Memento Mori

Designing with decay through differential erosion

a master thesis in architecture by:
John Bogren

Chalmers School of Architecture
Architecture and Urban design
Examiner: Daniel Norell
Supervisors: Jonas Lundberg, Karin Hedlund, Kengo Skorick

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CHALMERS
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Thanks to

Rasmus and Madeleine for the glimmer in your eyes.

Felix, for keeping me grounded.

Matilda, for our weird times together.

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Shea, and EarthLab, for your expertise and earth.

And to all my friends and loved ones, for putting out
with my obsessed bantering about this project.

Without any and all of you,
this could never have been finished!

About the author

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INTRODUCTION

Abstract

Life will end.

This is true for all living beings. And in some ways it is also true for buildings. If untreated, a structure will deteriorate over time until it can no longer sustain the functions it was once created for. This structural decay is generally seen as something negative and as such, a building will eventually be either repaired or torn down. This thesis aims to question this need of intervention by asking the question:

How can the decay of a building be turned into an architectural quality?

To answer this question, the subject of deterioration is explored through a series of iterative experiments on the subject of differential erosion. In nature, differential erosion is when some areas erode faster than others due to variations in their material compositions. By consciously recreating this phenomena, one can control the compositional layout of a structure to plan and program the entire decay process.

As this method is further investigated, the result is a new design method that can be used to create a wide variety of functions that develop over time utilising only the forces of nature.

As a conclusion, this new design language is embodied in a structure on the island of Gotland where it becomes a mean to exhibit the slow erosion of rock formations, known as rauks, through the structures faster decay. Thereby, this implementation aims to contemplate death and, consequently, also life.

Background

Memento Mori is a latin phrase that roughly translates into "remember death". You might have seen it above the entry to certain cemeteries and it encourages the visitor to contemplate the fragility of life and that you should appreciate it while it lasts. If you define life by the presence of death, then buildings also have a life. Slowly, but surely, natural forces such as wind, rain, or even rust and rot cause the materials to deteriorate. When these processes reach a critical level, the building can no longer effectively sustain the functions it was once created for. And then, you are faced with the choices of either repairing it, demolish it, or abandon it to let nature have its course.

In this thesis I stand opposed to these alternatives and instead explore a different path. A path without restorations or demolitions. A path that embraces the destructive forces of nature and directs them into shaping the architecture in ways that intensifies the functions and experiences rather than the opposite.

Research questions

How can the decay of a building be turned into an architectural quality by making use of differential erosion?

Purpose & aim

In the face of environmental challenges we as the human race has a huge responsibility to use our world's resources as efficiently as possible. Amongst other things this means to not over consume and buy new things even before the old has broken down. As architects we share this responsibility and have a huge impact on how the rest of the population is to view different types of architecture as well as taking the responsibility to design in a sustainable manor.

This thesis aims to widen the scope of what is deemed as beautiful and useful. To show that architecture, buildings and materials do not have to be in pristine condition to function well. Consequently, this will hopefully lead to an increased reuse of materials and lengthen the amount of time that materials can be in use before being replaced or repaired.

Method

The concept of differential erosion will be explored through a series of iterative experiments each building upon what interesting and useful features were discovered in the previous. From these experiments, a list of characteristics will be deduced to be used in the later design proposition.

This project will make use of, but not in detail explain or develop the building techniques of rammed earth.

Delimitations

This project will make use of, but not in detail explain or develop the building techniques of rammed earth.

Due to time and resource restraints, it will not be possible to try to test or develop any real-time experiments or techniques. Instead the experiments in this thesis will provide theories and the foundation of a new architectural concept.

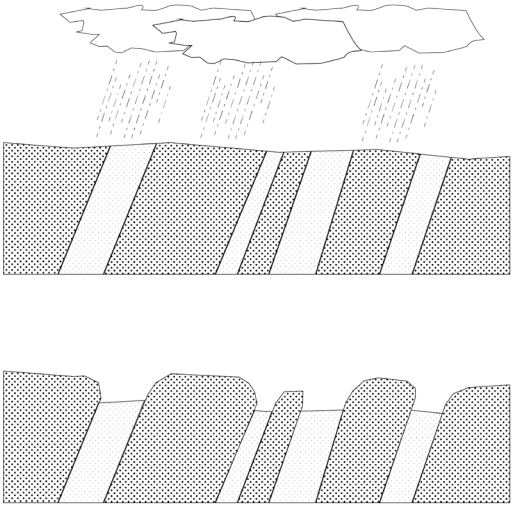
Reading instructions

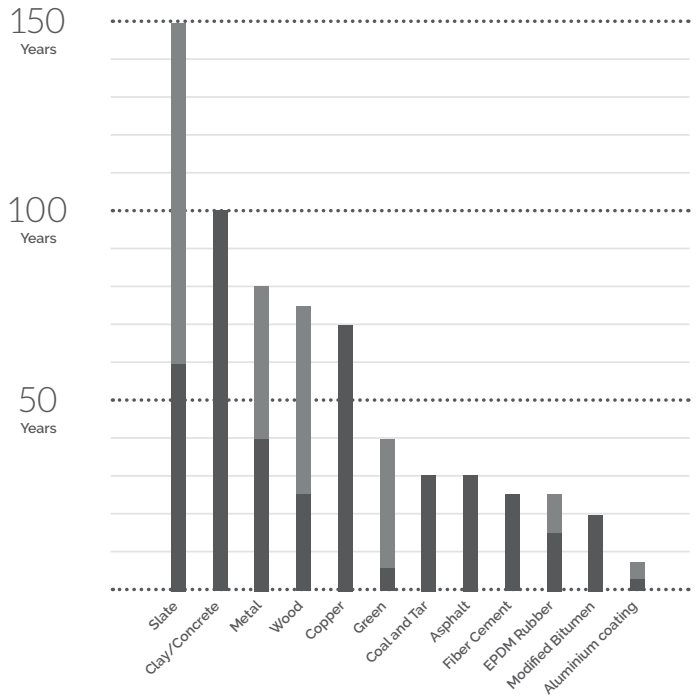
As stated above, the experiments and results within this thesis are not to be taken as facts, definite rules or functional methods. Rather it should be seen as a source of inspiration and help to develop your own thoughts on how to work with deterioration and decay in architecture and design.

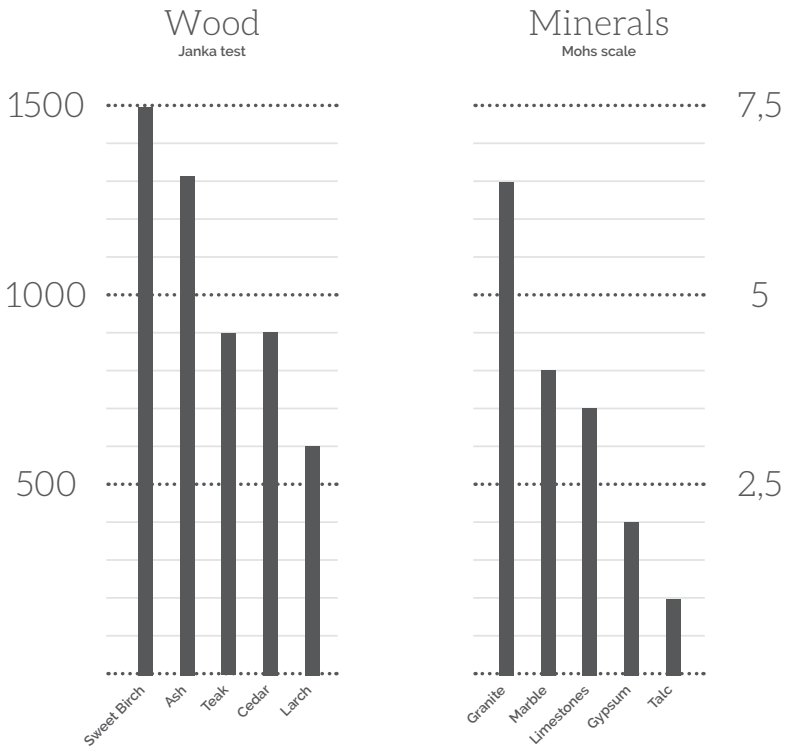
Differential erosion

Differential erosion is present at all times all around us and it is how difference in resilience or hardness of materials result in varied erosion over time. So basically, if two different materials are exposed to the exact same forces, the difference in toughness will cause one material to outlast the other. In architecture, this means that some building elements have a longer lifespan than others as can be seen in the diagram on the opposite side.

Stone slates for instance will last for about twice as long as wood when used for roofing. And then you can break it down further and look at different types of wood or different types of rock. You could also look at composite materials like I have done in my experiments and change the ratios of the ingredients of the material to achieve the lifespan you desire.




150
Years
100
Years
50
Years
Slate
Clay/Concrete
Metal
Wood
Copper
Green
Coal and Tar
Asphalt
Fiber Cement
EPDM Rubber
Modified Bitumen
Aluminium coating


Wood
Janka test
1500
1000
500
Sweet Birch
Ash
Teak
Cedar
Larch
Minerals
Mohs scale
7,5
5
2,5
Granite
Marble
Limestones
Gypsum
Talc

REFERENCES


ON WEATHERING
THE LIFE OF BUILDINGS IN TIME
MOHSEN MOSTAFAVI AND DAVID LEATHERBARROW

On Weathering - The life of buildings in time

Mohsen Mostafavi & David Leatherbarrow, 1993

The beginning of the end

In On Weathering, M. Mostafavi and D. Leatherbarrow argues that a building is never finalised. Instead, the act of weathering from natural causes continues to change the appearance of buildings indefinitely. They continue to state that this phenomenon is unavoidable and that we have tried to combat nature for ages with improved roofing, materials and details. The question the authors asks is whether the process of weathering should be seen as "subtracting" from the finish or that the environment instead "adds" it's own finish.

