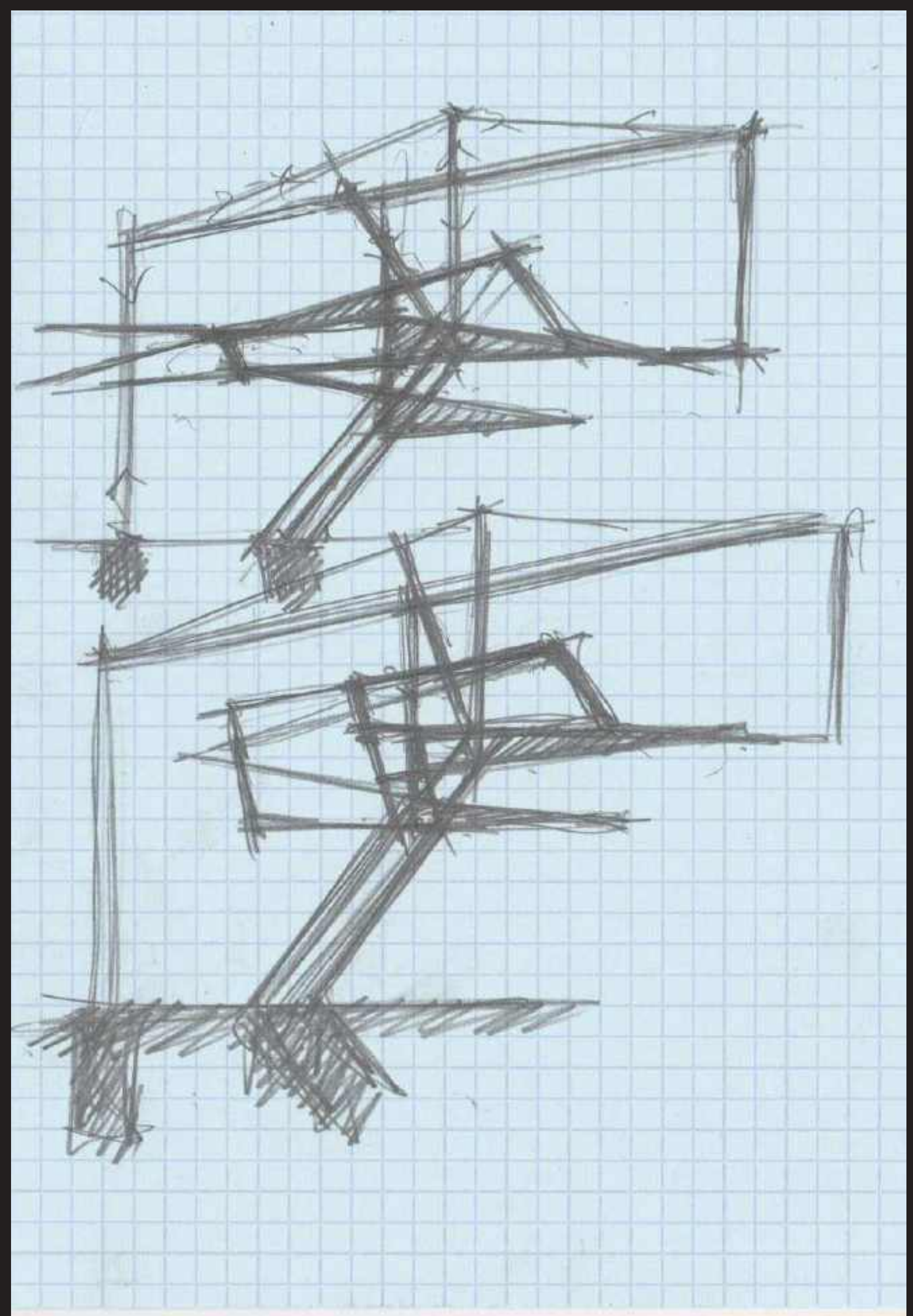


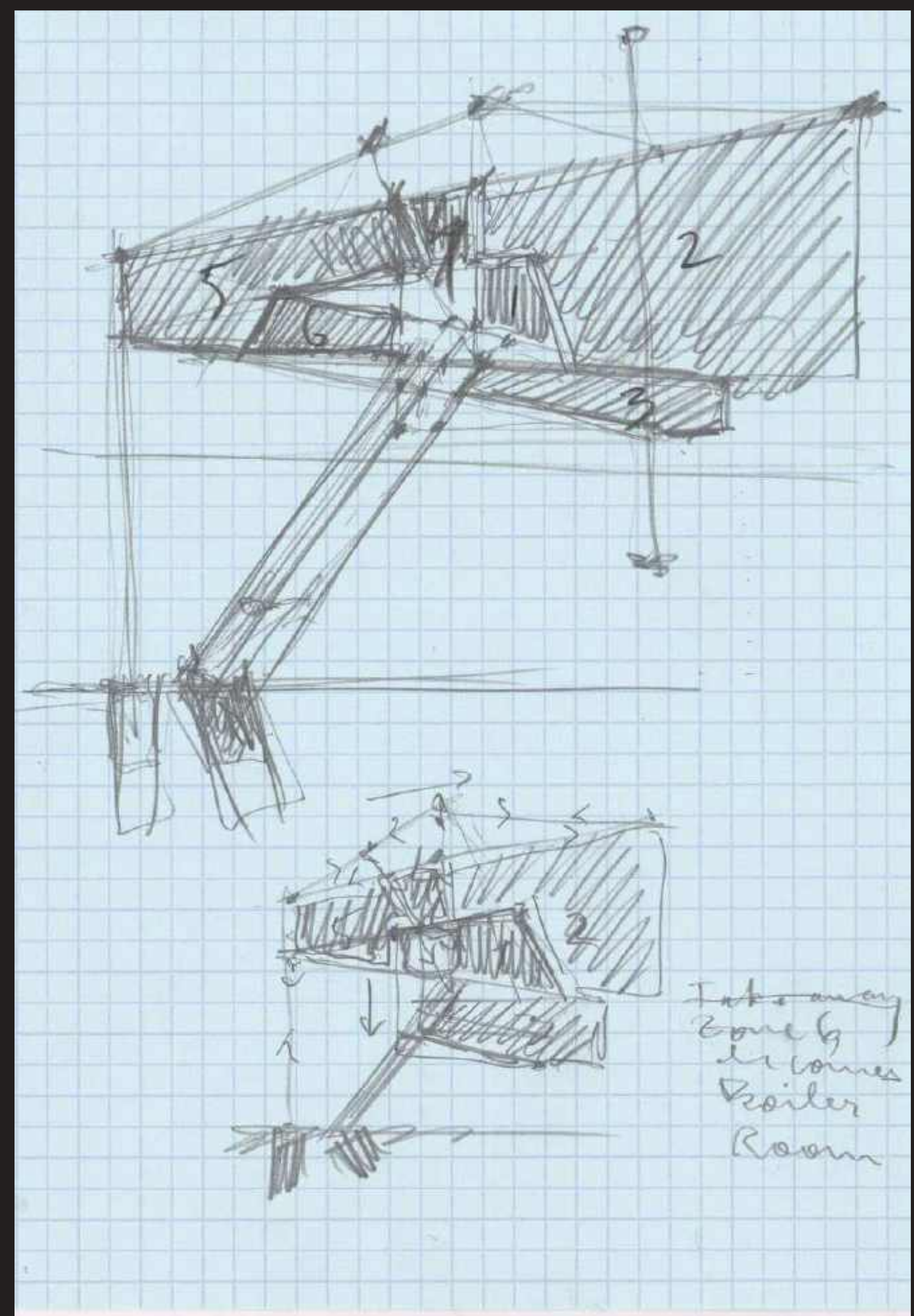


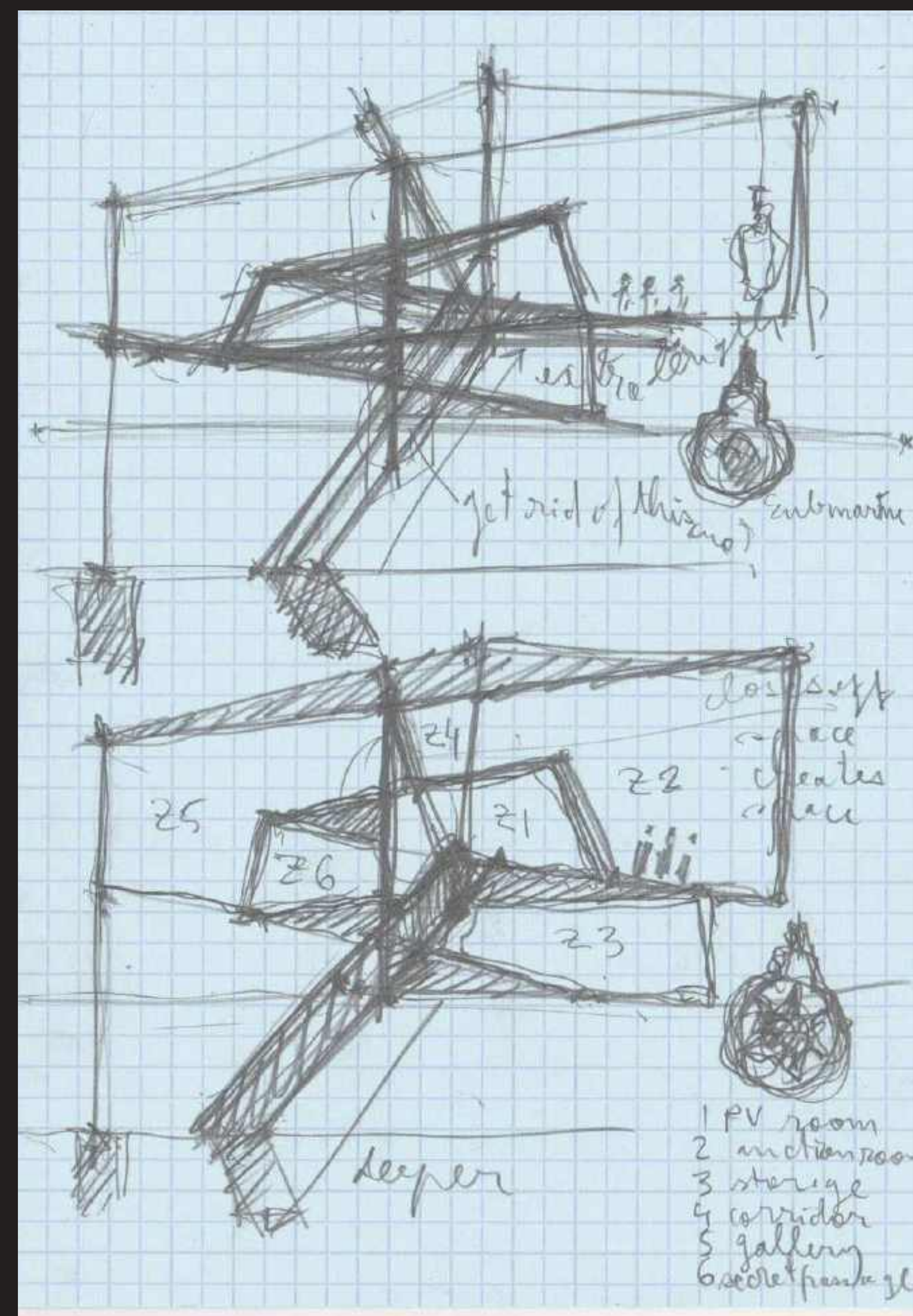

Both
+
TENSION
7m
7m
3.5m

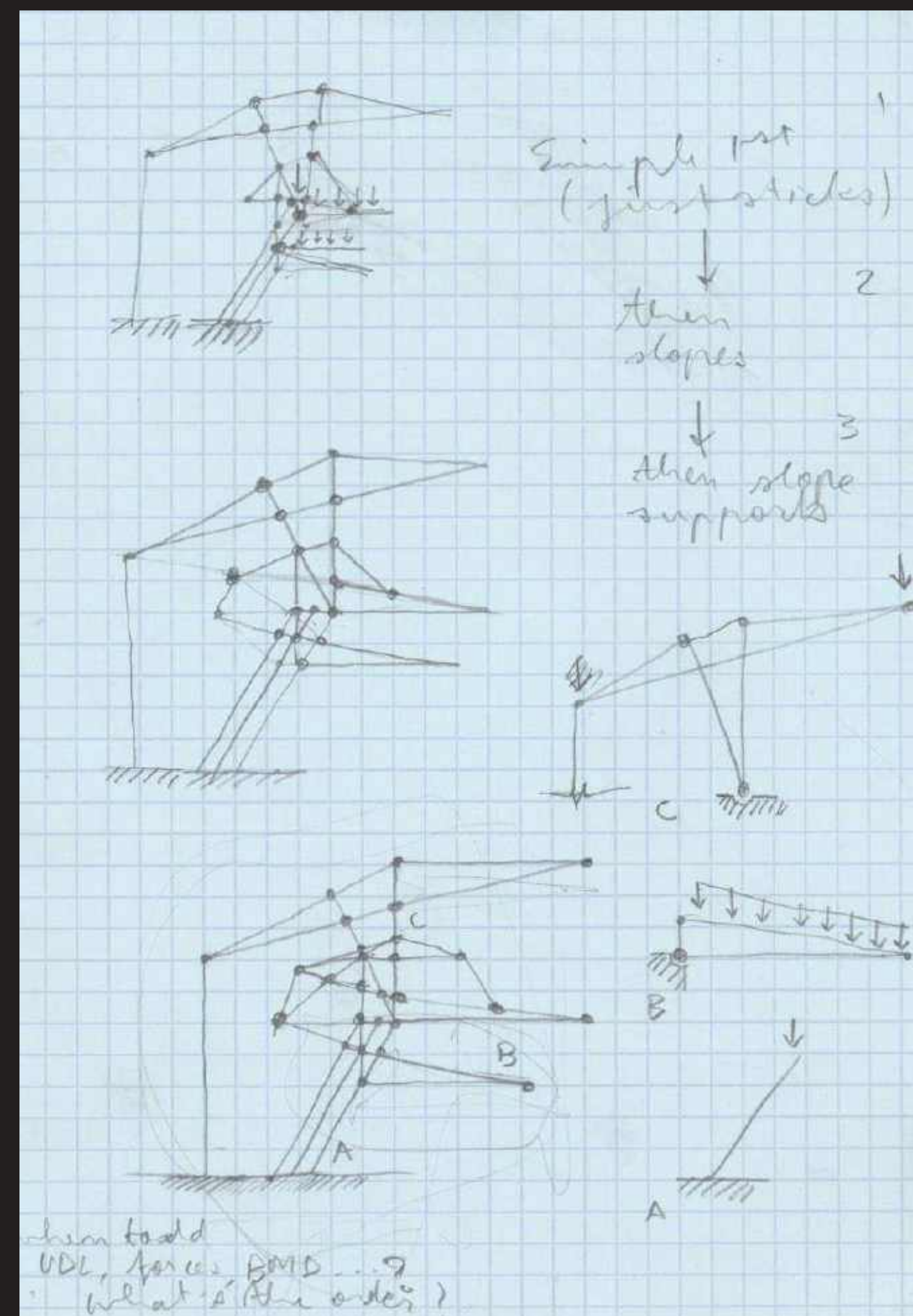

S3
S2
S3
S2
S1

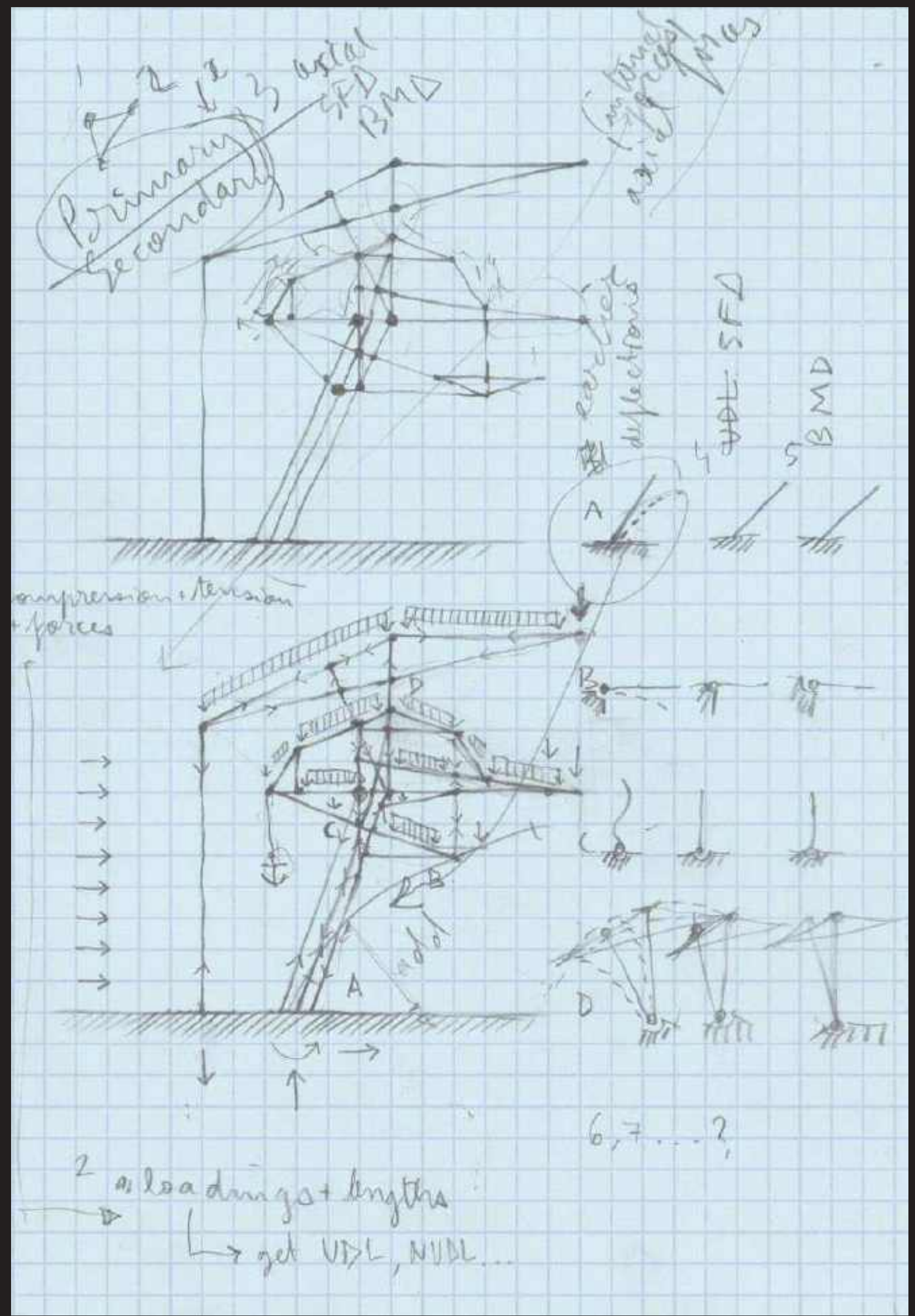

lower
S3
S2

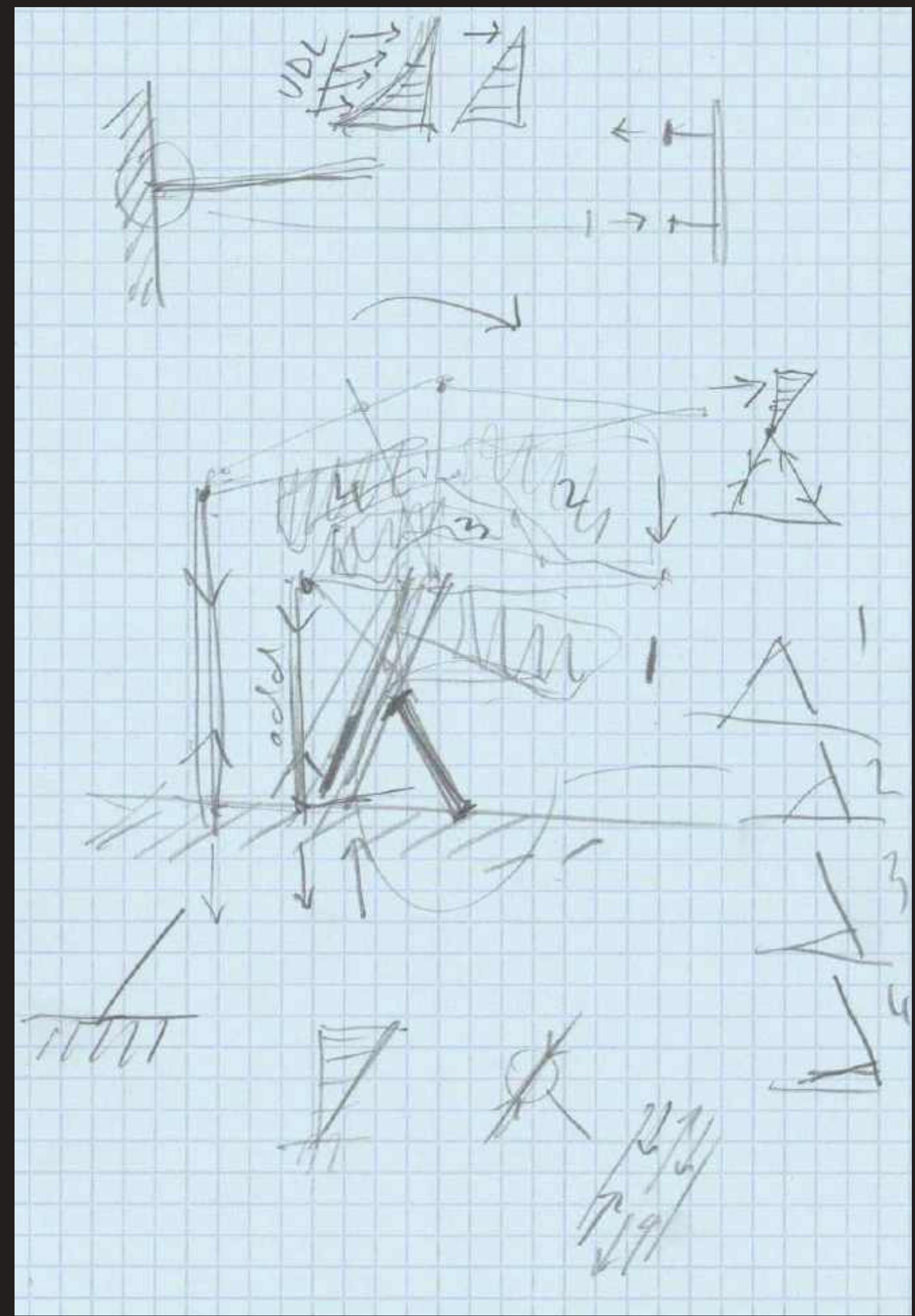


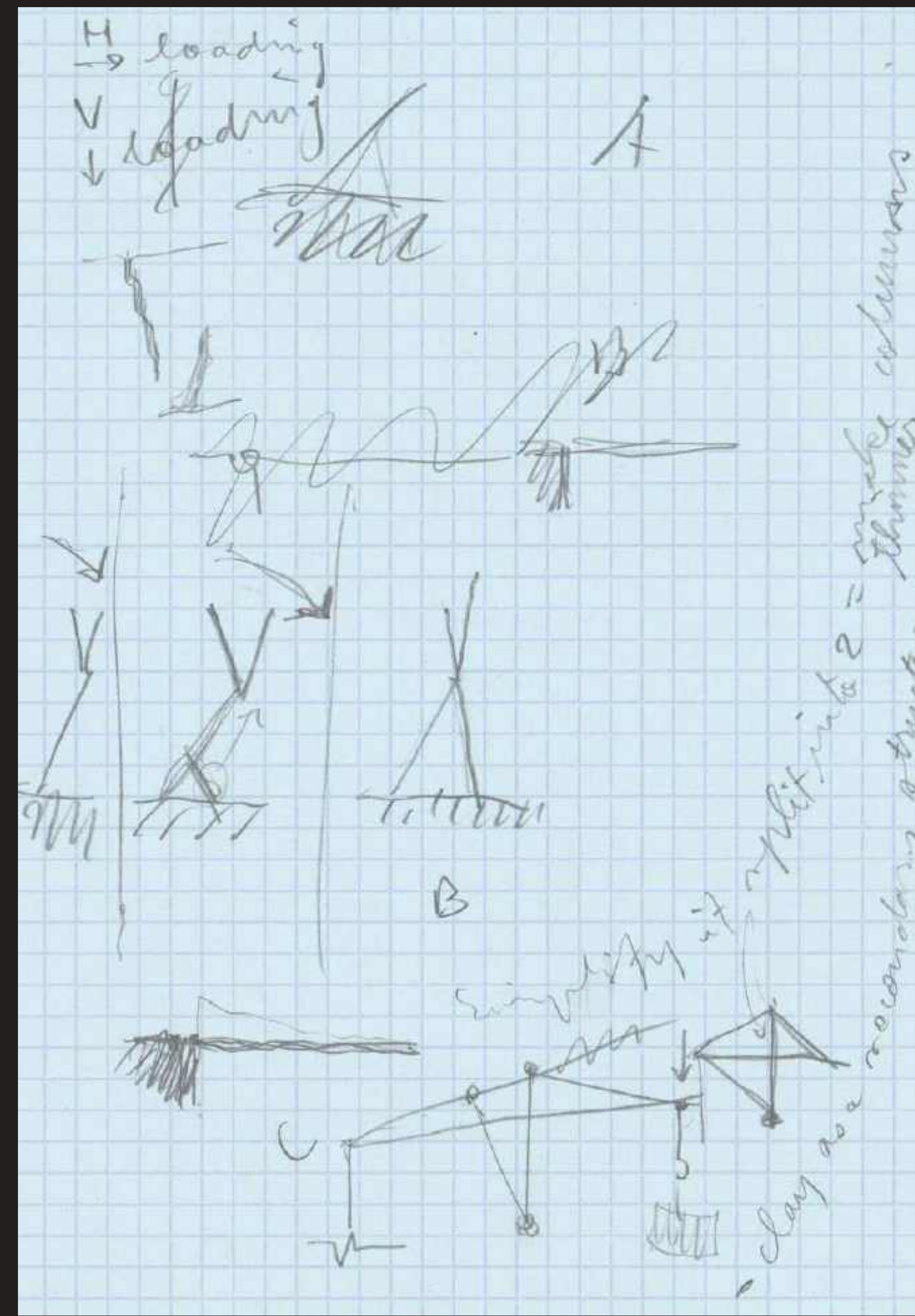

2
3
Boiler
Room

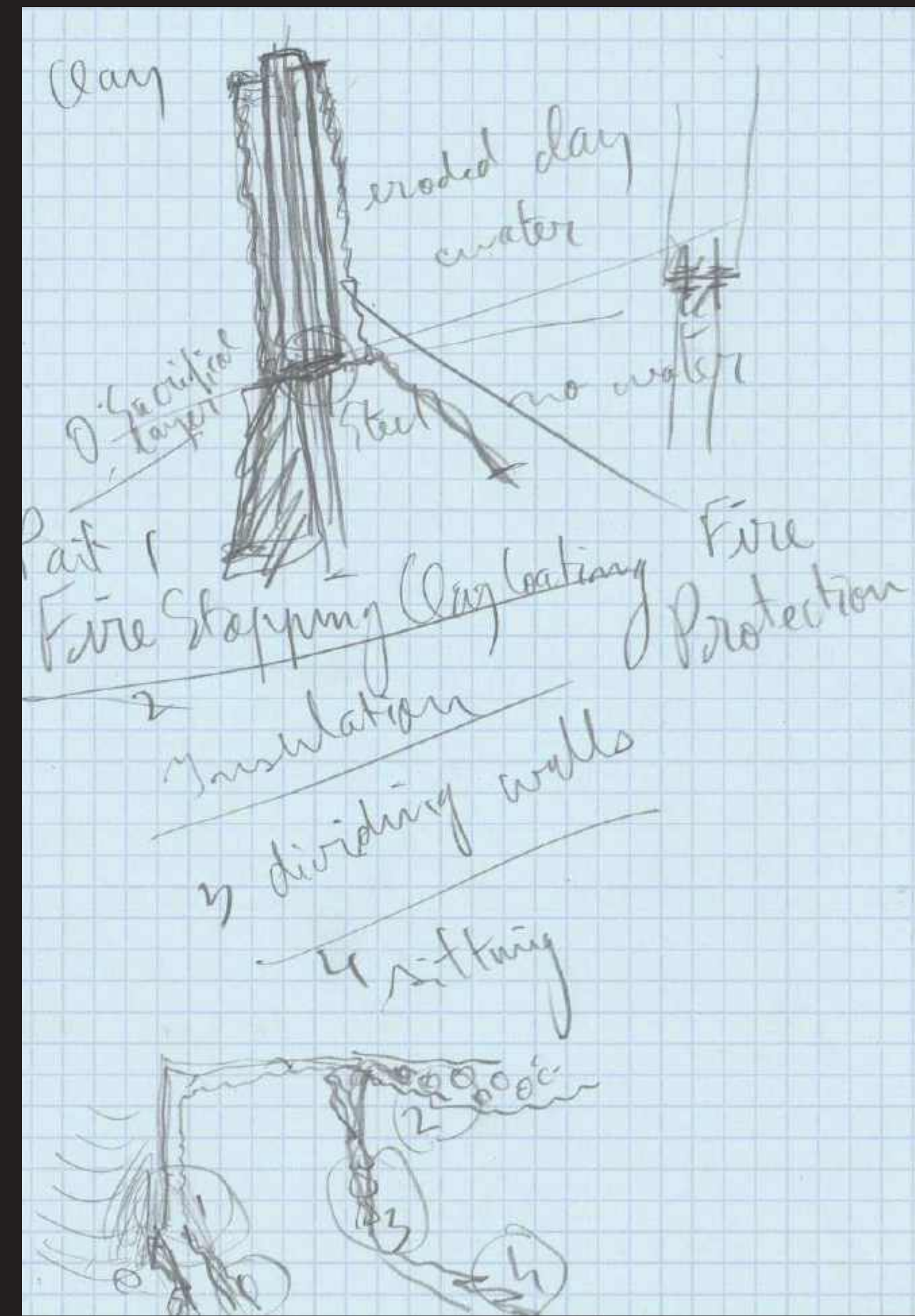

deeper
1 PV room
3 storage
4 corridor
5 gallery

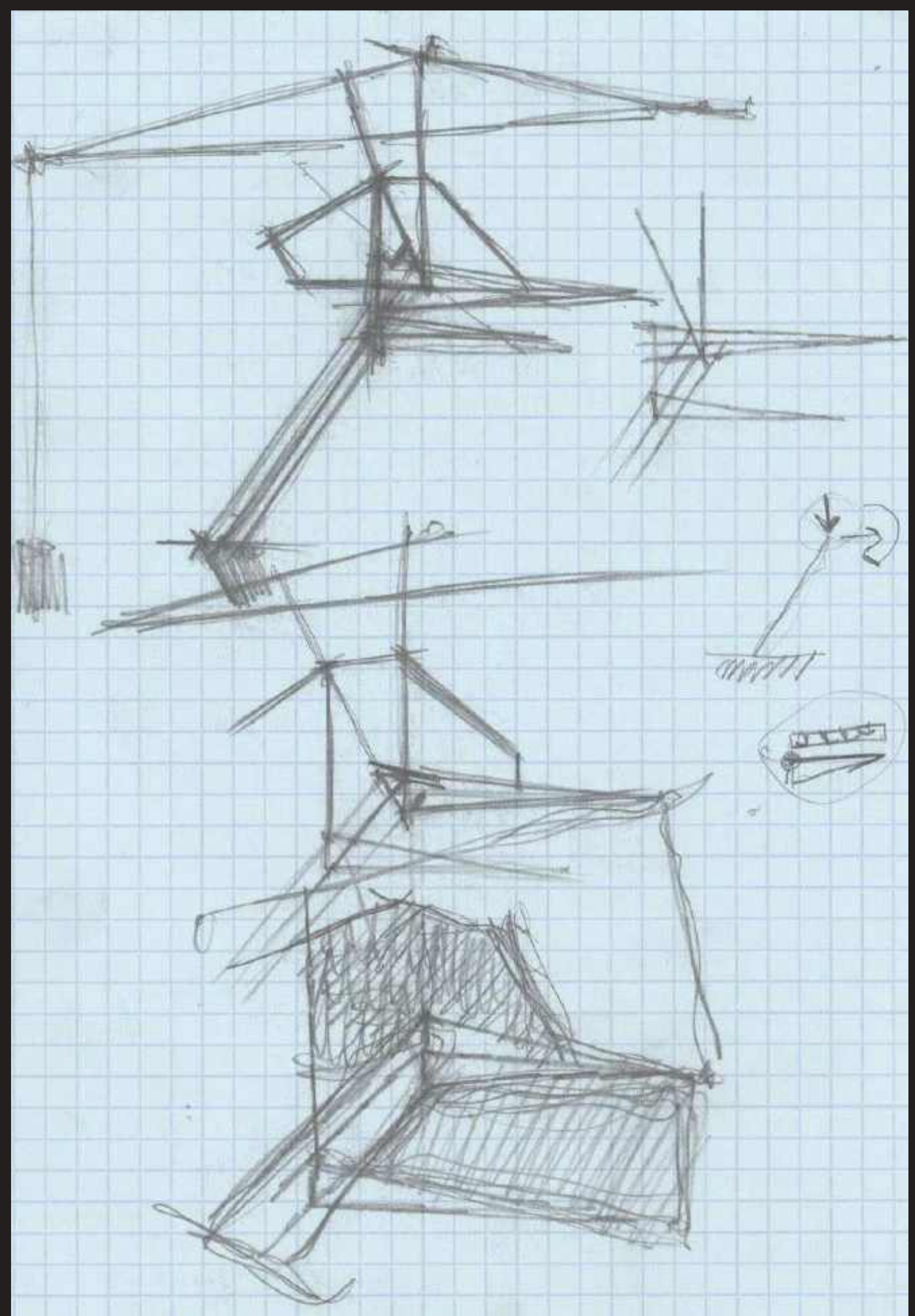

then
slopes
then slope
supports
C
B
A

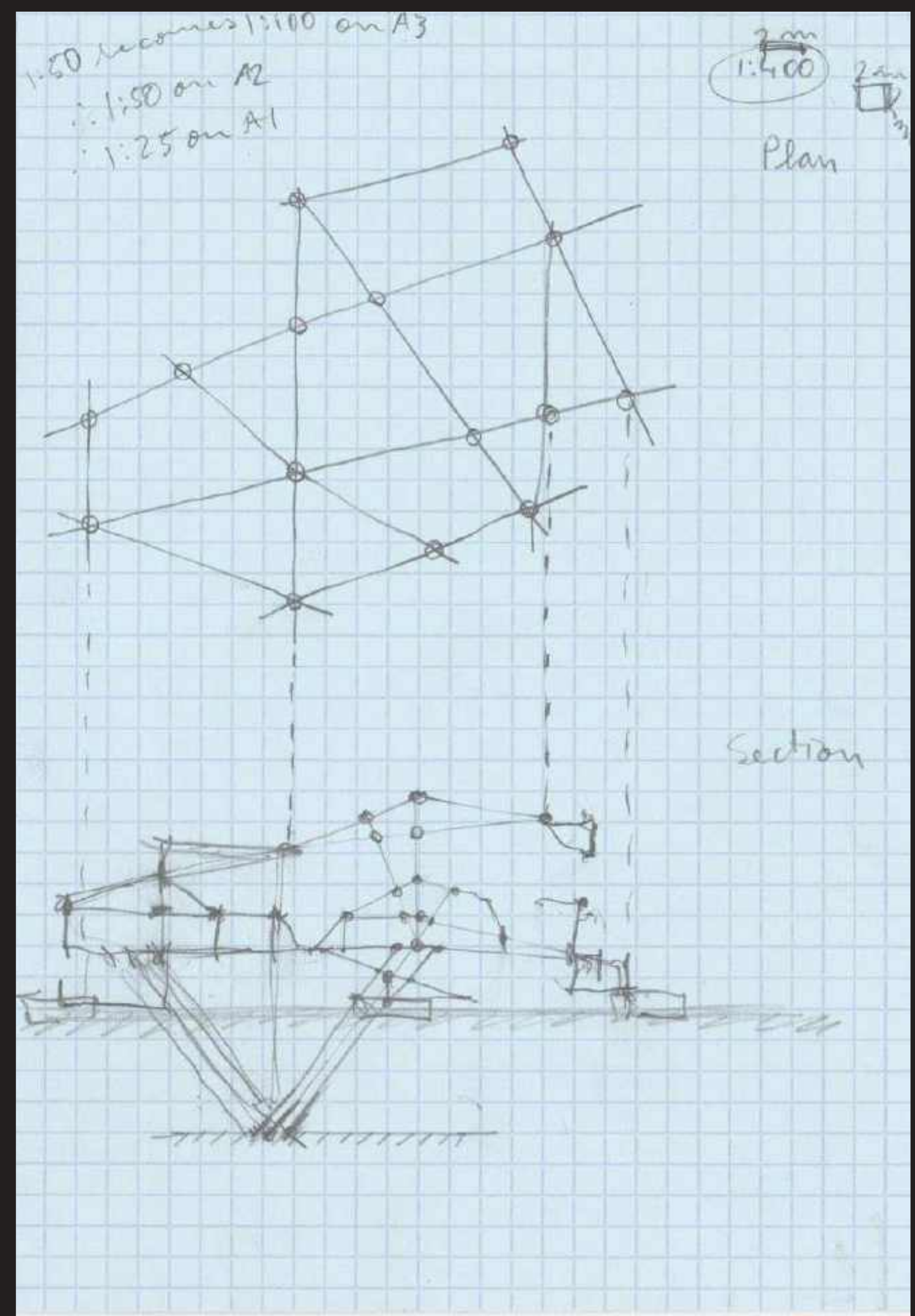

Primary
Secondary
axial
SFD
BMD
UDL SFD
BMD
compression + tension forces
2 x loadings + lengths
→ get UDL, NUDL...
6, 7 ... ?

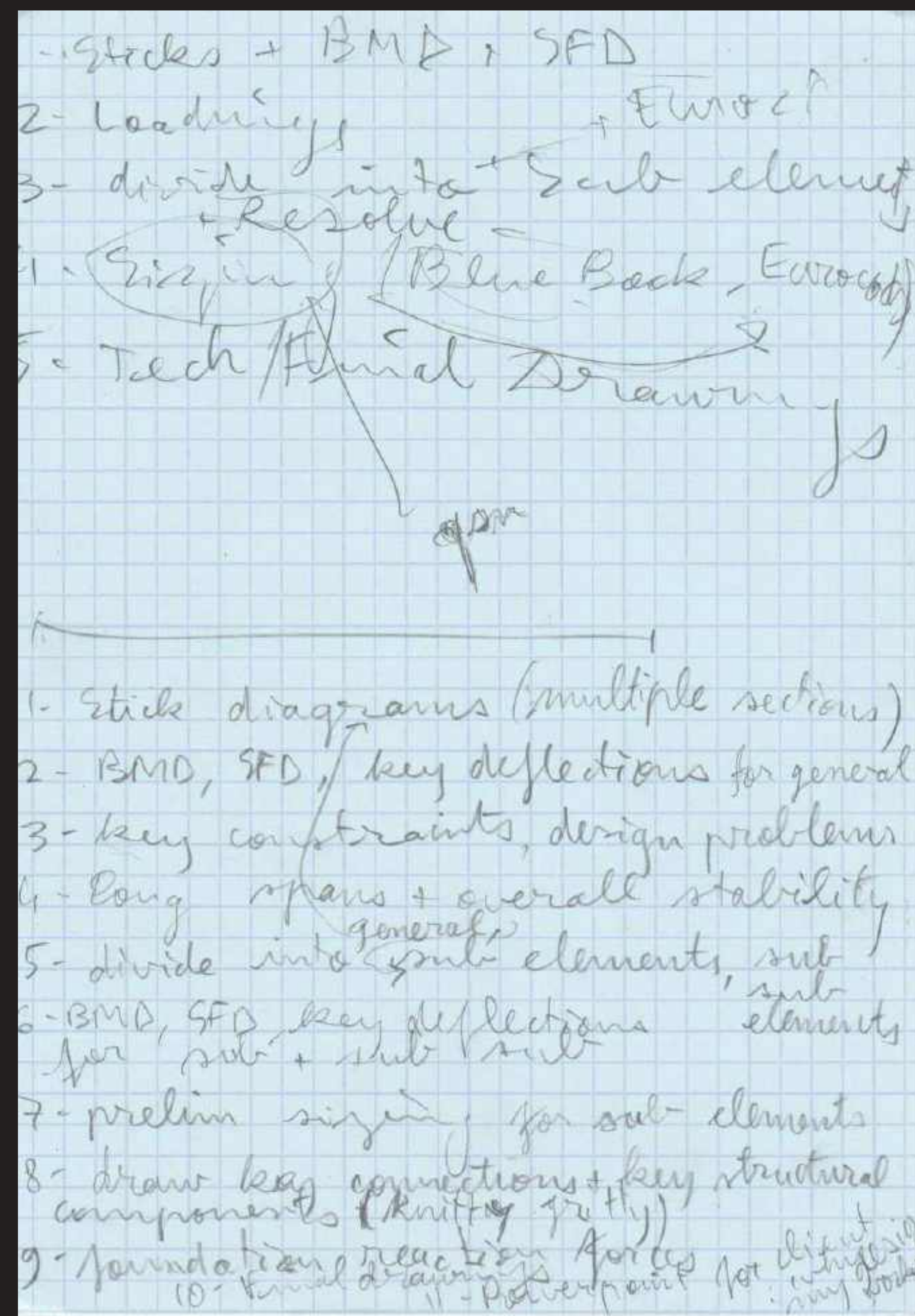

UDL

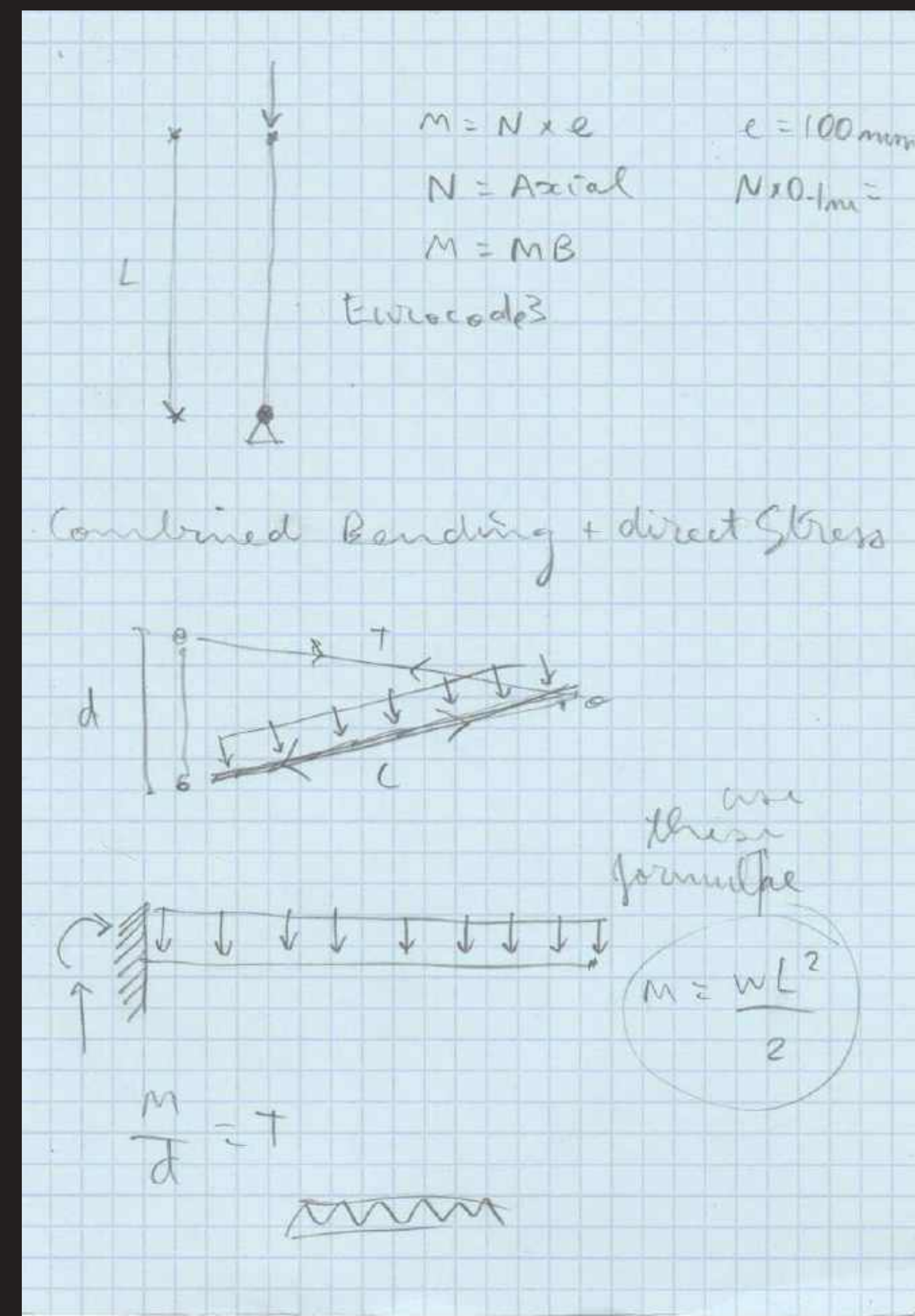

H loading
V loading
A
B
C
simplify it

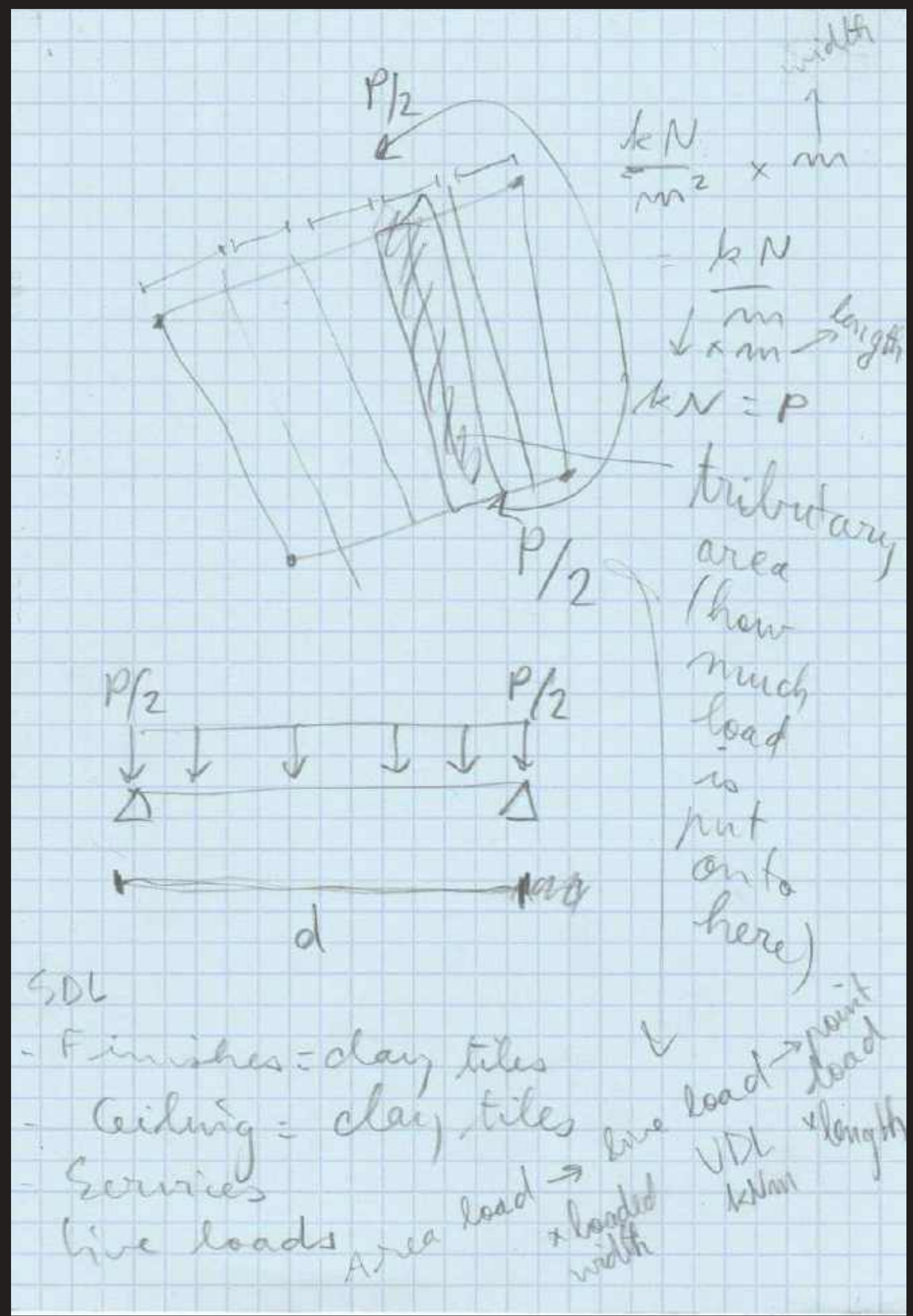

