WHAT FUTURE?

DESIGN WITHIN HISTORIC SETTINGS

Process Report | Ana Catarina Cabral | ma4-ARK18 | December 2011

“To insert a new building into the old requires the highest degree of skill and imagination. (...) The rules are simple, for there are none. Every case is unique, every situation different. Precedent is an unreliable guide, judgement more important than justice, quality than period.”

Sir Hugh Casson, ‘Old sites and new buildings: the architet’s point of view’, in *The Future of the Past*

tittle	**WHAT FUTURE?** *design within historic settings*
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student	**Ana Catarina Cabral**
semester and specialisation	**ma4 - ARK**
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Summary

This report documents the work related to the final project of the master in Architectural Design of the student Ana Catarina Cabral, from September to December of 2011, at Aalborg University, Denmark.

The report describes the design process of a new building, placed in the historic centre of Setúbal, Portugal. The project consist in a new residential building for the area, aiming to attract youngs and young families back to the place and encourage a sustainable growth and maintenance of this part of the city. There has been a great focus in the context analysis, in order to have a good understanding of the development of the place over the years until the current situation.

Wish you a pleasant reading,

_____
[Ana Catarina Cabral]
student

main supervisor: _____
[Claus Bonderup]

technical consultant: _____
[Alberto Pugnale]

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READER'S GUIDE

As explained in p10, there has been loops between the different phases of the project. However, for the readability and better understanding of the project, the report is presented in a logical way as one linear process.

Therefore, the present report is organised into five main parts: INTRO, ANALYSIS, DESIGN PROCESS, PRESENTATION and OUTRO, which are organised into chapters and subchapters. (see table of contents, previous page)

Throughout the report, references are used in accordance to the Harvard Method, for books and articles [author, year], for web pages [designated name] for illustrations [Ill. #]. The references can
be found at the end of the report. If nothing else is indicated the illustration is own production.

Appendixes are referred to by their respective [app. #, name].

MOTIVATION

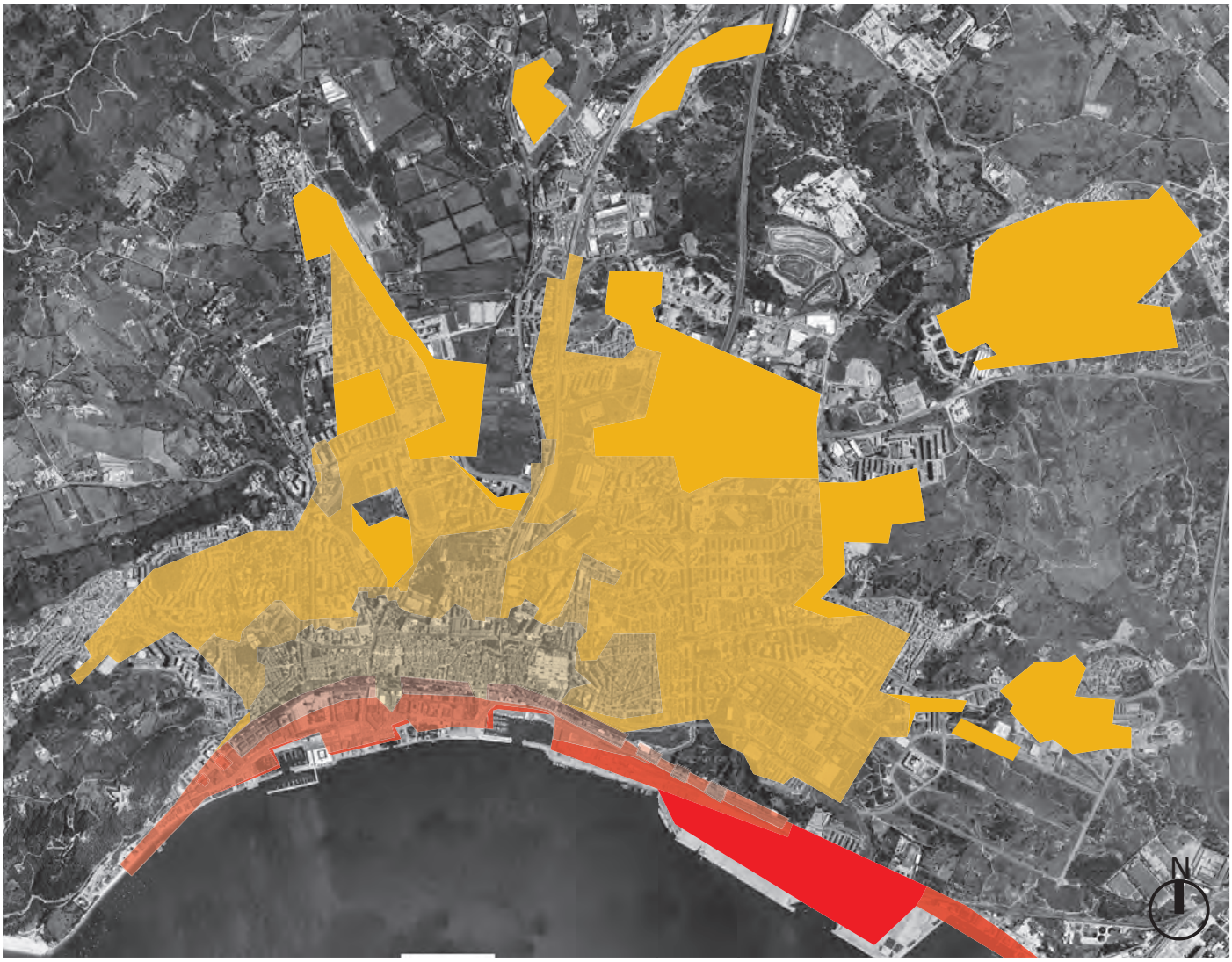
Europe is old. The desertification and increasing decay of historic centres has become a common problem to many european cities.

At the same time, cities keep expanding to the outskirts.

Setúbal is one of those cities - where the historic centre has already 28% of unoccupied buildings, not to mention the ones in decay and bad condition. However, when looking at the urban sprawl of the city, underneath, it is possible to verify the city continuous to embrace new areas.

At a time where sustainable and environmental concerns are growing relevance, seems emergent to raise the question: why not requalify what is already built instead of building more? If it is such a simple and obvious idea, how come it is not put into practice more commonly? Is it conservation policies that constitute a barrier to investment in this areas? Does it have to do with car circulation and parking? Is it related to economical reasons?

The present project aims to research these questions based on a specific context, Setúbal's historic centre, with the purpose to achieve an holistic perspective of the situation and design with a better understanding.



legend:

- 1800, urban sprawl
- 1930, urban sprawl
- 1985, urban sprawl
- 2004, urban sprawl
- 1800, harbor sprawl
- 1930, harbor sprawl
- 1985, harbor sprawl
- 2004, harbor sprawl

ill. 001_*urban and harbour sprawl, Setúbal*

TOOLS AND METHODOLOGY

The Method

As a final project of a Master of Science at Aalborg University, the method used is the Problem Based Learning, PBL, with focus on the Integrated Design Process, IDP. This method consists of five phases: 1.Problem and Idea, 2.Analysis and Programming, 3.Sketching, 4.Synthesis and 5.Presentation - see ill.002, below. The first procedure of IDP is to state the problem, which needs to be solved. Regarding the Analysis and Programming phase, the goal is to gather the amount of required information and knowledge in order to proceed to the Sketching phase. Here conceptual proposals and technical solutions are tested in order to move on to the Synthesis, where a more complex integration of the overall aspects is assembled resulting in a final design. The last phase in the IDP comprises the production of material in order to present and allow a good understanding of the final solution. [Knudstrup, 2004]

The IDP method is an iterative process, where the different phases of the project, overlap, inter-connect and relate to each other back and forth, the so called 'design loops', until a satisfying result is achieved - see ill.002 [Knudstrup, 2004]

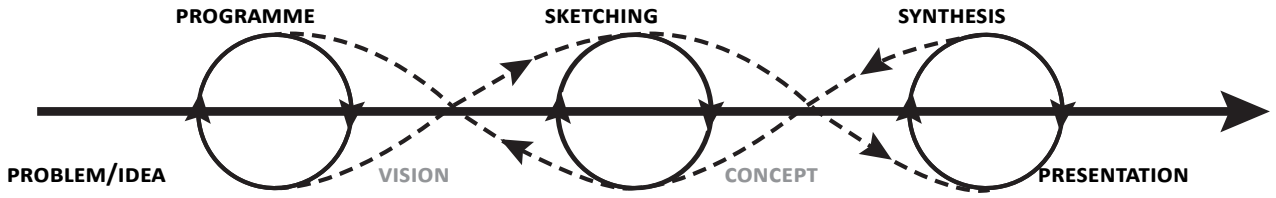
The IDP combines different design parameters, in this case the focus is on building integration attending the historical physical context, spatial organisation and perception, structure and construction. It is expected the final solution to integrate and reflect these aspects equally in the overall architectural design, both on a functional, technical and aesthetic level. [Knudstrup, 2004]

Planning

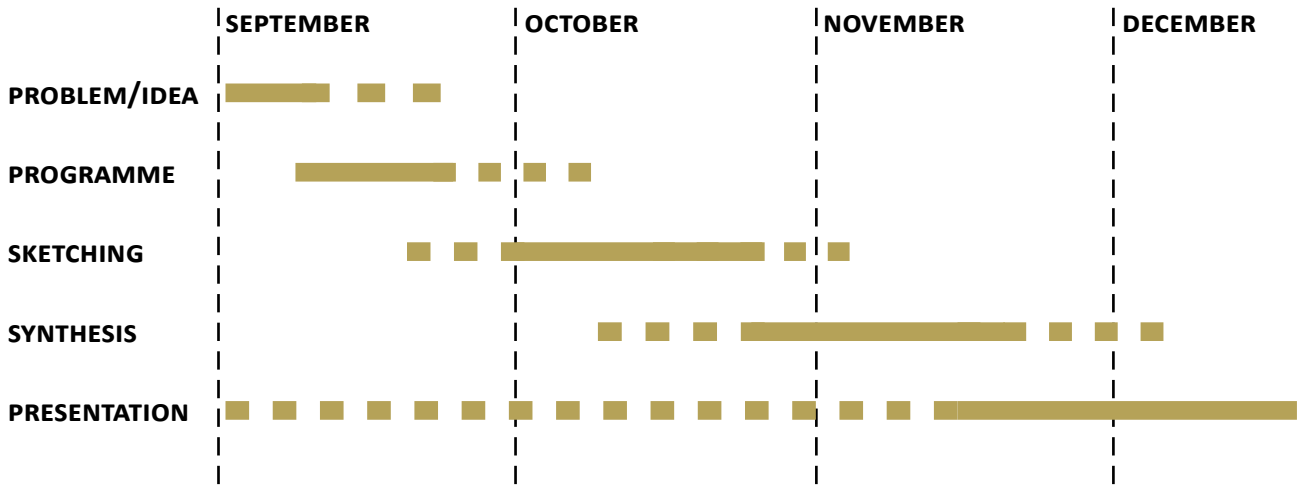
The project is expected be done from 1st September to the end of December 2011. Given the project deadline, a reference calendar and a tasks and tools table were made - see ill.003 below, and ill.004 in the next page -, in order to better plan the different phases and keep some control on the project flow. The constant overlapping of the different phases, see ill.002, reflects the iterative process when organised into a linear time planning schedule.

Learning Goals: Tools and Skills

During the project, the aspiration is not only to develop an interesting design proposal but also to develop qualified skills and tools. Therefore, regarding this project, the learning goals are to achieve a good understanding and fluency in presentation software, such as Adobe Suite Collection - Photoshop, Illustrator and InDesign - as well as rendering software. Besides that, it aims to develop skills in physical model making, specifically in what concerns the use of lasercutter technology.



ill. 002_*the iterative design process*



ill. 003_*project planning, reference calendar*

Report Organisation

It is important to stress that the report chapters are not named following the methodology phases. Although, some tittles might be the same. The methodology has been used as a guidance, specially regarding time planning and working schedule. The process documentation works independently, aiming for a good and clear understanding of the design process and final proposal.

Below, ill.004 presents a tools and tasks table, organised according to the methodology phases.

After, a new chapter takes place, ANALYSIS, with focus in the Theoretical Framework - concerning *Architecture in Historic Settings* - and the Context.

	TASKS	TOOLS
PROBLEM/IDEA	PROBLEM FORMULATION - theoretical framework	supervision/discussions litterature and internet hand sketching and photography
PROGRAMME	DESIGN PARAMETERS - context analysis - room programme - case studies - digital drawing, set up drawing base	supervision/discussions litterature and internet hand sketching and photography autocad adobe suite: acrobat, illustrator, photoshop and indesign
SKETCHING	DESIGN DEVELOPMENT sketching drawings physical and digital modelling initial calculations	supervision/discussions hand sketching and model workshop adobe suite: acrobat, illustrator, photoshop and indesign autocad, rhino and sketch up
SYNTHESIS	DESIGN DETAILING precise drawings physical and digital modelling exact calculations	supervision/discussions hand sketching and model workshop adobe suite: acrobat, illustrator, photoshop and indesign autocad, rhino and sketch up u-value spreadsheet robot structural analysis
PRESENTATION	DESIGN DOCUMENTATION 2d visualisations/technical drawings - plans, elevations, sections, details - renders and photocollages 3d visualisations/modelling - physical and digital models - renders and photocollages final calculations, tables and diagrams	supervision/discussions adobe suite: acrobat, illustrator, photoshop and indesign autocad, rhino + v-ray and sketch up + podium model workshop u-value calculator

***ill. 004**_project planning, tasks and tools according to the different project phases*

analysis

theoretical framework

ARCHITECTURE IN HISTORIC SETTINGS

Past and Future

Historical Heritage and Building Conservation are topics that became increasingly relevant during the last decades, not only due to the interest and research for our history and its remains, but also due to the arising of environmental consciousness and concerns. [ORBASLI, 2008] Therefore, new demands for building conservation and design of new buildings in historic settings and existing fabric has been set.

"In an analogy with human existence, the built environment demonstrates the delicate coexistence of longevity, gradual aging and sudden destruction." . [BREITLING, CRAMER, 2007, p15] As above mentioned, buildings have a life span. They are not eternal. They can last for few or hundreds (or thousands) of years. But they don't last forever. This rises some delicate questions:

- what to do when buildings are old and in decay?
- what is correct to do?
- what happens if all buildings in decay are restored and rebuilt as the originals?
- what happens if all buildings in decay are substituted by new buildings?
- what is the criteria that sets allows a balance between these two approaches and sets the guidelines?

Over the history, there has been several approaches. Old european cities (ex: Rome, Lisbon, Berlin, Copenhagen) present remains of their ancient buildings. But in those same cities, there are examples of scars, traces that hide the original constructions, but allow a reading of the history of a place, its continuous developement and adaption to culture, tradition and societies.

Change has been a natural process of cities and building's "life". Though, it is important to manage change, in order to respect the built environment, the values and traditions developed by society. [BREITLING, CRAMER, 2007]

As it will be further explained, under the topic *Ethics and Principles,* when working with existing fabric and historic settings, the key is to have a good understanding of the place - its history and development over the years, present situation and future ambition. The better the understanding of the context, the more qualified to produce balanced judgements, regarding the historical value of the place and present and future communities' needs. [ORBASLI, 2008]

Design Approaches and terminology

As it was mention above it is not obvious how to approach building design and conservation in historical settings and existing fabric. In these kind of projects, there has to be an understanding of the place and what is relevant to be maintained/preserved and what needs to be re-designed in order to serve the present users and their needs.

Therefore, there has been different design approaches that can be organised into:
1) Corrective Maintenance - design without noticeable works nor introducing contemporary elements, in order to extend the building life span; allow the building to express its aging process;
2) Adaptation - improving of a building for contemporary purposes;
3) Replacement - design of a new building to fullfill the place of a building that has reached the end of its useful lifetime.

[BREITLING, CRAMER, 2007]

These can be divided into more specific - conservation, restoring, requalification, rehabilitation, modernisation... -, however, when subdividing into these categories, there is no consensus according to different authors.

What is relevant is to be aware that there is a a wide spectrum of options when designing in historical context, and the design proposal can varie from very subtle - *Corrective Maintenance* - to radical designs - *Replacement*.

The next topic seeks to provide some guidelines for an adequate and right minded design.

Ethics and Principles

In what concerns design within historical context, there's always been some tension between the two opposite poles, the ones that stand for preservation strategies and the ones who stands for contemporary approaches. What is correct to do?

"A civilised environment should accommodate conservation and development in order to sustain continuity and rational discourse between architectural forms. The crux of the argument is how to prevent buildings from standing in opposition and producing a chaotic effect on the urban setting." [WARREN, 1998, p7] According to John Warren, there are some ethics when dealing with historic environments, an attentive look at the surroundings and sensitive design is required. It is a common perspective in different authors. Aylin Osbali, in *Architectual Conservation*, defided some guidance principles when designing in historic fabric of a city:

- be based on an understanding of the historic town, its morphological and social development;

- respect the setting and landscape;
- be appropriate in scale, height and volume to the inherent morphology of the townscape;
- in design, respect existing characteristics of the townscape and contribute to it rather than mimic or compete with the existing.

[ORBASLI, 2008, p206]

Furthermore, it is important to consider that it is an architectural intervention afterall, and therefore, the assessement of architectural quality is a unquestionable requirement, disregarding the approach taken.

As Vitruvius stated, architectural quality relate to function, structure, and beauty - *Utilitas, Firmitas, and Venustas* in his original Latin - and the ability to combine these qualities into coherent proposal, where a clear intention is presented.

Function and Structure relate to the objective universe of Architecture - fitting a purpose and making use of the right technology and techniques for its structural construction. The question of beauty is defended by some authors as an objective concept as well [Sherban Cantacuzino, WARREN, 1998] , althought it is not as obvious. It relates to subjective concepts as Integrity, Truth, Simplicity, Proportion, Harmony. According to Ralph W. Emerson, "We ascribe beauty to that which is simple; which has no superfluous parts; which exactly answers its end; which stands related to all things; which is the mean of many extremes."

In summary, there is a wide range of design strategies when designing within historic environment, and it's not objective or easy to agree on the best strategy. Every case is a new case and a good understanding and understanding about the place history and morphology is required, from the one in charge of the design and major decisions. However, disregarding the design strategy chosen, there are some guidance principles that must always be followed. As stated before, this principles concern both a sensitive approach to the surrounding buildings and the assessment of architectural quality.

Authorities and Decision Makers

Today protection and management of cultural heritage has a greater focus and is regulated through legal and administratives agencies, from an international to local level. [ORBASLI, 2008]

However, as it as seens previously in this chapter, not only there are opposite strategies, as the principles/guidelines presented are broad and allow different interpretations.

On the one hand, it is very positive, in the sense that everything is possible, there are no limits for creativity and innovation. On the other hand, a bad use from the controller authorities side can lead to a cease in the development of an area or to the destruction of valuable/irreplaceable historic heritage.

Therefore, it is of most relevance to assure the agents and authorities responsible for management and decision makers have a broad understanding and sufficient knowledge about the project and the context it applies to. It is also crucial to assure an efficient and clear communication between the different agents.

The next pages, under sub-chapter *Study Cases,* present some examples of working in existing settings or places with historic value.

STUDY CASES

Jardines Del Hospital Valencia, Guillermo Consuegra

The new garden of the Hospital of Valencia, in Spain, is a project of Guillermo Vázquez Consuegra that invests in reuse and enhancement of archaeological remains.

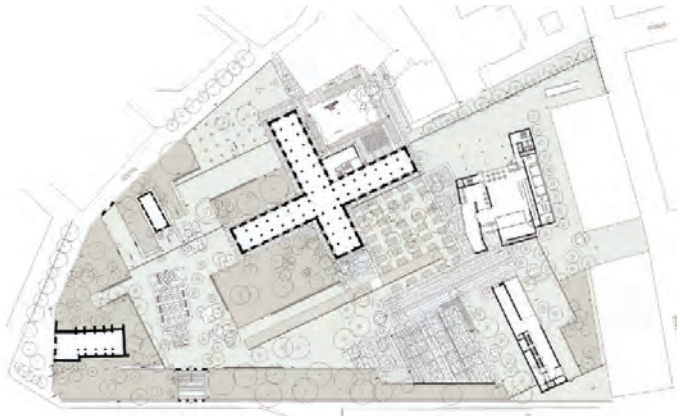
The buildings of the old Hospital and Faculty of Medicine were demolished in 1974, except the property that is now the public library.

The intervention rescue the remains of the old church of the hospital, as well as the friezes of the old Faculty of Medicine. The main entrance, located at the Hospital street, will show, along the access ramp, the 24 columns of the old hospital building.

The "Plaza de los Naranjos", where he has dug one meter deep, will house all archaelogical remains scattered around the garden before. The archaelogical remains of lesser importance will be distributed in the garden. A pergola will unify the space between the Museum of the Ilustration, the Library and the School of Crafts.

The project provides that all construction-free zones will be covered with a carpet of irregular stones. On this pavement will be placed ponds, children's games and street furniture.

[web: Guillermo Consuegra]



ill. 005_ *Jardines del Hospital de Valencia, plan*

ill. 006_ *Jardines del Hospital de Valencia, impression*

ill. 007_ *Jardines del Hospital de Valencia, impression 2*

Saving the Bacon, FNP Architekten

"Saving the Bacon" is a project by FNP Architekten, built in Ramsen, Germany, in 2004.

The architects renovated an old pig stable by placing a wooden box inside the old walls with the purpose of reusing an old construction: a prefabricated wooden building within an old building.

Geniality is the main feature of this project. The problem was how to reuse a construction of 1780, partially destroyed during the Second World War for a showroom.

The alternative of replacing the building with a new one was not possible, as the regulation didn't allow it because its proximity to the street, a quality indispensable for the intended use.

At the same time the building was in so bad shape that the possibility of a refurbishment was eliminated.

The solution was to mount, inside the ruins, a prefabricated wooden cabin sized to adjust to the interior space.

The roof sheltered both old and new buildings. The combination of both materials and architectural styles resulted in exciting proposal. The detail of preserving part of the interior as a porch allows visitors to appreciate the cleverness of design. [web: FNP Arch.]

ill. 008_ *Saving the Bacon, photo 1*

ill. 009_ *Saving the Bacon, photo 2*

ill. 010_ *Saving the Bacon, photo 3*

Two Houses at Orsara, Raimondo Guidacci

This project, designed by Raimondo Guidacci, takes place in Orsara, Italy and was built in 2004.

The project concerns two small buildings situated in two different streets that communicate via backyards, setting an irregular shape lot, near the old town of Orsara di Puglia. The streets are characterized by different typologies of buildings.

It was left uncovered an internal area to bring light inside the two buildings and relate them to each other.

The particular lot geometry has influenced volumetric development of the houses. Buildings follow the different directional lines that cross the area. The volume respects the surrounding proportions but introduces a totally new language.

