A VISITOR CENTER AT
CROMELEQUE DOS ALMENDRES

MA4-ARK34

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Ill. 01, Sunrise over the monument.

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SUPERVISORS
Claus Kristensen
Associate professor, Architect MAA

Lars Damkilde
Professor in Structural Mechanics, Ph.D.

ATTACHMENTS
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USB

DRAWING FOLDER

Andreas Falk Sheye

Peter Nordestgaard Rønnest

PROLOGUE

This report is the final outcome of a master thesis in architecture, developed at Architecture & Design, Aalborg University. The project takes its point of departure in the design of a visitor center for the monument of Cromeleque dos Almendres and the focus lies on a tectonic approach through and integrated design process. The project is developed by group MA4-ARK36 and spanned the period from 03.02.16 to 25.05.16.

ABSTRACT

This report concerns the design of a visitor center at the ancient monument of Cromeleque dos Almendres, situated in the Alentejo province of Portugal, well known for its 'landscape' of cork oak forests and prehistoric, monolithic monuments. The visitor center addresses the topic of creating a humble architecture that conveys and explains the unique astrological phenomenon that have shrouded the monument in mystery and religious worship through several millennia. The design aims to inform, intrigue and pace the visitors to explore the many functions of the center, reachable by foot. The humble expression of the facade culminates in an expressive interior, providing a multitude of functions, including an auditorium, a gallery and a wine bar.

The simplicity of the exterior expression of the visitor center improves the surroundings by contrasting it. The smooth transition from the terrain onto the fifth facade of the building provides the visitors a panoramic view of the valley. Below the visitors are invited into the darker subterranean exhibition to explore the multifaceted nature of the monument.

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METHODOLOGY

THE INTEGRATED DESIGN PROCESS

To ensure a comprehensive and thorough process of design the method of the Integrated Design Process is applied to the project. It is an iterative approach combining critical, analytical and theoretical methods to achieve an interdisciplinary approach to holistic architecture. The method is based on five iterative phases that merges general intuition with scientific research and results, constantly optimizing a project based on technical, aesthetical and functional qualities and considerations. As such it is a great tool to create architecture that is the result of a synthesis between aesthetical and technical parameters. [Hansen+Knudstrup]

In the *problem phase* the problem is described and clarified through a hermeneutic study of literature to form a basis for the design. The framework for the project is defined through an examination of the notions of Tectonics in Architecture and Sustainable Materials, and the competition brief is analyzed to assess the extent of the program.

In the *analysis phase* the conditions of the site and its surroundings is analyzed in various aspects. The majority of the studies involve empiric observations and documentation of climate conditions, historical context and general characteristics of the site such as topography. In order to build upon general conceptions of the functional requirements in public buildings, phenomenological field studies have been included. The results of the analyses provide an overview of the qualities and problems associated with the site. It forms the design criteria and the vision for the project and shapes the initial design concept.

In the *sketching phase* different proposals are sketched and investigated by applying many consecutive iterative loops. In this phase the project is optimized through technical, functional and aesthetical con siderations based on the results of the previous phases. It is an empiric and analytical approach, where the early stages consists of quick iterations, mainly visualized by hand sketches or quick analogue models. As the project gradually develops, and the concept becomes more refined, the analogue visualization technique is being supplemented by digital visualization techniques, utilizing 3D software to model and generate digital visualizations. A developed subjective and intuitive approach is used to base choices on immediate impressions. The result of the sketching phase is a more complete, coherent and informed design concept.

In the *synthesis phase* the iterative loops are continued till the final design emerges, integrating the technical and functional aspects with the aesthetical aspects. Subjective and intuitive considerations are balanced with empiric scientific data, creating a poetic synthesis and evoking a multifaceted design that expresses and encompasses the vision for the project.

In the *presentation phase* the final design is presented through various means of visualization techniques, appropriate for conveying the atmosphere and narrative of the architecture. [Hansen+Knudstrup].

“A great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable”

Louis Kahn, Architect [Kahn]

Ill. 02

INTRODUCTION

A VISITOR CENTER

This thesis takes its point of departure in a preliminary program made specifically for students of architecture. The competition was announced in the autumn of 2015 and involved the design of a visitor center to the prehistoric monument of Cromeleque dos Almendres. The center should provide and communicate information about the more than 8000-year-old Monument as well as facilitate secondary functions, unrelated to the monument, such as an art gallery and a wine bar.

In the *montado* landscape of the Alentejo region of Portugal 92 stones have been erected in a concentric ovoid shape, forming the monument of Cromeleque dos Almendres. The purpose and history of the monument is magnificent, but visitors are currently left with nothing to communicate this information to them. Visiting a prehistoric place like this is sure to raise questions, and one of the most important objectives for a visitor center is to answer them.

The Cromeleque dos Almendres is in many ways a piece of ancestral architecture. It was designed by our predecessors to provide a sense of space at a very specific geographical location. Our ancestors created this space by encircling a location with crudely shaped rocks of different sizes, much like modern construction practices can essentially be boiled down to creating confinements that separate the indoors from the outdoors. Designing a building that relates to said monument is a complex task and a task that requires a great deal of respect and understanding of the distinctive atmosphere of the place; the Genius Loci.

"The collision or interaction between topography and built, stacked interventions (buildings) have a very basic influence on the landscape … The landscape is the foundation. But an architectural feature might make it more sensual to consume and read the natural, or cultivated, attraction."

Allan de Waal, Architect [de Waal]

ANALYSIS

1.0

1.0 **FRAMING THE PROJECT**

1.0.1 TECTONICS IN ARCHITECTURE

The tectonic framework of this project is based upon Kenneth Frampton's *'Studies in Tectonic Culture'*, Anne Beim's *'Tectonic Visions in Architecture'* and Marco Frascari's *'The Tell-The-Tale Detail'*.

The term 'tectonic' has its origin from the ancient Greek noun - *tekton* which was the common term for an artisan/craftsman or a builder, or from the ancient Greek term - techné referring to the art of craftsmanship or creating [Frampton].

However in present day the term of tectonic is significantly more complex to describe and it is not something that can be pinned down to one definition. It is a term that has been interpreted by many different people in many different ways. It is not a specific style in modern architecture, but rather a way of letting the construction of a piece of architecture be expressed to achieve different atmospheres and create experiences throughout a building. Kenneth Frampton refer to this as 'the poetics of construction' and argues that there is a developing interest in being true to the materials by honoring both the potentials and the limitations of the materials, just like Louis Kahn famously proclaimed:

"If you think of Brick, you say to Brick, 'What do you want, Brick?' And Brick says to you, 'I like an Arch.' And if you say to Brick, 'Look, arches are expensive, and I can use a concrete lintel over you. What do you think of that, Brick?' Brick says, 'I like an Arch.' And it's important, you see, that you honor the material that you use. [..] You can only do it if you honor the brick and glorify the brick instead of shortchanging it." [Brick].

Frampton stresses that the different components of a building should be joined meticulously and with great thought to ensure that the structural scheme of a building remains transparent and logic to the eye of the beholder [Frampton].

Much like Frampton, Anne Beim stresses that building technology and construction practices are elevated to become tectonics when they are given thought and handled consciously. She argues that the term of tectonic is a marriage between the concept, the composition, the building technology and the construction principles and that the structure of a building should form a symbiosis with its functions and aesthetics [Beim].

"Materials may be signified in accordance with their inherent nature, and various architects have been inspired by their different physical qualities, e.g. surface textures, structural strength, firmness or softness" [Beim, p. 60].

Like Frampton and Kahn, Anne Beim confirms the importance of materials and the impact that the right choice of material can have on architecture, whether structurally or aesthetically.

To Marco Frascari the term of tectonic is a phenomenological concept. He believes that the details in a piece of architecture should act as a common thread and create a narrative that 'tells the tale' [Frascari].

"In architecture, feeling a handrail, walking up steps or between walls, turning a corner, and noting the sitting of a beam in a wall, are coordinated elements of visual and tactile sensation." [Frascari, p. 28].

According to Frascari the art of detailing is the art of merging spaces and materials in an aesthetic, structural and functional manner. He describes this as a critical field between the physical construction and the mental construing of a space, the thought and the furnishing that goes on in the mind when entering a space. This dualism allows the forming of spaces that are open for various interpretations and he speaks of two different kinds of joints, the material joints and the formal joints.

"Details can be 'material joints' … or they can be 'formal joints', as in the case of a porch, which is the connection between an interior and exterior space." [Frascari, p. 23].

A tectonic approach enables the design to form and convey different atmospheres and spatial experiences through its choice of materials, construction and details while simultaneously allowing for an interdisciplinary integration of aesthetical, technical and functional qualities.

Ill. 03, Kimbell Art Museum, Renzo Piano.

Ill. 03b, Hamar Museum, Sverre Fehn.

1.0.2 SUSTAINABLE MATERIALS

When looking up the word "sustainable" in the dictionary it is defined as *"…being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged"* [Merriam-Webster].

This notion has become increasingly important with the contemporary focus on the climate and the survival of our planet and while there are many culprits, one of the main contributors to the changing climate is the depletion in the stratospheric ozone later that is caused by an excessive emission of CO_2.

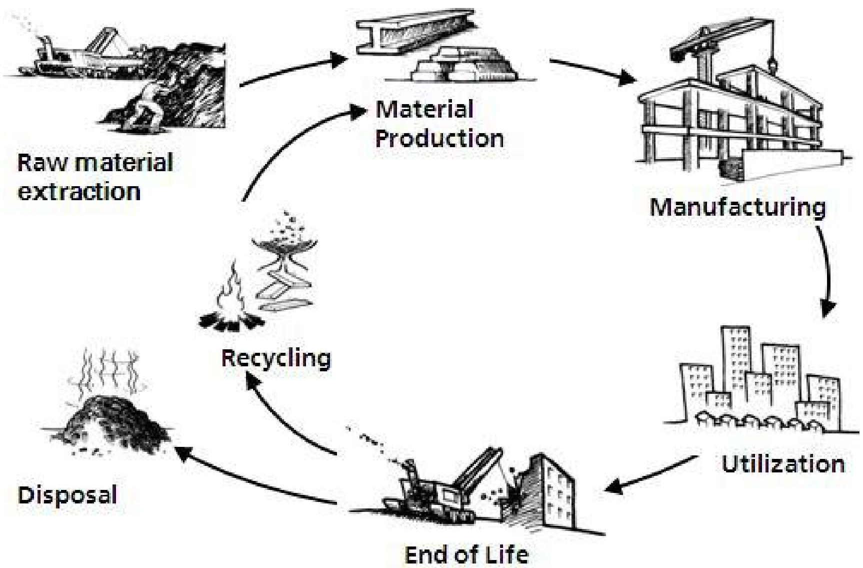
That is why bringing down the CO_2 emission is of high priority, and while there are many ways of effectively doing so, this section will focus on the aspect of selecting sustainable materials and the considerations associated with it.

A key consideration when choosing a sustainable material for your building is how the material is being processed; from extraction to production, packaging and shipping. This chain of steps is important to review because each phase will have an impact on the total calculated CO_2 emission of the final product. Take a look at wood for instance. Wood is often considered one of the most sustainable materials available due to the forests natural process of sequestering carbon for carrying out photosynthesis. However, if the wood chosen as the material is not being logged in a sustainable manner, it becomes an unsustainable material leading to deforestation and changes in the local microclimate of the harvesting site.

This depletion of raw materials, and wood in particular, is a very serious matter and it has a direct impact on our planet's ability to sequester the carbon that we emit. Luckily there are organization, such as PEFC and FSC, dedicated to ensuring that raw materials, and in this case timber, are not being harvested any faster than it can reproduce, and these organizations have supplied the sustainable manufacturers with a label they can use to ensure the consumer that the product has been harvested sustainably [PEFC].

When choosing a sustainable material, it is therefore important to consider the environmental impact of the carbon footprint produced by the manufacturing process. As a consumer you should ask yourself how it is being manufactured and how much energy the manufacturing process requires, how much energy is spent on transport from the producer to the consumer, how easy is it to maintain and dismantle the material and what happens at the end of its service life.

The following section contains an in-depth analysis of the sustainability of two materials; concrete and cork.


Raw material extraction
Material Production
Manufacturing
Utilization
End of Life
Recycling
Disposal

Ill. 04

1.0.3 SUSTAINABILITY OF CONCRETE

Typically concrete is made up of 41% crushed rock, 26% sand, 16% water, 11% Portland cement and 6% entrained air. The ingredients are mixed together and the cement reacts with the water to create a solid mass [BuildingGreen].

Portland cement is created through mixing a variety of materials in a rotary kiln and exposing the materials to temperatures of 900°C to 1500°C. The industry currently uses two kinds of kilns, the older and more inefficient 'wet' kiln, which combines the materials into a wet slurry before heating it, and the dry kiln which combines the ingredients in powder form and uses about 25% less energy. After cooling, the product of this process is then ground into a fine powder and gypsum is added to help with the setting time and workability of the cement [BuildingGreen].

Concrete is one of the most readily available materials used for construction and it has many great environmental advantages such as a high durability and longevity as well as a capacity for storing heat; something that can really benefit a building and help it maintain a steady indoor temperature throughout the day.

In buildings where passive solar strategies are being utilized, concrete's ability to perform as a structural element while providing thermal mass makes it a great choice of material and its ability of being applied as both structural element and finished surface in a building is unique and can reduce the amount of materials used in a project [BuildingGreen].

However, despite its many advantages, concrete also suffers from substantial disadvantages when it comes to embodied energy and CO_2 emissions. Cement production is a very energy intensive process due to the high temperatures that the raw materials are exposed to. But while cement has a very high embodied energy, it is actually lower per pound than steel and aluminum, and the embodied energy in concrete is significantly lower than that. Furthermore, due to its production method, concrete is one of the few building materials that can be reformulated to improve upon its environmental footprint, and there are numerous ways to reduce the environmental impact of concrete by using it wisely [BuildingGreen].
Reduce cement used - the most common method is to substitute some of the cement in the concrete for fly ash or other pozzolans. Up to 40% of the cement can be substituted for fly ash and 20% can be substituted for natural pozzolans such as rice husk ash. Rice husk ash also have the added benefit of accelerating early strength gain in the concrete, which solves one of the problems with fly ash, allowing more fly ash to be substituted for cement. While rice husk ash has great potentials it remains a niche product however which limits its availability [BuildingGreen].

Another way of reducing cement in the concrete is achieved by accepting a longer setting time. If 50 days is an acceptable time to wait before the concrete reaches its design strength is acceptable, instead of 30, it will reduce the amount of cement needed and the long-term strength of the concrete is enhanced in the process [BuildingGreen].

Reduce waste – the cement and concrete industries can reduce solid waste problems by burning waste as fuel for the kiln, but the industry is simultaneously the largest contributor or construction and demolition waste. Some of this waste can be recycled as highway substrate or fill around buildings. Using pre-cast concrete components when possible helps reduce the waste because the exact material quantities can be estimated more precisely and higher strengths can be achieved by controlling the conditions of the manufacturing process, resulting in less material required [BuildingGreen].

The process of producing cement, and therefor also concrete, produces significant CO_2 emissions, of which half comes directly from the process of producing cement and the other half comes from burning carbon-intensive fuels to heat the kilns. The best way to reduce the emission is to improve the energy efficiency of the kiln operation by using natural gas or agricultural waste as fuel. Substituting part of the cement in the concrete also reduce the CO_2 emissions. A new technology of sequestering carbon within the concrete blocks have proven to reduce the carbon emission while also increasing the strength of the concrete [BuildingGreen].

CONCLUSION

While the best way of reducing the environmental footprint of cement is to not use it at all, this is not an option due to a lack of commercially viable alternatives. That leaves the consumers with the option of attempting to reduce the amount of cement used in the concrete by applying some or several of the described strategies. And while concrete may not be considered one of the most sustainable materials, it delivers in availability, durability and flexibility. One can argue that applying strategies to increase the sustainability of a material that is used as extensively as concrete is in fact a sustainable approach. Utilizing new strategies and being a frontrunner shows the concrete industry that there is a market for sustainable concrete.

1.0.4 SUSTAINABILITY OF CORK

The site is located in the Portuguese region of Alentejo, currently the most productive cork land area hosting more than two-thirds of the cork oak forest landscapes of Portugal and for that, the region has become famous for its extensive contribution to the global cork market of which Portugal supplies roughly 60% [WWF].
The site is densely surrounded by cork oak trees, some natural and some having been planted to establish cork plantations. The following section examines the possibilities of using cork in a building because of its importance to the region.

Quercus suber is the botanical name for the cork oak tree. It grows in stony ground of little depth and prefers sandy soil over calcareous soil. It ordinarily reaches heights of 7.5 to 15.5 meters and the average tree live between 100-300 years. The branches are generally quite wide spread and covered with small, glossy evergreen leaves, which makes for a relatively scattered treetop. The roots are likewise spread widely and are often visible above ground. During April and May the tree blossom and takes on a yellowy appearance. The outer bark of the cork oak consists of very thin-walled cells, each containing a microscopic amount of air, sealed against each other to ensure that the entrapped air will not move within the material. This peculiar structure of the outer bark is what makes it such an efficient nonconductor of heat while also making sure that the bark is impermeable to air and water [Cork].

Only the outer bark of the cork oak is used to yield the product referred to as corkwood. The bark is removed in the summer months. When the tree is about 20 years old, measured by its circumference, the outer bark will be fit for harvest. Typically, this is done by cutting the bark free at the base of the tree and at the top of the trunk, just below the branches, and then performing two vertical cuts in the bark, connecting these two cuts makes it easy to pry off the outer bark. The first stripping yields a product referred to as *virgin cork*, which is rough, coarse and dense in its texture. Therefore, it is most commonly used in the production of linoleum and, when treated accordingly, the manufacture of cork insulation. The stripping of the outer bark is actually beneficial to the cork oak tree, which immediately begins forming a new 'covering' of better quality; ready to be harvested again after about 9 years. The second - and all subsequent strippings of the outer bark yields the cork that is used to manufacture commercial products such as cork stoppers. Following the harvest, the corkwood is boiled to remove some of the grit present in the bark due to its long exposure to the elements. The boiling process also removes the tannic acid and increases the volume, elasticity and pliability of the bark.

The vast majority of the harvested commercial cork is used for cork stoppers, representing almost 70% of the cork market value. To produce the cork stoppers the cork slabs are cut into strips of widths equal to the desired length of the cork stopper and then a tubular punch cuts out a single row of cork stoppers as close to each other as possible. Despite the efforts to minimize waste it is an industry that produces quite a lot of it and this have led to the manufacturing of various other products from granulated cork waste [Cork].

When manufacturing expanded agglomerated cork used for insulation, the cork is more roughly ground and obtained primarily from grinding the virgin cork and the cork from the branches, also known as falca [Materials for Construction].

This process also produces a significant amount of cork dust, which is stored in silos and used as biomass fuel for the boiler that generates 90% of the energy used to fuel the factory. The granulate for the agglomerated cork is then stored in silos that supplies the autoclaves in which the cork granulate is injected with superheated steam at about 350-370°C for 20 minutes. The procedure expands the cork inside the autoclave, but since the autoclave is a closed environment the compression binds the cork granules together naturally, without any additives, by using the resin present in the cork granules. After the cork block has been pulled out of the autoclave it is cooled down by injecting water into its core and then they are stored for 10 days without any further treatment. This is done to stabilize the block and allow it to maintain its shape so that it can be cut into the desired thickness, varying from 1cm to 30cm [Ecosupply].

Presently cork insulation has been widely used by the industries for thermal, acoustic and anti-vibration insulation, but because it takes a relatively small amount of insulation to achieve great results the quantity of cork used to manufacture this product is a small factor in the overall cork industry [Cork].

Ill. 05, Cork oak grove.

CONCLUSION

Cork is a completely natural and renewable material. The cork oak can be harvested every 9 to 12 years in the trees lifespan of 100 to 300 years and the harvesting procedure is environmentally friendly and done by hand.

The cork oak landscapes are a big contributor to reducing greenhouse gases in the atmosphere, as the trees are sequestering CO_2 as they grow. Every time the outer bark of the cork oaks is being harvested, the tree stores CO_2 in order to regenerate itself. Therefore, regularly harvested cork oak trees absorb up to 5 times as much CO_2 as unharvested cork oak trees during their life time.

Cork is a biodegradable material and it can be recycled completely to produce notice boards, floor tiles and insulation material.

The expanded agglomerated cork is a locally sourced material that is being manufactured in a carbon negative process, storing more carbon than the carbon footprint generated from the production, packaging and shipping of the product. This is possible because the cork oak trees are not cut down when obtaining the cork, allowing the trees to act as a carbon sink for their entire life span, and because up to 90% of the energy fueling the manufacturing is generated by burning cork dust, a residue of the grinding process, in an extremely efficient boiler. Furthermore, the only materials used in the process are the bark itself and the steam used to expand the cork granules.

The granules are primarily sourced from the outer bark of the branches, which is otherwise inadequate for use in the wine industry because of the irregular shapes, and from the virgin cork of the first harvest, likewise inadequate for use because of its very coarse and dense texture. The virgin cork makes for perfect insulation due to its high resin content, making it easier for the cork granules to stick together when compressed by the steam. The demand for virgin cork creates an economic incentive to plant more cork oaks, thus increasing the global carbon storage capacity [Ecosupply].

REFLECTION

Recently the cork stopper market has been steadily declining due to the increased market share of cheaper alternative stoppers such as plastic stoppers and screwtops. This is an issue because it removes the incentive for the cork farmers to harvest and maintain the cork oak landscapes. One way to solve this problem would be to greatly expand the market for other cork products such as insulation. However, this impose the important question of whether the cork industry could in fact realistically supply enough cork insulation to satiate the increase in demand, and compete with the production of foam-plastic insulation in terms of price and availability [WWF].

There is no simple answer to such a question because there are a variety of factors in play and most importantly it always comes down to one thing; money. It is important to remember that corkwood is an agricultural product and that with an agricultural process the price dictates the production rather than the production dictating the price. Plainly put; an agricultural product will only be continuously grown in volume if it brings in a price that makes it a profitable endeavor. If the demand grows beyond the volume being grown, then the producers will simply increase the volume, and if the ultimate capacity of the producing soil is reached, more soil will be prepared. Cork insulation offers many useful qualities and if the price were low enough it would be used to a much greater extent than it is presently, but unfortunately cost is usually the determining factor in the industries [Cork].

Currently cork insulation remains a niche product, appealing to the architects and engineers who are truly committed to sustainable materials and environmental protection. The producers are required to have a good amount of foresight, and they are very much dependent on a stable market to predict the future demand and act accordingly - the natural process of harvesting the bark can only take place every 9 years and they have to wait for 25 years before they can harvest the bark of a newly planted tree.

1.1 **A STUDY OF VISITOR CENTERS**

1.1.1 STONEHENGE VISITOR CENTER

The Stonehenge visitor center is chosen for a case study to investigate how architecture can interact with a megalithic monument.

The megalithic monument of Stonehenge is among the most iconic and well-known archaeological sites in the world. For many years the monument was being severely compromised by outdated visitor facilities and roads cutting it off from the beauty and coherence of the surrounding landscape. The new project restores a sense of greatness to the monument and its setting and allows for about 800.000 annual visitors to come and experience the monument in an almost unspoiled landscape [EuropaNostra].

The Stonehenge Visitor Centre is designed by the architects Denton Corker Marshall and was erected in 2013 [ArchDaily]. The centre is situated at the western periphery of the World Heritage Site, approximately 2.4 km west of the Stone Circle - and as such it remains invisible from the stones [The Guardian].

The new visitor center has a gross internal area of 1500 m^2 and consists of a grouping of three simple enclosures that rests on top of a limestone platform, sheltered by a perforated canopy that undulates to reflect the rolling landscape that surrounds the center.

The three enclosures are finished in different materials and provides the centre with the principal accommodation for its functions. The largest enclosure is clad in sweet chestnut timber, a locally sourced product, and houses the actual museum displays as well as the service facilities. The second largest is clad in glass and houses the educational facilities of the centre along with the café and the gift shop. The third and smallest enclosure is clad in zinc and accommodates the ticket office [ArchDaily].

The circular shape on the plan accommodates a digital laser scan of the stone circle, projected unto the surrounding walls. This allows the visitors to experience what it is like to stand in the center of the monument during summer and winter solstice, while the center of the actual monument is closed off to the public [TheGuardian].

Ill. 06

A
B
C
D
E
F
EDUCATION CENTRE
RETAIL
VISITOR TRANSIT SYSTEM
INTERNAL SEATING
ORIENTATION
INTERPRETATION
OBJECT CHAMBER

Ill. 07

1.1.2 BROOKLYN BOTANICAL GARDEN

The visitor center in Brooklyn Botanical Garden is chosen for a case study to examine how a building can integrate the natural contours of the landscape.

The visitor center for New York City's Brooklyn Botanical Garden interacts with a piece of topography that connects the city to the botanical garden. The center was designed by architects Weis/Manfredi and was completed in 2012. Since then it has received several awards including an award for excellence in design [Weis/Manfredi].

The design of the visitor center is a seamless extension of the landscape. Nested into an existing elevating landscape, the center is a continuation of the path system in the garden while framing a series of views into and through the garden. Located at Washington Avenue, the visitor center 'wanders' from the city and into the garden, providing clear orientation and access to its major areas. The visitor center includes an orientation room, information lobby, gift shop, exhibition gallery, cafe, and an elliptically shaped space for events [Weis/Manfredi].

The event space is 'squeezed' in-between two discrete outdoor areas. Along the glass wall, a terrace provides space for visitors to gather and for Brooklyn Botanical Gardens to host outdoor events. The hill opposite the center can be reached with an exterior stair that connects to the event space and provides the visitors with a passage that cuts through the building, eventually leading up to the Ginkgo Allée.

Weiss/Manfredi crafted two sinuous pavilions (one for events and exhibitions and the other for a gift shop), stitched together by a ribbon performing as a shaded breezeway. The entrance is marked by an expansive plaza and is paved with a local mix of concrete. Custom made benches allows for the visitors to experience the full urban experience of the botanical garden. [Brooklyn Botanical Garden].

From certain angles, the building seems to disappear altogether as the glazed wall becomes shrouded behind the garden's vegetation: the mounding vegetated roof looks like just another small hill in the countryside .

The building redefines the traditional way that a garden is arranged. It exhibits a higher interaction between building and landscape and through that the visitor can better connect with the surrounding nature of the site.

Ill. 08

Ill. 09

1.1.3 ULURU CULTURAL CENTER

The cultural center next to Ayers Rock in Australia is chosen for a case study because of the homage it pays to its spiritual site through its architectural composition and choice of materials.

The center was made by Gregory Burgess Architects and was completed in 1995. An extraordinary long design process took place beforehand, spanning over 4 years due to the commonwealth political agenda and the close involvement of the Aborigine people. The center is visited by 400.000 visitors annually.

The composition of the building tells an important story of the superstitious beliefs of the Aborigines – *tjukurpa*, with the fundamental principle of people and the landscape being one. The shape refers to two snakes interacting, a very important metaphorical reference to aborigine culture. The southern entrance to the building is represented by *Kuniya*, a female python, and the northern exit building is represented by *Liru*, the male poisonous brown snake. The two 'snakes' embrace a central courtyard where the *Anangu* (Aborigines) can gather and work. The courtyard also contains primitive dance facilities and shelters for shade [CulturalUluru].

The building was developed through a long design process which involved the Aborigine people and the process paid much attention to the choice of materials, all native to the vast land of Australia. Additionally Aborigine art-groups prepared decorative, directional tiles for the flooring throughout the building. These tiles help visitors navigate the center [NationalParks]. The infrastructure of the building is derived from contrasting parameters such as solid/void, hidden/revealed, enclosed/open or shaded/unshaded. These variations throughout the design create a dynamic motion when walking on the internal pathways of the center [A. Architecture].

"This building is for us all. Our beautiful cultural center has the Kuniya python built within its shape. Its body is made of mud and its roof is the spine of the python".

Topsy Tjulyata, Traditional Owner.

Ill. 10, the two snakes interacting.

Ill. 11

Ill. 12

1.2 **OBSERVATIONS**

1.2.1 KUNSTEN, AALBORG

The Aalborg Museum of Modern Art is located in Aalborg and designed by architect Alvar Aalto in cooperation with Jean-Jacques Baruël and his wife Elissa Aalto. It was erected in 1972. The exhibition includes a collection of modern art pieces from about 1900 and onwards.

The excursion to KUNSTEN revealed that different types of exhibitions require different infrastructural arrangements. There is no dictated infrastructural flow in the art museum and this allows the visitors to wander freely between the displayed art installations and galleries. Another thing to note is that the displayed art only provides little information to the visitor; such as the name of the piece and the artist, and the year of completion. Extra information about a specific piece of art may be retrieved at the reception or from the integrated library.