clay
eroded clay
water
steel
no water
Fire Stopping Clay Coating
Fire Protection
2 Insulation
3 dividing walls
4 sitting

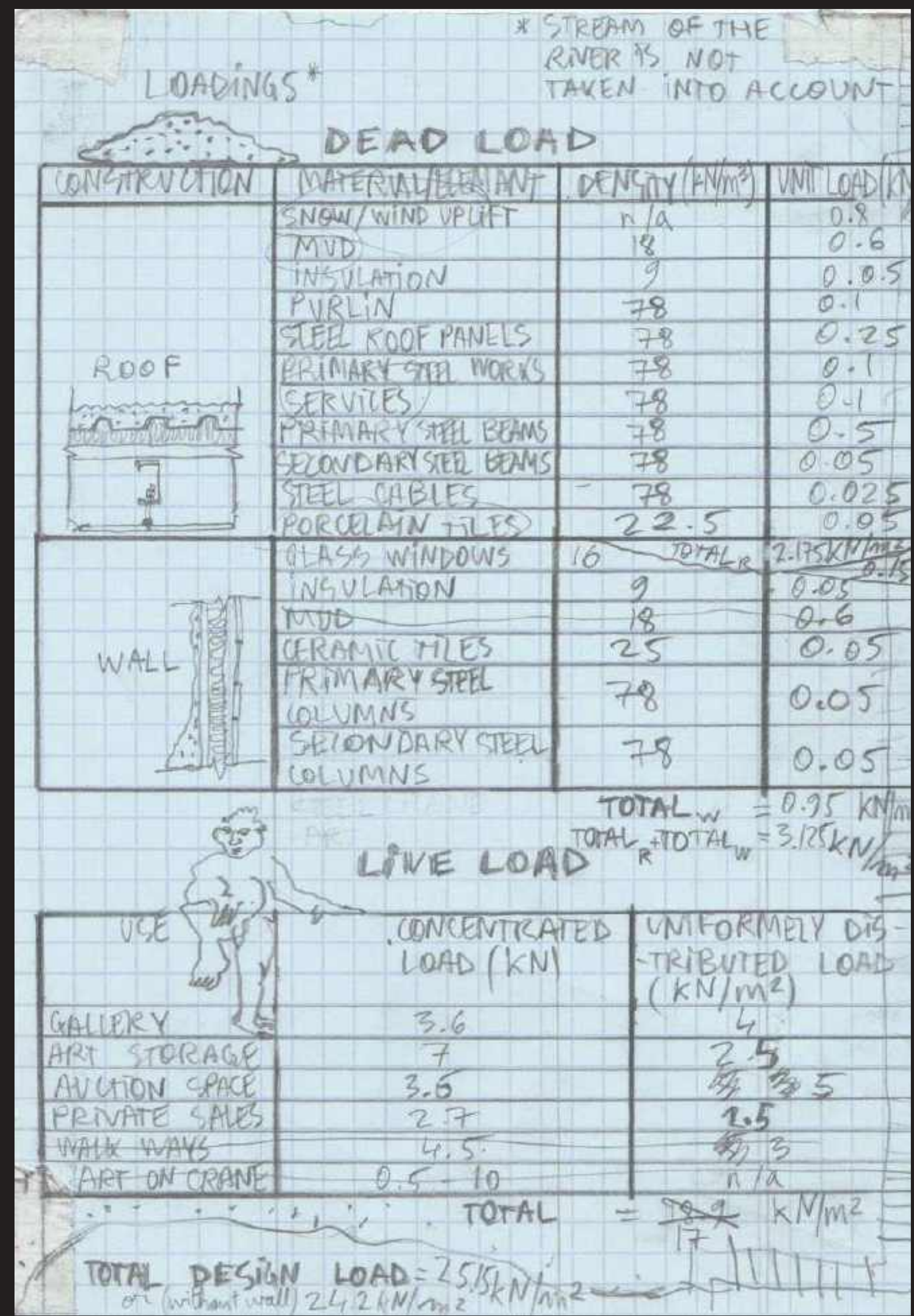


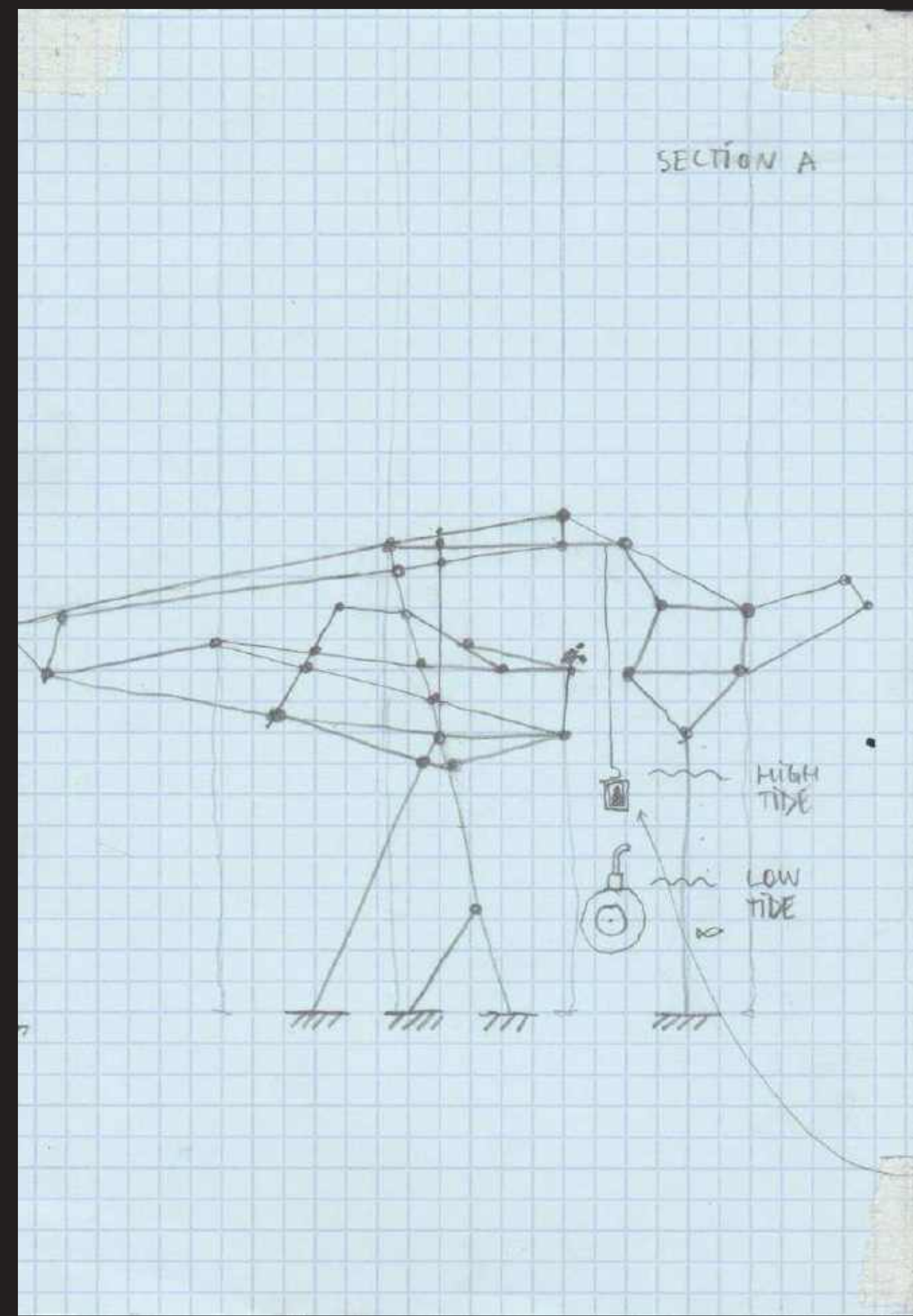

1:50 on A2
1:25 on A1
1:400
Plan
Section

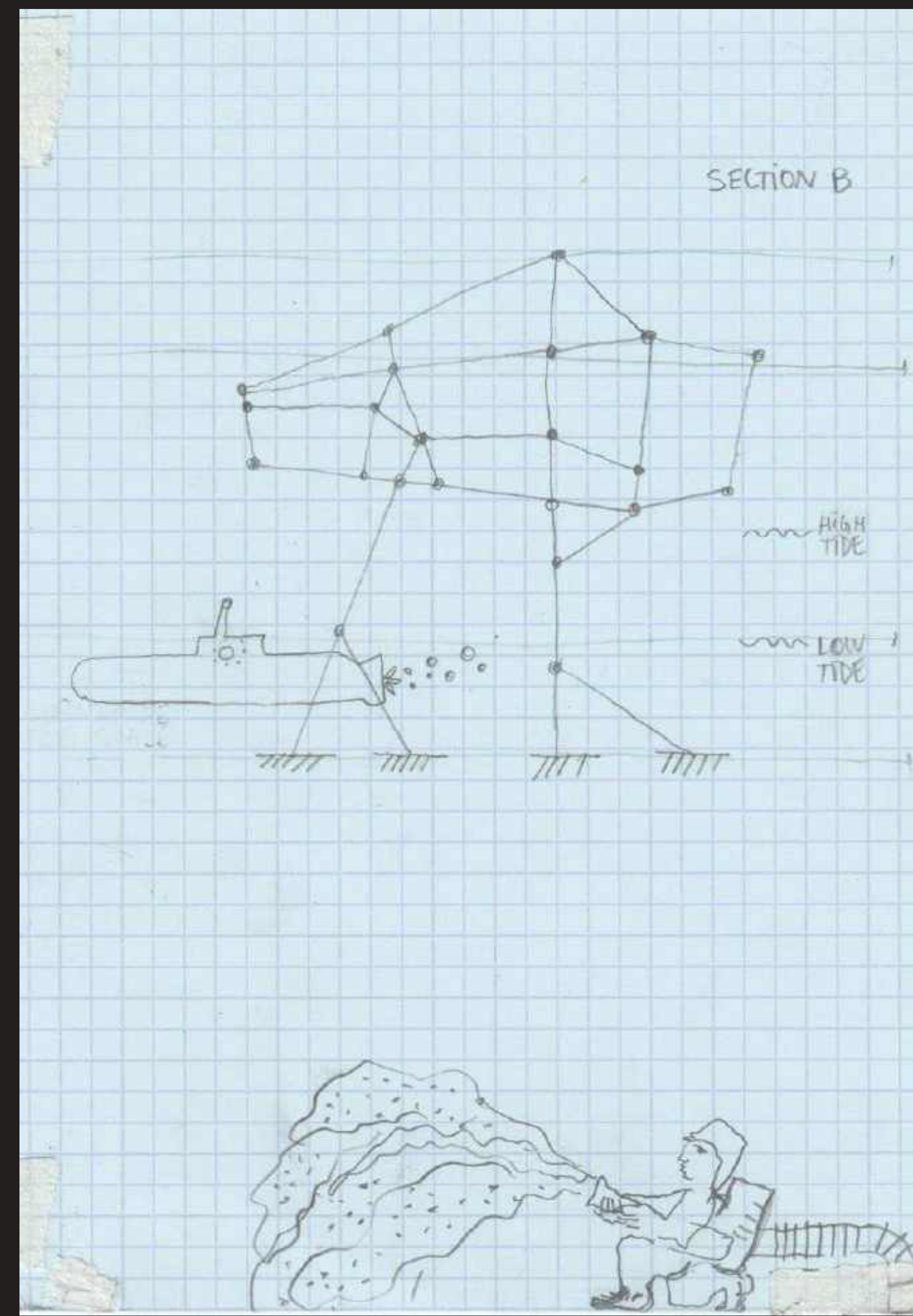

1- Sticks + BMD + SFD
2- Loadings
+ Eurocode
3- divide into sub elements
+ Resolve
4- Sizing (Blue Book, Eurocode)
5- Tech / Final Drawings
1- Stick diagrams (multiple sections)
2- BMD, SFD, key deflections for general
3- key constraints, design problems
4- long spans + overall stability
5- divide into general sub elements, sub sub elements
6- BMD, SFD key deflections for sub + sub sub
7- prelim sizing for sub elements
8- draw key connections + key structural components (knitty gritty)
9- foundations reaction forces
10- Final drawings
11- Powerpoint