The modernist's white ideals

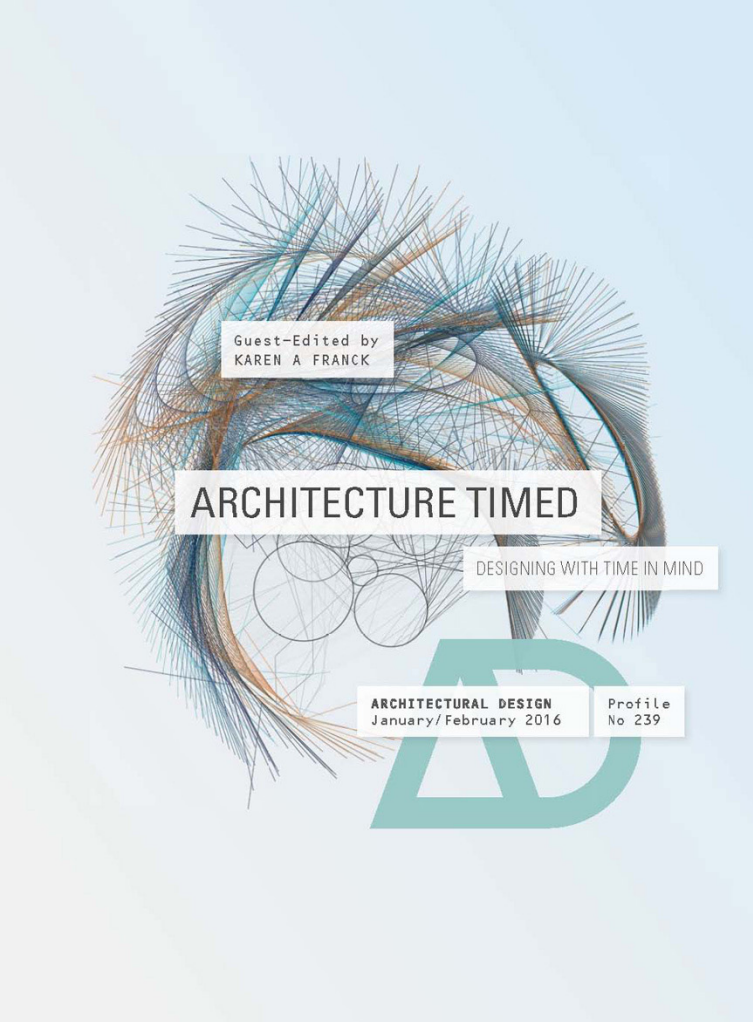
They go on to discuss the ethical implications of deterioration of buildings through several references, the most prominent of which is Le Corbusier with his modernist ideals. The text highlights quotes from Le Corbusier's text When the Cathedrals Were White which is best summarized as a puristic devotion to the color of white where any impurities are considered faults in the supposedly perfect machine that is the building. Additionally, the architecture should be as pure as possible to let the volumes converse with the light and interiors are often thought of as a tightly directed scenery where, ideally, everything is standardised.

On the other hand

With Le Corbusiere on one end of the scale, the text continues to contrast this with a reflection on the actuality of weathering. The environmental marks on buildings is compared to the mark left on it by its inhabitants, this by quoting Adolf Loos' criticism towards the scripted homes of the modernists and his claims that the users should make the house their own through furnitures, decorations and stains. The authors then goes on to say that all buildings are composed of matter, just the same as dirt and dust is also matter, and that imperfections therefore cannot be marked as faulty by default.

A design task

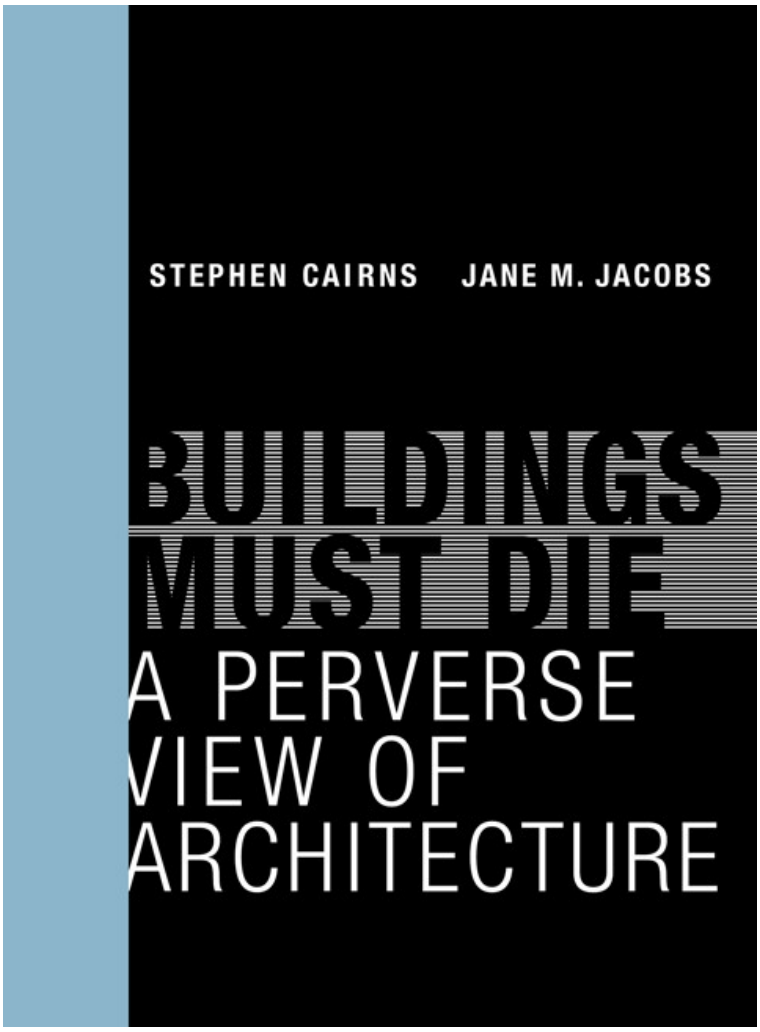
The last part of the essay tries to answer the question: *"Dirt and staining: Can they be anticipated?"* Which the authors summarise as a matter of intent and circumstance. A modernist building indeed becomes damaged by dirt since it is not considered a part of the pure design. However, when anticipated and even highlighted, weathering can add complexity and intrigue to a piece of architecture. And this is what I will bring with me into this thesis, designed deterioration with apparent intent.



Architecture timed - designing with time in mind

Helen Castle, 2016

In this volume, a variety of authors are invited into a wide discussion on the relationship between architecture and time. Amongst the articles, I found a few to be of more interest. First, the introduction by Karen A. Franck who describes so well the essence I try to capture in this thesis. She writes that "*...Buildings are not fixed, static objects rooted to a single moment and impervious to change, but mutable subjects much affected by everyday use, intentional intervention and unavoidable material decay.*" And then there is Philip Speranza who delves into the architecture of Enric Miralles and the Igualda Cementary where wood timber is mixed with the concrete roads, resulting in a differential erosion that forces repairs and thus highlighting the process of time.



Buildings must die - a perverse view of architecture

Stephen Cairns, Jane M. Jacobs, 2014

In their book, Cairns and Jacobs discuss the role of mortality in the context of buildings within five separate topics; decay, obsolescence, disaster, ruin and demolition. They do so by highlighting examples of how the death of buildings have been addressed throughout history and by a variety of architects, artists and authors. In their final remarks, they summarize their findings by stating that architecture as an artform does not have the authority to prioritize an inhabitable space in favor of a statement of death. Instead, architecture should be about celebrating life and designing for the living but taking into account the eventual death of buildings and perhaps turn it into an opportunity.

How can a process that has formed the site inform the architecture?
- Love Liljeqvist, KTH, Stockholm

A student project that uses a mixture of snow and concrete in a mold to leave impressions on the final cast that represents the history of how the surrounding landscape was shaped over the ages.

Imprint, Philosophical, Casting, Building scale

Erosion - DRL, AA, London

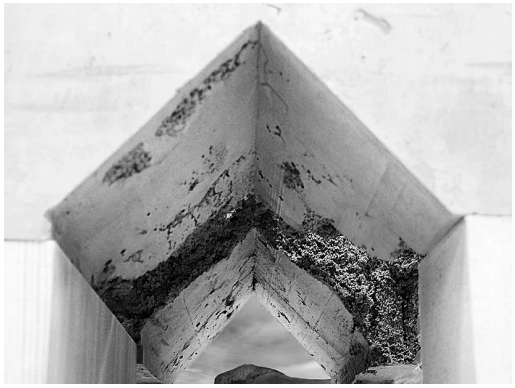
This project researched how rain erodes clay buildings and how this transformative process creates architectural elements such as windows and pools. The researchers discuss the issue of how buildings are not used to their full, possible life-span but are instead remodelled or demolished much sooner than necessary. They propose a clay building designed to last just as long as is required and slowly deteriorates during its life.

Subtractive, Practical, Material driven, Building scale

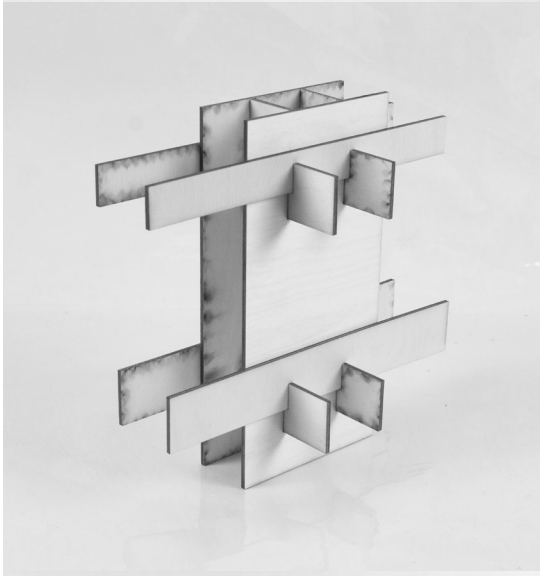
Fields & erosion - Architecture machines
- Kevin Yin He, Ithaca College, New York

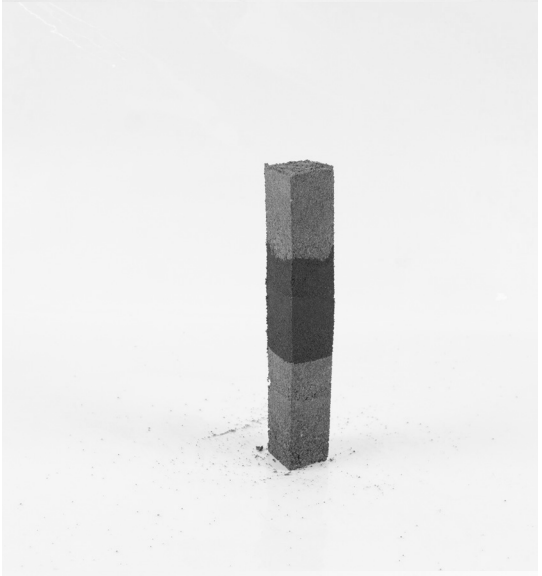
The project discusses the subject of control and unpredictability through the process of erosion. The control input is a waterjet moving in a programmed manner to carve out a set of linear cavities out of a block of salt. Concrete is then poured over the block and when the salt is removed, the concrete reveals the negative space.

