a Mo-clay Museum *on* Mors

Aalborg University

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illu 1. mo-clay cliff

Abstract

This thesis presents an investigation into how a new Moclay and Fossil Museum on Mors could be designed. The museum is to replace an existing one and needs to exhibit both ancient fossils and the unique landscape of the moclay excavation that it will sit in.

Both the placement and design of the museum follows an extensive analysis of the site, its surroundings and the existing museum conditions. The steep slopes of the excavations that cut into the typical rolling hills of the landscape and the curving lines of the revealed mo-clay layers are unique and important parts of the history of the landscape. These influence the design of the museum heavily as it makes the bottom of the excavation accessible and comes to contrast the landscape by using well-defined geometric shapes with facades of materials of the ground - brick and concrete.

A long, horizontal building housing most of the museum functions steps forward onto the edge of the excavation, becoming part of the landscape. The interior of the building is divided into a 7x7m grid, defined by a partition walls, some of them moclay bricks – and a system of timber columns and beams that carry roof and a second floor. The parametric software Karamba has been used in the design of this system, testing multiple layouts.

From this main building, visitors can take two directions: one leads into a subterranean space, designed to showcase a 10-meter-tall, petrified tree found in the ground. Another path leads to a tower, where visitors can take an elevator that will slowly move them down through the geological layers, framing views of it along the way.

The design is an attempt to balance between stepping into the background and letting landscape and fossils speak – by using simple, untreated materials and by refraining from imitations of the curved lines of the landscape – and of not being afraid to step forward, providing a constant and timeless feature in a landscape that is both eternal and everchanging.

illu 2. the excavation, the industry and the fjord

Introduction

In the northern part of Denmark, specifically on and around the islands of Mors and Fur in The Limfjord, a very rare geological situation exists. Millions of years ago, when the area lay beneath the sea, the flora and fauna of the time was preserved in the underground, in what we call mo-clay. Much later, during the last Ice Age, the mo-clay was pushed up by glaciers and within the last 150 years it has been revealed by industrial excavations – and the landscape is continually eroding and thus revealing itself again and again. The fossils and the landscape tell stories of both the smallest and largest scale and are of such high quality that there is an attempt to get the area on the UNESCO World Heritage List. This would potentially include replacing the existing Mo-clay and Fossil Museum with a new one.

In designing a new museum lies the potential to gather and lift a part of Denmark that is often forgotten, and to tell a story that is unique to this place and time but tells the story of a much larger part of the world on a timescale that is almost incomprehensible. The museum must convey stories on the tiniest to the largest of scales, from the very recent human impact to that of species that have been gone for millions of years.

A new building would place itself in a landscape that is both worth preserving, but also interchangeable – and which also continually reveals new secrets of the highest value. Any rock hiding in the mo-clay could tell stories that have never been heard before – and these continuous findings would shape the exhibitions at the new museum.

This project is an investigation into how such a museum could be designed.

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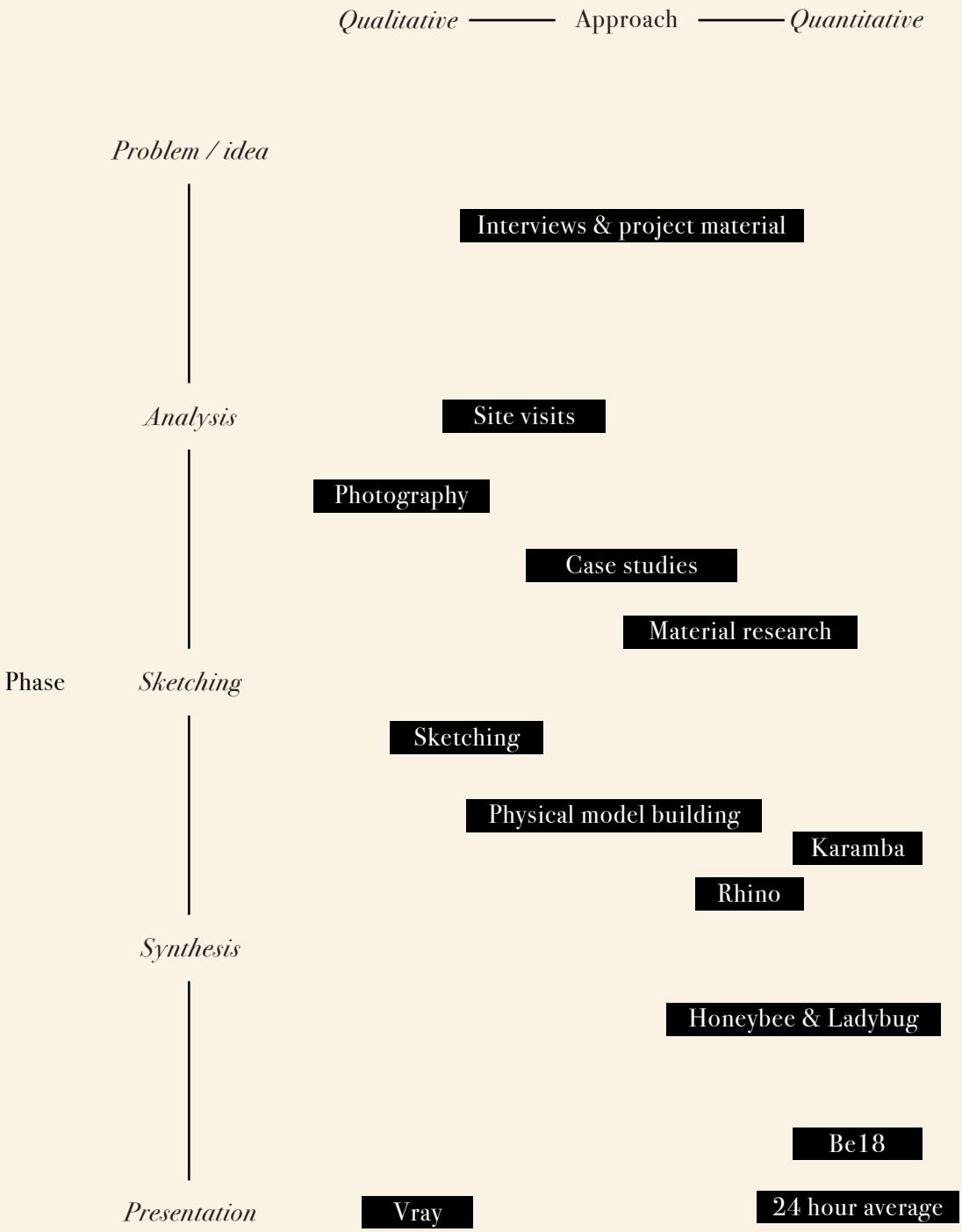
PROCESS

Methodology

qualitative / quantitative



IDP + phenomenological approach

To achieve a tectonically sound design the project follows the Integrated Design Process. Always letting newly obtained knowledge inform previous choices and motivate moving between different phases of the project to reiterate. In addition, the group considers in all phases both quantitative as well as qualitative methods to achieve a strong coherence between technical, aesthetic and functional aspects, comparing measured data with phenomenological experiences. The group wishes to design a project which is rational yet poetic and in order for this to be fulfilled everything logical and technical must be informed by what is sensed, felt, experienced and vice versa. In the following, the methods and tools used in the design process will be described.

Interviews & project material

This is a project with several interested parties - working together while still having individual demands, hopes and wishes. As designers the group must understand these agendas and form its own opinion. In the initial part of the project the group has interviewed Louisa - a representative from the municipality of Mors, Anders - the director of Museum Mors, which runs Fossil- & Molermuseet as well as other museums on Mors, and Henrik - the enthusiastic fossil hunter, curator and guide of Fossil- & Molermuseet as well as spoken to locals with a connection to the museum. The group bases its program upon written material from different sources and points in time - all of which represents a large amount of effort carried out by many different people all working towards making this museum a reality.

Site visits

As it is a central goal of this project to let the man-made landscape and architecture accentuate each other it is crucial to develop a deep understanding of the specific site. Therefore, the group will repeatedly return to the building site to let it inform the design process not just in the beginning, but throughout the project. Photography plays an important analytical role in seeing the site and its surroundings. Choosing to photograph something is to deem it meaningful and these photographs become our memory of the place in-between visits. During site visits the group will also sketch to interpret the landscape and develop a deeper appreciation - this is in order to develop a design which respects and accentuates its landscape.

Case studies

To better understand the museum typology and approaches to interacting with landscape the group will carry out case studies of projects of interest in Denmark and Italy.

Material research

Materials are what we interact with in relation to architecture, and research will form a basis for composing materials, considering both durability, carbon footprint and structural capability. Equally important are aesthetic concerns, and material combinations will also be studied with a phenomenological approach, using both digital rendering tools, physical models and material studies.

illu 3. experiencing the site

Sketching
To discover potentials and opportunities within the project, the group will utilise sketching by hand. This is a method not constrained by exact measures or other limiting factors, thereby allowing intuition to lead. For good ideas to tappear one must let the bad ideas flow and hand sketching allows for quick iteration to test promising suggestions against technical considerations, letting the sensible and rational evolve alongside each other. When these composed ideas are ready, they will then be further developed in increasing detail using digital tools.

Physical model building
Physical models will be utilised for a variety of purposes. In an increasingly digital world, the physical model is an opportunity to uphold a sensibility an care for tactility. They will serve as tools for creativity in design – revealing opportunities, for analysis of ideas – revealing challenges, for structural development, for exploring interplay between building and landscape, for light studies and finally for presentation to communicate the project. The opportunity to work physically within a certain scale allows one to focus on specific areas of a project. 1:500 places the volume in its context. 1:100 reveals the composition of the facades and how each building is bound to the ground. 1:50 and 1:25 allows going inside the building, focusing on structure, details and materials.

Digital tools
Digital tools will become more and more prominent during the sketching phase and play a central role in the synthesis and presentation phase. In Rhino the design is detailed in 2D and 3D to develop drawing material and basis for rendering with Vray and illustration. Plug-ins such as Honeybee and Ladybug will aid in addressing daylight levels and Karamba will inform the structural composition preferably already from the sketching phase.

Construction & tectonics
Throughout the process, the group will strive to achieve a high level of detail in the structural design. This will be done through a continuous iterative process, employing both digital tools such as Karamba, physical models, sketching and detail drawings. These will help to maintain a coherent and durable building at all scales.

Energy consumption & indoor environment
To ensure a maximum energy consumption of 41 kWh/m2 (BR18 §260) per year, a Be18 model will be developed and updated at specific points in the design process to expose areas in need of further consideration. Optimisation of energy consumption during operation will be a main parameter throughout the project. Passive strategies such as insulation, thermal mass, natural ventilation and shading shall motivate architectural motives throughout the project to ensure a low energy use and pleasant indoor environment, which will be tested using 24-hour average temperature calculation sheets.

In the pursuit of sustainability

Sustainability has become a central element not only in architecture, but in almost every facet of today's society. Current discussions talk of reducing the emissions of agriculture, which could come to change the makeup of the Danish landscape. At the meantime, the change from production of fossil to green energy is already making its mark on Denmark and much of the world – windmills and fields of solar panels are taking up more area by the day. The built environment is in the middle of a similar process, lowering carbon emissions in all phases of a building's life.

All of this is happening in the name of sustainability – but it is causing much debate. Windmills and solar panels are often at odds with both their neighbors and with biodiversity (and it doesn't tackle what many believe is the core problem – over consumption and economic growth).

As often happens with words that are overused, the meaning of sustainability is becoming more and more vague. The discussion is more nuanced than apparent at first sight. Sustainability is an ideal that we should strive for – but we should always be critical of what is actually sustainable and what merely symbolizes sustainability. Wooden architecture might look sustainable, but it depends on the forest it came from, how it was forested and transported, how it is used etc. And concrete may not seem like a green material, but used in the correct situations, it could help create architecture that lasts thousands of years.

At the same time, the focus on lowering used and embedded carbon in our built environment is of high importance – but it must not overshadow our core job as architects: to create architecture of high quality. This must always be present in the pursuit of sustainability, when working with new (or old) technologies and materials.

If the building ain't nice, the demolition team won't think twice.

MANIFESTO

Highlight the material
and Connect the material
Reveal the connection

Tricks are allowed but should be revealed

Building should pursue Sustainability

but Sustainability cannot be measured in numbers only

Different situations call for different solutions

but

A solution to most problems already exists

and

Imitation is okay

because Buildings are affected by their surroundings *and by their situation*

also Buildings should affect their surroundings *and their situation*

The human perspective is central

but Not all humans have the same perspective

Plans for a new museum

The municipalities of Mors and Skive in North-western Jutland are working together to get the Mo-clay cliffs along the coasts of Mors and Fur recognised as Unesco World Heritage.

Both Mors and Fur already have museums exhibiting the impressive collections of fossils from 55 mio. years ago found in the mo-clay layers, but the current museum building on Mors, located in an old barn, does not have the capacity to do its exhibition justice.

Therefore they wish to construct a new museum and have set down a committee which has begun the planning process. This committee has made a list of suggestions for the further work within the themes: target group, concept and mediation, placement, level of ambition, organisation and time horizon. (§17.4-udvalgets anbefalinger til den fremtidige formidling af moleret på Mors, 2023) As it is still very early in the process the suggestions should be seen as such and not set in stone.

The municipality have worked with 3 possible locations for the new museum - 2 of which depend on becoming part of an experimental program for coastal- and nature tourism in Denmark as they are located in near vicinity to the coast. To apply for this experimental program the municipality has carried out a preliminary investigation in collaboration with BARK Rådgivning, which contains market analyses, case-studies, estimated budgets and visitor numbers. (Forundersøgelse for et nyt Molermuseum, 2023)

illu 4. Hanklit

In the late 90's The municipality of Mors was in a similar process and even further along than today. In 1996 The municipality of Mors published a concept proposal for the visitor-functions of the new museum in collaboration with consultants Rasmussen & Witthøft. This proposal described in detail visions for the different exhibitions and the functional layout of the building. (Idéoplæg - Vulkan- og Molercenter på Mors, 1996) The Japanese architect Tadao Ando was to design the new museum but a change of the danish building regulations made the project much too expensive to carry out and the process could not continue.

The group will carry out the project on the basis of the current suggestions presented by the committee and the preliminary investigation as well as drawing inspiration from the concept proposal from 1996. Our understanding is deepened by interviews with The museum director, the museum curator and representatives from the municipality.

What is mo-clay?

Unless otherwise stated, the following paragraph is based on the article 'Molerets Historie' (Pedersen, S. & Pedersen, G. 2012).

Mo-clay is a phenomenon very rare in the world, but only experienced in Denmark, more specifically on the islands Mors and Fur in Limfjorden in northern Jutland. The mo-clay formations found in Denmark were formed around 55 million years ago, in the transition from the Paleocene to the Eocene era, when the region was covered by a vast sea. It was formed due to an increase in global temperatures, causing algal bloom and, in consequence, oxygen depletion. Mo-clay consists primarily of fossilized algae, meaning that it is a diatomite – a type of stone that consists of more than 50 percent diatom algae.

The mo-clay on and around Mors and Fur today rises above the sea-level due to glacial activity during the last ice age. Glaciers pushed the mo-clay up in front of them – because of this the layers are not flat and horizontal anymore, but often create wave-like patterns.

The oxygen depletion created conditions ideal for the creation of fossils. The layers of fossilized algae contain a myriad of flora and fauna from the era, preserved in very high quality. The mo-clay in this way tells a history of this period on earth, not told this thrillingly anywhere else. As the extinction of the dinosaurs around 65 million years ago was followed by a period with low levels of biodiversity, the period from around 55 million years is a period of high interest, as many of the ancestors of the flora and fauna found on earth today appeared during this time. Included among the fossils found in the mo-clay are turtles, fish, insects, tree trunks and leaves, and examples of some of the first songbirds.

Found between the layers of fossilized algae, layers of volcanic ash tell the geological history of the period. The ash stems from volcanoes in the North Atlantic and is in this sense of great interest for geologists researching this period of the history of the earth and the formation of the Mid-Atlantic Ridge.

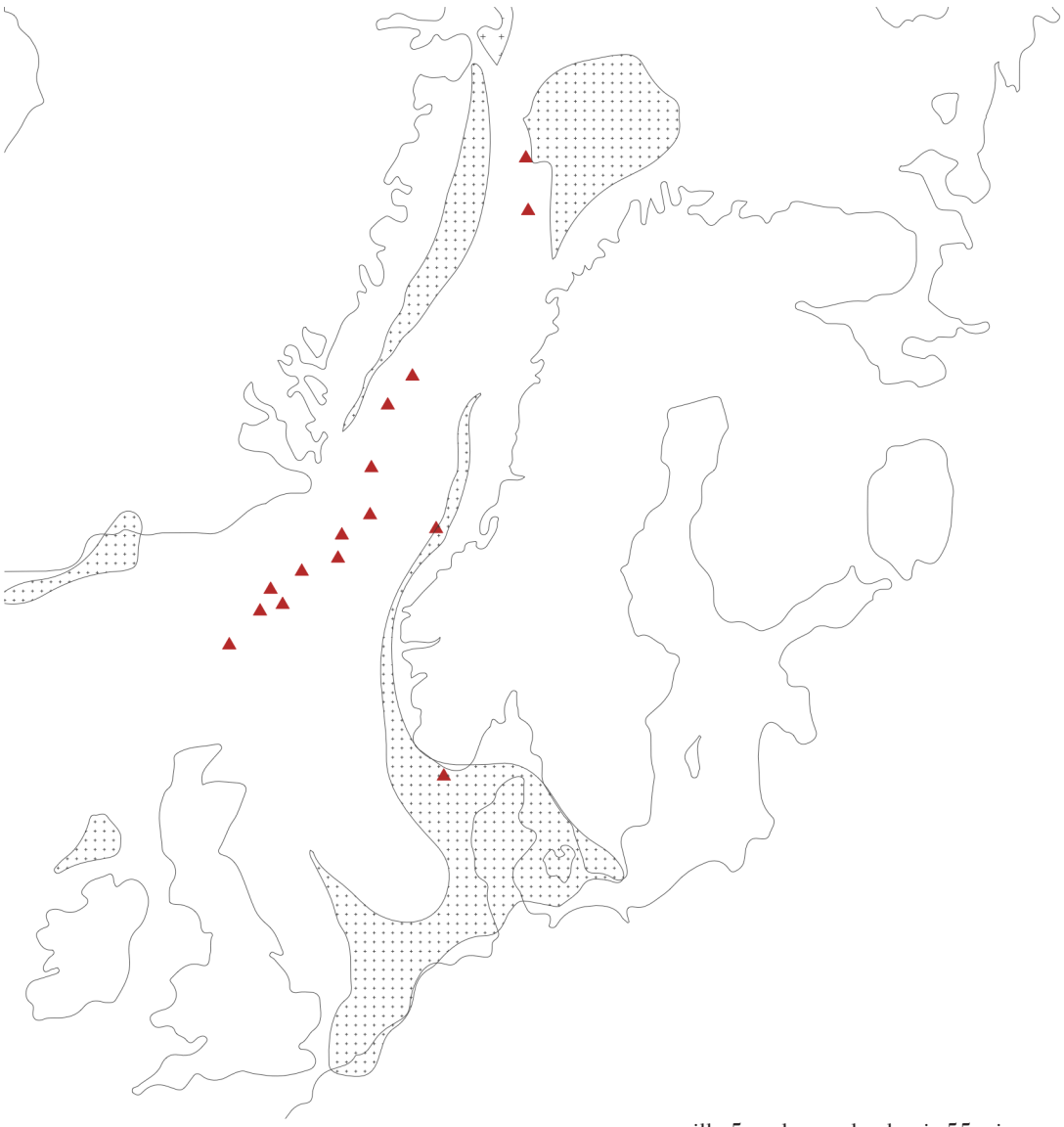
This means that a mo-clay museum must showcase both something on the tiniest of scales – the life of an insect or algae that has been frozen in time – and on the largest of scales, as it is also the geological history of the earth through millions of years. These stories can be told through artifacts (fossils), through the surrounding landscape and through interactive elements (showing for example the development of the landscape through time).

Industrial history

The mo-clay and its fossils would of course still be hidden in the landscape if human activity hadn't unveiled them. The mo-clay has been used in the production of bricks since the start of the 20th century, used especially in high-temperature ovens, for example for the melting of metals. A biproduct in the production of these bricks is a large amount of grain and dust. This was found to be highly absorptive – from this the idea of producing cat litter came. Mo-clay has also been used in producing dynamite and for filtrating beer.

Today, the production of mo-clay bricks takes place on the island of Fur, while most mo-clay on Mors is used for cat litter. Around the northern part of the island, active and non-active mo-clay excavations are scattered in the landscape, revealing both the short industrial history of the mo-clay, and the prehistoric origin of the material.

The industrial history of the mo-clay excavations is also a story that needs to be told in the museum.



illu 5. the north atlantic 55 mio. years ago

Geological scale

A map showing the coastal outlines of today at the position they would have been 55 mio. years ago when the moclay was formed.

shallow ocean

volcano

Choosing the site

illu 6. Mors, Thy & Salling, 1:400.000

Mors & its context

The committee suggest 3 possible locations for a new museum. 2 located around Ejerslev Harbour, 1 at the location of the current Museum at Skarrehage. Both locations have connections to non-active mo-clay excavations of unique character.

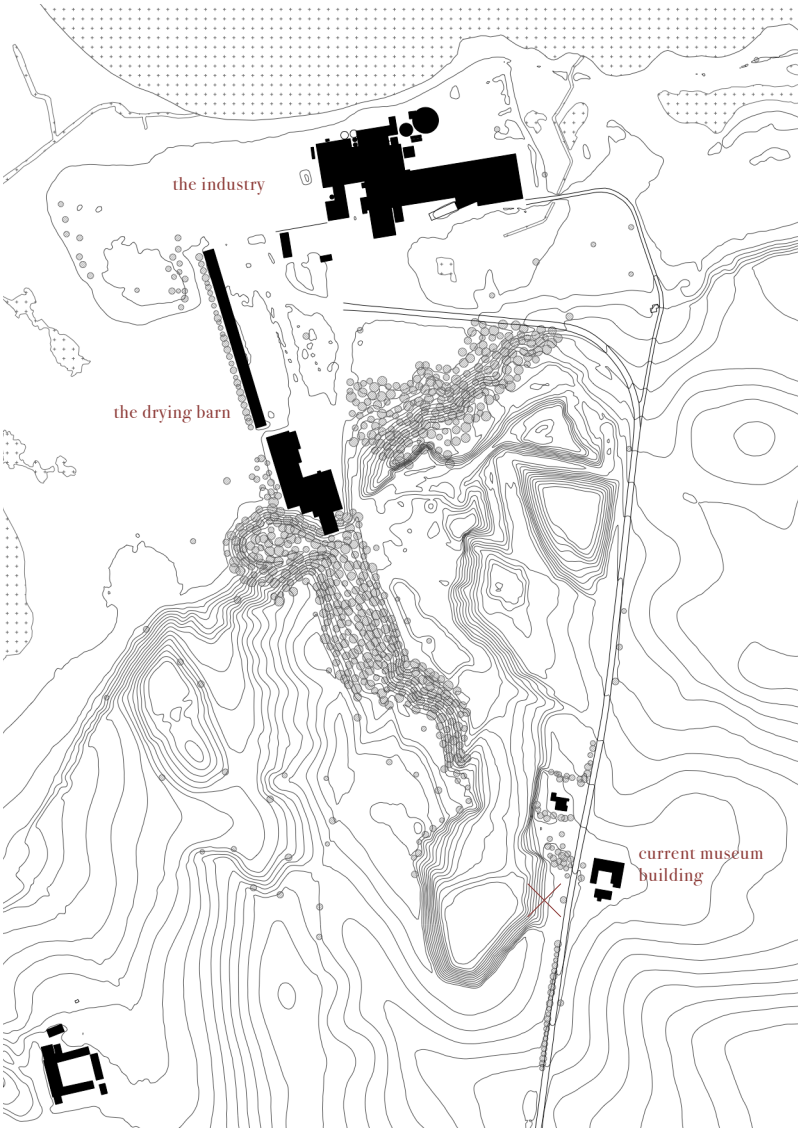
Ejerslev Harbour

Skarrehage

illu 7. Ejerslev Havn, 1:8000 - 2m contours

Ejerslev Harbour

A non-active excavation has been openend to the fjord and now forms a lagoon. The municipality wishes to place the new museum here to achieve a synergy with the harbour restaurant and a future landscape hotel. Option 1 is on the grounds of a former moclay brick factory - option 2 is above the lagoon.



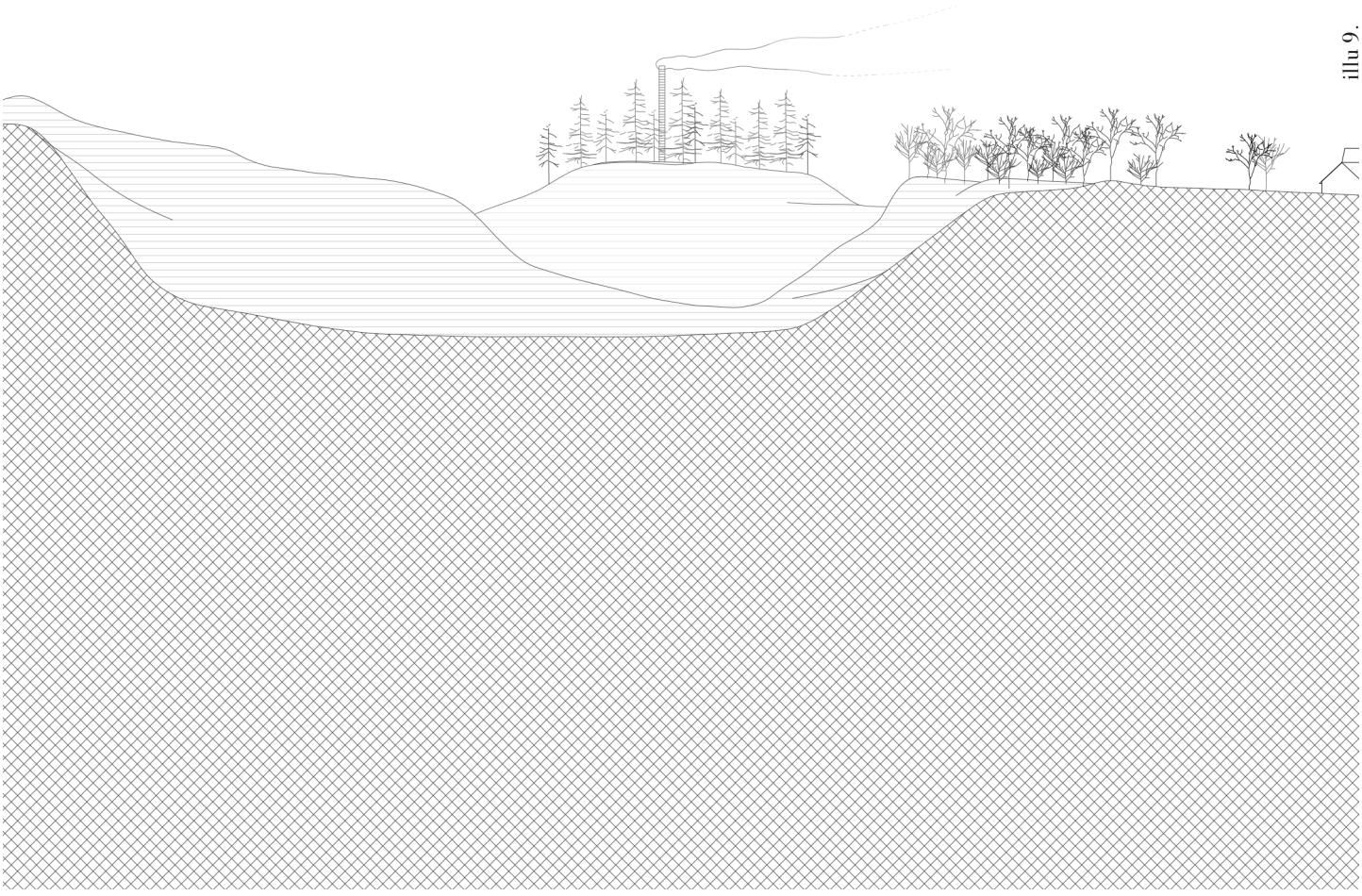
illu 8. Skarrehage, 1:8000 - 2m contours

Skarrehage

The 3rd option is to locate the new museum at the site of the current. The museum itself wishes to stay at this location as they own the excavation just across the road and a path through the man-made landscape leads the visitor to the drying barn, which conveys the industrial history.

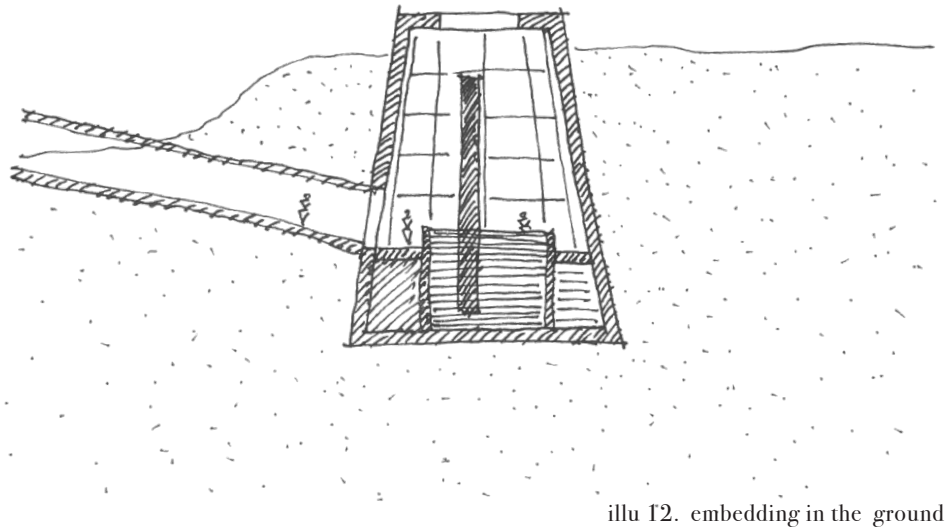
The project will suggest a museum which interacts with the mo-clay excavation landscape at Skarrehage.

The site at Skarrehage connects the arrival from the road to the bottom of the excavation. The museum must transport the visitor on a journey through the mo-clay layers into the darkness and out into the landscape to search for fossiles and walk to the drying barn. From the site the eye looks between mo-clay hills, over the industry and across the fjord.



illu 9. site section, 1:1000

Meeting the ground



illu 12. embedding in the ground

The mo-clay excavations have developed over the course of many decades of industrial mining. The series of illustrations show the evolution of the landscape through time as new dig sites are opened, and others are abandoned to be reclaimed by nature. Though not natural in origin, the scattered excavations around the northern parts of Mors, have become part of the cultural landscape on Mors.

"Cultural landscapes are those where human interaction with natural systems has, over a long time, formed a distinctive landscape. These interactions arise from, and cause, cultural values to develop." (Mitchell et al., 2009)

The landscape that has emerged from the excavations is now an integral part of Mors and has unlocked the historical potential hidden in the sediment layers from 55 million years ago. Without either the geological events or the industrial excavation, there would be no museum. Understanding and embracing these conditions is vital when designing a building for the area – or in the word of Peter Zumthor:

" Every new work of architecture intervenes in a specific historical situation. It is essential to the quality of the intervention that the new building should embrace qualities which can enter into a meaningful dialogue with the existing situation. For the intervention to find its place, it must make us see what already exists in a new light." (Zumthor p. 18)

illu 11. nside the excavation

The way the building meets the landscape and interacts with the surroundings needs to strengthen the experience of what already exists. This can be done by embracing the stereotomic nature of the mo-clay excavations. The Spanish architect and professor Alberto Zampa Baeza, known for his stone buildings, notes (on stereotomics):

"It is the massive, stony, heavy architecture. The one that sits on the earth as if it was born from it. It is the architecture that seeks the light, that pierces its walls so that the light enters it." (Baeza, 2020)

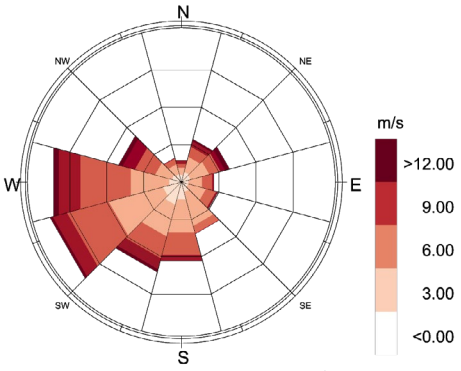
Through either embedding or completely burying parts of the museum, visitors are invited to experience cutting into the mass and becoming part of the excavation. Guided in darkness by carefully curated lights and surrounded by heavy materials, that allow them to feel the heft of the ground. Alberto Campa Baeza describes the tectonic as:

"[...] the bony, woody, light architecture. The one that rests on the earth as if rising on tiptoe. It is the architecture that defends itself from the light, that has to veil its hollows in order to control the light that floods it." (Baeza, 2020).

In the design of the museum, using stonework (as brick or actual stone) creates associations with the ground, and works well as a wall material, working under pressure, and letting light though punched openings into the exhibition spaces. The tectonic woodwork functions well as a roof material, moving loads to the walls, and through exposed elements add rhythm and warmth to the interior.