The exhibition is displayed in two ways; the traditional way of hanging paintings or placing installations along the walls, and the more modern approach of placing installations and pieces of art on pedestals in demarcated areas. By doing so, some of the installations become room dividers as well as art displays.

Some of the paintings are highly sensitive to light, so they are displayed in sections were they are only lit indirectly. Others are lit using spotlights, fluorescent lamps or LED lights.

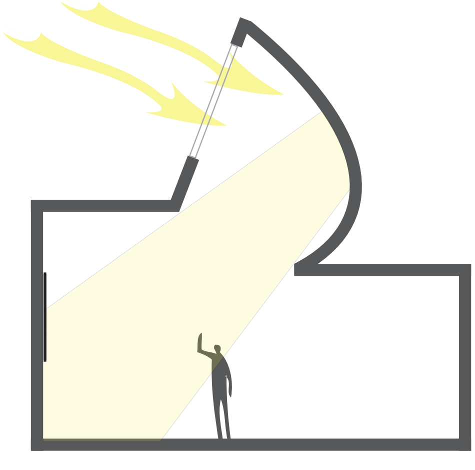
The installations are lit from various sides using either floor, walls and/or ceilings to attach the light source. Some of the art installations also have integrated lights as part of the installation.

Generally the adjoining galleries are very well lit by the daylight coming through the special skylights designed by Elissa and Alvar Aalto. The skylights are designed with a curved surface to scatter the sunlight and provide indirect daylight for the exhibited art below.

The surfaces of the galleries are kept in white tones entirely, with Carrara marble, painted bricks, veneer panels and concrete. The white surfaces help distribute the light evenly inside the galleries by reflecting it.

The main function of the museum is to display the art in a neutral setting with a lighting setting that ensures that the main focus is on the art pieces exhibited. Because the exhibition undergoes change regularly, the recent expansion to the building also resulted in a minor renovation to the original lighting in the galleries, where extra spotlights were added underneath the skylight.

Ill. 13, the light-installation at KUNSTEN.



Ill. 14

1.2.2 LINDHOLM HØJE MUSEUM

The museum of Lindholm Høje is located in northern Jutland and designed by architects Dam & Bengaard. It was erected in 1989 and it is built in relation to Lindholm Høje, an ancient burial mound from the era of the Danish Vikings. The exhibition is divided into two sections, one above ground and one below ground, and includes a collection of artifacts, posters and installations that displays the everyday life in the Iron Age and the Viking Age. The subterranean exhibition is approximately 500 m^2.

The excursion to Lindholm Høje Museum provided insight into how an exhibition of historical sequential time-periods is displayed. When entering the museum the exhibition starts in a darkened room with no windows or skylights. The only things lit are the wooden boardwalk and the historical artifacts placed adjacent to the boardwalk. The boardwalk is highlighted by its contrasting material and provides guidance for the visitors; by following it correctly, the visitor will be provided with knowledge of the different time-periods in a chronological order. The path is consistent throughout the museum, but the visitor does not have to follow it rigidly. Along the way the boardwalk can be left to examine some of the exhibited material further or to interact with a specific piece of the exhibition. The boardwalk also features ramps at specific parts of the exhibition; this particular feature generates a change in the flow and stages a downward view towards excavated graves, creating an eerie atmosphere. The boardwalk eventually guides the visitors to the end of the exhibition.

Throughout the exhibition three approaches towards educating and informing the visitors are being utilized. The combination of these three approaches provides the atmosphere of the exhibition;

The auditive – visitors are exposed to sounds that simulates specific parts of the exhibition; craftsmen working with stone and metal or people talking to each other, simulating the everyday life of a given time-period.

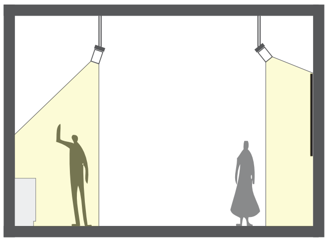
The visual – the majority of the exhibition is displayed visually, either through displays of excavated artifacts or graves or through posters, maps and drawings. A visual display of explanatory video material is also present.

The interactive – video footage simulates and guides the visitor through a naval journey while the visitor is 'rowing' using real ores provided in an installation of a section of a traditional longship.

Since daylight is never present in the exhibition area of the museum, the artificial lighting becomes very important. The majority of the lighting in the exhibition area consists of spotlights mounted on suspension racks. These racks are barely noticeable since the focal point is the exhibition and the artifacts, which is being stressed further by intensifying the light on the exhibited objects. Every spotlight is designed to cast its light with great precision, controlled by adjustable flaps capable of being opened or closed further, providing the ability to create either wide or narrow light cones.

The atmosphere of the final resting place of our ancestors at the burial mounds of Lindholm Høje is sacred, but it is also intrigues and sparks curiosity when visited. It is located on the periphery of the museum and the array of monoliths marking the burial mounds cannot be seen from the museum. The architecture of the museum does not interact with the light nor does it support it. The exhibition could have provided the visitors with the same experience if it was located in a basement somewhere else, were it not for the ancient monument of the burial mounds outside.

Ill. 15



Ill. 16

1.3 **THE MONUMENT**

1.3.1 HISTORICAL ANALYSIS

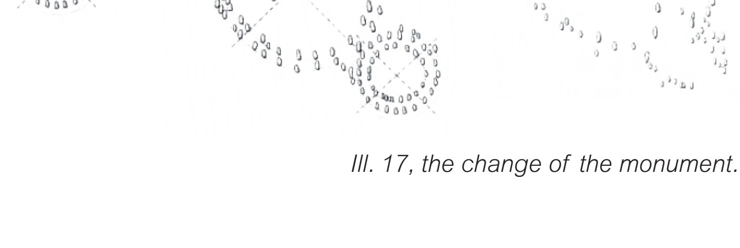
The Cromeleque dos Almendres is a megalithic monument which initially consisted of more than a hundred monoliths. In its current state it is the result of a long evolution, spanning several millennia from the Early Neolithic age in the end of the sixth millennium BC, to the beginning of the third millennium BC. The changes reflect the economic, social and ideological changes in the community during that time span. Despite it being situated in a region long known for its vast amount of megalithic structures, the Cromeleque dos Almendres were first discovered in 1964 by Henrique Leonor Pina, revealing itself as the largest collection of structurally placed menhirs in the Iberian Peninsula [Gomes, 1997].

The enclosure of Almendres was erected in an area with semi-dense soil, based on granite substrate. The type of rock used to whittle the menhirs differ, suggesting that the rock have been harvested from multiple sources. The menhirs have been crudely whittled into cylindrical or ovoid shapes, of which the majority are cylindrical in shape, and reaches three meters in height. The stones are engraved with various symbols, some with stellar aspects and some with phallic aspects. The cromlech is composed of two enclosures, erected at different times, but both being oriented towards the equinoctial directions (east-west). The first erected enclosure of the cromlech consists of three ranks of concentric circles, defined by smaller monoliths. The biggest circle measures 18.8 m in diameter and the smallest circle 11.4 m. The last erected enclosure consists of two ranks of concentric and irregular ellipses, formed by larger monoliths. The outer ellipse measured 43.6 m and 32.0 m at the major and minor axes respectively [Gomes, 1997].

The supporting structure of the menhirs can be classified into four main types. The first and most common one features an open pit in the bedrock, slightly larger than the circumference of the base of the menhir, with stones placed around the menhir as wedges to fill the remaining space, and finished off with a ‘crown’ of overlapping blocks of different dimensions, covered by dirt and fine stones. The second type of support structure features small cavities in the soil, almost never reaching the actual substrate, and here the monoliths are being supported by a ‘crown’ made of smaller rocks. The third type offers no cavities, having the monoliths, which are generally of smaller dimensions, kept upright by a ‘crown’ made of small rocks, but with larger rocks on the periphery. This solution seems to have been used when the slope of the land was more pronounced. The fourth variant has only a small amount of stones supporting a monolith with a flattened base. Due to the general scarcity of materials used when erecting the monoliths and, in some cases, the absence of pits it has become impossible to determine the location of all the missing menhirs [Gomes, 1997].

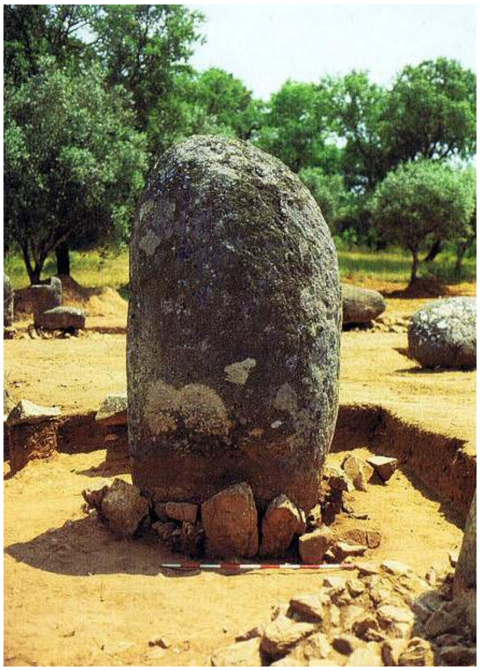
During the Late Neolithic age both structures of the cromlech underwent alterations. The smaller of the two was transformed into what can easiest be described as an atrium, directing entry into the larger enclosure [Gomes, 1997] . In the 4th millennium BC the majority of the monoliths were partially flattened in order to decorate and anthropomorphize the menhir statues, making them resemble human figures. In the 3rd millennium BC a sun iconography was brought into use, conforming with the cultural impact of the first metallurgist societies of the Chalcolithic era who worshipped a Mediterranean sun-goddess. These thematic transformations, changes and erasures of certain symbols or figures reflect the changes in both ideology and behavior of the local communities, who progressively adapted the monument to the changes [Gomes, 2010].

The Cromeleque dos Almendres has served as a multifunctional structure by creating and organizing space in both its physical and psychological term, establishing a hierarchy and providing a place for social assembly and political and religious authority and structure in a semi-nomadic, agro pastoral society. The structure was also tied to both astrological observations and predictions of the spring equinox, and to the propitiatory fertility practices in the area, which conforms with the phallic shape and decorations of the menhirs. The structure fell into disuse during the Chalcolithic era and was partially ruined because of it [Gomes, 1997].



Ill. 17, the change of the monument.

Ill. 18, aerial view of the monument.



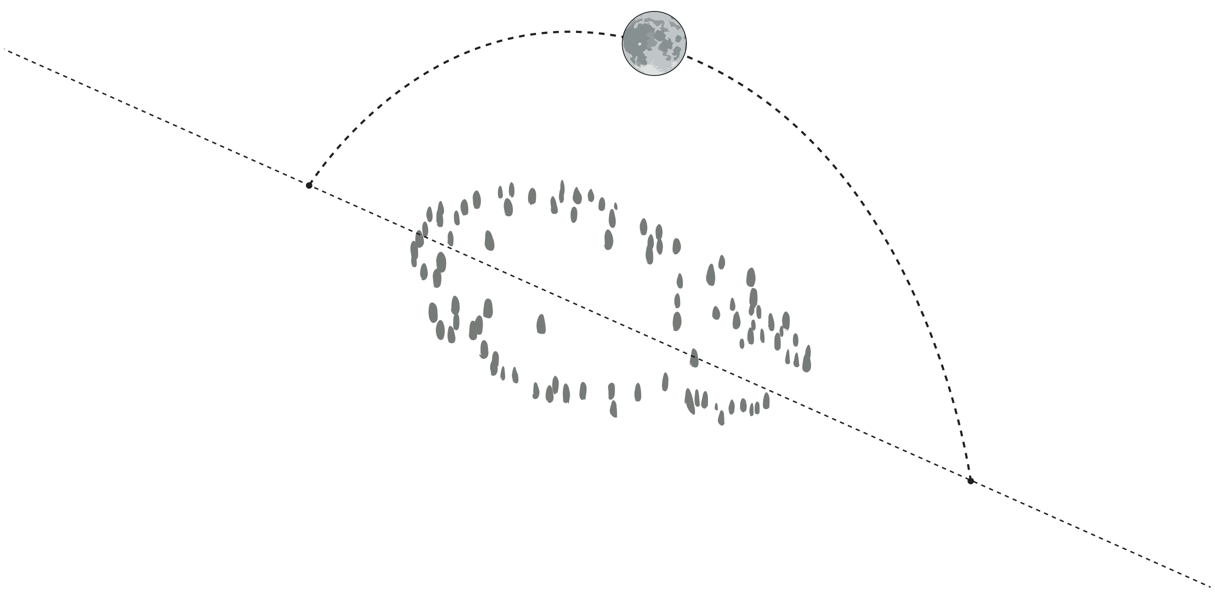
Ill. 19, the excavation of a menhir.

1.3.2 ASTROLOGY

The astrological principles have been a factor of high importance to the people in the particular region of the monument. Studies show that the lunar equinox follows the longitudinal axis of the monument along with the rising and the setting of the sun. This unique phenomenon is very rare, as it only appears at two very specific latitudes in the world. One is located at the monument of Stonehenge in Great Britain, representing the most northern position of the moon during its orbit, and the other is at the monument of Cromeleque dos Almendres in Portugal, representing the most southern position of the moon during orbit. The latitude of each monument correlate with the lunar path which means that the moon rises and sets along the latitude two time each year, at spring and fall equinox. During this time the moon travels directly above the monument.

People who lived in the region of the monument had a different prime meridian, but their system of calculating coordinates was essentially the same as the system that both the Greeks and the Egyptians used 4000-6000 years ago, based on geometry, mathematics and geographical alignment.

R. P. T. Furtado suggests that the astrological alignment of the monument points to a very precise understanding of mathematics. According to his calculations the monument is placed very carefully in the zone of the lunar equinox within a rectangle of just 800 m x 1100 m [Furtado].



Ill. 20

1.4 **LOCATION**

THE REGION OF ALENTEJO

The site is located in Portugal in the Alentejo region, 12 km west of Évora and about 100 km east of Lisbon, the capitol of Portugal.

Ill. 21

THE MUNICIPALITY OF ÉVORA

Évora has a rich history of being an old Celtic capitol, conquered by the Romans in 57 BC. The town functions as the capitol of the Alentejo region and due to its well-preserved old town centre, partially preserved medieval walls and large number of monuments it has become a UNESCO World Heritage Site [Wikipedia].

The premises for the visitor center is located to the west of the monument. On a sloping hillside it is situated in a landscape filled with cork oak trees deeply rooted in the characteristic reddish clay soil. Following a road straight to the monument will get you to the site. The monument arises above the terrain to the east, on a hill top with an eastern slope overlooking the valley and facing the rising sun.


Guadalupe
38°34'04.50"N
08°01'32.90"W
Population:
1.151
Évora
38°34'17.00"N
07°54'16.92"W
Population:
56.596
Site
38°33'27.00"N
08°03'39.99"W
P
SITE

Ill. 22

1.5 **MAPPING**

The municipality of Évora in the Alentejo region of Portugal is known for its many megalithic structures. It is often associated with being the 'Mesopotamia' of the Iberian Peninsula [Ancient].

The megalithic structures in close proximity to the Cromeleque dos Almendres:

Menhir dos Almendres
A single menhir located 1.2 km northeast from the Cromeleque dos Almendres. Historians have tied this lonely menhir to the monument of Cromeleque dos Almendres, speculating that it was used to determine winter solstice.

Anta Grande do Zambujeiro
Considered one of the biggest dolmen (gravemound) on the Iberian Peninsula.

Anta-Capelo de São Brissos
A dolmen which was Christianized in the 17th century.

Gruta do Escoural
An ancient cave with signs of occupancy dating back to 50.000 BC.

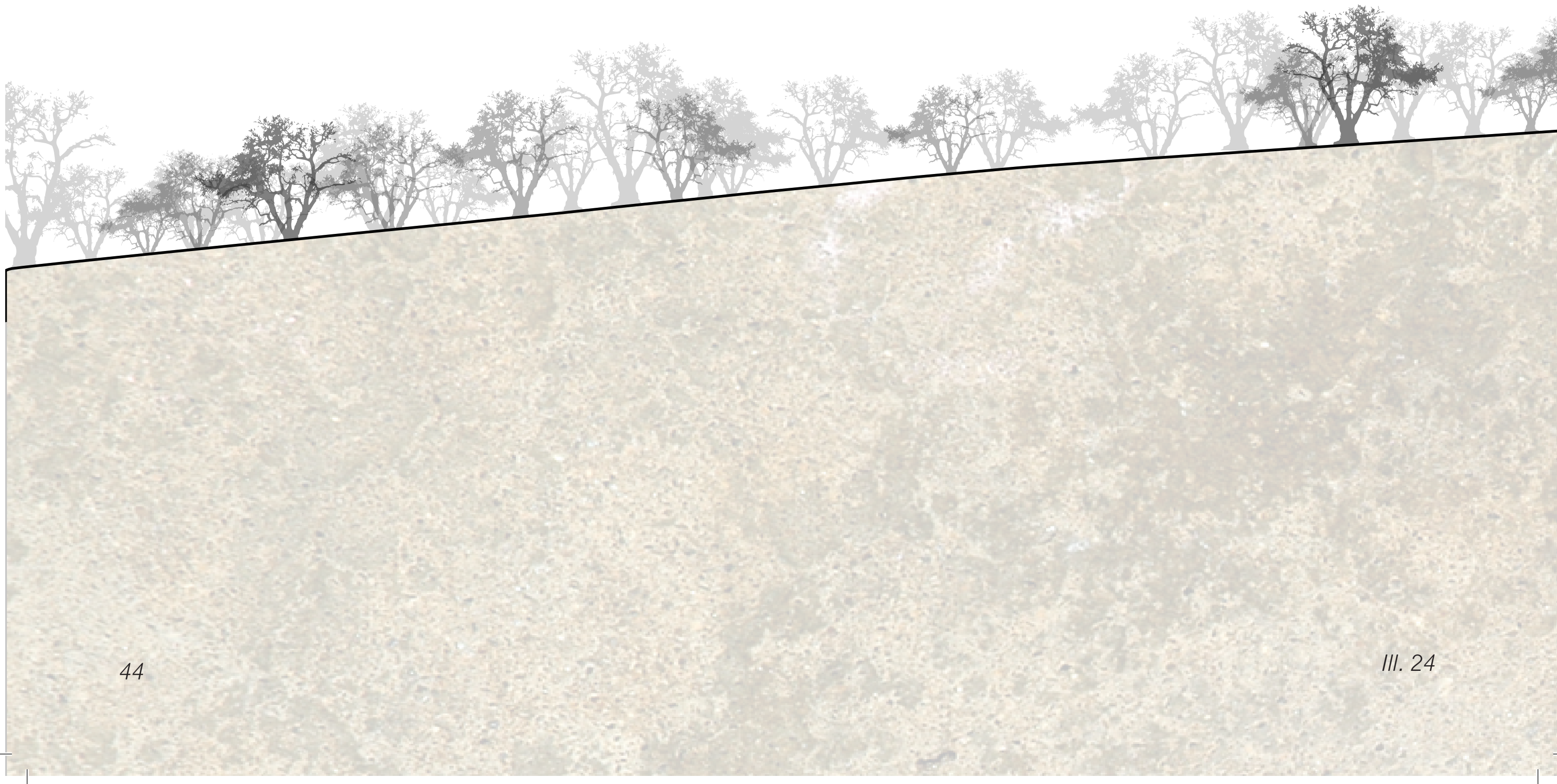
Today the site is accessed by a single road from the small town of Guadalupe, but can also be accessed on foot or by bike utilizing a series of bike trails in the landscape.


Cromeleque
dos Almendres
Menir dos Almendres
Gruta do Escoural
Anta-Capelo de São Brissos
Anta Grande do Zambujeiro

Ill. 23

1.6 **TOPOGRAPHY**

The monument is located near the top of a gentle, eastward facing slope with an altitude of 413 m. The site is located on the western perimeter of the monument, on a westward facing slope of 6°.



Ill. 24

1.7 **CLIMATE**

ANALYSIS OF SITE CONDITIONS

In this section the climate has been analyzed through a review of empirically collected data.

Information supplied by the competition brief:
Latitude: 38° 33' 45" N
Longitude: 8° 03' 40" W
Altitude: 408 m
Rainfall: Total annual precipitation averages 627 mm
Winds: Predominate winds northwest. On average, the most wind is in the Summer with an average daily wind speed around 12 km/h [ARKxSITE].

CLIMATE

The climate is typical for that of a Mediterranean country. The summers are hot and dry and the winters have moderate temperatures. The annual average temperature is 15.7°C, measured in the city of Évora 12 km east of the site and during the year the temperature generally varies between 5°C to 30°C. The hottest months are August and July with average daytime temperatures reaching heights of 30°C and the coldest month is January with average daytime temperatures of 13°C [Weather+Climate]. December, being the most humid month, has an average daily relative humidity of 83%, while July, being the least humid month has an average daily relative humidity of 48% [Yr.no].

PRECIPITATION

The majority of the precipitation falls in late autumn, through the winter and in early spring. The late spring, early autumn, and summer months are relatively dry in comparison [ClimatePortal].

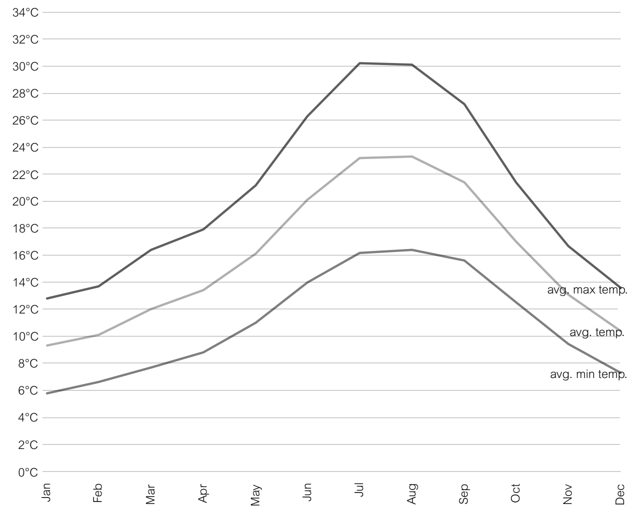
During the warm season that lasts from June 13 to September 11 there is an 8% chance of precipitation and when it does occur it is generally categorized as a light rain. During the cold season, lasting from November 13 to March 8, there is a 30% chance of precipitation, often categorized as light rain as well. Due to the average temperature in the cold season there is little to no chance of the precipitation to fall as snow [Weatherspark]. February and December has an average of 9 days with precipitation, while July and August has no precipitation [Yr.no].

WIND

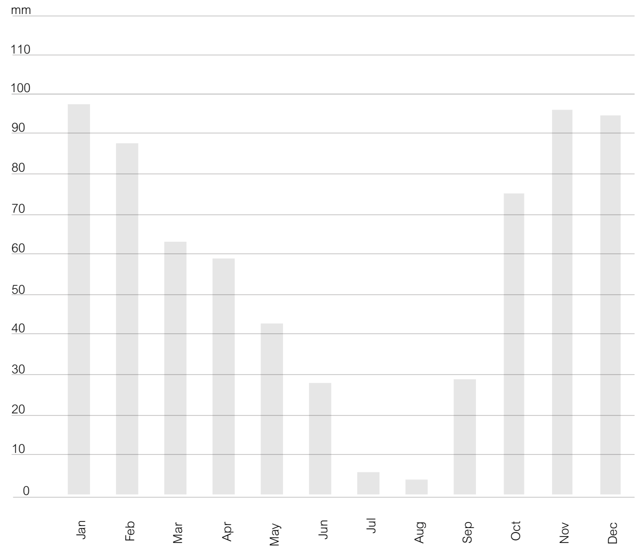
Annually the typical wind speeds vary from 1 m/s to 7 m/s and rarely exceeds 9 m/s [Weatherspark]. The average daily windspeeds varies between 4 and 5 meters per second, defined as a 'gentle breeze' on the Beaufort Scale [Beaufort]. The predominant wind direction changes between the seasons, from North-Western in the months of February, June, July and November to Eastern in the remaining months of the year, although Western winds occur more often than Eastern winds if North-western, Western and South-western winds are accumulated [Weatherspark].

SUNLIGHT

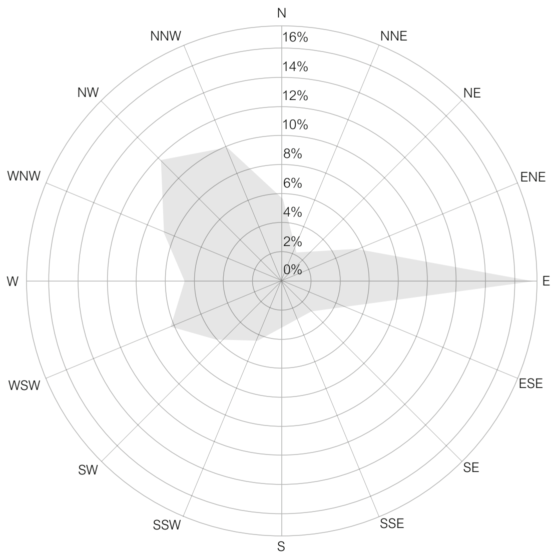
Due to the central latitude of the site, and its close proximity to equator, the length of the day only varies with about 5 hours anually. The shortest day being December 21st with 9.3 hours of daylight and the longest day being June 20th with 14.5 hours of daylight. The elevation of the sun varies between 30° and 75° on the shortest and longest day respectively [Sunearthtools]. This calls for considerations of how to provide the visitors with cooling shade while still retaining a sufficient amount of quality daylight in the visitor center.



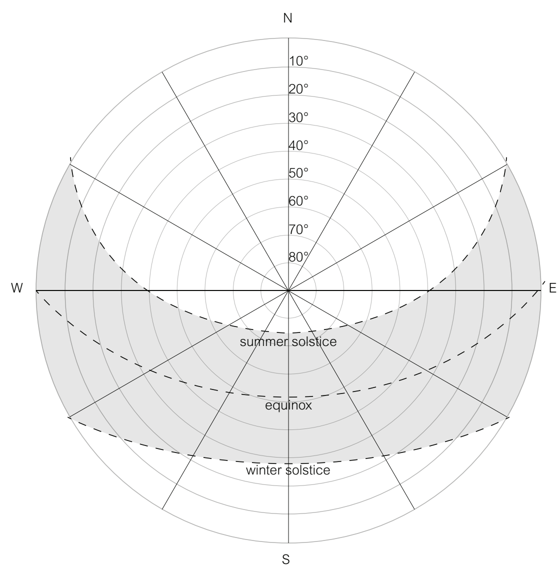
Ill. 25, the climate.



Ill. 26, the precipitation.