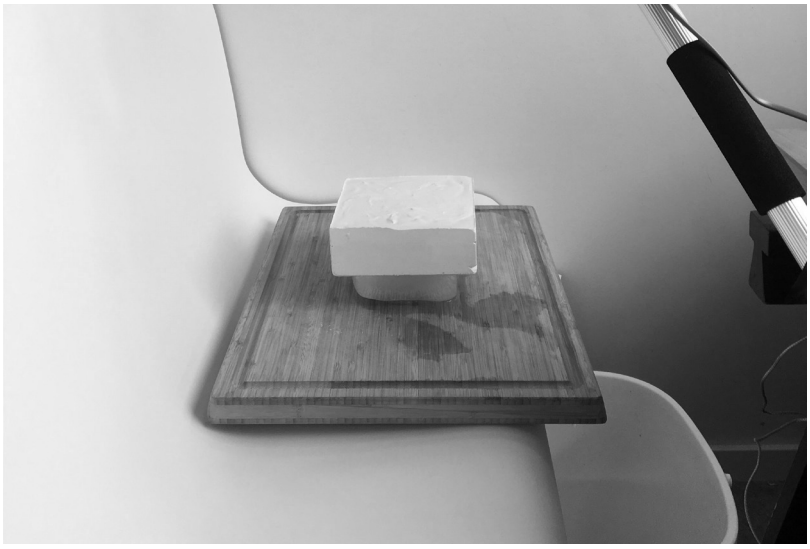
Subtractive, Imprint, Casting, Material scale



— EXPERIMENTATIONS —







Experimentation process

Experiment 01


Experiment 02


Experiment 03


Experiment 04


Experiment 05



Experiment 06



Experiment 07



Experiment 08



Experiment 09





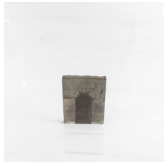
Experiment 10


Experiment 11

Experiment 12



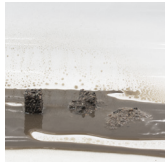
Experiment 13



Experiment 14

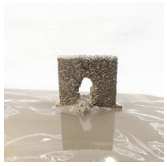


Experiment 15

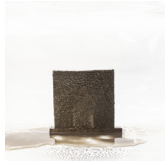




Experiment 16





Experiment 17

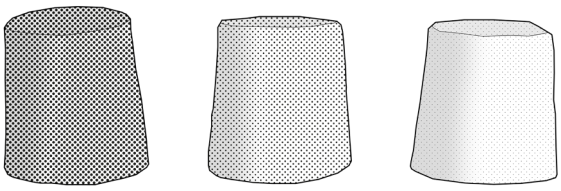

Experiment 18



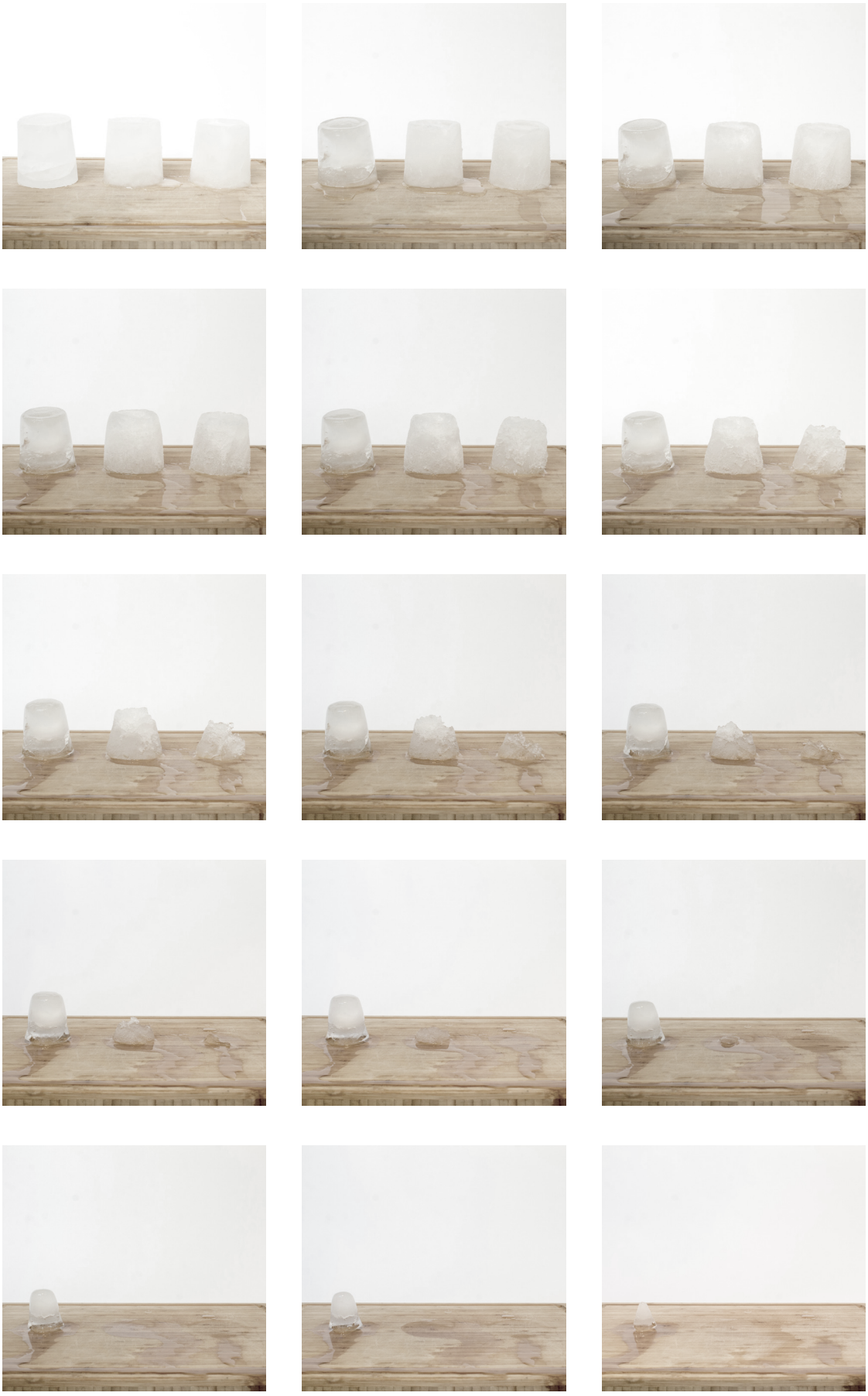
Experiment 19

Experiment 06

Experiment duration: 7 hours
Room temperature: 24 degrees
Medium: Ice with varying amounts of salt.
Method: The structure was created by freezing the ice into separate molds. Then set to melt in room temperature.
Purpose: To see if the melting rate of ice can be controlled by adding different amounts of salt.

