LIMESTONE MUSEUM

MARSEILLE

QUARRYING, CUTTING & CASTING

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Design Realisation 2016
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LIMESTONE MUSEUM

MARSEILLE

CONTENTS

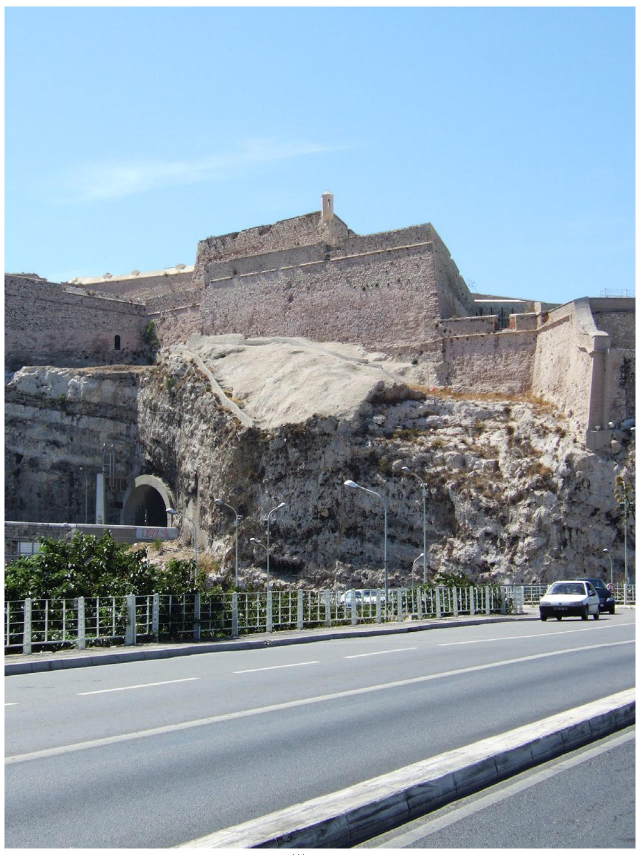
PART ONE

BUILDING FORM, SYSTEMS, PLANNING AND CONTEXT

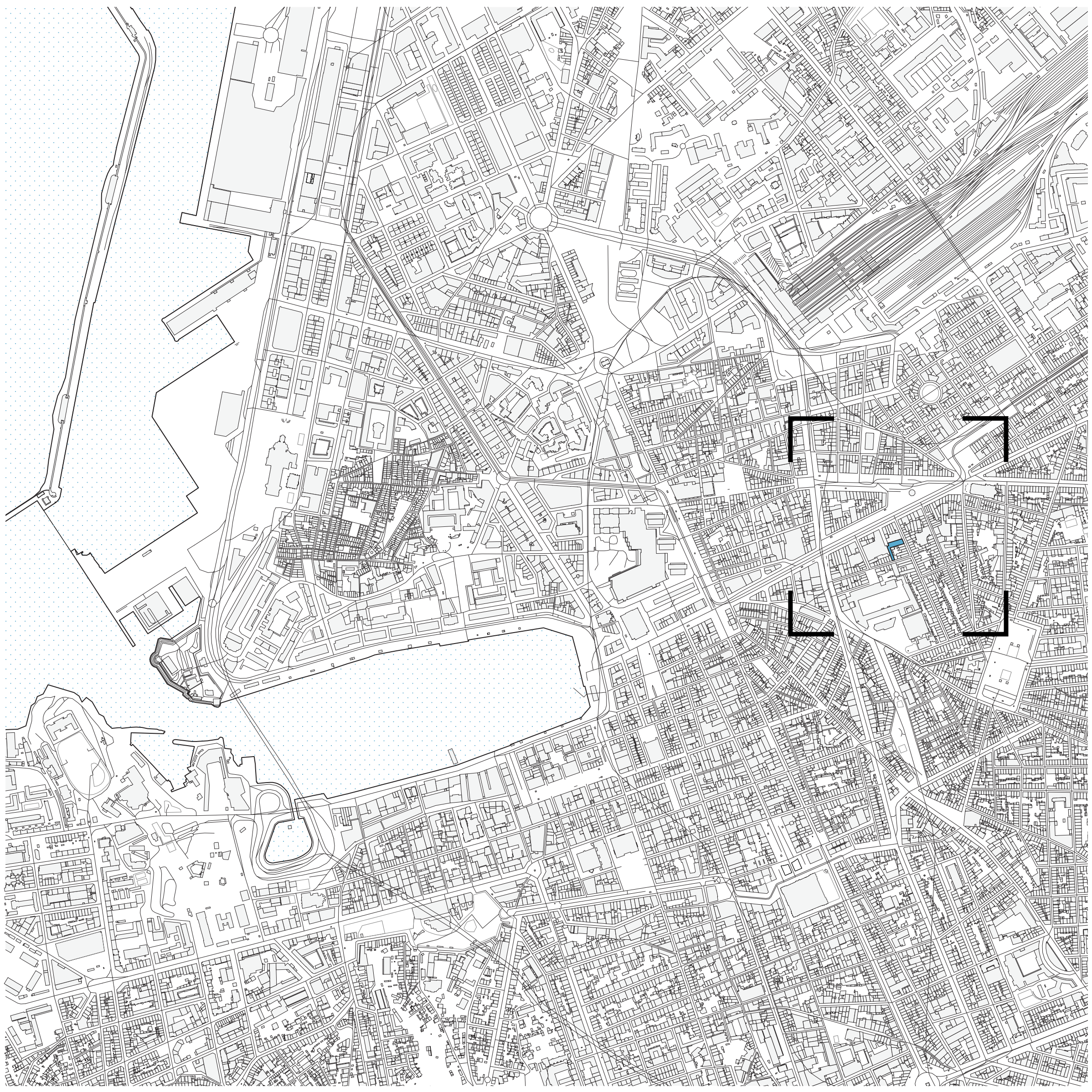
1.1.1 SITE CONTEXT

MARSEILLE

Marseille is a port city in southern France and has been a crossroads of immigration and trade since its founding by the Phoenicians in 600 BC. The cities trade, culture and history are concentrated at the Vieux Port where Greek Architecture and the regional limestone has been preserved and reconstructed to aid the tourist industry.



Limestone Heritage site in Marseillle



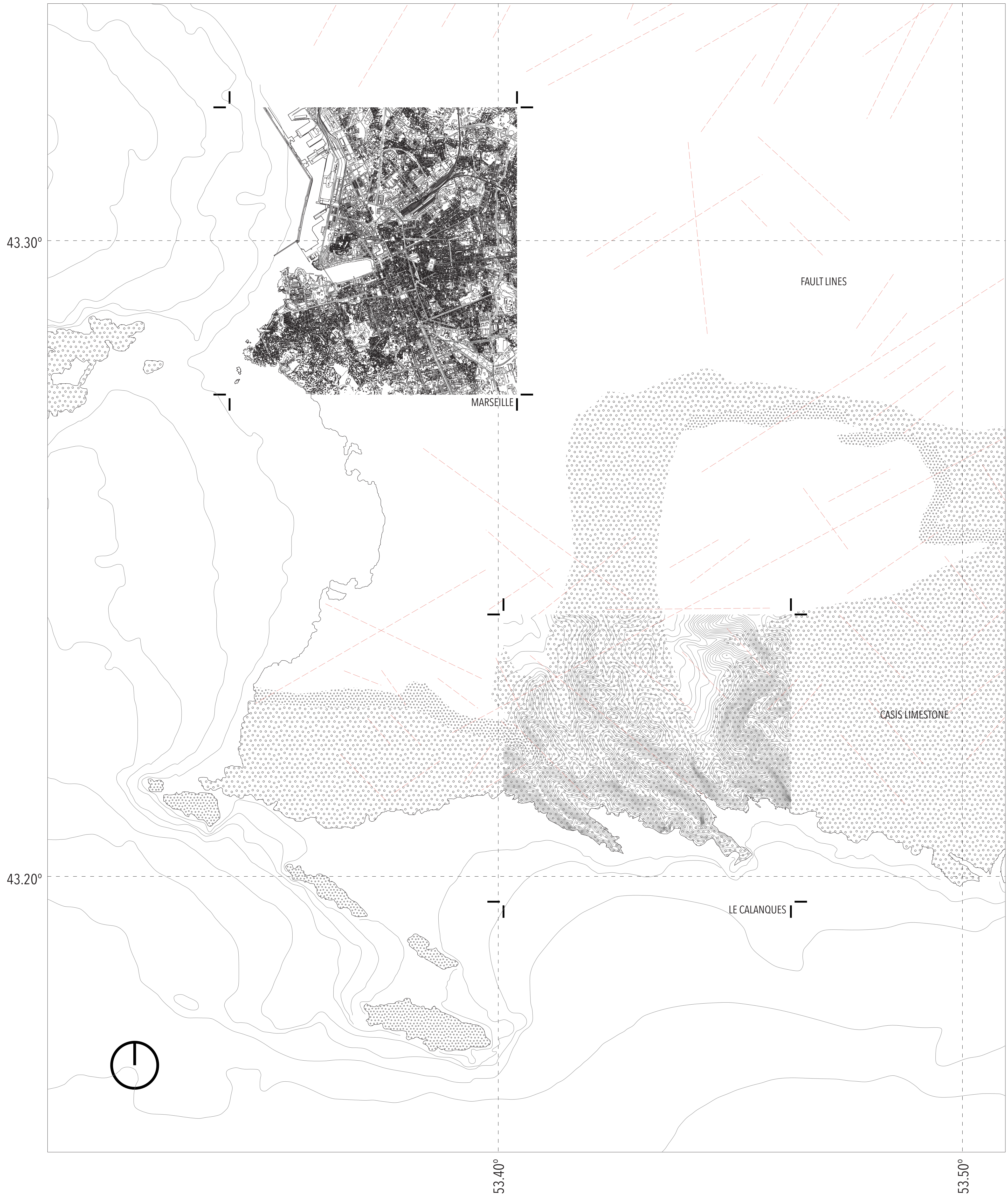
CITY CENTRE + VIEUX PORT

THE SITE

The site is located 50m from a main public square, just below L'eglise Saint Vincent de Paul. The square draws large numbers to the area with the addition of a University building which overlooks the site. Although the wider area and main roads experience a large amount of traffic and public visitors, the site is on a quieter street consisting of terraced residential buildings, with small businesses at ground level and apartments above. There are two entrances to the site; one located 40m from the main square and one narrower entrance on the south side.

Main Road, Le Canebiere

1ST ARR.



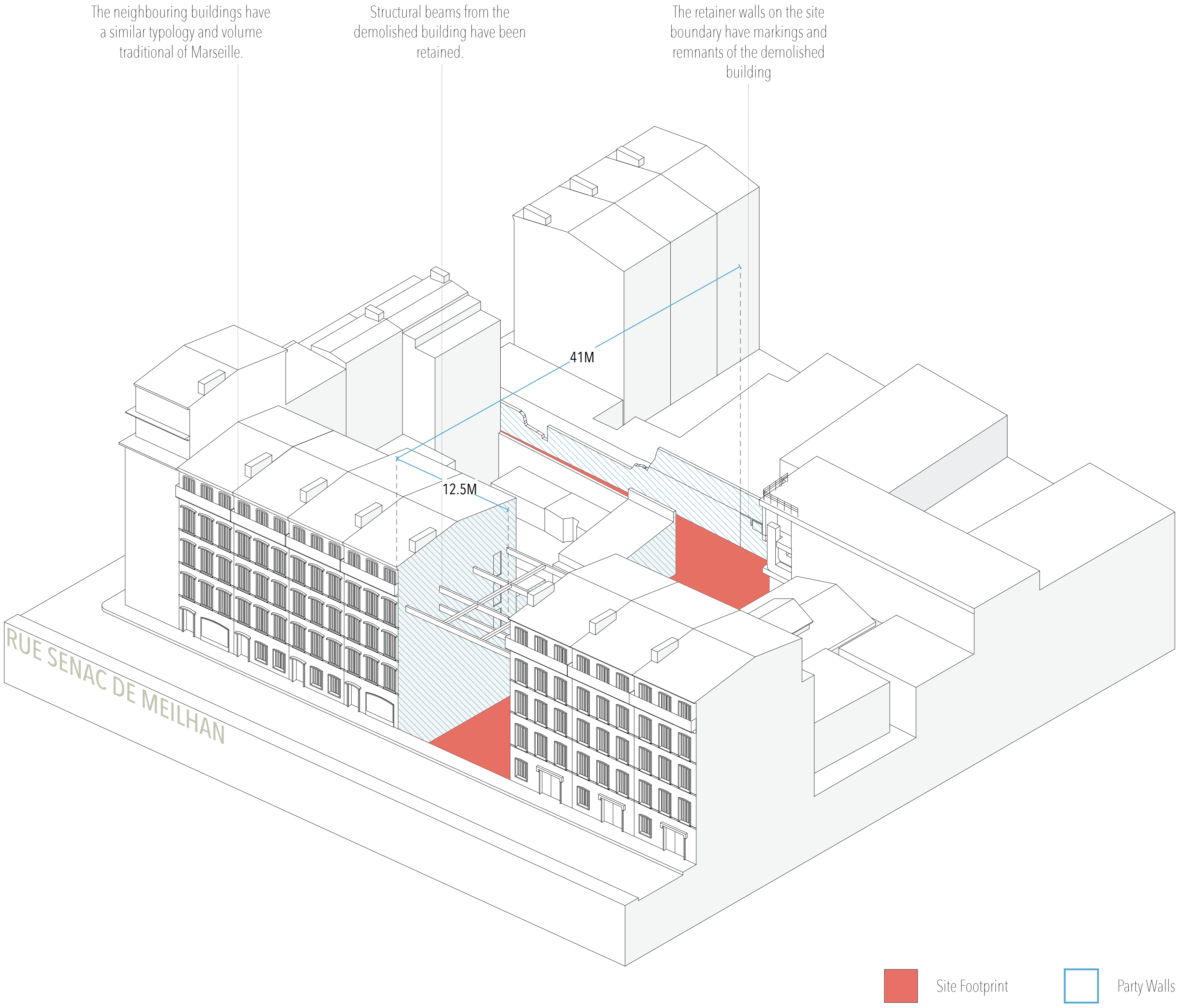
LIMESTONE OUTCROP

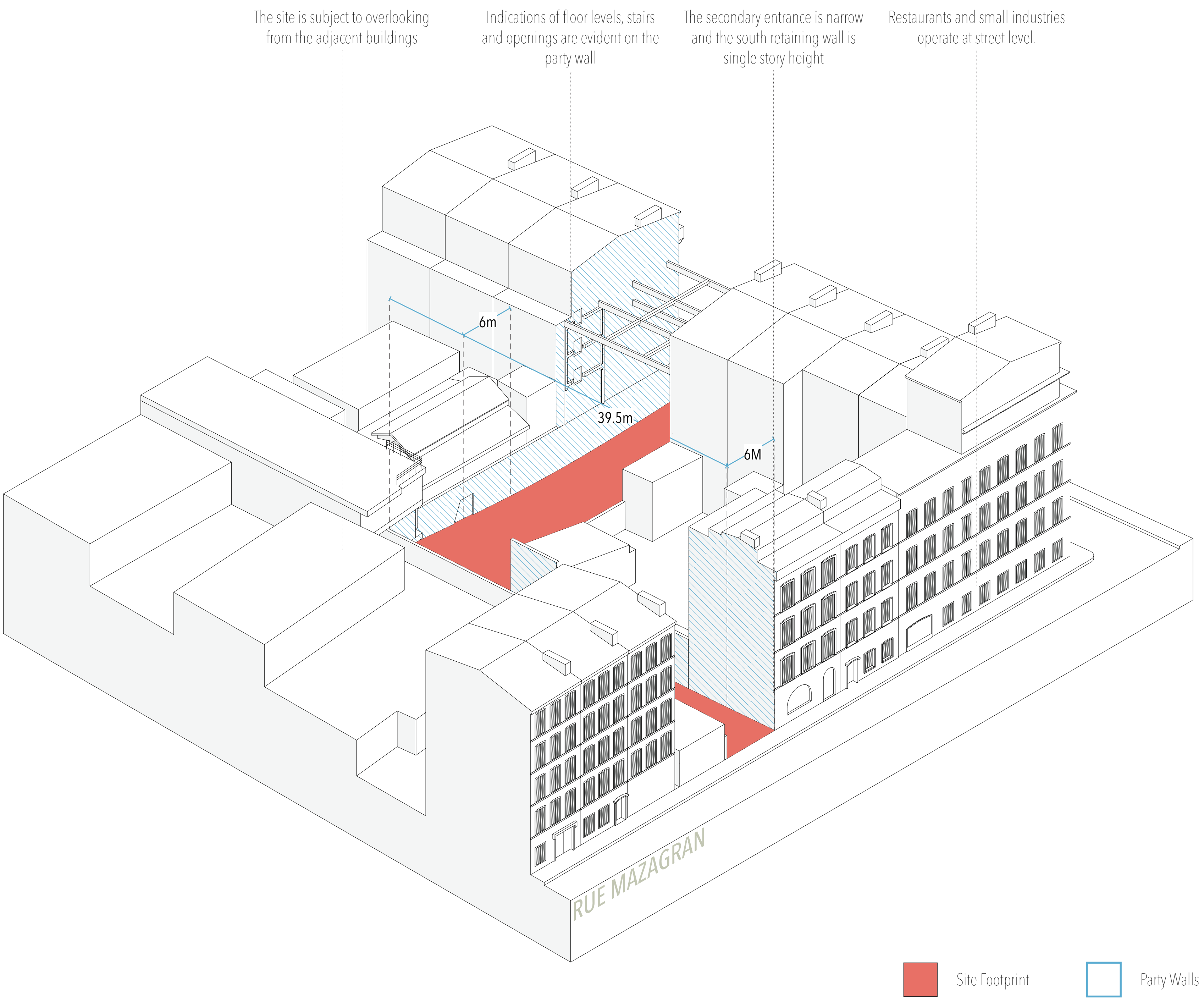
The Massif de Calanques is a region of limestone creeks on the coast of France bordering the Mediterranean. The bedrock of Marseille is clay, yet the city; its early infrastructure; ports and buildings were made from locally sourced limestone. The Limestone required for the building will be sourced from a quarry in the Calanques. The project will explore the relationship between this Limestone outcrop and the city of Marseille

1.1.2 SITE OVERVIEW

SITE OF URBAN EXCAVATION

The site itself is an urban excavation. There are archaeological remnants indicative of the sites past use. Incorporating elements of the site that remain from the previous structure is integral to the design strategy. The existing ground level has been excavated such that it is below street level.



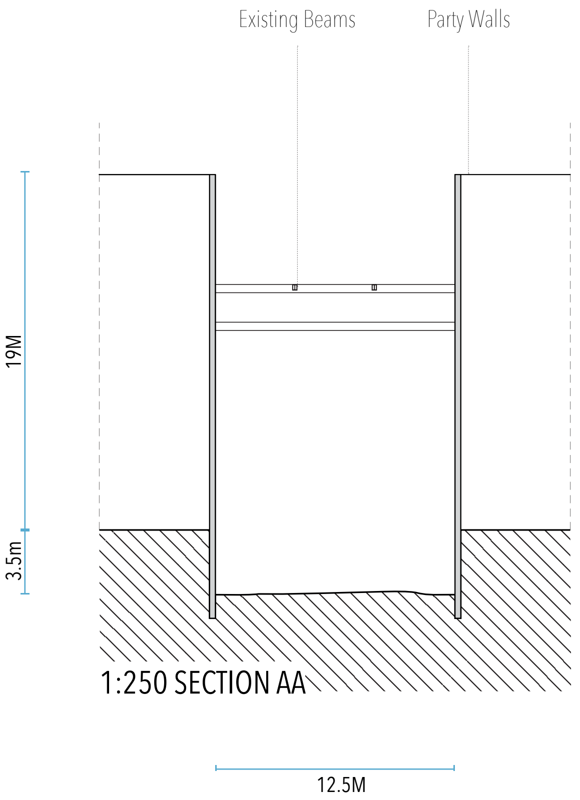

The site is subject to overlooking from the adjacent buildings
Indications of floor levels, stairs and openings are evident on the party wall
The secondary entrance is narrow and the south retaining wall is single story height
Restaurants and small industries operate at street level.
6m
39.5m
6M
RUE MAZAGRAN
Site Footprint
Party Walls

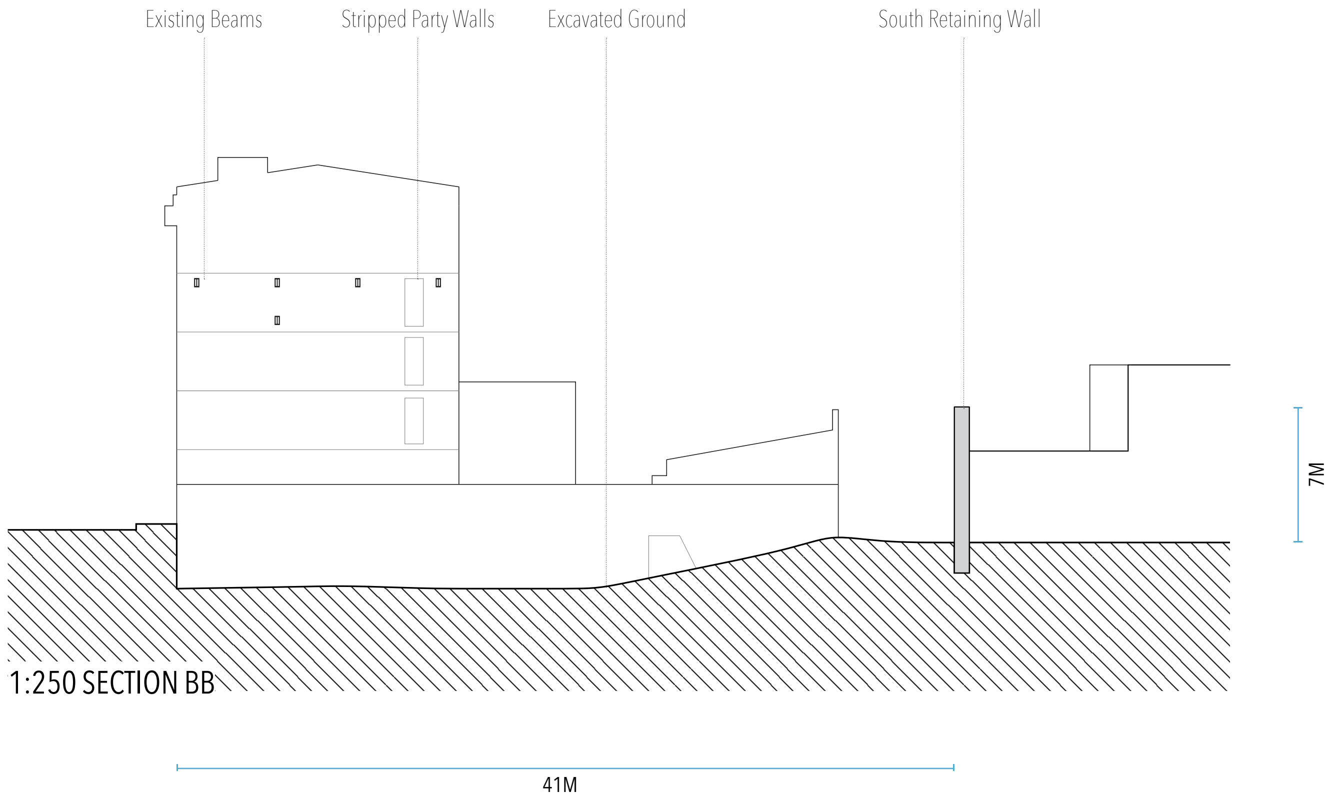

Rue Mazagran

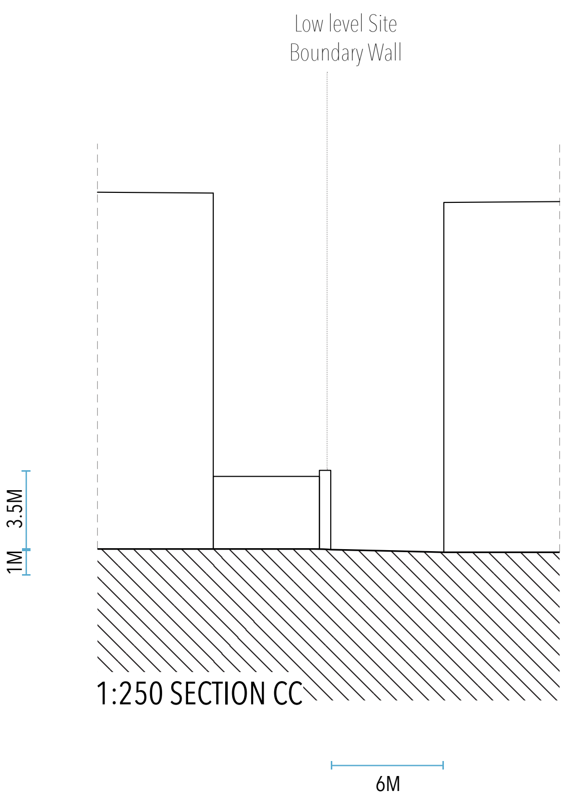
1.1.3 SITE ANALYSIS

EXISTNG SITE CONDITIONS

A large proportion of the site boundary will be incorporated into the building. Following discussions with an engineer, the existing party walls are sufficient to support a structure similar to that of the neighbouring buildings. The typology of the street is of terrace properties with shared boundary walls.