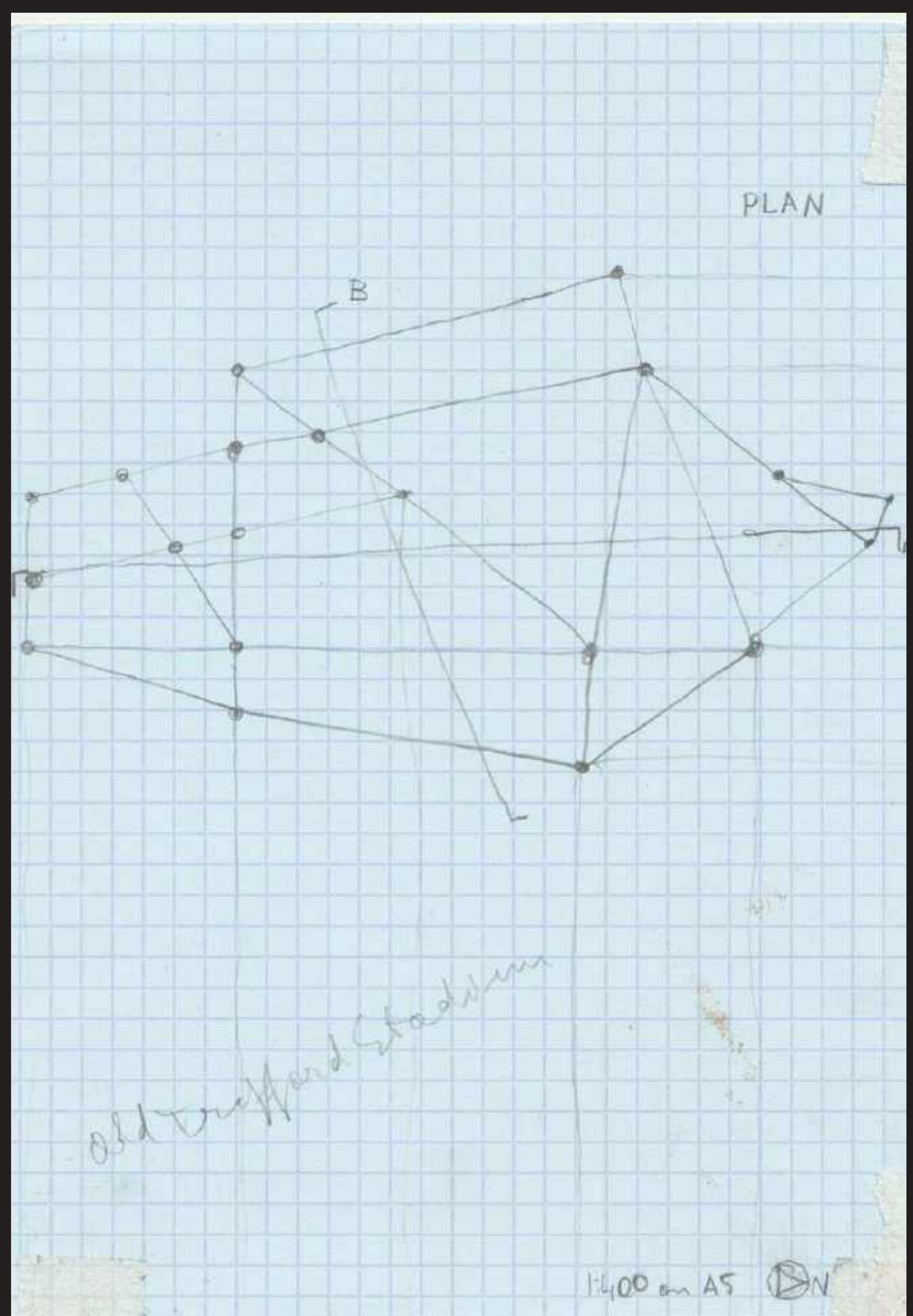

M = N x e
N = Axial
M = MB
Eurocode3
e = 100mm
L
Combined Bending + direct Stress
d
T
C
are these formulae
M = WL²/2
M/d = T

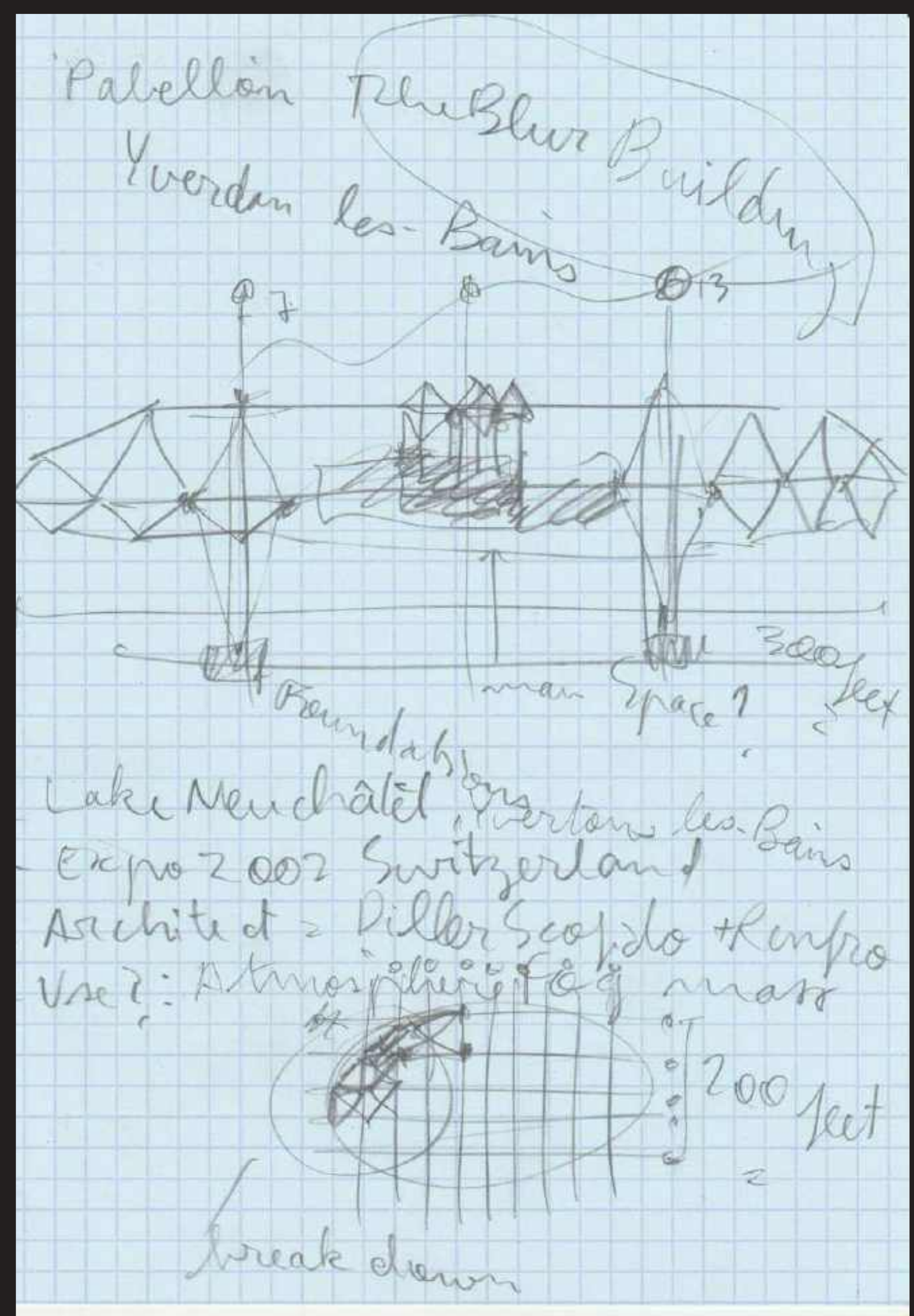

P/2
kN/m² × m
kN/m
× m
kN = P
tributary area (how much load is put onto here)
P/2
P/2
P/2
d
SDL
- Finishes = clay tiles
- Ceiling = clay tiles
- Services
Live loads
area load → live load → point load
UDL kN/m
× loaded width
× length

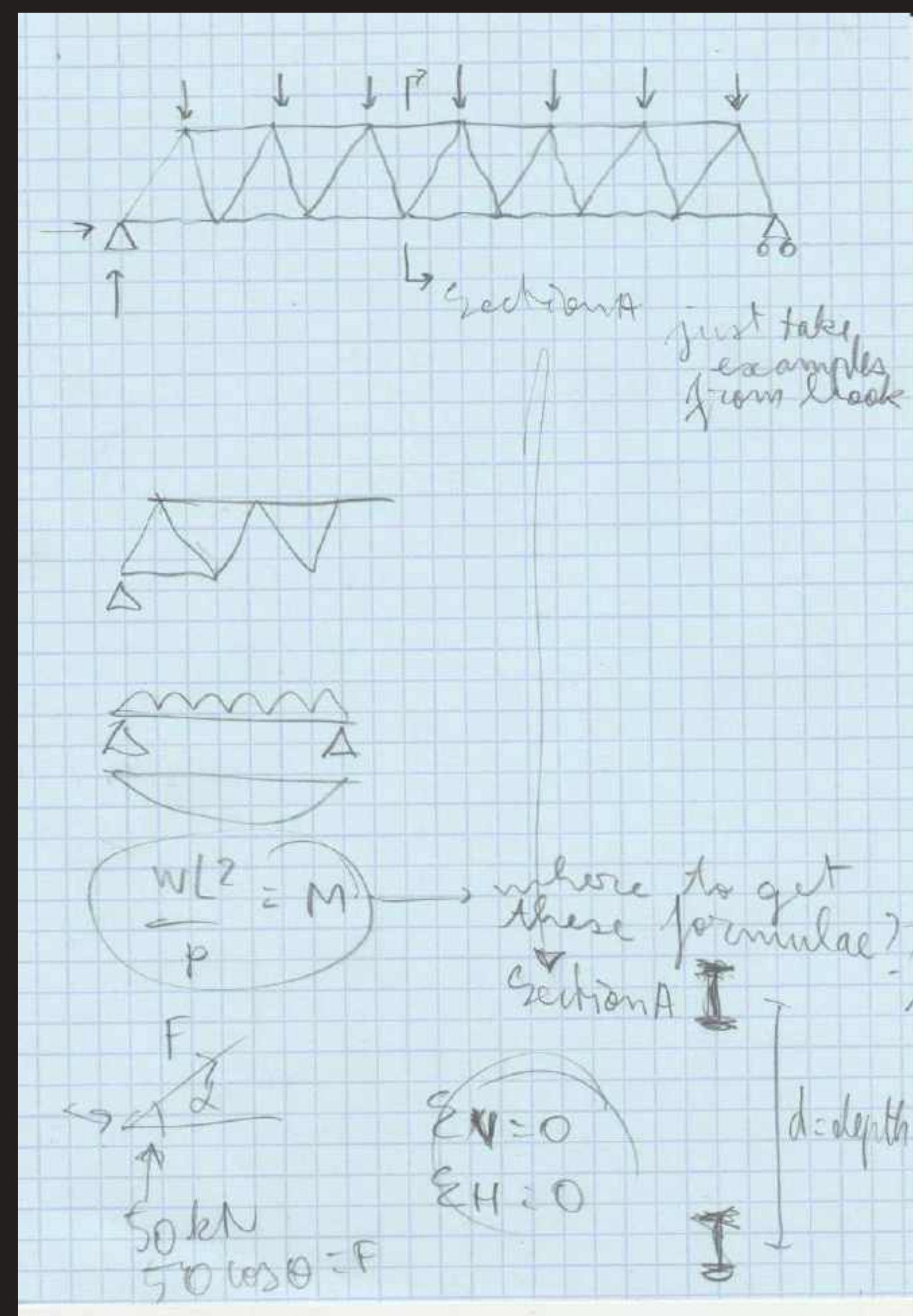

LOADINGS*
* STREAM OF THE RIVER IS NOT TAKEN INTO ACCOUNT
DEAD LOAD
CONSTRUCTION | MATERIAL/ELEMENT | DENSITY (kN/m³) | UNIT LOAD
ROOF
SNOW/WIND UPLIFT | n/a | 0.8
MUD | 18 | 0.6
INSULATION | 9 | 0.05
PURLIN | 78 | 0.1
STEEL ROOF PANELS | 78 | 0.25
PRIMARY STEEL WORKS | 78 | 0.1
SERVICES | 78 | 0.1
PRIMARY STEEL BEAMS | 78 | 0.5
SECONDARY STEEL BEAMS | 78 | 0.05
STEEL CABLES | 78 | 0.025
PORCELAIN TILES | 22.5 | 0.05
TOTAL_R 2.175 kN/m²
WALL
GLASS WINDOWS | 16 | 0.15
INSULATION | 9 | 0.05
MUD | 18 | 0.6
CERAMIC TILES | 25 | 0.05
PRIMARY STEEL COLUMNS | 78 | 0.05
SECONDARY STEEL COLUMNS | 78 | 0.05
TOTAL_W = 0.95 kN/m²
TOTAL_R + TOTAL_W = 3.125 kN/m²
LIVE LOAD
USE | CONCENTRATED LOAD (kN) | UNIFORMELY DISTRIBUTED LOAD (kN/m²)
GALLERY | 3.6 | 4
ART STORAGE | 7 | 2.5
AUCTION SPACE | 3.6 | 5
PRIVATE SALES | 2.7 | 2.5
WALK WAYS | 4.5 | 3
ART ON CRANE | 0.5 - 10 | n/a
TOTAL = 17 kN/m²
TOTAL DESIGN LOAD = 25.15 kN/m²
or (without wall) 24.2 kN/m²

