POLITECNICO DI MILANO

Master Science of Architectural Engineering 2012-2014

Sustainable Socio-Cultural Centre in Reinosa, Spain

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ABSTRACT

The project presented in this thesis comes as a proposal for a student competition. The task consists in the construction of a social-cultural center in the site of the former market of Abastos. The market, built in the city of Reinosa in the Cantabria region of Spain, was built in 1882 as a commercial hub for the city. It quickly became central in the social life of the little town thanks to its central position and is function of shelter against the severe weather conditions. The city in fact, located in the Northern part of Spain, stands more than 800 meters above sea level and it characterized by long and cold winters with abundant snowfalls and persistent snow (3 round months of frost a year). The former market was almost completely destroyed during a fire in the summer of 2012, leaving the city deprived of this important and beloved landmark.

A market is characterized by the presence of the commercial street: namely a central alley surrounded by two arrays of commercial buildings. This model dates back at the origin of the civilization, and still characterizes the modern shopping mall as well as the historic city centers in the European continent and in the middle east (bazaar).

The thing I like the most of a covered market is the ambiguity between the inside and the outside: the organization in alleys and commercial buildings recall an outside place as it reproduces the city. The ambiguity between inside and outside was a common theme in 19th century architecture, it was present in greenhouses and arcades, somehow also in the Eiffel tower.

According to the dimensions and proportions of the arcade it can refer and feel more as an inside or an outside, and be respectively private or monumental. In this project I tried recreate the feeling of covered market but alluding more to the square than to the street, to underline the prevailing social aspect over the commercial one. The squares can be used as a market, but are often divided, using the stands, into smaller street to reproduce the marketplace disposition. A single open space facilitates the visual contact with all the other occupants

serving as a privileged space for social interaction and casual encounters. The floor area of the previous building has been maintained, but the space occupied by the shops has turned into square space, while the space occupied by the alleys has becomes shops and other functions. The goal is to maintain the ancient floor space and the vibes of the covered market while promoting new functions thanks to an inside-out game.

The two internal public spaces differ in height and are surrounded by different environments in an effort to create the two main type of arcade i.e. the monumental one and the internal one. The building acts as a bridge between the small garden square in front of the theater, and a new square that will be built in direction of the city center. The visitor will have the possibility to go through a series of square: the modern one close to the south facade, the internal one with the arcade, and the existing compact one between the north facade and the theater. The three squares will form a pedestrian area characterized by abrupt changes of atmosphere in the surroundings. The steel structure is simple and gives regularity and clarity to the building. The ample glazing on the south facade favor the heat gain by solar irradiation and the photovoltaics on the roof generate electricity and give the building its silhouette.

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Chapter1
Competition introduction

1 COMPETITION INTRODUCTION

1.1 Competition Brief

1.1.1 The Competition

The competition invites qualified professionals in the fields of architecture, engineering, landscape architecture, urban design, planning and surveying and the general public to contribute innovation concepts on the design for the Cultural Center on the ruins of the old municipal supplies market, located in the Market Square in the town of Reinosa, Spain.

1.1.2 The Background

In the final years of the nineteenth and early twentieth centuries, many Spanish cities built their markets or municipal supplies lifting spaces buildings in many cases of significant architectural value and even artistic .Reinosa did it in 1882 , projecting an iron -framed and wood building, simple and functional . It supplied the service for nearly a century, until that in the 1980s was restored , not without raising an important controversy . Unfortunately, its modernization coincided with its decline , reflected in the rapid abandonment of many posts. "The Square" was semi-desert . Slowly began a process of collecting ideas to fill again a space full of possibilities, but there was no certainty about what should or could do.

In June 2012 the supplies market caught fire as a result of which were just standing four perimeter walls of the building. This apparent misfortune however opens the door to an intervention that aims to realize a draft proposal to build on the site of the Market Square a cultural center, a meeting point for the citizens of Reinosa.

1.1.3 Objectives of the Competition

The project bid for the construction of a Sociocultural Center on the Remains of Forme Municipal Market aims to achieve multifunctional space that brings balance history Reinosa and the original building, and innovation in building solutions and program consistent with contemporary socio cultural space.

In the quest for design excellence, the new cultural center is subject either as areas differentiated as either a space or a sum of flexible spaces adaptable, to meet the following features :

- Meeting of Reinosa society, especially its youth.

- Areas of work and knowledge transfer materialized in classrooms workshops or spaces co-working.

- Temporary reception or exhibition games, and outreach activities own center.

- Rooms spaces indoor / outdoor multipurpose

- Possible small cafe interior / exterior.

- Toilets.

- Warehouses and rooms technicians.

Chapter 2
Reinosa and the Site

2 REINOSA AND THE SITE

2.1 Reinosa

2.1.1 Geography

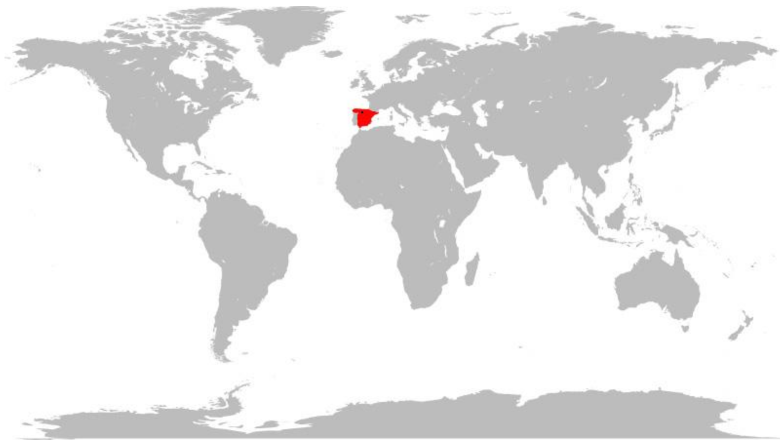


Figure 2.1 World Map (Spain)

Figure 2.2 Spain Map (Cantabria)

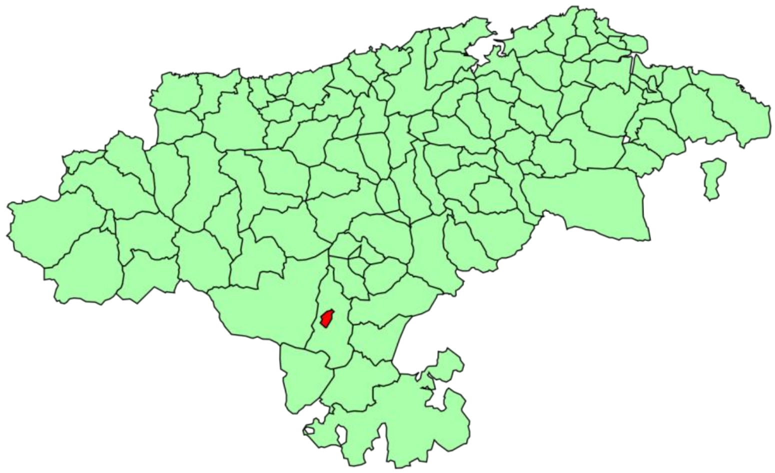


Figure 2.3 Cantabria Map (Reinosa)

Reinosa is a municipality in Cantabria, Spain. As one of the smallest town by land area in Cantabria, Reinosa is notable for being one of the nearest towns to the headwaters of Ebro River. Its area is just 4,12 km^2. As of H1 2009 the town had 10307 inhabitants, with a high density of 3000 inhabitant/km^2. The elevation is 851m above the sea level.

The source of the River Ebro is in the village of Fontibre where a stream emerges from the ground 3 kilometres away. A large artificial lake Embalse del Ebro was created by damming the river just below Reinosa, This is one of the largest reservoirs in northern Spain and is mainly filled in spring as a result of the melting of the winter snow in the mountain.

Figure 2.4 Topography of Cantabria (Reinosa)

Figure 2.5 Relationship among cities 1

Figure 2.6 Relationship among cities 2

2.1.2 History and development

Reinosa is 75 kilometres from the city of Santander, in the Campoo region. Its history dates back to the Middle Ages, and its old town is the setting for interesting monuments such as: the Baroque church of San Sebastián; stone buildings in the Town Hall Square from the 16th- and 17th-centuries; La Casona, a stately house dating from 1830.

Figure 2.7 Reinosa Old Town

The first documents mentioning the town date back to the year 1000, when it was divided into four solars by Sancho García, the Count of Castile. By 1404, it was emerging as the main town of the region and was organised into seven Hermandades, military units aimed at retaining law and order. The procurators of these brotherhoods met once a month with the Corregidor to organise the town's affairs.

It was not until the fifteenth century when the Merindad de Campo is configured with capital in Reinosa. From this period, the known Towers of the Plaza de Spain, located next to City Hall, which would become part of a line of defense consisting of Mioño Tower, Tower of Bravo and other house-tower, all in around the Plaza of Spain would constitute the pole around which the city grew.

In this defensive hypothesis, the Ebro River would be a source of supply and a natural barrier of the initial village. Already in this century there are references on the conclusion of Reinosa market.

In the sixteenth century the Corn Exchange Reinosa is instituted, in a building of San Sebastian Street No. 6, then known as College of Lisieux, Existing shields on the facade correspond to weapons of surnames donor. It is in this century when the construction of the church of San Sebastian (later renovated in the eighteenth century) is executed.

Other urban elements earlier this century are the Franciscan Convent, sold off by Mendizabal, who became House of Charity in 1856 and today is the Residence San Francisco; and the church of San Esteban today disappeared and who was in the location of the current cemetery.

Despite this apparent activity of the Villa it does not grow as exaggerated does not exceed 700 inhabitants in the seventeenth century. The old town is occupied mostly by residential building, which coexists with some of the main facilities and city services: Church, Hall, House of Culture, Market, Main Theater, etc. It is also the area where more intense civic-commercial activity takes place and the highest number of buildings of great architectural quality of the city is concentrated.

Figure 2.8 Villa de Reinosa Map

The economic structure changes from the eighteenth century when, under the reign of the Bourbons, the Camino Real and the Puente del Ebro are constructed. These works contribute to the economic boom in the region. The city becomes a bustling and prosperous place where the Castilian products are stored on their way to the port of Santander. Arise around this small business trade Smithies, large mills are built, established companies and services including shops, pharmacies and notaries are created.

With the arrival of the railway in the mid-nineteenth century, Reinosa is losing importance as head of road traffic, but emerged with the installation of food factories (flour, cheese, chocolate) and a major glass industry (the Santa Clara). Booming at this time as well as the culture, with prominent writers like Sánchez Díaz (generation 98), Angel Rivers, Duke and Merino or painters like Casimiro Sainz.

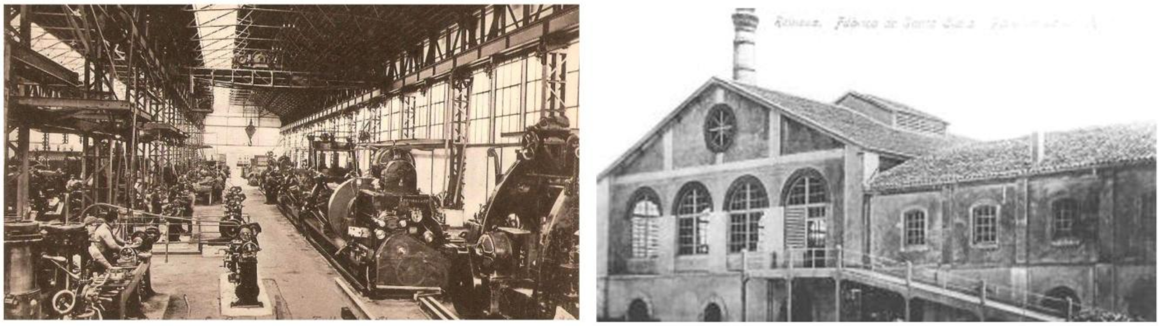


Figure 2.9 Santa Clara Interior (left) and Exterior (right) in 1887

Into the twentieth century, the economic life of the city was conditioned by the ups and downs suffered by the factory "La Naval", a large casting and forging factory, founded in 1919, and that caused a dramatic increase in the population. In 1923, 1324 workers are employed in it. Guns and weapons for boats are built, which means that during the Civil War, Reinosa was an important landmark for both sides.

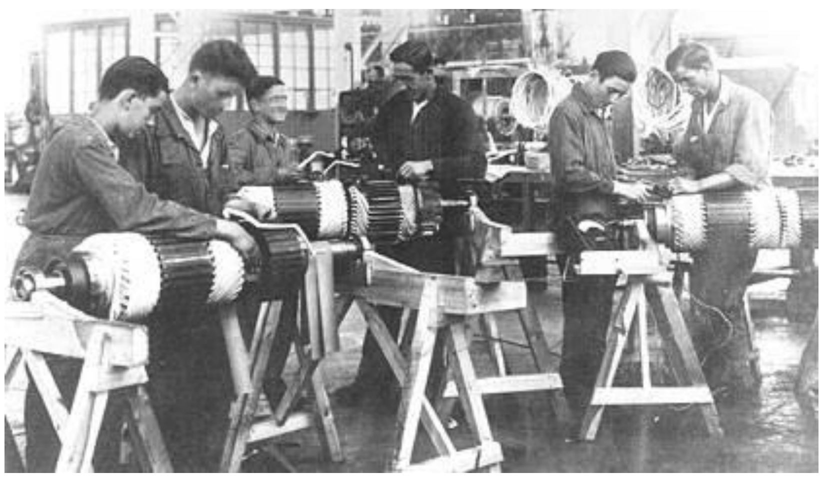


Figure 2.10 La Naval Factory in 1939

After the civil war, the factory and the population remain continuously increasing until the crisis of the armaments sector and foreign policy, forced to convert the factory. Unemployment and social unrest reaches its climax in 1987, when staff cuts, causing an economic crisis which increased unemployment and a decline in the population and the services that still endures.

In recent years, industry has experienced some recovery. The major companies are Siderúrgicas, North SIDENOR (heavy metal); Cantarey (generators); Cuétara (cookies); Columbia. They also give employment to disabled.

Figure 2.11 Reinosa in 1987

2.1.3 Culture

2.1.3.1 Festival

The festivals of San Mateo are the highlight of Reinosa's year. The day of San Mateo itself is the 21st September of every year, and the week around this date is full of activities and concerts around the town. There are several markets which take place during the two weeks, the biggest being on the 22nd, and also livestock markets and shows.

Figure 2.12 Santa Mateo Festival

Día de Campoo is a day in which the traditions of Reinosa and the people of Campoo (Campurrianas) are shown in full, with lots of people dressing up in traditional clothing, complete with clogs, and socialising in the town. There is much singing of traditional mountain songs (also called Campurrianas), and chanting in the streets.

San Sebastian – is Reinosa's other official fiesta, taking place on the 20th January every year. It takes place in and around the Plaza España.

2.1.3.2 Feature

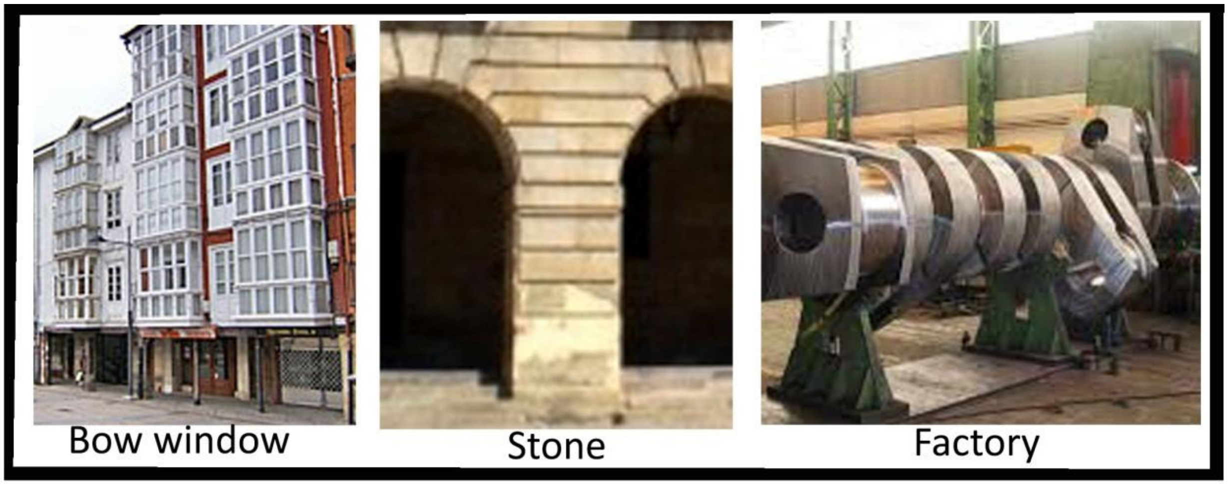


Figure 2.13 Feature of Reinosa

2.1.4 Tourist resources

2.1.4.1 Natural resources

Due to its mountain location, Reinosa is a great base for walking, with lots of well signposted walks in the area. It offers a different option to walking in the Picos de Europa, but often with stunning views back over in that direction.

Figure 2.14 Mountain view 1

Figure 2.15 Mountain View 2

2.1.4.2 Sports

As it is up in the mountains and surrounded by very varied scenery and culture, there are a lot of options for doing sports. Reinosanos (the people of Reinosa) are in general active, outdoorsy, mountain-loving people, and there are a lot of options here if you like the great outdoors.

Skiing

Located only 40 kilometers from Silió in the direction of Reinosa, the Cantabrian range ski station of Alto Campoo boasts two green, four blue and eight red runs. The station is ideal for mid-week skiing.

Figure 2.16 Skiing in Reinosa

Hiking and cycling

Figure 2.17 Other Sports in Reinosa

2.1.4.3 Cuisine

Its cuisine is based mainly on the country's products: potatoes and beef, white pig slaughter, cheeses and dairy products, and trout Ebro and Híjar.

2.2 Site

2.2.1 Location

The site locates in a small square, behind the Teatro Principal, facing West. The square is located in an area with steep slope, Calle del Sol (northern boundary) comes to be 4m above the highest elevation of the square, existing a stone mounted retaining wall and a ladder as a limit. At the southern limit (Calle Juan José Ruano) we are 2m below the highest point of the square, next to the stone wall and street access to a garage of an existing building.

Figure 2.18 Scale of the Site in Reinosa

Figure 2.19 Size and Direction of the Site

2.2.2 History and Development

This proposal refers to the construction of a socio-cultural center, established on the ruins of the old municipal market of Abastos in Reinosa – Spain, built in 1882.

Figure 2.20 Exterior of Abastos Market

Figure 2.21 Interior of Abastos Market

The building of the former market which was built in the center of a square, and that once acted as covered and interior space, aimed to procure food commodities to the population in the area, also serving as a meeting point. It is a square with connection to a small “plaza”, behind the Teatro Principal, facing west. This square is located in an area with steep slope, Calle del Sol (northern boundary) comes to be 4m above the highest elevation of the square, existing a stone mounted retaining wall and a ladder as a limit. At the southern limit (Calle Juan José Ruano) we are m below the highest point of the square, next to the stone wall and street access to a garage of an existing building.

It`s a place with urban axes and points of view that is important to emphasize, the arrival at the square by its western boundary, is accomplished through the Calle Marques de Cilleruelo, and the "plaza" on the back of the theatre, the eastern limit. The arrival to the square by its southern boundary is accomplished from Calle Menédez Pelayo, and north across the street of the garage of the existing building, a street parallel to Calle del Sol.

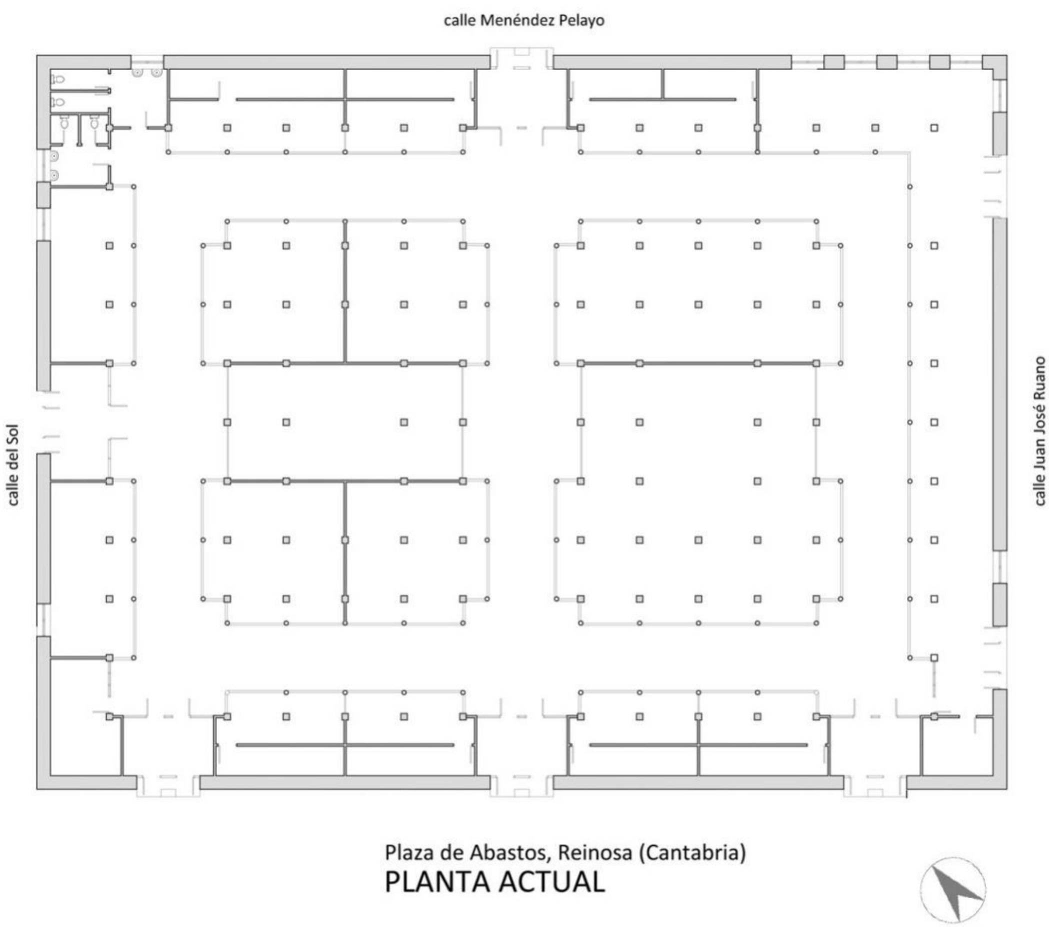


Figure 2.22 Plan of the Market

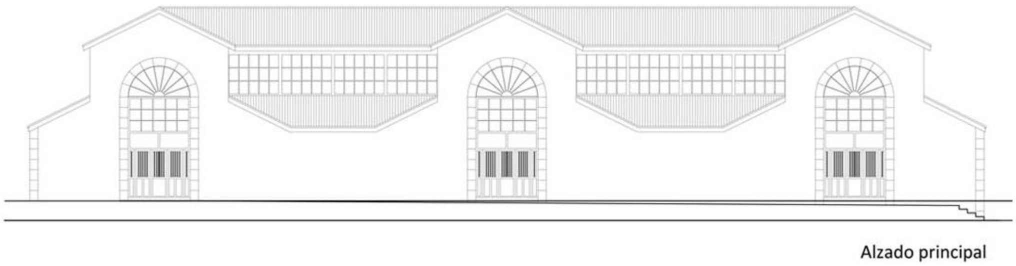


Figure 2.23 West Façade

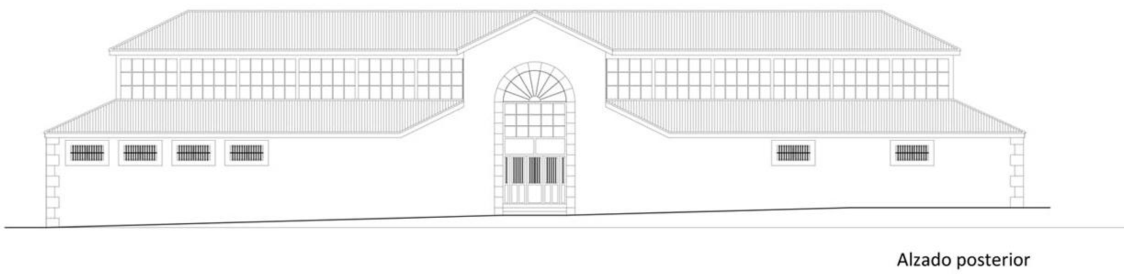


Figure 2.24 East Facade

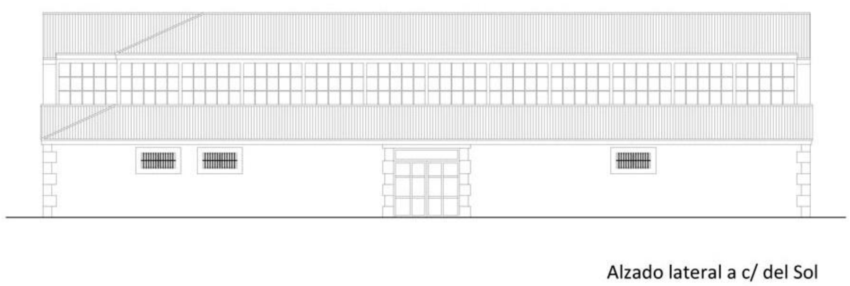


Figure 2.25 North Facade

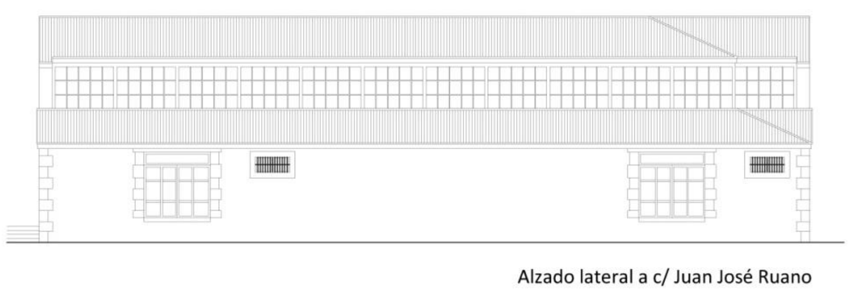


Figure 2.26 South Facade

In June 2012 the supplies market caught fire as a result of which were just standing four perimeter walls of the building. This apparent misfortune however opens the door to an intervention that aims to realize a draft proposal to build on the site of the Market Square a cultural center, a meeting point for the citizens of Reinosa.