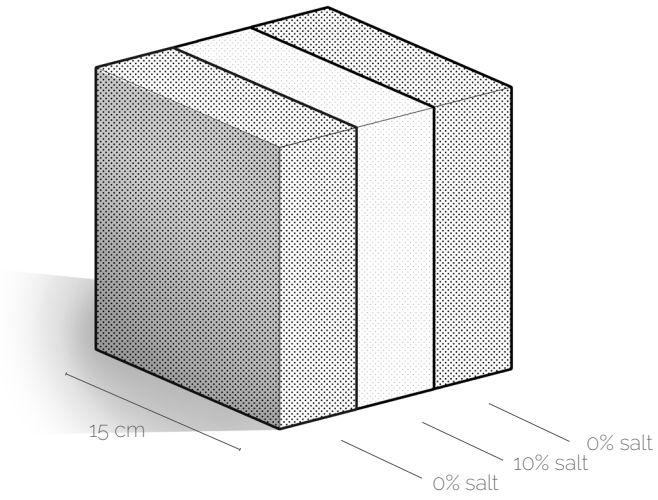


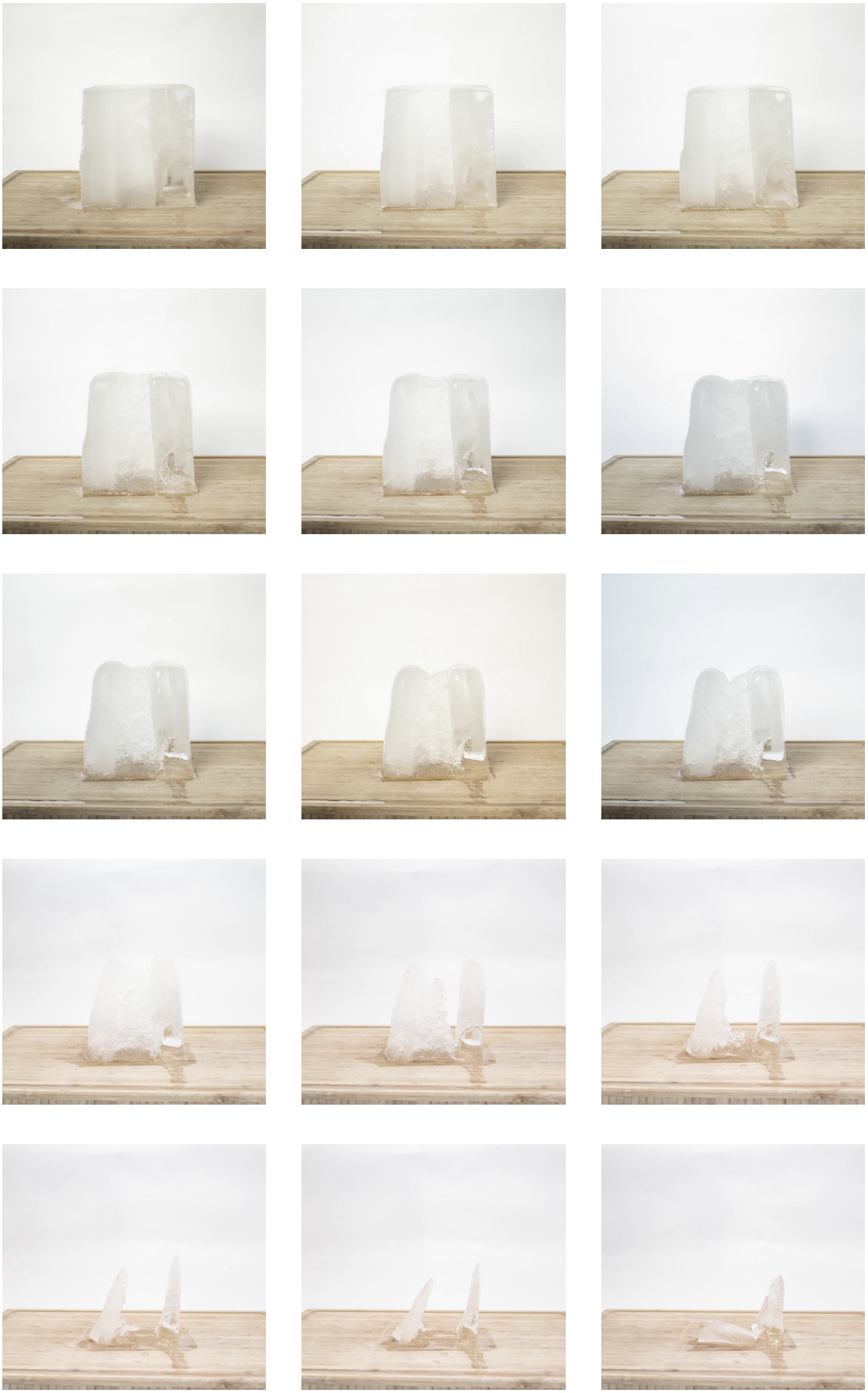
0% salt 10% salt 20% salt



Experiment 08

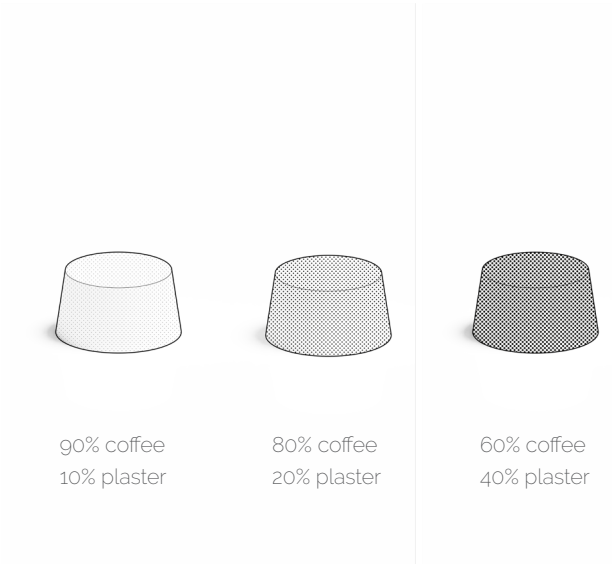
Experiment duration: 10 hours
Room temperature: 24 degrees
Medium: Ice with varying amounts of salt.
Method: The structure was created by freezing the ice in increments inside a mold. Then set to melt in room temperature. The melting speed is controlled by the salt. Experiment put on a wooden plank for water collection.
Purpose: To see how differential erosion behaves and how materials of different toughness behaves when eroding close to eachother.





Experiment 10

Experiment duration: 1 hours
Number of sprays: 430 per sample
Amount of water per spray: 0,6 ml
Method: Making 3 different samples of rammed coffee with 3 different amounts of plaster. Then simulating rainfall with water sprays.
Purpose: To see if the strength of the coffee can be controlled by adding a binding substance.



90% coffee
10% plaster

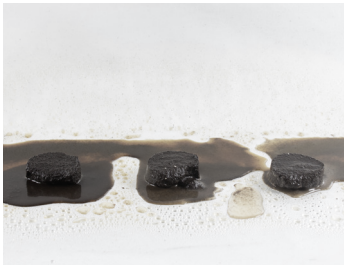
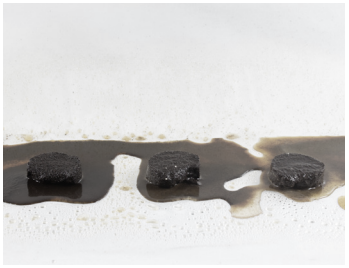
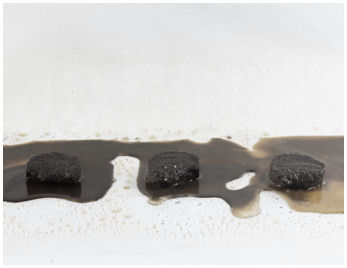
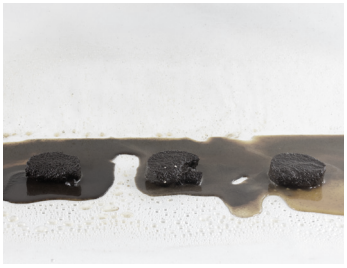
80% coffee
20% plaster

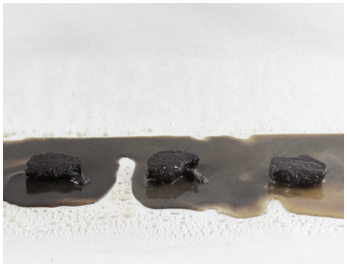
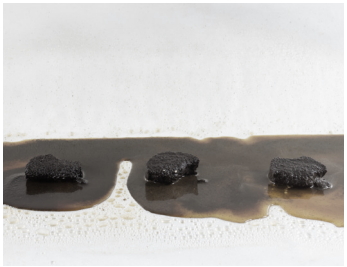
60% coffee
40% plaster





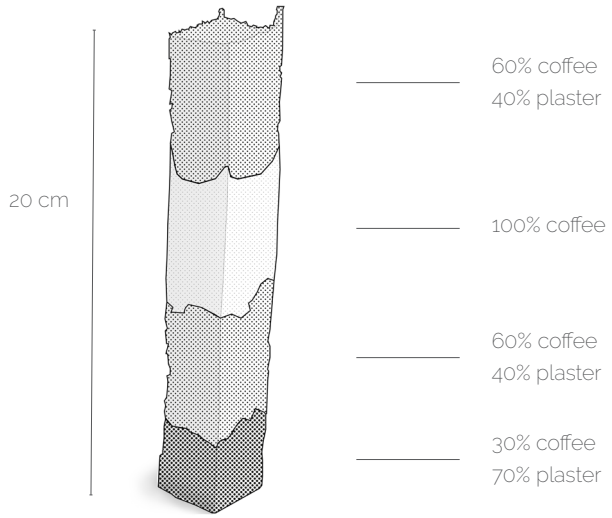


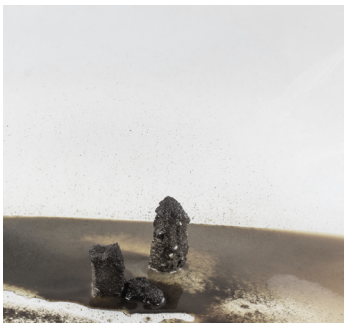
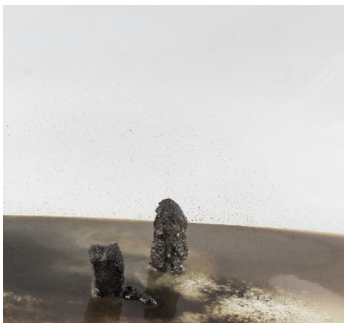
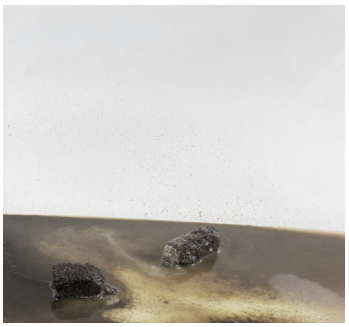
Experiment 13

Experiment duration: 3 hours
Number of sprays: 2715
Amount of water per spray: 0,6 ml
Medium: Brew coffee mixed with various amounts of plaster
Method: Ramming the coffee and using plaster to control it's toughness into the mold of a pillar. Then simulating rainfall with water sprays.
Purpose: To test if it is possible to program the point of collapse of a pillar by making the middle part the weakest. Also, a sturdy base was tested here to see if it helps the pillar to stand upright.







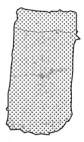




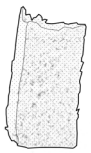

Experiment 16

Experiment duration: 2 hours
Number of sprays: 395 per sample
Amount of water per spray: 0,6 ml
Medium: Rammed earth with varying amounts of sand.
Method: Making 3 different samples with mixed soil and sand. Then simulating rainfall with water sprays.
Purpose: To see if rammed earth can have it's resistance be affected by adding sand to change the proportion of clay in the mixture.