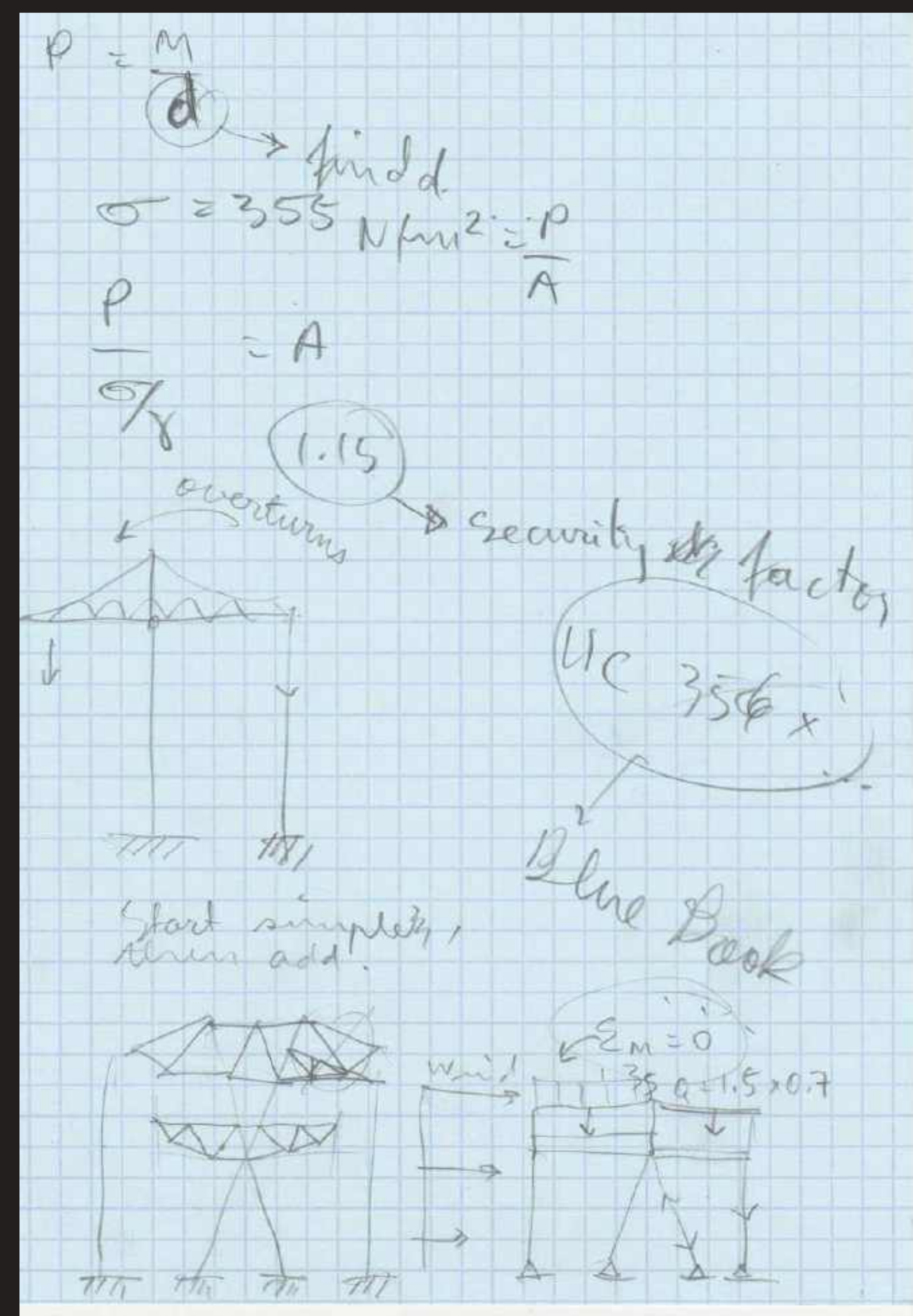

SECTION A
HIGH TIDE
LOW TIDE

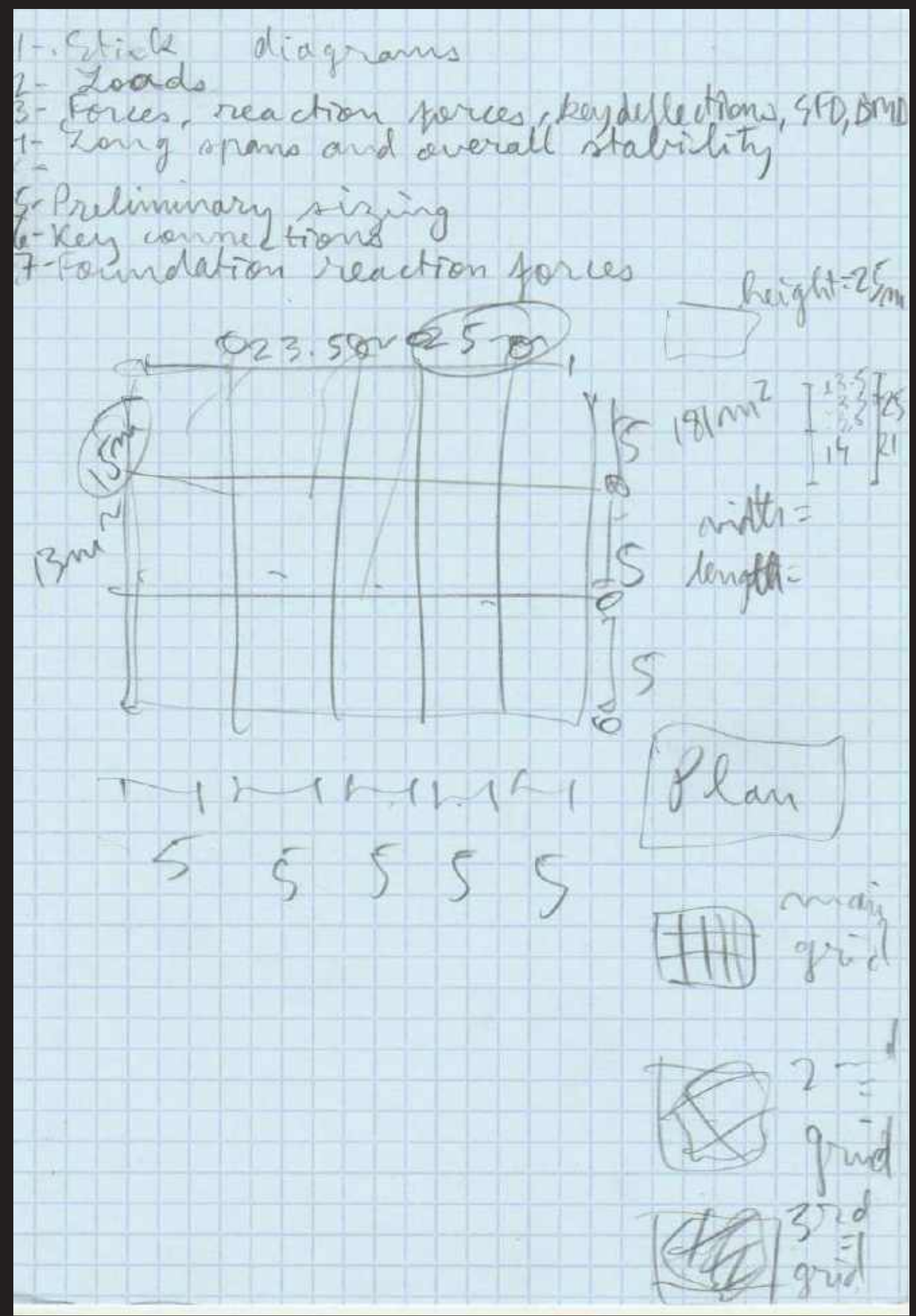
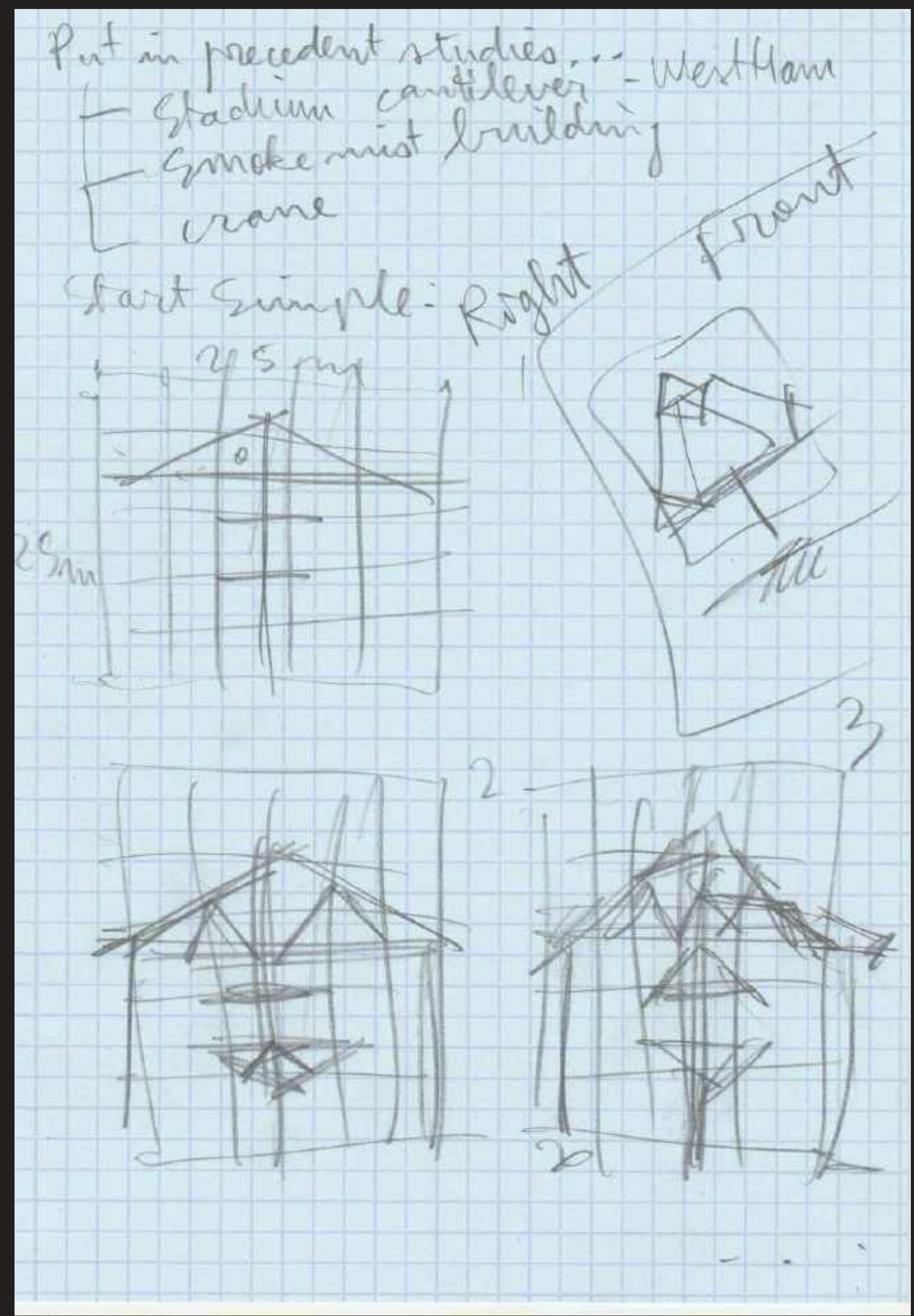
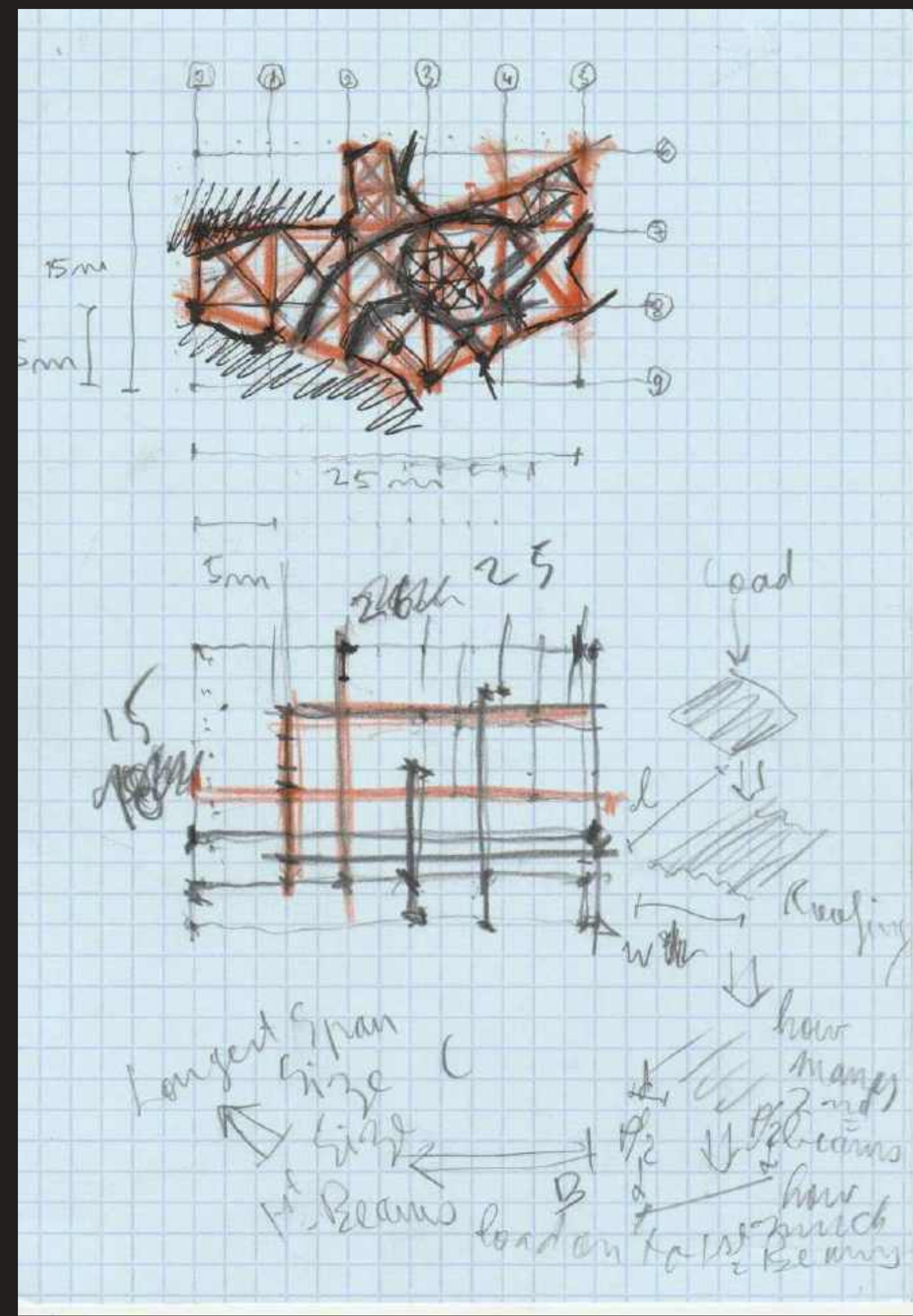
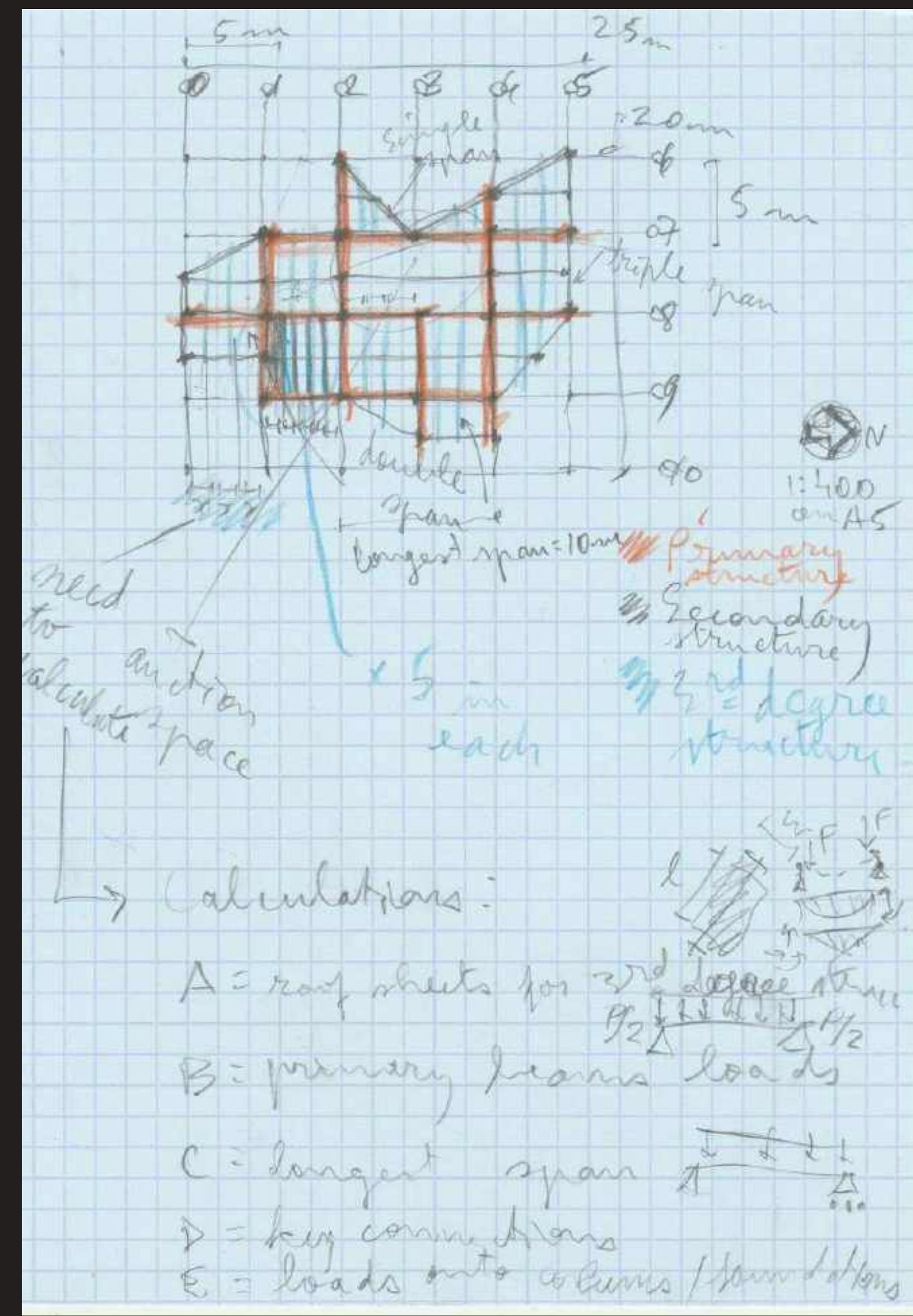
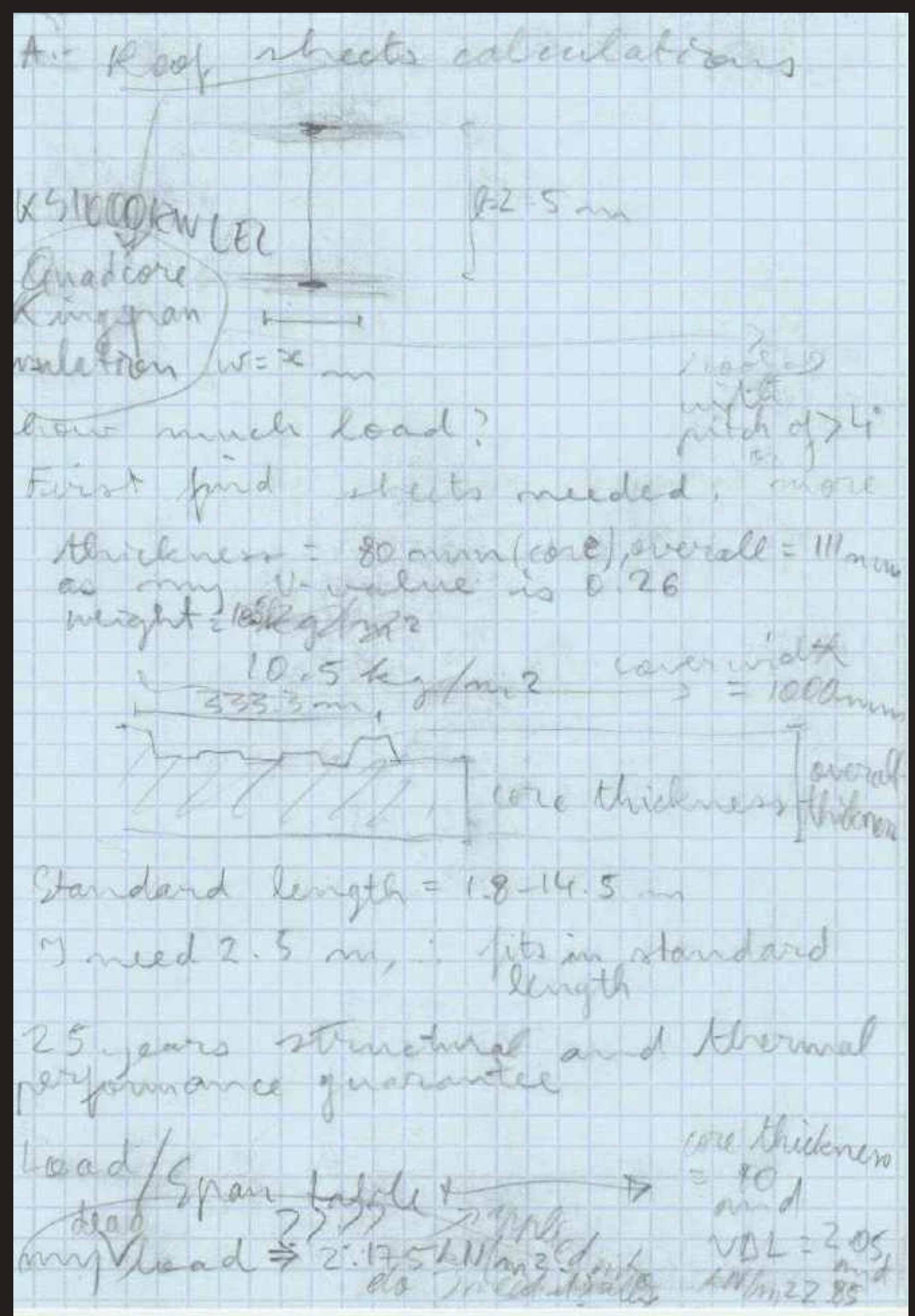
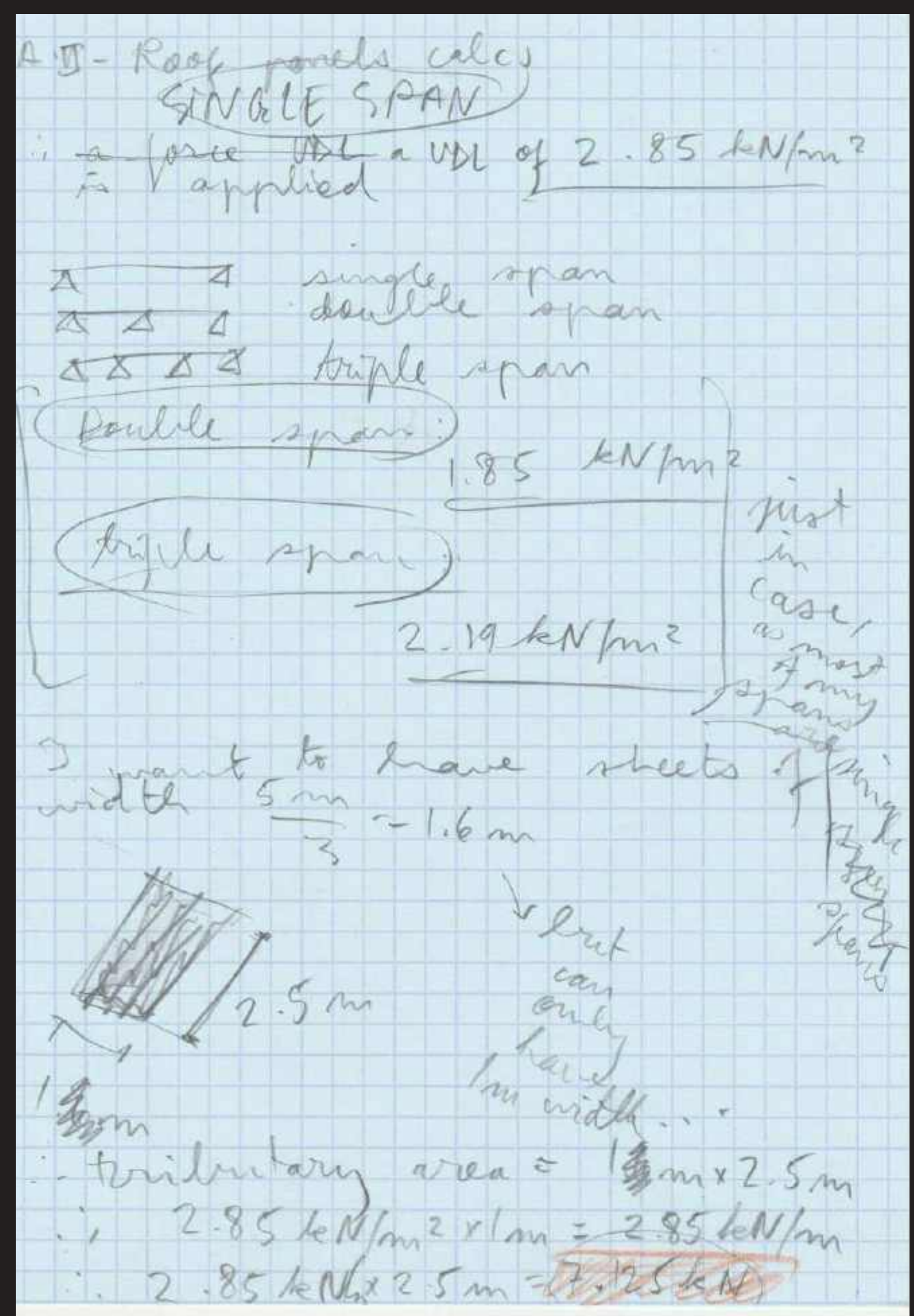
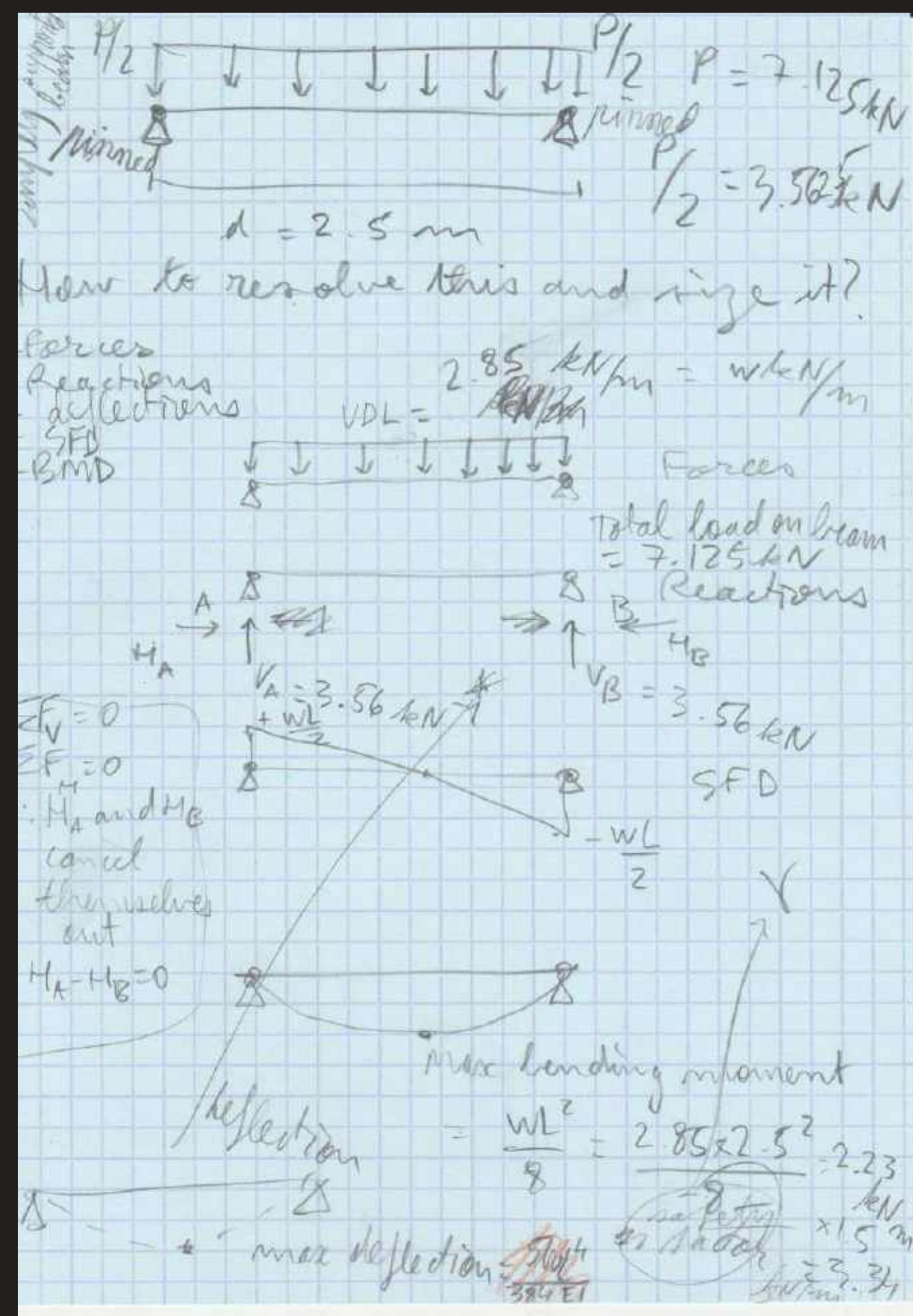
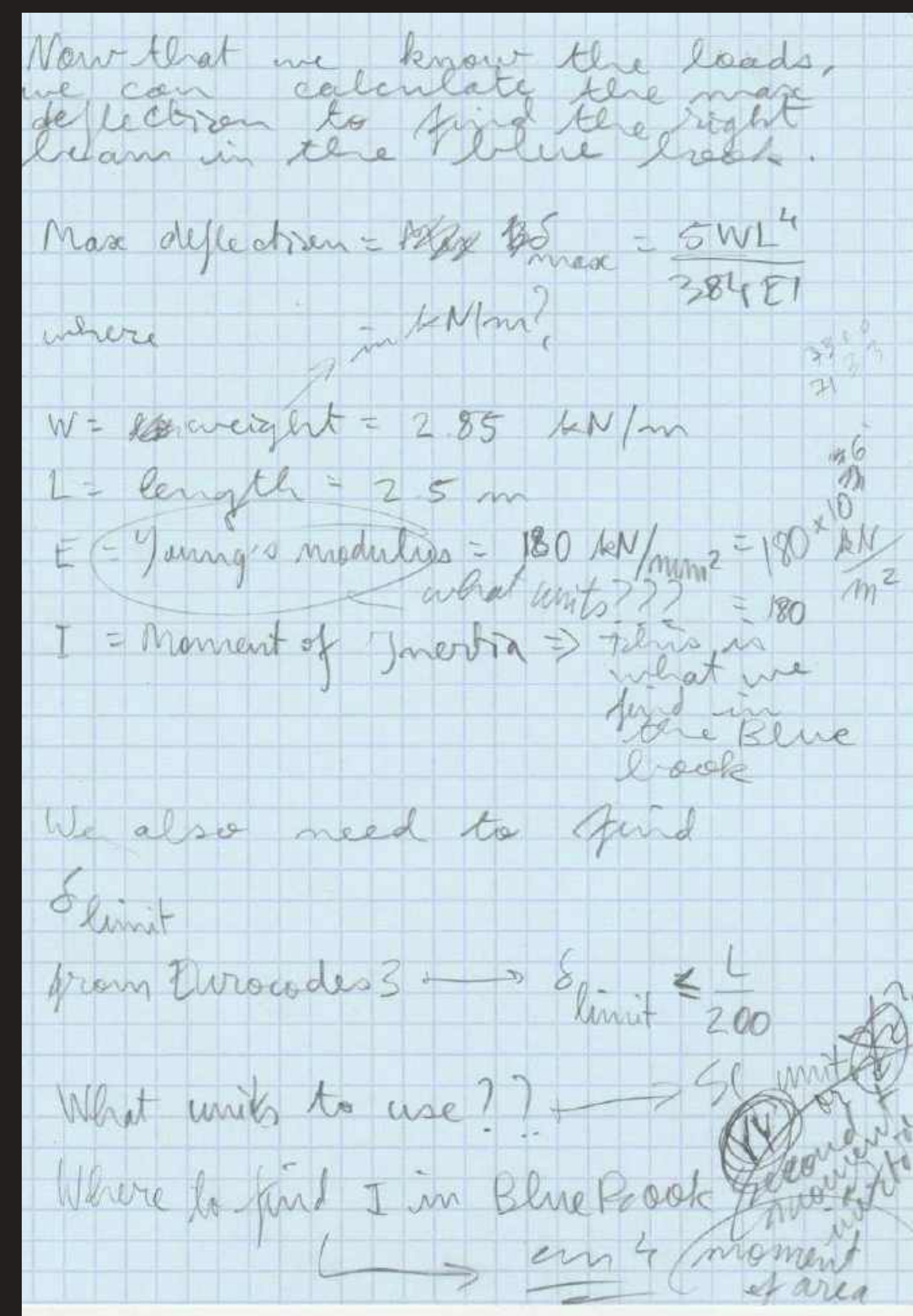

SECTION B
HIGH TIDE
LOW TIDE


PLAN
B
1:400 on A5


Pabellón The Blur Building
Yverdon les-Bains
Foundations
main space?
300 feet
Lake Neuchâtel, Yverdon les-Bains
Expo 2002 Switzerland
Architect: Diller Scofidio + Renfro
Use?: Atmospheric fog mass
200 feet
break down


P
section A
just take examples from book
WL²/P = M
where to get these formulae?
Section A
d: depth
F
ΣV = 0
ΣH = 0
50 kN
50 cos θ = F


P = M/d
σ = 355 N/mm² = P/A
P/(σ/γ) = A
1.15
security factor
overturns
UC 356 ×
Blue Book
Start simple, then add!
wind
ΣM = 0
1.35 G + 1.5 + 0.7


1- Stick diagrams
2- Loads
3- Forces, reaction forces, key deflections, SFD, BMD
4- Long spans and overall stability
5- Preliminary sizing
6- Key connections
7- Foundation reaction forces
Plan
5 5 5 5 5

Put in precedent studies...
Stadium cantilever - West Ham
Smoke mist building
crane
Start Simple: Right
Front
25m

15m
25m
5m
Load
Roofing
Longest Span
Size
Beams

Primary structure
Secondary structure
3rd degree structure
Longest span = 10m
Calculations:
A = roof sheets for 3rd degree structure
B: primary beams loads
C: Longest span
D = key connections
E = loads onto columns / foundations

A - Roof sheets calculations
How much load?
First find sheets needed
Standard length = 1.8-14.5m
I need 2.5m, ∴ fits in standard length
25 years structural and thermal performance guarantee
Load/Span table

A II - Roof panels calcs
SINGLE SPAN
single span
double span
triple span
double span
triple span
1.85 kN/m²
2.19 kN/m²
I want to have sheets of width 5m/3 = 1.6m
2.5m
tributary area = 1m x 2.5m
2.85 kN/m² x 1m = 2.85 kN/m
2.85 kN x 2.5m = 7.125 kN

P/2
P = 7.125 kN
P/2 = 3.56 kN
pinned
L = 2.5m
How to resolve this and size it?
Forces
Reactions
deflections
SFD
BMD
VDL = 2.85 kN/m
Total load on beam = 7.125 kN
Reactions
SFD
max bending moment
deflection
max deflection

Now that we know the loads, we can calculate the max deflection to find the right beam in the blue book.
where
W = weight = 2.85 kN/m
L = length = 2.5m
E = Young's modulus = 180 kN/mm²
I = Moment of Inertia
We also need to find δlimit
from Eurocodes 3
What units to use??
Where to find I in Blue Book

$I \geq \frac{1000}{384} \times \frac{wL^3}{E}$

$I \geq \frac{1000}{384} \times \frac{(2.85 \times 10^3) \times (2.5^3)}{(180 \times 10^9)}$?

$I \geq \frac{1000}{384} \times \frac{2.85 \times 2.5^3}{180 \times 10^6}$ 2500

$\therefore I \geq 6.44 \times 10^{-7}$

$I \geq 6.44 \times 10^{-7}\ m^4$

0.000000644

$I \geq 644\ cm^4$ too low? unit issue??

→ then

UB 356·171·67

WHAT UNIT DO I HAVE TO USE?

same if not ...

STRENGTH REDUCTION FACTOR = 0.85

$I \geq \frac{1000 \times 2.85 \times 10^3 \times 2.5^3}{384 \times 180 \times 10^9}$

$I \geq$

$\delta_{max} = \frac{5WL^4}{384EI}$

where:

W = load per unit weight = 2.85 kN/m = 2 850 Pa

L = length = 2.5 m

E = Elastic Modulus = 180 GPa = 180×10^9 Pa $\left(\frac{N}{m^2}\right)$

I = Moment of Inertia

$\delta_{limit} \leq \frac{L}{200}$

where:

L = length = 2.5 m

as $\delta_{max} \leq \delta_{limit}$

$\therefore \frac{5WL^4}{384EI} \leq \frac{L}{200}$

$\frac{5wL^3}{384EI} \leq \frac{1}{200}$

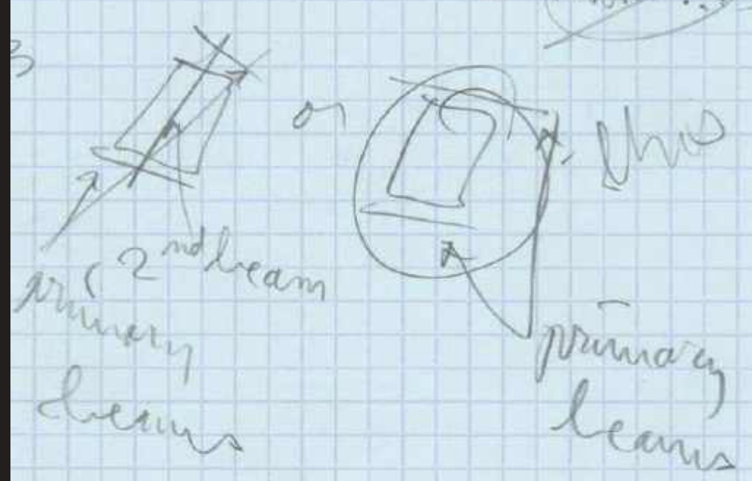
$\therefore \frac{5wL^3 \times 200}{384E} \leq I$

$I \geq \frac{1000\, wL^3}{384E}$

Questions for Harry ✓

- look at (Y-Y) cm^4 or Z-Z cm^4 in blue book?? ✓

is $\frac{L}{200}$ in mm? or m? doesn't matter? mm...



$\delta_{max} = \frac{5WL^4}{384EI}$

where

W = load per unit weight =

L = length =

E = Elastic Modulus =

I = Moment of Inertia =

All in mm? or convert

to m

$\delta_{limit} = \frac{L(mm)}{200} = \frac{2.5m}{200} = \frac{2500}{200}$

= 12.5 mm

= 0.0125 m

$\therefore \delta_{max} \leq \delta_{limit}$

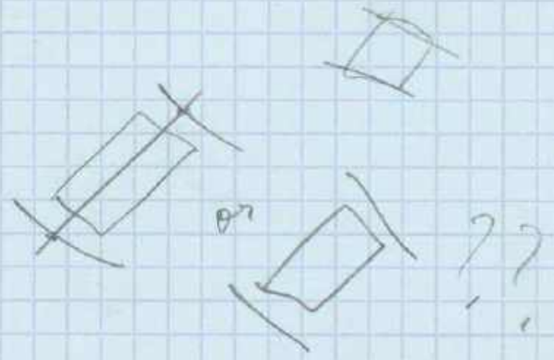
$0.0125 \geq \frac{5(2.85 \times 10^3)(2.5)^4}{384(180 \times 10^9)I}$ may too low

$I \geq \frac{5(2.85 \times 10^3)(2.5)^4}{384(180 \times 10^9)\,0.0125} = 2.57 \times 10^{-7}\ m^4 = 25\ cm^4$

$\delta_{max} = \frac{5WL^4}{384EI}$

~~0.00064~~

~~6.4×10^{-4}~~



B - Try longest span

C - Try load onto columns

64425

$\therefore I \geq$ ~~64 000~~ cm^4

× 0.85 safety factor

Mega is 10^6 !!!

Giga is 10^9

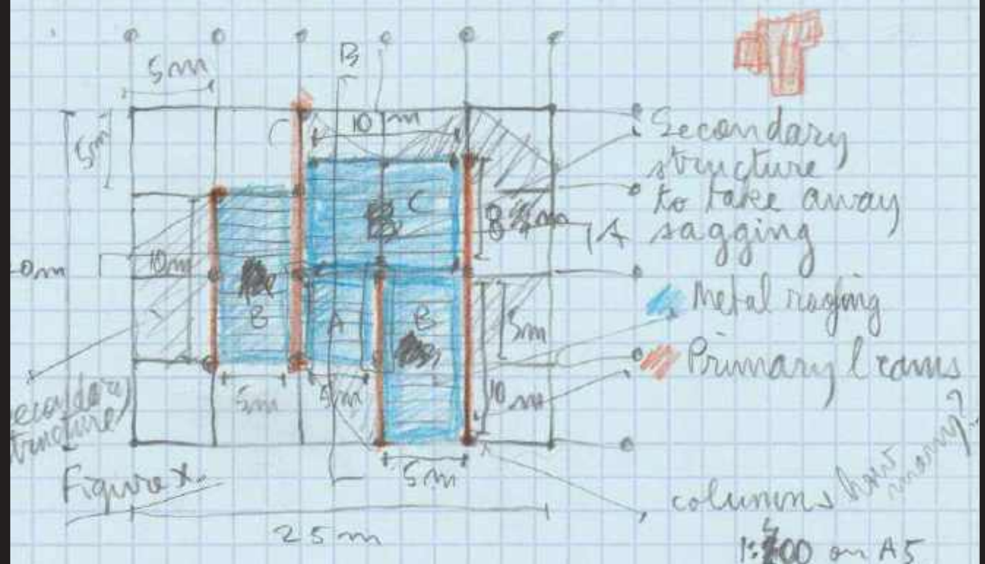
~~$\therefore I \geq 0.85 \times 64\,425\ cm^4$~~

~~$I \geq 54761\ cm^4$~~

$I \geq 64\,425\ cm^4$

$\therefore$ UB 610 × 178 × 100 → 72500 cm^4

w. SF → 61625



A: What type of beam can withstand load from A??

First, let's define the dead loads:

Looking at Kingspan metal roofing, with a core thickness of 80 cm:

Roofing = 0.8 kN/m^2 (Suction

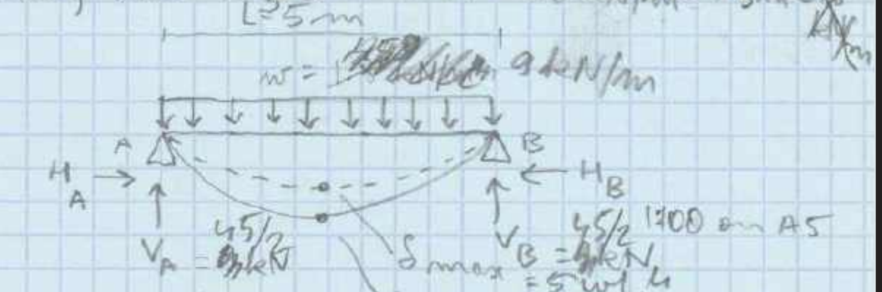
Services = 0.1 kN/m^2

Clay tiles = 0.1 kN/m^2

Wind uplift = 0.8 kN/m^2

Total = 1.8 kN/m^2

Tributary area = 5×5 → ∴ 1.8 kN/m^2 × 5m = 9 kN/m



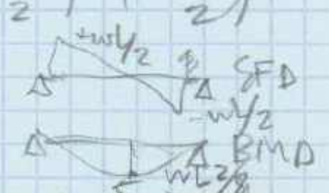
$\delta_{max} = \frac{5wL^4}{384EI}$

$\delta_{limit} \leq \frac{L}{200}$

$\Sigma F_H = H_A - H_B = 0$

$\Sigma F_V = V_A - V_B = \frac{wL}{2} - \frac{wL}{2} = \left(\frac{5 \times 9}{2}\right) - \left(\frac{5 \times 9}{2}\right)$

$= \frac{45}{2} - \frac{45}{2} = 0$



~~As in section A we have 5 roof panels, the total load on the beam is:~~

~~5 × 9 kN~~

We will now size the beams on both sides of section A:

$\delta_{max} = \frac{5wL^4}{384EI}$

$\delta_{limit} \leq \frac{L}{200}$

where

w = 9 kN/m = 9000 N/m

L = 5 m

E = Youngs modulus = 180×10^9 N/m^2

I = Moment of inertia

Stainless Steel 304L

$\therefore \delta_{max} \leq \delta_{limit}$

$\frac{5wL^4}{384EI} \leq \frac{L}{200}$

$\frac{5(9000)(5)^4}{384(180 \times 10^9)I} \leq \frac{5}{200}$

$I \geq \frac{5(9000)(5)^4(200)}{5(384)(180 \times 10^9)}$

$I \geq 1.6276 \times 10^{-5}\ m^4$

$\therefore I \geq 1627.60\ cm^4$

A suitable beam would be:

~~UB 457 × 191 × 82~~

~~as its I = 1870 cm^4~~

~~with a SF of 85% it's 1589 cm^4~~

~~1589 < 1627.6~~

~~∴ We need another beam, let it be:~~

VB 203 × 102 × 23

with I = 2100 cm^4

and applying a SF of 85%

we get I = 1785 cm^4

as 1785 < 1628 cm^4

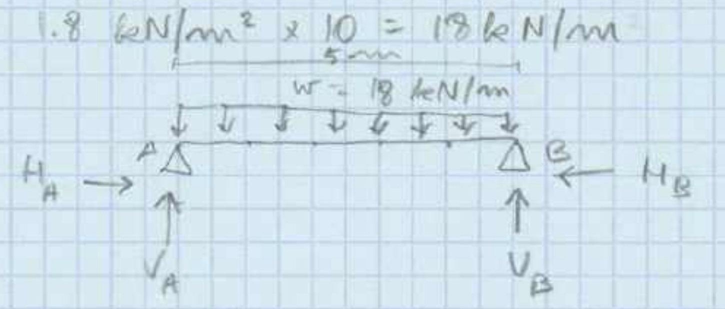
it is a suitable beam

B: Solving for section B, having already sized section A, let's see if the sized beams have to be changed as they overlaps with Section A

Section B as seen in fig X.