Figure 2.27 The Market catch fire

Figure 2.28 Site after fire

CHAPTER 3
URBAN DESIGN

3 URBAN DESIGN

3.1 Analysis of city

3.1.1 Traffic system

Figure 3.1 Railway and High way

Reinosa is on the main RENFE train line from Santander to Madrid, and is served by 2 long distance trains every day. It takes 3-4 hours to get to Madrid (via Palencia and Valladolid amongst others), and the morning train continues on to Alicante (7 hours). RENFE also run fairly regular (8 per weekday, less at weekends) local trains called Cercanias which run from Santander to Reinosa, stopping at many villages on the way. The journey time is around an hour and a half. There are two train stations in Reinosa, the main station next to the bus station, and the smaller Rio Ebro station, is close to the Dia supermarket.

There is also a regular bus service from Santander to Reinosa every hour during the day. This comprises of two versions of the same line, the quicker buses (taking an hour and a half), which go up the A67 motorway and only stop in Torrelavega and Los Corrales, and the slightly slower buses (taking around 20 minutes longer) which go up the old N611 and stop in all the villages along the way. They alternate hourly throughout the day. There are fewer buses at the weekend.

3.1.2 Urban Texture

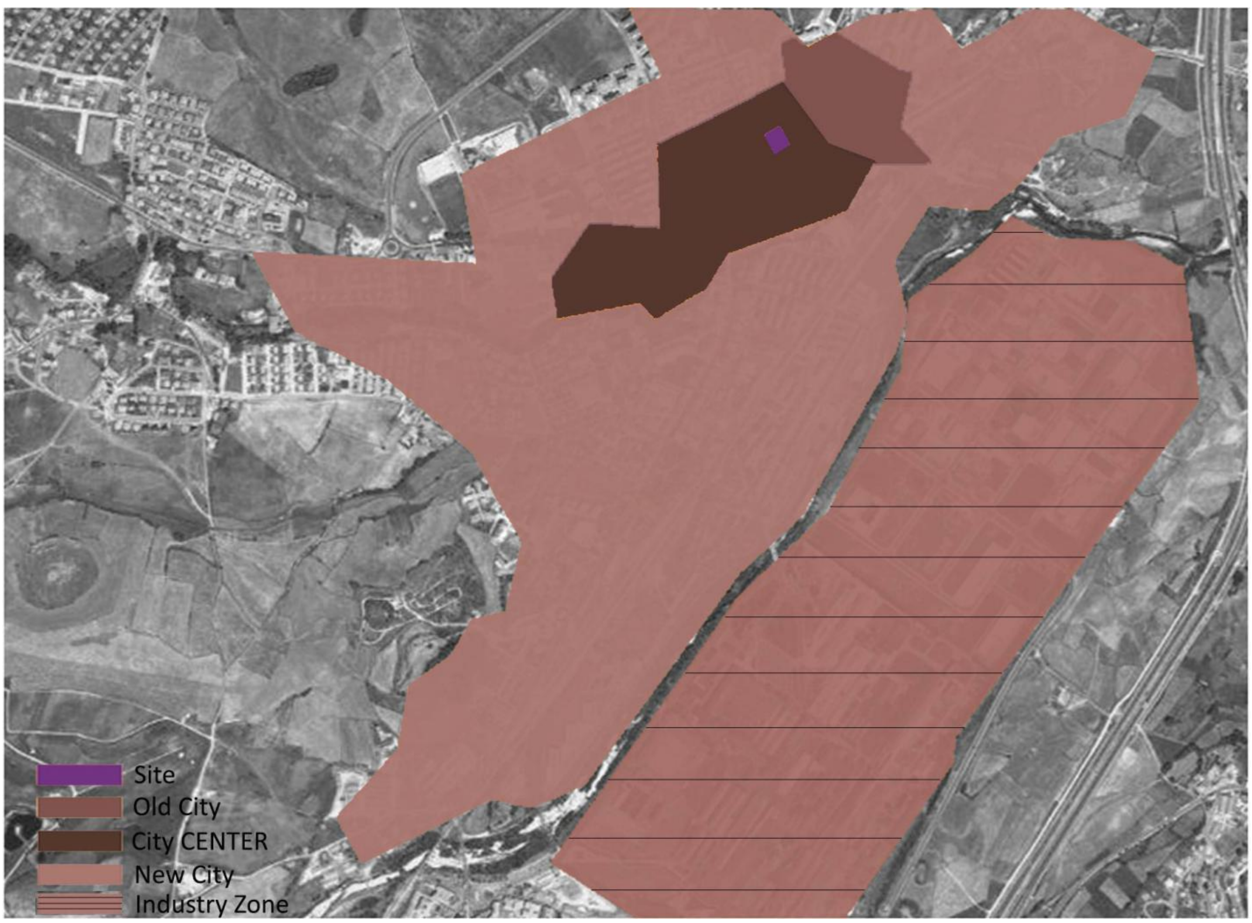


Figure 3.2 Zone Distribution

Reinosa is the largest town in this area of Cantabria which have the highest dense urban texture on in the city center and big industry zone on the other side of Erbo River.

The industry has traditionally been the most important activity of Reinosa, especially the steel industry and the food industry. However this activity has been losing weight in recent decades, although the city still remains the most relevant industrial center within Cantabria.

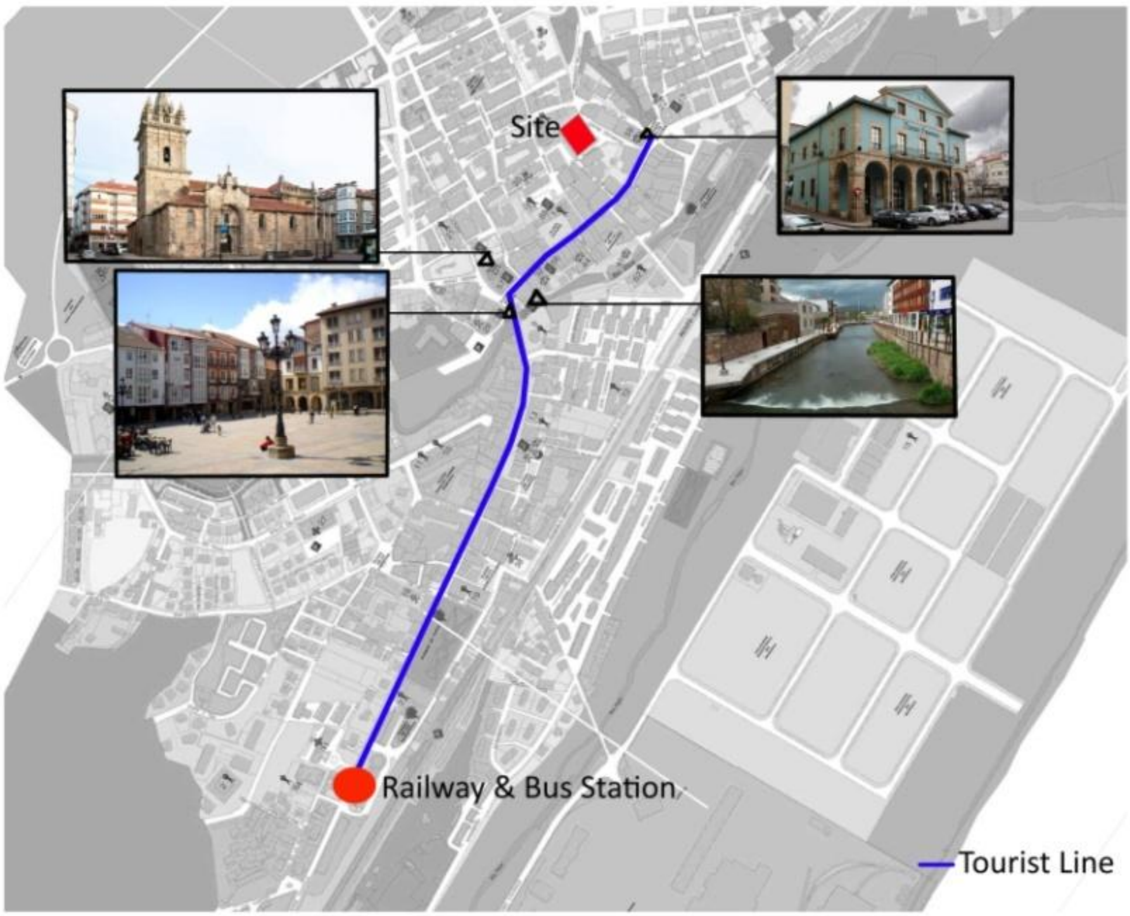


Figure 3.3 Landmarks Map

The prominent visual features of the city are its landmarks. Landmarks are an important element of urban form because they help people to orient themselves in the city and help identify an area.

3.1.3 Land use

Figure 3.4 City Block Functions

Figure 3.5 Level of Building

Figure 3.6 Material Map

Figure 3.7 Green Area

Figure 3.8 Open and Close Space

Figure 3.9 Analysis Surrounding the Site

3.2 SWOT Analysis

Figure 3.10 Analysis Sketch 1

Figure 3.11 Analysis Ketch 2

- **Strengths**

1) Existence of a small park and private green areas near the site
2) Existing cultural image and tradition (municipal market square)
3) Located near the historical place of town, enhancing the importance of the area
4) Adequate traffic entrances to the site with low congestion, together with existing bus routes
5) High accessibility and appropriate pedestrian accessibilities surrounding the area.
6) The site is located in a area of residential, cultural and commercial buildings
7) Existence of an architecture : approximately same styles, same colors, same textures and materials
8) There is a morphological organization of built areas, with particular attention to full and empty space.
9) Existing laws and regulations for the new buildings protecting the architectural and cultural heritage
10) located near the ski resort and water sports
11) near mountains , such as climb to Tres Mares Peak, with stunning views .
12) traditional dishes and also town's most typical sweet: “pantortilla” (puff pastry with caramelised sugar).
13) Appropriate average temperature (in winter can be below 0, in summer between 14-24)
14) river cross the town which bring high humidity and good view

- **Weaknesses**

1) The empty surroundings of the area give the sense of lack of identity.
1) The site is located at the inter-crossing of four streets. During rush hours, pedestrians cross the street in forbidden spots.
2) Lack of bicycle path
3) Due to catching fire the historic identity of the site is threatening
4) Lack of vitality in surrounded area due to no existing architecture identity
5) lack of image and identity of the city

6) 10,307 inhabitants use daily trains middle and long distance to connect to the big cities.
7) lack of night life

- **Opportunities**

1) Surrounded by culture and commercial centers (theater, bank,…)
2) High attraction of people due to the proximity to cultural and commercial buildings
3) Customers of commercial buildings and visitors of historical monuments enhance the flow of population to the site.
4) Proximity to the central part of the city and main street (Calle Mayor) attract the population flow
5) There are well-defined places for gathering, or centres with public services.
6) Improve the visual appearance of the site to increase the attraction of visitors
7) offer a relaxed place for young people

- **Threats**

1) Inter-crossing of four streets, makes hard the identification of the vehicular and pedestrian entrances.
2) Far from existing main train station is a disadvantage to achieve people effective flow.
3) Lack of architectural landmarks as reference nodes.
4) Possible rejections of the project by the local people, resistance of change
5) air pollution from the Industrial area

3.3 Goals, Objectives & Actions

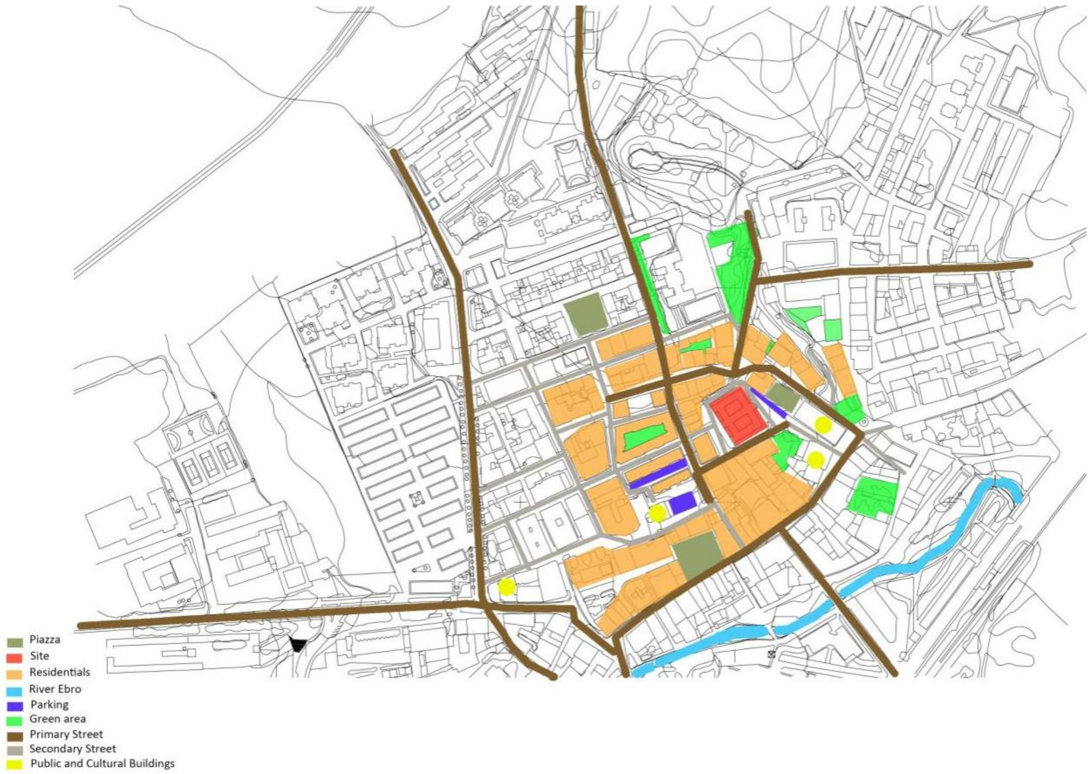
Regarding the goals set from competition brief, further objectives and actions are set coordinately before design process.

Goals	**Objectives**	Actions
1. Connection. Provide proper	1.1. Integrating among different	1.1.1.Create paths that pass from historical building in order to have visual connection to them

connection between different parts of the city.	piazzas , and enhance the connection between monument buildings 1.2. Considering the historical connection	1.2.1. Using the existing urban grid as a base line of design. 1.2.2. Considering the sky-line of the city while projecting new buildings.
2. Enhance accessibility / Mobility. Proper vehicular and pedestrian access	2.1. Enhance bike mobility 2.2. Enhance pedestrian access.	2.1.1. Create special path for bicycles 2.2.2. Provide proper paths and bridges 2.2.3. Provide water fountain
3.Vitality through social activities	3.1 Create open public spaces 3.2 Redesigning green area	3.1.1 Create good accessibility from Calle mayor street, shopping centre, main piazza et.c. 3.2.1.Create public linear park 3.2.2.Create private green areas, only accessible by the residents 3.2.3.Use trees and plants to reduce wind, sunlight and traffic sound
4. Comfort	4.1. Community safety. 4.2. Maximize accessibility	4.1.1 Maximize visual connections. 4.2.1Make public amenities accessible to all age people and handicapped people.

5.Sustainability	5.1. increasing mobility and convenience.(Walkable Urbanism) 5.2. Renewable Energy 5.3.Applying the concepts of landscape ecology(broad green areas, linear green areas, surrounding built-up areas) 5.4 Green resistant wall. 5.5 apply friendly transportation	5.1.1 Limiting cars with few parking. 5.1.2 transfer the motor way into pavements 5.2.1. Solar , Wind , Water , Biomass , Geothermal 5.3.1. Connectivity between patches or corridors (Green sites that are close to each other or contiguous can form a green network to permeate the built-up matrix) 5.3.2. Long corridors or linear green patches 5.4.1. Construction of a green bridge tunnel 5.5.1 Create new cycling path.

Based on the analysis of SWOT, the actions are designed. A new bike path is proposed, while the bike stops around the site are created, while the car parking beside the site can ease the pressure from motor vehicle. Further more, a new pedestrian pavement on the neighborhood of the site is designed to form the “island”.



3.4 Sustainability Approaches

3.4.1 Sustainable Solar Power

By converting solar energy into electrical energy, for each kWh generated, carbon dioxide (CO2) emissions that pollute the planet can be reduced by 600 grams. Solar energy is clean, unlimited and safe. Even when it is converted into electricity through photovoltaic or thermodynamic plants, it does not produce harmful emissions. That is why this renewable energy source has assumed a key role in the future of energy policy. Many governments started incentive plans to promote generation and integration of energy into the grid by means that minimize the environmental impact. Large rooftop installations are proposed in the town for the deliver electricity to the citizens.

Figure 3.12 Rooftop installations

3.4.2 Limitation of Cars

According to sustainability approaches, and due to creation of better intimated gathering spaces around the building, I propose to ban passing of cars in the neighbor streets to have more vitality space for pedestrian. And also change the pavement of this area to emphasize it as a public space.

Figure 3.13 pedestrian street

3.4.2.1 Modular Architectural Wind Microturbines

Nowadays, Aerovironment is ushering in an era of urban wind power with a sleek series of small, silent turbines that eschew the need for a tower. Dubbed ‘Architectural Wind’, the system seamlessly integrates into the parapets of buildings, taking advantage of aerodynamics to catch wind as its speed escalates up a structure’s side. The turbine’s innovative approach boasts up to a 30% increase in energy production, and their adaptable, modular assembly makes installation a snap.

Architectural Wind turbines rotate at low wind speeds, resulting in a form of 'kinetic architecture' that communicates clearly the generation of clean energy. Working alone or in tandem with other renewable energy technologies, Architectural Wind is designed to offer an attractive ROI and cost per kW of installed capacity." Installations have little or no structural impact upon existing buildings and are easily scalable starting at 6KW. Each module weighs approximately 200 pounds, measures 4 feet tall by 4 feet wide, and features a bird screen.

From costly installations to strict city ordinances, there are a number of factors that have limited the growth of wind power in urban environment

Figure 3.14 Modular Architectural Wind Microturbines

3.4.2.2 Garbage Disposal System

I propose a new garbage disposal system in the city: building occupants place recyclables and non-recyclable mixed waste in separate waste containers, either on a floor-by-floor basis or on the ground floor/basement for high-rise developments, depending on current practice. The waste is then evacuated through the pipes at 70km per hour to waste receiving stations at strategic locations on a precinct-by-precinct basis. The system, which will eventually whisk away the garbage generated by 2350 residences, a number of restaurants, and passersby taking in the various events and festivals happening in the downtown.

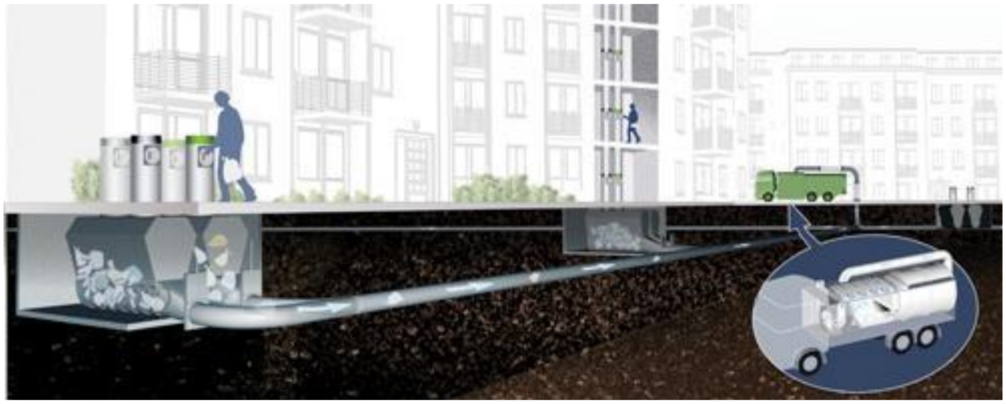


Figure 3.15 Garbage Disposal System

3.5 Location of the site

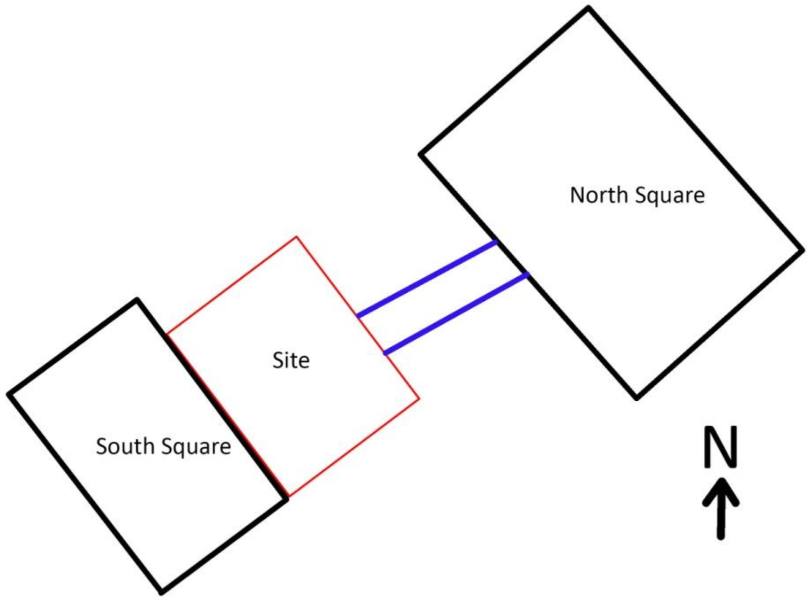


Figure 3.16 Position site and squares

The Cultural Center plays a role of main bond to connect the two squares. They work together to form an island which the entrance of the building should be positioned to link the two squares. Shaping of Square and Cultural Centre will be explained more in next two chapters.

CHAPTER4
SQUARE DESIGN

4 Square Design

Based on the existing site, there were two squares on the site, one is in front of the building while the other one is on the opposite side.

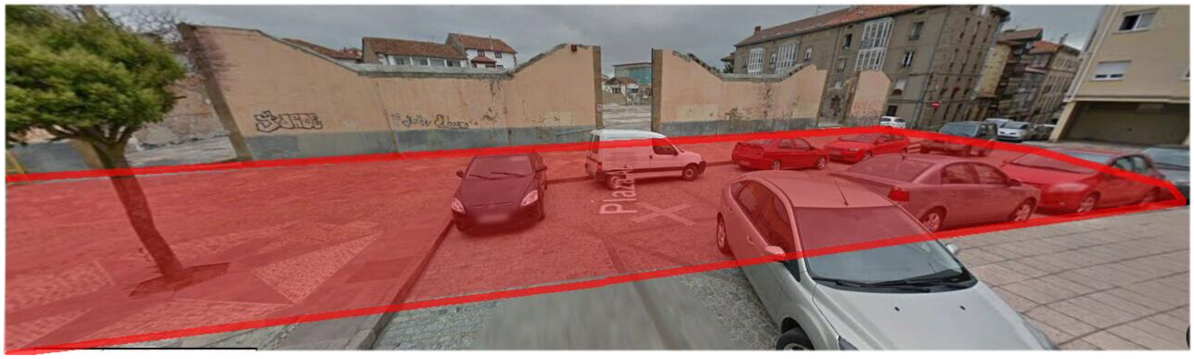


Figure 4.1 South Square

Figure 4.2 North Square

To connect these two square and the building, the idea of invisible island is formed. For the south square, to provide a relaxation place for the visitors, the element of bench and water would be present. For the north square, which is bigger, I propose an orchard which is not only represent the island view, but also relating the original market.