[web: Raimondo Guidacci]

ill. 011_ Two Houses at Orsara, photo 1

ill. 012_ Two Houses at Orsara, photo 2

context

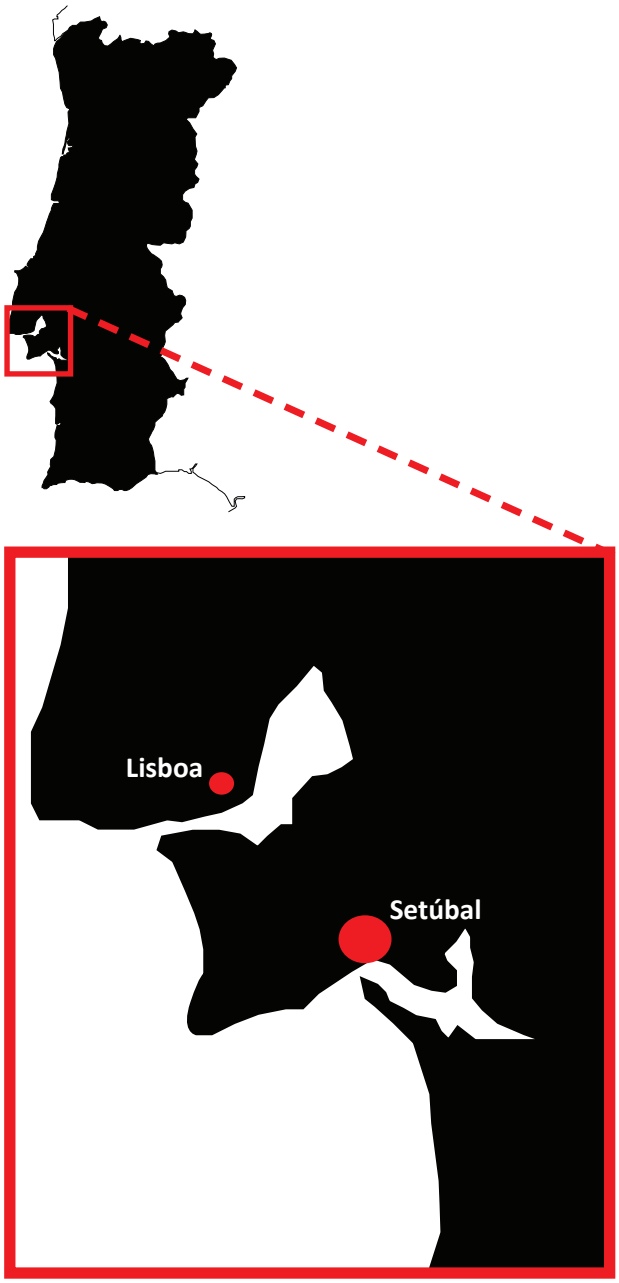
SETÚBAL

Branding Setúbal

Setúbal takes adavantage of a privileged location. Placed 30 km southeast from Lisboa, Portugal's capital city, Setúbal lays between two natural reserves: Arrábida Hills, stretching out along the southern coast and Sado Estuary, where the Atlantic waters embrace Sado river. Besides their uniqueness and beauty, both landscapes hide an enourmous value, hosting rare vegetation, protected fauna and flora - see ill. 015 to ill.021. [web: Costa Azul]

Historical Summary

Setúbal has been occupied by man since pre-historic times. Under Roman occupation developed an important urban and economic centre, related to the fish salting business. The city was founded in 1249, but it was in the 14th century, during the ruling of kings Afonso IV and Pedro, that its boundaries were established and the first walls of the town built. The great economical and social development transforms Setúbal in one of the country's most important industrial and economical centres and causes it to be raised to city status in 1860 and to District Capital in 1926. [web: Setúbal Municipality]. Nowadays, Setúbal is the fifth biggest city in Portugal, according to number of habitants - 124 555 habitants, within an area of 170.57 km^2, a population density of 730 hab./km^2. [web: Setúbal Wikipedia]



ill. 013 _ *location maps: Setúbal within Portugal*

ill. 014_ *view of Setúbal city from the S.Filipe's fortress*

ill. 015_ *protected species, lavender (lavandula stoechas), Arrábida Mountain*

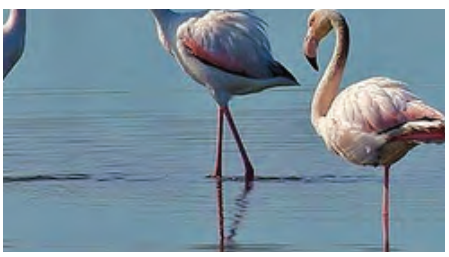
ill. 016_ *protected species, dolphin known as bottle nose (Tursiops truncatus), Sado Estuary*

ill. 017_ *Arrábida Mountain Natural Reserve*

ill. 018_ *bay of Setúbal, aerial view, photomerge;*

ill. 019_ *protected species, owl (bubo bengalensis), Arrábida Mountain*

ill. 020_ *fishing boats, fishermen harbour, Setúbal*



ill. 021_ *protected specie, flamingo (phoenicopterus ruber), Sado Estuary*

HISTORIC CENTRE

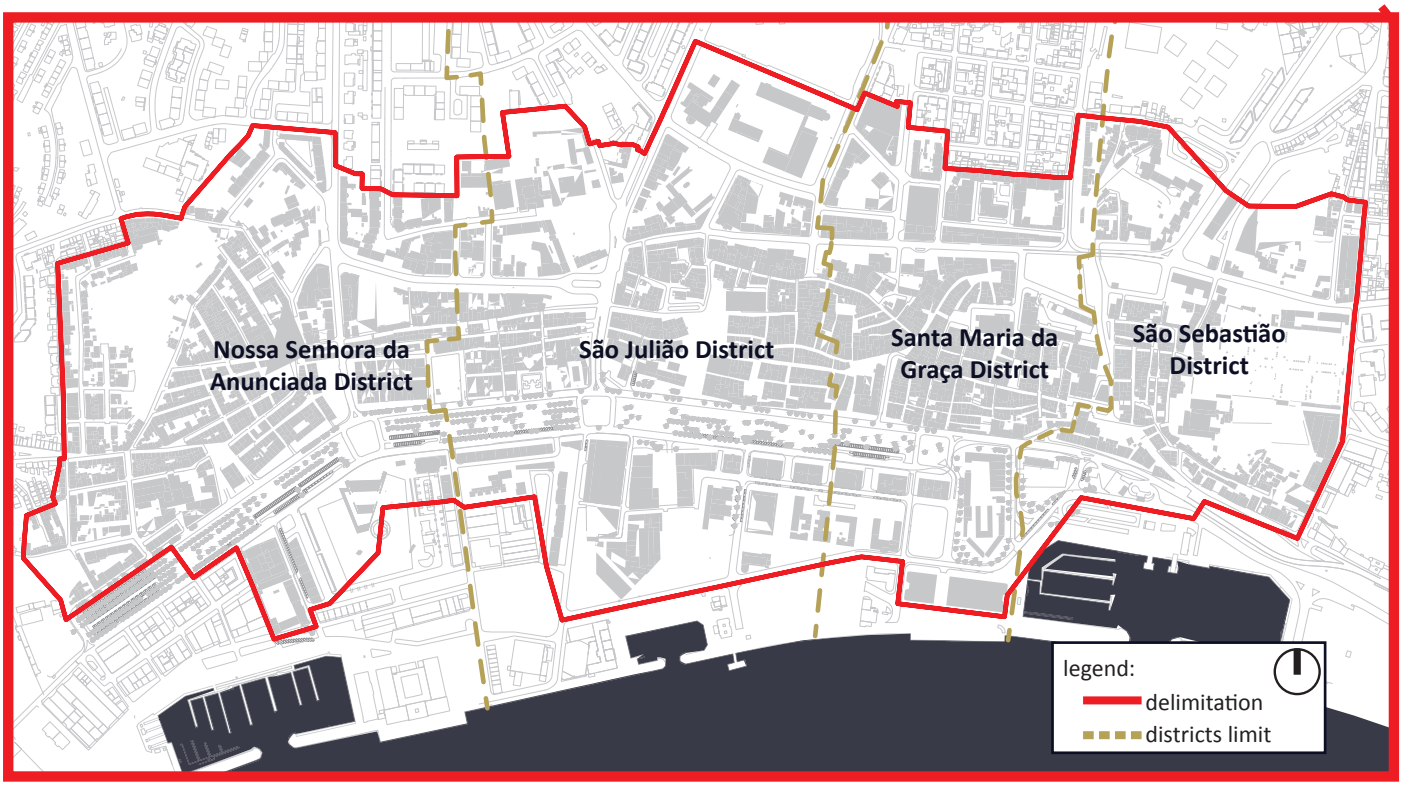
LOCATION, DELIMITATION AND ORGANISATION

Setúbal's historic centre is placed in the southern part of the city, facing the river towards South - see ill.022, below. The historic centre represents an area of circa 100 hectares, 1 000 000 sqm, and its comprised by part of 4 city districts, named after religious characters, Nossa Senhora da Anunciada, São Julião, Santa Maria da Graça and São Sebastião - see ill.022.

As explained in the previous page, Setúbal's historic centre has experienced several occupations since pre-historic times. A significant number of characteristics from the different occupations has been preserved. Setúbal's historic centre offers a unique and pictoresque experience, where the medieval urban layout, the churchs and chapels, the construction techniques, the tilework and all the small elements and details are well integrated in the ensemble . There is an inventory of classified patrimony and a list of buildings proposed to be classified [as it will be presented further, under the topic P*atrimony and Heritage*, in the next page] but the value of area is measureless. The variety in types and styles, the action of time in the building structures, elements and colors not only contribute for a rich and irreplaceable universe, as provide interesting clues for reading the development of the city through the various time periods.

When designing a new building in the area, it is mandatory to get a good understanding of the place. Therefore, the next pages attempt to analyse Setúbal's historic centre, with particular interest in Santa Maria da Graça district - where the project takes place. They are organised under the topics *Patrimony and Heritage*, *Architecture and Materials*, *Conservation Status*, *Inhabitants* and *Functions and Users*.

As it will be seen further, Santa Maria da Graça district is one of the most interesting districts. It contains part of the 1st city wall, dating from 1350, as well as the old city gate. It's the only area in the historic centre that is slightly elevated, allowing a good view towards Sado river and privileged in solar exposure. However, this district has a high percentage of abandoned buildings, most of them in ruins and decay, as it will be seen in p.34, ill. 046, under the topic *Conservation Status*.



ill. 022_ *Setúbal historic centre; TOP: aerial view; DOWN: delimitation and districts mapping*

Patrimony and Heritage

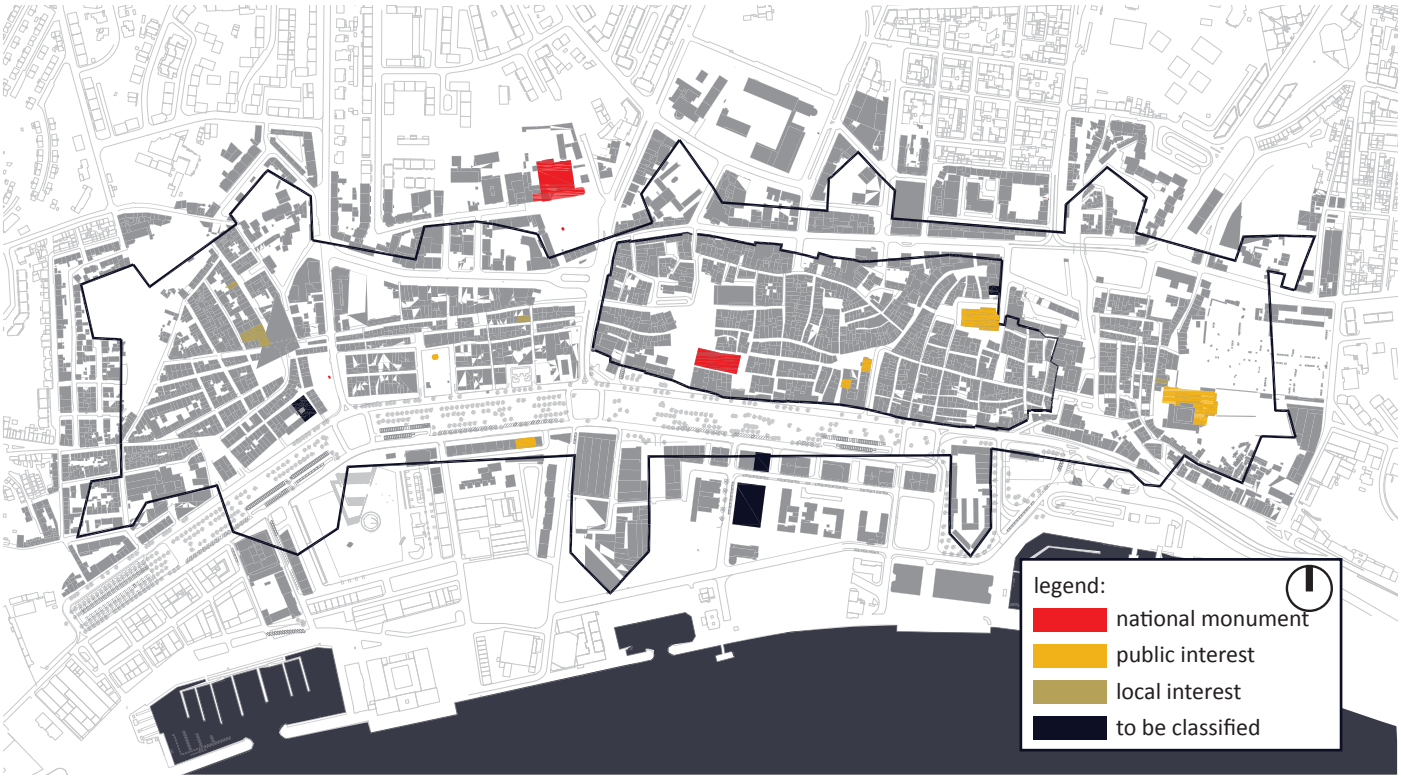
As said before, there is an inventory of classified patrimony and a list of buildings proposed to be classified. In ill.026, underneath, that can be seen by the color scheme, where *blue* identifies the buildings proposed to be classified and *red, yellow* and *light brown* the ones already classified. The different colors apply to different categories. The most significant, considered national monuments, are in red - Jesus Convent and S.Julião Church, see ill.024 and ill.025, underneath. Yellow applies to buildings of public interest - Santa Maria da Graça Church, for example; see ill.023, on the right hand side - and light brown to buildings of local interest.

But the value of the area doesn't relie only on these monuments. The area has a large variety in types and styles, charming elements and details, as well as unseen colors, some produced by the action of time. All these contribute

ill. 023_*Santa Maria da Graça Church*

ill. 024_*São Julião Church*

ill. 025_*Jesus Convent*



ill. 026_ *patrimony and heritage mapping, historic centre, Setúbal*

for a rich and irreplaceable universe and provide interesting clues for reading the development of the city through the various time periods. The next topic, *Architecture and Materials*, presents a deeper analyse on these aspects.

Althought the area is such an interesting place, people feel less and less atractted to inhabit there nowadays. The reason why this happens is not so simple. There are different aspects to consider. The main are:
1) infrastruture, concerning car parking and circulation;
2) indoor comfort, regarding old buildings and the question of outdated construction when compared with living quality standards nowadays;
3) lack of public equipment, likely for young population;
4) authorities and decision makers and their role in interventions in the area.

The first three will be further analysed, under the topic of *Users and Functions*, p35. The last aspect deals with the role of authorities and decision makers when operating in historic centres. As it has been seen before, p17, within the *Theoretical Framework* chapter, it is a very delicate position, that implies protection and preservation policies/procedures, but, most of all, sensitive and well balanced judgements in order to motivate a sustainable development for these areas, instead of a estagnation situation. There are many times where preservation policies are seen as obstacles to investors and, consequently, to potential new users/inhabitants, as well as an obstacle to the constant re-development and re-invention of places. It is of most relevance to understand what should be preserved and what is necessary to change in order to allow a future for the place and to accomplish the right balance between user's interests and respect for the historic values of the settings.

In summary, the role of authorities and decision makers requires competent and sensitive people, qualified and able to understand the interplay of the different subjects, in a holistic perspective.

More information on the topic *Architecture in Historic Settings* is presented in pp16 and 17, within the chapter of Theoretical Framework. The next pages address the topics *Architecture and Materials*, *Conservation Status, Functions and Users and Inhabitants,* willing to help on a better understanding of the aspects that play a major role in Setúbal's historic centre uniqueness and desertification.

***ill. 027_** Sun Gate, old city gate*

***ill. 028_** detail from facade*

***ill. 029_** detail from a facade, Setúbal's historic centre*

***ill. 030_** detail from a door, Setúbal's historic centre*

***ill. 031_** tratidional outdoor pavement, Setúbal's historic centre*

Architecture and Materials

The last topic addressed the question of classified heritage. However, the legacy present in the area goes far beyond monuments and religious buildings or classified patrimony. The variety in architectural elements and details, as well as in materials, colors and techniques contributes for the charm and uniqueness of the place.

In ill. 028 to ill.031 can be seen the action of time over materials and colors and the use of traditional/typical techniques such as tiles in street flooring or commonly disposed in facades, the iron work in window guards and door handles.

The next pages compile and organise relevant information regarding traditional constuction, materials and techniques the buildings in the area make use of. ***Structural walls, roof structure, openings, finishing elements*** and ***details***, as well as ***painting*** and ***cladding*** are hereafter presented.

As it can be seen in ill.032, ill.033 and ill.034, on the right hand side, it is common that ***structural walls*** are made of limestone or brick masonry, bonded with lime and sand mortars. In order to be resistent and take the loads, the walls are of great thickness. It is charming technique that makes use of local materials - mainly from Arrábida Mountain). However, during long raining periods the walls are able to storage a great amount of water, which is difficult to get rid of. That can cause serious damage on the walls and weak the construction system. [ARAÚJO, MACEDO, 2009]

Regarding ***roof construction*** and structures, they are normally made in wood. In Setúbal's historic centre, it is typical the use of pitched roof, with two to four pitch planes, never having more than 45º inclination angle, a reflex of the mediterranean climate. This roof planes are usually lined up with clay roof tiles, which when exposed to the sun light, exhibit a characteristic orange tone. The tiles are usually hung in parallel rows, and each row overlaps the row below it in order to protect from the rainwater. These pitched, lined up with clay tiles roof is a great characteristic of the area and can be seen in almost all buildings of the area, see ill.035 and ill.036, underneath. It plays a relevant role in the townscape perception, since it contrasts to recent built areas, where the construction doesn't, usually, make use of this kind of roofs and materials - no-

ill. 032_ *facade in decay, where the structural wall can be seen, made of lime and sand mortar*

ill. 033_ *detail from an external wall, lime and sand mortar*

ill. 034_ *detail from an external wall, lime and sand mortar*

ill. 035_ *traditional clay roofs, aerial view, Setúbal's historic centre*

ill. 036_ *traditional clay roofs, Setúbal's historic centre*

tice the contrast between the buildings in the front and in the back, on ill.036. [ARAÚJO, MACEDO, 2009]
Concerning the design of ***openings***, windows and doors, it is important to stress they seem to follow rules and codes, producing their own rhythm and playing an important role in the facade composition and users perception. They are normally rectangular shaped and vertically displayed, see ill.037, underneath. Their width varies between 0.8m and 1.1m. Regarding their height, it varies between 1.1m and 2.5m. They are, at least, 5cm inwards the external surface of the facade wall they belong to.

It is frequent that the openings are vertically and horizontally aligned, within each volume/building.

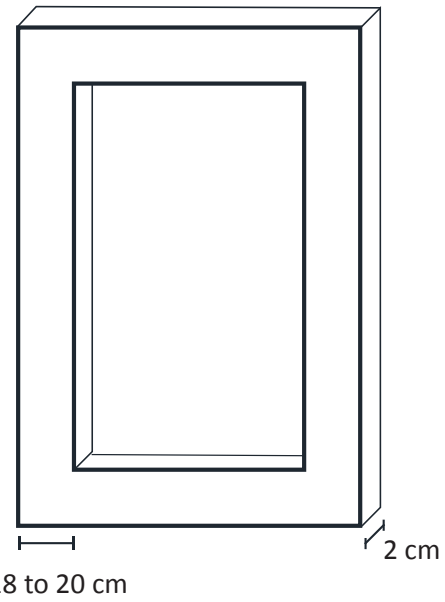
Another important characteristic, regarding both windows and doors, is the framing. It is common that to have two frames:
1) a wooden frame, painted - normally olive green or white;
2) an external frame, usually in stonework and making use of limestone, fine hammered.

The external frame thickness is normally around 20 cm and 2cm projected from the wall, as it can be seen in ill.038, on the right hand side. [ARAÚJO, MACEDO, 2009]

Despite its rectangular oultine, the openings frequently present internal subdivisions applying different geometries, as shown in ill. 039.

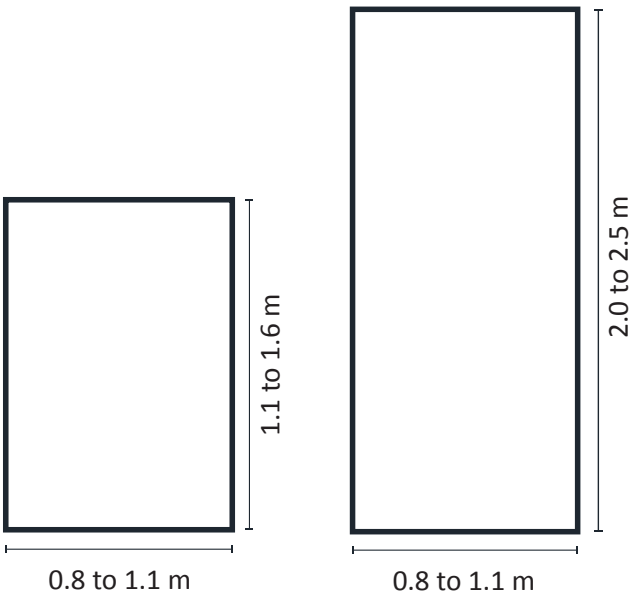
Iron guards, specially in the balconies, but also in windows are a relevant element/detal in townscape perception. As seen in ill.040, they also make use of geometrical patterns.

