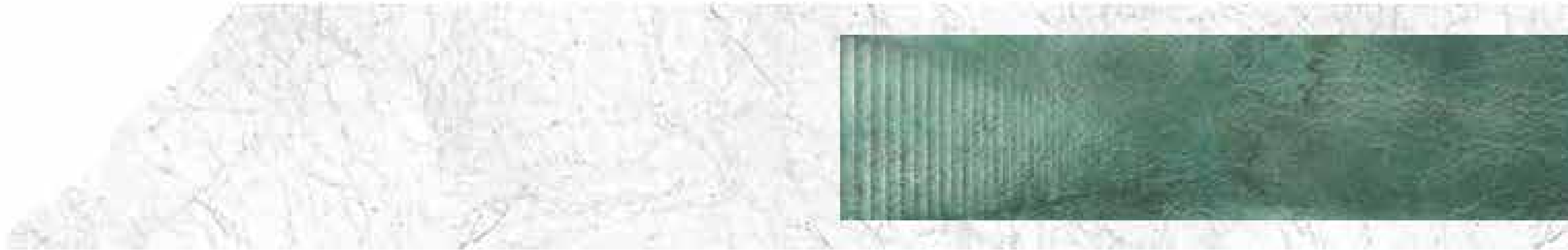

THE QUARRY THERMAL BATHS

Marble and Water...an atmospherical journey through the contrast.

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READERS GUIDE

The report is introducing the design development of a thermal bath in a marble quarry in Italy.

01 Prologue
The first part of the report is an introduction to pesent to the readers the approach to the project.

02 Program
The second phase is an excerpt of the site analysis to give a better understanding of the project area. Design parameters are introduced as guidelines coming from the analysis.

03 Presentation
The third phase implicates the final design including plans, sections, elevations and details. The technical key elements and strategies are presented together with the architectural solutions, according to the integrated design process.

04 Design process
The fourth phase contains the main steps that led to the final design solutions. The design process is presented as a logical itinerary throughout the project.

05 Epilogue
The epilogue contains a conclusion and critical reflection of the project followed by literature and illustration references.

06 Appendix
The appendix of the report contains the important documentation relating to the project as calculations, tables and software results.

ABSTRACT

The purpose of the design is to explore the design possibilities of an abandoned marble quarry located in the Italian municipality of Carrara.

The idea of the project came from a competition called “Carrara thermal bath” on the *Rethinking architecture* competition website [http://rethinkingcompetitions.com].

The design will take inspiration from the peculiar characteristics of the terrain conformation of the quarry, focusing on tectonic with an integration of sustainable solutions.
The history, the material and the natural elements will play the role of guidelines along the design process.

With this approach, an integration between aesthetics, structure, and functionality has to be achieved with a focus on the modern use of an ancient material such as marble and the atmosphere of the pleasure spaces of the thermal baths.

The room program will integrate pleasure and functional spaces, open and closed shapes, creating a visual dialogue between the quarry and the thermal baths, a place to take care of body and mind.

Figure 01 - Marble quarry, Photographer Unknown

METHODOLOGY

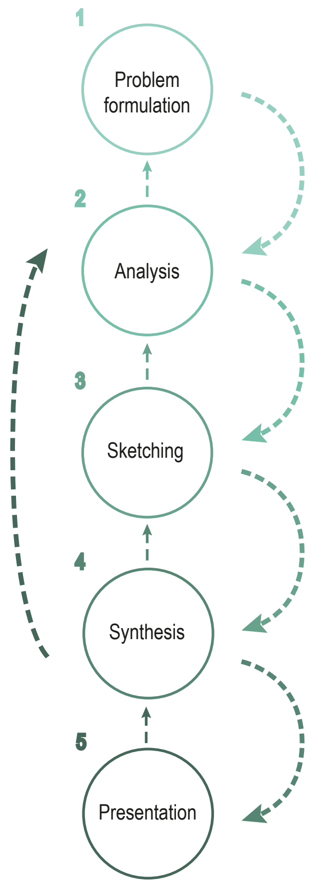


Figure 02 - Integrated design process, Own Illustration

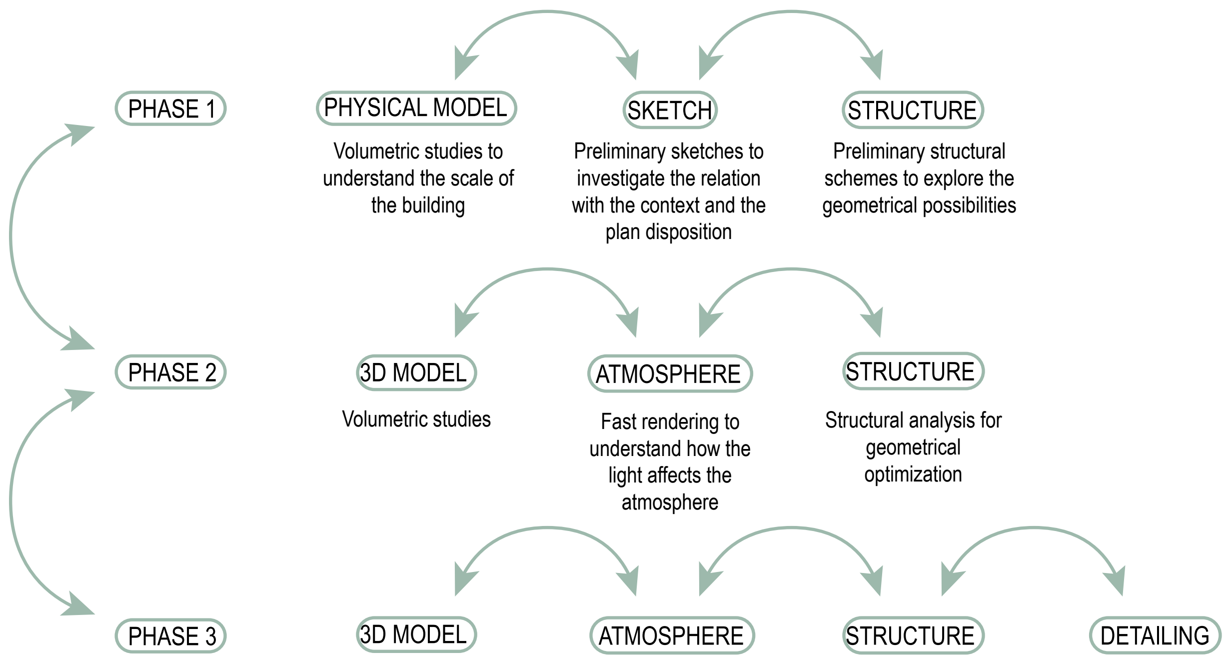


Figure 03 - Methodology scheme, Own Illustration

The main idea that will be followed for the methodology and the design process in general is to emphasize the use of computational tools in order to enrich creativity, together with the site analysis in an iterative process which attempts to integrate the multiple aspects of the project.

The project is based on a competition, whose aim is to re-vitalize an area that has been strongly modified by human activity, therefore the functional intentions have been already set. Afterwards, an analysis phase will be done, in which relevant aspects are pointed out, especially the one concerning the site condition, the historical context, the available local materials and techniques. This section aims to understand what the possibilities are and gives us a knowledge on how we can approach the site. Afterwards different theories and case studies will be analysed in order to let the reader understand the direction the project will take. Preliminary conceptual sketches will be then done, in order to communicate quickly the ideas and later developed through 3D modelling, structural analysis, plan and section drawings to understand the volumes in the context as well as their technical performances in an iterative process. All the parameters, the intentions and the solutions explored in the previous phase will be in the end combined into a symbiotic whole.

All those steps will not be developed in a linear way through the design process, but will be part of an integrated design process.

01

PROLOGUE

Figure 04 - Apuan Alps, Own Illustration

FRAMEWORK

Figure 05 - Italy, Own Illustration

SITE LOCATION

The project site is located in the western part of Italy along the Mediterranean cost of Tuscany in the Carrara province, on the mountain side above the city of Bedizzano.
The Quarry is situated on the Apuan Alps in the Gioia valley between the cities of Carrara and Colonnata and is one of the biggest marble extension in the area.
The preferable site for the project is a flatten area used for the movement of the machineries and enclosed into marble ledges. The flat area is situated 520 m above the sea level and the vegetation is rare or completely absent.

Tuscany

Italian peninsula

Figure 06 - Marble landscape, Photographer Unknown

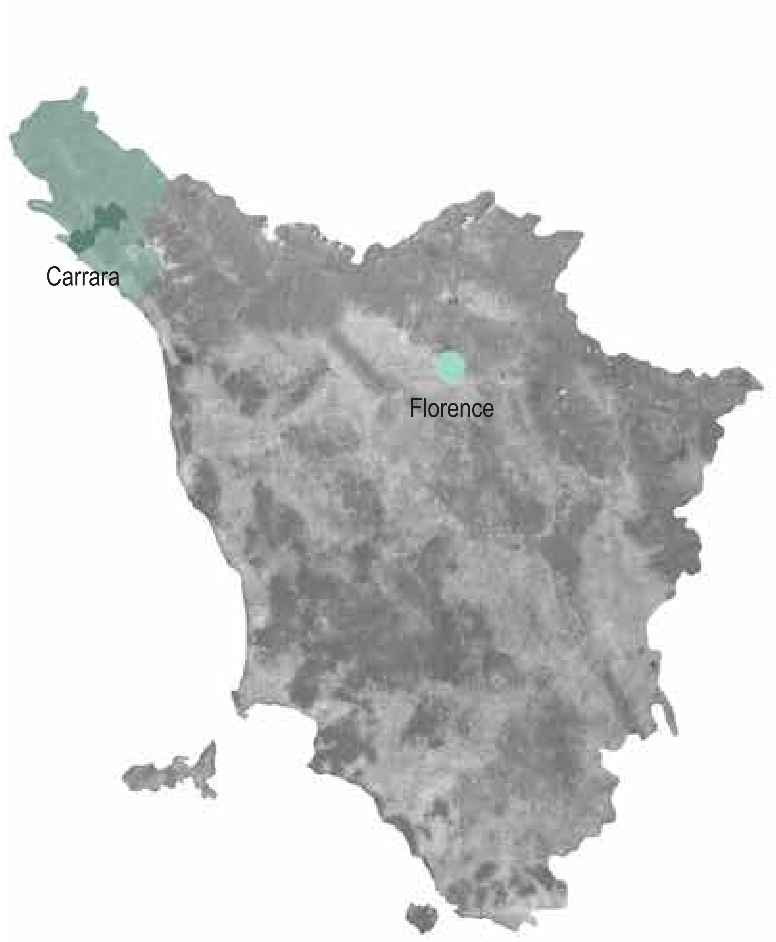


Figure 07 - Tuscany, Own Illustration

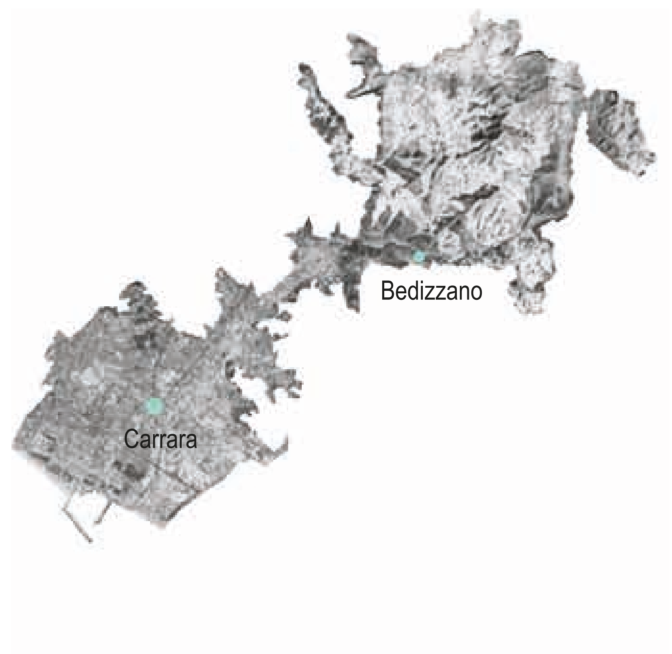


Figure 08 - Carrara, Own Illustration

Carrara province
Carrara city
Main cities

Marble quarry
Main cities

CONTEXT

The relation to the site in architecture is a fundamental aspect to take into consideration. The peculiar morphology of a marble quarry, with its terracing conformation, is the main feature in the design of the Thermal Bath centre and therefore it will give a lot of chances and challenges in the exploration of new structural systems and shapes. The scale of the project will also play a fundamental role in the perception of the building from the long distance, therefore the interconnection between the dimension of the building, where it is placed and which materials are used and the volumetry of the quarry has to be taken into consideration.

LOCAL IDENTITY

A project should relate to the local features and its surroundings, taking inspiration from the area where it is located and being either in contrast on in continuity with it. Marble is the main material present in the site and in rainy season the area is characterized by streams of water that flow over the quarry. The location of the area, on the Appennini mountains, results in a peculiar sun exposition and view on the valley . The combination of all these elements into an architectonic composition will highlight the *genius loci* of the site.

DENSITY

The quarries are a natural environment in which artificiality has been imposed by the human activity through different processes such as the extraction of materials and mobility of heavy machinery. These actions have left a strong mark, generating a landscape with predetermined qualities. Due to a boundless terrain consumption it is necessary nowadays to contain the urban sprawl, therefore this project opens up a discussion concerning the re-use of a quarry which might be abandoned in the future. Architecture can intervene and re-interpret the space and its surroundings, giving a new born to the area.

TECTONIC

A tectonic approach in architecture is able to communicate the concept behind the project to the visitor. The structural system will be part of the space itself and it will not have only the function to support the building and, together with the detailing, it will assume an aesthetic role in the design process. The architecture will serve not only as a functional space, but as a way to experience different sensations where not only the eye will play a part, but it will be incorporated together with the tactile and the thermal senses defining an architectonic whole.

SUSTAINABILITY

The architect should always remember about all the sustainable aspects which come into play in a design process. This mean that sociological, economical and environmental considerations will be taken into account but they will not be the main focuses. The idea is then to reuse all the marble that will be extracted and integrated in the new construction, as well as exploit the existing streets and collect the rainwater. The building should be accessible for everybody and it should create new economical possibilities for the area.

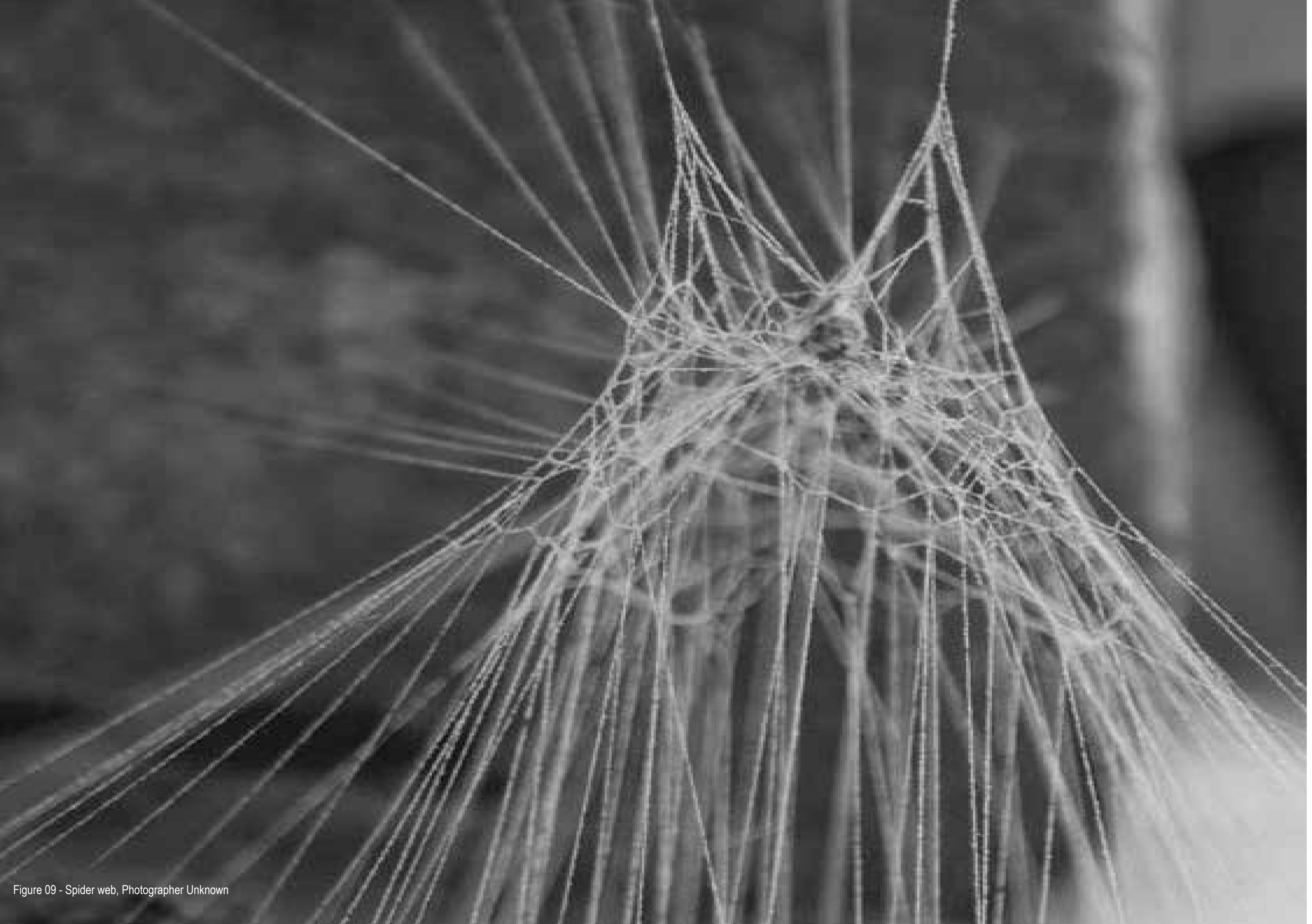


Figure 09 - Spider web, Photographer Unknown

THEORIES

TECTONIC

Tectonic in architecture is defined as “the science of art of construction, both in relation to use and artistic design” [Webster's Dictionary].
It refers not just to the “activity of making the materially requisite construction that answers certain needs, but rather to the activity, that raises this construction to an art form”. [Anderson S., 2002, p.117].
Through history several theorists and philosophers had already defined this word in different ways, but always starting from the etymology. According to Martin Heidegger's thinking in his book “Poetry, Language, Thought”, the art of construction is closely related to the concept of dwelling. Thus he analyses the etymology of the German word for building, *buan*, which means to dwell. Though to build is not only a way to inhabit, but it means to live itself. Kenneth Frampton said that it was derived from the Greek word *tekton*, which means carpenter or builder. The *tekton* later became the *archi-tecton*, or master builder [Frampton K., Gregotti V., 1999]. For both of them it is important to notice how the concept of constructing is closely related to the architecture practice, which cannot be considered simply as a geometric container for people but it is closely associated with technique.
Gottfried Semper referred to tectonics as a phenomenon that defined the use of different materials in architecture as something related to culture and traditions of the place, giving a cultural interpretation of tectonics [Semper G., 2011].
Rivka Oxman affirms that tectonic is about the integration between form, material, structure and construction. According to the architect, the origins of tectonic expression appear to reside in the tradition of vernacular buildings, which “represents the essence of material technologies in being a pure and, generally, a direct expression of the structural and constructional potential of the material” [Oxman R., 2010]. In her article, Digital Tectonics as a Morphogenetic Process, Rivka Oxman explains three different theoretical form-finding approaches to tectonics: designing based on the form, material or structure as main criteria.
Structure first is an approach were the morphological principle is established first, considering which type of supports should be applied in the design and if the construction is a cable net construction with tension stresses or a dome with compression stresses.
Material first is an approach, which takes the first step in analyzing the materials performance and afterwards establishes structural principles that suits the material performance best.
Form first is an approach were the main geometry parameters of form are decided early in the process and construction and materials must accommodate the chosen form.
In the Carrara Thermal Baths project, the form will be the first and main parameter in order to explore the relation with the context.
Afterwards structural, detailing and thermal analysis will be done to gain the wanted atmosphere in the building. Studies upon rainwater collection will be done since water is one of the main element in the project.


Figure 10 - Materility, Photographer Unknown

ATMOSPHERE

Böhmes theory says that atmosphere is a fundamental part of aesthetics, starting from Kant's aesthetic, in which it is essentially judgments, discussion and conversation, to Walter Benjamin's concept of aura, passing through the semiotic concept of the "iconic sign". They do not reproduce the object but *"some condition of the perception of this object"* [Eco U., 1972]. Many philosophers such as Hermann Schmitz dealt with the definition of what an atmosphere is and what aesthetic creations are. For Schmitz atmospheres are always extensive: *"without borders, disseminated and yet without place that is, not localizable".* Atmospheres are affective powers of feeling, spatial bearers of moods, and a phenomenon which is disjoined from real measurable objects. According to his thinking aesthetic creations are defined in this way: *"A sensuous object of a lower degree. I designate aesthetic creations if in this way they absorb into themselves atmospheres, which are objective feelings, in a quasi-corporeal fashion and thereby indicate a corporal emotion through them"* [Schmitz H., 1964].
Schmitz' conception rules out the possibility that they could be produced by qualities of things. For Böhmes instead atmospheres are *"Spaces insofar as they are tinctured through the presence of things, of persons or environmental constellations, that is, through their ecstasies"* [Böhmes G., 1993].
The change of the ontological meaning of objects it is clearly favourable to his aesthetic theory. Atmospheres are neither something objective nor something subjective. It is clear that there is an increasing aestheticization of reality, and the new aesthetics is a response to this phenomenon: *"Perception is basically the manner in which one is bodily present for something or someone or one's bodily state in an environment and the primary object of perception is atmospheres"* [Böhmes G., 1999].

For this reason many architects started to be interested in atmosphere, asking themselves what the architectural atmosphere is.
Peter Zumthor tried to answer this question by examining his relation with architecture and how it deeply involves the human perception. The first step to explain the atmosphere is to talk about the magic of the real. This 'magic' is described as the human interaction with objects. In order to perceive the feeling generated by a space, it is necessary to feel the endless interactions between the elements in the space, how the organs work in relation to each other and how the consequence of this collaboration creates an intangible strong power in the body (space) [Zumthor P., 2012]. To explain this empathy with the architectural space, it is possible to say that the architecture can touch the human as a real body would be able to.
The most important "organs" are the material, temperature and light. *"There are a thousand different possibilities in one material alone"* [Zumthor P., 2012] - and every material has its color and temperature. Therefore, the possibilities to generate an atmosphere are limitless. A good architect can find the meeting point between different materials, they should be not too far from each other and not too close in order to interact. In order to explain the third important element, Zumthor said *"to plan the building as a pure mass of shadows then, afterwards, to put in lights as if you were hollowing out the darkness, as if the light were a new mass seeping in".* [Zumthor P., 2012].
The light models the space and makes us able to see colours and textures. Light and darkness are the most communicative means through which the architecture can move people.

"Sensation comes from us, not from the object which we see. If we can understand the nature of what we see and the way we perceive it, then we will know more about the potential influence of man-made design on human feeling and thinking." [Gropius W., 1956, p. 30].

As Walter Gropius wrote in his essay called "Scope of total architecture" there is a powerful relationship between the perception of the reality and the sensations recalled in the observer. Perception is the cognitive act that occurs when a subject interacts with the environment around thorough the view organ. The psychological mechanisms are enhanced and they elaborate the physical stimuli following defined simple principles. This theory is based on the Gestalt laws of the perception founded by Max Wertheimer in Germany in the 20th century. The Gestalt rules are the product of visual experiments and the study of the relationship between the view organs and the brain behaviour during the visual perception.
Walter Groupius aimed to define objective architectural principles to shape the human world in order to enhance specific psychological and emotional responses in the observer and finding the common denominator for a good architecture.
The Gropius's interest in the Gestalt theory was mostly related to what Josef Albert calls "a meaningful approach to the production of form" [http://gth.krammerbuch.at/sites/default/files/articles/Create%20Article/Discussion_F.].
Architecture has to supply spiritual and material need of a human life according to the Gestalt psychologists investigations about how we perceive and interpret form and colours in the mind.

"I consider the psychological problems, in fact as basic and primary, whereas the technical components of design are our intellectual auxiliaries to realize the intangible through the tangible" [Gropius W., 1956, p. 30].

In the chapter "Is there a science of design" Walter Gropius tries to find key points relating architecture features with psychological or emotional reactions in the observer, aiming to define scientific principles for an objective good architecture creation.

Subconscious reactions

The eye can enhance different subconscious reactions in the experience of a transparent balcony railing at the 20th floor and an opaque one. The first architectural element recalls the sensation of giddiness even if it provides the same physical protection of the second element, and the second type provides both physical and psychological protection. In architecture it is possible to deduce how the design of the spacial environment directly effects the observer's unconscious reactions. [Gropius W., 1956]

"These examples show that there is a split between physical perception on the one hand and our intellectual knowledge on the other. [...] Our equilibrium is re-established through the illusion of safety although nothing has been added in fact for greater physical safety. The eye does not know, it reacts automatically ". [Gropius W., 1956, p. 32]

Optical illusions

According to the Gestalt principles is common knowledge that the eye is an unaware subject of optical illusions or image distortions created by the curvature of the retina. The principles of the vision applied in architecture balance the eye distortions and increase the quality of the perception. For instance in architecture white and black elements should be designed, placed and shaped according to the principle of irradiance or the stripes on the columns of a cathedral can give the perception of a more slender column if placed vertically. [Gropius W., 1956]

Psychological influence of shapes and colours

In the visual art as well as in architecture the use of shapes, lines , colours and textures have a direct impact on the human perception. For instance the human being is being accustomed to natural soft colours that derives from the natural environment more than strong colours and to organic shapes from rigid geometries. The dark colours are perceived heavier than the bright colours and in an architecture as well as in the natural landscape the balance is given from bright colours in the upper level, and dark colours on the ground (natural order). [Gropius W., 1956]

The human scale

The human body is the yardstick of the human surrounding. An architectural space designed in human scale gather to the feeling the human can control and order his own space, defining boundaries of a part in the infinite world that he can rule. Small scale and big scale affect the human perception in opposite ways. The over scaled architecture in history has been used, for instance, during the Egyptian emperor to enhance the feeling of fear and power of the gods and better control the population. As a contrast , enclosed spaces generate sense of intimacy and protection as the human had experienced at

the beginning of the life itself (innate memory). [Gropius W., 1956]

"The designer can organize the psychological effects of his creation by increasing or decreasing the scale of its parts which changes the relationship with us". [Gropius W., p. 37].

Distance, time and space relations

The space is a composition of massive elements and empty space. The architect has to find the flux, the order to place the volumes and how to design the voids that are essential for a good architectural composition. The balance between the mass and the emptiness generates what also Zumthor calls "the atmosphere" or space synergies. [Gropius W., 1956]

The need for change

Human beings need to be constantly stimulated in order to keep the receptive abilities alert. The experience of a long comfortable situation can, in the period of time, become uncomfortable because of our innate need of changing. The possibility to create a space with different features can satisfy the need of changing perceptions. For instance Gropius underlines the importance in architecture of the natural enlightenment of the space that according to atmospheric weather, time and day changes completely the appearance and the perception of the space. [Gropius W., 1956]

"Art must satisfy this perpetual urge to swing from contrast to contrast; the spark, generated by tension of opposites, creates the peculiar vitality of a work of art " [Gropius, p. 40].

"The architect of the future should create through his work an original, constructive expression of the spiritual and material needs of human life, thus renewing the human spirit instead of rehearsing thought and action of former times" [Gropius W., p. 40]

Walter Gropius determines in this way optical keys to make of the artistic act not just a sterile "*short cut of the brilliant mind but an integration between the intangible sensation of the space and the space itself, trying to define scientific impersonal basis for "meaningful shapes*". [Gropius W., 1956]

THE BATHS OF CARACALLA

The baths of Caracalla are one of the greatest example of imperial baths in Rome, built between AD 212 and 216, during the reigns of Septimius Severus and Caracalla.
Still preserved for most of their structure and free of any modern building, the complex has a strong symmetric plan inspired by the Baths of Trajan on the Esquiline, which is considered the prototype of the Roman imperial baths. The system is a great example of good spatial distribution based on sun exposure and heating system.

The main building has a strong symmetric structure, with the bathrooms placed on the central axis and the other functions duplicated on both sides. This is due to the water heating system used which was provided by hypocausts, hearts in the lower floors spreading warm air in the gaps under the floor supported by short brick pillars. Centering the baths on a main axis was a strategy to minimise the construction of hypocausts and so exploit better the floor heating.

The orientation of the complex exploits the best sun exposure, with the steam rooms and the Calidarium (hot bath) facing South, unlighted by large windows and sticking out from the main structure as a forepart.
Furthermore, the baths were an important meeting point for everybody, they were not just a place for baths, sport and body care, but also a place for study, discussing politics, walking and eat. It was the place where Romans loved to take care of their body and their mind. [Piranomonte M., 2012]

The illustration below allows the reader to have a walk through the whole structure, retracing the ancient itinerary that the users used to do and exploring the different environments and atmospheres.

1. The main access to the complex was placed on the North side of the enclosure. The space between the fence and the main building was a walking porch path leading to the main garden facing South.
2. Users could access the main building through four gates. Two gates led to vestibules, entrance halls which guided the users to other environments. From the vestibules, the users had the possibility to enter the changing rooms on the right, the outdoor swimming pool crossing the colonnade on the left or approach the cold bath passing through a rectangular room.
3. Two gates led to the gyms through three paved rooms with black and white mosaic and originally covered by vaults.
4. The changing rooms led to the gym area.
5. The gym area was composed by a central open courtyard closed by a colonnade porch on three sides.On one of the longer side of the porch a great hemicycle environment took place, covered by a half dome and with niches in the walls. On the other side a long tripartite and apsed room was located.
6. On the other minor side of the gym a path guided to a series of four steam rooms with different plan and dimensions, all heated and characterized by small oblique accesses in order to avoid the heating dispersion. Passing through these room it was possible to approach the calidarium.
7. The calidarium was a great round schaped room hosting the hot bath. The calidarium and steam rooms faced the South in order to gain as much solar heating as possible.
8. Leaving behind the round calidarium, the users could approach the tepidarium, a smaller and temperate environment composed of a squared room with two tanks on the sides and niches in the walls.
9. Carrying on along the main axis, the users could have a cold bath in the frigidarium.
10. The bath ended with a leap in the natatio, a big outdoor swimminpool rectangular shaped.
11. The vast quadrangular fence used for several services enclosed a ample garden facing South.
12. On both sides two great exedras were placed which included a hall with an apse, preceded by a colonnade and flanked by two smaller lecture rooms.
13. On the bottom of the fence a big exedra was placed hiding the huge tanks that had a capacity of 80,000 liters.
14. On the sides of this exedra two apsed rooms used as libraries were located.

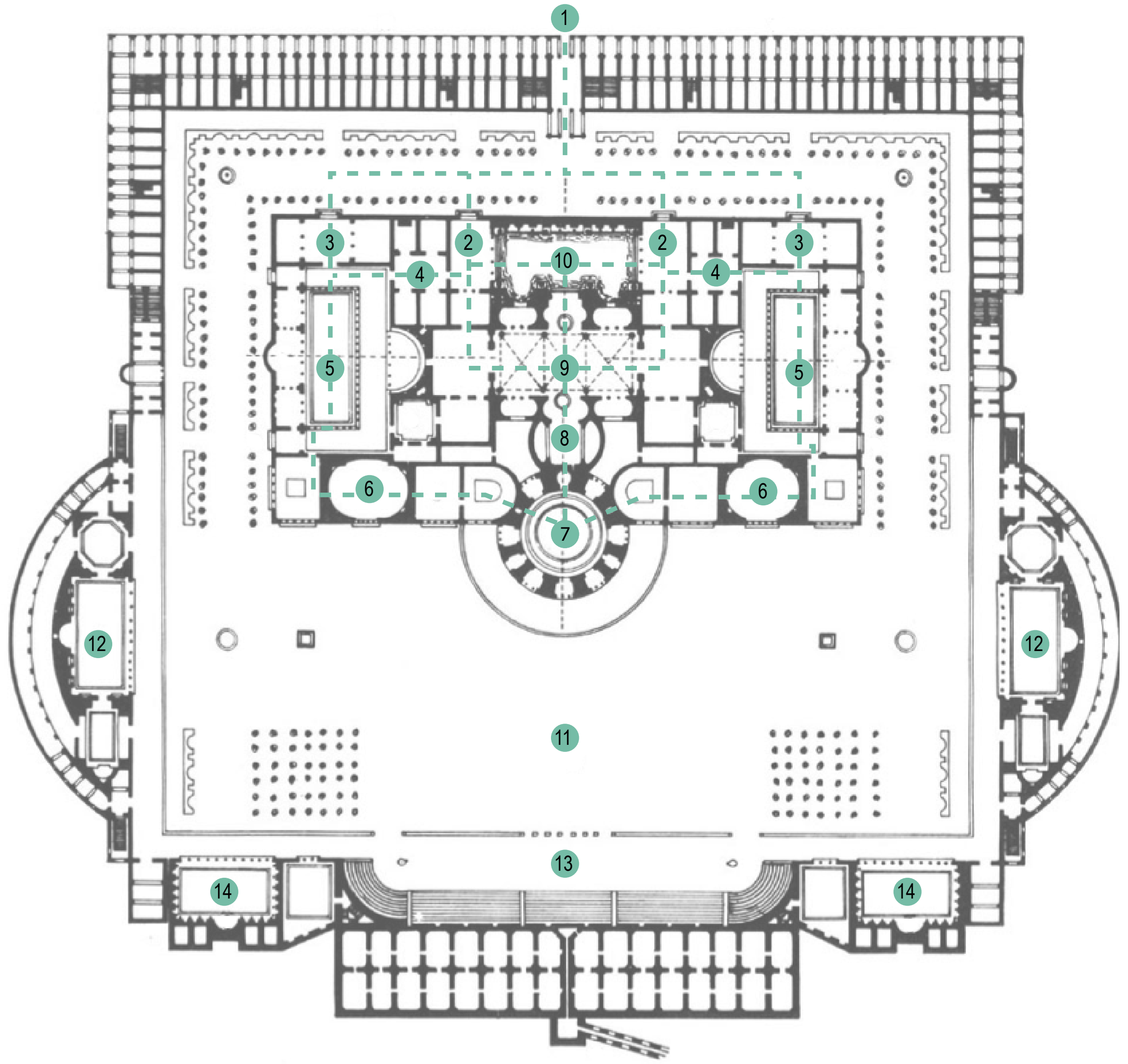


Figure 11 - Caracalla Thermal Baths, Own Illustration

THE THERMAL BATHS AT VALS

Peter Zumthor's Vals Thermal Baths can be seen as the material translation of the concept of atmosphere in one building. It has been explicitly designed to give to the user thermal experiences, as the Romans used to do with their baths, where the impact of light, temperature and humidity were controlled in well-defined spaces by their proportions, organization and use of materials. [Foged H. I. W., 2015]
The way Zumthor conceived the spatial composition concerns with *"mass and hollow, openness and compactness, rhythm, repetition and variation".* [Zumthor P., 2014]
It involves *"cutting gigantic tables out of the blocks of a quarry, then joining them together and stacking them on top of each other"* [Zumthor P., 2014], and eventually producing the image of *"one single mass of stone, hollowed out from the front, from the top, from inside".* [Zumthor P., 2014]
This way of proceeding is clearly reflected in the creation of different sequences of atmospheres and experiences inside the thermal baths, and it can be divided in four zones: the entrance, the steam rooms, the indoor pools and the tension between indoor and outdoor.
When entering the building a visitor will pass through a curve tunnel from the hotel, which leads to the "fountain hall", enlightened with soft artificial lights that distributes the changing rooms. In this pathway water from the spring spouts from five brass pipes at head height, leaving painterly traces of ochre and rust on the concrete walls and stone floor (fig. 12).
After this sequence of dark spaces (fig. 17) the building opens up in a raised stone platform which offers the first view towards the spatial continuum of the bathing landscape (fig. 13). The steam rooms are located in one corner of the building and the entrance is easily overlooked, not noticed until the second or third visit. Each of the two vestibules lead to a sequence of three sweat chambers, each successive room getting darker by the material colour and hotter, leading to the last and hottest one, with black floor, walls and ceiling, where a upright steam column stands and the contours gets hardly discernible as they reach upwards towards a diffuse light source (fig. 18).
After descending the long and smooth stair from the level of the steam and changing room a round circulation space opens for the visitor, where in the middle it is located the indoor pool (fig. 14). Four rectangular stones, each including a different sensorial experience, demarcate the limits of the pool and protect it from the surrounding circulation zone. A visitor will then pass through small and enclosed rooms where experiencing acoustic, olfactory and thermal sensations, to an open, brighter and less intimate space (fig. 19). Here the journey is even more enhanced by this continuous passage between small niches embedded in the stone and a large central zone with natural light coming from openings in the ceiling.
In the building the tension between indoor and outdoor is explored by Peter Zumthor in two ways: visual tension and thermal tension.
When walking around the central pool there is a sequence of open and closed view to the outside. The north and east sides have an inner focus, which means that the perspective vision is given by the building itself. Slowly, in the south facade, rhythmic openings offers the view on the natural landscape outside, and a visitor will experience the sensation of being in a linear envelope, projected towards nature (fig. 15).
In the east side there is a combination of visual and thermal tension: two small windows let the user seeing a built environment in the outside, but the most powerful expression can be found when the visitor dives in a narrow corridor of water, realizing that at the end there is a connection to the outside. This connection, hidden to the eye, is clearly reflected in the sight of water vapour coming from the meeting of hot water and cold air in the outer pool (fig. 16).


Figure 12 - Fountain Hall, Photographer Unknown

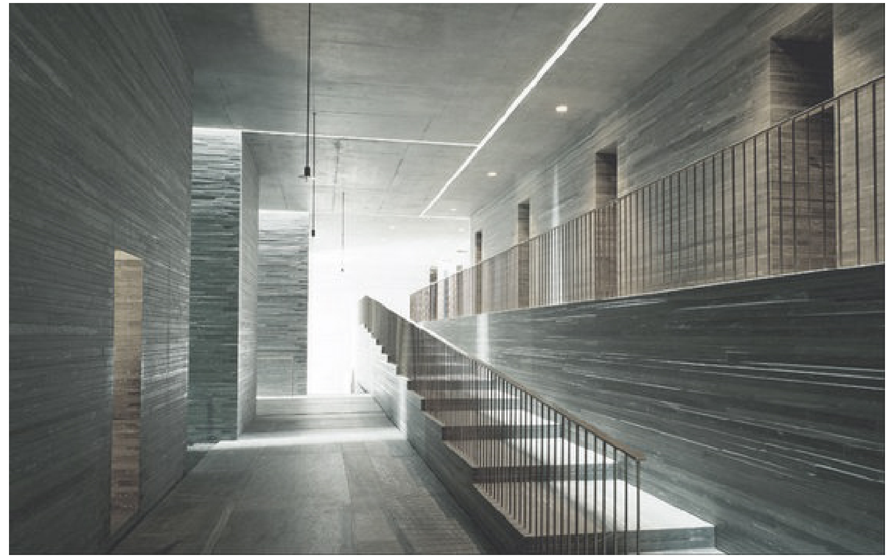


Figure 13 - Stoned platform, Photo by Margherita Spiluttini


Figure 14 - Central pool, Photo by Hélène Binet


Figure 15 - Natural landscape, Photo by Fernando Guerra


Figure 16 - Water vapour, Photo by Fernando Guerra

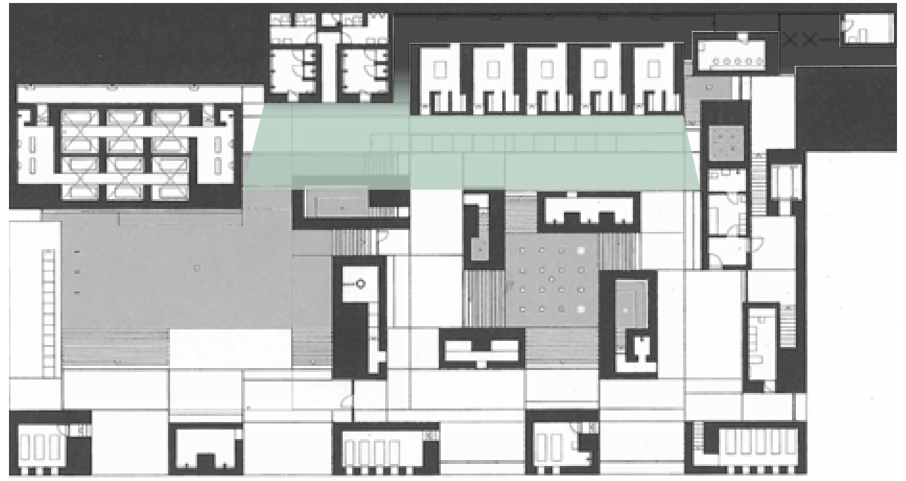


Figure 17 - Dark - narrow / light - open, Own illustration

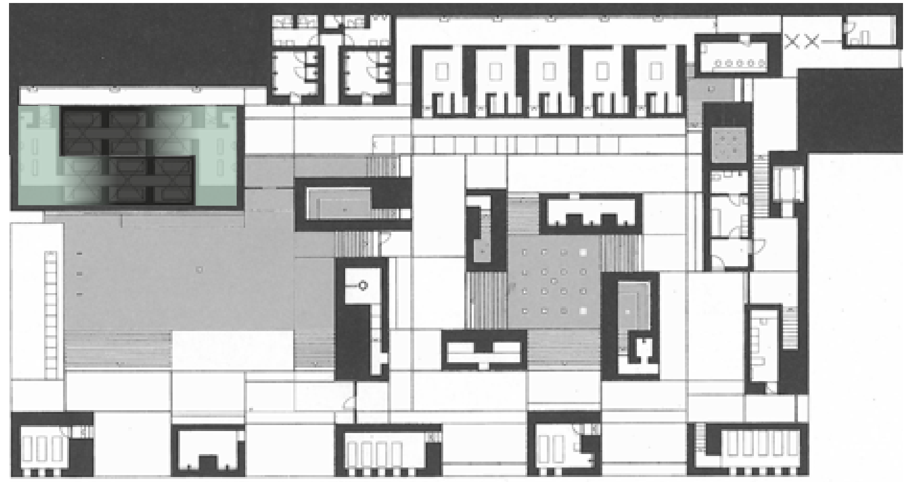


Figure 18 - Temperature - light sequence, Own illustration

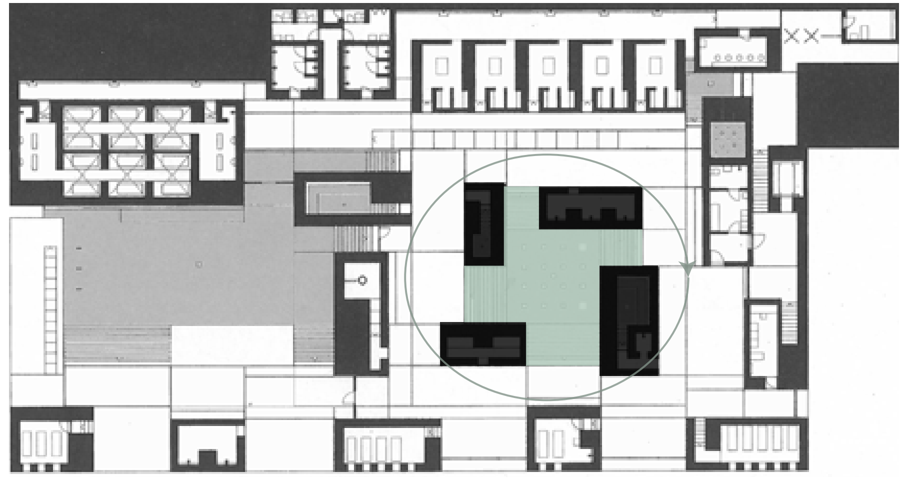


Figure 19 - Open - close sequence, Own illustration

HISTORY

Carrara is a small Italian municipality of 63.000 inhabitants located in Tuscany, between the Mediterranean Sea and the Apuan Alps. It is worldwide known for its activity of extraction and manufacturing of white marble, which takes the name Carrara Marble from the city indeed.

It is known that there were villages from the Apuan population since the IX century b.c., but the extraction of the precious stone started only during the II century b.c., when the Romans conquered the region. Therefore the actual city has its origin from the hamlet built to host the quarry workers, which were extracting the marble and exporting it to the rest of the Empire from the Luna colony, located at the outlet of the Magra river. [Callegari D., 1866]

In the course of the V century the extraction activity was subjected to a period of standstill due to the barbarian invasions, but afterwards with the diffusion of the Christianity and the start of the Middle Age, the marble was requested in big quantities for the construction of religious buildings. [ET Edizioni, 2016]

During the Renaissance the Carrara marble was used by Michelangelo for his sculptures, who used to go to personally choose the blocks to work on. [Rapetti C., 2002]

In the XX century marble was mainly used at the time of the Fascism: Mussolini's desire to go back to the Roman Empire magnificence, combined with a wish of economic self-sufficiency which demanded the use of local material, forced the use of this stone in public architecture.
[Biennale internazionale di scultura Città di Carrara, Crispolti E., Barbero L. M., 1998]
During the last century from a worldwide vision though, stones in general and marble especially were adopted mainly for cladding concerning architecture and they lost the structural function that they had during the Roman Empire.