The tributary load changes from 5 × 5 m to 10 × 5 m (w × l).

∴ 1.8 kN/m² × 10 = 18 kN/m



$\Sigma F_H = 0$

$\Sigma F_V = 0$ where $V_A = V_B = \frac{wL}{2} = 45$ kN

So there is a change in w in the formula:

$\delta_{max} \leq \delta_{limit}$

$\frac{5wL^4}{384EI} \leq \frac{L}{200}$

$I \leq \frac{5(18000)(5)^4(200)}{5(384)(180 \times 10^9)}$

$I \leq 3255$ cm⁴

∴ UB 254 × 102 × 28 with I = 4000 cm⁴

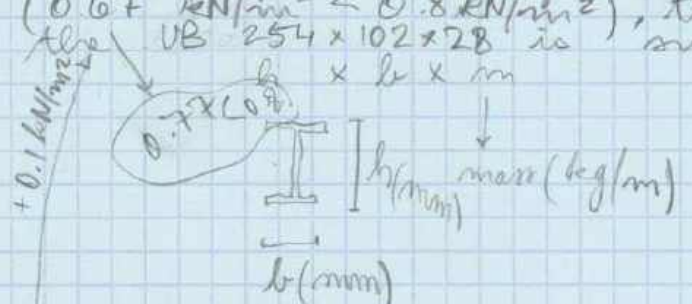
with SF 85% I = 3400 cm⁴

3400 > 3255

∴ Beam is suitable

So we need to change section A from UB 203×102×23 to UB 254×102×28

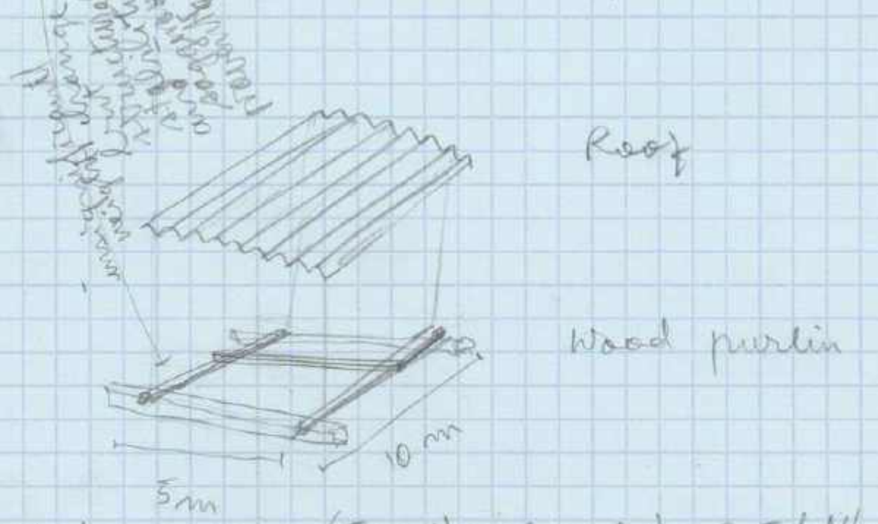
C: Knowing that for a longer span in section C (needed because of crane space under ceiling in auditori space), the load per unit weight is smaller (0.67 kN/m² < 0.8 kN/m²), therefore the UB 254 × 102 × 28 is suitable.



However a thicker core thickness is used (150 mm instead of 80).

To avoid any sagging in the center, secondary wood purlins are put.

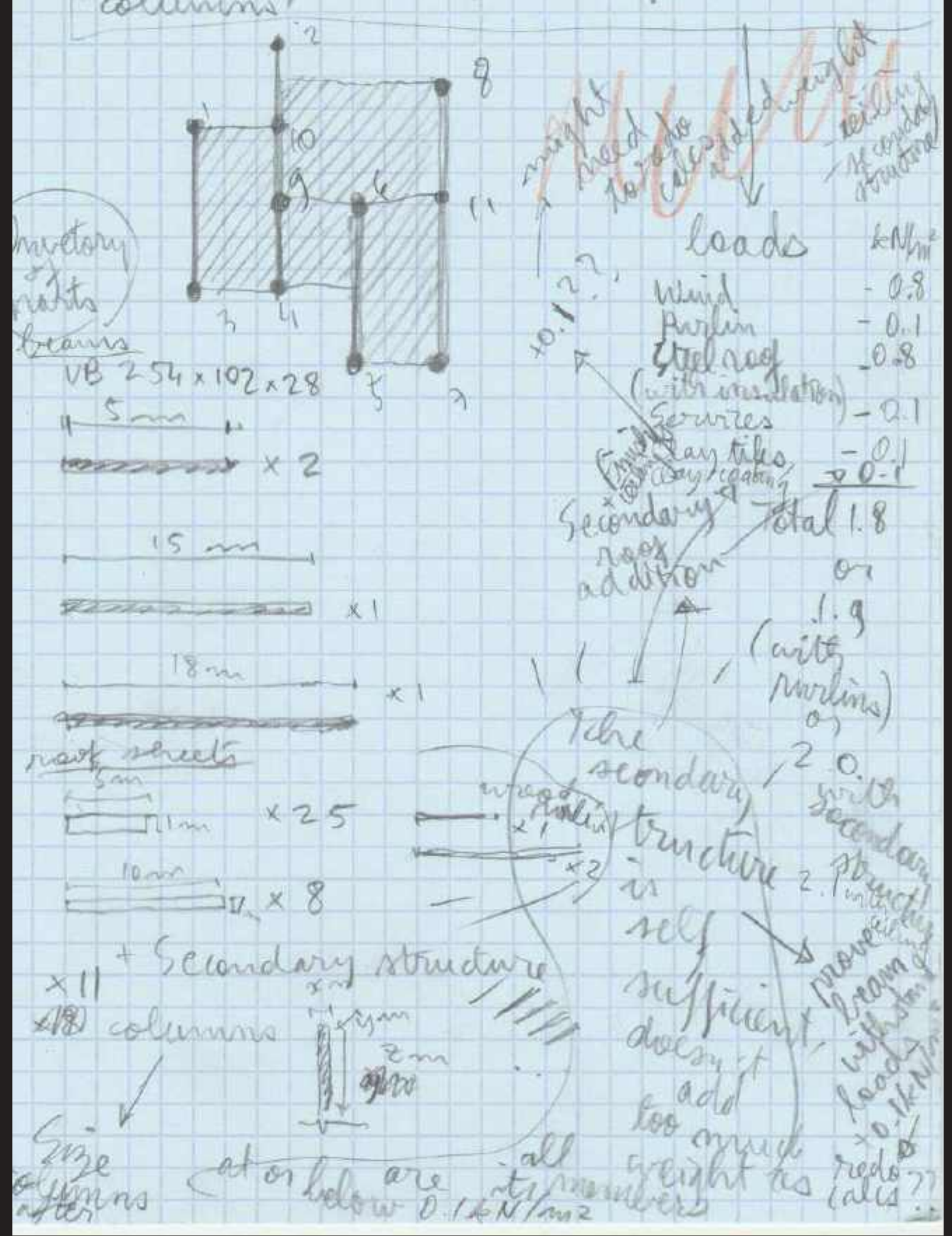
Wood purlin = 0.1 kN/m²

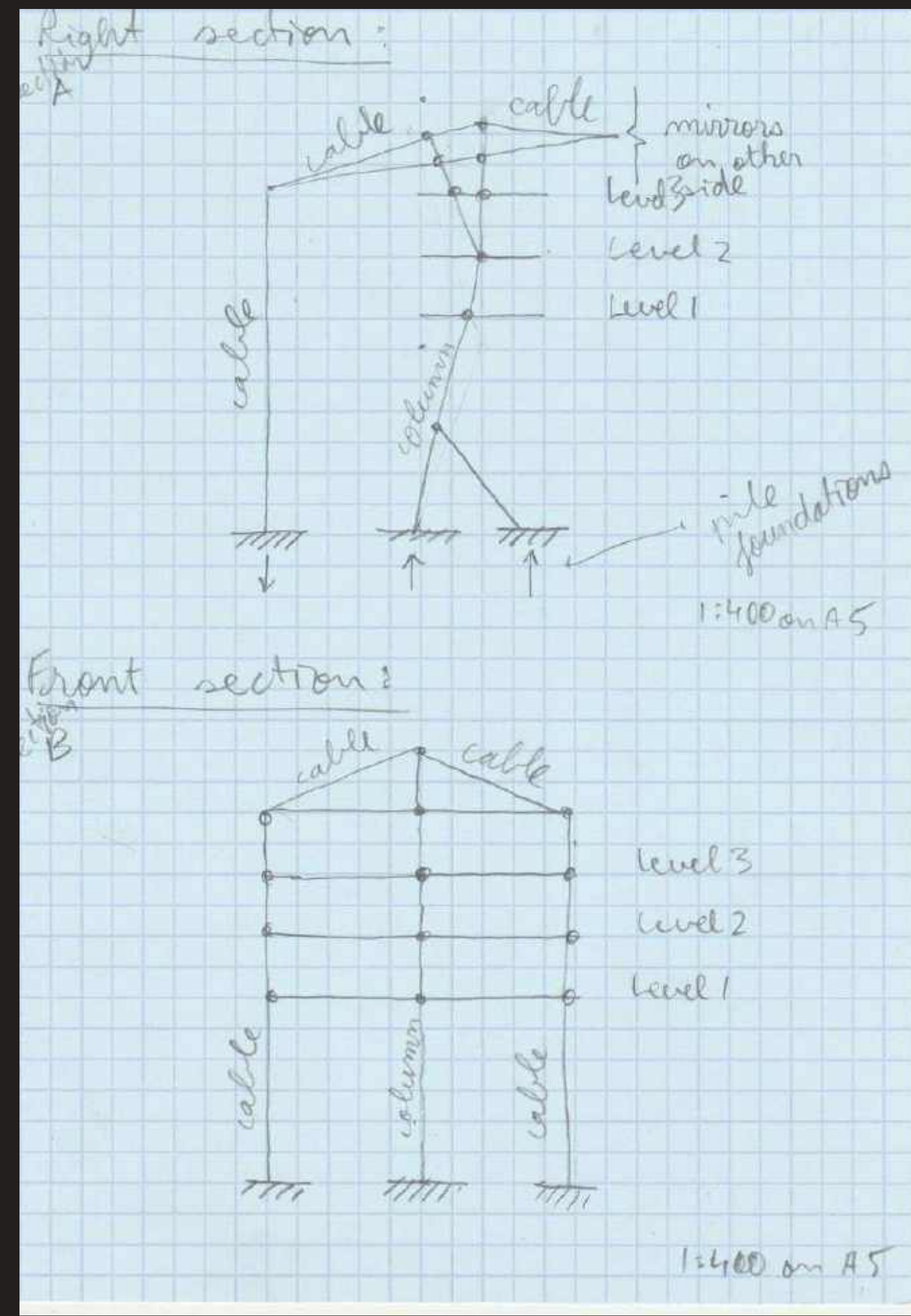


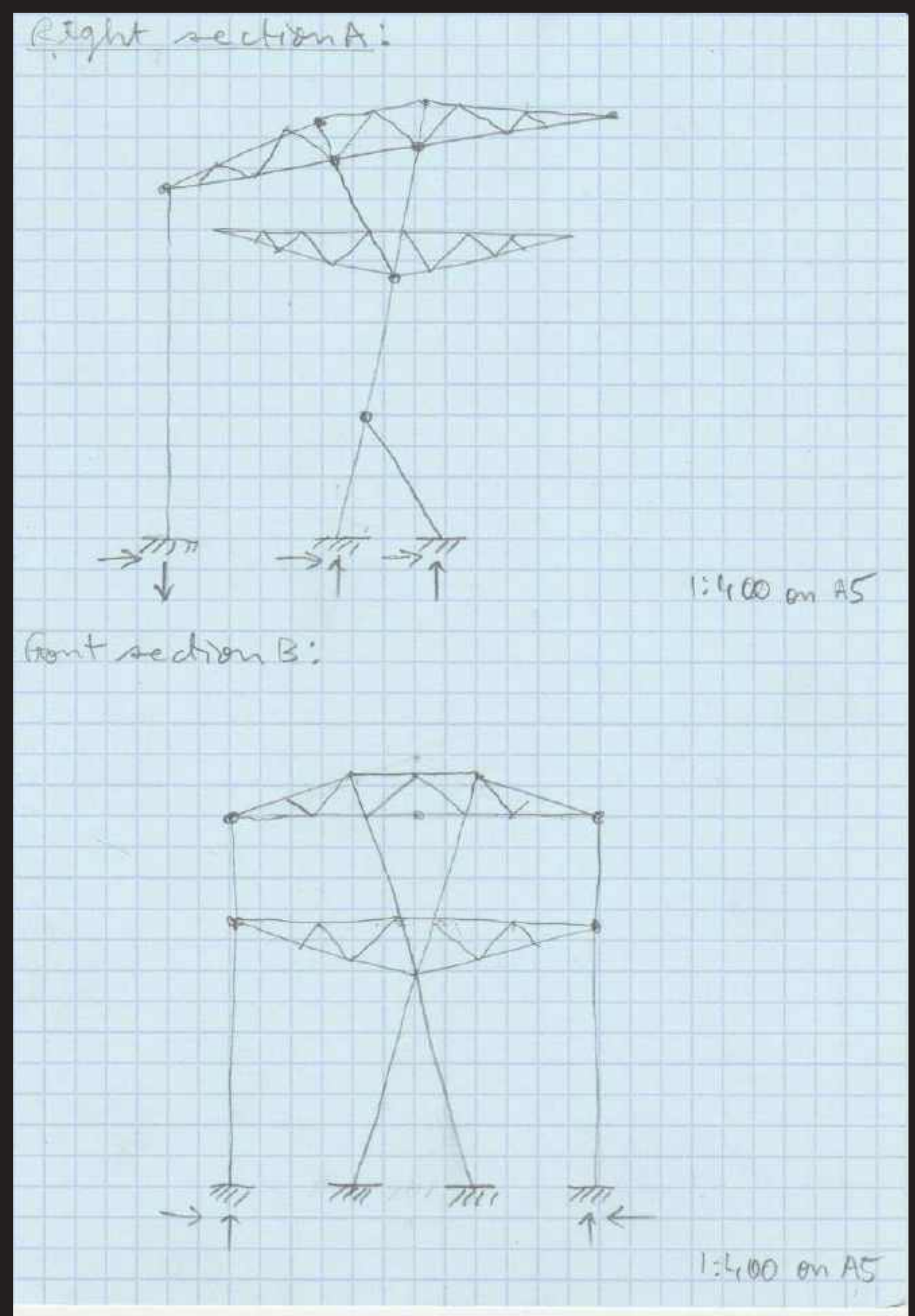
~~added weight = (5×0.1)+2(10×0.1) = 2.5 kN/m~~

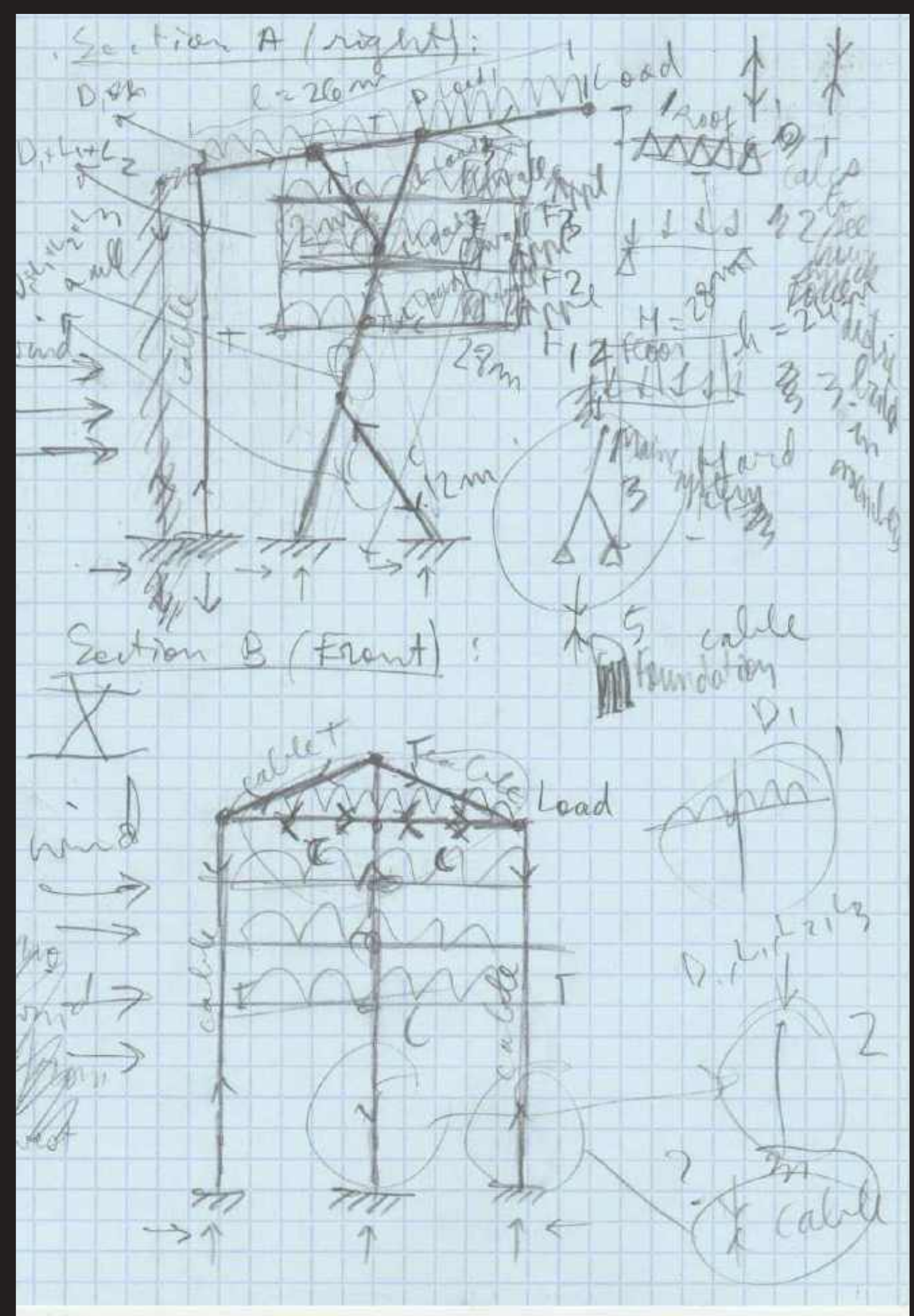
~~∴ added weight = 5×0.1 = 0.5 kN/m~~

D: How much weight is put onto columns?









Combined Bending and Direct Stress

combination of axial load and bending about 2 axes

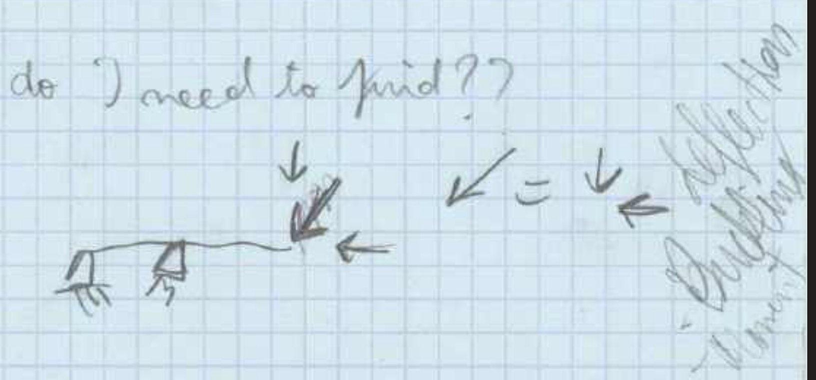
P = dead load + 3(live loads)

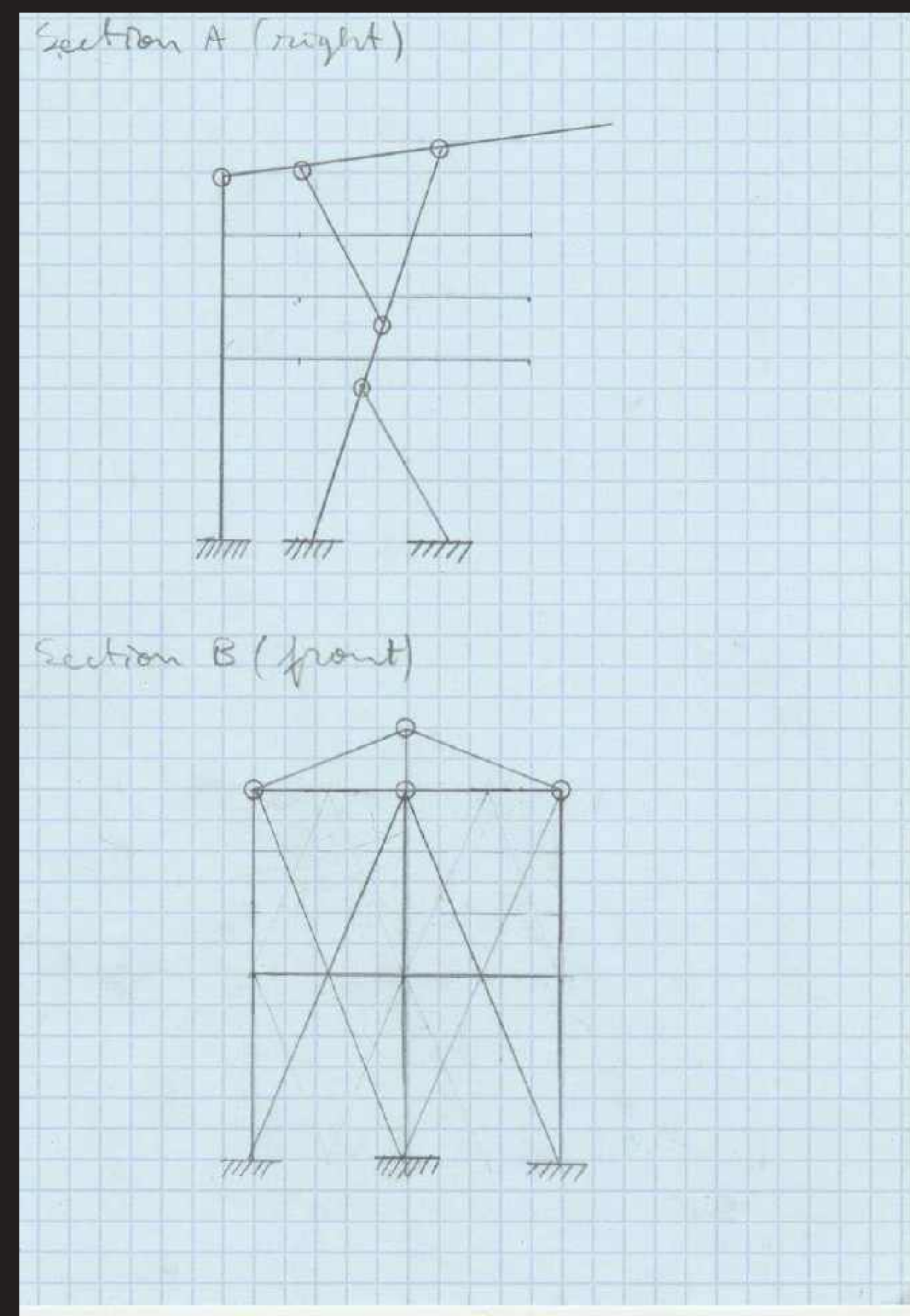
where dead load = 2.1 kN/m² + 3(0.95)
= 4.95 kN/m²