Other ***finishing elements/details*** specially relevant are



ill. 038_ *traditional framing, common dimensions*

ill. 039_*detail from windows in Setúbal's historic centre, subdivided into different geometries*



ill. 037_ *openings, common dimensions*

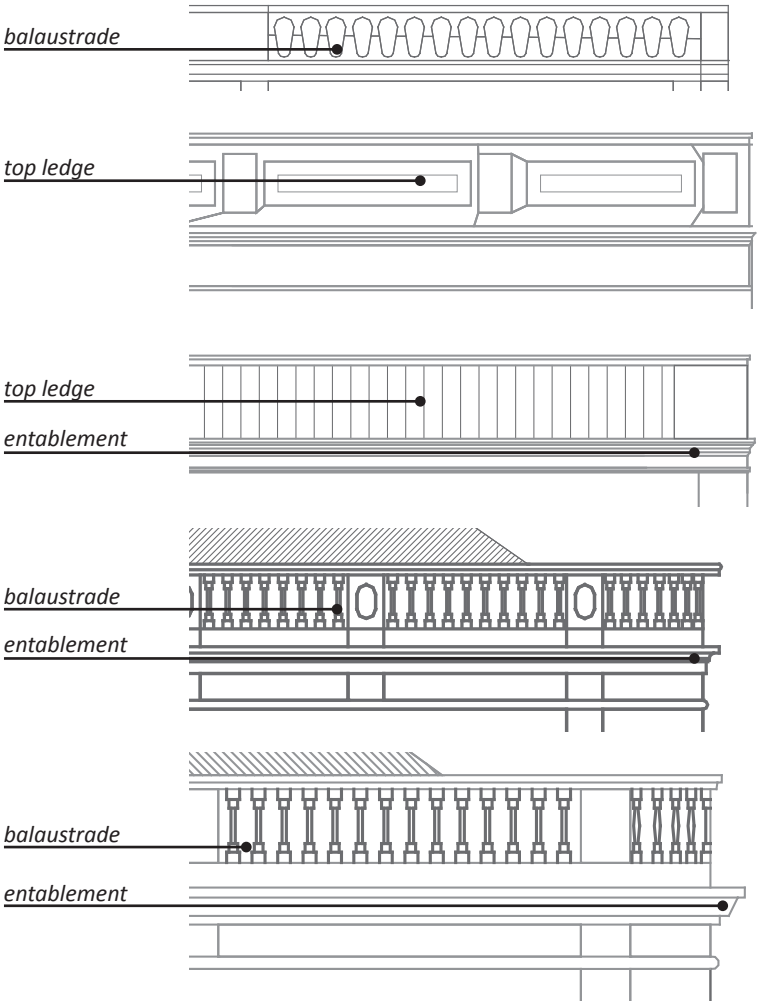
ill. 040_ *ensemble of window, frame, external frame and iron guard*

the top part of the buildings. As it can be seen in ill.041, they varie - normally according to the style and date of construction. The most common are the entablements, the balustrades and the top ledges. [ARAÚJO, MACEDO, 2009]

As it can be seen in ill.042, the area ends up having very different constructions - volumes, shapes, details - but it is amazing to see how harmoniously the different buildings and elements go together, contributing for a richer, singular universe, that is made of changes and constant adaptations over the time.

The final expression of the facade commonly makes use of ***tiles***. Tiles are a cultural expression representative of portuguese cultural identity. They result from the morrish occupation in earlier times. They are commonly used in the facade as cladding, specially in the historic centre.

There is a huge variety in tilework, as it can be seen in ill.044, on the next page. Usually, a piece is repeated, creating a pattern. The aesthetical value is achieved by the ensemble, not by the single piece.



ill. 041_*typical building tops, Setúbal's historic centre*

ill. 042_*typical building, Setúbal's historic centre; NOTE: stone framework on the openings, balcony guards, top finishings, and the ensemble of the elements and the different buildings working so harmoniously*

There are simple patterns, complex geometrical compositions and plain ones. Aesthectic value is added by the repetition, rotation, symmetry, proportion, regularity aspects used in the composition.

Technically, its a material that presents advantages. The tiles surface is effective in reflecting the sun rays and keep cool temperature inside. Given the climate, it is an important aspect. They are also easy to clean and maintain, as well as durable.

When not applied tiles, the buildings are painted. The paint aims to add an extra layer of protection to the structural materials, but plays an aehstetic role as well. It should never be applied to stonework. The typical colors used are, black smoke, red ocher, yellow ocher, ultramarine blue, “terra verde”, “terra de umbria”, ruddle and “terra de siena” - see ill.043, underneath.

Conservation Status

Despite its unrefusable value, the Historic Centre has a high percentage of abandoned buildings [28%, see ill.047, p34], not to mention the buildings in decay and bad condition. [see ill. 045, in the next page and ill.046 in p34]

The urban sprawl map, p9, ill. 001, confirms the city keeps expanding towards North and East, since it’s limited by the river and the mountain, respectively in the southern and eastern sides. However, a proportional population growth can’t be verified. This suggests people are leaving the historic city centre to live in the new built areas, what leads to the abandon and lack of interest in improving the built environment in the historic centre.

Why isn’t there a bigger effort in requalifying the buildings in Setúbal’s historic centre? What will happen to the existing buildings, if there isn’t an investment in improving them? How sustainable is it to keep expanding cities when it isn’t necessary? The answer isn’t simple. There is a complicated net of economical, governmental and

ill. 043_ *traditional colors applied to facades, historic centre, Setúbal*

ill. 044_ *ceramics tiles applied to facades, historic centre, Setúbal*

ill. 045_ *abandoned buildings in decay, historic centre, Setúbal*

social aspects contributing for its complexity. One of the major factors has to do with an old rent law, that forbided rents to be raised. [Queirós, 2007] That meant, people that have rented a place 20 years ago, would be paying the initial rent nowadays. That wasn't a fair policy to the owners, which didn't feel economically encouraged to improve the places they owned. That policy only changed in 2006, but the decay of buildings can still be seen. The law now admits a raise according to inflation plus a five percentual raise per year, but old renters still pay nothing compared to an average rent nowadays.

Therefore, owners hope is either for their renters to get old and die, so they can rent the places they own to new people, starting with normal prices and making use of the new rent policy or to let buildings in such decay condition that the Municipality will authorise its demolition and they can sell the plot for a bigger amount of money. [Queirós, 2007]

It is relevant to preserve this areas, the historic city centres, and as much as possible their patrimony and heritage, their ancient layers. However, it is even more significant to assure their continuity, since they are know by being capable of hosting different time periods of human civilisation, multiple societies and city layers.

	UNOCCUPIED [%]
Anunciada district	12,25
Santa Maria district	**24,90**
São Julião district	11,02
São Sebastião district	13,64
Setúbal city	12,47
Historical Centre	**28,00**

ill. 047_ *table compiling statistic study on unoccupied buildings, 2001*

	OWNER [%]	RENTED [%]
Setúbal	74,73	25,37
Historical Centre	34,36	**65,64**

ill. 048_ *table compiling statistic study on building possession, 2001*

Inhabitants

The inhabitants in Setúbal's historic centre are, in a great majority, elderly people - see ill.049 in the next page. There is also a great percentage of foreigners. Furthermore, according to National Poll from 2001, 33% of the inhabitants

ill. 046_ *conservation status mapping, historic centre, Setúbal*

is over 65 years old, 49% of the families living in the historic centre have, at least, one member over 65 years old, 35% of the residents are retired, 52% hasn't more than four years of basic education, and a high percentage of these can't even read or write. see ill.049, ill.050 and ill.051 on right hand side

The above information points out the substantially aged population, highly exposed to social loneliness, with lack of eduacation and highly depending on social services. The profile of its inhabitants is close related to the abandon and conservation status of the area, to the lack of investment, new actions and dynamics.

It is of major relevance to promote a wider range of inhabitants, to attract youngs and families to inhabit the area. By that, it would be possible to achieve a social diversity, support a wider range of activities and, consequently, stimulate a sustainable growth and maintenance of the area.

However, as it is at the moment, families and youngs have no interest in moving into this area of the city. As it was mention before, the buildings are old and in decay, its construction allows water infiltrations and the indoor climate isn't good when compared with comfort standards recent buildings offer nowadays. It is primal to design competitive buildings, with well designed spaces, low energy consumption and high quality indoor climate, pleasant and wise to inhabit, allowing for high standard living conditions.

However, as it will be further analysed in this page, within the topic *Functions and Users,* this won't be enough. Setúbal's historic centre lacks public equipment, such as qualified outdoor areas, playgrounds for children, kindergardens, schools, sports centre, not to mention the car circulation and parking are very limited. These aspects are crucial when the aim is to appeal to youngs and families.

Functions and Users

Aiming to get a better understanding of Setúbal's historic centre, building functions and users are also analysed. As it can be seen in ill.054, p37, there is a high percentage of public buildings in this area. Nossa Senhora da Anunciada ditrict allocates most of the restaurants, bars and cafés, while S. Julião district is were a great number of relevant services and shopping are located. Santa Maria da Graça and S. Sebastião

	HISTORICAL CENTRE [%]	SETÚBAL [%]
00 - 14 years old	10,1	15,5
15 - 24 years old	11,0	14,3
25 - 64 years old	45,5	55,4
+65 years old	33,4	14,8
TOTAL	100,0	100,0

ill.049_ t*able compiling statistics on inhabitants age*

	HISTORICAL CENTRE [%]	SETÚBAL [%]
Working	33,96	45,84
Unemployed	4,42	5,01
Retired	35,03	17,20
Studying	14,01	18,52
Other	12,57	13,43
Total	100,00	100,00

ill.050_ *table compiling statistics on inhabitants occupation*

	HISTORIC CENTRE [%]	**SETÚBAL [%]**
can't read or write	**18,28**	15,39
primary education	**34,14**	27,01
basic education 1	11,84	12,52
basic education 2	16,25	19,39
secondary education	13,15	17,03
superior education	6,34	8,66
TOTAL	100,00	100,00

ill. 051_*study on population education level, Setúbal*

"(...) I'm Brazilian, I moved to Portugal 10 years ago and to Santa Maria da Graça district 6 years ago. Î live upstairs, and run my café in the groundfloor. I like living here, there is a lot of Brazilians in the neighbourhood. (...)"

"(...) I've always lived here and I always leave my front door unlocked, that's the way I was raised. (...) Yes.. there's a lt of robbers, my house was robbered three times the past two months... (...)"

"(...) I collected 30 liters of in 3 days, with a dehumidifier machine... in Summer time... the water these walls store... (...) "

ill. 052_*inhabitants from Santa Maria da Graça district*

ill.053_ *café in Nossa Senhora da Anunciada district, historic centre, Setúbal*

districts mainly allocate private residential buildings. The two first districts register intense flows during day time. During night time, while the restaurants and bars are opened, some areas in these districts are still active, few though. The days these are closed, there is a big contrast, the streets are quiet and empty.

Regarding its users, during day time can be registered a wide range of users, from different ages and social backgrounds, since the most relevant services and shopping are still located in the historic centre.

Regarding its inhabitants, there is a high percentage of elderly population and a lack of youngs. As it was said before, it is of greater relevance to promote a diversity in the range of users and, specially, inhabitants. See p34 and p35, where the topic *Inhabitants* has been deeper analysed.

In the next page, there are nine maps, that present the public functions divided according to different categories:

- services (banks, police station, loyers offices, insurance and real state companies...)
- shops
- social equipment (kindergardens, schools, elderly homes)
- sports (sport associations, gyms)
- cultural (libraries, museums, theatres)
- restaurants (restaurants, cafes, bars)
- religious.

It is then clear the lack of schools, sport complexes and green areas, essential to encourage youngs and families to move closer.

It is of primal importance to design competitive housing. However, that won't be enough to promote and re-activate the area. The historic centre demands a urban strategy, a urban plan that organises and supports the construction of public equipment, such as kindergardens, schools, sport centres, parks as well as other qualified outdoor areas. These are crucial, intemporal aspects that appeal to youngs and families.

It is also important to rethink the way housing complexes connect with the urban fabric, allow qualified outdoor areas, where children can play while parents watch over from home.

Nevertheless, it is crucial to improve the car accesses and parking, since it's very limited at the moment. On the one hand, requalify infrastructure and set up more parking spaces. On the other hand, promote walkable distances for everyday routines work-home-school-leisure. Stimulate instead of obligate an healthy and sustainable lifestyle, walking and the use of bikes.

ill.054_ *private/public/unoccupied buildings, historical centre, Setúbal*

SERVICES

SHOPS

SOCIAL

SPORTS

CULTURAL

RESTAURANTS

RELIGIOUS

GREEN AREAS

ill.055_ *public buildings and specific uses, historical centre, Setúbal*

SUMMARY

Setúbal's historic centre faces an increasing desertification a great majority of its population is over 65 years old. Youngs and young families are not attracted to inhabit the area anymore. This situation comprimises the continuous development/future of the area.

WHY AREN'T YOUNGER USERS ATTRACTED TO LIVE IN THE AREA?

The main aspects are:

- constraint car circulation + parking;
- old construction, lack of comfort or quality indoor climate;
- lack of parks, gardens or outdoor qualified spaces;
- lack of public equipment that young users could take advantage on everyday life such as schools, sportive, cultural;
- vicious circle: lack of investment in the area > decay of the area > unattractive to inhabit in the area > lack of investment ...

HOW TO CHANGE THIS?!

Among others,

- review of outdated policies/laws (rent law for example)
- stimulate people that wants to recover the area - sponsorchip, taxes benefits, etc..
- invest in infra-structure and public equipment (mandatory)
- competitive housing, target on young population

NEXT CHAPTER...

The problems in the area are deep and comprehend a close interplay between different disciplines. However, it would be too ambituous to try to solve all the problems in this project.

Therefore, the project brief is to take a plot in decay and develop competitive housing for young population. The next chapter starts the design process, where the chosen site is presented, after which starts the sketching phase.

The design proposal should consider both the theoretical framework and context analysis previously introduced.

design process

site registration

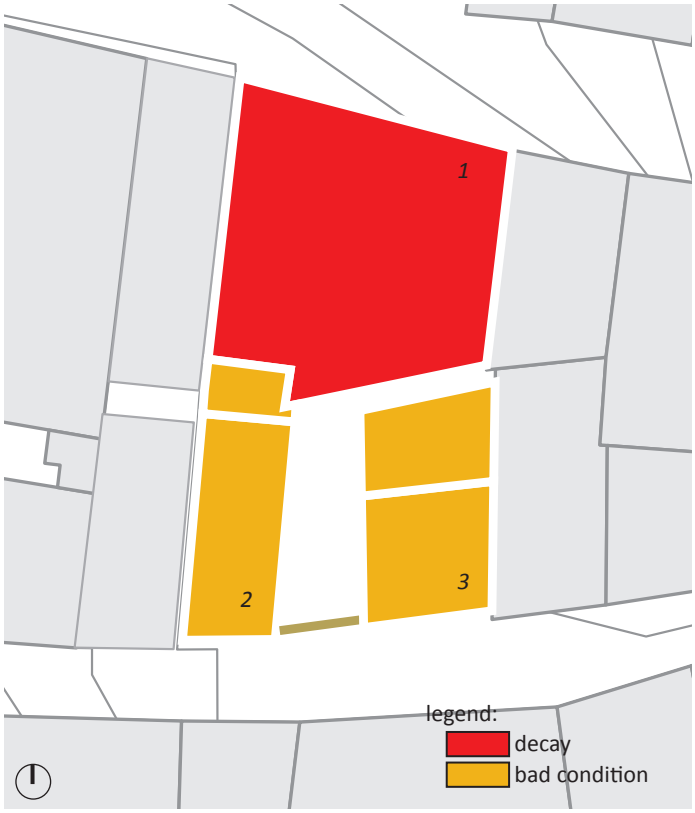
SENSING THE PLACE

General

The chosen plot is placed in Santa Maria da Graça district, see p26, ill.022. Its comprised of five buildings, one in decay and four in bad condition. see ill.056, on the side Unfortunately, there are few information about the buildings in the area. There has been a fire in the Municipality's Archives in 1910 and only the buildings modified after that date have a file that can be consulted.

The only information available is an the plans from the historic centre, dating from 1991. Besides that, there are the facades that can be seen from the street and the building tops from the aerial view of google maps. see ill.057 to ill.060

In the next pages, relevant information about the site is collected and a series of drawings presented, in order to have a fixed basis and start the sketching phase.



ill. 056_*conservation status of the chosen site, plan view*

ill. 057_*chosen site, aerial view*

ill. 058_ *chosen site, Northern facade, building 1, photo*

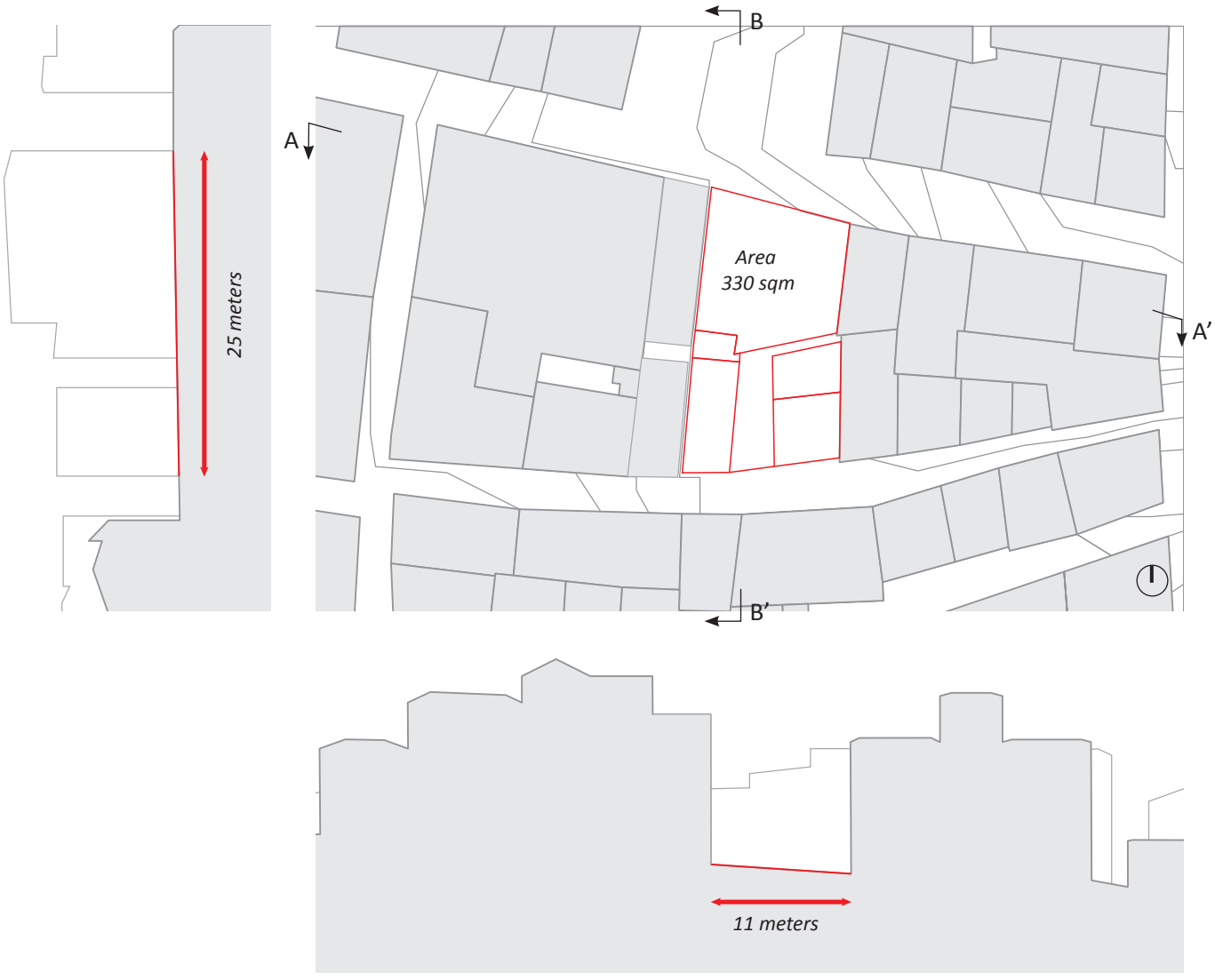
ill. 059_ *chosen site, Southern facade, building 2, photo*

ill. 060_ *chosen site, Southern facade, building 3, photo*

DOCUMENTING THE PLACE

The intention of this section is to create a basis of drawings, as a fixed starting point for the design process. The only available precise drawings were the city plans from 1991. Therefore, the elevations were made using the photos as guidance.

The drawings presented are a general plan, showing the existing buildings, Northern and Southern facades and two sections.



ill. 061_ *chosen site, plan and two sections, basis of drawings*

ill. 062_ *chosen site, Northern elevation, basis of drawings, scale 1:200*

ill. 063_ *chosen site, Southern elevation, basis of drawings, scale 1:200*

CLIMATE

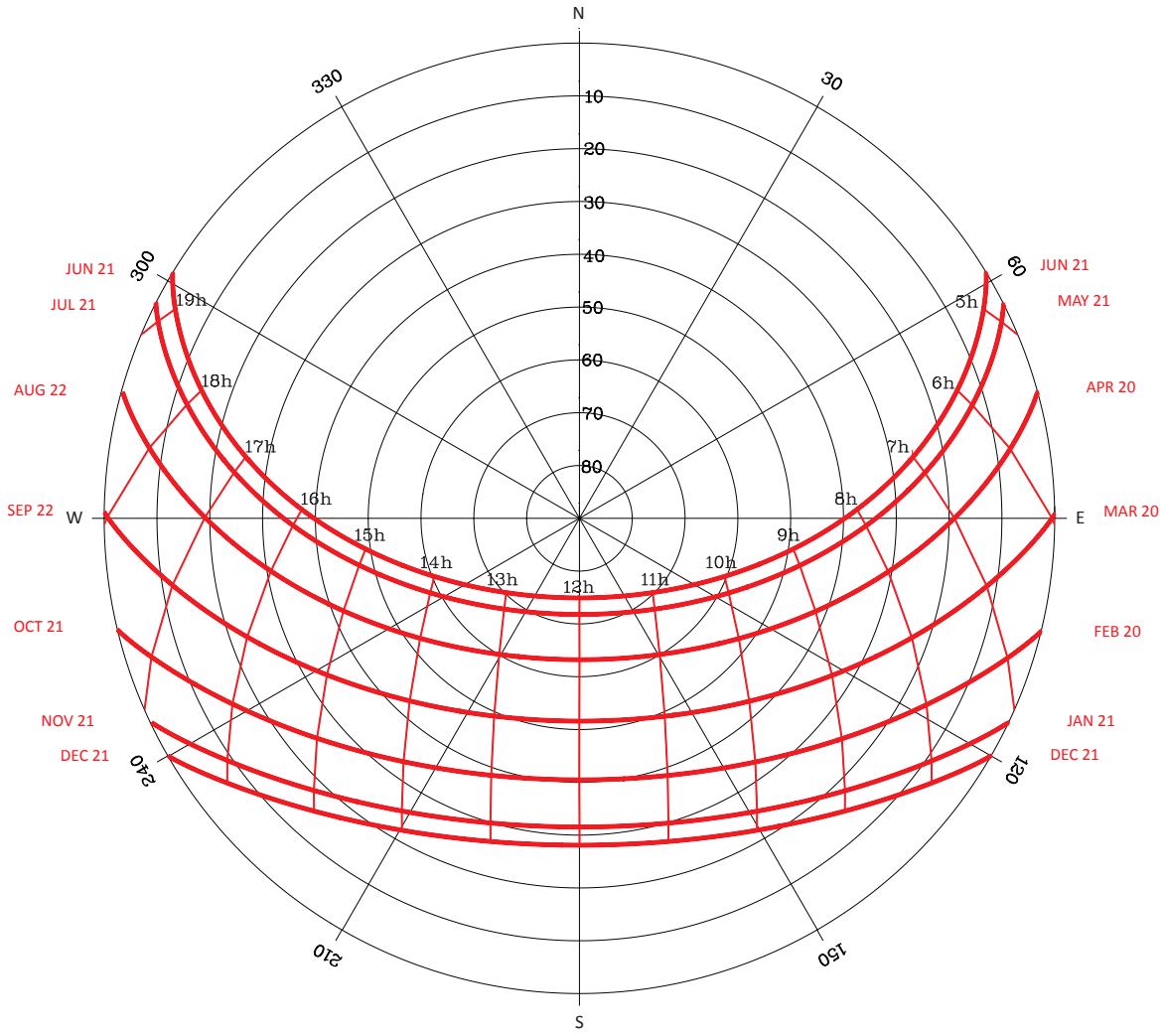
Portugal is characterised by a Mediterranean Climate and is one of the warmest european countries. In Setúbal, the annual average temperature is around 16º. [web: meteo]

The wind in the area is not significant, since the historic centre presents a dense urban fabric.