Today the marble of Carrara is running into hard times due to the financial crisis and the growing competition from abroad. Thirty years ago the marble produced in the world used to be finished in Carrara, but today countries such as China, India and Brazil have invested in tools to work this stone and they are manufacturing it locally instead of sending it to the historical marble capital. [AFP, 2010]

It is thus important to look at history and at the actual situation with a vision for the future and to understand that architecture can attempt to overturn the logic of the market. Experimenting new techniques in the use of this material can be a way to give new perspectives to the economy of Carrara, as well as to conceive alternative ideas for the use of stones in general.

MARBLE

The extraction, transportation and manufacturing methods used for the marble changed through history according to the development of technology in terms of machineries and tools.
ange in the extraction techniques occurred in the 16th century with the advent of explosives. This process beyond varying the act of quarrying, it also transformed radically the surrounding landscape: the explosions opened big gashes in the mountainside, which in turn led to the opening of new quarries. With the introduction at the end of the XIX century of wire saw several advantages came: it avoided the fracturing of the blocks, reducing waste to a minimum. In the last 100 years the development of technologies led to the evolution of several machineries to drill and extract the stone: today single-blade gang saws and mechanical diggers with a big power supplanted the work of men. [http://www.carraramarble.it]. The transportation method used during the Roman Empire have been used until few decades ago and it was called lizzatura. It consisted in moving the blocks from the quarry to a flat area by dragging it on purpose-built wooden lizzas (fig. 20). In remote times the block were conveyed with this technique all the way from the quarry to ship over trails. With improvements of the road system safer methods of transport occured, but nevertheless for centuries the use of lizzas remained the only option for the trajectory from the quarry to the platform. Only in the 1940s, with the construction of tortuous road network through the marble fields, rubber-tired vehicles could load the marble blocks in the quarry and transport them to the processing plant. [http://www.carraramarble.it]
Concerning the cutting techniques, the oldest description is contained in a passage by Pliny the Elder (Naturalis Historia I, XXXVI): "But whoever it was that first invented the art of thus cutting marble, and so multiplying the appliances of luxury, he displayed considerable ingenuity, though to little purpose. This division, though apparently effected by the aid of iron, is in reality effected by sand; the saw acting only by pressing upon the sand within a very fine cleft in the stone, as it is moved to and fro" (Rackham H., 1958). This technique has been in used until the second half of the 18th century, when water-driven sawmills came into use. Afterward cutting gang saws with several blades were invented and in the last century the technology developed different kind of tools: today multi-blade gantries with diamond-point cutting edges, vertical cutters, diamond-point cutters and other machines are used and they can be located directly in the quarry, revolutionizing in many case the working process. [http://www.carraramarble.it]

Figure 20 - Rest of a wooden lizza, Own photo

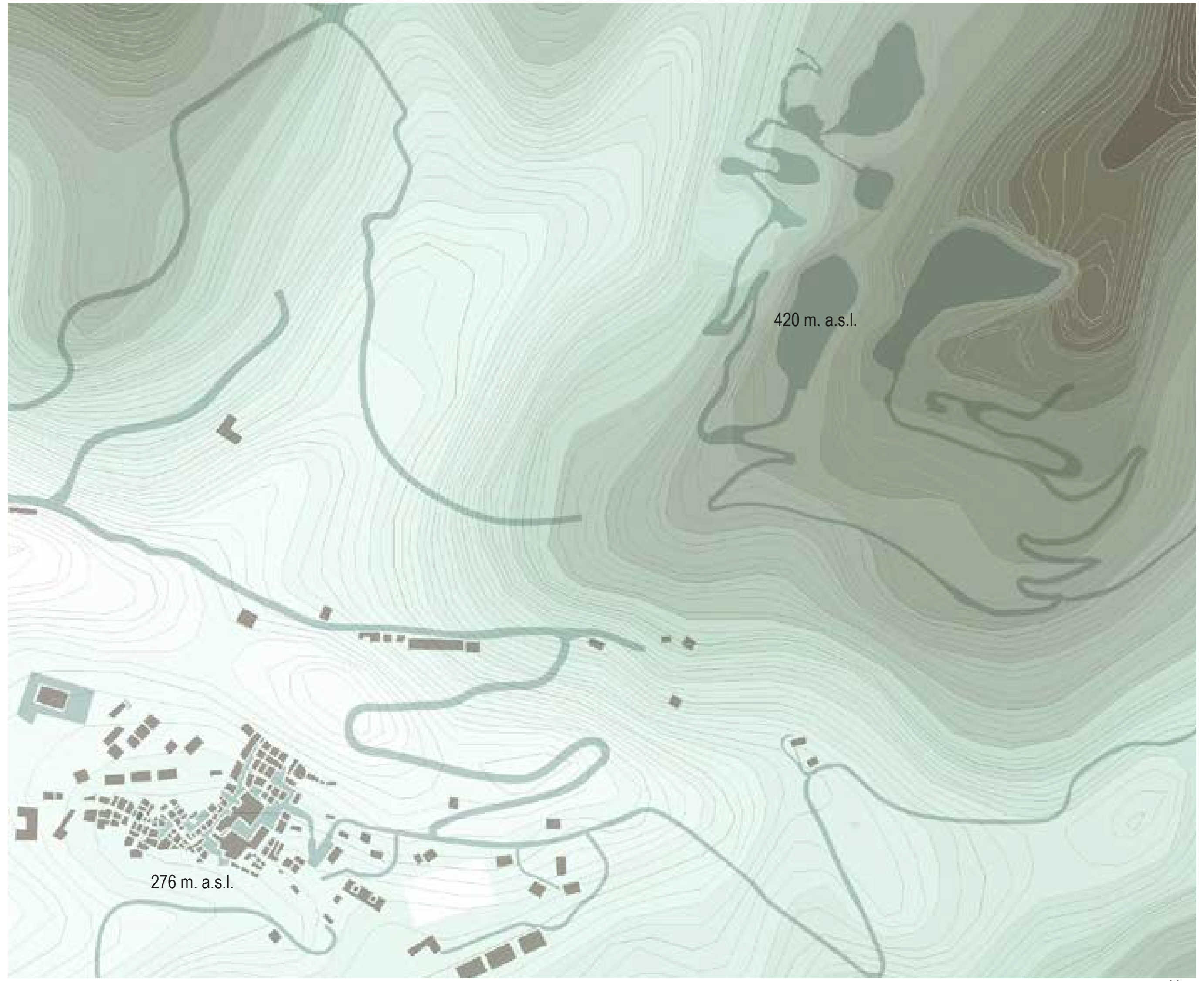
02

PROGRAM

Figure 21 - Marble quarry, Photographer Unknown

TERRAIN CONFORMATION

The thematic map shows how the conformation of the quarry follows the mountain shape, the concavity of the area is situated at the base of the mountains where the city of Bedizzano is placed. Some large flat terraces are present in the highest part of the promontory , product of the marble and machinery work. The terrain conformation analysis is divided in colours range set every 30 m above the s.l. (sigle levels are set every 5 m above s.l.).



Buildings

Streets

Highest levels

Lowest level

Level every 5 m

Figure 22 - Terrain levels, Own Illustration

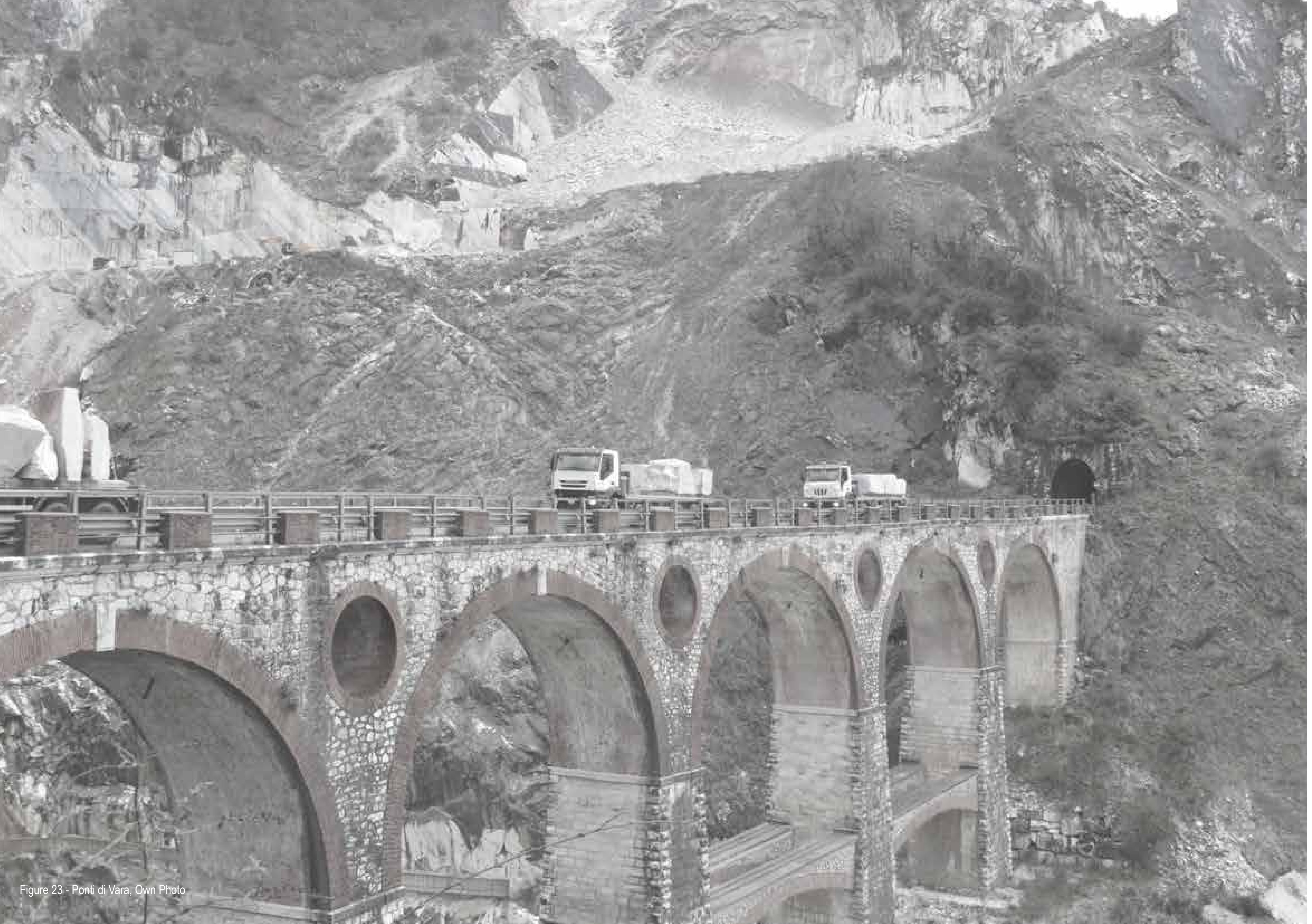


Figure 23 - Ponti di Vara. Own Photo

INFRASTRUCTURES

The main street Martiri del lavoro is situated at the bottom of the valley and it connects the city of Carrara with the city of Bedizzano and Colonnata. The secondary streets as the Miseglia Fantiscritti and Ponti di Vara gallery lead to the quarry streets that are not named but are signed in the map.These two streets are characterized by several galleries were a railway were placed to transport the marble blocks in the past.

Principal street

Secondary streets

Quarry paths and streets

Terraces area

Tunnels

Figure 24 - Infrastructure, Own Illustration

VEGETATION AND NATURAL LANDMARKS

In the site area the vegetation is really rare due to the composition of the ground and to the excavating works. The white areas underline the presence of the marble quarry, the light green areas are covered by low trees and bushes and the darker areas are covered by tall vegetation.
The river is called Carrione and it collects all the rain water not absorbed in the quarries.The debris that the water bring into the river erase the level of the river bottom and in the rainy days the river floods.

- River
- Low vegetation, bushes
- Tall vegetation, woods
- Infrastructure
- Marble quarry

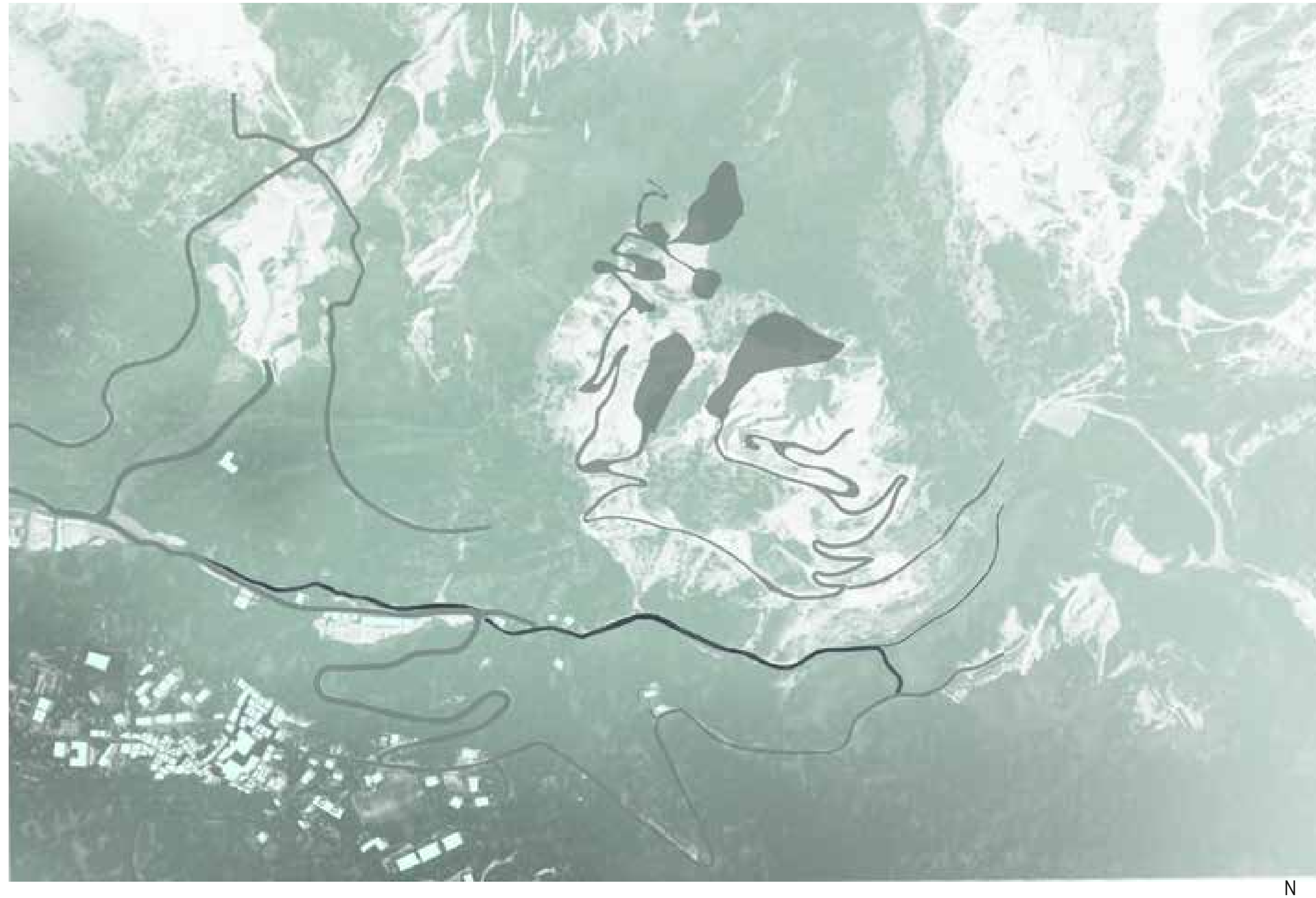


Figure 25 - Vegetation and natural landmarks, Own Illustration

SERVICES

Bedizzano is a small town which host several functions of restaurant and bed & breakfast. There is also an artistic laboratory for the manufactoring of marble and a football field.

Figure 26 - Services, Own Illustration

TYPE OF VEGETATION

On the hills of Carrara there is a varying vegetation based on the sun exposure.On the southern slope of Monte Sagro, where the site is located, it is possible to identify three slots of different vegetation based on elevation.

The first slot is placed on the first hillside of the mountain between 300 and 900 metres above the sea level, around the town of Bedizzano. Here oaks (quercus), hornbeam (carpinus), ash (fraxinus) and chestnut (castanea) trees form a quite dense vegetation.
The site project belongs to this area, but since humans intervened on the terrain with the quarries excavation, of course woods are no more present on the site and the surroundings nowadays consists in lower bushes and scattered trees.
The second slot which can be identified is placed between 900 and 1600 metres above the sea level. In this area the beech tree is mostly present, together with lower vegetation as the sedges (carex macrolepis) and the wood sorrel (oxalis acetosella). Beeches were used by humans to transport the marble in the quarries and they currently grow in bushes, on almost naked cliffs.
The third slot implies plants that can grow in alpine climate, above 1600 metres on the sea level. The leafless stemmed speedwell (veronica aphylla) and the rockfoil (saxifraga lingullata) are the most flashy and copious.

Being aware of the kinds of species present in the site and the surroundings, it will be possible to identify a type of wood good in construction in order to use it in the project.

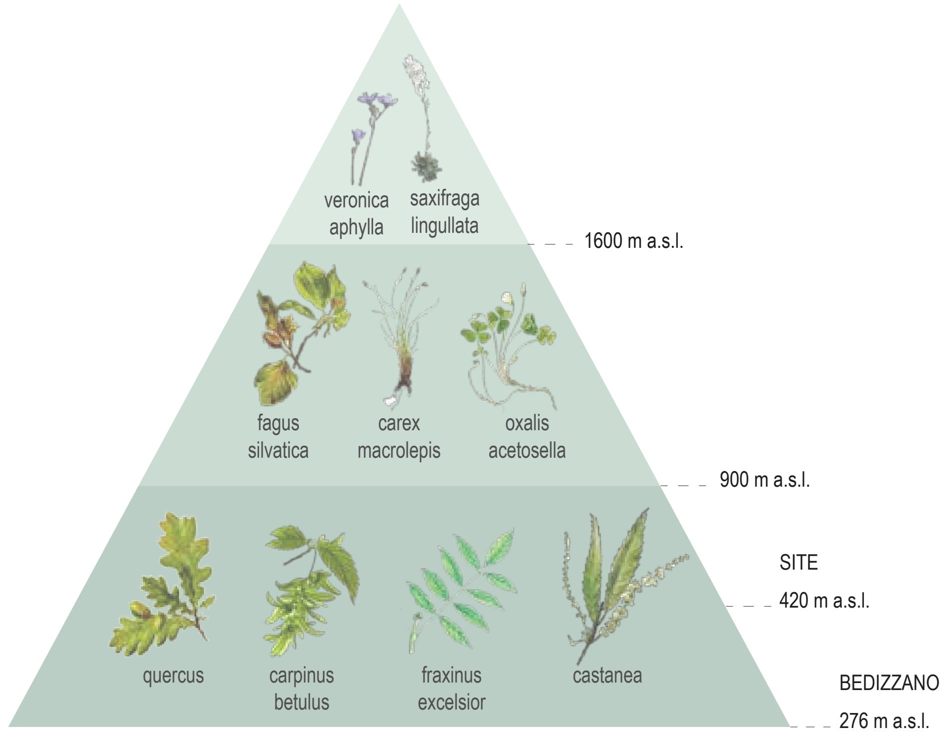
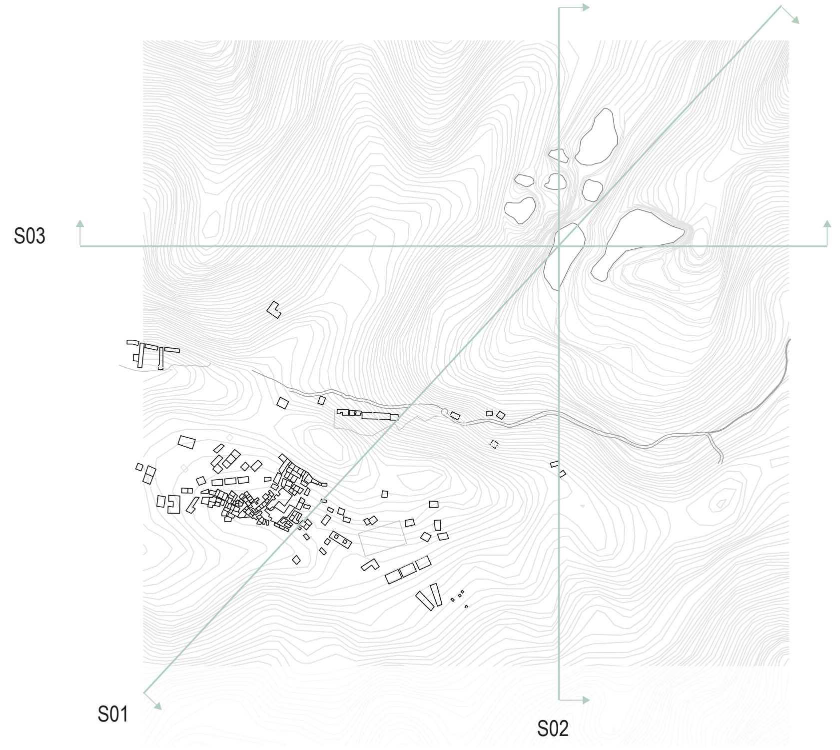


Figure 27 - Type of vegetation, Own Illustration

Figure 28 - Marble quarry, Photographer Unknown

TERRITORIAL SECTIONS

The project will be located on one of the several flat terraces that the human action created to move the machinery for the marble manifacturing. The terrain sections ideally show how the ground composition and the vegetation distribution change according to the level above the s.l. and the climate conditions.



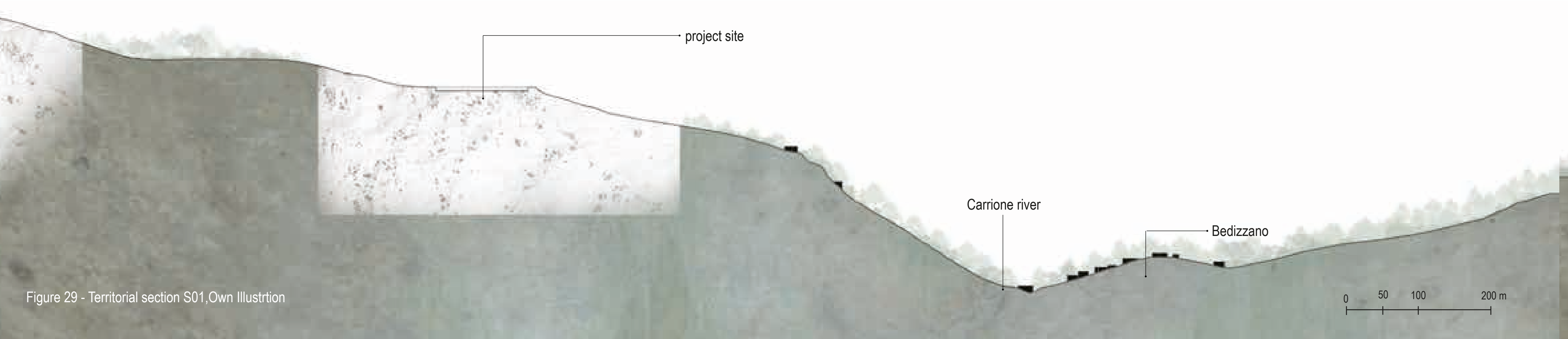


Figure 29 - Territorial section S01,Own Illustrtion

Figure 30 - Territorial section S02,Own Illustrtion

Figure 31 - View on the valley, Photographer Unknown

Figure 32 - Territorial section S03,Own Illustrtion

RAIN

The diagram shows how many days per month, certain precipitation amounts are reached. During spring and autumn the dry days are approximately 50% of the total days of the month, thus rain is an important factor to take into consideration.

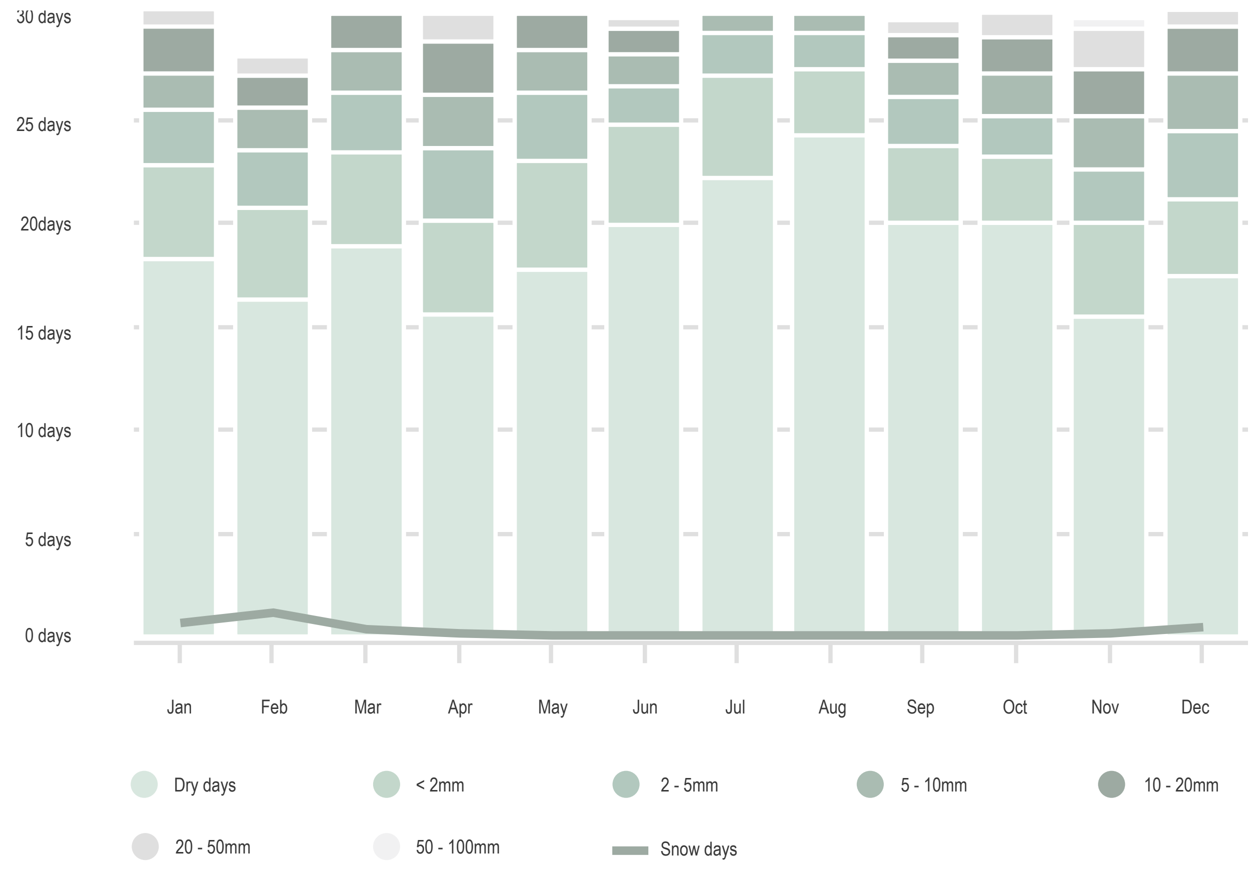


Figure 33 - Precipitation diagram, Own Illustration

TEMPERATURES

The diagram shows how many days per month certain temperatures are reached. During winter the frost days are almost 50% of the of the total days of the month, and during summer the temperature is above 25°C in 70% of the time: Mediterranean weather is characterized by cold winter and hot summer, though it is fundamental to find a balance between design strategy according to climatic conditions.

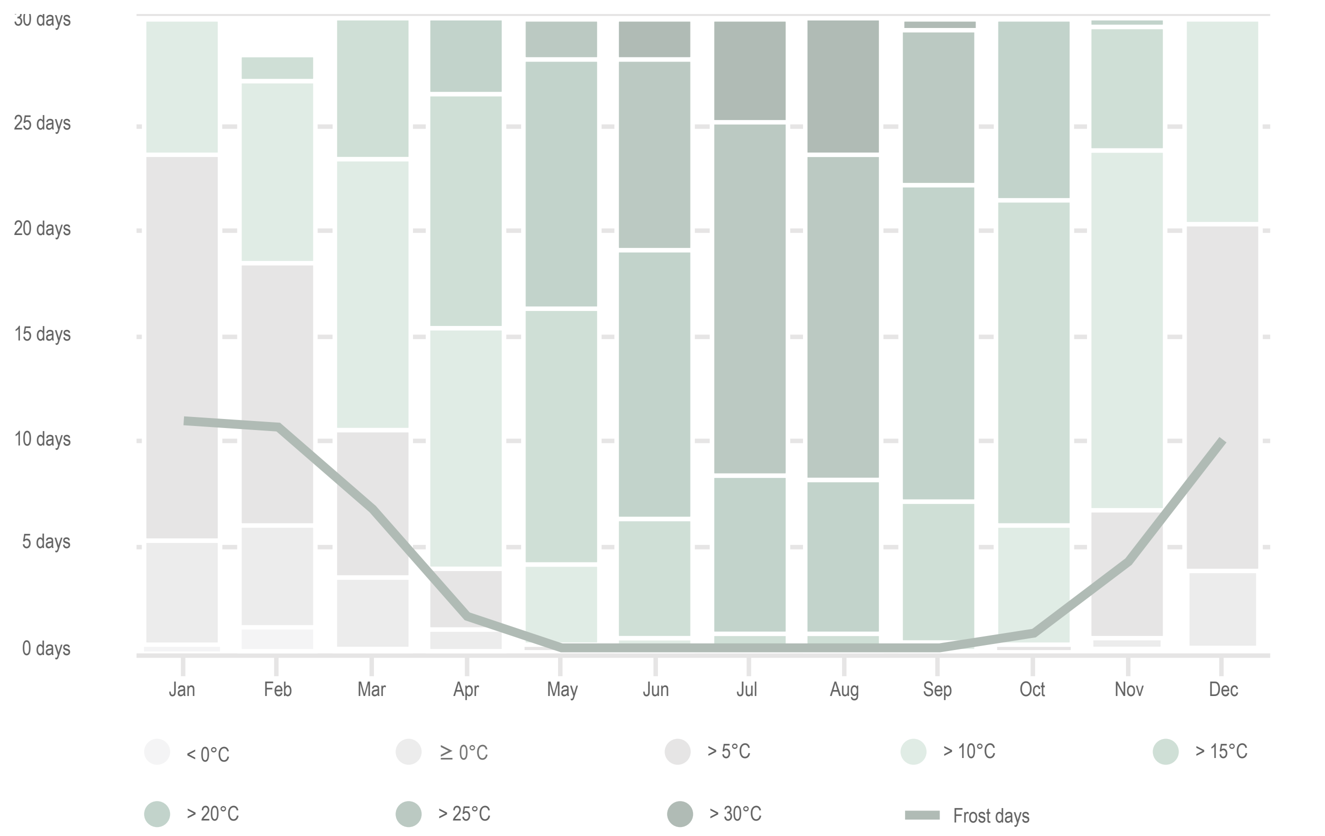


Figure 34 - Temperature diagram, Own Illustration

WIND

The diagram shows how many hours per year the wind blows from the indicated direction, considering a speed calculated in km/h. The South-West / North-East axis is the most windy, reaching a speed between 5 km/h and 12 km/h in 50% of the time during the year.
However, the project site is surrounded by mountains on three sides (North, East, West), therefore this aspect should be taken into consideration in the structural calculations.

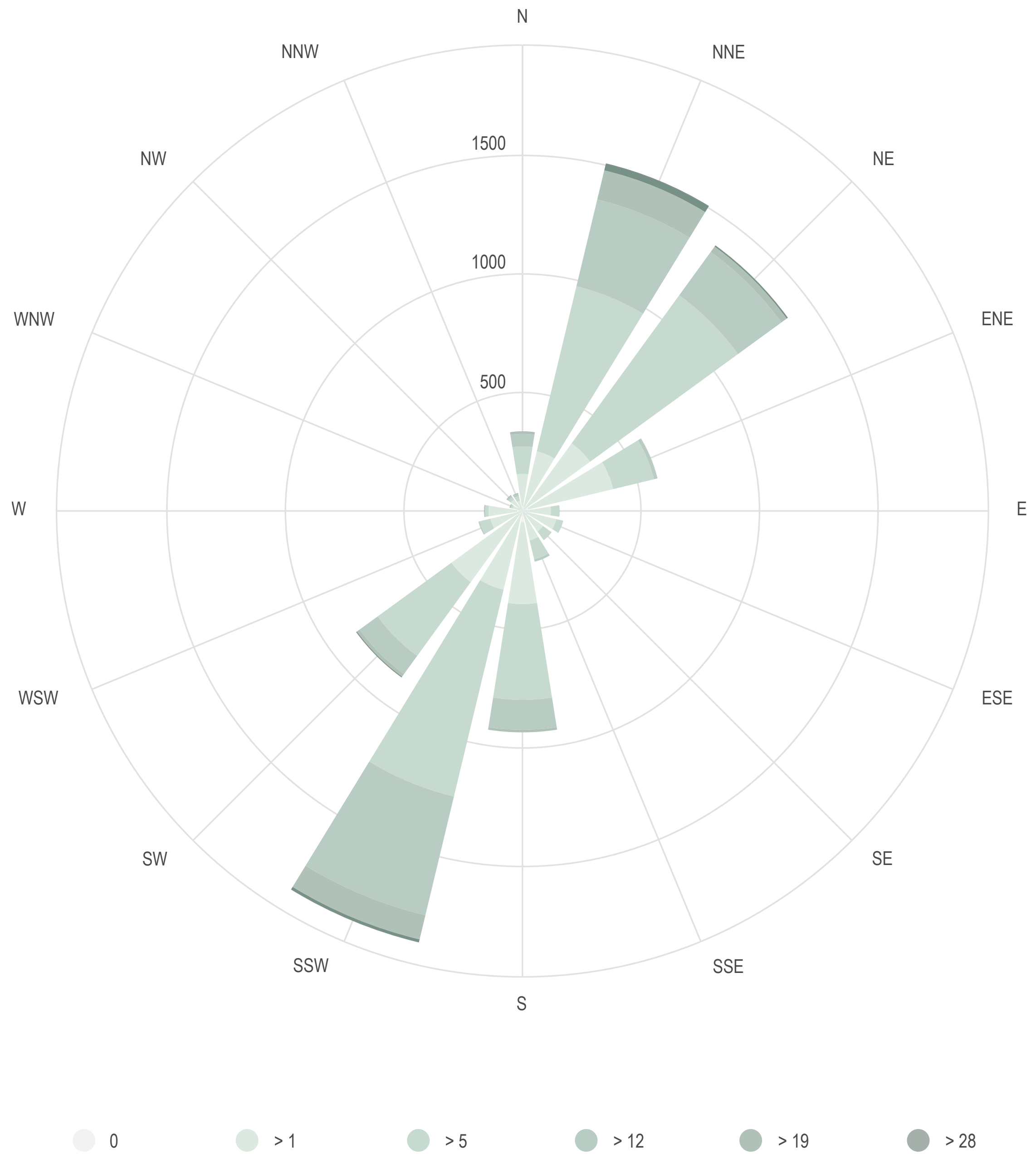


Figure 35 - Wind rose diagram, Own Illustration

SUN PATH

The diagram shows the annual variation of the sun's path through the sky. The hours of light reach the maximum during the June solstice and the minimum during the December solstice, and the sun angle varies from 80° in summer to 20° in winter. The position of the sun according to the horizon it is a very important factor to take into consideration in the design.
Due to the high amount of reflected light by the marble of the site, the building is exposed to high solar radiance during summer and more diffused light during winter.

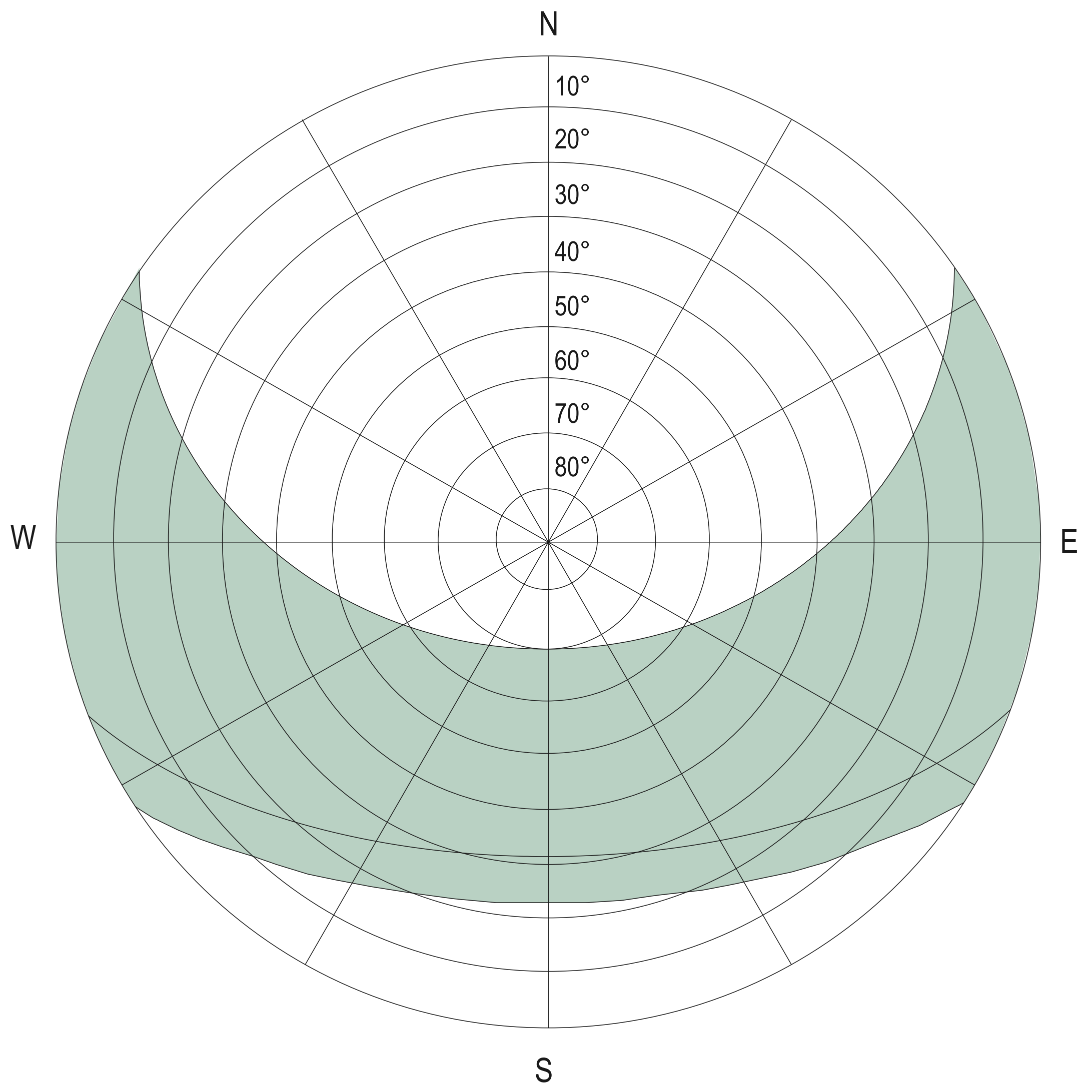


Figure 36 - Sunpath diagram, Own Illustration

Figure 37 - Terracing by night, Photographer Unknown

FUNCTIONS

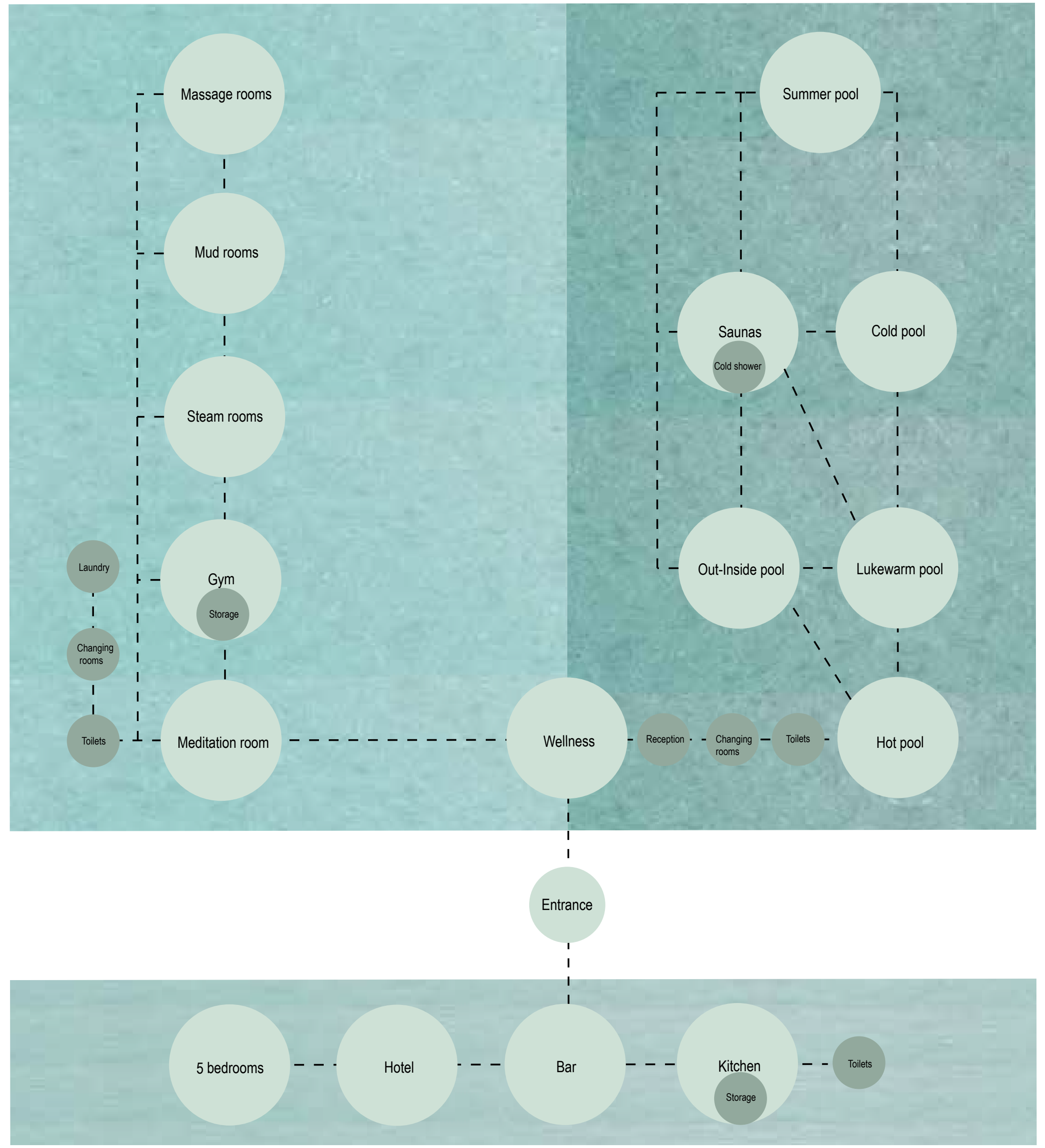


Figure 38 - Functions diagram, Own Illustration

The function diagram shows how the several functions should connect to each other and how the flow between them should be. The spatial distribution has been taught on the basis of the spatial principles reached from the case study of the Caracalla Baths.