Ill. 27, the wind



Ill. 28, the sun

PROGRAMME

2.0

2.0 **BRIEF ANALYSIS**

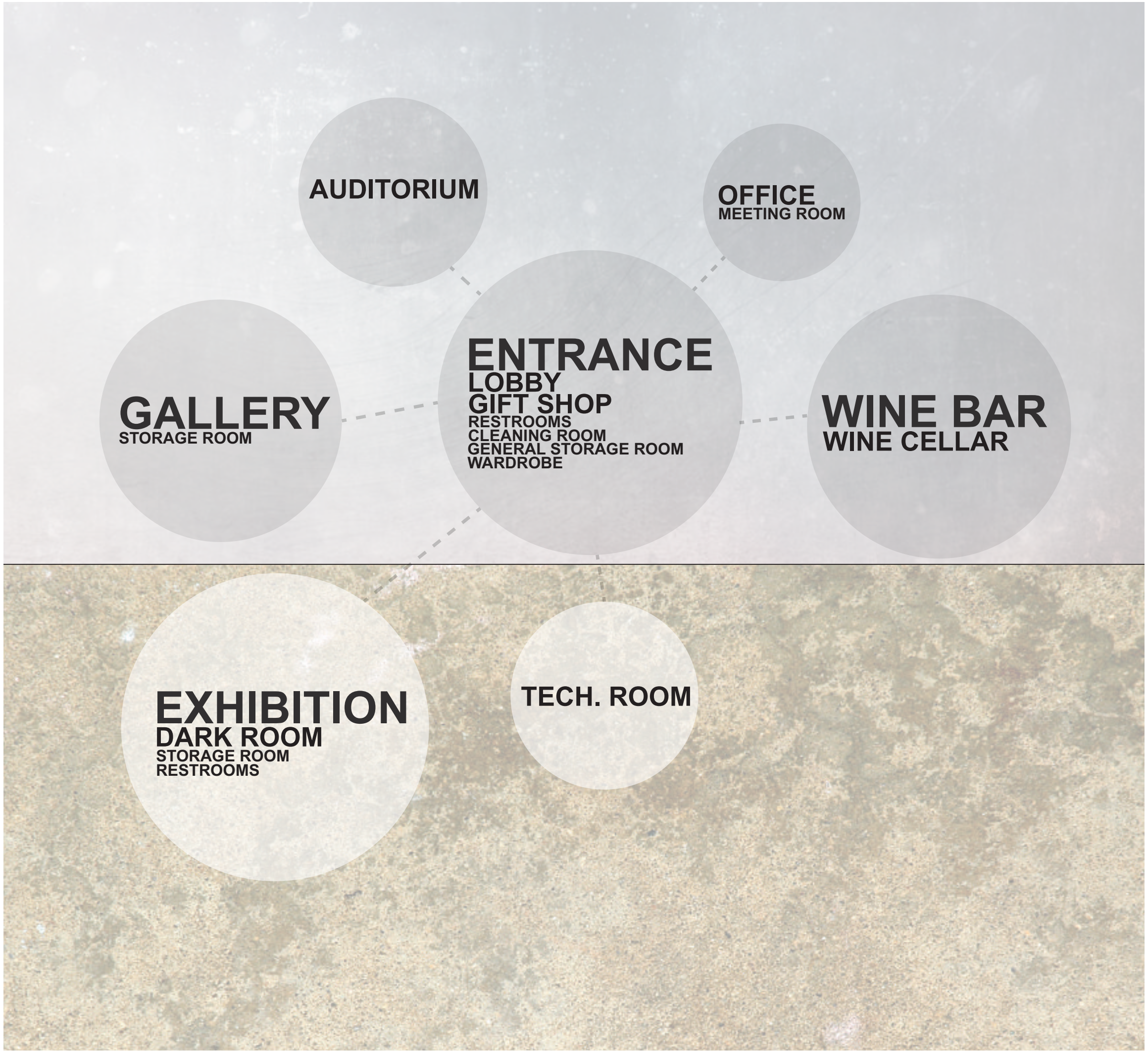
2.1 REVIEWING THE COMPETITION BRIEF

ARCHITECTURAL INTENT
The megalithic monument Cromeleque dos Almendres is a significant landmark on a prominent landscape, a place of great cultural heritage and historical significance with characteristics that must be fully preserved. The outline of a new visitor center should emphasize, respect and celebrate the site, while providing visitors with a unique experience.
The visitor center aims to promote a unique experience within a remarkable landscape and provide a space for visitors to become engaged with the historical heritage, focusing on the significance of megalithic monuments and the establishment of Neolithic communities in the region. The design proposal must be highly sensitive to the megalithic enclosure. [ARKxSITE]

THE USERS
Everyone is welcome in the visitor center and there is no admission fee to enter the premises of the monolithic monuments. It is possible to enter the visitor center before reaching the monument, but it is not necessary for the visitors to walk through the center to get there. The visitor center accommodates all age groups and should fulfill the necessary accessibility requirements for disabled people.

THE FUNCTIONS
The main focus of the visitor center is to facilitate and provide visitors with an understanding of the historical heritage of the megalithic monument and the site. These functions will be incorporated in the cultural area of the visitor center, along with opportunities for various exhibitions. In addition to these facilities there will be a reception area, functioning both as a meeting point and as the general public entrance. The administrative functions are also placed in the reception area as well as a gift shop and a café/wine bar. Additional auxiliary functions are also required, such as storage rooms which can facilitate and maintain other functions like the café/wine bar. The exterior functions contain a parking lot situated approximately 200 meters from the visitor center and a pedestrian path which connects the parking lot to the visitor center [ARKxSITE].

A diagram of the functions and their relations has been developed based on the considerations of the brief analysis. The observations made at Lindholm Høje produced the idea of separating the diagram into functions above and below ground.


AUDITORIUM
OFFICE
MEETING ROOM
GALLERY
STORAGE ROOM
ENTRANCE
LOBBY
GIFT SHOP
RESTROOMS
CLEANING ROOM
GENERAL STORAGE ROOM
WARDROBE
WINE BAR
WINE CELLAR
EXHIBITION
DARK ROOM
STORAGE ROOM
RESTROOMS
TECH. ROOM

Ill. 29

2.2 ROOM PROGRAMME

The room programme for the visitor center is developed on the basis of the information provided by the competition brief. Each function has been evaluated, additional functions have been added and certain functions have been merged to allow for a more flexible approach to the distribution of functions in the center.

The functions of the visitor center have been divided into four categories; the reception area, the cultural area, auxiliary rooms and exterior functions such as pathways and parking. Looking at the distribution of the area between these categories it becomes evident that the cultural area will serve as the main function of the visitor center, and that the remaining functions of the other categories are established to facilitate the cultural area.

Based on studies of similar types of exhibitions the initial requirement for exhibition space has been reevaluated and increases to better facilitate an exhibition that covers all the interesting historical, social, astrological and theological aspects of the monument and the region.

To create the relevant flow in the exhibition the exhibition area has been split into three sections, the first section exhibiting the early stages of the monument, the region and its people, the second section exhibiting the astrological significance and the third section exhibiting the later religious significance of the monument.

1.	RECEPTION	
	Entrance	40 m^2
	Lobby	60 m^2
	Gift shop	30 m^2
	Administration office	15 m^2
	Meeting room	20 m^2
	Winebar/café	80 m^2
	Wine cellar	25 m^2
	Total	270 m^2
2.	CULTURAL	
	Exhibition space	270 m^2
	Gallery space	70 m^2
	Auditorium	50 m^2
	Dark room	140 m^2
	Storage room (gallery)	15 m^2
	Storage room (exhibition)	40 m^2
	Total	585 m^2
3.	AUXILIARY ROOMS	
	General storage room	25 m^2
	Technical room	40 m^2
	Cleaning room	5 m^2
	Restrooms	35 m^2
	Wardrobe	10 m^2
	Total	115 m^2
4.	LANDSCAPE	
	Pedestrian pathway	
	Parking	
Total net area		970 m^2

Ill. 30

PRESENTATION

3.0

3.1 **VISION**

The visitor center will serve as a building capable of communicating the historical, religious and astrological nature of the monument. It should be humble in its interaction with the monument while still provide an architectural quality to the full experience of the monument - it is the intention to not have the addition of a visitor center interfere with the current atmosphere of the monument.

The visitor center will relate to its significant site by advantageously utilizing the topography, designing a composition that correlates with the landscape and the surroundings. Furthermore, the building should enhance the view of the valley to the west. To further emphasize and enhance the natural setting of the monument, visitors will approach the monument, and the new visitor center, by foot, leaving behind their cars at a distant parking lot.

The ley-lines of the monument will be emphasized and highlighted either within the building or through its composition.

Different types of lighting will be utilized in the building relating to our observations at Lindholm Høje - a combination of natural daylight and artificial lighting, depending on the different functions of the building and the types of exhibition areas.

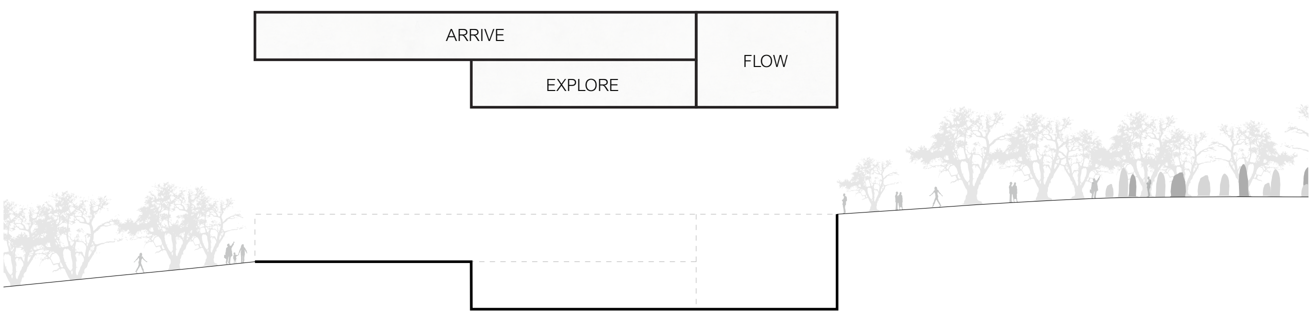
The structure of the building will be addressed tectonically to provide an interesting design that incorporates and merges the disciplines of architecture and engineering.

3.2 **CONCEPT**

ARRIVE AND EXPLORE

The concept is derived from the idea of not allowing the addition of a new visitor center to interfere with the present atmosphere of the monument. The building is divided into three sections, each performing key roles in the building; a section for arrival, a section for distribution and a section for exploring.

A cut in the landscape limits the visibility between the building and the monument while serving as an architectural metaphor; strengthening the narrative of archeology as the primary source of knowledge used to map the significance and history of the monument. The simple geometry of the composition strengthens its surroundings through contrast and the roof of the building is kept flush with the terrain to illustrate how the building derives from the terrain. The roof simultaneously allows visitors a remarkable view of the valley and its characteristic montado landscape of cork oak forests.

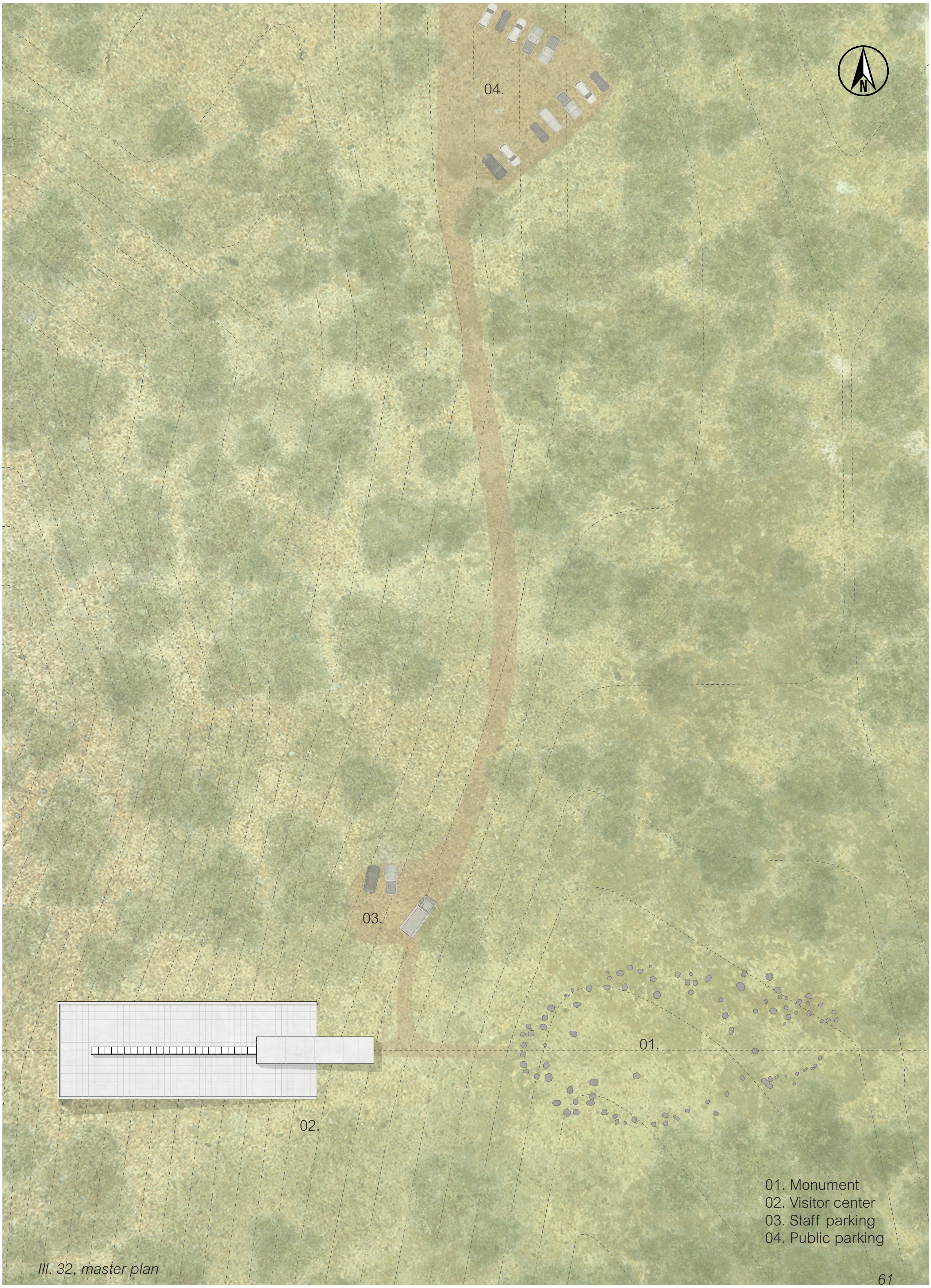


Ill. 31, the concept.

3.3 **MASTER PLAN**

Visitors will arrive to the north of the new visitor center, having parked their cars at the distant parking lot and continuing their journey on foot. When arriving, the visitors will be met by a split pathway, providing the choice of either visiting the monument to the east or the visitor center to the west.

The new visitor center is located on a downward slope to the west of the monument, overlooking the valley to the west. The building is placed with distance to the monument in order to separate the two structures and it is simultaneously placed so it intersects the central ley-line of the monument, continuing the axis by the entrance, the skylight and the composition of the visitor center.



Ill. 32, master plan

3.4 **ARRIVING**

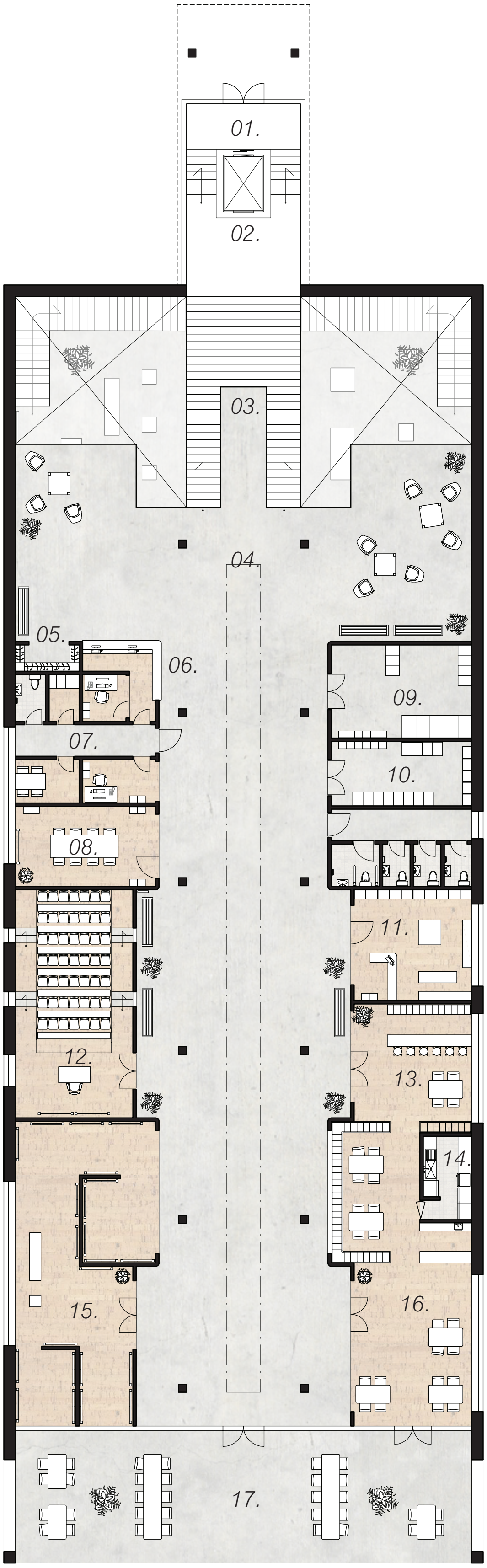
Before entering the premises of the ancient monument of Cromeleque dos Almendres the visitors will find themselves partaking in a journey through a landscape of cork oak trees, characteristic to the region. Following a pedestrian road, the visitors are guided towards the center, revealing itself among the stripped trunks of the old cork trees. The center is embedded into the westward sloping hillside, flush with the terrain and almost invisible at a first glance. The rooftop encourages visitors to experience the breath-taking view of the valley below and the very transparent entrance invites the visitors to enter and explore the visitor center through a downward underground journey, rousing the human instinct of exploring.

Ill. 33

3.5 **ABOVE GROUND**

GROUND FLOOR

The ground floor is generally symmetric in its layout, directed by the central axis which is an interpretation and continuation of the main ley line in the monument. The axis provides a clear direction for the visitors and guides them to the exhibition area below or unto the terrace next to the wine bar and gallery space. By distributing the individual functions on either side of the axis, the plan channels the magnificent view of the landscape outside and through multiple glass walls and general spaciousness, the plan appears transparent in its layout. The axis becomes a pivotal point for the building, not just for distribution but also for light, streaming from the skylight, highlighting the central axis.



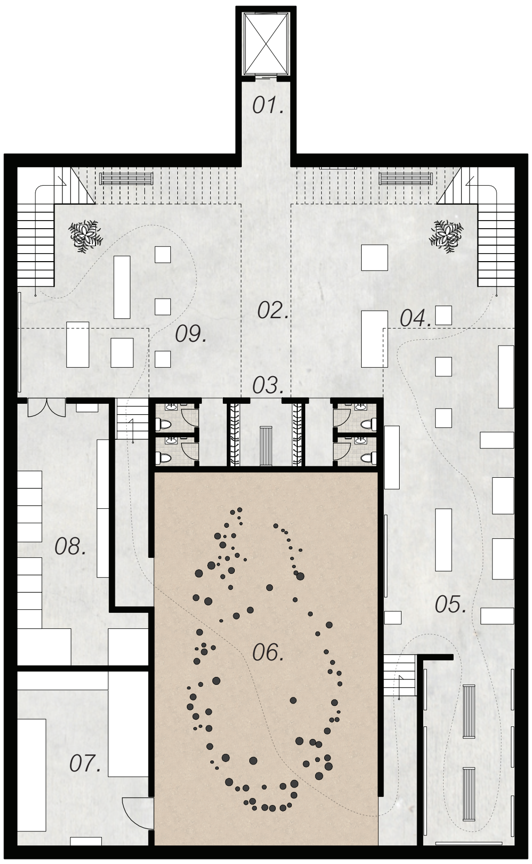
01. Entrance
02. Elevator
03. Staircase
04. Foyer
05. Wardrobe
06. Reception
07. Administration
08. Meeting room
09. General storage
10. Gallery storage
11. Gift shop
12. Auditorium
13. Wine bar
14. Kitchen
15. Gallery
16. Café
17. Outdoor terrace

Ill. 34, ground floor

3.6 **BELOW GROUND**

EXHIBITION FLOOR

Walking onto the elevated walkway and down the grand staircase the exhibition floor reveals itself and the visitors can get a glimpse of the exhibition in the double high room. The exhibition is divided into three sections, each of which displays fascinating characteristics of the monument and the region. Farthest back the central part of the exhibition is concealed from any presence of light and the visitors can enter it by going through a corridor, taking them a few steps further down before they arrive at the 'Dark room' which reveals some of the mystique of the ancient monument outside. The room contains a replica of the monument in scale and it incorporates a fully digital experience of the unique lunar equinoxes of the monument within the exhibition.



01. Elevator
02. Orientation
03. Wardrobe
04. History of the region
05. Astrological aspects
06. Dark room
07. Technical room
08. Exhibition storage
09. Religious aspects

Ill. 35, exhibition floor.

3.7 RECEPTION

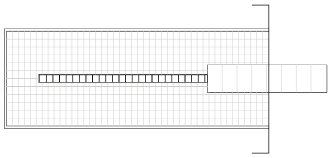
Inside the visitor center an extravagant staircase reveals itself leading the visitors into the building in a continuous motion before they arrive at the reception, where guidance and information can be obtained. The reception resides within the large lobby, centered around the main staircase that acts as a piece structural furniture and an integrated room divider, adding a dynamic and lively atmosphere within the great lobby.

Ill. 36

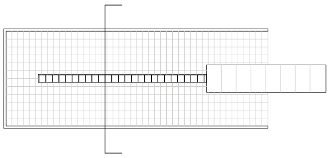
3.8 THE EXHIBITION

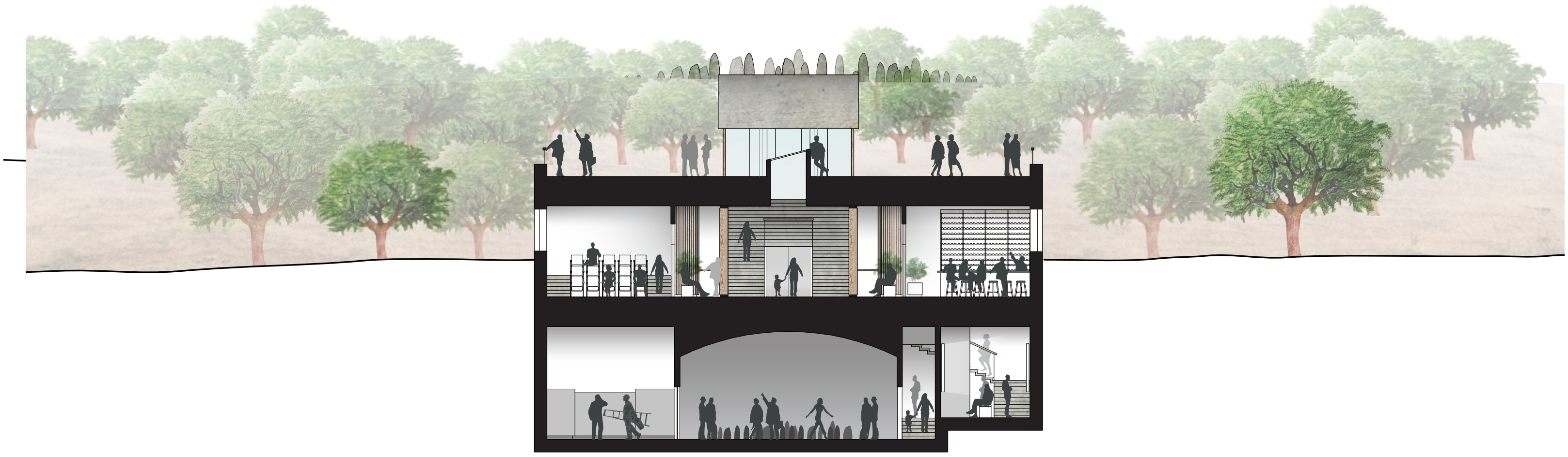
Walking down the stairs to the main attraction of the visitor center is an experience that provides a full view of the extents of the exhibition while also allowing the visitors some time to digest and plan their journey before entering the space. The exhibition displays a variety of information regarding the history and significance of the monument and the region. The visitors are intrigued to visit the ‘Dark room’ and experience the virtual representation of the unique astrological phenomenon inside, which contains a scaled model of the monument. The room is placed even lower yet to provide a sense of hierarchy in the exhibition and inform the visitors of its significance while also continuing the narrative of delving deeper down into the history of the monument.

Ill. 37



Ill. 38, section



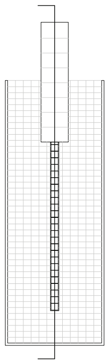


Ill. 39, section.

3.9 **THE AXIS**

The main infrastructure of the visitor center flows along an unbroken central axis that intersects and follows the main east-west ley-line of the monument. At the ground floor it emerges at the elevator and terminates at the western end of the building, framing the view of the natural landscape of cork oak trees.
The central axis divides and distributes the functions while creating and directing focal points to the nature outside at one end and to the main staircase and entrance at the other, guiding the visitors to explore and continue their journey downwards into the exhibition area further underground. The axis is lit up by the large skylight, almost stretching the length of the building.

Ill. 40

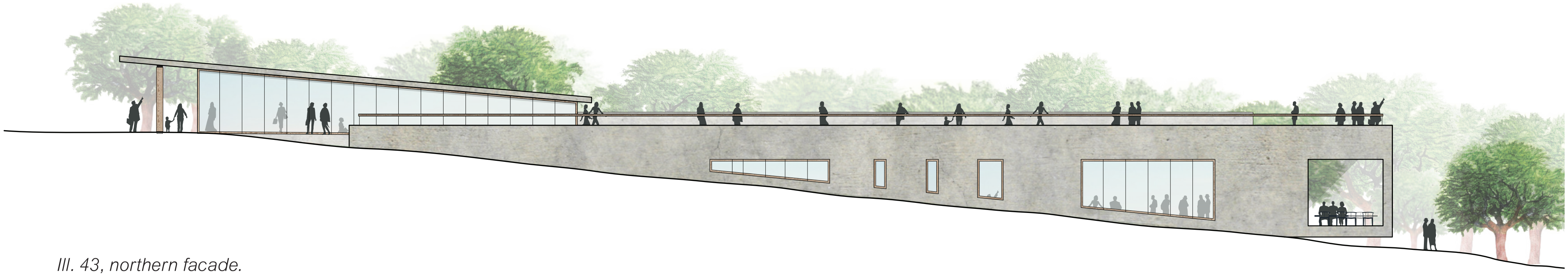


Ill. 41

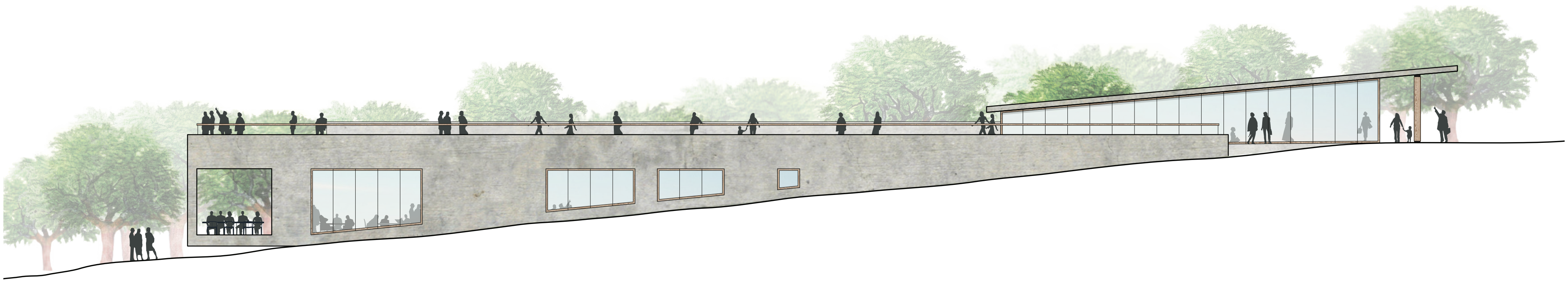
3.10 THE WINE BAR

The cultural inherence of Portugal houses one the world's finest wines, which can of course be tasted in the wine bar of the visitor center. The wine bar proposes a natural stop for the visitors to go visit after having explored the center, and as such it becomes the final destination of the visit. It is situated opposite the gallery space where artists can display their pieces of art in an exhibition. Both wine and light meals can be brought from the small café to be enjoyed on the outside terrace, overlooking the landscape or within the gallery.

Ill. 42

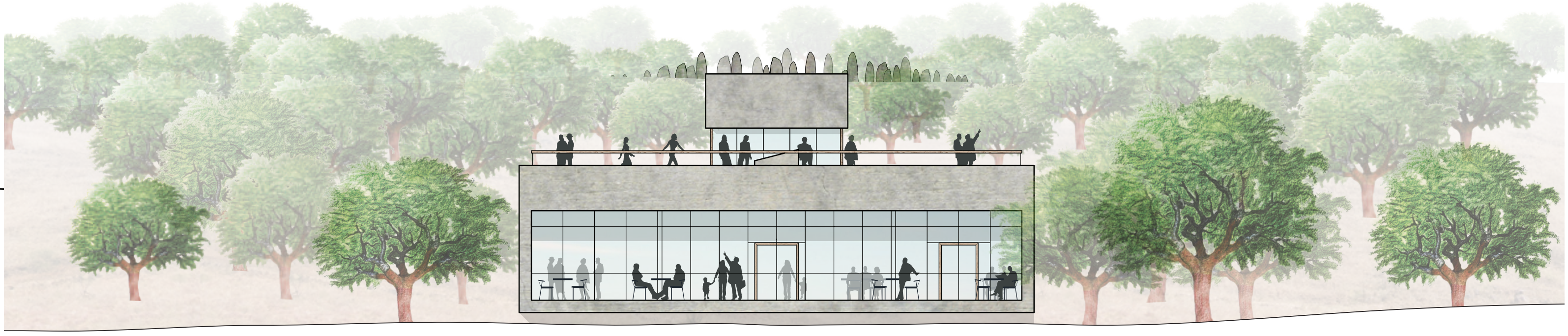


Ill. 43, northern facade.



Ill. 44, southern facade.

Ill. 45, eastern facade.



Ill. 46, western facade.

3.11 **MATERIALS**

TACTILITY, LIGHT AND INTERACTION

The materials chosen for the visitor center complements each other and enhances the architectural expression of the design.