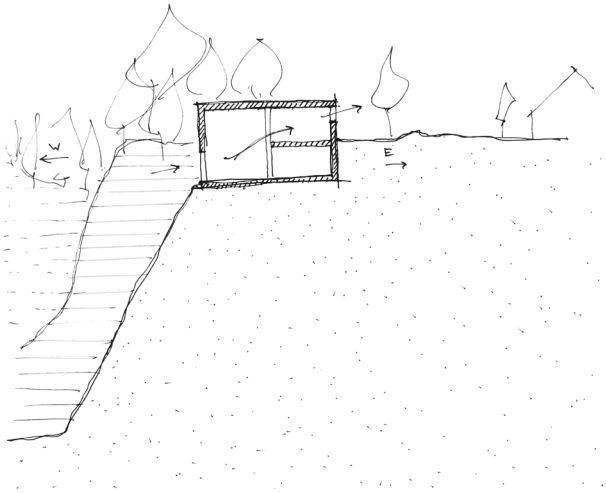
illu 13. view towards the fjord

Measuring

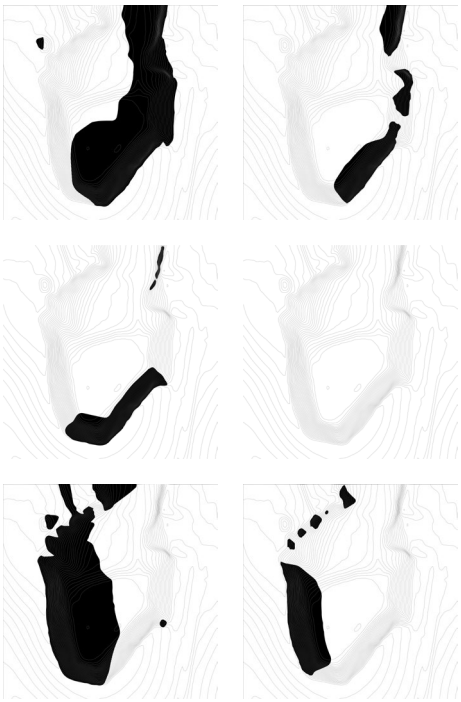


illu 14. windrose

To map the possibilities of using the wind actively for natural ventilation, the wind conditions of the surroundings are examined. Data and wind roses from the nearest weather station located in Silstrup, just south of Thisted are used. For the entire year, west is established as the dominant wind direction, but when each of the months are evaluated separately, the winter months have a tendency towards more southern winds compared to the rest of the year. The site is relatively unsheltered, allowing for ample opportunity to integrate natural ventilation strategies. The excavation pit will create a wind shadow resulting in lower wind speeds inside the pit itself.



illu 16. utilizing western wind



illu 15. shade study

As shown on the sun studies, the shading on our site is negligible, as we are placed on the edge of the excavation. The illustrations show the shadows being cast from the sun on three times of the day during equinox and the summer solstice. Winter solstice was deemed irrelevant, as the museum is not open to visitors during the winter months.

The main takeaway from the study is that it is mainly the excavation pit that is affected, through self-shadowing. Through this analysis of the light conditions, an informed design process can be instigated, leading to active utilization of solar heat gain during winter, mitigation of it during summer and utilization of the natural daylight as a design tool.

Feeling

Walking around the mo-clay excavation next to the existing Mo-clay and Fossile Museum on Mors, on a February morning, is a chilling experience. Along the edge of the hole, you are offered next to no lee from the wind, and the slippery ground makes you consider your steps carefully, as the drop is at some places above 25 meters. On the other hand, if the sun isn't hiding behind the clouds, it helps keep you a little bit warm as there are only patches of vegetation to create shade near the edge.

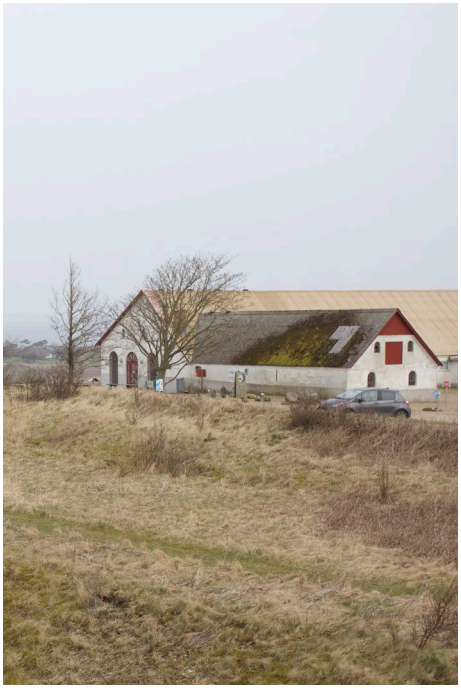
Most importantly, the view from here is more dramatic than most other places in Denmark: The rolling hills and agriculture so typical of this country, have been interrupted, torn open, to reveal much of the history of our region – lines in the mo-clay vary from straight and horizontal to sudden twists and curves and thus tell stories of ancient volcanoes and the glaciers that shaped our landscape. The hole in the landscape is in itself a reminder of our industrial past and our former, more loose and careless approach to our nature – and if you follow the rift in the landscape, your eyes will meet the smoke coming from the still functioning Mo-clay industry.

At a point, when walking along the edge, the drop into the hole becomes less and less steep, and you can carefully make your way down. The clay is soft and saturated with water at this time of year – only the top has a thin layer of ice, but after a crackling sound, your feet sink into the soft ground. Quickly, you get out of the wind, and the quietness and warmth of the sun is a sudden and pleasant change. At the bottom, it seems like you're somewhere else entirely, you are no longer walking on top of the landscape, and the climate is completely different, it is dead quiet, and you can feel the soft ground and look up on the face of the massive mo-clay walls. It really does feel like a space – the edge of the walls at the top doesn't vary much in height, creating a continuous meeting with the sky, and standing in the middle of the hole, you feel the scale, and the time that is at play here.

illu 17. sun & shadow

Architecture to relate to

The new museum will become part of an already existing narrative regarding the historical and industrial implications of the mo-clay excavations on Mors, and a mapping of the surrounding buildings, gives an understanding of the context.



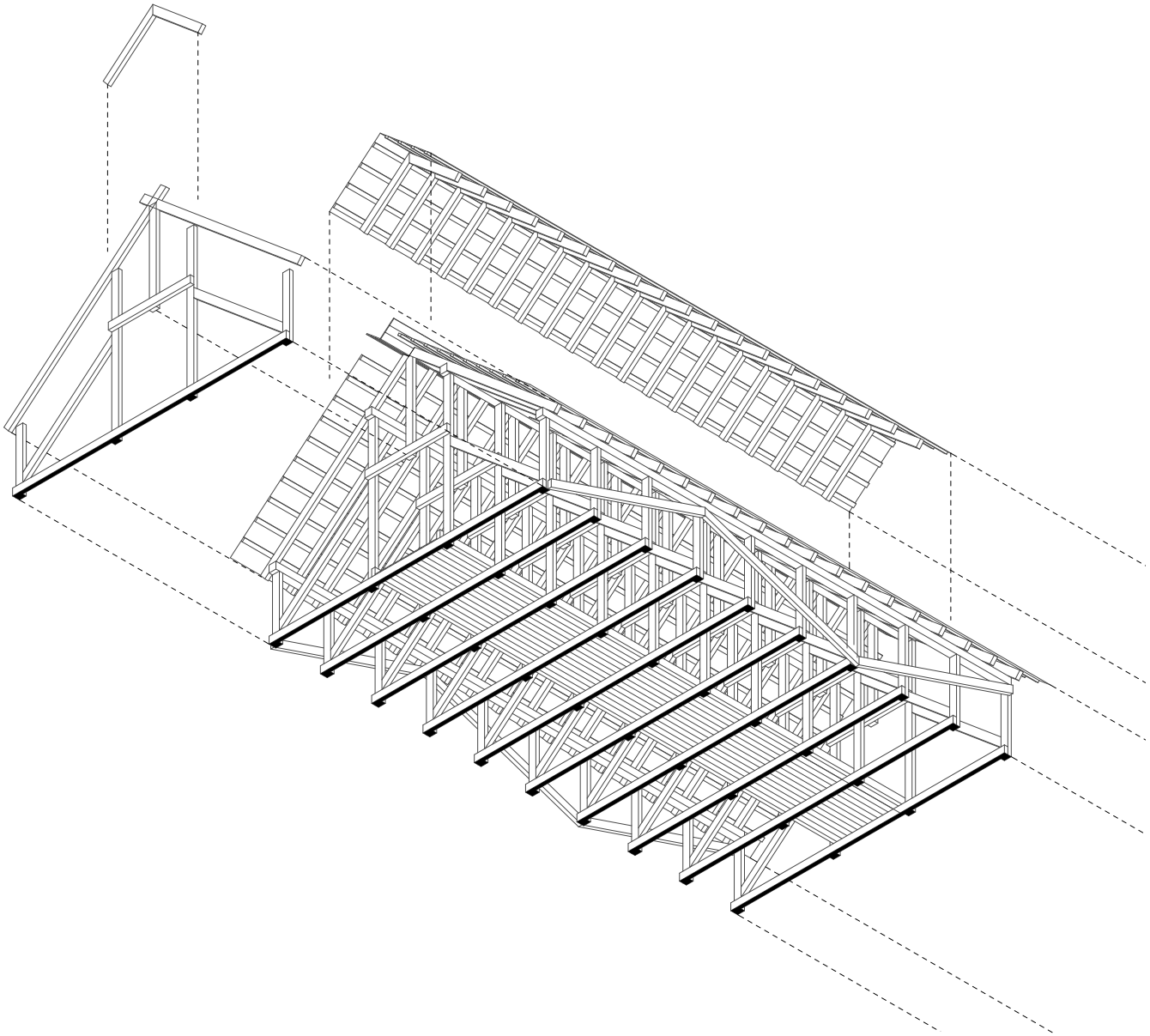
illu 20. existing museum

The existing museum on Skarrehagevej has been retrofitted into an old farmhouse across the road from the excavation site. Most of the exhibition is displayed in the part of the farm, that used to house cows – still complete with a trough running down the middle. The space has low vaulted ceilings. The other parts of the farmhouse are used for administrative work and storage for the museum.

illu 18. excavation

The existing museum is located just south of the still active mo-clay industry. It is a compound consisting of large industrial buildings, where the excavated mo-clay is processed and distributed from. Though the industrial compound is not a part of the museum, it is important to understand their part in the story – without the excavations, the museum would not exist.

illu 19. Imerys



illu 23. drying barn, axonometric from below

illu 21. drying barn

Further information on the industrial history of the mo-clay excavations can be found in The Drying Barn – an old wooden building, in which the mo-clay bricks were placed to dry naturally. It was designed and oriented to make us of the wind. Back in the day, the drying barns had an adjustable façade allowing for the right amount of shelter in case of something like rain. There are elements of the Drying Barn, that can be taken into consideration, when working with the tectonics of the new museum.

illu 22. drying barn

Case study
Stevns Klint Experience

In Denmark, there are other spots where the underground is uncovered, unveiling major events in the world's history. One of these are at the Cliffs of Stevn (Stevns Klint in Danish), where the underground is visible due to both erosion and industry. A line in the cliffs shows the traces of the event that caused the fifth mass extinction and with it the disappearance of the dinosaurs. Because of this, the cliffs are on UNESCOS list of World Heritage, and a new 'experience center' has been built recently by Praksis Architects. This differs from the new Fossil and Mo-clay Museum as Stevns Klint Experience, as it is called, is a completely new institution and not a museum – which has some implications, as they for instance do not have to do research.

The building sits on the edge of an old industrial excavation, hiding from sight on arrival. It is a very humble building; it lets the landscape take main stage. Here, the landscape is really the main character, as they do not have the same diversity in fossils as they do on Mors.

The reception shares a large and light room with a shop and café. The space is multifunctional and includes an office space for the employees that can thus always help at the reception if visitors have questions. Dug into the hill, two darker rooms form the exhibition – one room with a large 'cutout' of the cliff, where an informative video is projected onto, and one large room with a mostly interactive exhibition – only few things from the surrounding landscape are found here.

The museum is clad in limestone in both the interior and exterior. The stone is of a slightly different format than the usual brick and has a light colour that matches the colour of the cliffs.

The employees emphasized the close connection between their working space and the landscape, the aesthetics and functionality of the materials – a cast concrete floor makes it easy to clean off the mud from the landscape, and pine slats in the ceiling ensure pleasant acoustics along with the limestone. What was missed was especially a more flexible space for exhibitions – to make the building more interesting for both locals and employees.

illu 24. Stevns Klint Experience

illu 25. Stevns Klint Experience

The art of exhibiting

A museum has the potential to be both gathering point and educator – its main function is to inform and create experiences, but in doing so, it can also bring different social groups and generations together. Making a museum that can be a shared space, depends on how you organize the space and on what and how you exhibit. For instance, a museum focused solely on looking (on artefacts i.e. painting and sculpture), is generally more interesting for an adult audience, while interactive exhibitions (i.e. info screens, games or videos) may create an experience better suited for children.

The exhibitions at a mo-clay and fossil museum create interesting opportunities for setting up exhibitions that differ from these two types. Some fossils will function solely as artefacts, almost as some sort of nature-made sculpture, only for looking, while others are for picking up and touching. As part of the museum is the surrounding landscape, and some of the fossils - or artefacts - are still in the very ground that the museum sits in and on, part of the whole experience becomes an interaction with the surroundings, and an 'interactive' element is to possibly find new fossils to add to the museum exhibition.

The fact that the museum guests will continually add objects to the museum means that parts of the exhibition will be under constant change. Furthermore, the museum will have temporary special exhibitions, in this way hoping to attract local visitors to supply the flow of tourists expected to come with a place on the UNESCO World Heritage list. The museum must be able to both accommodate these interchangeable elements, whilst showcasing the fossils that are of high enough quality that they will surely be on exhibit for good. These include a 9,5 m fossilized tree, a fossilized crystal and the turtle Luffe that has been declared 'Danekræ' – a natural history object from Denmark of exceptional scientific or exhibition value.

The museum will differ from an art museum, as it will have a stronger emphasis on education and information. Both landscape and many of the fossils can be enjoyed from an aesthetic point of view – but a big part of the experience is to understand the significance of both time and geographical scale, the composition of the landscape and the complexity of the organisms that have been found in the mo-clay. For this educational reason, the order in which different elements of the exhibition are seen is rather important.

In an art museum, space may be more organic and diffused, as the audience can often see the art in whichever order they want and thus build their own, personal experience. In this museum, the flow needs to be more controlled, and the spatial progression thus to be more linear and unified. This can, however, be interrupted by rooms with the artefacts placed in more "free" compositions.

Bruno Zevi argues, in his book "Architecture as Space – How to look at Architecture" (Zevi,1974), that the spatial element of architecture has been long neglected. Zevi tells the history of architectural space and uses the Christian Basilica as an example of a space created for progression. The museum on Mors should of course not be built as a basilica but could take inspiration from some of its spatial language. He writes:

"Space, in fact, is liberty of movement. [...] We adapt ourselves instinctively to the spaces in which we stand, project ourselves into them, fill them ideally with our movements. [...] When we enter the end of a nave and find ourselves in a long vista of columns, we begin, almost under compulsion, to walk forward: the character of the space demands it." (Zevi, 1974, pp. 217).

In modern society, a new language of space exists, born out of a whole new set of conditions – new technology and the birth of modern psychology as a science among them.

"An undulating wall is no longer undulated purely in response to a poetic vision, but to better accompany a movement, a path taken by man. [...] Man in the diversity of his activities and life, in his material and psychological needs, in his spiritual nature, the whole man, whose body and soul are vitally integrated, is the cultural center for contemporary art." (Zevi, 1974, pp.)

Something that has affected much architecture in contemporary society, is the phenomenological approach. Described and evolved in writings by Heidegger, Norberg-Schulz and Pallasmaa among others, it is a way of putting the person experiencing the architecture at the center of things. Instead of putting on layers of theory, obscure to the layman, the way the architecture - the space – feels, is of the highest importance.

illu 26. Scarpa exhibition space

illu 27. Scarpa exhibition space

An architect that has worked extensively with museums – the exhibition of objects and peoples' movement through space and between the exhibited objects – is Carlo Scarpa. His work is highly atmospheric and creates a continuous movement throughout the space, this is seen, for instance, in his museums Castelvecchio and Canova. In an article called Suggestions of Movement, Federico De Matteis investigates Carlos Scarpas work, looking at how he places sculpture and creates relationships between different exhibited elements - and between these and the visiting audience. "Scarpa detaches many displayed objects from the walls, arranging them within the rooms to occupy key positions along the visitors' paths." (De Matteis, 2019, pp. 108)

The suggestion of movement, the appeal to the kinesthetic sense, helps generate a flow through the building, but also becomes part of the atmosphere of the space.

"Buildings continuously suggest movement, and in doing so collaborate with the "un-moving" characters expressed by material qualities such as color, texture and heft to generate the indivisible atmosphere that spaces elicit." (De Matteis, 2019, pp. 106)

Carlos Scarpas work is focused mainly on classical sculpture – mostly of idealized humans – but still there is something to learn when exhibiting elements with sculptural qualities, such as a fossilized flora and fauna. A tall, fossil tree requires a completely different space than that of a small intricate fossil turtle – both spaces should, however, be designed with the people experiencing the objects in mind. Scarpas sensual use of materials, colour and light create atmospheres that are tailored to the individual sculpture – or to a carefully composed arrangement of sculptures:

"In the Zen temple, the observer must contemplate the mineral landscape from the side, while in Castelvecchio's hall he or she may roam freely between the figures: but in both cases the experienced sensation is that of being surrounded by agents that one cannot steadily keep under visual control." (De Matteis, 2019, pp. 109)

This suits a possible layout of exhibition spaces at the new Mo-clay and Fossile Museum – some spaces tailored for one specific object – some will host a more dynamic array of objects.

Making & revealing

In Kenneth Framptons text Rappel À L'Ordre: The Case for the Tectonic (Frampton), he talks of tectonics, and of the act of making and revealing as a poetic act of construction: "[...] we are not alluding here to mechanical revelation of construction but rather to a potentially poetic manifestation of structure in the original Greek sense of poesis as an act of making and revealing." (Frampton, 1990, pp. 21)

'Making' here means the act of creating a physical element through craft, and 'revealing' means to show its meaning – symbolic, historical, cultural (..). This is also embodied in Frampton's reference to the terms constructing and construing, used by Marco Frascari, and similarly talking of the physical presence and meaning of a thing. Constructing means the creation of a thing, the act of building, crafting, while construing means to embed it with meaning.

A thing can be seen as a thing in its own right but can also be something that refers to another thing – it can be representational.

"[...] one may assert that building is ontological rather that representational in character and that built form is a presence rather than something standing for an absence. In Martin Heidegger's terminology we may think of it as a 'thing' rather than a 'sign'. [...] I believe it is necessary for architects to reposition themselves given that the predominant tendency today is to reduce all architectural expression to the status of commodity culture." (Frampton, 1990, pp. 23)

When mentioning commodity culture, he speaks of the tendency to create a scenographic, representational architecture that is common in the built environment today. Often a building is 'wrapped' in something to be in accordance with the fashion of the day, for example concrete is often seen covered in brick, to adhere to the nostalgic view of old brick architecture.

It is a dangerous thing to start talking of honesty in architecture. Maybe there isn't much value in showing the insulation in a wall, and the meaning, or essence, of a ceiling, might be found in its function as a surface, a spatial limiter, rather than in the beams that carry it – so maybe one thing doesn't necessarily have to be emphasized more than the other in all cases.

However, in a world where we are bombarded with 'signs' – both actual signs but also things that represent something else (fx. the brick covering the concrete alluded to above) - showing a thing as it is and revealing whatever meanings lie in it, is of high value. For example, making a column that clearly carries, and a beam that is clearly being carried, is an act of making and revealing, and the same goes for emphasizing whenever something is structural and whenever it is a wrapping.

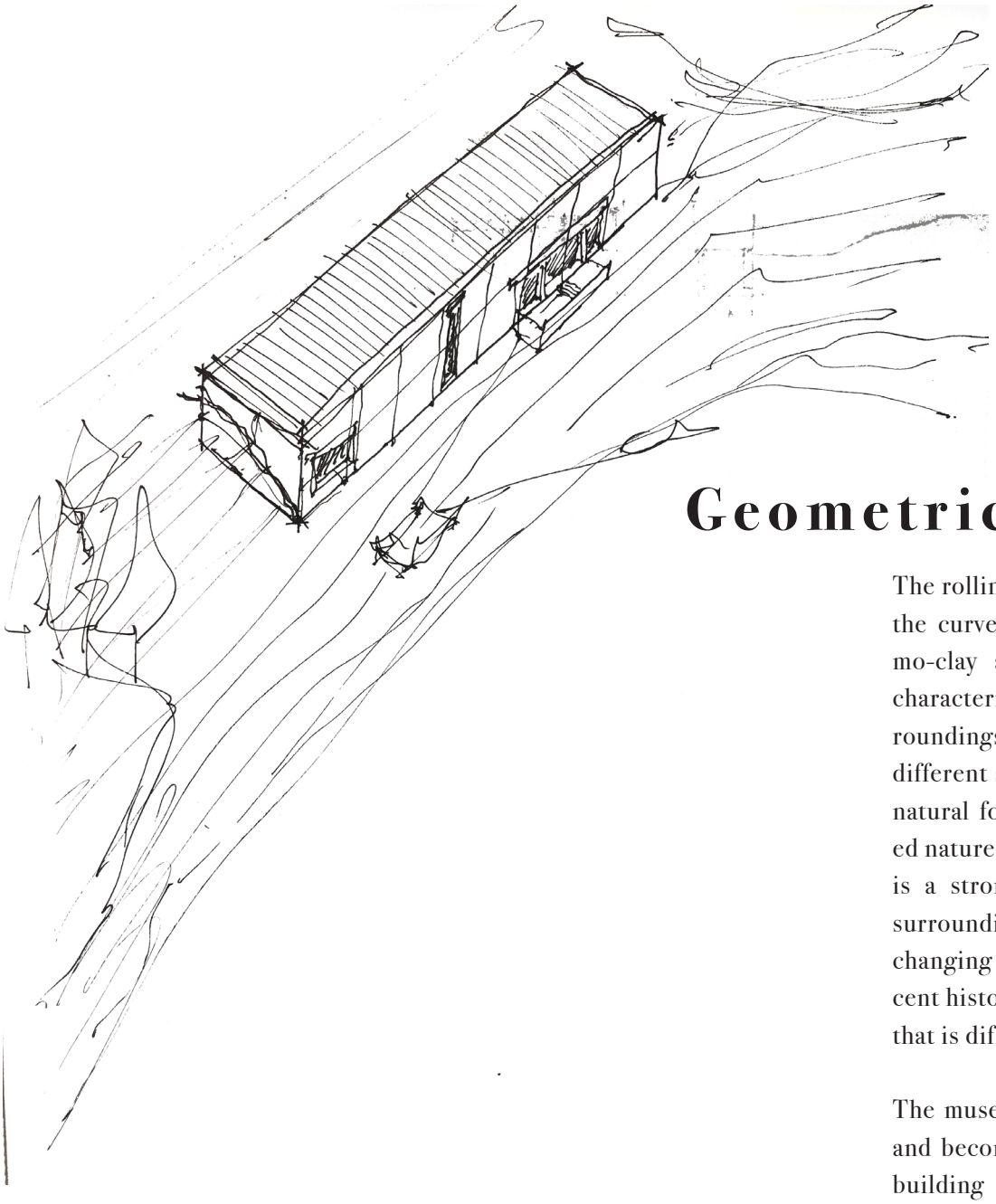
A piece of architecture can also reveal the essence of a site. Martin Heidegger writes of the 'being' of a place, and uses a bridge crossing a stream as an example.

"The bridge swings over the stream with case and power. It does not just connect banks that are already there. The banks emerge as banks only as the bridge crosses the stream. The bridge designedly causes them to lie across from each other. One side is set off against the other by the bridge. Nor do the banks stretch along the stream as indifferent border strips of the dry land. With the banks, the bridge brings to the stream the one and the other expanse of the landscape lying behind them. It brings stream and bank and land into each other's neighborhood. The bridge gathers the earth as landscape around the stream." (Heidegger, 1971, pp. 150)

When working with a landscape like that of the mo-clay excavation, this analogy is useful. The landscape of the mo-clay excavation consists of the typical Danish rolling hills, an edge, the steep slope or the 'wall' of the hole, and the ground at the bottom. The excavation already feels as a site – the rift in the landscape reveals the hidden landscape of the mo-clay, but it can be further enhanced. How does the top of the slope become an edge, the slope a wall, and the ground the bottom. And how is the hole emphasized as a hole? Follow us in the upcoming report for more info.

"The location is not already there before the bridge is. Before the bridge stands, there are of course many spots along the stream that can be occupied by something. One of them proves to be a location, and does so because of the bridge. Thus the bridge does not first come to a location to stand in it; rather, a location comes into existence only by virtue of the bridge."

(Heidegger, 1971, pp. 151-152)



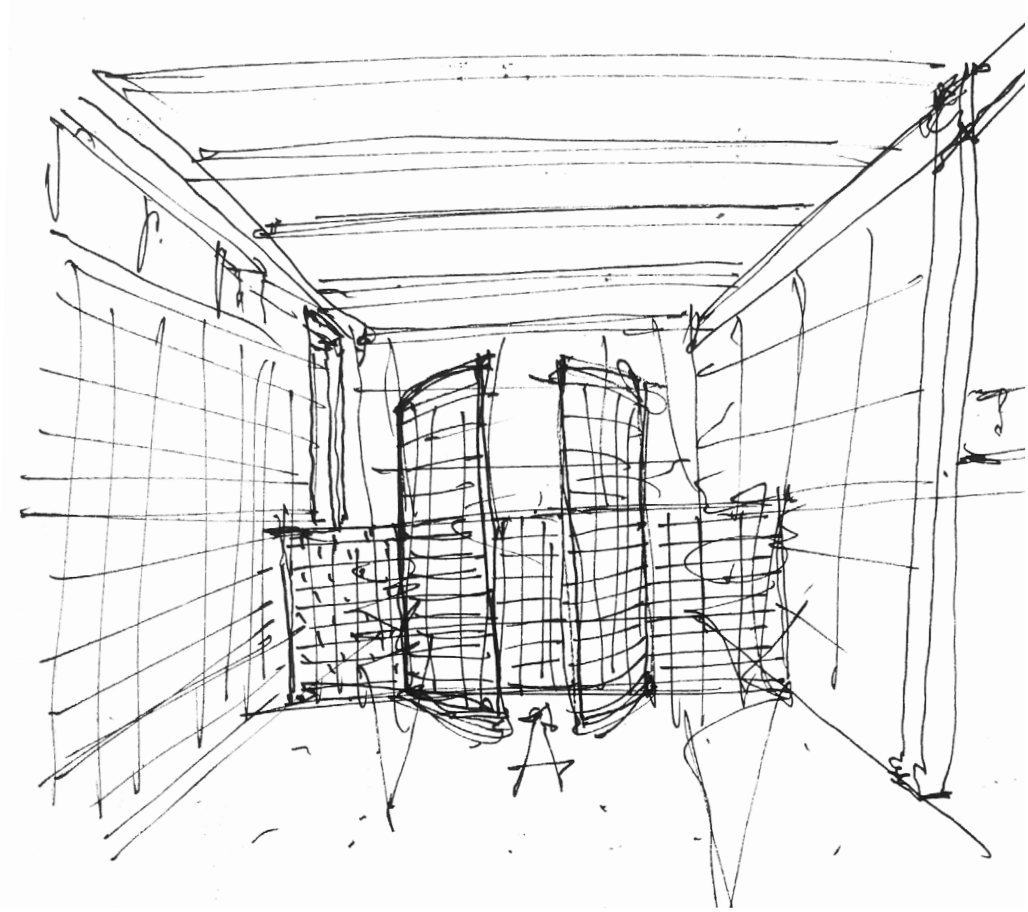
illu 28. axonometric sketch

Geometric elements

The rolling hills of the landscape, and the curved lines in the layers of the mo-clay are, as mentioned before, characteristic of the site and its surroundings. These represent nature in different shapes – ancient and violent natural forces but also a domesticated nature, used for production. There is a strong element of time in the surroundings – they are constantly changing and tell the story of both recent history and history in a timescale that is difficult to comprehend.

The museum building needs to enter and become a part of this context. A building that is geometric and defined would distinguish itself from its surroundings as a purely cultural element, not shaped by natural forces but by human ingenuity. Using basic geometries – rectangles and circles – and hard and durable materials such as brick and concrete, a building can seem both human-made and timeless when seen from afar, contrasting and in this way emphasizing the qualities of the surroundings.

From a closer point, the building needs to have a sense of human scale and warmth – as it will be inhabited by humans. This could be achieved in the detailing of the building – in the materials of doors and window frames, in the design of railings and light switches (etc.).



illu 29. interior sketch

Materials

Here, a selection of materials thought to be relevant in the construction of the museum will be mentioned. These are chosen and will be used based on both aesthetic and technical concerns, including (when relevant) embodied carbon, thermal conductivity, heat capacity, effects on indoor air quality, etc. The website materialpyramiden.dk has been used to look at embodied carbon of the materials.

Wood A sustainable and versatile material, that can be used for both structural purposes or as finishes and cladding. Possible uses could be flooring, integrated furnishings or doors and windows. It is a light and warm material, that brings a tactility and softness to a space.

Mo-clay bricks The mo-clay brick is mostly used in interior walls – this is due to its ability to regulate indoor climate through moisture absorption and through their heat capacity. The bricks are a large part of the industrial history of the area, and can thus function simultaneously as a non-loadbearing spatial divider and as part of the exhibition. They come in different shades and can, if exposed, add warmth and tactility to interior.

Bricks An element that, even more so than mo-clay bricks, heighten the buildings' thermal capacity (when used in the interior). They can be loadbearing and are a durable façade-material.

Concrete Taking a material that is from the ground and utilizing it in the ground, the concrete will be used in the intersection between the earth and the stereotomic spaces, contrasting the warmer nature of the wood. In regards to the indoor climate, the high heat capacity will mitigate large temperature fluctuations throughout the day.

Steel Used strategically in the building, as the material has a high level of embedded carbon. The material will be used in the joining of elements, and when its high strength in tension and compression is needed.

Insulation Instead of using some of the more well-known insulations, such as stone wool or fiberglass, a more sustainable solution has been chosen in woodfiber insulation. It has a thermal conductivity close to that of stone wool or fiberglass, but much lower levels of equivalent embodied carbon (Kumar et al., 2020). Local mussel company on Mors, Vilsund Shells, sells excess shells from their food production that can be used for insulation beneath buildings, which can reach a thermal conductivity of down to 0,11 W/mK (Andersen & Munch-Andersen, 2001).

Design goals

The museum building must live up to the requirements for energy usage stated in BR18.

The building should employ natural ventilation strategies during warmer months, making use of the western wind, while it should use mechanical ventilation during winter.

The height of the main museum building should be approximately the same as that of the excavation edge.

The building should use materials with a high heat capacity, and in this way mitigate fluctuations in temperature.

The design should strive to create spaces that can be experienced by both people with or without disabilities – even if the experiences may differ.

The museum spaces should both accommodate interchangeable exhibitions and allow specific important objects to affect the design of the space.