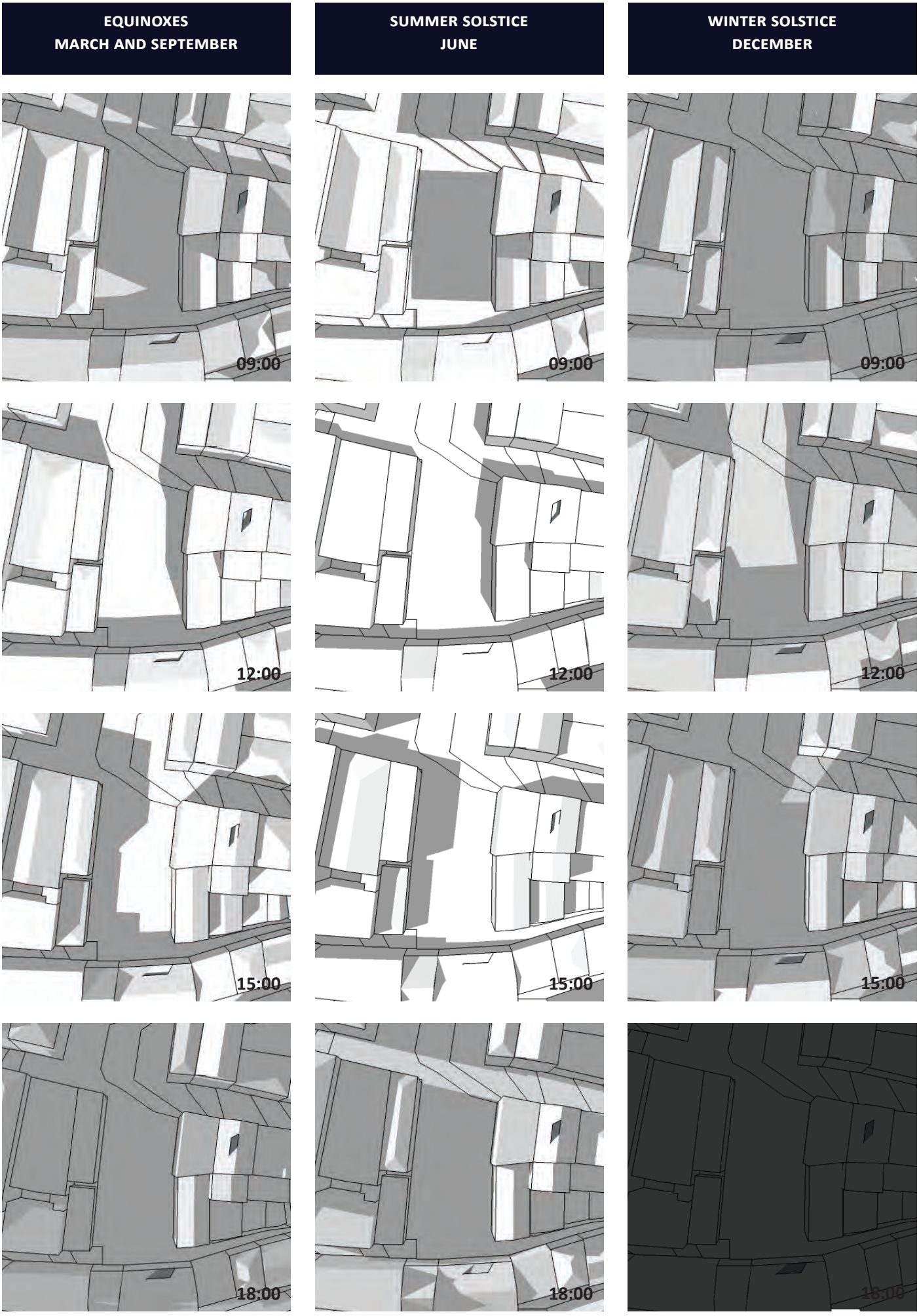
The sun chart is presented underneath, ill.064, where it is possible to verify the angle of the sun and the period of sunlight over the year.

On the next page, ill.065 presents a shadows and light investigation specificaly for the site, which shows that there is a reasonable amount of light, only in December the light is not so intense and due to the radiation angle, the shadows have a bigger influence.

It is now set the basic information to proceed to the Design Process chapter.



ill. 064_ *sunchart for Setúbal, Portugal*



ill. 065_ *shadows investigation for the site*

sketching

INITIAL SKETCHES

Intro

In the beginning of the sketching phase the aim was to explore a wide range of possibilities and analyse its impact in the given context. Different tools have been used - hand sketches, schemes, 3d model (both physical and digital) - see ill.066, on the right hand side.

A working model of the area was made, in scale 1:100. Given its simplicity and the fact the volumes were made out of foam, it became easy and fast to test a great variety of proposals, and to develop a sensitive understanding of the site, this means, become familiar with its characteristics and limitations and realise the general dimensions and proportions that would contribute for a better integration of the design proposal within the given context.

Some sketches have been chosen to work further with - building organisation and apartment plans. The three most relevant are presented in the next pages, concept #1, concept #2 and concept #3.

Main Considerations

As it was explained before, p44, there has been a fire in the Municipality Archives, in 1910 and the buildings that haven't been updated since, have no file. Therefore, there isn't infomation of the buildings in the site. There is only what is visible from the street, the facades and from google maps, the roof. This forced the project to go in a direction, the integration of a new construction.

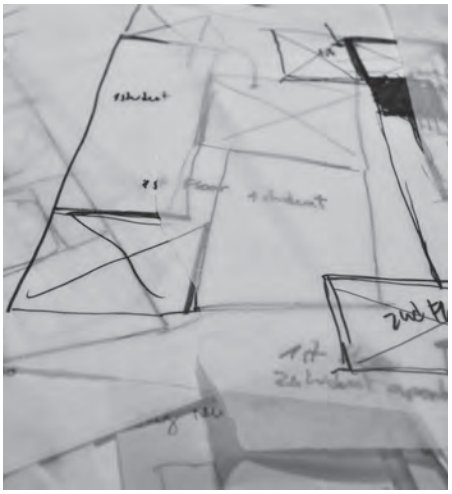
However, what is visible is very charming, specially the facade towards North. As it can be seen in a lot of sketches, there has been a strong will to keep the old facade and use its lines to shape the new building. This can be seen in p54 and p56, when presenting concept #1 and concept #2.

Another consideration has to do with the light that can get into the apartments. The plot is blocked towards East and West by other buildings. It's clear the need of a strategy in order to have light breaking into the apartments and assure daylight at least in the bedrooms, living and dining room. The strategy can regard the creation of voids/ courtyards, or the design of an innovative skylight, or an innovative building design. But it is an issue to consider, how to get light inside the apartments.

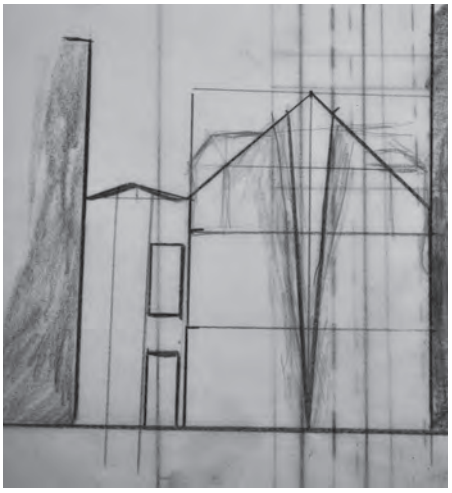
Besides the light, there are some constraints with the plot dimensions. As it can be seen in p46, the plot has a good area, circa 330sqm (ground floor area). However, it is not so wide, 11m, specially when trying to integrate voids to get the light in.

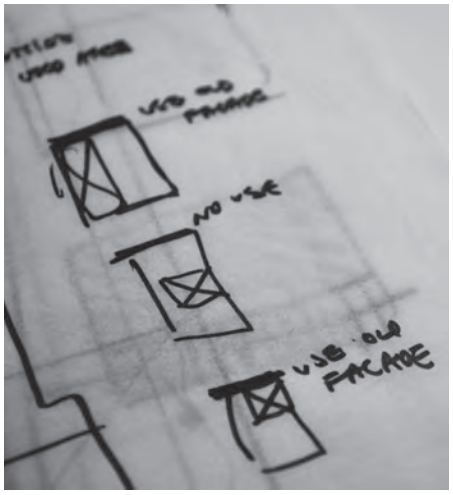
These considerations will be further explored in the next pages. Three concepts were selected and are developed and presented, addressing the topics of building and apartment organisation.

The sketching phase ends with the selection of one of the concepts to work further with, in the detailing phase.











ill. 066_ *first sketches: schemes, drawings, models*

CONCEPT #1

Description

Concept #1 consists on a pure/simple volume creating a clear axis between the main and back streets. It keeps the old facade, in the northern side and makes use of its outline to shape the new building. Furthermore, it gives the old facade an unexpected function, a gate to a new green space/axis, which connects the main and back street.

The main intention behind this concept was to enable an extra facade for the placement of windows and to take advantage of contrasts: old, new and green.

Volume Studies

As it can be seen in ill.067 and ill.068, the concept started as a smaller volume, keeping a "patio" inbetween the new building and the old facade.

During the development of the building circulation and apartment plans, there was the need to expand it, and consequentely, in the end, it seemed more appropriate to extend it until the old facade - not only the space was to small, as it seemed wiser and simpler that the new construction would support the old facade instead of another structure. see ill.069

Building Organisation

Several building organisations were tried. The one working better was when having three apartments, one per floor. The one on the ground floor would be smaller, allowing to access the circulation core (stairs + elvator) and for an extra space that could be used as a cafe or other public function. (see ill.070 and ill.071 in the next page)

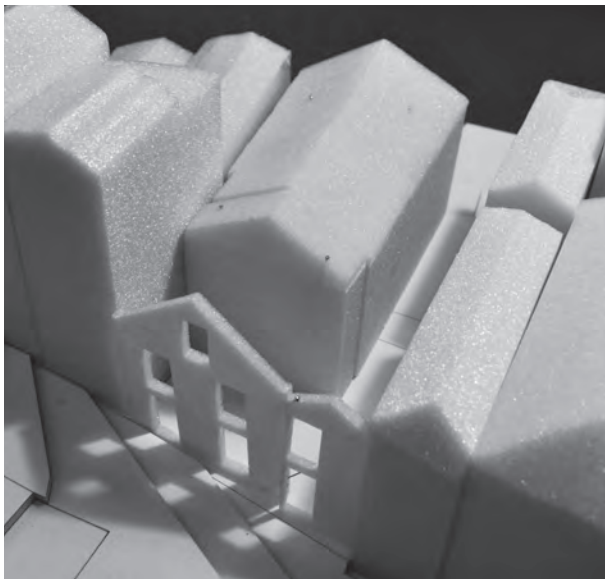
However, as it will be explained in the next topic, the apartment plans didnt work that well. Besides, the axis started raising questions about its quality as an outdoor space. It represented a great area, of 77 sqm, but it was a very long "corredor", it was difficult to see what was the quality in this outdoor area and how people would use it and experience it.

Apartment Plans

Different apartment organisations were tried, none of them were successful. On the next page, it is presented the best solution for this concept. However, this solution consists in a very long apartment, with an enourmous problem in getting the circulation inside the apartment work, without having a long "boring" corredor. Furthermore, it had an area of 110sqm and more rooms than needed, since the target users were youngs and young families. The idea of having 2 apartments per floor was explored as well. But the apartments ended up very small, with only 1 or none bedrooms.

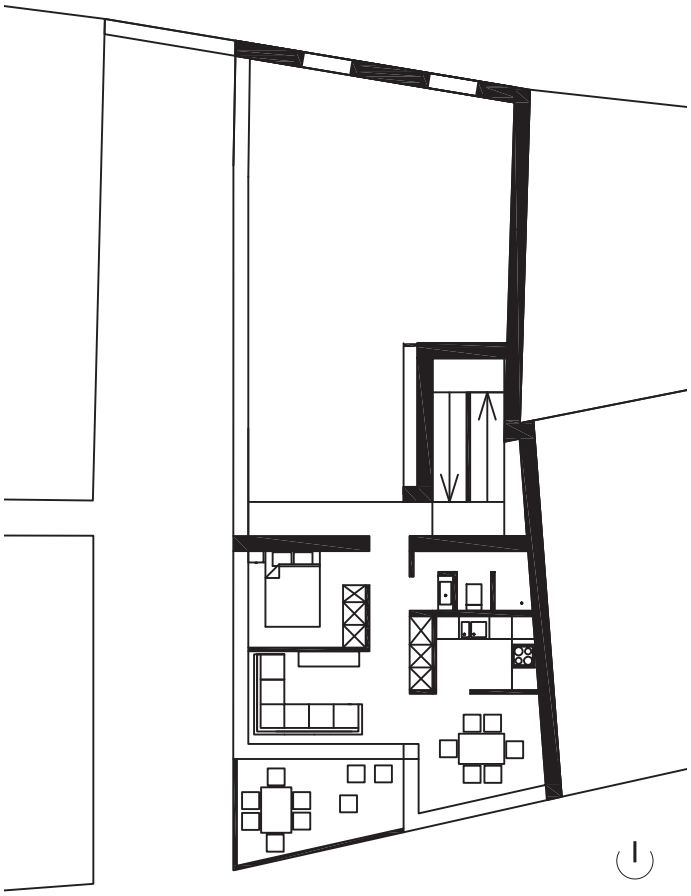
Concept #2, presented in the next page, tried to develop a better proposal.

ill. 067_*old facade and new construction, impression*



ill. 068_*concept #1, early phase, foam model, photo*

ill. 069_*concept #1, development, foam model, photo*



ill. 070_apartment plan, gound floor, *concept #1*

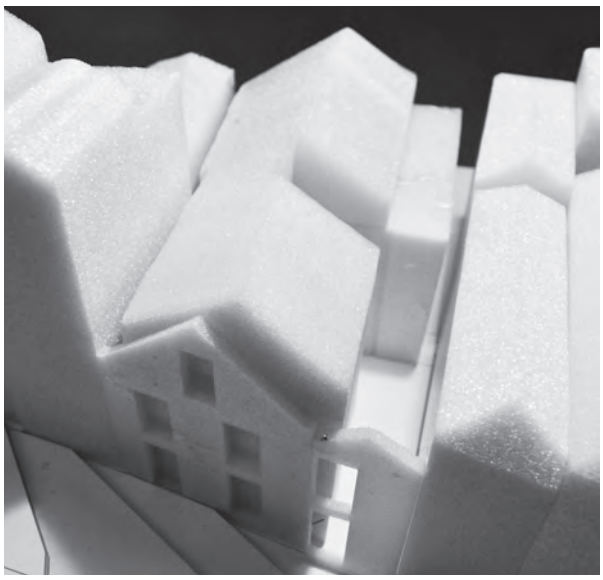
ill. 071_apartment plan, 1st and 2nd floors, *concept #1*

CONCEPT #2

Description

Concept #2, when compared with concept #1, is not such a pure shape. It can be read as two volumes, with the circulation core inbetween them and united by the roof line. (see ill.072, on the side)

This concept also makes use of the old facade, its outline and the interplay between old, new and green. The different is in the attempt to explore the variation of volumes aiming to create an interior courtyard - quality outdoor space - instead of passage/clear axis.



ill. 072_*concept #2, foam model, photo*

Volume Studies

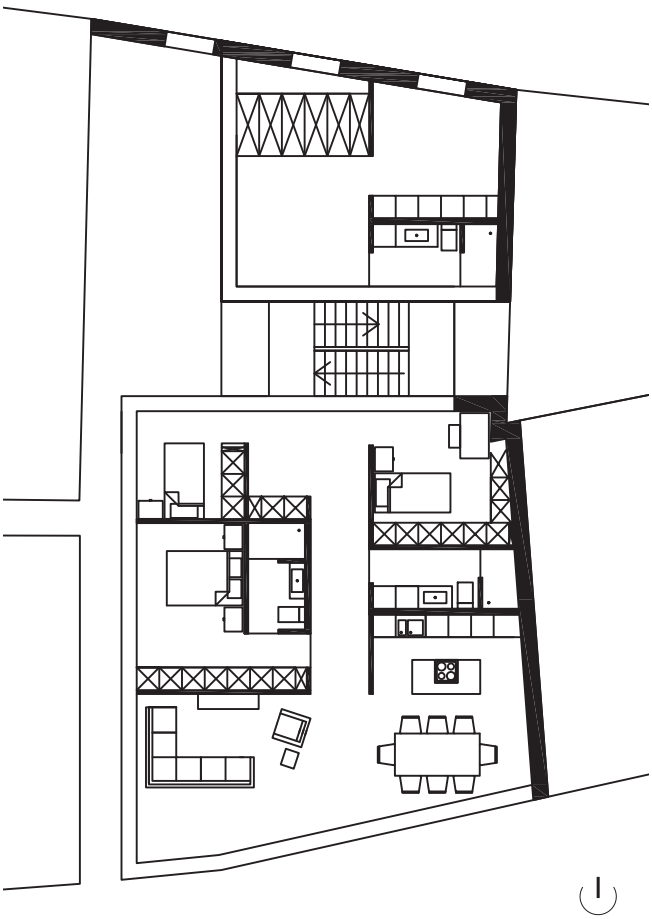
In the beginning, the volumes were smaller and the space inbetween them was bigger, working as a good courtyard. The fact of keeping the old facade and using it as a passage/gate conditionated a lot the design. The volume on the northern part of the plot was always very small and the passage to courtyard to wide. With the development of the building organisation and apartment plans, the courtyard disappeared, again.. (see ill.073)

Building Organisation

In the development of this concept, the building organisation haven't changed much. There has always been six apartments, two per floor, and the circulation core placed inbetween them. (see ill.073)
However, there has been a lot of proposals for the stairs, regarding its orientation and type, in order to create space inbetween the two volumes and, consequently, a courtyard.

Apartment Plans

The apartment plans were working better than in concept #1. The area and number of rooms was suiting better the target users and defined program. However, the apartment on the north was very little and the distribution in both of them wasn't very elegant. (see ill.073)



ill. 073_apartment plan, *concept #2*

CONCEPT #3

Description

Concept #3 is a totally new approach. It does NOT keep the old facade. It can be seen as a whole volume, from which was subtracted a part, creating an internal courtyard. (see ill.074, on the right hand side) The intention is to keep the courtyard as public space, therefore, the accesses connecting both the main and backstreet to the courtyard must be “carved” in the building volume.

Volume Studies

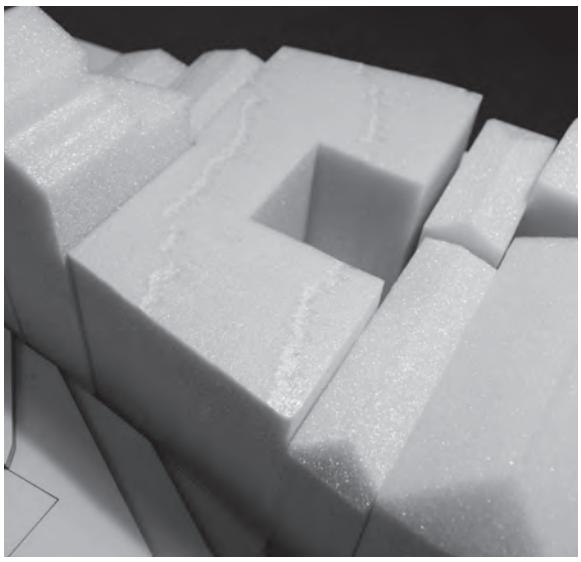
At first view, it is a very massive volume and, from the three concepts presented, it is not the most attractive. However, because it doesn’t follow the old facade outline, it is also the one more abstract, more “raw”, if it can be said. This means, it is actually a concept that can be widely explored and develop into something completely different through its refinement.

Building Organisation

The fact this concept doesn’t use the old facade as guideline allows to organise the building into six apartments, two per floor, all of them with a good area and proportion. Furthermore, the creation of an internal courtyard is finally successful.

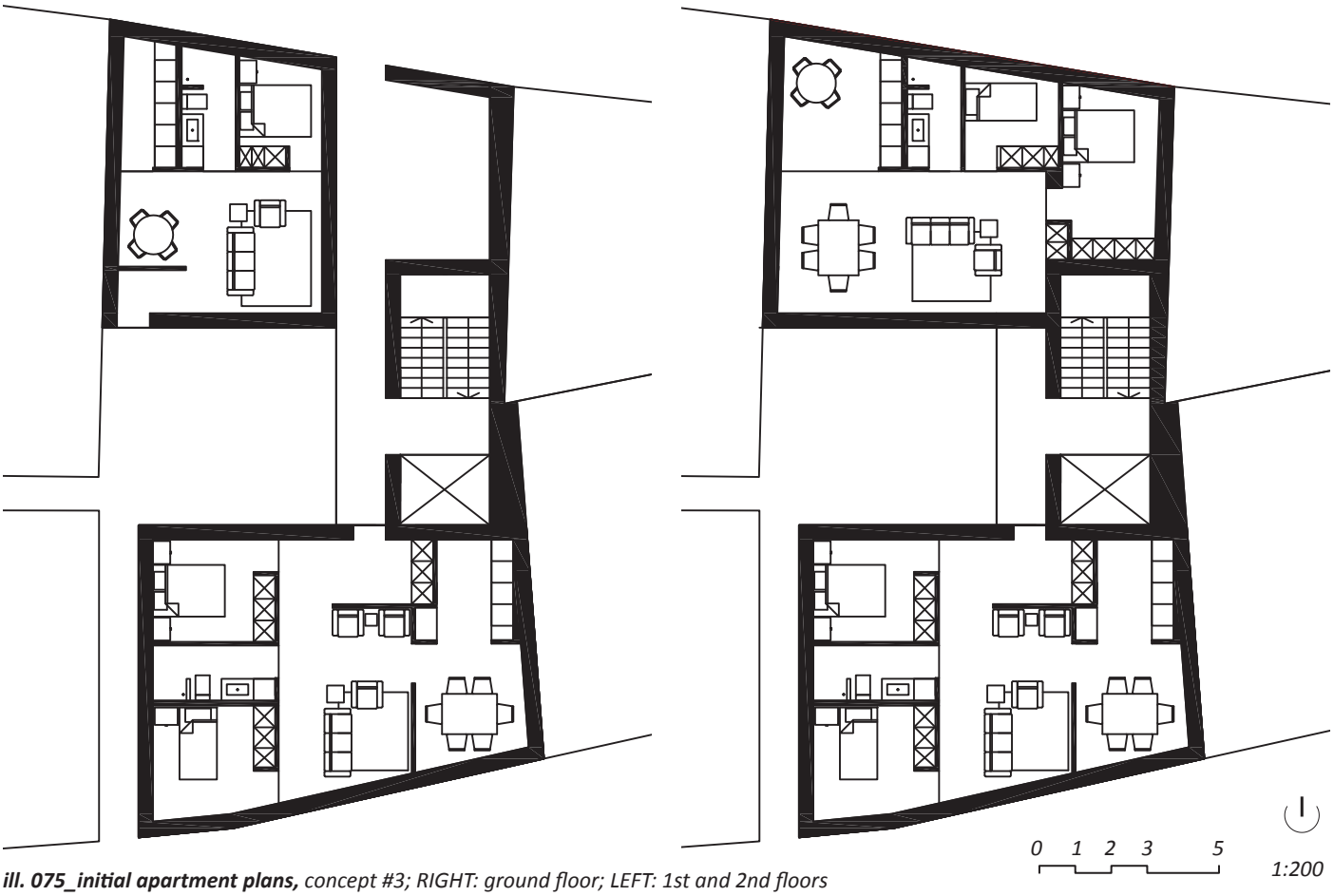
Apartment Plans

The apartments have a good area and dimensions, so it is easier to develop the plans, comparing to the other concepts.



ill. 074_*concept #3, foam model, photo*

Despite its brutish volume, concept #3 is actually the one working better in what concerns architectural intention, building organisation and apartment plans. It has potential to be further developed and refined. (see ill.075)



ill. 075_initial apartment plans, *concept #3; RIGHT: ground floor; LEFT: 1st and 2nd floors*

FINAL CONCEPT

Why Concept #3?