CONCRETE

Entering the visitor center the visitors are lead downward immediately. The downward motion bears resemblance to the notion of entering a cave and to further emphasize this, the material choice of the stair naturally fell upon (a rough) concrete. In order to achieve a more imperfect appearance the concrete has been polished to produce a smooth, yet dirty surface thanks to the highlighted dark sparks in the concrete. Finally the concrete has been treated with wax to maintain a uniform look.

WOOD

Before arriving at the monument the visitors partake in a journey through the landscape of cork oaks and cork plantations. The same wood has been used throughout the visitor center, both as a structural element and as a cladding. The structural oak columns appear massive and raw, complementing the appearance of the concrete. They are treated with an oily finish to highlight the characteristic grain structure of the cork oak.

Refined cork oak wood lamellae cover the walls adjacent to the central axis, contrasting the massive expression of the columns. The wall behind the lamellae has been painted white to allow the lamellae to stand out, especially along the rounded edges of the niche walls.

GYPSUM

Entering the visitor center the well-lit staircase leads you down toward the lobby which is partially lit by the skylight. To fully utilize the light coming from the skylight, the embrasures surrounding it have been clad with white painted gypsum. This will help reflect the sunlight into the building and the gypsum will simultaneously act as a sound absorbent along with the lamellae walls, reducing some of the reflected sounds from the hard concrete surfaces.

THE TALE OF DETAILING

The joint of the materials relate in both colour and transmission. Where the concrete floor meets the walls, the wooden lamellae has been elevated, creating a recess that reveals 5 cm of the white painted gypsum wall behind the lamellae. This allows the lamellae to stand out even further as the warmth of the wood contrasts the plain white surface underneath. The wooden columns mimic this effect by standing on a small concrete plateau, elevated above the concrete floor. The columns relate to the ceiling in a similar manner, displaying a plateau with the same appearance as the white painted gypsum. This feature of transitioning between different with a pronounced recess creates a hierarchical order of the materials and allows for a continuous interaction between the materials.

Ill. 47, polished concrete.

Ill. 48, cork oak wood.

Ill. 49, gypsum.

3.12 **STRUCTURAL PRINCIPLE**

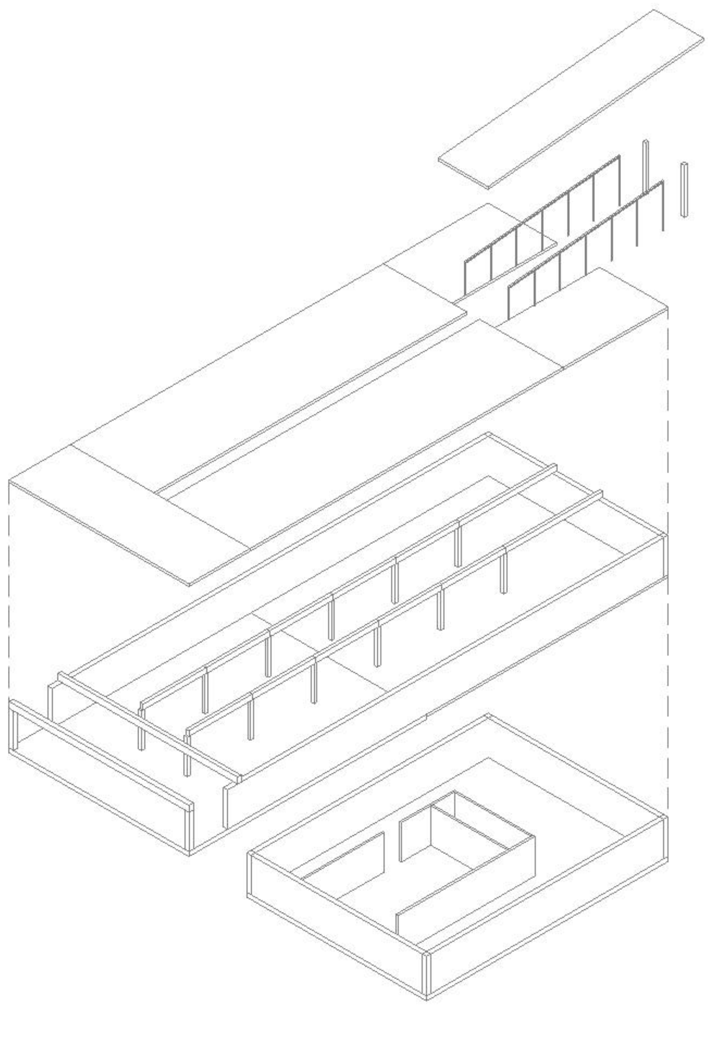
THE STRUCTURAL NARRATIVE

The structural principle of the design is based on the narrative of above and below ground and an interaction between density and transparency. As the visitors move down the building, it becomes more dense and less transparent.

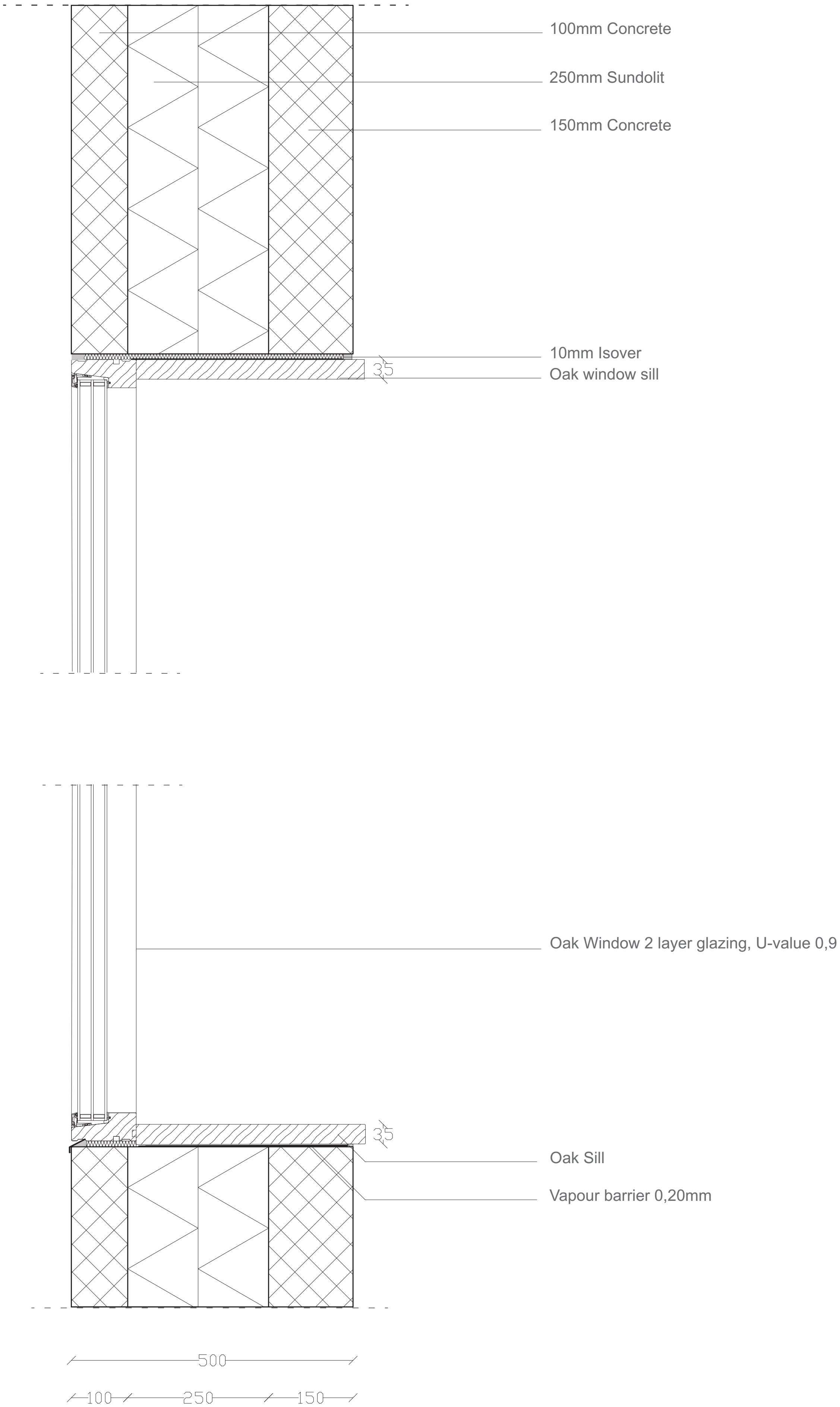
The transparent entrance is composed of glass and steel and a structural steel core containing the elevator. Steel rafters transfer the load of the roof to the IPE profiles which are supported by slender structural steel pillars nestled between the vertical window posts of the façade composition. Where the entrance meets the rooftop, the load of the structure is being transferred to the structural system that supports the roof.

The structural principle of the floor plan is dependant on an array of timber columns combined with the loadbearing outer concrete walls. The timber columns support a beam, fastened and mounted to the columns with a concealed bracket. The beam and the loadbearing exterior walls supports the concrete deck elements. This principle allows for an open, semi-transparent plan.

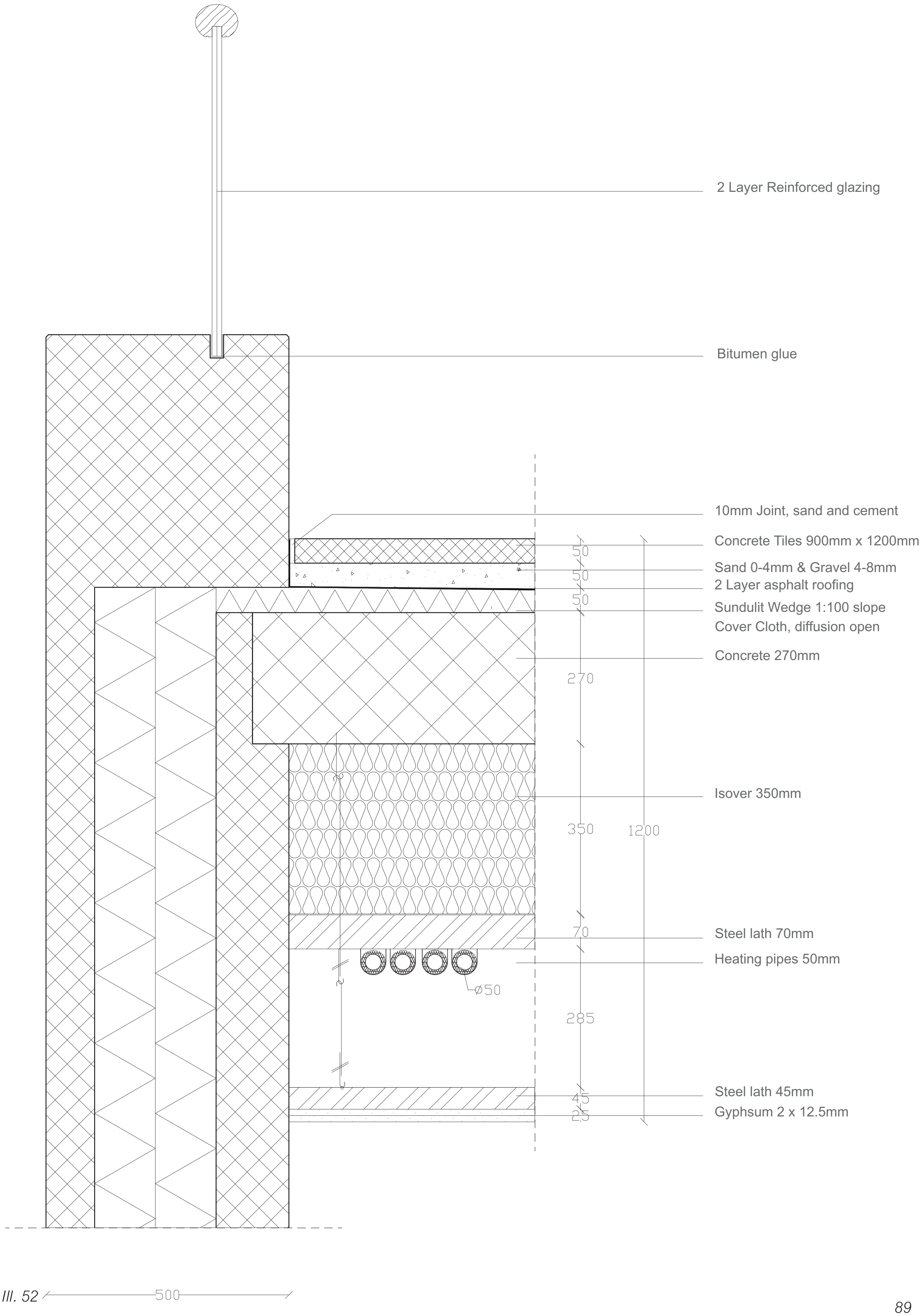
The structural principle of the exhibition floor is dependant on the loadbearing, concrete walls encircling the 'Dark room', combined with the loadbearing exterior walls. This system makes for a more rigid and less transparent plan, which helps the visitors experience the cave-like notion of being below ground.



Ill. 50, structural principle.

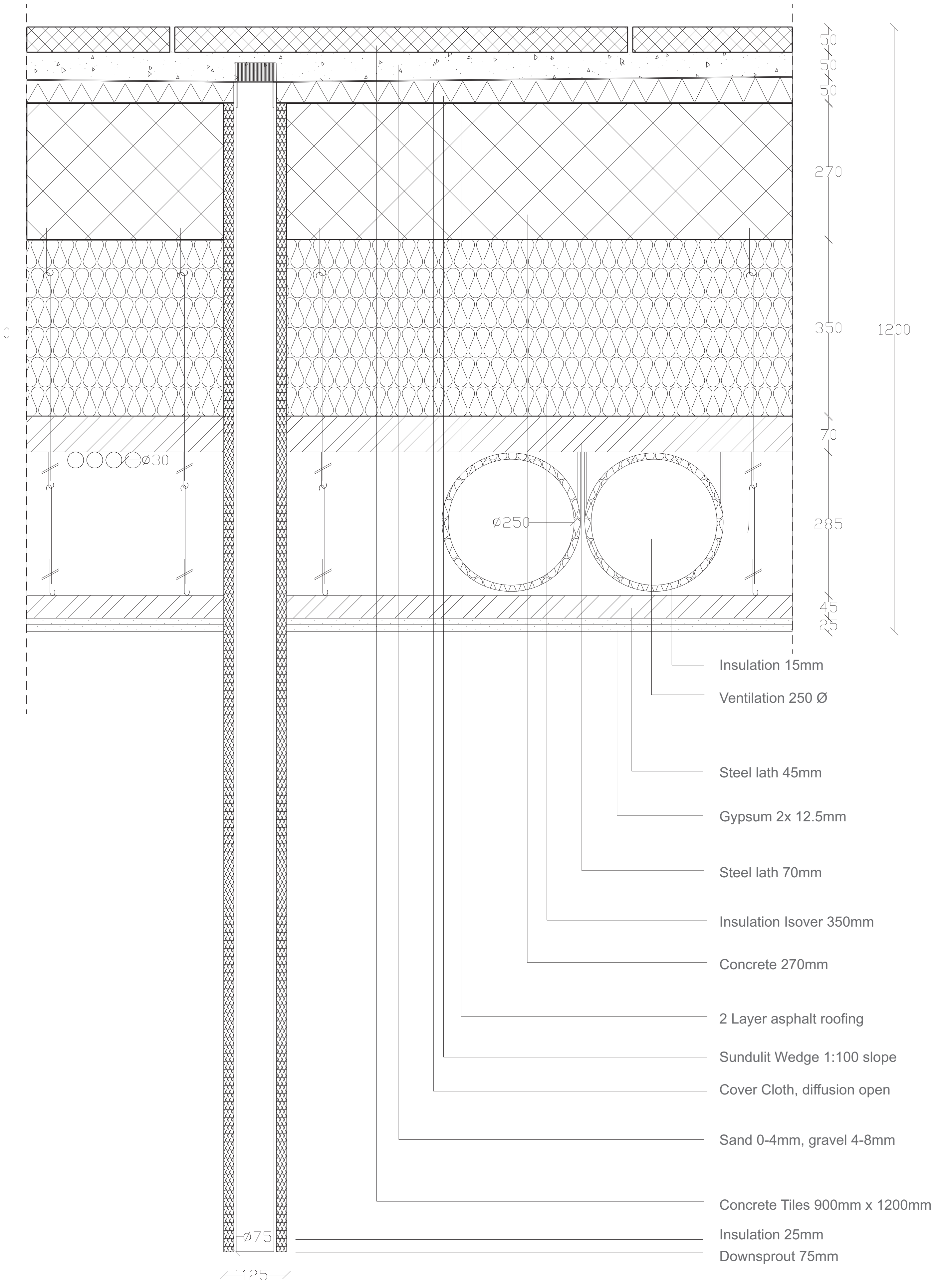

100mm Concrete
250mm Sundolit
150mm Concrete
10mm Isover
Oak window sill
35
Oak Window 2 layer glazing, U-value 0,9
35
Oak Sill
Vapour barrier 0,20mm
500
100
250
150

Ill. 51

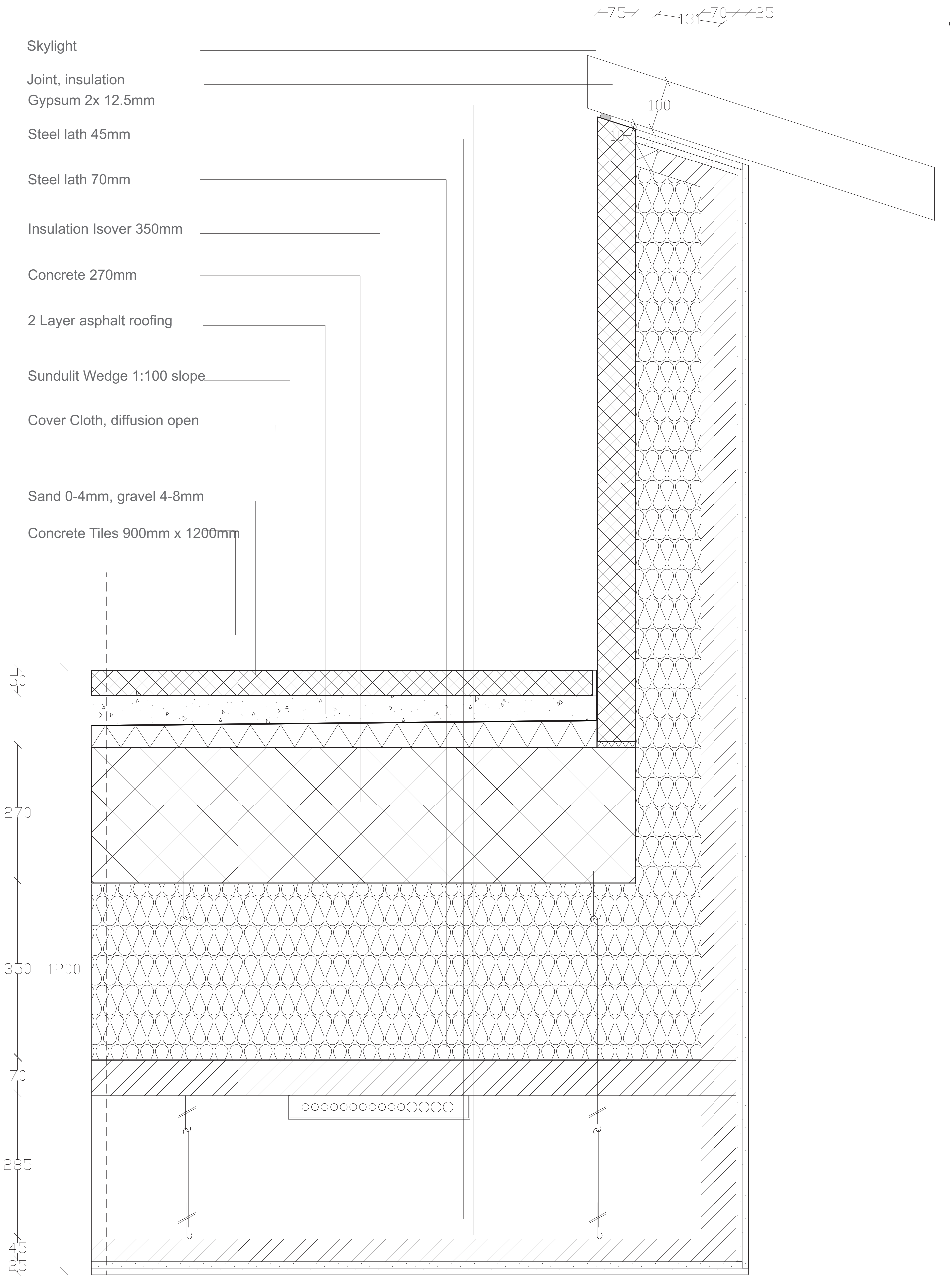


2 Layer Reinforced glazing
Bitumen glue
10mm Joint, sand and cement
Concrete Tiles 900mm x 1200mm
Sand 0-4mm & Gravel 4-8mm
2 Layer asphalt roofing
Sundulit Wedge 1:100 slope
Cover Cloth, diffusion open
Concrete 270mm
Isover 350mm
Steel lath 70mm
Heating pipes 50mm
Steel lath 45mm
Gyphsum 2 x 12.5mm
50
50
50
270
350
1200
70
ø50
285
45
25
500

Ill. 52

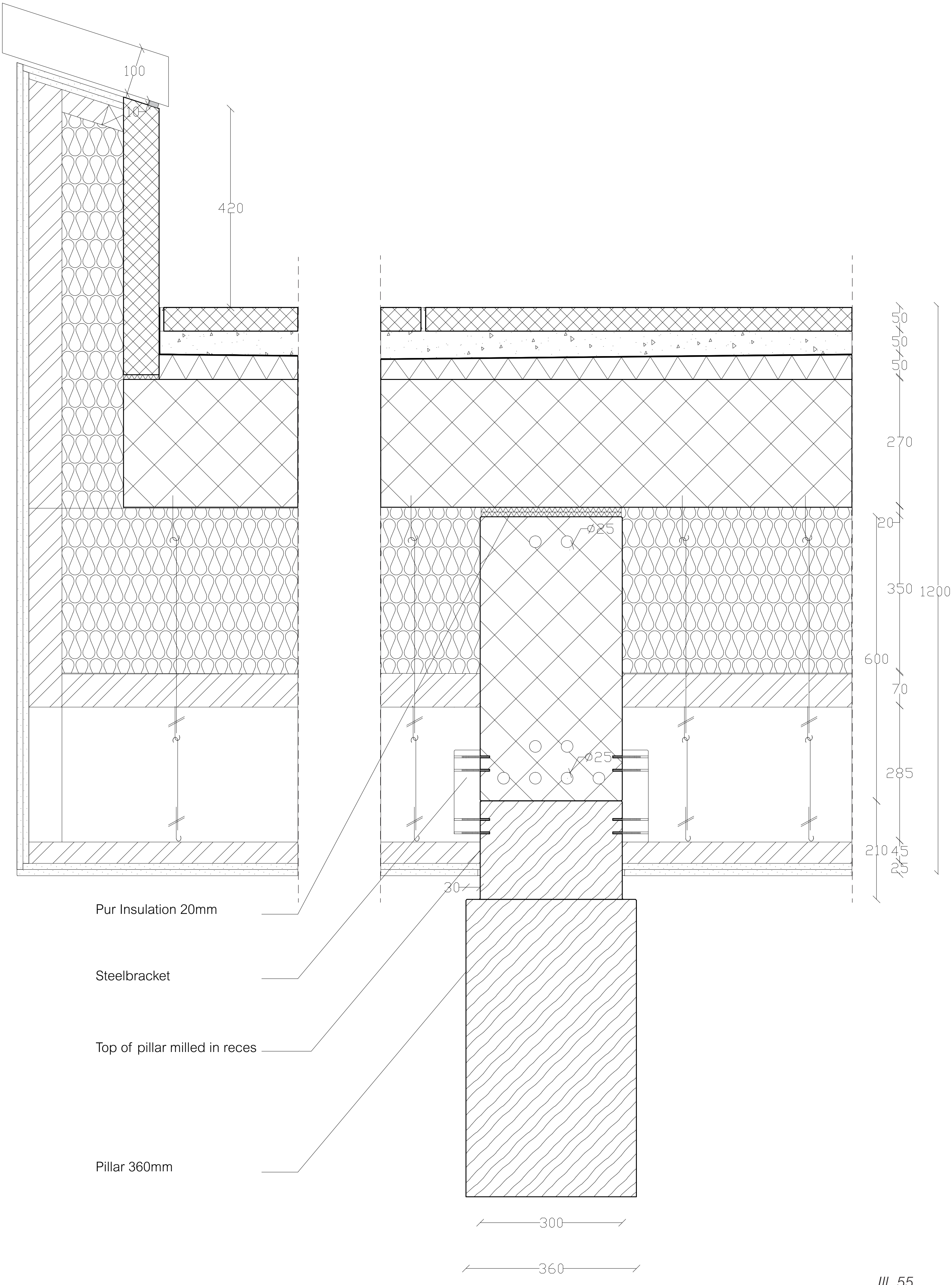

50
50
50
270
350
1200
70
285
45
25
0
ø30
ø250
Insulation 15mm
Ventilation 250 Ø
Steel lath 45mm
Gypsum 2x 12.5mm
Steel lath 70mm
Insulation Isover 350mm
Concrete 270mm
2 Layer asphalt roofing
Sundulit Wedge 1:100 slope
Cover Cloth, diffusion open
Sand 0-4mm, gravel 4-8mm
Concrete Tiles 900mm x 1200mm
Insulation 25mm
Downsprout 75mm
ø75
125

Ill. 53

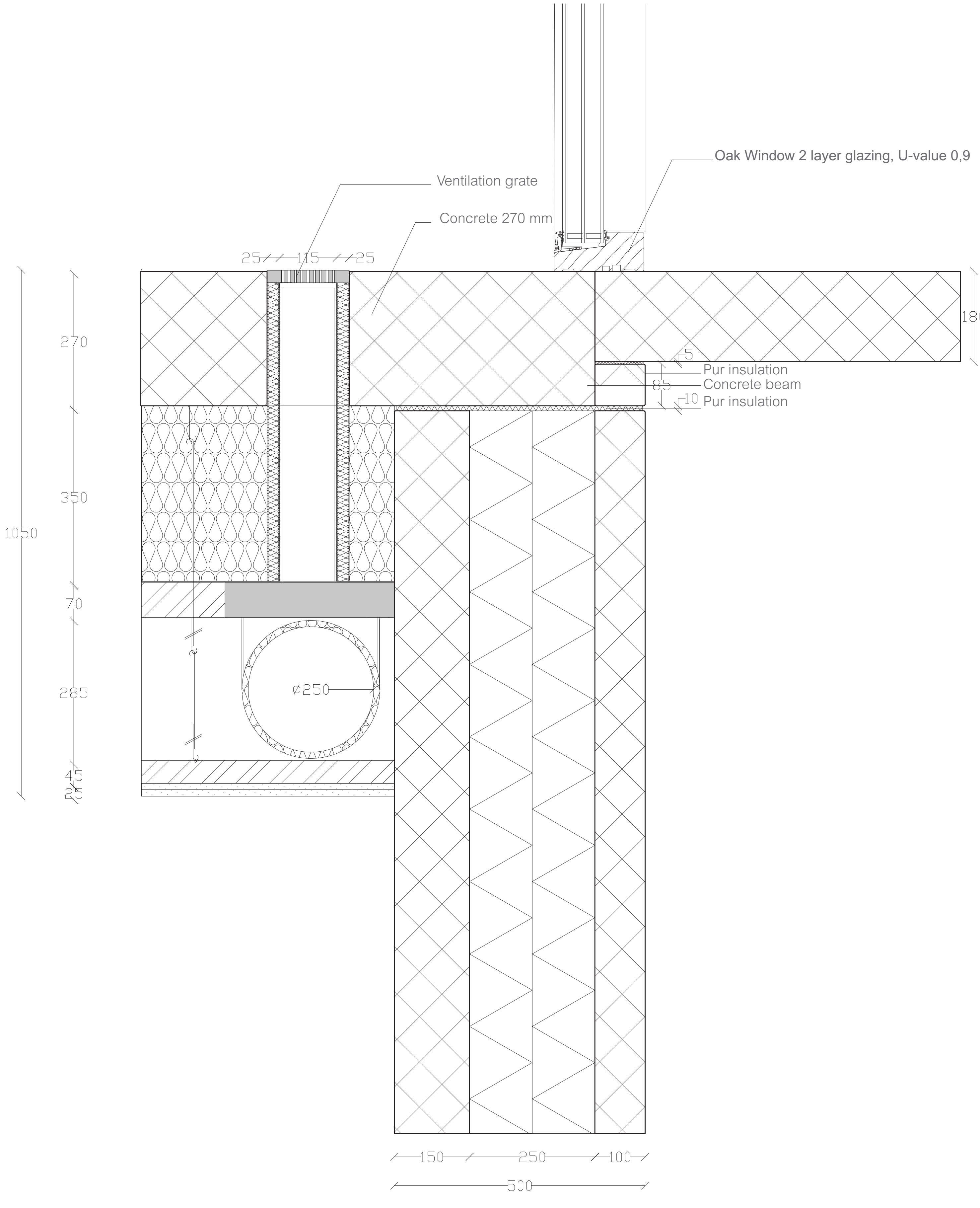


Skylight
Joint, insulation
Gypsum 2x 12.5mm
Steel lath 45mm
Steel lath 70mm
Insulation Isover 350mm
Concrete 270mm
2 Layer asphalt roofing
Sundulit Wedge 1:100 slope
Cover Cloth, diffusion open
Sand 0-4mm, gravel 4-8mm
Concrete Tiles 900mm x 1200mm
75
131
70
25
100
10
50
270
350
1200
70
285
45
25

Ill. 54


100
10
420
50
50
50
270
20
350
1200
600
70
285
210
45
25
30
ø25
ø25
Pur Insulation 20mm
Steelbracket
Top of pillar milled in reces
Pillar 360mm
300
360

Ill. 55


Oak Window 2 layer glazing, U-value 0,9
Ventilation grate
Concrete 270 mm
25
115
25
180
270
5
Pur insulation
85
Concrete beam
10
Pur insulation
350
1050
70
285
ø250
45
150
250
100
500

Ill. 56

DESIGN DEVELOPMENT

4.0

4.0 **DEVELOPING THE CONCEPT**

4.0.1 DESIGN CRITERIA

ELEVATED VIEW

The visitors of the monument currently do not get a very great view of the surroundings despite it being located on top of a ridge. The view from the site is hindered by the countless cork – and olive trees that inhabit the landscape. To enhance the view of the valley to the west of the monument the building is elevating itself above the terrain and the treetops.