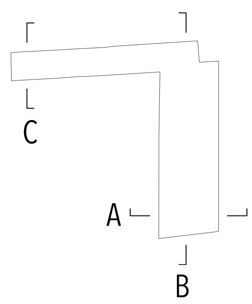


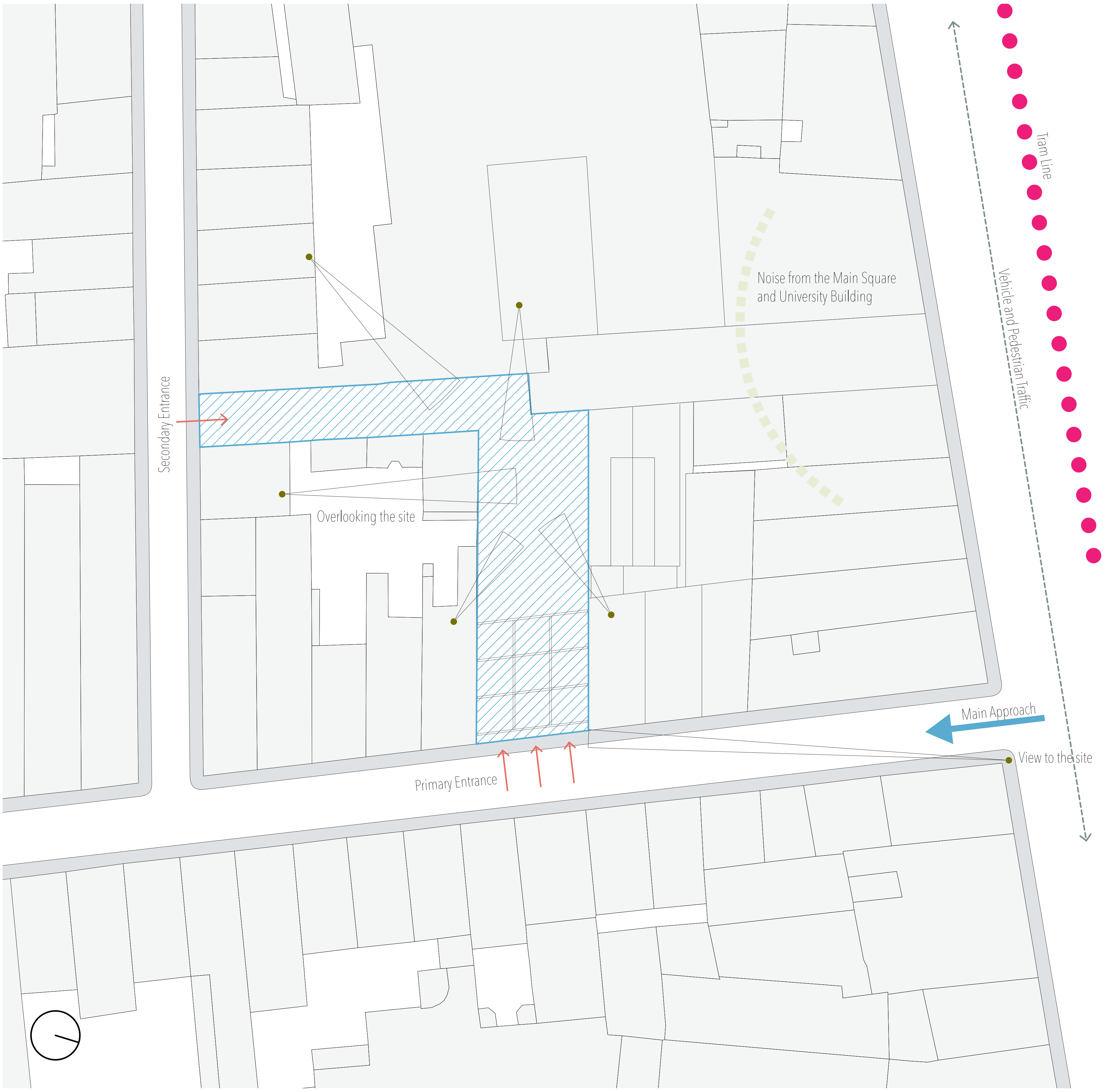




GROUND LEVEL SECONDARY ENTRANCE

GROUND LEVEL PRIMARY ENTRANCE





SITE PLAN 1:500

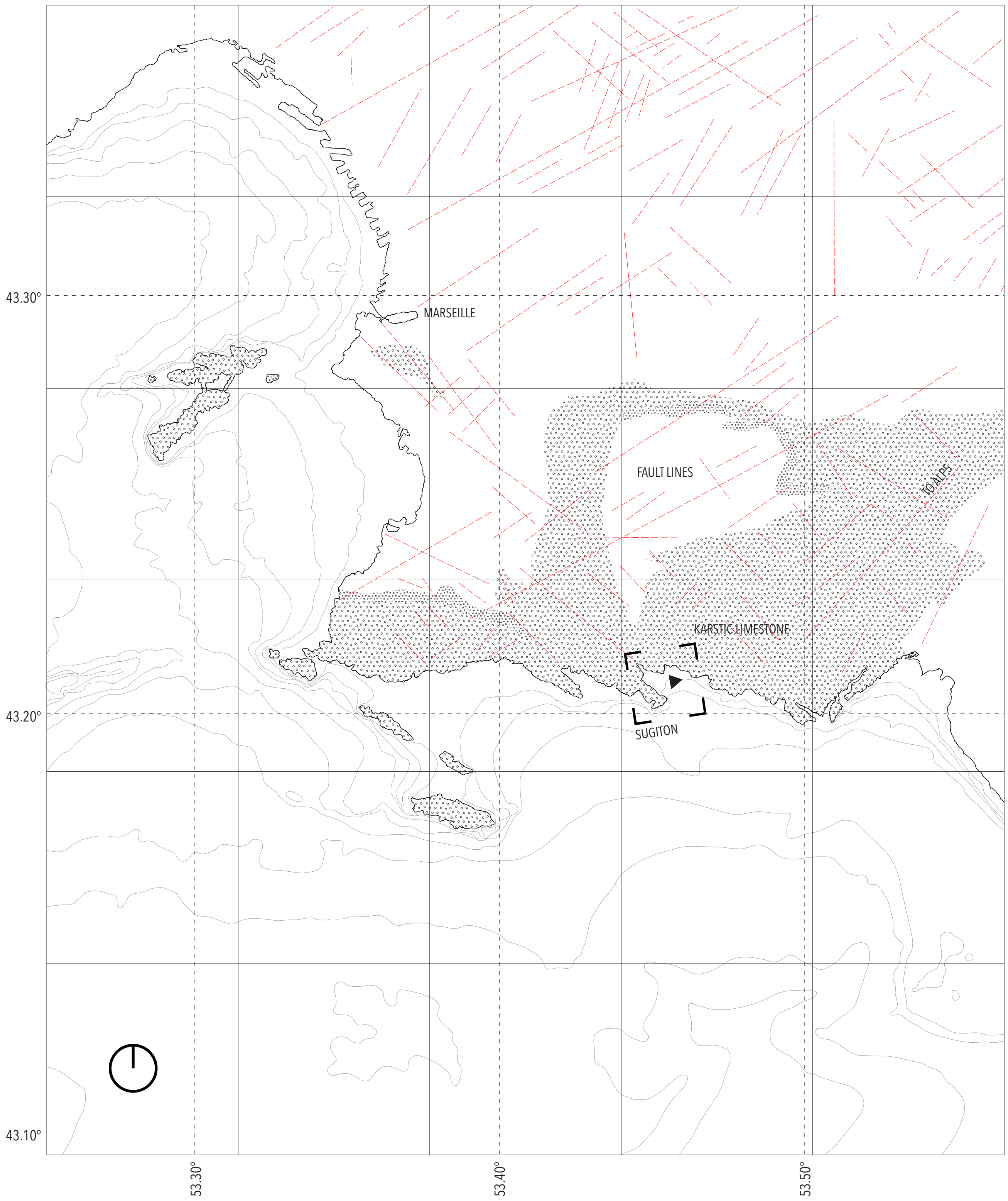

The site and glimpse of the public square


View from Primary Entrance

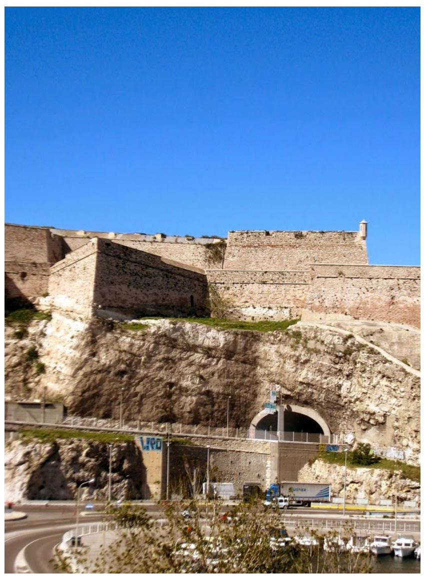
1.1.4 GEOLOGY

CASIS LIMESTONE

The Massif de Calanques is a region of limestone creeks on the south coast of France. The impressive rock forms have been heavily studied by geologists. Marseille is built on a clay bed, yet the city; its early infrastructure; ports and buildings were made from the locally sourced stone. Romanticism of its monumental cliffs has lead to the stone being quarried and exported across the Mediterranean and beyond. The base of the statue of Liberty and port of Alexandria are made from Casis Limestone.



Marseille's bedrock is clay. Casis Limestone occurs along the same fault lines that formed the Alps



BUILDING MATERIAL

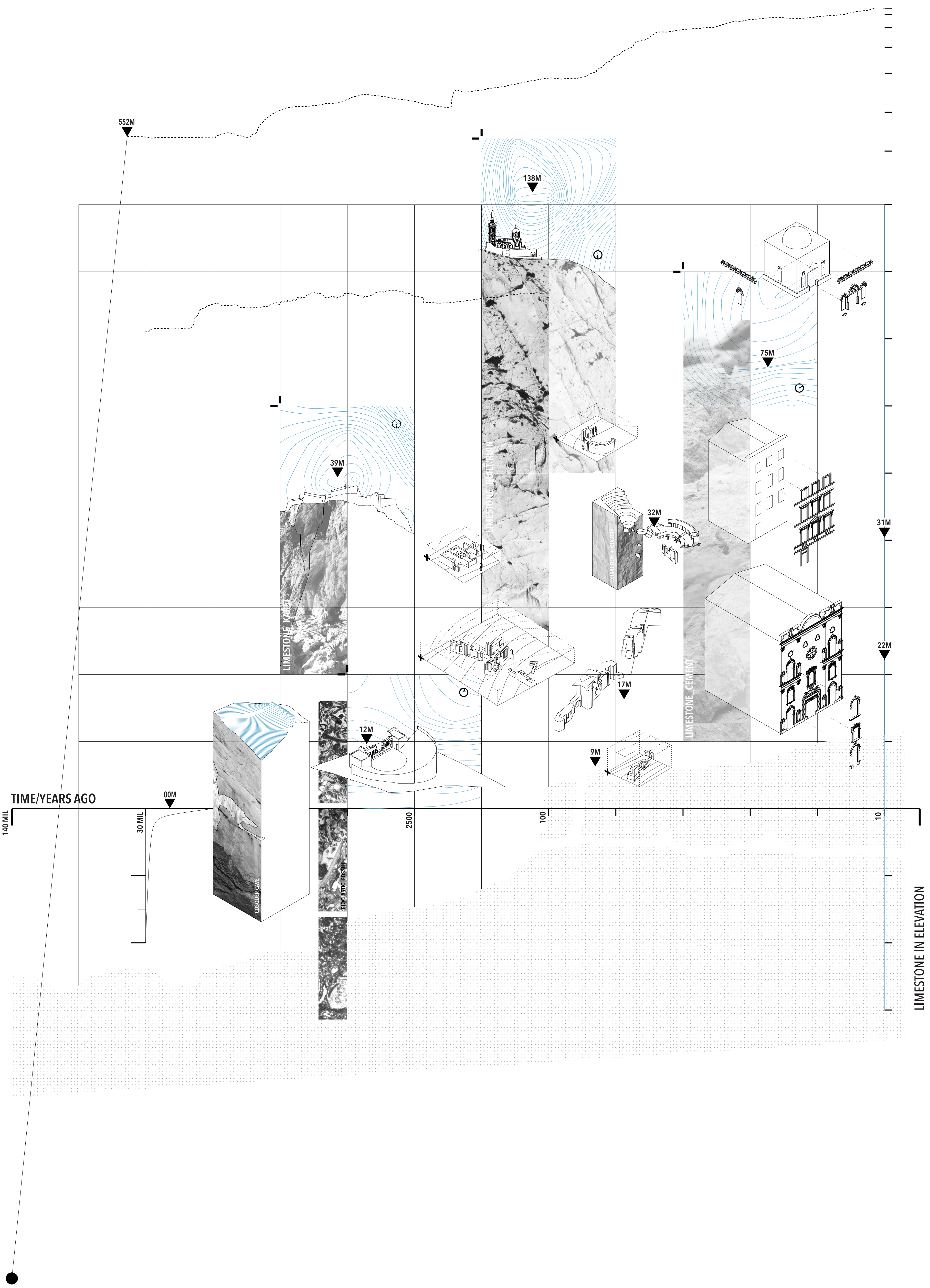
The Greeks founded the city of Marseille using local limestone as there primary building material. Heritage sites and buildings of historic significance are predominantly limestone.

BELOW GROUND

Water infrastructures were developed by the Greeks using Limestone to construct cisterns underground. Archaeological excavations in the city continue to demonstrate the varied use of the stone.

CEMENT OF THE MEDITERNEAN

Limestone was mixed with local clay and processed to form cement. The cement industry in Marseille was first to manufacture prefabricated facade elements.



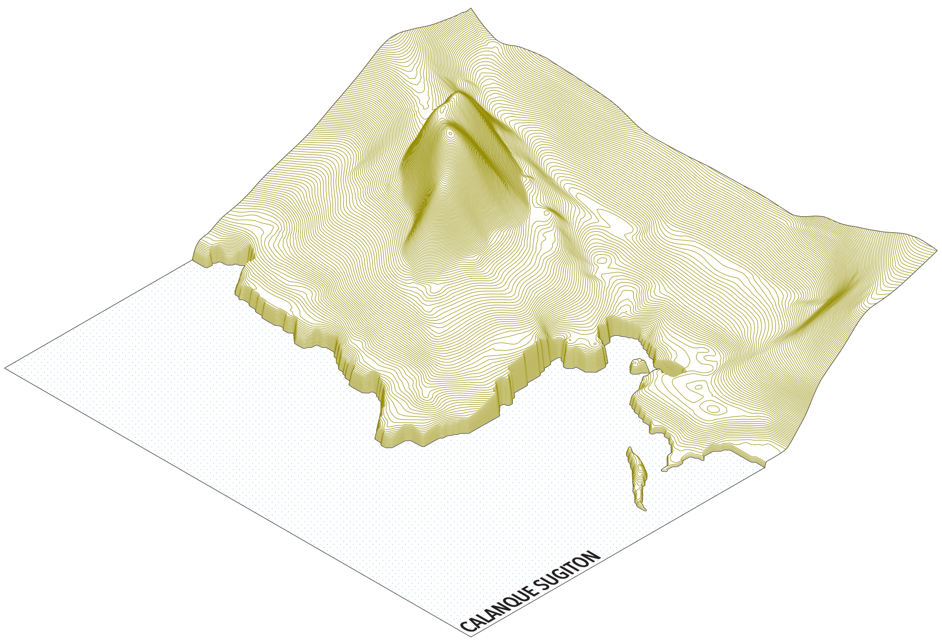
LIMESTONE DATA

Tracing the existence of limestone in Marseille; past excavations and new urban translations provide data. Above and below ground, the stone is part of the cities infrastructure. Marseille has a visual identity of limestone.

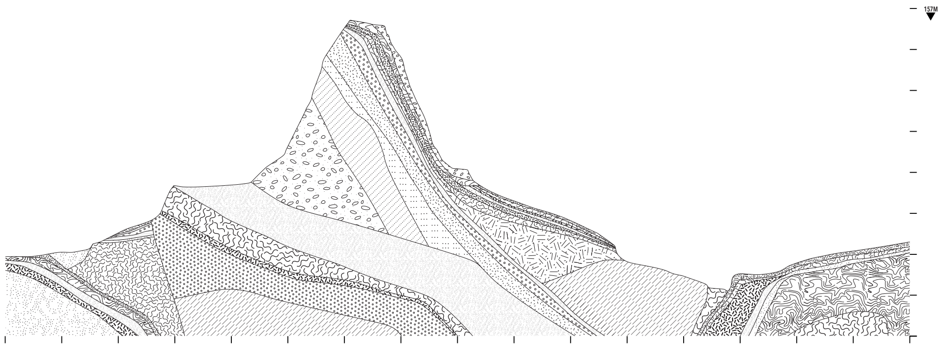
1.1.5 LIMESTONE QUARRY

EXCAVATION
Extraction of the stone is achieved using stone cutters and water pressure . The standard block is cut from 2m^2 area at the surface. This unit is an industry standard set by quarry machinery and transportation methods.

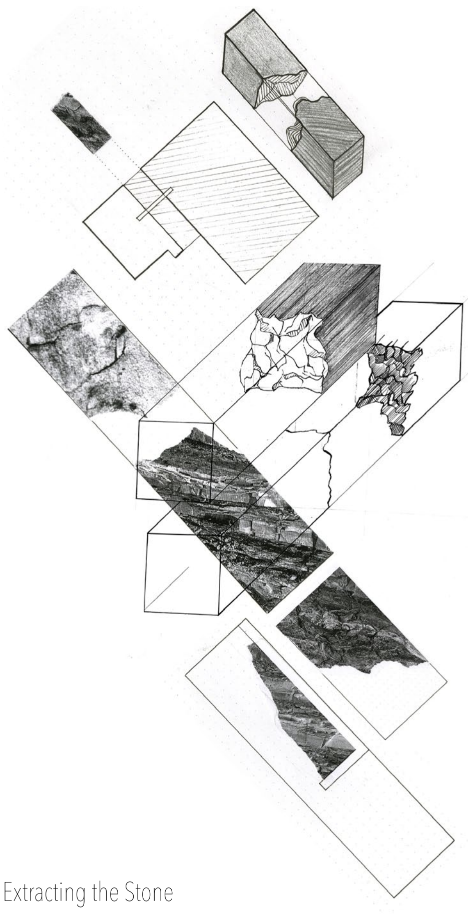
QUARRY SITE
Calanque Sugiton is an outcrop of Limestone which exhibits multiple folds of stone strata and rich geological material showing minor fault lines at which a transition of limestone layers occurs on the surface. These are as ridges and folds on the landscape.



STRATA
The Calanques are made up of sedimentary layers. In the formation of the alps, these layers were forced upwards to form ridges. Calcareous sediment provide a chronological record of time due to their carbon content. The quarry will be on the Calanque Sugiton.

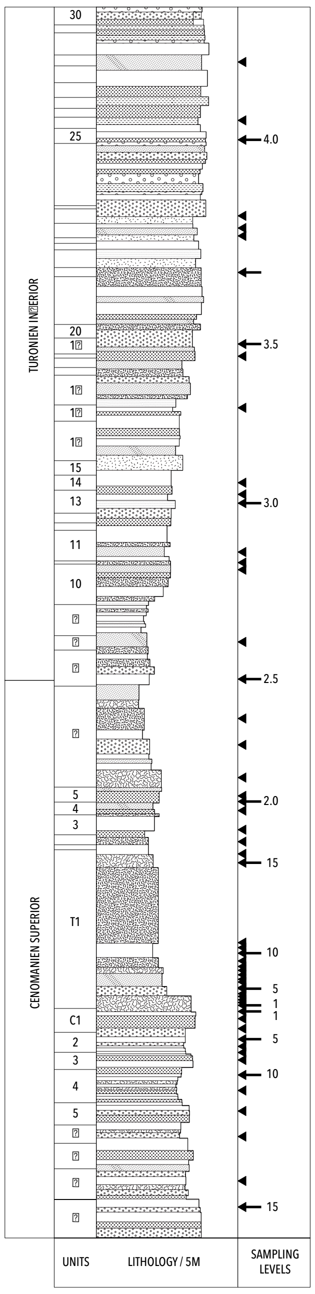


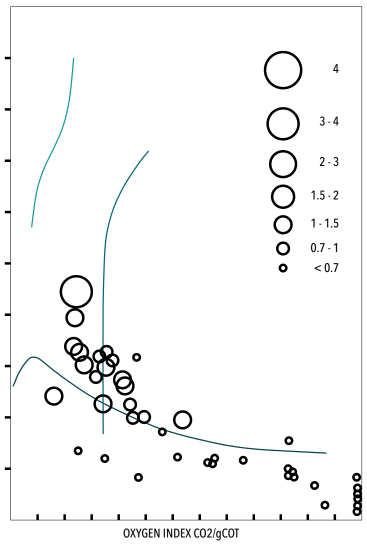
CASTING IMPRESSIONS
Excess limestone is ground on site and used to make cement and then concrete. Impressions of the Calanque litholgy at fault line transitions are cast from the manufactured concrete.

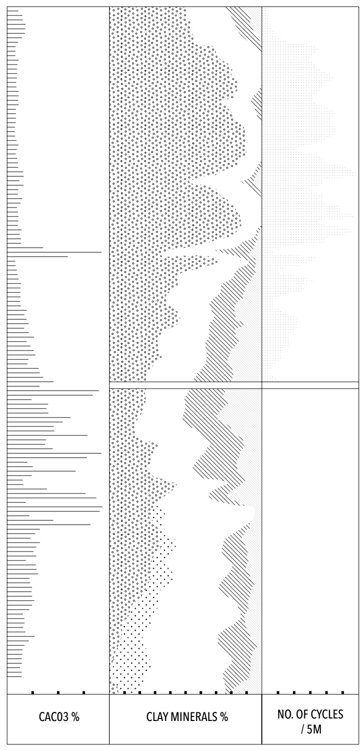


Extracting the Stone

LITHOLOGY
Similar to carbon dating, the age of the stone can be read from the compressed carbon and fossil matter within it. Levels of carbon and sediment effect the characteristics of the stone. The lithology of a rock unit is a description of its physical characteristics visible at outcrop.

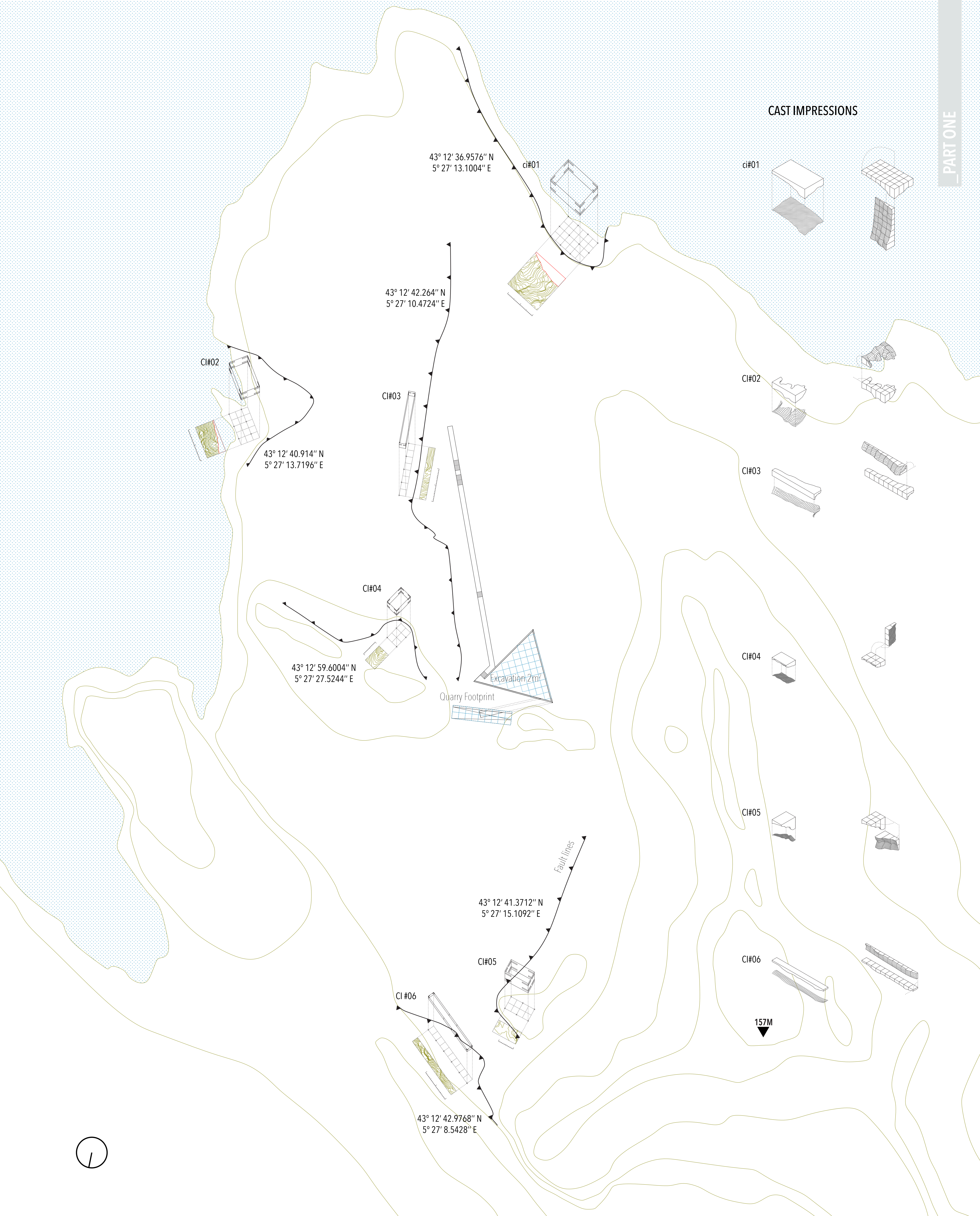






AN EXERCISE IN ARCHAEOLOGY

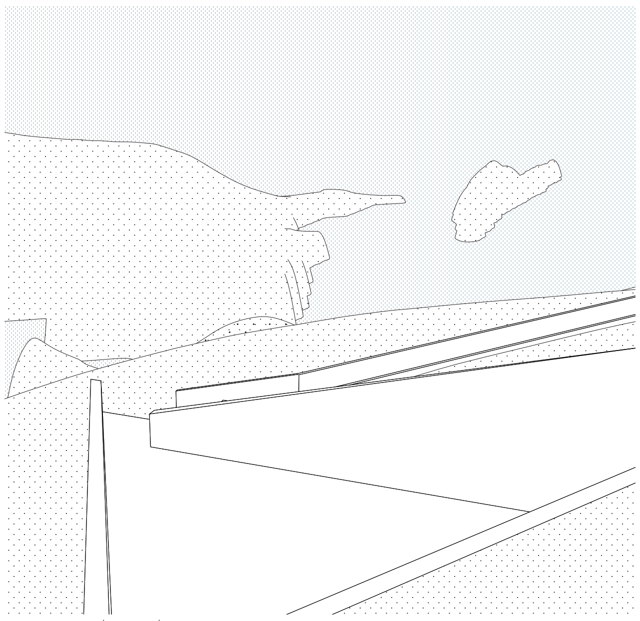
The quarry was approached in the same way an archaeological site is mapped and recorded. Studying the lithology of the site informed the chosen area of excavation and typology of interest. Like an archaeological dig, ground impressions are recorded to preserve and document the site.



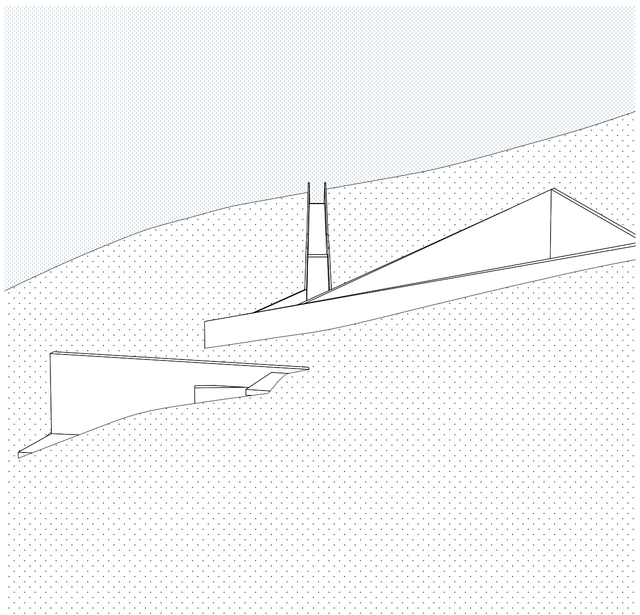
1.1.6 RECONSTITUTING STONE

QUARRY FOOTPRINT

Typically Quarry's become wastelands or leave eye saws in the landscape. By calculating the volume of stone required to construct a building on the given site, a more sustainable approach to quarrying is achievable. The standard industry cutting machines used at a quarry cut blocks of 2m sq top surface area with varying depths. Using this dimension, I designed an intervention on the site of the Calanques that provides the Marseillaise with a new way of experiencing the landscape.