	FUNCTION	NUMBER	IDEAL NUMBER OF PEOPLE	m^2	INDOOR/OUTDOOR
WELLNESS CENTRE	hot water pool	1	25	115	indoor
	lukewarm water pool	1	15	84	indoor
	cold water pool	1	8	16	indoor
	hot water pool	1	10	80	indoor/outdoor
	hydromassage pool	1	5	24	indoor
	sauna	2	6	7.5	indoor
	steam room	3	10	17	indoor
	treatment room	3	2	15	indoor
	mud room	2	4	12	indoor
	meditation room	1	9	46	indoor
	gym room	1	15	100	indoor
	realax spot	1	2	18	indoor
	solarium	1	5	38	outoor
	marble garden	2	6	90	outoor
	summer pool	1	7	18	outdoor
	hydromassage pool	2	5	15	outdoor

	FUNCTION	NUMBER	IDEAL NUMBER OF PEOPLE	m^2	INDOOR/OUTDOOR
LEISURE AREA	bar terrace	1	30	66	indoor
	bar/restaurant terrace	1	20	55	outoor
	meeting room	1	10	54	indoor
	public square	1	15	50	outdoor
	terrace	1	20	60	outoor
	public hydromassage pool	1	5	16	outdoor
HOTEL AREA	double room	4	2	37	indoor
	family room	1	3	47	indoor
SERVICE AREA	toilet users	4	—	10	indoor
	changing room	2	—	20	indoor
	technical room	1	—	35	indoor
	lockers room	1	—	19	indoor
ADMINISTRATION AREA	reception area	1	2	20	indoor
	toilet	3	—	10	indoor
	staff changing room	2	10	20	indoor
	storage	2	—	20	indoor
	kitchen	1	5	25	indoor
	laundry	1	2	11	indoor
TOTAL				1 680	

* Toilets are conceived as the block of igenic services for the changing room (2) and for the restaurant (1)

ROOMS ATMOSPHERE


Figure 39 - Photographer Unknown

HOT WATER POOL

- cozy
- direct natural light
- brightness
- view towards the site
- wood
- perception of the structure

air temperature: 28 °C

water temperature: 37 °C


Figure 40 - Photo by Art Gray

LUKEWARM WATER POOL

- natural filtered light
- meeting between materials
- intimacy

air temperature: 23 °C

water temperature: 34 °C


Figure 41 - Photo by Amir Corour

COLD WATER POOL

- soft light
- experience into the marble
- cold colours tones

air temperature: 15 °C

water temperature: 10 °C


Figure 42 - Photographer Unknown

INDOOR/OUTDOOR WATER POOL

- deepness
- meeting with marble
- natural indirect light reflected by the quarry wall
- vapour

indoor air temperature: 25 °C

water temperature: 37 °C


Figure 43 - Photographer Unknown

SUMMER POOL

- natural environment
- strong connection to the marble
- proximity to solarium
- caustic phenomena

air temperature: environment

water temperature: 29 °C


Figure 44 - Photographer Unknown

HYDROMASSAGE POOLS

- intimacy, privacy
- marble surrounding

air temperature: environment

water temperature: 38 °C


Figure 45 - Photographer Unknown

MUD BATHS

- relaxing
- view towards the marble
- attention to provacy

air temperature: 23 °C

water temperature: 38 °C


Figure 46 - Johnathan Friedman

SAUNAS

- intimate space
- wood

air temperature: 70 / 90 °C

-


Figure 47 - Photographer Unknown

STEAM ROOMS

- light coming from the ceiling and diffused by vapour

air temperature: 50 °C

-

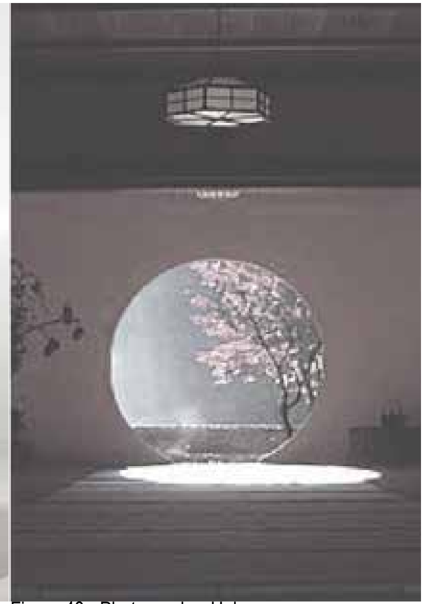


Figure 48 - Photographer Unknown

MEDITATION ROOM

- natural light
- view towards the marble
- warm materials

air temperature: 23 °C

-

Figure 49 - Marble quarries, Photographer Unknown

PROBLEM STATEMENT

QUALITIES

Carrara is located between the mountains and the sea. The natural landscape is thus very wide and the touristic possibilities heterogeneous: the visitor are attracted by either the mountains, the sea, or the history of the city.

CRITICISM

The marble economy is at the moment in a deep crisis due to the economic down of the last years. Carrara is not anymore the most important centre of marble manufacturing since. As a consequence of the globalization, other countries developed local techniques rather than sending the marble to Tuscany for finishing. Since the main economic source of Carrara was the extraction and the manufacturing of the marble, it is nowadays necessary for the city to find new strategies for an economic growth.
The mountain landscape has been strongly modified by the marble excavation and extraction, assuming the typical terracing conformation of the quarries. But what does it happen when these quarries become inactive?
The problem statement focus is to rethink the quarry as a design challenge, when they will be dismissed.
The de-naturalization process has left a deep mark in the ecosystem of the area. A lack of strategies for the future of the quarry might let it as a skeleton of the past, with no qualities beyond the historical memory.
The streets construction to access the quarries and the reduction of the riverbed span is nowadays causing serious problems of overflowing in the city of Carrara. An urban intervention is needed in order to restore the original capacity of the riverbeds.

POSSIBILITIES

Carrara marble is well known, at least from an historical point of view. For this reason, around the city there are a lot of museums and organised excursions through

to the quarries. In this way an occasional tourist might be interested in seeing how these famous quarries apear, and how the manufacturing of the marble is made.
Nowadays, people interests are more focused on the research of sensations and experiences, for this reason the biggest possibility for the development of tourism in the area at the moment would be to experience the sense of the marble. A very pleasant way to experience it is to create a wellness centre with thermal baths, offering possibilities for different typology of users.
Furthermore, the design of the building will partially solve the water issue within the site, through a punctual intervenction of rain water collection.

CONCLUSION

The Quarry Thermal Baths attempts to be a place where people experience different sensationstaking care of their own body and mind. The design will enhance the genius loci of the place. Furthermore, the Baths will create new employment positions and they will open up new economical possibilities for the near cities and villages.

Figure 50 -Graphic work by Sarah Wickings

TARGET GROUP

Figure 51 - Own Illustration

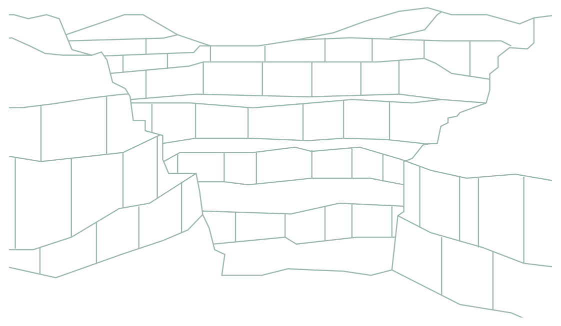


Figure 52 - Own Illustration

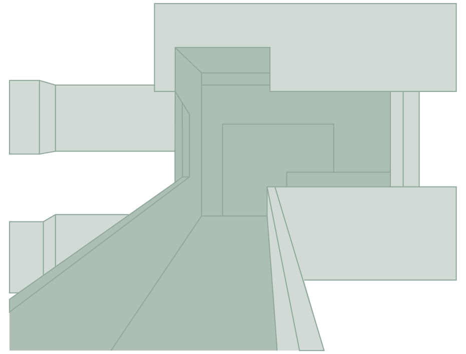


Figure 53 - Own Illustration

RELAX

- people of every gender and age who want to take care of their body and soul

QUARRY EXPERIENCE

- Tuscany and bordering regions inhabitants who want to live the quarry
- international tourists visiting the quarries
- photographers and artists

ARCHITECTURAL EXPERIENCE

- architecture lovers

PERCEPTION

- IDENTITY: EYE PERCEPTION
  - FAST ARTIFICIAL EXTRACTION
  - BRIGHT COLOURS
  - HEAVY AND GIANT MARBLE MASS
  - GEOMETRICAL LINES AND CUTS
  - TERRACING CONFORMATION
  - OPEN VIEWS
  - PROTECTION
  - MARBLE PATTERNS
- SENSES: FEELING PERCEPTION
  - SILENCE
  - ANCIENT PLACE
  - PERCEPTION OF GIANT MASSES
  - SMOOTH SURFACES
  - DISSONANCE BETWEEN HORIZONTAL AND VERTICAL FORCES

DESIGN PARAMETERS

- ENHANCED CONTRAST BETWEEN MASS AND VOID 〈 MONUMENTAL ENTRANCE
- UNDERLINED GENIUS LOCI OF THE SITE 〈 VIEWS ON THE QUARRY
- EXPERIENCE IN THE NATURAL ELEMENTS SUCH AS WATER, MARBLE, WOOD . 〈 USE OF MATERIALS ACCORDING TO THEIR INNER PROPERTIES AND BEHAVIOUR TO LIGHT

03

PRESENTATION

Figure 54 - The cut, Own Photo

CONCEPT: THE CONTRAST

01

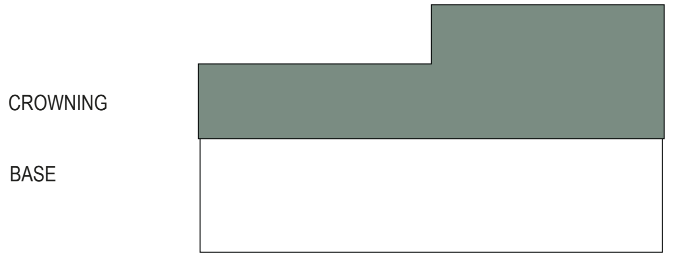


Figure 55 - Contrast 01, Own Illustration

02

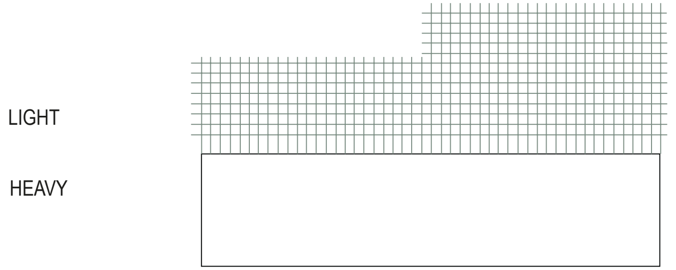


Figure 56 - Contrast 02, Own Illustration

03

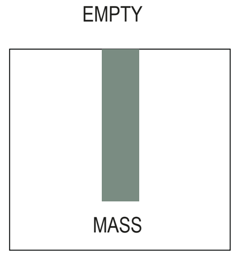


Figure 57 - Contrast 01, Own Illustration

The concept of the project is to create an experience of the contrast. The site has certain defined peculiarities that could make the building disappearing in the context.
Acting by contrast, the difference of identities of the building and the surrounding marble is underlined.
To experience the contrast means to perceive opposite sensation in different levels. The concept is declined into three main levels of constrast that lives together creating sinergies in the composition.

01

The contrast can be explored thinking about the difference between a crowning, the building, and the base that is already existing in the site as a 9.3 m hight terrace of massive marble.

02

The contrast can be visually perceived in terms of volumes. The innate heaviness of the marble base clearly counterposes itself to the lightness of the building, which seems to delicately float on the marble.

03

The contrast can be discerned in terms of mass and its negative space. While the marble base conserves its intrinsic massivity, the access to the building is done through cutting the primary material, allowing the visitors to experience the mass trough its emptiness.

BASE AND LEVELS

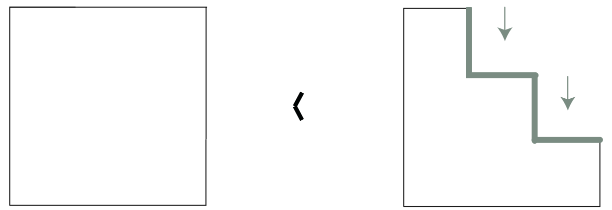


Figure 58 - Own Illustration

The project implies the escavation of the marble base in order to play with levels within the building. This strategy will help to experience the marble in all its possibilities so to create different atmospheres according to the functions.

DIALOGUE

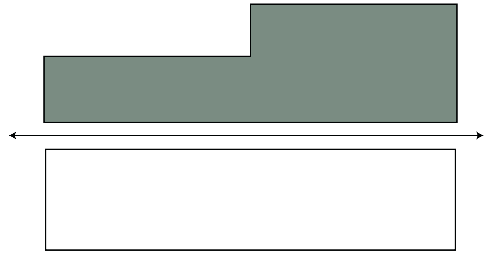


Figure 59 - Own Illustration

A strong relation of contrast between the base and crowning is enhanced. In order to underline the conceptual separation between the two, the connection of the building to the terrain aims to be light and as transparent as possible.

HUMAN SCALE

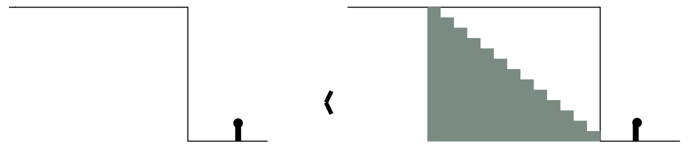


Figure 60 - Own Illustration

The human scale is introduced within the wide site by cutting the 9.00 m height block in the shape of a staircase, allowing the users to overstep the natural barrier and approach the building through the direct experience of the marble itself and experience the human and the context scale.

WATER COLLECTION STRATEGY

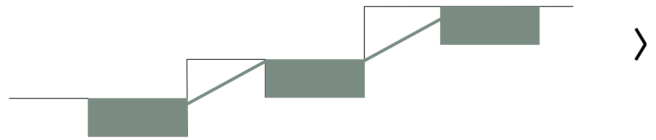


Figure 61 - Own Illustration

The standard water collection strategy used in quarries implies the exploitation of terraces for the escavation of hollows. When the rain water is collected, the heavy refuses deposit themselves on the bottom of the hollow, letting the “clean” water on the surface to flow towards the next hollow and so on exploiting the height difference. At the end of this process the water is dirtless and reusable for other activities.

APPLICATION TO THE SITE

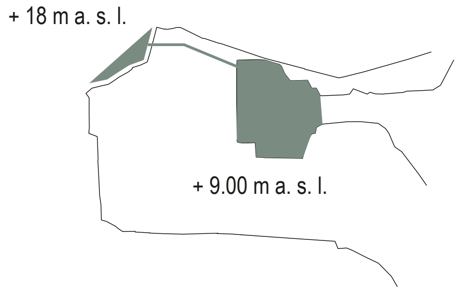


Figure 62 - Own Illustration

This strategy is adopted within the building site, exploiting the natural difference of levels, in order to reuse as much collected rainwater as possible in the thermal baths functions.

MAIN AXIS

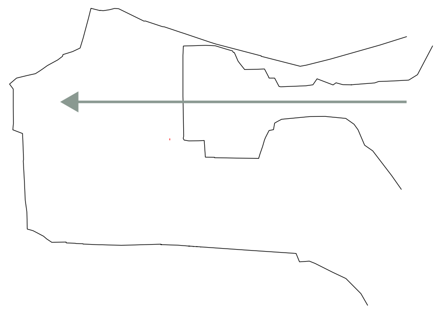


Figure 63 - Own Illustration

The natural site conformation allows to identify a main axis which connects the scenic entrance to the hollow. The building is spread along the axis.

BOUNDARIES

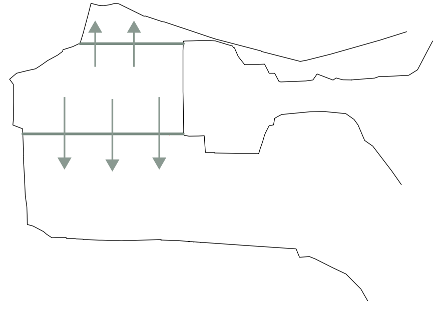


Figure 64 - Own Illustration

The extension of the hollow sides allows to define the boundaries for the building, marking a clear division between the building site and its negative space which it has to relate to.

GRID

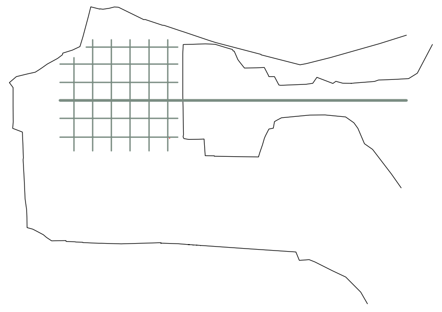


Figure 65 - Own Illustration

Based on the defined main axis and boundaries the plan follows a grid, which also leads to a specific structural method.

LIGHT REFLECTION

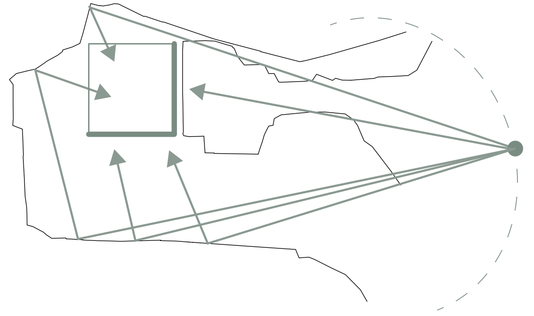


Figure 66 - Own Illustration

Due to the high amount of reflected light within the site, the building is placed in the most sheltered and strategic area. Doing so, while the West and South facades are more closed in order to avoid the direct light coming into the building, the North and the East facades are open to let the reflected light go in and benefit from the proximity to the quarry marble mass.

SPREAD VOLUMES

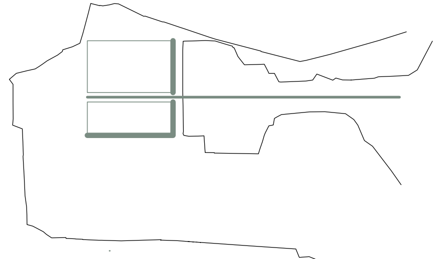


Figure 67 - Own Illustration

The volumes are defined thanks to the boundaries and the main axis, and they are spread along the main axe.

Figure 68 - Territorial section, Own Illustration

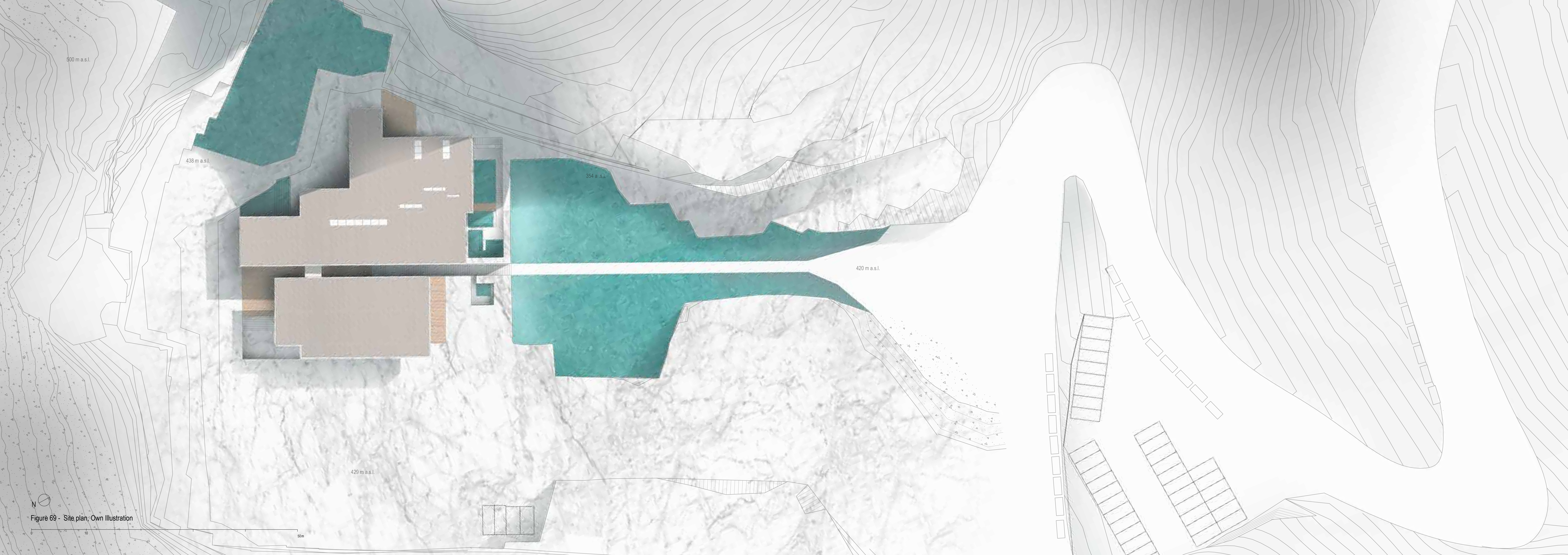


Figure 69 - Site plan, Own Illustration

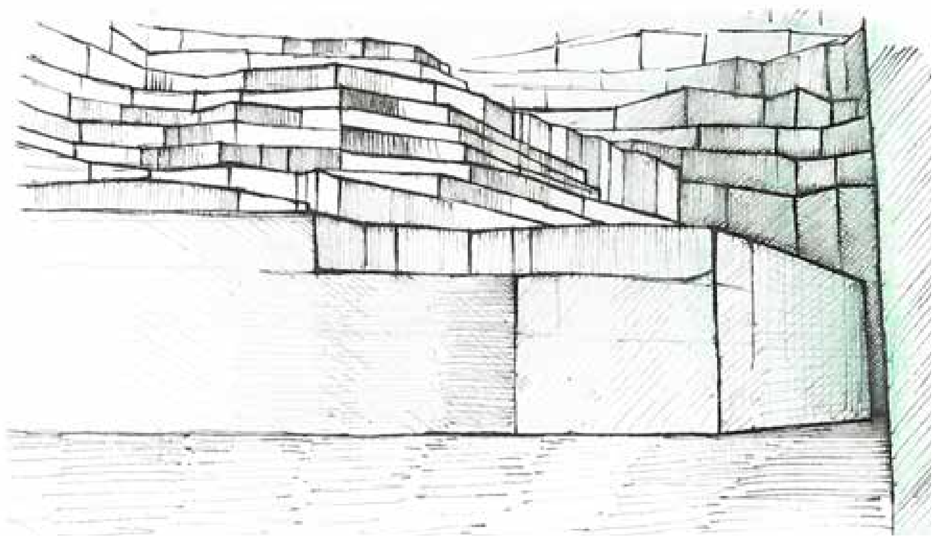


Figure 70 - Marble promenade, Own Illustration

Approaching the quarry thermal baths, visitors walk along a beautiful promenade surrounded by the marble, easiliy guided by the massive conformation of the quarry.

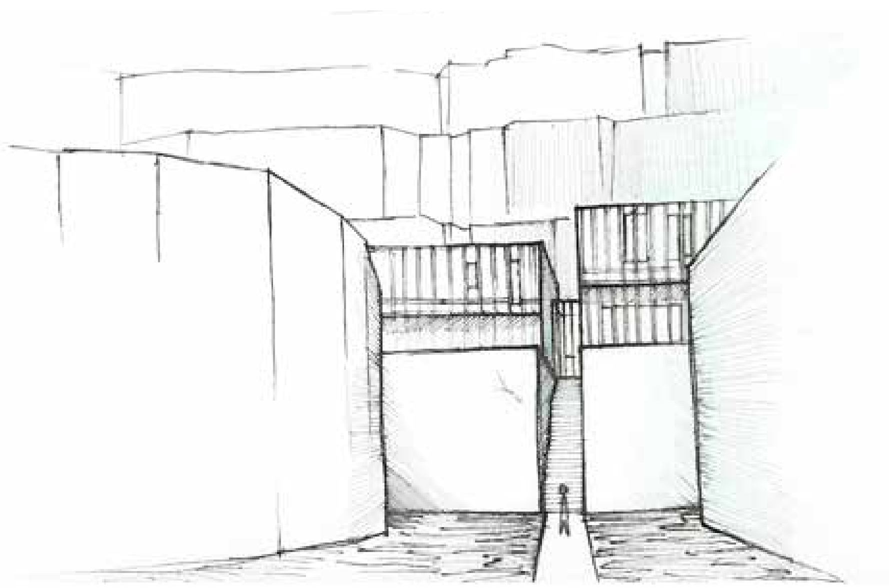


Figure 71 - The building, Own Illustration

The building suddenly appears to the visitors eyes, floating on the majestic marble block. At the first glimpse, the entrance of the thermal baths allows the observer's eyes to perceive the contrast between the light building and the heavy marble base, enriched by the presence of the water. The building seems to float on the water surfaces, enhancing the heavyness of the marble.

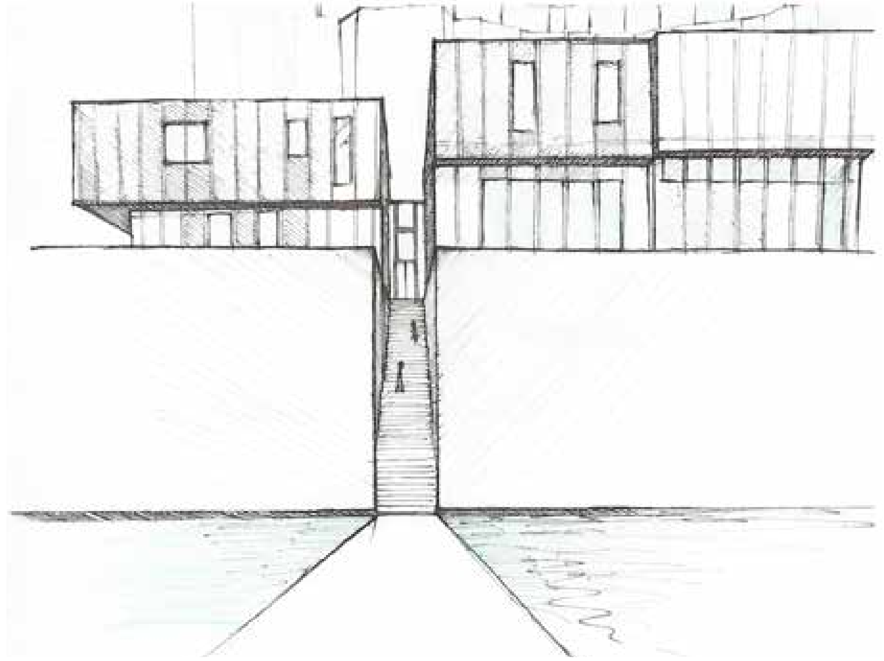


Figure 72 - The carved staircase, Own Illustration

The closer visitors get to the marble base, the more they become aware of the quarry scale. They are able to overstep the natural barrier and reach the building through the cut staircase, which founds a dialogue between the hollow and marble block, the marble block and the building, restoring the human scale within the site.

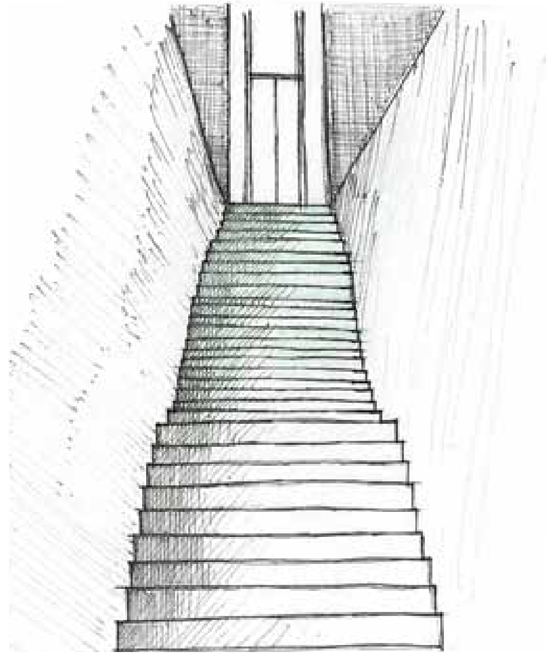


Figure 73 - The entrance, Own Illustration

Climbing the cut staircase, visitors experience the massivity of the marble block being inside. The visual and tactile perception of the material already starts from here. When at the end of the stairs, this sensation of being oppressed by the marble mass disappears, and gives way to the perception of lightness and transparency of the building.

The entrance of the Quarry Thermal Baths is a transparent cube that does not interrupt the view in the carved stairs of the quarry terraces. The backgroun wall of the quarry shows the signs of the extraction process that is the strongest aspect of the site.
Entering the building, on the right, there is the reception and from there it is possible to go to the second floor where the wellness and sport facilities are placed. On the right, instead, the visitors can experience a total immersion in the thermal baths atmospheres.
On the ground floor, the floor and the walls are covered with wood planks. The material gives a warm atmosphere in contrast with the views on the marble garden in which the light projects blue reflection effects. Walking on the right from the changing rooms is possible to go into the hot water pool where the dark entrance hides the bright and wide pool. The vapor catches the light in the air while the structure and the shape of the openings project shadows on the floor in the sunny days. The light and the atmosphere in the pool change with the seasons and the weather. The stairs in the entrance end up in the hot blue water and the user can stay in the pool or walk again up on the second stair. The disposition of the walls and the stairs guide the user thorough different visual and thermal atmospheres.
From the hot water pool a hidden stair guides the visitor to the lukewarm pool where the contrast between the marble on the floor and 1.5 m slabs on the walls are combined with the wood, giving a special sensation of warm wood and colder marble floor.
The intimacy is enhanced by the hidden light coming from the right and the light rays that filtrate thorough the polycarbonate facade and thorough the lamellas of the ceiling. From the lukewarm pool is possible to go downstairs in the cold water pool, that is completely embedded in the marble. The only light source is a bright cut in the marble ceiling.
Going upstairs from the lukewarm pool, instead, is possible to reach the double height hydromassage pool with the view on the marble garden and the vertical view connection with the upper floor, the saunas and the outer pools dig into the base block of the building. The outer pools are placed in different levels according to the sun protection. The summer pool gains more sun light and the hot pools are more protected into the mass of the marble. Both from the inner corridor and from the outer marble garden is possible to reach the out-inside hot pool where the marble outside meet the warm wood room inside using a movable glass door into the water.

LEGENDA

1 entrance
2 reception
3 changing rooms
4 hot water pool
5 lukewarm water pool
6 juice room
7 marble relax spot
8 saunas
9 marble showers
10 hydromassagepool
11 quiet spot
12 indoor/outdoor hot water pool
13 sumer pool
14 solarium
15 hydromassagepools
16 meeting area
17 bar/restaurant
18 bar/restaurant terrace
19 users toilets
20 staff toliet
21 kitchen
22 storage
23 terrace
24 marble public square
25 public hydromassage spot

GROUND FLOOR

Figure 74 - Ground floor plan, Own Illustration

LEGENDA

26 meditation room
27 staff changing rooms
28 laundry
29 users toilets
30 gym storage
31 gym
32 steam rooms
33 showers
34 treatment rooms
35 mud rooms
36 lockers room
37 balcony
38 quiet spot

FIRST FLOOR

N

Figure 75 - First floor plan, Own Illustration

To access the second floor is possible to take the elevator and go to the meditation room on the left with the view on the out-inside pool. The corridor is enlightened from a skylight that allows the filtration of the light in between the trusses of the waffle wood ceiling. On the left part of the corridor there is an inner solarium and a terrace. At the end of the corridor a wide gym is placed, characterised by views on the valley. The steam rooms and the treatment rooms are placed on the South next to the gym. In each of the ma different opening has been designed according to the views and provacy requirements. The leisure and hotel area are placed in the building on the left side of the entrance, where visitors can relax and experience the Quarry Thermal Baths by night.

GROUND FLOOR

Figure 76 - Light in the ground floor, Own Illustration

FIRST FLOOR

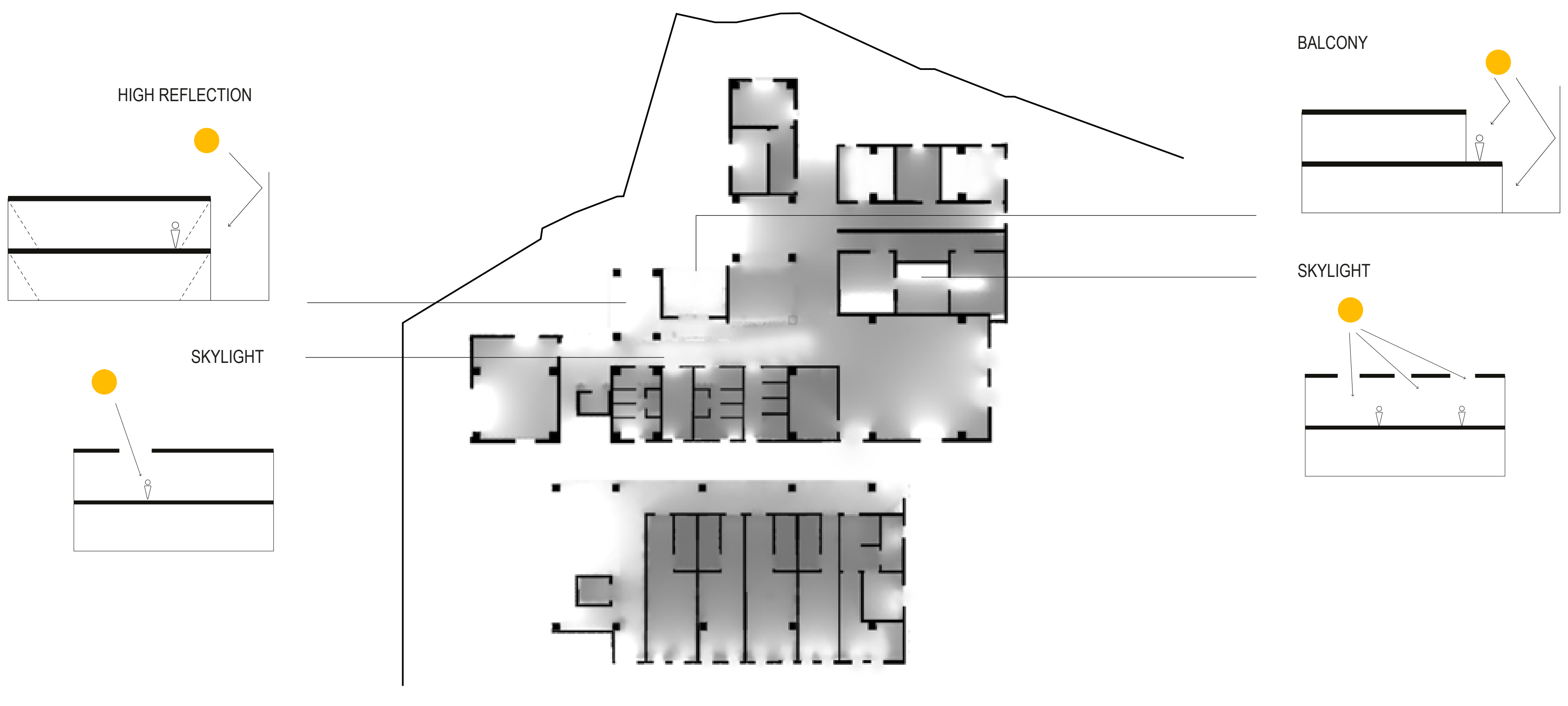


Figure 77 - Light in the first floor, Own Illustration

WATER COLLECTION STRATEGY

LEGENDA

39 cold water pool
40 black water
41 grey water
42 white water
43 pumps
44 boiler hot water
45 water purifier
46 water collector hollow

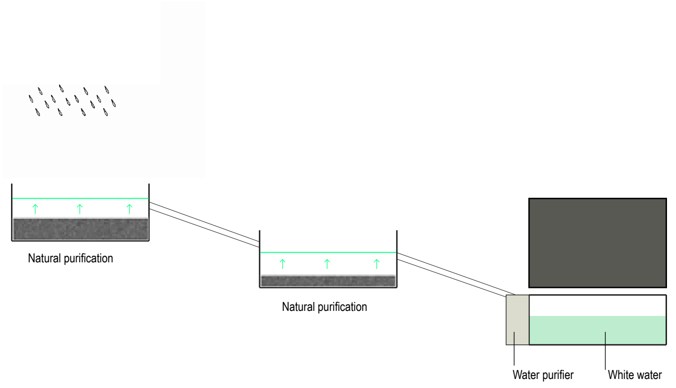


Figure 78 - Water collectors hollows, Own Illustration

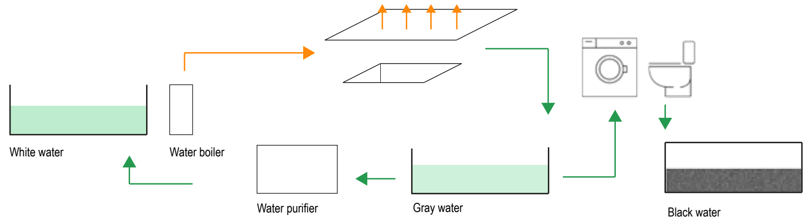


Figure 79 - Water purification, Own Illustration

The water in the quarry is stored in water collectors dug into the ground. The collected rain water gradually loses its impuirities flowing from a collector to the other. Adopting this strategy it is possible to purify the water and reuse it into the building, exploiting the already existing hollows.

The purified water is heated up by a boiler and brought to the hot pool and the floor heating by a pump. The exausted water is then stored in the gray water collector, while part of it is used for toilets and washing machines, the other part is purified and used again in the pools. The black water collector is a septic tank that has to be cleaned once a year due to the fact that the quarry is not well connected to the urban sewer.

COLD WATER POOL AND TECHNICAL ROOM

N

Figure 80 - Cold water pool and technical room plan, Own Illustration

SOUTH ELEVATION

Figure 81 - South elevation, Own Illustration

WEST ELEVATION

Figure 82 - West elevation, Own Illustration

FACADE

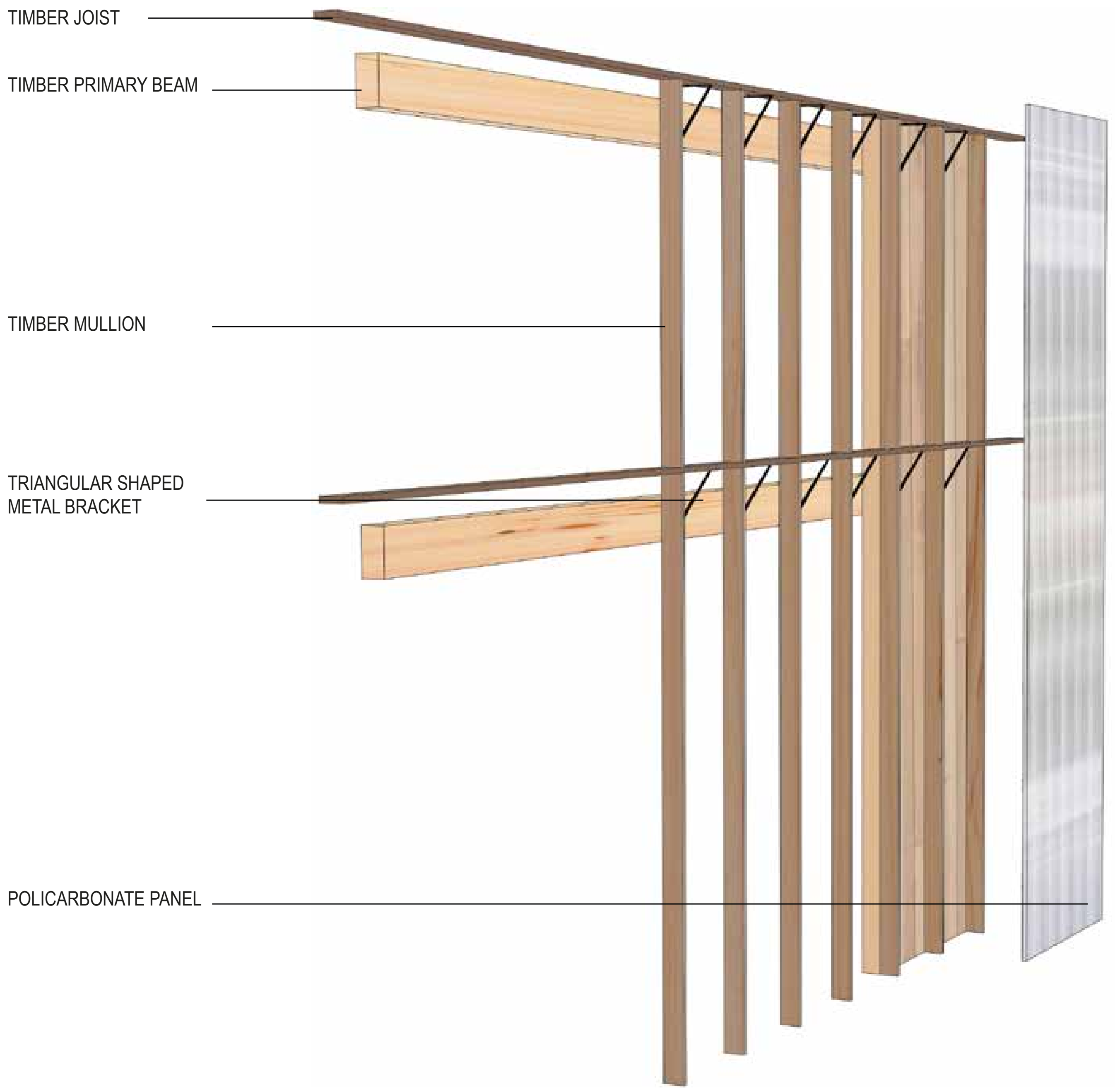


Figure 83 - Facade axonometric projection , Own Illustration

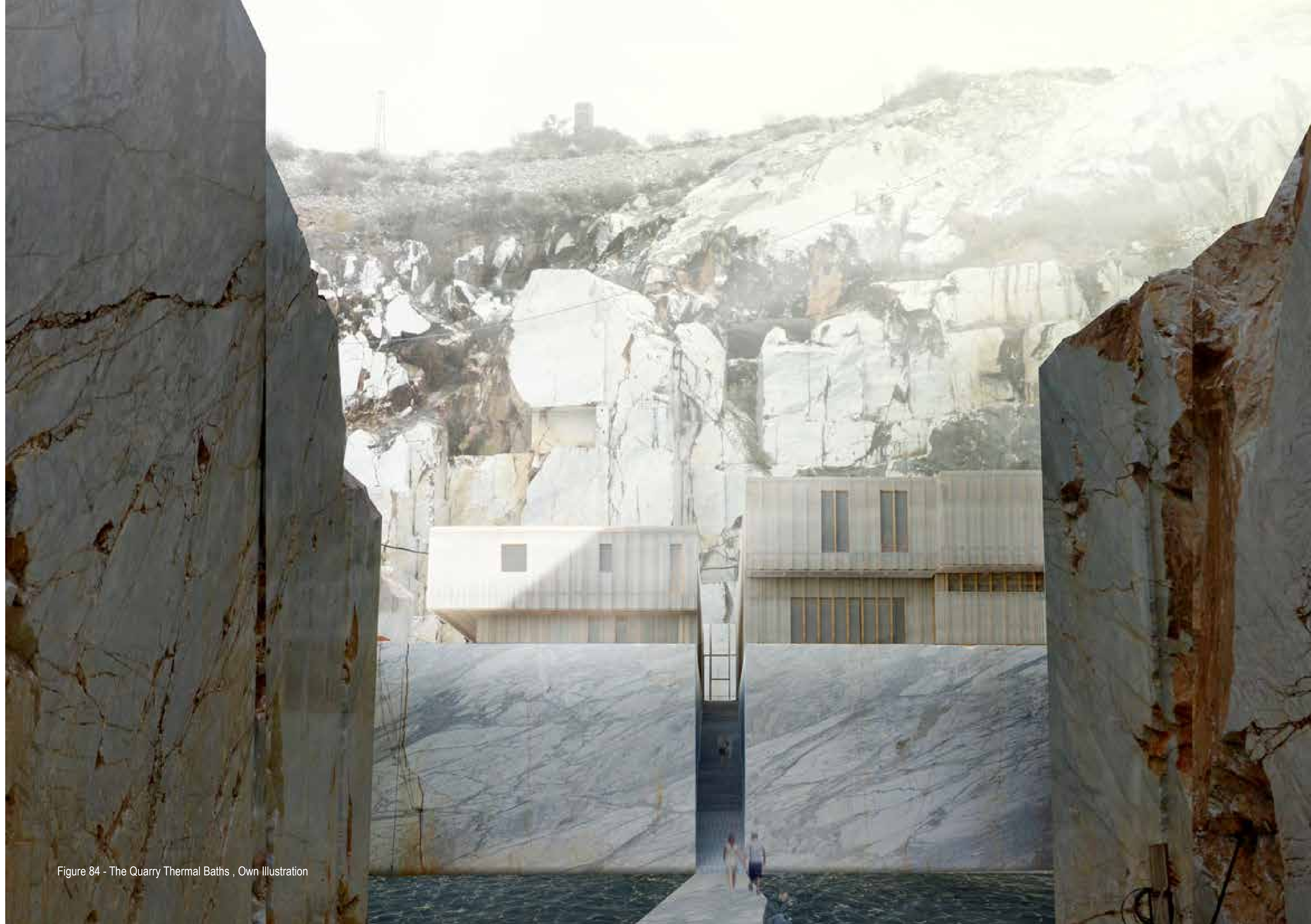


Figure 84 - The Quarry Thermal Baths , Own Illustration

CUT SECTION

Figure 85 - Cut section , Own Illustration

LONGITUDINAL SECTION

Figure 86 - Longitudinal section , Own Illustration

CROSS SECTION 01

Figure 87 - Cross section 01, Own Illustration

CROSS SECTION 02

Figure 88 - Cross section 02, Own Illustration

STRUCTURE

GRID

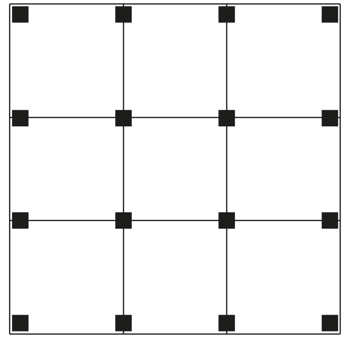


Figure 89 - Own Illustration

BOXES

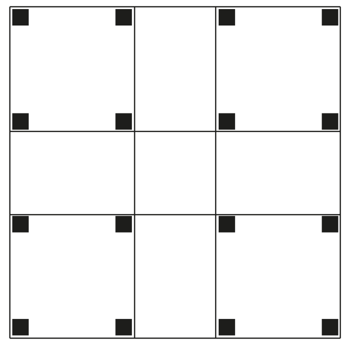


Figure 90 - Own Illustration

ROOM MODULE

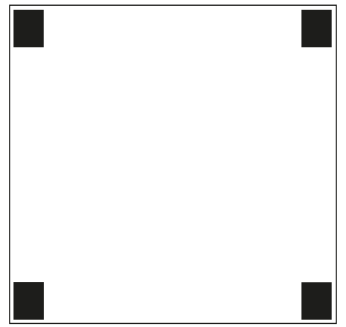


Figure 91 - Own Illustration

The contrast between the heavy base and the light crowning suggested the use of a punctual structure and timber has been chosen due to its intrinsic properties of being a warm material. The structural system has been conceived as a grid (fig. 89) made of boxes (fig. 90), enclosing different room modules (fig. 91). At the same time, due to the fluid plan disposition, an effort has been made in order to merge together the fluency of the spaces and the rationality of this system. It also has been possible to create different perceptions of the structural system in the rooms, giving to a visitor a sense of dynamism despite the classical idea of rigidity of a grid.