RECEPTION - CULTURAL

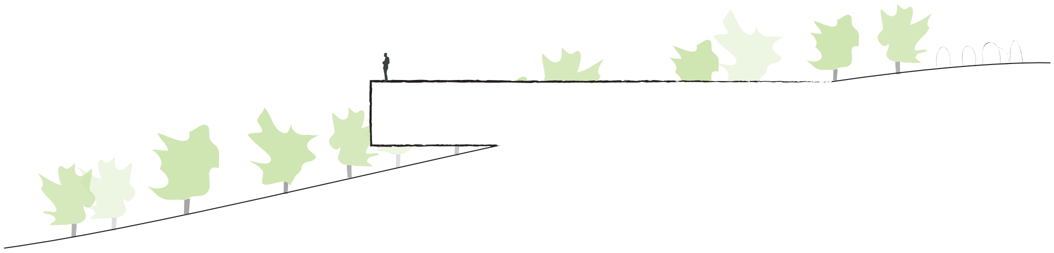
To organize the building based on its functions the programme provided by the competition brief has been divided into two parts; a cultural part, accommodating the main exhibition space of the visitor center, and a reception part, accommodating the reception, gift shop, gallery and wine bar. This division is carried out in the design as well to create a logical infrastructure, both for the visitors and for the administration of the visitor center.'

ARRIVAL ON FOOT

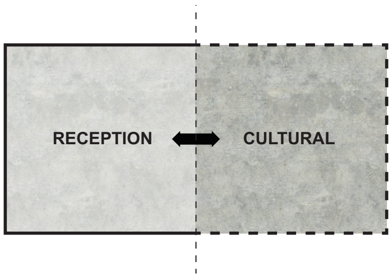
A road runs straight to the monument, disrupting the natural atmosphere of the landscape. To enhance the experience of the natural setting of the monument and the visitor center, the arrival should happen by foot.

LEY-LINES

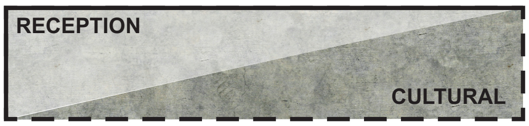
An interesting aspect of the monument is that it highlights a series of ley-lines that bears astrological significance; implying that its original creators had knowledge of – and tracked the orbit of the moon. The visitor center should emphasize and highlight the orientation of these ley-lines.



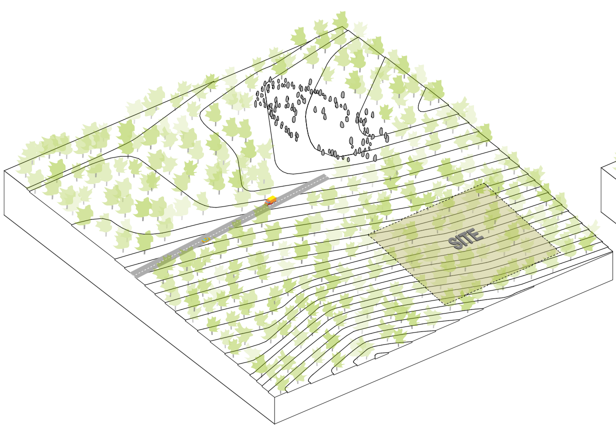
Ill. 57, elevated view.



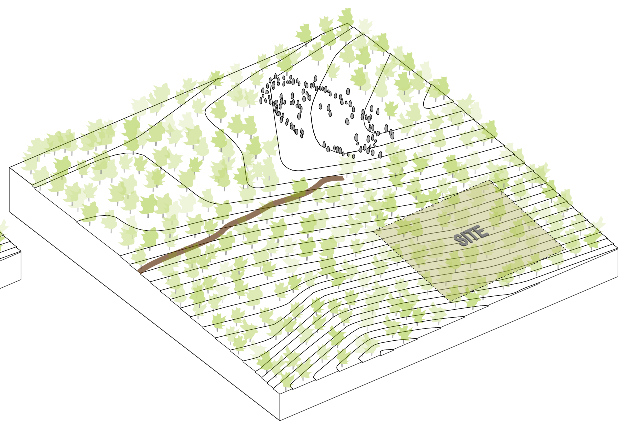
Ill. 58, separated functions - plan.



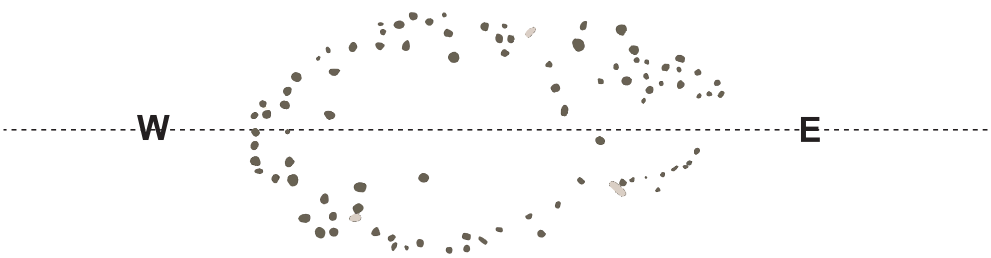
Ill. 59, separated functions - section.



Ill. 60, the road running straight to the monument.



Ill. 61, the road is removed and a pathway introduced.



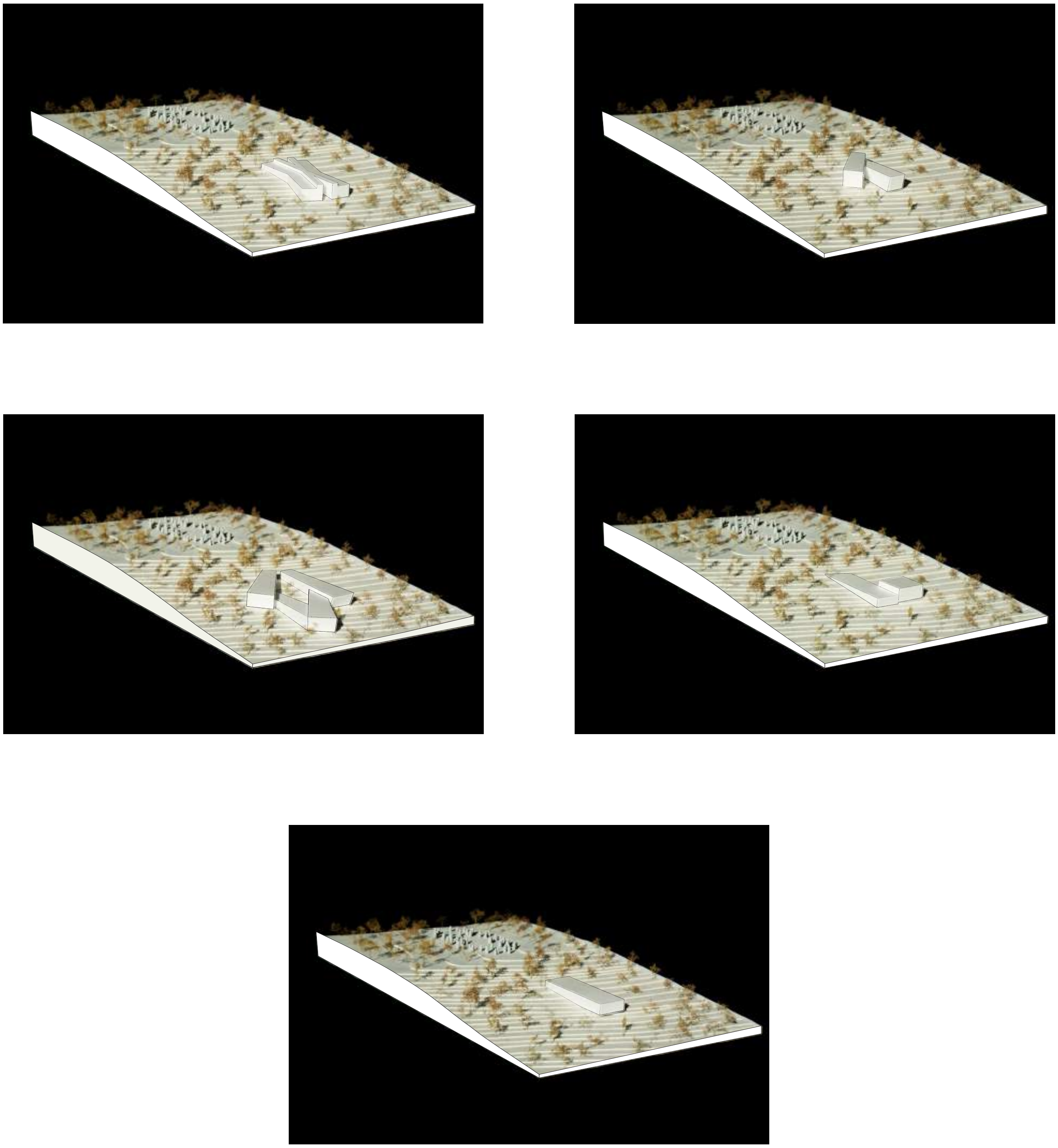
Ill. 62, the main ley-line of the monument.

4.0.2 WORKSHOP

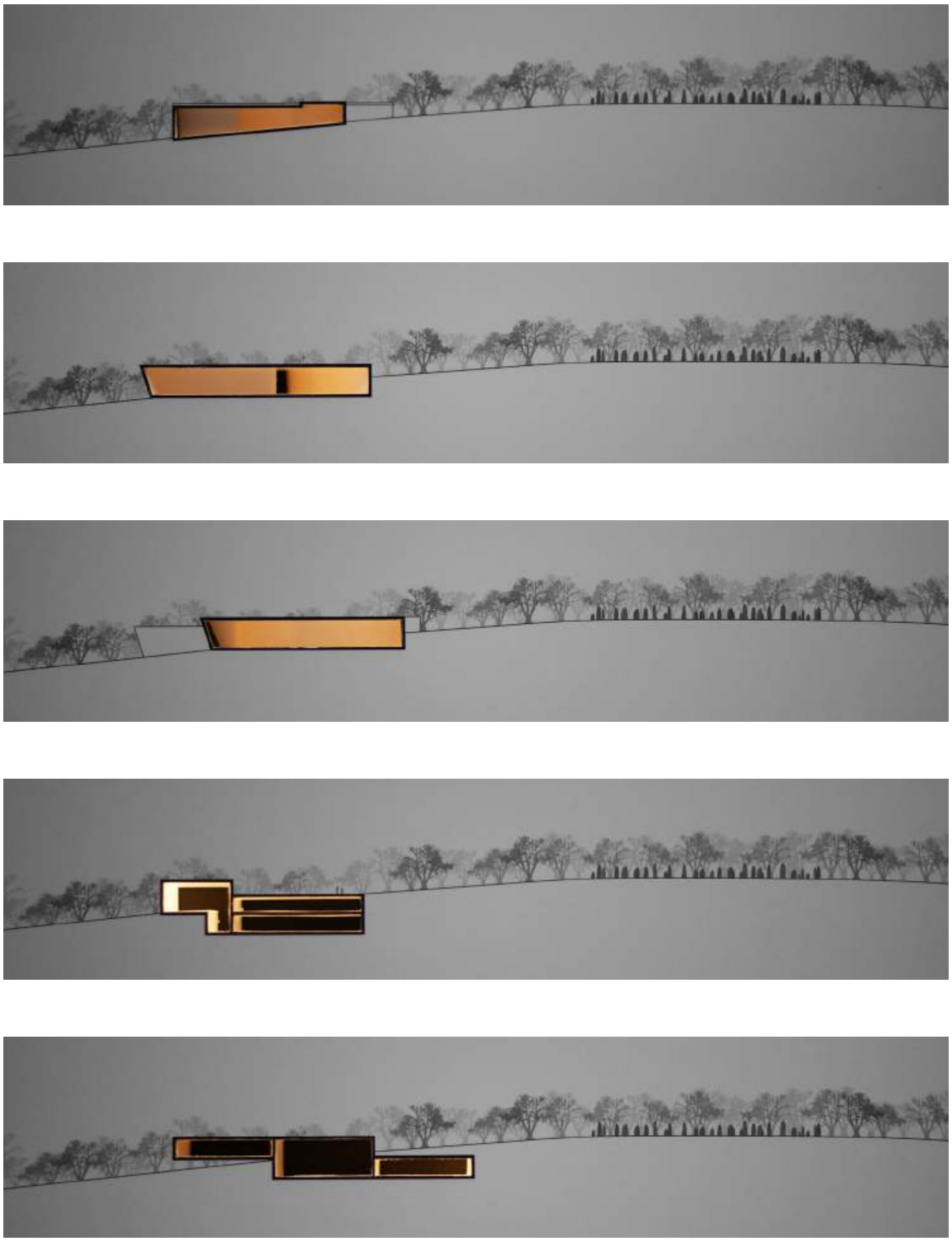
The goal of the workshop was to provide knowledge of how a structure could be placed on the site, using the various parameters set in the design criteria. The workshop includes both a volumetric study and a section study. The section study provided an extra dimension to the workshop and provided a better understanding of the depth and internal flow within each iteration.

During the workshop two themes were of particular interest; how to incorporate the main ley-line of the monument into the design and how the new visitor center should relate to the monument and the surrounding terrain.

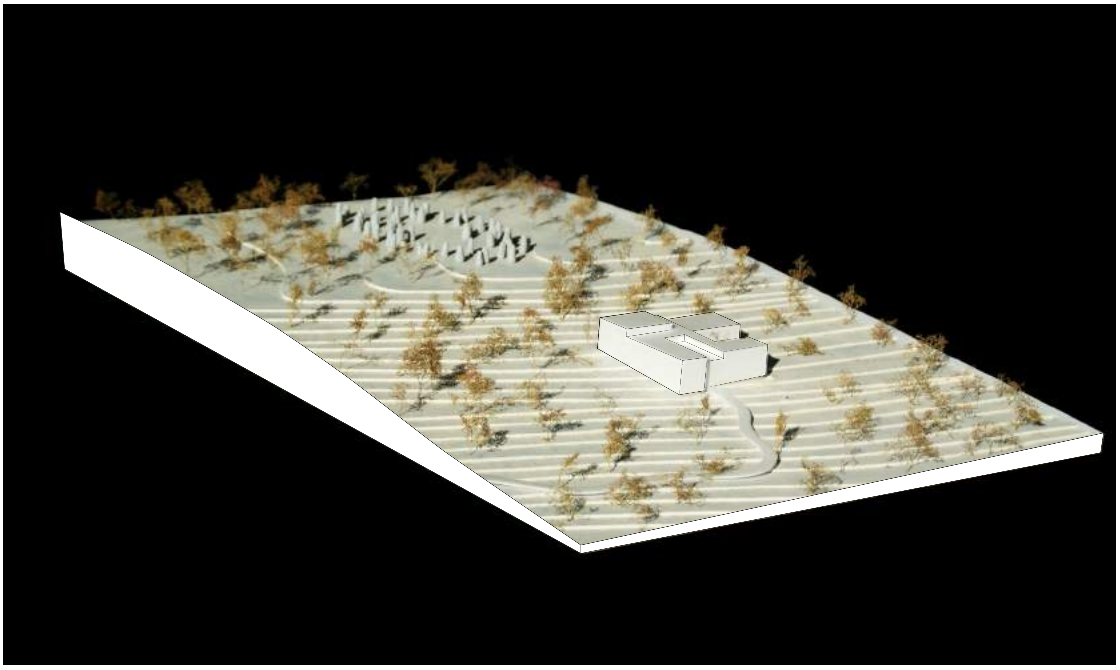
The outcome of the workshop was three proposals that each featured various qualities. The three proposals and their qualities are elaborated upon in the following section.



Ill. 63, workshop iterations.



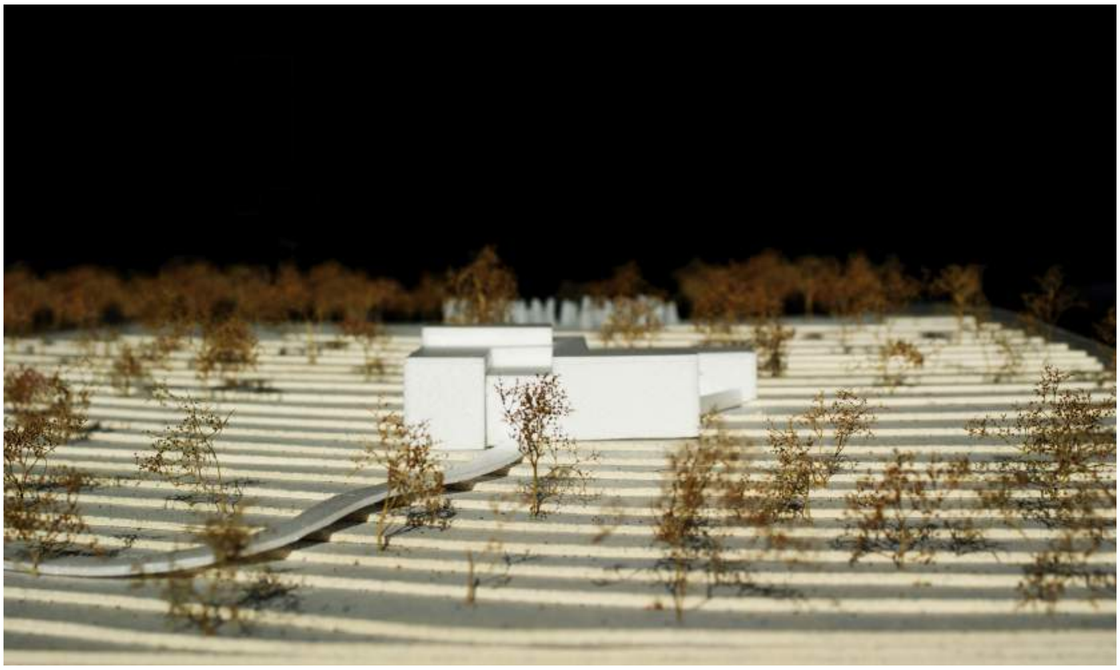
Ill. 64, section models.



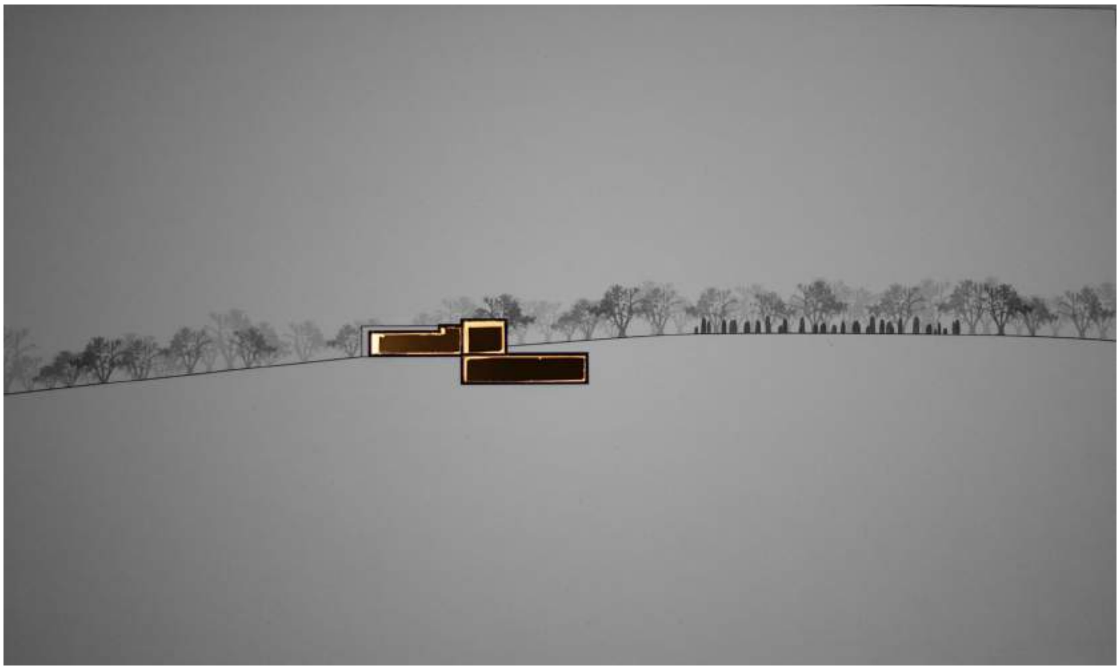
Ill. 65

VOLUMES AND COURTYARD

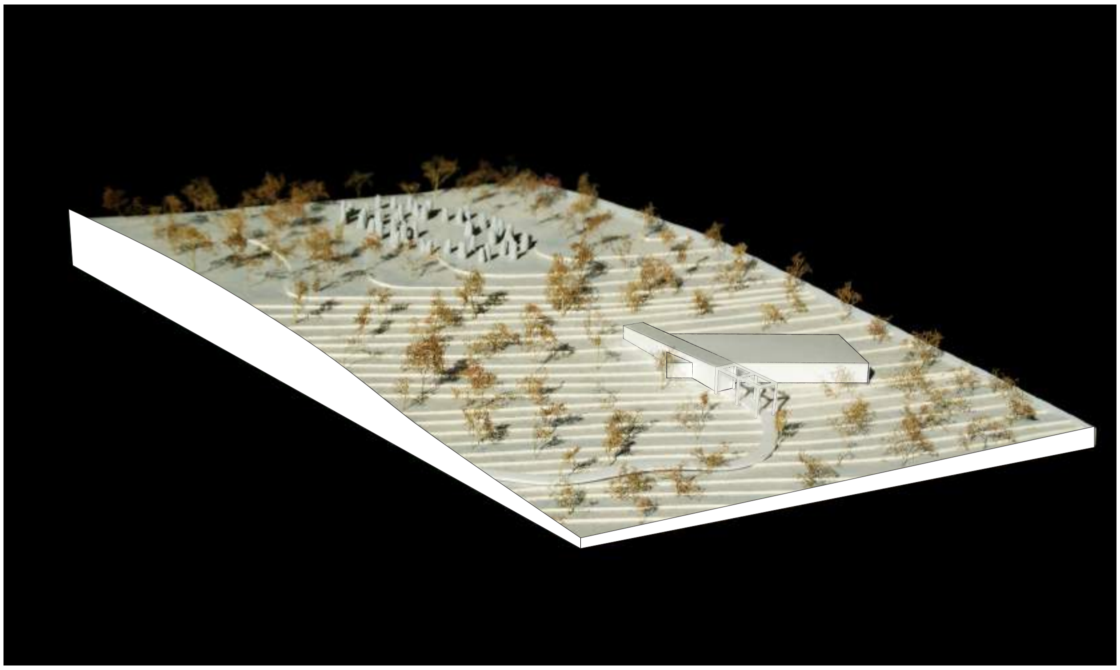
This proposal features multiple volumes embedded into the terrain. The volumes correlate and facilitate several viewpoints and are distributed by a central axis, relating to the main ley-line of the monument. The volumes create and share a courtyard among them and the shifting heights of the volumes provides for good daylight conditions within the design by integrating vertical windows in the transition between the rooftop of one volume and the exterior walls of the next.



Ill. 66



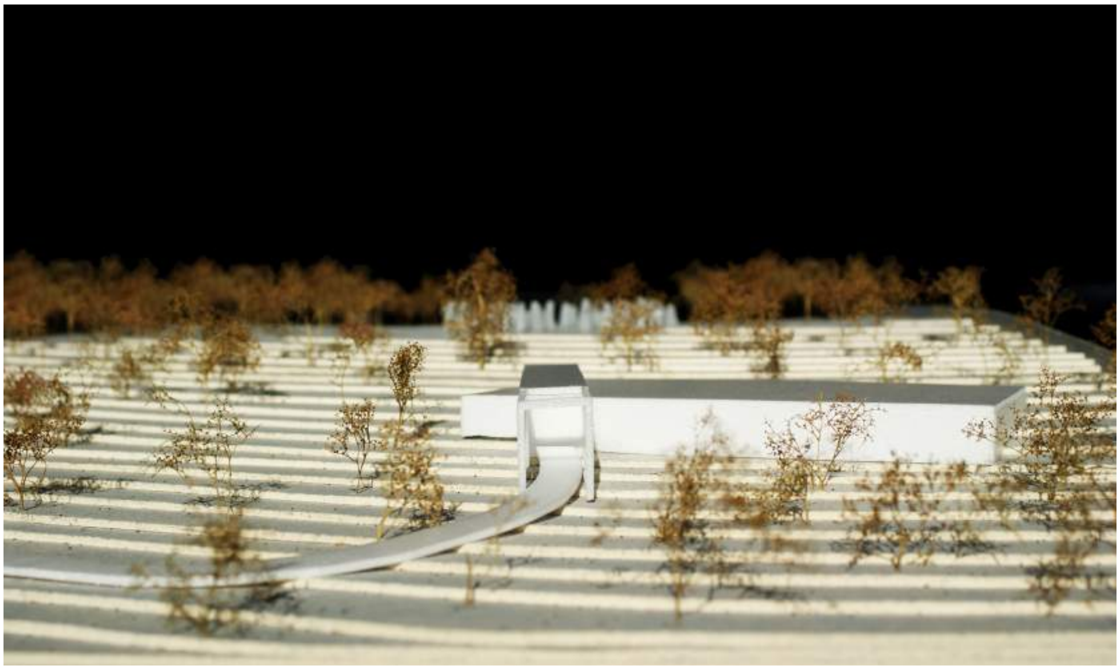
Ill. 67, section model.



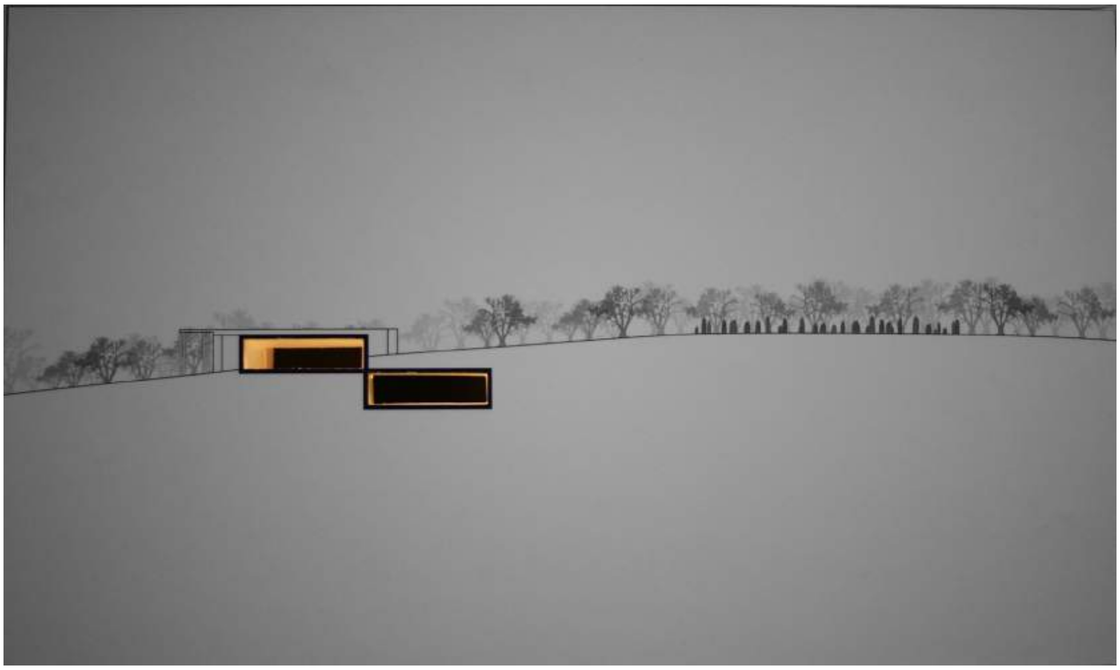
Ill. 68.