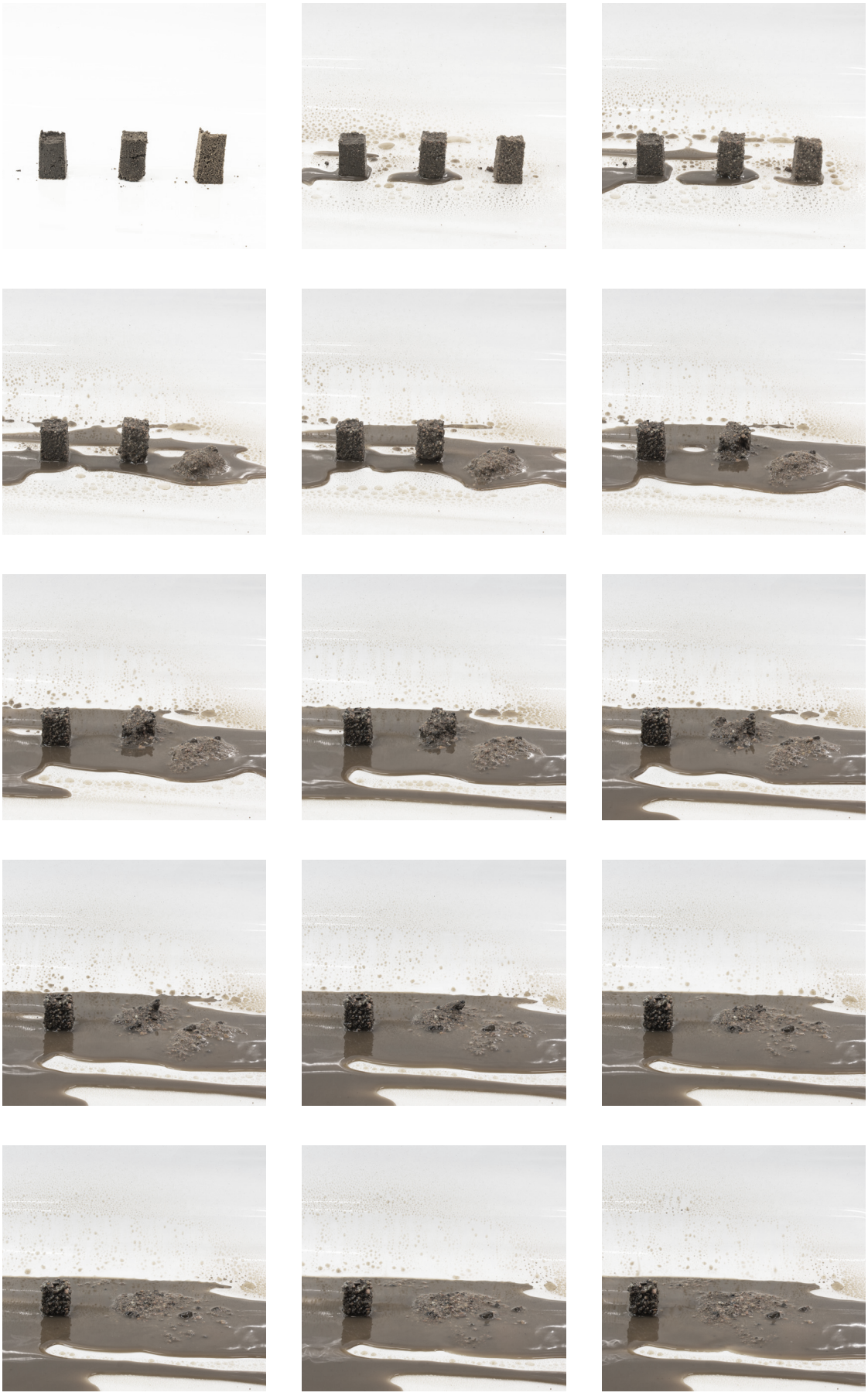
70% sand
30% clay



80% sand
20% clay

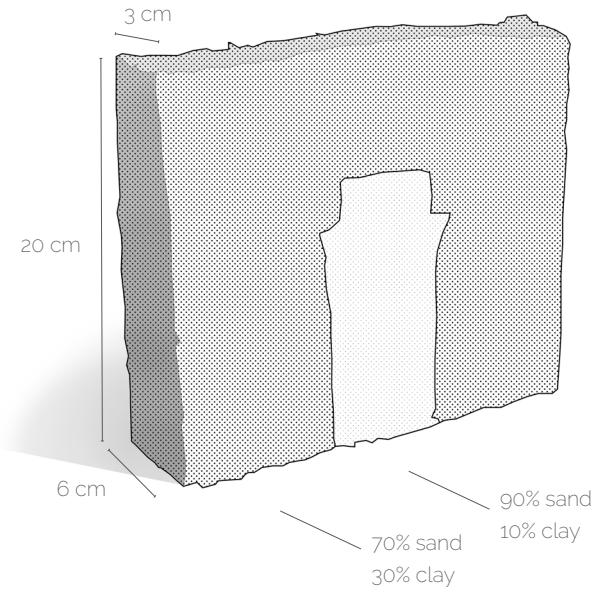


90% sand
10% clay



Experiment 19

Experiment duration: 2 hours
Number of sprays: 6120
Amount of water per spray: 0,6 ml
Medium: Rammed earth with varying amounts of sand.
Method: Ramming earth into a tapered mold with a programmed archway. Then simulating rainfall with water sprays.
Purpose: To see how distinct shapes you are able to get from a preprogrammed structure. Also, to check if a wider base helps to maintain a stable center of mass.



Erosion characteristics

During my experiments, I became very familiar with the process of erosion and how it behaved in changing the shape and transforming the materials. The list below is a quick summary of what I learned and it can perhaps be of use for any kind of design work relating to erosion.

• Even if one material is much harder than another, it still undergoes erosion, just at a slower pace.

• The eroded sediment will travel along the wall and pile up into these typical slopes by the bottom.

• If water is present at the base of the structure, this will erode much faster. A similar effect is also that as water gains speed along the face, it results in more severe erosion.

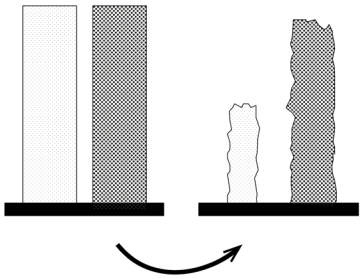
• A harder material will act as protection for a softer one if it is an position to do so.

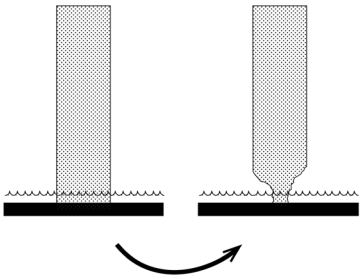
• The sides that are facing the source of erosion will deteriorate faster.

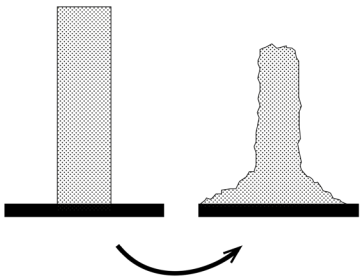
• Any harder particles in a softer material will come to the surface as the softer material disappears

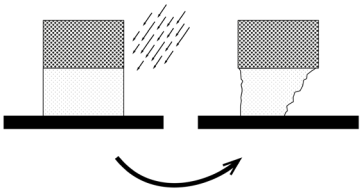
• If a part of the structure lacks support under its center of mass it is likely to fall down. This can be compensated for by adding materials by the base or tapering the thickness.

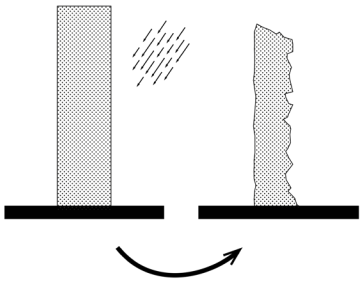
• Any hard edges will "quickly" be shaved off and become smooth. This is why cast concrete or rammed earth walls have beveled edges as to counteract any chipping.

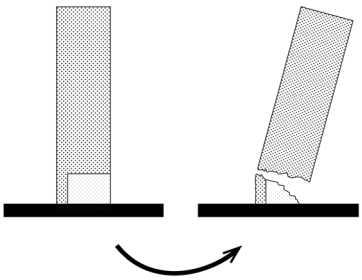


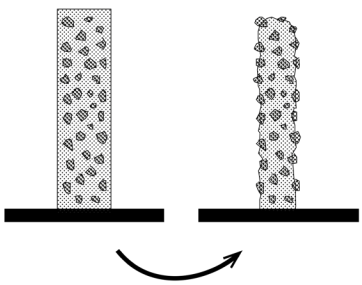


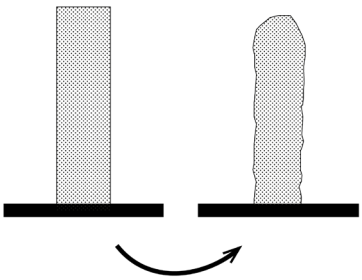












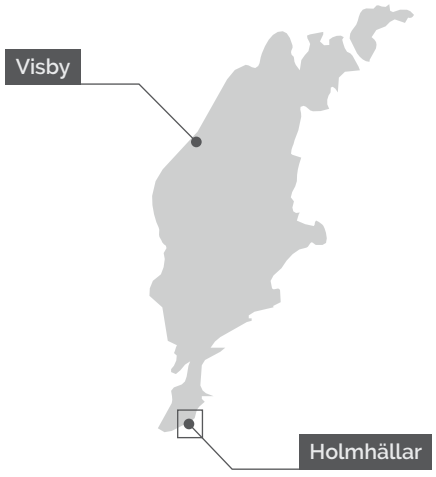
THE SITE

Holmhällar, Gotland

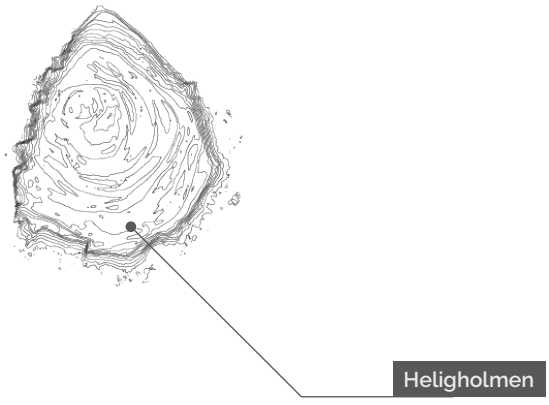
The summer of 2018 I was on a bike trip with some friends of mine around the island of Gotland which is a swedish island in the Baltic sea. We started out in the city of Visby and went all the way down to the southern tip. On the way, we passed a site known as Holmhällar. A long stretched rocky beach covered in grey gravel, in some parts wide as a 100 meters.