From the three concepts presented, one has to be chosen to proceed the design process. Concept #3 is the chosen one. It shows greater architectural quality when compared with the other two and potential be well developed through the refinement and detailing phases.

Before proceeding to the detailing phase, the concept has been refined in what regards building organisation and apartment plans.

Building Organisation

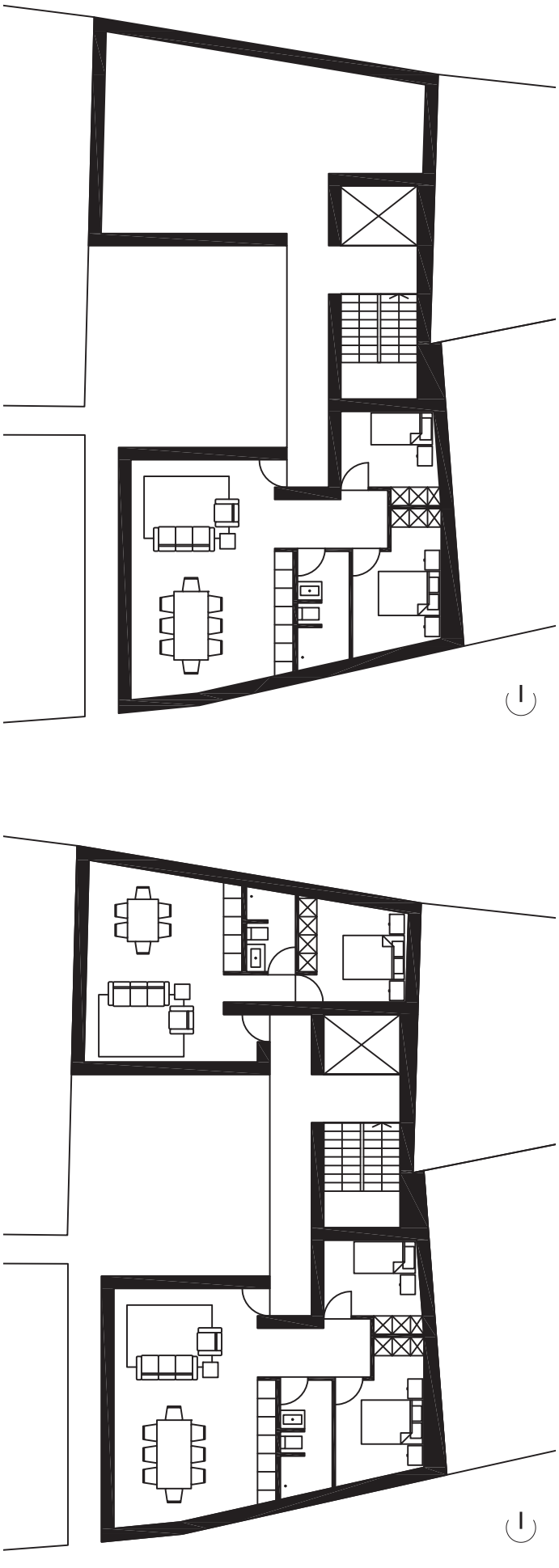
The building organisation has been refined, there is now space for two shops/cafés at the ground floor level, facing the main street and five apartments, one on the ground floor and two on 1st and 2nd floor. In this way, the public dimension of the courtyard, specially during day time.

Apartment Plans

The plans have also changed. The intention was to privilege the social areas of the apartment. Thus, in all the apartments, the living and dining room are the largest rooms and making use of the most interesting views. (windows will be detailed in p64; however, from ill.076, on the side, it is possible to have an idea where they can be placed; for the social area of the house it is actually possible to keep visual contact with the street and the internal courtyard at the same time) The entrance is always pointing to the living room and the private area of the house concealed.

The next part of the report concerns the refinement and detailing of the proposal. It will fous on the refinement of the volume, facade composition and openings, materials and construction details.

The final drawings can be seen in the Presentation Chapter. (p83 and p84)



ill. 076_*apartment plans, final concept; TOP: ground floor; DOWN: 1st and 2nd floors*

detailing

VOLUME REFINING

Intro

From the three concepts analysed before, the final concept was the one which was looking rough and massive, and, therefore, in great need of refining in order to integrate with the surroundings.

The volume refining focusses in two aspects: height and shape of the roof.

ill. 077_*three floors and flat roof, foam model, photo*

Height

The building looked very massive when having three floors, so the same building but with two floors has been tested in the foam model, scaled 1:100. (see ill.078)

The result was not good. The surrounding buildings enhance the vertical direction and by reducing the building height, it become very horizontal and out of context. Some other proposals were tried, assuming different heights for the northern and southern part of the building. However, it became clear that the volume was substantially more "fat" and not suiting the proportion and harmony of the surrounding townscape.

The search for a strategy to add verticality to the building started.

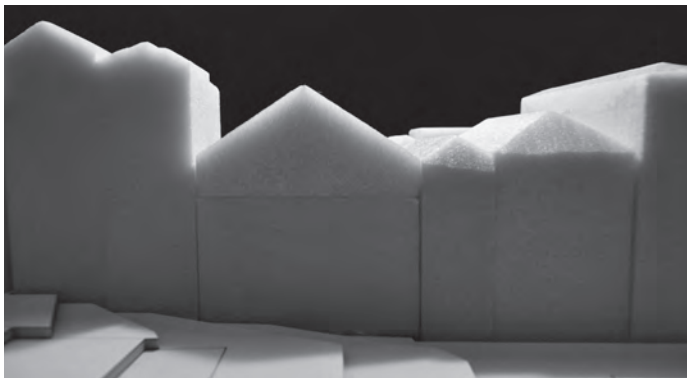
ill. 078_*two floors and flat roof, foam model, photo*

Roof

The pitched roof seemed a good strategy, not only in contributing for a vertical perception of the building but also dissolving its massiveness. Besides, the pitched roof is a characteristic of the surrounding context.

The inclination angle had to be defined. There has been some studies, see ill.081. The incliantion selected was close to the one on ill.080, a higher inclination angle but still subtle and alike the surroundings

An important detail that cannot be perceived from the foam model is the roof edges. It is a common detail in the surrounding buildings to have the edges of the roof flat, for 20 to 50 cm. The final proposal makes use of it, which helps to dissolve the brutish appearence.



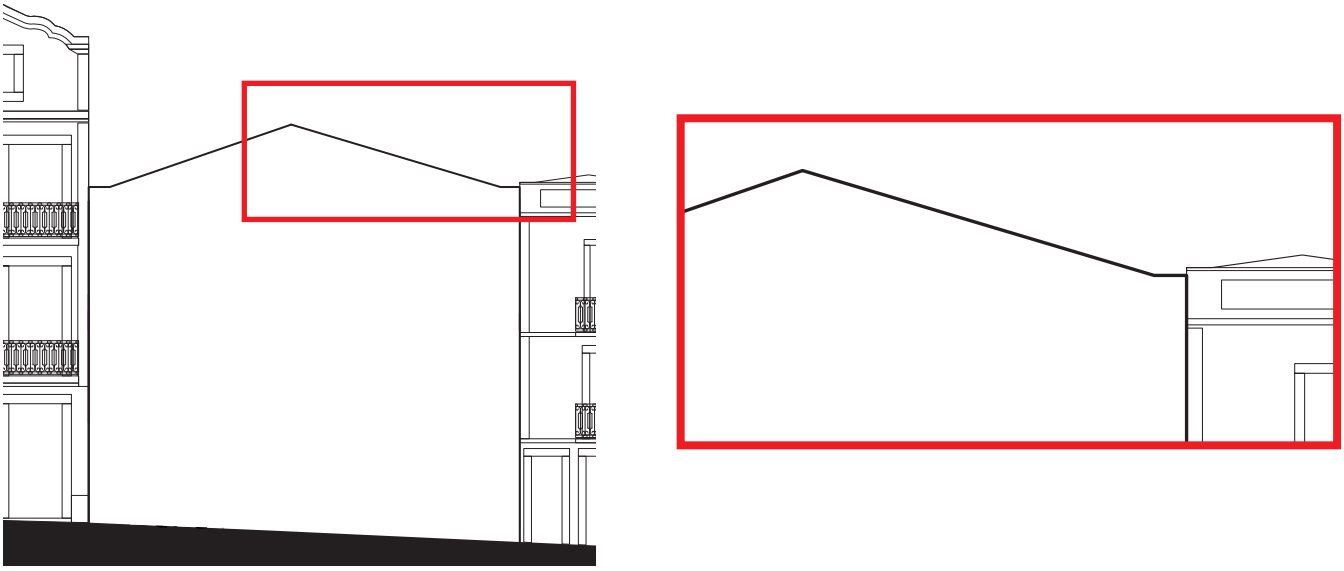
ill. 079_*pitched roof, high inclination, foam model, photo*

Final Volume

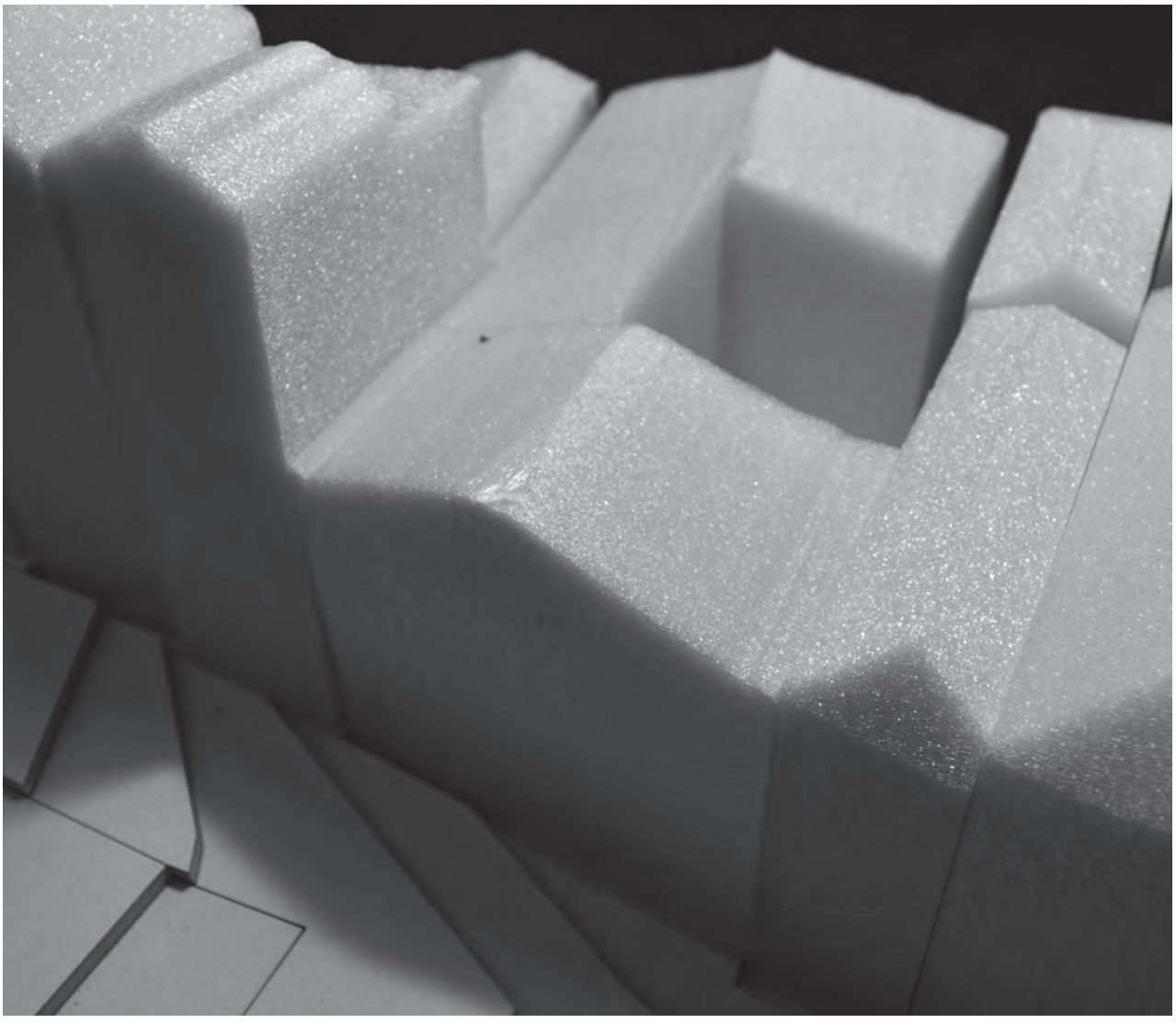
The final volume consists of three floors and makes use of pitched roof. The roof has a subttle angle, see ill.082, and makes use of flat edges on the sides.

able to keep the same height for the entire building, appropriate for facades streets and courtyard

ill. 080_*pitched roof, subtle inclination, foam model, photo*



ill. 081_ *roof edges, detail, CAD drawing*



ill. 082_*final proposal, foam model, photo*

FACADE STUDIES: OPENINGS

General

The openings design concern three main factors, natural ventilation, daylight and facade composition. Since it is a residential building and the apartment areas are relatively small, the first two don't require major concerns. However, given the historic settings and the theoretical framework behind the project, it is relevant to look deeper into the facade composition.

Therefore, and in order to fit with the surroundings, some general criteria has been defined. The windows should be vertical. Not only to suit the surrounding townscape as it is more appropriate - the streets are narrow and buildings are placed very close to each other; there is no endless landscape or horizon to contemplate, so vertical windows are more appropriate. (see ill.083 and ill.084 on the side)

Another aspect concerns the translation of private and social areas in the apartment through the facade. The living areas (kitchen, dining and living) should have bigger windows, privileged areas, more light. The private areas (bedroom and batheroom) should have smaller windows. This are used for shorter periods of time and require some privacy. Besides, there are used for small periods of time or at night, so there are no high demands for daylight. Besides, smaller windows usually allow a better thermal behaviour.

There are some exceptions to the general criteria explained in the next topics.

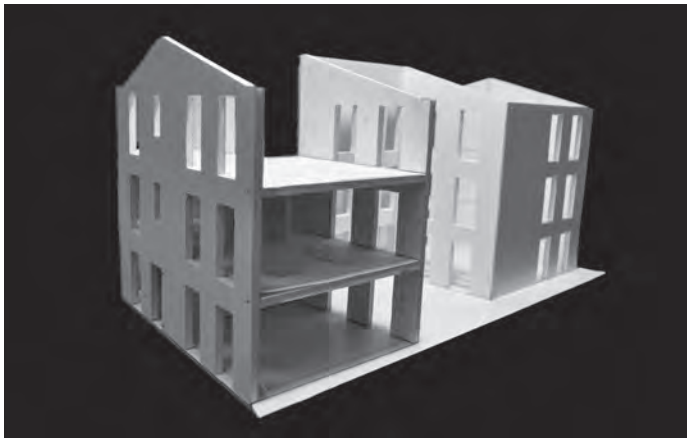
Towards Main Street (North)

The facade towards the main street has received a special treatment. Instead of a smaller window in the bedroom, it makes use of the regular window, circa 2m hight. This happens because the facade composition overules, given the importance of the facade expression towards the main street.

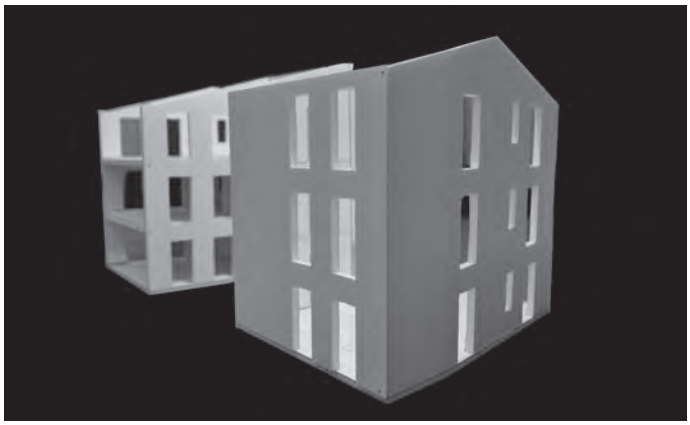
Towards Back Street (South)

The facade towards the back street also represents an exception, this time it has to do with the building orientation according to the sun.

This facade is the Southern facade, therefore, there is the need to control the glass area in the facade. The goal is to aim for less window area in order to prevent from overheating in the Summer. It is recommended to have high mass walls that are able to absorb a great anount of heat and take longer time before letting the heat pass through.



ill. 083_*openings, model, photo*



ill. 084_*openings, model, photo*

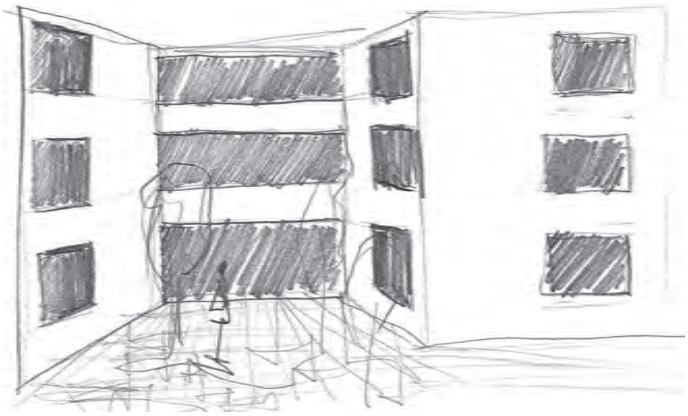
ill. 085_*inside the forest, reference picture*

ill. 086_*openings towards green facade, model, photo*

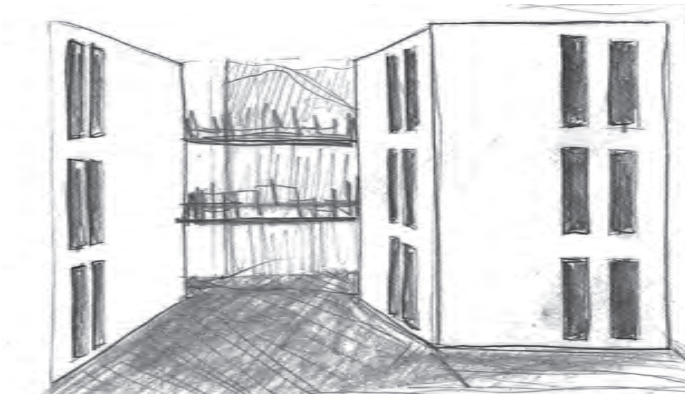
In this way, the dining room windows have been placed in the Western facade, towards a green wall. The green wall placed outdoor, attached to the next building, intends to imitate the peaceful and relaxing feeling when walking in a forest, that it is dense and not possible to see long further, but it is very green and visually relaxing. see ill.085 and ill.086

Towards Internal Courtyard

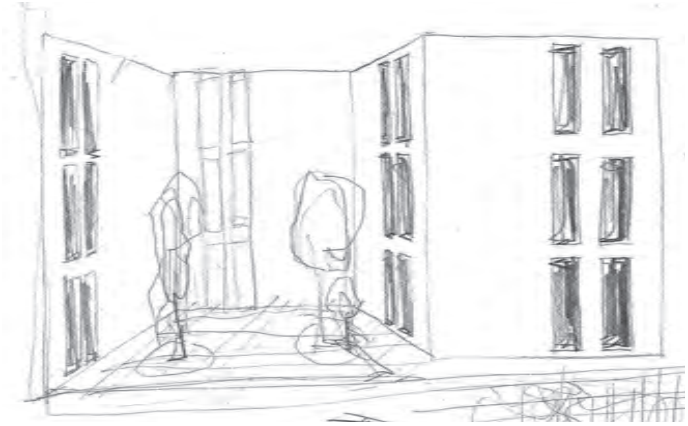
The courtyard is a key element in the project. The idea here was to give continuity to the vertical lines of the openings. So, collumns have been placed as in ill.090, below, prolonging the rhythm of the main volumes on the circulation core. When looking at ill.087, ill.088 and ill.089, it becomes clear this proposal is far more appropriated than the use of horizontal long openings or total enclosure of the circulation core facade.



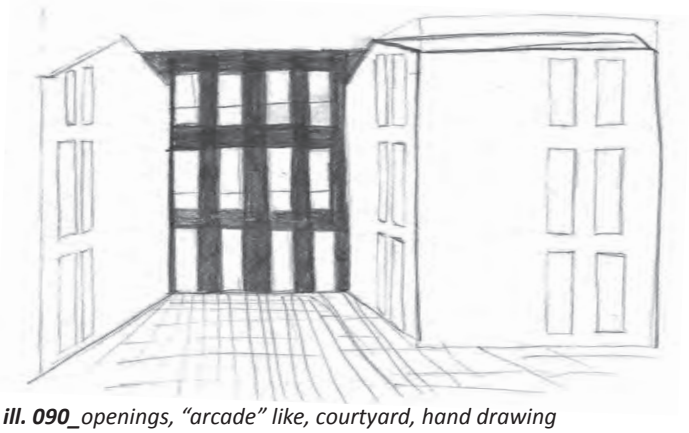
ill. 087_"fat" *openings, courtyard, hand drawing*



ill. 088_vertical and horizontal *openings, courtyard, hand drawing*



ill. 089_vertical *openings, courtyard, hand drawing*



ill. 090_*openings, "arcade" like, courtyard, hand drawing*

FACADE STUDIES: MATERIALS AND EXPRESSION

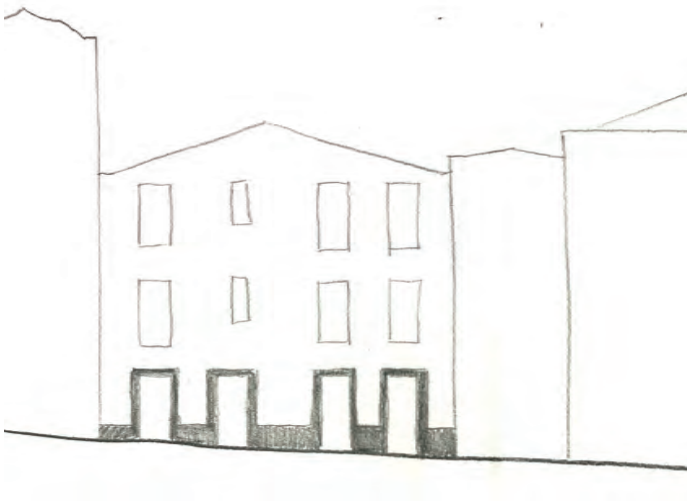
Overall Concept

The choice of materials and expression has to do with the architectural intention. As seen before in the Theoretical Framework, p16, the new building should not disturb the perception of the historic setting, but should also not hide its contemporary time as should not compromise its architectural quality.