CUTTING THROUGH

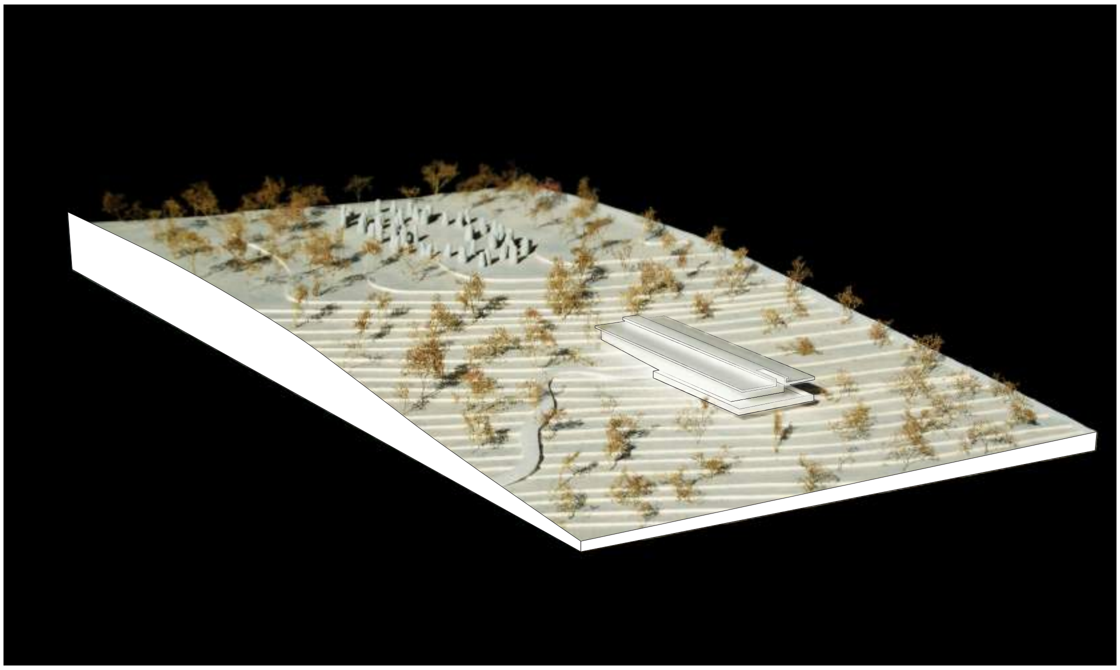
This proposal features a simple composition that is slanted towards the monument. A transparent structure cuts through the solid mass of the volume, following the main axis of the monument and providing a breach in the simple composition. The western part of the 'cut' performs the role of entrance while the eastern part provides an exit in the direction of the monument.



Ill. 69



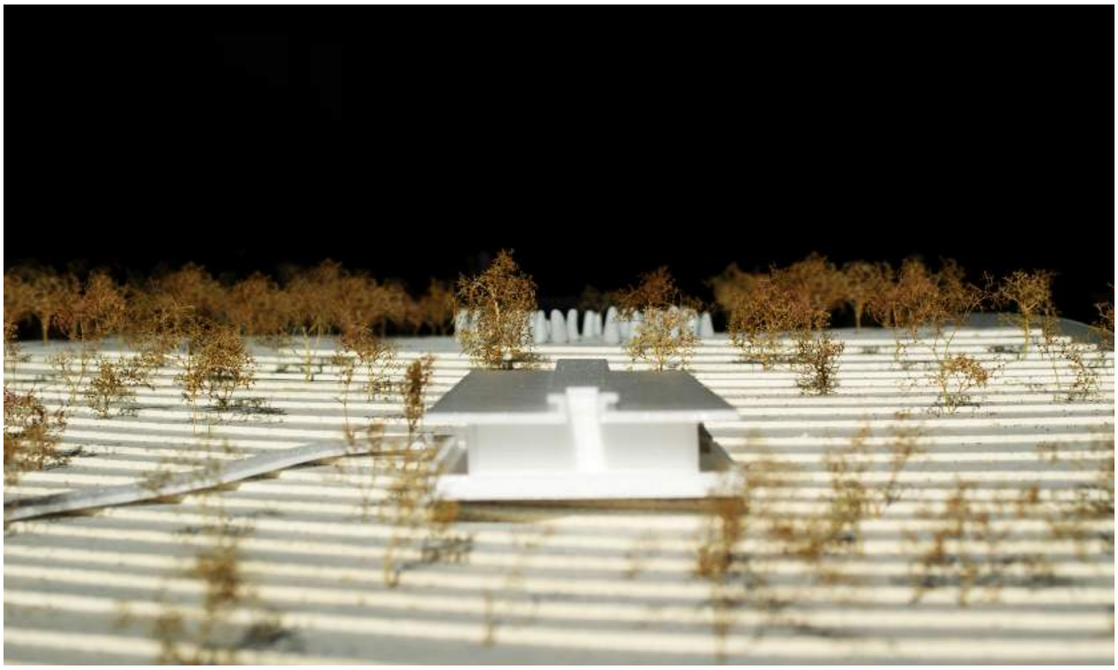
Ill. 70, section model.



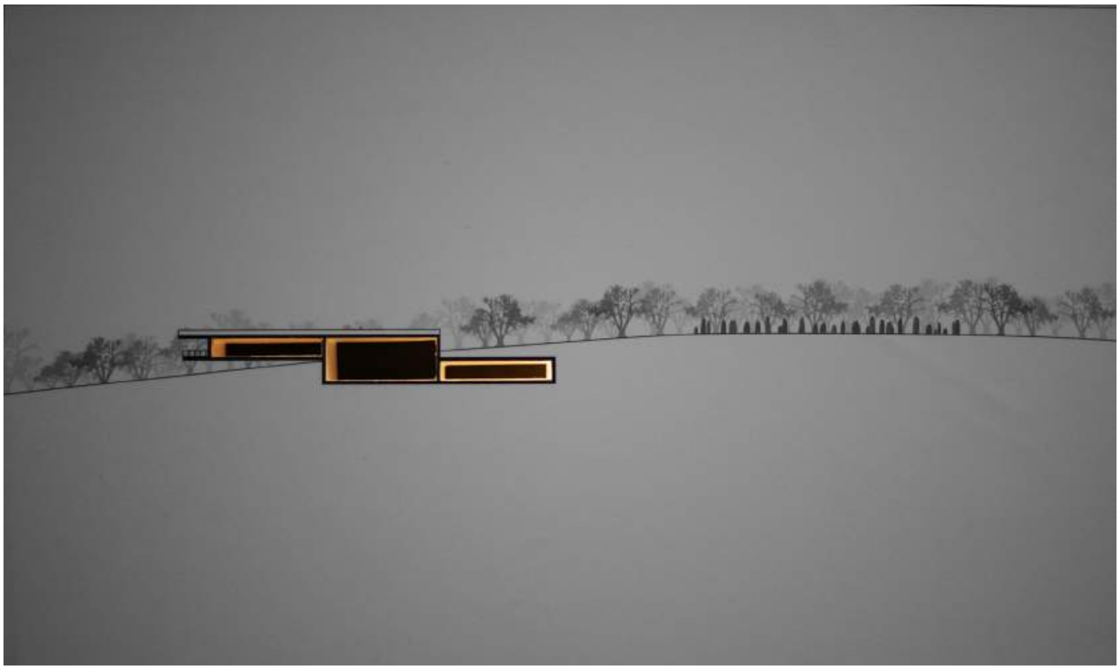
Ill. 71

PLATE AND TERRACE

This proposal features a simple composition that follows the central axis of the monument. It is embedded into the terrain and has a characteristic roof overhang that generates an integrated sunscreen, protecting the interior from overheating. The overhang continues to the west and becomes an extended roof, hovering freely over a terrace featuring a panoramic view of the landscape. A skylight is integrated in the rooftop, providing good daylight conditions for the interior space.



Ill. 72



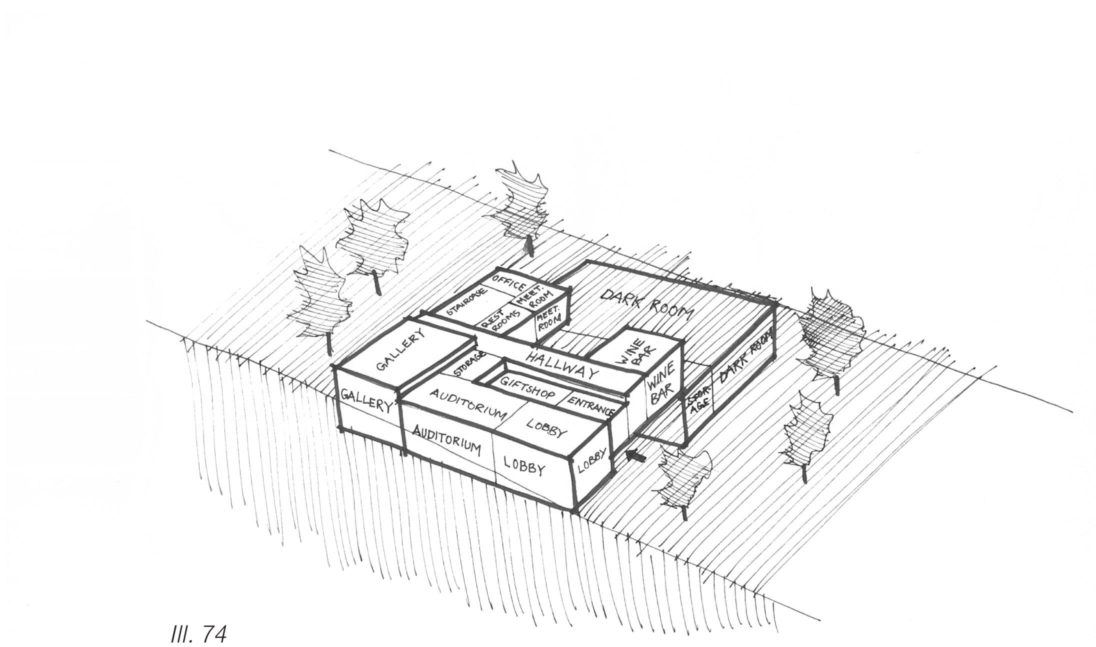
Ill. 73, section model.

4.1 DISTRIBUTION OF FUNCTIONS

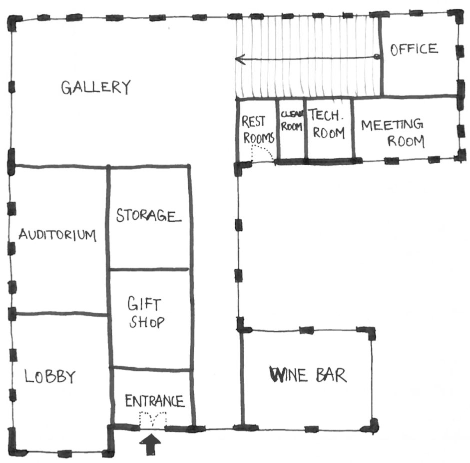
The three chosen compositions from the workshop were further investigated by accounting for the functions and the infrastructure of each proposal. The arrangement of the functions was mainly explored through plan-drawings and axonometric sketches, to get an understanding of how each individual composition and its accommodated functions related to the terrain. The focus was to create an internal layout that promoted a logic infrastructural flow and connected the interior functions according to their relation.

Initial considerations of where the different functions should be placed according to daylight were included in the process and helped establish optimal placements for the individual functions. The gallery space would be best placed facing north to avoid direct sunlight and promote indirect light while simultaneously having a view of the valley to the west to frame the characteristic natural landscape of the montado and provide visitors with an ever-changing piece of art work. The administrative functions and the auditorium would also benefit from the indirect northern light to allow for good working conditions. Like the gallery the wine bar should provide the visitors with a great view while they enjoy their spirits. It would be best placed towards the south and preferably with access to an outdoor terrace. The main exhibition space would be best placed on a level beneath these functions to create a contrasting spatial experience while simultaneously expressing the narrative of descending deeper down into the layers of archeological history. The exhibition at Lindholm Høje revealed that historical exhibitions does not need any natural daylight and would actually best be displayed using artificial lighting to avoid damaging the excavated pieces and control the light setting to create various atmospheres.

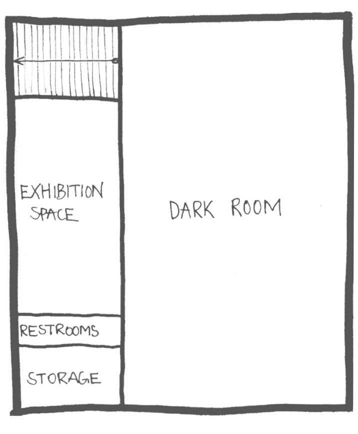
The considerations and sketches revealed that while all iterations provided ample space for the interior functions, the simple ‘plate and terrace’ iteration held greater potential in highlighting the main ley-line of the monument in its composition and utilizing it for directing and distributing the functions of the interior space.



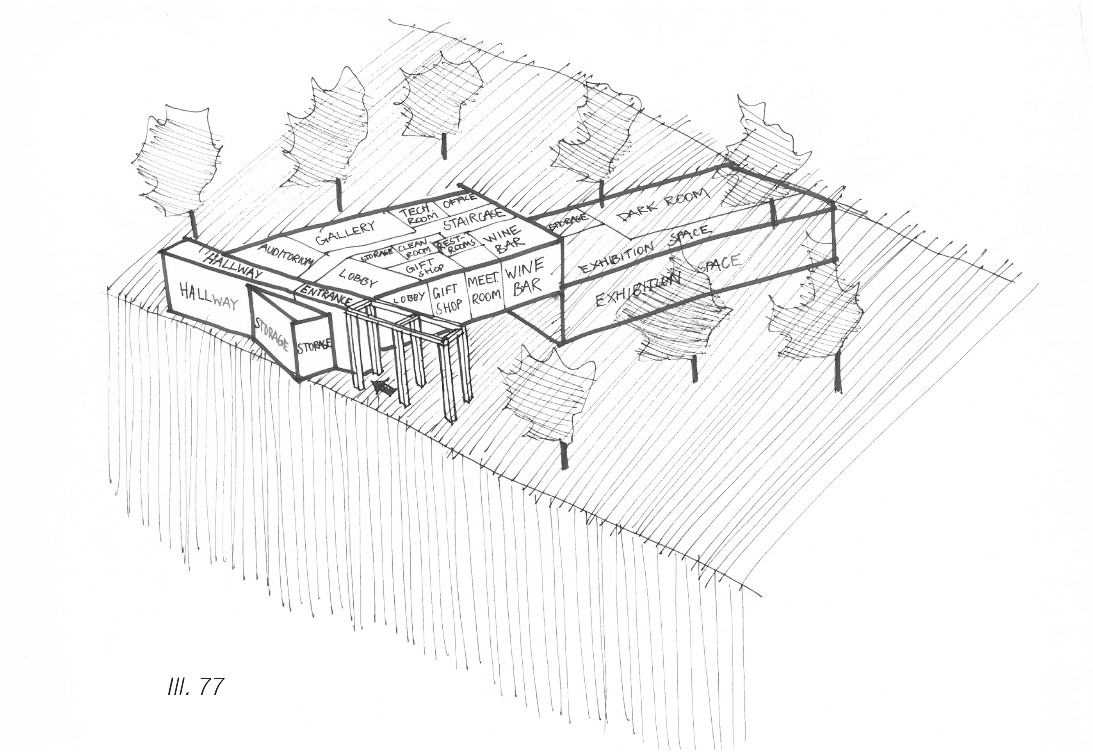
Ill. 74



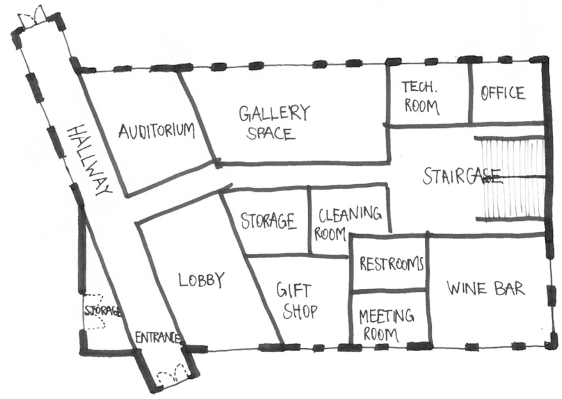
Ill. 75, ground floor.



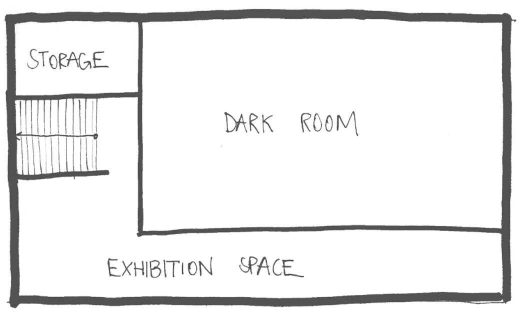
Ill. 76, basement.



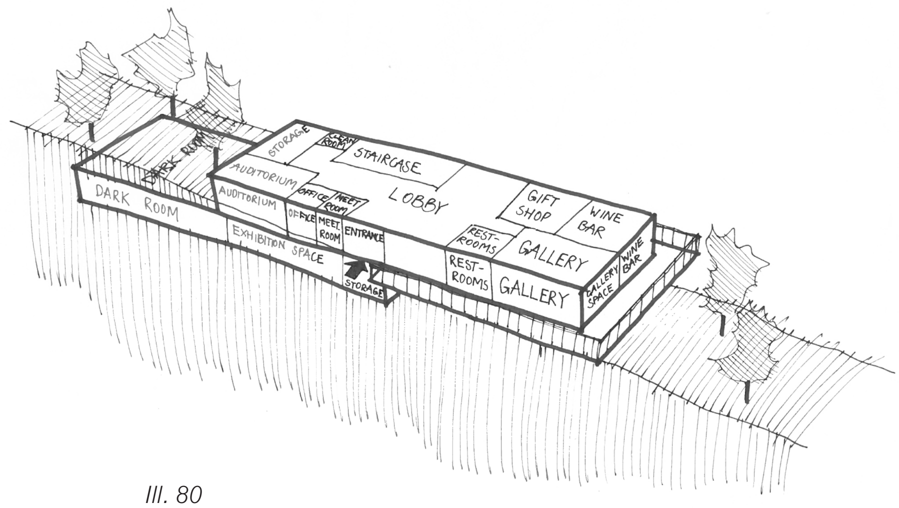
Ill. 77



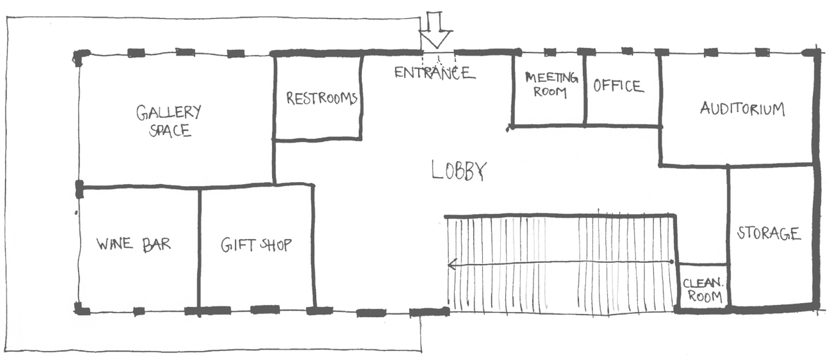
Ill. 78, ground floor.



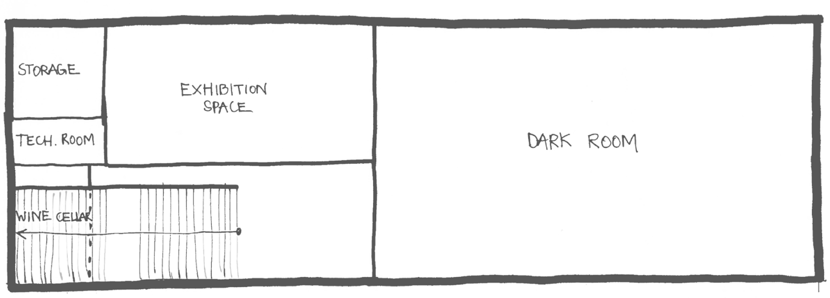
Ill. 79, basement.



Ill. 80



Ill. 81, ground floor.



Ill. 82, basement.

4.2 **PLAN DESIGN**

The process of exploring the plan design featured considerations for how the functions should distribute themselves in accordance with one another, and how every function could be designed and placed to achieve a great infrastructural flow. The main flow in the plan iterations all relate to the conceptual idea of having an axis as a continuous line, separating the building and distributing the functions on either side.

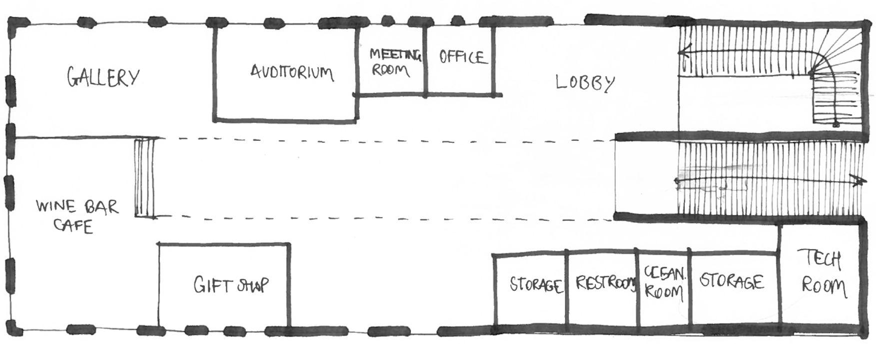
The different iterations shows the intent of placing the gallery adjacent to the wine bar, as they could be regarded as an attraction outside the traditional openings hours of the visitor center. The iterations also reveal how the 'Dark room' have consistently been placed below ground, following the axis. This particular room is to be almost blacked out entirely before the visitors can experience the digital depiction of the starry sky above the monument, during the lunar equinoxes, and as such it makes perfect sense to place it on the subterranean level of the building. The view towards the valley to the west has also been explored in the plan to achieve the best result.

For the final design the general distribution of functions had already been decided, but had to be revised to optimize the flow and the design. In the gallery the transparency was an important parameter, but due to the high amount of glass walls surrounding the gallery it had to be refurbished with room dividing walls that would simultaneously provide space to exhibit the different pieces of art.

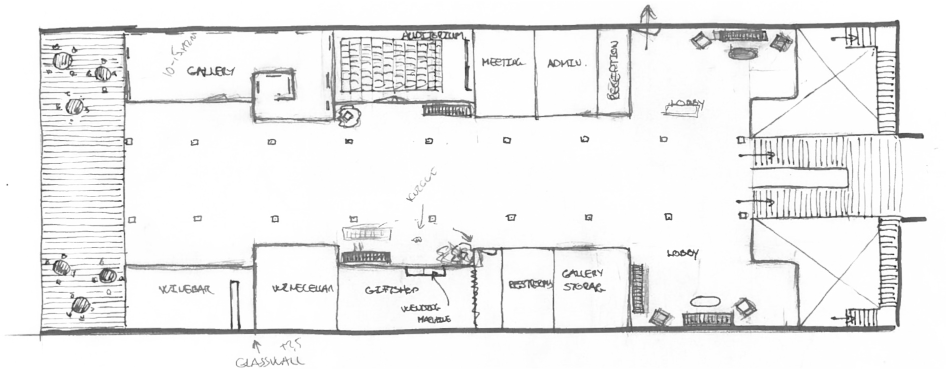
The auditorium has been developed to be elevated into three levels with two smaller staircases at each side of the row of chairs, consisting of three steps each. This provides a better view for the audience towards the whiteboards.

The wine bar required a wine cellar to store the copious amount of wine. At first this was proposed to be placed at the subterranean level. That separated the wine bar from the wine cellar, however, so the idea of integrating the 'wine cellar' in the walls surrounding the wine bar appeared, providing a way to separate the space and expose the wine in transparent walls facing the distribution area of the axis and advertising the wine bar to the visitors when passing by.

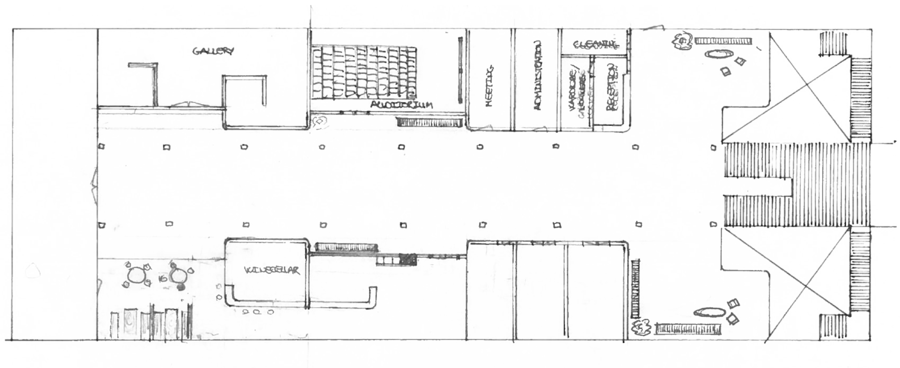
The lobby has also been refined in the process of developing the plan. The grand staircase naturally divides the lobby and by extending a part of the separated lobby into the double high room the visitors are provided with a platform from which to admire the spacious staircase while also better being able to utilize the space.