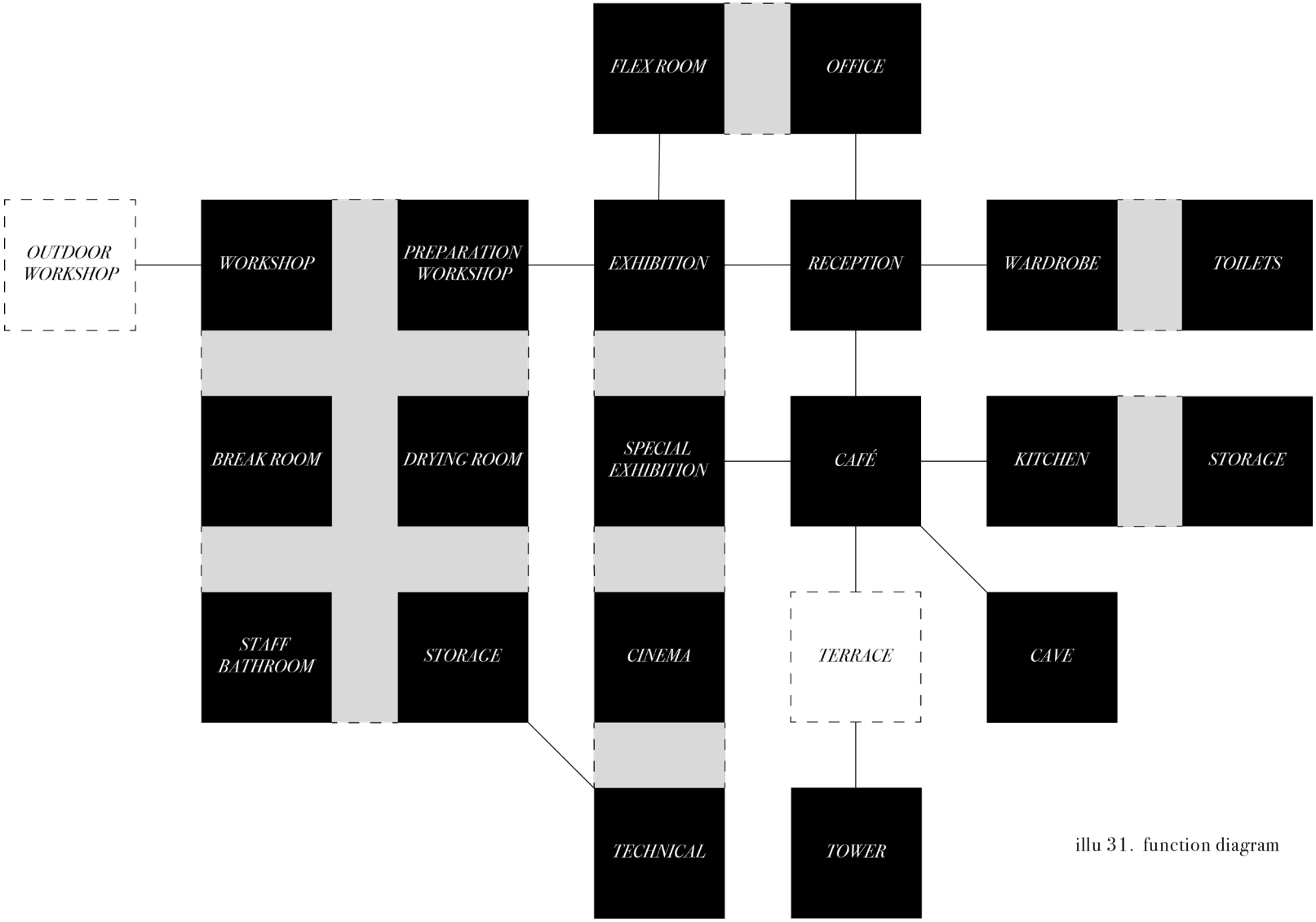
When relevant, local materials should be used – both to refer to local culture and landscape, and for sustainability reasons.

The museum should live up to daylight requirements – some exhibition spaces may however require more darkness than others, while café, reception and workspaces should have higher levels.

The museum should contrast its surroundings by using defined, geometric shapes on the larger scale – but should soften these in the detail level.

illu 30. mo-clay excavation wall

Function diagram



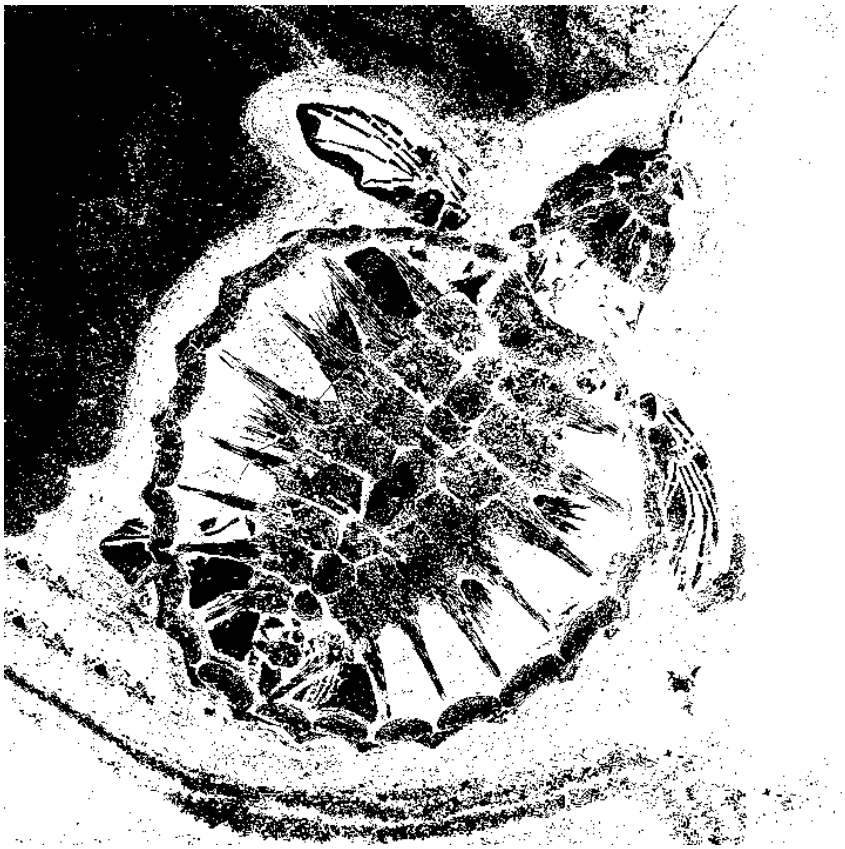
illu 31. function diagram

Room program

FUNCTIONS	AREA	USE TIME	VENITLATION (WINTER)	VENTILATION (SUMMER)	VENTILATION (SYSTEM)	LIGHT REQUIREMENTS
						DS/EN 12464-1:2021
ENTRANCE						
entrance/reception	50 m2	seasonal	mechanical (minimal)	hybrid	centralised	300 lx
toilets	30 m2	all year	mechanical (minimal)	mechanical	centralised	200 lx
wardrobe	20 m2	seasonal	mechanical (minimal)	hybrid	centralised	200 lx
ADMINISTRATIION						
office	50 m2	all year	mechanical (variable)	hybrid	decentralised	500 lx
flex room	50 m2	all year	mechanical (variable)	hybrid	decentralised	500 lx
EXHIBITION						
exhibition, upper floor	200 m2	seasonal	mechanical (minimal)	hybrid	centralised	-
exhibition, double height	100 m2	seasonal	mechanical (minimal)	hybrid	centralised	-
exhibition, dark	125 m2	seasonal	mechanical (minimal)	hybrid	centralised	-
exhibition, special	75 m2	seasonal	mechanical (minimal)	hybrid	centralised	-
café	100 m2	seasonal	mechanical (minimal)	hybrid	centralised	200 lx
cinema	50 m2	seasonal	mechanical (minimal)	mechanical	centralised	-
kitchen	50 m2	seasonal	mechanical (minimal)	mechanical	centralised and process	500 lx
kitchen storage	50 m2	seasonal	mechanical (minimal)	mechanical	centralised	100 lx
WORKSHOP AREA						
preparation workshop	20 m2	all year	mechanical (variable)	hybrid	centralised and process	1000 lx
workshop	50 m2	all year	mechanical (variable)	hybrid	centralised and process	300 lx
storage	200 m2	all year	mechanical	mechanical	centralised	200 lx
drying space	15 m2	all year	mechanical	mechanical	centralised	-
break room	35 m2	all year	mechanical (variable)	hybrid	centralised	200 lx
technical	50 m2	all year	mechanical	mechanical	centralised	200 lx
TOTAL	**1320**					

illu 32. room programme

Presentation

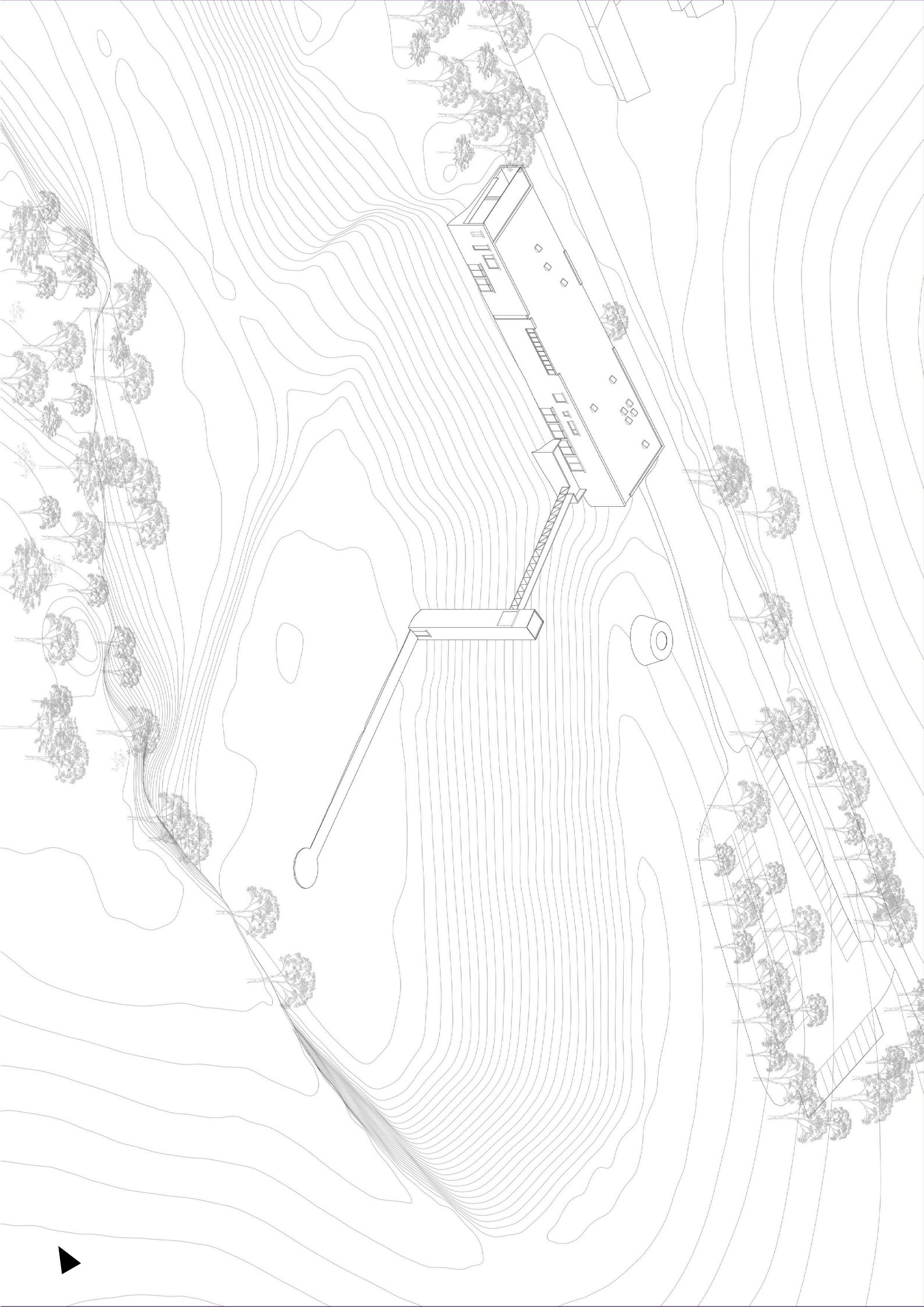


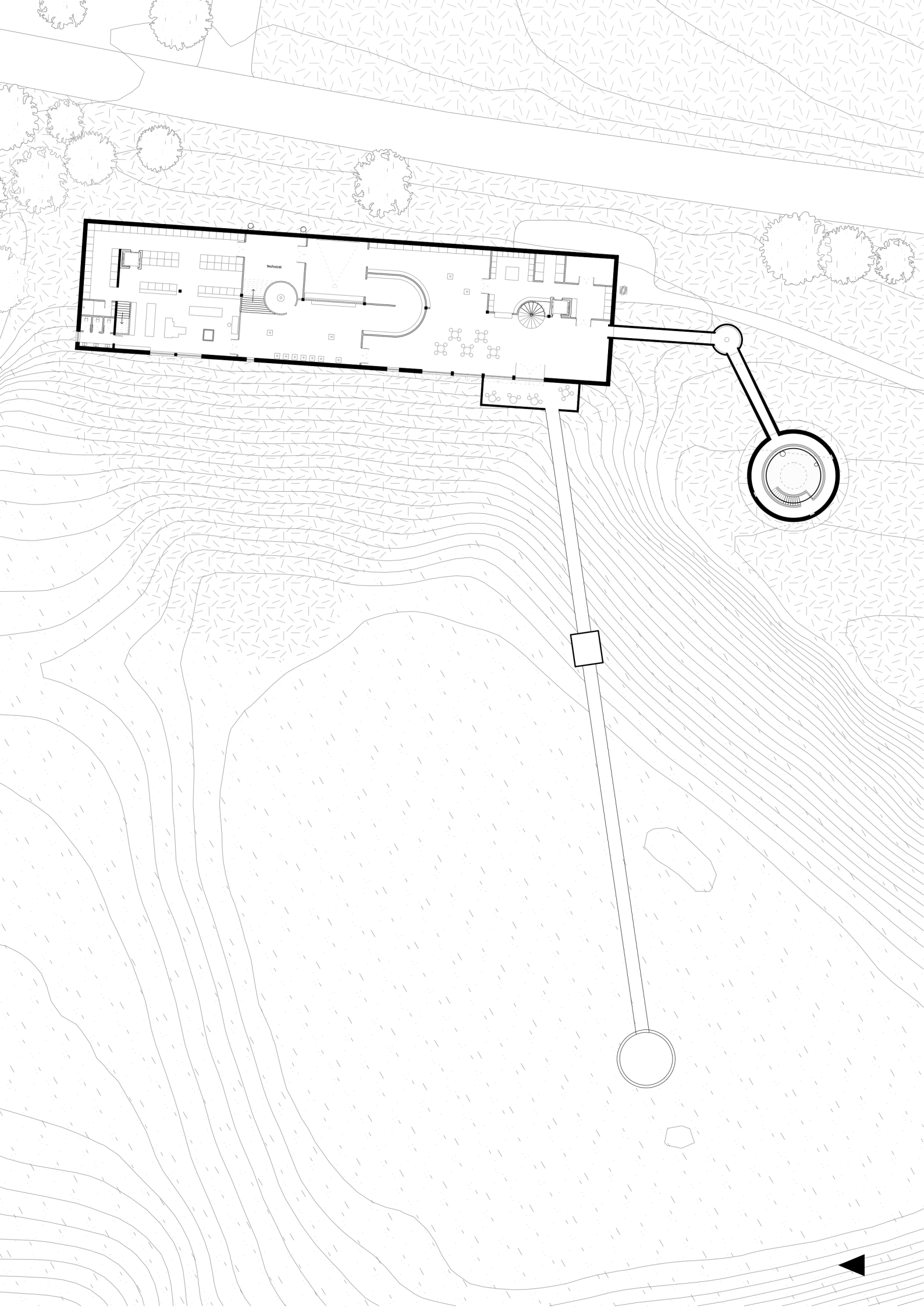
illu 33. site plan - 1:2000

The main building of the museum – a long, horizontal building, sits itself between the excavation and a road leading towards a moclay excavation plant, right across from the former museum building. It has a slight angle towards the road, instead it follows the lines of the landscape, sitting right on the edge of the excavation. From this building, an underground tunnel leads to a subterranean space that mysteriously protrudes from the ground by a path from the parking lot to the entrance.

From the horizontal building, a small bridge also leads to a tower that lets visitors take an elevator into the excavation, onto a pathway that leads to the middle of the excavation, making this experience accessible to more people. The horizontal building has a roof height that matches the height of the edge of much of the excavation, in this way becoming an active part of the landscape.

illu 34. site isometric




technical

illu 36. museum viewed from across the excavation

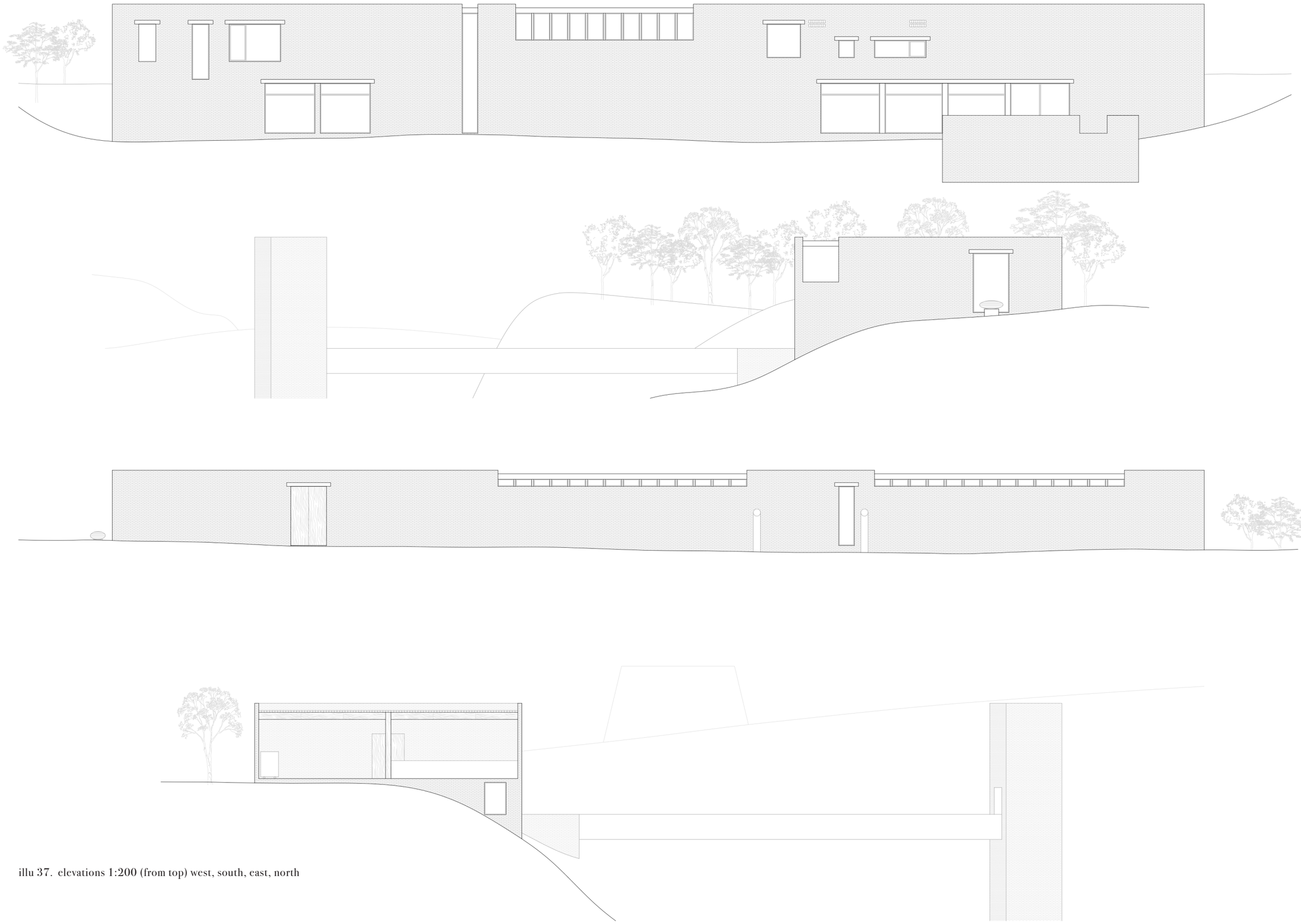
The horizontality of the main building enters into a relationship with the verticality of the tower. The orthogonal nature of the architecture contrasts the curving lines of the landscape and the geological layers. The subterranean space sits like a lone and mysterious structure of pure geometry, not revealing any connections or ways of entry from the exterior.

The main building sits on top a grassy slope, not taking anything from the exposed moclay, while the tower brings people close to the layers, at the meantime making the scale and depth of the excavation apparent.

illu 35. ground floor plan - 1:500

The facades of the building – especially the one facing the excavation – balance composition with considerations for the interior. The result is a playful composition that has several points of interest – a tall, vertical window and a horizontal band of windows have a relationship that mirrors that of the facade itself and the tower.

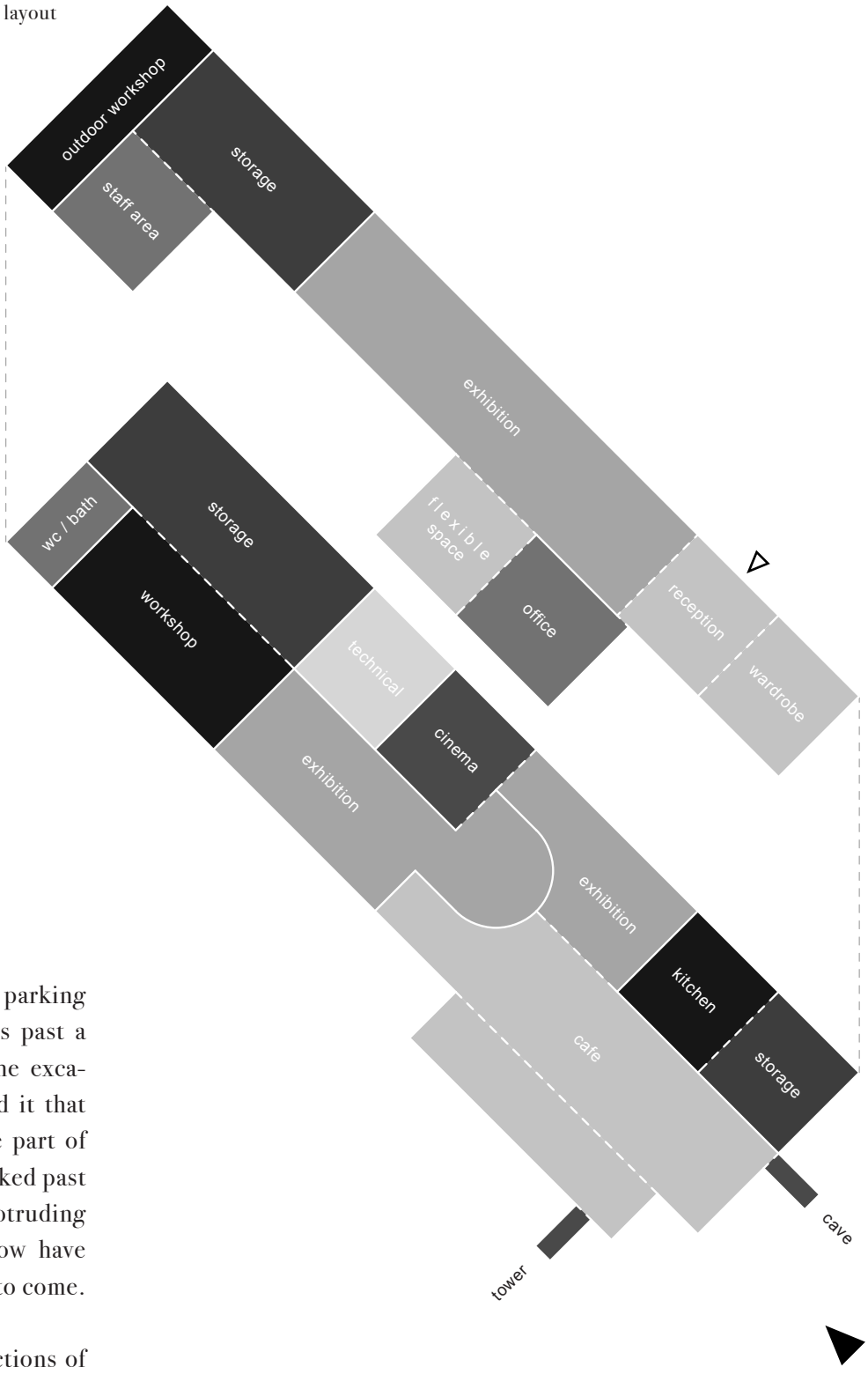
The facade facing the road is discreet and long – the museum does not reveal much about itself when seen from here, it even looks as if it is a one-story building.



illu 37. elevations 1:200 (from top) west, south, east, north

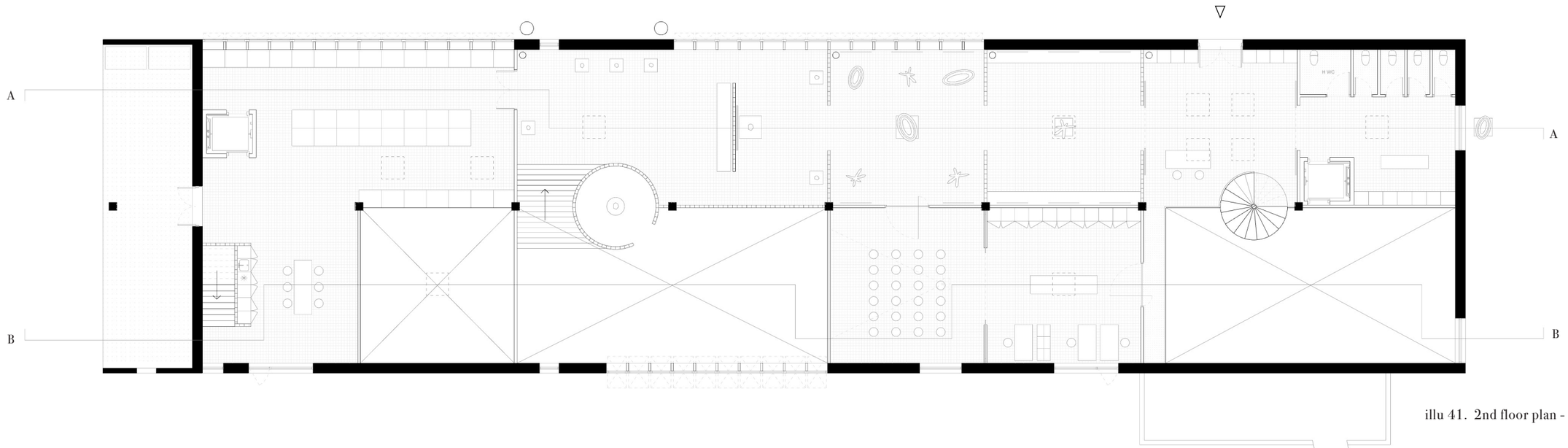
illu 38. arrival

illu 39. functional layout

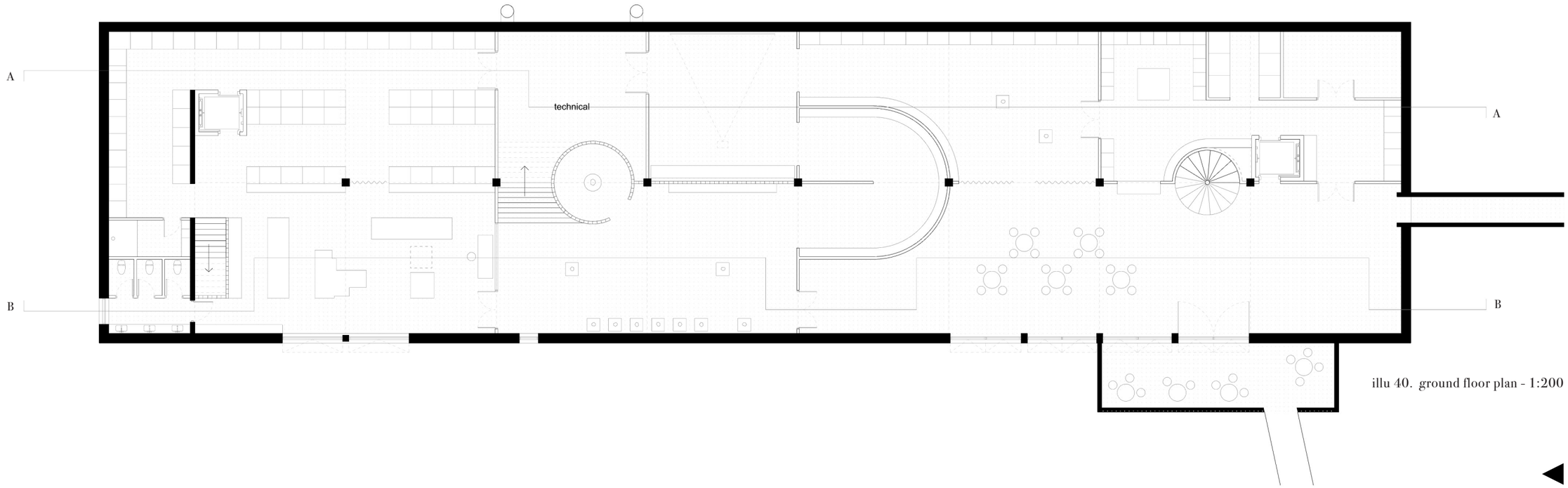


Facing south, a path from the parking lot to the entry takes visitors past a pedistal with a stone from the excavation, with a window behind it that offers a view through a large part of the museum. After having walked past the cone-shaped structure protruding from the ground, visitors now have had several teasers of what is to come.

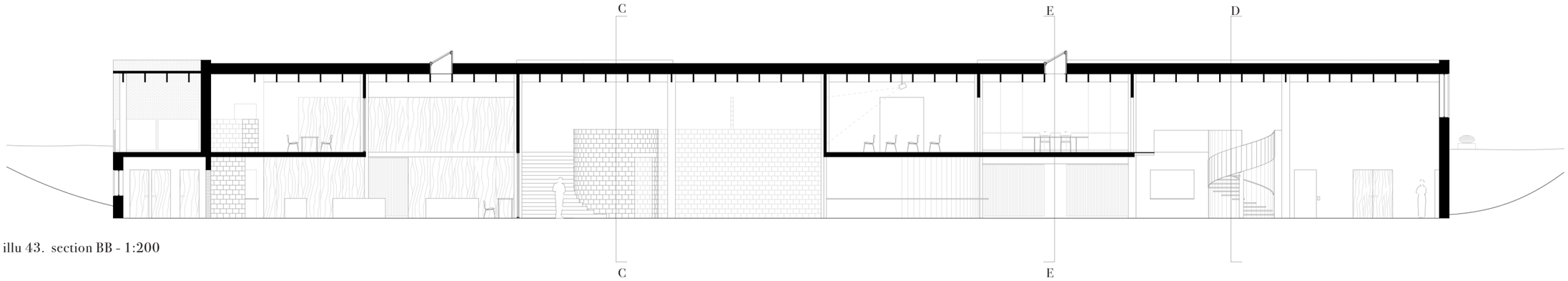
Many of the more public functions of the building are in the southern end of the building – the reception, café and access to the exhibition spaces and the excavation. In the north end of the building are the workshop spaces, still letting visitors pass by and look in, while an office sith in the middle of it all, putting employees close to the visitors.