The grid structure is statically indeterminate (fig. 92):

degree of freedom: $3 \cdot 1 = 3$
external costraints: $2 \cdot 2 = 4$

Structural calculations have been done in Robot, considering both the primary structure, the secondary one and the facade all together (fig. 93).
For more detailed investigations see Appendix 03 and 04.

DEGREE OF FREEDOM

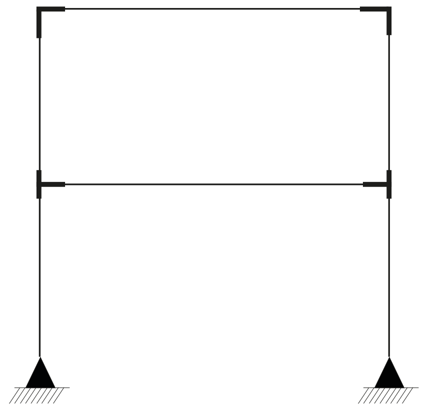


Figure 92 - Own Illustration

GEOMETRY

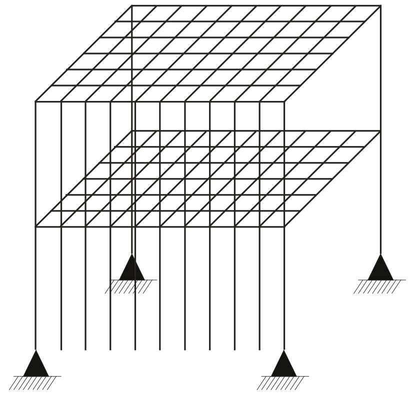
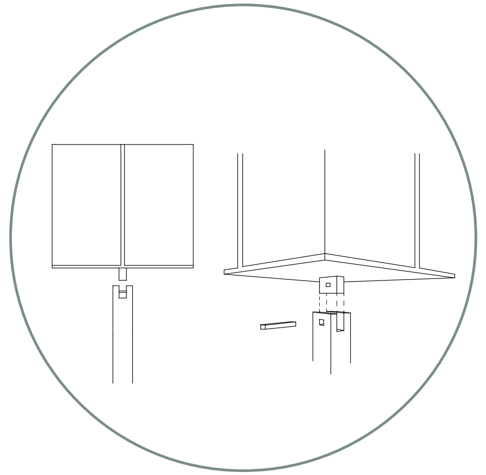


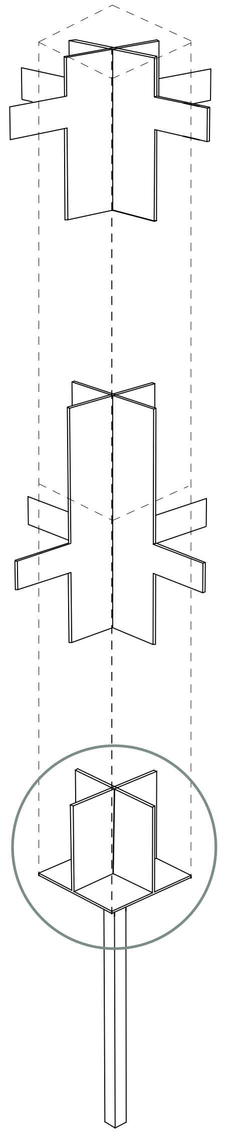
Figure 93 - Own Illustration

Figure 94 - The structure, Own Illustration

JOINTS



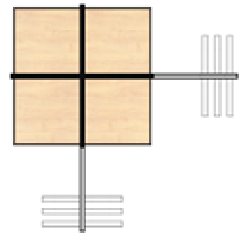
GROUND JOINT



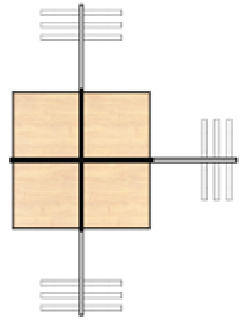
The joint design has been made to enhance even more the distinction between base and crowning, therefore dethatching the structure from the ground. The cross metal plate enters the column at the base and continues for 40 cm inside the timber, giving at the pillar a sense of slenderness. The bottom of the joint ends with a steel plate, which is connected through a pin joint to a pole, necessary not to transfer the bending moment to the marble. This vertical element ends into concrete foundations. The connection between two different pieces of column at the level of the first floor has been made with the same idea of having a cross metal plate entering the timber (fig. 95). In this way the transportation to the project site is easier. A similar idea has been used for the connection of the beams with the columns, using a steel plate which has been left visible, creating a gap between the elements (fig. 96).

Figure 95 - Own Illustration

CORNER JOINT



PERIMETER JOINT



MIDDLE JOINT

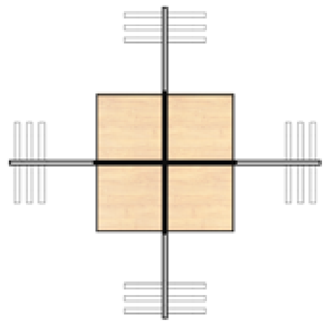


Figure 96 - Own Illustration

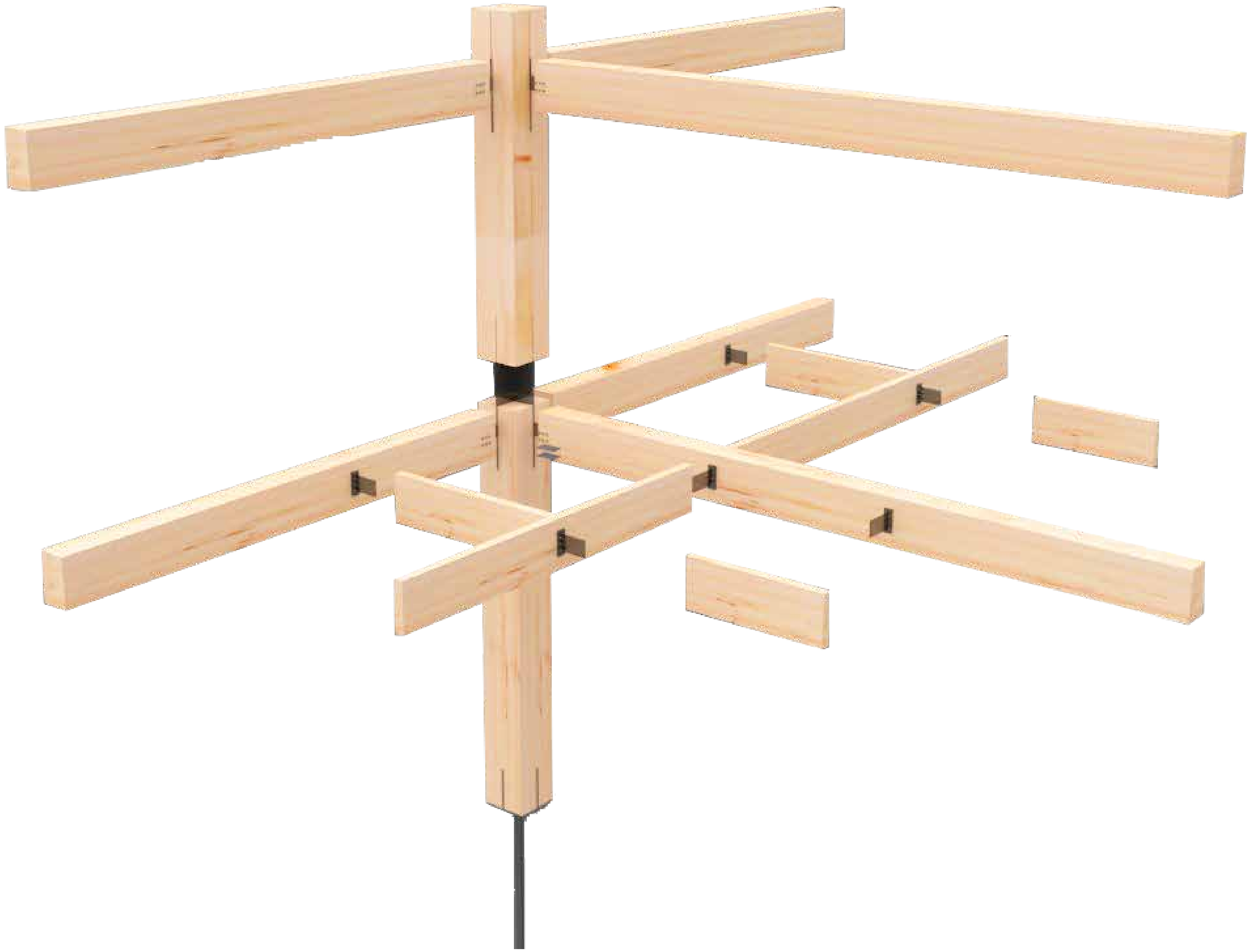


Figure 97 - Structural system, Own Illustration

MATERIALS

QUERCUS PRETAEA, OAK

hard timber, quite straight but irregular fibers, good mechanical resistance to compression
used for maritime constructions, interior high footfall floors, interior cladding

durable through time, slight colour change from a light brown to a straw-coloured tone due to chemical treatement, warmer tone over time (10 years) after the adaptation to the surrounding environment characteristics (light, humiduty)

easy manufacturing, easy assembly with screws and nails, it is necessary to prepare the holes to house the screws
necessary preliminary chemical tratement in order to protect from humidity

necessary periodic use of woodstains in order to prevent the bacteria attack due to humidity

change over time

Figure 98 - Wood, Own Illustration

WHITE CARRARA MARBLE

one of the hardest type of marble, fine-grained, good mechanical resistance to compression
used for exterior facades, interior floors and cladding

long life span, change of colour due to the exposition to weather over time, removable patina

nowadays faster and easier manufacturing thanks to new technologies

quite easy to mantain since the fine grain of the product allows a limited absorbtion, but necessary periodic use of waterproofing products to prevent mold issues
treatements do not change the aspect of the product

change over time

Figure 99 - Marble, Own Photo

POLYCARBONATE

strong and resistant to impact, UV protection barrier and weatherability, thermally insulating glazing material, good light trasmission
wide range of applications including factories and industrial buildings, greenhouses and agricultural buildings

durable through time

easy assembly with screws and nails on a steel or timber structure

no particular maintenance required, washing once a year

Figure 100 - Polycarbonate, Own Illustration

HOT WATER POOL

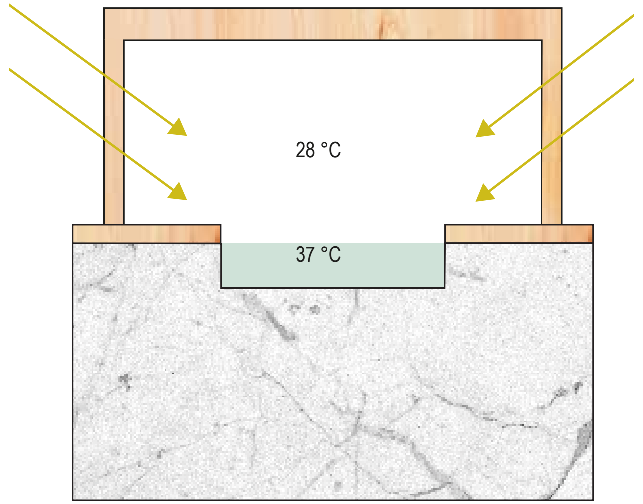


Figure 101 - Own Illustration

The hot water pool room is placed on 9 m level, above the marble base from the hollow level, with a water temperature of 37 °C. The atmosphere within the room is warm, cozy and bright thanks to materials and openings on the most exposed South and West sides.
The surrounding timber cladding gives the visitors a pleasant sensation of shelter, protection and relax.
The columns are visible, defining the boundaries of the room ad making perceive it as a shelter box. The visible waffle ceiling of the grid structure creates interesting plays of light and shadows.
The natural solar light coming through the windows is reflected by the water surface, and together with the vapour in the air it creates atmospherical patterns in the whole room.
Thanks to the heated timber floor, the room is kept warm and visitors can have a pleasant tactile sensation when seated. The water acts as a reflective surface and makes the light bouncing within the room.

Figure 102 - The hot water pool, Own Illustration

LUKEWARM WATER POOL

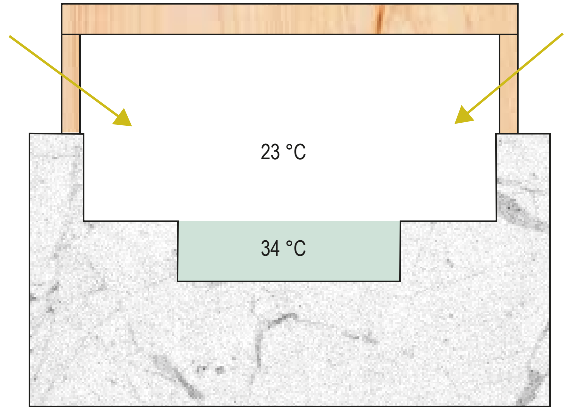


Figure 103 - Own Illustration

The lukewarm water pool room is placed on 7,5 m level, half embedded in the marble basement and with a water temperature of 34 °C.
The atmosphere of the room is emblematic in terms of experiencing the contrast, since the room is placed where the meeting between the marble base and the building clearly happens. Visitors can perceive that the room is half embedded in the marble due to the lack of floor heating, the marble is indeed cold when touched. On the other hand, thanks to its properties, the upper timber cladding is perceived as warm, taking benefit from the hot pool room proximity. The contrast can be perceived visually but also in a tactile and thermal experience.
The room is less bright and cozy, the attention is focused on the meeting of the materials.
A timber lamellas suspended ceiling helps in the creation of the atmosphere, allowing the presence of games of light. The structure is not visible within the room, just the waffle ceiling can be barely noticed through the suspended ceiling.

Figure 104 - The lukewarm water pool, Own Illustration

COLD WATER POOL

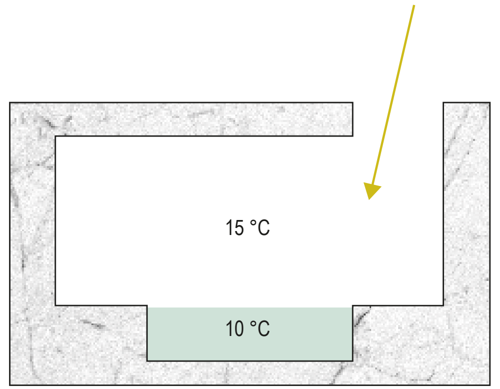


Figure 105 - Own Illustration

The cold water pool is placed on 6 m from the hollow level and, completely embedded in the marble, it has a water temperature of 10 °C. Indeed, the deeper into the marble the room is placed, the coldest the temperature is, and the less light the room gets.
The room is accessible from the lukewarm and it is placed close to the saunas. In this way the users can have a quick cold bath after that.
Vistors can experience the unheated marble base from the inside, perceiving the cold and dark atmosphere of the environment.

Figure 106 - Cold water pool, Own Illustration

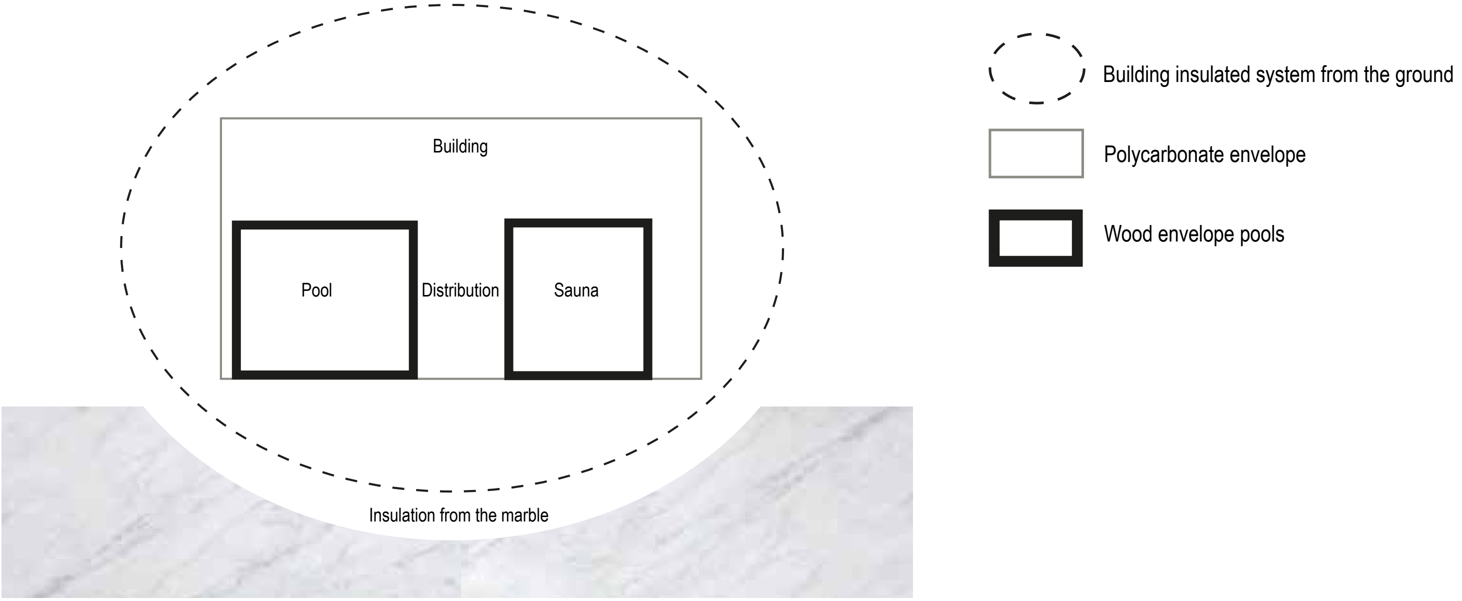


Figure 107 - Building thermal system, Own Illustration

In the design of The Quarry Thermal Baths a focus is done on the exploitation of the thermo-dynamic principles of conduction and convection. The application of these thermal strategies helped to place the functions within the plan, to choose the proper materials and so to create different atmospheres within the building.

"Conduction is the transfer of heat energy through the contact of molecules in directly connected objects". [Moe K., 2010]

The Quarry Thermal Baths building has layers of insulation to improve the thermal transmittance gradually, offering a variety of temperatures, atmospheres and luminosities. The plan of the building is conceived by boxes, which host the thermal functions, and their negative surrounding spaces. While the rooms have walls with a 10 cm thick insulation layer with a U value of 0.33 W/m^{2}K, the circulation area is insulated by the polycarbonate panels of the envelope, with a U value of 0.83 W/m^{2}K (for further calculations see the Appendix 07). Visitors will pass from the outdoor space to the circulation space first, warm and bright, and then they will be able to access the several functions inside the boxes, more dark, well insulated and characterised by a particular atmosphere.

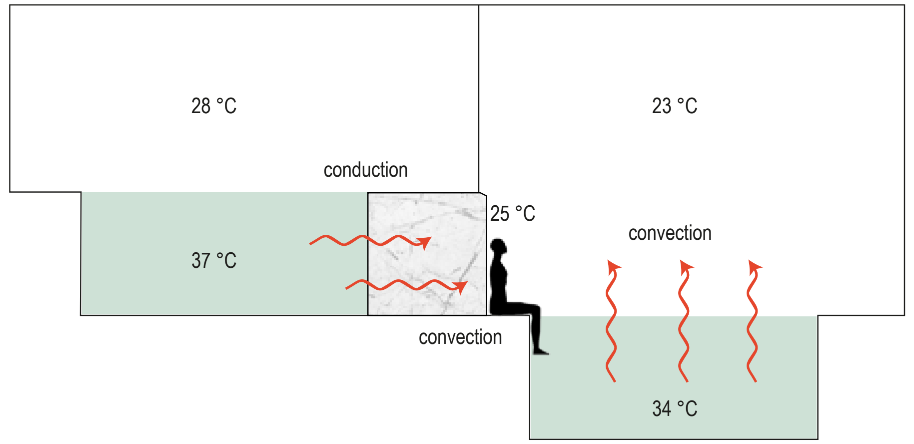


Figure 108 - Heat transfer scheme, Own Illustration

"Convection is the transfer of heat energy through the movement of molecules within a fluid or a gas, resulting in a current flow of energy". [Moe K., 2010]

The thermodynamic principle of conduction has been exploited together with convection by transferring heat energy between the hot and the lukewarm pools (fig. ?). The hot pool is conceived as a radiator room, with an air temperature around 28 °C and a water temperature of 37 °C. On the other hand the lukewarm pool, with a water temperature of 34 °C and an air temperature around 23 °C, should benefit from the proximity to the hot pool. The heat transfer is possible thanks to the marble mass placed in between the rooms, which works as thermal mass. The heat is transmitted from the hot pool to the marble mass through conduction (water-to-marble) and it is in turn transmitted to the lukewarm pool room through convection (marble-to-air). Furthermore, the air temperature of the lukewarm pool is increased thanks to the heat transfer through convection (water-to-air). An insulation layer encloses the two rooms that are still conceived as two boxes, since the insulated dividing wall allows to keep the difference of temperature and so the different atmospheres in the rooms.
Thanks to this design strategy, the energy need of the lukewarm room will considerably decrease. The users can easily perceive the heat flow and have a pleasant thermal sensation leaning their back on the marble mass, which will have a superficial temperature around 25 °C (see Appendix 06).

MARBLE - TIMBER

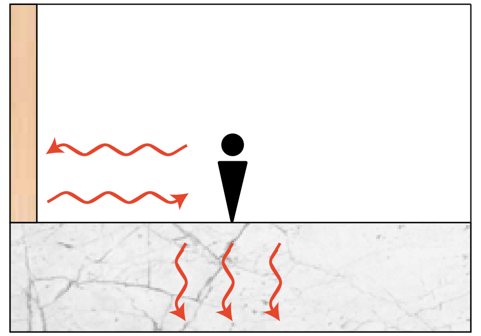


Figure 109 - Own Illustration

The thermal and tactile sensation of the marble gives a sense of coldness and smoothness while the properties of the wood reveal a rough and warm surface. When these two materials are placed together one will have the sensation of walking on a cold ground and being surrounded by the warmth, therefore understanding the inner properties of these two materials.

MARBLE - WATER

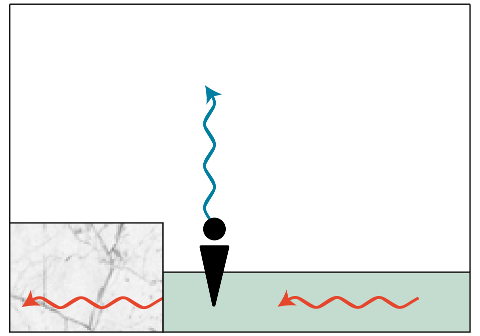


Figure 110 - Own Illustration

Marble is a thermal mass, so it accumulates the heat. Therefore when placed in contact with a hot surface like water it will be perceived as a warm surface, overturning one's expectation of feeling it cold. Thus it will feel warmer in the water and in contact with the marble than when standing in contact with the air of the room.

COLD WATER - COLD ENVIRONMENT

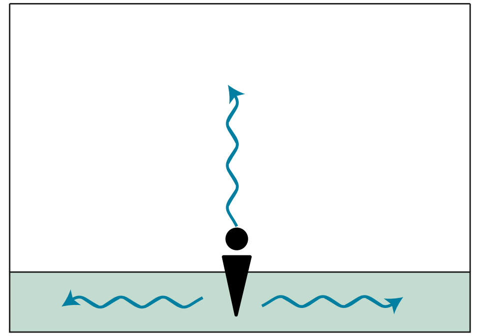


Figure 111 - Own Illustration

When entering a room with cold water the air temperature will also feel cold. Therefore one will have a gradual travel from the cold air to the raw water.

HOT WATER - COLD ENVIRONMENT

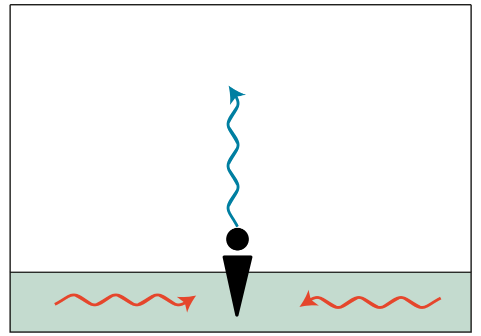


Figure 112 - Own Illustration

In an environment with hot water and cold air, one will have the sensation of feeling protected inside the warmth of the pool and it will have the tendency to stay.

DETAILS

NAVIGATION MAP

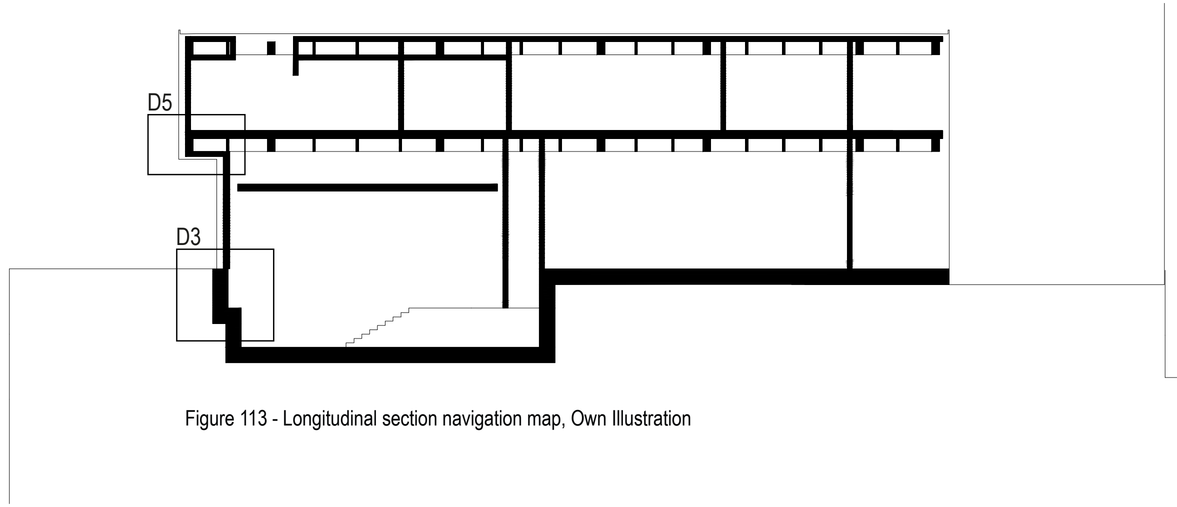


Figure 113 - Longitudinal section navigation map, Own Illustration

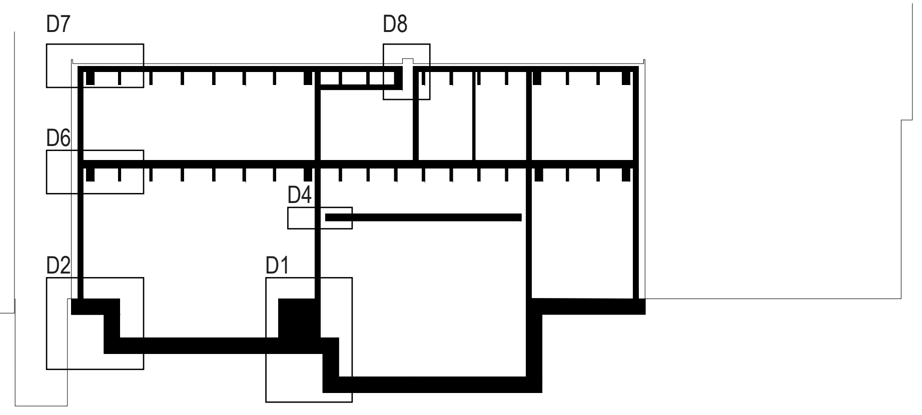


Figure 114 - Cross section navigation map, Own Illustration

An intense study of details have been made in order to understand the dynamics involved in the design of a thermal bath. Another challenge has been the construction on the marble, which is an uncommon context for a project.

LEGENDA

01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adehesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate

D 01 - Scale 1:30

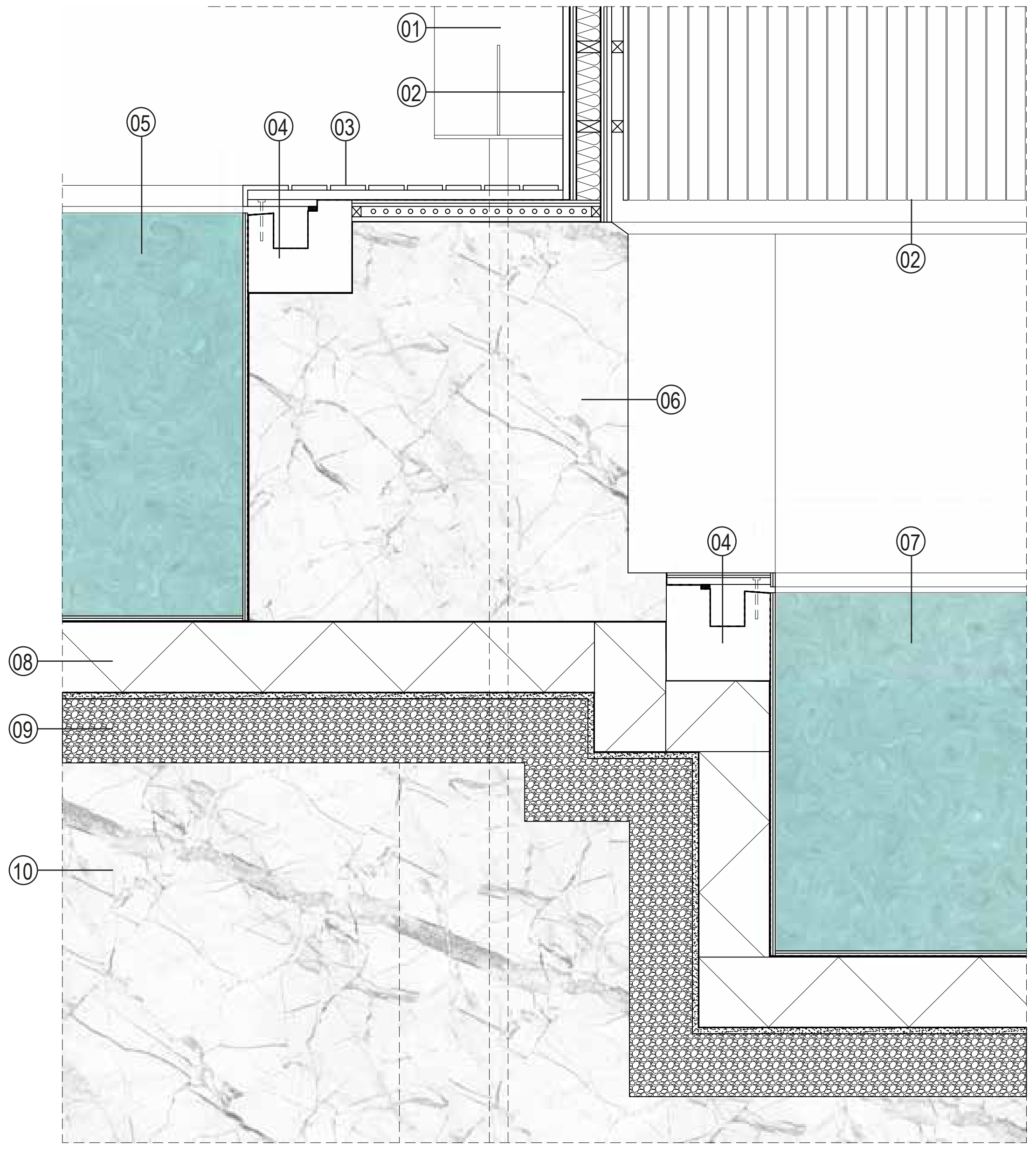


Figure 115 - Detail 01, Own Illustration

D 02 - Scale 1:10

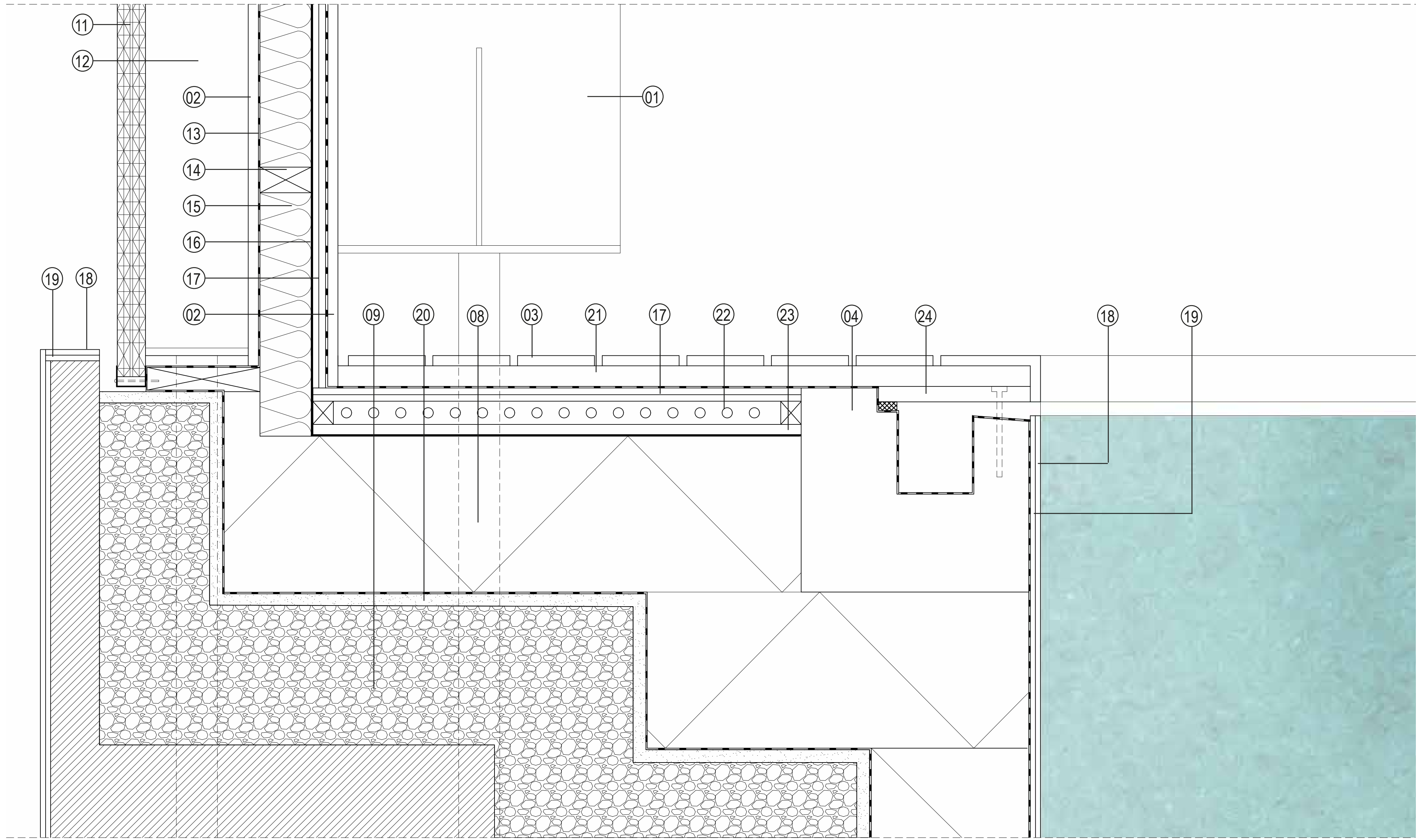


Figure 116 - Detail 02, Own Illustration

LEGENDA

01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adhesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate

D 03 - Scale 1:10

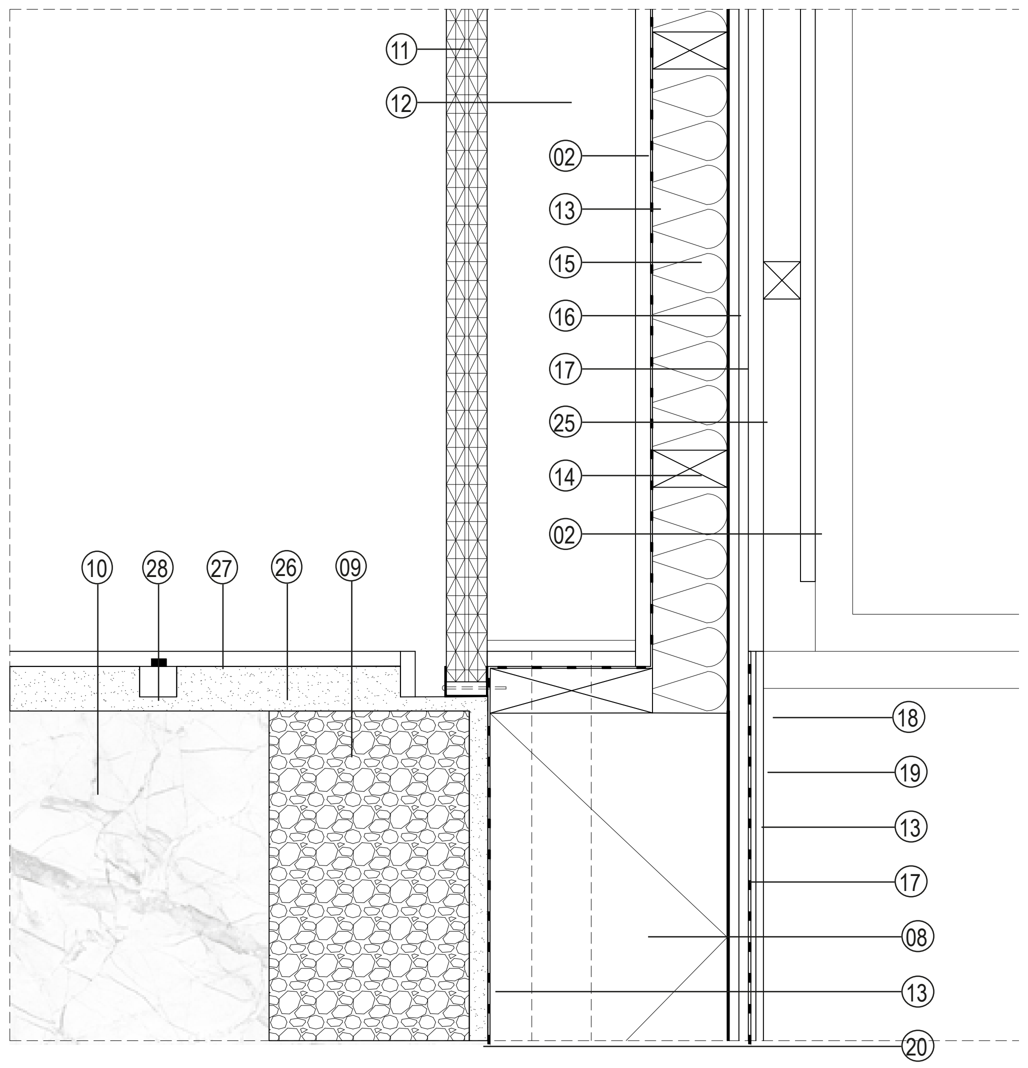


Figure 117 - Detail 03, Own Illustration

LEGENDA

01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adehesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate

D 04 - Scale 1:10

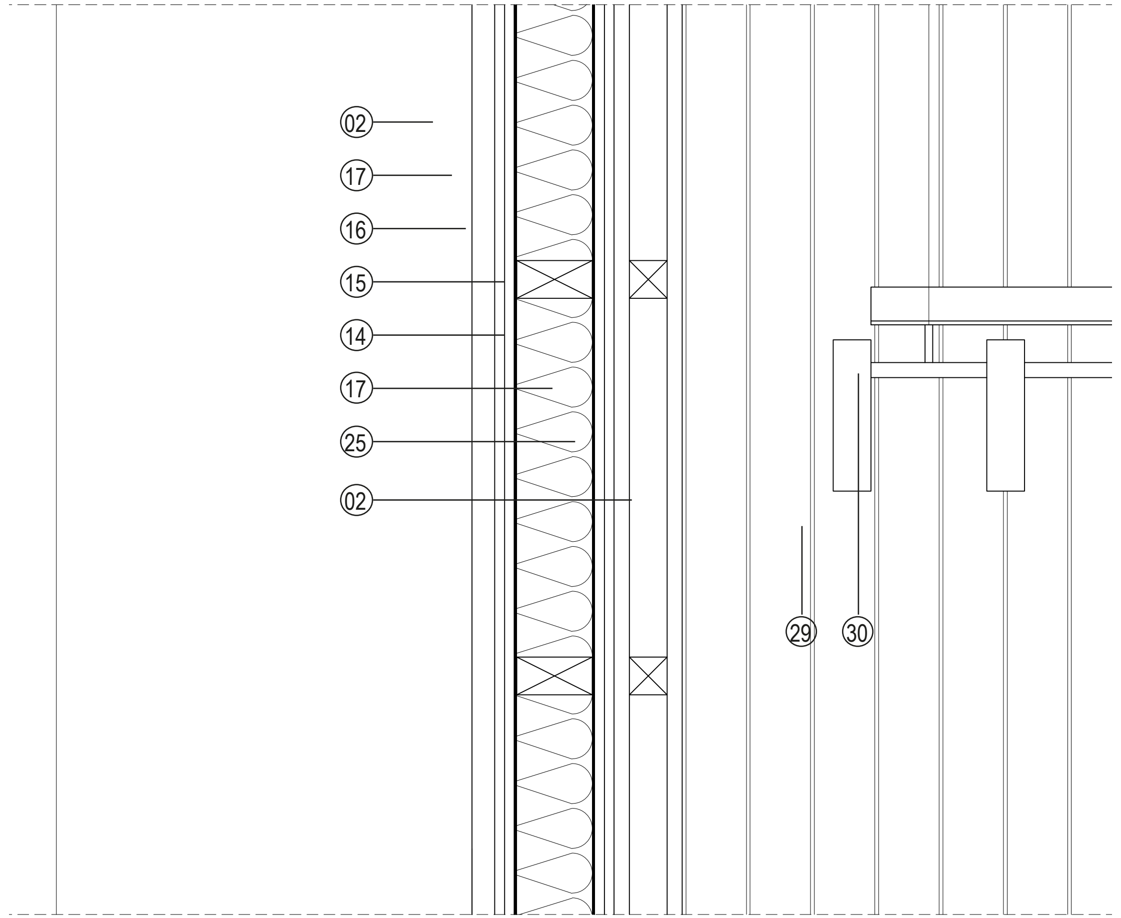


Figure 118 - Detail 04, Own Illustration

D 05 - Scale 1:10

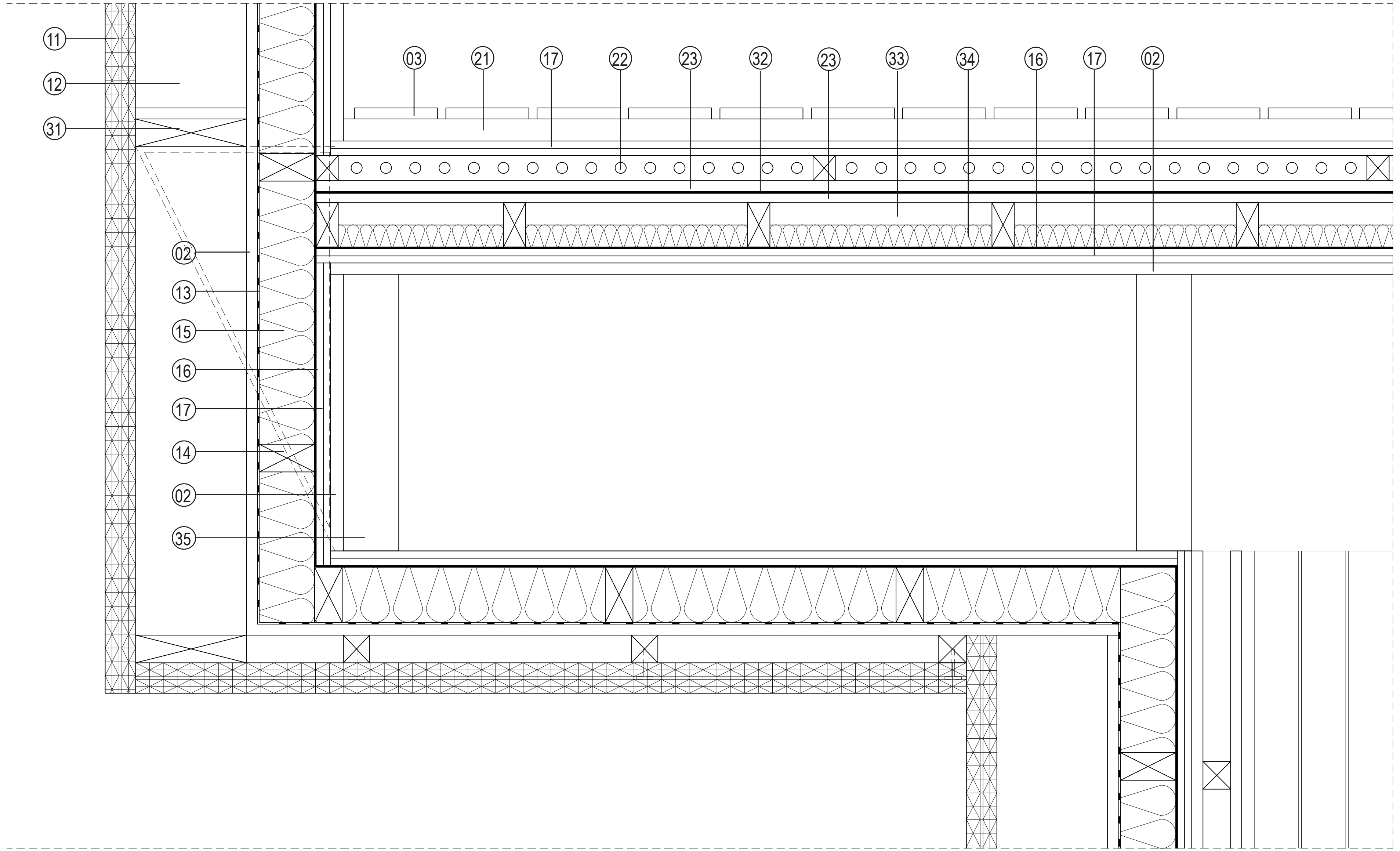


Figure 119 - Detail 05 , Own Illustration

D 06 - Scale 1:10

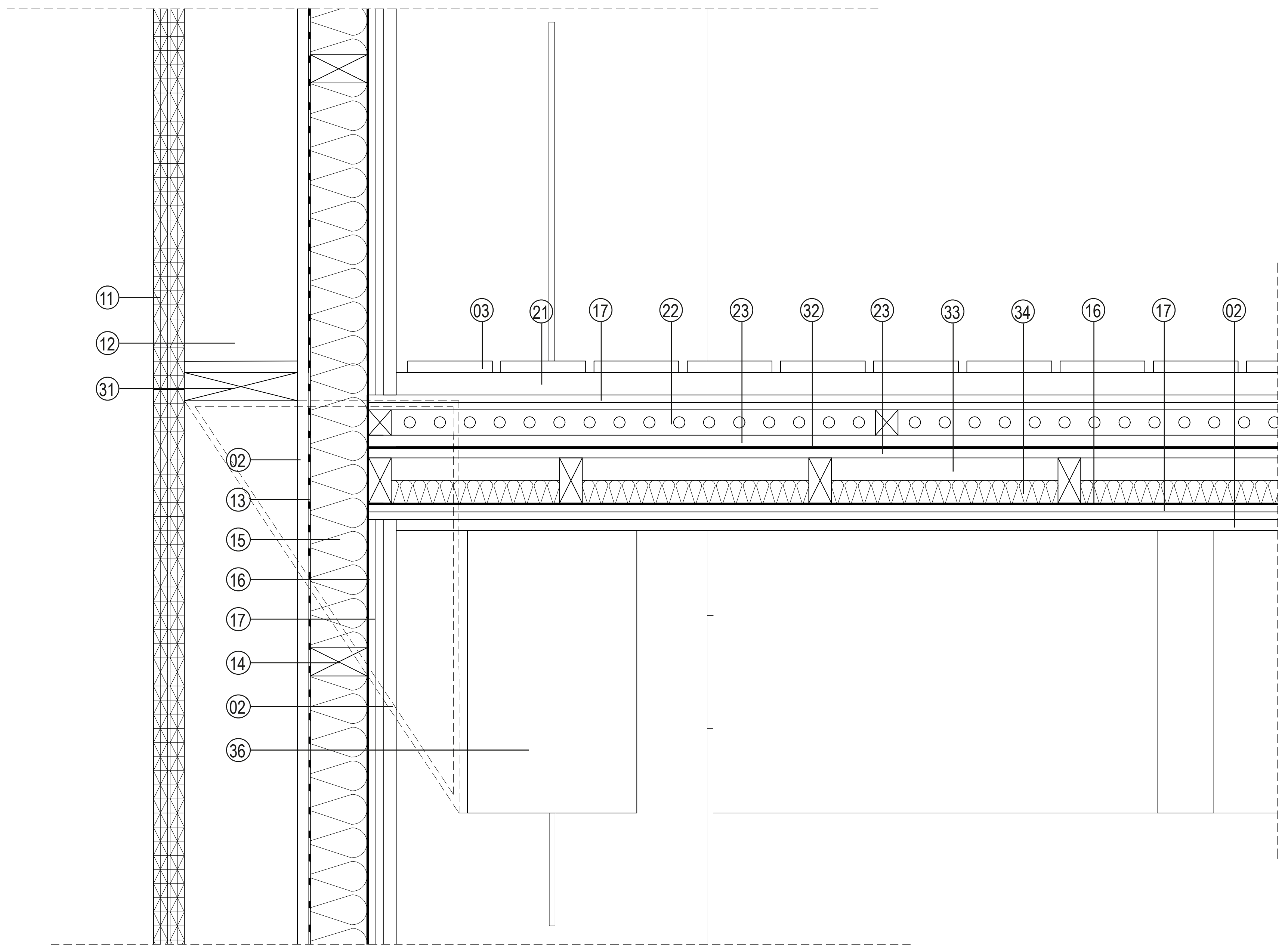


Figure 120 - Detail 06 , Own Illustration

LEGENDA

01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adehesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate

D 07 - Scale 1:10

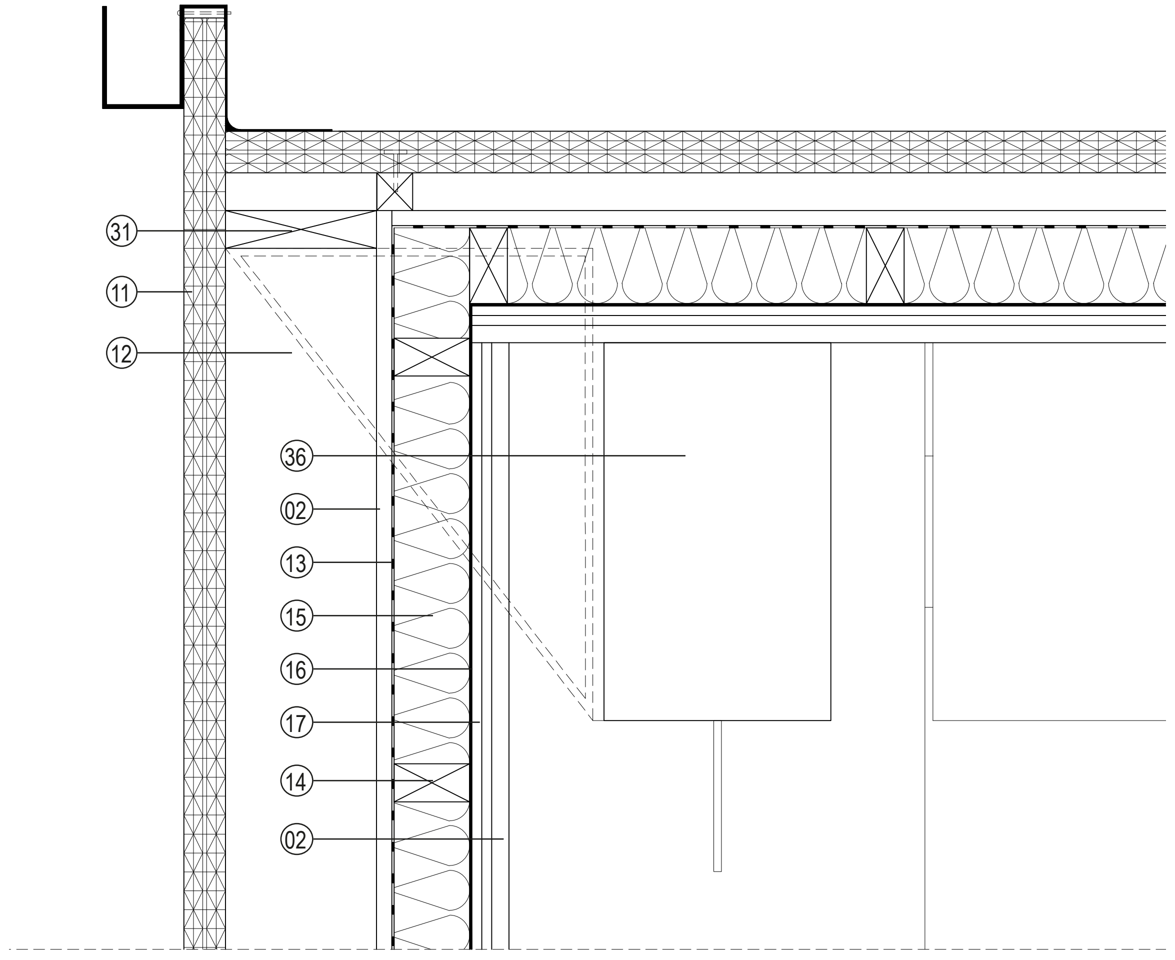


Figure 121 - Detail 07 , Own Illustration

D 08 - Scale 1:10

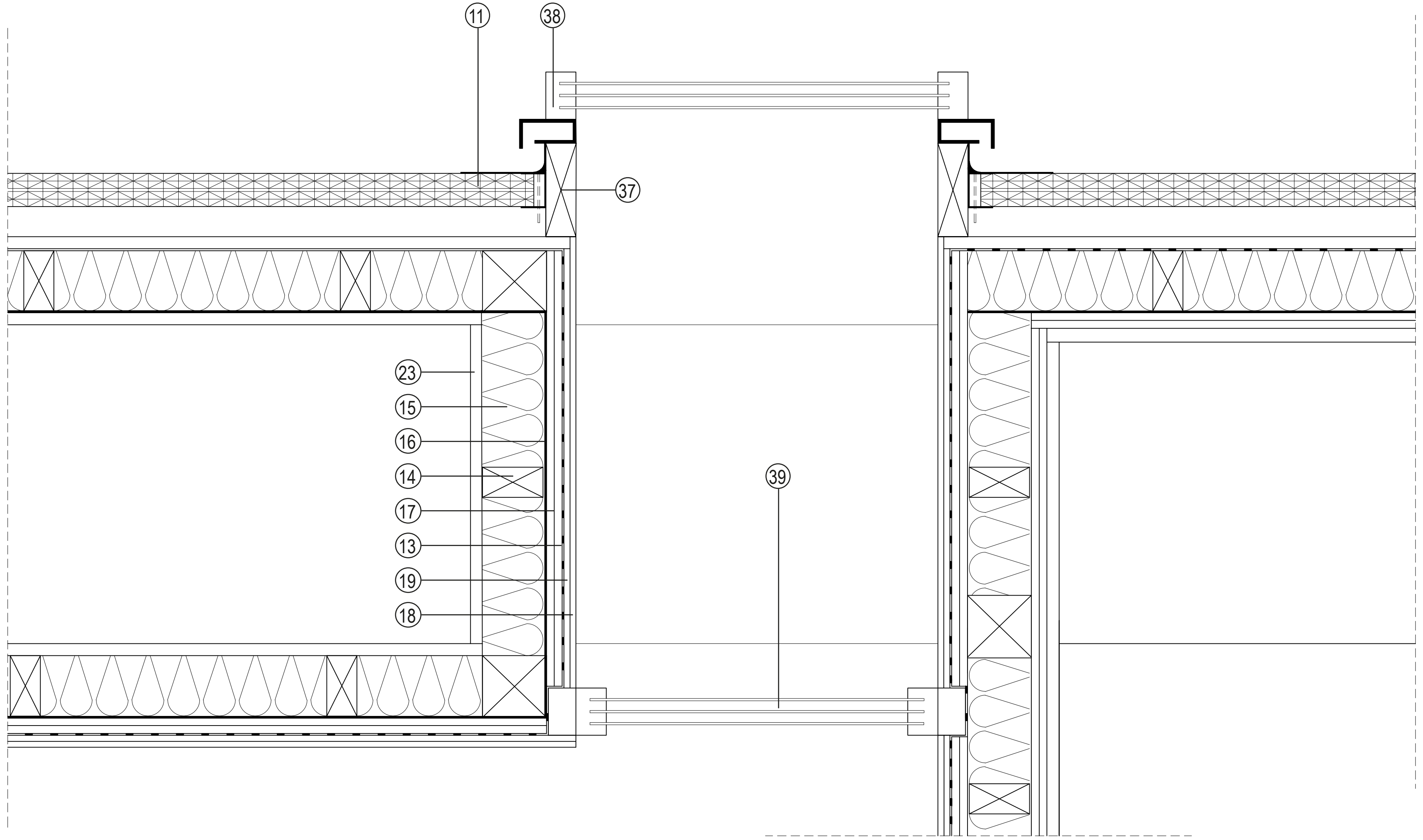


Figure 122 - Detail 08 , Own Illustration

LEGENDA

01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adehesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate

D 09 - Scale 1:10

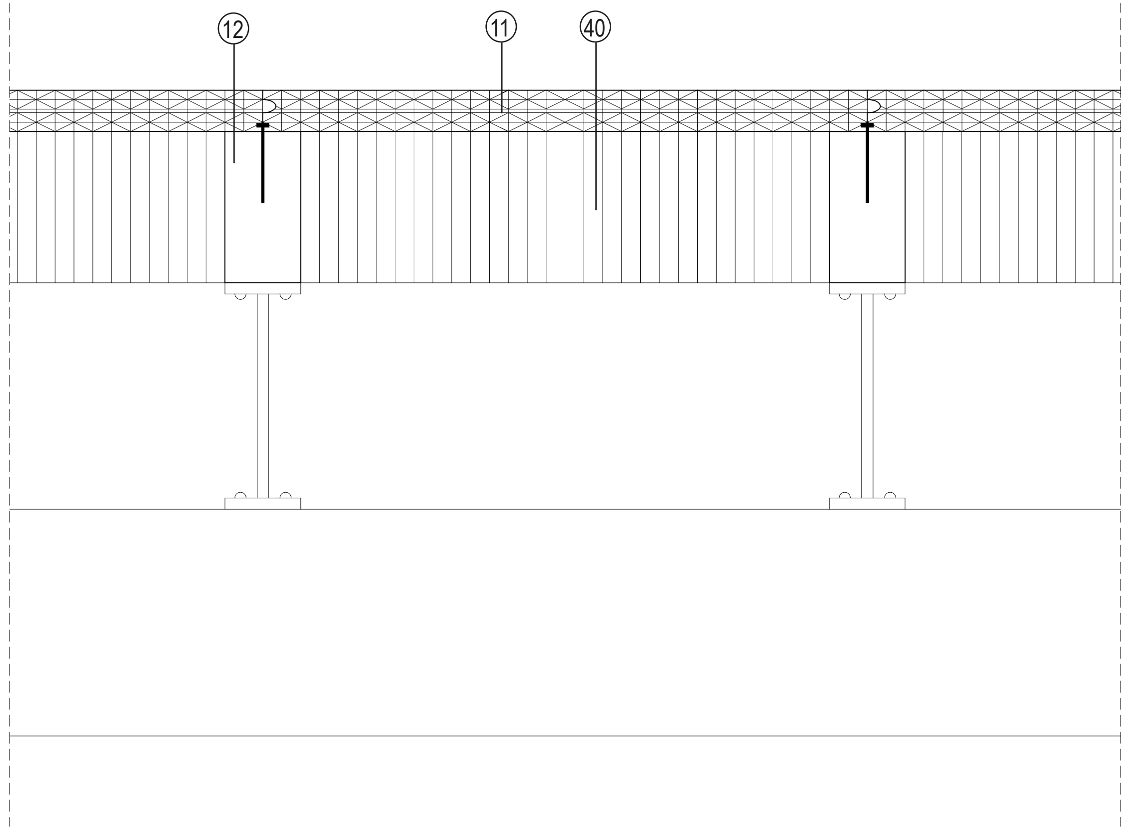


Figure 123 - Detail 09: Polycarbonate facade plan , Own Illustration

04

DESIGN PROCESS

RELATION TO THE TERRAIN

LIGHT

PLANS

STRUCTURE

JOINTS

CEILING

FACADE

The peculiar terrain conformation of the quarry offeres several possibilities for the placement of the building.
Three main options have been considered, each of that led to a completely different approach to the quarry.

The first possibility was to place the building within the entrance hollow, conceptually aiming to restore an equilibrium of volumes. The solution would have brought great issues due to the lack of light and the lack of dialogue between the upper block and the hollow of the quarry.
Furthermore, the building would have not been visible from the outside and it would tend to disappear within the quarry, not allowing to perceive the disposition of the functions from the outside (fig. 124).

In order to relate more to the terrain, the volumes have been arranged on multiple levels following the terracing conformation. Even if there would be no great issues of light conditions, the implemented dialogue between the building and the quarry proved to be trivial, since it would not allow the visitors to fully and consciously experience the marble basement trough all its possibilities (fig. 125).

The volumes have been placed on the upper block, in a way that the building relate not only to the entrance hollow, but also to the wide terracing of the upper level. In this strategic position the building has a fascinating dialogue with the quarry walls on the East side, playing with views and reflected light. The marble base of appears as a perfect shaped block. Its mass can be underlined by carving a longitudinal cut into it, offering to the visitors a full and conscious experience of the marble. The experience in the mass strarts when approaching the building from the hollow (fig. 126).

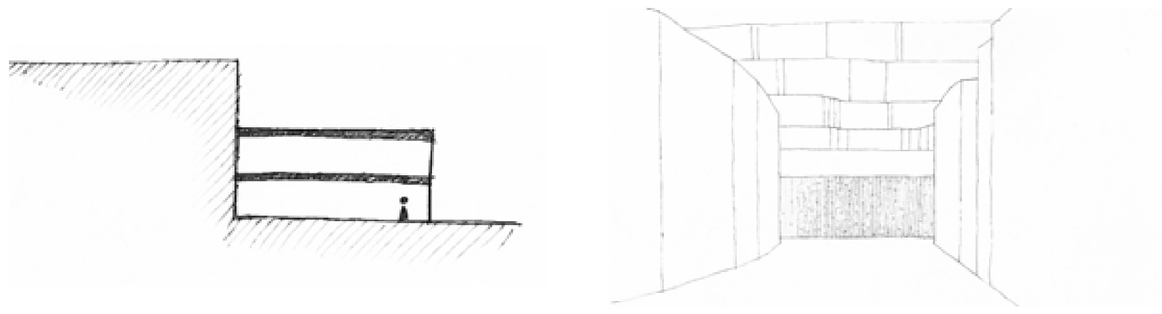


Figure 124 - Section and perspective view 01, Own Illustration

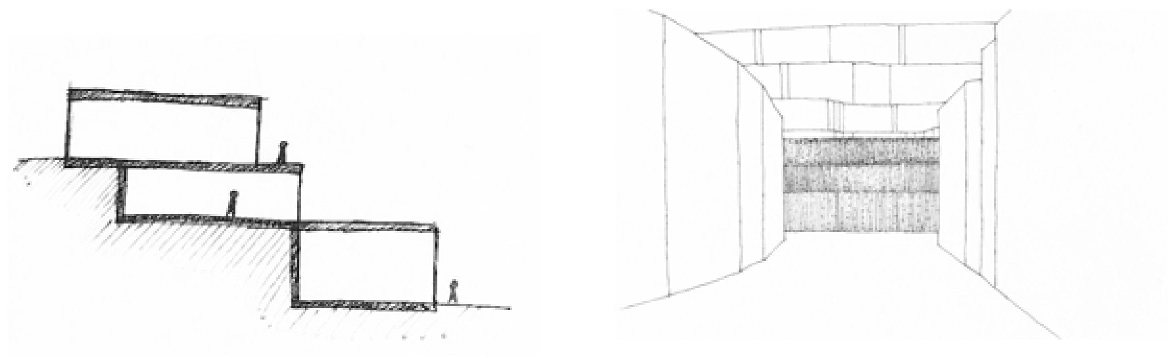


Figure 125 - Section and perspective view 02, Own Illustration

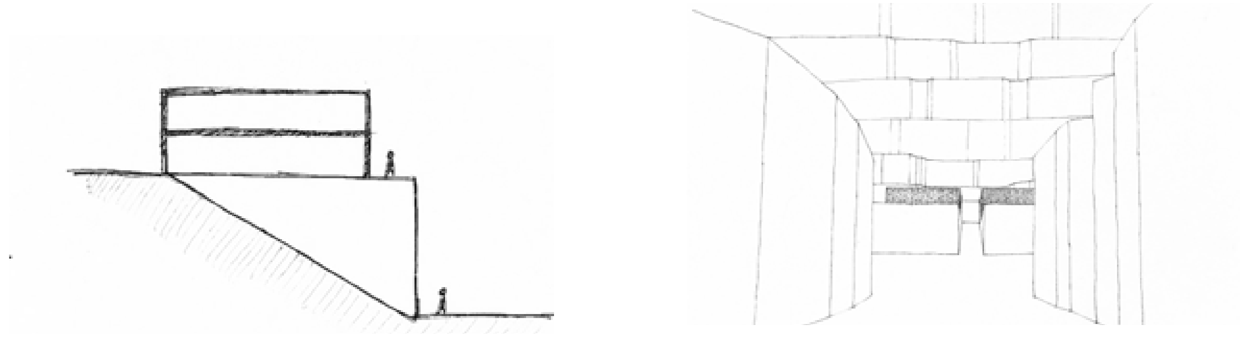


Figure 126 - Section and perspective view 03, Own Illustration

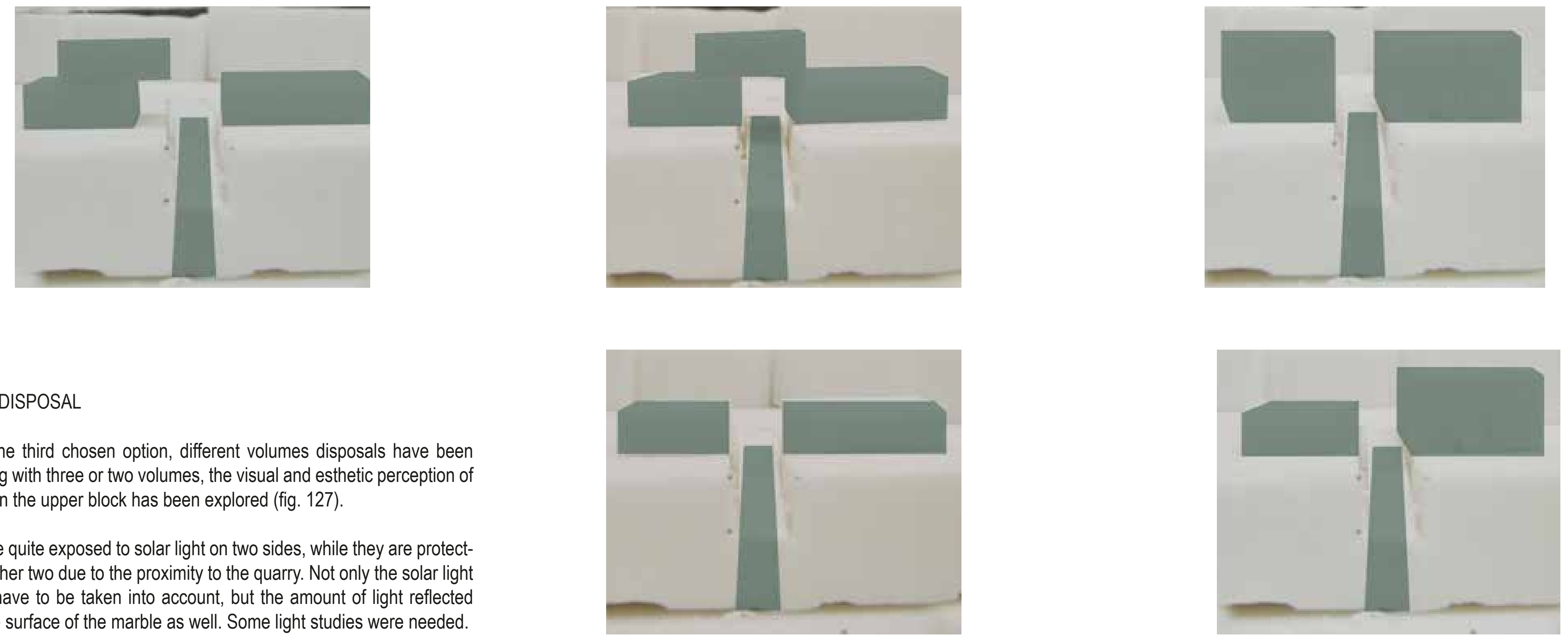


Figure 127 - Volumes disposal, Own Illustration

VOLUMES DISPOSAL

Based on the third chosen option, different volumes disposals have been tried. Playing with three or two volumes, the visual and esthetic perception of the shape on the upper block has been explored (fig. 127).

Volumes are quite exposed to solar light on two sides, while they are protected on the other two due to the proximity to the quarry. Not only the solar light conditions have to be taken into account, but the amount of light reflected by the white surface of the marble as well. Some light studies were needed. These studies have been carried on simultaneously with the light investigation and the room program design.

LIGHT

Due to the peculiar site conditions of the project, some early light investigations have been made. The white and bright surfaces of the marble reflect an high amount of light and this affected the design. The reflection had to be explored in plans in order to be exploited it in the disposition of the openings and in the use of the materials.
The building placement offers the opportunity to play with the proximity to the quarry walls and so with the reflected light.

Some investigations on shadows and reflected light have been carried on symultaneously, using respectively Velux and Diva software. Renderings of the pools have been done every hour during winter and summer soltice, in order to explore the change of atmosphere throughout the day (for further informations see Appendix 01, 02, 03).

Results have been explored through three iterations of different plan configurations. Each plan relates to the quarry walls in a different way.

The iterations on Diva (fig. 130) have been made on the 21^{th} of December and the 21^{th} of June. The North and East facades have been made totally in glass to understand the possible amount of gained reflected light.

The most articulated plan gains the highest percentage of lux (iteration C).
The compromise between the iterations A and B seems to be the best solution in order to minimise the reflection during summer and optimise the gained reflection during winter. This analysis has been integrated with the shadows studies, leading to the dimensioning of the marble gardens and the levels of the outer pools.
Results showed that the plan configuration of iteration B and C offered the best solar conditions for the design of an intimate outdoor space along the quarry walls. For the final design an integration between these two iterations has been made enlarging the courtyards in order to implement the sun exposure.
The outer pools have been tested on different levels and the 6m and 7.5m high have been chosen.
Based on these results, a compromise between the light and the shadows analysis led to a new plan disposition and shape.

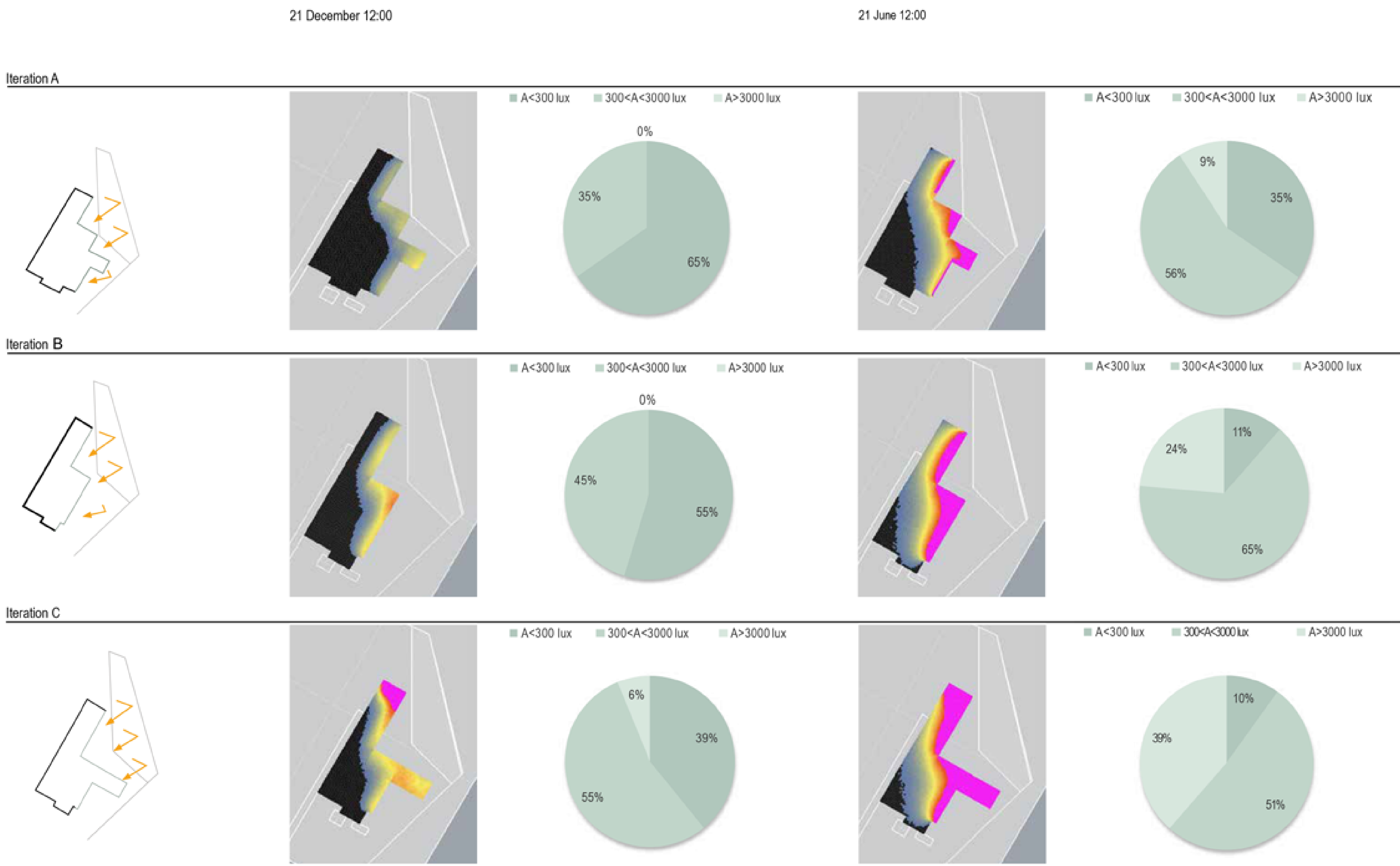


Figure 128 - Diva analysis 01, Own Illustration

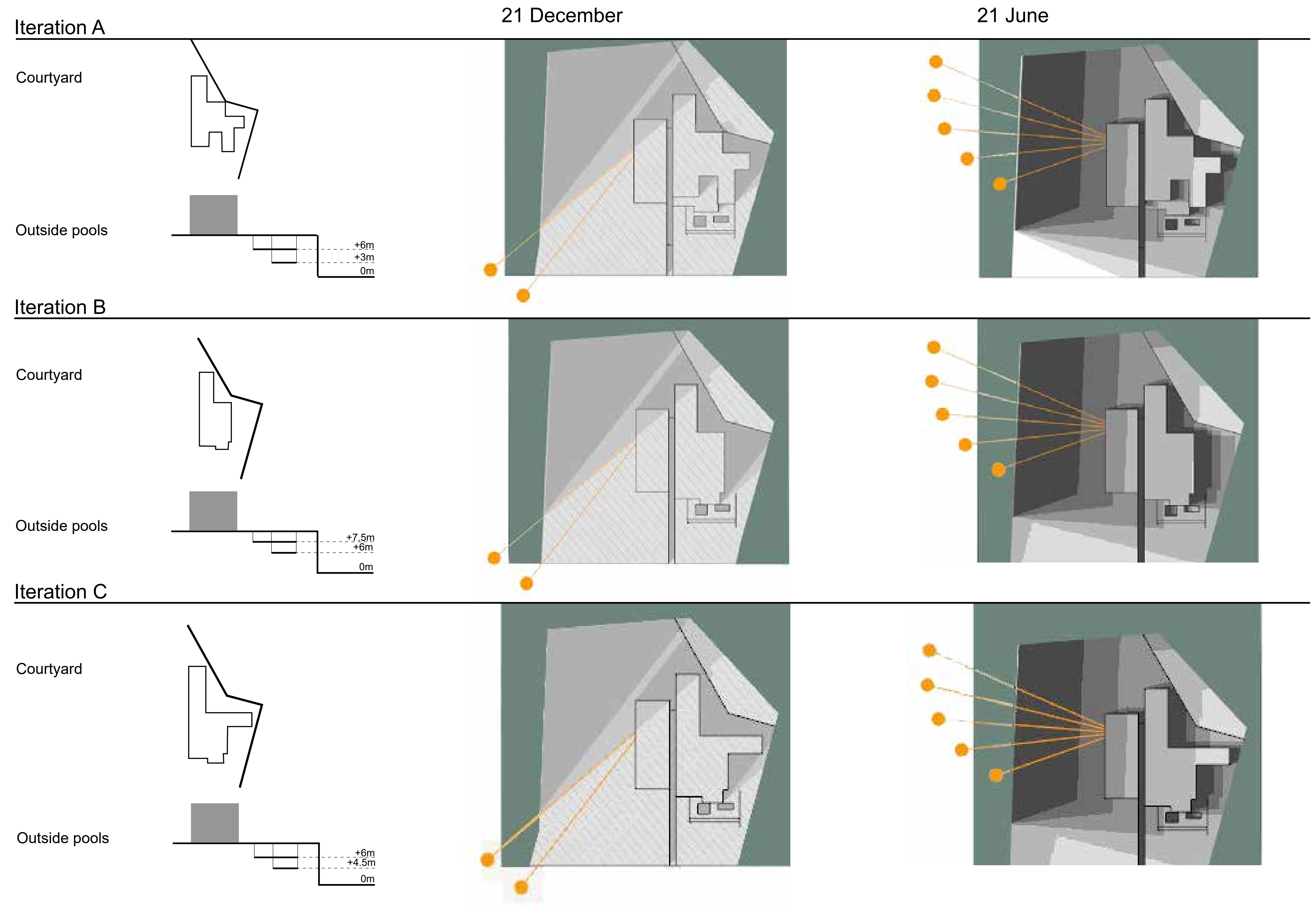


Figure 129 - Diva shadows analysis, Own Illustration

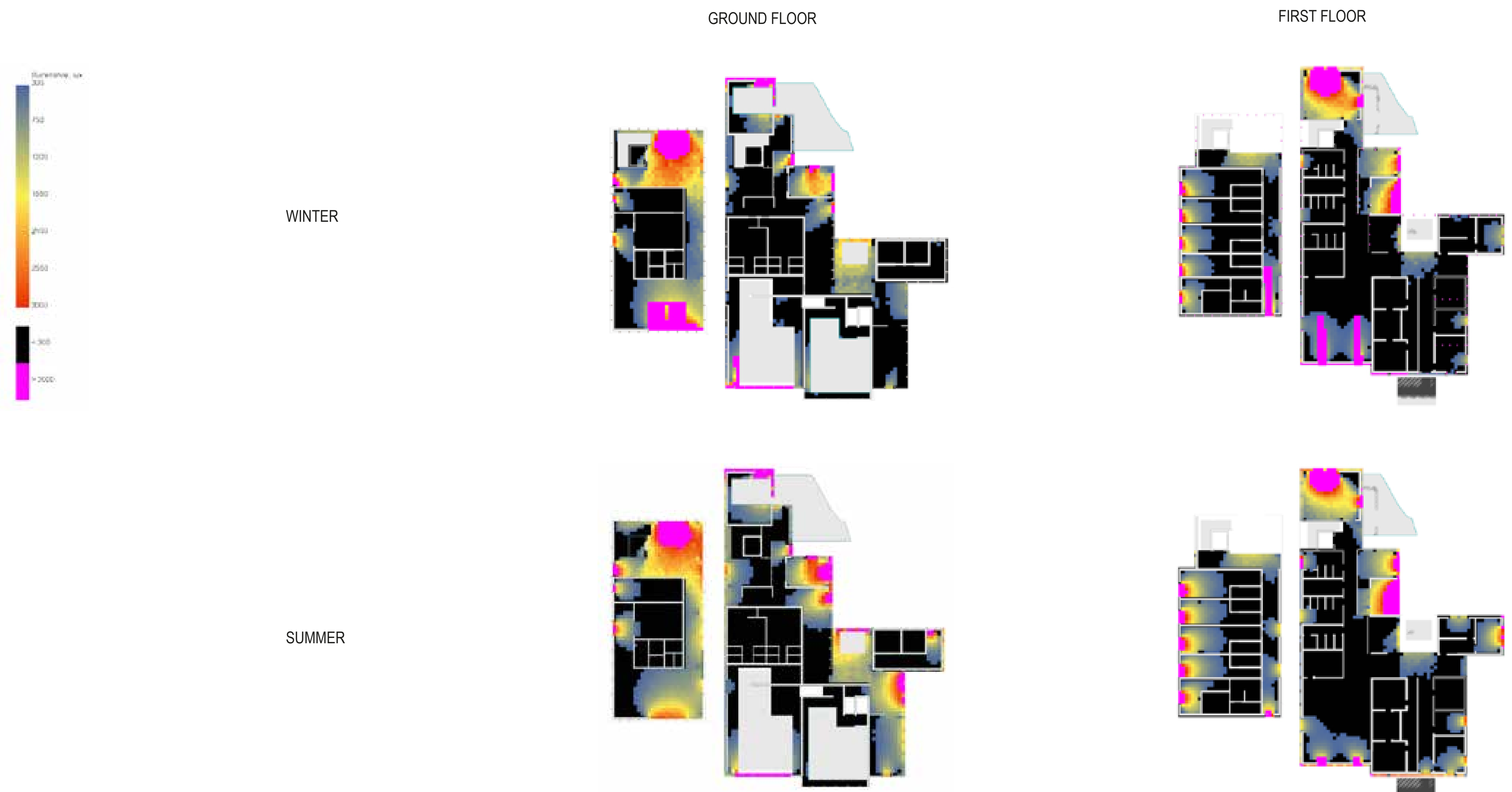


Figure 130 - Diva analysis 02, Own Illustration

New calculations have been made on the new plan disposal on Diva, both in winter and summer, in order to test the amount of reflected light within the functions more accurately (fig. 130). The new model for the calculation had a more detailed envelope, according to the design and disposition of windows, polycarbonate panels and the area of the water surfaces. It is possible to see how the water reflects the light inside the rooms.
Results showed that the amount of reflected light was too high or too low in some parts of the plan, so based on that the cladding and the window disposition have been changed.
Further studies on plan and facade have been made simountaneously untill the achievement of an integrated solution between amount of reflection and atmosphere. The analysis also led to the design of skylights in the upper floor (see fig. 76,77 and Appendix 04).

PLANS

Figure 131 - Plan iteration 01, Own Illustration

Figure 132 - Plan iteration 02, Own Illustration

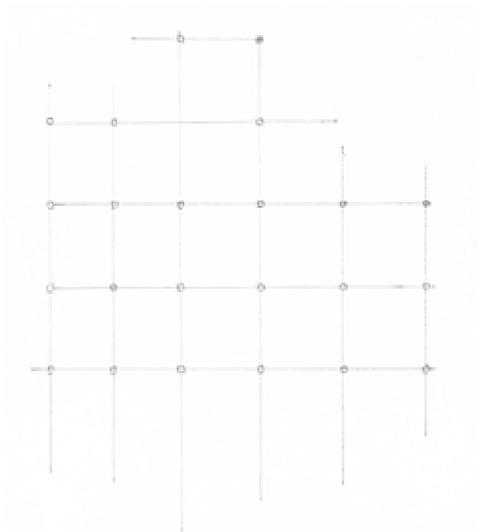


Figure 133 - Grid structure, Own Illustration

Plans development has been strongly affected by the conformation of the terrain and the proximity to the quarry walls, and it has been always carried on together with light and structural investigations.

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The aim was to have a fluid circulation within the plan, so that visitors could easily go around the building discovering the different thermal functions and their atmospheres little by little.
Based on the case study of Caracalla and Vals Thermal Baths, an atmospherical journey has been thought. The hot, lukewarm and cold pools have been placed in sequence, allowing an easy passage from an atmosphere to a completely different one .

On the first iteration the focus was on the programatic disposition of the functions. Due to that and the fact that the entrance was placed towards the northern side, the changing rooms have been placed facing North. However their disposition did not relate to the marble and the exploitation of reflected light.
The main pools have been placed facing South according to the view and the solar gain, in a way that the deeper in the marble the environment is embedded, the lower the water temperature become, exploiting the inner characteristics of the materials (see fig. 131, 132).

On the second iteration more sketches have been made focusing on the integration of the grid structure (fig. 133). The plan disposition has been conceived more by boxes and their negative spaces. The new disposal was less performing due to a decrease of the initial fluid circulation (fig. 134, 135).

On the third iteration a compromise between the fluidity and the rational grid structure has been found. The disposition of the main pools has been restored according to the first iteration and the changing rooms have been placed in a more central position, allowing to locate an other pool on the northern side. In this iteration all the functions facing the quarry wall exploited the reflection of the marble (fig. 136, 137, 138, 139).

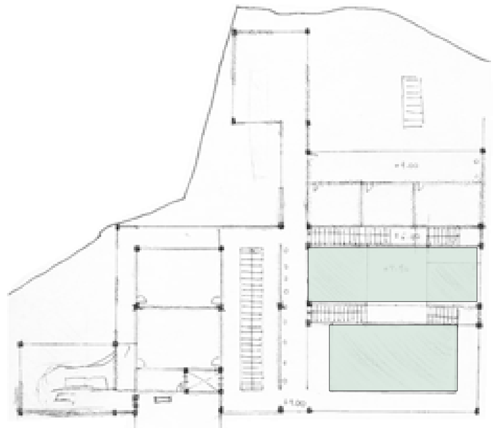

Figure 134 - Plan iteration 03, Own Illustration

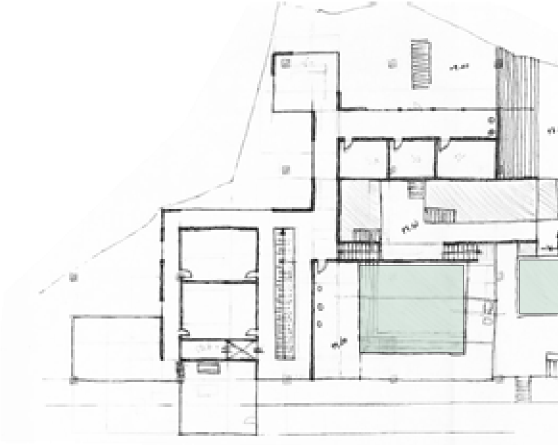

Figure 135 - Plan iteration 04, Own Illustration

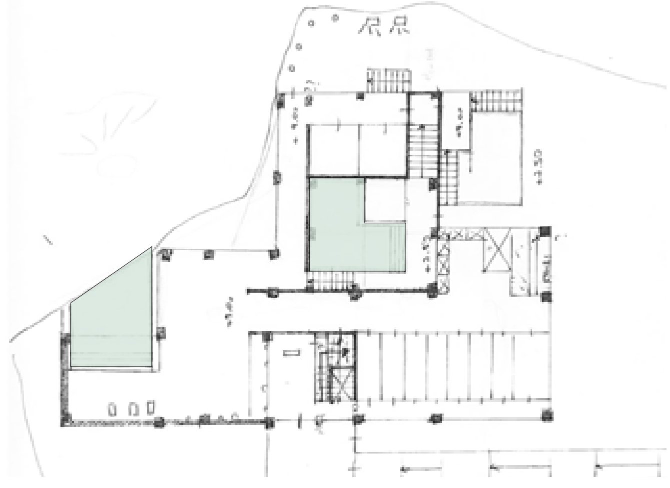

Figure 136 - Plan iteration 05, Own Illustration

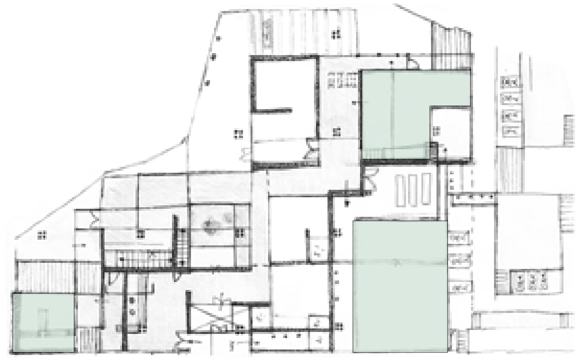

Figure 137 - Plan iteration 06, Own Illustration

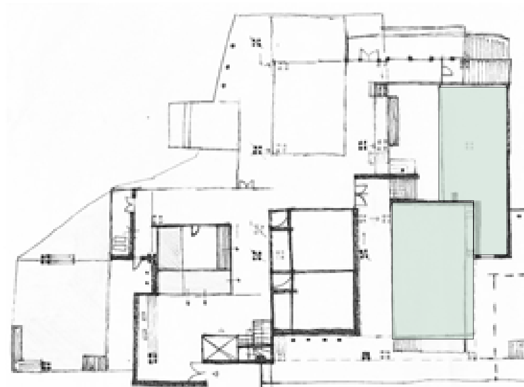

Figure 138 - Plan iteration 07, Own Illustration

Figure 139 - Plan iteration 08, Own Illustration

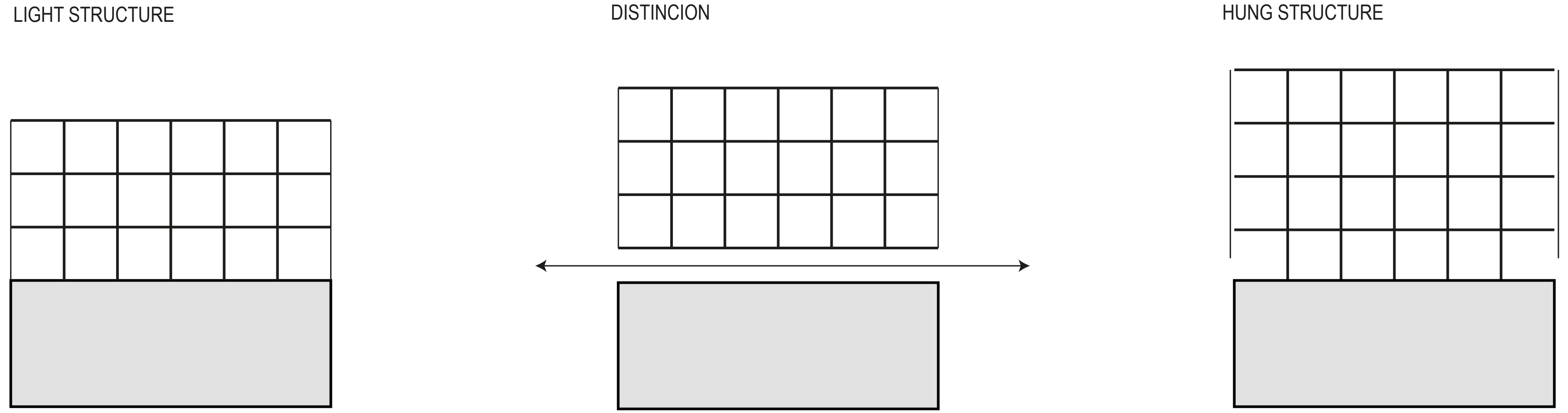

Figure 140 - Structural concept, Own Illustration

Structure studies have been always carried on together with the plan sketches and light investigation.
A grid structural system has been chosen early in the design process, in order to support the fluid circulation of the plans. The elements of the structure have to be as light as possible according to the concept of the contrast with the heavy and massive marble base (fig. 140).