4.1 Concept

4.1.1 Island Access

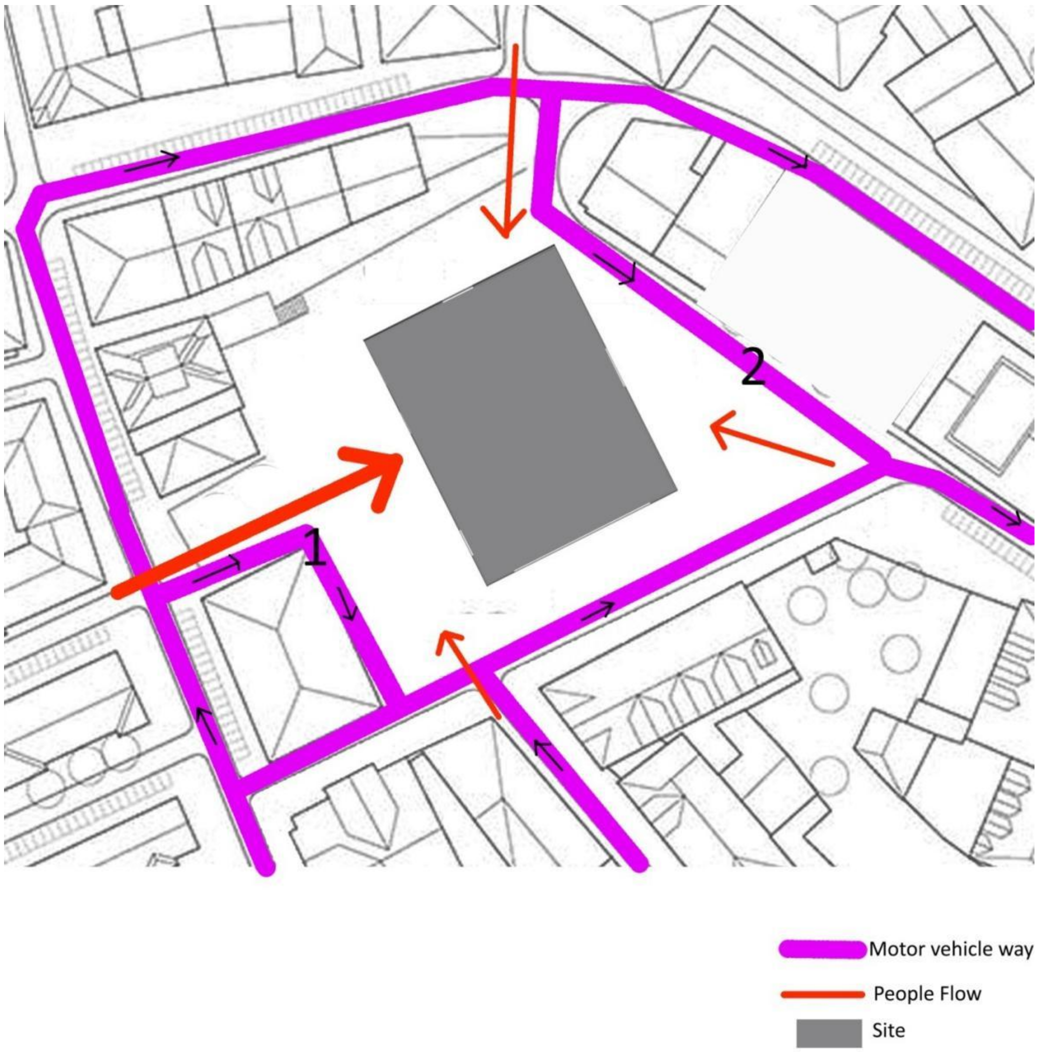


Figure 4.3 Site Access

As shown in the figure 4.3, within the outline zone of cultural center, the major axis is orthogonal to the whole site, where the main people flow is from city center. In addition, it is important to exploit the entrance square in front the cultural center and the orchard behind it to accentuate the orientation of urban axis.

Therefore the accesses are designed, as shown in figure 4.4.

Accesses 1 and 2 are cut to avoid the intervention of motor vehicle, thus the cultural center and the orchard garden are directly linked by the pedestrian.

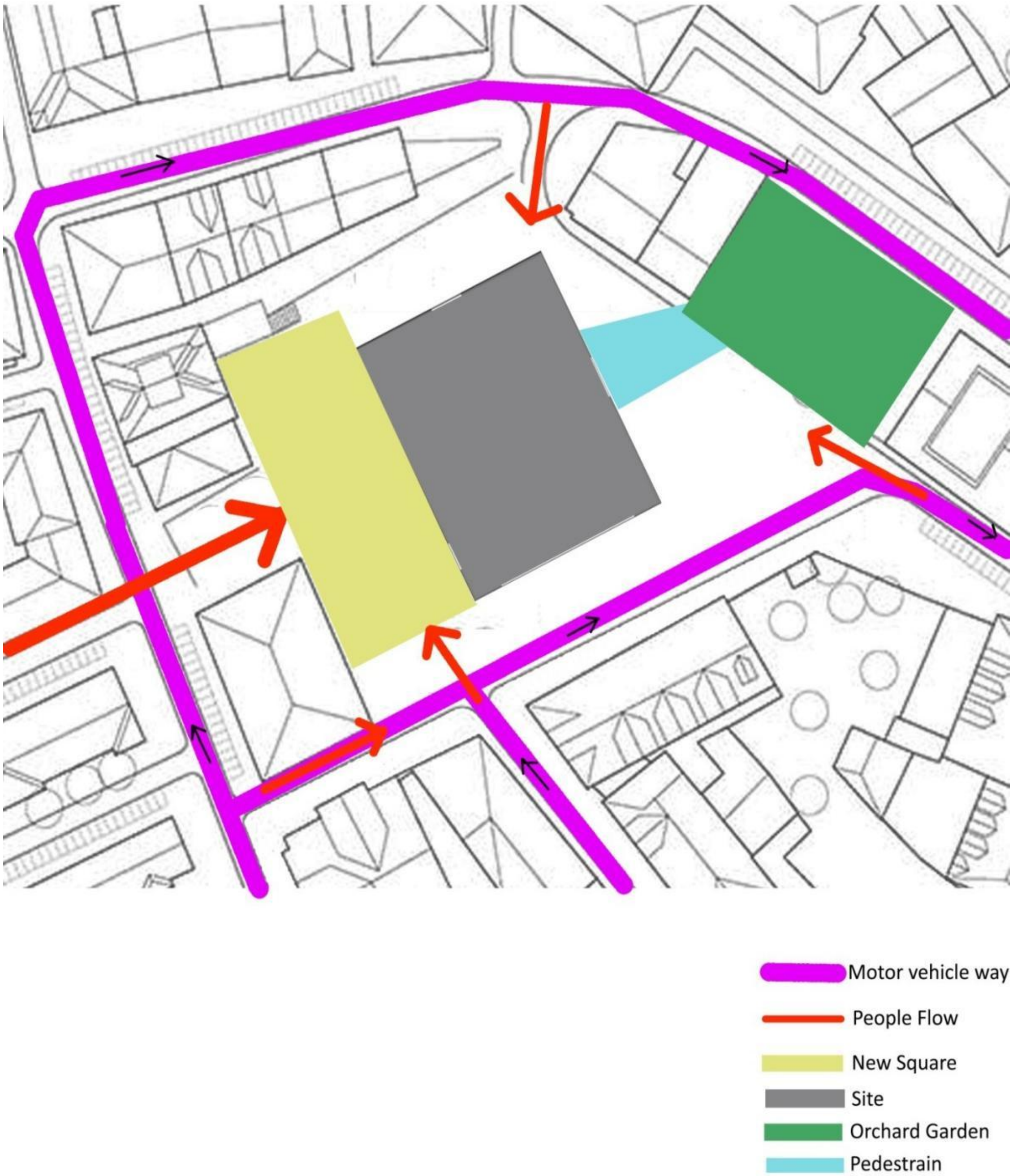


Figure 4.4 New Access

4.2 Orchard Garden Design

4.2.1 Study of Orchard

Across Europe, for many years, orchards have been grubbed up or concreted over to make way for housing, roads or more intensive forms of cultivation. Recently though, orchards have made a comeback for three reasons:

1) People are beginning to recognize the role of fruit trees in maintaining biodiversity and wildlife corridors
2) The economic crisis has caused many to wish to grow some of their own food – especially costly items that have a high nutritional value
3) Community gardening has become popular again, so community orchards are being created on allotment sites, in parks and other public places, and at schools and colleges.

Therefore a background research on orchards' was first conducted to have a better understanding to the garden design, as well as to create a concept of adopting traditional style into a modern outlook under same philosophy.

4.2.1.1 Orchard classification

In temperate, non-tropical regions, orchards were traditionally placed near bodies of water to try and limit exposure to frost, and laid out in a rectangular grid-like formation adapted from the designs used in medieval monasteries which were, in turn, an interpretation of heavenly gardens. Having grass or bare soil under the trees is a classic feature which allows easy maintenance: pruning, treating for insects, and fruit collection.

There are two forms of modern orchard garden: the permaculture garden, often seen on allotments and organic farms, and the multipurpose orchard.

4.2.1.2 Modern Orchard Gardens

There are two forms of modern orchard garden: the permaculture garden, often seen on allotments and organic farms, and the multipurpose orchard.

Permaculture Orchards: Creating a permaculture orchard means choosing a blend of food trees and other trees that have value for medicine, cosmetics, wildlife or beauty. As an example, a lilac tree may be used to attract pollinating insects, to harvest blossom for the home and to make toiletries using the scented flowers – so although it is not a traditional orchard tree it has great value in an permaculture orchard.

Underneath these non-fruiting trees it is usual to plant flowers or crops that can be harvested: so a lilac may have an under-planting of spring bulbs to look pretty or edible flowers such as nasturtiums, or the planting may be a low-growing shrub like a cranberry to provide a crop, or an annual grass like millet offering winter seed to birds that are valuable to the orchard.
Multipurpose Orchards: The classic monastic pattern of orchard design has become the starting point for many different styles of orchard gardening, including hexagon layouts with a central barbecue, summer house, table or paved area, or the walking orchard: a rectangular space with trees along each side, providing open ground in which children can play, washing can be dried, or people can walk or exercise.

Obviously, for gathering people and provide a relaxation place for the citizen, the multipurpose orchards garden style would be the right choice for the site.

4.2.1.3 Soil Conditions

Orchards can be created in most soils but where there is heavy clay, some soil remediation at depth will be needed to stop water logging which can kill trees at the root. Sandy soil can also present a problem, especially with larger trees which can develop root rock if the soil is very friable, but this can often be resolved by building good walls or fences around the orchard in the traditional fashion.

4.2.2 Orchard Design

4.2.2.1 Garden Material

To create different visiting experiences, four patterns of pathway are chosen, namely pebble pavement, stone pavement, stone pavement, lawn and water.

Figure 4.5 Pebble Pavement

Pebble is only used in solid mass section to decorate the broken pieces in solid mass section.

Figure 4.6 Stone Pavement

Stone pavement is the pavement of main walk path. Rectangular stone is preferred to match the textures of stone pillar remnants so to create a harmonious sense in geometry design.

Figure 4.7 Lawn

Lawn is selected to be the buffer material between different walking planes. Lawn slope can gently lead visitor into different areas.

Figure 4.8 Water

Water will only appear in water mass section. It can also reflect the surrounding landscape and architecture.

4.2.2.2 Orchards

Good soil management is essential for sustainable production in orcharding. It is an issue that affects the flexibility, profitability and long-term sustainability of the site properties. The major rainfall in Reinosa occurs in spring and autumn. Thus the most important issue is to limit erosion in the orchard, which need to reduce both the amount of water travelling over the land surface and the speed at which this water moves. To solve this, a groundcover which covers the soil surface and protects it from erosion and moisture loss is needed.

Figure 4.9 Groundcover in Orchard

To have iridescent view all year long, the different trees and flowers which bloom in different season has to be considered.

- olive tree

the olive tree which is an evergreen tree or shrub native to Mediterranean. It is short and squat, and rarely exceeds 8-15m in height. The small white and feathery flowers, are born generally on the previous year's wood, in racemes springing from the axils of the leaves.

Figure 4.10 Olive Tree

- Lemon tree

The lemon is a species of small evergreen tree, the type of "Eureka" grows year-round and aboundantly, it is also known as "Four Seasons" because of its ability to produce fruit and flowers together throughout the year.

Figure 4.11 Lemon Tree

- Magnolia Tree

Magnolia is a species of evergreen tree, as with all magnoliaceae, the perianth is undifferentiated, with 9-15 tepals in 3 or more whorls. The flowers are bisexual with numerous adnate carpels and stamens are arranged in a spiral fashion on the longated receptacle. The fruit dehisces along their dorsal sutures.

Figure 4.12 Magnolia Tree

- Chimonanthus praecox

Chimonanthus praecox, also known as wintersweet, is a species of flowering plant in the genus chimonanthus of the family calycanthaceae. The plant is cultivated in gardens, producing valued flower colour in the formant season.

Figure 4.13 Chimonanthus praecox

- Apple Tree

The apple is a deciduous tree which the leaves are alternately arranged dark green-colored simple ovals with serrated margins and slightly downy undersides. Blossoms are produced in spring simultaneously with the budding of the leaves, and are produced on spurs and some long shoots. The fruit matures in late summer or autumn, and varieties exist with a wide range of sizes.

Figure 4.14r Apple Tree

4.2.3 Garden elements

4.2.3.1 Main entrance

The Main entrance locates in the south-west corner where connected with the pedestrian to the cultural center. it is total open which three existing parking place are needed to be removed. The height of the square is 0.2m higher than the pedestrian, hence a small slope is designed to connect the two levels, meanwhile is available for the disabled.

4.2.3.2 Pebble and stone pavement

One of the main features in Reinosa is Stone, as well as the main material for orchard. The south part is laid with stone pavement which the north part is laid with pebble pavement. It can not only create a visual experience on due to height difference, but also allow visitors to have closer observation to the “island”. In the north part, Lawn serves as groundcover for the orchard.

4.2.3.3 Post and paling

1.2m high post and paling between the two parts which mentioned before will act as a connection as well as an isolation.

4.2.3.4 Flower bed

Three flower beds with a size of 8m*8m are designed which provide a seating place for people to relax.

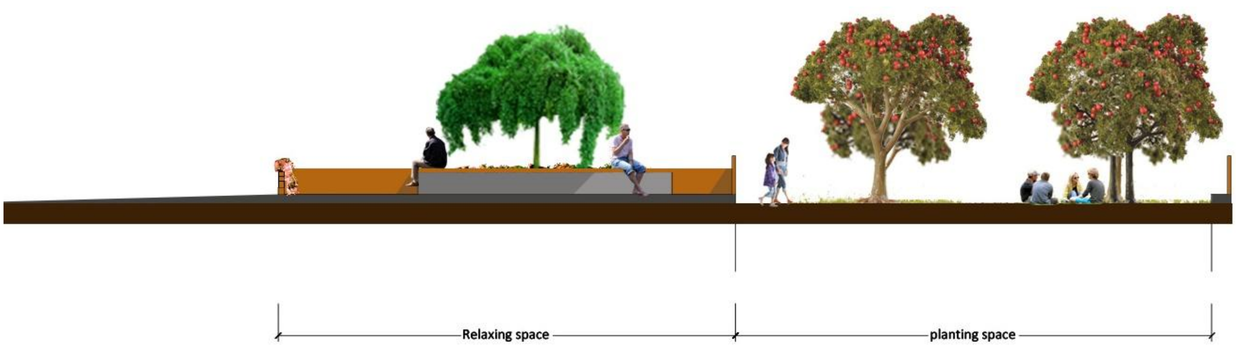


Figure 4.15 Garden Section

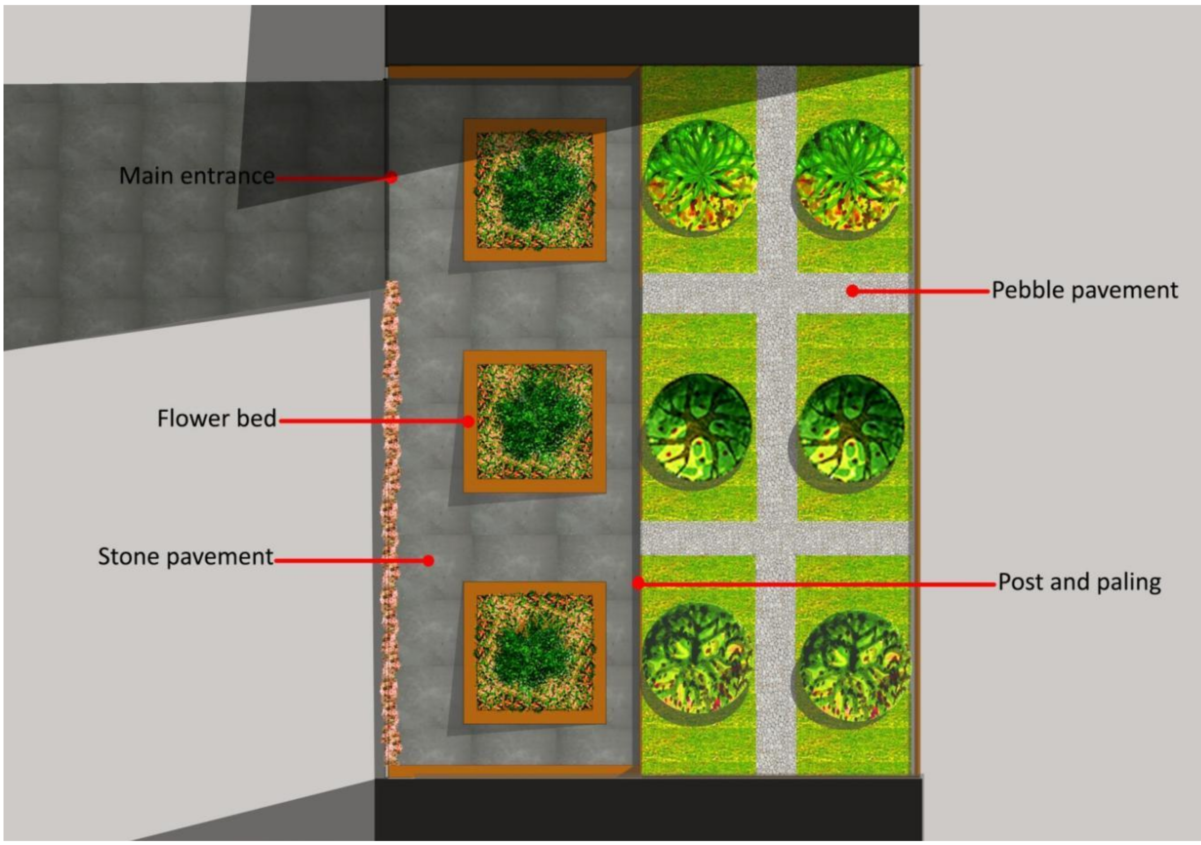


Figure 4.16 Garden Plan with Elements

4.3 South Square Design

It's a location with urban axes of view which is important to emphasize. The arrival at the square by its western boundary, is accomplished through the Calle Marques de Cilleruelo. The arrival to the square by its southern boundary is accomplished from Calle Juan Jose Ruano, and north across the street of existing building, a street parallel to Calle del Sol. The square typology is designed to suit the current site typology. The Square elements are designed as following.

4.3.1 Square Element

4.3.1.1 Fountain

The simplified fountain with a edge which for seating is located in the center of the square, to create vitality around the building.

4.3.1.2 Flower bed

Due to topography and location of the site in different levels, I decide to design step flower bed in the south side of the square. It can also calls for the orchard.

4.3.1.3 Stone pavement

The same pavement surrounding the building will emphasize the “island” which is distinguish from the bituminous street.

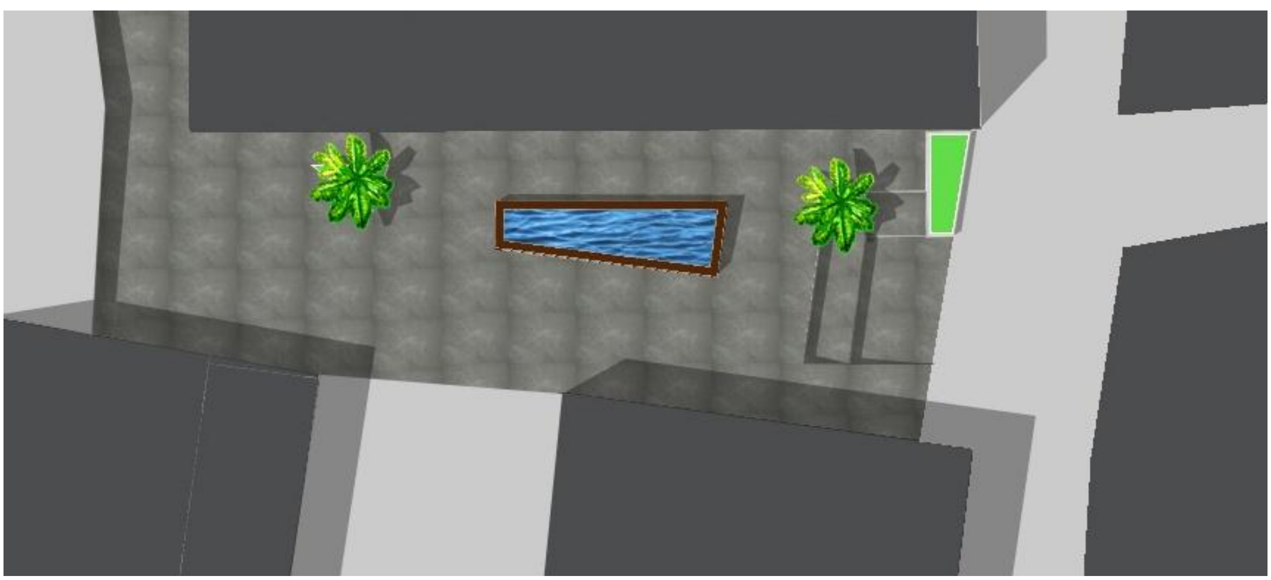


Figure 4.17 Plan of Square

4.4 Drawings

4.4.1 Section

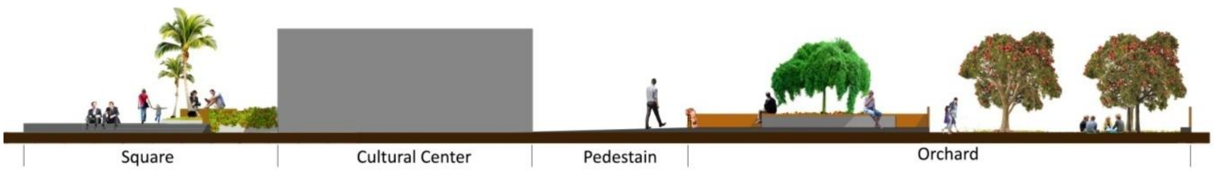


Figure 4.18 Island Section

4.4.2 Masterplan

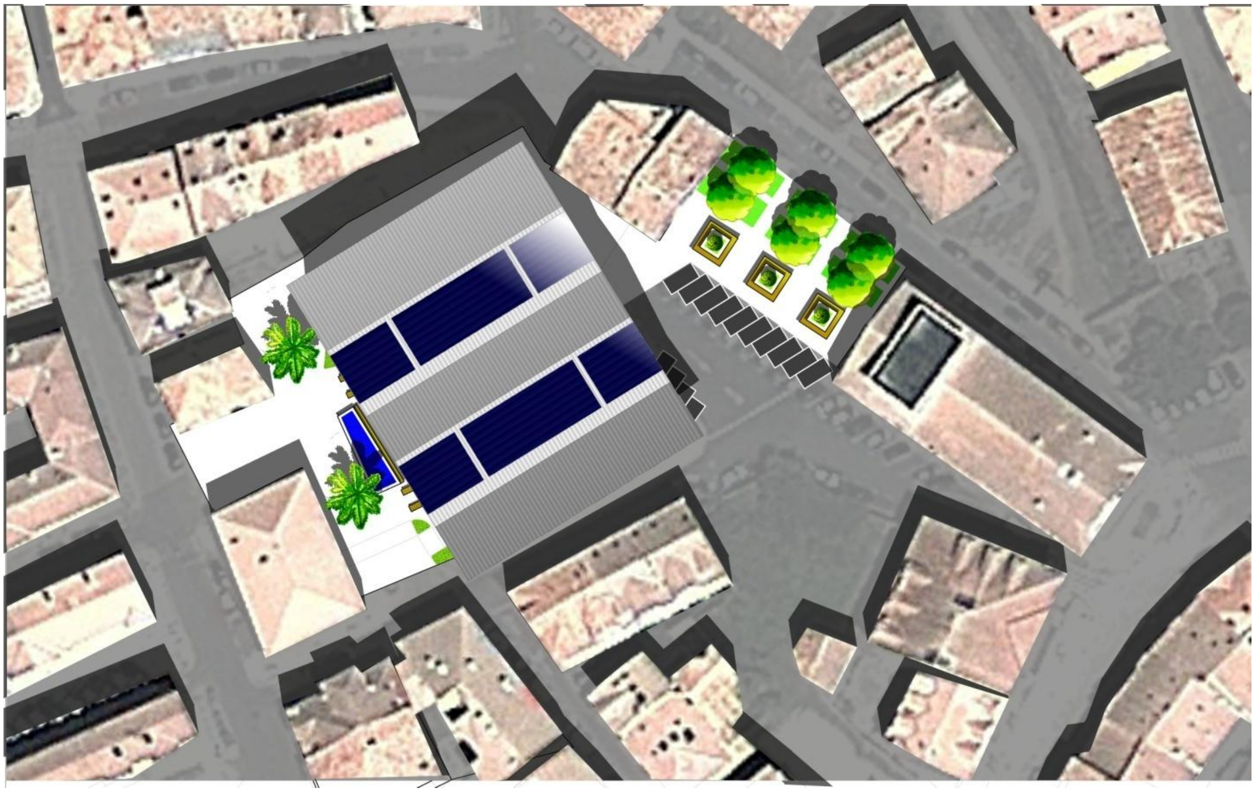


Figure 4.19 Masterplan

CHAPTER 5
ARCHITECTURE DESIGN

5 Architecture Design

5.1 Case Study

5.1.1 Cultural center

Culture is the shared patterns of behaviors and interactions, constructs, and affective understanding that are learned through a process of socialization. A cultural center is community space. It is building which is used for a range of disparate activities, which can be a representation of the local culture. It also provide a base for initiatives such as cafes, shops, book store, etc. It is the place for community celebrations at various occasions and traditions; public meetings of the citizens on various issues; politicians or other official leaders come to meet the citizens and ask for their opinions, support or votes; housing local clubs and volunteer activities; passes on and retells local history; local activities are organized.