When developing the overall expression and facade materials, the key words have been honesty and integrity.

As it will be explained in the p68, under the topic Construction System, the building structure is made of concrete, a collumn/beam/slab system, having masonry walls fullfilling the space between the collumns - very common construction in Portugal. Towards the outside is then applied plaster, in white color. Furthermore, the traditional roof tiles are also replaced by the white plaster (construction details presented in p70) The intention is to have a clean, modern appearence, afirming its own identity, but in an abstract simple expression, without disturbing the surrounding settings.

Some characteristic elements of the surrounding buildings, when appropriate, are applied - such as stone framework and iron guards. However, they should not be applied just for aesthetical reasons, but for functional, as it explained in the next topics.



ill. 091_*stone work composition, Northern facade, hand drawing*

ill. 092_*stone work composition, Northern facade, hand drawing*

ill. 093_*Northern elevation, building outline, scale 1:200*

Stone Framework

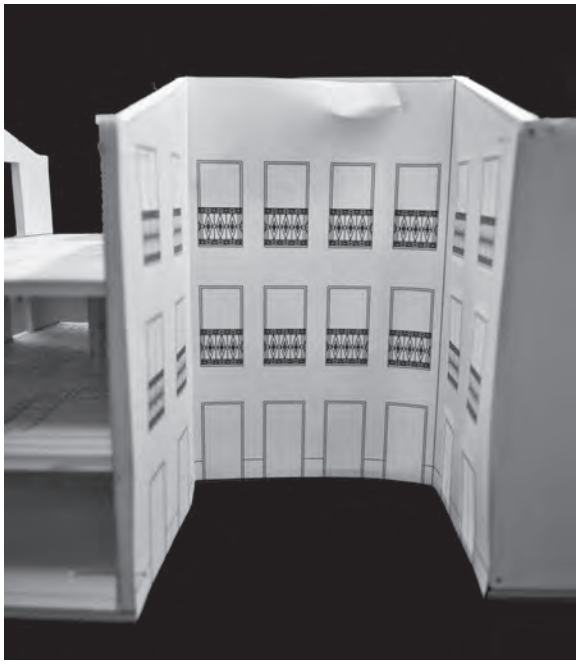
Stone framework is applied in the ground floor with the aim to protect and diferentiate the ground level. It is applied as footbar to the whole perimeter and as opening frame to some of the openings. (see ill.091, on the left hand side)

There has been some studies both from the aesthetical and thermal insulation perspectives in order to deci0de if the stone framing should be applied to the upper floors.

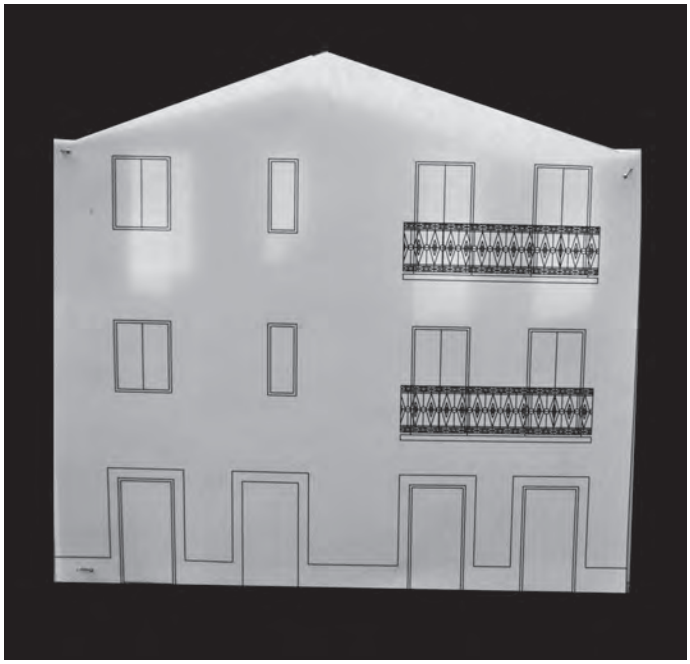
As it will be seen in the next page, under construction details, when the stone framing is applied, the thermal insulation becomes weaker. (see ill.101 and ill.102, p71 and p72, respectively) Therefore, the strategy decided is to apply the stone framing to places that host public functions and maintain high values of insulation in the places hosting residential functions.

Balconies and Iron Guards

There has also been the question about balconies and iron guards. The final proposal makes use of the iron guards, using them in a “french balcony” concept - when the balcony guard is aligned with the facade outline. In this way, the same type of balcony can be applied to all the openings: street facades, courtyard and circulation core. (see ill.094, below)



ill. 094_*iron guards study, courtyard, photo*



ill. 095_*iron guards study, Northern facade, photo*

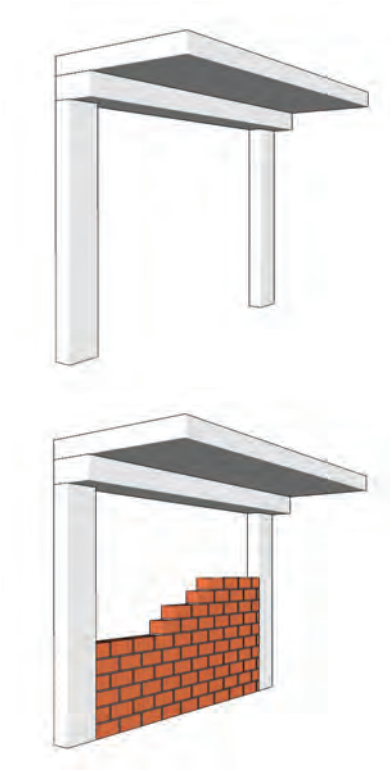
CONSTRUCTION SYSTEM

Structural System

The structural system is based on collumn/beam frames. The structural elements - collumns, beams and slabs - are made of reinforced concrete, cast in situ. Since there aren't extravagant loads and the final expression doens't make use of exposed concrete, the walls are made of self supporting masonry, holding together with a regular cement mortar - see ill.096. This solution is rather common and cheap in the portuguese context. Besides, masonry is slightly better than concrete in therms of thermal perfomance.

On the next page, ill.098 presents a plan of the structural system, with the final placement of the collumns and beams. It is also indicated the slabs' sections and direction of the reinforcement.

In order to get a better understanding of the structural elements and the influence of their dimensions and material properties, a verification of the critical beam design is presented on App.2: Structural Analysis (p.95).



ill.096_ *construction system: loadbering concrete elements and self supporting mansonry walls.*

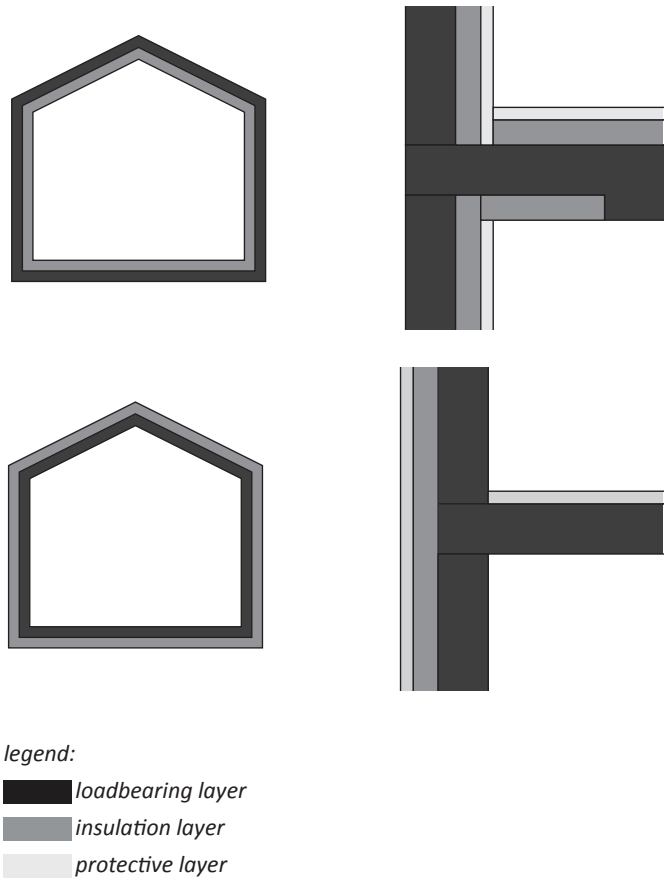
Insulation Concept

There are two main concepts to choose from when defining the insulation layer in a building construction. This concerns its placement among the loadbearing and protective layers - see ill. 097, on the right hand side.

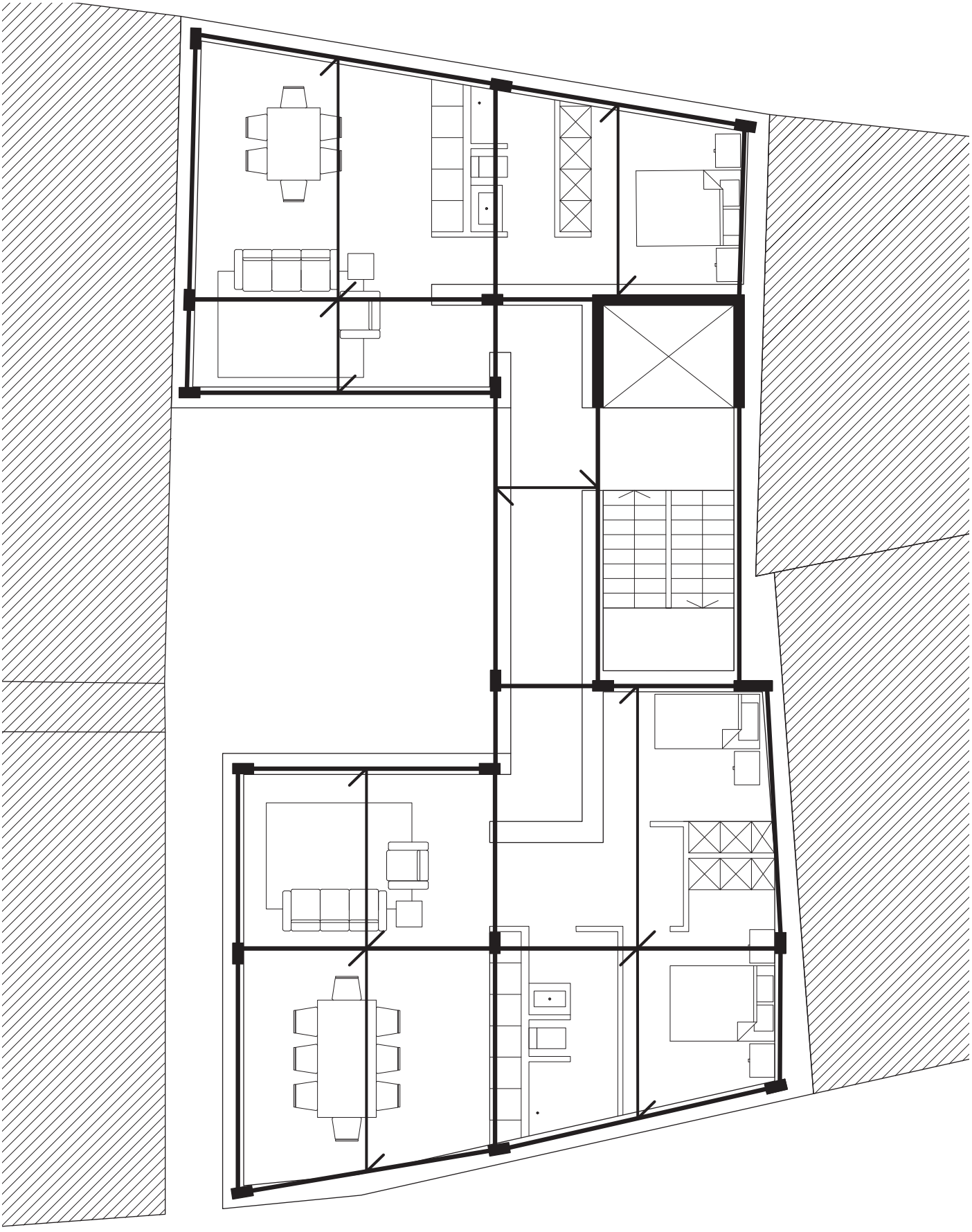
The concept on top, where the insulation layer in on the internal side is not, normally, as efficient as the one down, where the insulation is placed externally from the loadbearing layer. The fact that the loadbearing layer is placed on the "cold side", highers the chances for thermal bridges - see detail diagram of concept on top, ill.097. However, regarding holliday houses, could be more appropriate to adopt this concept, since these houses are unoccupied for long time and there is the need to warm up the place very fast and keep it warm for a shorter period of time than a everyday house.

In the concept adopted, the loadbearing layer is exclusively on the "warm side", completely enclosed within the layer of insulation. The outermost layer intents to protect the insulation against mechanical damage and climatic effects, having no loadbearing function - see ill.097, down concept. [DEPLAZES, 2008] Due to the uninterruption of the insulation layer, the thermal bridges are very reduced and the thermal perfomance is excellent. [DEPLAZES, 2008]

The next chapter looks deeper into construction details and its development according to building expression and thermal performance.



ill.097_*insulation concepts; TOP: insulation on the internal layer; conceptual diagram (on the left hand side) and diagram of wall/floor junction (on the right hand side); DOWN:insulation on the external layer; conceptual diagram (on the left hand side) and diagram of wall/floor junction (on the right hand side).*



ill.098_*structural grid: placement of collumns and beams and direction of slabs reinforcement.*

CONSTRUCTION DETAILS

General

This chapter regards construction details. The goal is to develop an understanding of how material layers should be displaced together, as well as the relation between the materials, its thickness and impact in the envelope thermal behaviour.

To proceed with this analysis, the u-value calculation is considered for different parts of the building envelope. Portuguese Regulation for Thermal Behaviour, RCCTE, is used as a guidance for the calculation and analysis of the results. (see p92, App. 1: Thermal Insulation)

The next topics analyse different parts of the building envelope. Material layers and their respective thickness are defined in order to calculate its u-value and compare it with the reference and maximum values from RCCTE. (see p92, ill.122 and ill.123) Material data has been taken from different sources - RCCTE and specific material companies website.

Marmorit u-value calculator has been used to simplify the calculations.

As it will be seen in the next topics, the different parts of the envelope have a similar u-value, rounding the 0,2 W/(m^2.K), which means the construction is efficient in what concerns thermal insulation, specially when comparing the result with the portuguese reference value, 0,7 W/(m^2.K). see p92, ill.123, on App. 1: Thermal Insulation.

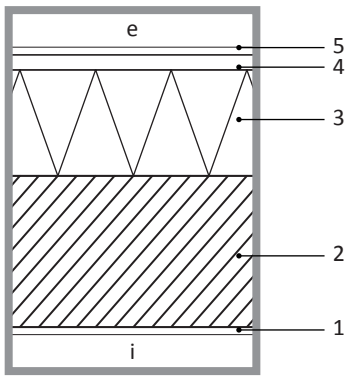
However, in what concerns the stone framework, it shows the u-value doubles. The limestone has a hight thermal conductivity level, so it requires some awareness when applying it to the building envelope, in order to keep the good level of insulation.

In this project, the intention has been to safeguard the thermal comfort in the interior of the dwellings and apply the stone framework only to the openings of the public spaces.

Building Envelope: regular

The regular envelope walls concern the self supporting masonry wall, placed in between the structural concrete collumns.

	thickness (mm)	thermal conductivity (W/(m.K))	thermal resistance ($(m^2.K)/W$)
1	10	0.160	0.063
2	200	0.446	0.448
3	140	0.038	3.684
4	20	0.830	0.024
5	10	0.050	0.200



material description:

1. plaster, white (lightweight);
2. masonry, clay bricks (self loading);
3. rigid insulation, rockwool flexi;
4. undercoat, mineral mortar;
5. plaster, white (dense);

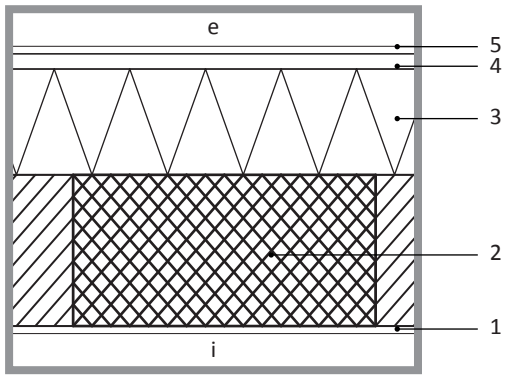
total tickness: 380 mm
u-value: 0.218 W/ (m^2.K)

ill.099_*LEFT:table compiling data regarding regular building envelope u-value; RIGHT: detail of regular building envelope*

Building Envelope: structural collumn

This representation applies when there is a structural concrete collumn. In this case, the masonry brick has the same thickness as the collumns, so it is very simple.

	thickness (mm)	thermal conductivity (W/(m.K))	thermal resistance ((m².K)/W)
1	10	0.160	0.063
2	200	1.750	0.114
3	140	0.038	3.684
4	20	0.830	0.024
5	10	0.050	0.200



material description:

1. plaster, white (lightweight);
2. reinforced concrete, C30/37 (cast in situ);
3. rigid insulation, rockwool flexi;
4. undercoat, mineral mortar;
5. plaster, white (dense);

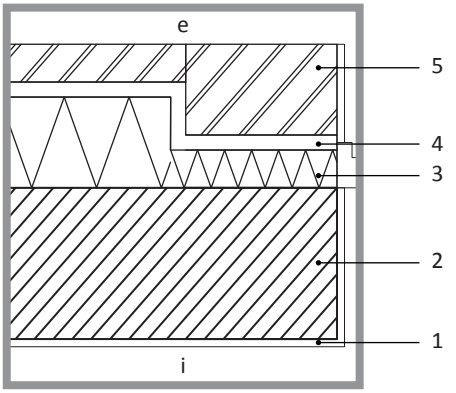
total tickness: 380 mm
u-value: 0.236 W/ (m².K)

ill.100_*LEFT:table compiling data regarding building envelope with structural collumn u-value; RIGHT: detail of building envelope with structural collumn*

Building Envelope: stone framework

This representation and calculation applies to the openings, when there is a stone framework.

	thickness (mm)	thermal conductivity (W/(m.K))	thermal resistance ((m².K)/W)
1	10	0.160	0.063
2	200	0.446	0.448
3	50	0.038	1.316
4	20	0.830	0.024
5	120	1.250	0.096



total tickness: 400 mm
u-value: 0.475 W/ (m².K)

material description:

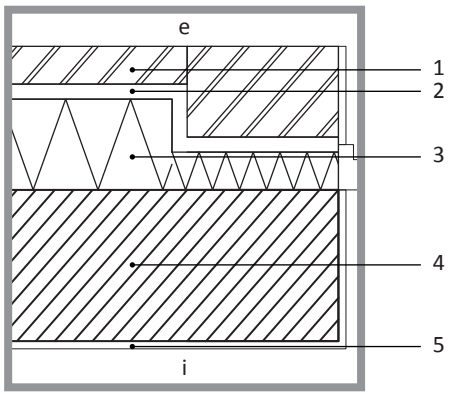
1. plaster, white (dense);
2. masonry, clay bricks (self loading);
3. rigid insulation, rockwool flexi;
4. undercoat, mineral mortar;
5. limestone;

ill.101_*LEFT:table compiling data regarding building envelope when applied stone framework u-value; RIGHT: detail of building envelope when applied stone framework*

Building Envelope: stone footage

These representation and calculation regard the lowest part of the walls, at the ground floor level, when applied the limestone footage.

	thickness (mm)	thermal conductivity (W/(m.K))	thermal resistance ((m².K)/W)
1	50	1.250	0.040
2	20	0.830	0.024
3	120	0.038	3.158
4	200	0.446	0.448
5	10	0.160	0.063



material description:

total tickness: 400 mm
u-value: 0.257 W/ (m².K)

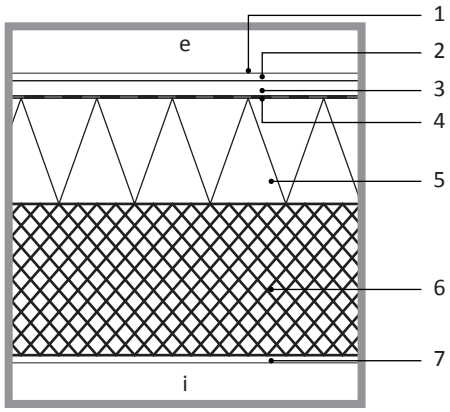
1. limestone;
2. undercoat, mineral mortar;
3. rigid insulation, rockwool flexi;
4. masonry, clay bricks (self loading);
5. plaster, white (dense).

ill.102_*LEFT:table compiling data regarding building envelope when applied stone footage u-value; RIGHT: detail of building envelope when applied stone footage*

Building Envelope: roof

This representation and calculation regard the roof slab. It is very similar to the building envelope, when there is a structural collumn, however there is two extra layers, a vapour barrier an a top coating. Their thickness and thermal conductivity can be ignored.

	thickness (mm)	thermal conductivity (W/(m.K))	thermal resistance ((m².K)/W)
2	10	0.160	0.063
3	200	1.750	0.114
5	140	0.038	3.684
6	20	0.830	0.024
7	10	0.050	0.200



material description:

total tickness: 380 mm
u-value: 0.236 W/ (m².K)

1. extra coating;
2. plaster, white (dense);
3. undercoat, mineral mortar;
4. vapour barrier;
5. rigid insulation (rockwool);
6. reinforced concrete (cast in situ);
7. plaster, white (lightweight).

ill.103_*LEFT:table compiling data regarding roof u-value; RIGHT: detail of roof*

presentation

INTRO

The project takes place in Setúbal, Portugal. It consists in the design of a new building for the historic city centre, which has been experiencing an increasing decay and desertification during the last decades.

Different approaches regarding architectural interventions within historic settings have been studied, as well as an extensive analysis of Setúbal's historic centre, in order to design with a better understanding of the place.

The final proposal results in a modern building, able to afirm its own time, while integrating and respecting the surrounding townscape.

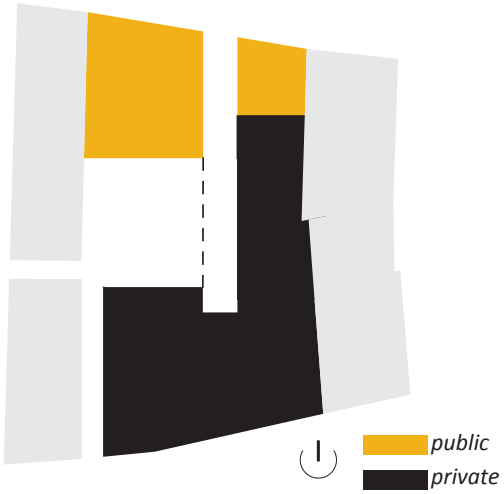
It can be described as one volume, from which is subtracted a smaller volume in the middle. A narrow street (South) and a public passage through the building (North), assure the connection between the main and the back street and encourage the discovery of the unexpected patio. see ill.104

It is a mixed use building, with five apartments and two spaces reserved for commercial use, facing the main street, at the grounf floor level. (see ill.105 and 106)

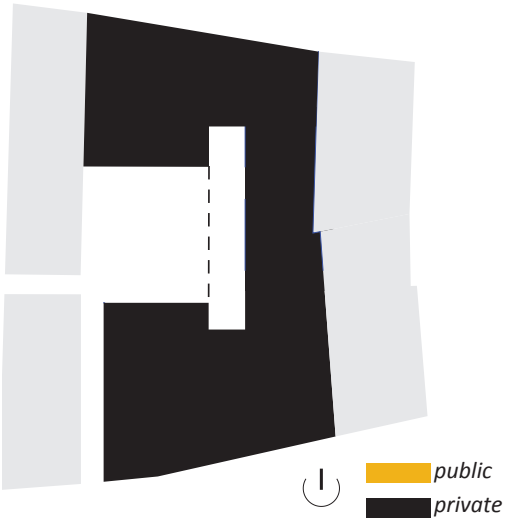
Elevations, Plans and Sections, as well as creative impressions and diagrams follow in the next pages, in order to present the final proposal.