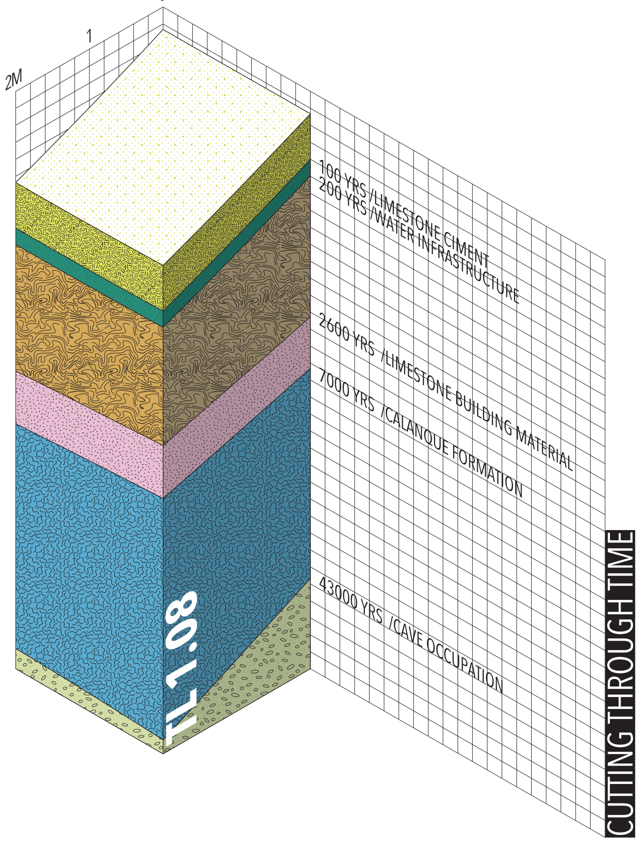


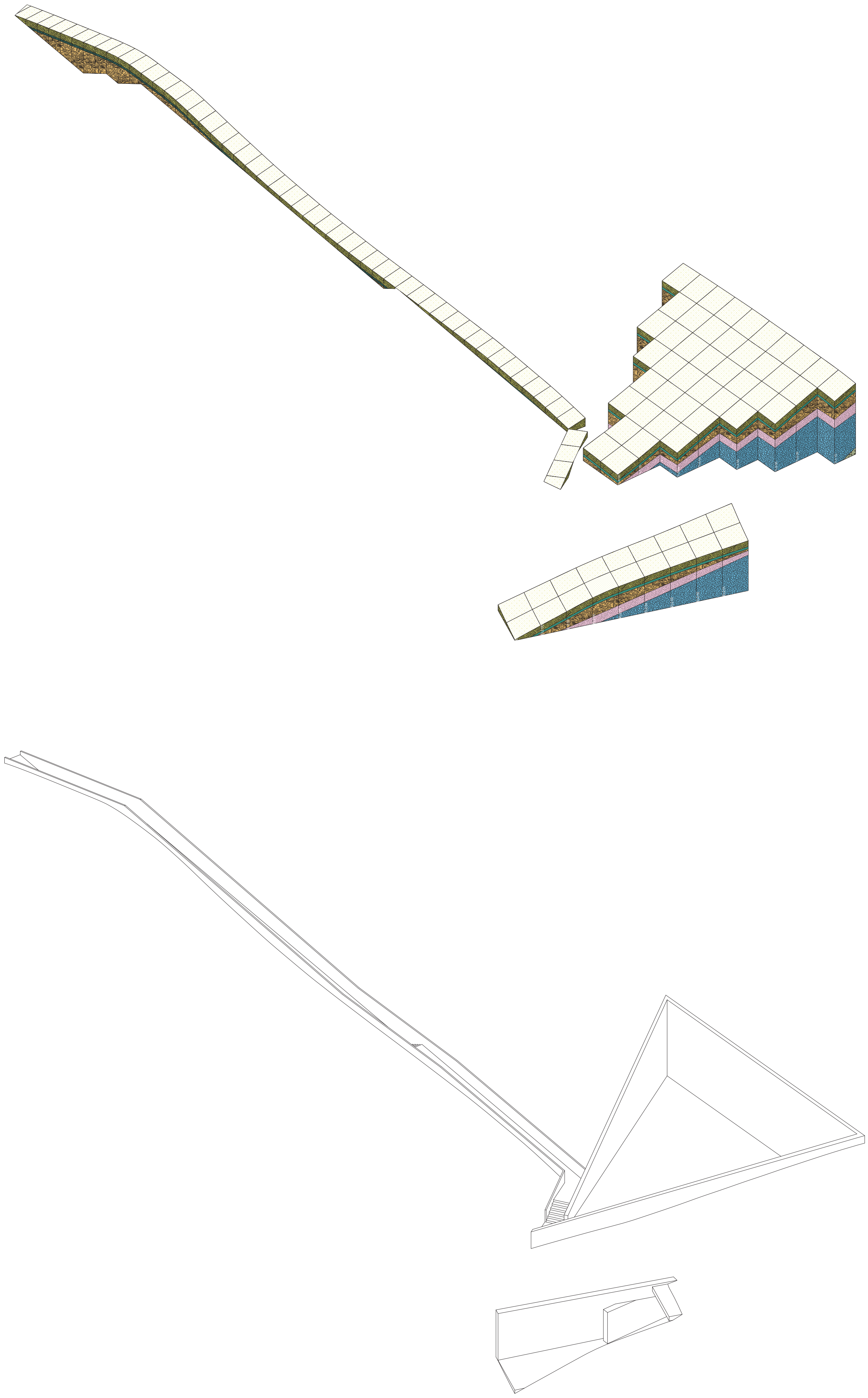
View across the creek



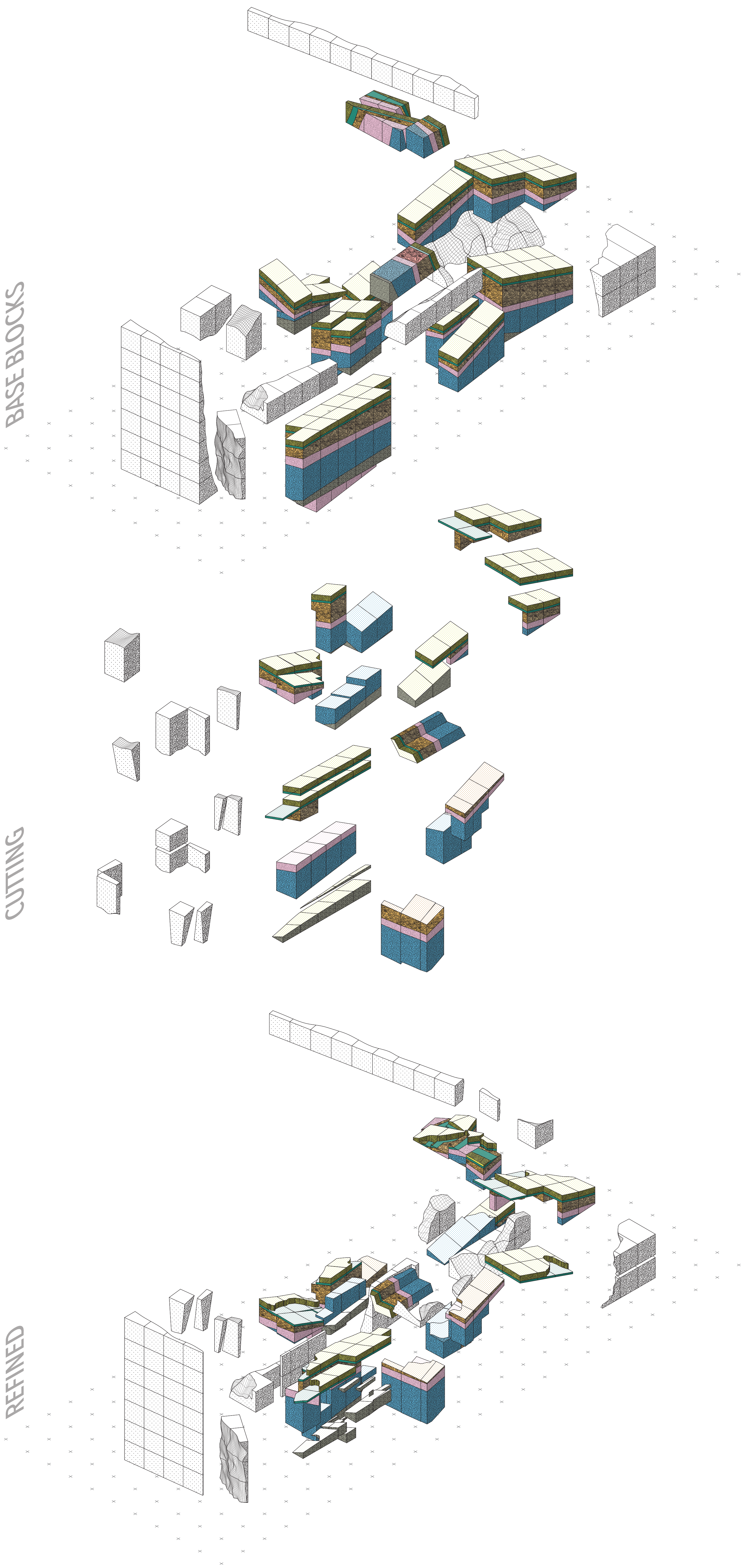
View out to sea

Cutting through the stone exposes rock stratas which correlate to the past narrative of limestone in Marseille. These include the development of the limestone as a building material. Time periods of note are identified.

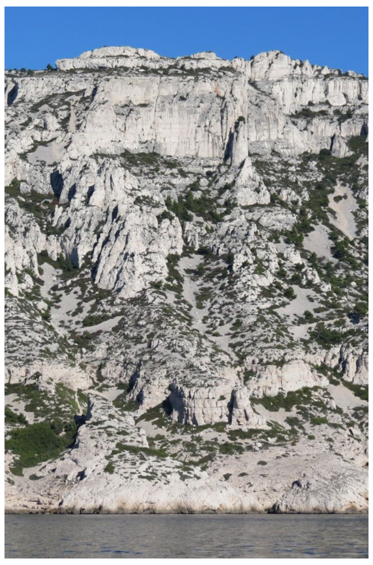




EXTRACTED LIMESTONE + EXCAVATED FOOTPRINT


BASE BLOCKS
CUTTING
REFINED

1.1.7 PROGRAMME



LIMESTONE MUSEUM

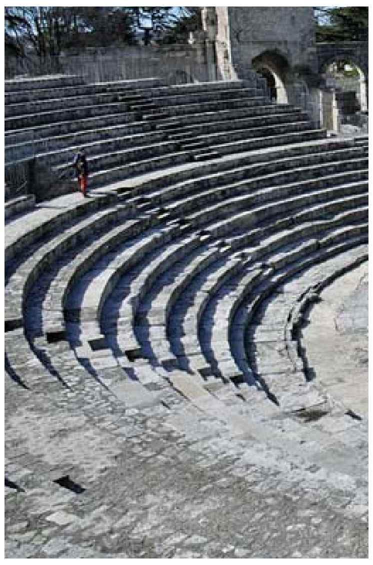
The building will exhibit past, present and future use of Casis Limestone to the public. The purpose of the building is to inform the users of the transformative processes the regional limestone undergoes to become different building materials and the design capabilities of each material; Limestone, Cement and Concrete. The Museum will exhibit methods of working with these materials and current research into developing new ones. The buillt form itself constitutes the exhibition, from structural elements to hand rails, capabilities of the stone will be experienced during a coureographed route through the museum.

RESEARCH LAB

The basement Laboratory provides a workshop environment for researchers to test and study limestone. The lab will consist of desk space, archival storage, electrical equipment and machinery. This private space is to be environmentally controlled, sound insulted and mechanical extraction systems ensure that dust and fumes are removed from the air. An integrated track system and hydraullic lift enable material to be brought in and out of the lab.

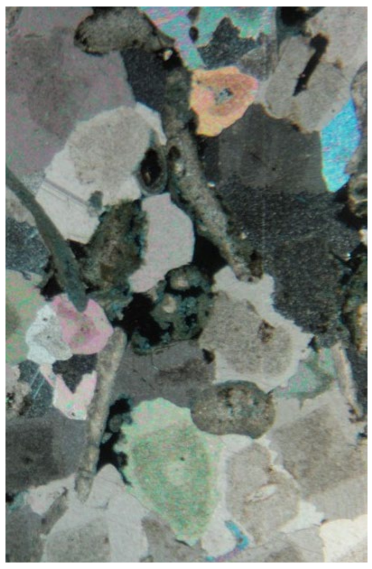
CAFE

Intergral to the use of the building will be the public cafe. This will provide a relaxed environment with spaces of shade and direct sunlight for the users to enjoy. The terrace should reconstitute qualities of the calanques into the urban sphere of Marseille.



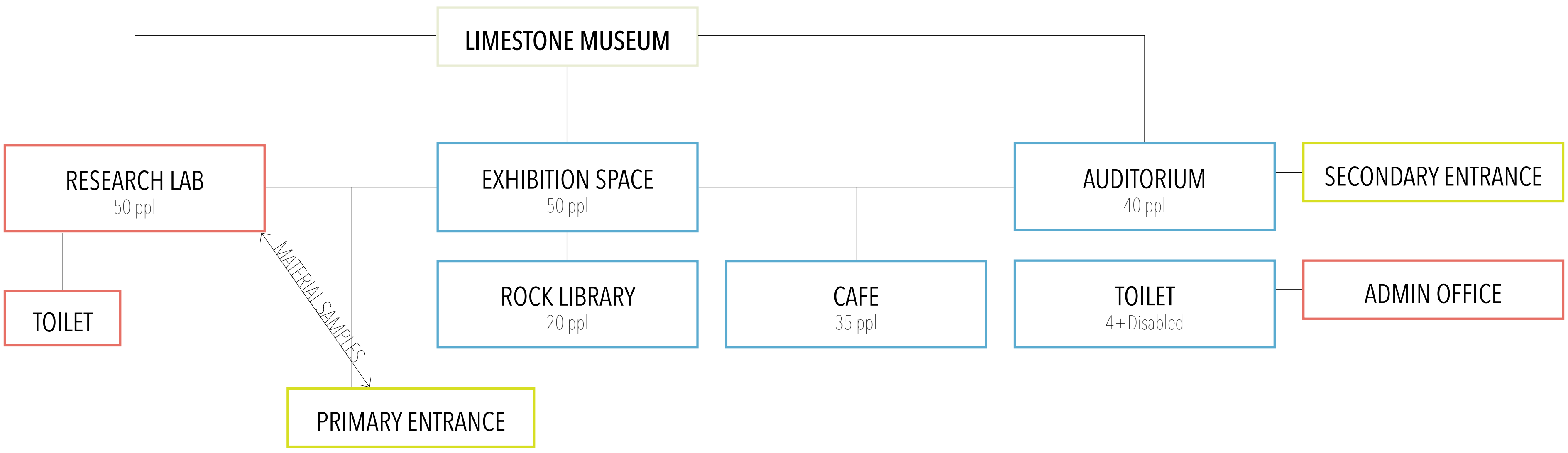
AUDITORIUM

Greek auditoriums in Marseille were sourced from Casis limestone. Lectures, seminas and film screenings will feature on evenings and weekends to inform the public and industry about Limestone construction and developing technologies. The Auditorium must be comfortable, environmentally controlled and well insulated from circulation noises. Lighting, projection and audio systems must be integrated.



ROCK LIBRARY

A Library of Limestone resources and research articles occupies the first floor. Samples of thin rock will be availble for the Public to examine under a microscope. A reading area will provide a comfortable space to browse books about limestone lithology, archaeology and construction. The library must be well insulated from loud noises and recieve plenty of natural light.

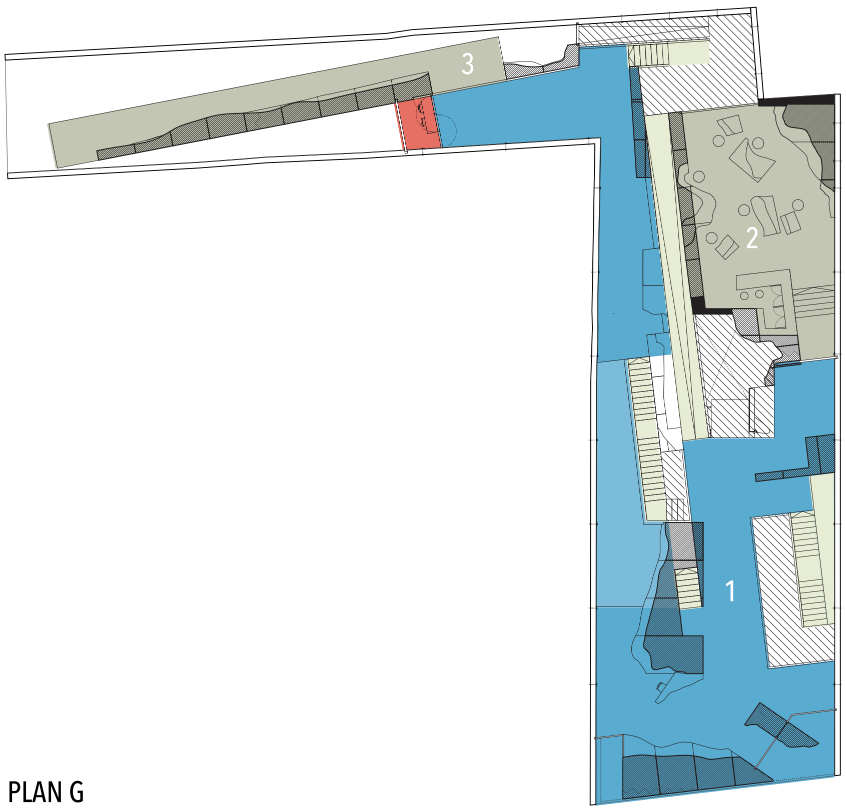


Private
Public

1.1.8 SPACIAL STRATEGY

DEFINING ACTIVITIES

The museum must perform efficiently to accommodate three different modes of operation. During the working day it will operate as a museum and research lab. Lectures may be hosted and the Museum will stay open until early evening. The cafe will be open during the day, and the terrace used for evening events during the summer. It is important that the auditorium can be entered independantly, so that a particular event does not disturb the museum or the Lab.

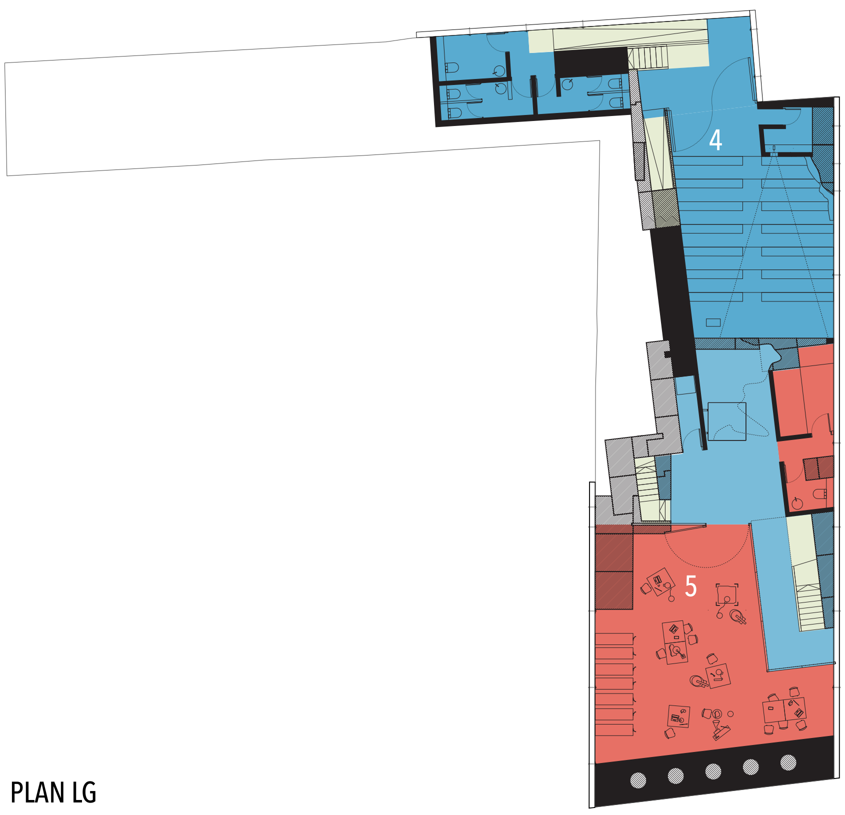


PLAN G

1. The exhibition space is designed to guide visitors through the building. The primary entrance is immediately off the street. The openness of the exhibition allows for views from one space into another and amplifies natural light.

2. The Cafe inhabits a sheltered outdoor space furthest from the noise of the street. Limestone is cut and treated to create a unique and carefully designed environment.

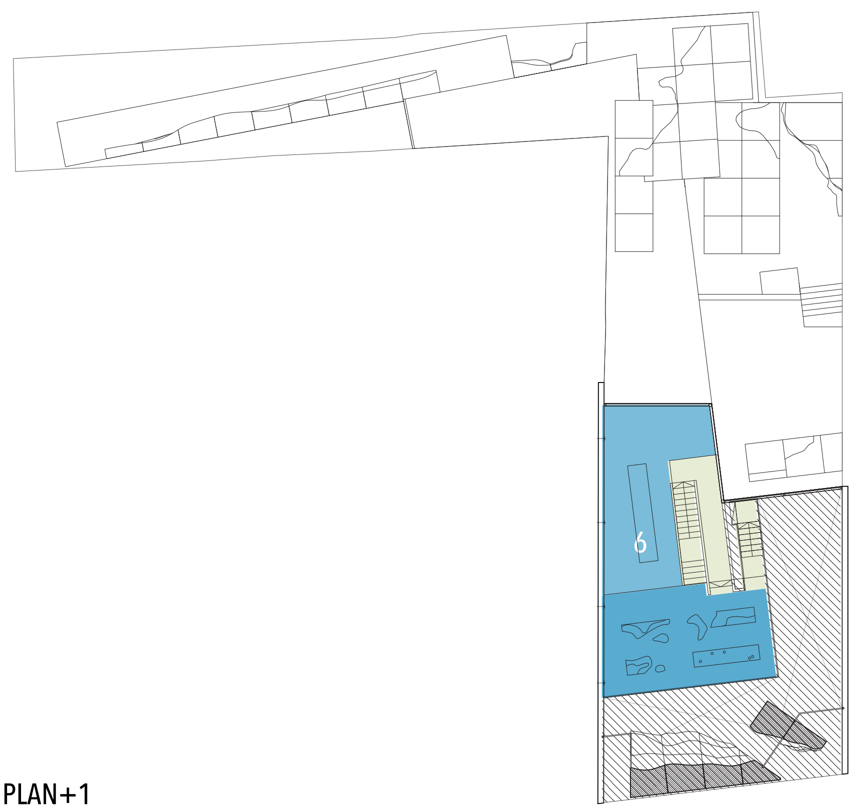
3. The Secondary Entrance to the site is a garden path adorned with quarried limestone and its distinctive flora.



PLAN LG

4. The Auditorium is served by the secondary entrance during an event. This ensures minimal disturbance to the rest of the museum and convenience.
The auditorium exhibits multiple states of limestone. In this space, the stone performs in tactile conditions and absorbs sound. Techniques to increase the wall and ceiling surface area achieve this. The Limestone is polished to provide an ideal surface for projection..

5. The Research Lab is reasonably isolated to prevent sound leaking into the rest of the building. There is a visual relationship to the exhibition space so it's operation can be observed by the public. The space allows for flexible working and moving elements.



PLAN+1

6. The rock library provides a studious environment to sit, read and examine rock samples. Circulation is contained so as not to disturb the space.

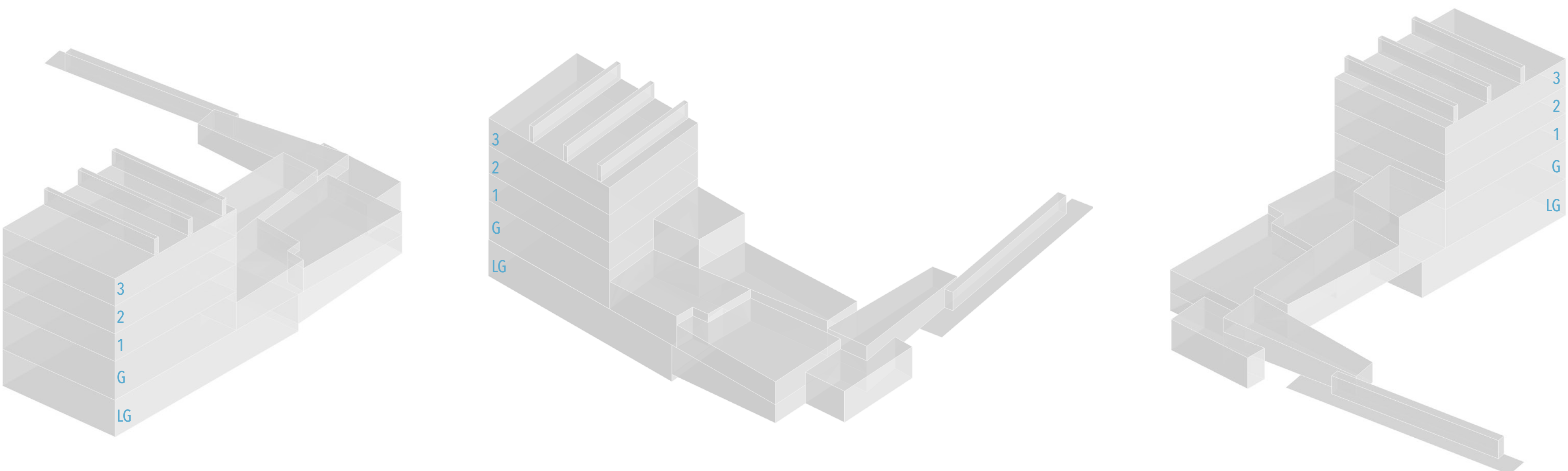
Private
Public
Circulation
Outdoor
Open to below

7. The exhibition space continues on this level. Lightweight and thinly cut limestone are employed to control light and temperature. Open space to below connects the spaces and builds on the journey through the museum.

PLAN +2

8. The top floor serves as view point from which the rest of the building can be seen, including the roof scape below. Deep horizontal limestone beams provide shade.

PLAN +3

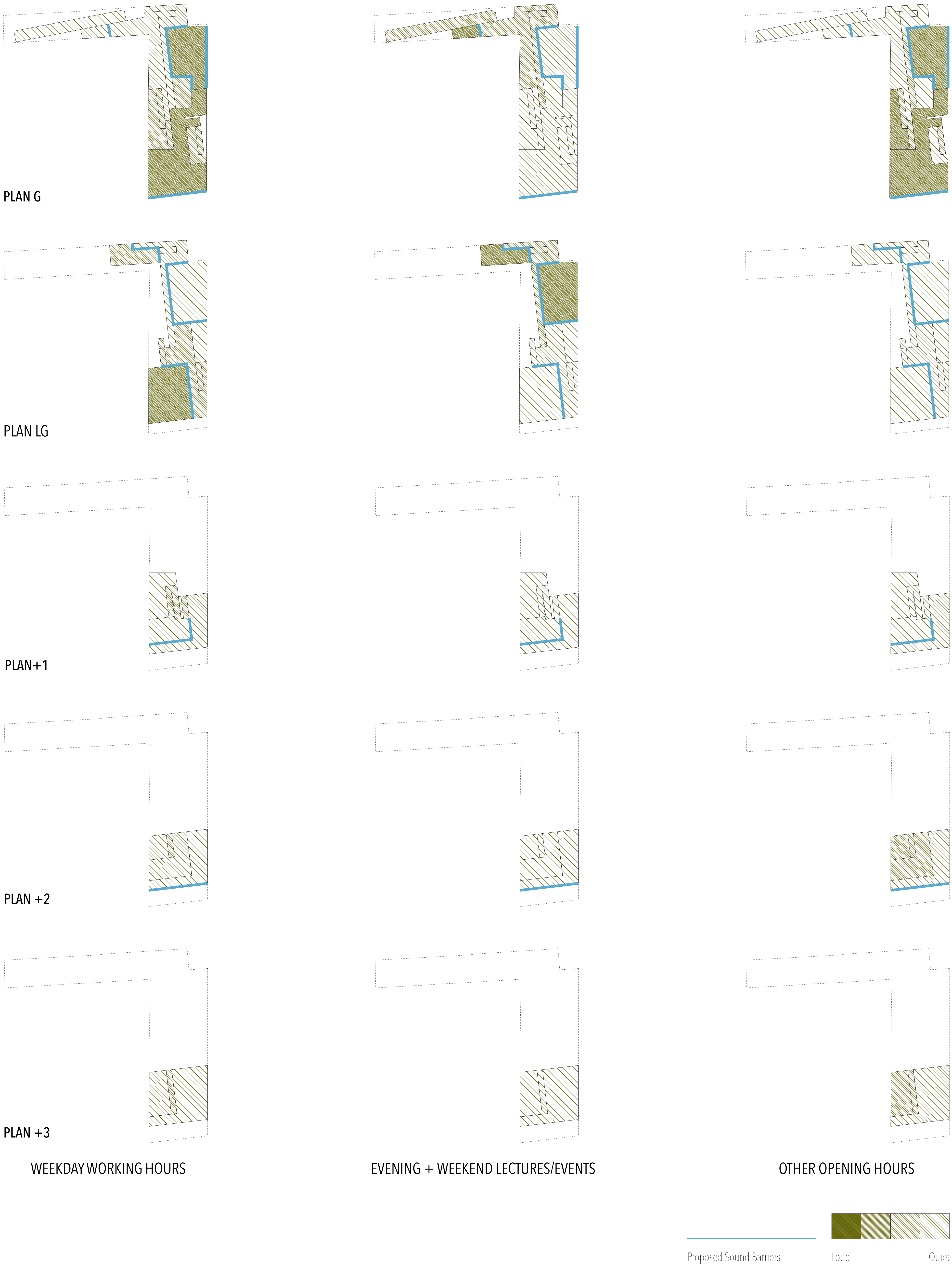


MASSING MODEL

1.1.9 ACOUSTIC STRATEGY

CONTROLLING POTENTIAL NOISE

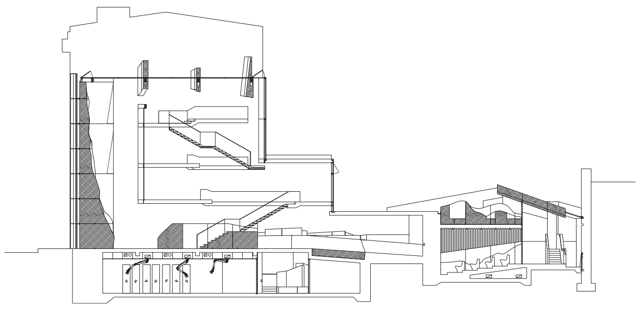
During the specified periods of operation, the building must perform acoustically at different noise levels.