The first iteration was a grid structure hung to loadbearing columns. The structure would have appeared light and floating, but issues would have arised when coming to the placement of walls.
Abandoned the idea of the hung structure, two kinds of column have been investigated.

The first proposal consisted in the division of the massive column in four thinner ones, aiming to create an interesting game of light passing through the middle spaces.
The conformation of the columns allowed to place the walls passing across (fig. 141), making the visitors perceive the thickness of the walls compared to the empty space between the column elements. Placing the structural grid on the plan, some issues arised, since the perimetral columns, located outside the walls, created consistent thermal bridges. Moreover, the resistance of columns, being divided in four by the wall, would have been affected differently according to the specific temperature of the room in which are placed. Because of its disposition, the structure was often not involved in light games and the boundaries of the rooms were not clearly defined because of the diverse perception of the vertical elements of the column.

The next step was to place the grid structure inside the walls (fig. 142) in order to avoid the thermal bridges and to give a complete and ordered perception of the structure in relation the walls of the rooms. Though this column configuration has been abandoned since the walls seemed to be completely not related to the structure. Additionally, this configuration made the structure hard to be perceived as enclosing rooms.

Moquettes (fig. 143) have been made in order to have a better understanding of the columns together with walls, material and light.

The columns became simplier and packed (fig. 144). The boundaries and the rythm of the rooms became more defined according to the rooms features and the fluidity of the distribution.Therefore the grid followed the idea of boxes and their negative space.
In the same way, moquettes have been done to explore the potential of the new columns, both with full walls and polycarbonate panels (fig. 145).

Calculations of the structural grid system have been made in Robot, elements have been dimensioned throughout several iterations (see Appendix 05).

FOUR-DIVIDED COLUMNS

WALL INSIDE


Figure 141 - Own Illustration

WALL OUTSIDE

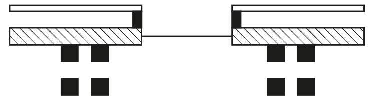
Figure 142 - Own Illustration

FULL WALL

FULL WALL + POLICARBONATE


Figure 143 - Own Photo

PACKED COLUMNS

WALL OUTSIDE

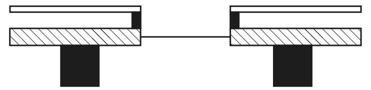
Figure 144 - Own Illustration

FULL WALL

FULL WALL + POLICARBONATE

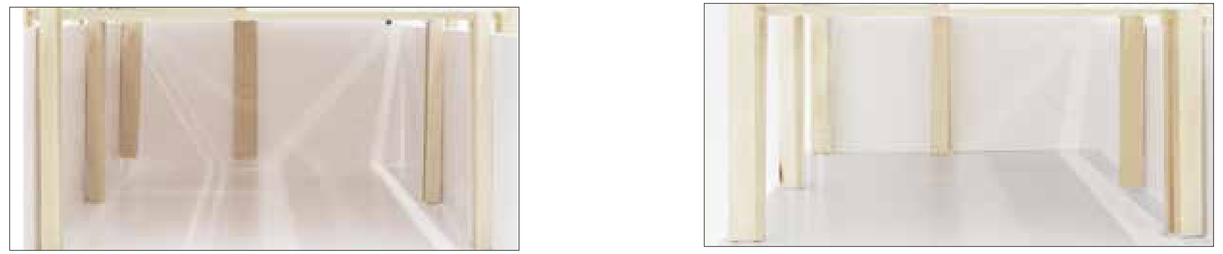
Figure 145 - Own Photo

Some further iterations for the design of the joints have been made, for both kinds of column.
The design of the joints has been treated according to the concept of the contrast between the marble base and the building. The joint on the ground visually underline the clear distinction between the marble and the structure, both having their own identity.

Concerning the four-divided column, a simple single joint has been investigated through a moquette (fig. 146) as well as a single joint for all the four elements (fig. 147). On the same model the joints between beams and column have been explored as well, trying to place the beams all at the same level (fig. 148), and one on top of the other in a second moment in order to create a deeper ceiling (fig. 149).

The joints of the packed column have been investigated through a 3D model. The new ground joint consisted in a singular crossed section metal element, reflecting the same concept of detachement (fig. 150).

A metal plate has been inserted in the bottom and in the top of the column in order to make the structure visually more slender.
The metal plate between the columns and the beam is inserted in the top part of the trasversal section of it, but this solution would have arised mechanical resisistance issues of the beam itself (fig. 151)

For the design of the final joint the metal plate is inserted in the middle of the beam, ensuring a stable connection between the elements (fig. 152)

FOUR-DIVIDED COLUMN

Figure 146 - Singular joint, Own Photo

Figure 147 - Divided joint, Own Photo

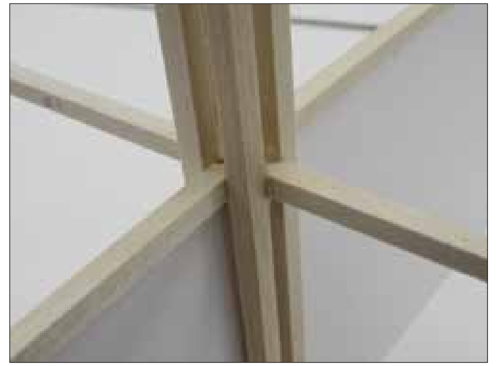

Figure 148 - Beams at the same level, Own Photo

Figure 149 - Beams at two levels, Own Photo

PACKED COLUMN

Figure 150 - Column joint, Own Illustration

Figure 151 - Beam joint, Own Illustration

Figure 152 - Exploded diagram, Own Illustration

CEILING

TYPE CEILING

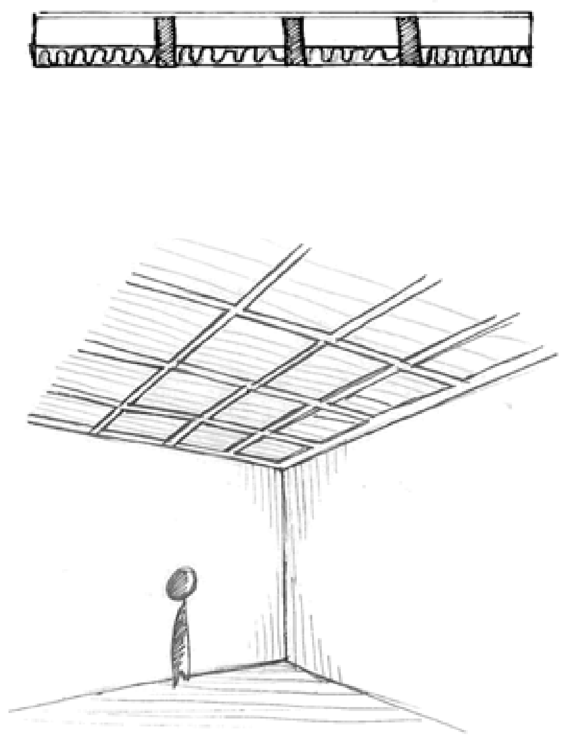

Figure 153 -Invisible waffle structure, Own Illustration

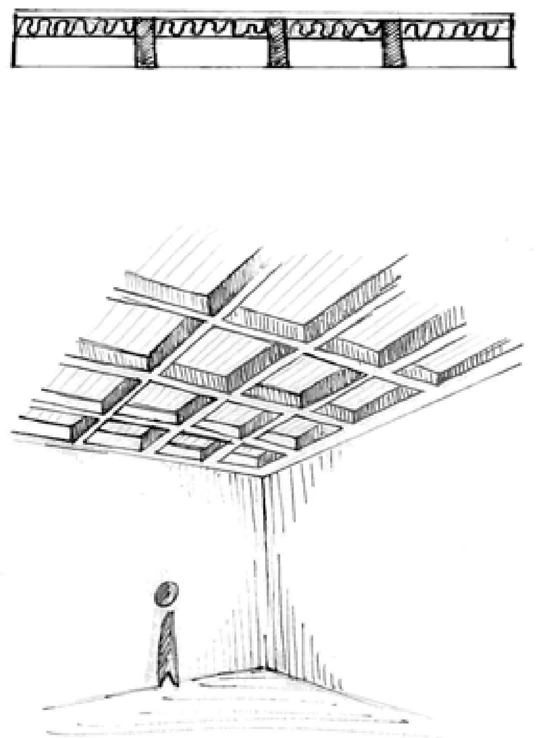

Figure 154 - Half visible waffle structure, Own Illustration

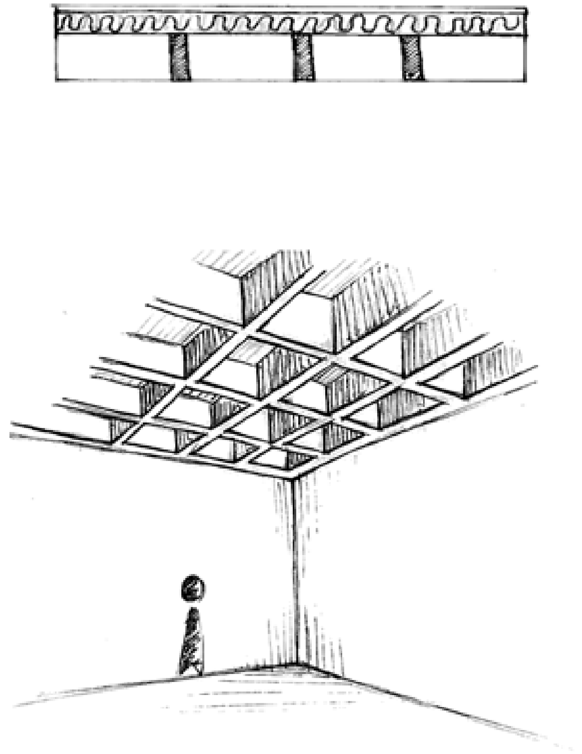

Figure 155 - Visible waffle structure, Own Illustration

The perception of the space changes according to the position of the ceiling.
Different solutions have been tested to affect the inner atmospheres.

SUSPENDED CEILING

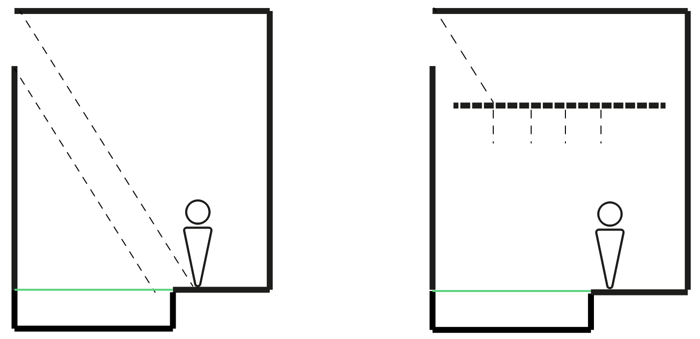

Figure 156 - Suspended ceiling light, Own Illustration

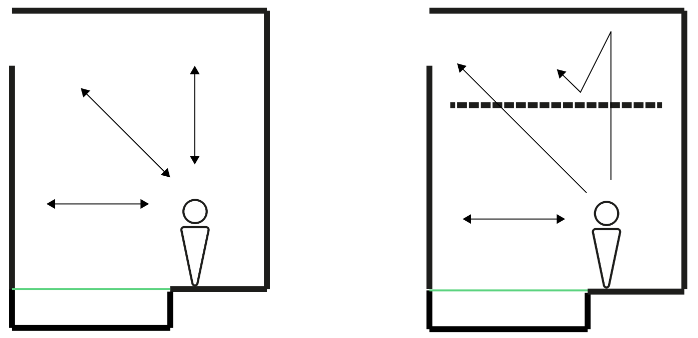

Figure 157 - Suspended ceiling intimacy, Own Illustration

The atmosphere of the lukewarm water pool room has been enhanced placing a suspended ceiling.
The room had a really high ceiling, which did not give any different expression to the atmosphere and users would have felt lost in this huge environment.
The placement of the suspended ceiling helped to filtrate the solar light within the room in a delicate way (fig. 156), and it is assumed that it performs as a sound absorber any possible.
Users can experience a more intimate and cozy space (fig. 157).


Figure 158 - Wood envelope, Own Illustration


Figure 159 - Metal corten envelope, Own Illustration


Figure 160 - Wood and metal corten envelope, Own Illustration


Figure 161 - Polycarbonate envelope, Own Illustration

Different materials have been explored in order to explore different kinds of contrast we could have achieved between the building and the context. Wood (fig. 158), metal corten (fig.159), a mix of the two (fig. 160) and polycarbonate (fig. 161) have been investigated through some visualisations. The iteration with a polycarbonate envelope and wooden elements has been chosen for its properties of semi-transparency and its light appearance.
Further studies on the facade have been carried on (see Appendix 05) in connection to the dimensioning of the vertical elements of the structure.

05

EPILOGUE

CONCLUSION

This project concerns the development of a Thermal baths in a marble quarry in Carrara.
The atmosphere created from the dialogue between the different materials, the structure, the space flux and the magnificent context has been investigated in a multi-sensorial and technical way. The views, the peculiar characteristics and the material of the quarry challenged the design from the beginning. The focus was mainly to act in contrast with the context, which is characterised by a specific atmosphere, and design an experience journey step by step into the building.
The Thermal baths of Peter Zumthor and the Caracalla baths have been investigated and taken as main sources of inspiration.
According to the design parameters, the project is a fluent space closely related to the human needs of constant changes and intimacy. The materials and their thermal inner characteristics create different atmospheres within the building.
Thanks to the complexity of the context the design has a strong identity.

REFLECTION

Throughout the project, the integrated design process has been a useful tool in the iterative method.
The atmosphere is a complex phenomenon that is given by the cooperation of many factors. According to time schedule, not all these factors have been developed.

The first aspect which have been considered is the light. It has been demanding to test how the light reflects on the marble and water and therefore affects the internal atmosphere. The rendering tool was used to study the qualitative aspect of the light, while DIVA and Velux were used to evaluate quantitative aspects. However both the tools had limitations in the truthfulness of the results because the atmosphere cannot be tested but just experienced through the senses.

A second challenge was to work with the rough marble in the project. It has been technically complex to build on top and inside the marble due to the need of insulation in the design. Therefore the integration of other materials such as concrete and metal elements has been necessary for structural aspects.

A grid structure has been chosen for its flexibility in the division of the spaces. However some of the elements could have been thinner and lighter according to the density of the grid in the different rooms. In this way the span and the section of the elements could have resulted in a different spatial perception. A visible joint has been chosen according to the idea of the contrast, but its dimensioning needs further investigations.

Assumptions and simple calculations concerning the thermal properties of the materials have been done, but they would need to be tested with a thermal model to verify the design solutions.

Considerations concerning the construction of a project on the marble will have to be explored further according to the need of sofisticated machinery work and deep knowledge of techniques of extraction, escavation and manufacturing.
Thanks to the complexity of the context the design has a strong identity.

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06

APPENDIX

HOT WATER POOL

21 DECEMBER, EVERY HOUR FROM 8 TO 17

21 JUNE, EVERY HOUR FROM 8 TO 17

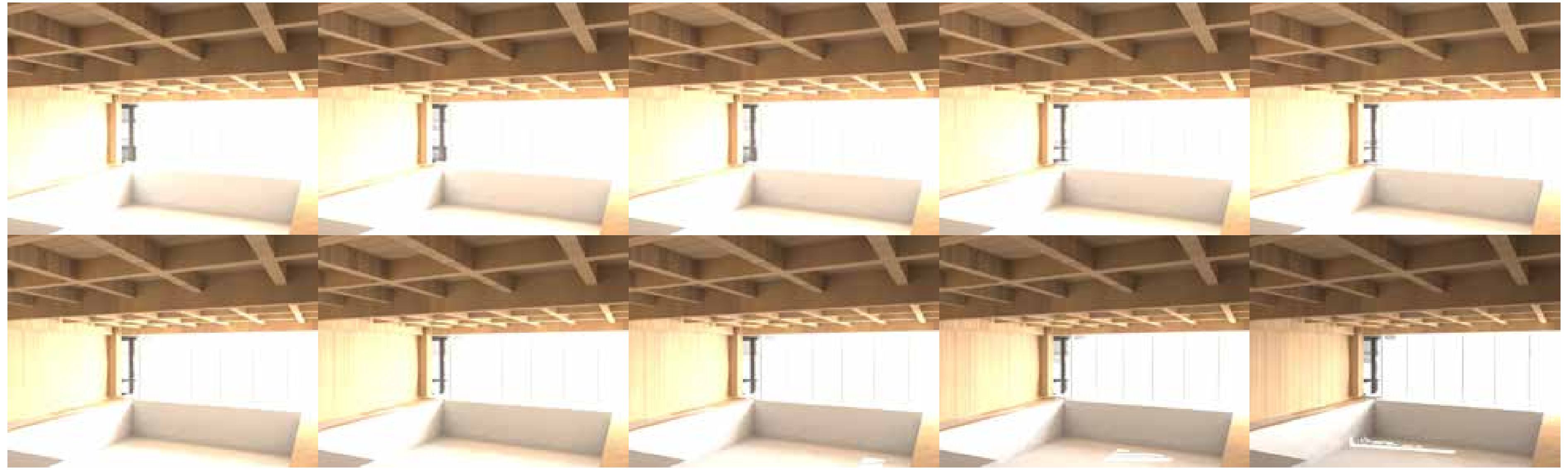
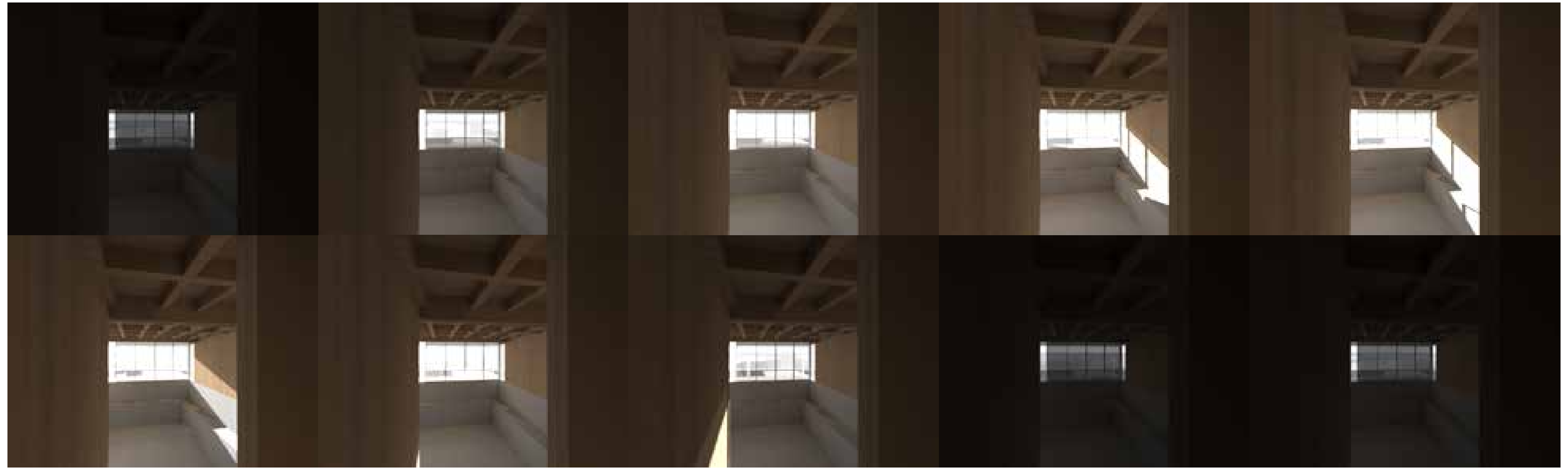


Figure 162 -Hot water pool Velux light analysis, Own Illustration

LUKEWARM WATER POOL

21 DECEMBER, EVERY HOUR FROM 8 TO 17



21 JUNE, EVERY HOUR FROM 8 TO 17

Figure 163 -Lukewarm water pool Velux light analysis, Own Illustration

INDOOR/OUTDOOR WATER POOL

21 DECEMBER, EVERY HOUR FROM 8 TO 17

21 JUNE, EVERY HOUR FROM 8 TO 17

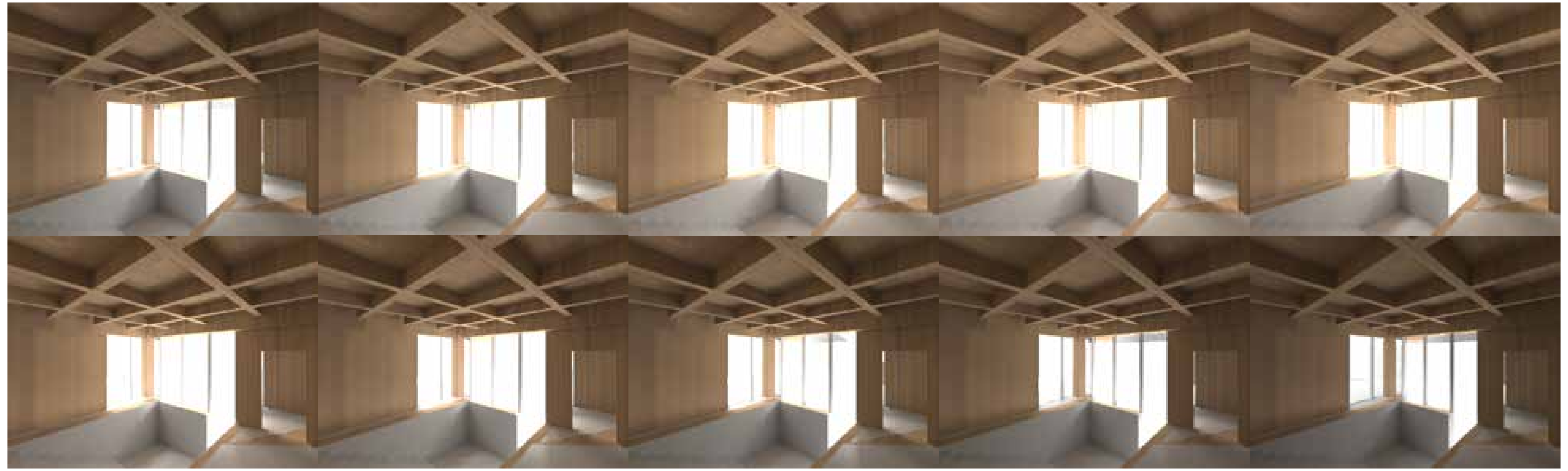


Figure 164 - Indoor/outdoor water pool Velux light analysis, Own Illustration

APPENDIX 02: LIGHT CALCULATIONS ON DIVA

GROUND FLOOR

FIRST FLOOR

WINTER

SUMMER

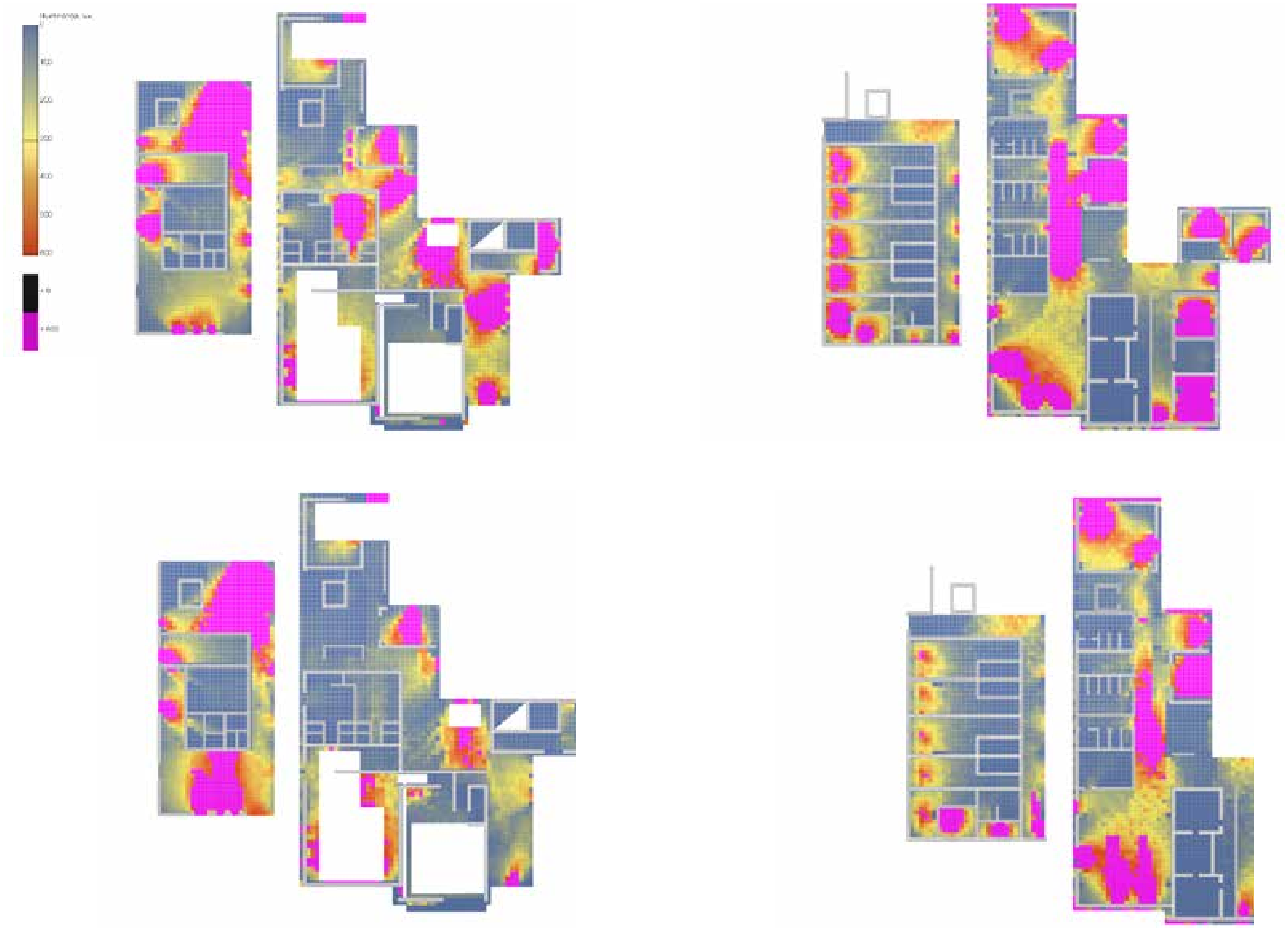


Figure 165 - DIVA final analysis, Own Illustration

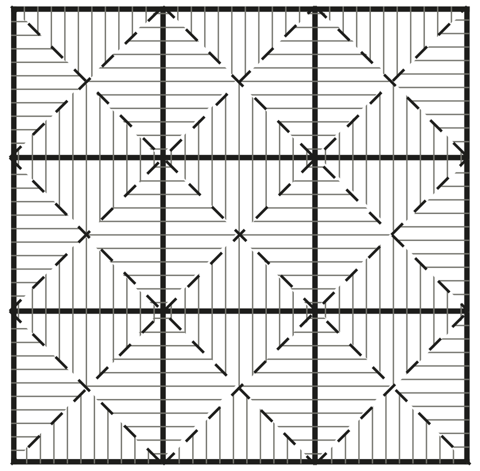


Figure 166 - Structural distribution of forces in a grid, Own Illustration

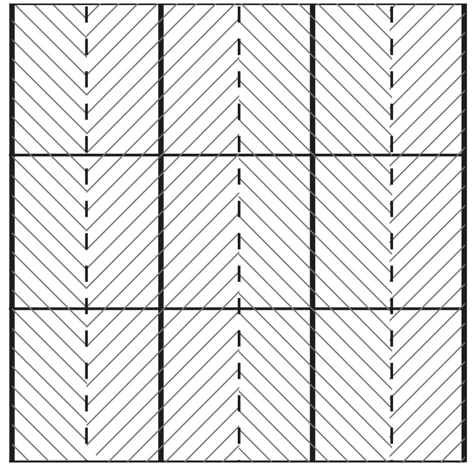


Figure 167 - Simplification on Grasshopper, Own Illustration

LOADS

Roof load + Snow load applied on the roof structure
Ceiling load + People load applied on the ceiling structure
Wind load applied on the south facade

The fix joint between the elements allow an homogeneous redistribtion of forces among all the beams. For this reason on which component the forces are applied becomes non influential in terms of structural calculation and member verification.

DEAD LOADS

Roof construction: G_{roof} = 1.5 KN/ m^2
Ceiling + people load: G_c = 4.3 KN/ m^2
Structural elements: calculated by Grasshopper

SNOW LOAD

$s = \mu_i \cdot C_e \cdot C_t \cdot S_k$

Roof inclination: 1°

μ_i: shape coefficient = 0.8
C_e: exposure coefficient = 1.1
C_t: thermal coefficient = 1
S_k: characteristic value of snow on the ground = 1.53 KN/m^2

Q_{snow} = 1.35 KN/m^2

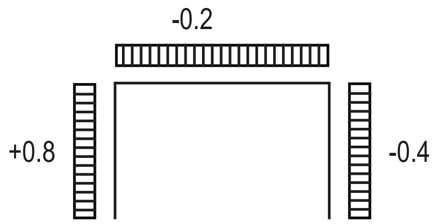
WIND LOAD

$q_p(z) = C_e(z) \cdot 0.613 \cdot V_b^2$

Terrain category: III
$C_e(z)$: exposure coefficient = 1.2
V_b: wind velocity = 27 m/s

$q_p(z)$ = 0.5 KN/m^2

$C_{pe,10}$ values



Q_{wind} zone A: 0.4 KN/m^2
Q_{wind} zone C: 0.2 KN/m^2
Q_{wind} zone D: 0.1 KN/m^2

LOAD COMBINATION - DOMINANT SNOW LOAD

ULS

$\sum \Upsilon_{G,j} \cdot G_{k,j} + \Upsilon_{Q,k,1} \cdot Q_{k,1} + \sum \Upsilon_{Q,i} \cdot \Psi_{Q,i} \cdot Q_{k,1}$

$\Upsilon_{G,j} = 1.35$
$\Upsilon_{Q,k,1} = 1.5$
$\Upsilon_{Q,i} = 1.5$
$\Psi_{Q,i} = 0.5$

ULS = 12.9 KN/m^2

SLS

$\sum G_{k,j} + Q_{k,1} + \sum \Psi_{0,i} \cdot Q_{k,1}$

$\Psi_{0,i} = 0.5$

SLS = 9.4 KN/m^2

LOAD COMBINATION - DOMINANT WIND LOAD

ULS

$\sum \Upsilon_{G,j} \cdot G_{k,j} + \Upsilon_{Q,k,1} \cdot Q_{k,1} + \sum \Upsilon_{Q,i} \cdot \Psi_{Q,i} \cdot Q_{k,1}$

$\Upsilon_{G,j} = 1.35$
$\Upsilon_{Q,k,1} = 1.5$
$\Upsilon_{Q,i} = 1.5$
$\Psi_{Q,i} = 0.5$

ULS = 12.25 KN/m^2

SLS

$\sum G_{k,j} + Q_{k,1} + \sum \Psi_{0,i} \cdot Q_{k,1}$

$\Psi_{0,i} = 0.5$

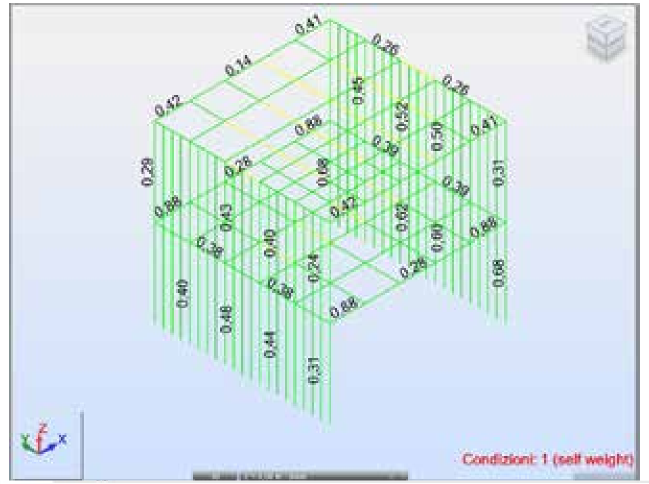
SLS = 9.0 KN/m^2

In all the calculations it has been chosen the worse situation, where there is a span of 10 m among columns and primary beams.

This calculation has been done considering only one cell of the grid system instead of the whole. Therefore the dimensioning of the elements consider an unfavourable security factor and they are designed to resist the worst case scenario.
The result ended in a section of 60x60 cm for columns, 50x50 cm for primary beams, 50x20 cm secondary beams and 20x10 cm wooden mullion with a distance of 50 cm between them.

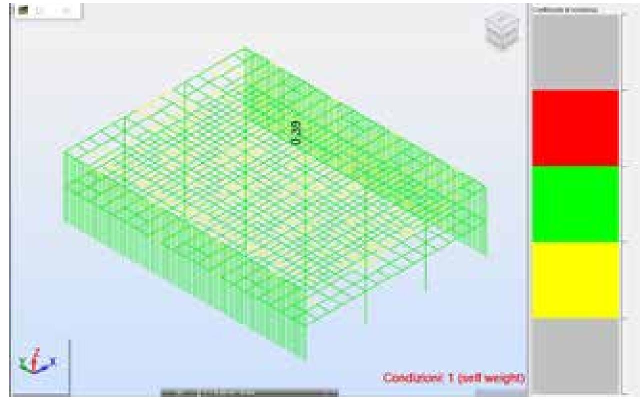
This calculation has been done considering a system of 4x3 grid.Therefore the stresses can be distributed among more elements. The dimensions have not been changed (section of 60x60 cm for columns, 50x50 cm for primary beams, 50x20 cm secondary beams and 20x10 cm wooden mullion with a distance of 50 cm between them) and thus the ratio of each element decreased.

In this calculation it has been tried to optimize the structural dimensioning by trying to lower all the sections to 50x50 cm for the columns, 50x30 cm for the primary beams, 50x20 cm for the secondary beams and 20x10 cm for the wooden mullion with a distance of 50 cm between them. The results show that some of the columns and of the primary beams will break.



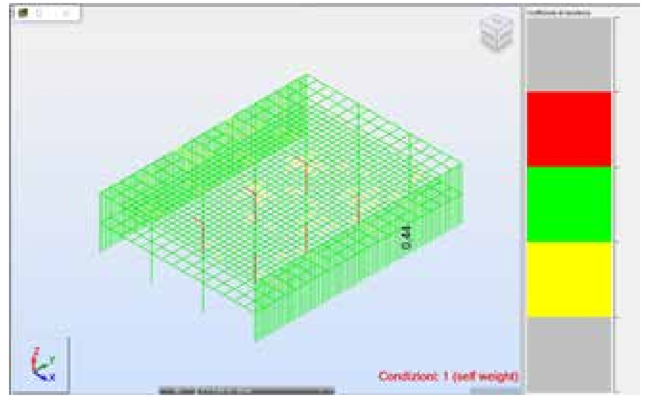
Barra	Profilato	Materiale	Lay	Laz	Resist.	Condizione
1	transversal beam	D30	13.86	13.86	0.88	3 wind load
6	transversal beam	D30	13.86	13.86	0.88	3 wind load
5	transversal beam	D30	13.86	13.86	0.88	3 wind load
10	transversal beam	D30	13.86	13.86	0.88	3 wind load
15	longitudinal bea	D30	13.86	13.86	0.86	3 wind load
11	longitudinal bea	D30	13.86	13.86	0.86	3 wind load
20	longitudinal bea	D30	13.86	13.86	0.86	3 wind load
16	longitudinal bea	D30	13.86	13.86	0.86	3 wind load
117	columns	D30	28.87	28.87	0.68	3 wind load
118	columns	D30	28.87	28.87	0.68	3 wind load
137	columns	D30	28.87	28.87	0.68	3 wind load
138	columns	D30	28.87	28.87	0.68	3 wind load
90	cordolo verticale	D30	86.60	173.21	0.65	4 ULS
86	cordolo verticale	D30	86.60	173.21	0.65	4 ULS
89	cordolo verticale	D30	86.60	173.21	0.62	4 ULS
87	cordolo verticale	D30	86.60	173.21	0.62	4 ULS
88	cordolo verticale	D30	86.60	173.21	0.61	4 ULS
91	cordolo verticale	D30	86.60	173.21	0.60	4 ULS
85	cordolo verticale	D30	86.60	173.21	0.60	4 ULS
94	cordolo verticale	D30	86.60	173.21	0.58	4 ULS
82	cordolo verticale	D30	86.60	173.21	0.58	4 ULS
92	cordolo verticale	D30	86.60	173.21	0.58	4 ULS
84	cordolo verticale	D30	86.60	173.21	0.58	4 ULS
93	cordolo verticale	D30	86.60	173.21	0.57	4 ULS
83	cordolo verticale	D30	86.60	173.21	0.57	4 ULS
124	secondary beam	D30	13.86	34.64	0.53	3 wind load
121	secondary beam	D30	13.86	34.64	0.53	3 wind load
197	secondary beam	D30	13.86	34.64	0.53	3 wind load
200	secondary beam	D30	13.86	34.64	0.53	3 wind load
40	longitudinal bea	D30	13.86	13.86	0.52	4 ULS
36	longitudinal bea	D30	13.86	13.86	0.52	4 ULS

Figure 168 - Robot calculation iteration 01, Own Illustration



Barra	Profilato	Materiale	Lay	Laz	Resist.	Condizione
717	columns	D30	28.87	28.87	0.68	3 wind load
683	columns	D30	28.87	28.87	0.68	3 wind load
718	columns	D30	28.87	28.87	0.67	3 wind load
716	columns	D30	28.87	28.87	0.67	3 wind load
684	columns	D30	28.87	28.87	0.66	3 wind load
682	columns	D30	28.87	28.87	0.66	3 wind load
594	primary beams	D30	13.86	13.86	0.65	3 wind load
575	primary beams	D30	13.86	13.86	0.65	3 wind load
574	primary beams	D30	13.86	13.86	0.65	3 wind load
555	primary beams	D30	13.86	13.86	0.65	3 wind load
584	primary beams	D30	13.86	13.86	0.62	3 wind load
585	primary beams	D30	13.86	13.86	0.62	3 wind load
564	primary beams	D30	13.86	13.86	0.61	3 wind load
565	primary beams	D30	13.86	13.86	0.61	3 wind load
514	primary beams	D30	13.86	13.86	0.61	4 ULS
544	primary beams	D30	13.86	13.86	0.61	4 ULS
580	primary beams	D30	13.86	13.86	0.61	3 wind load
589	primary beams	D30	13.86	13.86	0.61	3 wind load
560	primary beams	D30	13.86	13.86	0.61	3 wind load
569	primary beams	D30	13.86	13.86	0.61	3 wind load
539	primary beams	D30	13.86	13.86	0.61	4 ULS
579	primary beams	D30	13.86	13.86	0.60	3 wind load
590	primary beams	D30	13.86	13.86	0.60	3 wind load
559	primary beams	D30	13.86	13.86	0.60	3 wind load
570	primary beams	D30	13.86	13.86	0.60	3 wind load
519	primary beams	D30	13.86	13.86	0.57	4 ULS
549	primary beams	D30	13.86	13.86	0.57	4 ULS
534	primary beams	D30	13.86	13.86	0.56	4 ULS
12	cordolo verticale	D30	86.60	173.21	0.55	4 ULS
122	cordolo verticale	D30	86.60	173.21	0.55	4 ULS
685	columns	D30	28.87	28.87	0.55	3 wind load

Figure 169 - Robot calculation iteration 02, Own Illustration

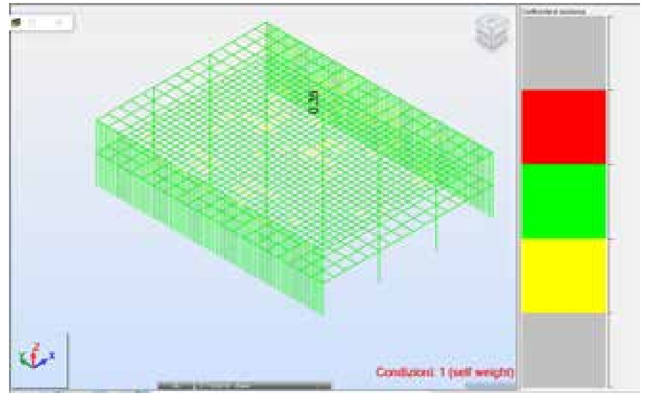


Barra	Profilato	Materiale	Lay	Laz	Resist.	Condizione
717	columns	D30	34.64	34.64	1.12	3 wind load
603	columns	D30	34.64	34.64	1.10	3 wind load
718	columns	D30	34.64	34.64	1.12	3 wind load
716	columns	D30	34.64	34.64	1.12	3 wind load
682	columns	D30	34.64	34.64	1.12	3 wind load
684	columns	D30	34.64	34.64	1.12	3 wind load
529	primary beams	D30	13.86	23.09	1.01	4 ULS
534	primary beams	D30	13.86	23.09	1.01	4 ULS
564	primary beams	D30	13.86	23.09	1.01	4 ULS
535	primary beams	D30	13.86	23.09	0.95	3 wind load
520	primary beams	D30	13.86	23.09	0.94	3 wind load
550	primary beams	D30	13.86	23.09	0.94	3 wind load
525	primary beams	D30	13.86	23.09	0.92	3 wind load
539	primary beams	D30	13.86	23.09	0.91	3 wind load
524	primary beams	D30	13.86	23.09	0.91	4 ULS
554	primary beams	D30	13.86	23.09	0.91	4 ULS
510	primary beams	D30	13.86	23.09	0.90	3 wind load
508	primary beams	D30	13.86	23.09	0.90	3 wind load
519	primary beams	D30	13.86	23.09	0.90	4 ULS
549	primary beams	D30	13.86	23.09	0.90	4 ULS
460	primary beams	D30	13.86	23.09	0.90	3 wind load
475	primary beams	D30	13.86	23.09	0.90	3 wind load
534	primary beams	D30	13.86	23.09	0.90	4 ULS
474	primary beams	D30	13.86	23.09	0.89	3 wind load
409	primary beams	D30	13.86	23.09	0.89	3 wind load
711	columns	D30	34.64	34.64	0.89	3 wind load
649	columns	D30	34.64	34.64	0.89	3 wind load
504	primary beams	D30	13.86	23.09	0.88	3 wind load
505	primary beams	D30	13.86	23.09	0.88	3 wind load
564	primary beams	D30	13.86	23.09	0.88	3 wind load
565	primary beams	D30	13.86	23.09	0.88	3 wind load
686	columns	D30	34.64	34.64	0.86	3 wind load
681	columns	D30	34.64	34.64	0.86	3 wind load
750	columns	D30	34.64	34.64	0.86	3 wind load
752	columns	D30	34.64	34.64	0.85	3 wind load
719	columns	D30	34.64	34.64	0.85	3 wind load
715	columns	D30	34.64	34.64	0.85	3 wind load
648	columns	D30	34.64	34.64	0.85	3 wind load

Figure 170 - Robot calculation iteration 03, Own Illustration

In this calculation the size of the columns have been raised (55x55 cm for the columns, 50x30 cm for the primary beams, 50x20 cm for the secondary beams and 20x10 cm for the wooden mullion with a distance of 50 cm between them). The results show that all the elements resist to the loads

Despite the last positive result, investigations on the distance between the wood mullions has been tried. In this simulation the mullions have been set at a distance of 100 cm. The results show that some of them break.