It can also be a school community center which providing facilities to inner city communities out of school hours. An early celebrated example of this is to be found in Rochester, New York from 1907. One of the organizers, described it as "A community organized about some center for its own political and social welfare and expression; to peer into its own mind and life, to discover its own social needs and then to meet them, whether they concern the political field, the field of health, of recreation, of education, or of industry; such community organization is necessary if democratic society is to succeed and endure".

Cultural center have become one of the most desirable commissions for architects to win, now that cities have discovered cultural center as a marketing factor. A spectacular cultural center building possesses supra-regional attraction, and in the best cases assures the city bothe a distinctive emblem and a city-centre function. Rundown or peripheral parts of cities can be revived by a cultural centre and linked to the rest of the city- examples that spring to mind are the Hong Kong Cultural Centre in Tsim Sha Tsui, Hong Kong designed by Architectural Services Firm. The architecture of the cultural centre itself, the building anchored in its urban context together with its functional room for the administration, must function in the dialogue between building and art, architecture and users. In the end, it is therefore the experience of every individual visitor to the cultural center that decides whether the definition of the space in which he finds himself and sees cultural art facts is a success or a failure.

Figure 5.1 Hong Kong Cultural Centre, Hong Kong

Figure 5.2 Son Ferriol Cultural Centre in Palma, Spai

5.1.2 Social Cutultral Centre & Market

How to combine the new building with the physical traces (traces, old building shape,…) abd intangible trace (cultural, memory,…), The arcade is one of the most important feature from the former market. Hence the cultural centre, indoor market and arcade were studied before the design work.

5.1.2.1 Jaw-Dropping CentroCentro Cultural Center in Madrid

Jaw Dropping CentroCentro Cultural Center is originally designed by architects Antonio Palacios y Joaquin Otamendi, Palacio de Cibeles (also known as Communications Palace), opened its doors in 1919 and quickly became a symbol of modernization and progress. This impressive cathedral-like landmark was first home to the City Hall Postal and Telegraphic Museum until 2007 when it became Madrid's official City Hall and a central hub within the city.

The "central operational yard" is still the soul of the building. The big front windows overlooking the street's plaza have been re-opened, and the beautiful glass skylight panels and original crystal tiled floor have been cleaned and restored to allow natural light to shine all the way down to the basement floor.

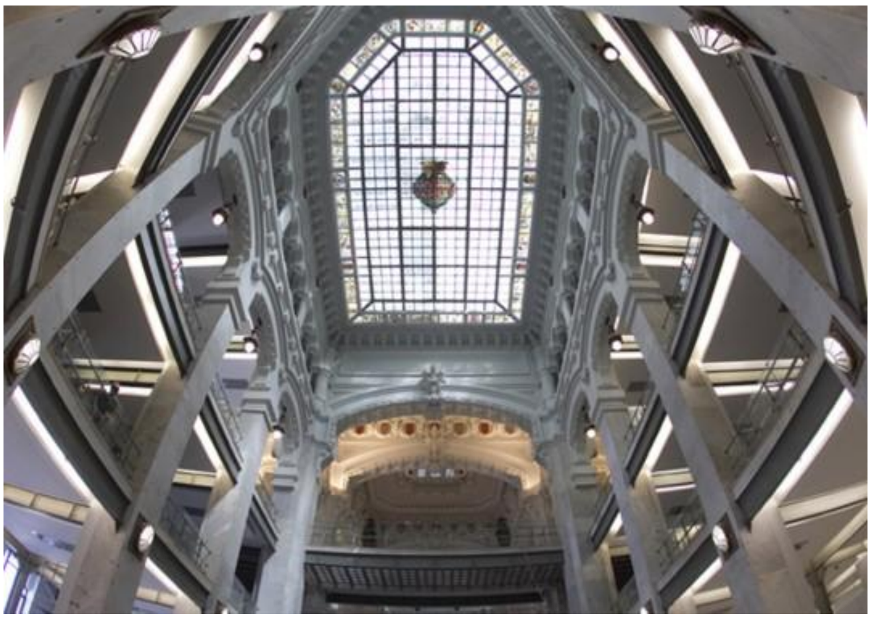


Figure 5.3 Central Operational Yard

Both ends of the central yard have been designated as social areas, where visitors can go to learn about the cultural activities that the bustling Spanish capital has to offer. As a contrast to the classic-but-cold building's architecture, these people-friendly areas are designed to combine innovation, information, and comfort.

This bright, bold and open spaces feature colorful sofas and bean bags, wooden furniture that is designed for disassembly, and recycled honeycomb cardboard tables. All the furniture from these areas has been specially designed for the context to make visitors feel at home. Newspapers, brochures and books are available on small side tables and shelves, while the striped hanging lamps are replicas of the fixtures that Antonio Palacios designed back at the time.

Figure 5.4 Social Area

The building's auditorium offers space for 296 spectators and features an amazing interior made from triangular wood panels. The magnificent room was inspired by music boxes, and it boasts excellent acoustics for chamber music concerts.

Figure 5.5 Auditorium Room

After all, it is the city's soul and a national platform for formulating new ideas.

5.1.2.2 Hong Kong Cultural Centre

The Hong Kong Cultural Center stands on one of Hong Kong's finest waterfront sites, looking out over Victoria Harbor with its quaint wooden fishing junks and busy passenger ferries parading past the colony's glistening glass and metal skyscrapers. It is on the former location of the Kowloon Station of the Kowloon-Canton Railway. Adjacent to the centre on the west is the Tsim Sha Tsui Ferry Pier of the Star Ferry, while to the east are the Hong Kong Space Museum and Hong Kong Museum of Art. The expectations of a new building should represent Hong Kong and its culture. The light pink-colored ceramic wall and fixed facade brought the building to a memorable history.

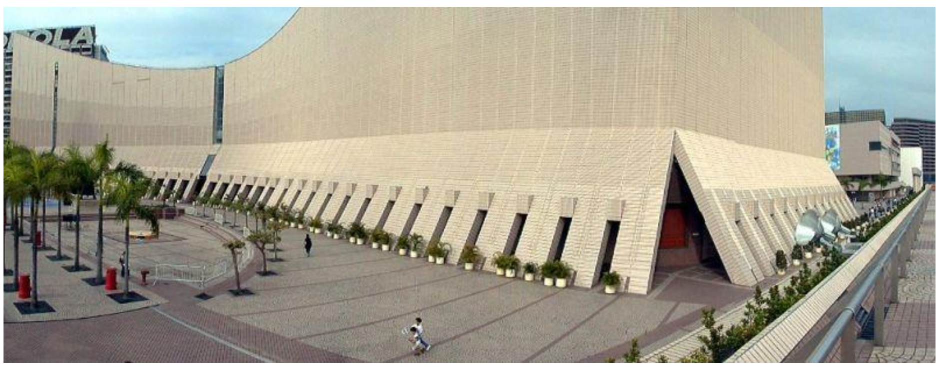


Figure 5.6 Building Facede

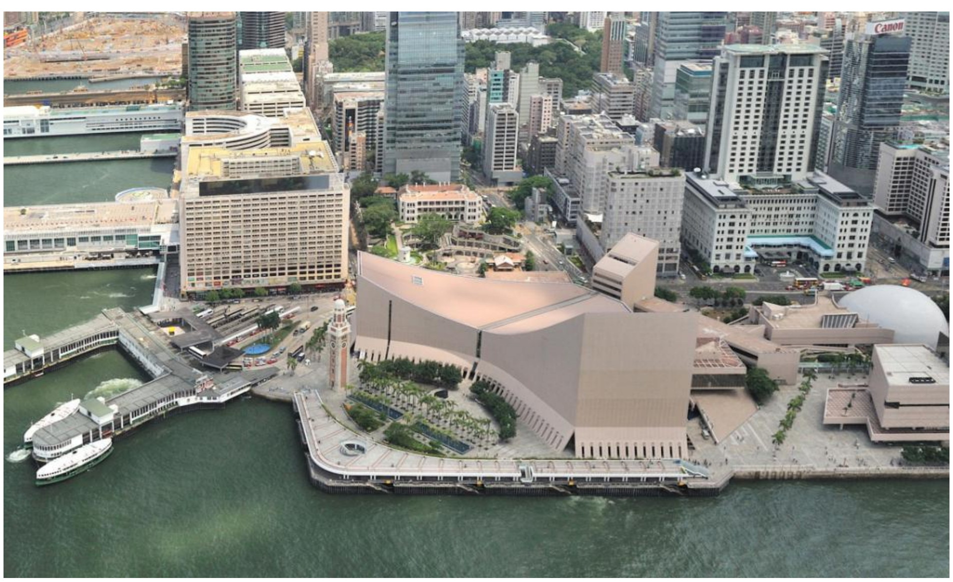


Figure 5.7 Location of Hong Kong Cultural Center

To cater for performing arts of all variety, the Centre is designed to house three major performing halls, namely the Concert Hall, the Grand Theatre and the Studio Theatre. There is also an Exhibition Gallery and four foyer exhibition areas. Other ancillary facilities include eleven rehearsal and practice rooms and two conference rooms.

The Exhibition Gallery is located on the fourth level of the Administration Building, covering an area of 287 square meters. It is equipped with audio and projection equipment, desks and chairs, etc, designed for meetings and tea parties. The center has four exhibition sites and a main foyer space for small scale art exhibitions. The Serenade Chinese Restaurant offers a good view of Victoria Harbor and a fine selection of dim sum. Encore Bar, Café Muse and Starbucks are other choices.

Figure 5.8 Exhibition Gallery

On the upper levels of the Concert Hall and Grand Theatre wings of the Auditoria Building are 11 rehearsal and practice rooms. The rooms are of varying sizes ranging from 16 square metres to over 300 square metres. In order to improve the acoustic performance of the concert hall, the Leisure and Cultural Services Department, Hong Kong Special Administrative Region Government (LCSD) commissioned Ove Arup & Partners Hong Kong Ltd (Arup) as the acoustic adviser and structure adviser to study the hall’s acoustics and produce recommendations for how the hall could be improved. Arup investigated potential improvements and advised to build a mock-up extension of sound reflective over-stage reflector to cover the extended downstage area to enhance additional reflection.

Figure 5.9 Auditorium Room

The column on the west part of the buidling, which not only strength the structure but also providing a light and shadow staggered view where naturally shaping an archway.

Figure 5.10 Arch Way

5.1.2.3 Market Santa Caterina

Mercat Santa Caterina (Market Holy Catherine) is the latest market built in Barcelona. Totally renovated in 2005 with brilliance by the architects Enric Miralles and Benedetta Tagliabue of EMBT, is a little marvel located in the district of Ribera in Ciutat Vella. Beautiful architectural idea for this multicoloured ceramics roof having the shape of wave posed on an air structure of wood, which shelters all the stalls of the market.

Figure 5.11 Market Santa Caterina

The colourful roof made up of tessellations with the colours of the fruit sold within the St Caterina Market. Seen from the street the dominant forms are the rippling vaults of the roof edges. The vaults vary in section along their length just as Enric Miralles designed at the Scottish Parliament. However, rather than heavy concrete, here EMBT's touch is light and energetic, a brilliant icon for selling the colourful life of Barcelona.

Santa Caterina Market redevelopment is, like many Barcelona buildings featured, an organic piece of architecture. The interior is functional and not trying to be cool, allowing the market traders to sell their wares in time-honoured tradition. Seen from street level the Santa Caterina facades are moderately playful with changing rhythms, but overshadowed by the roof in more ways than one. The vaults are quite fluid compared to those in Enric Miralles' Scottish Parliament building.

Figure 5.12 interior (left) and exterior (right)

5.1.2.4 Gallerie Vivienne in Paris

The Galerie Vivienne is one of the covered arcades of Paris, in the second arrondissement. It is 176 metres long and 3 metres wide. Pedestrianised, glass-ceilings, artificially illuminated at night, highly ornamented and decorated are the characteristics of the covered passages.

Figure 5.13 Exterior View

Visitors can admire the colourful mosaics on the ground and then lift their eyes to appreciate the beautiful glass roof which lets in the light. There are many of shops: ready-to-wear boutiques, tea rooms, gourmet food boutiques, wine cellars, grocery shops, old bookshops and much more. Thus it will give people a sense of big living room among the city.

Figure 5.14 Interior View

5.1.2.5 Galeries St Hubert Brussels

Built in 1846, they were commissioned bythe king to protect the inhabitants of Brussels from rain while shopping. They are a symbol of Belgium. They were the first shopping galleries in Europe. This urban passage, crowned with a glass and ornamented with columns, was the first of its kind in Europe. The Brussels galleries consist of three wings Gallery, named the King Galley, the Queen Gallery and the Princes Gallery.

The gallery consists of two major sections, each more than 100 meters, and a smaller side gallery. The main sections are separated by a colonnade at the point where the Rue des Bouchers / Beenhouwersstraat crosses the gallery complex.

At this point there is a discontinuity in the straight perspective of the gallery. This "bend" was introduced purposefully in order to make the long perspective of the gallery, with its repetition of arches, pilasters and windows, less tedious.

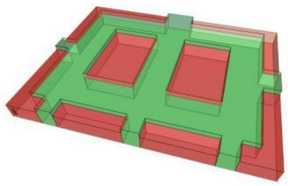
With the huge and high arcade, the visitors get the impression of serious and magnificent when entering.

Figure 5.15 Arcade of the Gallery

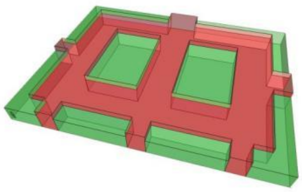
5.2 Socio- Cultural Center Concept

The socio-cultural center, will be characterized by its multi- functionality and balance between the story of Reinosa and its original market building, in a contemporary and actual image. Taking the feature of arcade, the socio-cultural center model was gradually formed to highlight the connection in time and in shape.

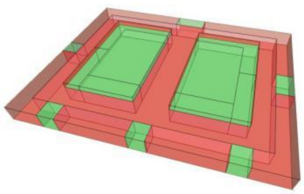
5.2.1 Shaping



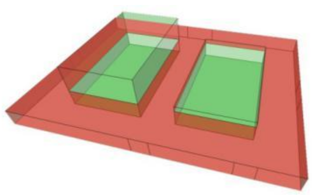
The layout of former market was designed with dynamic movement (void) and stationary part (volum).



The new building plan will keep the original shape while exchanging the location of volume with void.



Gathering all the void in the center, forming two large spaces.



Extending one of the large spaces in vertical direction to have two different level voids, namely arcade.

The volume is layout on the outskirt of the building while the two voids located on the center of the building, allowing the visitors to approach from the former entrance (west side and east side) to the voids where multi-function activities design would present. With the void, large arcade with pitched roof will be presented.

The very early sketch is as following

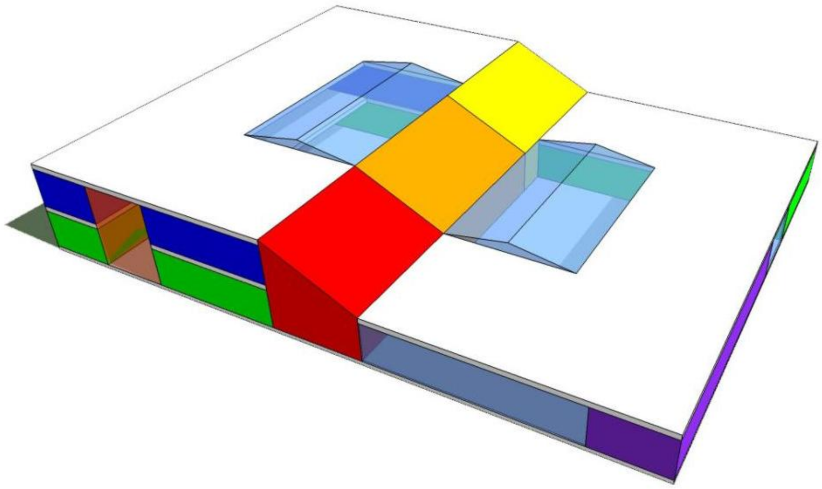


Figure 5.16 Early Stage Sketch shape of the Building

5.2.2 Strategy

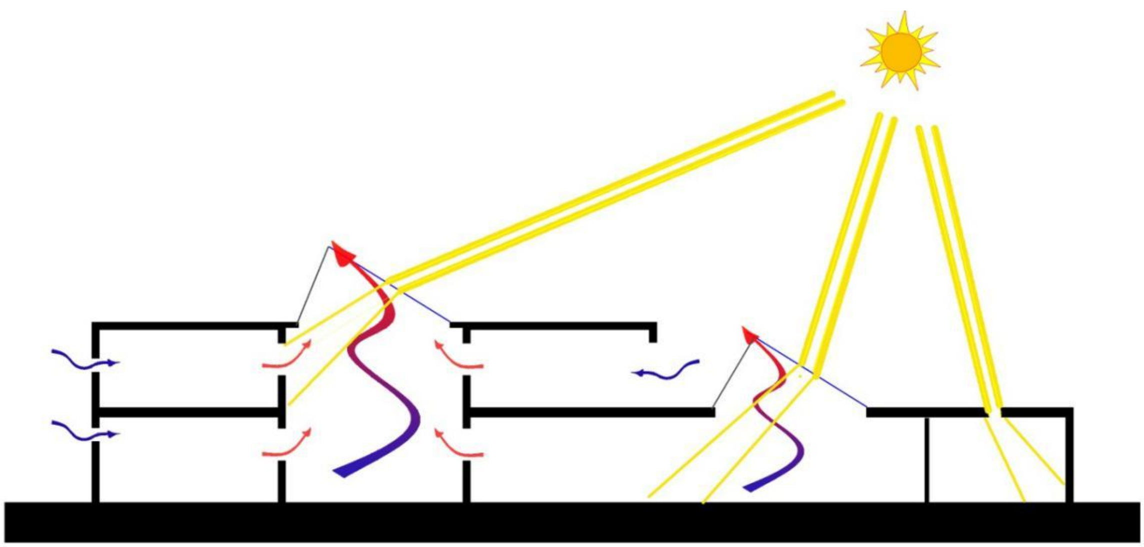


Figure 5.17 Natural Light and Ventilation Strategy

5.2.3 Envelope Development

5.2.3.1 Roof

To emphasize the function of arcade to get moderate natural light and ventilation, at the beginning, I propose an arrayed pitched roof made by building-integrated photovoltaics, which can get sun light as well as to be opened for exchanging air in off season.

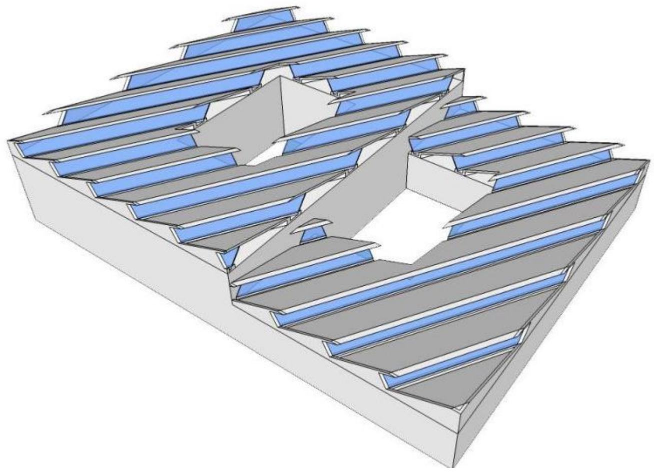


Figure 5.18 Arrayed Pitched in Early stage

From the point view of maintenance and aspect, the massive pitched is preferred.

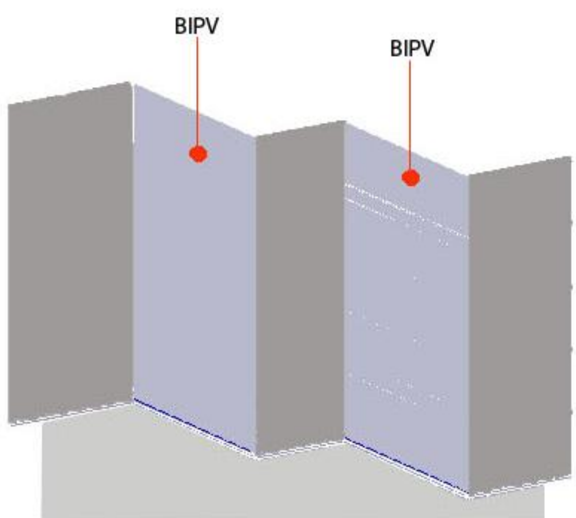


Figure 5.19 Pitched Roof

5.2.3.2 Façade

The concrete facade of the building transition into concrete site walls extending the architecture into the landscape. Openings are made where needed.

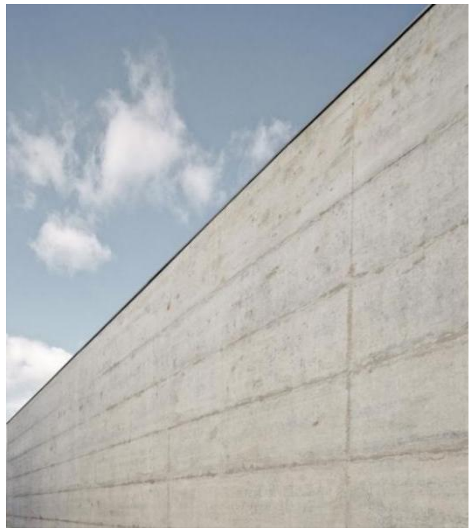


Figure 5.20 Concrete Façade Texture

5.2.4 Function Hieraichy

On the ground floor, the space have different functions, mainly lobby, café, toilets, market, auditorium room and exhibition room. On the first floor, the spaces have functions including workshops, toilets, lobby and stuff office.