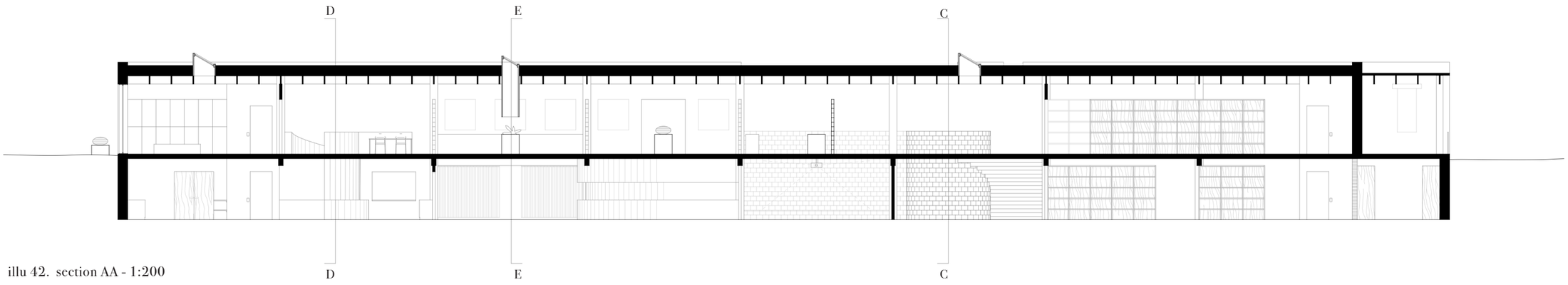
illu 41. 2nd floor plan - 1:200



illu 40. ground floor plan - 1:200



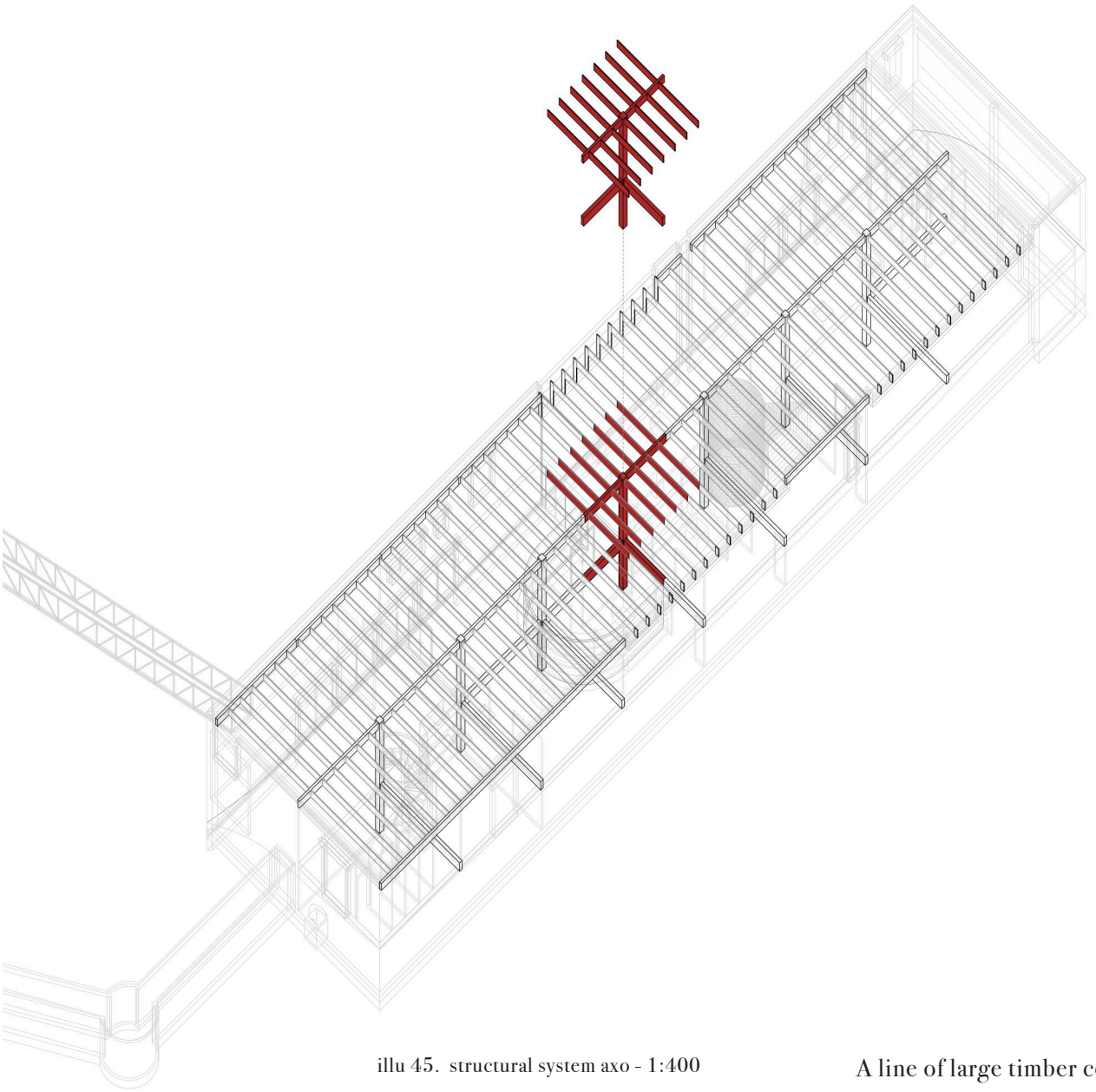
illu 43. section BB - 1:200



illu 42. section AA - 1:200

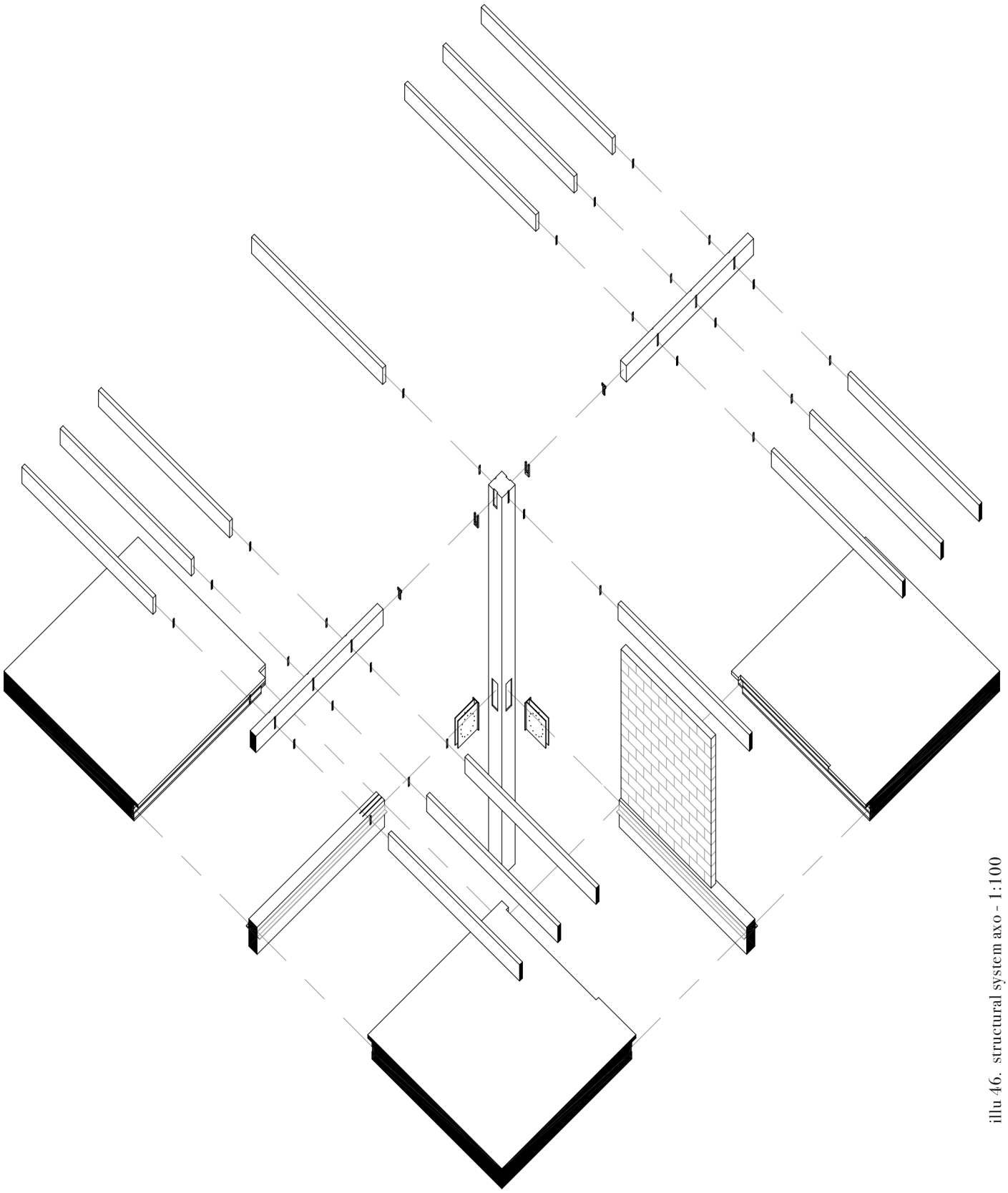
illu 44. exhibitions seen from the reception

The exhibition starts right at the reception – a series of partition walls build in a moclay brick with great qualities for interior climate add warmth, texture and a bit of history to the spaces, while dividing the rooms in a 7x7 meter grid. A skylight pulls light down into a darker room, shining on one of the sculptural limestones found in the surrounding landscape. It sits on an axis of openings that starts at the window facing the path from the parking lot and continues through several more exhibition rooms.



illu 45. structural system axo - 1:400

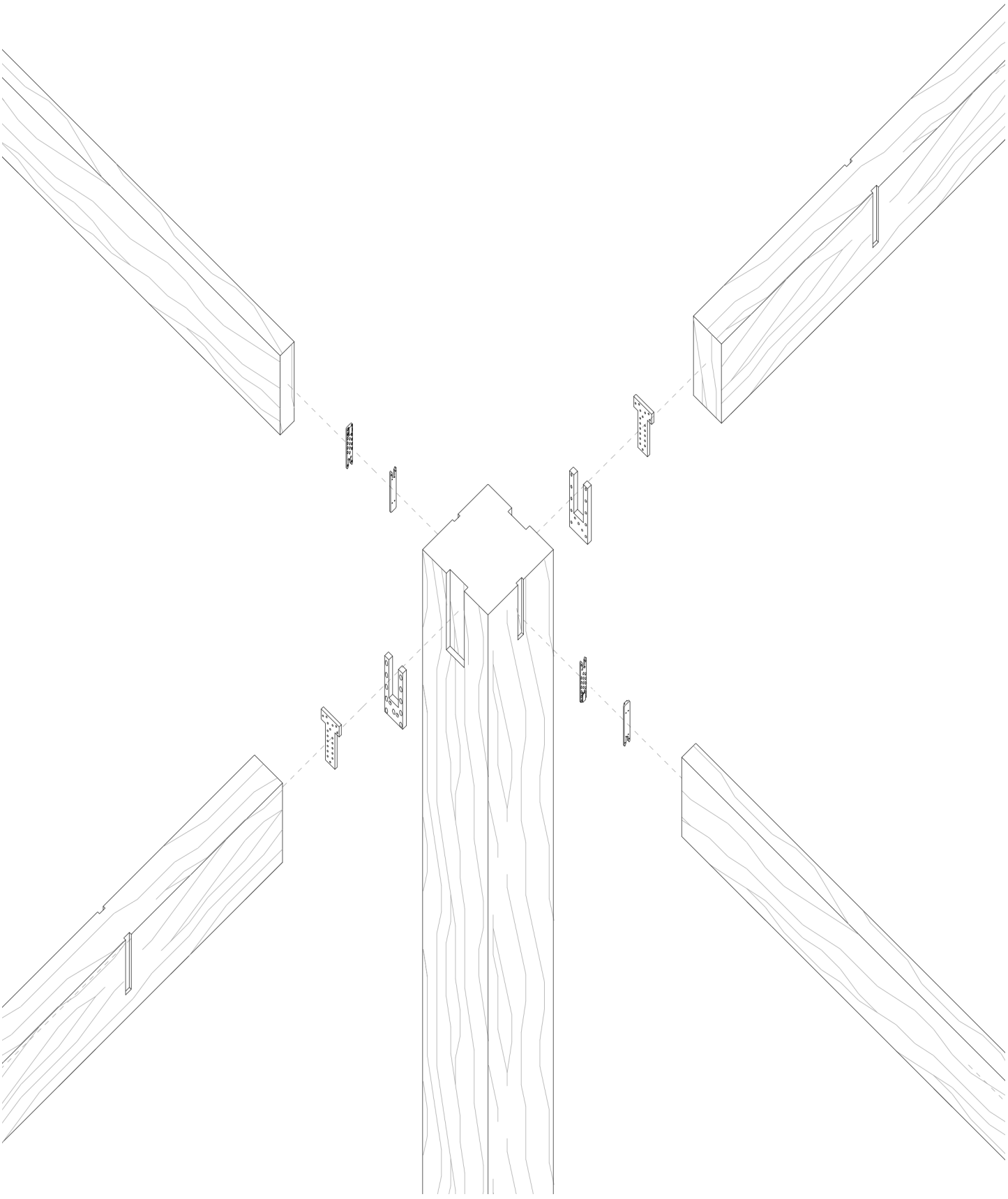
A line of large timber columns follows the 7x7 meter grid, carrying the roof and CLT floor slabs through a system of beams. These are joined seamlessly, using concealed hanger joints. The column is glulam, but the beams are LVL, allowing for a tall and slender cross section that along with the hidden joints adds to the calmness of the museum spaces.

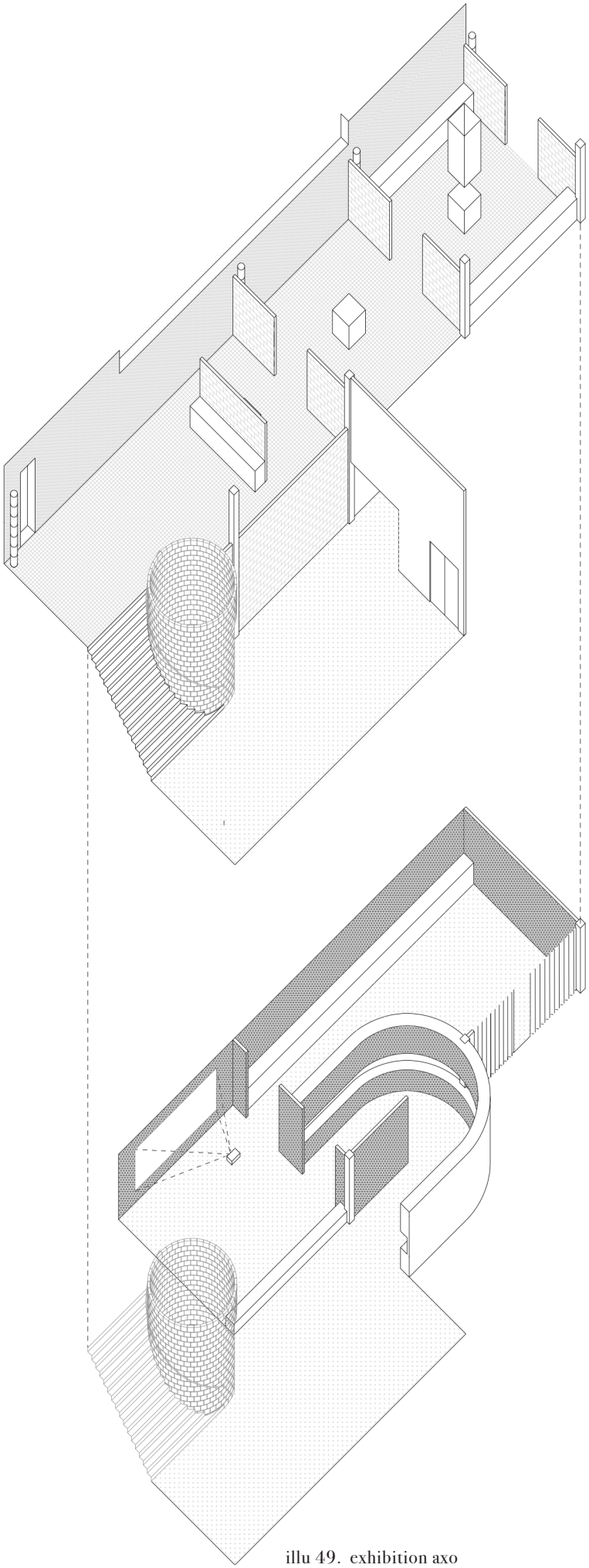


illu 46. structural system axo - 1:100

illu 47. beam-column connection

illu 48. beam-column connection axo - 1:20



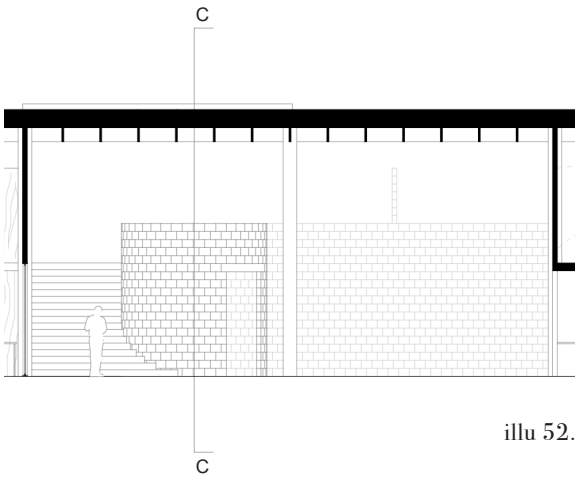


illu 49. exhibition axo

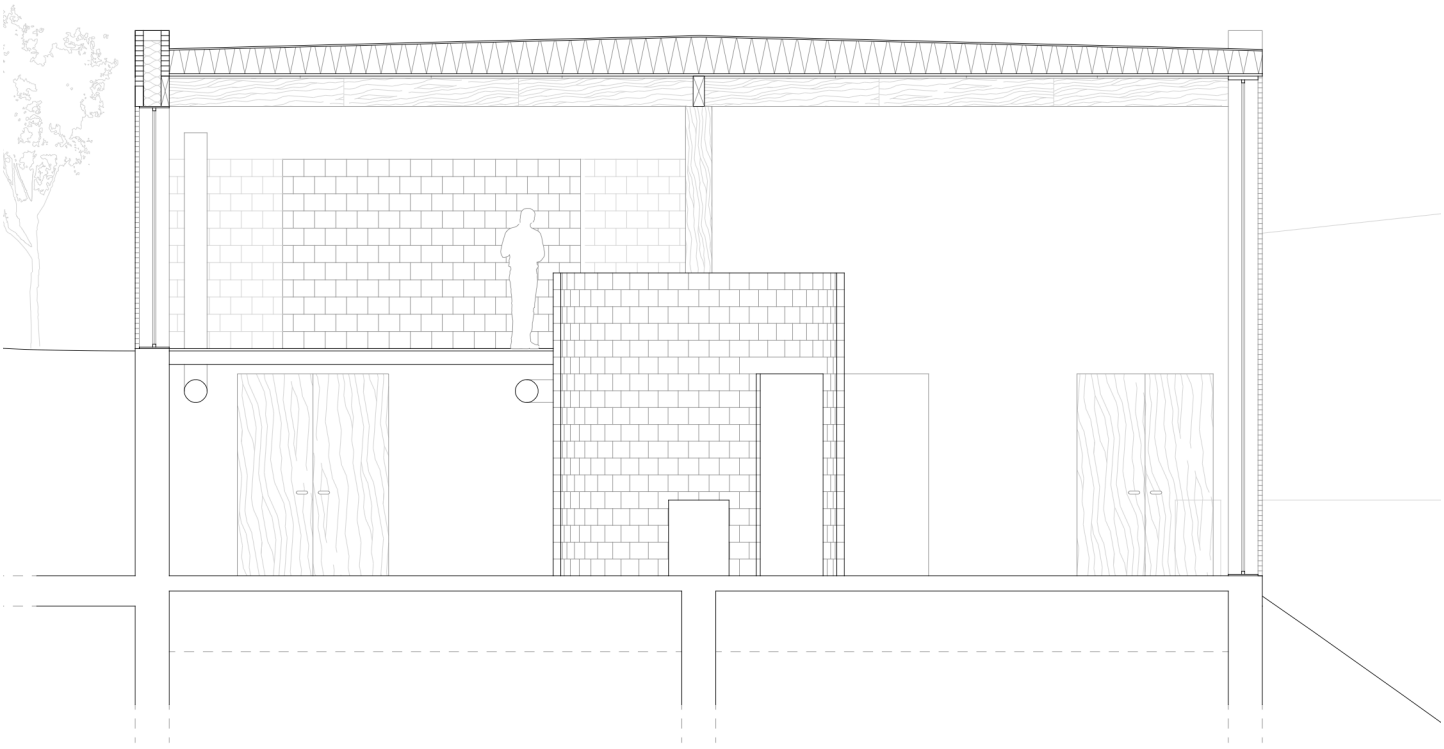
The upper floor is very clearly divided by the building grid and features several exhibited objects and posters that tell the story of the moclay, letting people understand what they will experience later on. Moving down, the character changes slightly, first marked by a circular moclay brick wall with a staircase curving around it. A large, double-height space follows, with a more open composition of rooms. Then, a curved wall leads to a series of darker rooms, ideal for displays of smaller objects with artificial light - and a cinema.

illu 50. exhibition

A tall light right under the ceiling lets in light that reflects between the tall beams and spreads and diffuses around the space. This is ideal for sculptural objects, objects that should be viewed in the round – like many of the large limestones or petrified trees found in the area. The artefacts are placed somewhat loosely in the space, reminiscent of a Japanese Zen garden, a place for contemplation. A display case with artificial light hidden in the wall can be seen in the background.



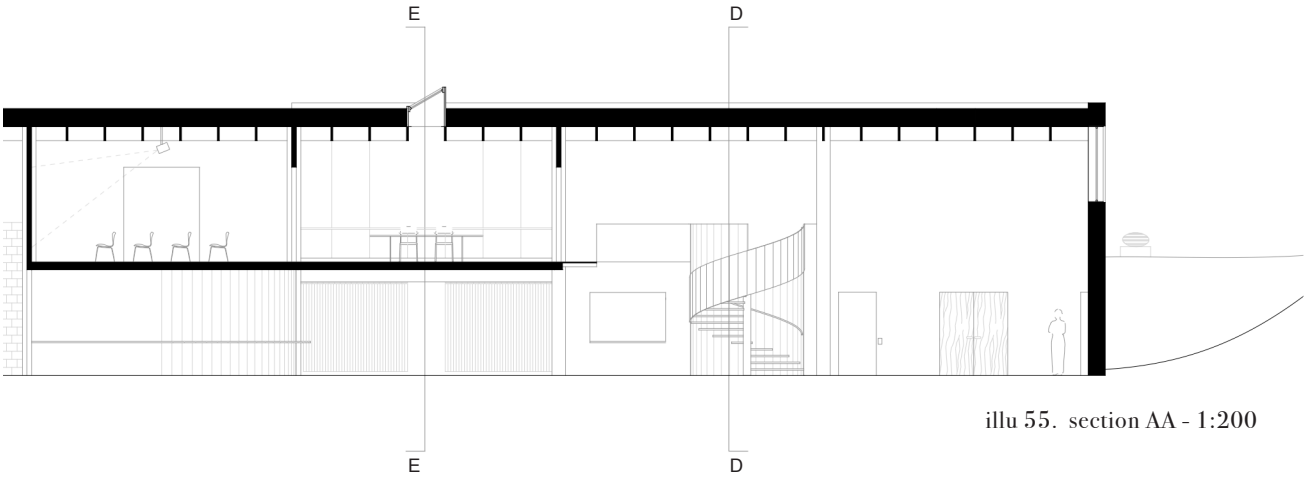
illu 52. section AA - 1:200



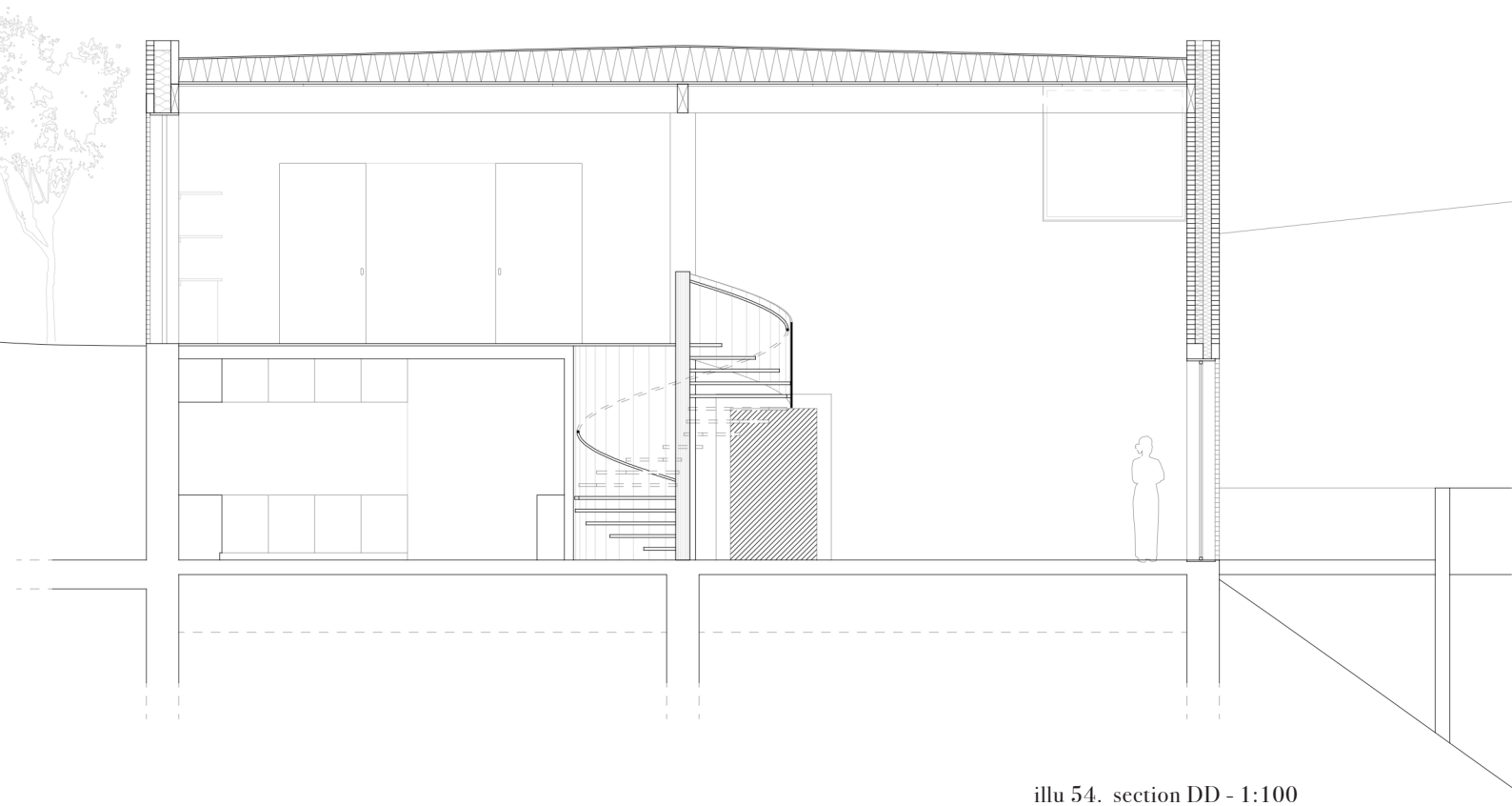
illu 51. section CC - 1:100

The café is a public space, a point of connection. Many of the functions of the museum connect to it, the office, reception, exhibition, tower, and the underground space. It is one of the few spaces of the museum where a bit of chaos reigns – it is also a meeting point between visitors and employees. The room is double-height and has windows looking out at the landscape, giving a bit a calm to the space.

illu 53. café



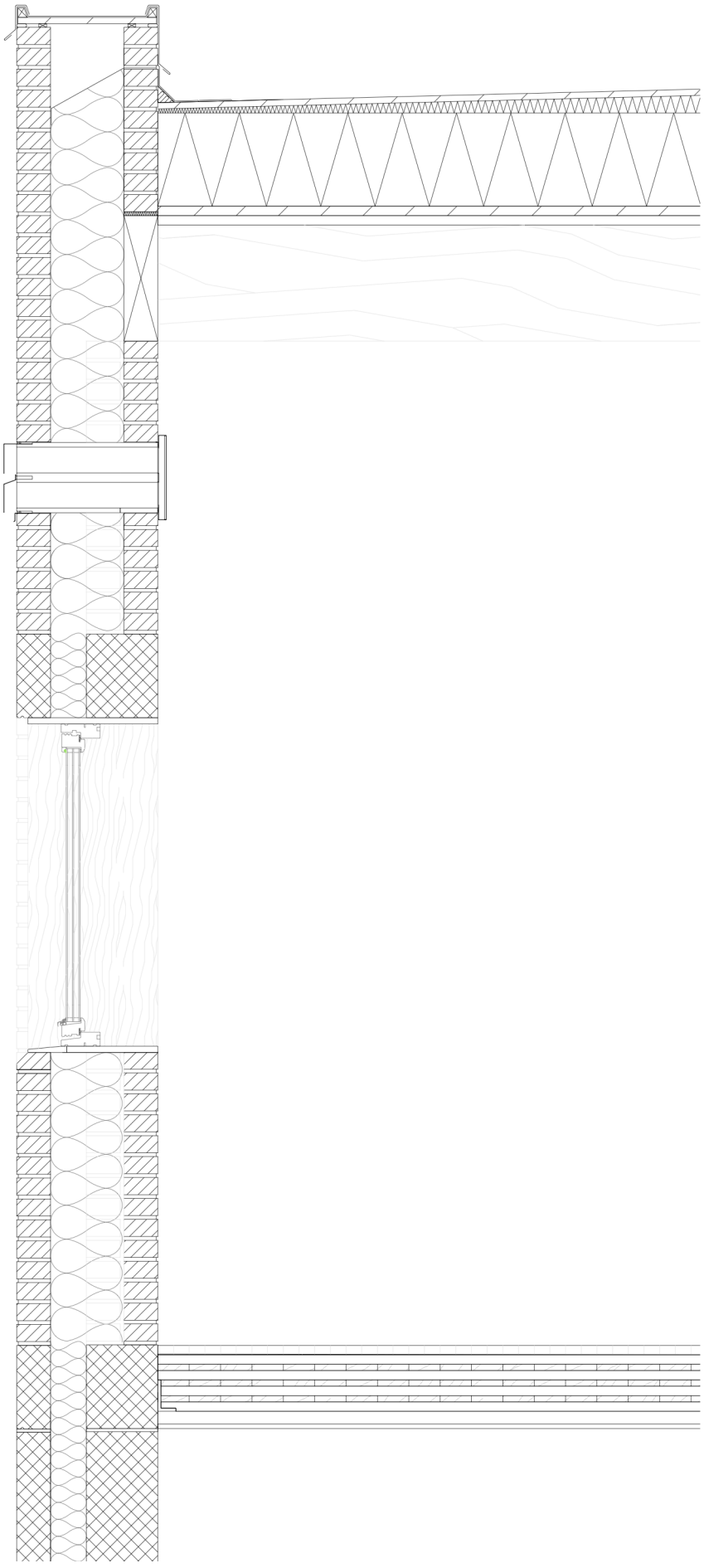
illu 55. section AA - 1:200



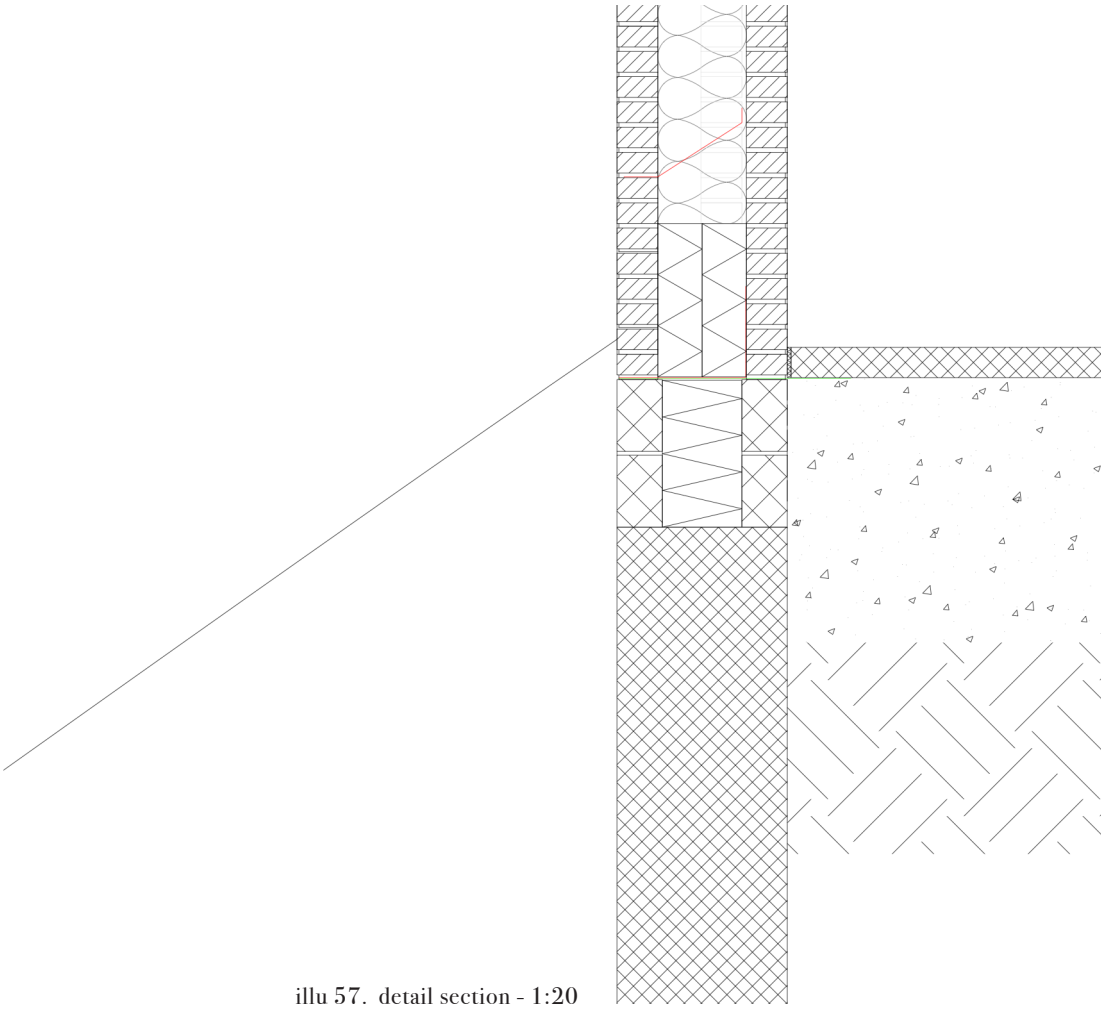
illu 54. section DD - 1:100

The window openings are of high interest in this project – they are the point where the geometries of the buildings are broken, adding some rhythm and human scale to the exteriors of the museum. It is also where the light is let into the building illuminating the exhibitions and where views of the landscape are framed.