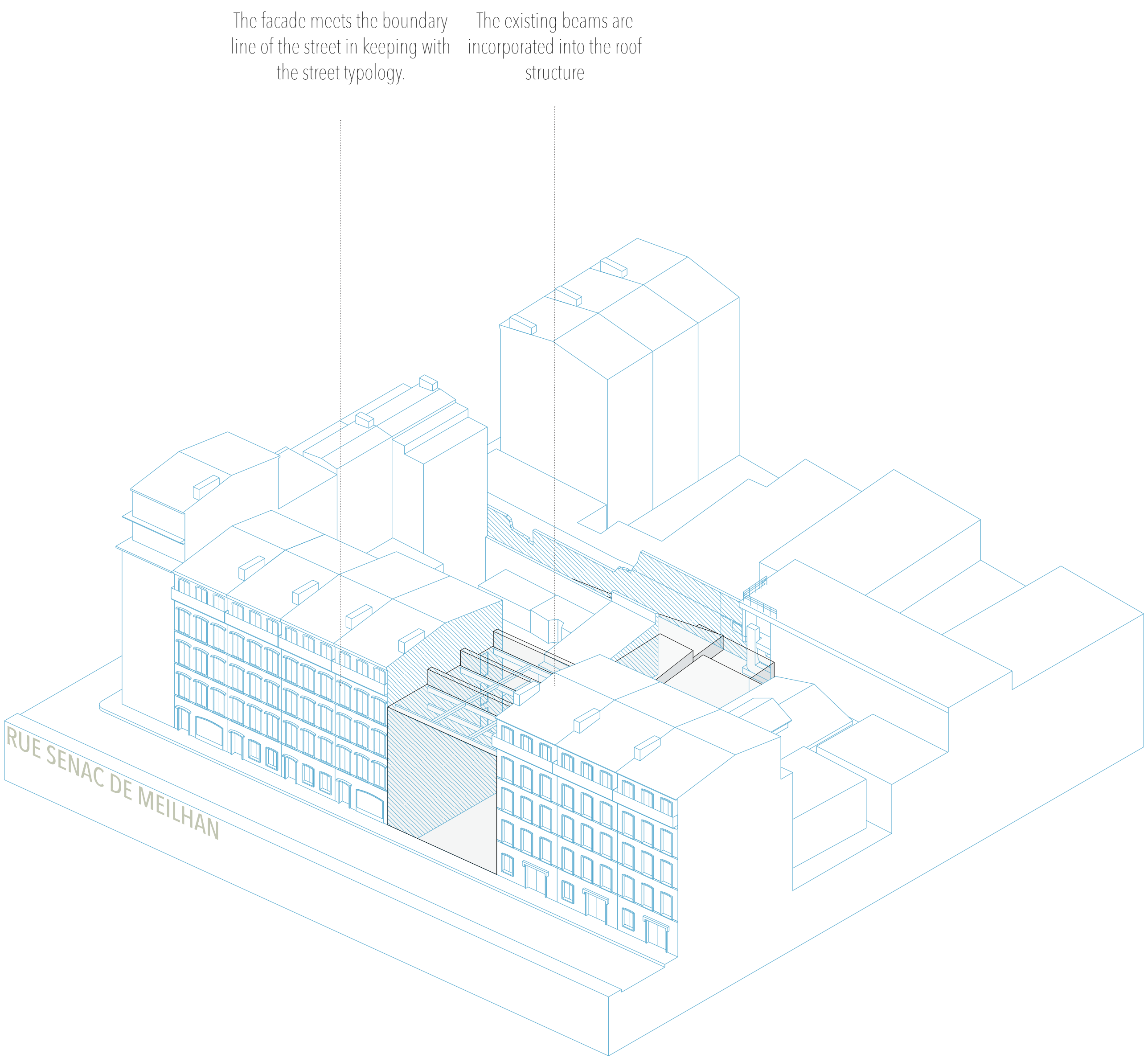
1.2.0 SITE STRATEGY

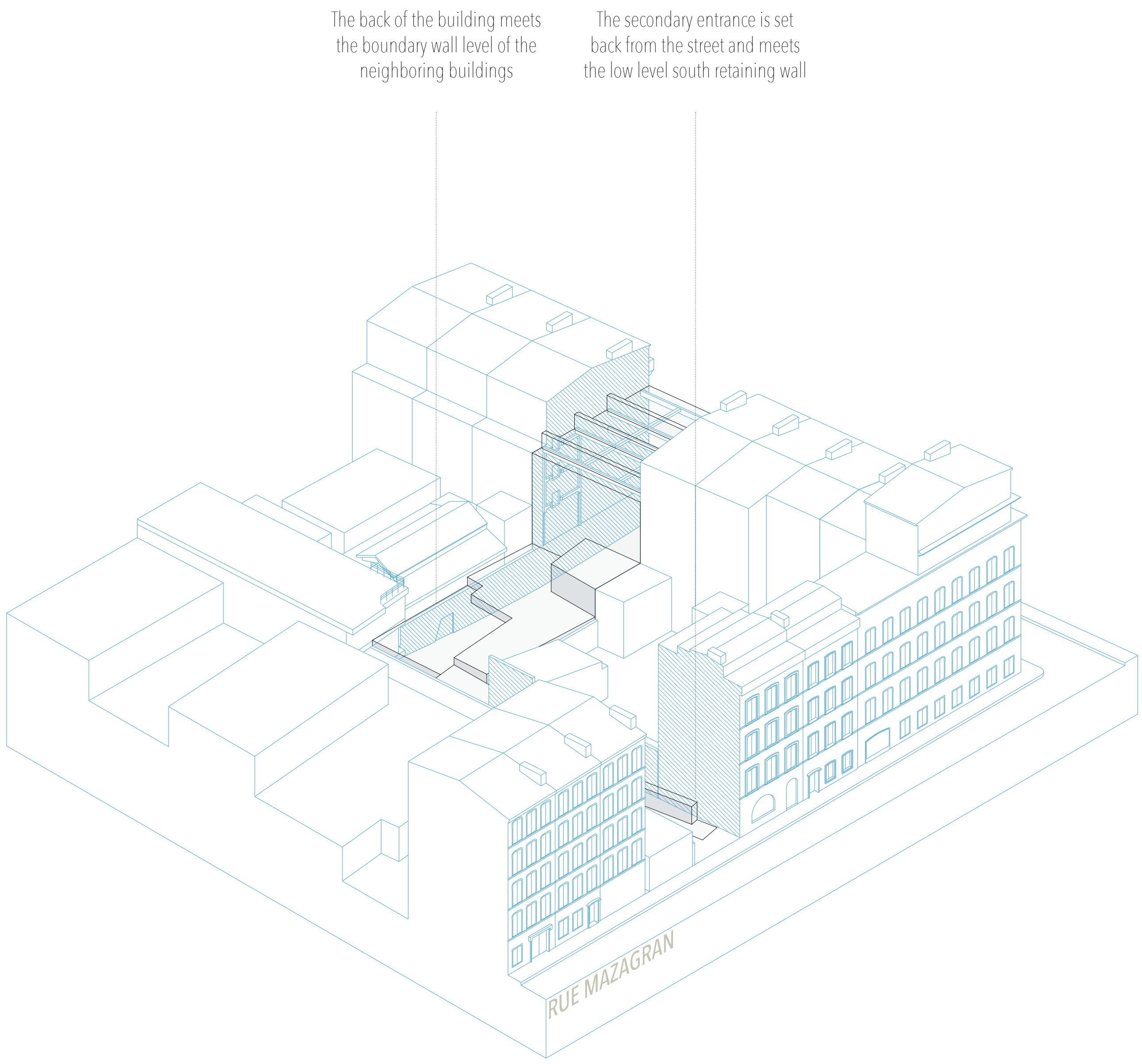
VOLUMETRIC STUDY

The building envelope responds to the existing site by occupying the 'ghost' space of the building that went before. The building is similar to an archaeological reconstruction of a collection of artefact's. Small clues as to how the previous building filled the space are used to set floor levels, opening heights and stair locations.



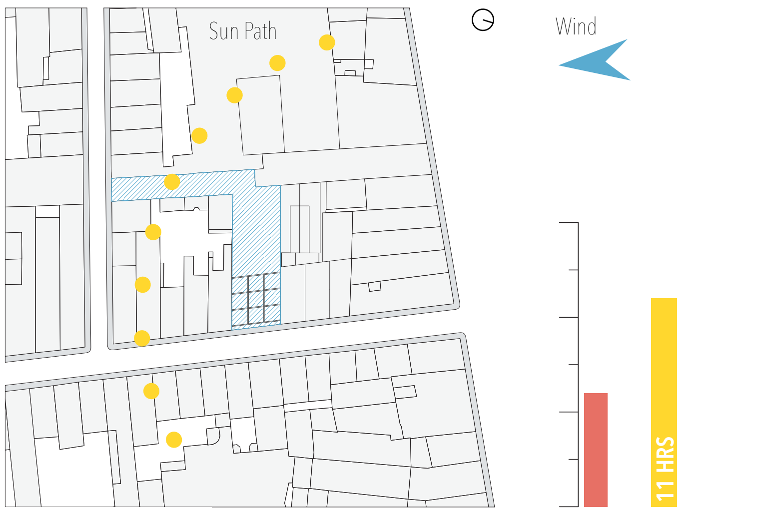
The building sits just below the elevated outline on the site. Each floor level responds to exposed structure on the existing party wall.



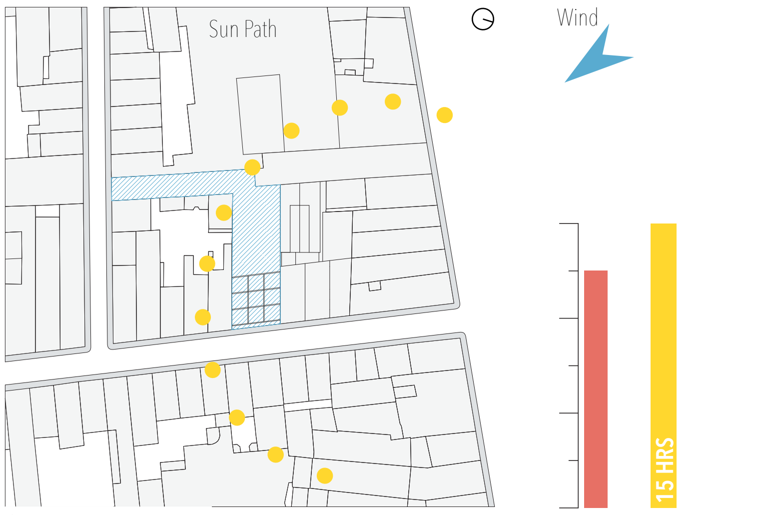


1.2.1 ENVIRONMENTAL CONDITIONS

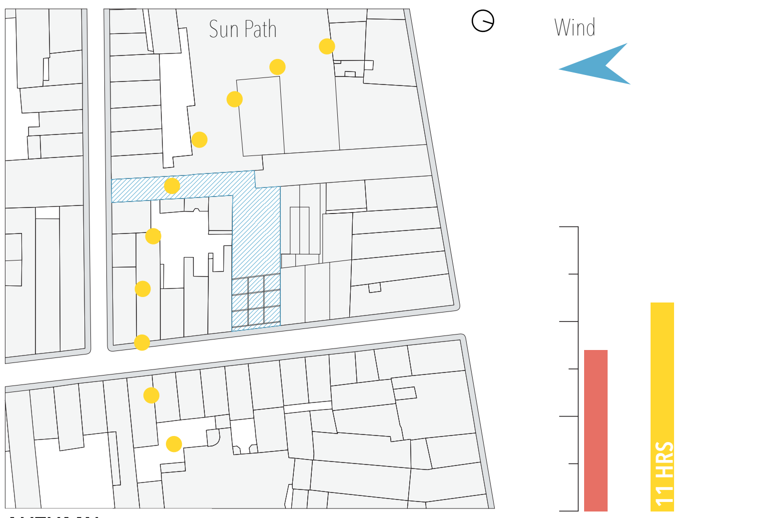
ENVIRONMENTAL CONDITIONS



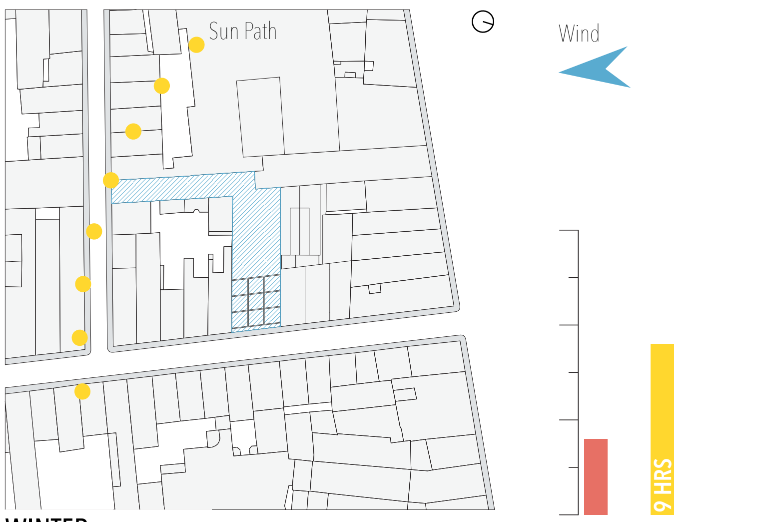
SPRING



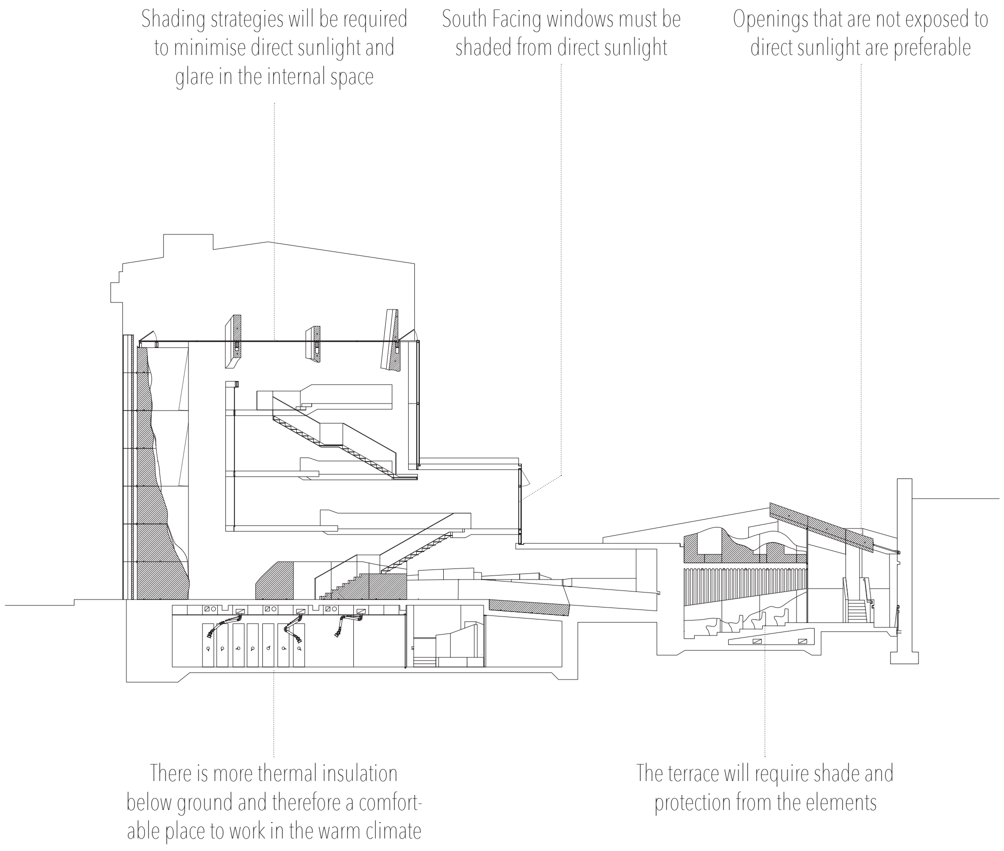
SUMMER



AUTUMN



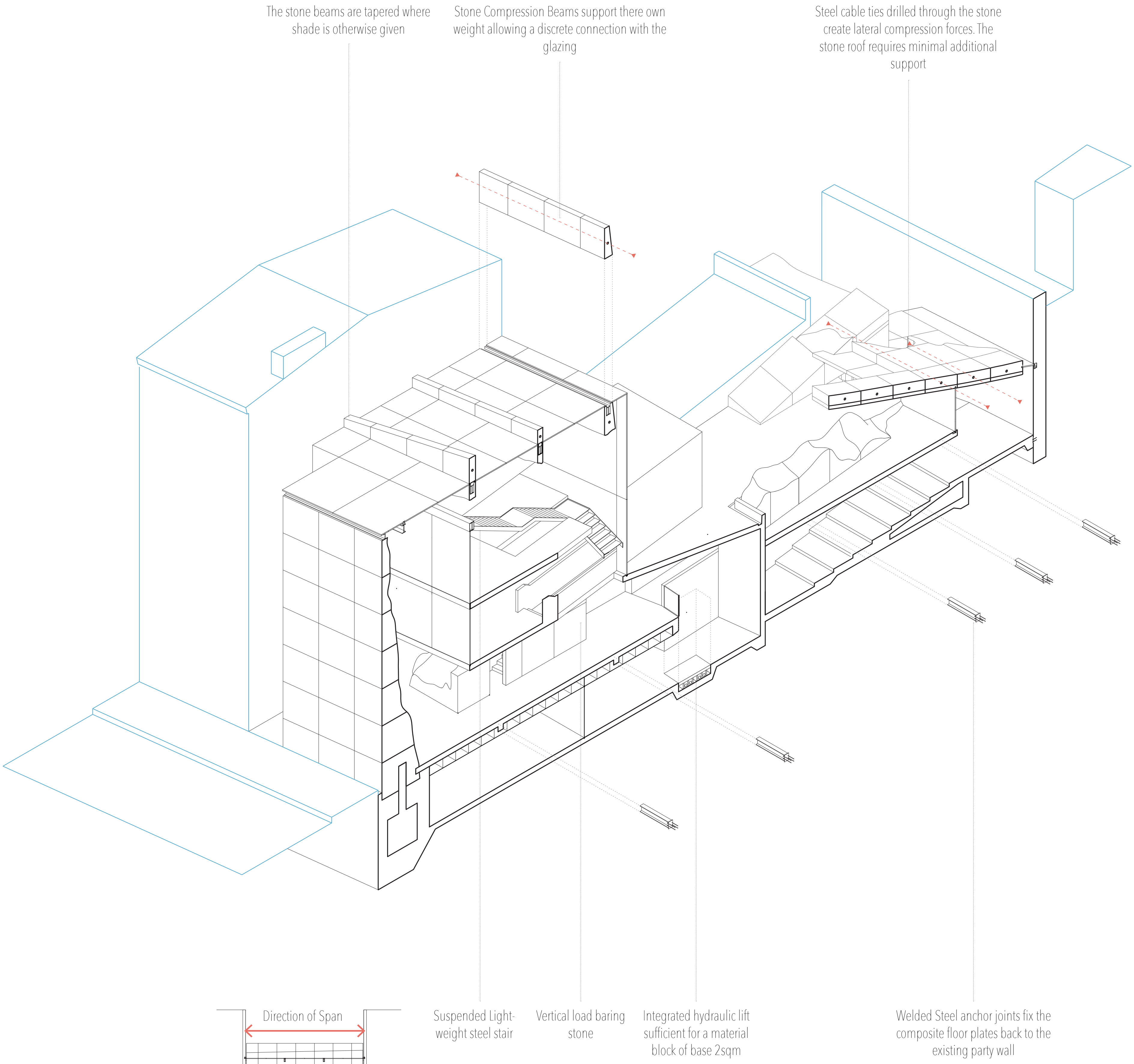
WINTER

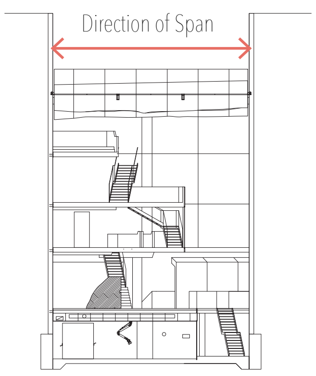


1.2.2 STRUCTURAL STRATEGY

ISOMETRIC SECTION

In order to change the structural capacity of the stone, post tensioning systems will enable the stone to span by holding the individual blocks in compression. Limestone in concrete form is more flexible as a structural element than pure limestone which can only take compression load.





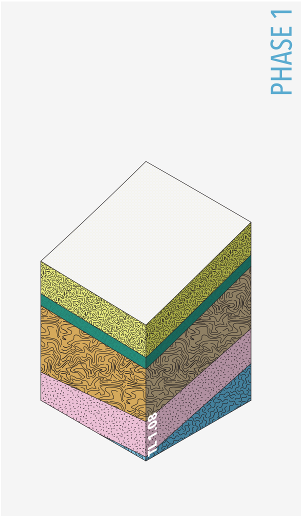
PART TWO

BUILDING CONSTRUCTION

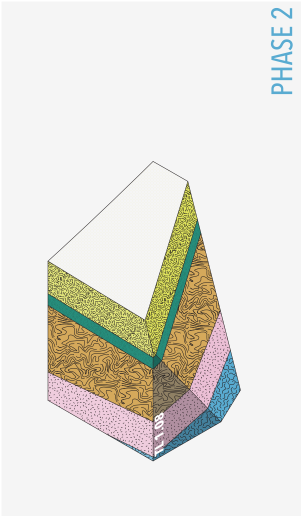
2.1.1 CUTTING STONE

PHASES OF REFINEMENT

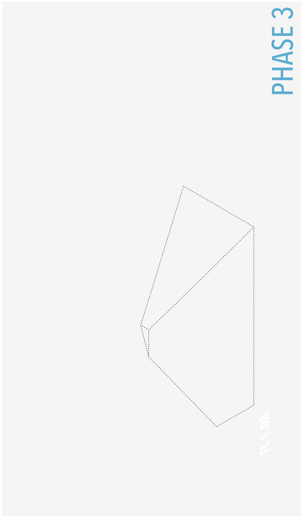
The stone is cut, carved and reconstituted once extracted from the Calanque. Each block is referenced and fashioned according to its position and performance in the building. No material is wasted. The same volume of stone removed from the calanque is reconstituted as either stone, cement or concrete.



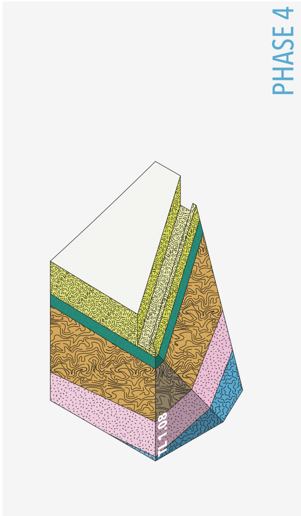
The stone is cut and exported from the quarry in as a 2m^2 block with varying depth.



The stone is cut in a single plane as required for its performance within the building.



The 'waste' is crushed or ground to form aggregate or powder for cement or concrete production.



In some cases the rock requires a more complex cut, which is carried out by a water jet laser or a hand held tool.

STONE CUTTER

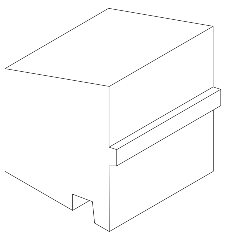
CIRCULAR SAW

GRINDER

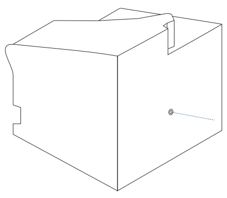
WATER JET

STRUCTURAL REQUIREMENTS

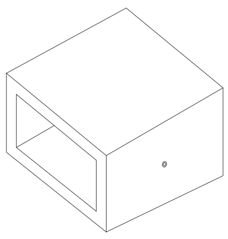
Further alterations are made in order for the stone to perform structurally.



TONGUE + GROOVE
Ridges and grooves are cut into the stone blocks to provide stronger connections and prevent movement under compression



POST TENSIONING
For an unbonded post tensioning system, holes are drilled through the stone as required. Steel cables compress the stone blocks together. This compression increases the distance the stone is able to span.



REDUCING LOAD
Roof elements are hollowed out to reduce weight whilst maintaining shape under compression. This also provides insulation.

#	PHASE 1	PHASE 2	PHASE 3	PHASE 4
TL1.1				
TL1.2				
TL1.3				
TL1.4				
TL1.5				
TL1.6				
TL1.7				
TL1.8				
TL1.9				
TL1.10				
TL2.1				
TL2.1				
TL2.2				
TL2.3				
TL2.4				
TL2.5				
TL2.6				
TL2.7				
TL3.1				
TL3.2				
TL3.3				
TL3.4				
TL3.5				
TL3.6				
TL3.7				
TL3.8				
TL4.1				
TL4.2				
TL4.3				
TL4.4				
TL4.5				
TL4.6				

#	PHASE 1	PHASE 2	PHASE 3	PHASE 4
TL5.1				
TL5.2				
TL5.3				
TL5.4				
TL6.1				
TL6.2				
TL6.3				
TL6.4				
TL7.1				
TL7.2				
TL8.1				
TL8.2				
EL1.1				
EL1.2				
EL1.3				
EL1.4				
EL1.5				
EL1.6				
EL1.7				
EL1.8				
EL1.9				
EL2.1				
EL2.2				
EL2.3				
EL2.4				
EL2.5				
EL2.6				
EL2.7				
EL2.8				
EL2.9				

STONE INDEX

2.1.2 TOLERANCES

DEFINING SURFACES

The texture of the limestone varies throughout the building. The allocated finish depends on elevation and location within the building. For this to be achieved, tolerances in the cutting process need to be accounted for and the definition of surface tolerance clearly defined.

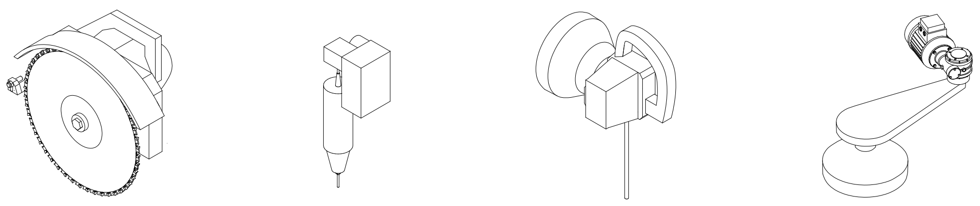
Important reasons to consider surface

A. Aesthetic reason
B. Safety
C. Friction and wear
D. Affects the mechanical integrity of a material
E. Ability to assemble
F. Control contact/touch

In construction, the Nominal Surface is the intended surface contour of a part, where as the Actual Surface is determined by the manufacturing processes.

Repetitive deviation from the nominal surface is categorized as follows:

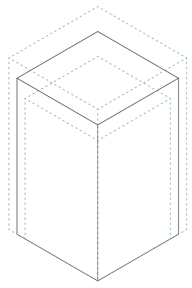
Roughness - the small, finely spaced deviations from the nominal surface
Lay – the predominate pattern of the surface texture
Waviness – the deviation over much larger area that come about from deflection, vibration, heat treatment and etc.
Flaws – irregularity such as cracks, scratch, inclusions



Cutting Tool	Circular Saw	CNC Water Jet	Orbital Sander	Diamond Polishing Wheel
Phase	#1	#2	#4	#4
Cutting Plane	Single	Single	Multiple	Multiple
Material Loss	180mm	2mm	Curved Surfaces: 40mm Flat Surfaces: 3mm	Curved Surfaces: 20mm Flat Surfaces: 2mm
Surface Finish	Rough	Smooth	Smooth	Polished
Tolerance	± 260	±3mm	±6mm	±4mm

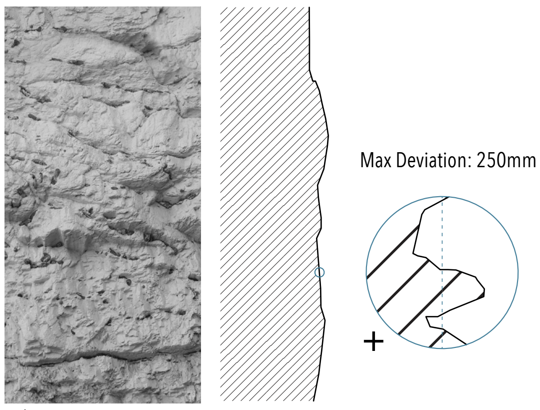
DIMENSION TOLERANCES

For a particular part to perform as intended, deviation from the optimal dimension is limited. Due two the large degree of error in the initial cutting process. The dimensions of a stone part is likely to fall outside the window of tolerance.