5.3.1 Plan

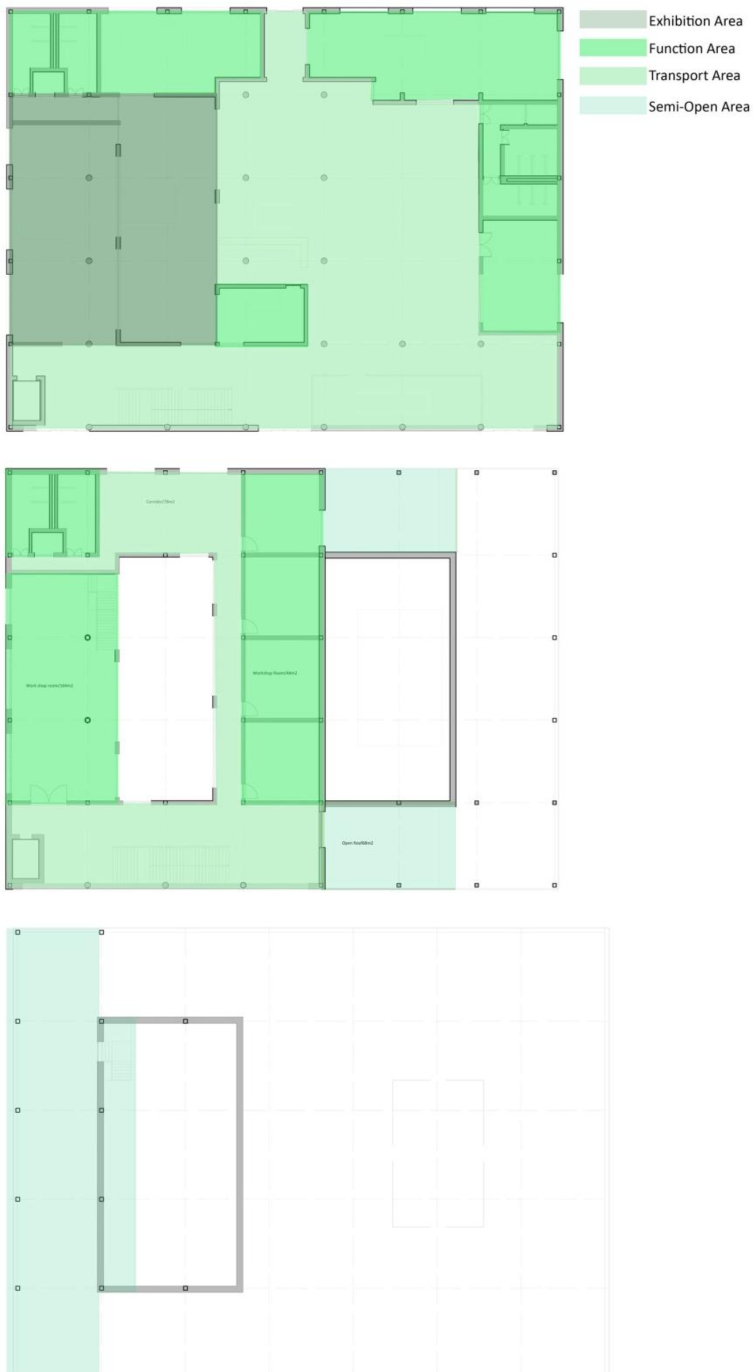
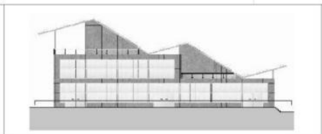
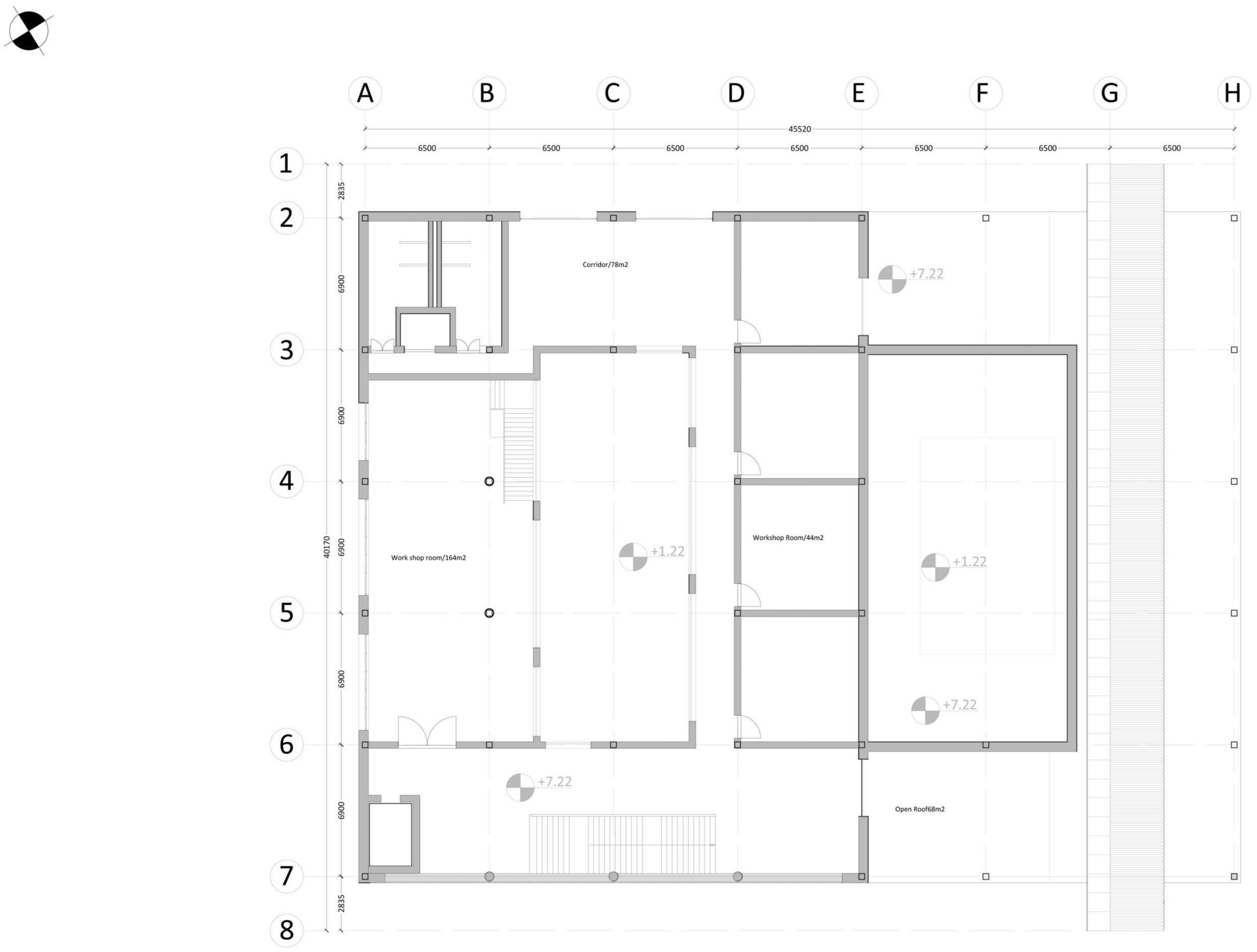


Figure 5.21 Plan in Function

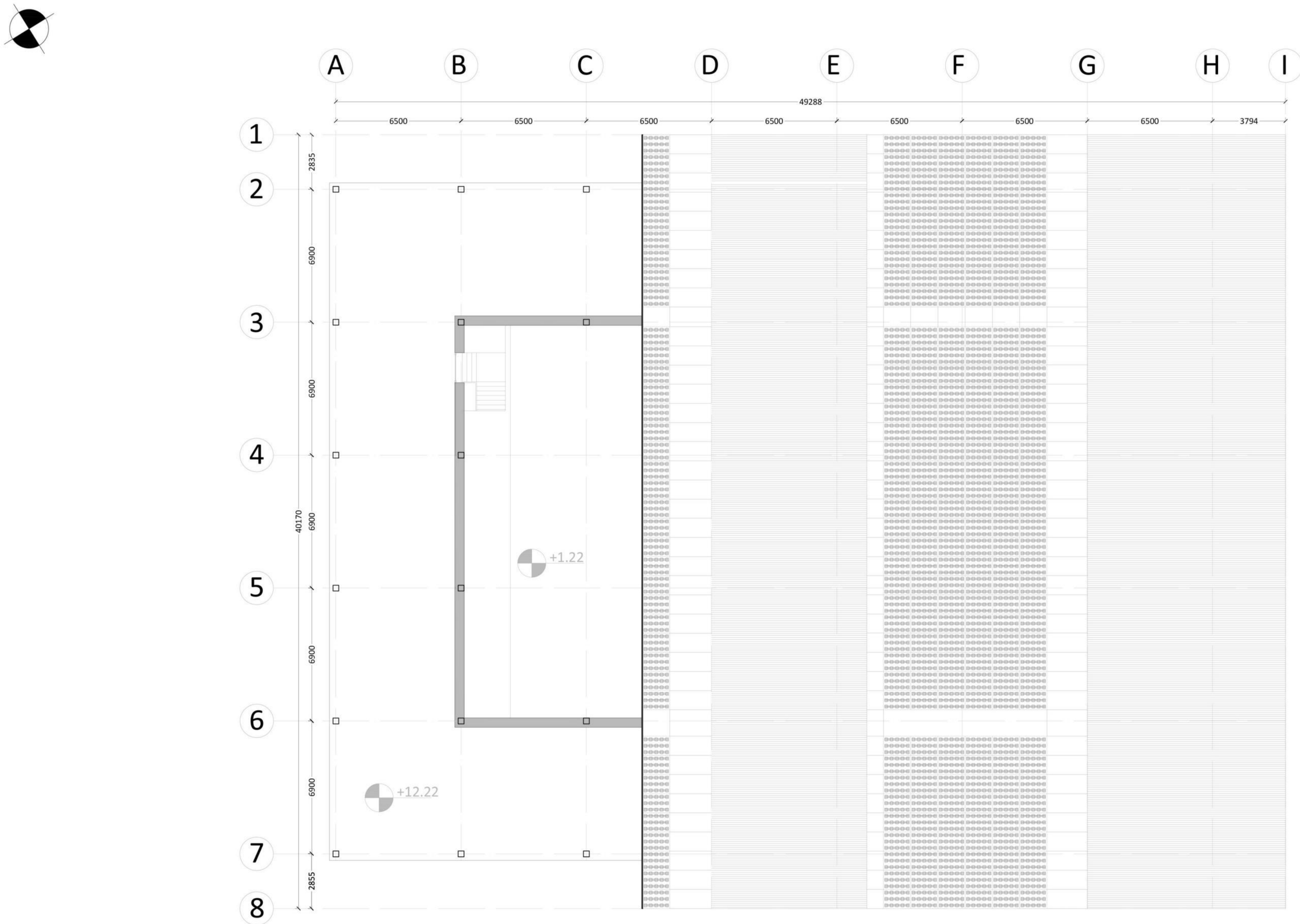
5.3 Drawings

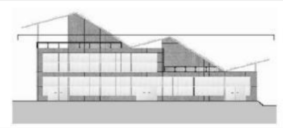
5.3.1 Plan

	Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI		Drawing Code Architecture - Ground Floor Drawing Scale 1: 200



	Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI		Drawing Code Architecture - First Floor Drawing Scale 1: 200



	Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI		Drawing Code Architecture - Second Floor Drawing Scale 1: 200

5.3.2 Elevation

Final Submission
21-09-2015

POLITECNICO DI MILANO
MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING
GRADUATION THESIS

PROJECT
SOCIO-CULTRAL CENTRE
REINOSA - SPAIN

AUTHOR
CHEN CHI

Drawing Code
Architecture - Elevation 1

Drawing Scale
1: 300

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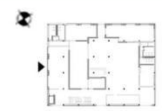
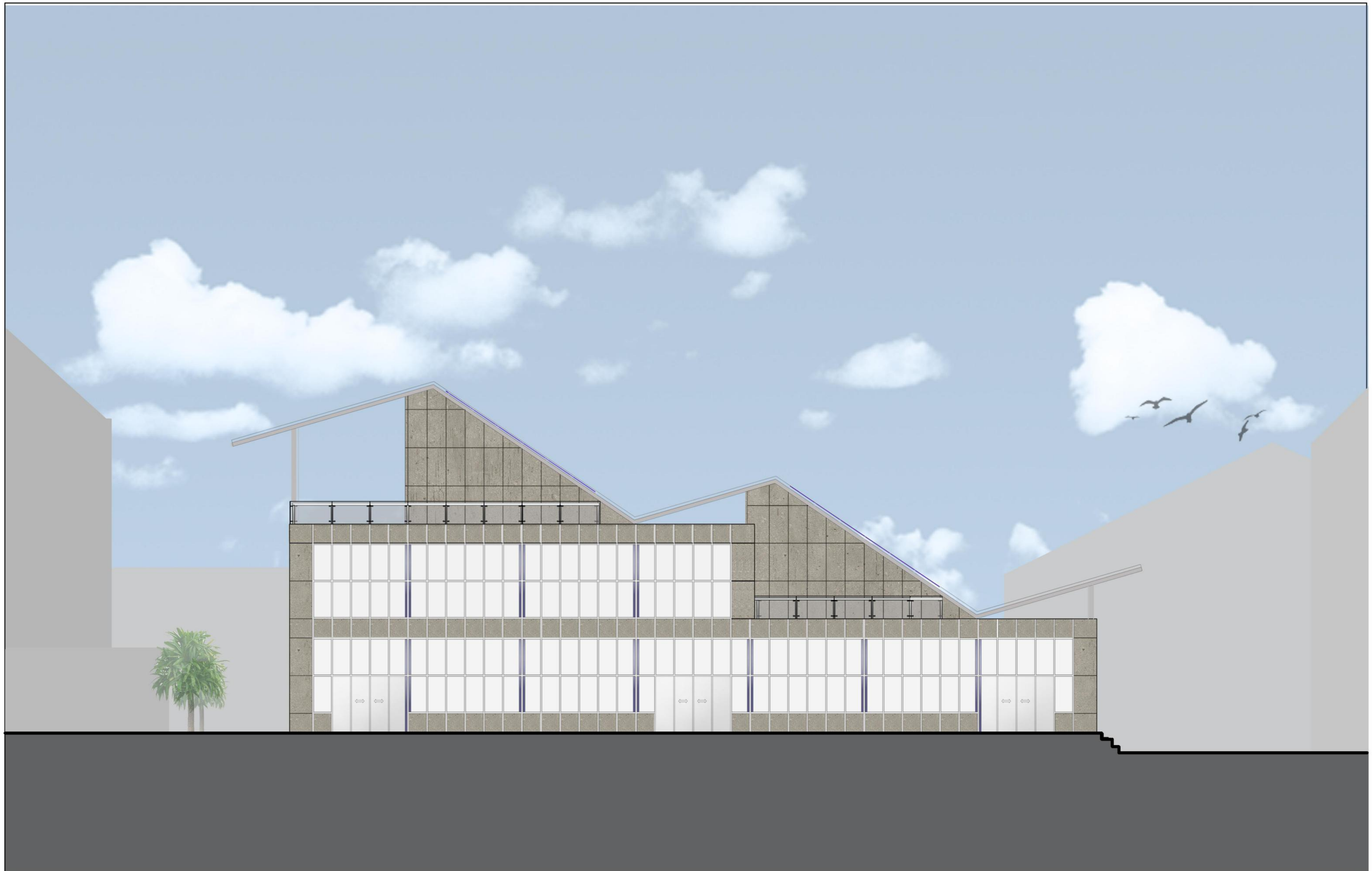
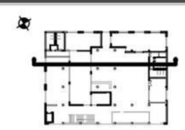
Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI		Drawing Code Architecture - Elevation 3	Drawing Scale 1: 300

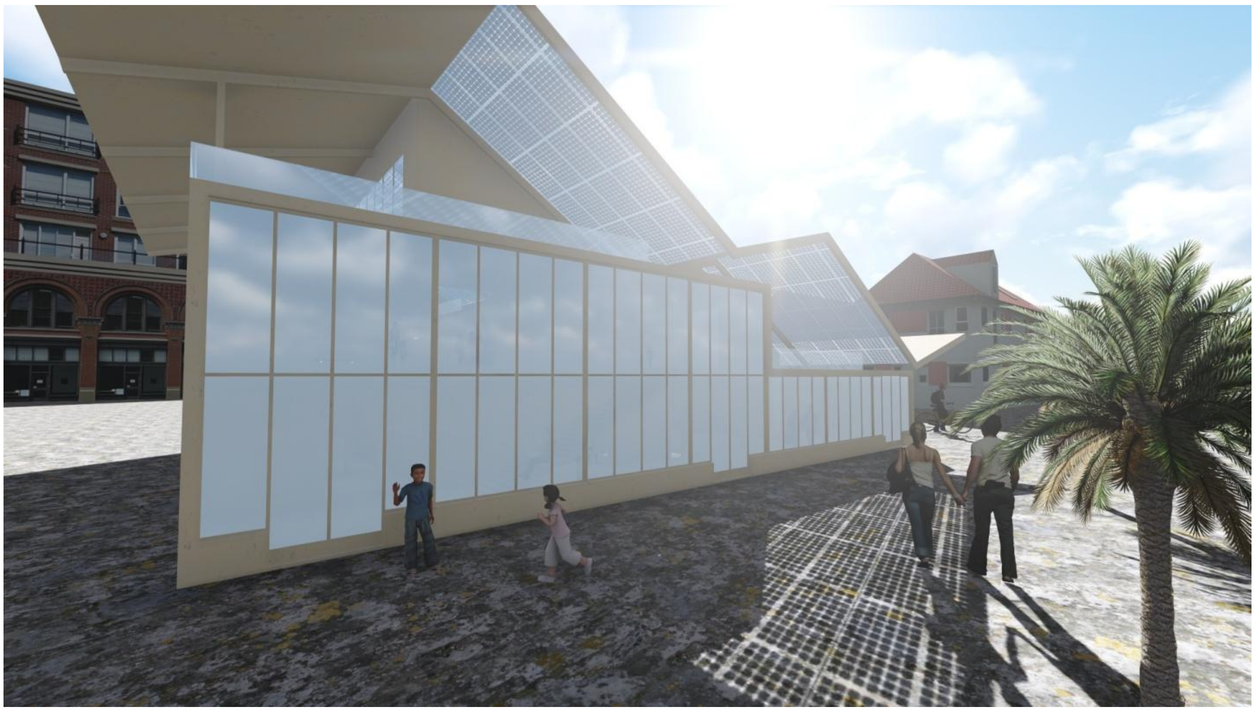


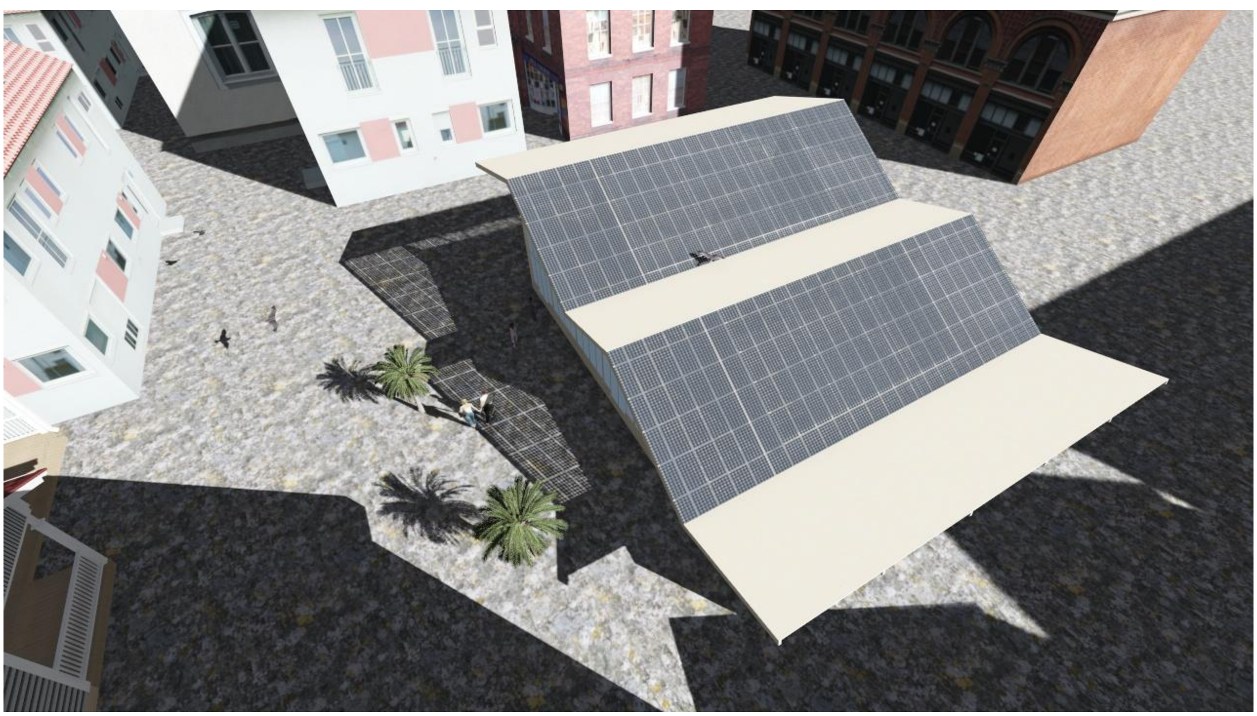
Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI	Drawing Code Architecture - Elevation **4**	Drawing Scale 1: 300

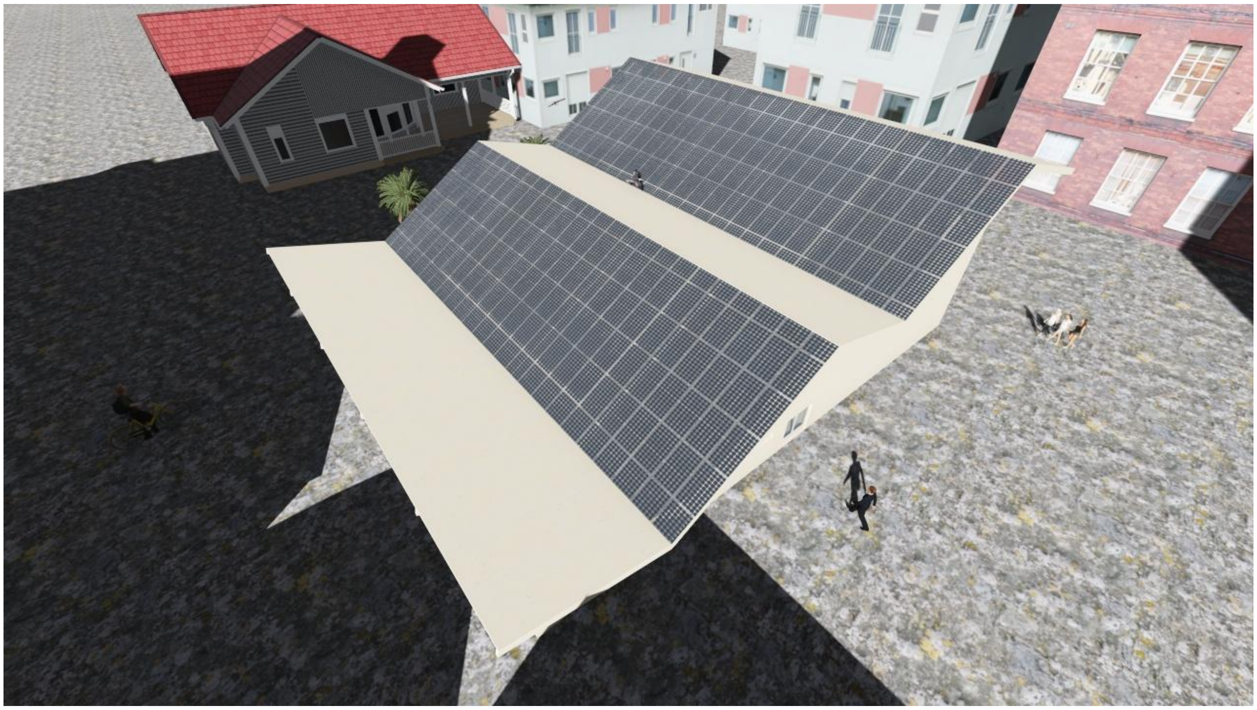
5.3.3 Section

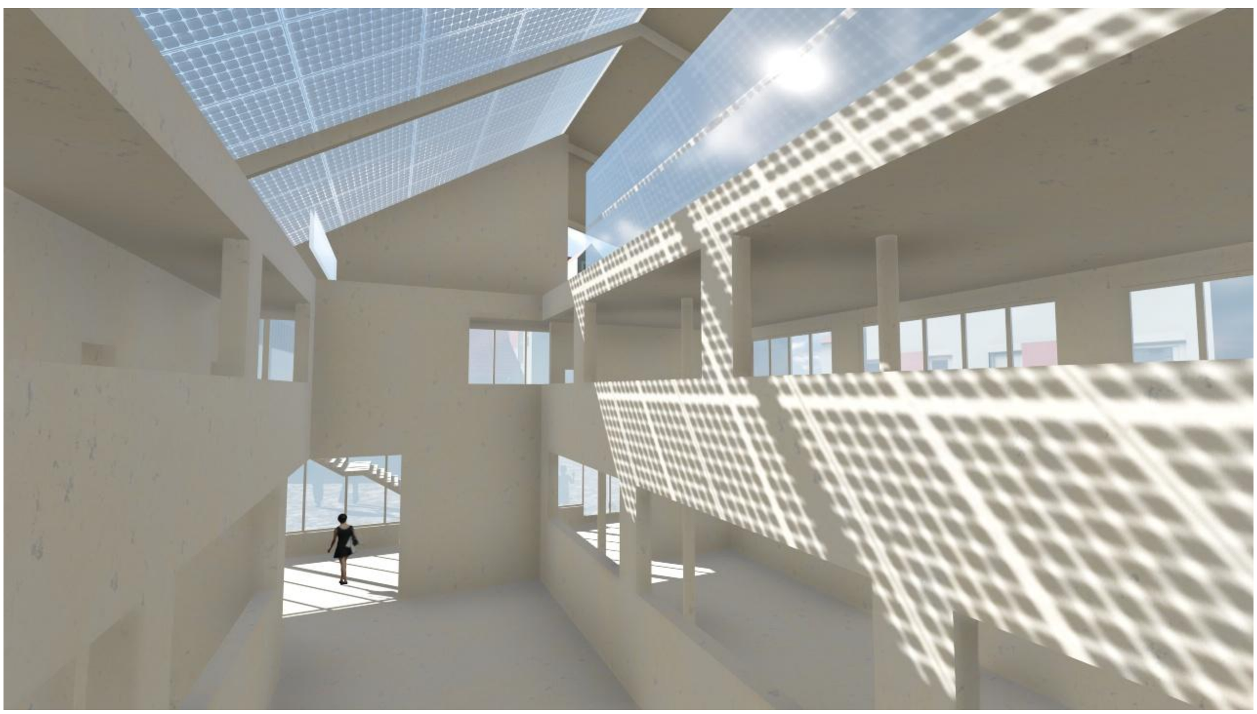
Final Submission 21-09-2015	POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	PROJECT SOCIO-CULTRAL CENTRE REINOSA - SPAIN	AUTHOR CHEN CHI		Drawing Code: Architecture - Section Drawing Scale: 1: 200