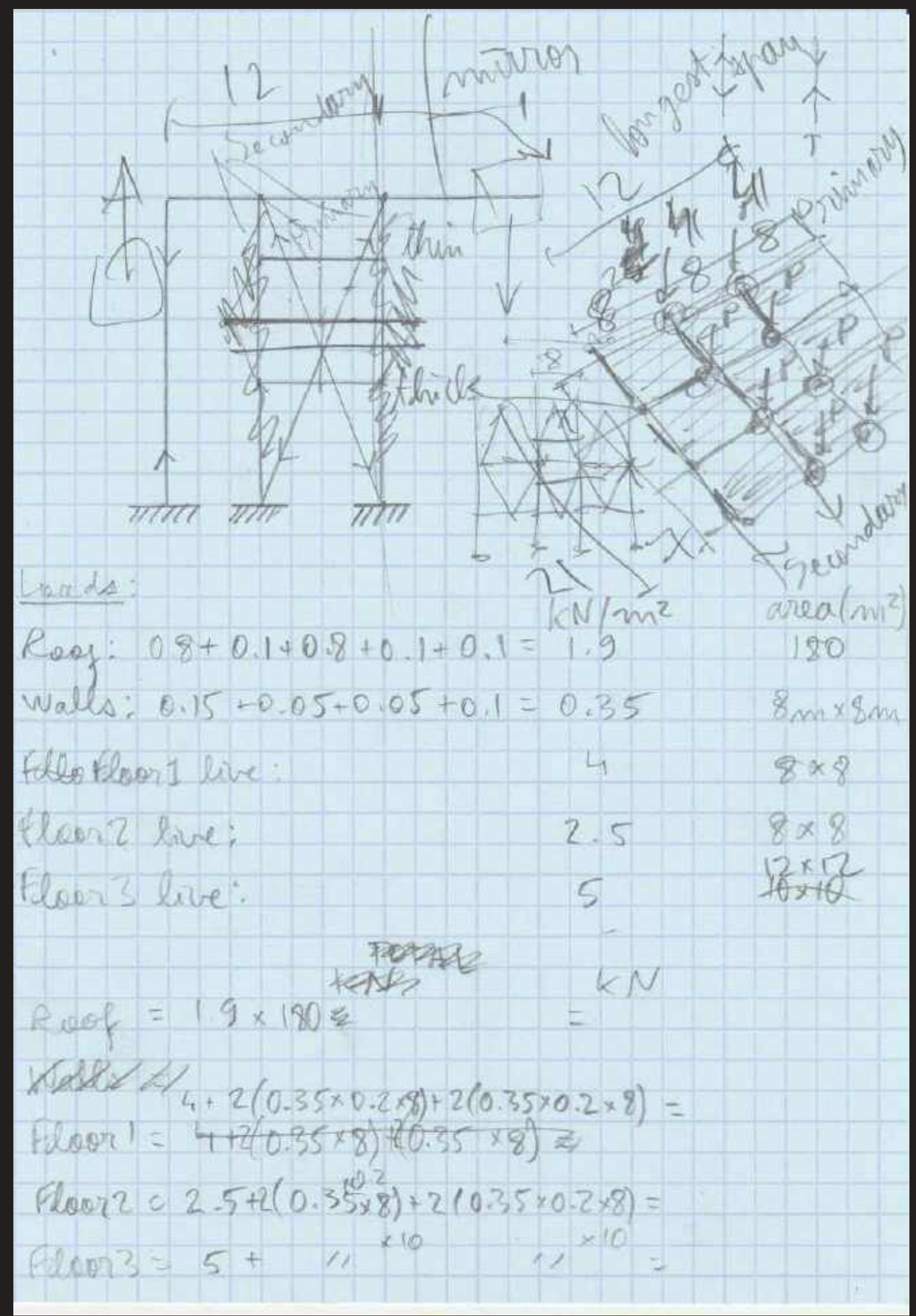
and live load = 17 kN/m²

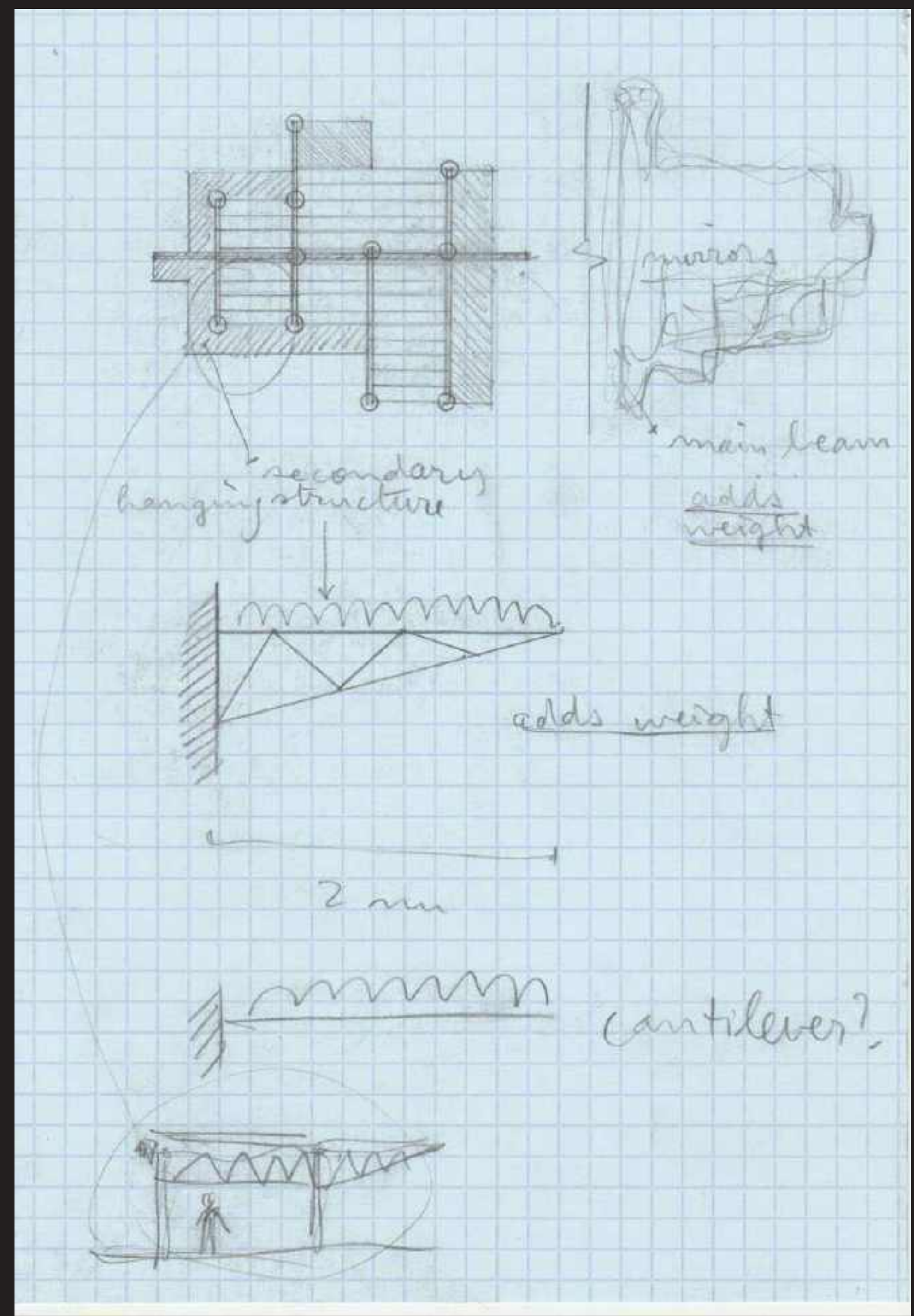
Total P = 4.95 + 17 ≈ 22 kN/m²

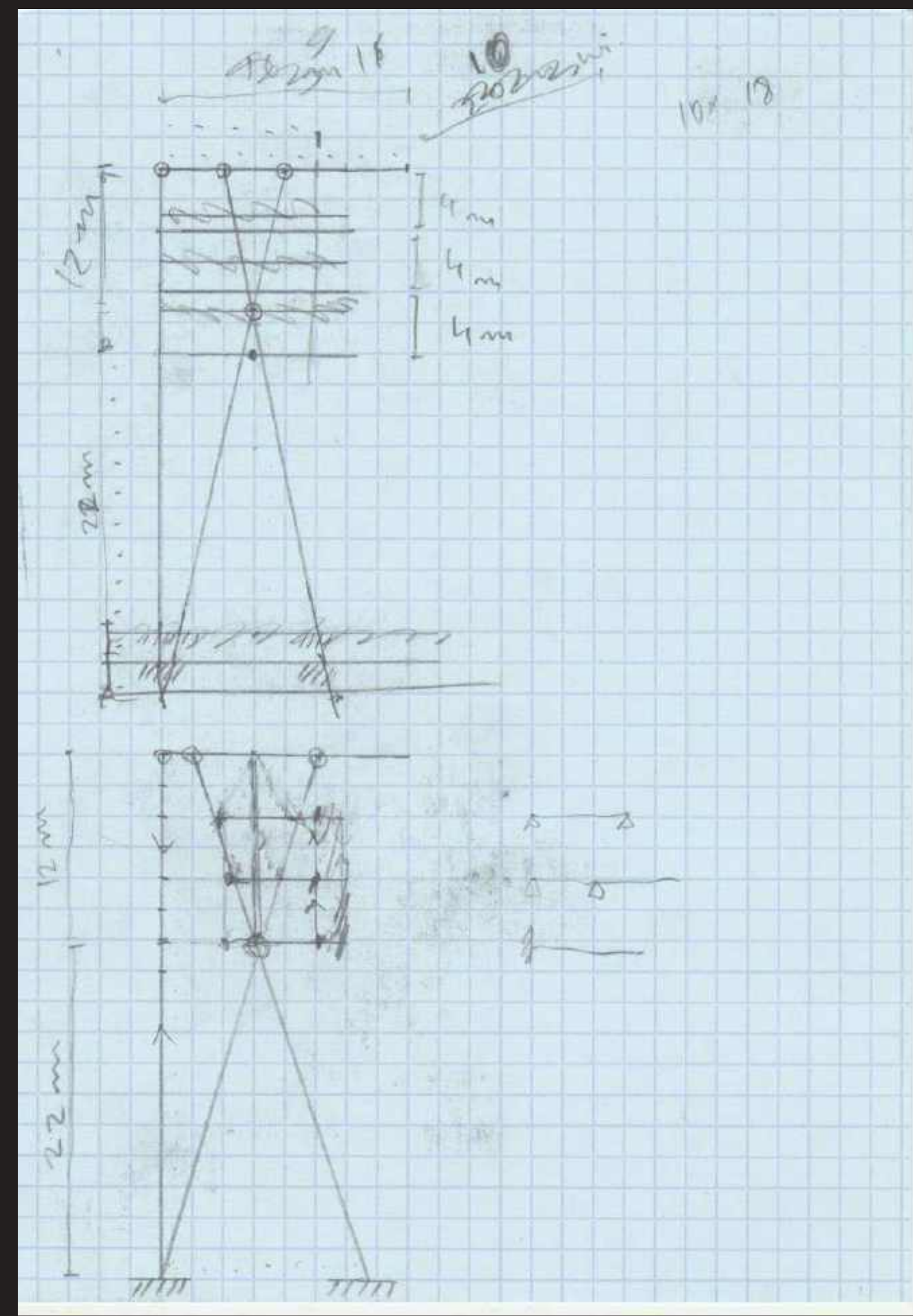
What do I need to find??

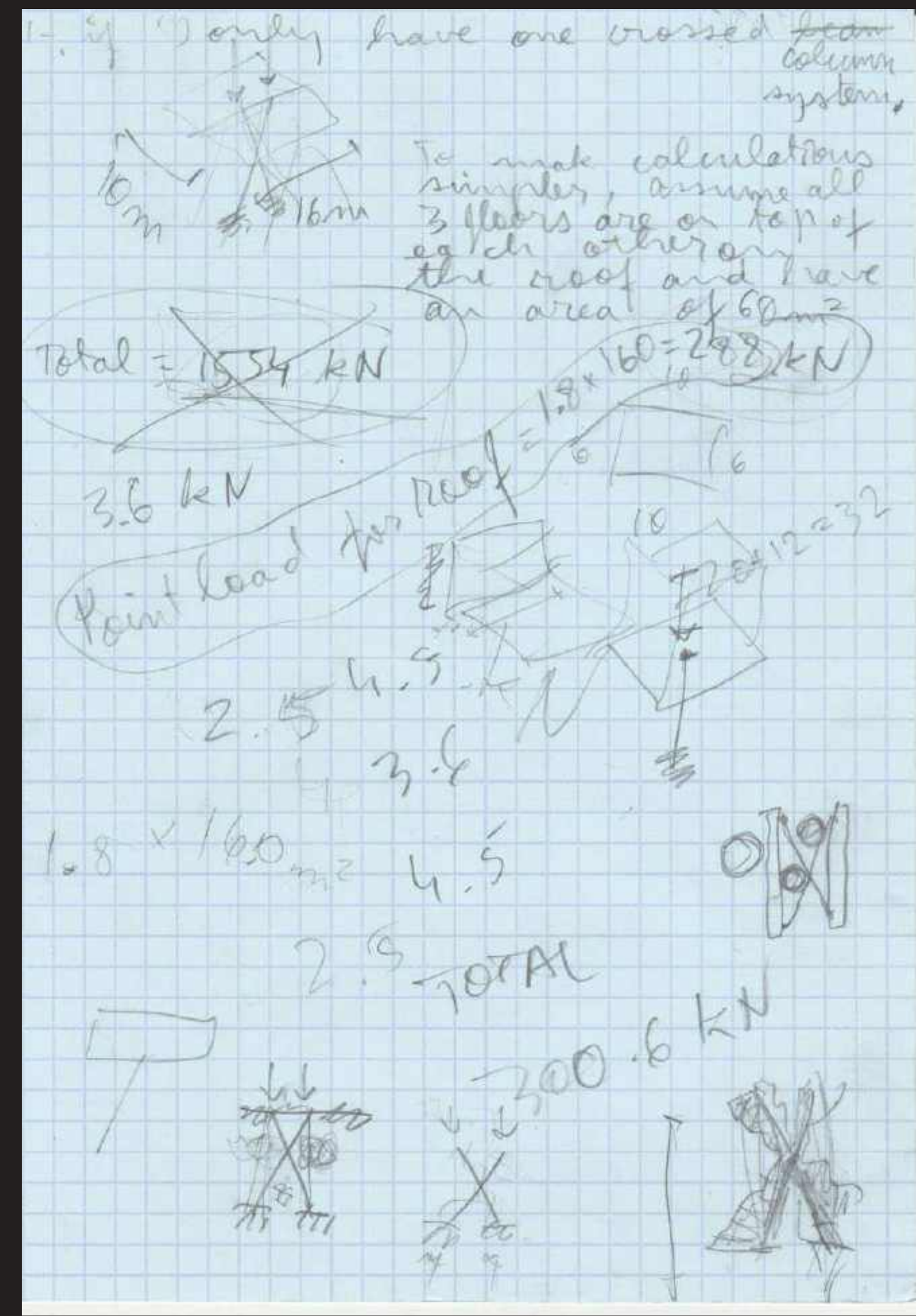


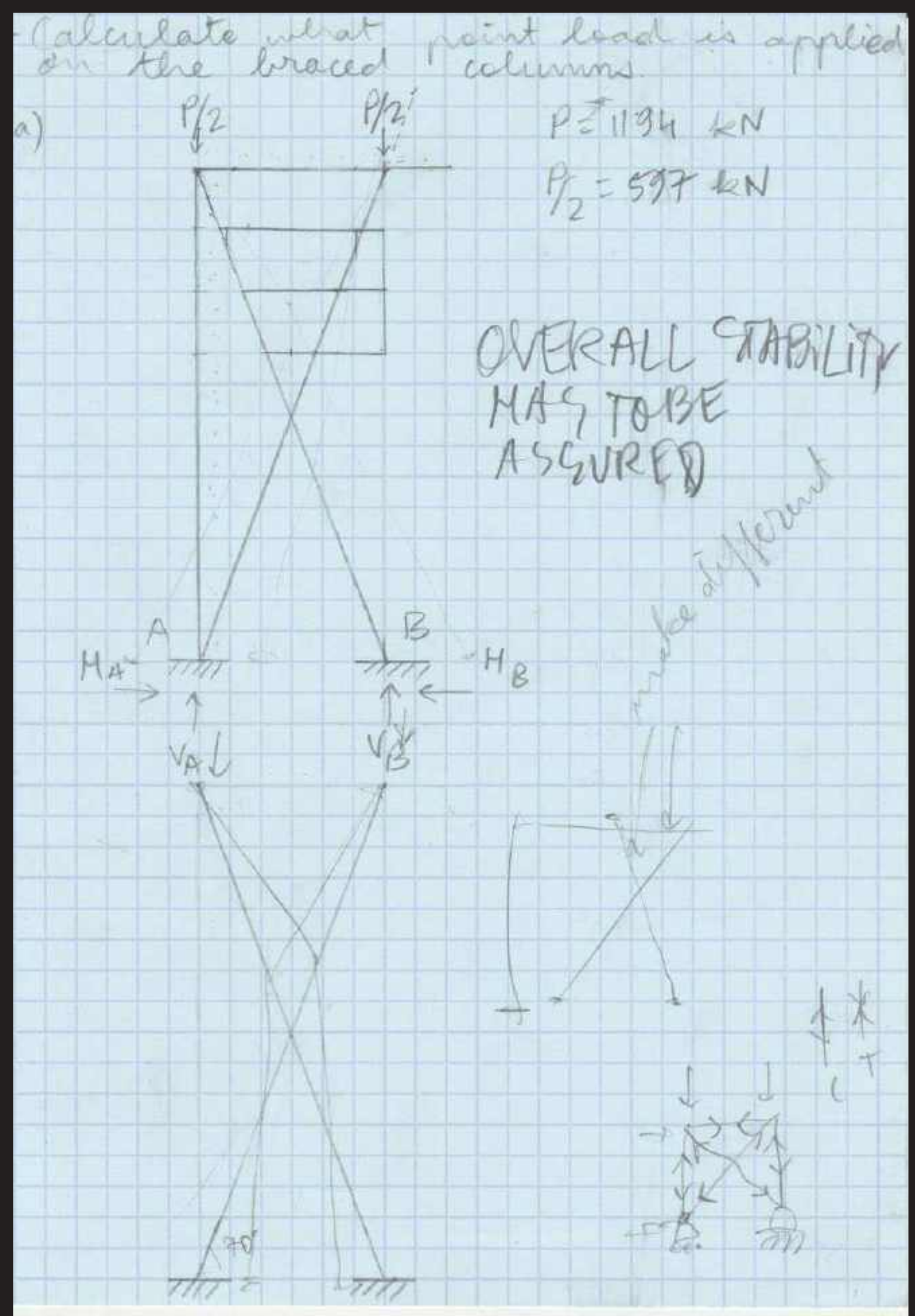


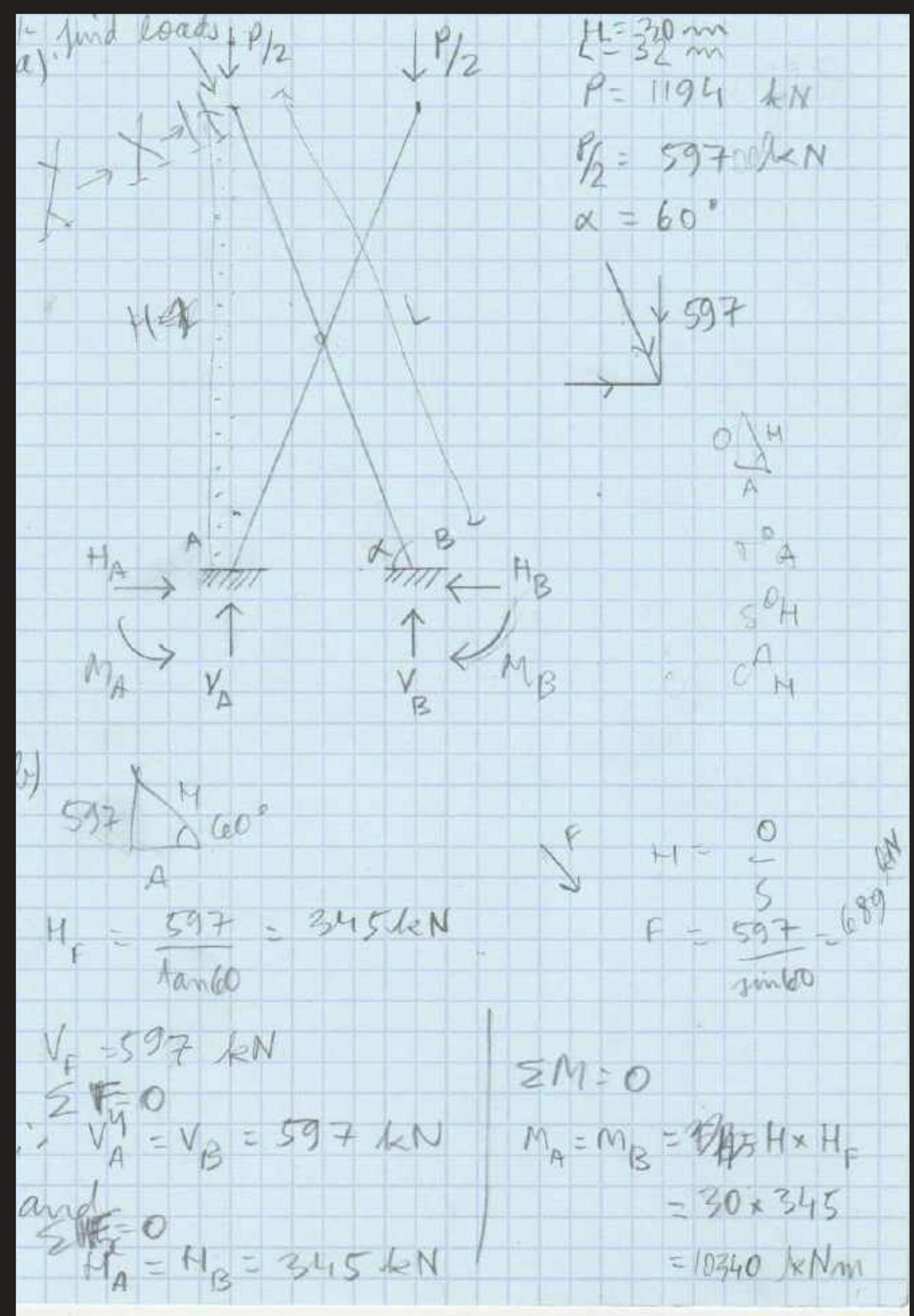

12
mirror
longest span
12
primary
secondary
thin
thick
21
Loads:
kN/m²
area(m²)
Roof: 0.8+0.1+0.8+0.1+0.1 = 1.9 180
Walls: 0.15+0.05+0.05+0.1 = 0.35 8m×8m
Floor1 live: 4 8×8
Floor2 live: 2.5 8×8
Floor3 live: 5 12×12
kN
Roof = 1.9 × 180 =
Floor1 = 4+2(0.35×8)+2(0.35×8) =
Floor2 = 2.5+2(0.35×8)+2(0.35×0.2×8) =
Floor3 = 5+

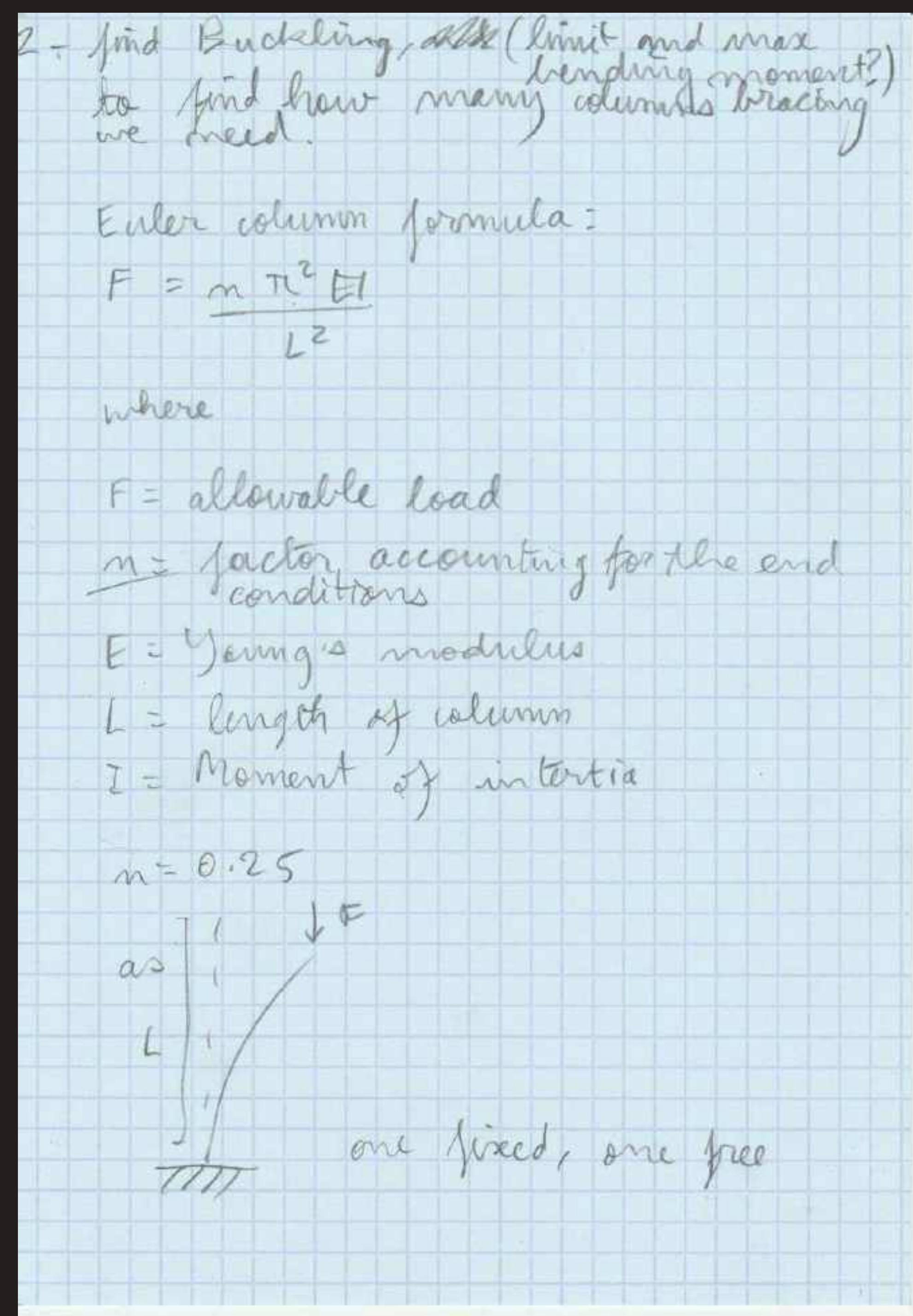

mirrors
secondary hanging structure
main beam
adds weight
adds weight
2 m
cantilever?

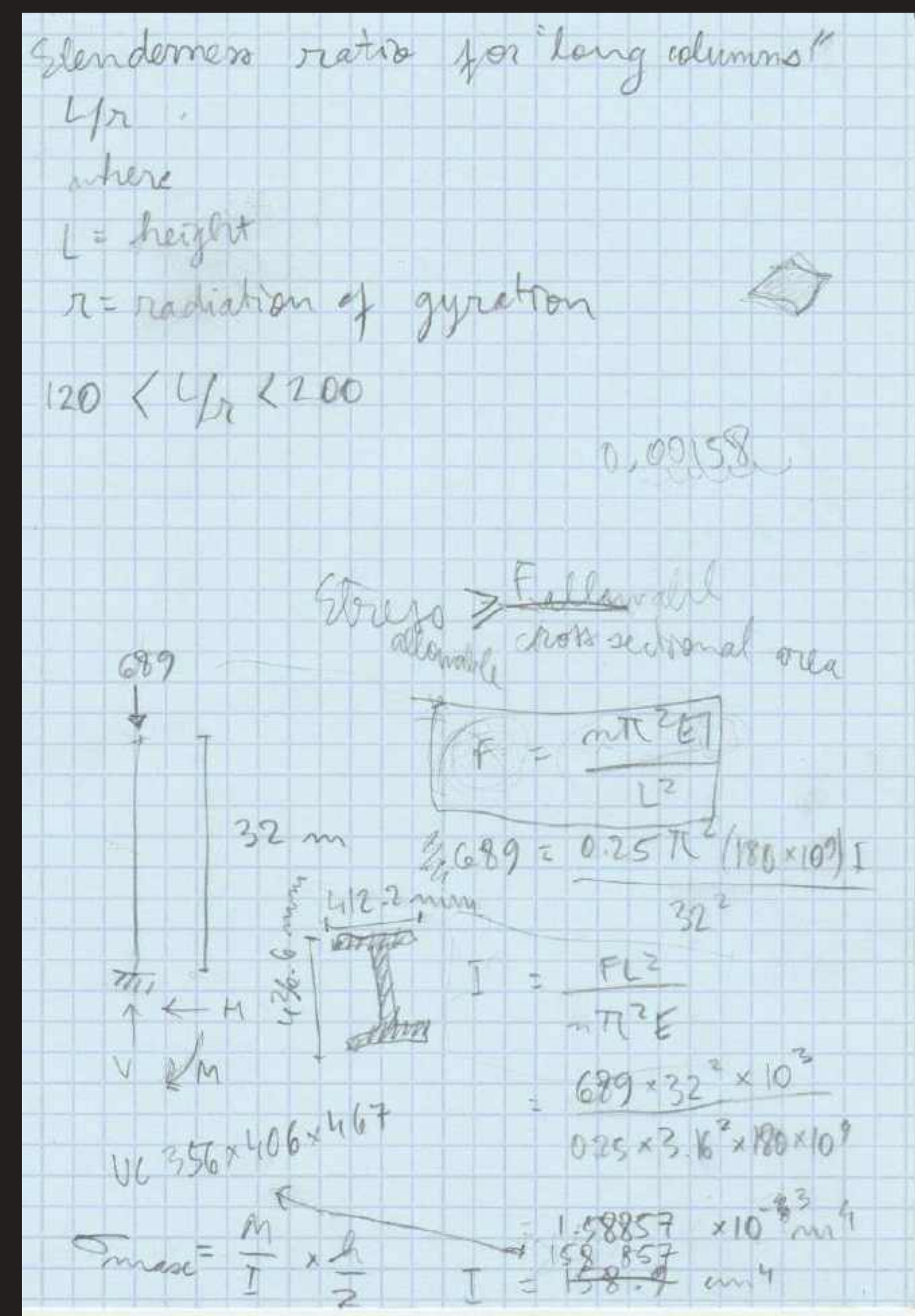

10×18
4 m
4 m
4 m
12 m
22 m
12 m
22 m

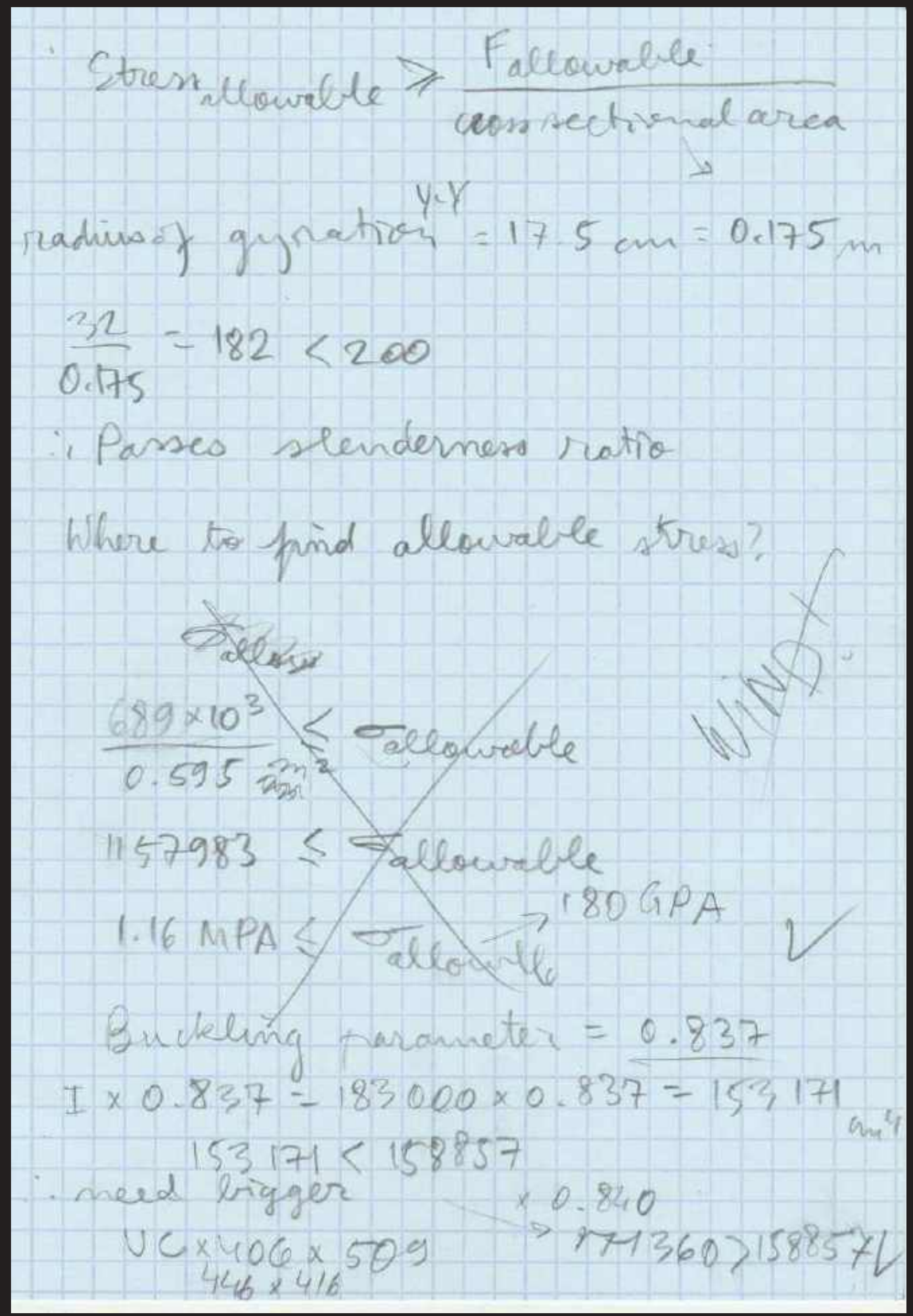

If I only have one crossed column system,
To make calculations simpler, assume all 3 floors are on top of each other on the roof and have an area of 60m²
Total = 1554 kN
3.6 kN
Point load for roof = 1.8 × 160 = 288 kN
10 m
16 m
2.5
4.5
3.6
1.8 × 160 m²
TOTAL
1200.6 kN