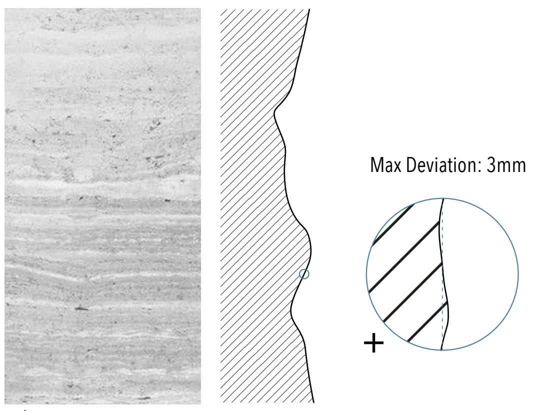
Stone Part	Block	Compression Beam	Veneer
Depth	±220mm	±4mm	±0.4mm
Width	±220mm	±1mm	±1mm
Height	±220mm	±8mm	±1mm
Volume	±180³mm		

ROUGH



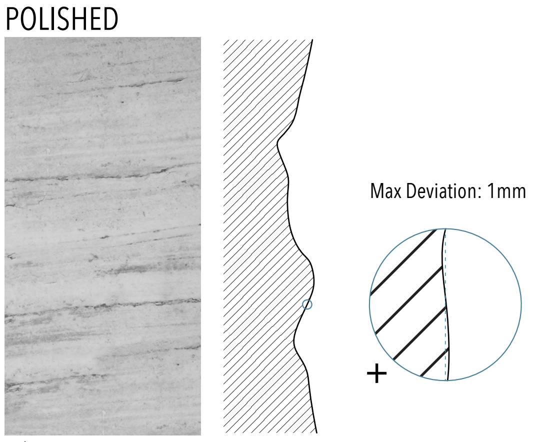
Tolerance: ± 250mm

SMOOTH



Tolerance: ± 3mm

POLISHED



Tolerance: ± 1mm

WHEN A PART IS NOT WITHIN TOLERANCE...

SCENARIO A
For a protrusion of over 250mm from the most set back point

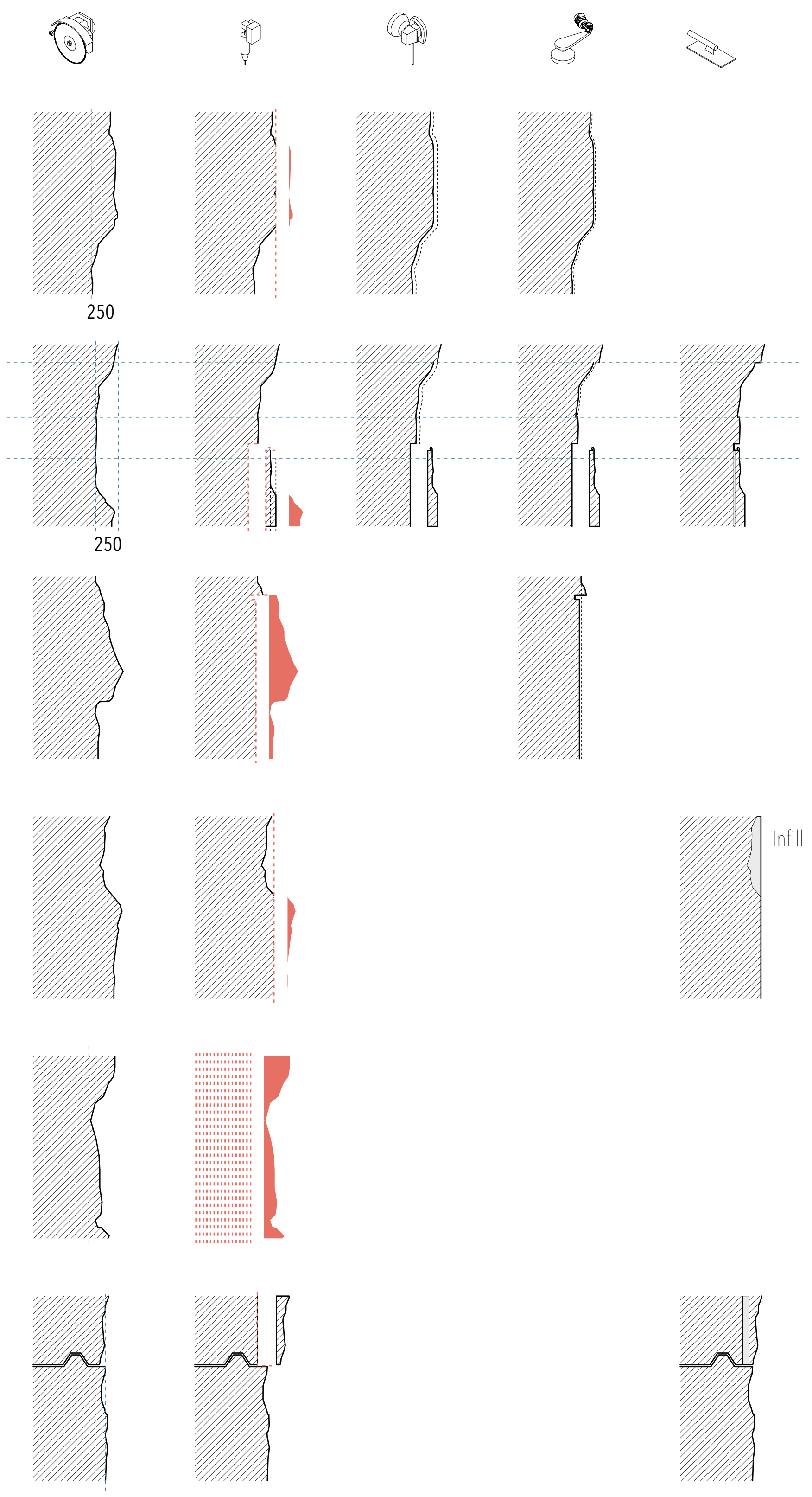
SCENARIO B
For multiple surface finishes on a single face

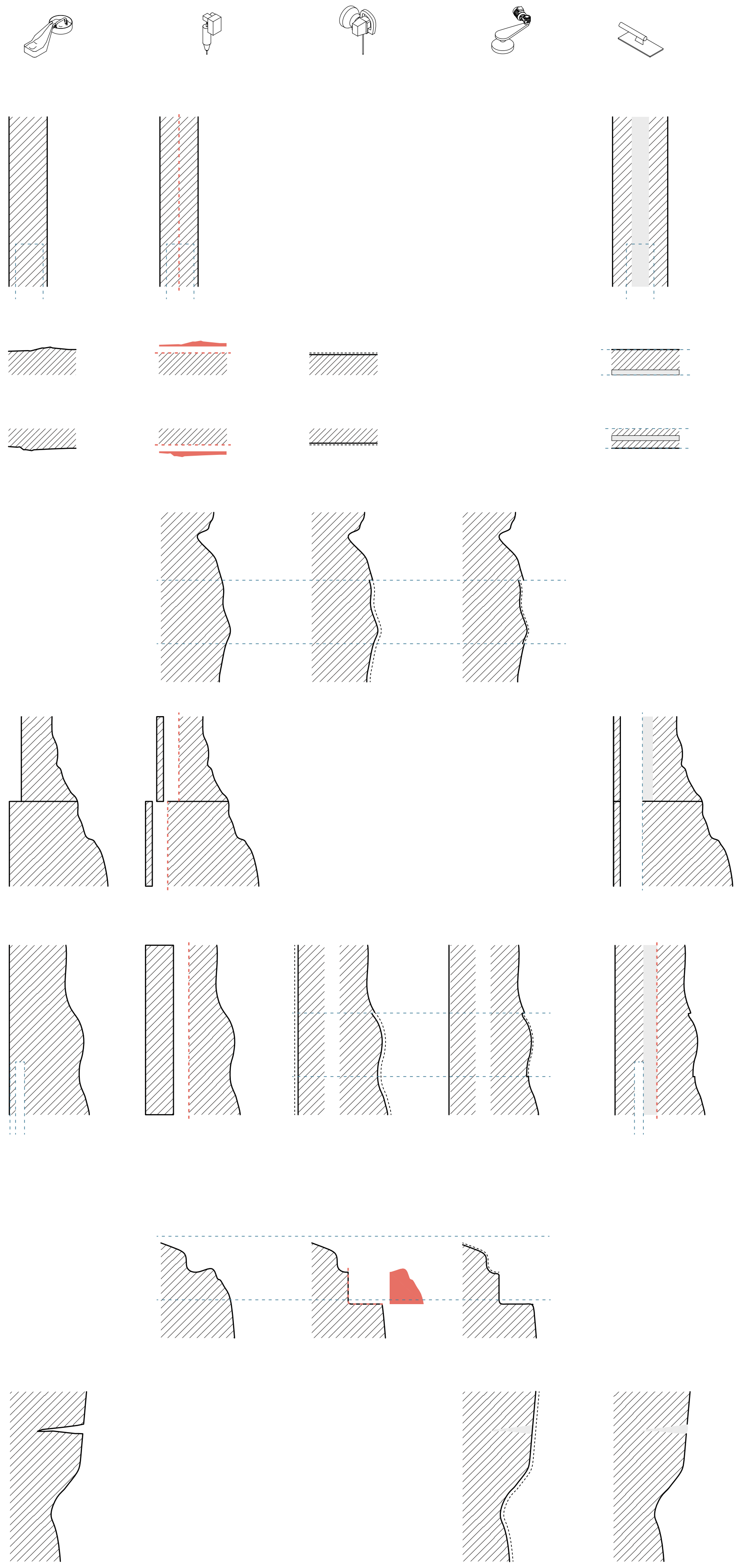
SCENARIO C
For an uneven surface required to be flat.

SCENARIO D
For a uneven surface that will not be exposed

SCENARIO E
For stone to be cut into thin veneer sheets

SCENARIO F
For when two faces do not align





SCENARIO G
For a part that is below the minimum width tolerance

SCENARIO H
For a floor/ceiling surface that is below/above the minimum depth tolerance

SCENARIO I
For a cast block with multiple surface finishes

SCENARIO J
For a cast block below the minimum depth tolerance

SCENARIO K
For a cast block below the minimum width tolerance

SCENARIO L
For a cast block with a seating

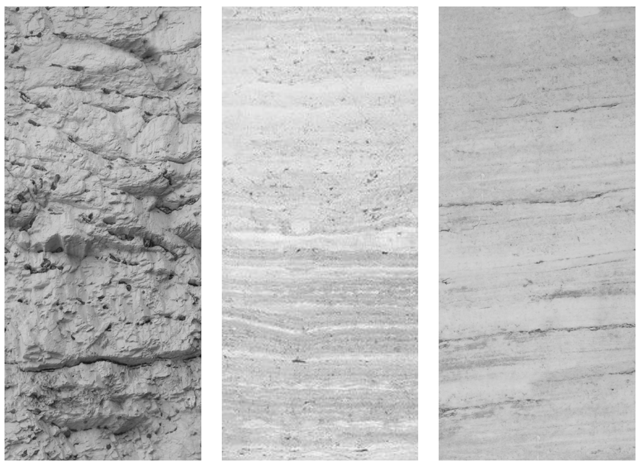
SCENARIO M
For a crack in a cast block

2.1.3 SURFACE TEXTURE

DEFINING INTERACTION

The way the user interacts with the stone is controlled through the treatment of surfaces throughout the building. Surface textures subtly define the nature of the space and the appropriate behavior.

ROUGH SMOOTH POLISHED



LIMESTONE

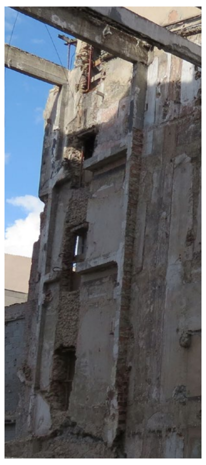
Variations of the stone in elevation

SMOOTH POLISHED

CONCRETE

Variations of cast concrete

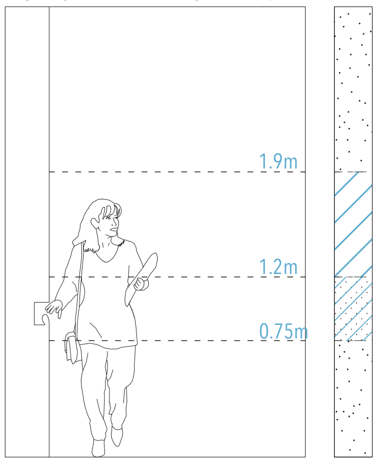
ROUGH



EXISTING

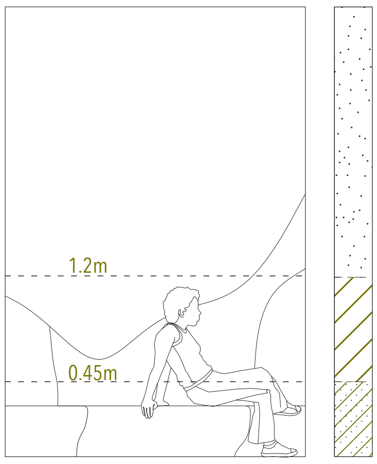
The existing walls

RULES IN ELEVATION 1:50



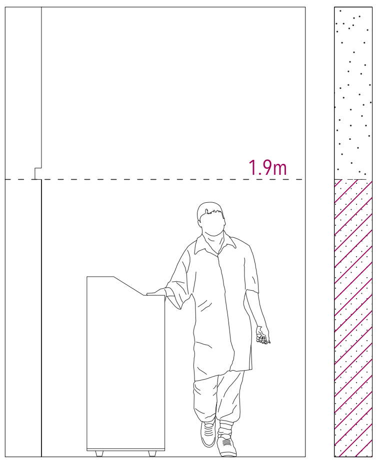
MUSEUM/CIRCULATION

Visitors are guided through the Museum through the experience of touch. The stone is smooth in areas they are invited to touch, this enables them to feel their way around the museum. A polished surface at eye level accentuates the stratas in the stone.



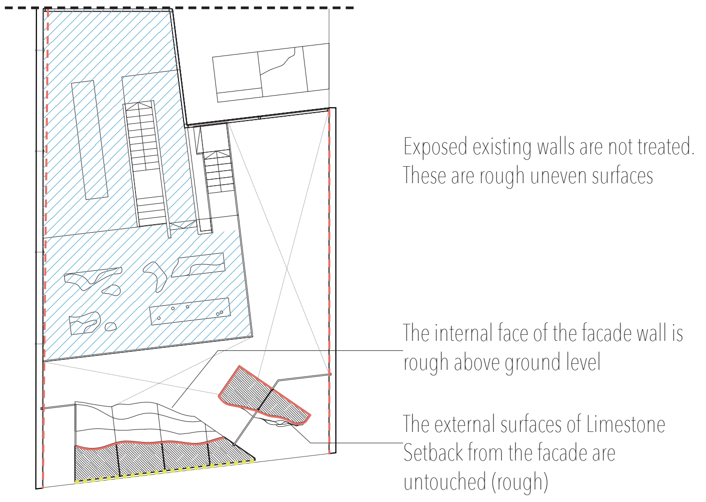
SEATING AREAS

The auditorium and outdoor cafe are typically experienced from a lower level where contact with the buildings surface is greatest. Using a carefully designed mold, it is possible to create comfortable surfaces to sit on using a concrete.



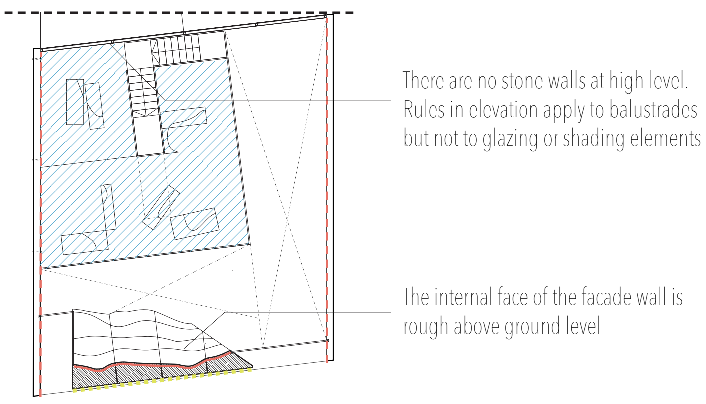
PRIVATE/LAB

Due to the operational nature of the lab, it is important that these private ares are made to be heavy duty. For this reason surfaces below 1.9m above FFL are to be smooth and sealed concrete.

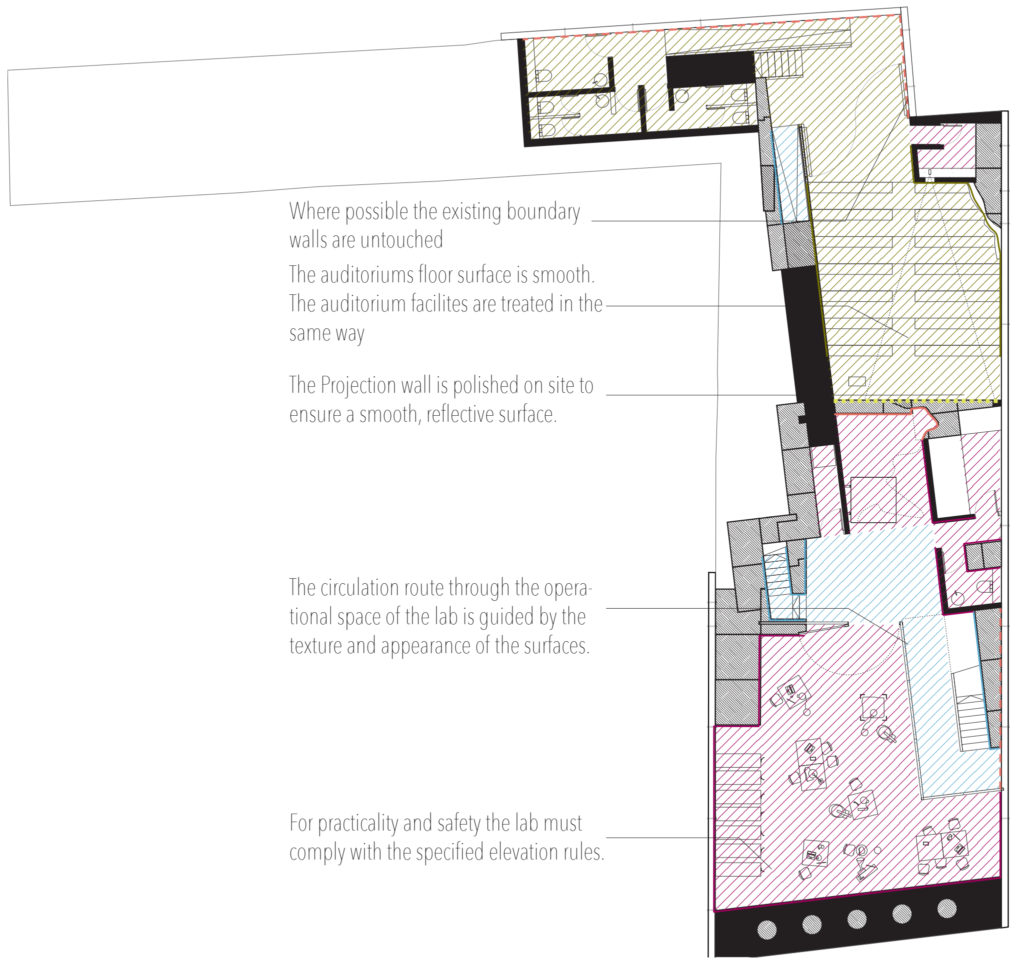


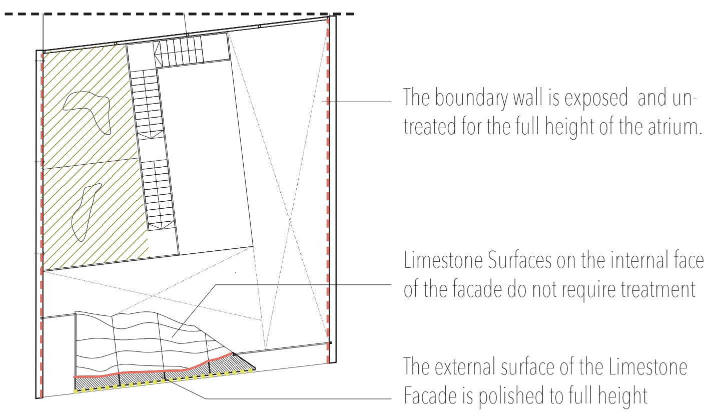
PLAN +1

PLAN G



PLAN +2





PLAN +3

PLAN LG

untouched

existing

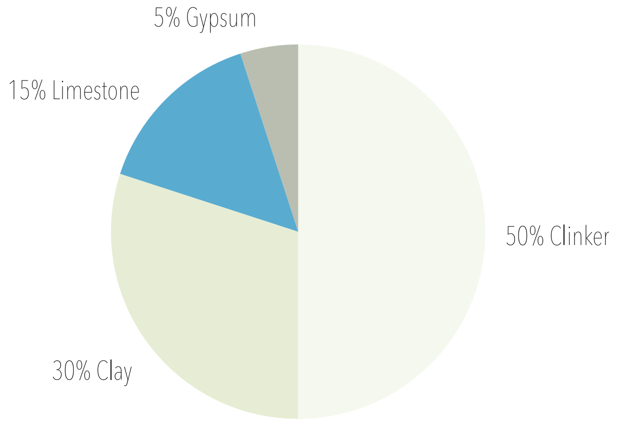
polished

2.1.4 MATERIAL CONVERSIONS

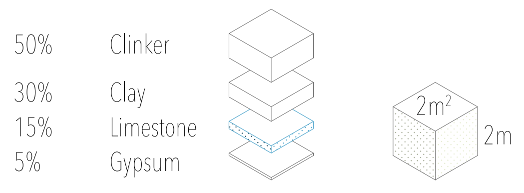
LIMESTONE CEMENT

The geological context of Marseille is such that the material components of cement are all local resources. The city of Marseille is situated on a clay bed neighbouring a limestone outcrop with local cement manufacturing kilns. LC3 is a recently developed cement that includes an addition of clay and limestone. This reduces the carbon footprint (fuel required to heat the cement)

Material components of LC3 cement:



Volumes within a 8m³ of cement:

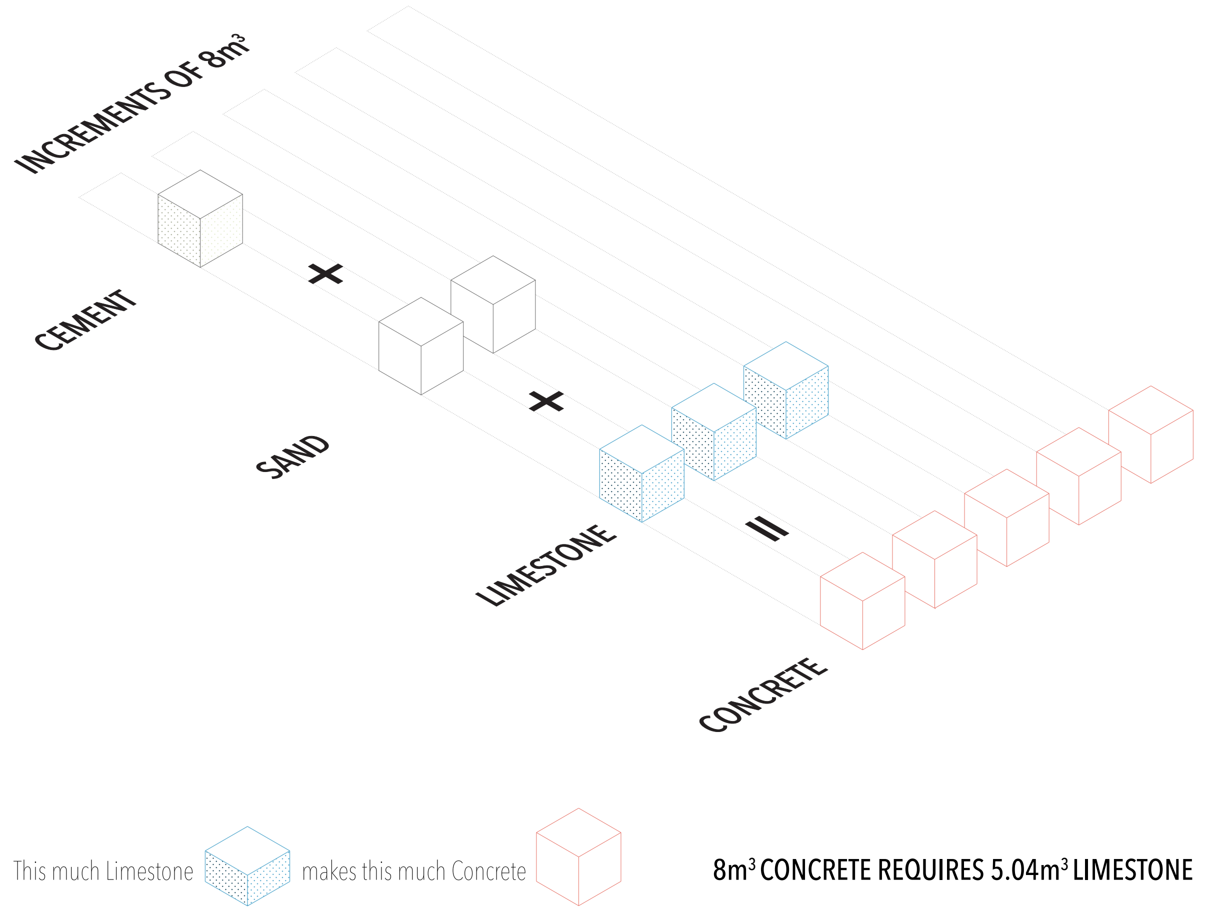


8m³ CEMENT REQUIRES 1.2m³ LIMESTONE

LIMESTONE CONCRETE

Concrete can be made with varying components of sand aggregate and cement. The aggregate can be made from a range of materials, one of which is limestone. This can be crushed or ground to gravel or powder. The reduction in the carbon footprint of LC3 consequently reduces the carbon footprint of Limestone concrete.

Concrete component ratio 1:2:3



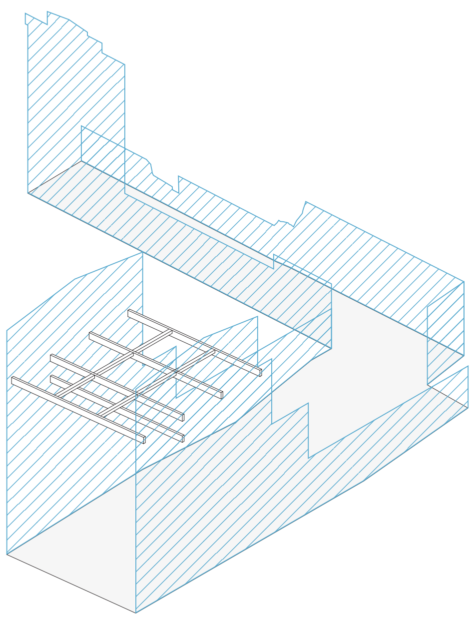
8m³ CONCRETE REQUIRES 5.04m³ LIMESTONE

2.1.4 STRUCTURAL SEQUENCE

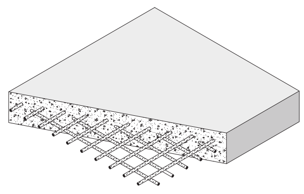
THE BUILDING FABRIC

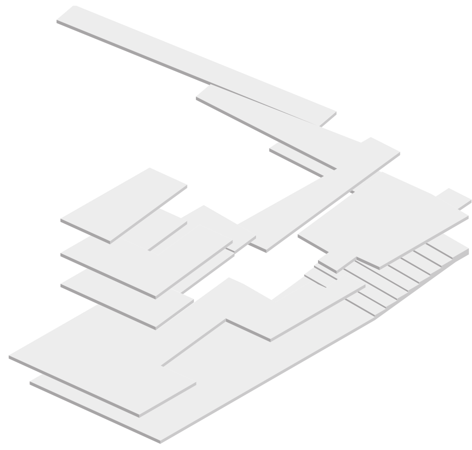
The building consists of limestone iin different forms. Typically stone cannot span, it can only support force under compression. Changing limestone into limestone concrete gives it this ability. In addition, post tensioning systems can compress limestone together, making it rigid and able to span as a beam.