Around Holmhällar, there is a lodging house, some small fish huts, a couple of farms and a small harbor. Though there are some people living here, the area is far from crowded, but you do meet some bikers, hikers or tourist every now and then. There is also a small Island known as Heligholmen to which you can walk when the tide is low.

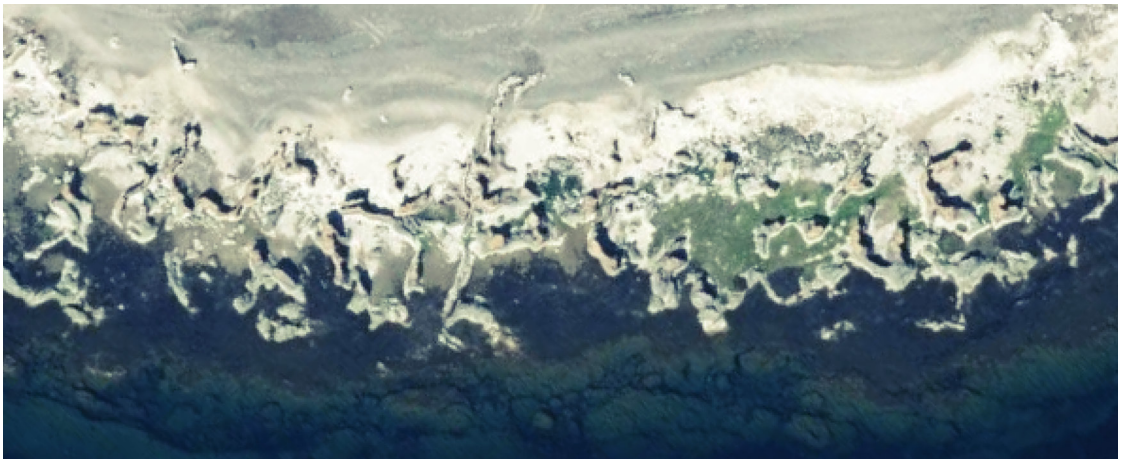
However, the most interesting feature of the place are the rauks that line the edge of the shore. These mysterious formations can be seen in a number of places around Gotland with this being one of the major locations.



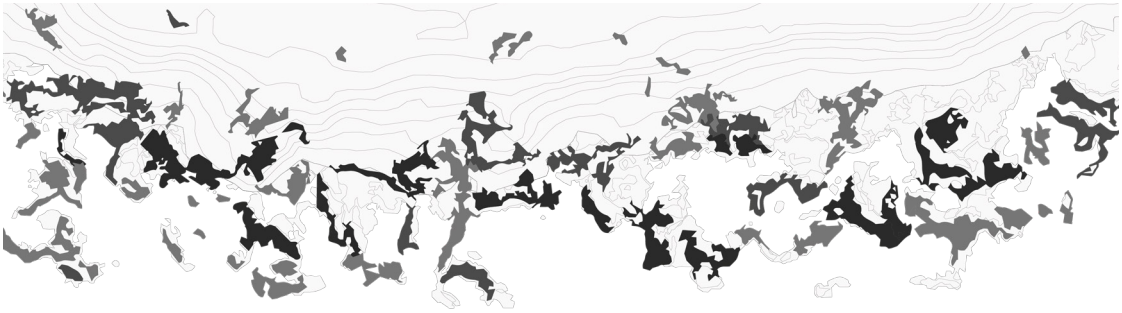

Site location


Heligholmen


100 meters



Holmhällar's raukfield from above. Scale 1:200



Estimated erosion - 0 years

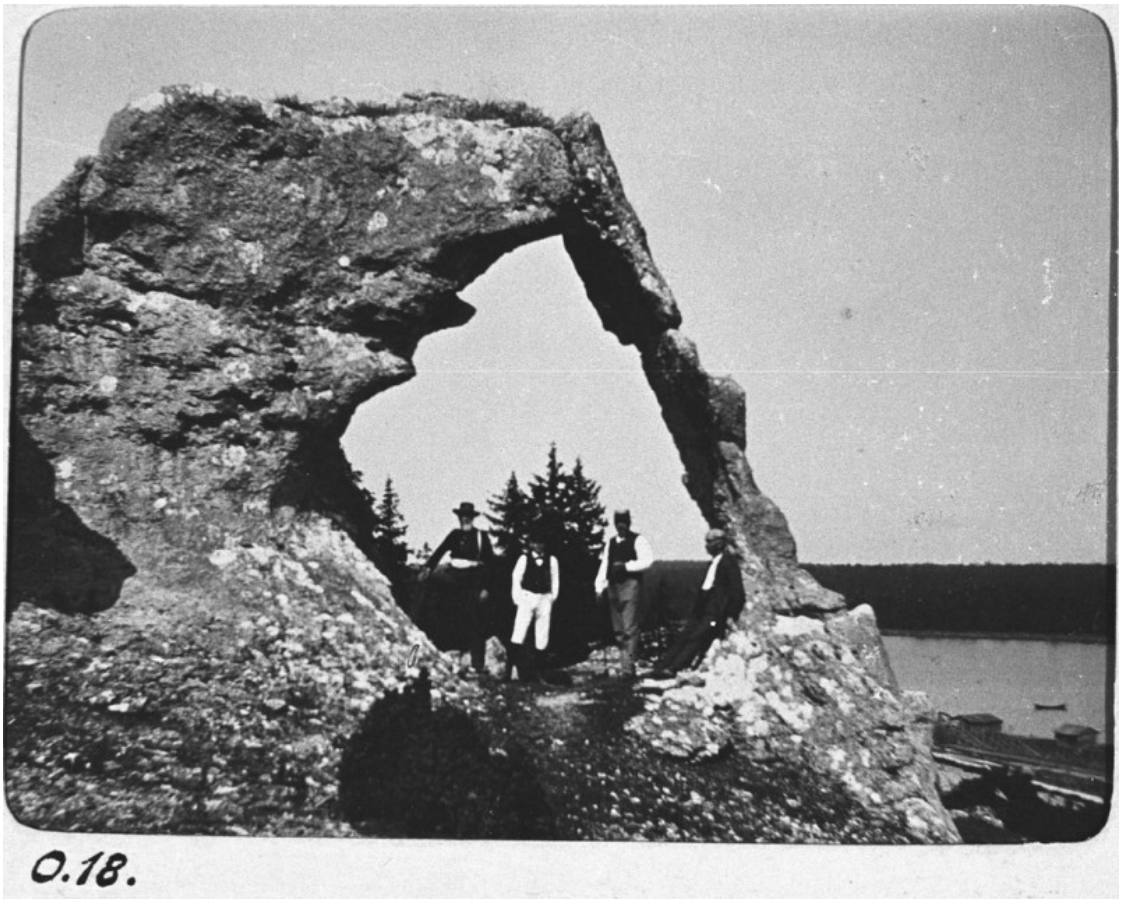
Estimated erosion - 1000 years

Estimated erosion - 2000 years

History of the rauk

About 400 million years ago, due to the shifting continental plates, Gotland was the seabed of a tropical sea. On this ocean floor grew a coral reef that later were fossilized and covered with limestone from dead animals. During the recent ice-age, Gotland was weighed down by the ice and when it later melted, the island began to rise from the sea, bringing the previous seabed above the surface. Due to rainfall and other erosion, the softer limestone eroded and left the harder core of the reefs behind in the form of the rauks.

Now, these strange rock formations can be seen in various places around the island and people come from far away to see them.