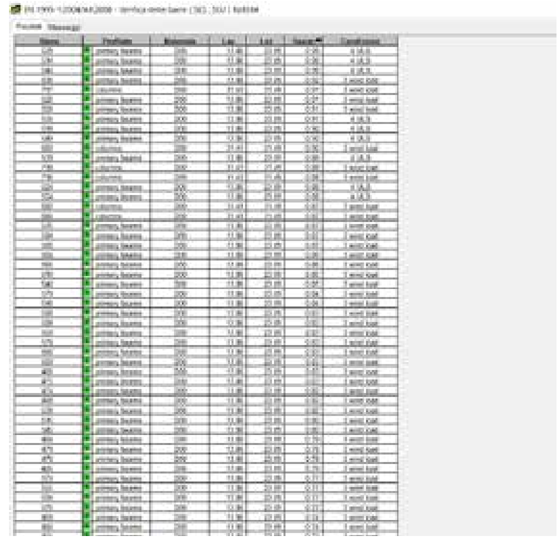
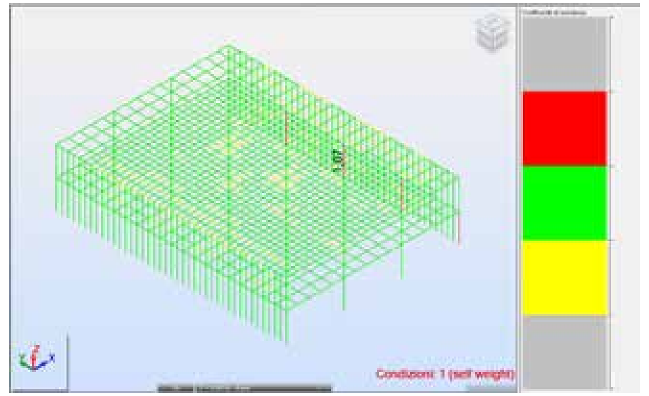


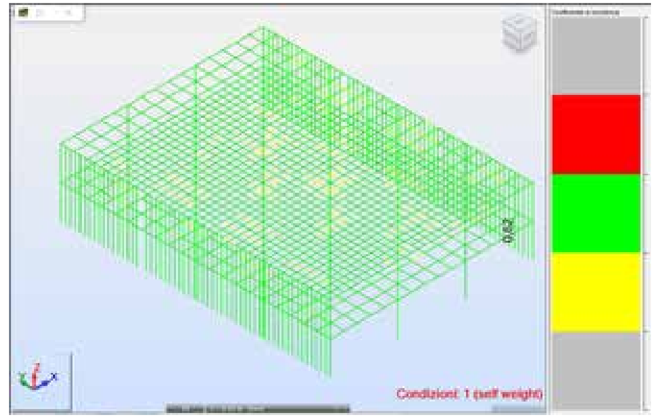
Figure 171 - Robot calculation iteration 04, Own Illustration

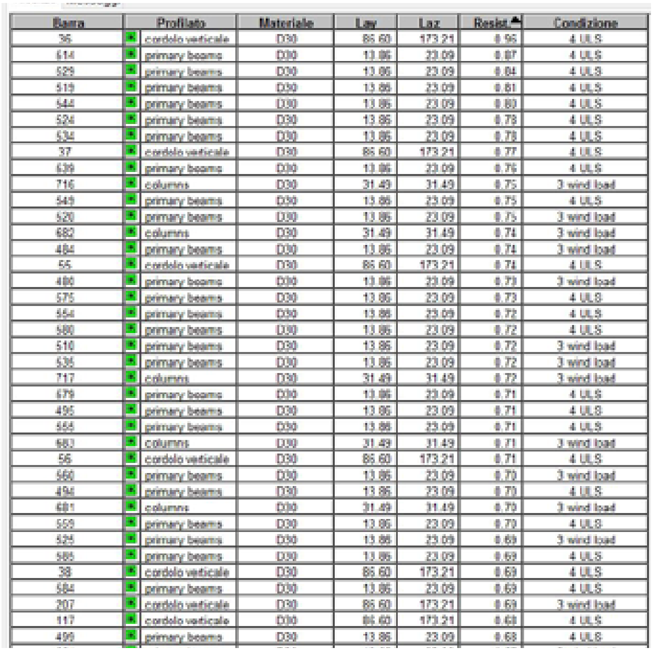


11	cordolo verticale	D30	86.60	173.21	1.06
20	cordolo verticale	D30	86.60	173.21	1.01
29	cordolo verticale	D30	86.60	173.21	0.94
31	cordolo verticale	D30	86.60	173.21	0.93
133	cordolo verticale	D30	86.60	173.21	0.93
2	cordolo verticale	D30	86.60	173.21	0.92
18	cordolo verticale	D30	86.60	173.21	0.92
12	cordolo verticale	D30	86.60	173.21	0.92
28	cordolo verticale	D30	86.60	173.21	0.91
32	cordolo verticale	D30	86.60	173.21	0.90
49	cordolo verticale	D30	86.60	173.21	0.90
38	cordolo verticale	D30	86.60	173.21	0.89
3	cordolo verticale	D30	86.60	173.21	0.89
9	cordolo verticale	D30	86.60	173.21	0.88
58	cordolo verticale	D30	86.60	173.21	0.88
13	cordolo verticale	D30	86.60	173.21	0.88
68	cordolo verticale	D30	86.60	173.21	0.87
21	cordolo verticale	D30	86.60	173.21	0.87
182	cordolo verticale	D30	86.60	173.21	0.87
163	cordolo verticale	D30	86.60	173.21	0.86
22	cordolo verticale	D30	86.60	173.21	0.86
153	cordolo verticale	D30	86.60	173.21	0.85
26	cordolo verticale	D30	86.60	173.21	0.84
34	cordolo verticale	D30	86.60	173.21	0.83
36	cordolo verticale	D30	86.60	173.21	0.83
24	cordolo verticale	D30	86.60	173.21	0.83
6	cordolo verticale	D30	86.60	173.21	0.82
519	primary beams	D30	13.86	23.09	0.82
48	cordolo verticale	D30	86.60	173.21	0.82
7	cordolo verticale	D30	86.60	173.21	0.82
58	cordolo verticale	D30	86.60	173.21	0.81
27	cordolo verticale	D30	86.60	173.21	0.81
514	primary beams	D30	13.86	23.09	0.81

Figure 172 - Robot calculation iteration 05, Own Illustration

In the last simulation the distance between the wooden mullion has been set at 70 cm. The results show that all the elements resist to the loads.





Barra	Profilato	Materiale	Lay	Laz	Resist.	Condizione
36	cordolo verticale	D30	86.60	173.21	0.96	4 ULS
614	primary beams	D30	13.86	23.09	0.87	4 ULS
529	primary beams	D30	13.86	23.09	0.84	4 ULS
519	primary beams	D30	13.86	23.09	0.81	4 ULS
544	primary beams	D30	13.86	23.09	0.80	4 ULS
524	primary beams	D30	13.86	23.09	0.78	4 ULS
534	primary beams	D30	13.86	23.09	0.78	4 ULS
37	cordolo verticale	D30	86.60	173.21	0.77	4 ULS
639	primary beams	D30	13.86	23.09	0.76	4 ULS
716	columns	D30	31.49	31.49	0.75	3 wind load
549	primary beams	D30	13.86	23.09	0.75	4 ULS
520	primary beams	D30	13.86	23.09	0.75	3 wind load
682	columns	D30	31.49	31.49	0.74	3 wind load
484	primary beams	D30	13.86	23.09	0.74	3 wind load
55	cordolo verticale	D30	86.60	173.21	0.74	4 ULS
486	primary beams	D30	13.86	23.09	0.73	3 wind load
575	primary beams	D30	13.86	23.09	0.73	4 ULS
554	primary beams	D30	13.86	23.09	0.72	4 ULS
580	primary beams	D30	13.86	23.09	0.72	4 ULS
510	primary beams	D30	13.86	23.09	0.72	3 wind load
535	primary beams	D30	13.86	23.09	0.72	3 wind load
717	columns	D30	31.49	31.49	0.72	3 wind load
679	primary beams	D30	13.86	23.09	0.71	4 ULS
495	primary beams	D30	13.86	23.09	0.71	4 ULS
555	primary beams	D30	13.86	23.09	0.71	4 ULS
683	columns	D30	31.49	31.49	0.71	3 wind load
56	cordolo verticale	D30	86.60	173.21	0.71	4 ULS
560	primary beams	D30	13.86	23.09	0.70	3 wind load
494	primary beams	D30	13.86	23.09	0.70	4 ULS
681	columns	D30	31.49	31.49	0.70	3 wind load
559	primary beams	D30	13.86	23.09	0.70	4 ULS
525	primary beams	D30	13.86	23.09	0.69	3 wind load
585	primary beams	D30	13.86	23.09	0.69	4 ULS
38	cordolo verticale	D30	86.60	173.21	0.69	4 ULS
584	primary beams	D30	13.86	23.09	0.69	4 ULS
207	cordolo verticale	D30	86.60	173.21	0.69	3 wind load
117	cordolo verticale	D30	86.60	173.21	0.68	4 ULS
499	primary beams	D30	13.86	23.09	0.68	4 ULS

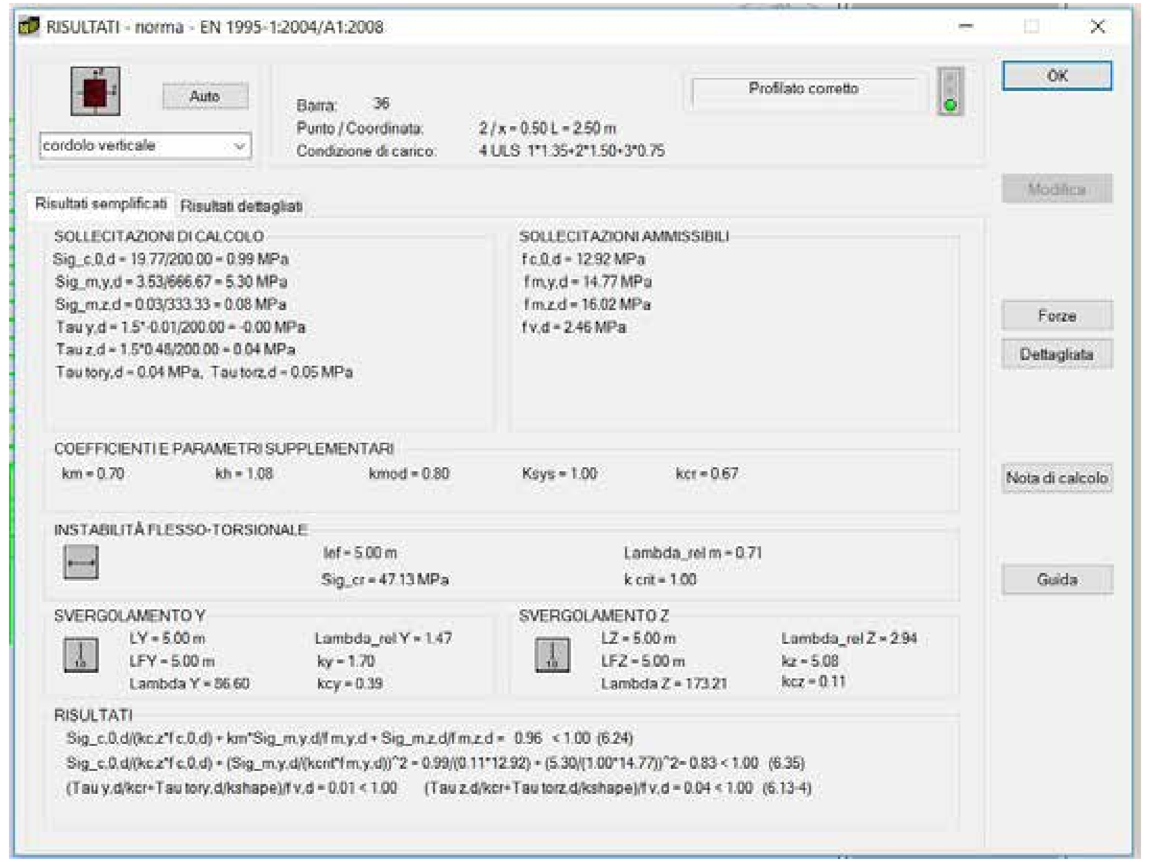


Figure 173 - Robot calculation final iteration, Own Illustration

Hot pool water temperature (t_e):	37°C
Lukewarm pool (estimated) air temperature (t_i):	23°C
Conduction material:	marble with an U value of 1.1 W/m²K

R_{is} = 0.13 m²K/W h_i = 7.7 W/ m²K

$$t_s = t_i - \frac{U}{h_i} \cdot (t_i - t_e) = 25\ °C$$

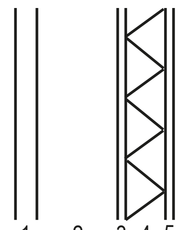
APPENDIX 07 - U VALUE CALCULATIONS

U VALUE LIMIT

Climatic zone: D

Vertical closing:	0.34 W/m²K
Horizontal closing:	0.30 W/m²K
Transparent closing:	2.00 W/m²K

POLYCARBONATE + WALL



1 - polycarbonate	t: 0.055 m R: 1.2 m²K/W
2 - air	t: 0.2 m λ: 0.16 W/mK (maximum value for a thickness of 0.02m, see fig. XX)
3 - wood	t: 0.02 m λ: 0.1 W/mK
4 - rockwool insulation	t: 0.1 m λ: 0.04 W/mK
5 - wood	t: 0.02 m λ: 0.1 W/mK

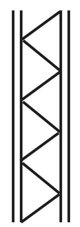
R_{is} = 0.13 m²K/W R_{es} = 0.04 m²K/W

$$U = \frac{1}{R_{es} + t_p/\lambda_p + t_a/\lambda_a + t_w/\lambda_w + t_i/\lambda_i + t_w/\lambda_w + R_{is}} = 0.1\ W/m^2K$$

POLYCARBONATE

U = 0.83 W/m²K

WALL



1 - wood	t: 0.02 m λ: 0.1 W/mK
2 - rockwool insulation	t: 0.1 m λ: 0.04 W/mK
3 - wood	t: 0.02 m λ: 0.1 W/mK

R_{is} = 0.13 m²K/W R_{es} = 0.04 m²K/W

$$U = \frac{1}{R_{es} + t_w/\lambda_w + t_i/\lambda_i + t_w/\lambda_w + R_{is}} = 0.33\ W/m^2K$$

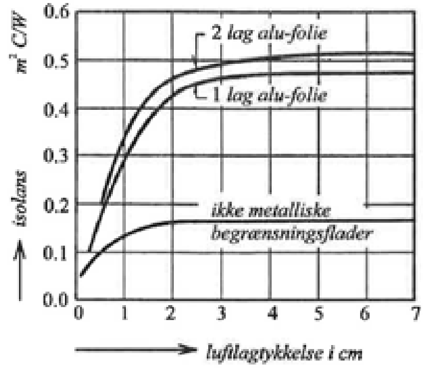
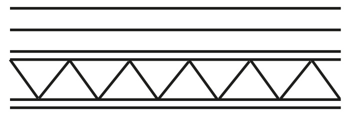


Figure 174 - U value air gap, from Aalborg Universitet

GLASS

U = 0.6 W/m²K

ROOF

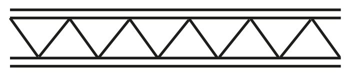


1 - polycarbonate	t: 0.055 m R: 1.2 m²K/W
2 - air	t: 0.05 m λ: 0.16 W/mK (maximum value for a thickness of 0.02m, see fig. XX)
3 - wood	t: 0.02 m λ: 0.1 W/mK
4 - rockwool insulation	t: 0.1 m λ: 0.04 W/mK
5 - wood	t: 0.02 m λ: 0.1 W/mK

R_{is} = 0.10 m²K/W R_{es} = 0.04 m²K/W

$$U = \frac{1}{R_{es} + t_p/\lambda_p + t_a/\lambda_a + t_w/\lambda_w + t_i/\lambda_i + t_w/\lambda_w + R_{is}} = 0.1\ W/m^2K$$

STEAM ROOM CEILING



1 - wood	t: 0.02 m λ: 0.1 W/mK
2 - rockwool insulation	t: 0.1 m λ: 0.04 W/mK
3 - marble	t: 0.01 m λ: 2.5 W/mK

R_{is} = 0.13 m²K/W

$$U = \frac{1}{R_{is} + t_w/\lambda_w + t_i/\lambda_i + t_m/\lambda_m + R_{is}} = 0.36\ W/m^2K$$

$$U_{tot} = \frac{1}{R_r + R_c} = 0.08\ W/m^2K$$

GROUND FLOOR

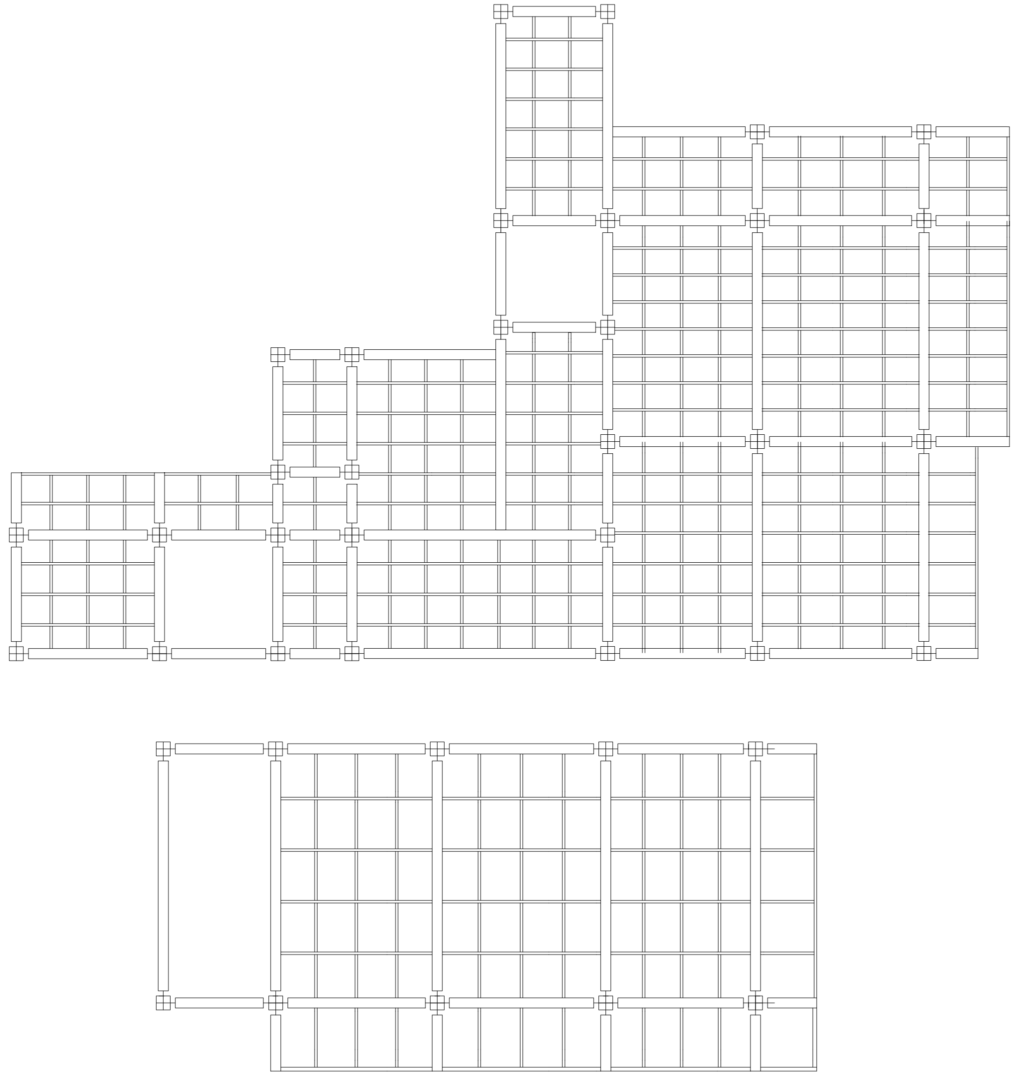


Figure 175 - Ground floor structural plan, Own Illustration

FIRST FLOOR

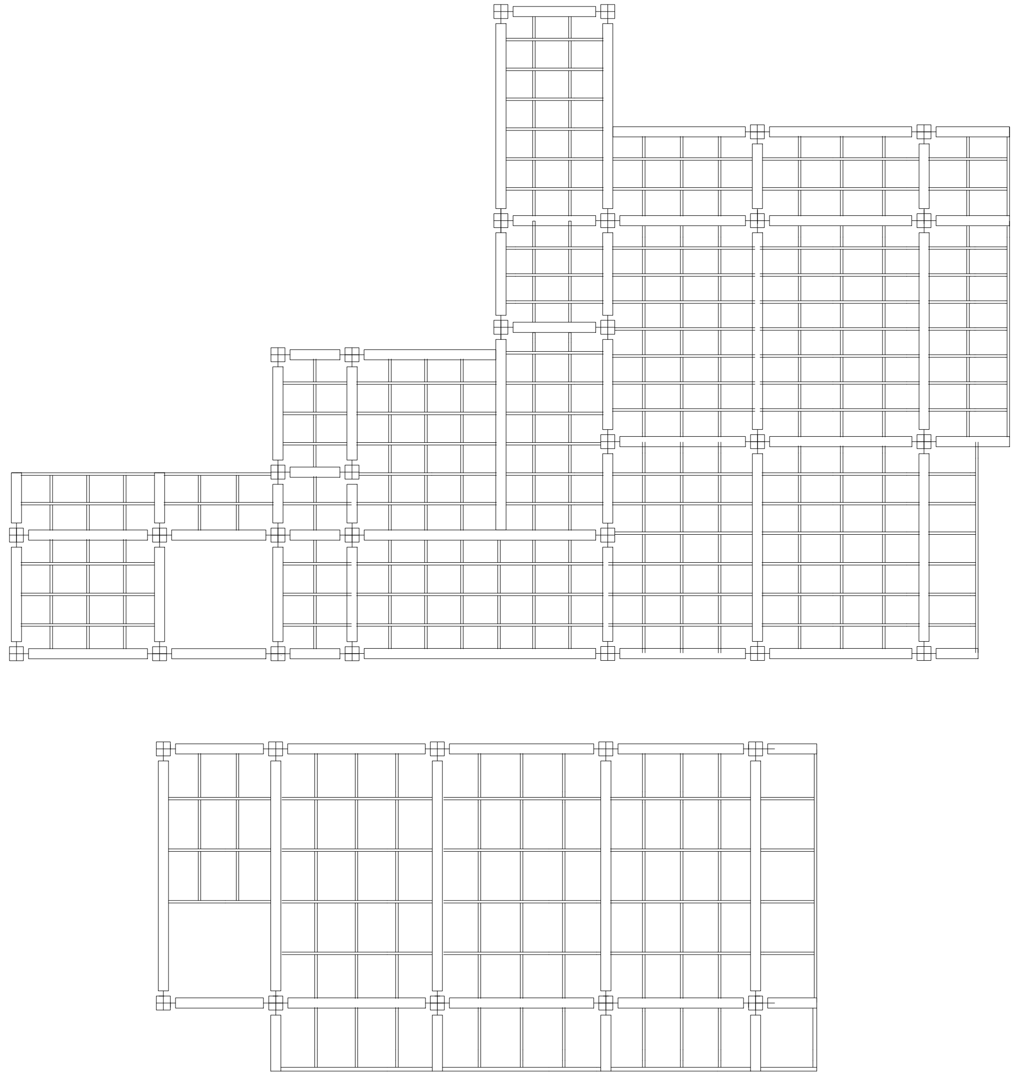


Figure 176 - First floor structural plan, Own Illustration

APPENDIX 09: MECHANICAL VENTILATION DEVICE

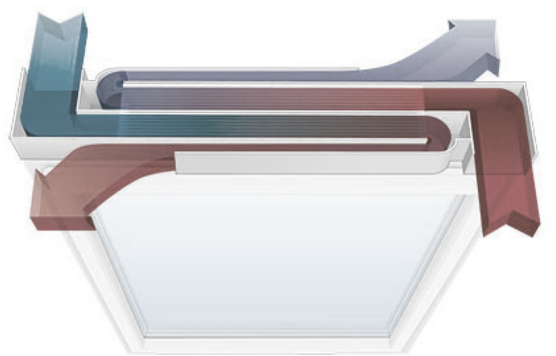


Figure 177 - Mechanical ventilation device, http://mikrovent.si/en/homepage/how-works

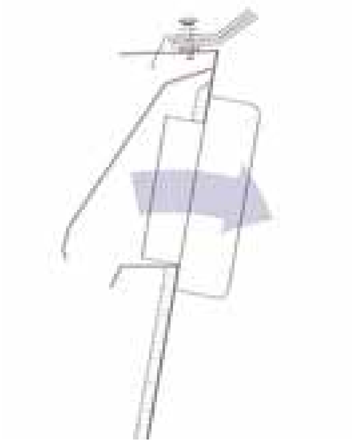


Figure 178 - Mechanical ventilation device skylight, http://www.skylights.co.uk/brand/other/xtralite.php

The Mechanical ventilation unit (MVHR) is a device for fresh air supply providing climate control, while also saving energy. The device is installed in the windows frame and it surveys the exausted air and expels the odors.
It's ideal for bathrooms and environments where is difficult to install the mechanical ventilation pipes.
The unit has a motor joined with two fans and it is studied for a continuous and extremely silent running with a low speed.

APPENDIX 10: VENTILATION SCHEME

GROUND FLOOR

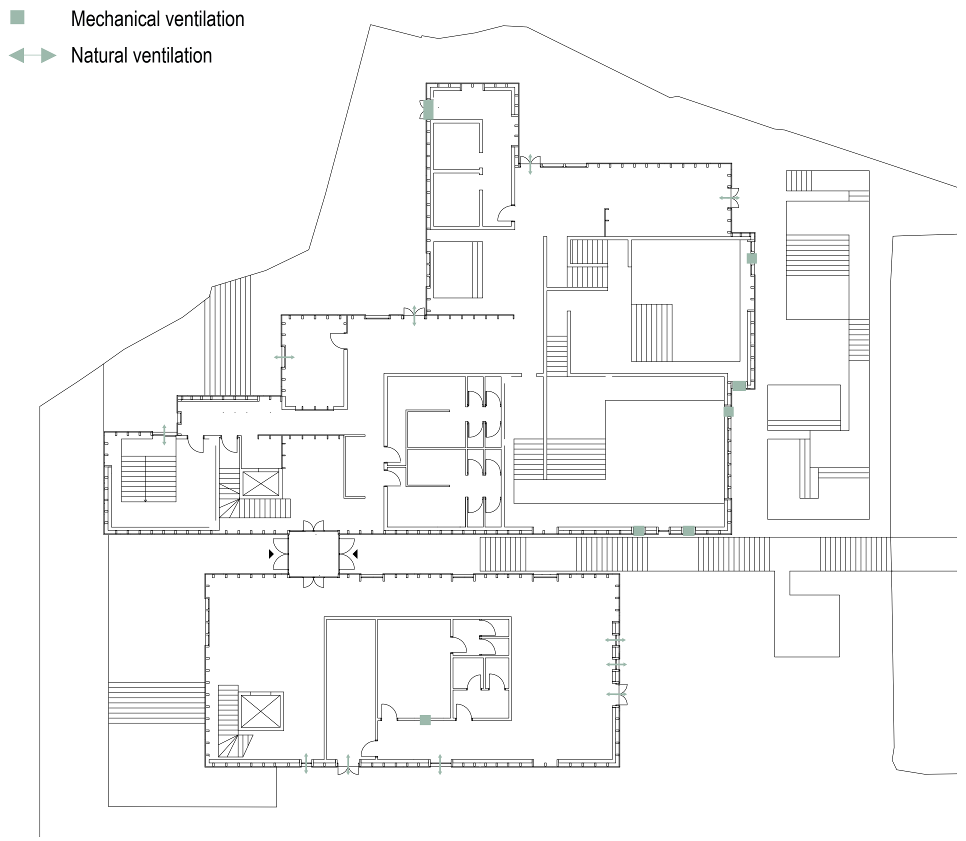


Figure 179 - Ground floor ventilation plan, Own Illustration

FIRST FLOOR

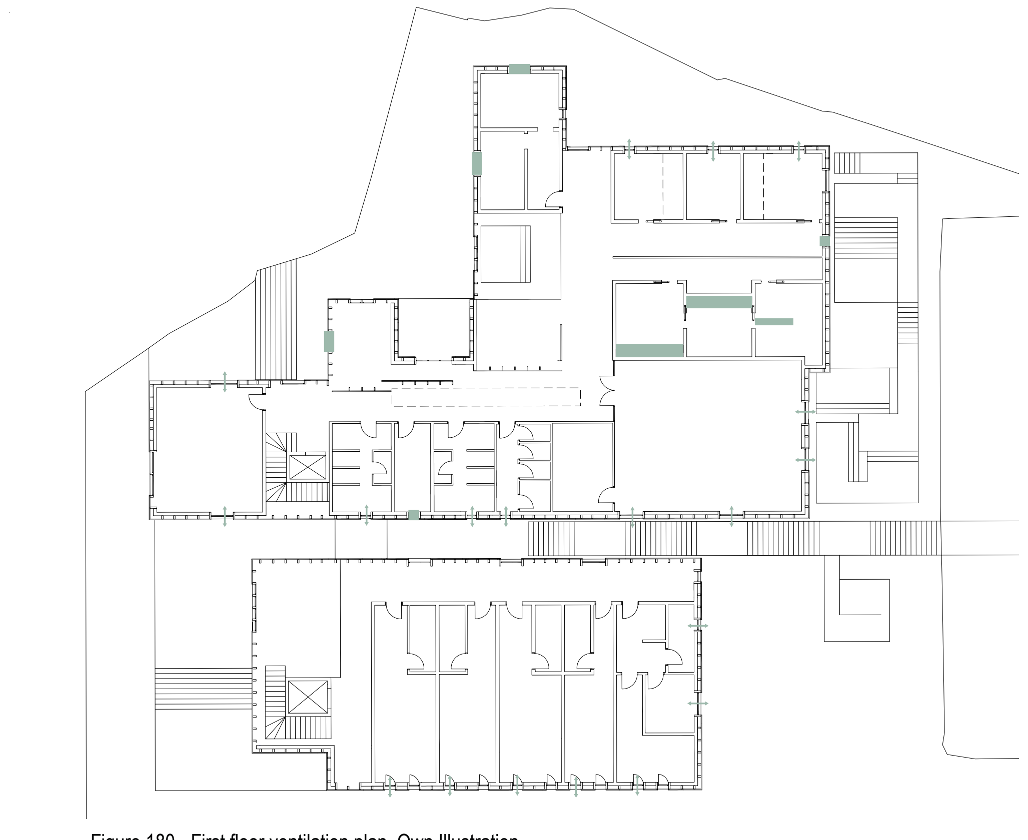


Figure 180 - First floor ventilation plan, Own Illustration

APPENDIX 11: XPS INSULATION

Figure 181 - Xps insulation, http://www.styrodur-italia.it/prodotti/styrodur-5000-cs/

Material: extruded polystyrene foam

Dimensions: 1250 x 600 x 100 mm

Applications:

- Thermal insulation of foundation slab in contact with the ground
- Thermal insulation under load applications

Property	Value	Unit	Standard
Compressive strength or compressive stress at 10% deformation	700	kPa	DIN EN 826
Permissible compressive stress over 50 years at < 2% deformation	250	kPa	DIN EN 1606
Rated value of compressive stress under foundation slabs (multilayer)	355	kPa	DIBT Z-23.34-1325
Modulus of elasticity E50	14,000	kPa	DIBT Z-23.34.1325
Dimensional stability: 70°C; 90% R H	≤5	%	DIN EN 1604
Deformation behaviour: load 40 kPa; 70°C	≤5	%	DIN EN 1605
Linear coefficient of thermal expansion Longitudinal Transverse	0.08 0.06	mm/mK	DIN 53752
Water absorption with long-term immersion	0.7	% in volume	DIN EN 12087
Application temperature limit immersion	75	C°	DIN EN 14706

APPENDIX 12: FIRE PLANS

The fire routes have been implemented to ensure no less than 25 meters towards the nearest exit area.

— — — Fire escape routes

GROUND FLOOR

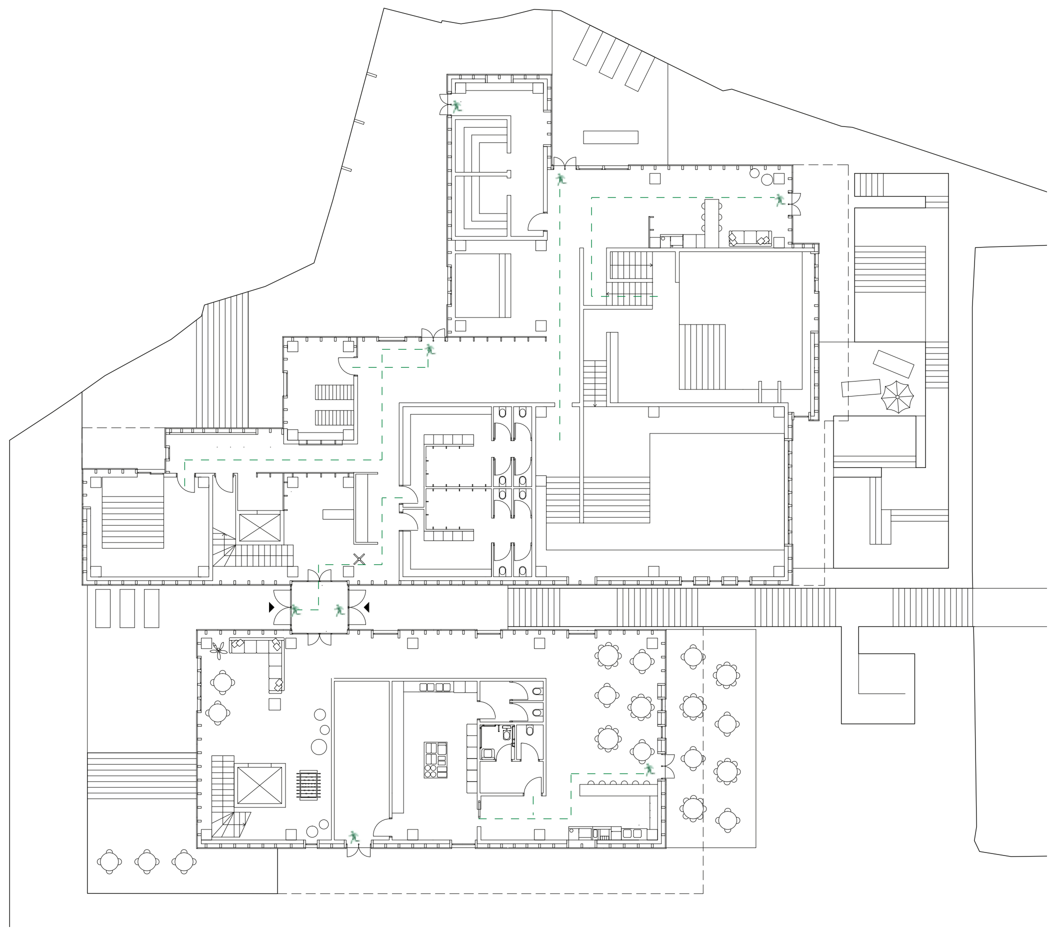


Figure 182 - Ground floor fire plan, Own Illustration

FIRST FLOOR

Figure 183 - First floor fire plan, Own Illustration

APPENDIX 13: DRAINPIPES PLAN

Figure 184 - Roof plan, Own Illustration

APPENDIX 14: INSPIRATIONS

CONTRAST

clear distinction between a base and a crowning

Figure 185 - Caixa Forum, Madrid, Herzog De Meuron, Photographer Uknown

STRUCTURE

timber grid structure with transparent envelope

Figure 186 - Nest We Grow, Hokkaido Kengo Kuma, Photographer Uknown

PATH

monumental entrance, sense of astonishment in front of the site

Figure 187 - Museum of civilisation, Beirut, GM Architects, Photographer Uknown

CLADDING

tranparency, different layers of privacy, visible timber structure

Figure 188 - Sendagrup Medical Centre, San Sebastian, Pauzarq, Photographer Uknown

APPENDIX 15: POSSIBLE FACADE SOLUTION

An effort has been done to enhance the project verticality and to make it relate with the quarry walls. For this reason the horizontal joists have been placed only at the level of the first floor and on the roof. Due to structural reasons their thickness creates an air gap of 20 cm, with a height of 5 m. However in order to exploit the insulating properties of the air gap, there should not be movement of air inside it. For this reason test on the performance of this solution should be investigated further. A possible solution is to enclose the air gap in air pokets by using horizontal elements more often. The use of polycarbonate partitions will still allow a light appereance of the building and it will theorically solve the possible movement of air.

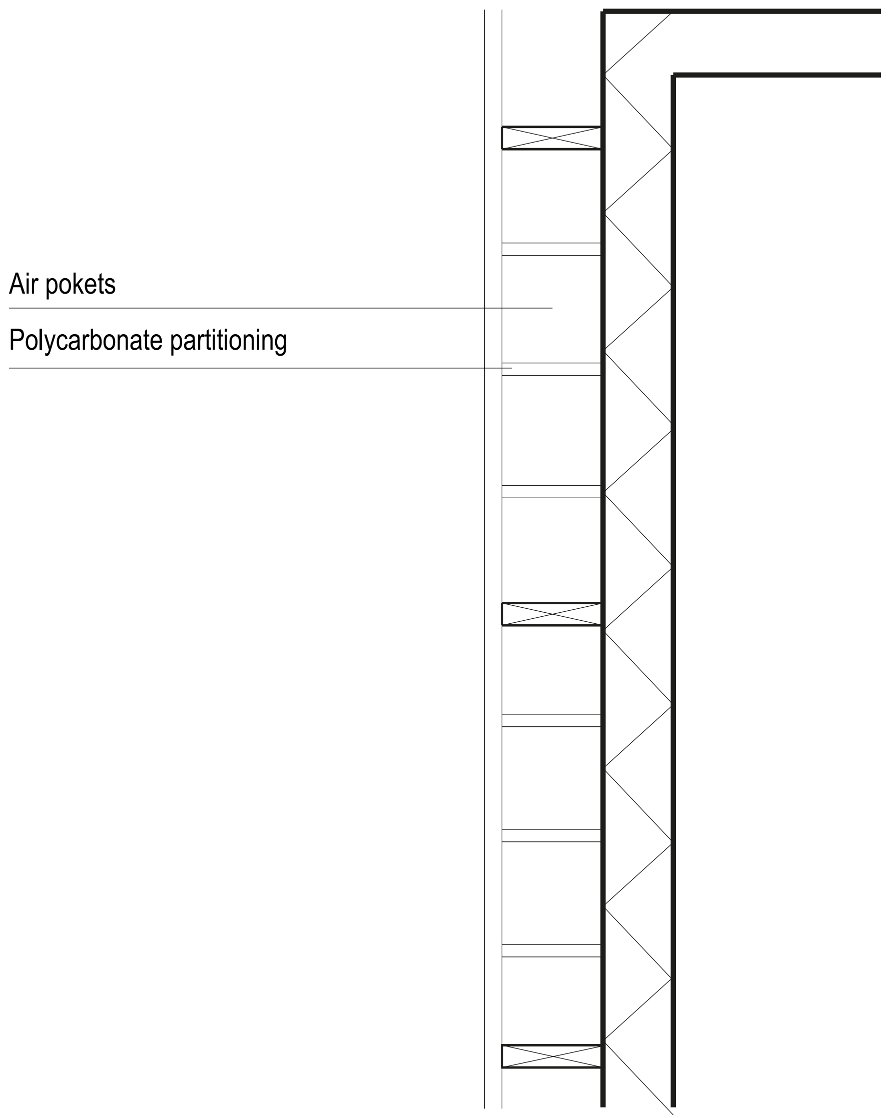


Figure 189 - Facade section scheme, Own Illustration

Figure 189 - Facade exploded diagram, Own Illustration

DRAWING LIST

Site plan, scale 1:500

Territorial section, scale 1:650

Cold water and technical room plan, scale 1:200

Ground floor plan, scale 1:200

First floor plan, scale 1:200

Longitudinal section, scale 1:200

Cut section, scale 1:200

Cross section 01, scale 1:200

Cross section 02, scale 1:200

South elevation, scale 1:200

West elevation, scale 1:200

Navigation map, no scale

Detail 01, scale 1:30

Detail 02, scale 1:10

Detail 03, scale 1:10

Detail 04, scale 1:10

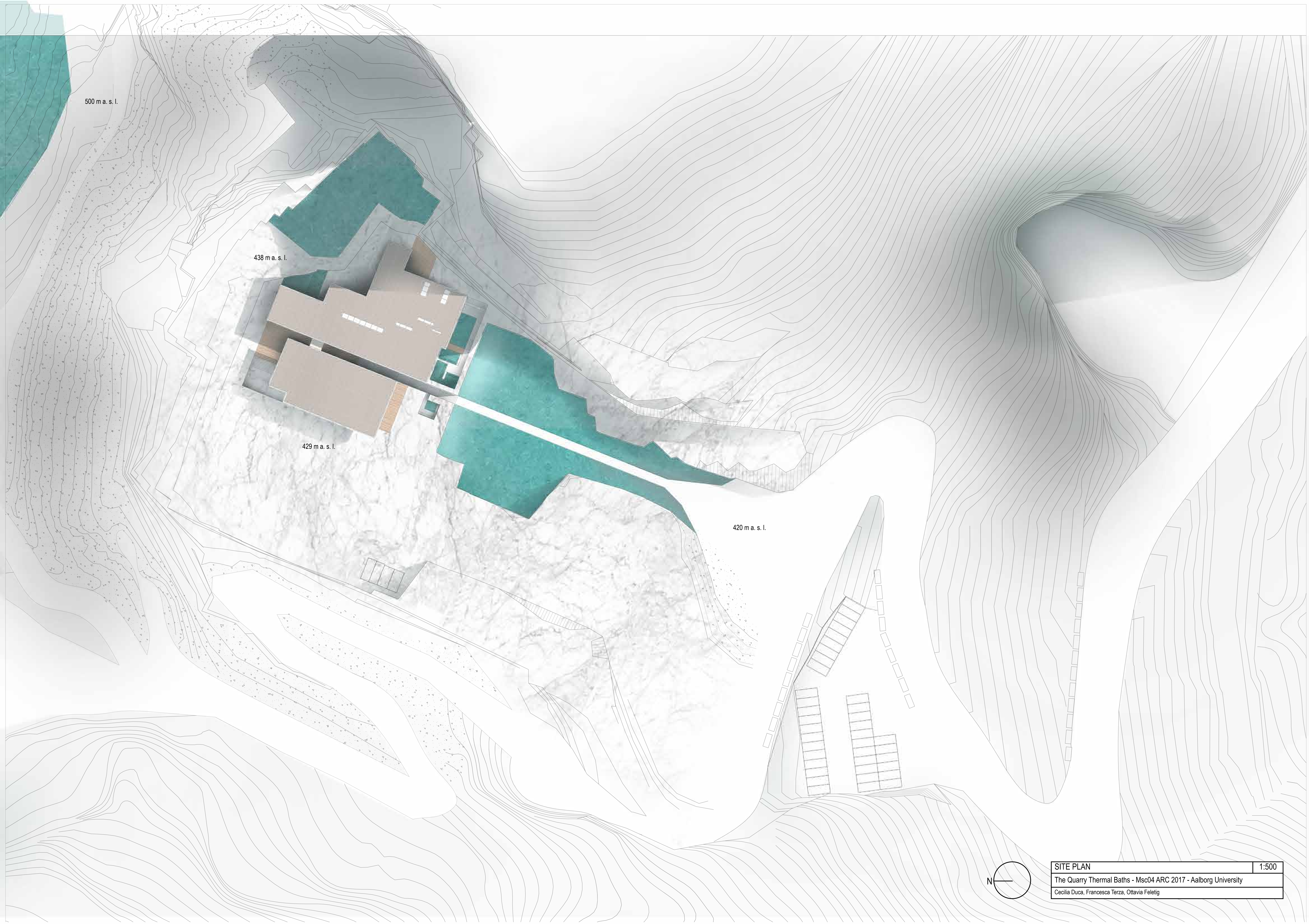
Detail 05, scale 1:10

Detail 06, scale 1:10

Detail 07, scale 1:10

Detail 08, scale 1:10

Detail 09, scale 1:10



SITE PLAN	1:500
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

TERRITORIAL SECTION	1:650
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

39 cold water pool
40 black water
41 grey water
42 white water
43 pumps
44 boiler hot water
45 water purifier
46 water collector hollow

COLD WATER AND TECHNICAL ROOM PLAN	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