STRUCTURAL SITE ELEMENTS
The identified party walls will provide structural support and exist as finished surfaces within the building. In addition, the existing steel beams will be incorporated into the roof design.

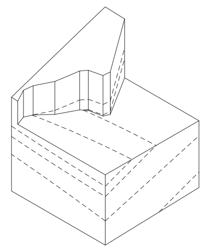


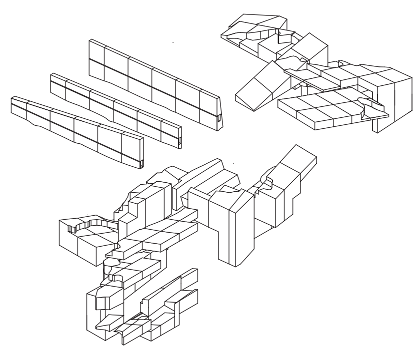
REINFORCED CONCRETE FLOOR PLATES
The composite floor plates are cast from



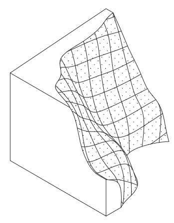


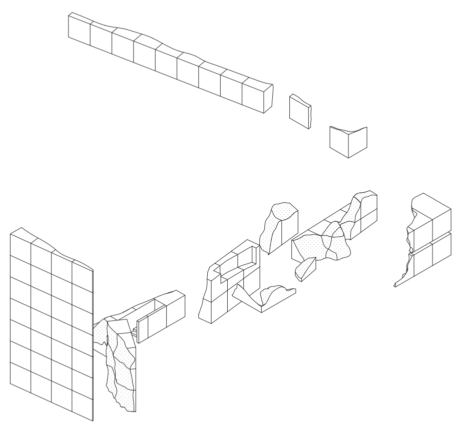
LIMESTONE
Following extraction from the calanque, the stone is cut into shape at the quarry and then configured on site. Only phase 4 of the refining sequence is done on site.



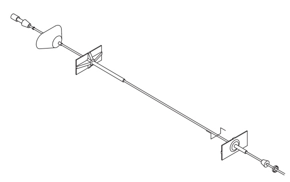


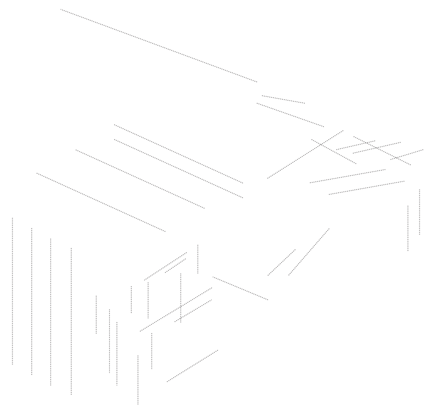
CAST IMPRESSIONS
The cast impressions of the calanque are cut into shape at the quarry and then configured on site. Only phase 4 of the refining sequence is done on site.



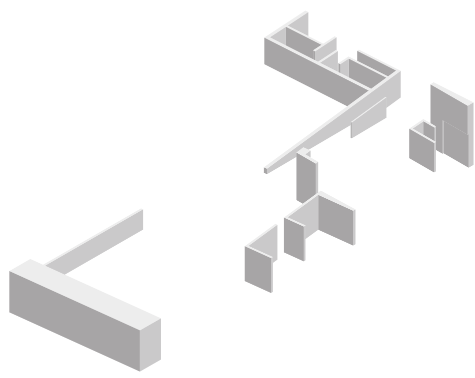


POST TENSIONING CABLES
Steel cables are drilled through the stone and pulled into tension. The cables hold the stone and cast blocks in compression such that force is carried from the roof load to the ground.

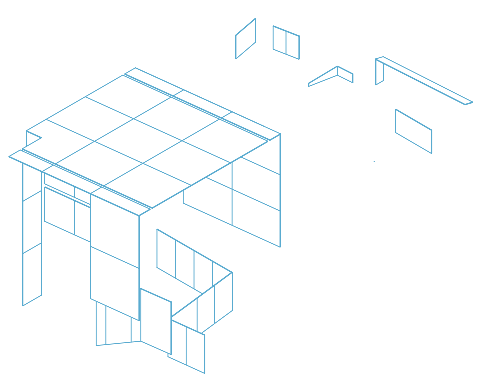




CONCRETE INFILL
Solid concrete walls provide bracing and some of the dividing walls. These are made in concrete derived from the quarried limestone. They can be prefabricated to reduce on site construction.



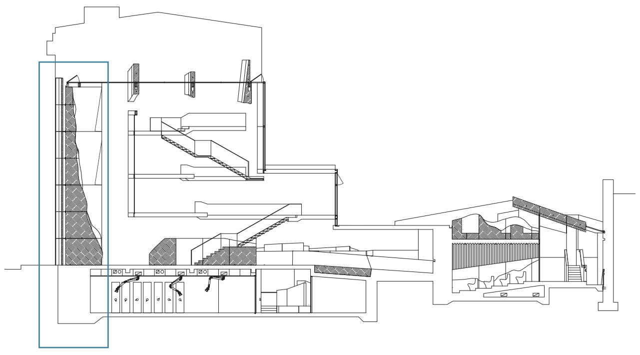
GLAZING
Steel frame glazing is fitted last to prevent damage.

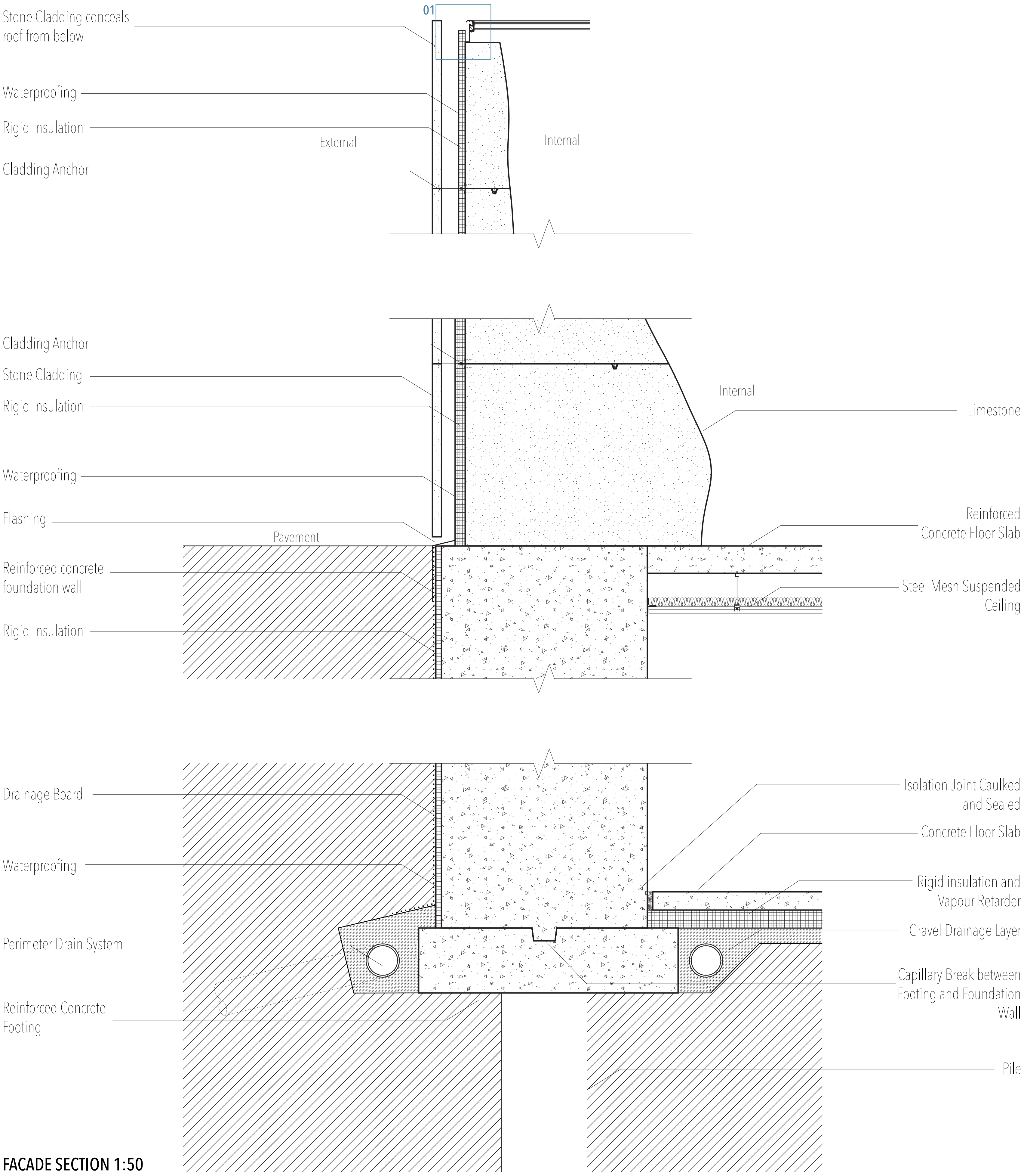


2.1.6 ENVELOPE

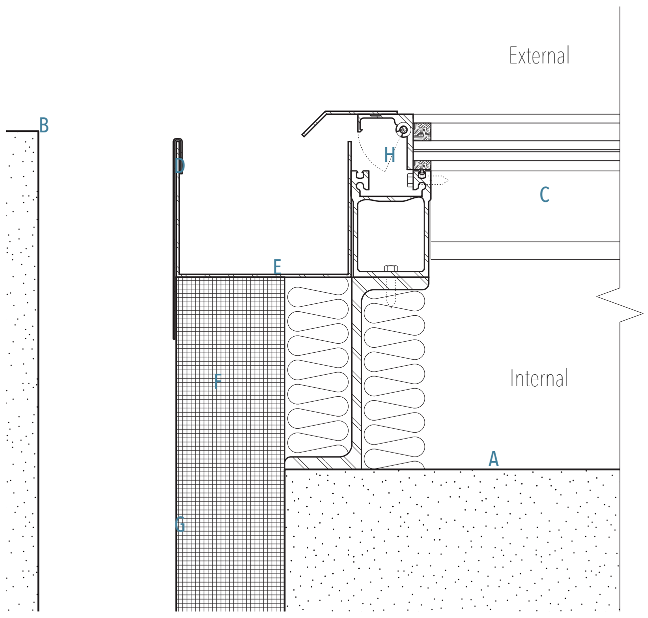
LIMESTONE INTEGRITY

In order for the Limestone to appear monolithic, insulation and junctions throughout the building must be well considered. The facade speaks for the Museum and it should therefore convey integrity.

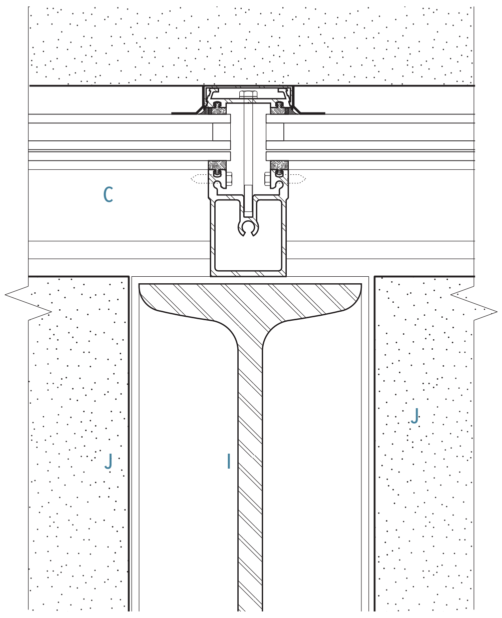




FACADE SECTION 1:50



DETAIL 01_1:5



DETAIL 02_1:5

A. Limestone
B. Limestone Cladding
C. Glazed Roof
D. Steel Flashing

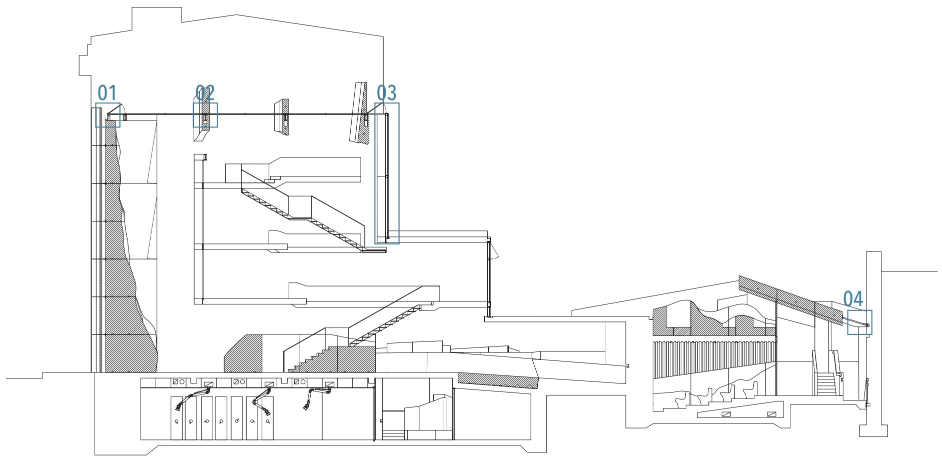
E. Gutter
F. Rigid Insulation
G. Vapoul Barrier
H. Hinge

I. Existing I Beam
J. Limestone Beam
K. Limestone Veneer
L. Double Glazing

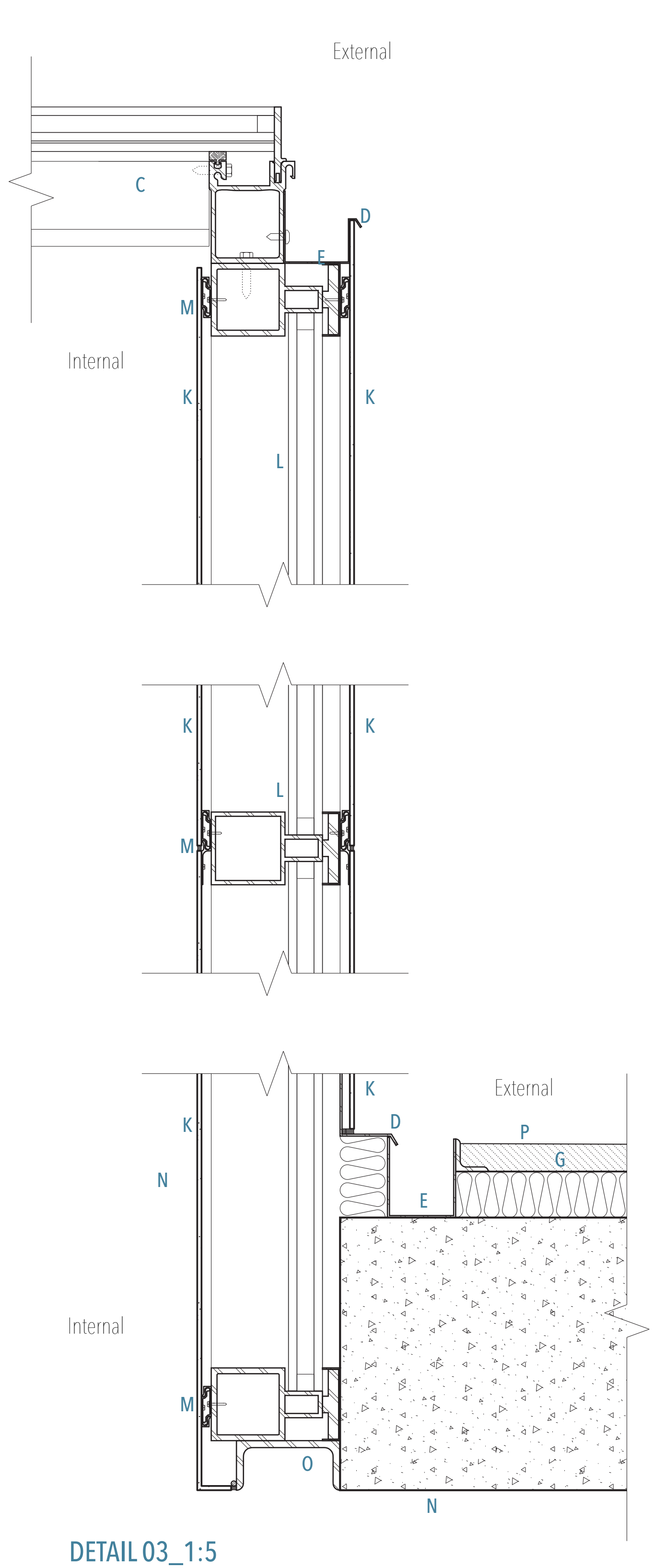
M. Steel Clip and Rail
N. Concrete Roof Slab
O. Steel Lintel
P. Screed

GLAZING + STONE CONNECTIONS

The design intention is to seamlessly enclose the front of the museum with a glazed envelope. This envelope should have subtle connections so that it appears to be merely touching the stone.
The stone is used as a light diffusing screen (Detail 03) to temper the internal environment.



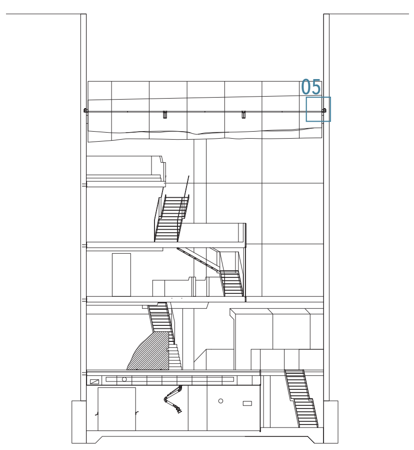
SECTION AA



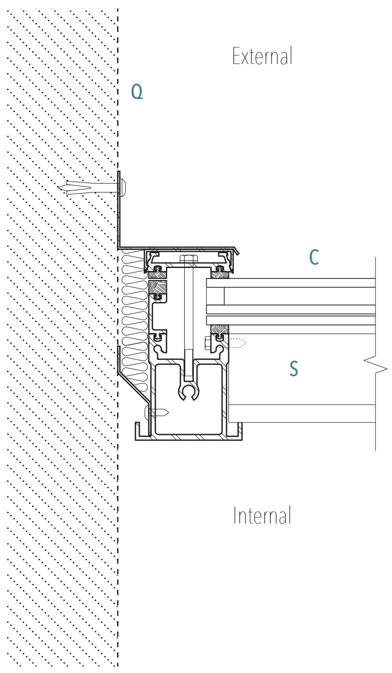
DETAIL 03_1:5

EXISTING WALL CONNECTIONS

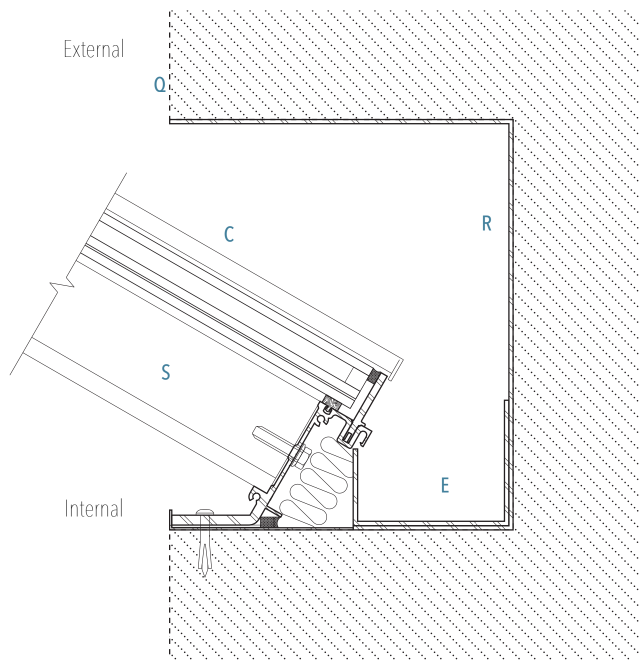
The intention to preserve and respond to the excavated site means that contact between the building and the existing party walls is important.
The glazed roof should appear to be lightly touching the party walls.



SECTION BB



DETAIL 05_1:5



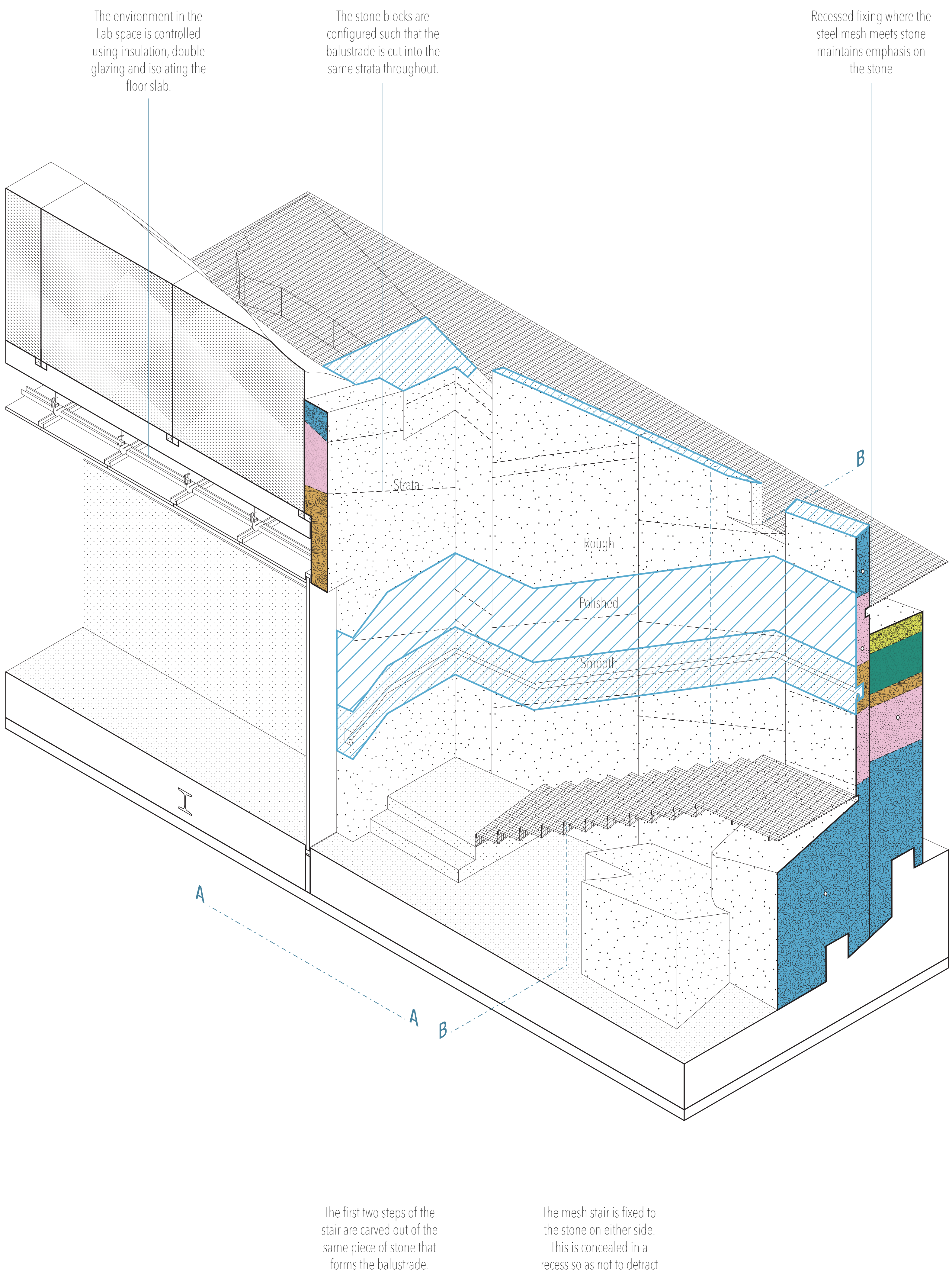
DETAIL 04_1:5

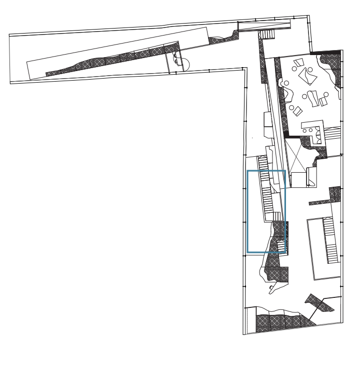
Q. Double Skinned insulated party wall
R. Steel Lining
S. Beam Behind

2.2.1 STUDY 01

STONE STRATAS

The stone is configured so that the user only touches one strata of stone. To achieve this, steel is used to support and join the stone, whilst fixing it to the concrete floor plates. Despite multiple elements, the integrity of the stone is preserved; as if it were an archaeological excavation itself.



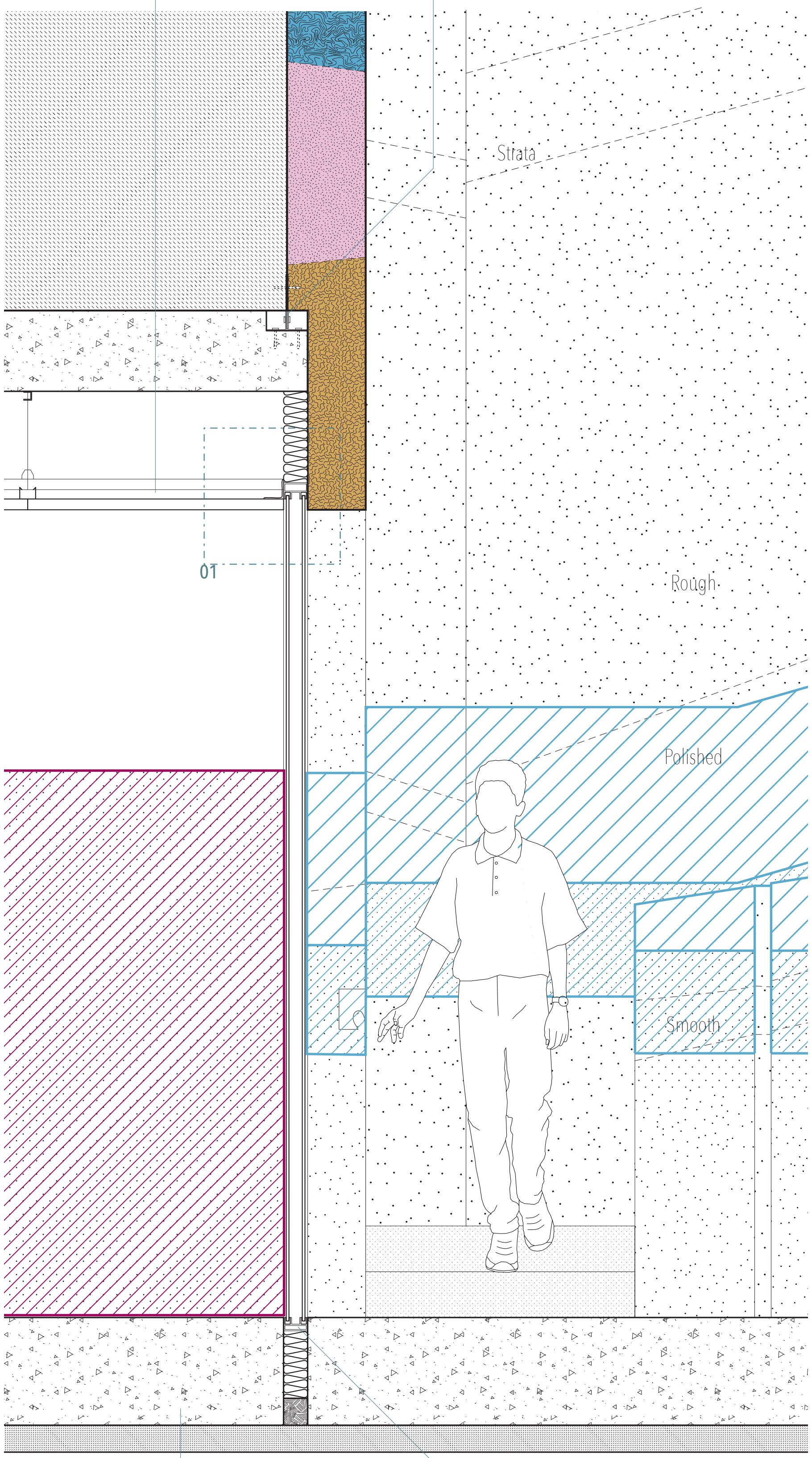


A suspended steel mesh ceiling in the lab allows for mechanical extraction and services above.