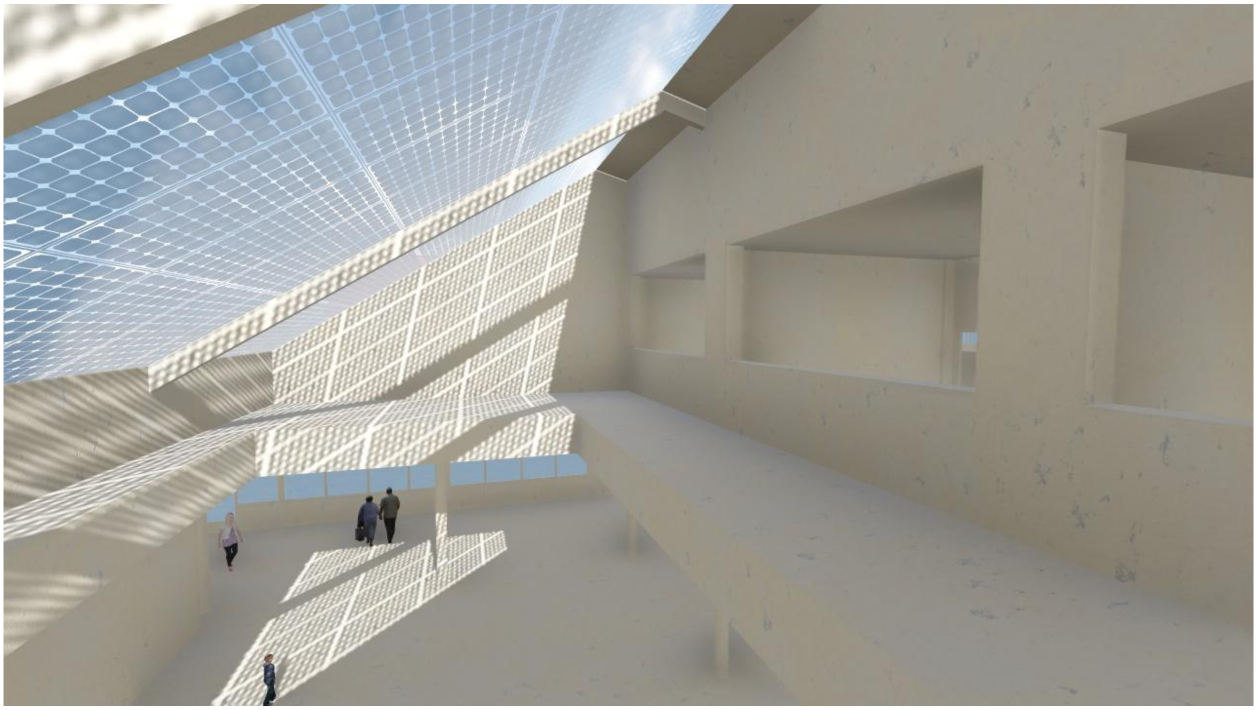
5.3.4 Impression











Chapter 6
STRUSTURE DESIGN

6 STRUCTURE DESIGN

6.1 Introduction

6.1.1 Design Philosophy

The present work concerns with the calculation of the structures of a two-storey building shown in the following figures: the cross-section and the typical floor plan are respectively illustrated in Fig. 6.1

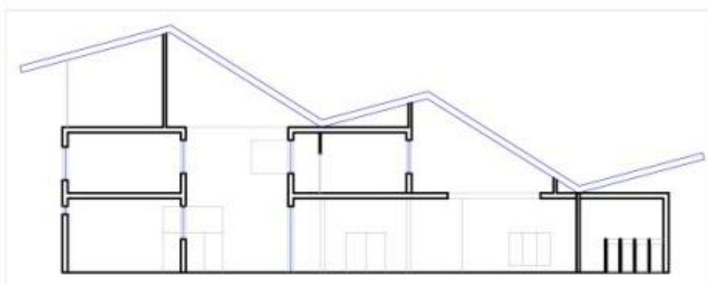


Figure 6.1 Section of the building

The building will be constructed in the neighborhoods of Reinosa, Spain and will be used as a cultural center edifice. It is composed of 2 stories in elevation and open roofs above ground floor and first floor level with a gross height of floors of 6m(ground floor) and 5m(first floor) and a rectangular floor plan of 46 m x 35m. The bearing structure will be made of steel in place and it represents one of the most common layouts for this type of buildings.

6.2 Material properties

According to BS EN 1993-1-1:2005, 3.2.1(1), the nominal values of the yield strength fy and the ultimate strength f_u for structural steel should be those obtained from the product standard. The ultimate strength f_u should be taken as the lowest value of the range given for R_m in the product standard.

In order to ensure structures are designed to EN 1993-1-1 with steels that possess adequate ductility, the following requirements are set out in Clause N.A 2.5 of the UK NA.

- Elastic global analysis

The limiting values for the ratio f_u/f_y, the elongation at failure and the ultimate strain ε_u for elastic global analysis are given below.

f_u/f_y, ≥ 1.10;

- Elongation at failure not less than 15%;

$\varepsilon_u \geq 15\varepsilon_y$, where ε_y is the yield strain($\varepsilon_y = f_y/E$).

- Plastic global analysis

Plastic global analysis should not be used for bridges. For buildings the limiting values for the ratio f_u/f_y, the elongation at failure and the ultimate strain ε_u for plastic global analysis are given below.

f_u/f_y, ≥ 1.15;

- Elongation at failure not less than 15%;

$\varepsilon_u \geq 20\varepsilon_y$.

6.3 Actions on Structure

6.3.1 Limit States and design situations

These are states beyond which a structure no longer satisfies the design performance requirement. The Eurocode prescribes two different classes of limit states: Ultimate Limit States (ULS): are those associated with the collapse or with other forms of structural failure which may endanger the safety of people. In particular are considered the

- Loss of equilibrium of the structure or any part of it
- Failure by excessive deformation

- Failure by rupture
- Failure by loss of stability of the structure or any part of it

Serviceability Limit States (SLS): are those corresponding to states beyond which specific service criteria are no longer met. In particular are considered:

- Deformation or deflections which are adversely affect the appearance or use of the structure or cause damage to finishes or non-structural elements.
- Vibrations which cause discomfort to the people, damage the building or its contents or which limit its functional effectiveness. The combination of equations for ULS are defined in the BS EN 1990: 2002 (clause 6.4.3) and are listed below

$\xi_J * \gamma_{G,J} * G_{K,J} + \gamma_P * P + \gamma_{Q,1} * Q_{K,1} + \gamma_{Q,1} * \Psi_{O,1} * Q_{K,1}$

Where,

$G_{K,J}$: is the characteristic value of an unfavourable permanent action

P: is a pre stressing action (not considered in steel design)

$Q_{K,1}$: is the characteristic value of the leading variable action

Γ, Ψ, ξ: are the partial, combination and reduction factors on actions, as given in BS EN 1990.

These values are subject to modification in the National Annex (NA) which is consulted.

6.3.2 Dead Loads

In Eurocode the permanent actions are the self-weight of the steel structure including the non-structural member such as the exterior wall, floor finish, ceiling floor etc. The calculation of are shown below:

6.3.2.1 External Wall

Materials	Specific weight (N/m³)	Thickness (m)	Total weight (N/m²)
Cement Panels	12740	0.03	328.2
Wood Fiber Board	2450	0.01	24.5
Rockwool Insulation	490	0.15	73.5
YTONG Block	5145	0.15	771.75
Plasterboard	392	0.015	5.88
TOTAL WEIGHT			1204
			1.204KN/m²

Table 6.1 Dead Load Calculation of the Exterior Wall

Total height of the floor is 6m. Considering the slab thickness to be 280mm (0.28m) and the net floor height as 5.72m, the linear weight of the wall will be equal to the total weight of the exterior wall multiplied by the net floor height.Linear weight of the wall for each floor = total weight of the exterior wall x net floor height = 6.89 KN/m.

Assuming 20% opening in each wall we need to decrease the total weight of the wall by 20%, Total linear weight of the wall = 6.5 KN/m

The load of the external wall is directly applied on the end beam along the perimeter and is not shared out with the slabs

6.3.2.2 Floor Finish

Materials	Specific weight (N/m³)	Thickness (m)	Total weight (N/m²)
Terrazzo tiles	25117	0.01	251.17
Screed layer	21188	0.06	1271.28
Light wt. concrete	9800	0.05	490
Profiled steel deck	38	0.01	0.38
Rockwool insulation	490	0.03	14.7
Steel ceiling grid	38	0.01	0.38
plasterboard	392	0.015	5.88
TOTAL WEIGHT			2033.79
			2.034KN/m²

Table 6.2 Dead Load Calculation for Floor Finish

6.3.2.3 Roof

Materials	Specific weight (kg/m³)	Thickness (m)	Total weight (kg/m²)
Light wt. concrete flags	1600	0.03	240
Screed laid to falls	1400	0.06	14
Protective membrane	30	0.01	1.5
Bitumen membrane	1400	0.01	70
Extruded polystyrene	14	0.2	0.28
TOTAL WEIGHT			325.78
			3.194 KN/m²

Table 6.3 Dead Load Calculation for the Roof

6.3.3 Variable Actions

In Eurocode the variable actions are time dependent loads which include the weight of the occupancy, maintenance and movable interior partitions. It also includes, imposed loads, snow load, wind pressure and seismic load (neglected due to the consideration of the leading action of wind & snow load). The calculation of are shown below:

6.3.3.1 Imposed loads

According to Section 6 Imposed Loads on buildings, EN1991-1-1:2002, Imposed loads shall be classified as variable free actions. They are those arising from occupancy, including

- Normal use by persons;
- Furniture and moveable objects
- Vehicles;
- Anticipating rare events.

The imposed loads specified are modeled by uniformly distributed loads, line loads, or concentrated loads or combinations of these loads. Only uniformly distributed load is taken here for load simulation. Table 6.4 below shows the category of floor/roof use that provided in EN1991-1-1:2002, and the value that selected for our project.

Category	**Specific Use**	**Sub-Category**	**Example**	**q_k (kN/m2) (uniformly distributed load)**	
				Characteristic Range	Value Used in our Project
B	Office Area			2.0-3.0	3.0
C		C1: Areas with tables	schools, café, receptions, etc	2.0-3.0	3.0
		C2: Areas with fixed seats	conference rooms, lecture halls, etc	3.0-4.0	3.0
		C3: Area without obstacles for moving people	museum, exhibition rooms	4.0-5.0	5.0
Roof- I	Roof accessible with occupancy according to Categories A to G				2.0

Table 6.4 Categories of use and values for Imposed Load, According to EN 1991-1-1:2002 Table 6.1, 6.2 and 6.9

Assuming the even distribution of areas under Category C, an average value qk=4 kN/m2 is taken for calculation.

6.3.3.2 Snow Load Calculation for a Pitched Roof

According to EN 1991-1-3 with specifications according to the National Annex apply. For persistent design calculations the snow load on the roof is expressed by the formula (5.1 EC1 – 1-3)

$S = \mu_i * C_e * C_t * S_k$

Where

$\mu_i = 2.4-0.04\ \alpha$ is the snow load shape factor co-efficient (for pitched 30˚< α< 60˚) (EN 1991-1-3, fig 5.1)

$C_e = 0.9$ is the exposure factor of topography of site (EN1991-1-3, table 5.1 of NA)

$C_t = 1.0$ is the insulation factor that should be used to account for the reduction of snow load on roofs with high thermal transmittance. It is considered as 1.0 unless otherwise specified

$S_k = 1.5\ KN/m^2$ is the characteristic value of snow load on the ground for Reinosa [National Annex EN1991-1-3] for a design working life of the structure of 50 years in accordance with the initial design assumptions.

Hence, the value of snow load on roof = 1.12 * 0.9 * 1.0 * 1.5 = 1.512 KN/m^2

6.3.3.3 Wind Load Calculation

- The basic wind velocity V_b

According to EN 1991-1-1-4, (ex 4.1) the following procedure applies for calculation of wind load

$V_b = V_{b,o} * C_{dir} * C_{season}$

$V_{b,\,o}$ is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle height. Where the influence of altitude as on the basic wind velocity V_b is not included in the fundamental value in National Annex

$V_{b,\,o} = 18.5$ m/s is the fundamental value for the basic wind velocity in Reinosa

$C_{dir} = 1.0$ is the directional factor (standard taken from NA)

$C_{season} = 1.0$ is the season factor (standard taken from the NA)

Hence, the value of basic wind velocity, V_b = 18.5 * 1.0 * 1.0 = 18.5 m/s

As per EN 1991-1-4, section 4.5 ex 4.10, the basic velocity pressure is

$$q_b = ½ * \rho * V_b$$

ρ=1.25 kg/m³ is the air density as specified in the National Annex

V_b = 18.5 m/s is the basic wind velocity calculated previously from eq.5.3

Hence, the basic velocity pressure, q_b = ½ * 1.25 * 18.5 = 13.875 N/m²

- The mean wind velocity $V_{m(z)}$

The mean wind velocity $V_{m(z)}$ at a height z above the terrain can then be calculated and

it depends on the terrain roughness and orography and on the basic wind velocity, v_b

[Expression 4.3-EC1-1-4]:

As per EN 1991-1-4, section 4.4(1), ex 4.7, the mean wind velocity is

$$V_{m(z)} = Cr(z) * Co(z) * Vb$$

Where

$C_{o\,(z)}$ = 1.0 is the orography co-efficient which is always taken as 1.0

(Where the orography (e.g. Hills, cliffs etc.) increases wind velocities by more than 5% the effects should be taken into account using the orography factor to be calculated following the procedure given in Annex A.3)

Cr(z) is the roughness coefficient which accounts for the variability of the mean wind velocity at the site of the structure due to the height above ground level and the ground roughness of the terrain upwind of the structure in the wind direction considered. The recommended procedure for the determination of the roughness factor at height ‘z’ is based on a logarithmic velocity profile and is given in the following equation (EN 1991-1-1, ex 4.4)

This equation is for the condition when Zmin ≤ Z ≤ Zmax

Where Kr is the terrain factor depending on the roughness length Z_0

kr = 0.19 x (z_0 /$z_{0,II}$) 0.07

Where $z_{0,II}$ = 0.05 m (refer to the Table 6.5 below)

Z_{min} is the minimum height (refer to the Table 6.5below)

Z_{max} is to be taken as 50 m, unless otherwise specified in the National Annex

kr = 0.19 x (0.3 /0.05) $^{0.07}$=0.215

Z_0 = 0.3 is the roughness length

Z_{min} = 5 is the minimum height

Which is refer to that Reinosa belongs to the terrain category III, which is the area with regular cover of vegetation or buildings or with isolated obstacles with separation of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)

Hence the roughness co-efficient Cr(z) = 0.215 * ln (11/0.3) = 0.77

And the mean wind velocity $V_{m\,(z)}$ = 0.77 * 1.0 * 18.5 = 14.25m/s

Category	Specific Use	Sub-Category	Example	q_k (kN/m_2) (uniformly distributed load)	
				Characteristic Range	Value Used in our Project
B	Office Area			2.0-3.0	3.0
C		C1: Areas with tables	schools, café, receptions, etc	2.0-3.0	3.0
		C2: Areas with fixed seats	conference rooms, lecture halls, etc	3.0-4.0	3.0
		C3: Area without obstacles for moving people	museum, exhibition rooms	4.0-5.0	5.0
Roof- I	Roof accessible with occupancy according to Categories A to G				2.0

Table 6.5 Terrain Categories and terrain parameters, drawn from Table 4.1, Eurocode 1991-1-4

- Peak velocity pressure

The peak velocity pressure which includes long and short term fluctuations in velocity can be determined from EN1991-1-4, ex 4.8

Where,

ρ is the air density. The recommended value is 1.25 kg/m3.

I v (z) is the turbulence intensity which depends on the turbulence factor K and the height of the building.

Iv (z) = for $z_{min} < z < z_{max}$

Iv= Iv (z_{min}) for $z < z_{min}$

Iv (z)= = 0.28

Where, k_l is the turbulence factor= 1.0 (recommended by EN 1991-1-4)

Hence, the value of peak velocity pressure:

$qp(z) = [1 + 7 * 0.28] * ½ * 1.25 * (14.25)^2 = 375.67 N/m^2$

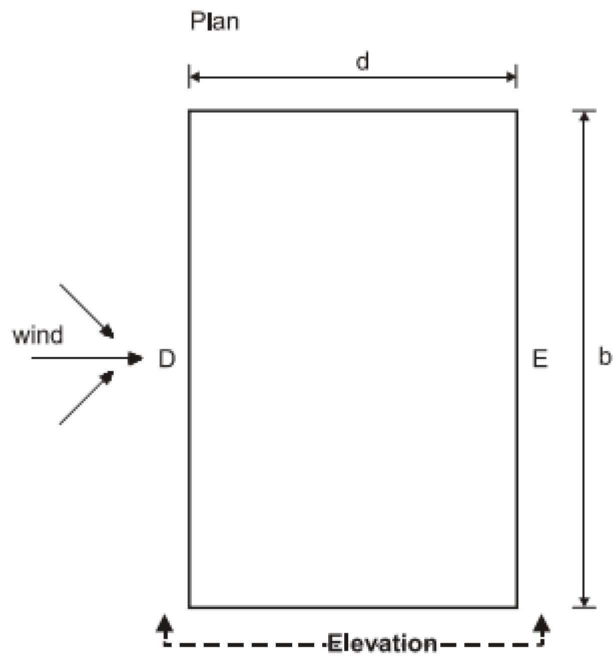


Figure 6.2 Dimension of Building Measurement

Here height of the building, h = 11m above ground level, length of the building in the longest side, d = 46m and the width of the building, b = 35m. Since the height to depth ratio (h/d) is equal to 0.24 and for the condition h ≤ b we get the below profile for wind velocity pressure, in accordance with EN 1900, (fig 7.4)

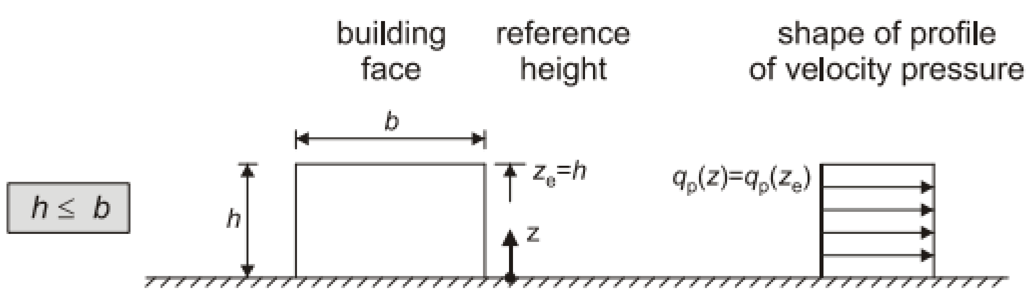


Figure 6.3 Profile of Velocity pressure for h≤b

C_{pe} = +1.2: is the pressure co-efficient along the windward wall in accordance with EN 1990-1-1-4 figure7.5 and table 7.1 for h/d ≤ 0.25

Z_e = 6m : is the reference height of the building for one level

$w_e = C_{pe} * qp * Z_e$

$F_w = cs * cd * we * A$

Where,

Cs * Cd = 1: structural factor considered for height ≤ 15m

A = 6 * 6.9 = 41.4 m^2: area of façade between two columns at each level, with wind acting along the X direction

A = 6 * 6.5 = 39 m^2: area of façade between two columns at each level, with wind acting along the Z direction

The wind pressure acting on the external surface along the X- direction

W_e= 1.2 * qp * 6 = 1.2*375.67*6=2.70 KN/m^2

And the wind force acting on the structure along the X-direction

F_w = 1 * 2.7 * 41.4 = 111.78 KN

Similarly the wind force acting on the structure along the Z- direction

F_w = 1* 2.7 * 39 = 105.3 KN

6.4 Design of a Composite Slab

Composite slabs comprise reinforced concrete cast on top of profiled steel decking, which acts as formwork during construction and external reinforcement at the final stage. Composite construction is very popular mainly because concrete is very good in compression and steel in tension.

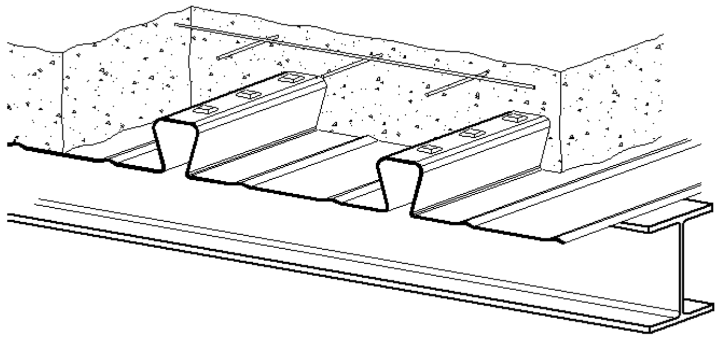


Figure 6.4 Typical Cross Section of Composite Slab

Consider a slab, with the shorter span, a = 2m and the longer span, b = 6.9m. If the ratio of longer to shorter span < 2 it is a two-way slab which means the load is transmitted along all four directions. If the ratio of longer to shorter span is ≥ 2 it is a one-way slab and the load is transmitted along the longer span. Here the ratio longer to shorter span >2 hence we shall design a one way composite slab. The continuous floor slab will be designed as a series of simply supported span.

6.4.1 Floor Slab and Material Properties

Consider,

Total depth of slab, h = 80 mm

Corus profile steel sheeting from Comflor 60 [19]

Thickness of profile, t = 1.0 mm

Depth of profile, h_p = 30 mm

Span, L = 6,9 m

Effective cross-sectional area of the profile Ape = 1894 mm/m²

Second moment of area of profile, I_p = 177.15 cm^4/m

Yield strength of profile deck, f_{yp} = 350 N/mm²

Design vale of bending resistance (sagging), M_{rd} = 11.27 KNm/m

Profile of Concrete

According to BS EN 1992-1-1 table 3.1 and the strength class of normal concrete is C25/30

Density of normal weight, concrete = 24 KN/m³

Thickness of concrete slab = 50 mm

Cylinder strength f_{ck} = 25 N/mm²

Modulus of elasticity, E_{cm} = 31 KN/mm²

6.4.2 Combination of Actions

6.4.2.1 Permanent Actions

Self-weight of concrete slab = $24 * 10^{-6} * 80$= 1.92 KN/m²

Self-weight of steel deck = 0.11 KN/m²

Dead load of floor finish = 2.034 KN/m²

Total permanent actions, G_k= 4.064 KN/m²

6.4.2.2 Variable actions

Imposed load for an workshop area = 2.5 KN/m²

Self-weight of inside movable partitions = 0.8 KN/m²

Total variable actions, Q_k = 3.3 KN/m²

- Construction Stage

At the construction stage, the permanent action considered is only the self-weight of the steel deck and the variable action considered is the self-weight of the concrete slab plus an additional weight of 0.75 KN/m²

Permanent action at construction stage = 0.11 KN/m²

Variable action at construction stage = 0.75 + 1.92= 2.67 KN/m²

- Composite Stage

At the composite stage, the permanent action considered is the weight of the concrete slab and the steel deck and also the floor finish, while the variable action considered is the total imposed floor load which included the live load for an office building and weight of the movable partitions.