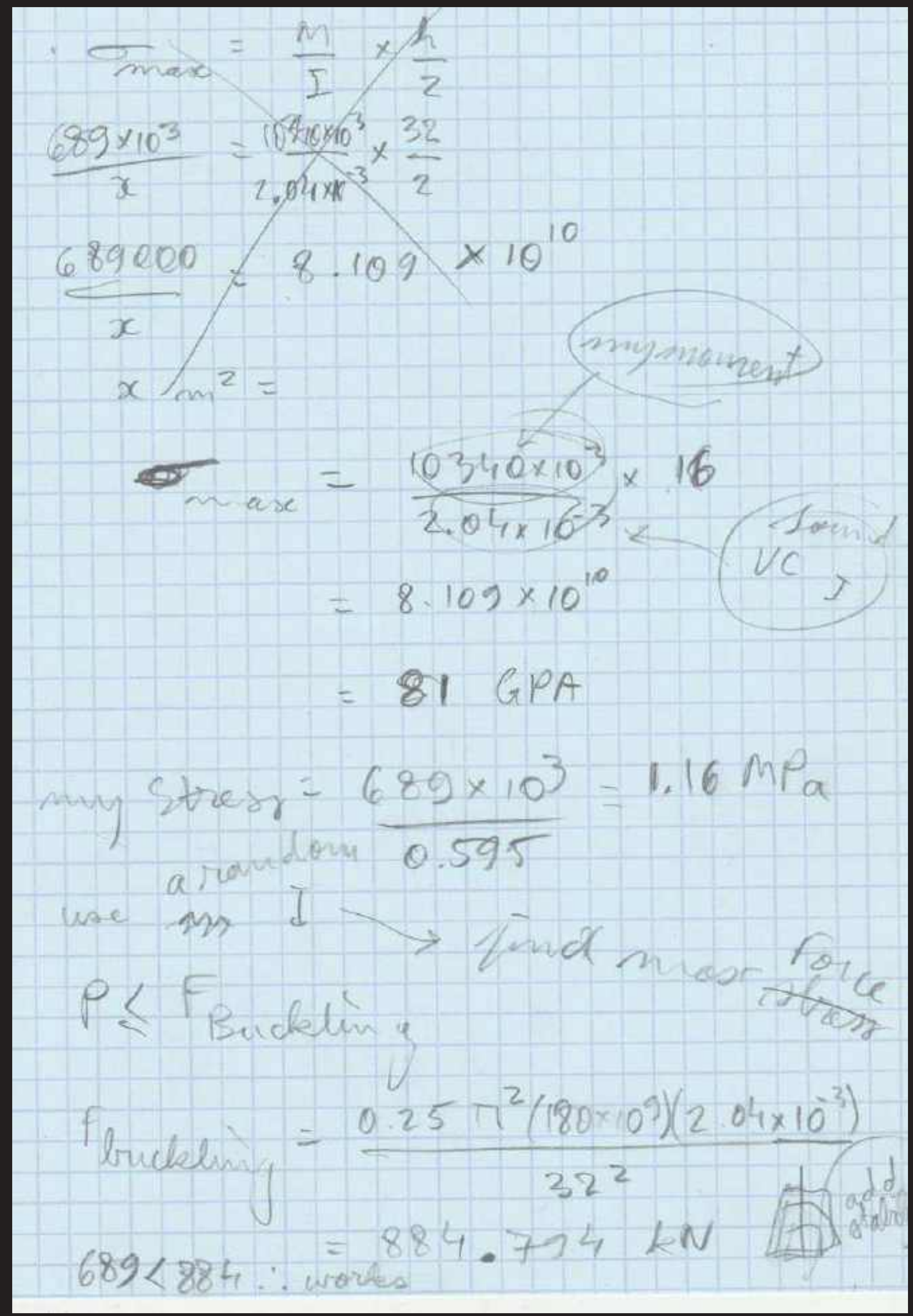

Calculate what point load is applied on the braced columns
a)
P/2
P/2
P = 1194 kN
P/2 = 597 kN
OVERALL STABILITY HAS TO BE ASSURED
A
B
H_A
H_B
V_A
V_B

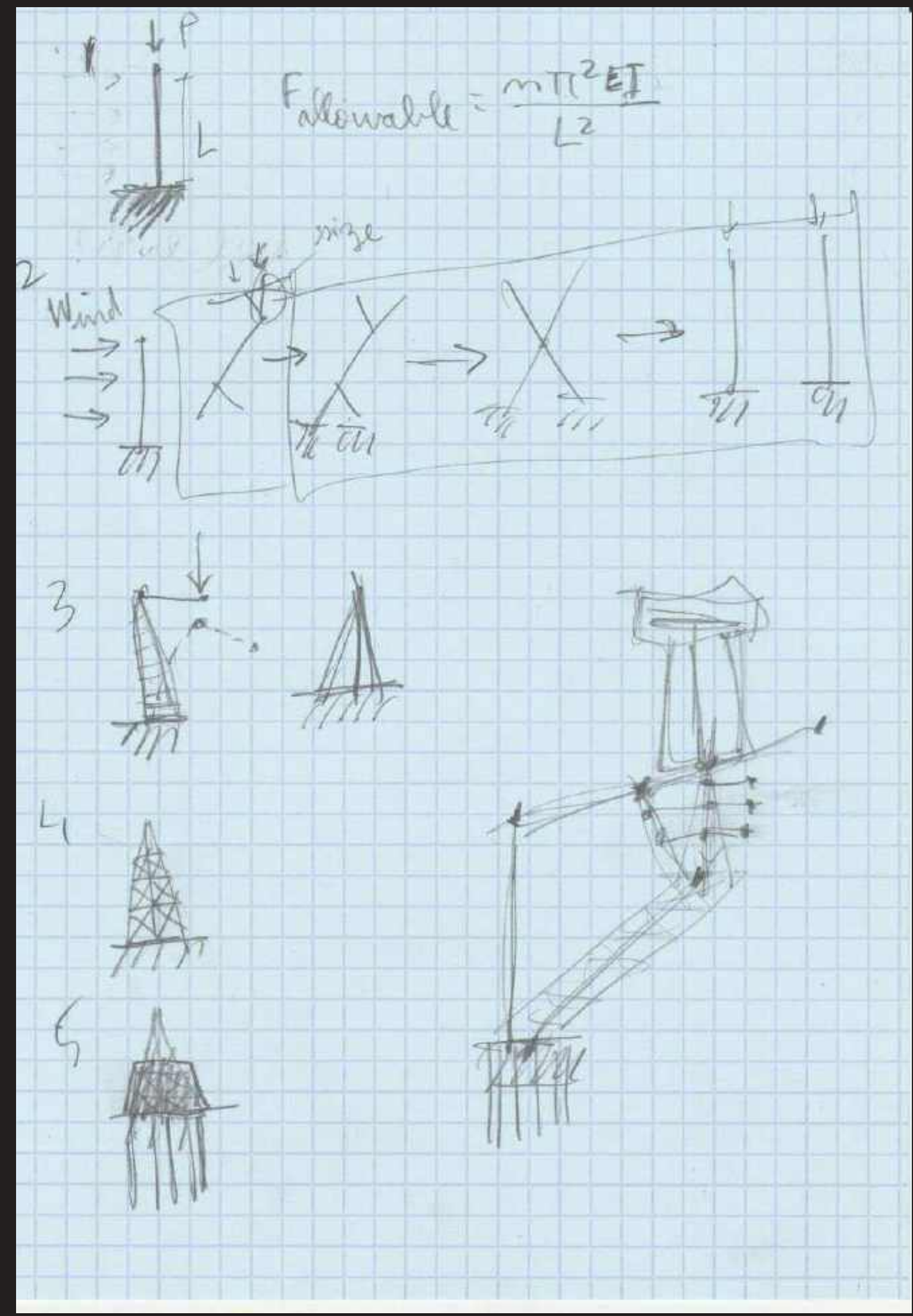

find loads
P/2
P/2
H = 30 m
L = 32 m
P = 1194 kN
P/2 = 597 kN
α = 60°
597
H_F = 597/tan60 = 345 kN
F = 597/sin60 = 689 kN
V_F = 597 kN
ΣF = 0
V_A = V_B = 597 kN
and ΣF = 0
H_A = H_B = 345 kN
ΣM = 0
M_A = M_B = H × H_F
= 30 × 345
= 10340 kNm

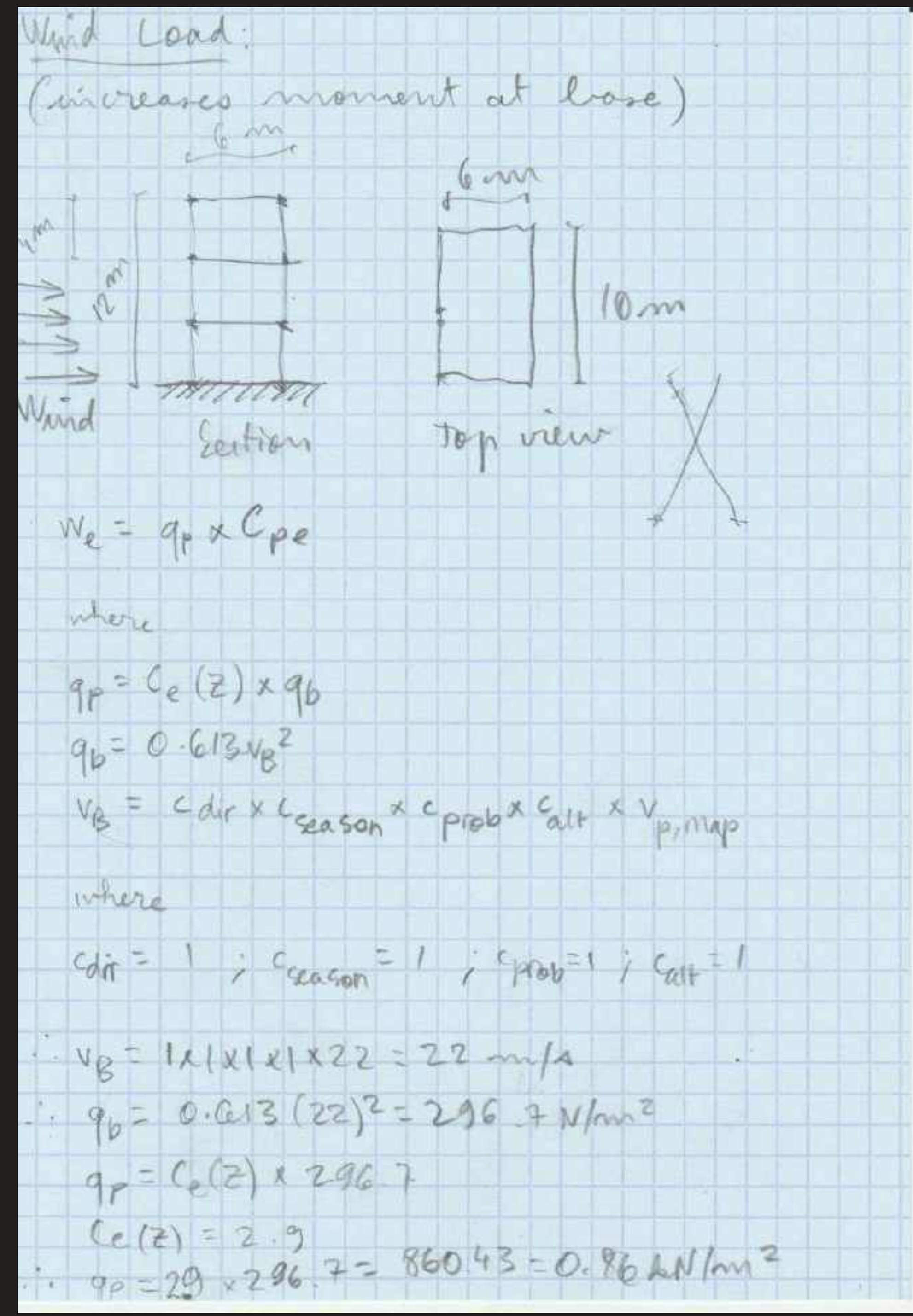

2. find Buckling (limit and max bending moment?) to find how many columns bracing we need.
Euler column formula:
F = nπ²EI / L²
where
F = allowable load
n = factor accounting for the end conditions
E = Young's modulus
L = length of column
I = Moment of intertia
n = 0.25
one fixed, one free

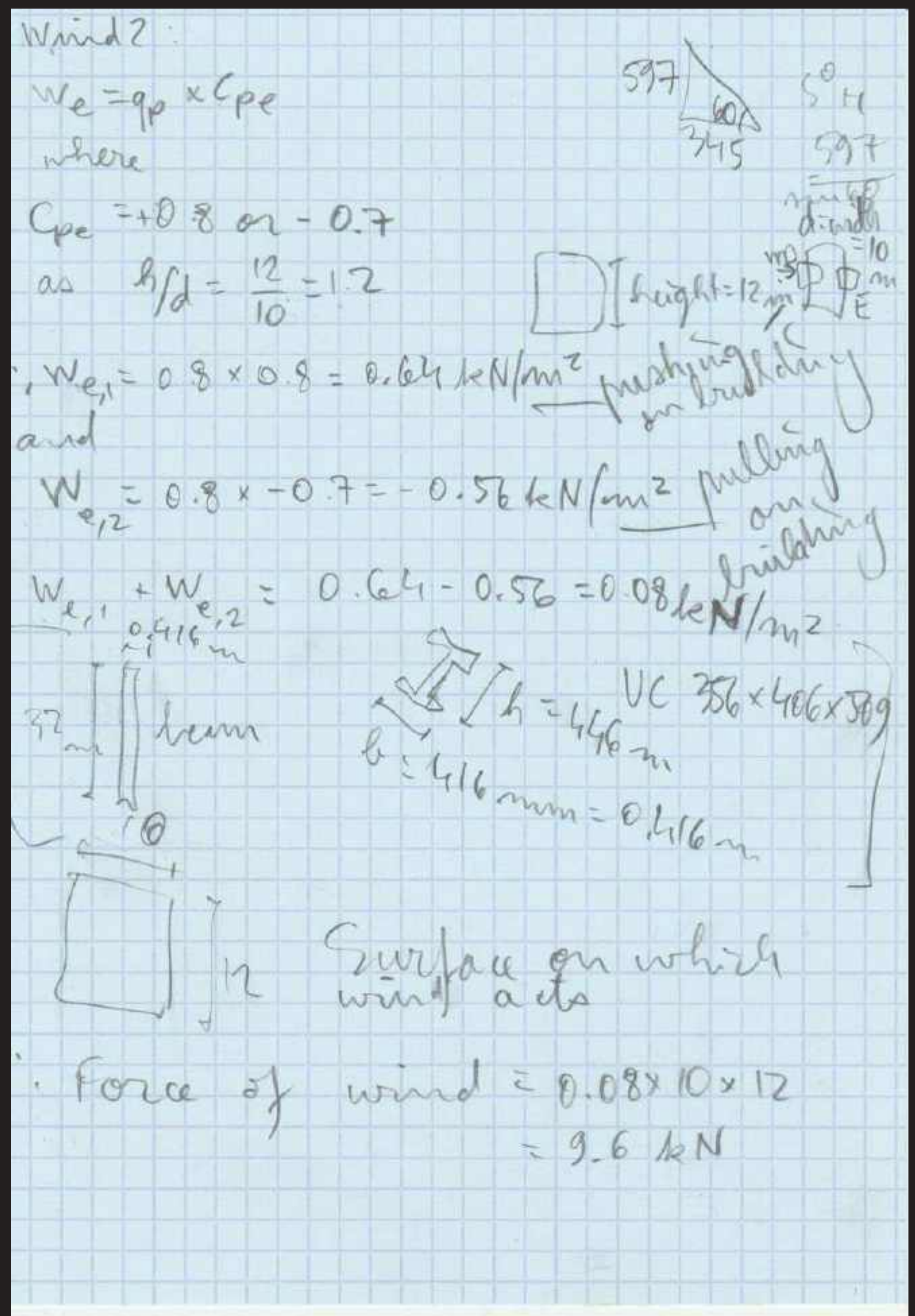

Slenderness ratio for "long columns"
L/r
where
L = height
r = radiation of gyration
120 < L/r < 200
0.00158
Stress = F allowable / cross sectional area
F = nπ²EI / L²
689 = 0.25π²(180×10⁹)I / 32²
I = FL² / nπ²E
= 689×32²×10³ / 0.25×3.16²×180×10⁹
= 1.58857 ×10⁻³ m⁴
I = 158857 cm⁴
689
32 m
412.2 mm
UC 356×406×467
σmax = M/I × h/2

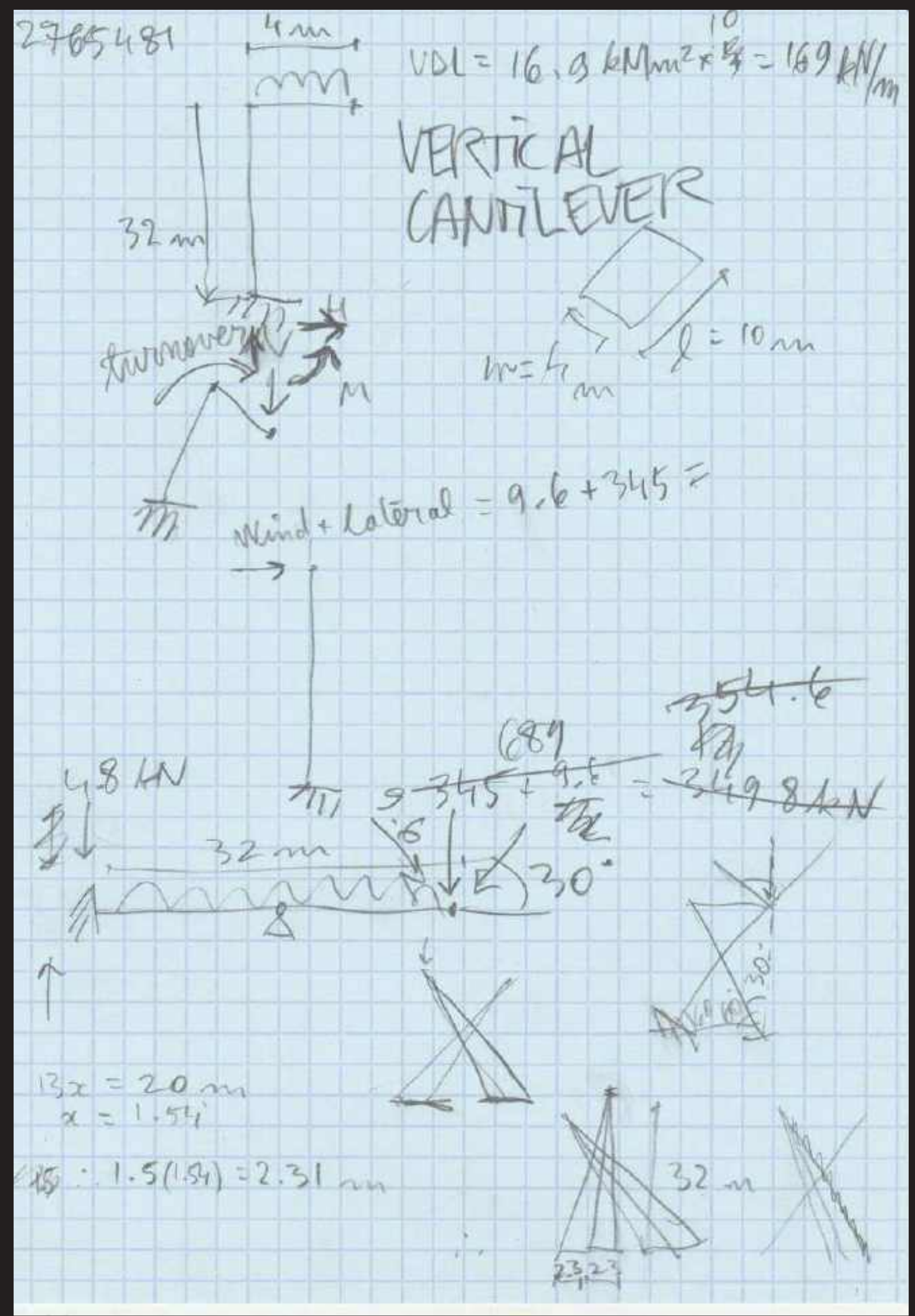

Stress allowable → F allowable / cross sectional area
radius of gyration = 17.5 cm = 0.175 m
32 / 0.175 = 182 < 200
∴ Passes slenderness ratio
Where to find allowable stress?
689×10³ / 0.595 ≤ F allowable
1157983 ≤ F allowable
1.16 MPA ≤ F allowable
180 GPA
WIND?
Buckling parameter = 0.837
I × 0.837 = 183000 × 0.837 = 153171
153171 < 158857
∴ need bigger
UC×406×509
× 0.840

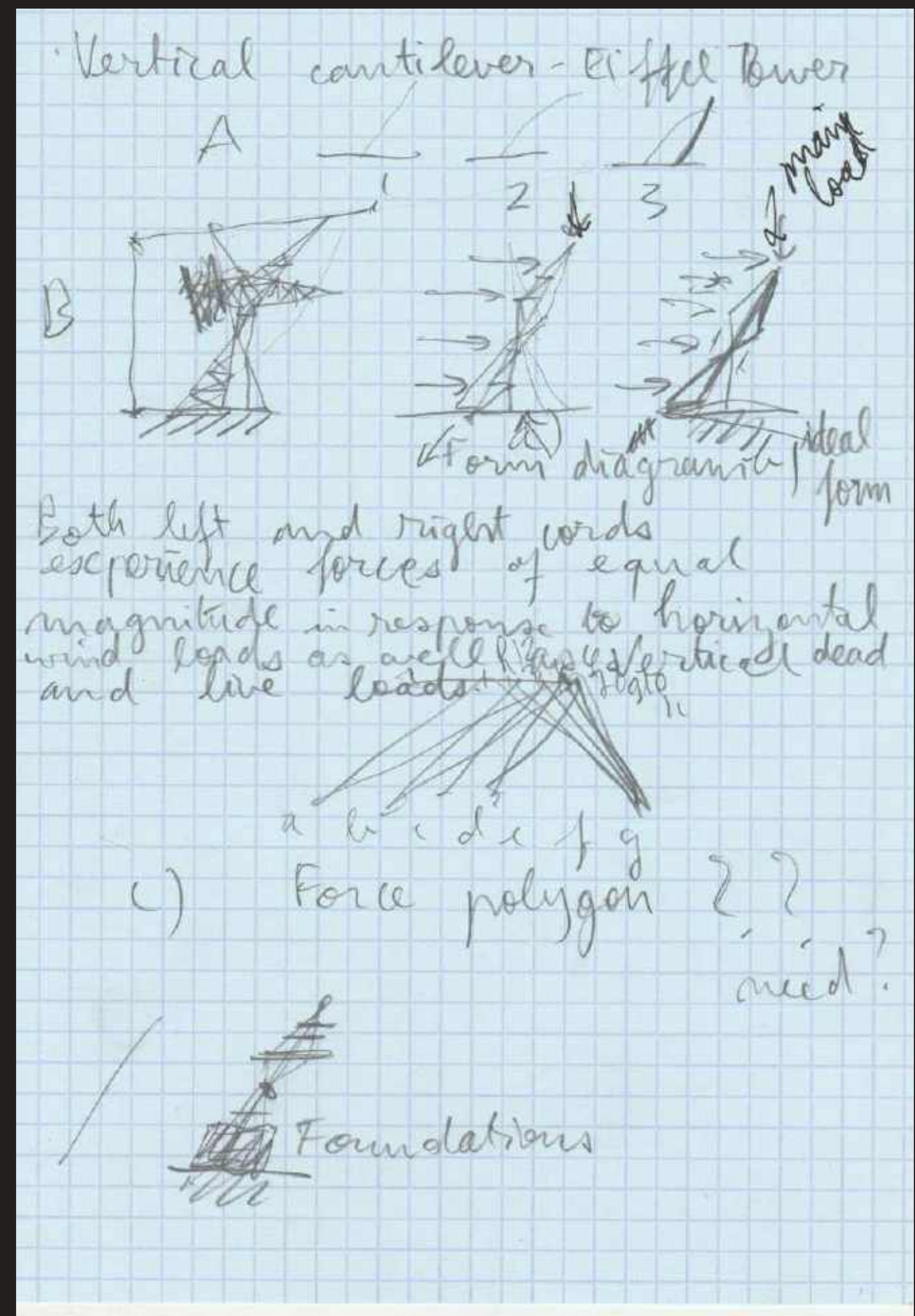

σmax = M / I × h / 2
689×10³ / x
689000 / x = 8.109 × 10¹⁰
my moment
σmax = 0340×10³ / 2.04×10⁻³ × 16
= 8.109×10¹⁰
= 81 GPA
my Stress = 689×10³ / 0.595 = 1.16 MPa
use a random I → find max force
P ≤ F Buckling
F buckling = 0.25 π²(180×10⁹)(2.04×10⁻³) / 32²
= 884.794 kN
689 < 884 ∴ works

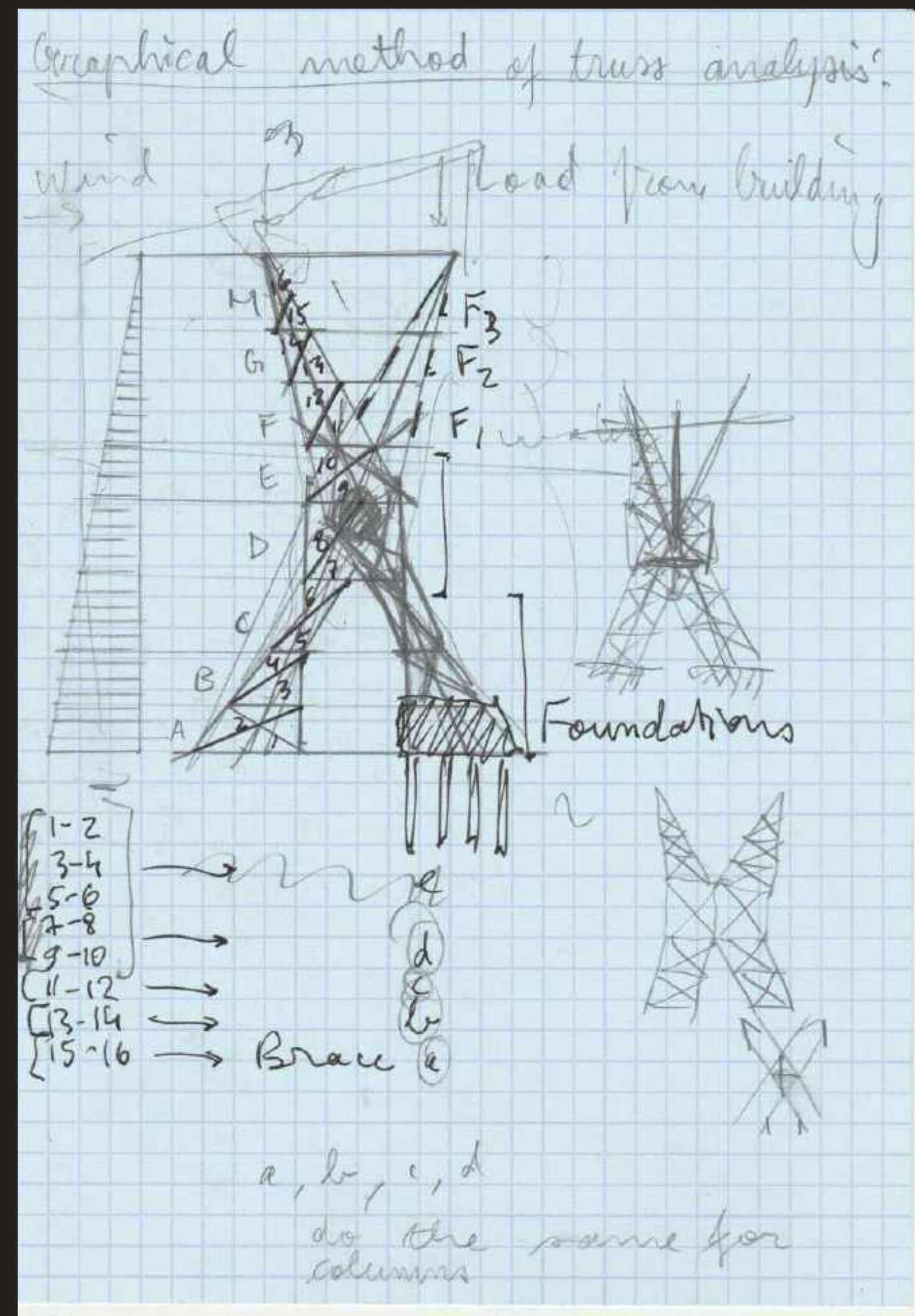

F allowable = nπ²EI / L²
Wind

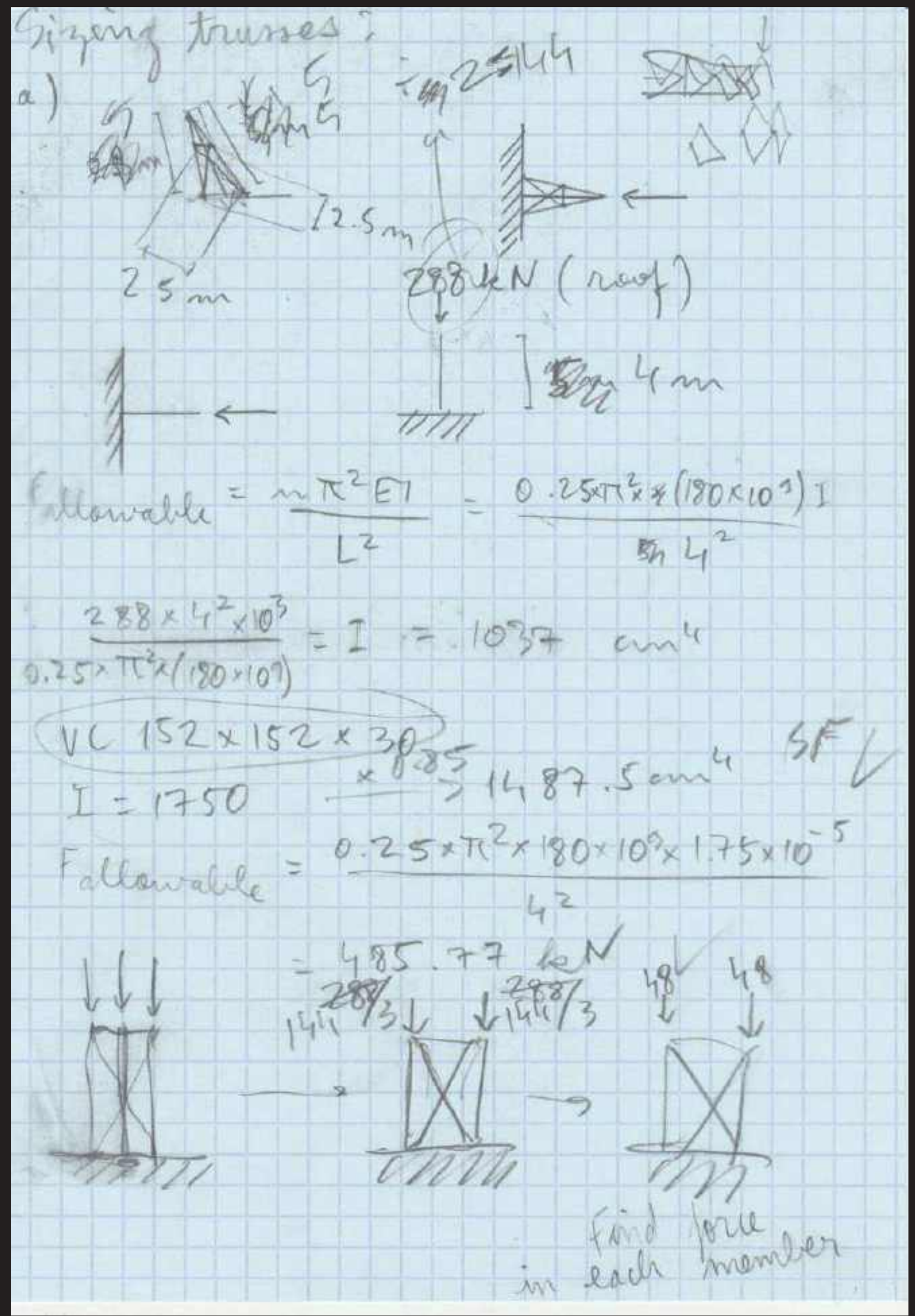

Wind Load:
(increases moment at base)
6 m
10 m
Wind
Section
Top view
We = qp × Cpe
where
qp = Ce(z) × qb
qb = 0.613 vB²
vB = Cdir × Cseason × Cprob × Calt × Vb,map
where
Cdir = 1 ; Cseason = 1 ; Cprob = 1 ; Calt = 1
∴ vB = 1×1×1×1×22 = 22 m/s
∴ qb = 0.613 (22)² = 296.7 N/m²
qp = Ce(z) × 296.7
Ce(z) = 2.9
qp = 2.9 × 296.7 = 860.43 = 0.86 kN/m²