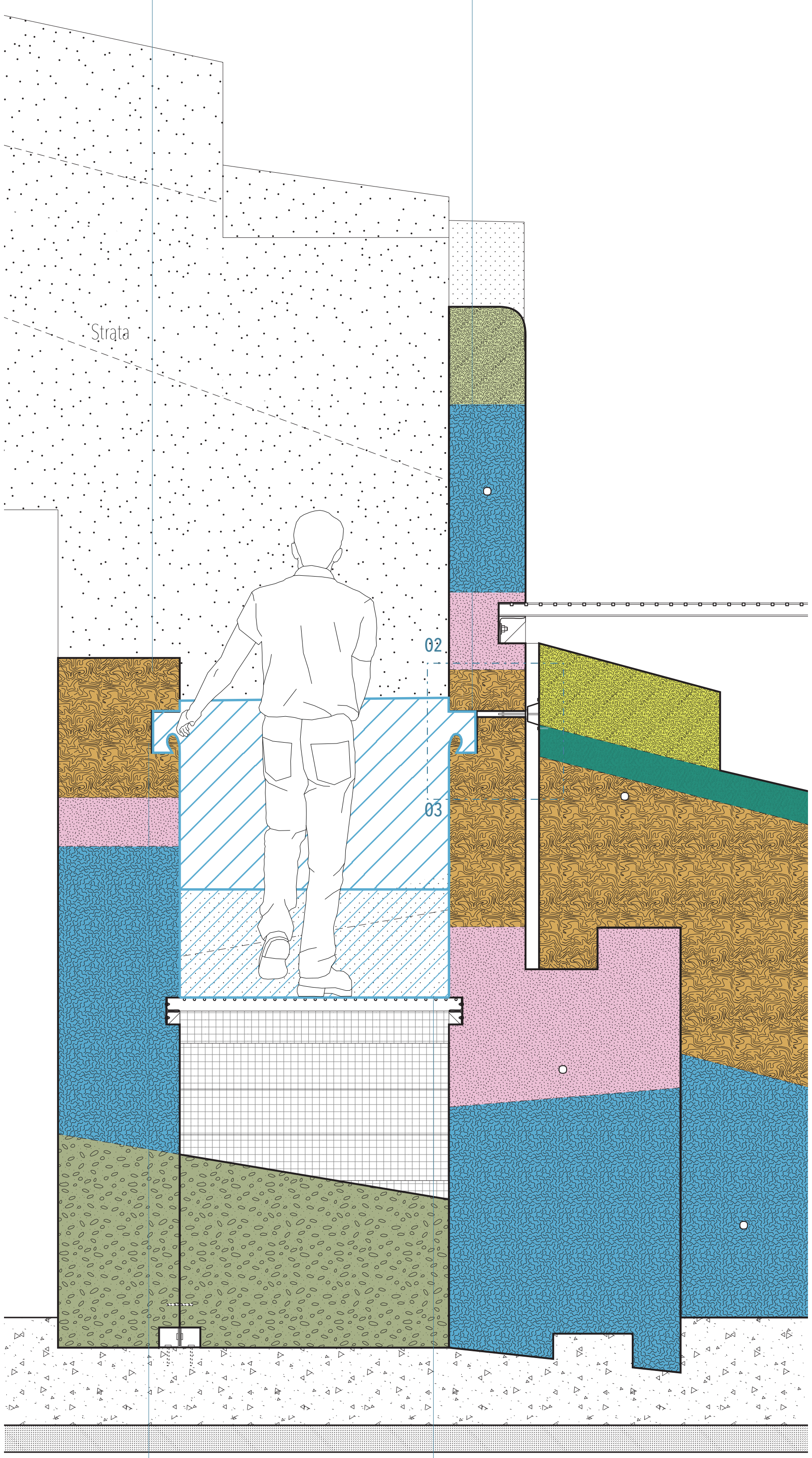
Load-bearing steel anchors with restraint pins fix the stone to the concrete floor slab

The stone is cut and positioned so that the same strata of stone provides the balustrade throughout

A monolithic impression is achieved through concealed fixings and carefully designed details



AA_1:25



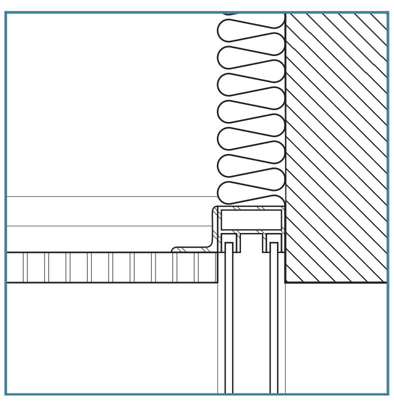
BB_ 1:25

The concrete floor slabs are isolated from one another to prevent sound being carried from the lab into the museum space.

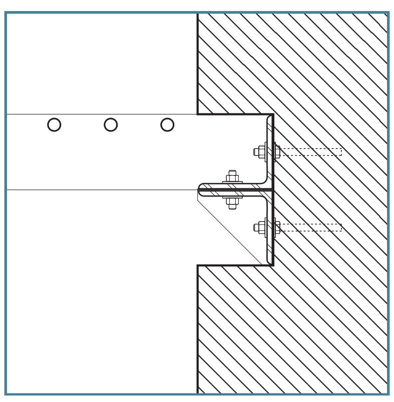
Double glazing and insulation enables tight climate control in the lab and prevents sound travel.

Recessed balustrade finished by a hand held wet stone grinder is smooth to touch.

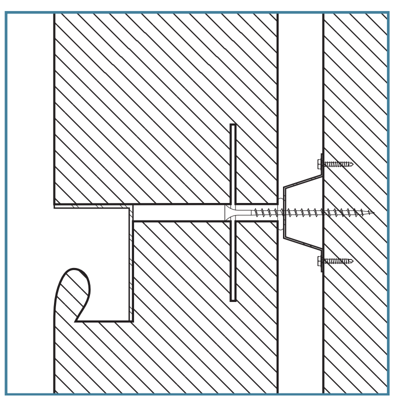
The steel mesh stair spans the preserved rock surface below. Like an archaeological artifact the stone is exhibited whilst being protected from wear.



DETAIL 01_1:10



DETAIL 02_1:10

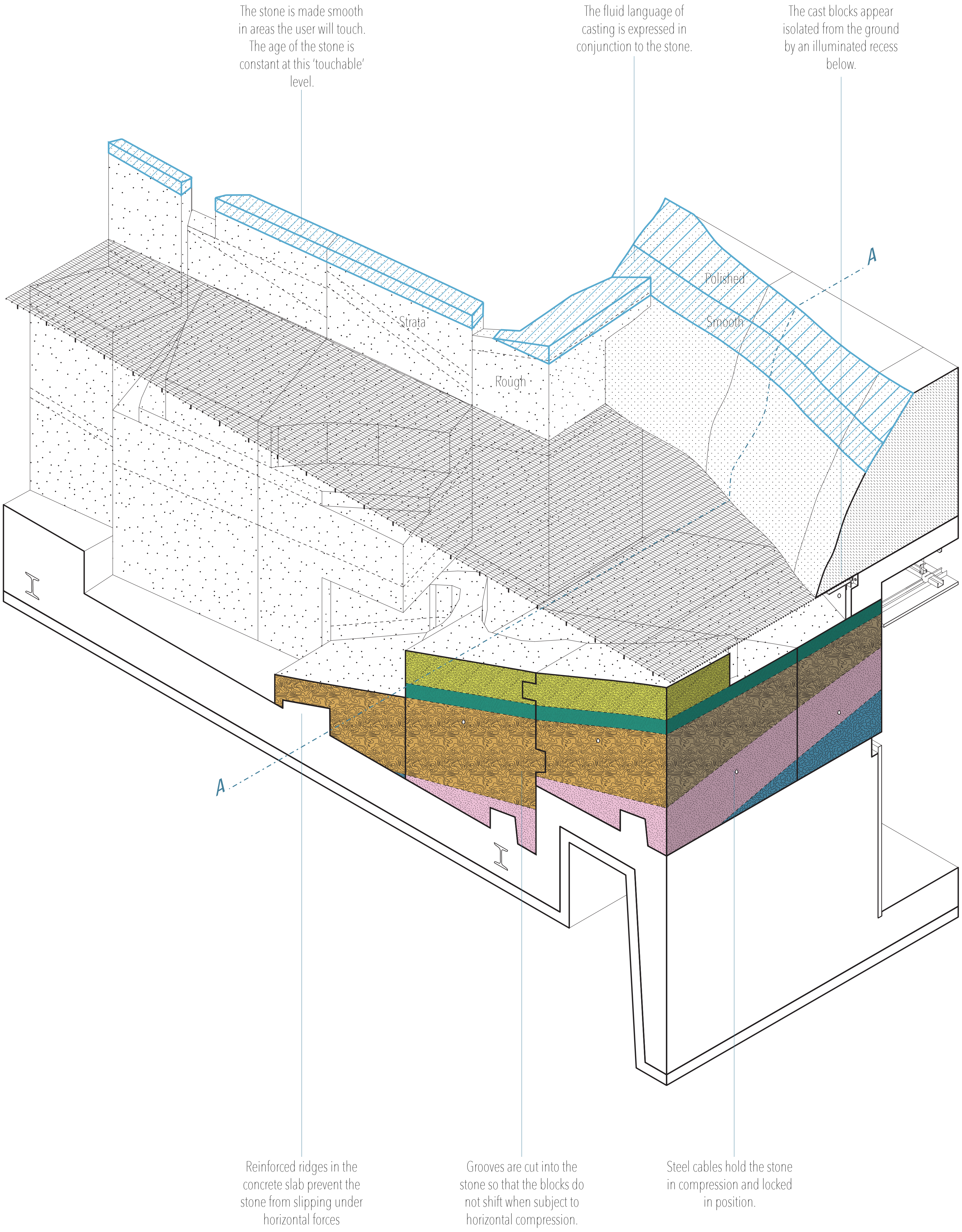


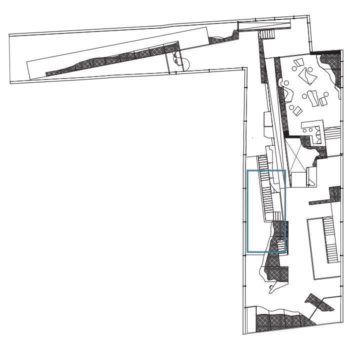
DETAIL 03_1:10

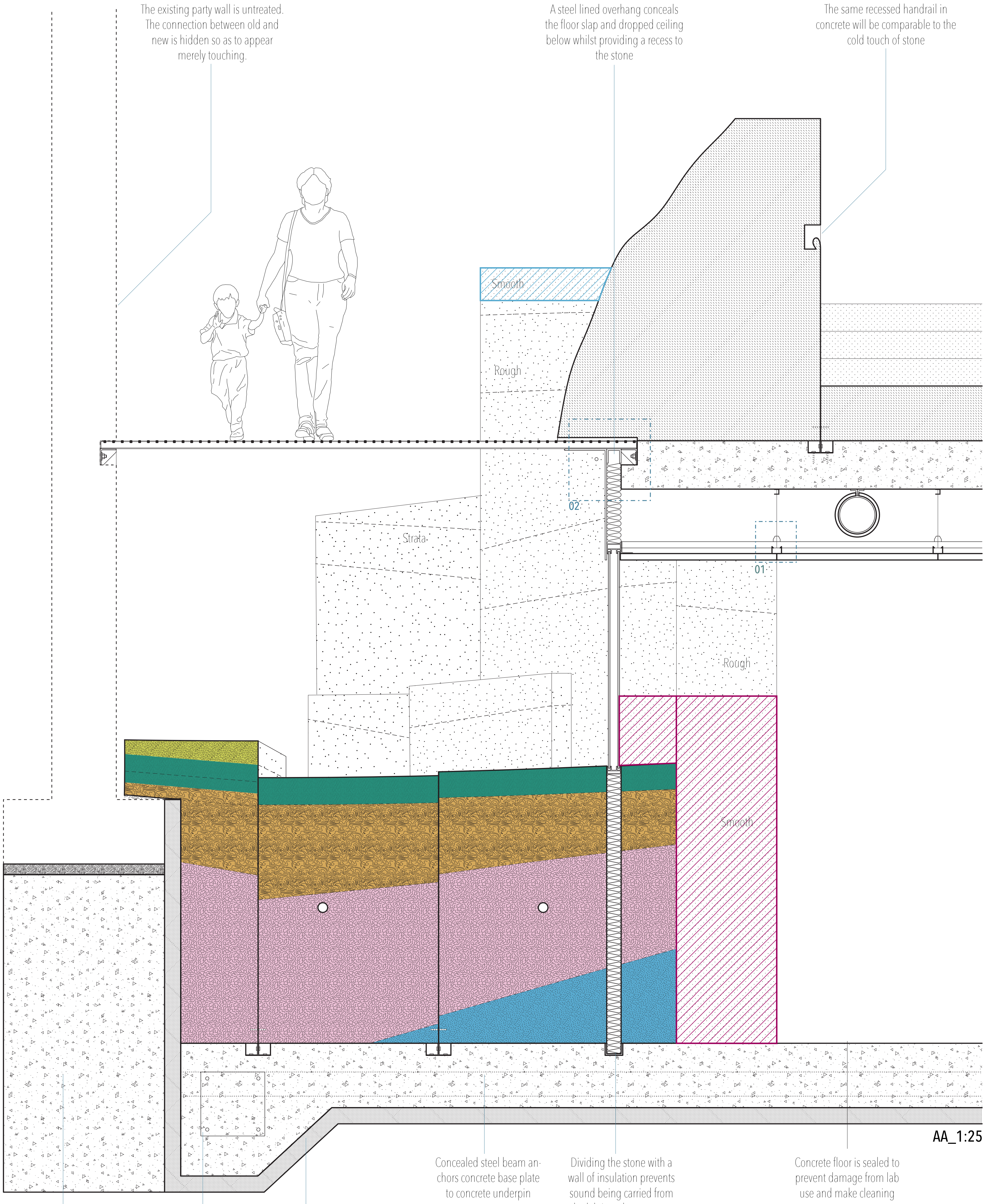
2.2.2 STUDY 02

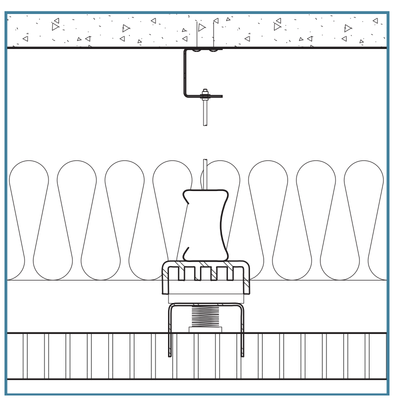
MESH WALKWAY

A mesh walkway bridges the stone and the existing party wall, and thus the archaeology of the Calanque to the archaeology of the urban site.





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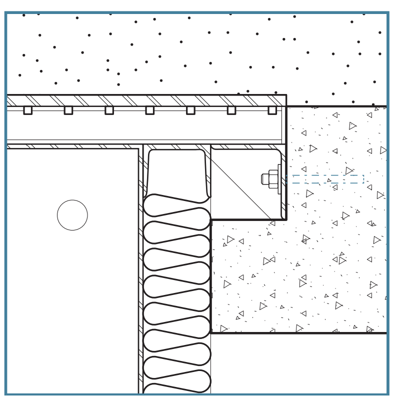
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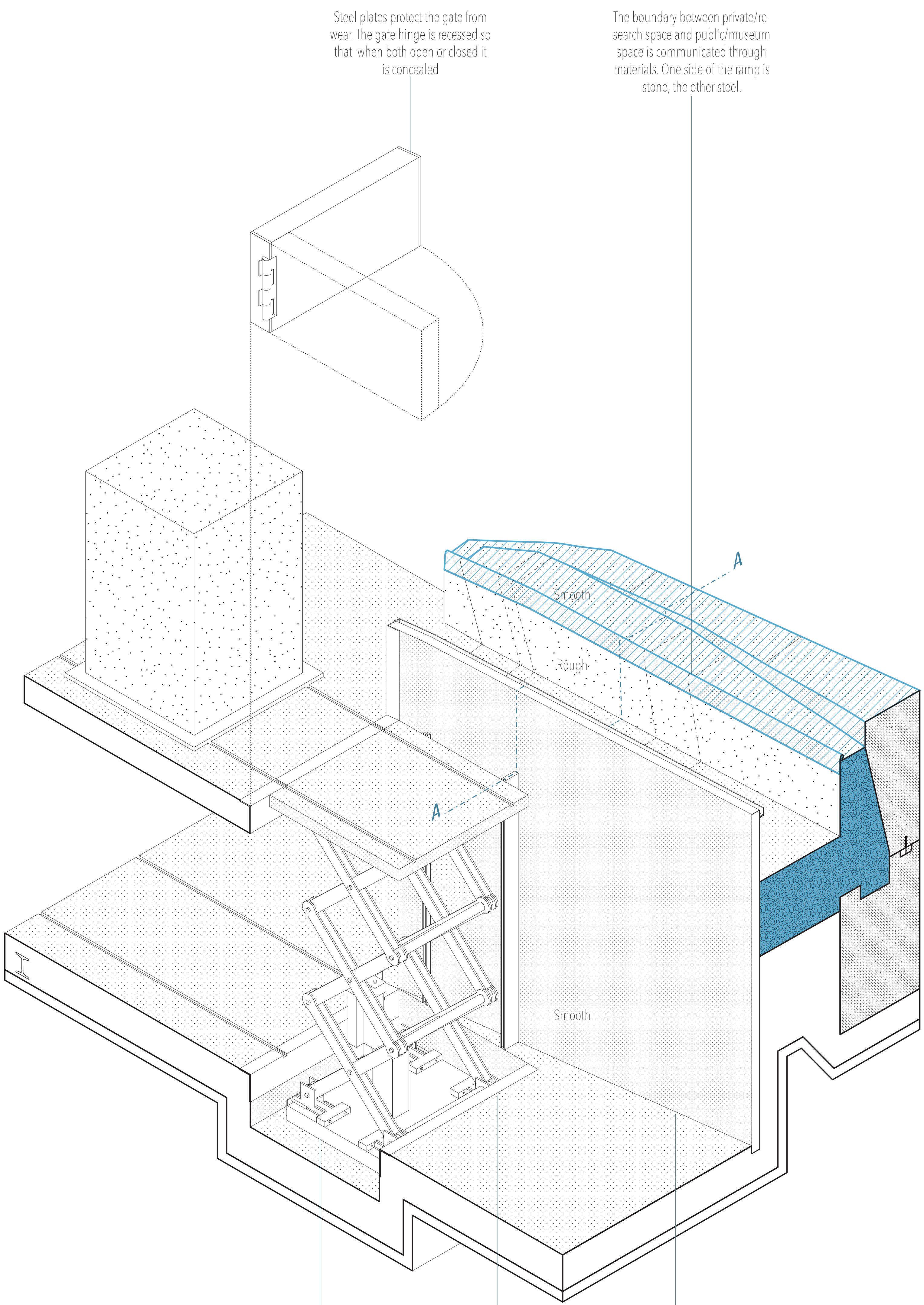
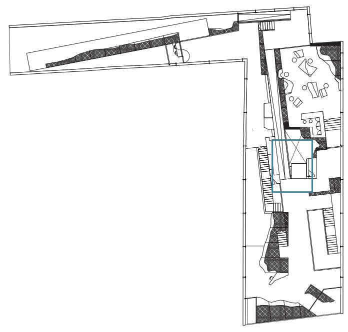
2.2.3 STUDY 03

STONE ACCESS

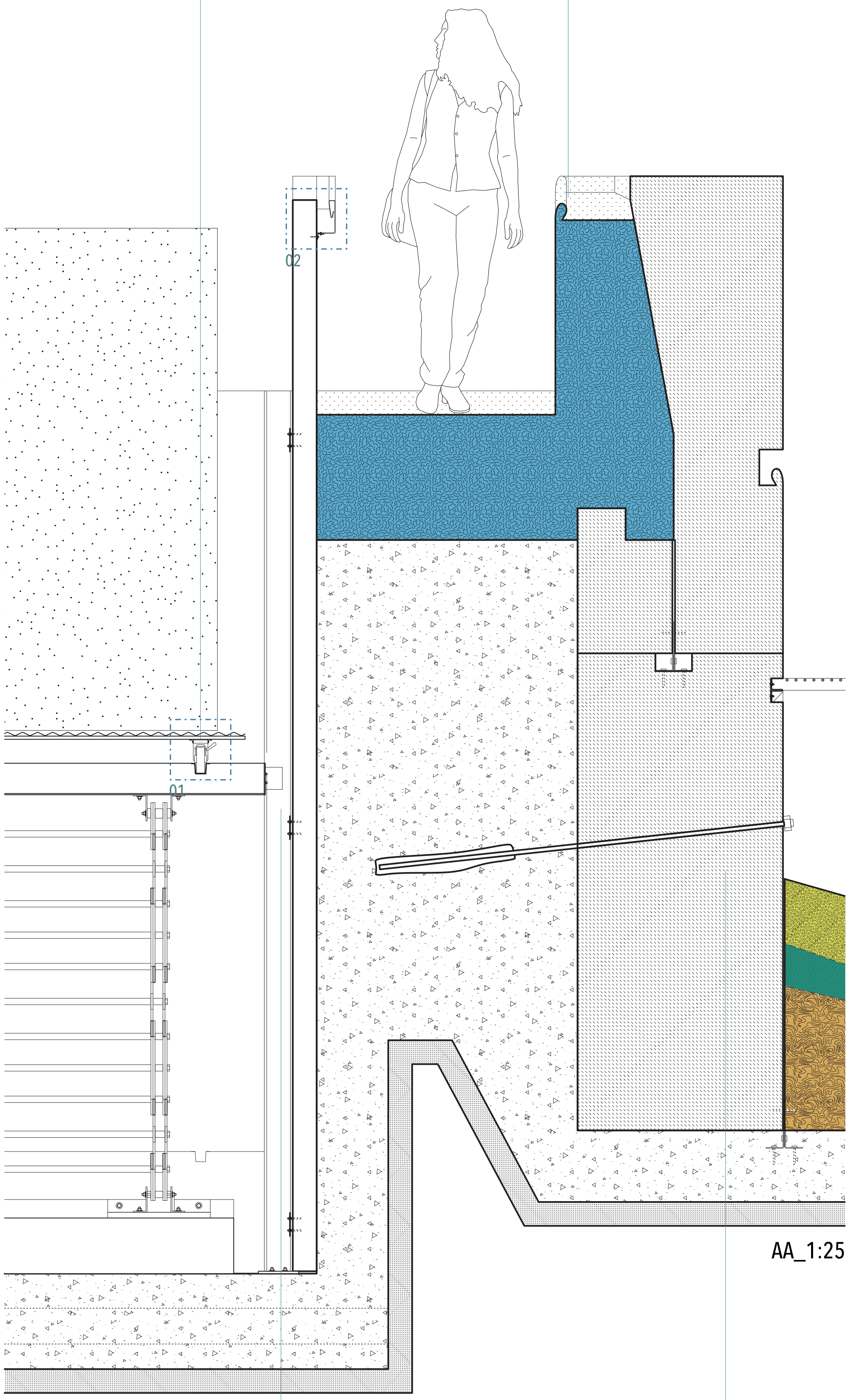
The building must be able to efficiently transport stone in and out of the building. The standard quarry block of base $2m^2$ can be imported and exported from the building via inlaid floor tracks and hydraulic lift.





A serrated steel plate with rubber break wheels smoothly transfers the stone between the lift platform and the concrete floor.

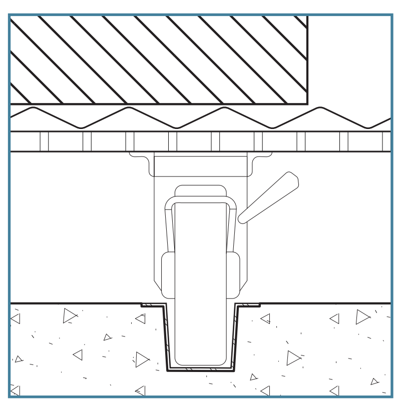
The boundary between operational space and ehibition space is expressed in the materiality of the handrails; steel vs stone.