Permanent action at composite stage = 1.92 + 0.11 + 1.0 = 3.03 KN/m²

Variable action at composite stage = 2.5 + 0.8 = 3.3 KN/m²

In accordance with BS EN 1990, NA 2.2.3.2, table NA.A1.2B, the value of partial safety factors and reduction factor are the following.

Partial safety factor for permanent actions, $\gamma_{G,1}$ = 1.35

Partial safety factor for variable actions, $\gamma_{Q,1}$ = 1.5

Reduction factor, ξ_1 = 0.925

The design values may be calculated using ex 6.10 b from BS EN 1990 which has been mentioned above

- Construction stage

Distributed load = (0.925 * 1.35 * 0.11) + (1.5 * 2.67) = 4.14 KN/m²

- Composite stage

Distributed load = (0.925 * 1.35 * 4.0) + (1.5 * 3.3) = 9.9 KN/m²

6.4.3 Design Moment and Shear Force

- Construction stage

The design bending moment per metre width of steel deck is

= = 24.64 KNm

The design shear force per metre width of steel deck is

= = 14.28 KN/m

- Normal stage

The design bending moment per metre width of steel deck is

= = 58.91 KNm

The design shear force per metre width of steel deck is

= = 34.16 KN/m

The partial safety factors to be considered for resistance in the case of structural steel which is in accordance to BS EN 1993-1-1 and NA 2.15 and in the case of concrete, reinforcement which is in accordance to BS EN 1992-1-1 and NA 2, Table NA.1 are

Structural Steel, $\gamma_{mo} = 1.0$

Concrete, $\gamma_c = 1.5$

Reinforcement, $\gamma_s = 1.15$

Longitudinal Shear, $\gamma_{vs} = 1.25$

6.4.3.1 Design Value of Material Strength

Design yield strength of the profile steel deck

= = 35 N/mm²

Design value of concrete compressive strength

= = 14.17 N/mm²

where = 0.85 according to BS EN 1992-1-1 and NA 2, table NA.1

6.4.4 Verification of Composite Slab at ULS

6.4.4.1 Bending resistance- location of plastic neutral axis

Maximum compressive design force per metre in the concrete above the sheeting, assuming the plastic neutral axis is below the solid part of the slab is determined as

= 14.17 * 50000 = 735 KN/m

Where

f_{cd} = 14.17 N/mm² which is the design value of concrete compressive strength

A_c = 50 * 1000 * 10^{-3} = 50000 mm which is the area of concrete slab per metre

The maximum tensile resistance per metre of the profile steel sheet is determined as

= 350 * 1424 = 498.4 KN/m

Where,

$f_{y,pd}$ = 350 N/mm² which is the yield strength of profile deck

A_p = 1424m/m² area of profile deck (from manufacturer's data)

check: As $N_p < N_c$ the neutral axis lies above the profile sheeting

Therefore the sagging bending moment resistance should be determined from the stress distribution shown in the figure below with respect to the BS EN 1993-1-3, 9.7.2(5)

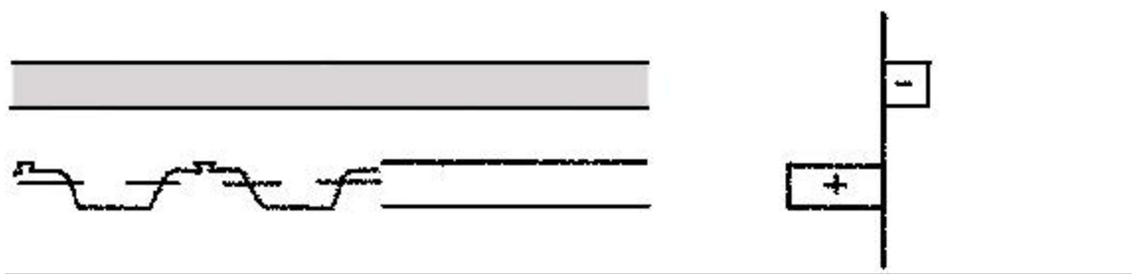


Figure 6.5 Centroid Axis of the Composite Slab

The depth of concrete slab in compression is

= 35.18 mm

Where

b = 1000m is the width of the slab per metre

A_{pe} = 1424 mm/m² is the area of the profile deck

$f_{yp,d}$ = 350 N/mm² is the yield strength of the profile deck

f_{cd} = 14.17 N/mm² is the design value of concrete compressive strength

Bending resistance- full shear connection

For full shear connection the design moment resistance is

=75.71 KNm

Where,

d_p = depth of slab – depth of soffit = 80 – 50 = 30 mm

M_{ed} = 58.91 KNm is the design moment per metre width of steel deck

$M_{pl,rd}$ = 75.71 KNm is the design moment resistance

= 0.78 < 1.0

Check: As <1.0 the bending moment resistance for full shear connection is adequate

Longitudinal shear resistance using m-k method

The method given in BS EN 1993-1-3, 9.7.3 is used to determine the design resistance to the longitudinal shear

=19.68 KN/m

Where,

b= 1000 mm is the width of the slab per metre

m = 157.2 N/mm^2 for steel decking (from manufacturer's data)

k = 0.123 N/mm^3 f or steel decking (from manufacturer's data)

Ls = = 937.5 mm for a uniform load applied to the whole span length

34.16 KN/m is the design shear force for steel deck

= 0.72 < 1.0

Check: As <1.0 therefore the design resistance to longitudinal shear is adequate

- Vertical shear resistance

The vertical shear resistance will normally be based on BS EN 1992-1-1, eq 6.2b. Using the nomenclature in BS EN 1994-1-1, the equation becomes

)

Al though in reality the slab is continuous, it is normally convenient to design it as a simply supported. As a consequence of this, the beneficial effect of hogging moments at the support is neglected, such that =0

The recommended value = 0.035 * 2.83 *5 = 0.49 N/mm²

Where,

dp = 30mm is the diff between depth of slab (h) - depth of soffit

> 2 taking the lower value, k = 4

f_{ck} = 25 N/mm² is the cylinder strength of concrete

14.28 KN/m is the design shear force for steel deck

Hence, =0.49 * 30 = 14.7 N/mm²

= 0.97 < 1.0

Check: As <1.0 therefore the vertical shear resistance is satisfactory

All design check for the composite slab in ULS is satisfactory

CHAPTER 6
TECHNOLOGICAL DESIGN

7 Technological Design

7.1 Climate analysis

7.1.1 Reinosa Climate Data

Reinosa is one of the cities in the north of Spain with the lowest average temperature, climate presents many features of the continental climate typical of the Castilian plateau (high insolation and temperature contrasts than normal in the rest of Cantabria) but tinged with some influence of the Atlantic climate and mountains. At a height of 851 meters above sea level, the city and the region have very cold winters with heavy snowfalls, registering 90 days a year of frost and warm summers. The major rainfall occurs in spring and autumn.

7.1.1.1 Temperature

The mean temperature is about 14 °C. Snow is frequent in higher zones of Cantabria between the months of October and March. The driest months are June and July, although droughts are unknown because rain is frequent and temperatures never get particularly high.

Since the data of Reinosa is rarely to be collected, the following data is based on Burgos, which is a small town 7km far from Reinosa, but with the very similar climate.

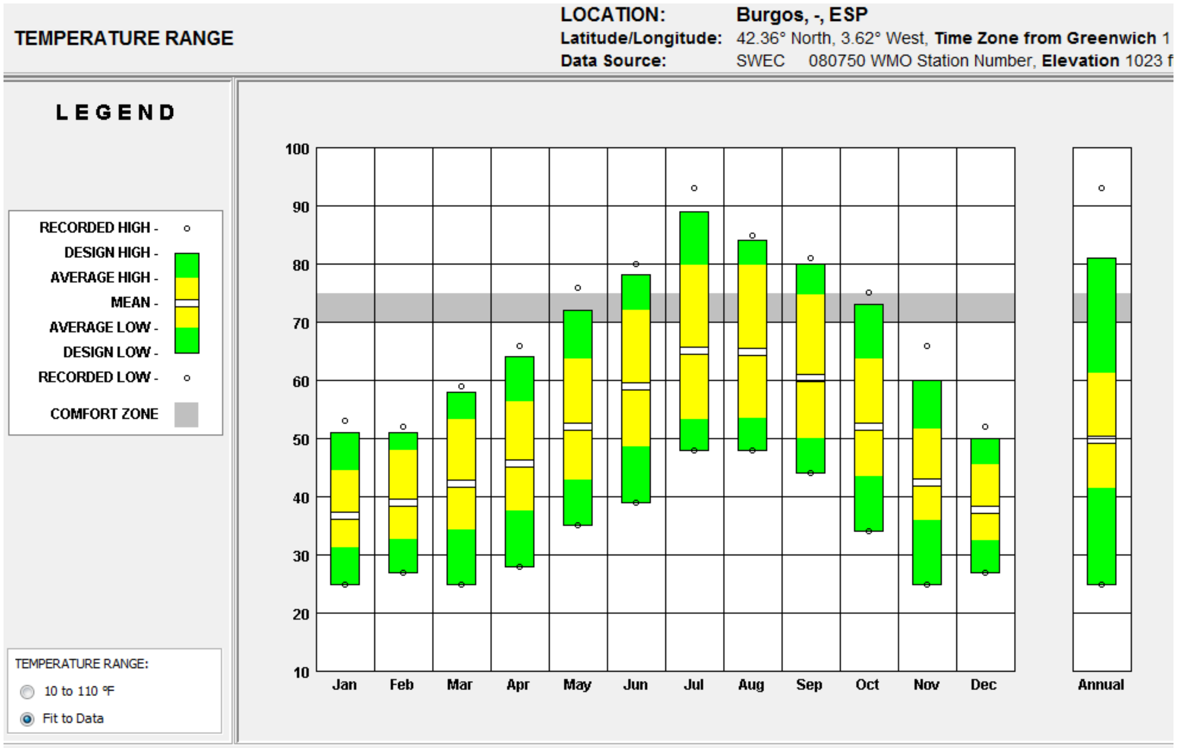


Figure 7.1 Temperature Data

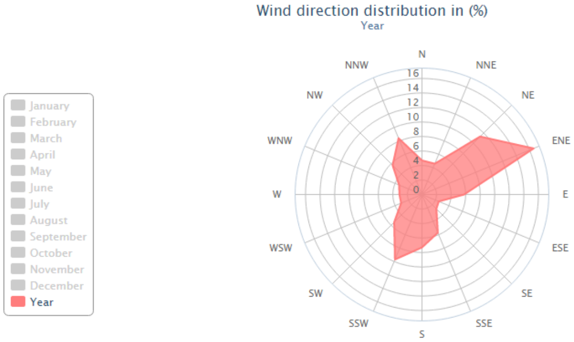
7.1.1.2 Wind

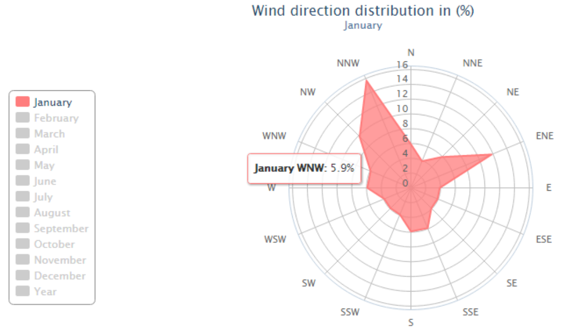
In Reinosa, Wind direction is reported from North East most time of year, except at January and February from North West, November and December from South.

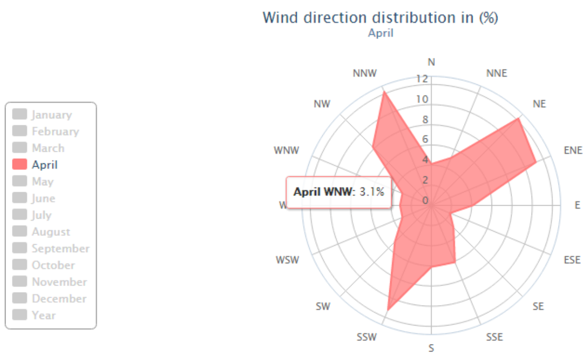
Month of year	Jan 01	Feb 02	Mar 03	Apr 04	May 05	Jun 06	Jul 07	Aug 08	Sep 09	Oct 10	Nov 11	Dec 12	Year 1-12
Dominant Wind dir.													
Wind probability >= 4 Beaufort (%)	9	29	10	19	15	13	8	13	14	15	24	15	**15**
Average Wind speed (kts)	5	8	6	7	7	6	6	6	6	6	7	5	6
Average air temp. (°C)	4	5	9	10	14	16	17	19	18	13	9	5	**11**

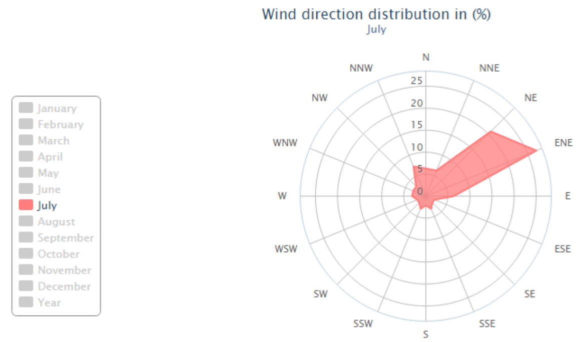
Figure 7.2 Wind Data

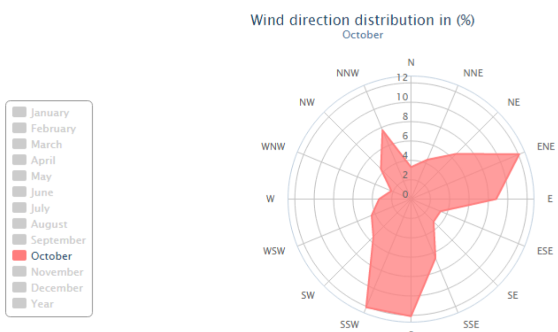
Typical months' wind direction rose map is following:

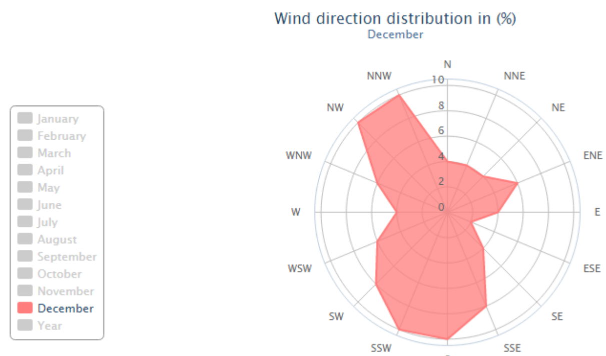












7.1.1.3 Solar

In Reinosa, the annual average horizontal solar irradiance can reach 320kwh/m^2. The solar energy can reach peak from May to September.

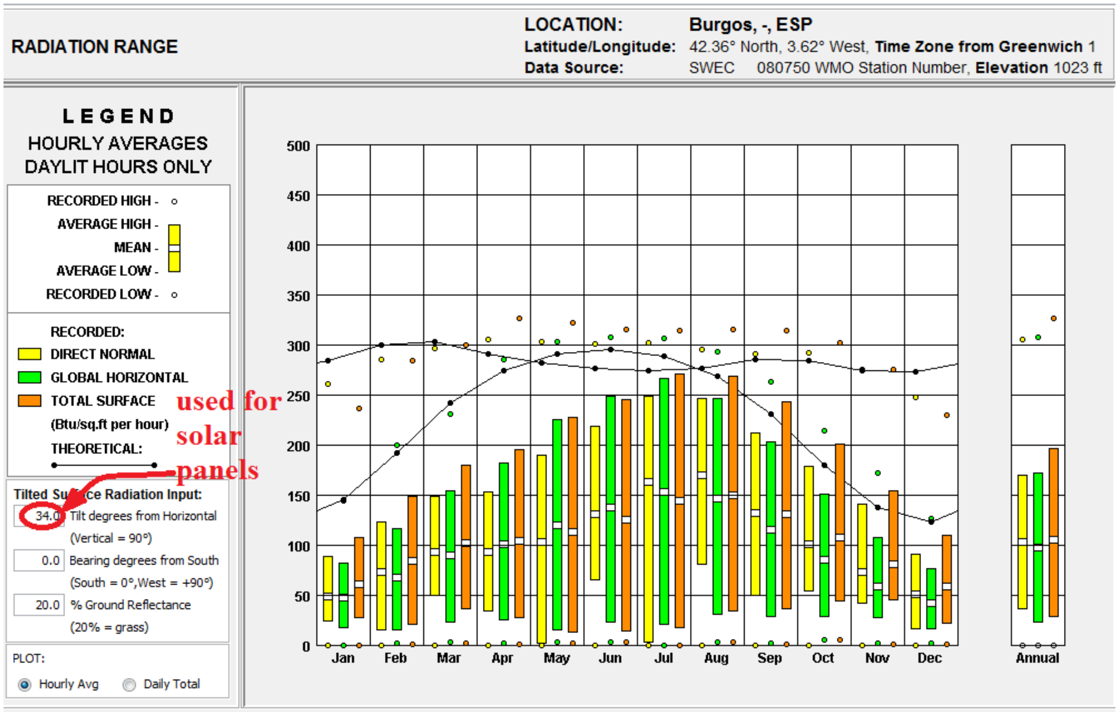


Figure 7.3 Solar Radiation Data

7.1.1.4 Comfort Zone

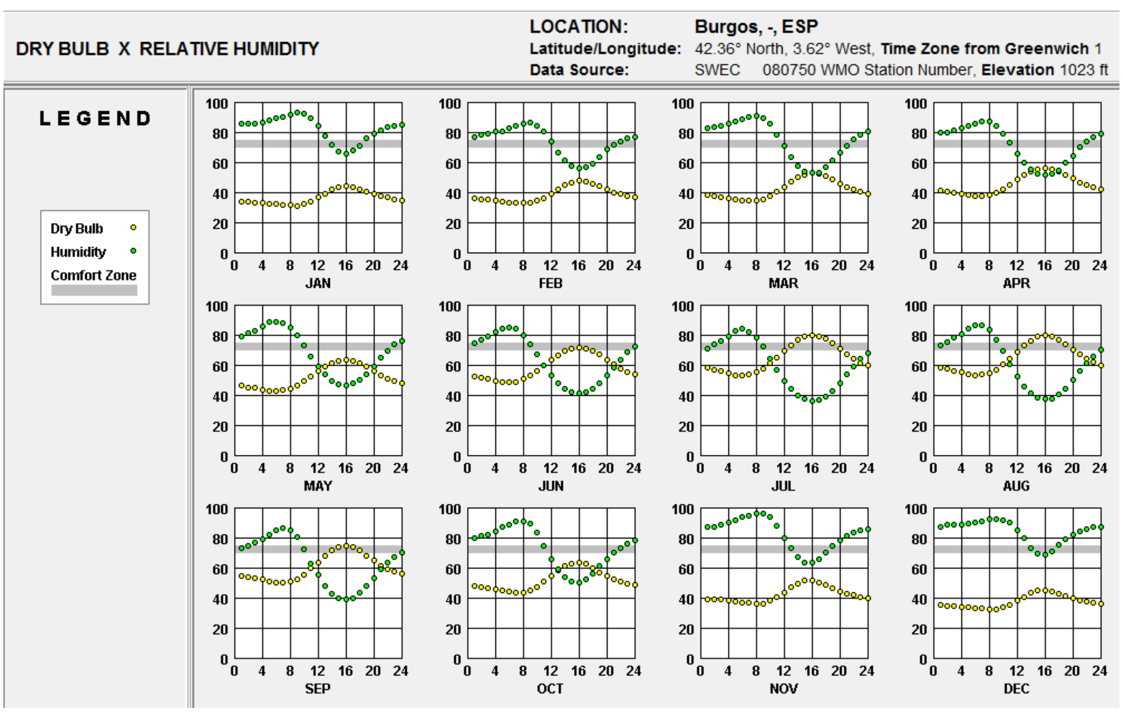


Figure 7.4 Dry Bulb Temperature & Relative Humidity Monthly

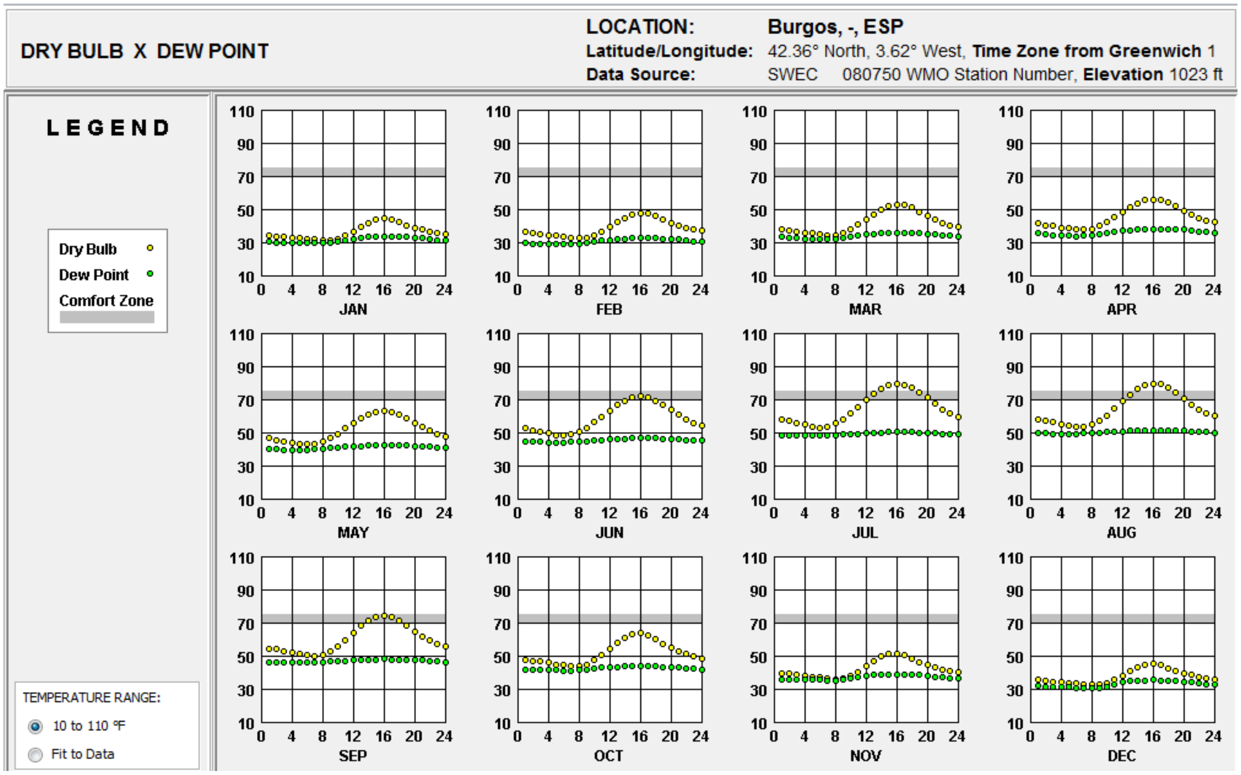


Figure 7.5 Dry Bulb Temperature & Dew Point

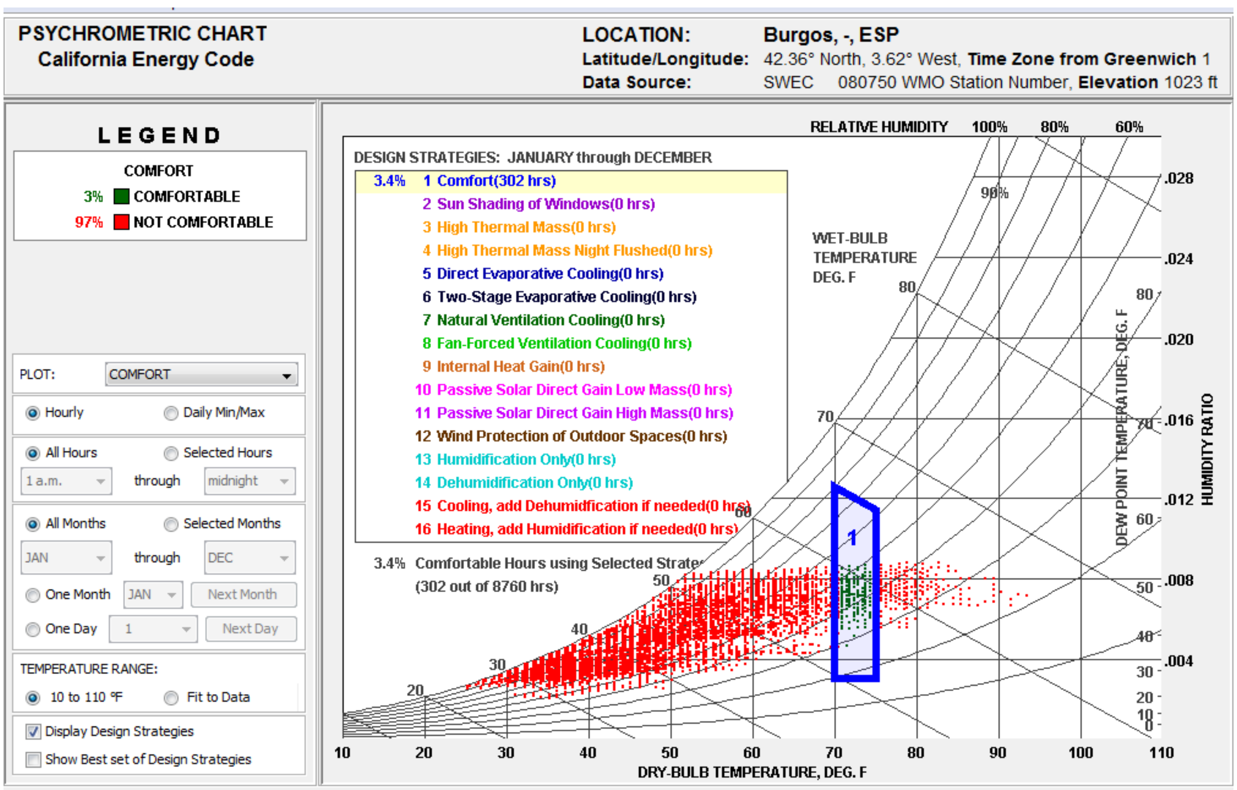


Figure 7.6 Comfort Zone for Winter Time

During winter the graph shows most of the temperature and humidity lays outside comfort band. Heating system might be considered regarding different aspects.