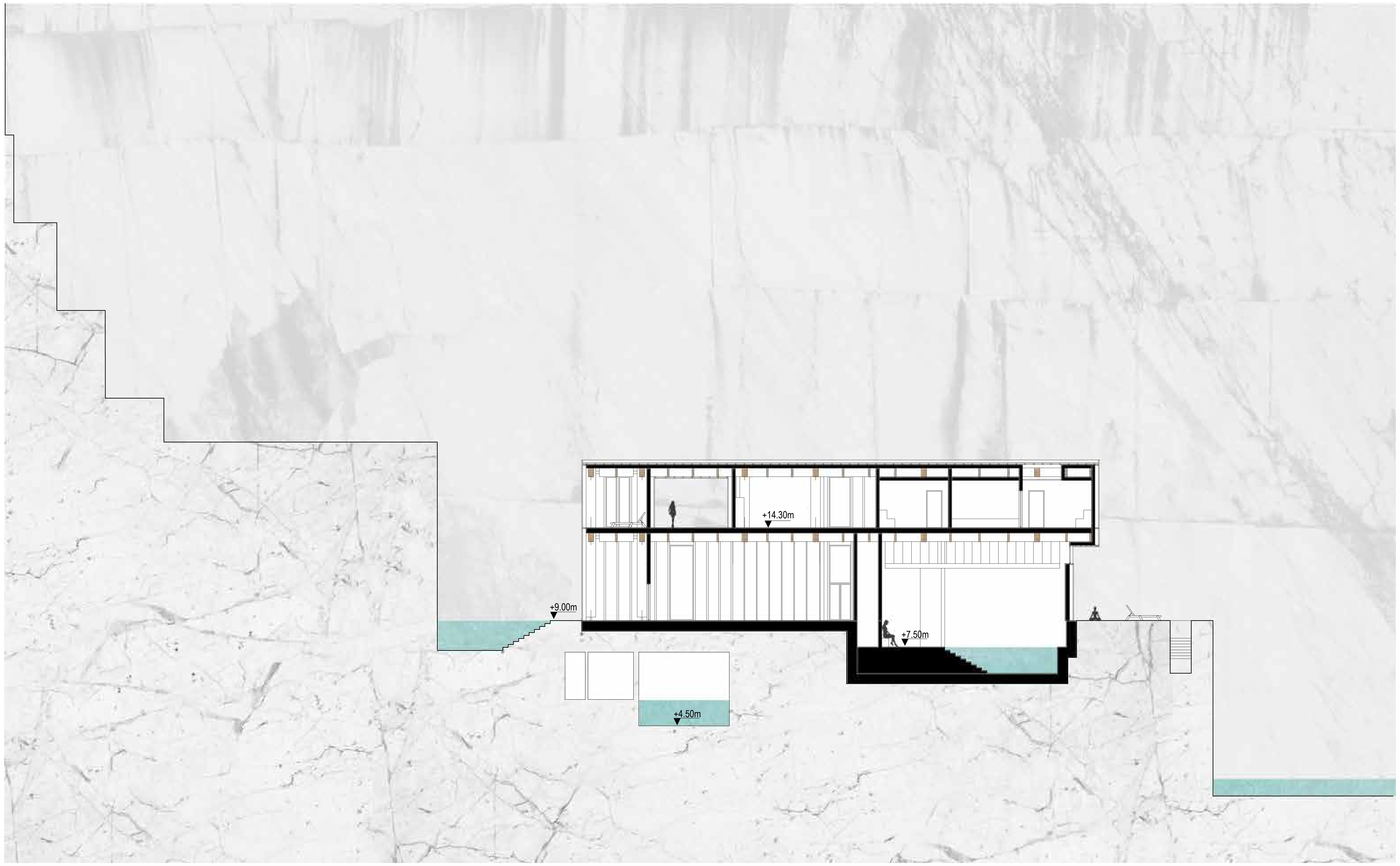
1 entrance
2 reception
3 changing rooms
4 hot water pool
5 lukewarm water pool
6 juice room
7 marble relax spot
8 saunas
9 marble showers
10 hydromassagepool
11 quiet spot
12 indoor/outdoor hot water pool
13 sumer pool
14 solarium
15 hydromassagepools
16 meeting area
17 bar/restaurant
18 bar/restaurant terrace
19 users toilets
20 staff toliet
21 kitchen
22 storage
23 terrace
24 marble public square
25 public hydromassage spot

GROUND FLOOR PLAN	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

26 meditation room
27 staff changing rooms
28 laundry
29 users toilets
30 gym storage
31 gym
32 steam rooms
33 showers
34 treatment rooms
35 mud rooms
36 lockers room
37 balcony
38 quiet spot

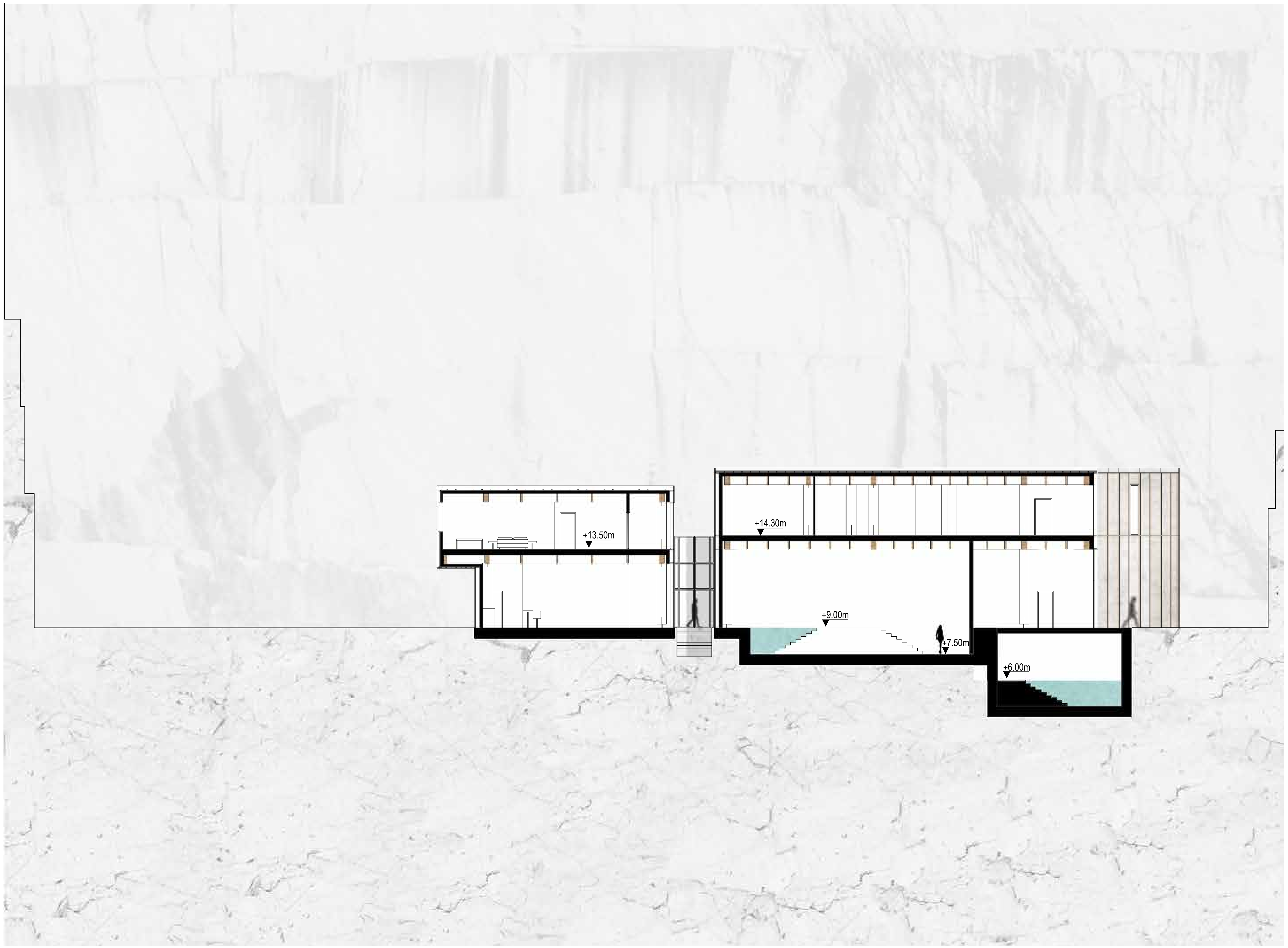
FIRST FLOOR PLAN	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	



LONGITUDINAL SECTION	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

CUT SECTION	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

CROSS SECTION 01	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	



CROSS SECTION 02	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
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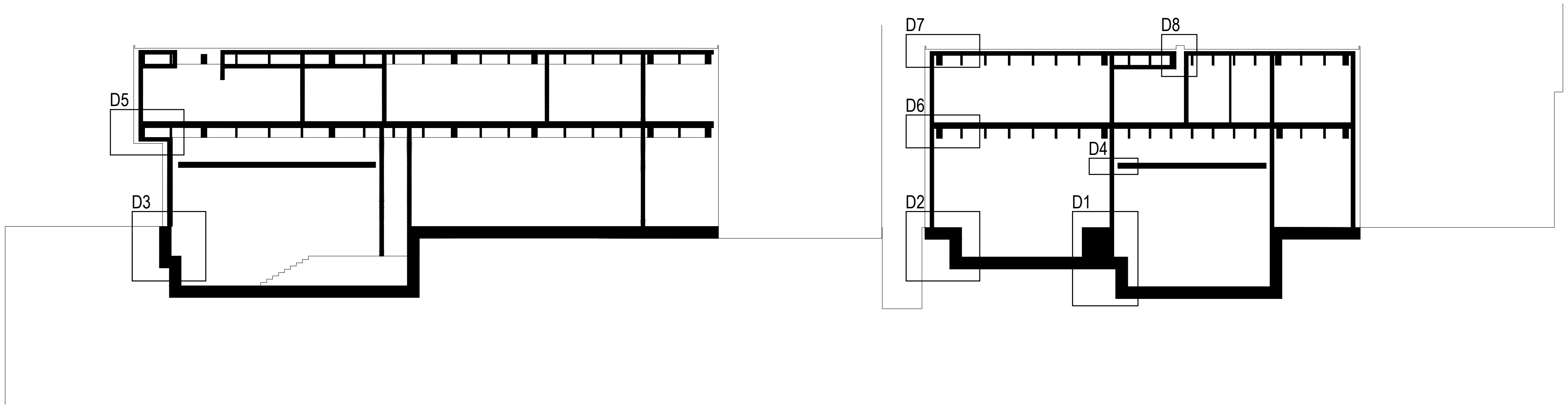
SOUTH ELEVATION	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

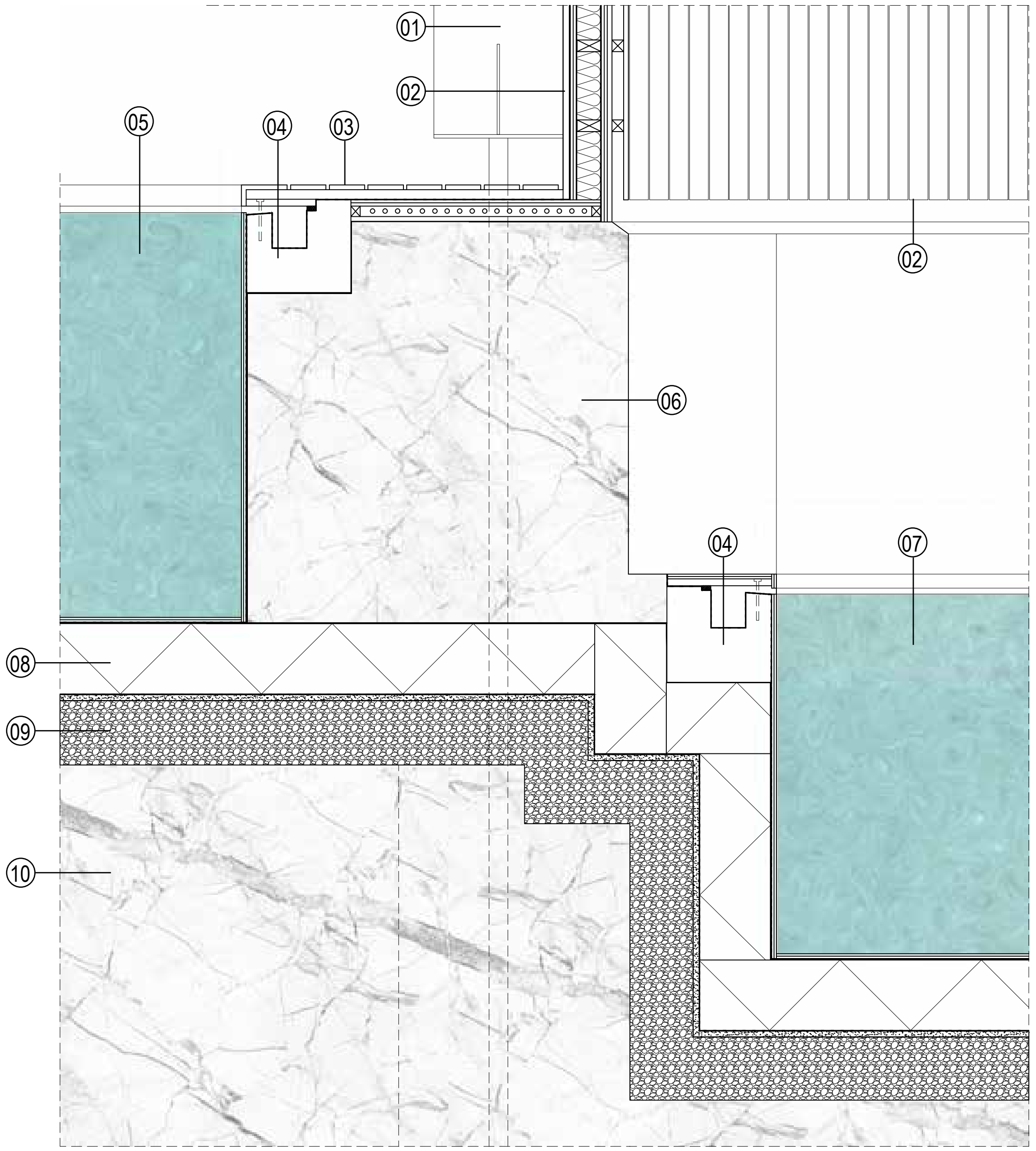
WEST ELEVATION	1:200
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	



NAVIGATION MAP	-
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

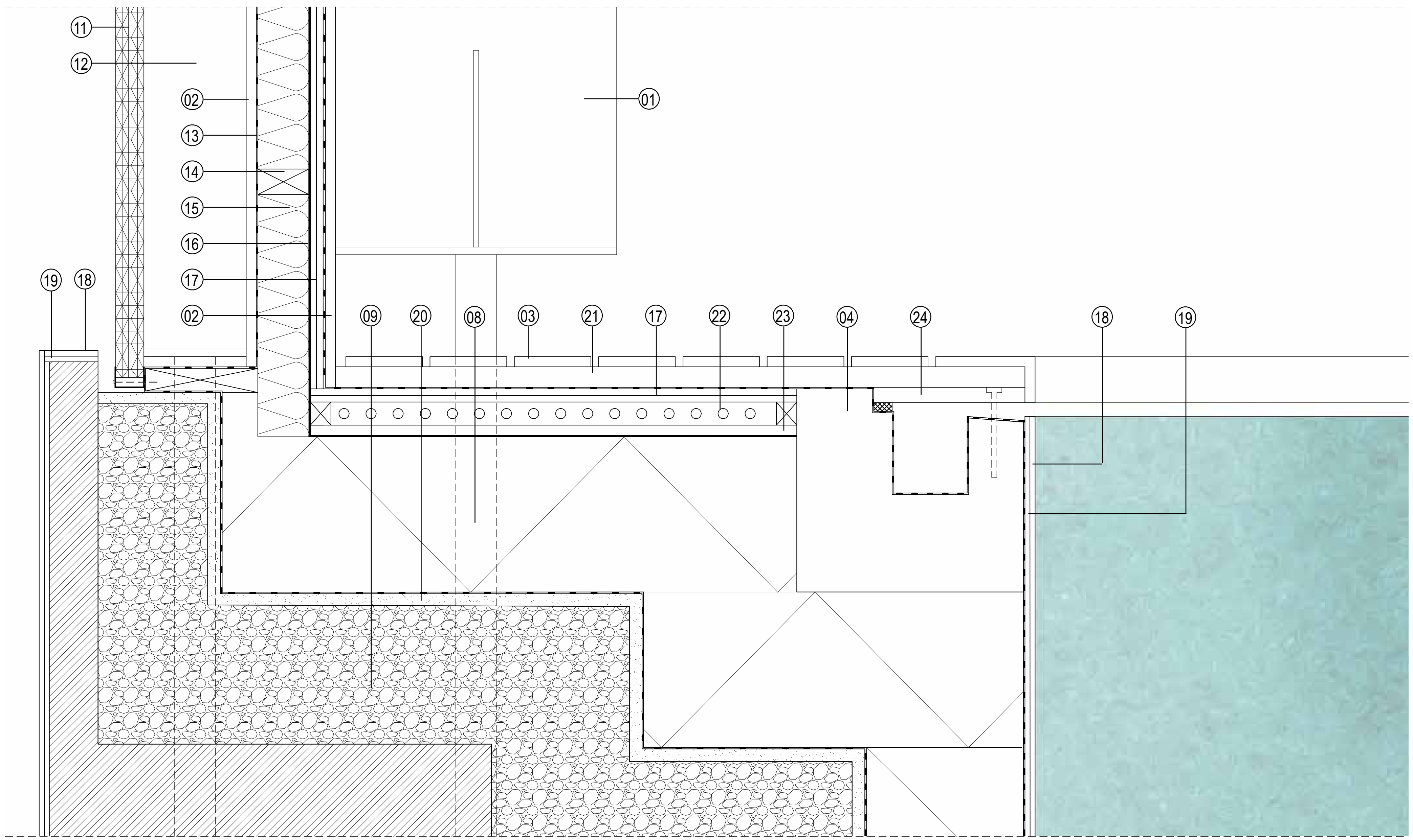
01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adehesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate



DETAIL 01	1:30
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

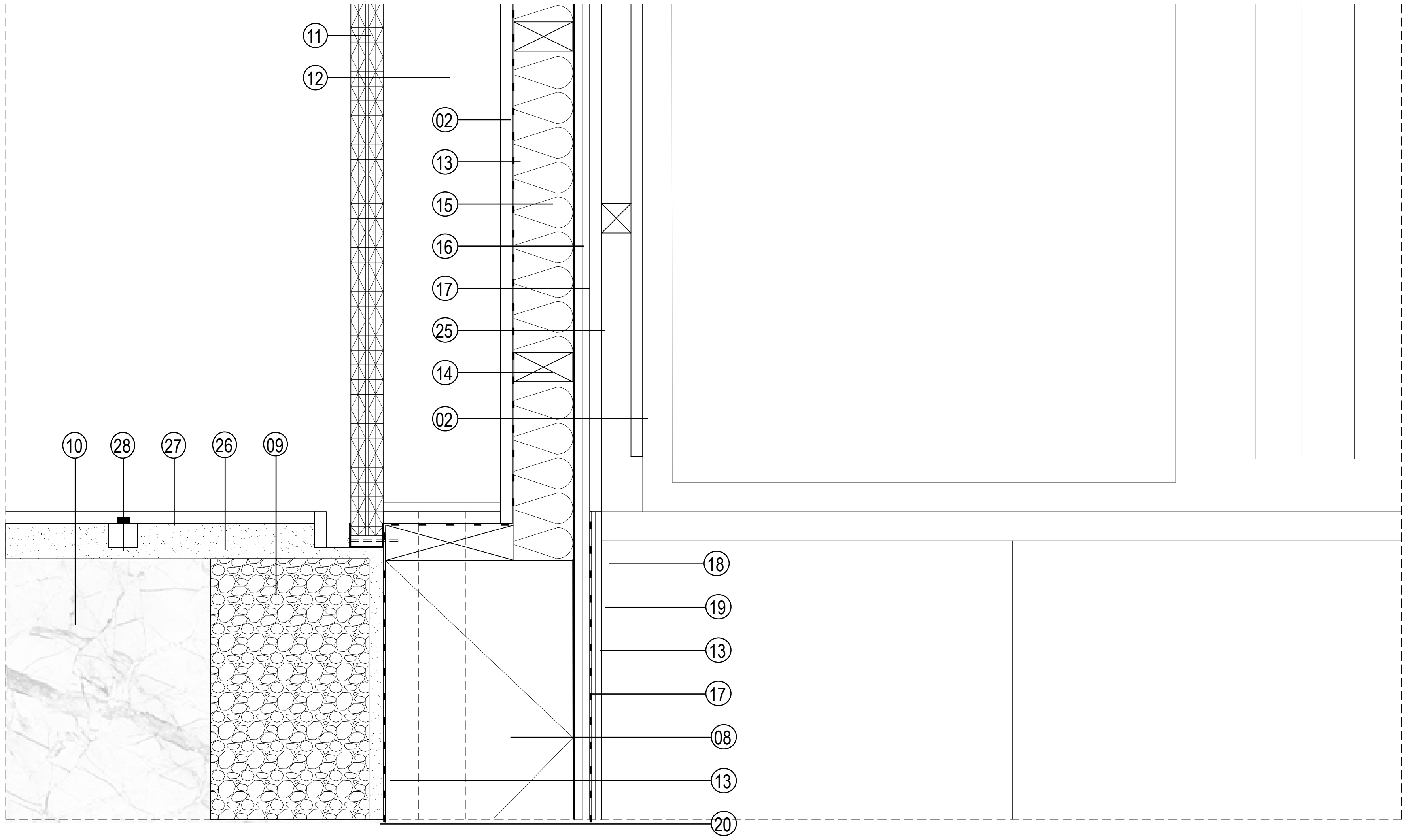
01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adhesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate



DETAIL 02	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

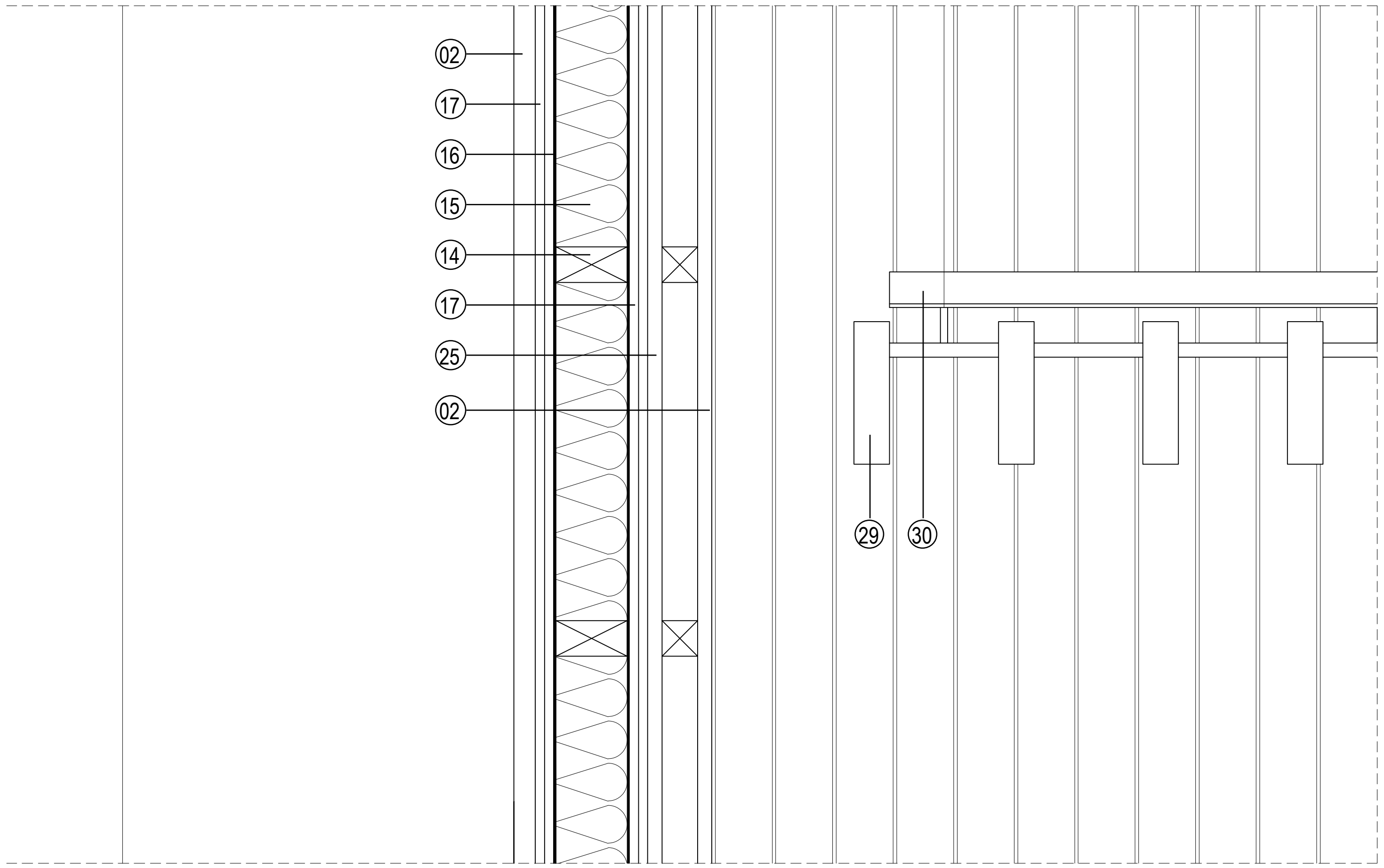
01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adhesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 03	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

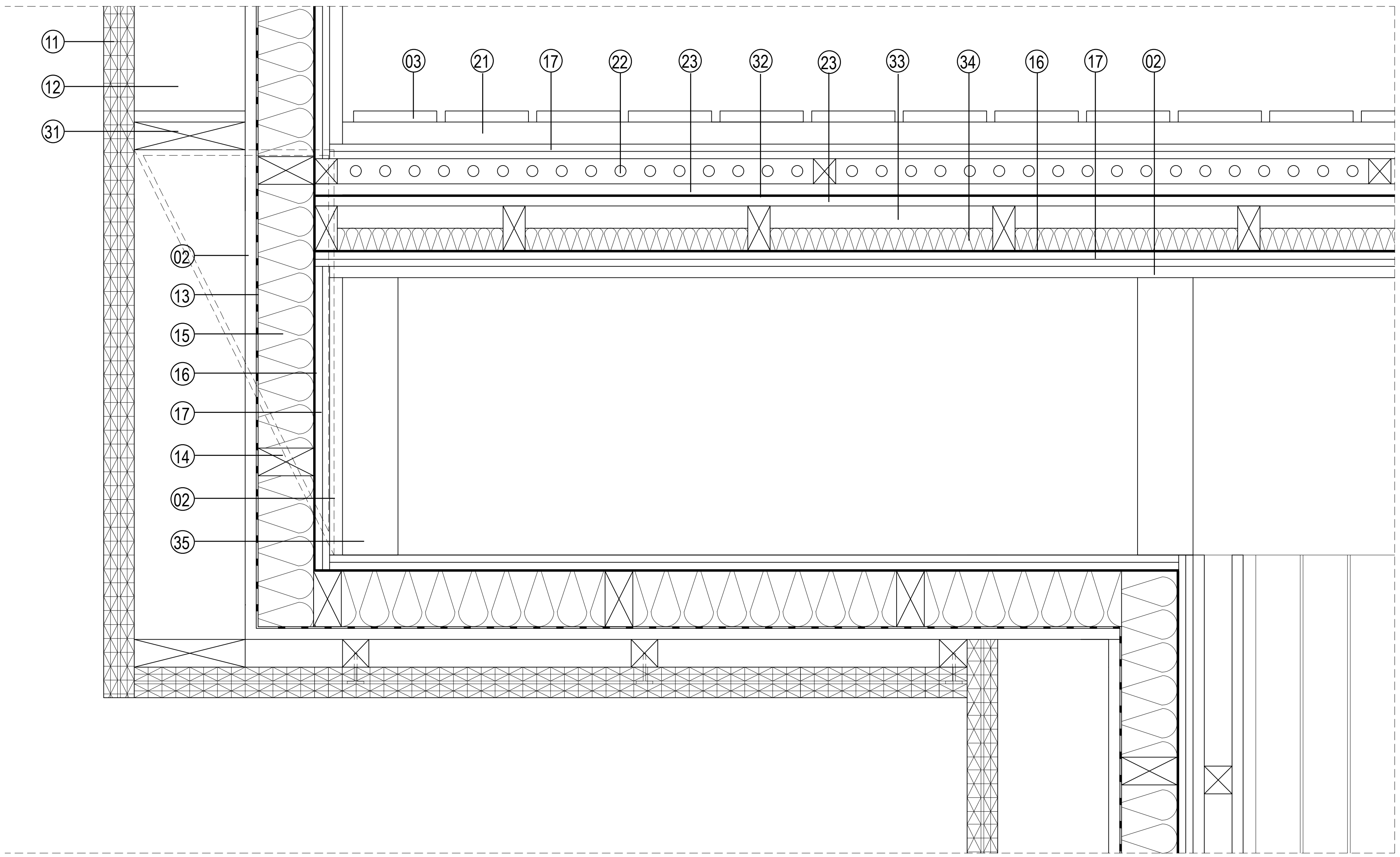
01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adhesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 04	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

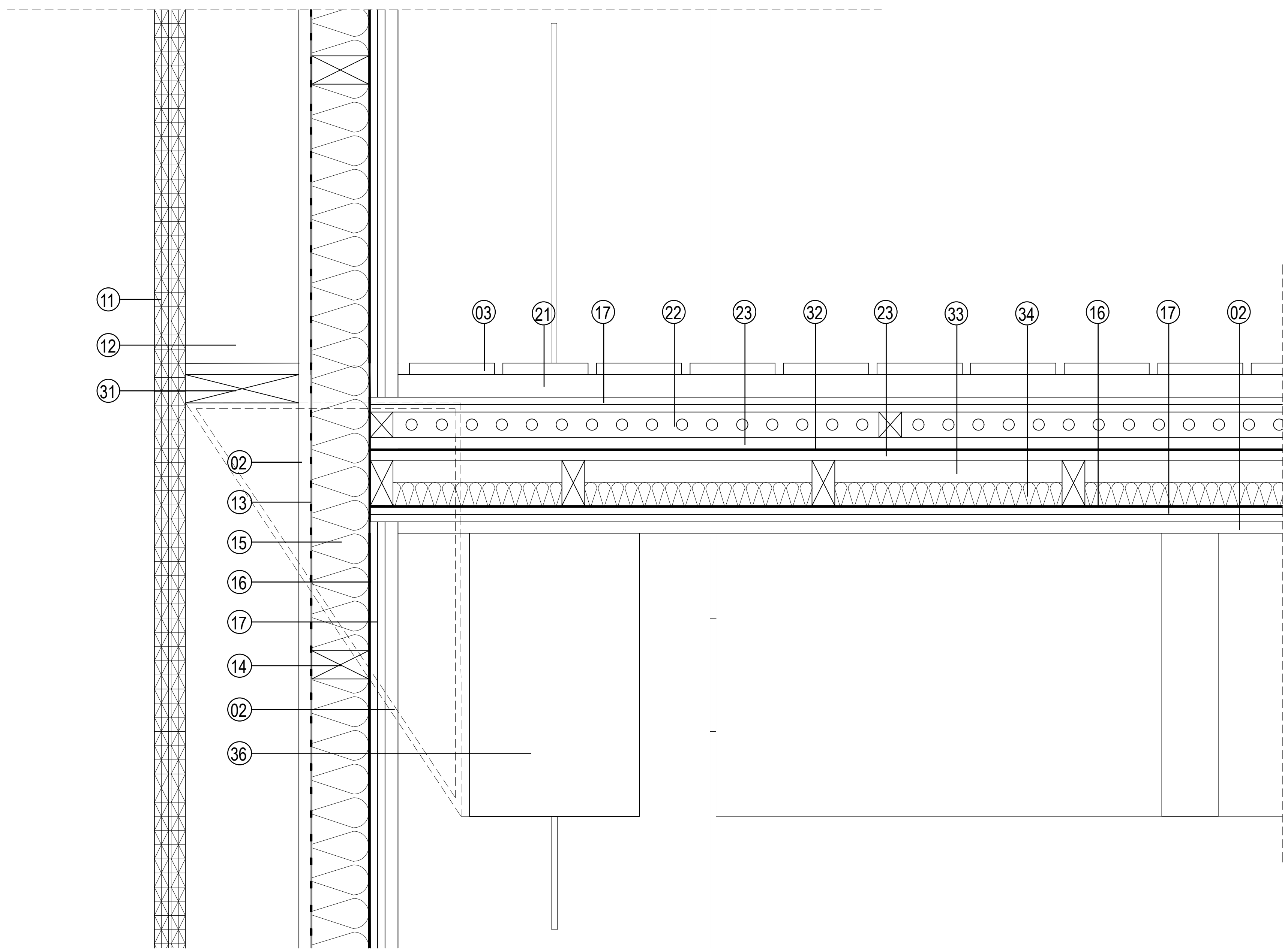
01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adehesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 05	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

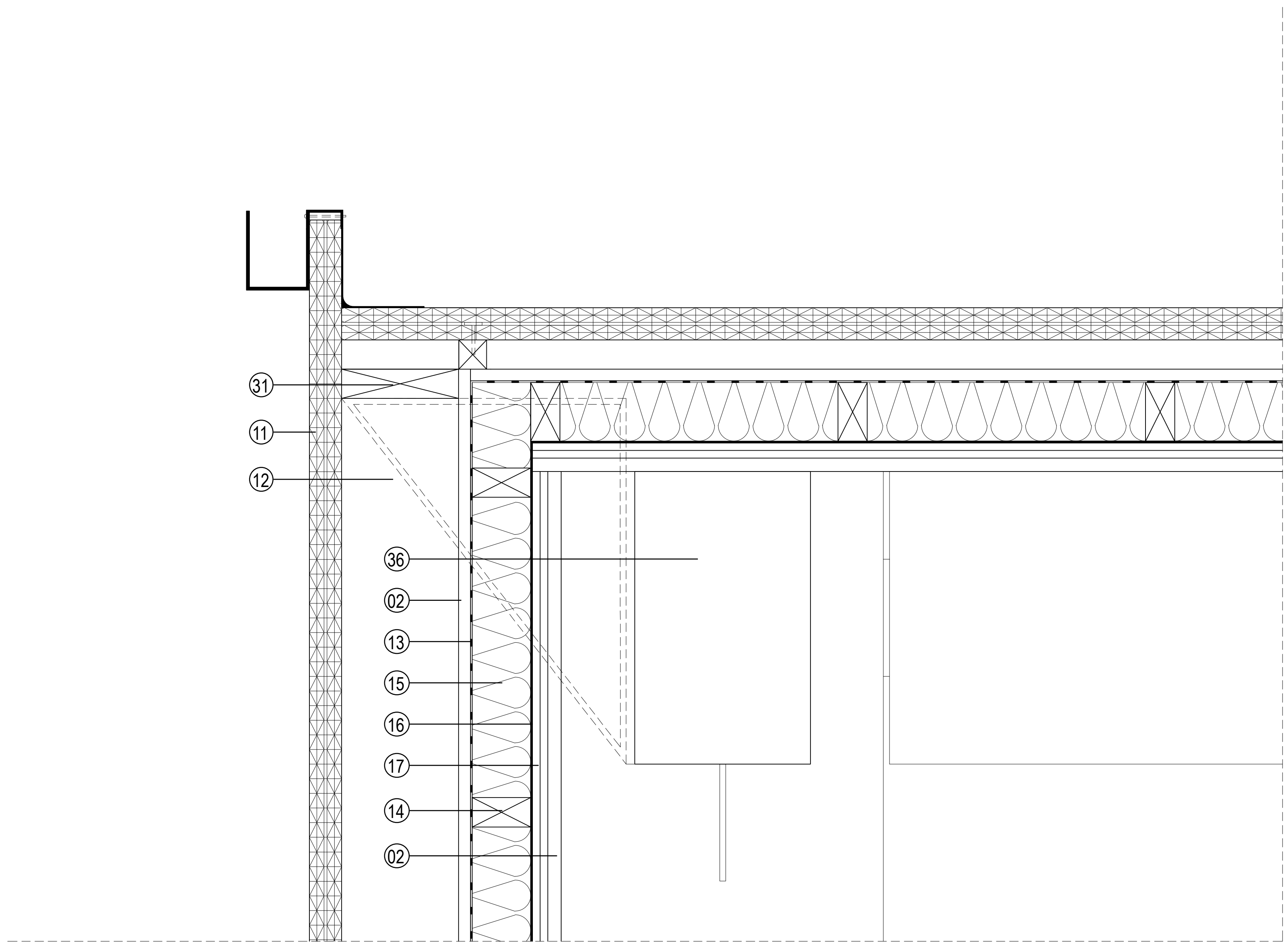
01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adehesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 06	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

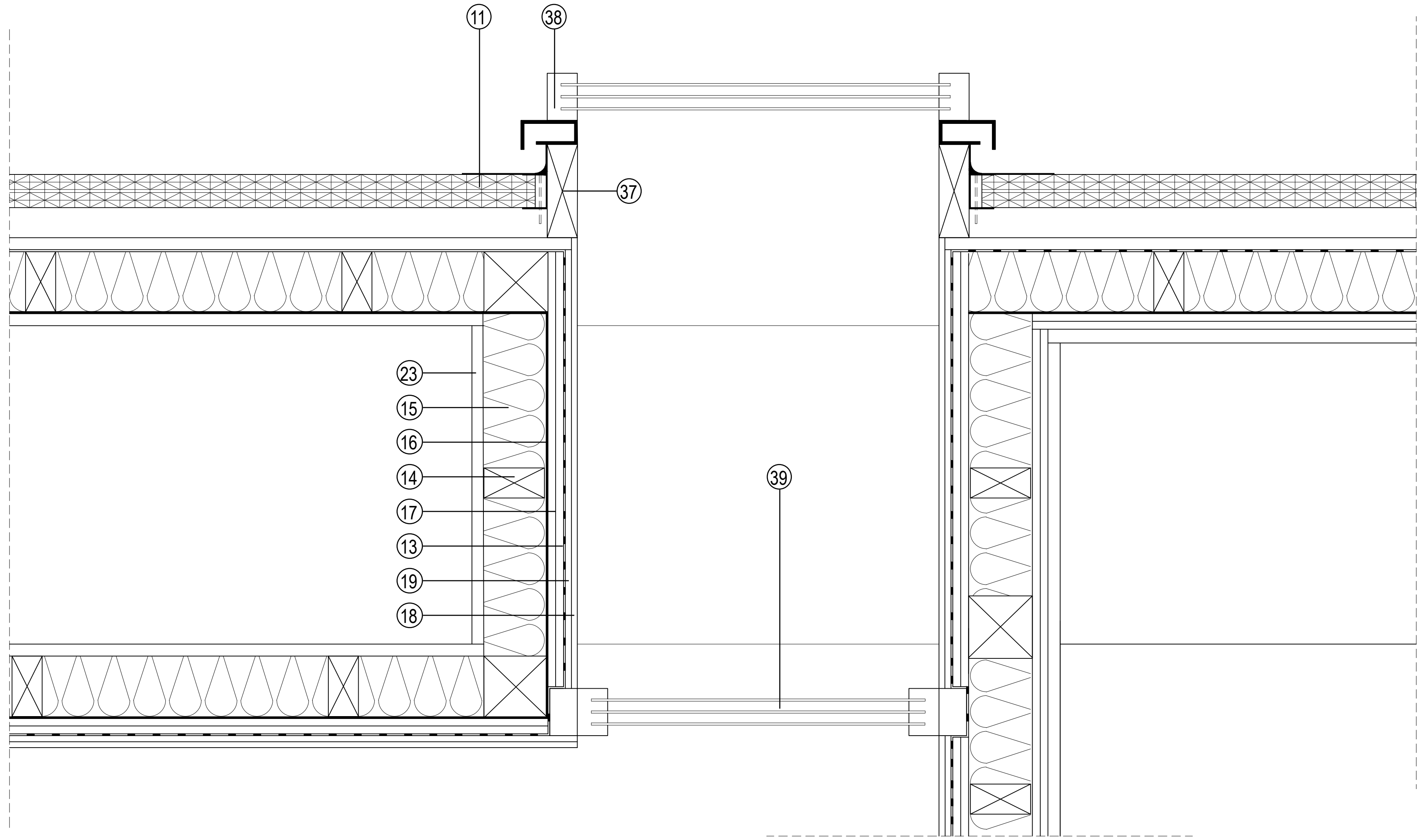
01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
06 marble block
07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
10 quarry marble
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adehesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 07	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

01	550x550 mm column
02	20 mm oak cladding
03	20 mm oak flooring
04	drainage channel
05	38°C water pool
06	marble block
07	34°C water pool
08	3x100 mm XPS insulation
09	300 mm drainage gravel
10	quarry marble
11	55 mm polycarbonate
12	200x100 mm wooden mullion
13	waterproof barrier
14	100x50 mm wooden joist
15	100 mm stone wool insulation
16	moisture barrier
17	2x13 mm gypsum boards
18	20 mm marble slab
19	20 mm adehesive layer
20	25 mm sand
21	40 mm subfloor
22	20 mm floor heating pipe with sand/cement mix
23	20 mm sterling board
24	wooden batten
25	20 mm MDF wood panel
26	26 mm sand
27	20 mm teak flooring
28	50x40 mm subfloor
29	5x20 mm suspended ceiling
30	50 mm metal structure
31	200x50 mm wooden joist
32	sound insulation mat
33	40 mm air gap
34	40 mm sound insulation
35	100x500 mm secondary beam
36	300x500 mm primary beam
37	50x150 mm wooden joist
38	skylight frame with heat recovery system
39	openable skylight
40	30 mm polycarbonate



DETAIL 08	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	

LEGENDA

01 550x550 mm column
02 20 mm oak cladding
03 20 mm oak flooring
04 drainage channel
05 38°C water pool
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07 34°C water pool
08 3x100 mm XPS insulation
09 300 mm drainage gravel
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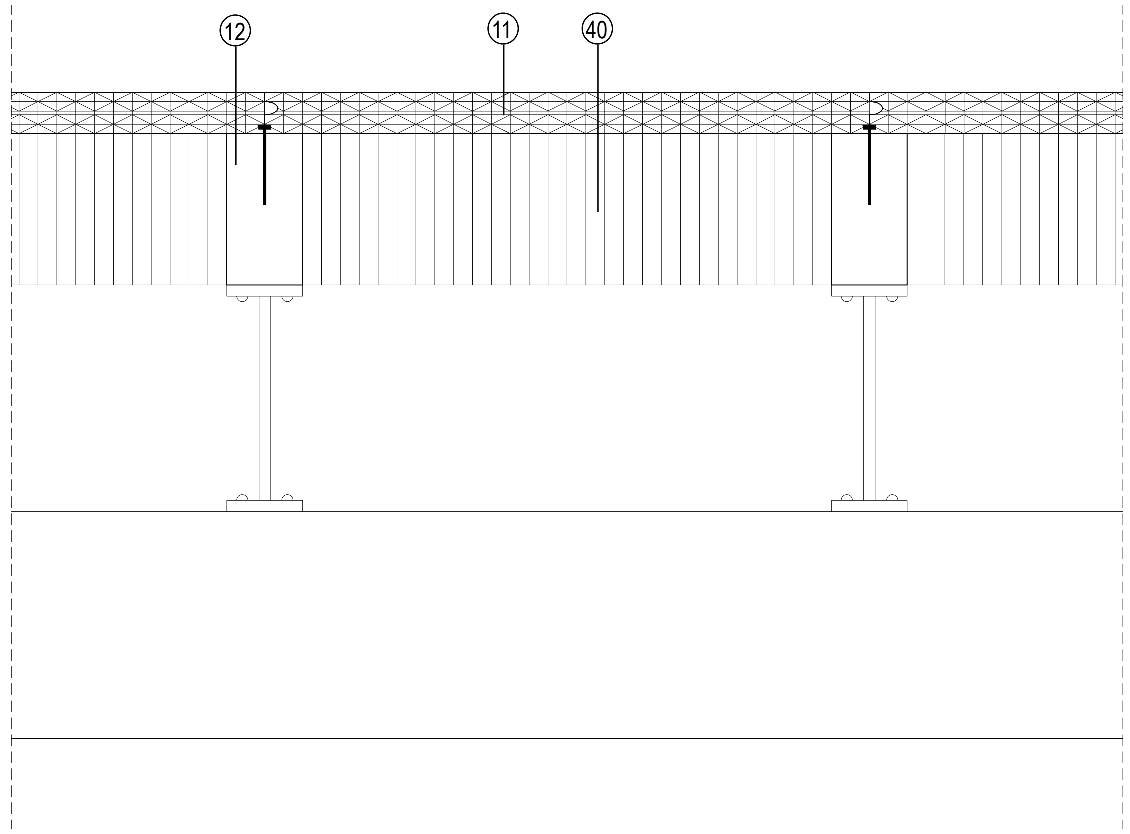
11 55 mm polycarbonate
12 200x100 mm wooden mullion
13 waterproof barrier
14 100x50 mm wooden joist
15 100 mm stone wool insulation
16 moisture barrier
17 2x13 mm gypsum boards
18 20 mm marble slab
19 20 mm adehesive layer
20 25 mm sand
21 40 mm subfloor
22 20 mm floor heating pipe with sand/cement mix
23 20 mm sterling board
24 wooden batten
25 20 mm MDF wood panel
26 26 mm sand
27 20 mm teak flooring
28 50x40 mm subfloor
29 5x20 mm suspended ceiling
30 50 mm metal structure
31 200x50 mm wooden joist
32 sound insulation mat
33 40 mm air gap
34 40 mm sound insulation
35 100x500 mm secondary beam
36 300x500 mm primary beam
37 50x150 mm wooden joist
38 skylight frame with heat recovery system
39 openable skylight
40 30 mm polycarbonate



DETAIL 09 - POLYCARBONATE FACADE PLAN	1:10
The Quarry Thermal Baths - Msc04 ARC 2017 - Aalborg University	
Cecilia Duca, Francesca Terza, Ottavia Feletig	