AA_1:25

The platform is guided vertically by a steel column with integrated tracks preventing the platform from twisting or tilting

Steel cables are drilled through cast blocks to fix them to the concrete foundations



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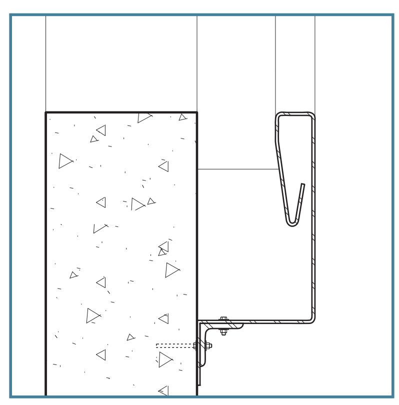
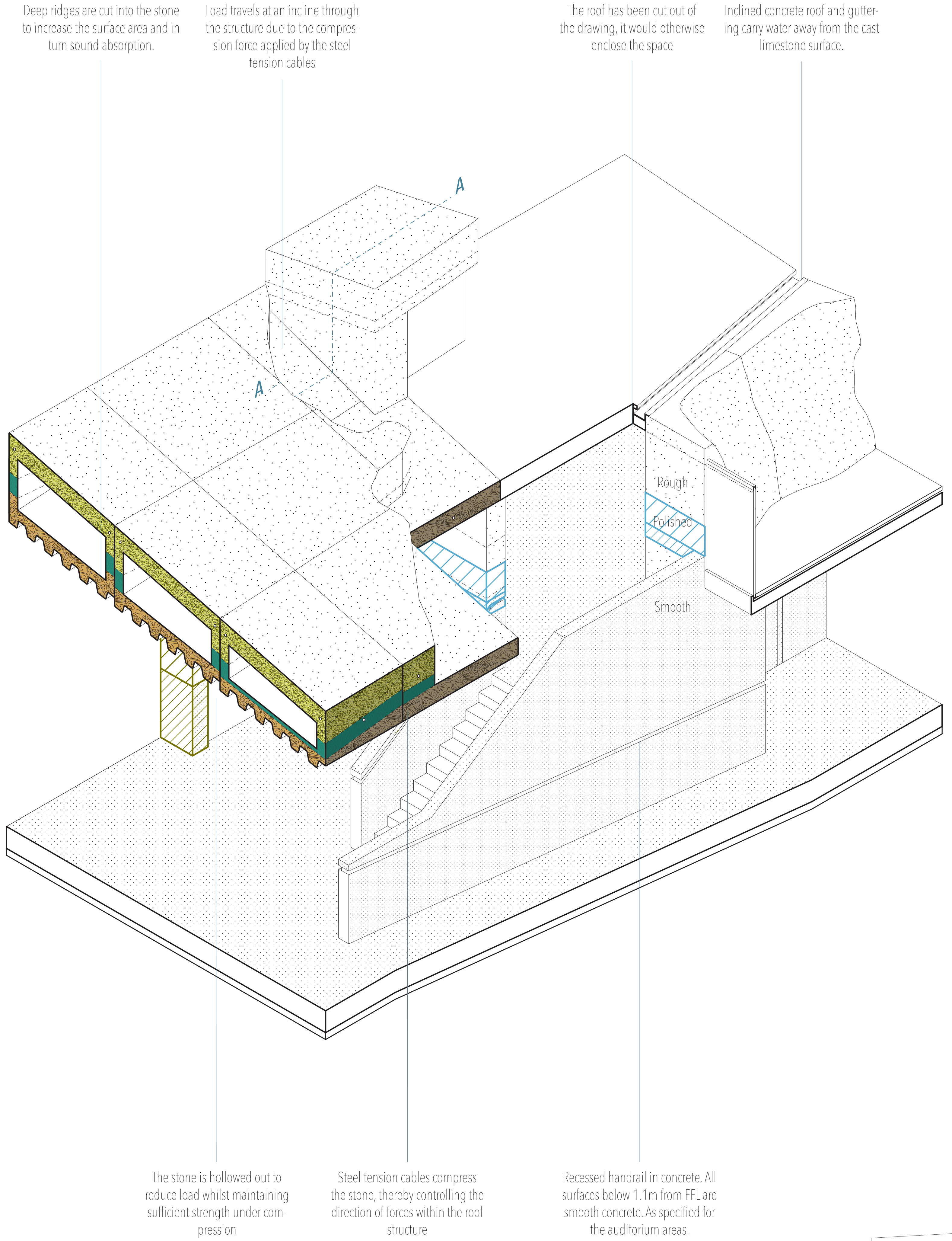


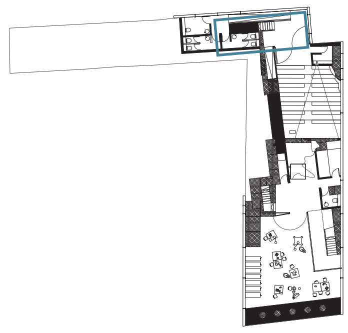
DETAIL 02_1:5

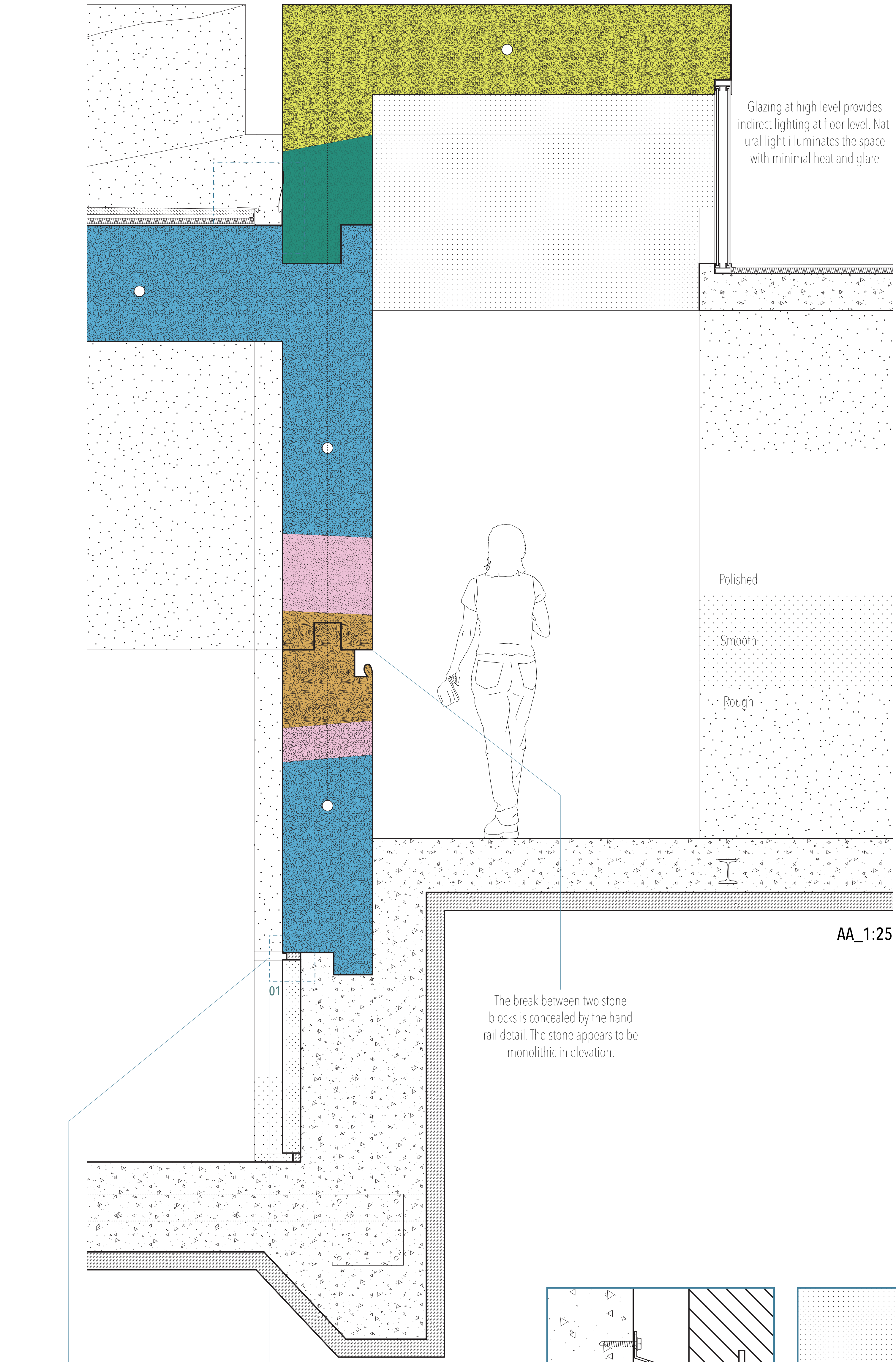
2.2.4 STUDY 04

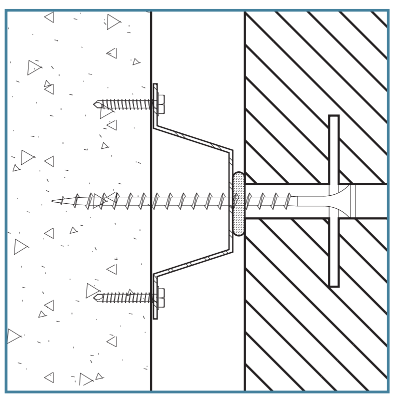
STONE COMPRESSION STRUCTURE

Structural capabilities of the stone are demonstrated through the building design. The stone functions as a roof in the same way to an arch and a dome. Compression forces are directed downwards in multiple planes within the structure. Steel cables drilled through the stone are pulled into tension so that the blocks of stone compress one another and the structure becomes rigid. In this way the inclined force is controlled.





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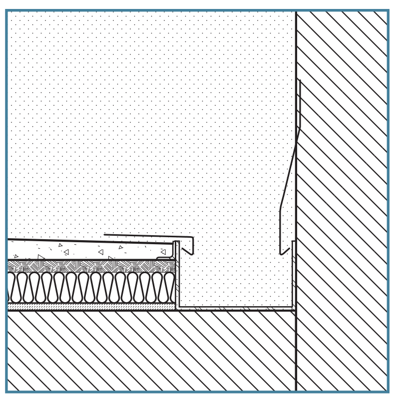
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PART THREE

BUILDING PERFORMANCE

3.1 ENVIRONMENTAL STRATEGY

OVERVIEW

The building's energy strategy combines both passive and active systems. Natural ventilation is sufficient for tempering the museum, however, the Auditorium, and Lab areas need specific environments that require active systems.

VENTILATION

Natural Ventilation has been encouraged through stack effect. Openings at entry level draw cool air into the building whilst warm air rises through the full height atrium to the openings in the glass roof.
Mechanical assisted ventilation will be required to control temperature in the auditorium. This will be achieved using by pumping cool air through the floor and removing warm air from a unit above the control room. The

LIGHTING

Natural light is used where appropriate. Due to high temperatures and sunlight levels in Marseille design strategies have been made to draw natural light into the building without glare. Shading methods have been incorporated into the design to avoid over heating in summer. The building diffuses direct sunlight by placing windows at high level and cladding south facing windows in veneer stone.
However, the Lower Ground Level has stricter lighting requirements. The auditorium needs to have a range of lighting environments; complete darkness when a film is running; partial illumination during a presentation and well lit for cleaning purposes.
The Lab requires also multiple light environments, where high visibility and non directional light is often needed.

ACOUSTIC DAMPENING

The Auditorium is an area in which sound needs to be managed. It should be well insulated from the elsewhere in the museum, and it should dampen the acoustics within the space. Deep ridges have been designed into the walls and ceiling of the space to increase surface area and absorb sound. Double glazed doors reduce noise from the circulation outside.
The noise produced in the lab must not carry into the museum. It's floor slab has been isolated using insulation to ensure this. Acoustic insulation in the void ceiling contains the noise of the mechanical extractors.

RAINWATER + DRAINAGE

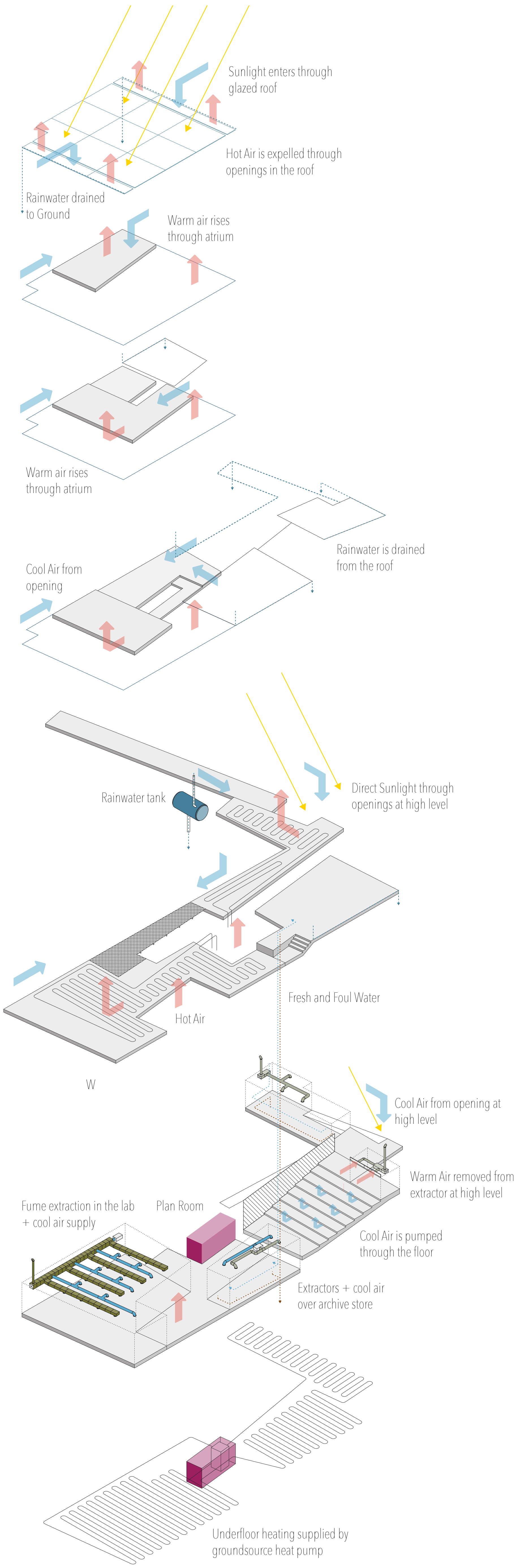
Rainfall in Marseille is relatively low, particularly in the summer months and therefore strategies have been taken to harvest and recycle rainwater.
A. Fresh Water is supplied from the mains to the Cafe, ps and Lab.
B. Rainwater is drained from the roof and collected
C. Harvested rainwater is supplied to the toilets
G. Waste is carried to sewage pipes below ground

FUME EXTRACTION

Potentially Harmful fumes in the Laboratory will need to be removed locally and effectively. A system of hanging fume hoods connected to a ducted mechanical extraction system above the lab will expel waste safely at higher level.

GROUND SOURCE HEATING AND COOLING

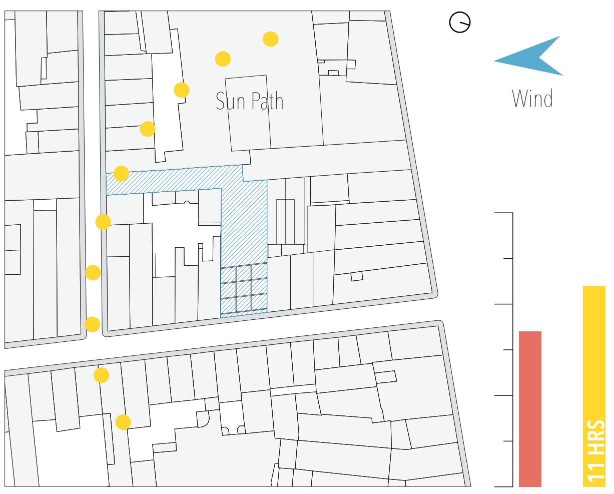
During the winter and occasional evenings, the building will require active heating, this should be achieved with minimal energy expenditure. Therefore, providing there is sufficient water in the ground, the building will rely on a ground source heating system which uses the thermal mass of the ground to cool and heat water.



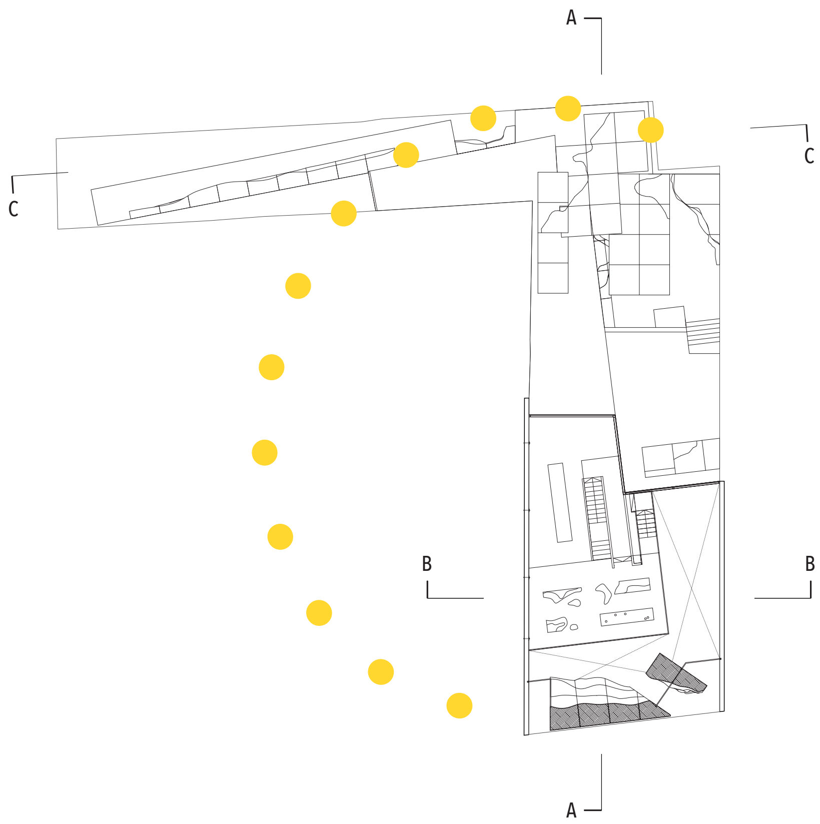
3.2 PASSIVE SOLAR DESIGN

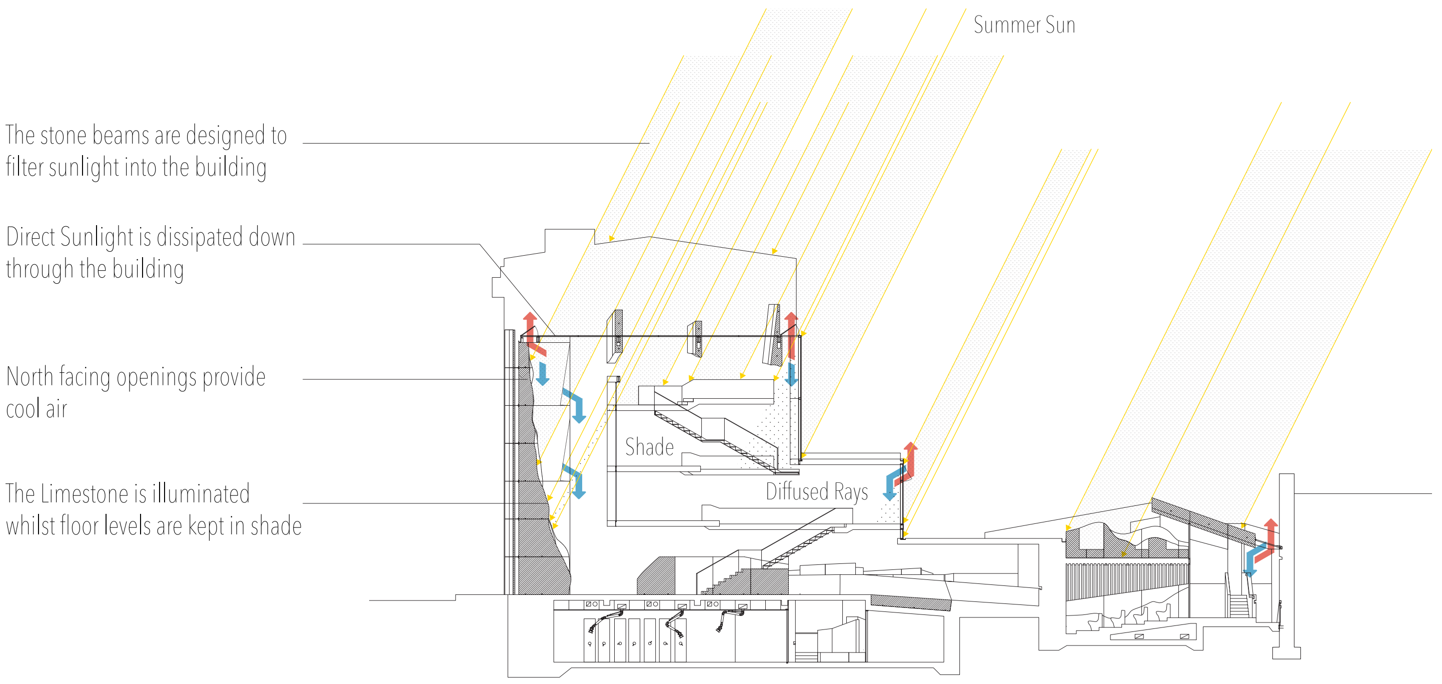
TEMPERING THE ENVIRONMENT

Due to the nature of Marseilles climate, the building will be exposed to high temperatures and intense sunlight. It is important to manage the amount of sunlight entering the building. Strategies have been employed to address this.

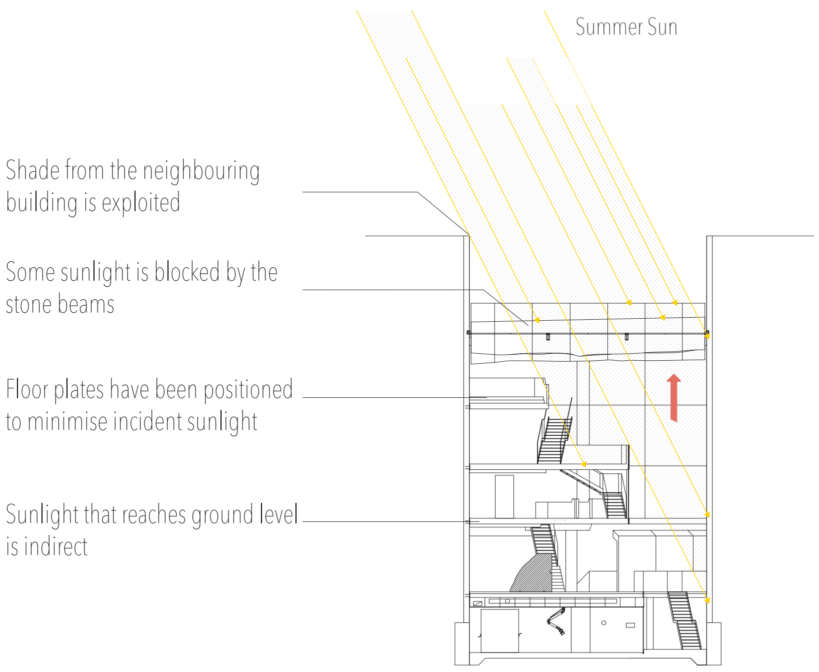


SUMMER CLIMATE





SECTION AA



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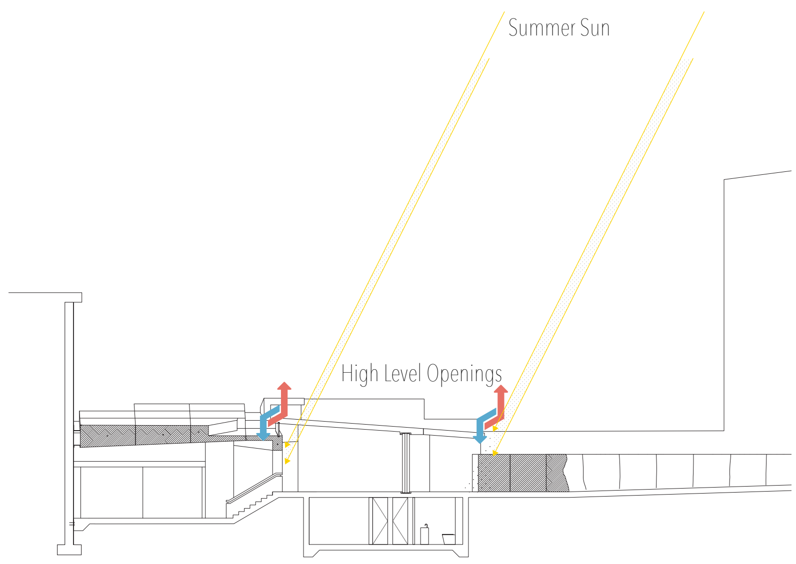
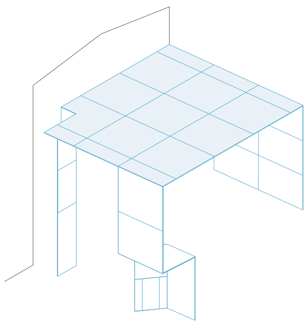


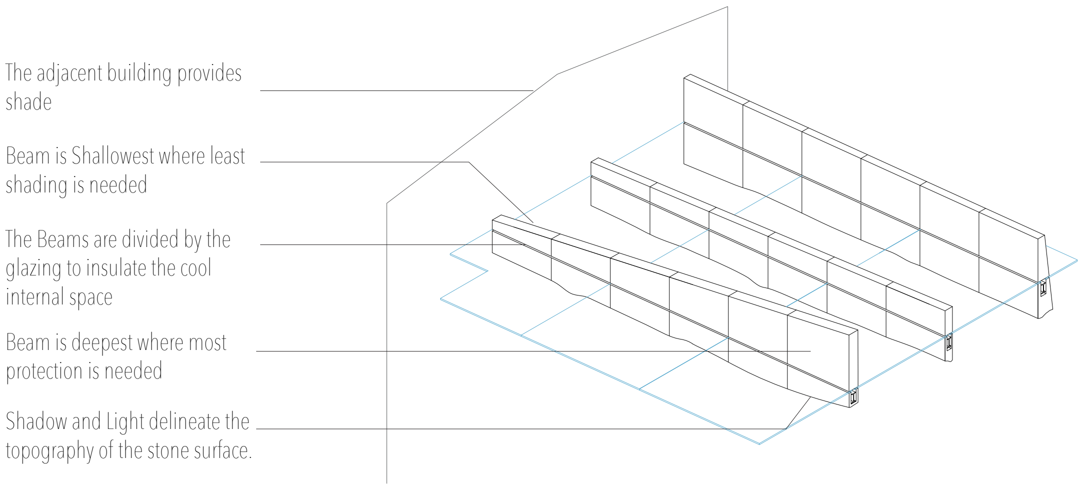
SECTION CC

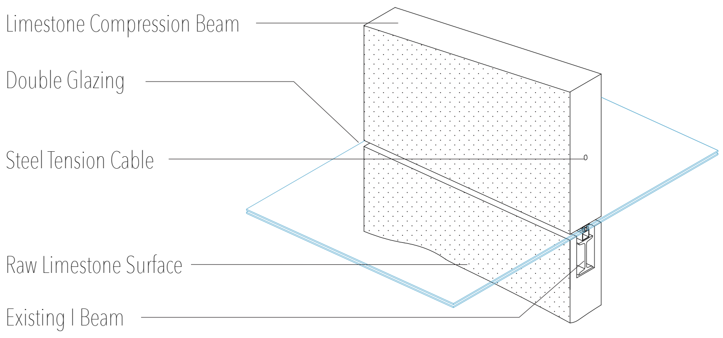
GLAZED ENVELOPE

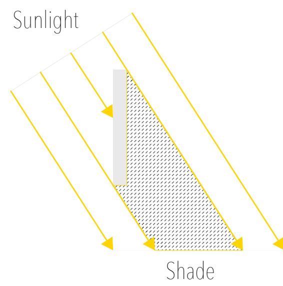
ROOF

Due to the nature of Marseilles climate, the building will be exposed to high temperatures and intense sunlight. It is important to manage the amount of sunlight entering the building. Strategies have been employed to address this.



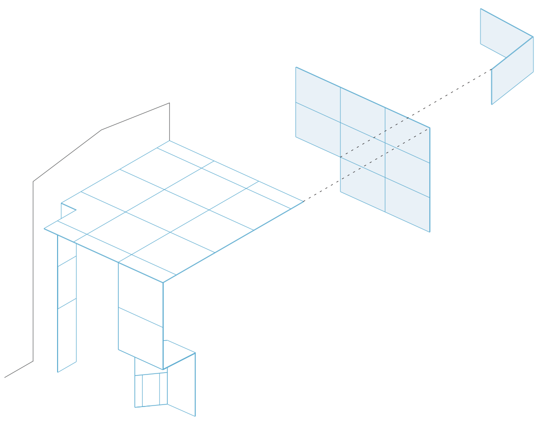


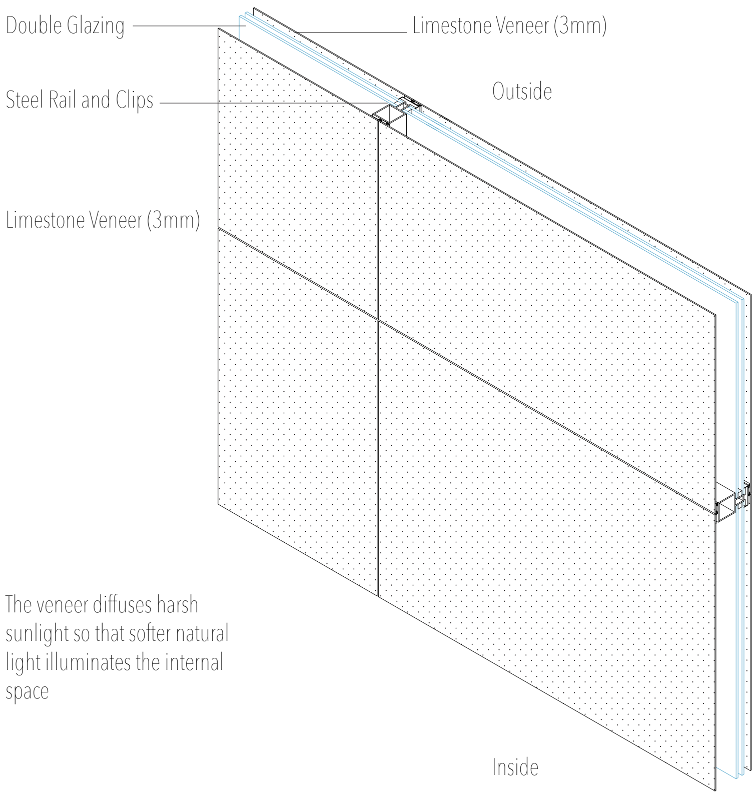


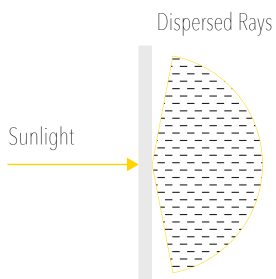


SOUTH FACING

Glazing most exposed to sunlight is clad in limestone veneer. This greatly reduces the quantity of light incident on the internal surfaces.







NORTH FACING

Windows have been set back to prevent direct sunlight at lower levels.
The adjacent building outline provides shade at a higher level. Incident sunlight is much less intense on this face and therefore no further shading is necessary.