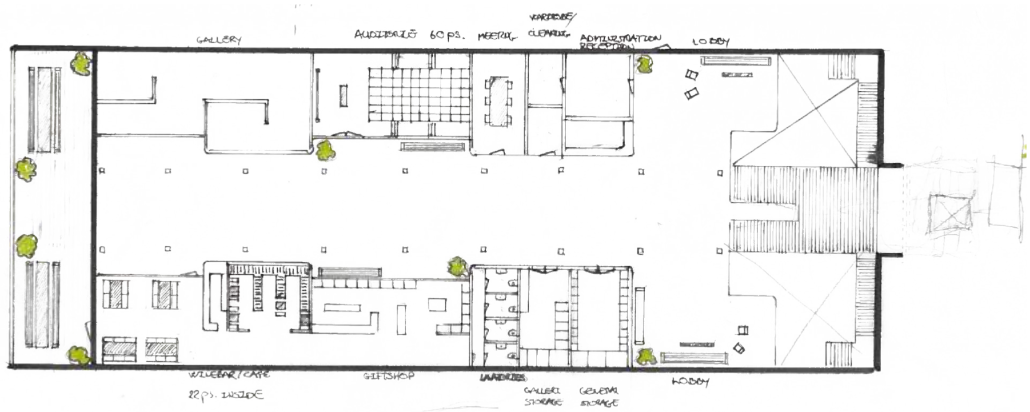
Ill. 83



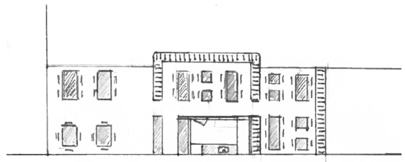
Ill. 84



Ill. 85



Ill. 86



Ill. 88

Ill. 87

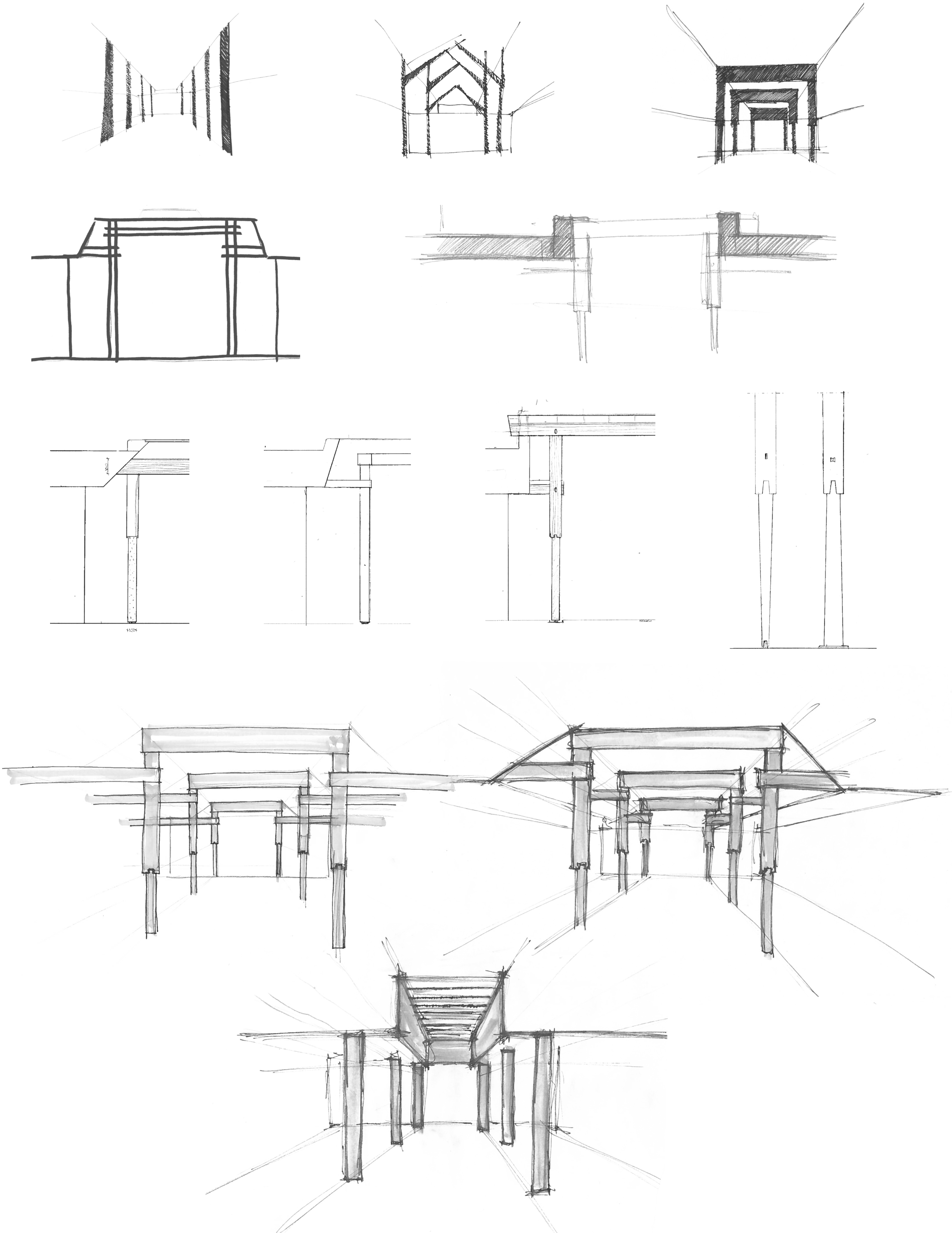
4.3 **EXPRESSION OF THE COLONNADE**

The idea of having a central colonnade highlighting the axis of the building and creating a spacious and transparent distribution area was explored in this section, and multiple iterations were tested.

Initially the process was coloured by tectonic measures, having the columns express a structural focal point. The process changed consistently and eventually the design evolved from its complex nature to a very simple proposal of massive rectangular columns placed 7.4 meters apart. This correlated well with the existing architectural expression of the building and allowed the columns to stand out by not having them interact with several other structural elements.

Two separate aspects were in play while designing the columns. One aspect was the presence of light coming from the skylight above. The filter the light and promote the shadows, a horizontal element was initially added to the structure. The idea arose from a desire to create a rhythmic and dynamic expression of the shade created by the structure.

The other aspects involved a feature that should exemplify the structural transition between concrete and wood, illustrating the structural strength of each material by changing the section of the column based to the material used. The choice fell upon a singular column of cork oak wood, standing on a small recess elevated from the concrete floor. The detail provided the column with its own hierarchy and made it appear as if floating above the concrete, contradicting its function as a structural element.

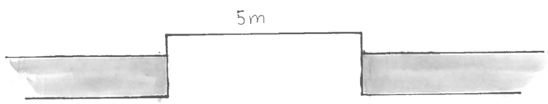


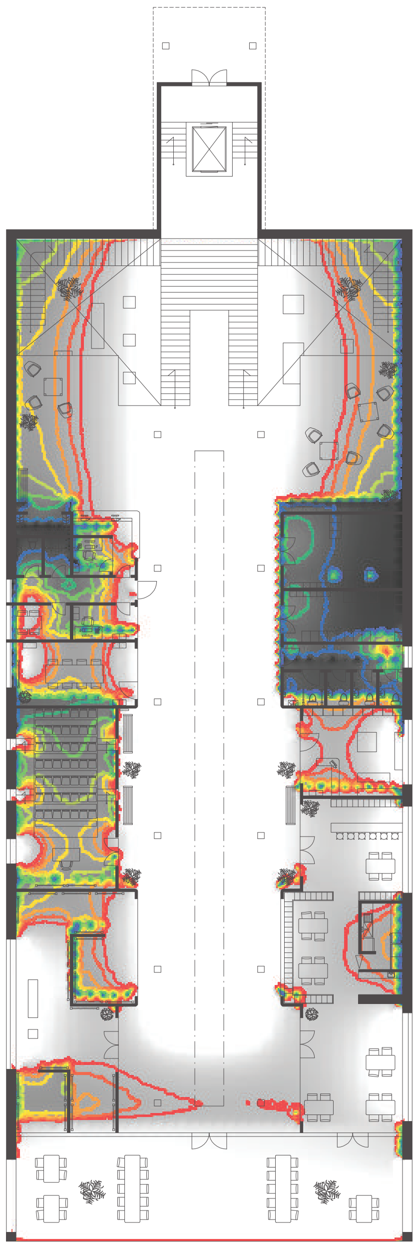
Ill. 88, iterations of the colonnade.

4.4 **DAYLIGHT AND THE SKYLIGHT**

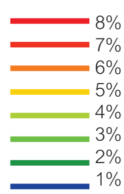
The conceptual plan for the building was to have the majority of the light coming from a natural source. Because the building is embedded into the terrain the design of a skylight was explored. The skylight should provide enough light to the plan, almost stretching the entire length of the building, while highlighting and emphasizing the axis of the visitor center. Several proposals were designed and tested using Velux Daylight Visualizer. The results showed that the initial suggestion of a skylight spanning the width of the main distribution area (5 m) provided far too much light and became disharmonic in its composition. Iterations were made to reduce the size of the skylight and a strategy for passive sun screening was included to reduce overheating of the building. The strategies involved adding internal screening lamellas to the windows and raise the southern facing wall of the skylight.

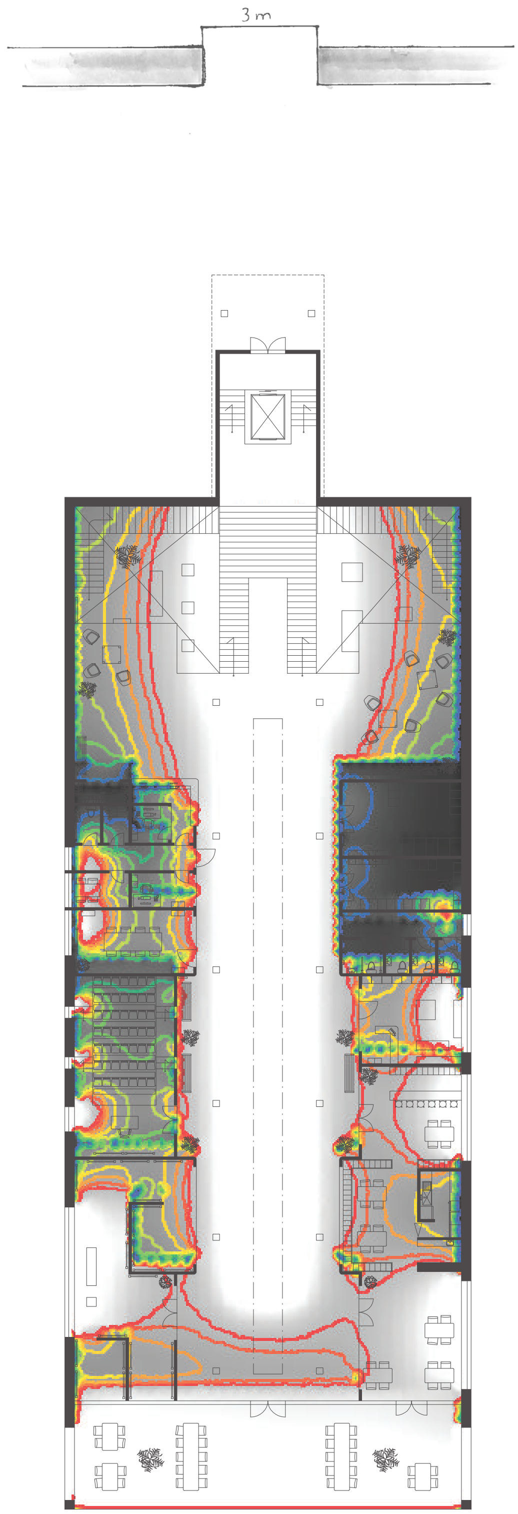
Scaling down the skylight still provided amble daylight conditions in the visitor center while also providing a more subtle expression for the building.



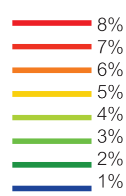


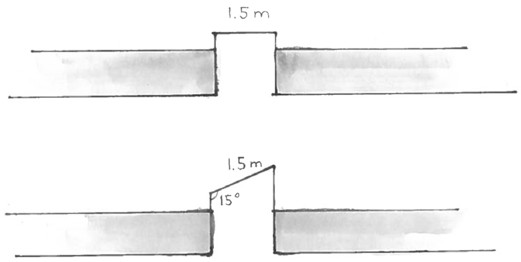
Ill. 89, 5 m wide skylight.

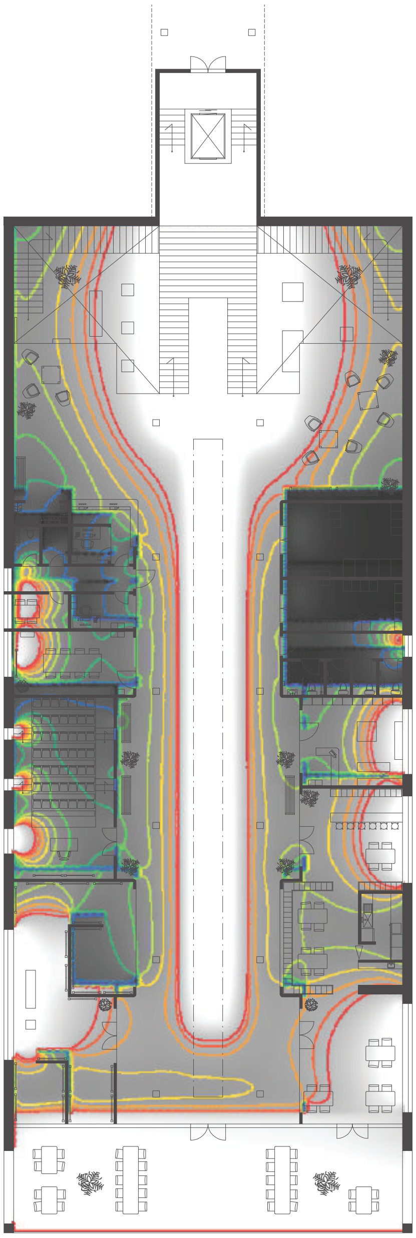




Ill. 90, 3 m wide skylight.





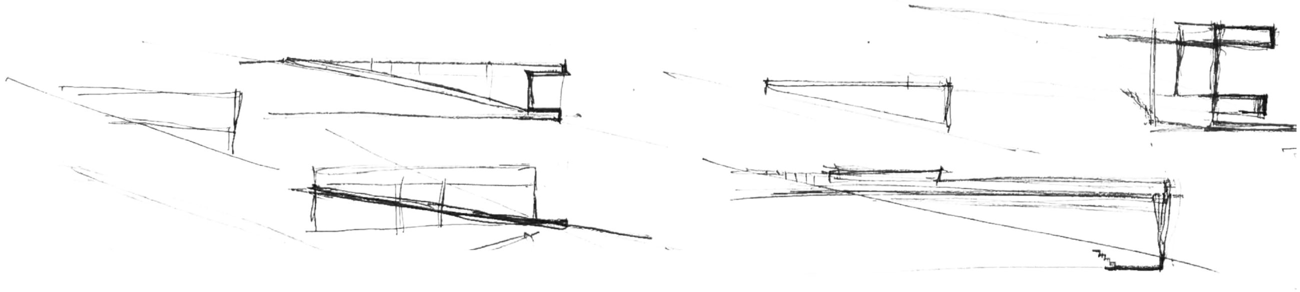


Ill. 91, 1.5 m wide skylight.

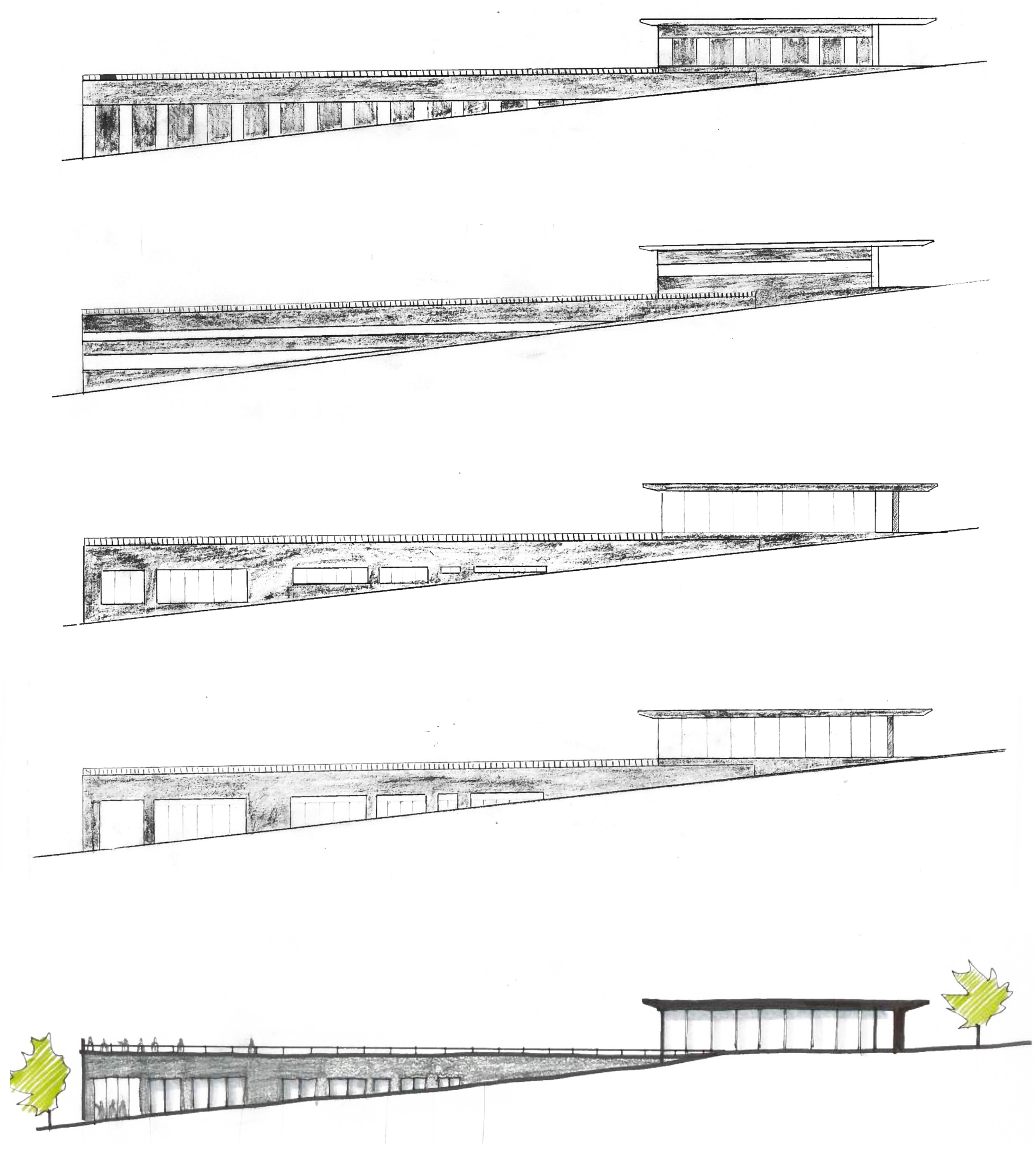
4.5 **EXTERIOR EXPRESSION**

The final expression of the facade composition was tested through multiple iterations. Two different approaches were reviewed. One featuring horizontal ribbon windows and another featuring vertical windows, cut out in the facade, with either straight or slanted base, following the slope of the terrain.

The iterations revealed that the horizontal ribbon windows had too much of a resemblance to an office building while also taking away some of the focus from the expression of the facade, making it appear even longer. In the iterations with the angular cut at the base of the windows the facade appears to have more integrity while still allowing the it to remain subtle in its expression.



Ill. 92, preliminary sketches.



Ill. 93, facade iterations.

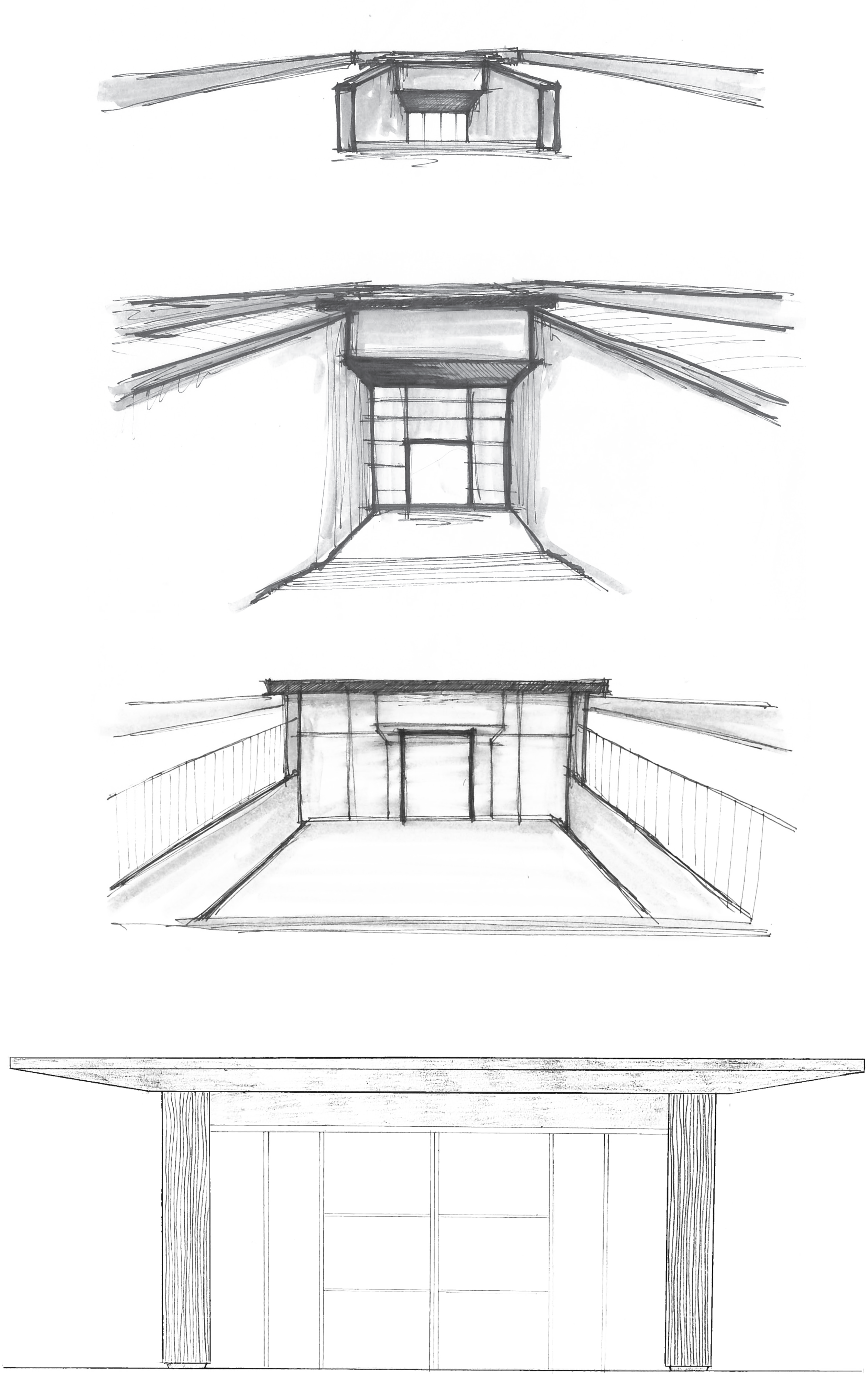
4.6 **ARRIVAL**

The entrance is of great importance to the project. First and foremost it is the part of the building that the visitors will be met by when arriving to the site so it would have to clearly communicate its intent while still being humble in its expression towards the monument.

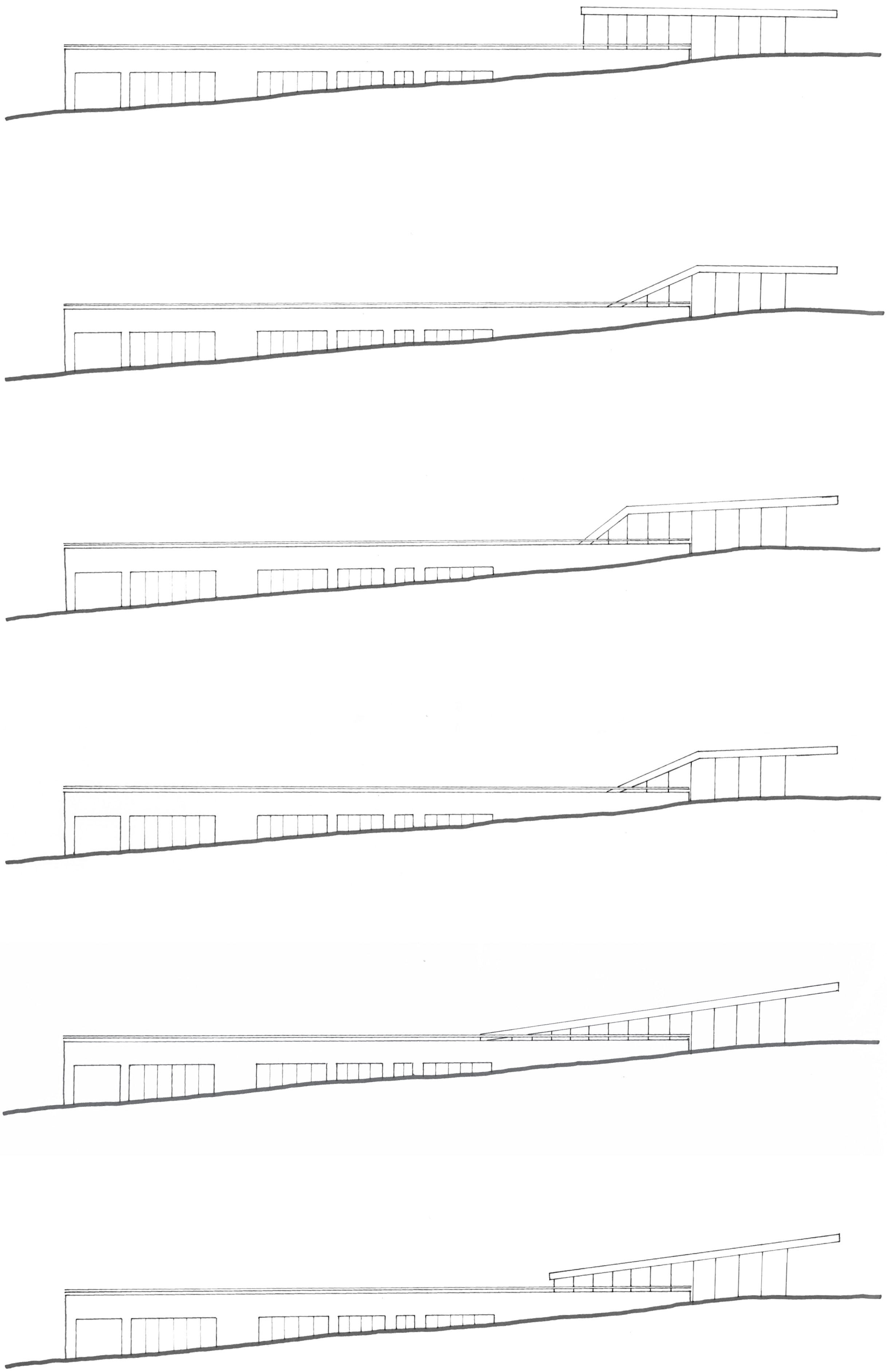
From the beginning the arrival to the center were meant to be a fluent transition from the exterior and into the different levels of the interior. The rooftop would be utilized for recreational space and provide a view of the valley.

The process examines multiple iterations concerning the shape of the entrance building. The entrance should express a downward motion of walking down towards the subterranean levels of the building.

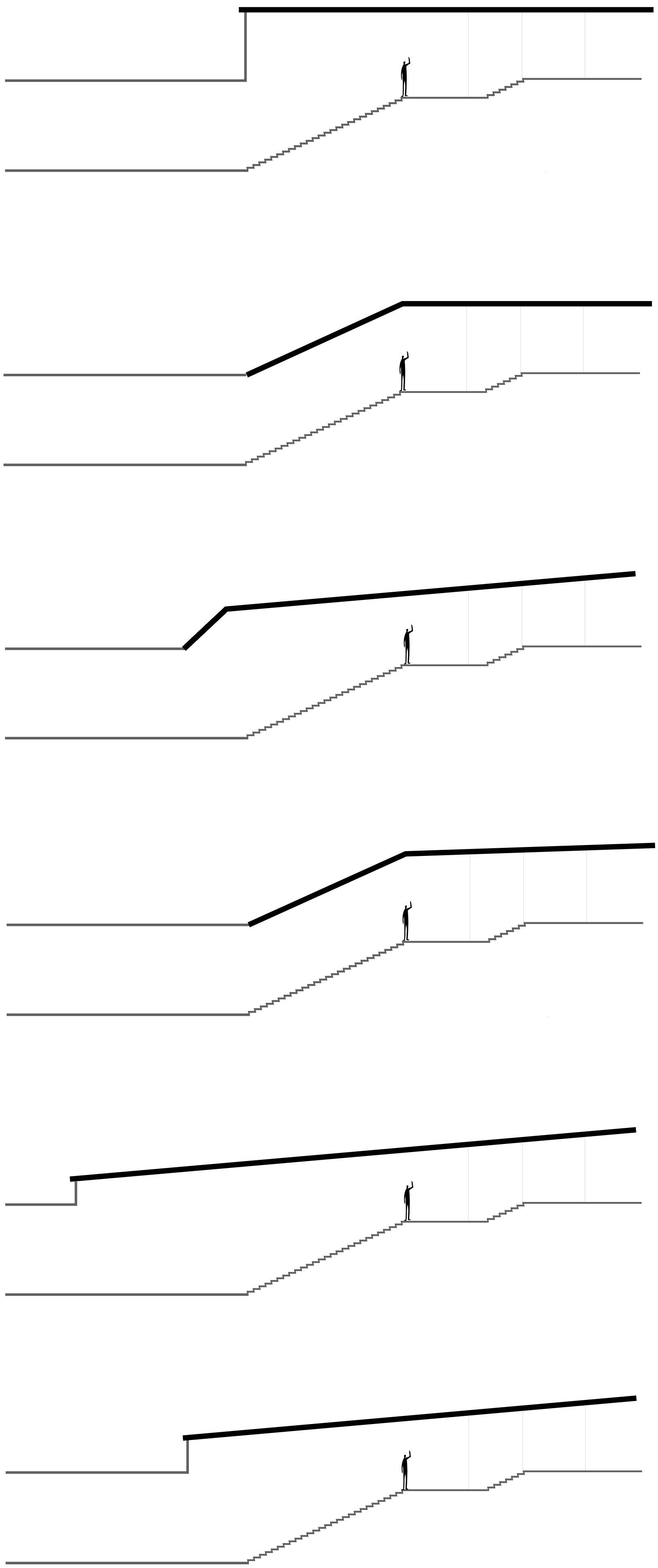
The resulting shape features a sloping roof that follows the terrain, with a calm composition that still expresses a dynamic and welcoming gesture.



Ill. 94, entrance iterations.