A wooden frame covers the insulation where bricks in many other situations would be used, making the wall seem like a massive one. Instead, the wood shows that there is something to cover and lets the same material continue form interior to exterior without a significant line loss. The wood is moved in a few centimeters from the facade, protecting it from water.



illu 56. detail section - 1:20

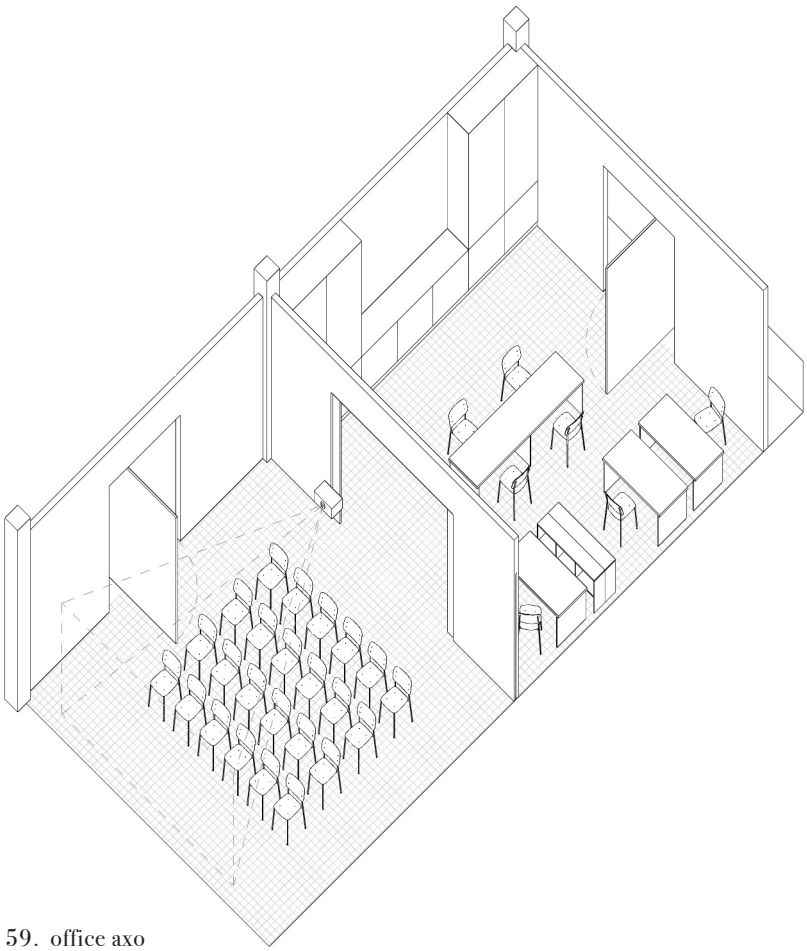


illu 57. detail section - 1:20

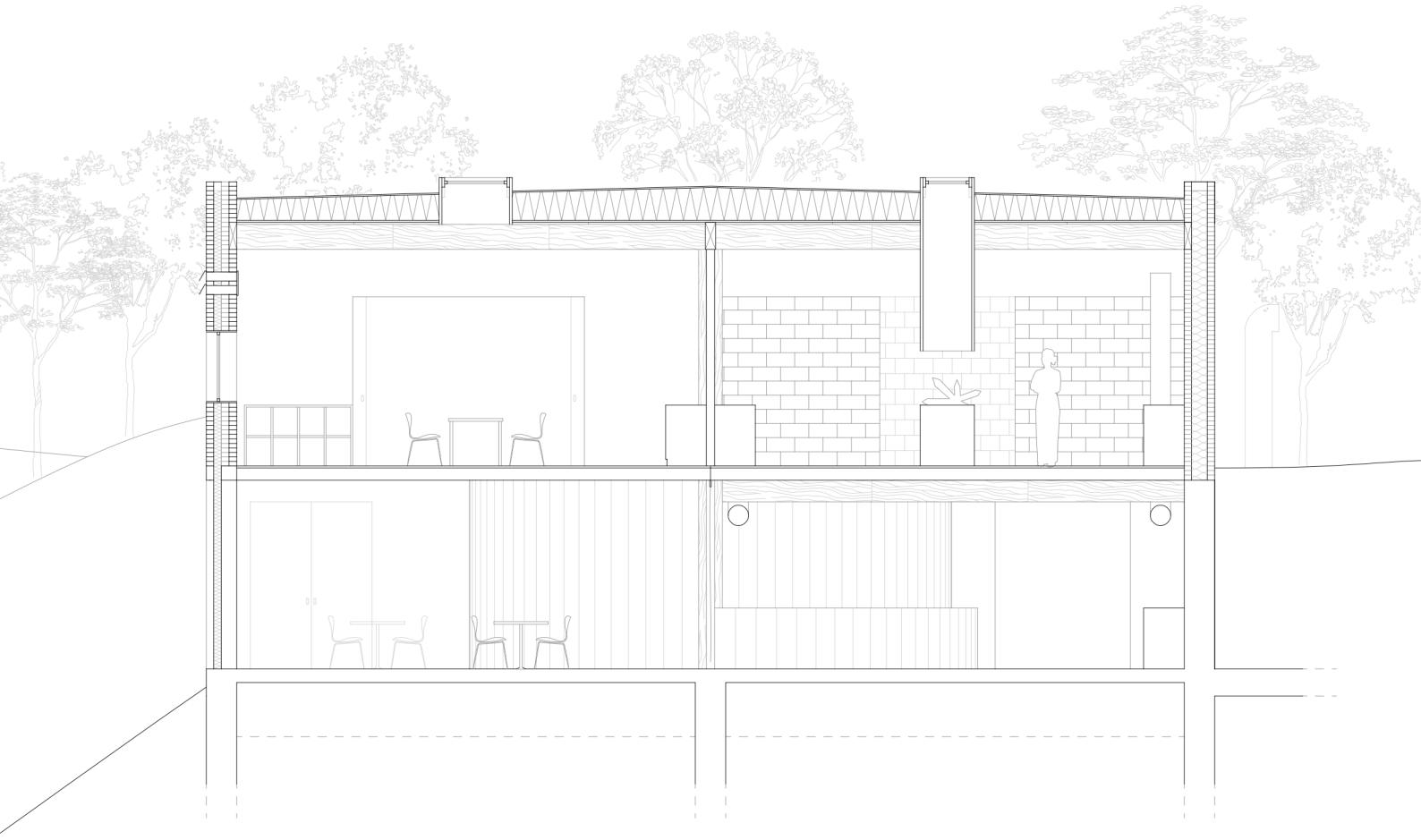
Where the bottom of the building meets the ground also has great significance in how the building is experienced from the outside. Instead of letting the footing show, the brick facade continues, making it look like it is growing out of the ground, like something that has always been there, instead of an object that has been placed there on top of a base.

illu 58. the building meets the ground

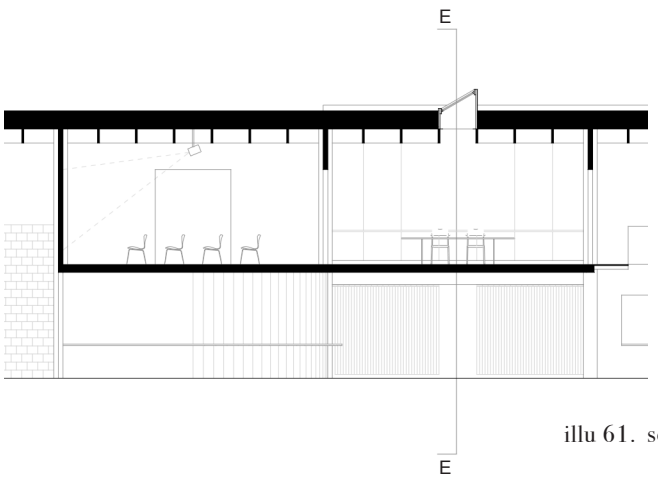
The office neighbors a flexible room that can be used by both the office or for visiting groups – the room can be closed off or opened up both towards the office and the exhibition. It has three workstations and a door out onto a small, raised walkway leading to the reception.



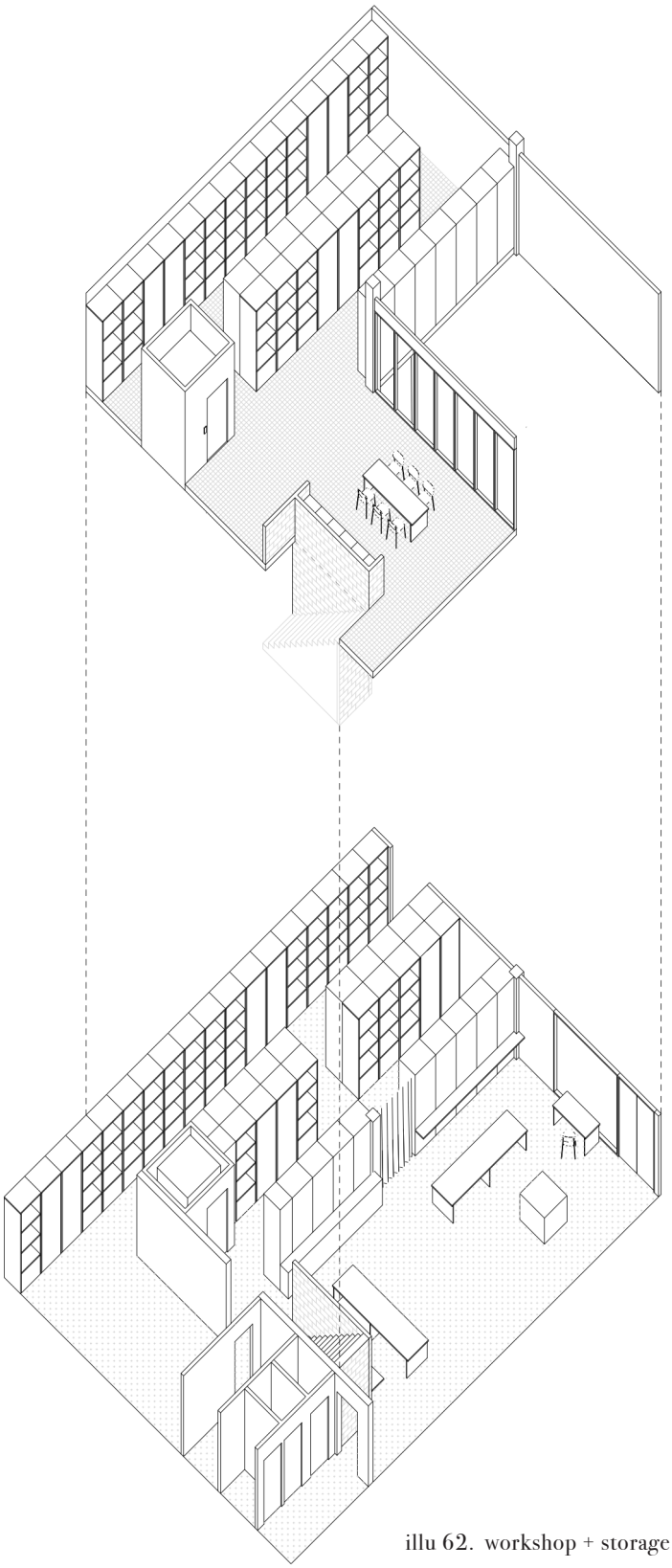
illu 59. office axo



illu 60. section EE - 1:100



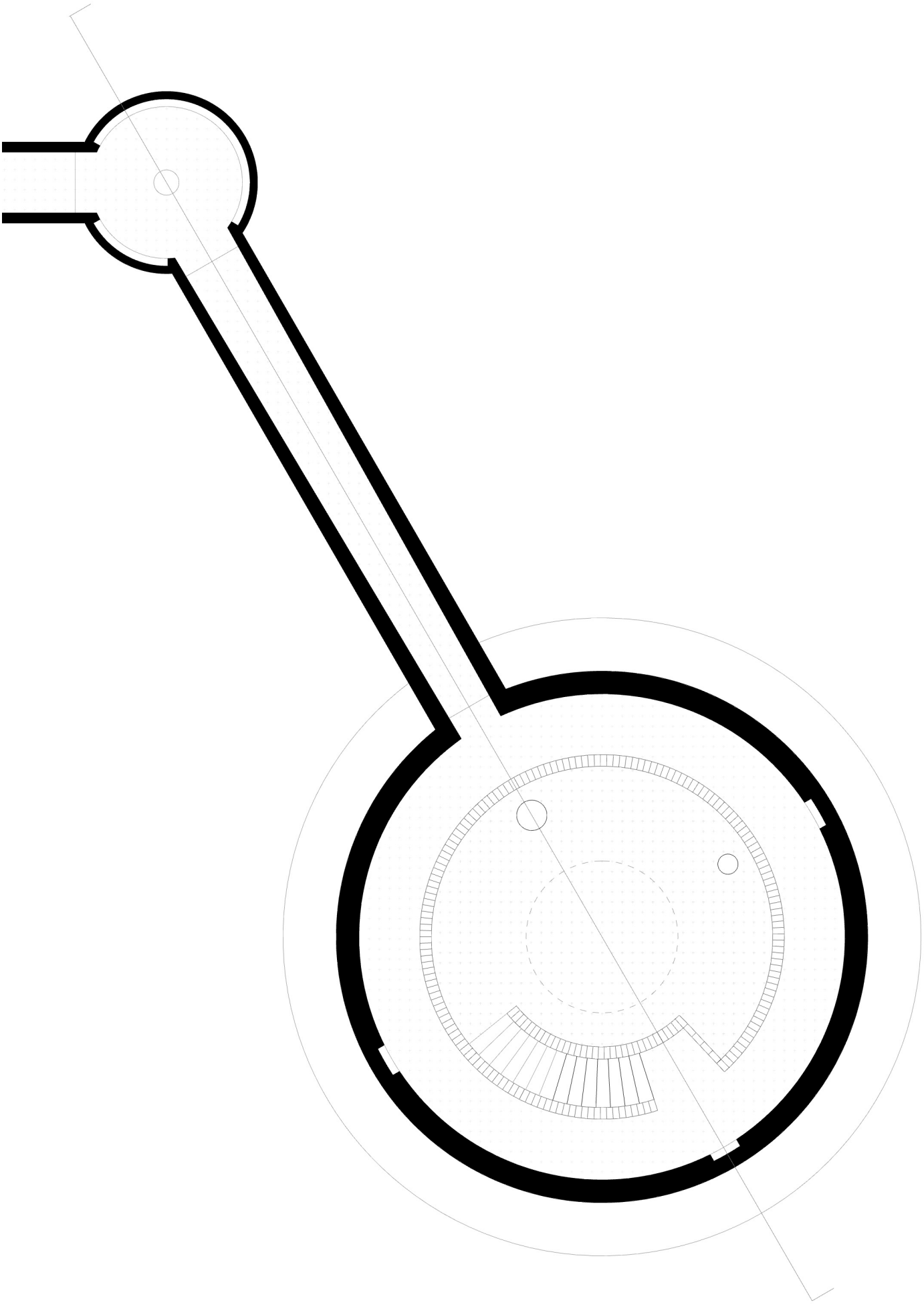
illu 61. section AA - 1:200



illu 62. workshop + storage axo

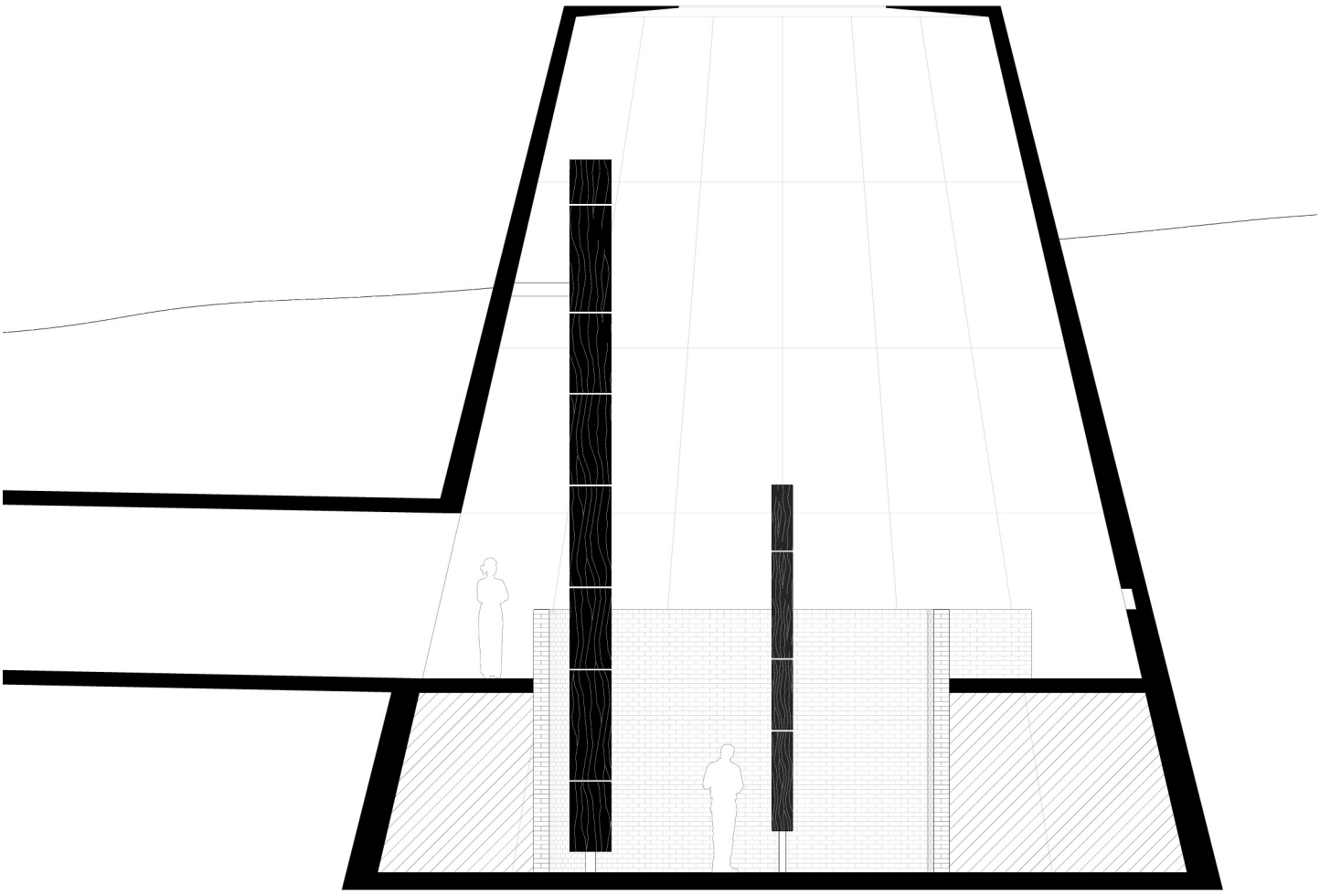
The workshop is closely connected to the storage of rock and fossil samples and a small space for employee breaks and lunch. An elevator lets them transport the heavy stones up and down, and an opening leads out to a covered outdoor workshop area, hidden within the outlines of the building.

Panes of glass let visitors look into the workshop and follow the daily work of preparing and examining different samples.



illu 63. underground space plan - 1:100

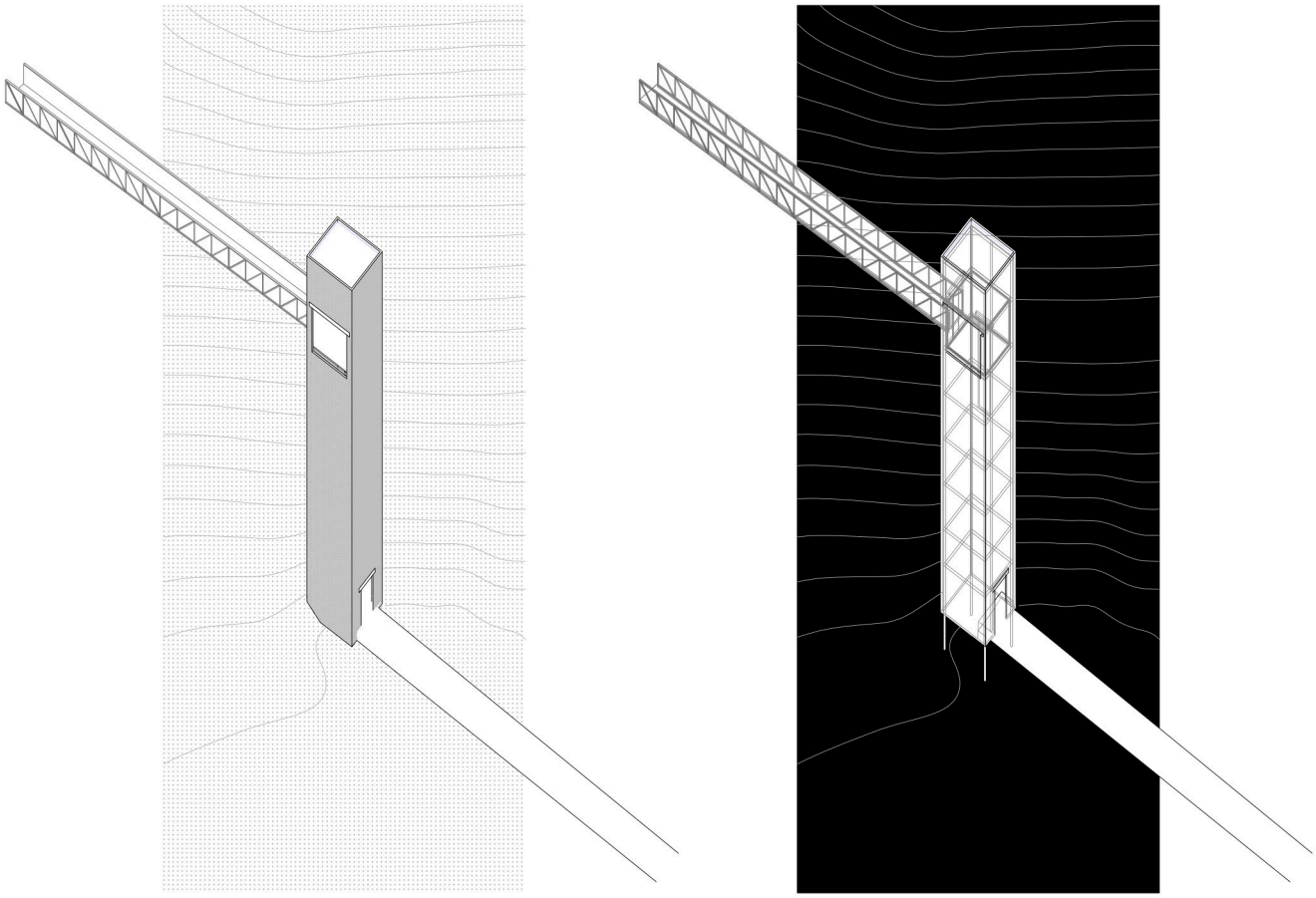
As one of the last stops on the tour of the museum, visitors are led underground through a long tunnel, which narrows as it gets closer to its destination, pushing people closer together when passing and strengthening the dark and heavy feeling of moving below ground. A circular walkway lets all experience the space and the exhibition, while a staircase leads to the bottom.



illu 64. underground space section - 1:100

This cone-shaped space has been designed with a single object in mind – a 10-meter-tall petrified tree that stands up, crossing through the layers of the ground just like it was found. It is moved to one side, letting people pass closely by it and pushing it close to the wall and into a relationship with the smooth and light surface of the concrete. The opening above is uncovered, creating a relationship with the outside weather, letting rain and snow fall down in the middle of the room, an experience reminiscent of the Pantheon.

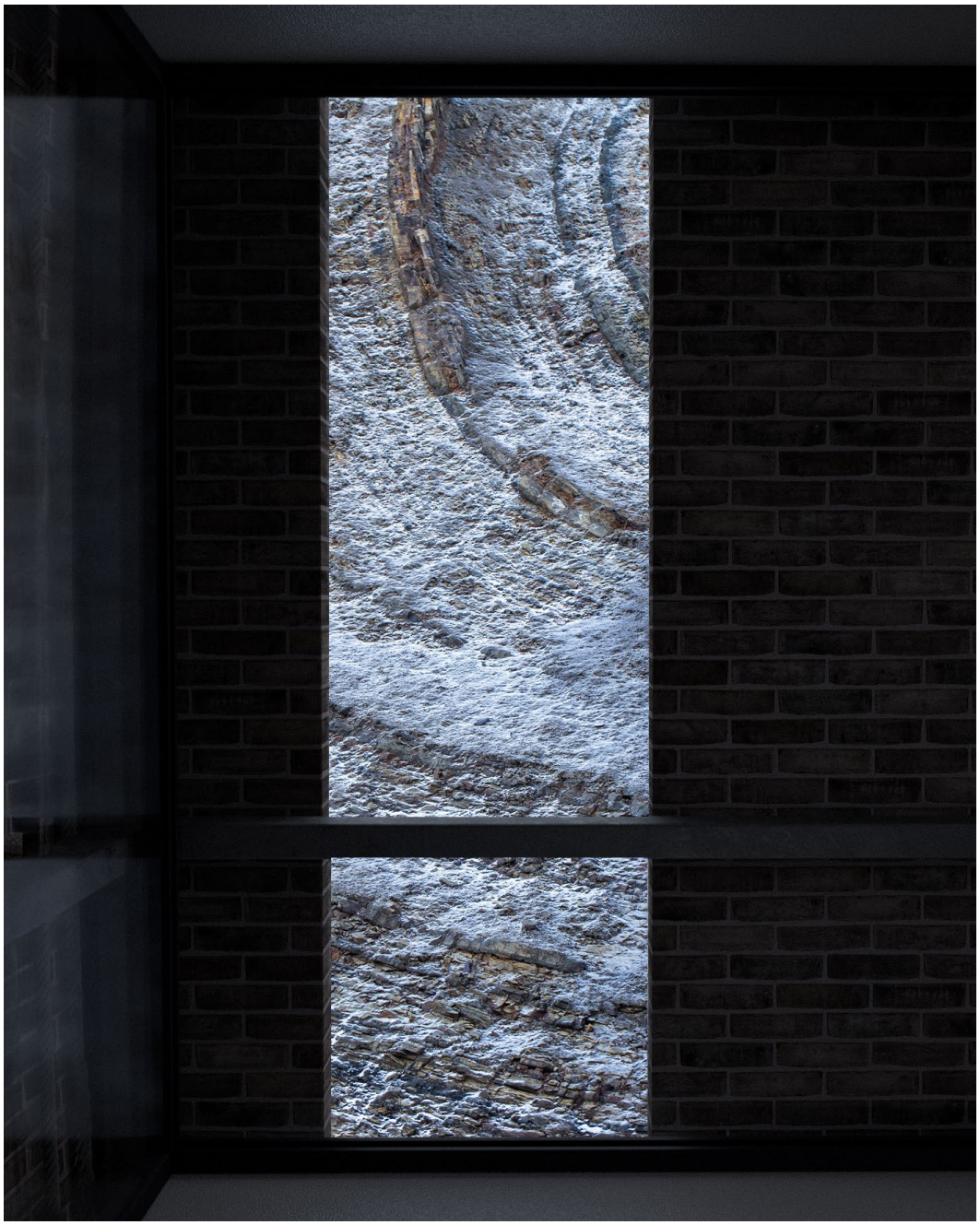
illu 65. tree and sky



illu 66. tower axo

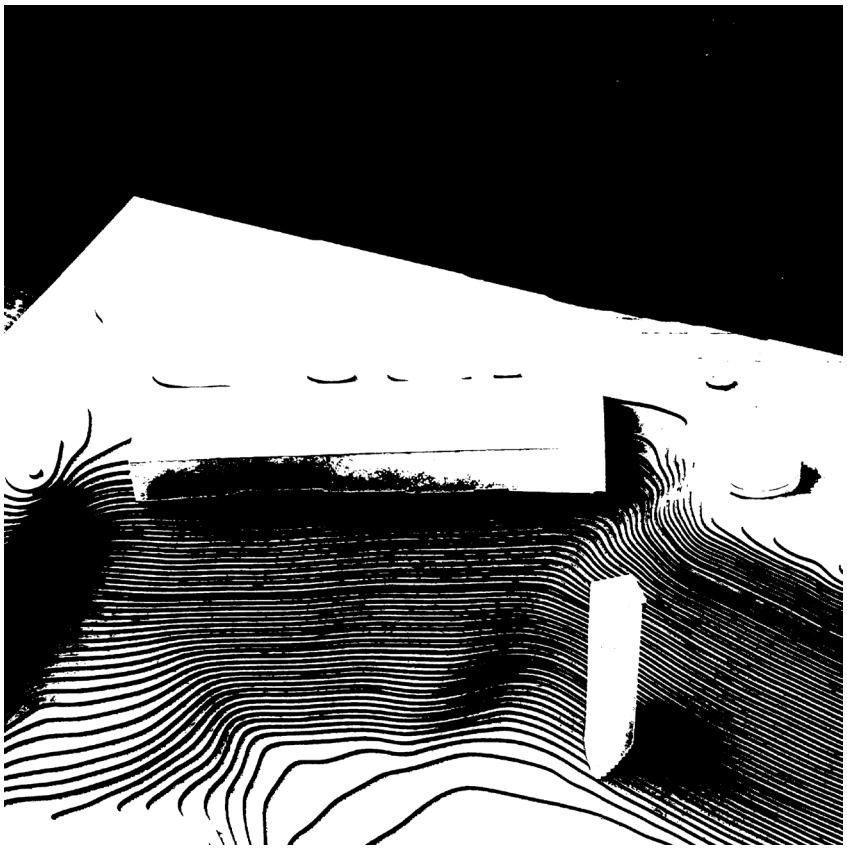
illu 67. view from tower elevator

The tower leading people into the excavation has a simple structure: steel carrying a glass elevator and a wrapping of bricks. The elevator has a door at the top and the bottom, and two openings framing the landscape. One large one at the top, letting people take in the panoramic views, and one vertical facing directly into the moclay cliff. The elevator can move slowly down, telling the story of the geological layers and letting something as uninteresting as an elevator shaft become a shared learning experience.