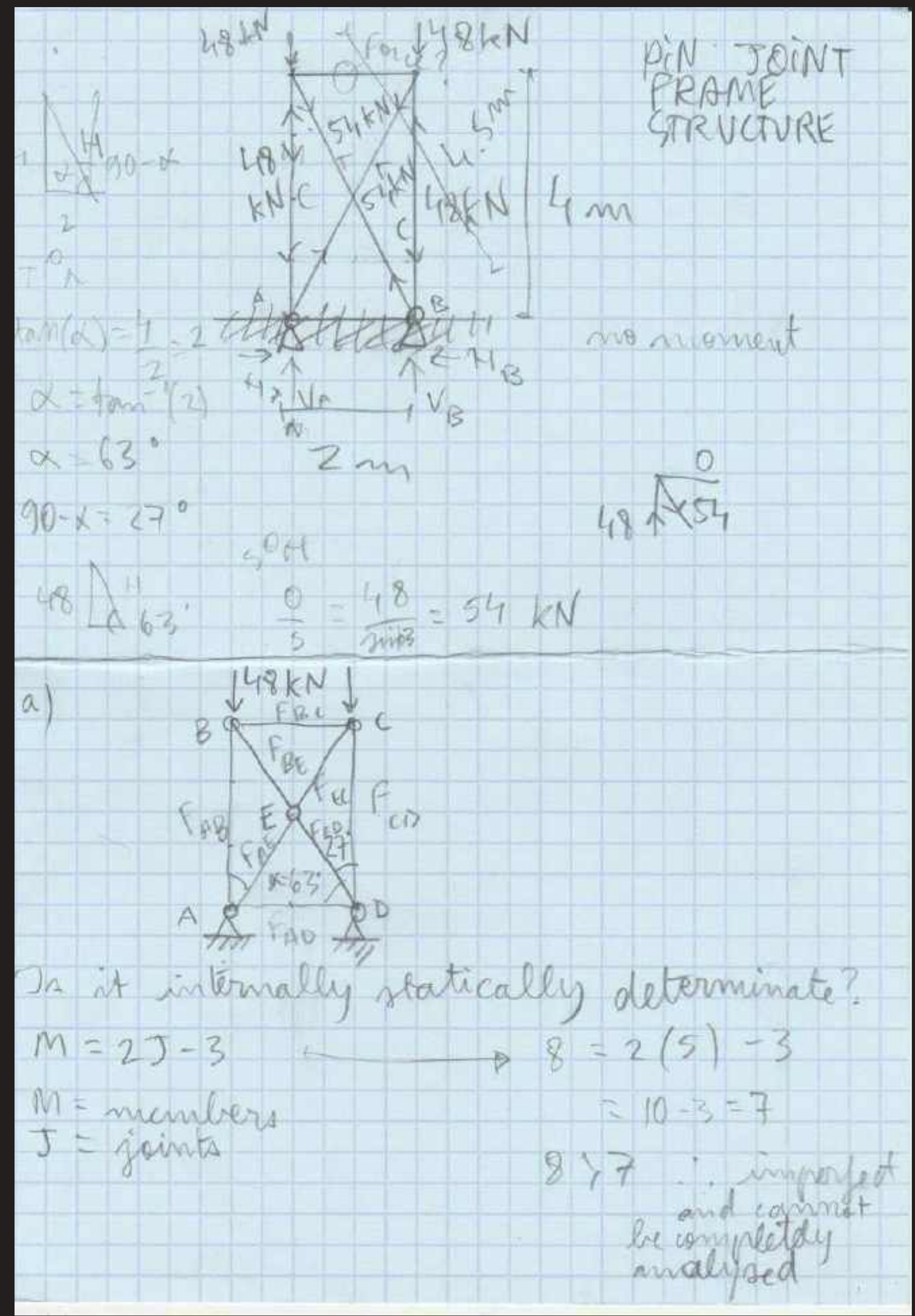

Wind?
We = qp × Cpe
where
Cpe = +0.8 or -0.7
as h/d = 12/10 = 1.2
∴ We,1 = 0.8 × 0.8 = 0.64 kN/m² pushing on building
and
We,2 = 0.8 × -0.7 = -0.56 kN/m² pulling on building
We,1 + We,2 = 0.64 - 0.56 = 0.08 kN/m²
UC 356×406×509
h = 446 mm
b = 416 mm = 0.416 m
Surface on which wind acts
∴ Force of wind = 0.08 × 10 × 12
= 9.6 kN

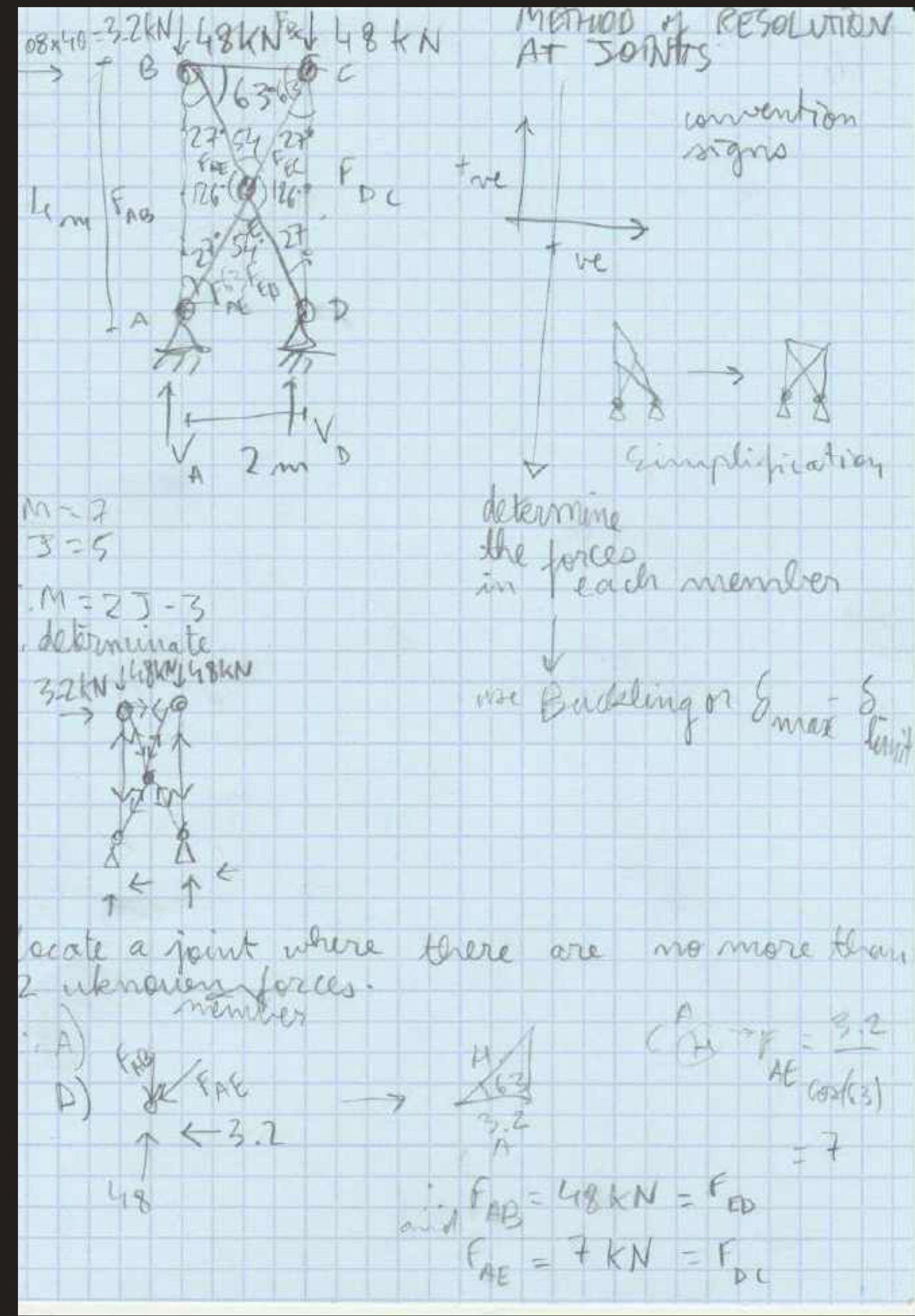

VERTICAL CANTILEVER
UDL = 16.9 kN/m² × 10 = 169 kN/m
32 m
l = 10 m
Wind + Lateral = 9.6 + 345 =
4.8 kN
32 m
30°
13x = 20 m
x = 1.54

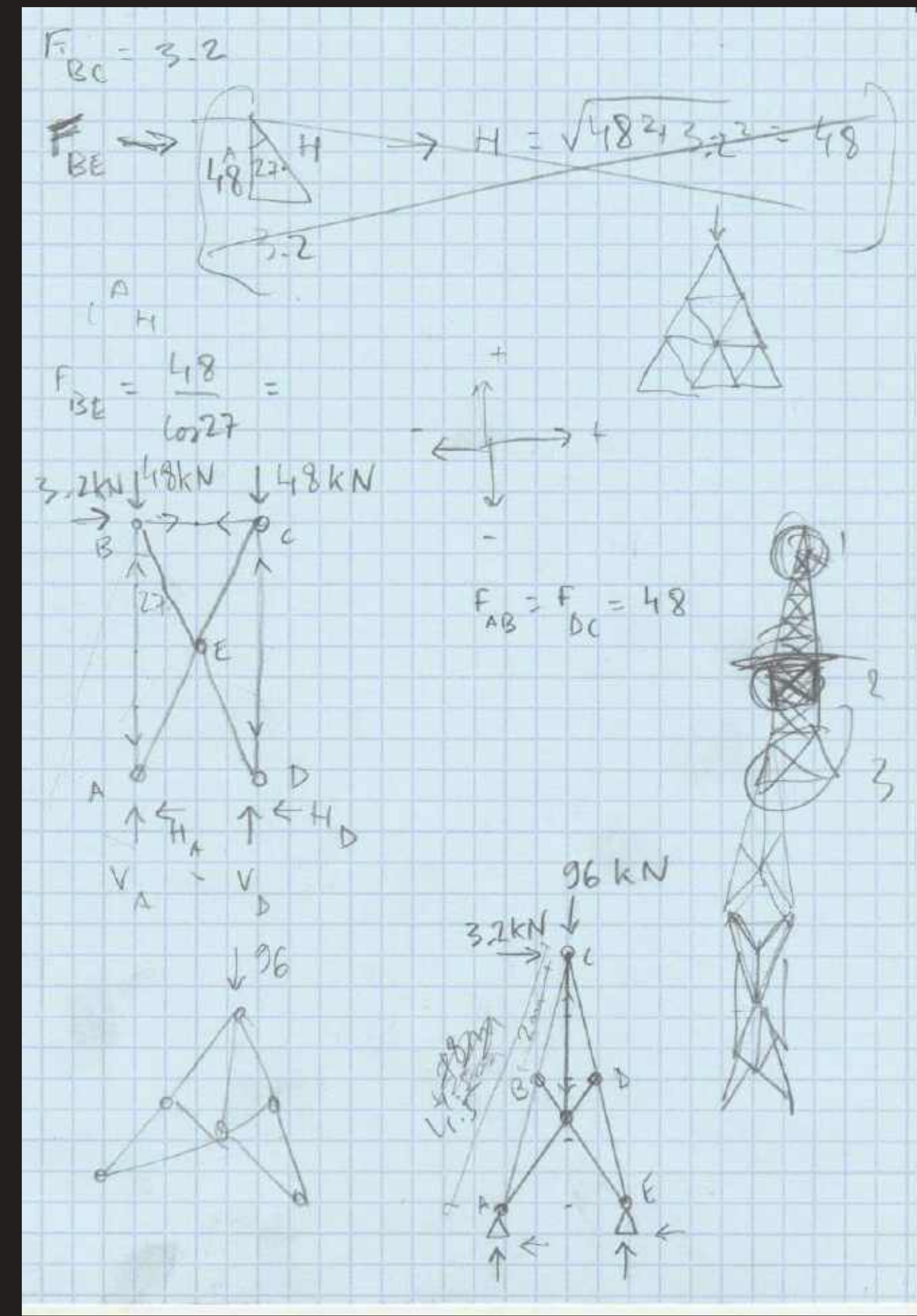

Vertical cantilever - Eiffel Tower
A
B
1 2 3
Form diagrams
Ideal form
Both left and right cords experience forces of equal magnitude in response to horizontal wind loads as well as vertical dead and live loads
a b c d e f g
C) Force polygon ??
need?
Foundations

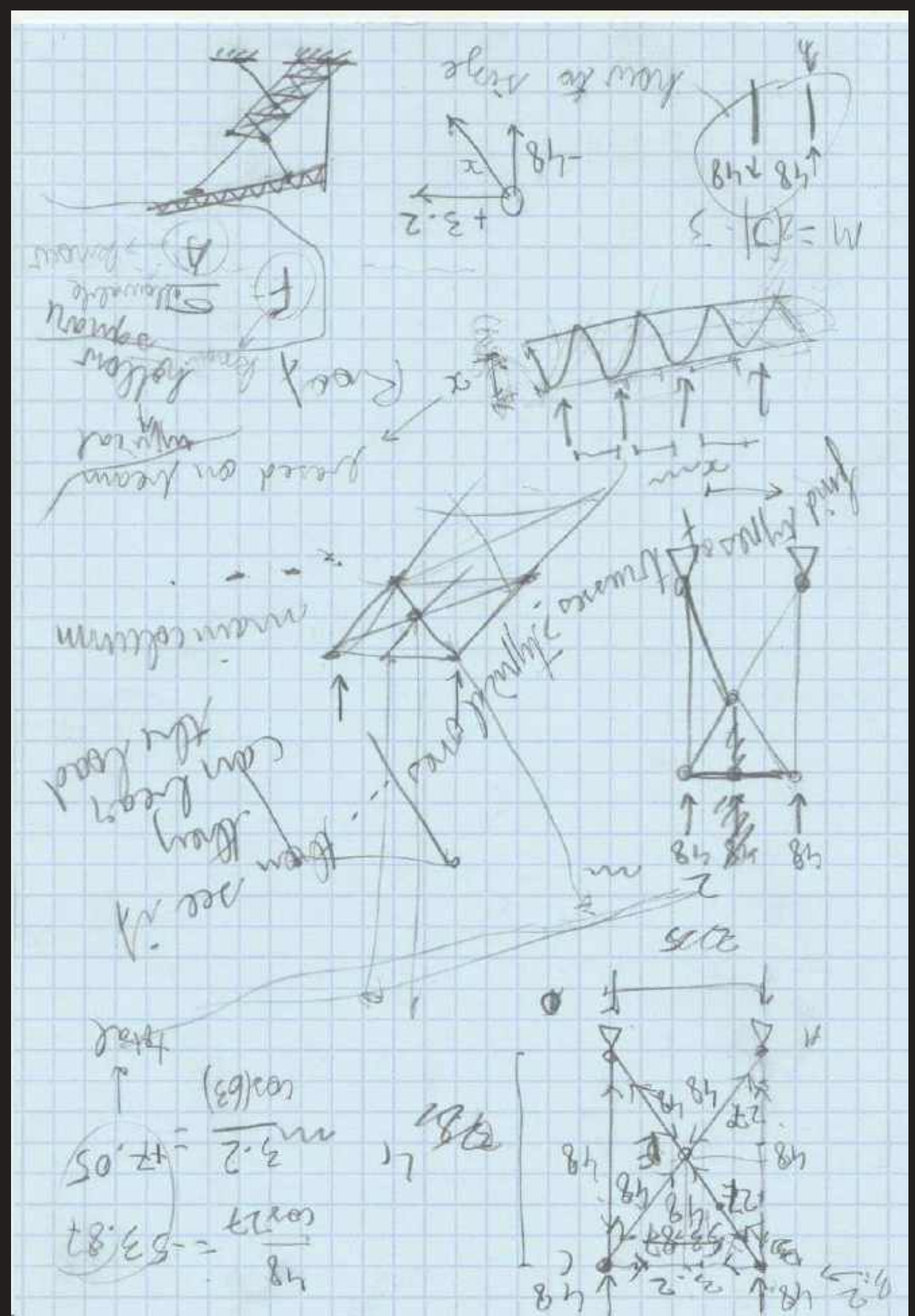

Graphical method of truss analysis:
Wind
Load from building
F3
F2
F1
Foundations
1-2
3-4
5-6
7-8
9-10
11-12
13-14
15-16
Brace
a, b, c, d
do the same for columns

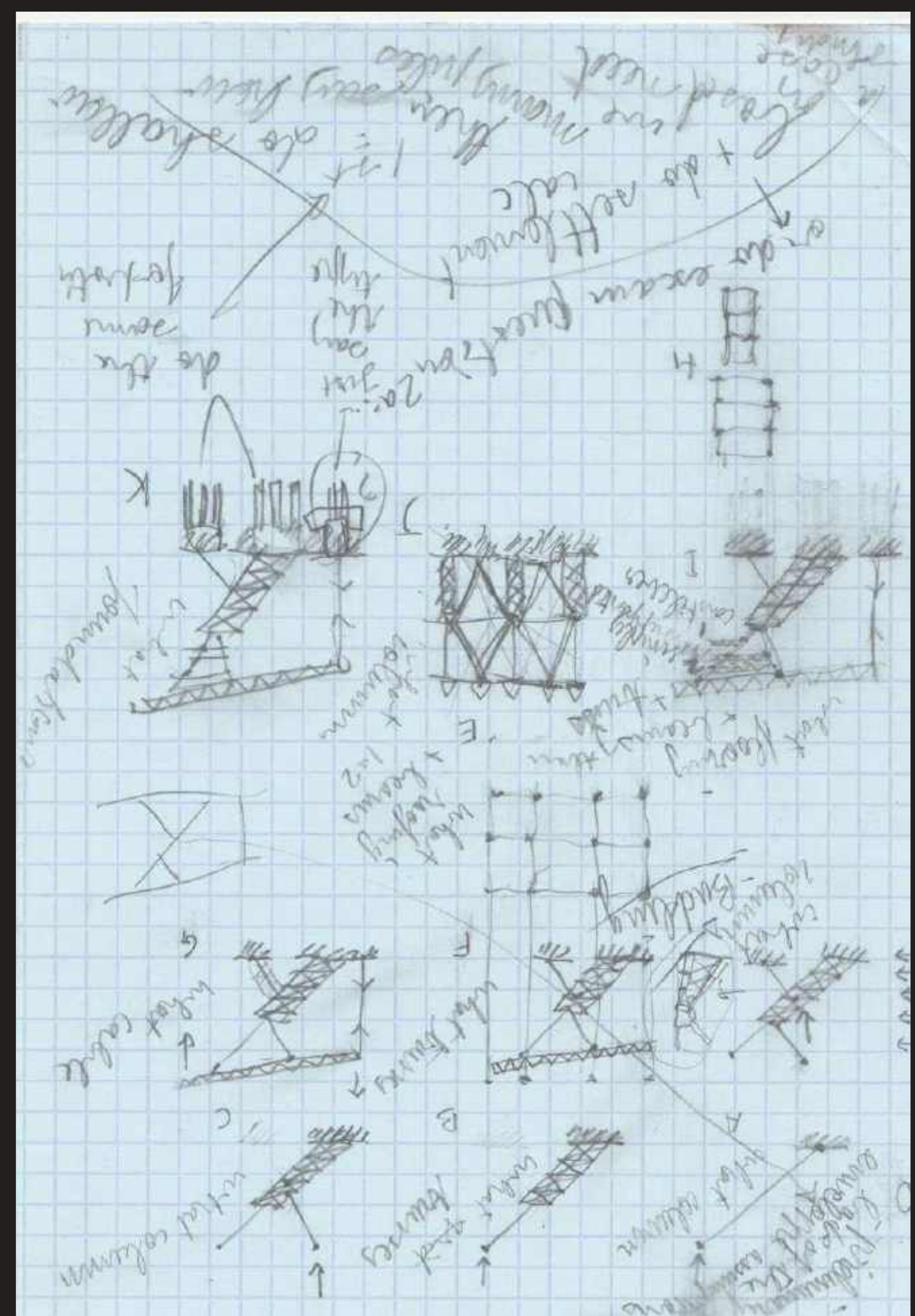

Sizing trusses:
288 kN (roof)
F allowable = nπ²EI / L²
UC 152 x 152 x 30
I = 1750
= 485.77 kN
find force in each member

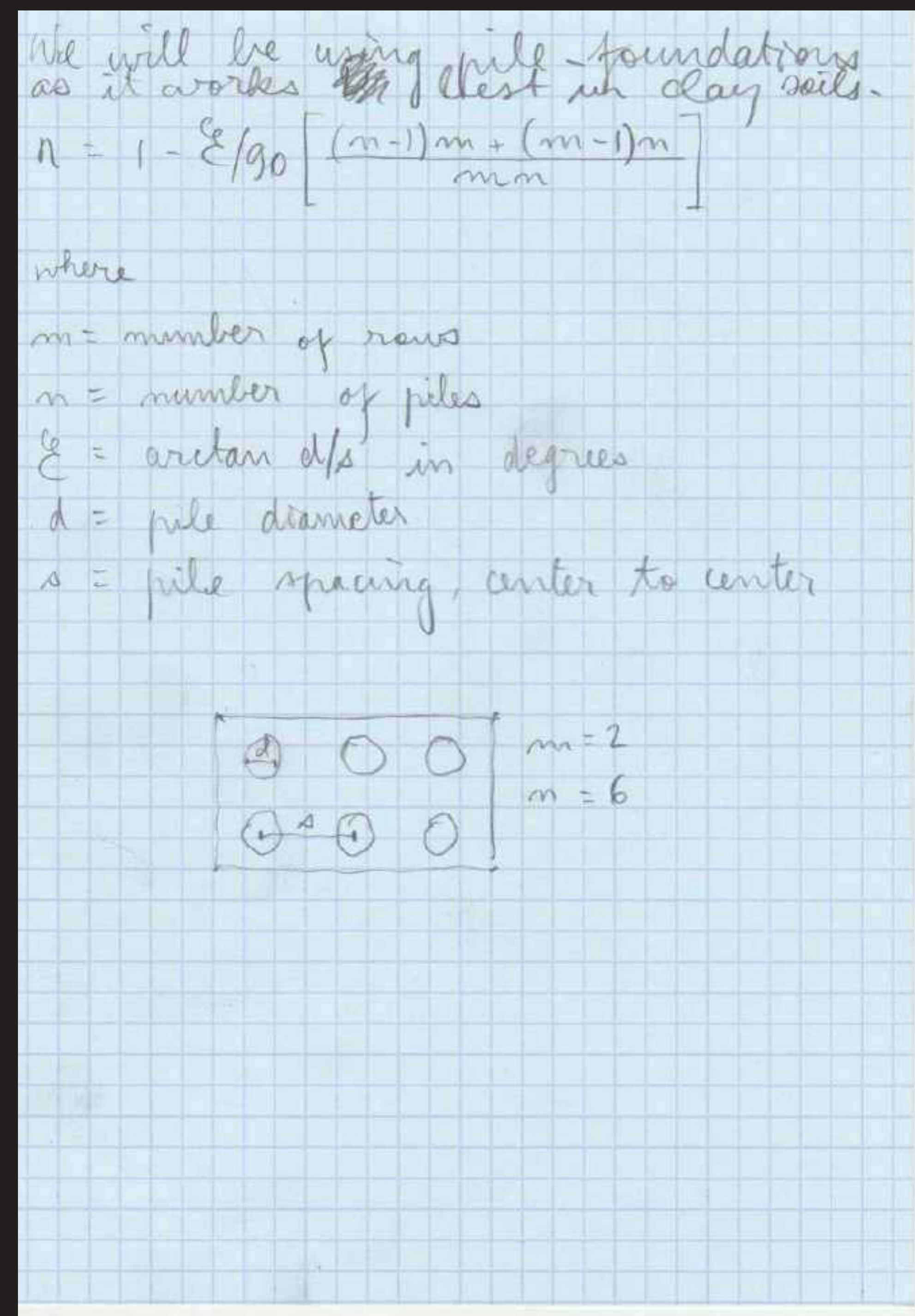

PIN JOINT FRAME STRUCTURE
48 kN
4 m
2 m
α = 63°
90 - α = 27°
no moment
= 54 kN
Is it internally statically determinate?
M = 2J - 3
M = members
J = joints
8 = 2(5) - 3
= 10 - 3 = 7
8 ≠ 7 ∴ imperfect and cannot be completely analysed


METHOD of RESOLUTION AT JOINTS
convention signs
simplification
determine the forces in each member
M = 2J - 3
Locate a joint where there are no more than 2 unknown forces.
F_AB = 48 kN = F_ED
F_AE = 7 kN = F_DC


F_BC = 3.2
F_AB = F_DC = 48
96 kN






We will be using pile foundations as it works best in clay soils.
η = 1 - ξ/90 [(n-1)m + (m-1)n / mn]
where
m = number of rows
n = number of piles
ξ = arctan d/s in degrees
d = pile diameter
s = pile spacing, center to center
m = 2
n = 6

Maxime Ostroverhy

Max Ostroverhy (b. 2000) is a Franco-British artist and aspiring architect and engineer that speaks four languages fluently with extensive knowledge in German and Russian culture. Since his childhood, he has been interested in creating all sorts of things with his hands. His unconventional Parisian education at Steiner-Waldorff School introduced him to a range of creative arts from dancing, singing, drawing and working with wood. This passion and interest can be reflected in his latest work: his architectural diploma, in which he linked architecture with ceramics, an activity he used to do when he was a young child every Wednesday. This love for creativity was united with his love of nature best during the holidays where he used to go landscape painting with his father in the Alps and the French Riviera. There he learnt to paint landscapes, draw plants and people with meticulous care and foster his love for swimming, climbing and long-distance trail running.

From Munich, Bristol, the French Riviera and London, Max was able to develop his drawings and painting skills, especially in Bristol where he developed a passion for chalk graffiti. It has continued to help him to this day, in producing not only works of artistic beauty but works of practical use. The earliest example of this cooperation between the artistic and the practical is when Max was four. At the time, he designed a machine that would tear down all the publicity that can be found in the Parisian underground stations so that it would replace the walls with his father's artworks. A more recent example could be his recent architectural drawings and his Venetian studies that have now been incorporated into his architectural diploma. Max is an individual that is keen in issuing out statements to the world, aided by his love for art, and the unbent desire to reconcile the modern with the ancient, the beautiful with the practical, the artistic with the scientific, the rational with the impulsive. Perhaps that energy has been best reflected when Max was 16 years old, when he decided to sleep during winter on the balcony with only a tarp for a cover, for reasons that remain unclear to this very day.

www.maxostroverhy.com

Living Clay: A Sinking Auction
by Maxime OSTROVERHY
1st Edition, printed in 3 copies
by Kommanda Crew
London 2023