Ill. 95, entrance building iterations - facades



Ill. 96, entrance building iterations - sections

EPILOGUE

5.0

5.1 **CONCLUSION**

The new visitor center at the ancient monument of Cromeleque dos Almendres communicates the astrological aspects of the monument through its composition. The building interacts with the monument in a humble way, being embedded into the terrain, almost hidden from the monument. This approach limits the visual interaction between the building and the monument and allows for the visitors to still experience the monument undisturbed. The rooftop elevates itself above the terrain and grants the visitors a panoramic view of the valley below.

The layout of the building is arranged in relation to the main ley-line of the monument. The ley-line continues through the building in a central axis that divides and distributes the functions and directs the visitors towards the monument to the east and the view of the landscape to the west.

The visitor center communicates the various significant aspects of the monument through its exhibition, separated into three sections and containing a historical exhibition, a religious exhibition and an astrological exhibition. The astrological exhibition features the 'Dark room', a dark showroom that reproduces the experience of the lunar equinoxes digitally in a time lapse, allowing visitors to experience this unique phenomenon during their visit. To maintain a natural approach to the monument and the visitor center, the road to the monument has been removed in favour of a smaller pedestrian pathway, encouraging visitors to leave their car behind and approach the site on foot

Different types of lighting have been utilized in the visitor center. Above ground the main source of light is the natural daylight that enters from the skylight, highlighting the central axis and below ground the light is primarily artificial, providing more control when organizing the exhibited material.

The tectonic approach of the visitor center is revealed through its attention to details and tactility, its spatial qualities and its transparent plan.

5.2 **REFLECTION**

Designing a building on a location so closely related to an ancient monument requires careful considerations of the architectural approach and the expression of the architecture. This project chose a subtle approach of toning down the exterior architectural expression to a minimum. This choice brought forth an interesting dilemma; the architecture of a building is often expressed through its facades and the overall composition because it is the first thing people lay their eyes upon, but the design of the visitor center is approached in a more subtle manner, almost trying to hide the building within the landscape. Nevertheless the choice of a subtle exterior expression opened up for a detailed refinement of the interior composition. The concept for the interior expression was to express the main axis of the monument through a colonnade of columns adjacent to the central transit area of the center. The design should support the tectonic approach and provide spatial qualities to the main distribution area of the visitor center. During the process of developing and designing the columns and the structure following a tectonic approach, many iterations were tested and the preliminary choice fell upon a structure that had a very tectonic expression and stood out architectonically. However the design did not contribute to the simple appearance of the interior design so the strategy of designing the structure changed from aiming for a very expressive tectonic structure to aiming for a more simple design, despite having put great effort into designing and solving the initial structure. This change reflected the general idea that 'simple' is sometimes better than complicated and the result provided a structure that contributes much more to the overall appearance of the interior composition.

Another preliminary approach was to utilize local materials from the region to generate the architectural language of the building. The idea originated from a sustainable approach of using materials with a low carbon footprint while also providing a design with a regional expression. One material in particular was of interest to us, the cork oak wood – which turned out to be a very sustainable material that was also a very characteristic part of the landscape. As the concept of the design developed further, we realised that it would be hard to solve an underground construction with the material palette available and instead the natural choice fell upon concrete due to its superior durability in this application. That choice resulted in a revision of the initial approach. Instead of striving to only use low carbon emissive materials, we changed the approach to ensure that steps had been taken to increase the sustainability of the concrete without damaging its durability. We found that by replacing some of the cement, which is the biggest carbon emitter in concrete, with fly ash, a by-product from the coal industry, could help reduce the carbon footprint of the concrete. Strategies such as picking a local producer and distributor would also reduce the footprint, and generally limiting the amount of concrete used in the structural system by adding wooden columns and interior drywalls instead of concrete elements.

Designing a piece of architecture on such a remote location provides a huge degree of freedom regarding the architectural expression. The architecture would not have to relate to any surrounding buildings. At the location of Cromeleque dos Almendres the design is isolated, it does not have to act in accordance with any municipal plan. The final design could very well have been an iconic structure, visible from long distances, reaching up from the hilltop to stage itself in the surrounding landscape. In the early design development the design proposals had a more formalistic approach of relating to the nature and the landscape with little concern for the experience of the monument. Reviewing this process, a different approach could have narrowed down the amount of ideas and produced a more productive process. Even though the iterations generally originated from the vision, it became evident that the proposals examined very different ways of relating to the nature and the monument and as such the iterations became hard to discuss in relation to each other. The approach of designing a visitor center that would appear subtle in its correlation with the landscape and the monument, while at the same time being expressive, appeared to clash and provided an irresolute design. The project developed from this stage onwards, following the deduction of the solution to this conflict; that simple is often better when designing in such a unique and historically significant context.

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6.0

6.0 **REFERENCES**

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6.2 ILLUSTRATIONS

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Any illustrations that are not mentioned is the authors own.

APPENDIX

7.0

7.0 **APPENDIX A**

7.1 LOADS

PERMANENT LOADS

The permanent loads affecting the structure consists of two different sources; the load of the structure itself and the load of the roof construction.

The load of the roof construction is calculated by adding the load of the concrete deck to the load of the concrete tiles covering the roof.

The load of the concrete deck is found to be $3.71\ kN/m^2$, in a table of carrying capacity for the product Xstrumax provided by Spæncom, a Danish supplier of concrete construction elements [Spæncom].

The load of the concrete tiles is calculated for a $1200x1600x50mm$ tile, with a concrete density of $1800\ kg/m^3$.

$$1800\ kg/m^3 * 0.00981 = 17.66\ kN/m^3$$

And:

$$17.66\ kN/m^3 * 0.05m = 0.88\ kN/m^2$$

This gives us a total load of $4.59\ kN/m^2$

VARIABLE LOADS

WIND LOAD

The wind load depends on the location – and shape of the building. The expressions found in Eurocode 1.4 have been used to calculate the wind load.

BASIC WIND VELOCITY

$$v_b = c_{dir} * c_{season} * v_{b,0}$$

Where:

c_{dir}	is the directional factor	$= 1$
c_{season}	is the seasonal factor	$= 1$
$v_{b,0}$	is the fundamental value of the basic wind velocity read from the map on fig. 1	$= 24\ m/s$

$$V_b = 1 * 1 * 24\ m/s\ = 24\ m/s$$

WIND LOAD ON THE BUILDING
MEAN WIND VELOCITY

The mean wind velocity is calculated from the basic wind velocity, a terrain factor (orography) and a roughness factor.

$$v_m(z) = c_r(z) * c_o(z) * v$$

Where:

$v_m(z)$	is the mean wind velocity at a height z above the terrain	
z	is the height of the building	$= 5\ m$
$c_r(z)$	is the roughness factor	
$c_o(z)$	is the orography factor	$= 1$

The *roughness factor* accounts for variability in the mean wind velocity at the site due to the height above ground level and the roughness of the terrain (upwind of the structure in the considered wind direction).

$$c_r(z) = k_r * \ln\left(\frac{z}{z_0}\right)$$

Where:

z	is the height of the building	$= 5\ m$
z_0	is the roughness length, defined by the terrain category, chosen to be category III	$= 0.3\ m$

Category III: area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest).

k_r is the terrain factor, dependant on the roughness length and calculated using:

$$k_r = 0.19 * \left(\frac{z_0}{z_{0,II}}\right)^{0.07}$$

Where:

$z_{0,II}$	(terrain category II)	$= 0.05\ m$
z_0	is the roughness length, defined by the terrain category, chosen to be category III	$= 0.3\ m$

$$k_r = 0.19 * \left(\frac{0.3\ m}{0.05 m}\right)^{0.07} = 0.2154 = 0.22$$

$$c_r(z) = 0.22 * \ln\left(\frac{5\ m}{0.3\ m}\right) = 0.6190 = 0.62$$

So the *mean wind velocity* is:

$$v_m(z) = 0.62 * 1 * 24\ m/s = 14.88\ m/s$$

TURBULENCE

The turbulence intensity $I_v(z)$ at height z is defined as the standard deviation of the turbulence σ_v divided by the mean wind velocity $v_m(z)$.

$$I_v(z) = \frac{\sigma_v}{v_m(z)}$$

The standard deviation of the turbulence σ_v is determined by the expression:

$$\sigma_v = k_r * v_b * k_I$$

Where:

k_r	is the terrain factor	$= 0.22$
v_b	is the basic wind velocity	$= 24\ m/s$
k_I	is the turbulence factor	$= 1$

$$\sigma_v = 0.22 * 24\ m/s\ * 1 = 5.28\ m/s$$

So the *turbulence intensity* is:

$$I_v(z) = \frac{5.28\ m/s}{14.88\ m/s} = 0.35\ m/s$$

PEAK VELOCITY PRESSURE

The peak velocity pressure $q_p(z)$ at height z, includes both mean and short-term velocity fluctuations and should be determined using the expression:

$$q_p(z) = [1 + 7 * I_v(z)] * \frac{1}{2} * \rho * v_m^2(z)$$

Where:

$I_v(z)$	is the turbulence intensity	$= 0.35\ m/s$
ρ	is the air density	$= 1.25\ kg/m^3$
$v_m(z)$	is the mean wind velocity	$= 14.88\ m/s$

So the *peak velocity pressure* is:

$$q_p(z) = [1 + 7 * 0.35\ m/s] * \frac{1}{2} * 1.25\ kg/m^3 * 14.88^2\ m/s = \ 387.47\ Pa$$

$$\frac{387.47\ Pa}{1000} = 0.39\ kN/m^2$$

WIND PRESSURE ON SURFACES – ROOF

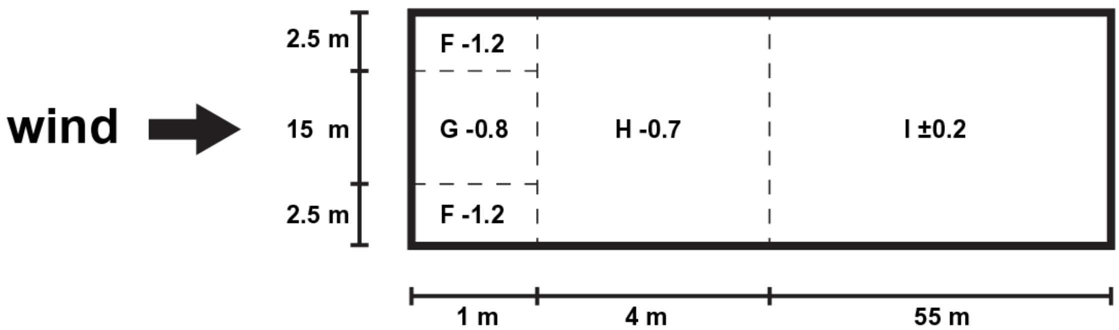
The wind pressure acting on the external surfaces is obtained from the expression:

$$w_e = q_p(z_e) * c_{pe}$$

Where:

$q_p(z_e)$	is the peak velocity pressure	$= 0.39\ kN/m^2$
z_e	is the reference height	
c_{pe}	is the pressure coefficient	

The roof is considered flat (a slope α of $-5° < \alpha < 5°$) with $1.10\ m$ high parapets.



EN 1991-1-4:2005 (E)

Table 7.2 — External pressure coefficients for flat roofs

Roof type		Zone F $c_{pe,10}$	F $c_{pe,1}$	G $c_{pe,10}$	G $c_{pe,1}$	H $c_{pe,10}$	H $c_{pe,1}$	I $c_{pe,10}$	I $c_{pe,1}$
Sharp eaves		-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2 -0,2	
With Parapets	h_p/h=0,025	-1,6	-2,2	-1,1	-1,8	-0,7	-1,2	+0,2 -0,2	
	h_p/h=0,05	-1,4	-2,0	-0,9	-1,6	-0,7	-1,2	+0,2 -0,2	
	h_p/h=0,10	-1,2	-1,8	-0,8	-1,4	-0,7	-1,2	+0,2 -0,2	

$$h_p/h = \frac{1.1\ m}{5\ m} = 0.22$$

ROOF

Zone:	G
Area:	$15\ m^2$
Wind pressure:	$w_e = 0.39\ kN/m^2 * (-0.8) = -0.312\ kN/m^2$
Load:	$-0.312\ kN/m^2 * 15\ m^2 = -4.68\ kN$

Zone:	F
Area:	$2.5\ m^2$
Wind pressure:	$w_e = 0.39\ kN/m^2 * (-1.2) = -0.468\ kN/m^2$
Load:	$-0.468\ kN/m^2 * 2.5\ m^2 = -1.17\ kN$

Zone:	H
Area:	$80\ m^2$
Wind pressure:	$w_e = 0.39\ kN/m^2 * (-0.7) = -0.273\ kN/m^2$
Load:	$-0.273\ kN/m^2 * 80\ m^2 = -21.84\ kN$

Zone:	I
Area:	$1100\ m^2$
Wind pressure:	$w_e = 0.39\ kN/m^2 * (\pm 0.2) = \pm 0.078\ kN/m^2$
Load:	$\pm 0.078\ kN/m^2 * 1100\ m^2 = \pm 85.8\ kN$

NOTE 3 In Zone I, where positive and negative values are given, both values shall be considered.

Total wind pressure for the roof:

$$(-0.312\ kN/m^2) + (-0.468\ kN/m^2) + (-0.273\ kN/m^2) + (\pm 0.078\ kN/m^2) =$$

$$-1.131\ kN/m^2\ or - 0.975\ kN/m^2$$

Total loads for the roof:

$$(-4.68\ kN) + (-1.17\ kN) + (-21.84\ kN) + (\pm 85.8\ kN) =$$

$$-113.49\ kN\ or\ 58.11\ kN$$

CONCLUSION

Looking at the calculated values for the wind loads it becomes evident that the wind load on most of the zones acts favorably, meaning that the wind is affecting the zone with suction rather than pressure. However zone I can be affected by either suction or pressure. In the zones where only suction is affecting the surface the permanent load of the roof (pressure) must be higher than the wind load (suction):

Permanent load:

$$4.59\ kN/m^2$$

Wind load:

$$-1.131\ kN/m^2\ or - 0.975\ kN/m^2$$

This means that the pressure of the permanent loads will counteract the suction of the wind load.

Because *zone I* can be affected by either suction of pressure the pressure load will have to be further accounted for when calculating the dominating load combination.

Beside the wind load, a people load of $3\ kN/m^2$ corresponding to approximately $300\ kg/m^2$ have also been accounted for. This value is found in Eurocode 1, table 6.2 - 'payload on floors, balconies and stairs' for category A4 (stairs).

CALCULATING THE DOMINATING LOAD COMBINATION

Because the person load of $3\ kN/m^2$ is much higher than the worst case scenario wind load of $0.078\ kN/m^2$ it is safe to assume that the people load will be the dominating variable load in the equation:

$$K_{FI} * \gamma_G * G + K_{FI} * \ \gamma_{Q_1} * Q_1 + K_{FI} * \gamma_{Q_i} * \psi_0 * Q_i$$

Where:

K_{FI} is 1 for Consequence class CC2 – normal

γ_G is 1 for category C (larger assembly areas)

G is our permanent loads, in this case $4.59\ kN/m^2$

γ_{Q_1} is 1.5

Q_1 is our dominant variable load, in this case our people load of $3\ kN/m^2$

$\gamma_{Q_i}$is 1.5

ψ_0 is 0.8

Q_i is the remaining variable loads, in this case our wind load of $0.078\ kN/m^2$

This gives us:

$$1 * 4.59\ kN/m^2 + 1.5 * 3\ kN/m^2 + 1.5 * 0.8 * 0.078\ kN/m^2 = \ 9.18\ kN/m^2$$

7.2 REINFORCED CONCRETE BEAM, ULS

The following calculation will prove the structural integrity of the building by calculating on a beam with one of the longest span and highest load.

CHARACTERISTICS:

Width $w = 300\,mm$

Height $h = 600\,mm$

Length $l = 10500\,mm$

Efficient height $d = 468.33\,mm$

Area of reinforcement

$$A_s = \left(\frac{\pi}{4} * Ø^2\right) * n_{reinf} = \left(\frac{\pi}{4} * 25mm^2\right) * 6 = 2945.24\,mm^2$$

The cover layer and distances between the reinforcement in the cross section have been designed according to fig. 5.8 in Teknisk Ståbi [Ståbi] and the width of the beam has been decided in relation to the amount of reinforcement bars in one layer, according to table 5.7 in Teknisk Ståbi [Ståbi].

The cross section has 6 bars of 25 mm steel liners in the bottom and 3 bars in the top.

Concrete C45

Compressive strength $f_{ck} = 45\,MPa$

Max strain $\varepsilon_{cu} = 0,35\%$

Density $\rho = 2400\,kg/m^3$

Steel liner 25mm

Tensile strength $f_{yk} = 550\,MPa$

Modulus of Elasticity $E_{sk} = 210000\,MPa$

Control class

Normal $\gamma_3 = 1$

Design factors

Concrete $\gamma_c = 1.45 * \gamma_3 = 1.45 * 1 = 1.45$

Steel $\gamma_s = 1.2 * \gamma_3 = 1.2 * 1 = 1.2$

Design values

Concrete

$$f_{cd} = \frac{f_{ck}}{\gamma_c} = \frac{45\ MPa}{1.45} = 31.03\ MPa$$

Steel

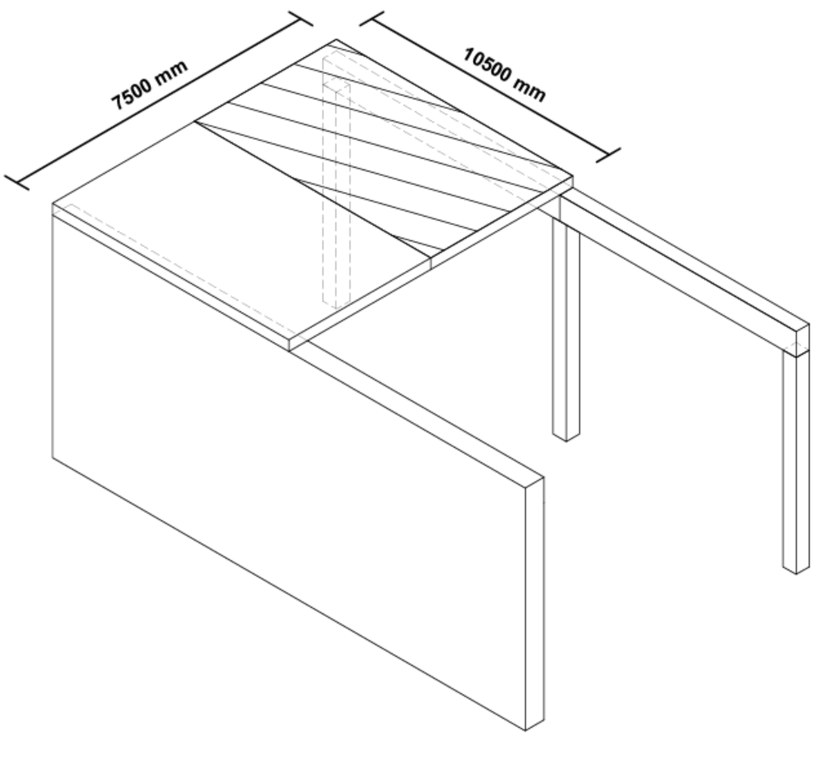
$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{550\ MPa}{1.2} = 458.33\ MPa$$

LOADS

ULS load combination, dominating people load with variable wind load:

$$9.18\ kN/m^2$$

A presumption has been made regarding the loaded area of the beam:



The design lineload ρ_d is calculated:

$$9.18\ kN/m^2 * \left(10.5\ m * \frac{7.5\ m}{2}\right) = 361.46\ kN$$

$$\frac{361.46\ kN}{10.5\ m} = 34.42\ kN/m$$

We find x, where pressure becomes tension in the cross section of the beam with the equation:

$$x = 1.25 * \frac{A_s * f_{yd}}{b * f_{cd}}$$

$$x = 1.25 * \left(\frac{2945.24\ mm^2 * 458.33\ MPa}{300\ mm * 31.03\ MPa}\right) = 181.24\ mm$$

We find the maximum moment occurring in the beam:

$$M_{max} = \frac{1}{8} * \ \rho_d * L^2$$

$$\frac{1}{8} * 34.42\ kN/m * (10.5\ m)^2 = \ 474.35\ kN * m$$

We find the moment carrying capacity of the beam:

$$M = F_{steel} * z$$

Where:

z is the inner moment arm given by the equation $d - 0.4 * x$
F_{steel} is the force in the reinforcement - $F_{steel} = f_{yd} * A_s = 458.33\ MPa * 2945.24\ mm^2 = 1349891.85\ N$

$$M = 1349891.85\ N * (468.33\ mm - 0.4 * 181.24\ mm) = 534333091\ N * mm = 534.33\ kN * m$$

$$M \geq M_{max}$$

$$534.33\ kN * m \geq 474.35\ kN * m$$

Since $M > M_{max}$ it can be concluded that the reinforced concrete beam can take the largest moment present without reaching its yield moment.

It is presumed that the beam is normal-reinforced which is proven by:

$$\varepsilon_y < \varepsilon_{cu} < 10\%$$

$$\varepsilon_s = \varepsilon_{cu} * \left(\frac{d - x}{x}\right) = 0.35 * \frac{468.33 - 181.24}{181.24} = 0.55\%$$

$$\varepsilon_y = \frac{f_{yk}}{E_{sk}} = \frac{550\ MPa}{210000\ MPa} = 0.21\%$$

Since $0.21\% < 0.55\% < 10\%$ is fulfilled the beam is normal-reinforced.

7.3 REINFORCED CONCRETE BEAM, ULS

The following calculation will prove the structural integrity of the building by calculating one of the 12 timber column that plays a vital part in the structural scheme of the building.

CHARACTERISTICS:

Width	$w = 350\,mm$
Height	$h = 350\,mm$
Length	$l = 3800\,mm$
Area of cross section	$A = 122500\,mm^2$

Construction timber C30

Values found in 'Statik og styrkelære' [Statik og styrkelære]

Compressive strength $f_k = 23\,MPa$

$k_{mod} = 0.6$

$\gamma_m = 1.3$

Design value for compressive strength

$$F_d = \frac{f_k * k_{mod}}{\gamma_m} = \frac{23\,MPa * 0.6}{1.3} = 10.6\,MPa$$

The carrying capacity of the column is calculated following the example in 'Statik og styrkelære', page 282.

The column must abide by the following definition, which will be proven through calculation:

$$\sigma_{c,0,d} = \frac{N_{Ed}}{A} \leq k_c * k_d * f_{c,0,k}$$

Where:

$\sigma_{c,0,d}$ is the design value for the compressive stress in the column

N_{Ed} is the design value for the loads affecting the column

A is the area of the cross section

k_c is a column factor, found in table 6.08 in 'Statik og styrkelære'

k_d is a conversion factor, found in table 6.2 in 'Statik og styrkelære'

$k_d = 0.444$ for indoor permanent loads

$f_{c,0,k}$ is the characteristic compression strength, found in table 6.1 in 'Statik og styrkelære'

$f_{c,0,k} = 23\,MPa$ for compression along the grain

To find k_c in table 6.08 we first have to know the relative slenderness ratio λ_{rel} which is calculated with the equation:

$$\lambda_{rel} = \frac{k_{rel} * l_s}{h}$$

Where:

k_{rel} is a factor found in table 6.3 in 'Statik og styrkelære' k_{rel} = 0.059 for Construction timber C30

l_s is the efficient length of the column, corresponding to $2 * l$ for our scheme

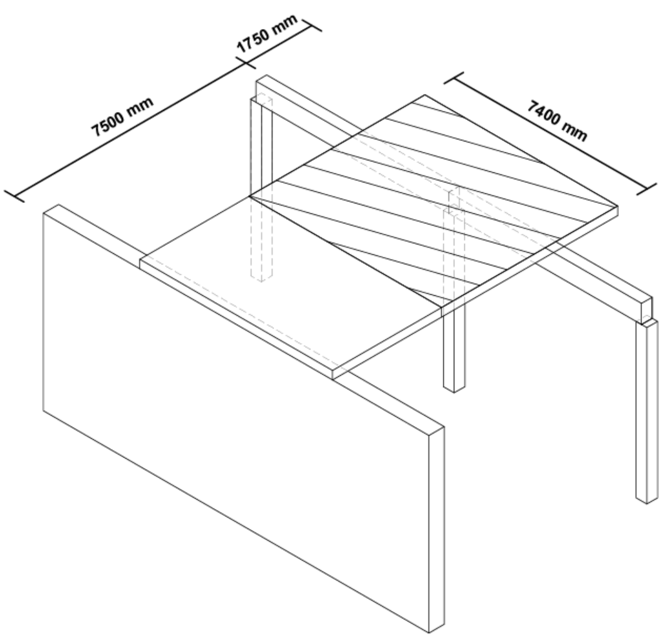
h is the height of the cross section

That gives us:

$$\lambda_{rel} = \frac{0.059 * (2 * 3.8m)}{0.35m} = 1.28$$

And from that we find k_c to be 0.48

The design value for the loads affecting the column N_{Ed} is calculated following a presumption made regarding the loaded area of the column:



ULS load combination, dominating people load with variable wind load:

$$9.18\ kN/m^2$$

Load of the reinforced concrete beam:

$$((0.3\ m * 0.6\ m * 7.4\ m) * 2400\ kg/m^3) * 0.00981 = 31.36\ kN$$

The design load N_{Ed} is calculated:

$$9.18\frac{kN}{m^2} * \left(7.4\ m * \left(\frac{7.5}{2}\right) + 1.75\ m\right) = 270.81\ kN = 270810\ \mathrm{N}$$

$$270.81\ kN + 31.36\ kN = 302.17\ kN = 302170\ N$$

The strength parameter is then examined:

$$\frac{N_{Ed}}{A} = \frac{302170\ N}{122500\ mm^2} = 2.46\ MPa \leq\ k_c * k_d * f_{c,0,k} = 0.48 * 0.444 * 23\ MPa = 4.90\ MPa$$

Since $2.46\ MPa \leq 4.90\ MPa$ it can be concluded that the timber column can withstand the affecting loads.

8.0 **APPENDIX B**

8.1 ACOUSTICS

An estimation of the reverberation times in the auditorium have been calculated using Sabine's equation.

$$RT_{60} = \frac{0.16 * V}{A}$$

Where:

RT_{60} is the reverberation time in seconds

V is the total volume of the room, $4.8m \ * \ 10m \ * \ 5.2m \ = 249.6 \, m^3$

A is the absorption of the room in m^2_{sabin} is given by $S * \alpha$, where:

S is the total surface area of the given material in the room

α is the absorbance coefficients of the given materials surface

Absorbance coefficients for the different frequencies are found for the different materials in the room.

Building component	Material	Area	$125 \, Hz$	$250 \, Hz$	$500 \, Hz$	$1000 \, Hz$	$2000 \, Hz$	$4000 \, Hz$
Ceiling	Plasterboard	51.5	0.02	0.03	0.04	0.05	0.04	0.03
Walls	Plasterboard	123.7	0.02	0.03	0.04	0.05	0.04	0.03
Floor	Cork	52.3	0.02	0.02	0.04	0.05	0.05	0.10
Doors and windows	Glass	17.5	0.35	0.25	0.18	0.12	0.07	0.04
Auditorium seat, occupied	Wood, skin, clothing	21.4	0.37	0.48	0.68	0.73	0.77	0.74
$RT_{60} =* \frac{0.16 * V}{A}$			2.15	1.91	1.49	1.37	1.46	1.48

The auditorium is deemed the most acoustically critical room in the building due to its function as an educational space. The estimated average reverberation time in the auditorium is $RT_{60} = 1.64$ seconds which is just above the recommended level of somewhere between 1.5 and 2 seconds. While it is in the lower end of the spectrum it is deemed appropriate since the auditorium will primarily serve educational purposes. Lower reverberation times are recommended for speech while higher reverberation times are recommended for music and concerts.

9.0 APPENDIX C

9.1 VENTILATION STRATEGY

The ventilation system has been accounted for by providing substantial space in the suspended ceiling. The general room height of the building allows for us to use the displacement strategy for the mechanical ventilation, avoiding the need for changing all the air in the room and only focusing on providing fresh, clean air in the occupied zone and by that lowering the amount of air supply required.

The overall strategy is to have a centralized mechanical ventilation system with a low SEL-value and a high heat recovery to utilize when needed. The ventilation system will be located in the technical room in the subterranean part of the building, providing fresh air supplied from grill inlets in the floor and having the polluted air blown out via outlets in the ceiling. A technical shaft located in the staff section of the building will connect the ground floor to the technical room on the parterre floor.

The large double high space of the entrance area and the changing room height in the skylight provides the potential for using thermal buoyancy. By providing adjustable openings in the skylight and in the entrance building, the stack effect can be utilized for natural ventilation both in the subterranean and superterranean parts of the building.