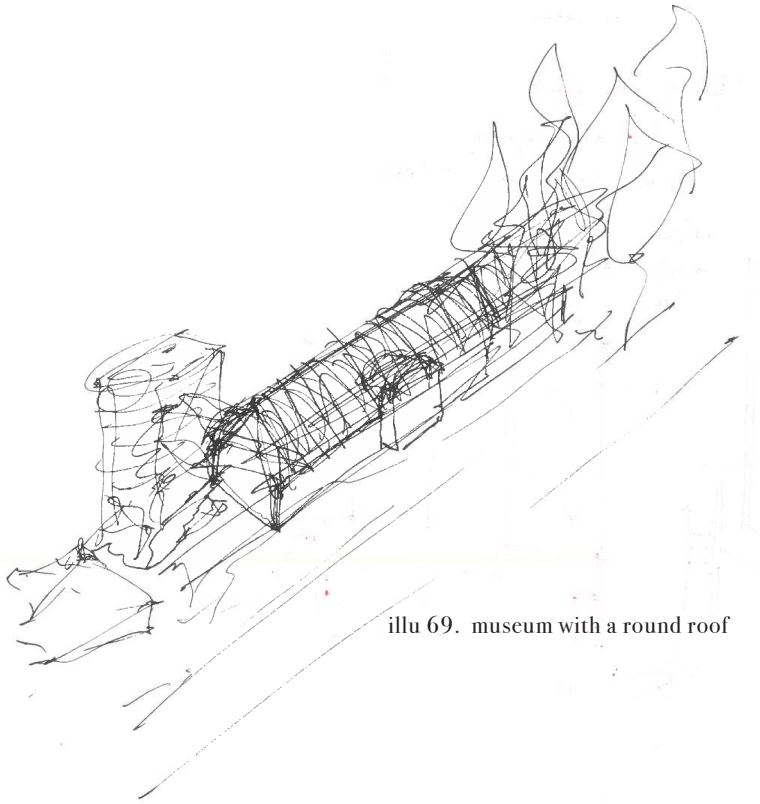


illu 68. a vertical window displays the mo-clay layers

Process



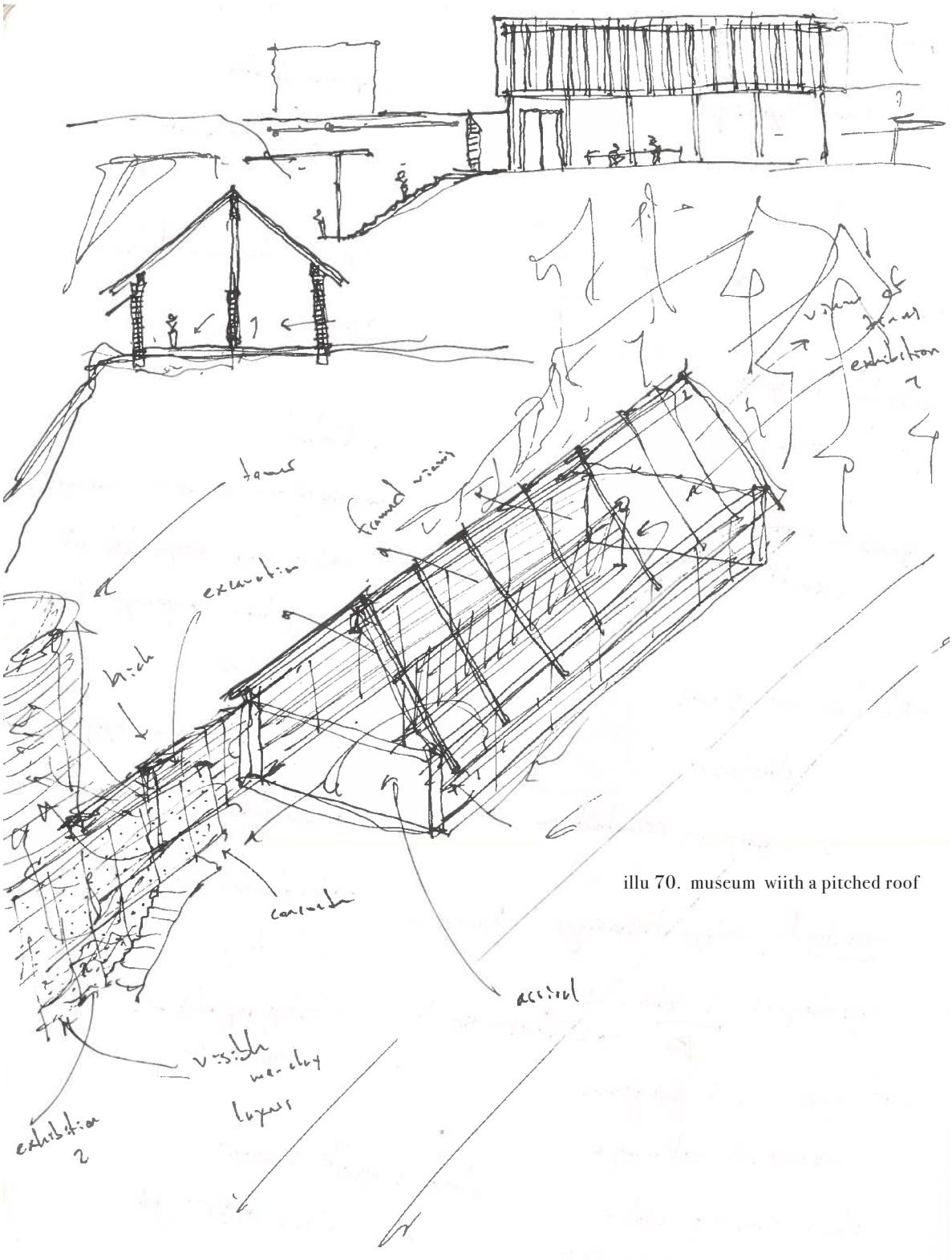
Geometry & formfinding



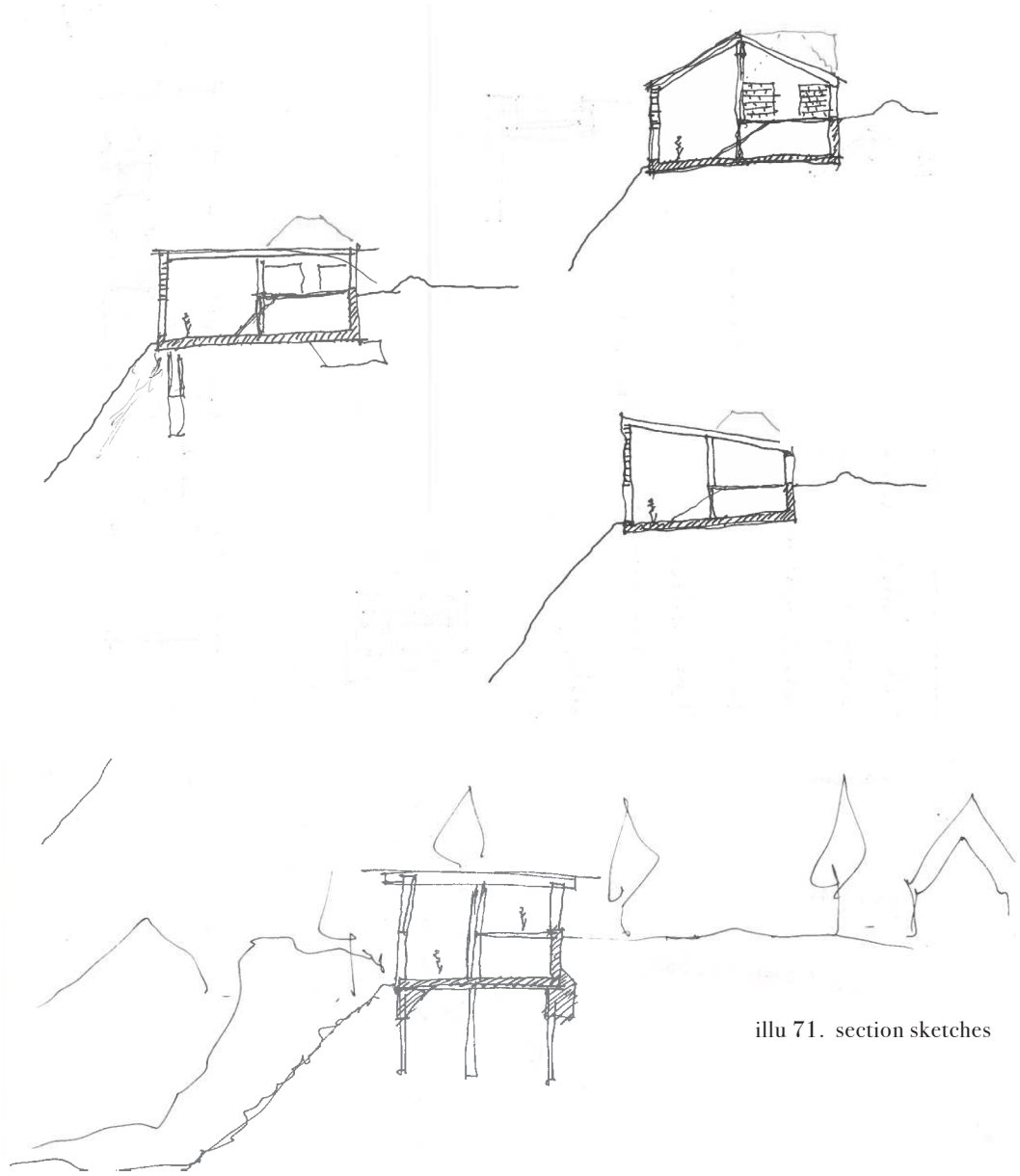
illu 69. museum with a round roof

After deciding to place the museum at the edge of the mo-clay excavation of Skarrehage, it was of great importance that the building complimented and accentuated the beautiful man-made landscape around it. Should the building follow the organic curving of the edge or be a geometric contrast? While the first option submits to the landscape, it weakens it as well. Therefore the building should carve clearly into the cliff - highlighting the rolling landscape against the defined intervention.

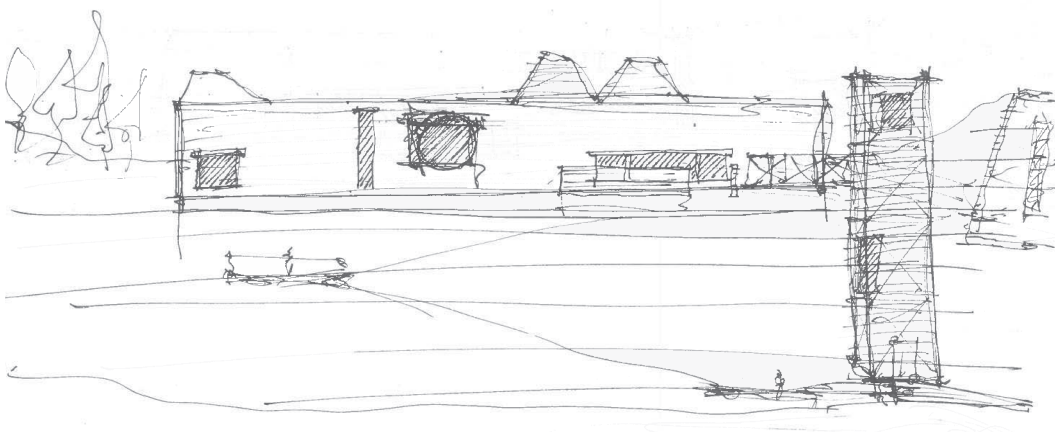
With a rectangle as the footprint of the building, studies into the role of the roof examined the relationship between the spaces created inside the museum and the outwards identity.



illu 70. museum wiith a pitched roof



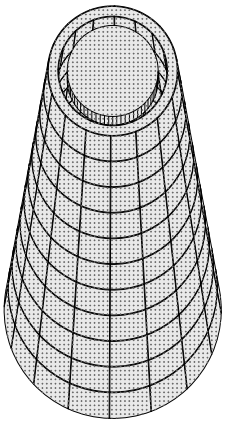
illu 71. section sketches

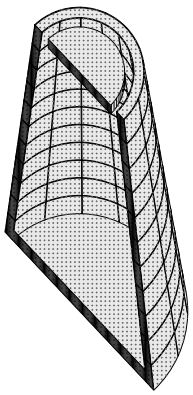


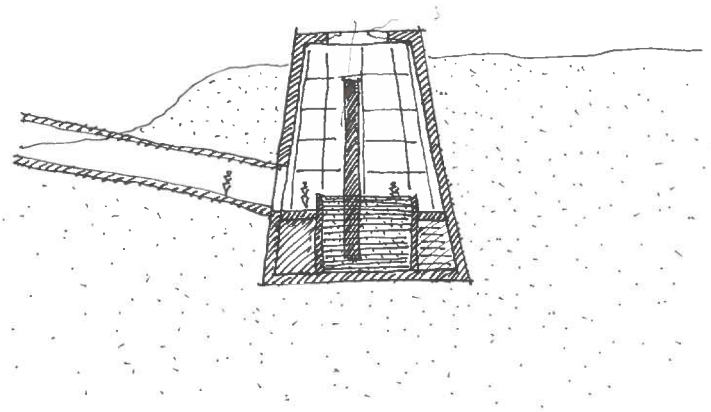
illu 72. elevation sketch

A two-sided pitched roof tells of a rational approach to structural stability and weather but seems too familiar while a single-sided pitched roof gives the apperance of a building looking out across the excavation. The functional layout called for a museum in two stories with an entrance from the back in the upper floor - letting the visitor focus on the interior space at first and later stepping down into a double-height space and revealing the excavation. As the height of the floor creates the contrast between these experiences the roof should be a constant - a flat roof, which also enforces the appereance of a geometric entity in the landscape.

This form language continues in the underground part of the exhibition which takes the shape of a cone mostly buried into the side of the taller cliff next to the rectangular building. While a square shape was considered, the circle efficiently deals with the pressure from the ground outside and allows the petrified tree to be a centerpiece of the space.



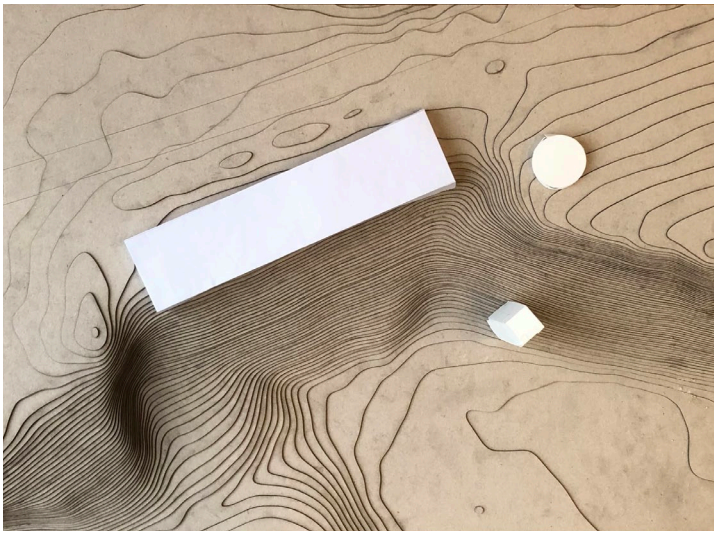




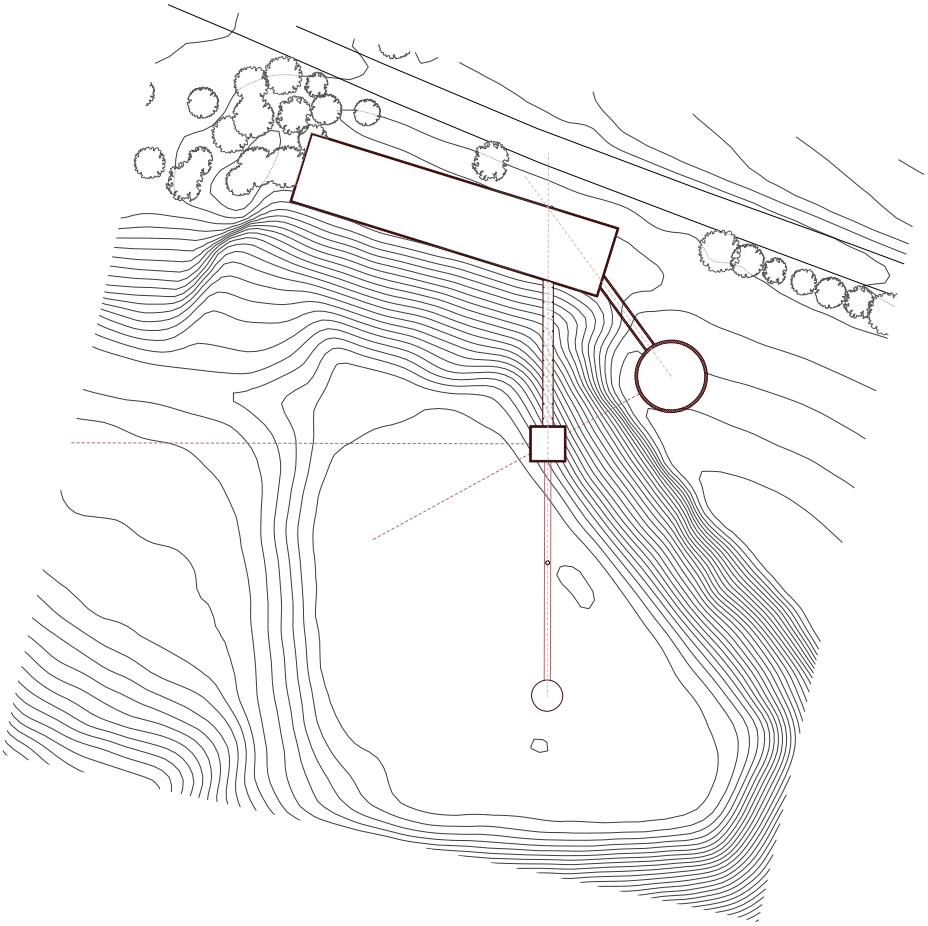
illu 73. underground exhibition

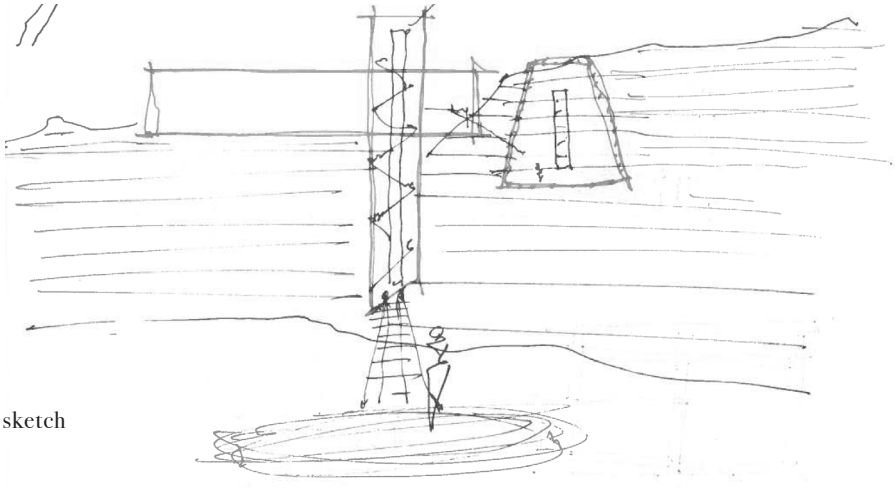
The horisontal rectangular shape of the museum is complimented with the vertical rectangular shape of the tower and the composition is balanced by the cone - slightly appearing above the ground. The relationship between these three elements was developed with the use a terrain model in the scale 1:200 and buildings in paper

The exhibited fossils consists of the organic shapes of fish, birds and insects imprinted in stone. The museum consists of geometric shapes imbedded in the landscape.



illu 74. 1:200 process model





illu 75. plan and sketch

Meeting the ground

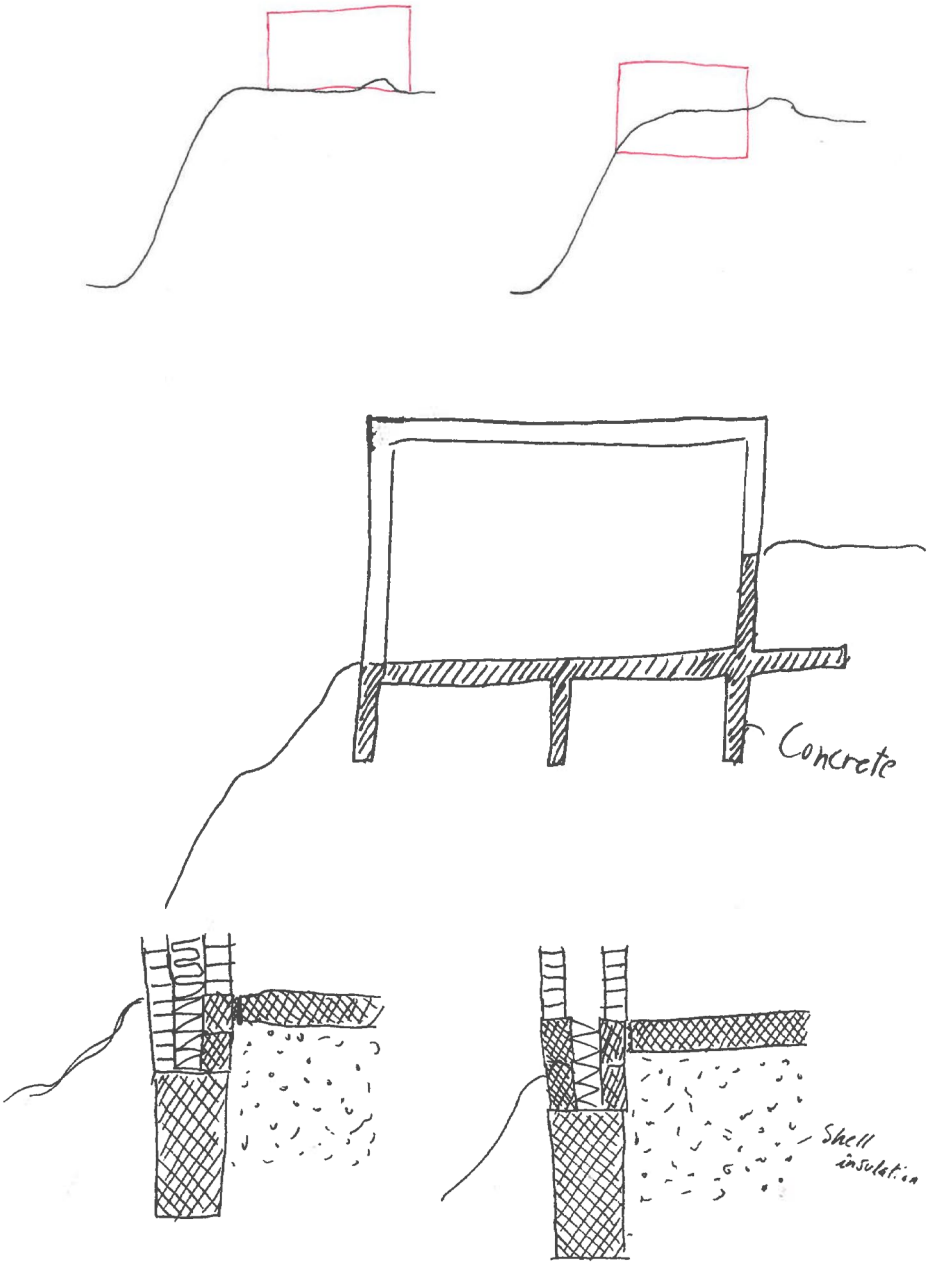
As the moclay museum deals very closely with and sits on a very unique type of ground, its relationship to it is of extra importance. Initially, thoughts of whether to place the museum a little from the edge of the excavation or to place it on or almost over the edge was a point of discussion. Placing the building as on the sketch on the right (see ill. 77), means that people can enter on one side and then step down on a lower story that puts them right on the side of the mo-clay cliff.

It also means letting the building step forward and continue the height of the surrounding cliff edge and become a more active part of the landscape.

illu 76. moclay cliff

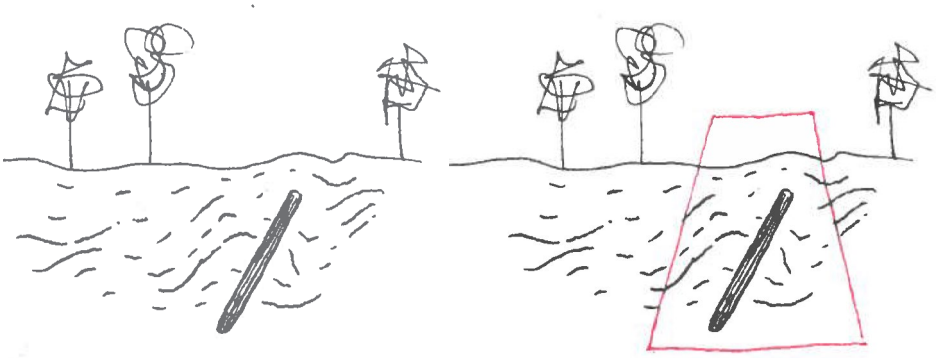
Putting a building right on the edge of a slope as steep as here - and especially on a soft soil as mo-clay - means that measures to hold the building in place must be taken. Among these are a concrete foundation with pillars pilotede into the ground and a horizontal concrete slab letting the pressure of the ground hold the building in place (see ill. 77).

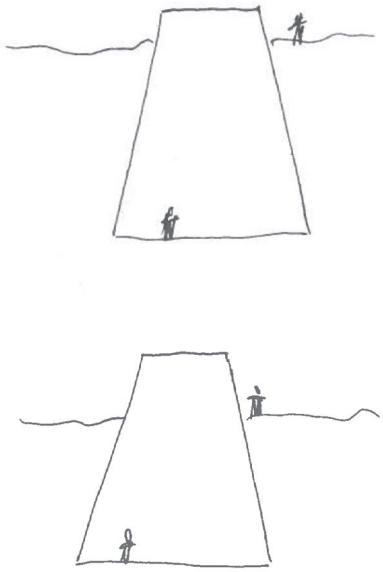
The drawings below show ideas of how to construct the foundation - should the footing be visible from the outside (and tell of the concrete holding the building in place), or should the brick wall continue into the ground and cover the footing? The second option comes with complications, as bricks would need more maintenance, but as the geometry of the wall is in focus, an interruption of its material in its meeting with the ground would not strengthen the project.

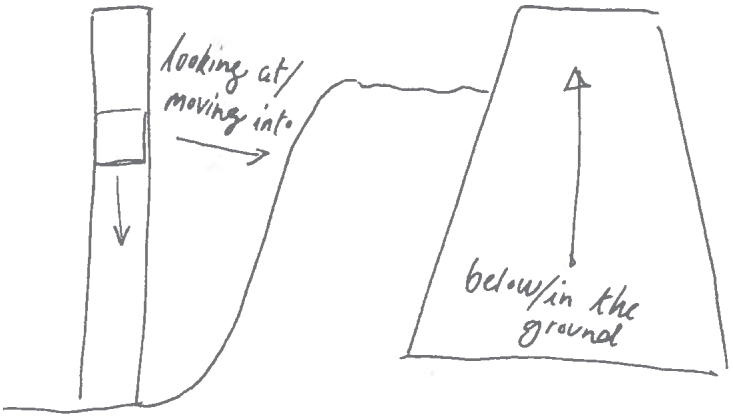


illu 77. sketches of different placement and foundation solutions

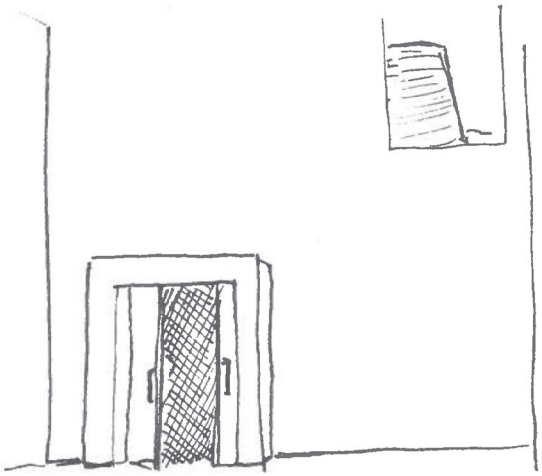
The objects exhibited in the museum are all found in the ground, and have been kept there for more than 50 million years. One of these objects was an almost 10 meter tall tree, when found it had been pushed to be crossing through multiple layers of the moclay and volcanic ashes. The exhibition space for this tree should resemble where it was found - below the ground. Therefore a conic chambre buried partly below the ground, allowing the tree to stand up, was conceived of. The chamber was initially buried almost completely, but was later pushed further up (see ill. 78) so as to allure somewhat mysteriously to what was to come for arriving visitors.





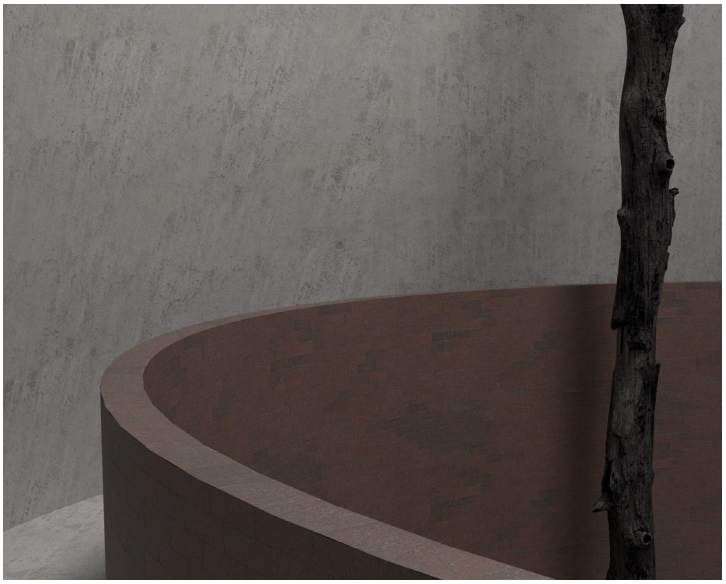


illu 78. (all above) sketches of subterranean exhibition space



illu 79. entry to the subterranean space

illu 80. subterranean space



illu 81. excavation

Materials

For the museum's facade the choice of material is crucial for the building's identity. A wooden building would appear as a light structure hovering above the cliff. It is a sustainable building material and inspiration could be found in the nearby historic drying barn. It was considered if the motive of clay bricks resting between wooden frames could be interpreted, however, as the fossils have an eternal quality - having been buried underground unchanged for millions of years - the museum could convey this through the choice of long lasting hard materials like stone and concrete. A such building accentuates the geometric shape and has a higher thermal capacity.

illu 82. colorful rocks in the mo-clay excavation of Ejerslev

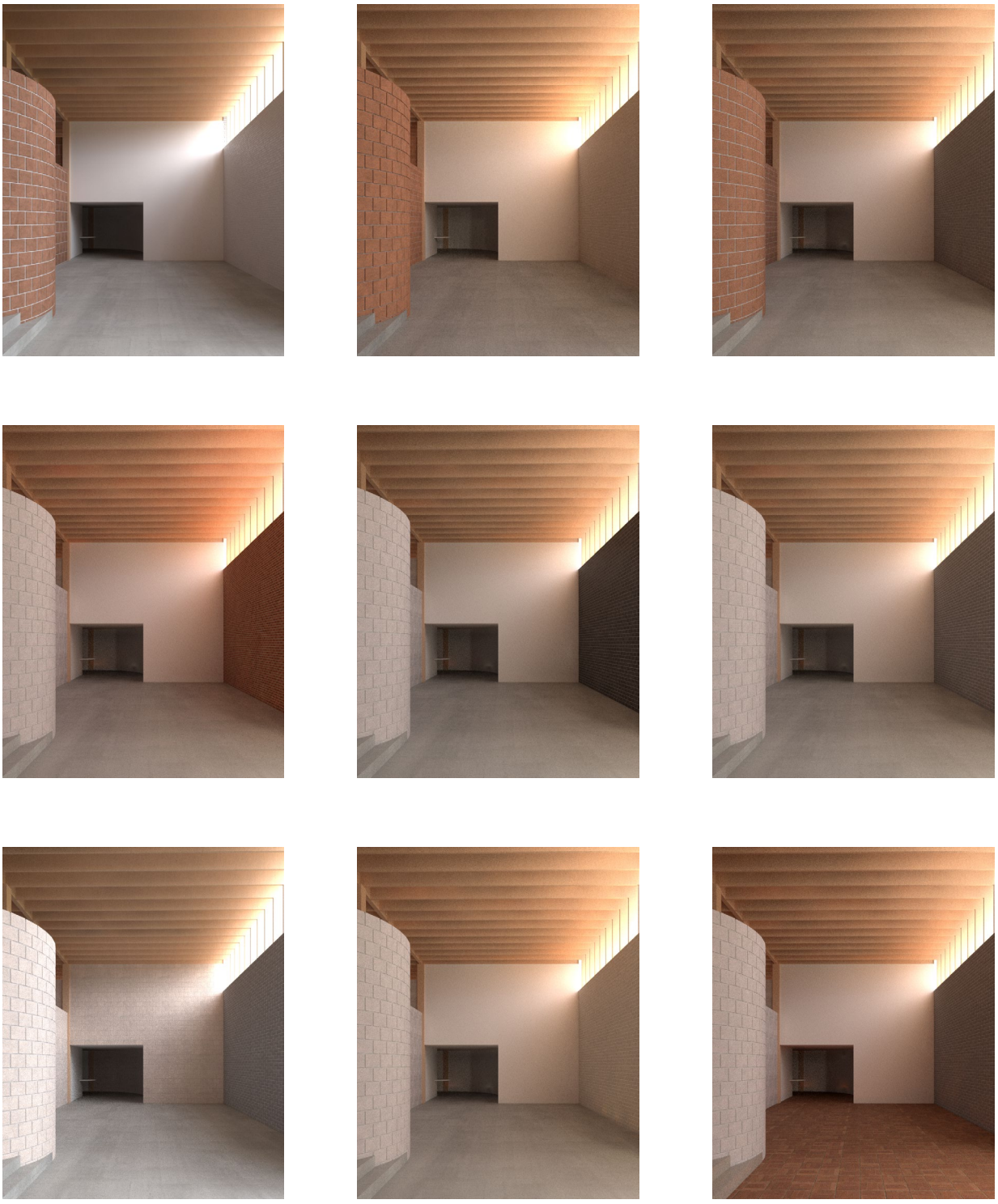
illu 83. mo-clay formations of Hanklit

Inspiration was found in the surrounding landscape and the mo-clay itself. As seen on photos 80-83 many nuances are found in the rock formations. Red and white/beige rocks can be mirrored through burned or unburnt mo-clay blocks and the ash layers through dark burned clay bricks. As the mo-clay blocks are very light and absorbs moisture they are not suited as a facade material. They are, however, favorable as non-load bearing interior walls - putting less stress on the building's structure and contribution to mitigite the indoor climate.

illu 84. left - colorful mo-clay and mo-clay bricks,
right - ash layers and burned dark bricks

illu 85. steel frames within clay brick exterior

The museum's interior is softened and warmed by the choice of a wooden structure carrying the roof and 2nd floor. To experiment with the material composition the double-height exhibition space was used to compare many different combinations of floor materials, brick colors and textures and which spatial qualities they bring.



illu 86. exploration of interior material composition

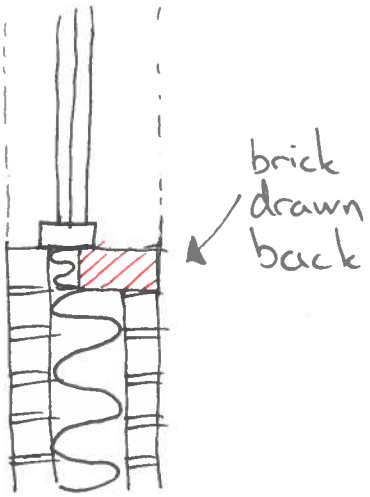
Framing the openings

Wooden windows were chosen for the project in the early phases of the design, and through the process, detailing the meeting between the windows and the brick wall was an important point.

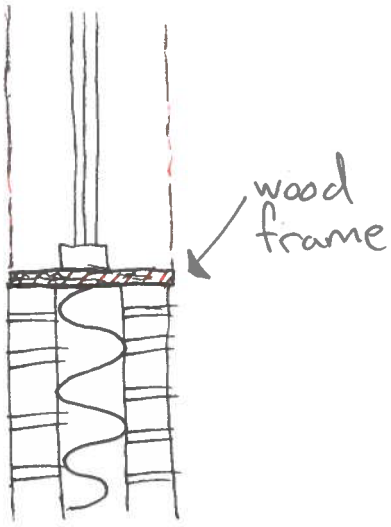
The traditional process of letting bricks perpendicular to the wall be the bearing part of the frame was discussed, but a want to create a clear definition between the inner and outer brick layers arose.