Rauk from around year 1900

Rauk from around year 2000

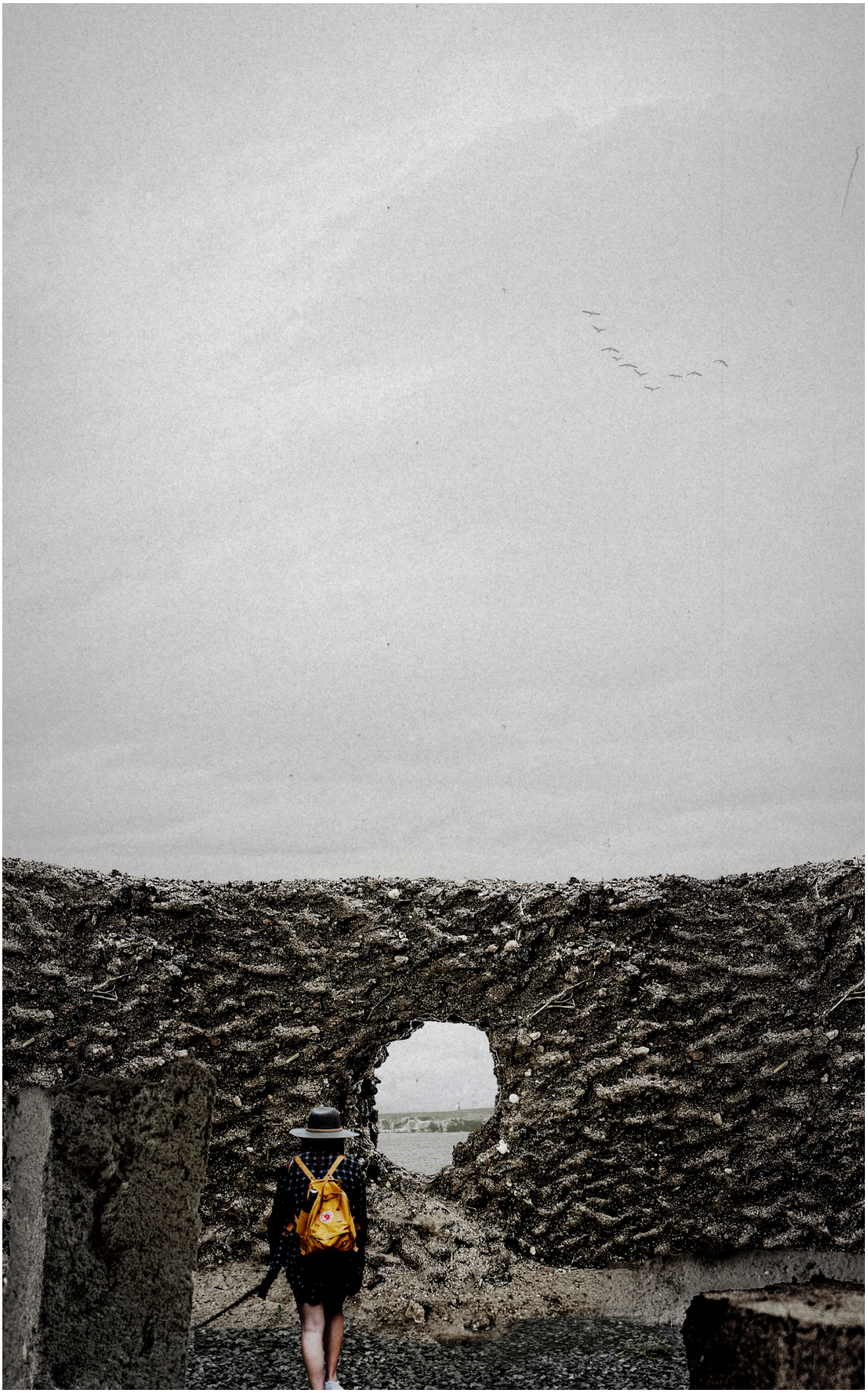
DESIGN PROPOSAL

Concept

Following the encounter of the rauks, and gaining the knowledge of their creation and inevitable demise, I became interested in the human experience of time in relationship to nature. In the context of the history of the earth, the rauks will be eroded to dust in milliseconds, while for us humans they seem almost frozen in time. There is a temporarity that is simply lost on us.

Therefore, the concept of my design proposal is to represent the erosion of the rauks in a human timescale. This with a structure that would go from new and pristine to dissolved in around 50 years or so. By doing this, it would add value to each and every visit to the site because you know that you will never get to experience it in the same way ever again.

However, I also want the structure to not follow a linear decomposition pattern that other buildings do when they are decomposing. Instead, I want the structure to morph it's initial fuctions and even gain new ones as time passed. This would create a statement of not seeing erosion as something that can only be destructive. Additionally, it would draw attention to how fragile the surrounding nature is, which is highly relevant now when the environment is close to collapse.



0 years

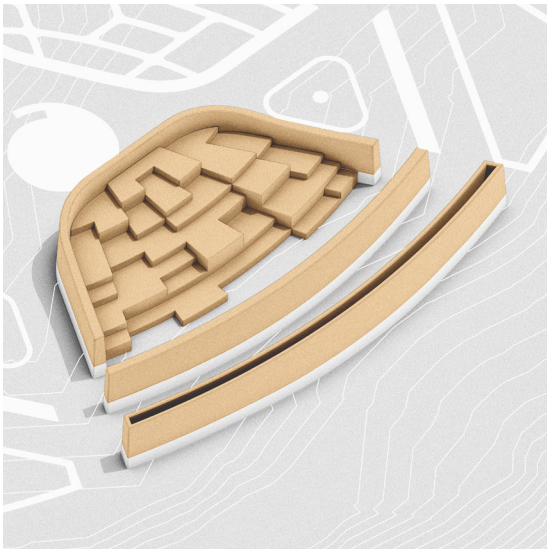
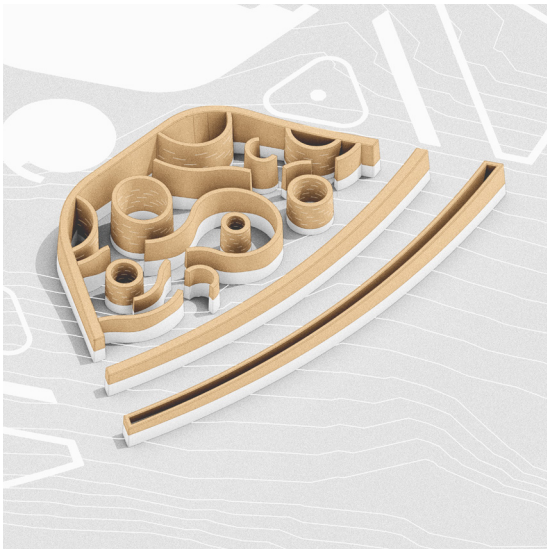
The initial structure is a series of walls and volumes made up majorly by rammed earth but also rammed limestone and integrated limestone plates.

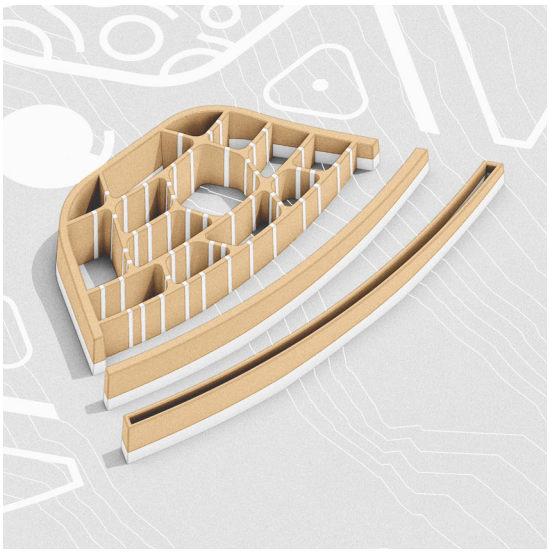
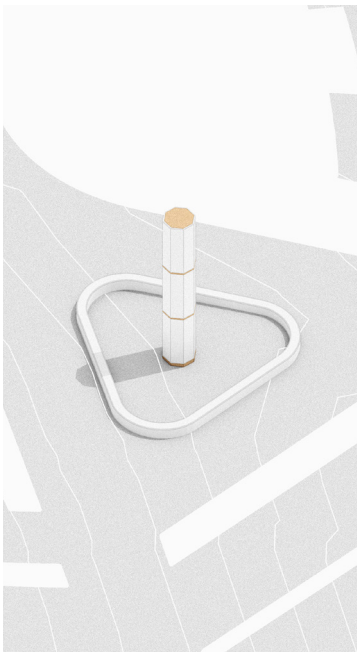
The shape is highly ordered with it's outer shape being a curve of constant width which provides an outer circular path. This shape is divided by three diagonal sight lines forming a triangle and are meant to draw in the hikers passing on the nearby trail.

In each of every corner of the center triangle is a pillar, each one similar to the other with ten sides of smooth lime stone. These are to represent the demise of the three elements that can be found on the site: The sea, the forest and the rocks.

The three larger cells of the structure are to embody the same three elements but these are instead supposed to celebrate their life and functions. "The rock" has harder, sharper edges and is made for jumping, running, sitting and school gatherings. "The sea" is a maze with smooth and flowing paths. "The forest" is currently closed off and currently only has vertical patterns, resembling trees.

In the center, there is a watchtower, reaching about seven metres in height. Providing an overview of the rest of the structure and also of the beach and the rauks.