Due to the format of the report, the drawings are presented in a smaller scale. The drawing folder - attached A3 file - complements the presentation, having the technical drawings in a more appropriate scale.

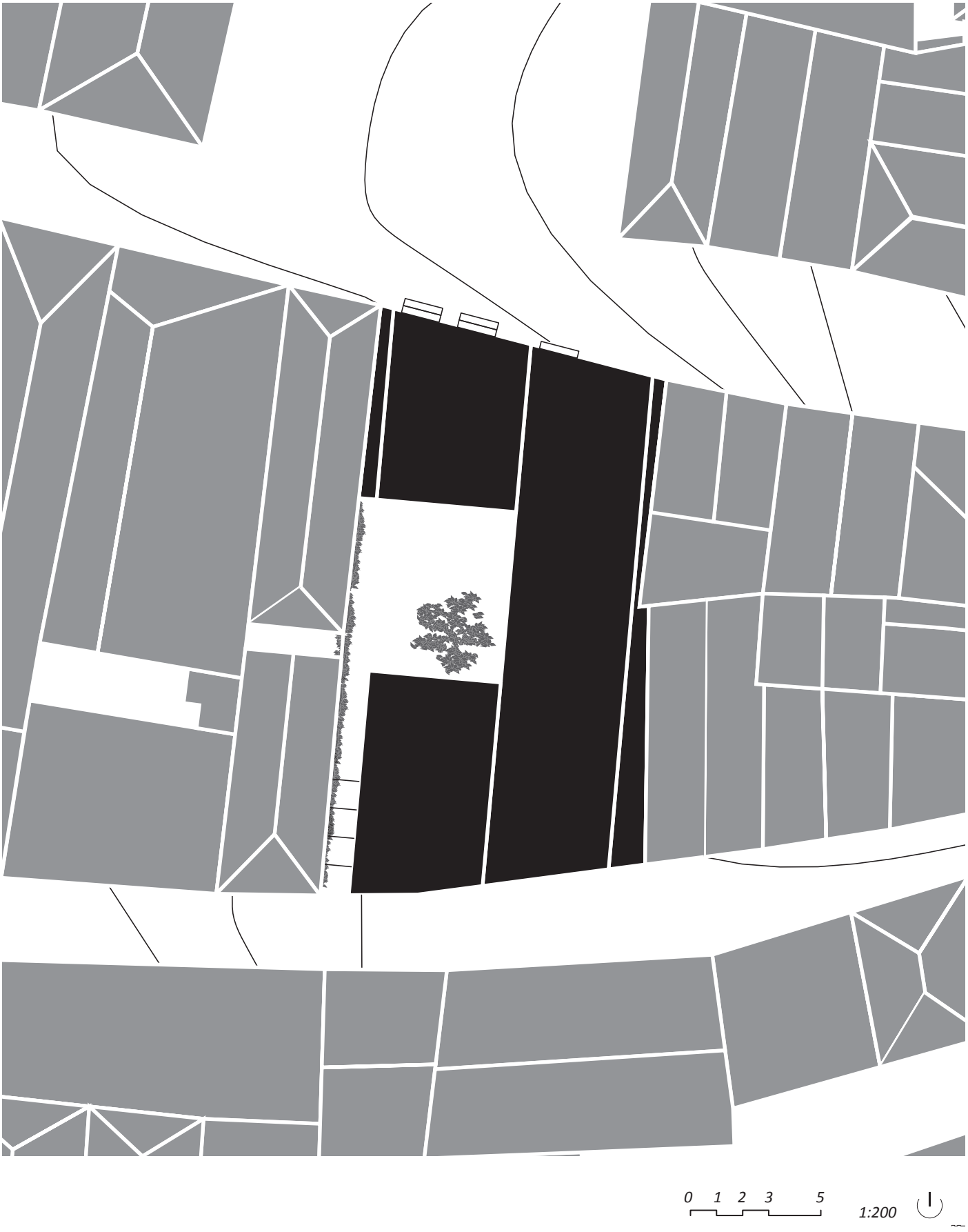
***ill.104**_public accesses and connections diagram*



***ill.105**_public/private space diagram, ground floor*



***ill.106**_public/private space diagram, 1st and 2nd floors*



ill.107_*situation plan, scale 1:200*

FACING THE STREET

The facades make use of a very simple and modern expression. They are covered in white plaster, as well as the pitched roof. Limestone footage is applied in the entire ground floor perimeter, in order to give some extra protection to the facade coating and better integrate with the surrounding townscape.

The northern facade makes use of limestone framing, in the openings that refer to public functions, a the ground floor level, as well.

The back facade has been designed with special concern regarding overheating in the Summer. Therefore, the window area is smaller.

ill.108_*Northern Elevation, scale 1:200*

0 1 2 3 5

1:200

ill.109_*Southern Elevation, scale 1:200*

0 1 2 3 5

1:200

ill.110_*Northern Facade, impression*

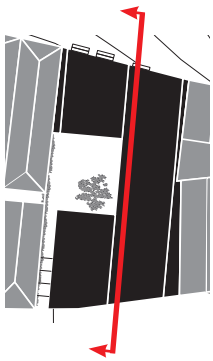
ill.111_*Northern Facade, close up, impression*

THE COURTYARD

The courtyard is the key element of the design proposal. By the simple act of subtracting a small volume from the gross volume, it is given great architectural quality to the proposal.

It allows the creation of better interior spaces, that take advantage of natural daylight, while creating an interesting interplay between public/semi public/private spaces.

***ill.112**_passage to the courtyard from South, impression*

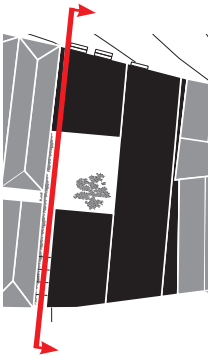


***ill.113**_section, attention to courtyard and public access from the main street, scale 1:200*

0 1 2 3 5

1:200

ill.114_*courtyard, view from top, impression*



ill.115_*section, attention to Easthern facades, scale 1:200*

0 1 2 3 5

1:200

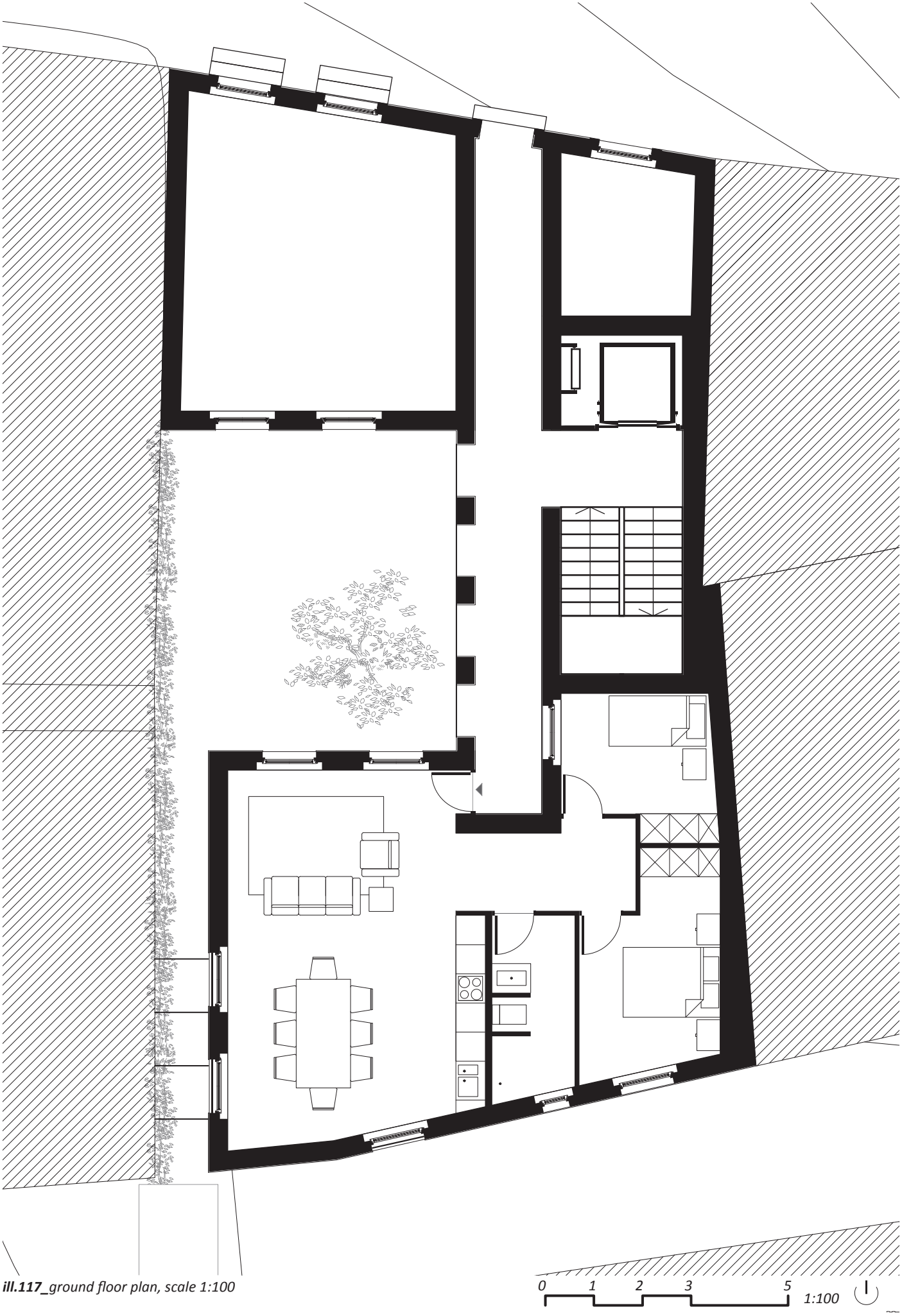
THE APARTMENTS

The dwellings are accessed through a circulation core, connected to the public passage that gives access to the courtyard.

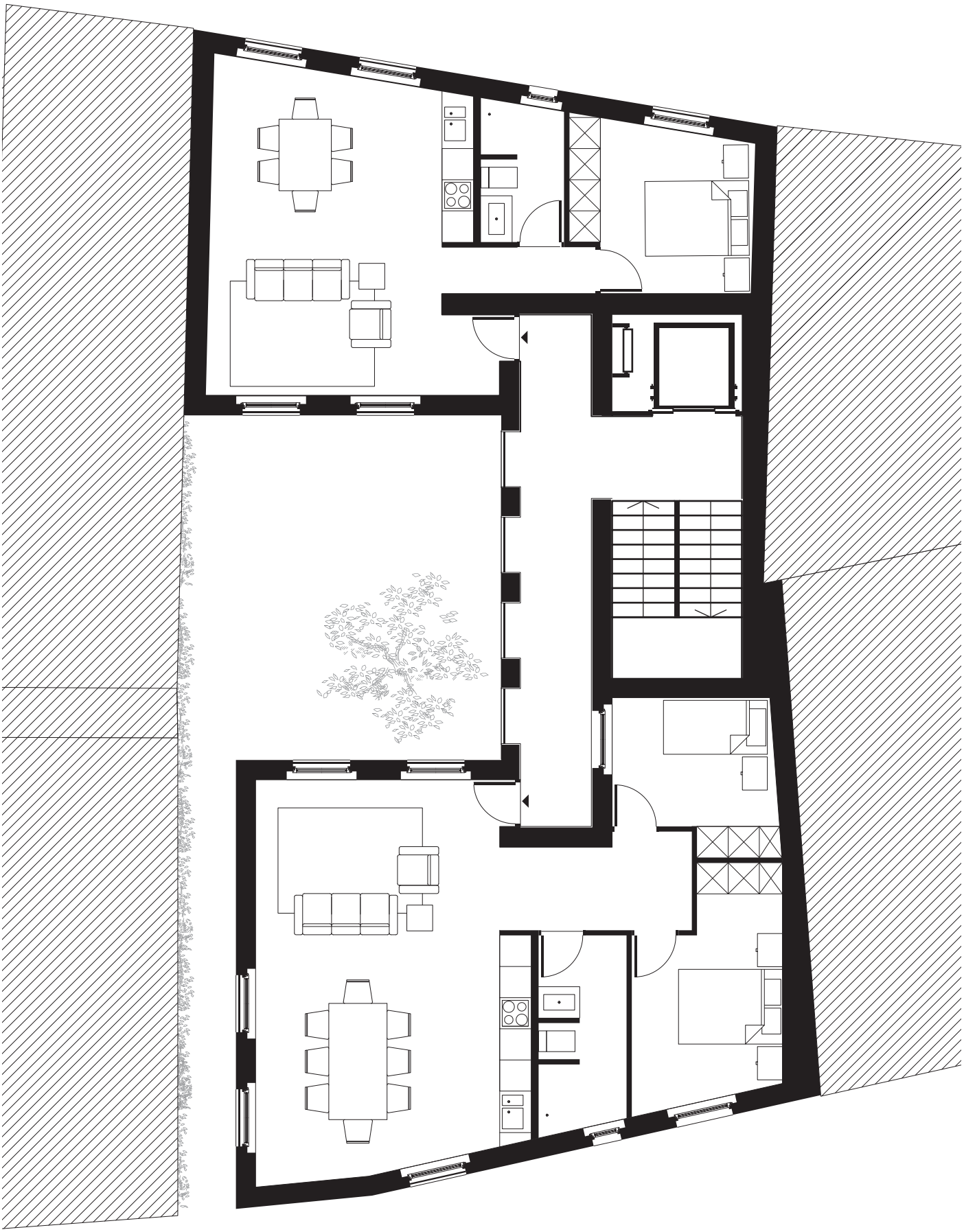
In both dwellings, the entrance is facing the living room, and the private areas are safeguarded.

All the rooms have windows and good areas. However, the privilege was given to the social areas - living and dining room -, which are designed having bigger areas, more light and better visual connections.

ill.116_*view to dining and living room, Southern apartment, impression*



***ill.117**_ground floor plan, scale 1:100*



***ill.118_**1st and 2nd floor plan, scale 1:100*

ill.119_*view to dining and living room, Northern apartment, impression*

outro

REFLECTION

Topic

It has been fascinating to work within the topic of Architecture in Historic Settings. It is, though, a broad subject, influenced by several different matters, that pushes the initial investigation into a longer process than initially planned.

It has been difficult to strickly follow the planning, and must be recognised that there's been too much time spent with the analysis phase, that could have been useful in the design process phase.

Anyway, I'm pleased with the knowledge acquired, both regarding the topic and Setúbals historic centre and I believe it has been crucial to for the design process.

Design Process

As said before, it was really interesting to get an holistic perspective about Setúbal's historic centre. However, it was very difficult to focus in the design of a single building after such broad research. This means, to pass from such the analysis of the whole historic centre, circa 1 000 000 sqm, to the development of a 330sqm plot.

The design process has made a great use of hand drawing and modelling workshops, which allowed a sensitive approach to the site and a sensitive analysis of the impact of the sketching proposals in the surrounding townscape. Digital tools - such as digital modeling and lasercutter technology - speeding up the testing phase and allowing to proceed with a solid understanding of each proposal.

Some phases of the design process were very time consuming. Special attention was given to the initial volume and room distribution, which compromised the development of the detailing phase.

Final Result

In general, it has been a positive experience. The project allowed the development of knowledge in new areas and an extension of working tools and skills.

I have become more fluent in specific software, Autocad, Rhino + V-Ray, Adobe Suite Collection (InDesign, Photoshop and Illustrator) which are very useful when presenting, not only this but future projects.

The project itself developed into a simple proposal, according to the principles and ethics studied in the Theoretical Framework, p16 and p17.

In such a project, I believe it could have been nice to go further in the detailing phase. I believe that in this phase would enhance the connection new building/surrounding, by making use of the *Architecture and Materials* topic, p28, developed in the Analysis phase.

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[web: meteo] http://meteo.pt
[web: wikipedia, r-value] http://en.wikipedia.org/wiki/R-value_(insulation)

Illustrations

If nothing said, the illustration is own production.

ill.001: own production, data from PEREIRA, Margarida. in *Setúbal, a Cidade e o Rio, Revalorizar a Frente Ribeirinha, p.63*
ill.002: own production, based on KNUSTRUP, Mary-Ann. in *The Aalborg PBL Model : Progress, Diversity and Challenges*
ill.005: http://www.vazquezconsuegra.com/JardinesValencia.html
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ill.041: own production, data from Municipality
ill.042: own production, data from Municipality
ill.046: own production, data from Municipality
ill.047: data from National Statistic Poll 2001, *Censos 2001*
ill.048: data from National Statistic Poll 2001, *Censos 2001*
ill.049: data from National Statistic Poll 2001, *Censos 2001*
ill.050: data from National Statistic Poll 2001, *Censos 2001*
ill.051: data from National Statistic Poll 2001, *Censos 2001*
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ill.056: own production, data from Municipality
ill.057: http://maps.google.com/
ill.064: http://solardat.uoregon.edu/SunChartProgram.html
ill.085: http://gettyimages.com
ill.120: RCCTE
ill.121: RCCTE
ill.122: RCCTE
ill.123: RCCTE
ill.127: EUROCODE 4
ill.128: EUROCODE 3
ill.129: EUROCODE 3

APPENDIX 1: THERMAL INSULATION

Portuguese Regulation, RCCTE

This appendix aims to compile relevant regulation regarding thermal comfort. Since the building is situated in Portugal, portuguese regulation is considered.

The main regulation for indoor climate in Portugal is the *Regulamento das Características de Comportamento Térmico dos Edifícios*, RCCTE. In this project, the RCCTE has been used to calculate and evaluate the thermal efficiency of constructions elements, through the U-Value calculation, as the next topic will explain.

U-Value Calculation

The U-Value is a measure of thermal resistance, under uniform conditions. [web: wikipedia, r-value] It normally relates to the topic of insulation.

It is calculated through the expression

$$U = 1 / (R_{si} + R_j + R_{se})$$

R_{si}: internal superficial resistance
R_{se}: external superficial resistance
R_j: resistance of each material layer

The internal and external superficial resistance are defined by the RCCTE, and varie according to the placement of the element and the direction of the heat flow. The values are compiled and presented in ill.121.

The resistance of the material layers can normally be found in material tables, otherwise, it is calculated according to the thickness and thermal conductivity of the material, through the expression

$$R_j = e_j / \lambda_j$$

e_j: thickness of the layer
λ_j: thermal conductivity of the material

The RCCTE sets the maximum and reference u-values, according to the climatic zone of the building - see ill.120, on the next page - and the placement of the element, see ill.122 for maximum u-value allowed and ill.123 for reference values.

The U-Value Calculation has been used in the detailing phase of the project, in order to optimise the design of construction elements, by integrating not only aesthetical and architectural intention, but also technical criteria. Therefore, when detailing the building envelope, different combinations of layers have been tested according to their thermal resistance and evaluated according to the RCCTE tables.

For the calculation itself, the Marmorit U-Value Calculator has been used, which permited to fast and easily test different materials and thickness combinations. It allowed, as well, to get a better understanding of the impact of different layers - insulation, structural and protective - and their contribute in terms of building insulation.

On p70 to p72, under the chapter of Design Process, it is presented the solution for different parts of the buildind envelope, and how they meet.

Energy Classes

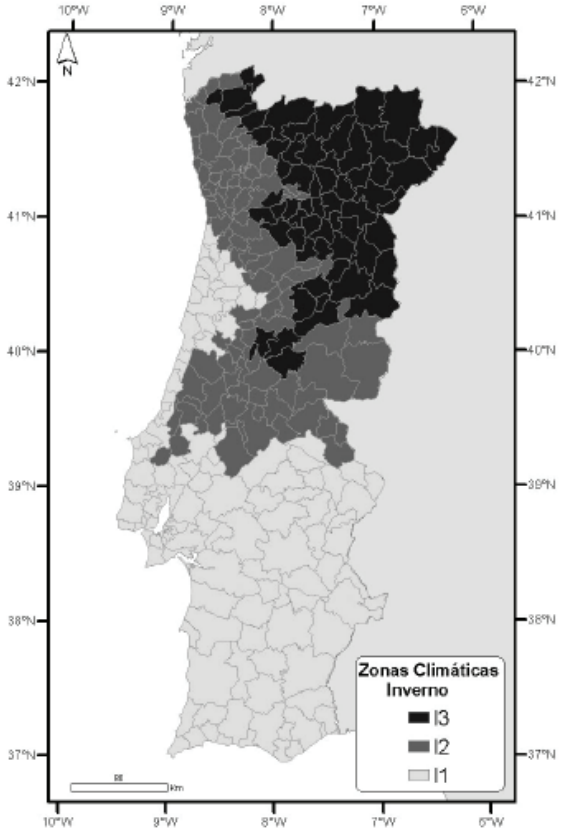
Energy Classes is a complementary system to the portuguese thermal regulation that is now being implemented in Portugal. It is more complete and demanding than the RCCTE, and aims to categorise building construction according to their overall energy consumption. Therefore, it addresses the topics of insulation and heat gain/loss, but it is not so easy to integrate it as a tool in the design process. It is a very detailed and time consuming tool and, therefore, it is mainly used as a verification tool, in order to categorise building construction in an environmental scale.

For this project, it was considered more relevant to work with a tool able to give feedback earlier in the design process.

However, when comparing the U-Value requirements from the RCCTE with the Danish Regulamention, it is impressive how low the portuguese requirements are, outstanding the call for an update of the RCCTE or the new Energy Classes system.

Consequently, while detailing the building envelope, the intention was not to be within the RCCTE reference values, but to achieve better values. For example, the reference u-value for external walls in climatic zone I_1, where the project takes places, is 0,70 W / (m^2K), see ill.123. To stress that this is not the maximum alllowed, but the value that should be used as reference. It is very low! Therefore, the goal has been achieve a lower value, around 0,35 W / (m^2K).

As mentioned before, the construction details can be seen on p.70 to p72.



ill.120 _ *Winter Climatic Zones in Portugal, according to RCCTE*

Resistências térmicas superficiais

Sentido do fluxo de calor	Resistência térmica superficial ($m^2 \cdot °C/W$)		
	Exterior R_{se}	Local não aquecido (*) R_{se}	Interior R_{si}
Horizontal (**)	0,04	0,13	0,13
Vertical (***):			
Ascendente	0,04	0,10	0,10
Descendente	0,04	0,17	0,17

(*) Os valores indicados traduzem o facto de, no caso do cálculo do coeficiente de transmissão térmica de um elemento que separa um local não aquecido de um local aquecido, se adoptar $R_{se} = R_{si}$.