A wooden frame in the full depth of the wall was implemented all around the window to emphasize the material change as seen on illu. 87

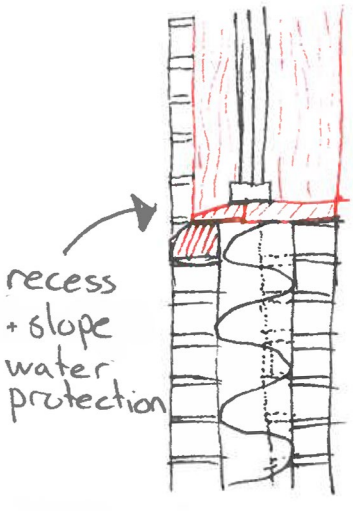
This frame will house the window frame, and thorughout the entire museum these frames will frame the curated views, and works as wrapping for the cavity wall without the visual deception of whether it is a solid masonry wall or not.



illu 87. Brick sill



illu 88. Wood sill



illu 89. Drawn back with slight slope

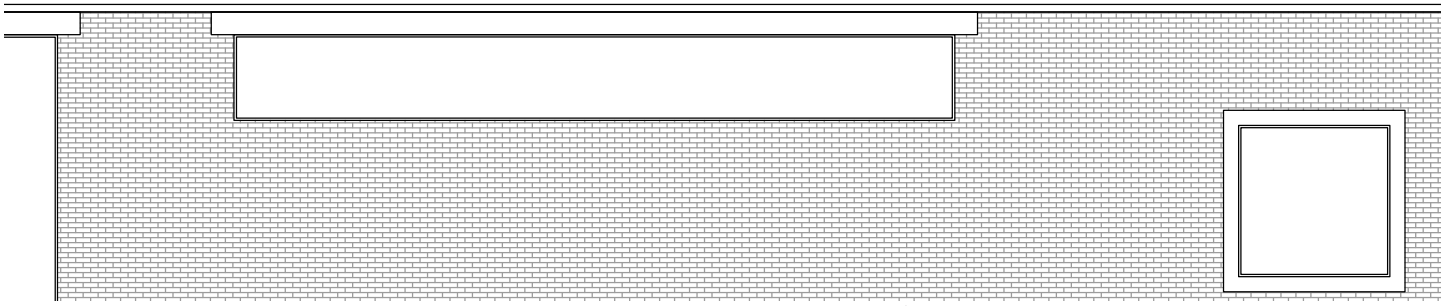
The design of the wooden frame was refined by recessing the frame slightly and through the design of a sloped external cill, that meets a shaped brick below the frame. The frame is divided in two seperate parts making them more managable, and allowing for implementation of a thermal break in the window frame, shown on illu. 88.

The placement of the windows in the wall also has a great effect on the experience of the facade.

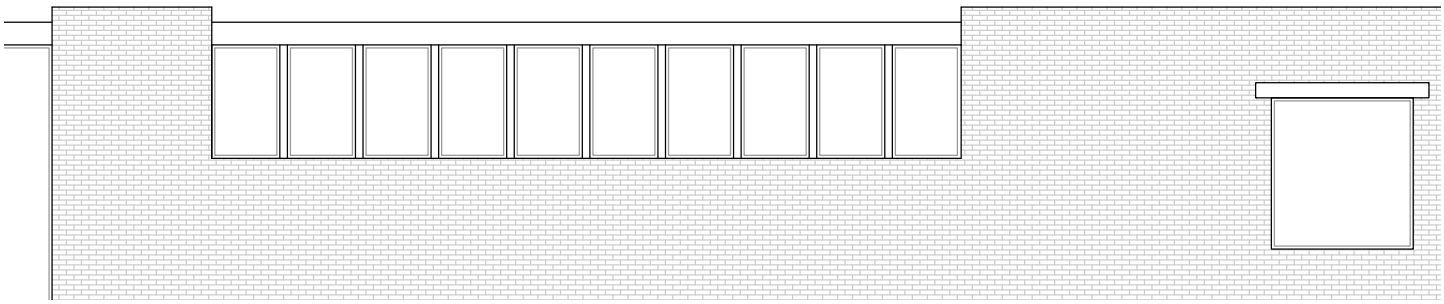
It can strengthen the span of the facade if they are set in the plane of the outer wall. On the interior this allows for deep sills, that can be utilized.

To create a sense of depth and break the facade up, the windows can be inset in the facade. The resulting overhang also works against excessive solar gains in summer.

Placing the window in the middle of the wall, depth in the facade is achieved, and led to further work with the frame around the windows



illu 91. Concrete frames, lintels at horizontal window bands



illu 90. Concrete lintels, recessed parapet at horizontal band

Working with a brick cavity wall requires considerations regarding the frames around the openings in the facade. Early in the process concrete became the material of choice, but the shape of them has been through a process of changes.

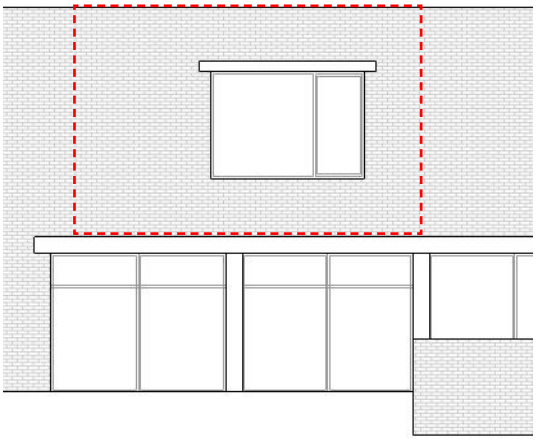
The first iteration on illu. 90 above used concrete frames surrounding the openings, with the exception of the window bands near the roof, where a lintel was used.

The process led to concrete lintels being used over most windows, with the exeption of windows placed at the height of the roof. Instead of adding additional framing at these intersections, the parapet wall made way for the roof to break through instead.

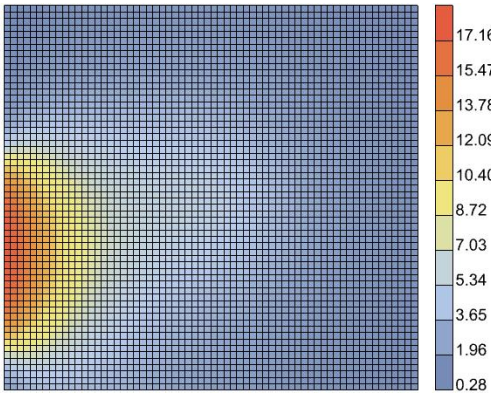
The break in the parapet wall resulted in a visual division of the large spanning facade into parts of a more human scale. The result can be seen on illu. 89

Daylight conditions

The daylight conditions for the office have been investigated in accordance to the danish building regulations. One way to document sufficient daylight in buildings is by ensuring, that the glass area of a rooms windows is equal to or greater than 10 % of the rooms relevant floor area. Below are three iterations of the window design for the office, and next to each a corresponding daylight simulation including an average daylight factor and the window to wall ratio. Not shown is the 1 m2 skylight in the middle of the room.

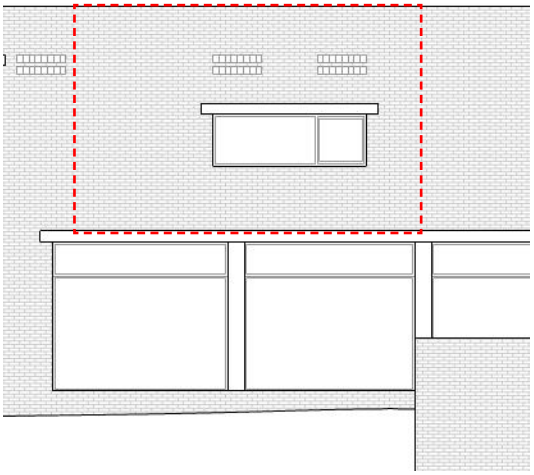


illu 94. singular large window

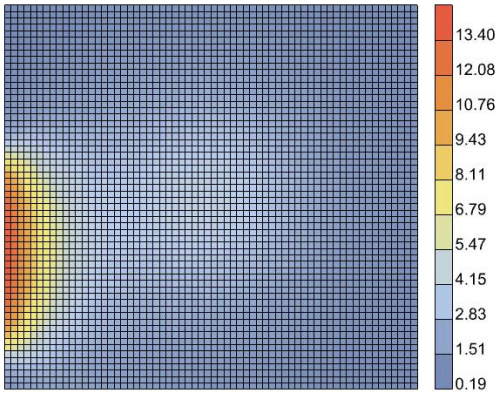


Avg. daylight factor - 3,18 %

Window-Wall ratio - 17,3 %

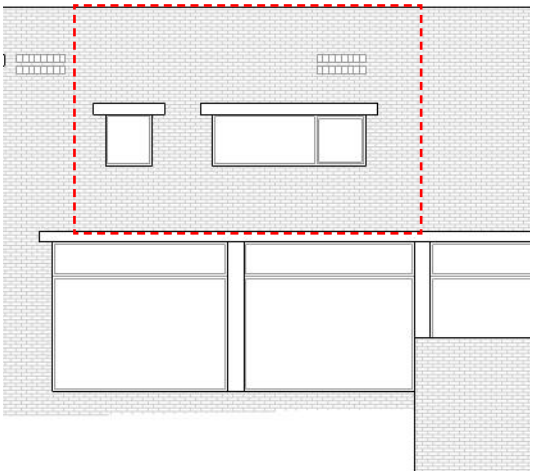


illu 93. singular low window

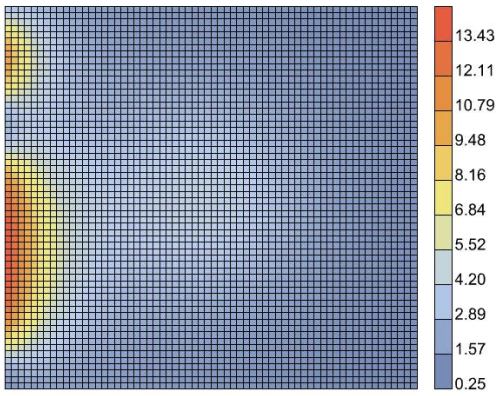


Avg. daylight factor - 2 %

Window-Wall ratio - 9,9 %



illu 92. two low windows



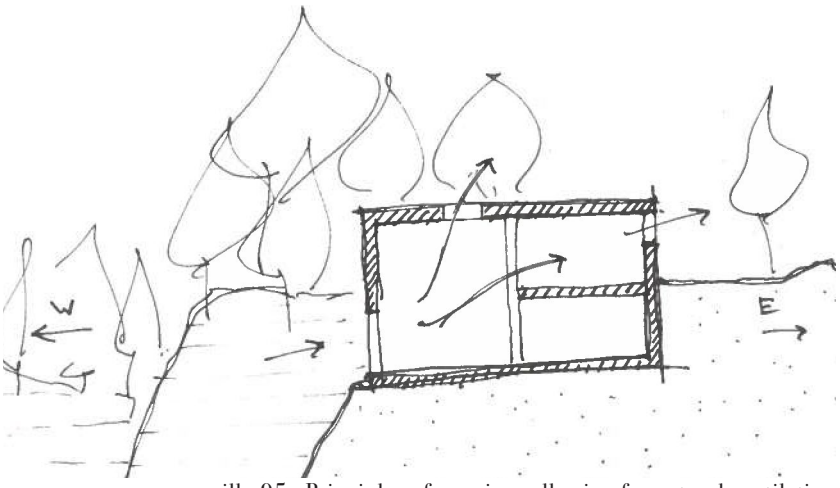
Avg. daylight factor - 2,3 %

Window-Wall ratio - 12,5 %

Openings

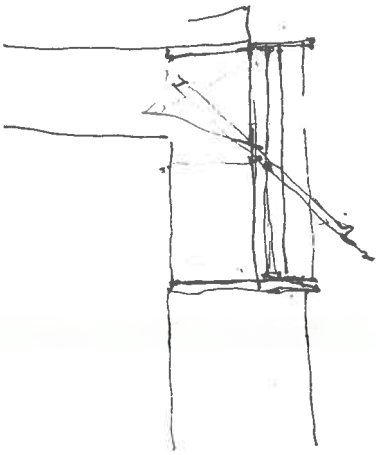
The orientation with large facades towards east and west; the predominant windward and leeward sides during the summer months, allows for great utilization of natural ventilation based on the placement of the openings.
Operable windows in the facades supplies cross ventilation through the open spaces, while skylights are a driving factor for the stack effect for the more enclosed rooms. No room is dependant on single-sided ventilation.

Two main types of window openings were investigated; fold up windows and tilting windows of different kinds. The openings that are manually operable by the museum employees during their working hours are designed as awning windows allowing for greater ventilation and limiting the interior space taken up when open.



illu 95. Principles of openings allowing for natural ventilation


illu 97. Fold up window


illu 96. Tilting window

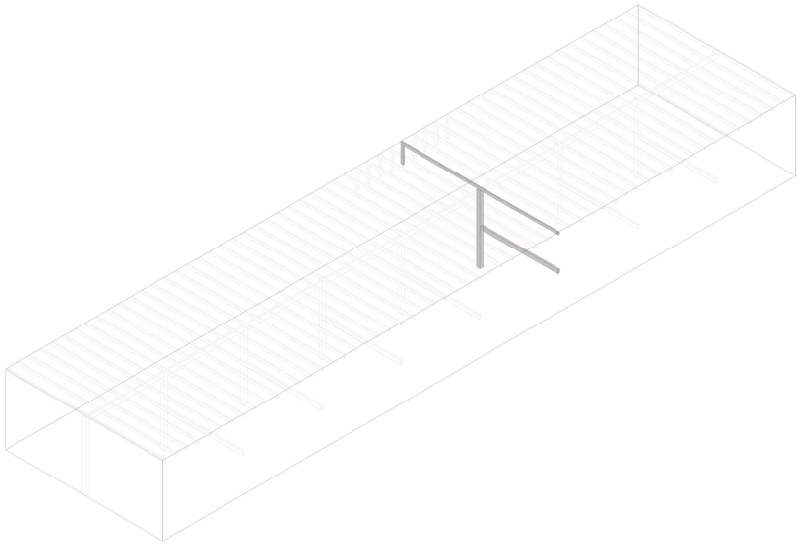
The window bands placed along the roof differ from the rest, as they require a system to operate them from below. A few iterations, ranging from pulley system visible in the ceiling between the beams to more hidden mechanichal solutions, were investigated.

To leave the rhythm of the roof beams unobstructed, the choice fell on a hidden mechanism integrated in the window frames.

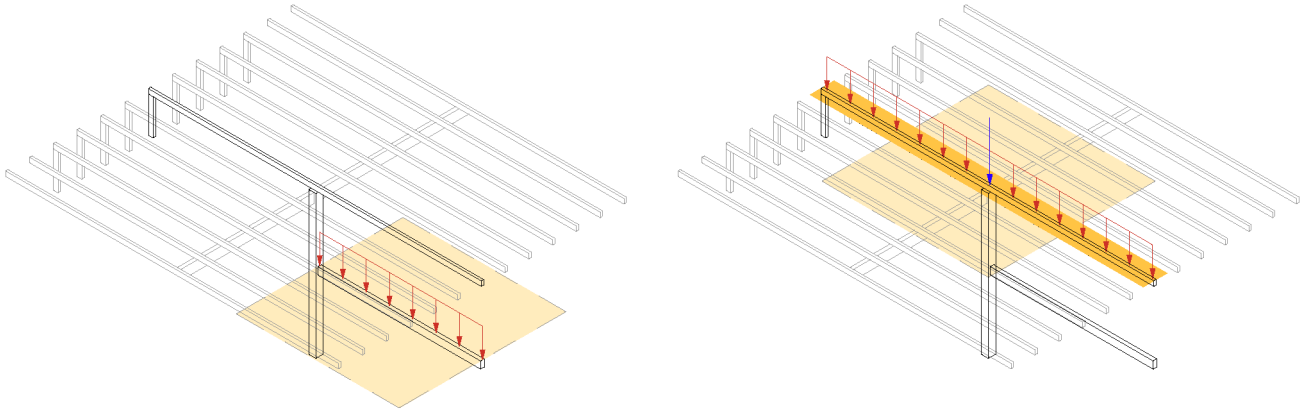
A vertical folding window was choosen for the larger windows to the west, where an automated awning window is used to smaller window bands facing east.

Structural system

The structural system follows the 7x7m grid of the building. This creates a situation where each beam or column carry a similar load, and creates a rhythm in the structure that follows the spatial order. Examining the structure, a small two-dimensional section is chosen (see ill. 98).
This is tested accordning to Eurocode 5 using Karamba, looking at two load combinations, one with a dominant snow load and one with a dominant live load, omitting any wind load, as this would have a favorable effect on the roof structure. The loads are put on a beam carrying the roof, a beam carrying the floor, and a column that these connect to. Another beam runs across the length of the building but is not a part of the 2D system. Below the load areas for the different elements are illustrated.

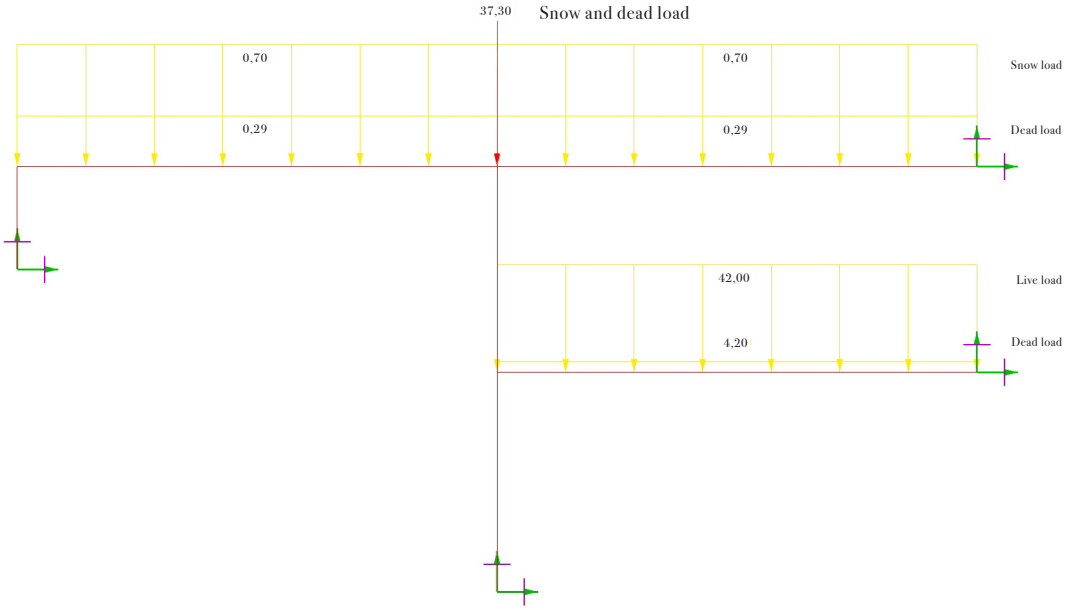


illu 98. structure for examination

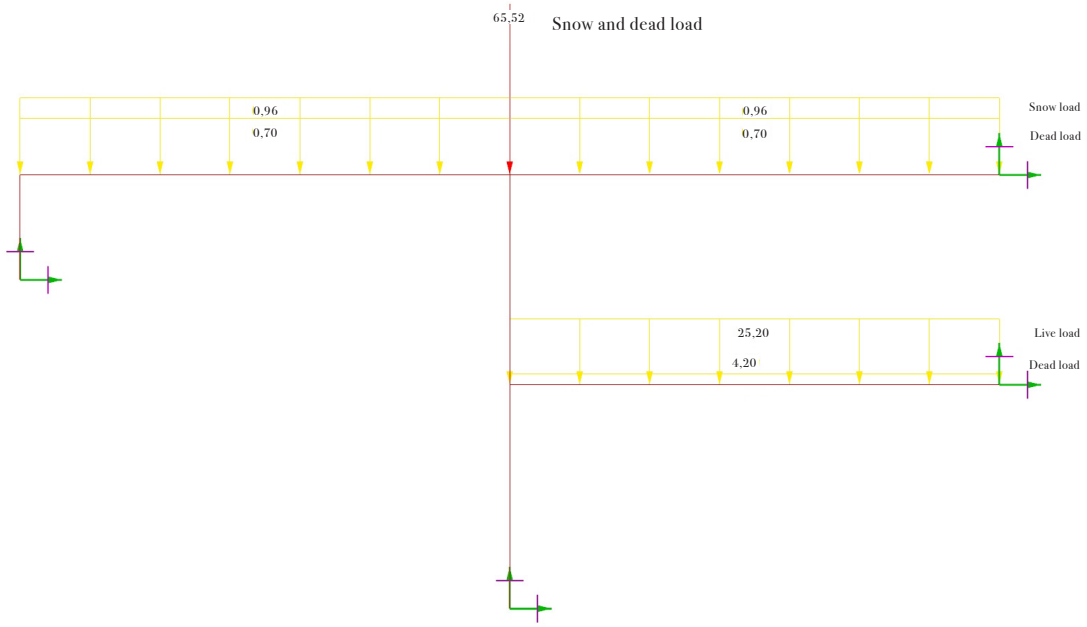


illu 99. load areas (split into floor and roof loads)

ULS1 -dominant live load



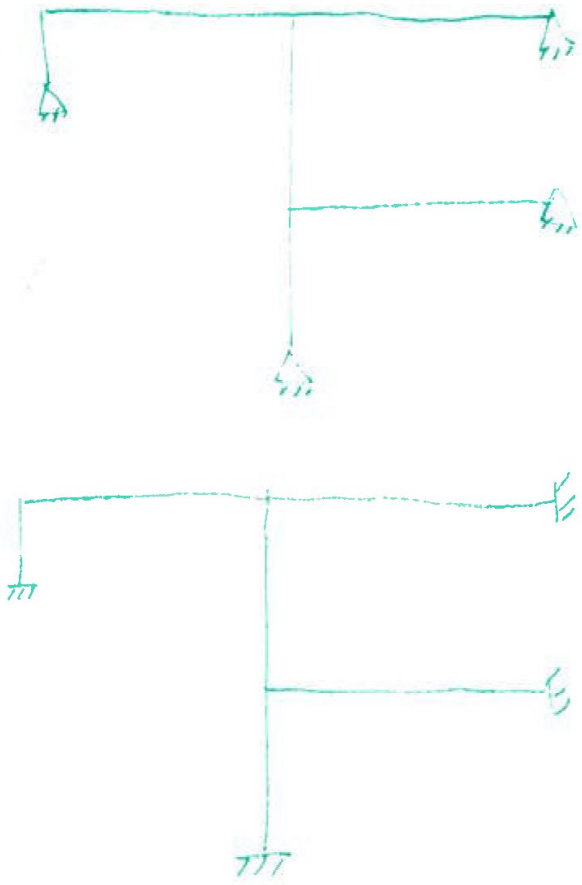
ULS2 -dominant snow load



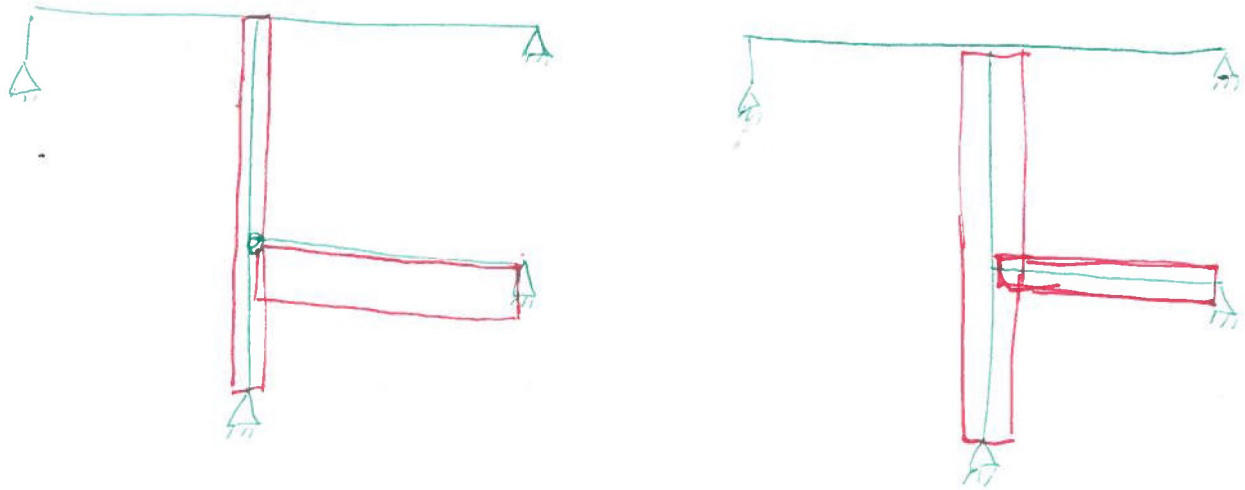
illu 100. load combinations. loads are not in scale and in kN (point loads) or kN/m (line loads).

Structural system

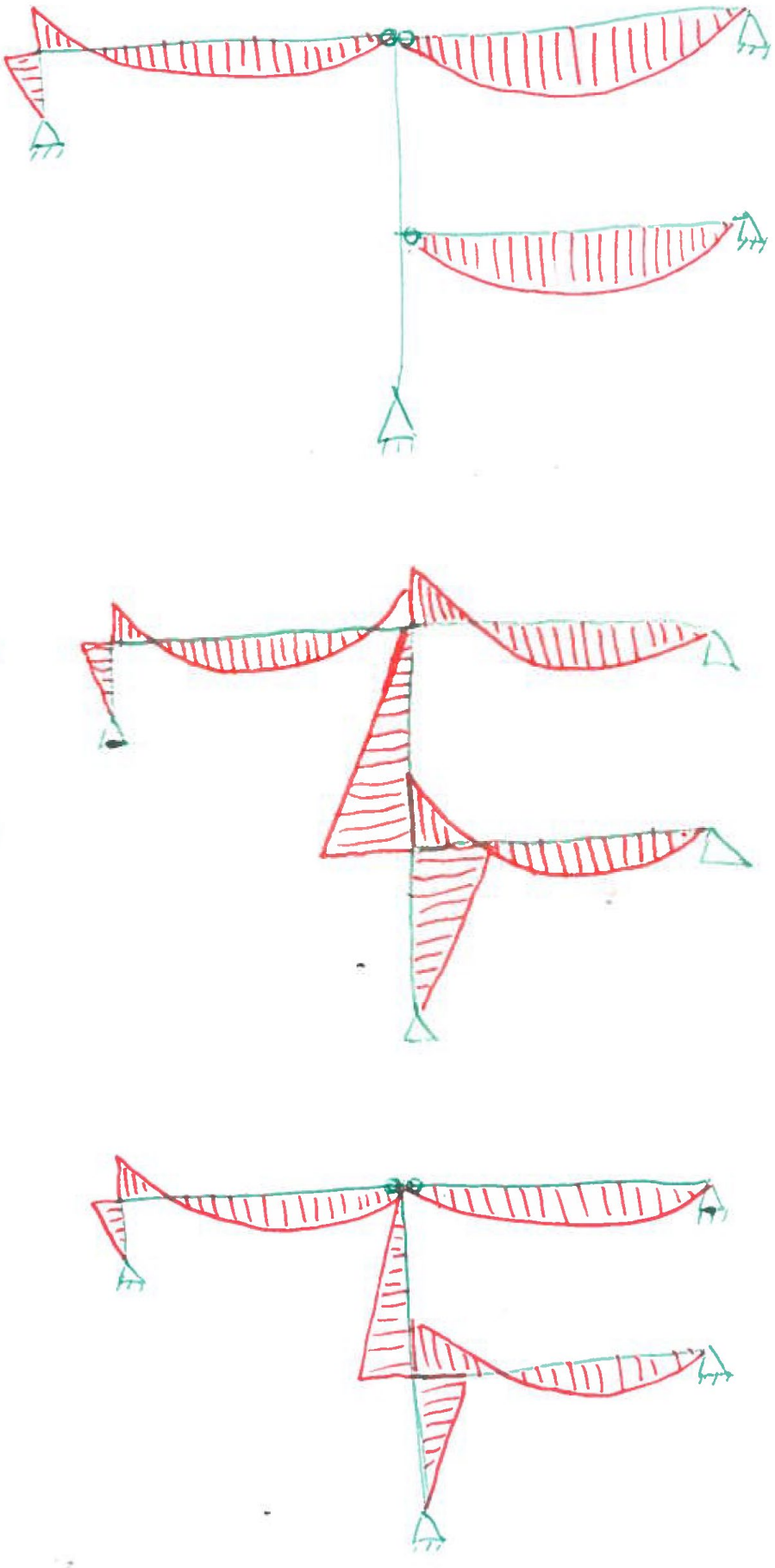
Using free body diagrams, different connections between the beams and column are tested. Looking at bending moment diagrams for the system, it is clear that a fixed connection between column and beam means that the column will take some of the bending moment, and therefore that the beam can be smaller and the column needs to be bigger.



illu 101. free body diagrams for different support conditions.



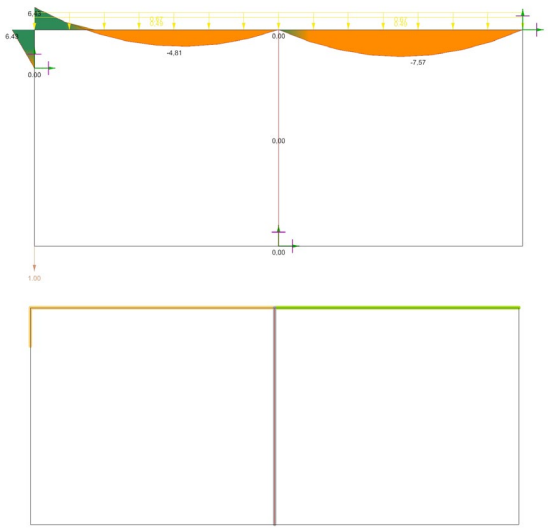
illu 102. cross sections for different connections. a fixed connection means a larger column and a smaller beam.



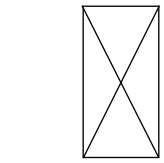
illu 103. moment diagrams for different connections between column and beams.

Roof beam tests

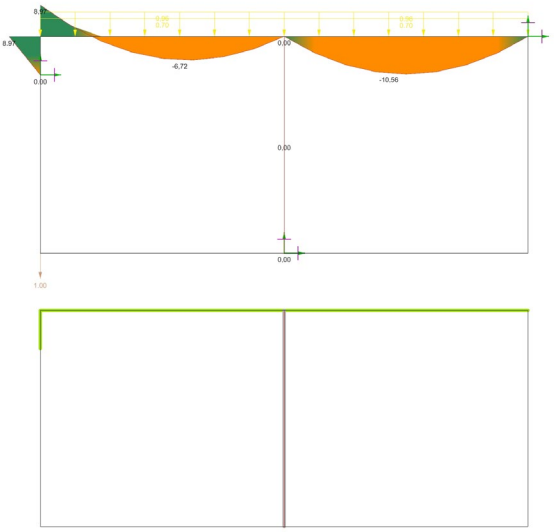
Along the length of the building, a series of beams carry the roof (Beam 01). The dimensions, material and the spacing between the beams have been tested extensively, looking at a load combination with dominant snow. The tests have been carried out through Karamba looking at bending utilization around the Y-axis according to Eurocode 5, using rendering software to evaluate the aesthetic outcome of the different structural layouts (only of systems that have a utilization below 100%).



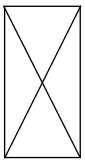
100x200mm
GL32h
Spacing 0,7m
Hinge at column



An initial layout of glulam beams with a spacing of 0,7m, fitting within the buildings 7x7m grid. The beam is joined to the column with a hinge. The utilization of the beam is rather low.



100x200mm
GL32h
Spacing 1m
Hinge at column

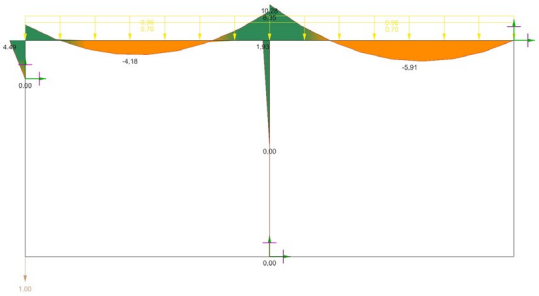


The same cross section as above, but with a larger spacing of 1m. This makes the bending moment on the beam larger, but with the same general shape of the bending moment diagram. The beams look very slim, even if the structure has a bending utilization below 100%.

illu 104. (on both pages). visualizations, moment diagrams and utilization of different structural elements.

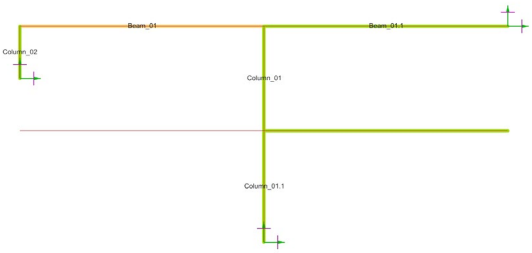
Utilization (bending Y-axis)

>100%
50-100%
10-50%
0-10%
0%



3 9 x 3 0 0 m m
LVL32P
Spacing 1m
Fixed at column

The material of the beam is changed to LVL, which allows for a tall and slim cross section. The connection to the column is thought to be fixed, lowering the bending moment in the beam and letting the column utilize its cross section.