25 years

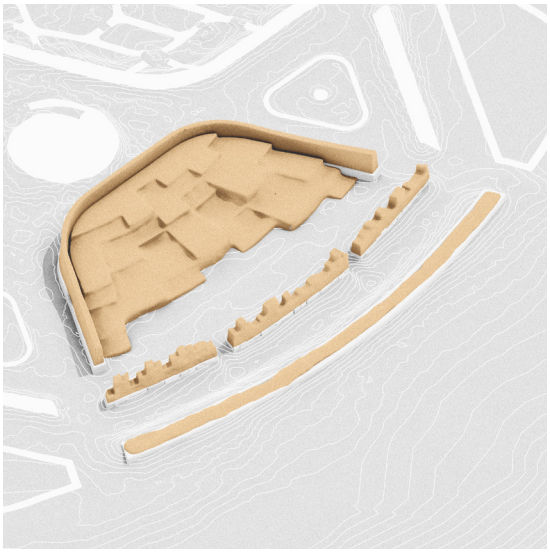
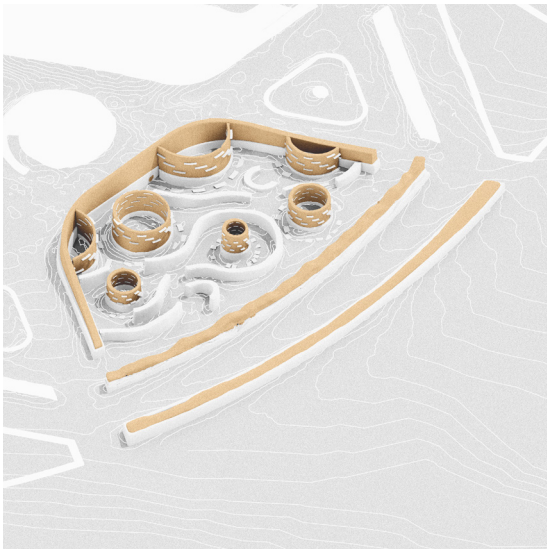
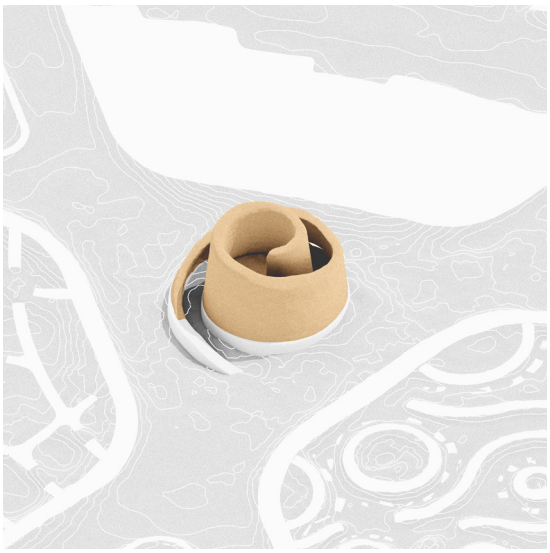
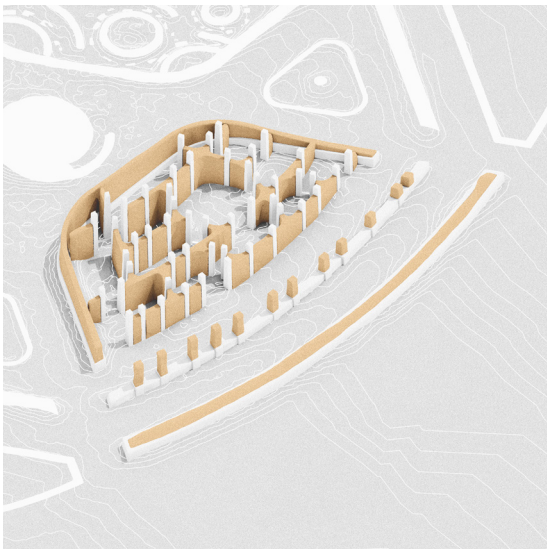
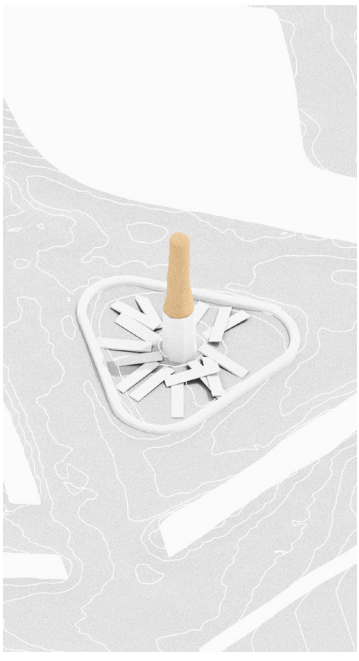
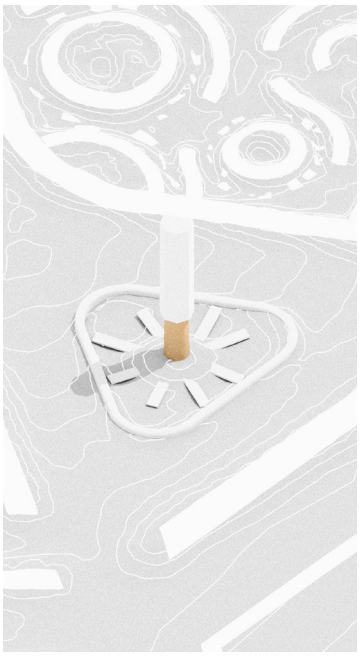
After some time has passed it is time for our second visit and now we are met with a certain amount of disarray. Some walls are gone, providing new paths, and all over the site, grass and some plants has started to grow on the debris left from the eroded walls.

The outer, circular path is no longer closed off by walls on each side, instead it opens up to the surroundings. Where the wall previously stood, there is now a flowerbed left in its footprint. In each corner of the shape, a tree has sprouted.

The pillars are no longer the same, some of the lime stone plates has come off, revealing a softer rammed earth core. The new pattern that is formed represents a sea about to dry out, a tree about to be cut down and a rock about to fall.

The three larger cells have now had their functions changed due to their new layout. "The rock" has become smoother and pathways in the nearby wall has opened up to allow a backstage area for occasional theatre acts. "The sea" has had some walls being converted into curved benches and has a circular area in the center which could function as a bar with protruding shelves made of lime stone plates. "The forest" has opened up into a series of spaces to be used as a maze or as an art gallery.

In the center, the watchtower has now been converted into an enclosed wind shelter, as it's platform eroded faster than it's walls. Rather than overlooking the horizontal views, the focus is now on the vertical one towards the sky.


50 years

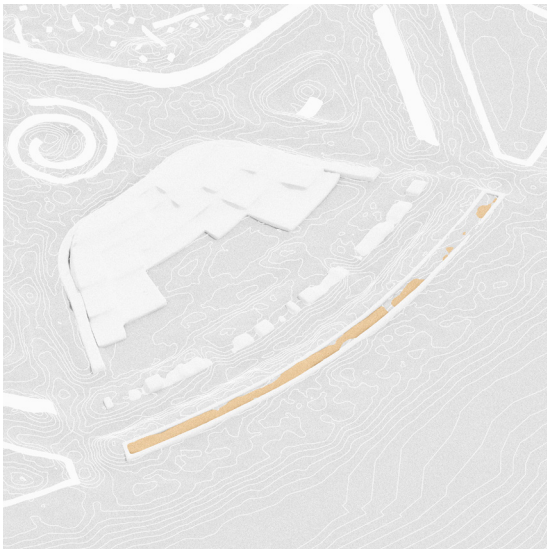
Our final visit we are met with an overgrown ruin. None of the walls are left and instead, all that can be seen is the footprint of the previous structure, marked by the much tougher rammed limestone, all covered with plants.

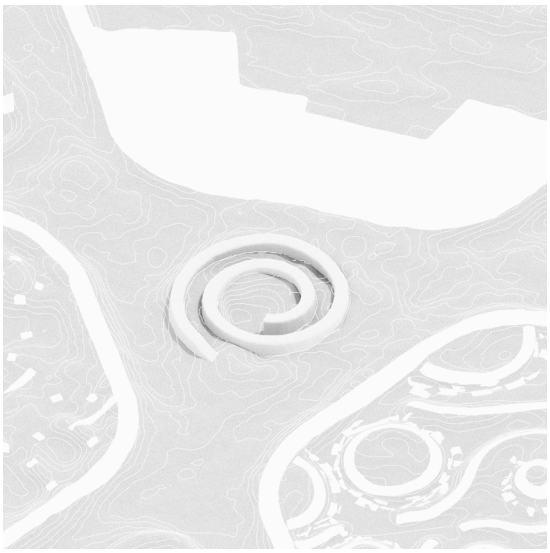
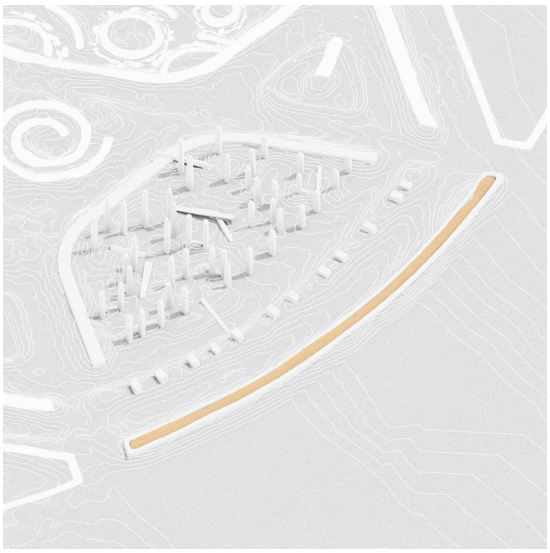
Where people have walked, paths and trails have formed. And in each corner now stands a tall pine tree, the same kind that can be found in the nearby woods.

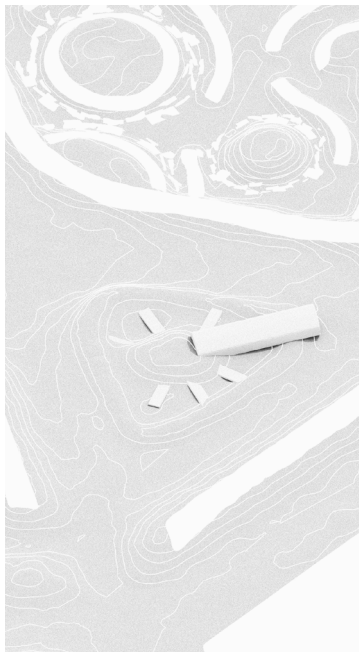
The elemental pillars are now all broken down, there is no longer a sea, the tree is chopped off at the base and the rock has tumbled down to the ground.

The three larger cells are yet again transformed. "The rock is now all covered in grass, becoming a hill where you can lie down and watch the waves roll in over the rauks. "The sea" have now had it's limestone shelves fallen down to the ground and paving the paths through a series of hills. "The forest" now lives up to its name since all that is left is a number of vertical columns, some that have already fallen over.

In the center, the windshelter has now become a fireplace in the shape of a fossil. Providing a place to gather and celebrate life as well as death in the midst of the ruin that has now become a Memento Mori.






EPILOGUE

Summary

This thesis and it's following design proposal has been a journey into understanding the natural phenomena of erosion and how to work together with it rather than against it.

By working with erosion through a set of physical experiments, my knowledge of the phenomena expanded and allowed for an intuitive design process to follow.

The design proposal was challenged by working with an extra dimension, time, in a manor and scale that is rarely seen in the field. This, along with a site that connects to the concept of the construction, lead to an estranged typology that can be best described as a combination of landscape architecture and building architecture. A structure that is developing and changing itself over time by making use of natural forces and predicting in advance what the decay process will look like.

In my opinion, this thesis proves that it is indeed possible to work with erosion and decay in a way that improves upon the structures features and qualities. Additionally, it provides a different way of working with materials in architecture by taking into account the differential erosion of materials.

Discussion

Working with time and decay in this thesis has been an eye opener for me. How the great force of time can truly have a major impact on how you approach the design of architecture. Also, it has made me confident in that if you approach any new design challenge with an open mind, you will always gain some sort of knowledge that will be of use for you.

Looking back at the process of the thesis, I am satisfied of the scope I managed to cover. From developing an entirely new technique by working with differential erosion in architecture, to applying this technique in designing a structure.

However, there is still a lot that can be further investigated from discovering how to properly adapt materials to a larger timescale to how this can be applied in everyday architecture.

My ambition is that this thesis might inspire other architects, designers and engineers to include aging of materials into their design and to not see every defect or crack as something distinctly negative, but rather a possibility of telling a story of a building's life.

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Pictures on page 15

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