(**) Aplicável a paredes (até mais ou menos 30° com a vertical).

(***) Aplicável a coberturas e pavimentos

ill.121_ *table compiling superficial thermal resistance values, according to RCCTE*

Coeficientes de transmissão térmica superficiais máximos admissíveis de elementos opacos

(U-W/m²ºC)

Elemento da envolvente	Zona climática (*)		
	I_1	I_2	I_3
Elementos exteriores em zona corrente (**):			
Zonas opacas verticais	1,8	1,60	1,45
Zonas opacas horizontais	1,25	1	0,90
Elementos interiores em zona corrente (***):			
Zonas opacas verticais	2	2	1,90
Zonas opacas horizontais	1,65	1,30	1,20

(*) V. anexo III.
(**) Incluindo elementos interiores em situações em que $\tau > 0,7$.
(***) Para outros edifícios e zonas anexas não úteis.

ill.122 *_ table compiling maximum u-values, according to RCCTE*

Coeficientes de transmissão térmica de referência

(U-W/m²ºC)

Elemento da envolvente	Zona climática (*)			
	I_1	I_2	I_3	RA (**)
Elementos exteriores em zona corrente:				
Zonas opacas verticais	0,70	0,60	0,50	1,40
Zonas opacas horizontais	0,50	0,45	0,40	0,80
Elementos interiores em zona corrente (***):				
Zonas opacas verticais	1,40	1,20	1	2
Zonas opacas horizontais	1	0,90	0,80	1,25
Envidraçados (***)	4,30	3,30	3,30	4,30

(*) V. anexo III.
(**) Regiões Autónomas da Madeira e dos Açores, apenas para edifícios na zona I_1.
(***) Para outros zonas anexas não úteis.
(****) Valor médio dia-noite (inclui efeito do dispositivo de protecção nocturna) para vãos envidraçados verticais; os vãos envidraçados horizontais consideram-se sempre como se instalados em locais sem ocupação nocturna.

ill.123 *- table compiling reference u-values, according to RCCTE*

APPENDIX 2: STRUCTURAL ANALYSIS

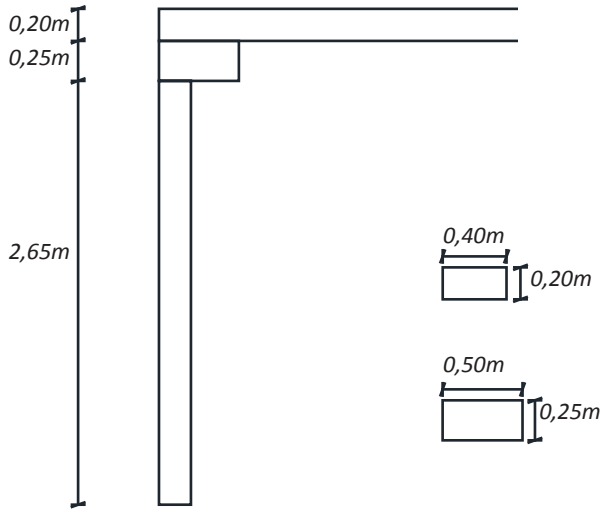
Intro

The structural analysis aims to verify the dimensions of a reference beam (the worst/critical case) according to Ultimate Limit States, ULS, and Service Limit States, SLS. The critical beam is placed in the north western part of the building, at the first floor level - see ill.125, below, on the right hand side. For a better understanding, the analysis is organised into five steps: 1) Pre-Dimension, 2) Data, 3) Loads, 4) Load Combination and 5) Verification.

1) Pre-Dimension

In this first step, the structural elements - collum, beam and slab - are dimensioned. The values are assumed having as reference similar projects - 3 floors, residential functions.

The dimensions adopted can be seen in ill.124, on the right hand side.



ill.124 _ *dimensions adopted for reinforced collumn, beam and slab*

2) Data

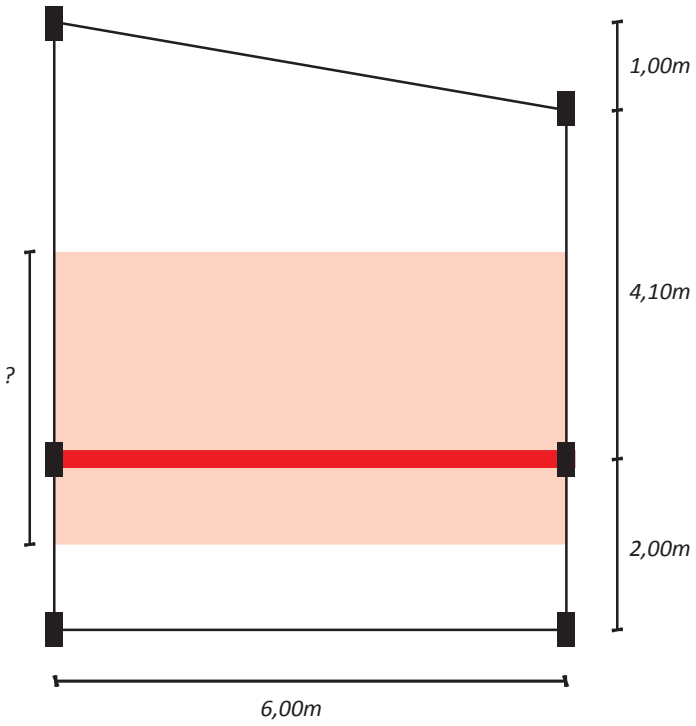
To proceed with the structural calculation, it is necessary to define the area of influence, colored in ill.125. The influence area is the area related to the critical beam. The loads applied to this area, are transmitted to this beam. The influence area is calculated as a normal area

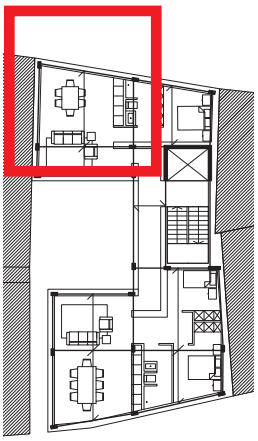
$$A_i = b \cdot l$$

l = 6,00m
b = (2,00/2) + ((4,10+5,10)/2)/2 = 1,00 + 2,30 = 3,30m

A_i = 3,30 . 6,00 = **19,80m²**

Since the structural system is in reinforeced concrete (RC), it is necessary to have RC characteristic weight, **25 kN /m³** [NP EN 1991-1-1-2009, EUROCODE 1, p30, Appendix A, Table A.1]





ill.125 _ *area of influence*

3) Loads

The relevant loads for ULS and SLS verification are:

- self-weight;
- live load;
- wind load;
- snow load.

Self weight

The self weight is calculated by the sum of the weight of relevant construction elements. In this case, the relevant elements are only the RC collumns, beams and slabs. The masonry walls are self supporting elements, therefore is

more correct they are ignored. The weith of the other materials is minimal and can be ignored. Therefore, the self weight is given by

$$Q_{SW} = (V_s \cdot W_{RC} \cdot n_{s+r}) + (V_b \cdot W_{RC} \cdot n_b) + (V_c \cdot W_{RC} \cdot n_c)$$

V_s, V_b, V_c: volume of the slab, beam and collumn elements
W_{RC}: characteristic weight of reinforced concrete
n_{s+r}, n_b, n_c: number of elements - slab and roof, beam and collumn - within the influence area

Therefore,

$(V_s \cdot W_{RC} \cdot n_{s+r})$ = (0,20 . 3,30 . 6,00) . 25,00 . 3 = **297 kN**
= **49,50 KN/m** (*)

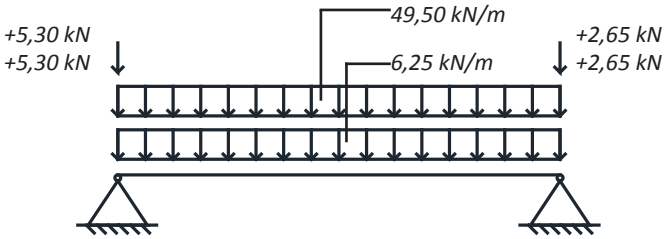
$(V_b \cdot W_{RC} \cdot n_b)$ = (0,25 . 0,50 . 6,00) . 25 . 2 = **37,5 kN**
= **6,25 KN/m** (*)

$(V_c \cdot W_{RC} \cdot n_c)$ = (2,65 . 0,20 . 0.40) . 25 . (1,5 . 2)
= **15,90 kN**
= 2 . 5,30 kN + 2 . 2,65 kN (**)

(*) because it is a distributed load, the result is divided by the lenght of the element.
(**) the collumn on the left side is part of the external wall, so its whole weight is acting in the area of influence; the collumn on the right side is internal, so only half of its weight is applied.

Q_{SW} = 297,00 + 37,50 + 15,90 = **350,40 kN**

Underneath, ill.126, can be seen a diagram with the self weight load distribution.



***ill.126** _ diagram of self weight loads acting on the reference beam*

Live load
The live load is given according to the function of the building and its value is defined by regulations. In this case, the building belongs to category A, residential functions, and the regulamentar live load is **2kN/m²**. [NP EN 1991 -1-1-2009, p19, table 6.1]. When applied to this case, the live load is

$$Q_{LL} = Q_A \cdot A_i \cdot n_f$$

Q_A= regulamentar live load

A_i= area of influence

n_f = number of floors

Therefore,

Q_{LL} = 2,00 . 3,30 . 6,00 . 2 = **79,20 kN**
Q_{LL} = **13,20 kN/m**(*)

(*) because it is a distributed load, the result is divided by the lenght of the element.

Wind load
The wind load is calculated according to the Eurocode 1, part 4. It is given by the expression

$$Q_w = c_s c_d \cdot q_p(z) \cdot A_i$$

[NP EN 1991-1-4-2010, p31, (5.3)]

$c_s c_d$ = structural coefficient
$q_p(z)$ = dynamic pressure, according to construction height
A_i = area of influence

In this case,
$c_s c_d$ = 1,00; the building height is less than 15,00m
[NP EN 1991 -1-4-2010, p33, (6.2)]

$$q_p(z) = c_e(z) \cdot q_b$$

$c_e(z)$: exposition coefficient
q_b : reference dynamic pressure, given by the expression

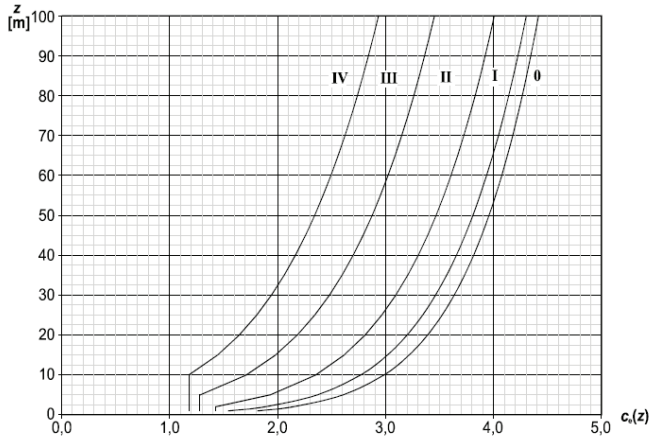
$$qb = 1/2\ \rho \cdot v_b^2$$

ρ: air density
recommended value is **1,25 kg/m³ =12,25 N/m³**

[NP EN 1991 -1-4-2010, p28, (4.5)]

v_b: reference value for wind speed is **4 km/h = 1,11 m/s**
c_e(10,5m) = 1,20

[graphic evaluation, , see ill.127, below; category IV, NP



***ill.127** _ exposition coefficient according to building height, graphic, from EUROCODE 4*

EN 1991 -1-4-2010, p25, table 4.1]

Q_w = 1,00 . (1,20 . (1/2 . 1,25 . 1,11²)) . (3,30 . 6,00)
= **17,97 kN**

Q_s = 0,80 (0,190 . 1 - 0,095) (1+ (12/524)²) = **0,076 kN/m²**
= 1,50 kN (*)
= 0,25 kN/m (**)

(*) when applied to the area of influence
(**) because it is a distributed load, the result is divided by the lenght of the element.

Snow load
The snow load is calculated according to Eurocode 1, part 3. It is calculated through the expression

$$Q_s = \mu_i S_k$$

[NP EN 1991-1-3-2009, p17, (5.2)]

μ_i : coefficient of shape for snow load
S_k : snow characteristic value, at ground level

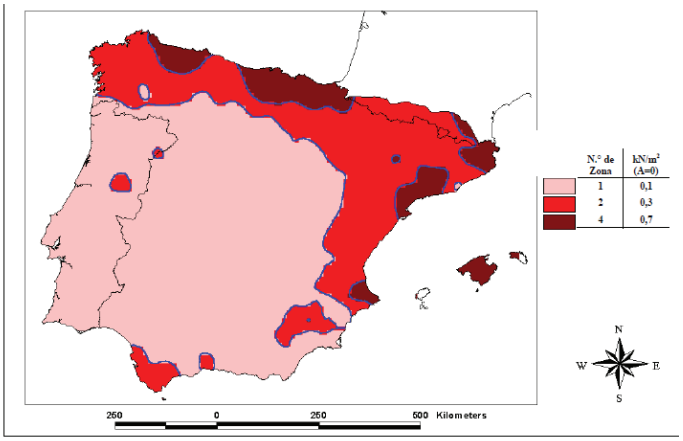
μ_i = 0,80

[NP EN 1991-1-3-2009, p19, (5.2)]

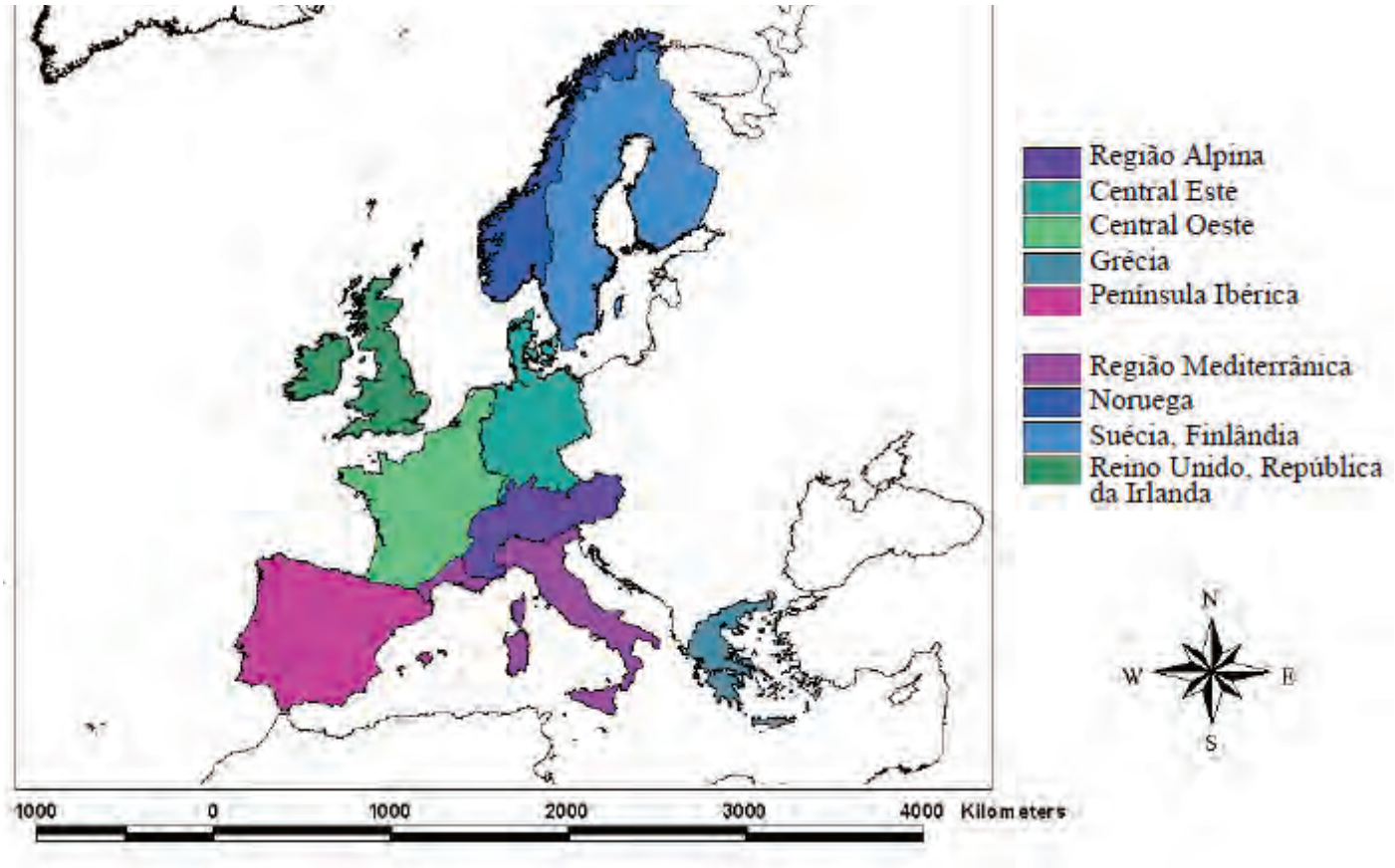
S_k = (0,190Z - 0,095) (1+(A/524)²)

Z: number of the zone, from Iberic Peninsula map = 1
A: local height, above sea level = 12,00 m

[NP EN 1991-1-3-2009, p34, table C.1]



ill.128_ *snow load at sea level, Iberic case, map, from EUROCODE 3*



ill.129_ *european climatic regions, map, from EUROCODE 3*

4) Load Combination

The loads have been calculated,
Q_{sw}=350,40 kN
Q_{LL}= 79,20 kN
Q_{W}= 237,60 kN
Q_{S}= 1,50 kN

it is now time for the load combinations. The load combinations regard Ultimate Limit State, ULS, and Servive Limit State, SLS. The ULS allows the verification of maximum stress, while the SLS the maximum deflection.

The ULS combinations are:

1) self-weight dominating

$$1{,}2 \cdot Q_{SW}$$

= 420,48kN

2) live load dominating

$$1{,}00\ Q_{SW} + 1{,}50\ Q_{LL} + 1{,}50 \cdot 0{,}30\ Q_{W} + 1{,}50 \cdot 0{,}30 \cdot Q_{S}$$

= 477,96 kN

3) wind load dominating

$$1{,}00\ Q_{SW} + 1{,}50\ Q_{W} + 1{,}50 \cdot 0{,}50\ Q_{LL} + 1{,}50 \cdot 0{,}30 \cdot Q_{S}$$

= 437,43 kN

4) snow load dominating

$$1{,}00\ Q_{SW} + 1{,}50\ Q_{S} + 1{,}50 \cdot 0{,}30\ Q_{LL} + 1{,}50 \cdot 0{,}30 \cdot Q_{W}$$

= 396,38 kN

The SLS combinations are:

1) live load dominating

$$1{,}00\ Q_{SW} + 1{,}00\ Q_{LL} + 0{,}30\ Q_{W} + 0{,}30\ Q_{S}$$

= 435,44 kN

2) wind load dominating

$$1{,}00\ Q_{SW} + 1{,}00\ Q_{W} + 0{,}50\ Q_{LL}$$

= 407,97 kN

3) snow wind dominating

$$1{,}00\ Q_{SW} + 1{,}00\ Q_{S} + 0{,}50\ Q_{LL} + 0{,}3\ Q_{W}$$

= 396,891 kN

Both on the ULS and SLS, the critical load concerns the live load dominating combination. Using the load value, it is now possible to verify the maximum stress and maximum deflection allowed.

5) Verification

As said previously, the ULS load combinations apply to the verification of the maximum stress allowed, given by the expresssion

$$\sigma_{max} < f_{ck}$$

[NP EN00 1992-1-1]

f_{ck}: characteristic value of breaking stress of concrete, when is 28 days old

The basic expression for stress is

$$\sigma = P/A$$

P: load
A: area of influence

Then,

$$P_{max} / A_i < f_{ck}$$

P_{max} = 477,96 kN [ULS, live load combination result]
A_i = 19,8 m^2
f_{ck} = 30 MPa [1MPa = 1000 $kN/m^{2\sim}$]

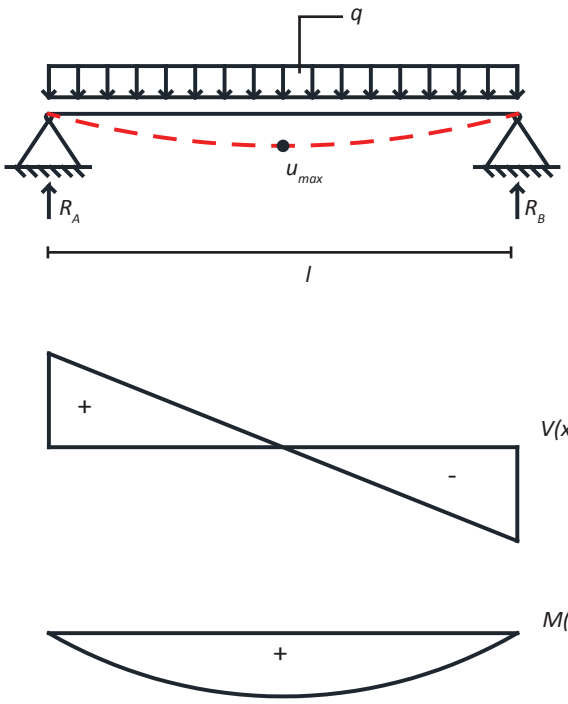
σ_{max} = 24,14 kN/m^2 < 30 MPa OK!

The SLS load combinations apply to the verification of the maximum deflection allowed, which is given by the expresssion

$$u(x)_{max} < l/250$$

[NP EN00 1992-1-1]

It is then necessary to calculate the maximum deflection of the beam, when the highest SLS load combination is applies. Therefore, a diagram with the load and reaction can be seen in underneath and after, the determination of the maximum deflection of the beam.



$R_A = R_B = (1/2)\ q$

$M(x) = (1/2)\ q \cdot x \cdot (l - x)$

$M_{max} = M(x=l/2) = (1/8)\ q \cdot l^2$

$u(x) = ((q \cdot l^3 \cdot x) / (24\ EI)) \cdot (1 - 2(x/l)^2 + (x/l)^3)$

$$u_{max} = u\ (x=l/2) = 5/384\ .\ (q\ .\ l^4)/(EI)$$

q: highest value of SLS load combination [435,44 kN]
l: beam lenght [6,00 m]
E: coefficient of elasticity [33 000 MPa = , for C30/37, NP EN 1992-1-1]
I: moment of Inertia

Since the beam section is rectangular, the moment of Inertia is calculated through the expression

$$I = (1/12)\ b\ .\ h^3$$

b: width of the beam [0,50m]
h: height of the beam [0,25m]

l/250 = 6/250 = **0,024 m**
1MPa = 1000 kN/m^2

u_{max} = u (x=3) = 5/384 . (435,44 . 6^4)/(33000000 . (1/12) . 0,50 . $0,25^3$) = **0,34 m**

$$u_{max} = 0,34m < 0,024m\ X$$

The beam largely verifies the allowed stress, but doesn't verify the maximum deflection allowed. This means, something has to be re-evaluated. It can be the material or the dimensions. An extra option would be to place an extra collumn and, therefore, reduce the beam lenght.

In this case, the concrete chosen has good characteristic values, and to add an extra collumn would comprimise the architectural space, so it would be more wise to extend the width of the beam, which wouldn't comprimise the spaces created.