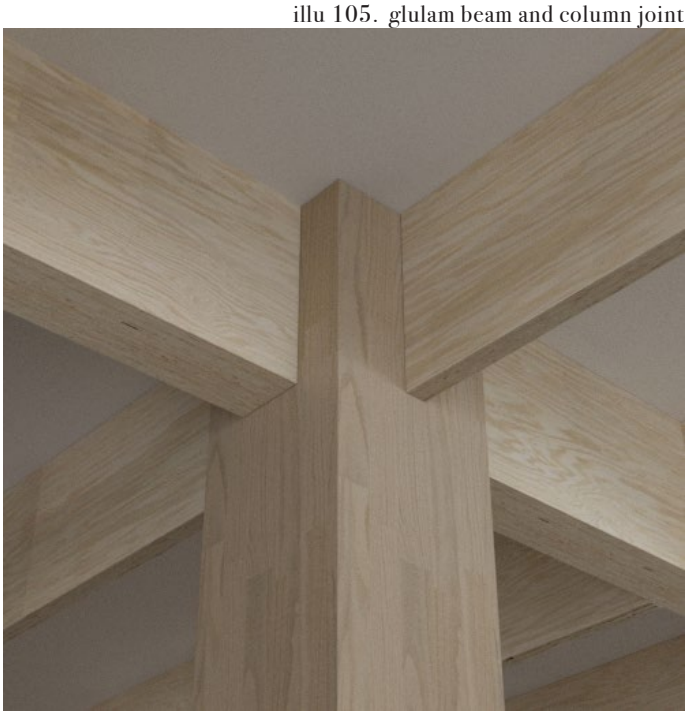
5 1 x 4 0 0 m m
LVL32P
Spacing 1m
Hinge at column

Testing an even taller cross section, the connection to the column is again thought to be a hinge, in this way utilizing the material of the beam (with a moment diagram similar to that below on the opposite page). The small column in the window, is made a bit smaller (51x250mm), better utilizing the material and making it fit easier into the depth of the wall.

Roof beam material tests

A glulam beam usually has a more ‘regular’ cross section, whereas LVL beams are often very tall and slim. The glulam beam is made from lamellaes that are glued together - which is apparent on its surface, while the LVL beam is made from thin veneers glued together, also apperent on its surface. The thin and tall LVL beams filter in light through several bands of windows below the ceiling and create a clear rhythm through the building (see also illustrations on pages above).

illu 105. glulam beam and column joint



illu 106. LVL beam and glulam column joint

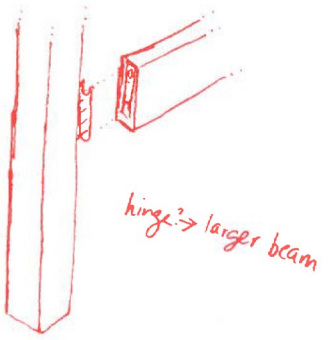
illu 107. LVL beams

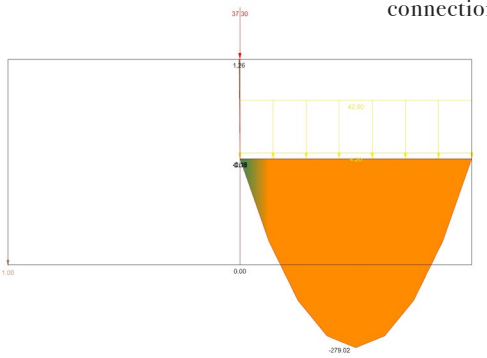
Floor beam tests

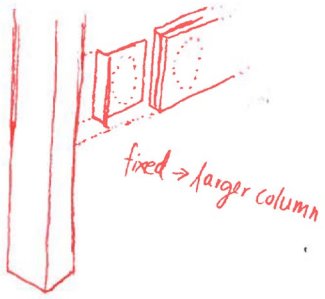
Initial tests of the beams carrying the floor (see plan below on ill. 110), had them connected to the columns with a hinge. This required a smaller column, as it would not be affected by bending, but would also mean a very large beam. The connection was therefore changed to a fixed one - see ill. 111. Several tests were carried out checking the beams bending moment and the columns combined bending and compression (see ill. 108 and 109).

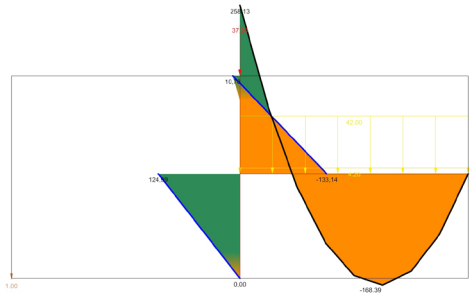
The plan below shows where beams carry the floor slabs - CLT elements of 7x3,5m and a depth of 180mm. These beams are thought to carry the live load incl. the large loads from the exhibited objects and the moclay partition walls placed on the floor above, in this way also mirroring the grid of the building.

illu 110. bending moments for different types of connections



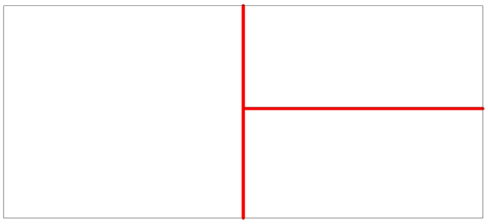






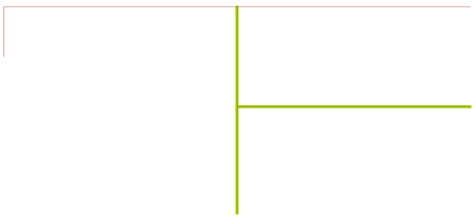
Combined comp. and bending on the y-axis (fixed joint):

Column
360x360mm
GL32h
Beam
400x150mm
LVL32P

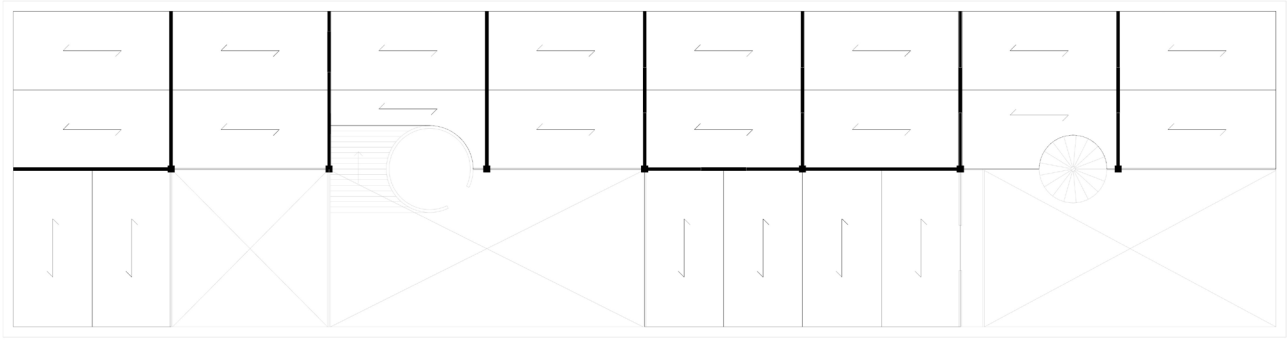


illu 109. column util.: 11% comp., 120% bending

Column
360x360mm
GL32h
Beam
500x216mm
LVL48P



illu 108. column util.: 11% comp., 87% bending

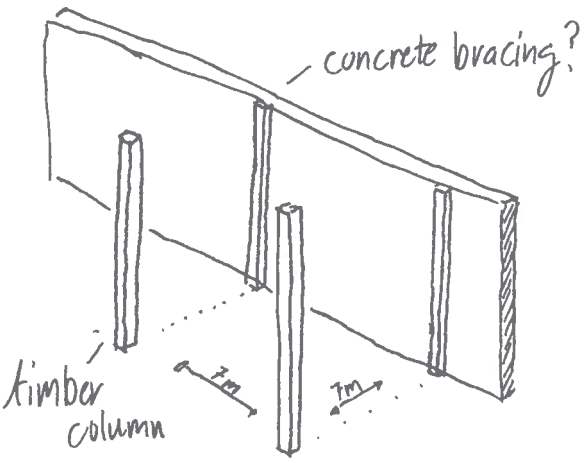


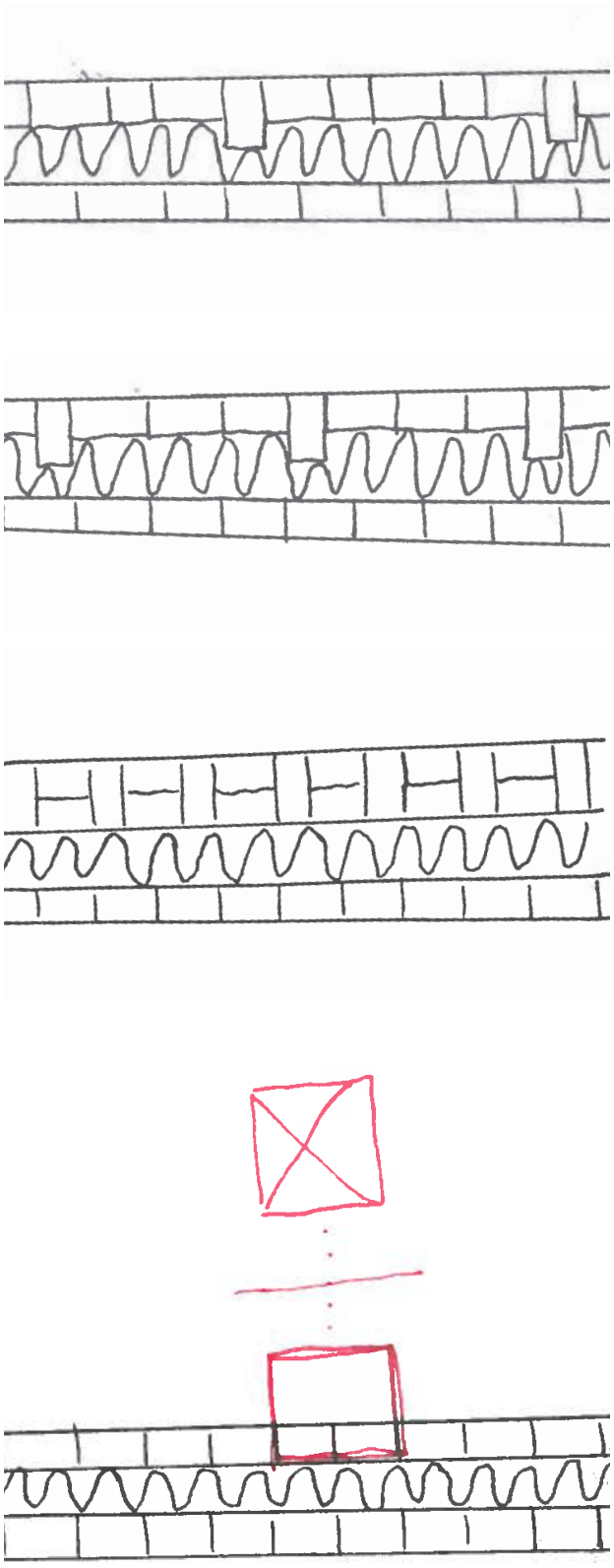
illu 111. load direction of CLT slabs

Wind loads

In the examination of the timber structures of the building, no wind loads have been taken into account. The wind load on the roof has been omitted, as it would generate an upward force, in this way 'helping' the structure. Lateral wind loads have been omitted, as they are thought to be absorbed by the brick walls. This means, however, that the brick walls must be designed so as to be able to withstand wind loads. As we do not have the tools to do any calculations. this process was carried out on a conceptual basis.

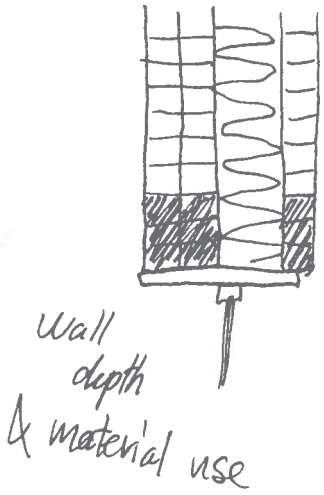
The drawings on this page show ideas of adding more lateral strength to the west-facing wall (as it is the tallest and will be exposed to the most wind) by either making the inner wall two bricks deep, or by adding a bracing rib structure, either using brick or concrete.





illu 112. sketches of different bracing systems

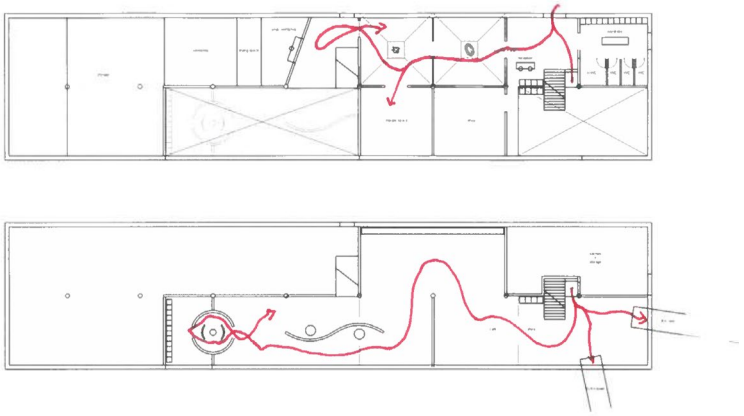
Making the brick wall deeper, would mean deeper openings, which would make the wall more ‘inhabitable’ on the inside. It would also make it possible to push in the windows from the exterior, in this way both emphasizing the opening and the brick wall when seen from the outside. It would, however, also mean using a lot more material than needed.
On the other hand, a bracing rib stucture would save material, but could also mean compromizing the unity of this wall (see ill. 113).
Adding the rib structure on the inside of the wall, would only make it visible in the brick bond as seen on the drawing on the opposite page (ill. 111).
This would lower the u-value of the building, but save a large quantity of material.



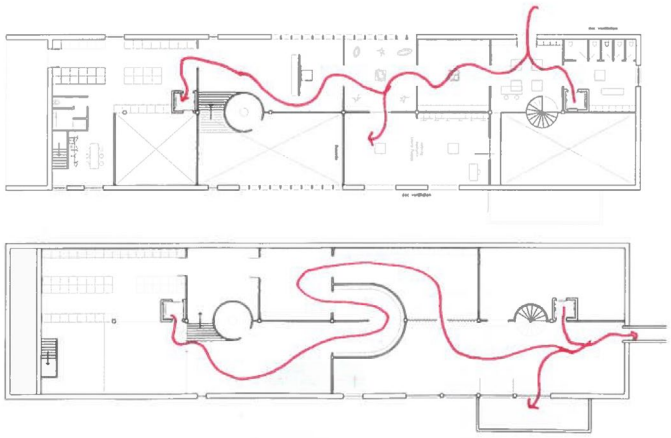
illu 114. section sketch of a thickened wall

illu 113. visualizations of different wall systems

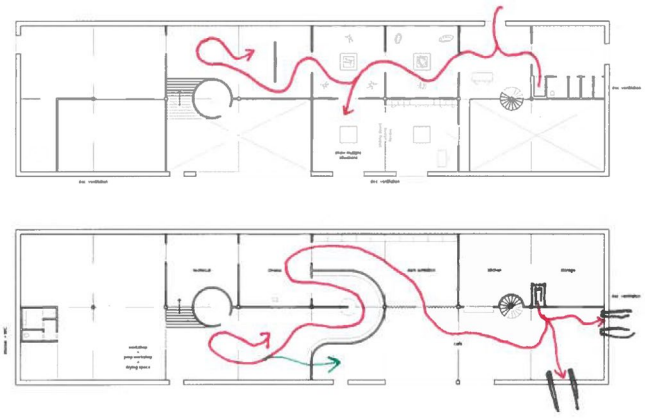
Moving around



illu 117. people with disabilities must walk through both exh. floors twice



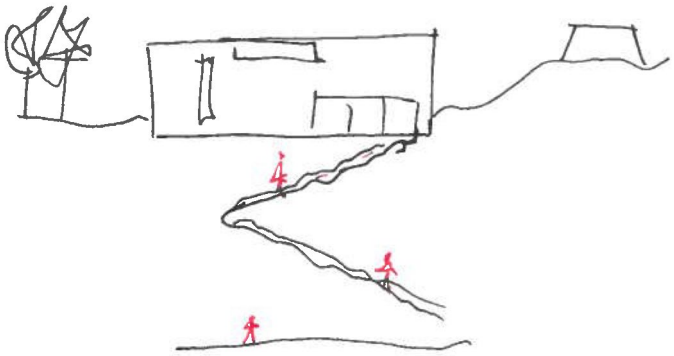
illu 116. a lift in the workshop to the left lets people move to the bottom floor



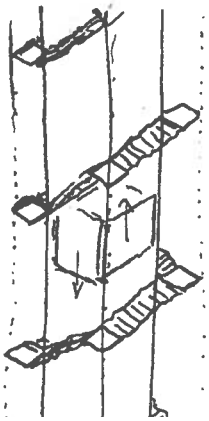
illu 115. an opening lets people pass back into the café (the green arrow)

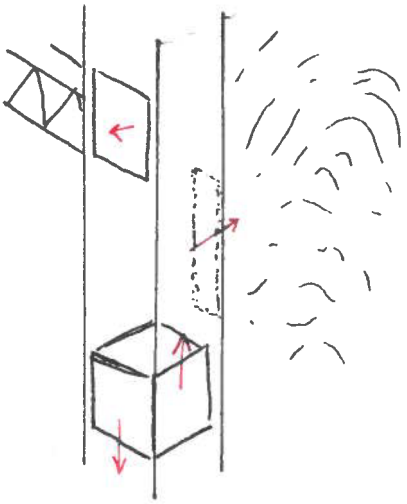
The buildings layout provides a rather straightforward route for people to take when moving around the building - moving north on the eastern side of the building and south on the western side. The route for people who are not able to walk on stairs has been more of a design driver - whether or not to have a lift in each end of the building or let these people cross through the exhibition twice to access a lift by the entrance, has been discussed in depth.

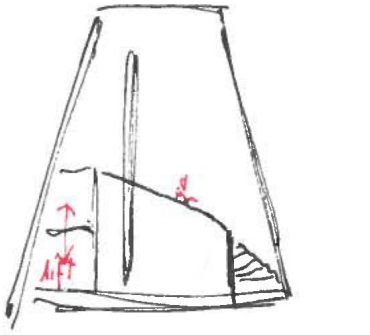
illu 119. sketches of circulation into the excavation

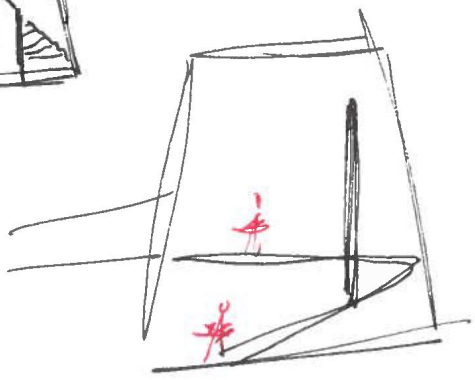


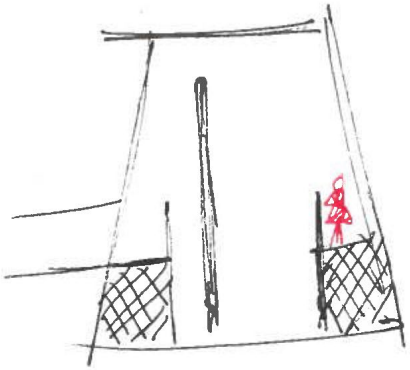
The museum sits in a landscape that is difficult to access for many people - the slopes are steep and the ground is soft. As a large part of the experience of the landscape is to stand at the bottom of an excavation - and another big part of the museum is to move below ground - a lot of sketches on how to move people up and down have been drawn. A central idea has been that while it may not be possible to give everybody the same experience, it is possible to create a positive experience for everyone - and sometimes an annoying ramp or elevator may strengthen the experience for everyone.









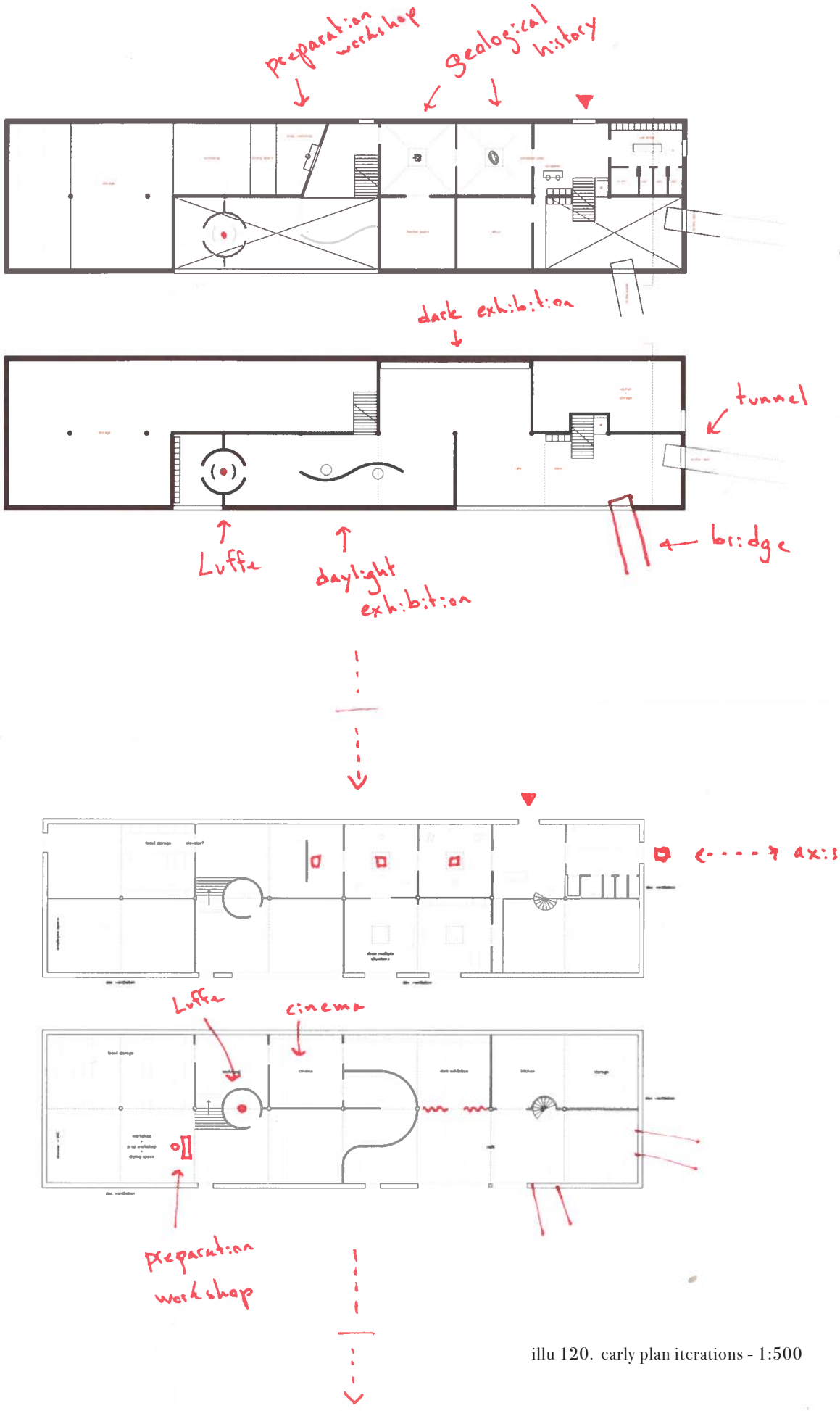


Letting people move down into the excavation on a steep path or a staircase would let them feel the steepness of the slope on their own bodies. A staircase wrapping around an elevator shaft could also achieve this - but instead, a tower with only an elevator would be able to be slim and clear in its verticality - while it would at the same time let everyone move down at the same pace, offering them views of the layers of moclay and volcanic ash that they are moving past (see sketches above).

While using a ramp to let people access the bottom of the subterranean space seems logical, it would not be able to reach it on one rotation. As a lift would here be very disruptive to the space, here the experiences will differ as a staircase will connect a circular walkway to the ground.

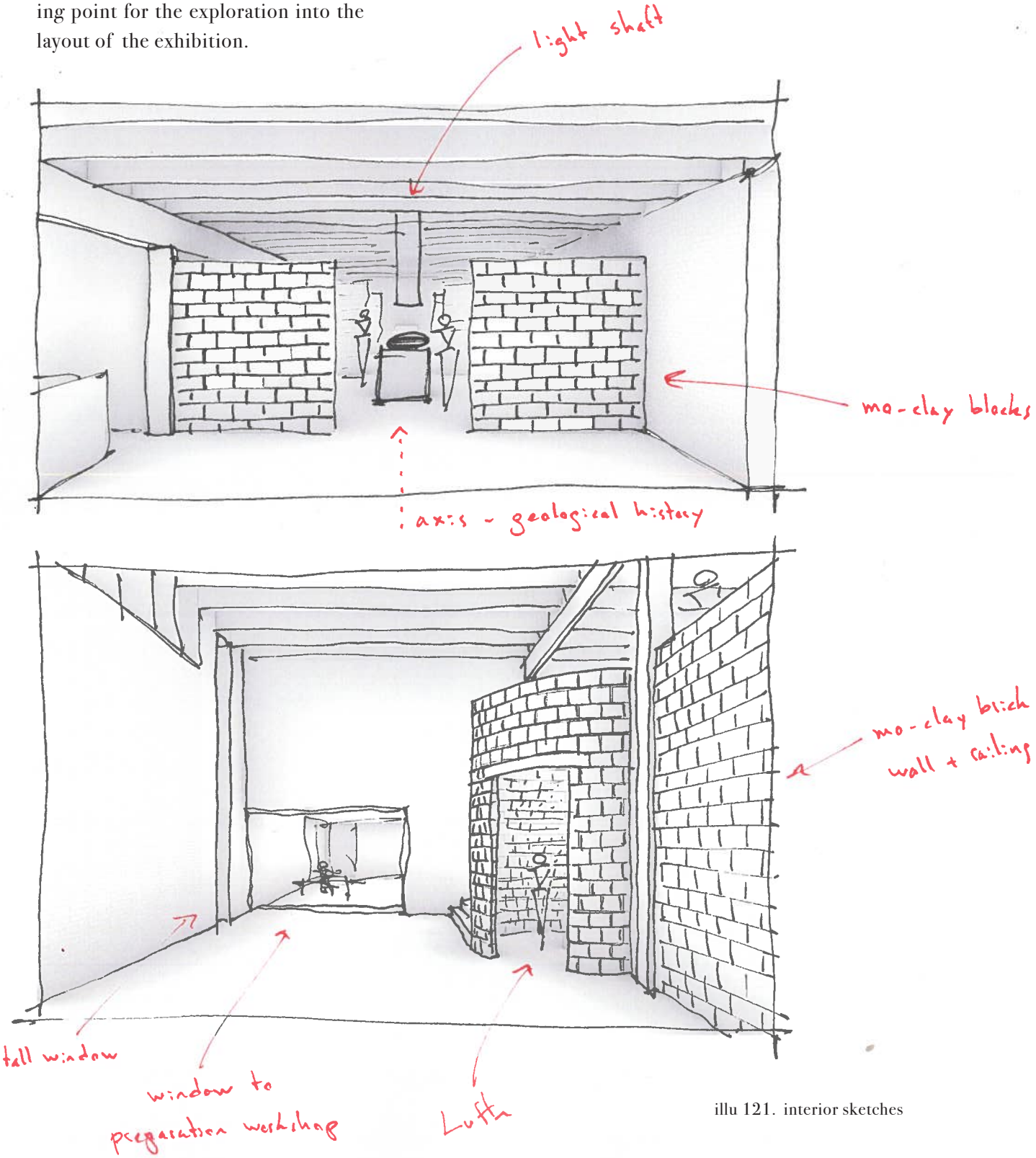
illu 118. sketches of circulation in subterranean space

Exhibition



illu 120. early plan iterations - 1:500

The exhibition spaces needs to present both sculptural, robust elements bathed in flattering daylight and fragile valuabe fossils behind glass displays. Therefore it must be a journey through light open spaces and dark spaces where the lighting can be completely controlled. This was the starting point for the exploration into the layout of the exhibition.



illu 121. interior sketches

Outro

As the museum sits itself in the landscape, it becomes a part of it. This design attempts to balance between when to contrast and stand out in its surroundings and when to blend in and let the surroundings or the exhibited objects take the limelight. The answer has been to let the forms and geometry of the buildings stand out, while materials stay their natural colour and in this way do not overshine the slight shades of earthy colours found in the landscape and fossils.

The museum uses durable materials – it sits in a landscape that has changed continuously through millions and years and is not shy to say that it belongs there, that it is here to stay. It is an attempt to shine a light on some of the most dramatic and unique landscape found in Denmark, making it accessible and apparent to more people.

Visitors move up and down through their visit, feeling the slope of the landscape, they move into and under the ground, through the layers of the moclay. A ramp makes a subterranean space with a petrified tree accessible to all, while a slim tower with a glass elevator creates a shared journey into the excavation, slowly moving past the curving layers of moclay and volcanic ash, making the circulation into an almost interactive element.

An office space sits centrally in the museum, making employees and visitors interact. As the visitors move through the exhibitions the spaces go from light to dark, and offer several views of both the preparation workshops and the surrounding landscape, making the connection between the exhibited objects and the surroundings apparent.

Reflections

As any design project is not only a designing process but also a learning process, the group has learned things along the way that would have changed the beginning of the process, had we started again now. Among these, working with bricks and incorporating the geometry of the material into the design would affect the grid of the building.

The landscape of the mo-clay excavations on northern Mors provide a multitude of possibilities for placement and design of this museum. An architect must always take decisions when facing the blank piece of paper, that is part of the job description, but with this specific project, there is a feeling that there were many other roads that could have been taken. Had the museum been placed at another one of the excavations – fx. near water – this would have provided a whole other set of challenges and possibilities.

As engineers, we are able to use our skills to inform design decisions. In this project, the structural analysis in Karamba has had a large influence on the design – other tools for calculating energy use and indoor environment (Be18, Ladybug etc.) have had a small influence on the process – using these consistently through the design phase would have led to more informed decisions. However, when time is limited, it is important to be able to use intuition, for example to make a building more compact, heighten its options for natural ventilation and its thermal capacity.

The project in a lot of ways lives through its details – when seen from afar, it may consist of singular shapes and large surfaces, but when up close this is broken down to a human scale, through detailing. How materials meet, how a brick wall wraps around a corner, how a column is fastened to the ground, these are all important in making the spaces pleasant to inhabit. Given further time, a lot more detailing could be done, leading to a strengthened proposal.

References

Energiforbrug og klimapåvirkning (§ 250 - § 298) (2024) BR18. Available at: https://bygningsreglementet.dk/Tekniske-bestemmelser/11/Krav (Accessed: 09 May 2024).

§17.4-udvalgets anbefalinger til den fremtidige formidling af moleret på Mors (2023) Forside - Dagsordener og referater. Available at: https://dagsordener.mors.dk/vis?Referat-Kommunalbestyrelsen-d.27-06-2023-kl.17.00&id=58d033c7-d77d-461d-a84e-884f58a0a5a5 (Accessed: 09 May 2024).

Bark Rådgivning (2023) Forundersøgelse for et nyt Molermuseum på Mors. Morsø Kommune.

Bach Rasmussen, J. (1996) Idéoplæg - Vulkan- og Molercenter på Mors, et internationalt besøgscenter. Morsø Kommune.

Pedersen, S. and Pedersen, G. (2012) 'Molerets historie', Geoviden, 3, pp. 1–20.

Mitchell, N., Rössler, M. and Tricaud, P.-M. (2009) 'Foreword', in World Heritage Cultural Landscapes A Handbook for Conservation and Management. Paris, France: UNESCO World Heritage Center, p. 5. Available at: https://whc.unesco.org/en/series/26/ (Accessed: 09 May 2024).

Semper, Gottfried (1851): "The Four Elements in Architecture" in Reader – Tectonics in Architecture. Aalborg University Library. Pp. 21-46

Baeza, A.C. (2020) Stereotomic vs. tectonic, campobaeza.com. Available at: https://www.campobaeza.com/wp-content/uploads/2022/01/2020-Stereotomic-vs-tectonic.pdf (Accessed: 09 May 2024).

Zumthor, P. (1998) 'A way of looking at things', in Thinking Architecture. Baden, Switzerland: Lars Müller Publishers, p. 18.

Zevi, B. (1993) Architecture as space: How to look at architecture. New York: Da Capo Press.

Matteis, F. de (2019) archimaera, 8(Atmospharen), pp. 103–116.

Frampton, K. "Rappel a l'ordre: The Case for the Tectonic." Architectural Design, AD (1990): n. pag. Print.

Heidegger, M. (1971). Building, Dwelling, Thinking. Transl. by Hofsdater (Ed.), Poetry, Language and Thought (pp. 143-162). New York: Harper & Row.

DS/EN 12464-1, Light and lighting - Lighting of work places - Part 1: Indoor work places

Illustrations

All illustrations unless mentioned below is produced by the group.

illu. 26 Scarpa exhibition space
https://unsplash.com/photos/building-interior-with-statue-9KkPloRgOUY?utm_content=creditShareLink&utm_medium=referral&utm_source=unsplash
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https://unsplash.com/photos/a-hallway-with-statues-ErXKLroNPcY
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