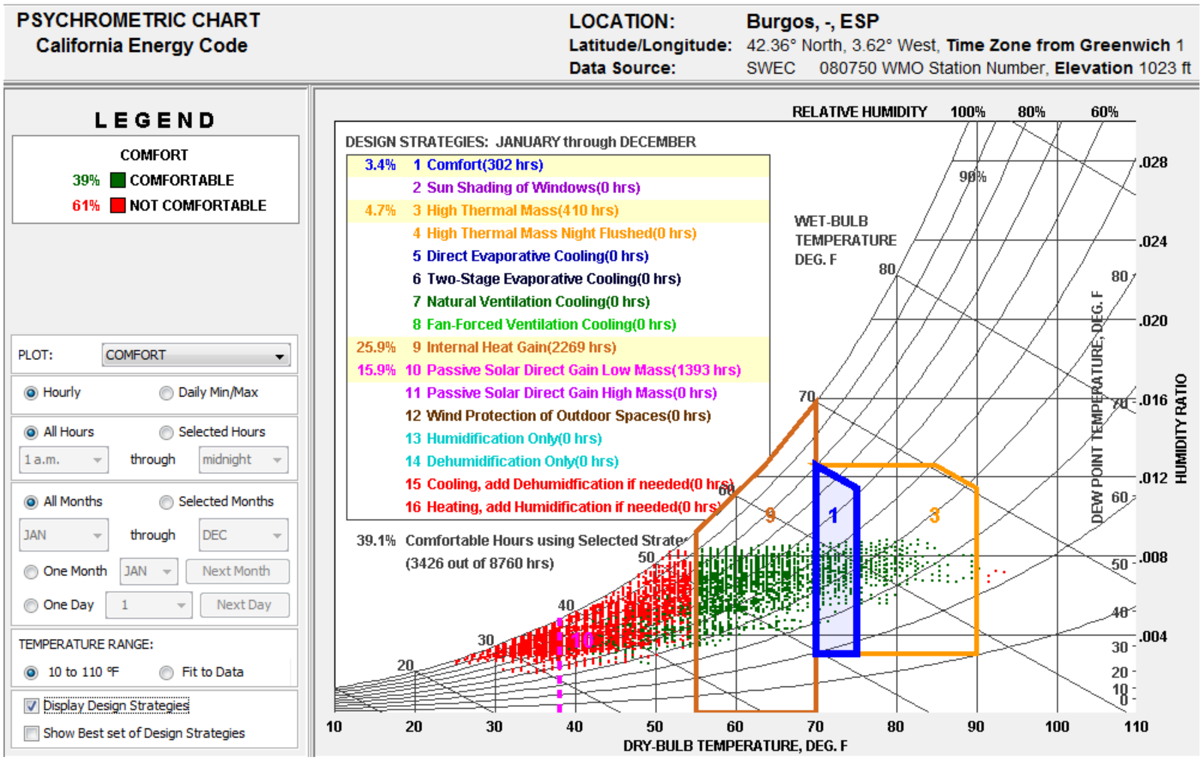


Figure 7.7 Comfort Zone for Summer

During summer the figure shows almost half of the temperature and humidity lay inside comfort zone, HVAC system might be considered regarding different aspects.

7.1.2 Site Climate

7.1.2.1 Winter

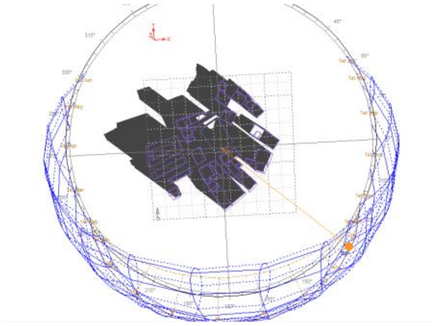


Figure7.8 Shading at 9am on 27th January

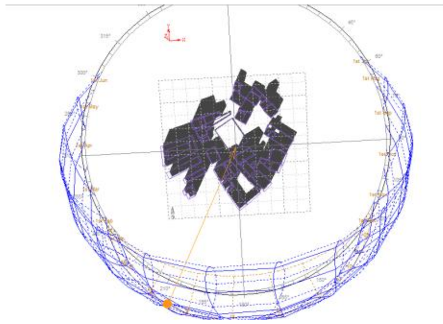


Figure 7.9 Shading at 12am on 27th January

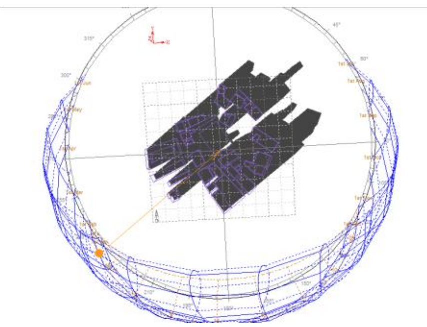


Figure 7.10 shading at 14.30pm on 27th January

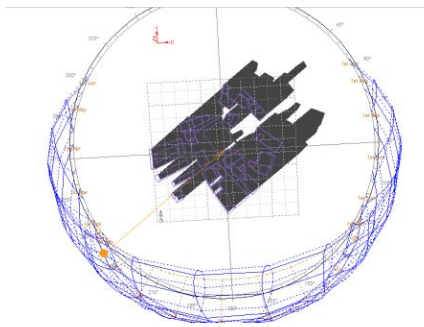


Figure 7.11 shading at 16.30 on 27th January

From the graphs, in winter, the site is in the shadow before 12am and after 14.30pm, it needs to be considered getting more natural light during architecture design with the best orientation of building and the optimal transparent envelope.

7.1.2.2 Summer

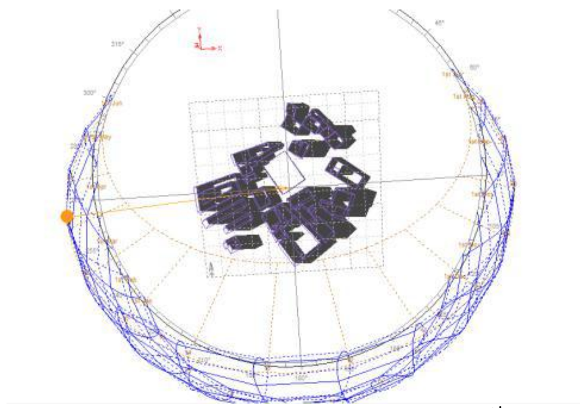


Figure 7.12 Shading at 9am on 27th July

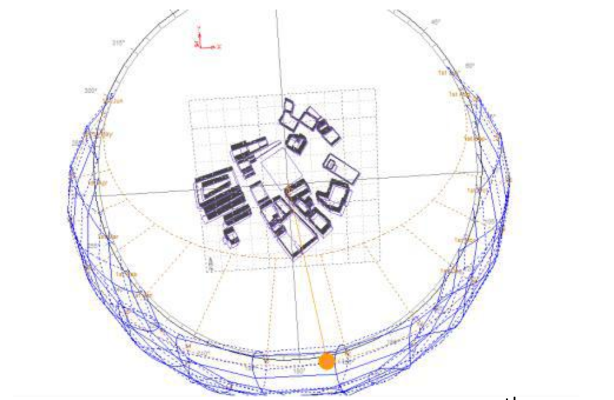


Figure 7.13 Shading at 12am on 27th July

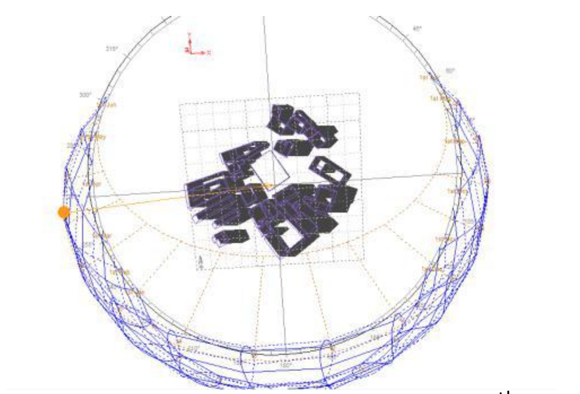


Figure 7.14 Shading at 17pm on 27th July

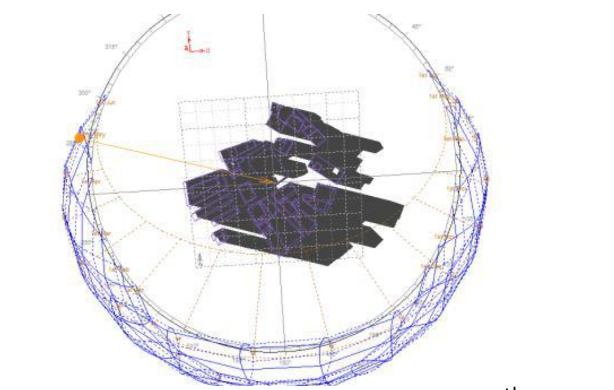


Figure 7.15 Shading at 19pm on 27th July

From the graphs, in summer, from 9am till 17pm the site is exploded under the sun. To add shading systems on both the architecture to avoid sunshine are necessary.

Besides, we have to avoid the afterglow in the afternoon. We can propose different shading system for the building and sun shield for the open space surrounding.

The figure 7.16 shows the light radians on part of the building.

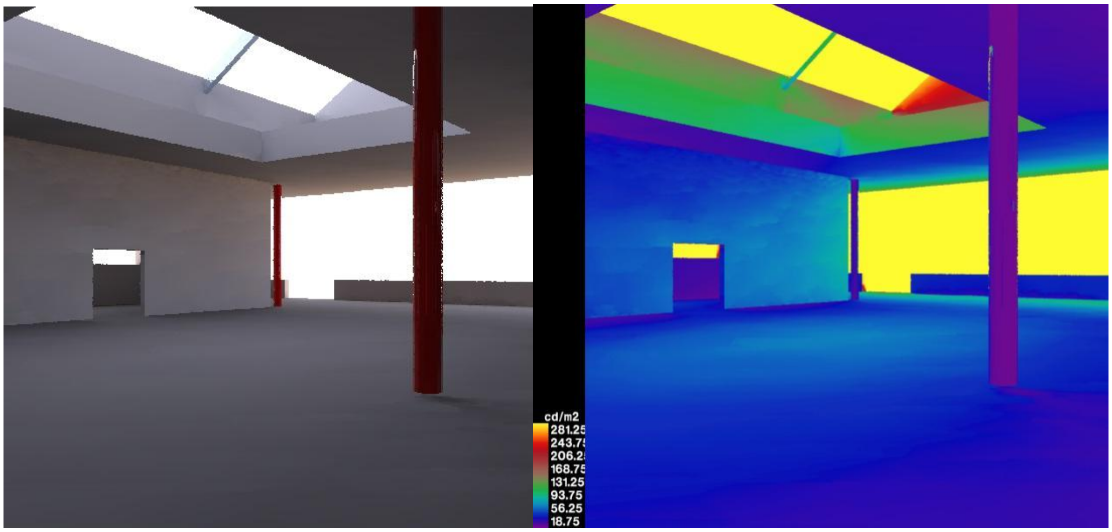


Figure 7.16 Radians of natural light

7.2 Technical Solutions

7.2.1 Ventilated Façade

It rains a lot in autumn and snows heavily in winter in Reinosa. In the rain screen system, the outer panel deflects rain and solar heat away from the building. The ventilation apace allows air to freely circulate behind the cladding panel, improving the thermal conditions inside the building and installing the insulation on the outside so to avoid thermal bridging.

Fiber concrete is a composite material with lightweight and high strength. Compared to wooden cladding, fiber concrete is not susceptible to termites or rot. It is a non-combustible material and requires little maintenance after installation.

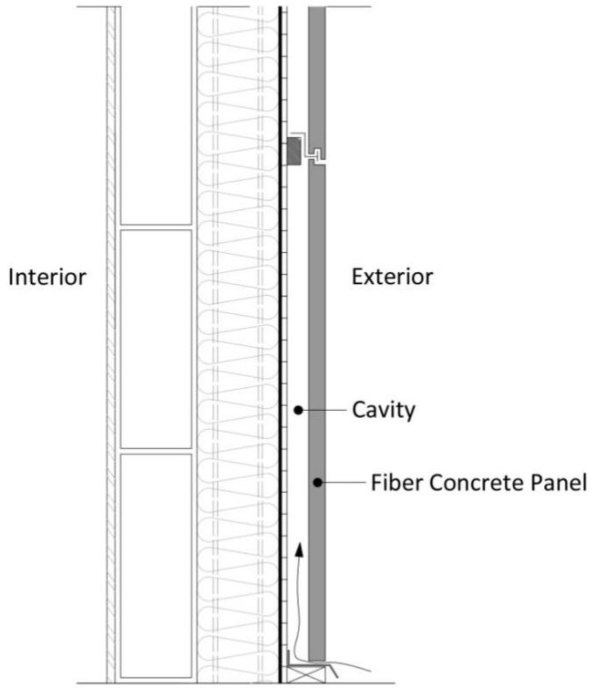


Figure 7.17 Vertical Section of Ventilated Facade

7.2.2 Glazing Wall

Curtain Wall facades are constituted by an auxiliary structure (mullions+tansoms=stick system) where infill panels are inserted. The parts between floors are transparent panels while the parts parallel to the slab are opaque to hide the slab and matching with other part of the facade.

Double glazing which inserts argon between low-E glass, forms a layer of insulation from conductive and convective heat transfer.

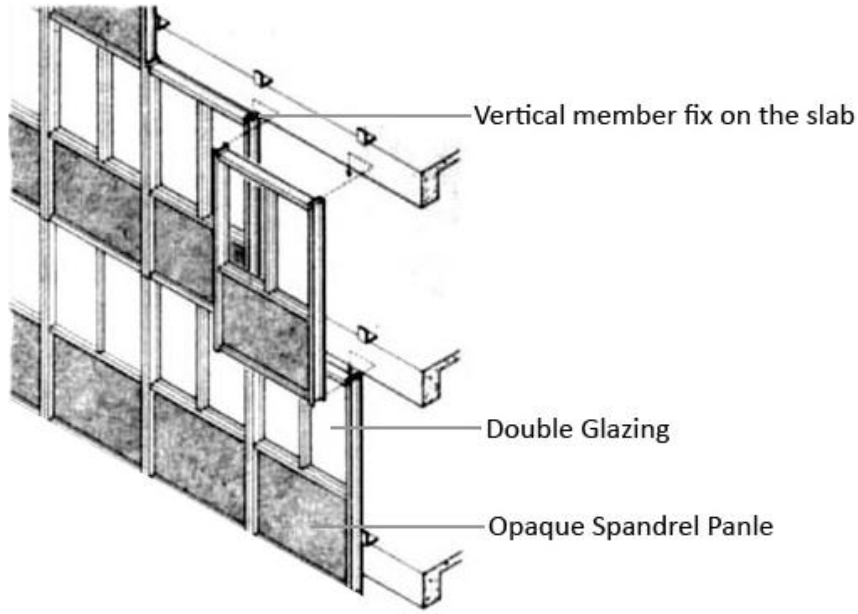


Figure 7.18 Sketch of panels' distribution

7.2.3 Dropped Ceiling

It is important to integrated dropped ceiling with mechanical, electrical and plumbing, since most of these system are by definition above the ceiling, meanwhile it is also used to aid acoustics.

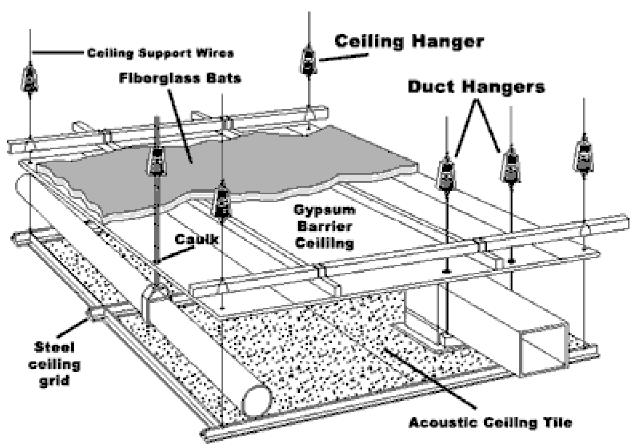


Figure 7.19 Dropped Ceiling

7.2.4 Chimney Effect

The design shape of arcades forms a chimney effect. Since building are not totally sealed(there are ground level entrance), the chimney effect will cause air infiltration. During the heating season, the warmer indoor air rises up through the building and escapes through ventilation openings. The rising warm air reduces the pressure in the base of the building, drawing cold air in through open doors, windows. During the cooling season, the stack effect is reversed, but is typically weaker due to lower temperature differences.

The draft flow rate induced by the stack effect can be calculated with the equation presented below:

Where:

Q=stack effect draft (draught in British English) flow rate, m^3/s

A=flow area of the openings,m^2

C= discharge coefficient (usually taken to be from 0.65 to 0.70)

g=gravitational acceleration, $9.81 m/s^2$

h=height of the building

T_i=average inside temperature, K

T_o=outside air temperature, K

Assume in summer indoor air temperature is 308K, outdoor air temperature is 306K. Thus the draft flow rate is:

m^2/s

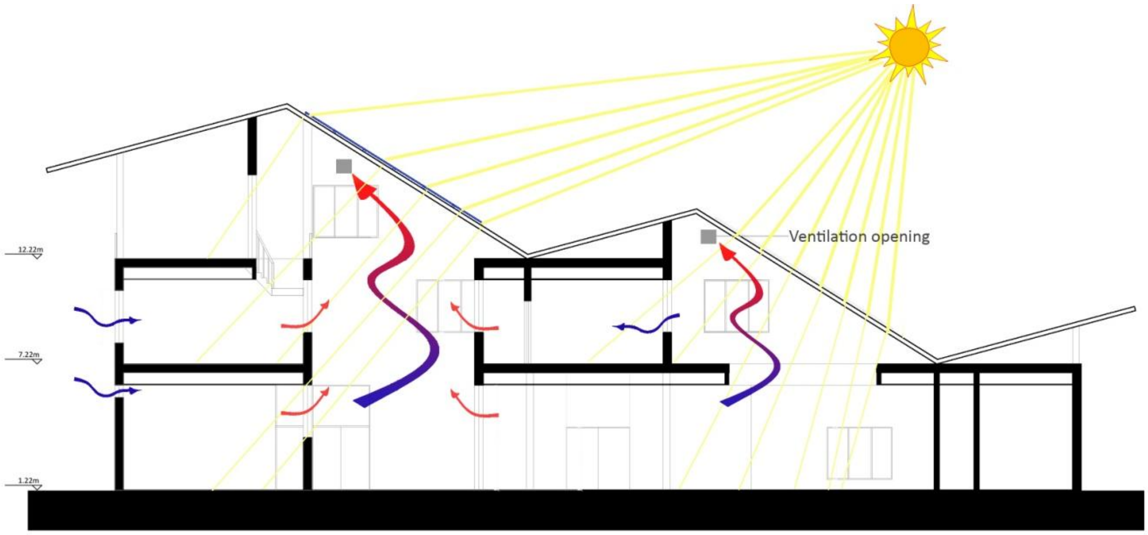
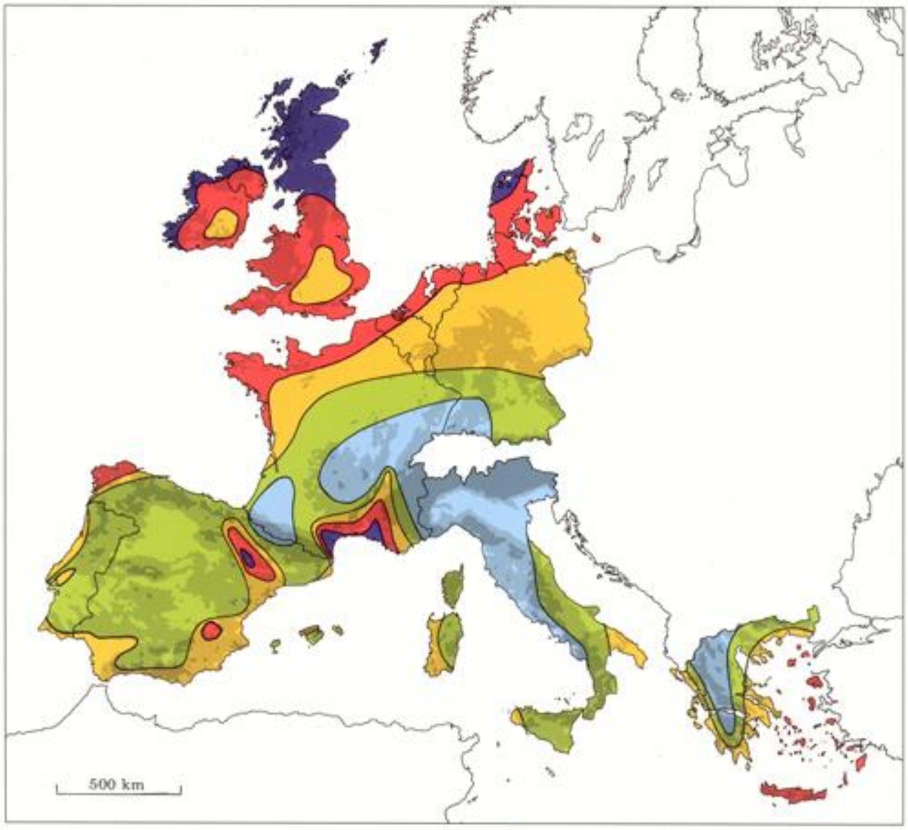


Figure 7.20 Scheme on daylight and natural ventilation

Figure 7.21 Ventilation Opening on the wall

7.2.5 BIPV

The energy efficiency cannot make a building become net zero energy. No matter how little a building consumes, if it does not have means of energy production it will still be energy demanding. A few alternatives exist for in situ energy production, and have been analyzed. From all the renewable technologies that exist on the market only a few offer the possibility of a decentralized production. The wind resource is far from being in its most suitable position as shown in figure 7.22. Furthermore, wind, due to scalability issue, tend to not be implemented in small scale presumes projects. Biomass can be implemented only for heat generation as it is, due to high temperatures and pressures and maintenance, unpractical and inefficient for projects below 100 kW. As biomass, solar thermal energy at this scale can only be used for heating.



Wind resources[1] at 50 metres above ground level for five different topographic conditions										
	Sheltered terrain[2]		Open plain[3]		At a sea coast[4]		Open sea[5]		Hills and ridges[6]	
	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0- 8.5	400- 700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Figure 7.22 Map of the Wind Energy from Riso National Laboratory, Denmark

Photovoltaic, on the other hand, do not have scalability issues as it works at the same efficiency also at the scale of few kilowatt. Photovoltaic systems can produce electricity without producing steam and without any moving part, the electricity can then be used to cover any type of building need, from heating and cooling to direct electricity consumption. Furthermore, with the possibility to use photovoltaic as a building material, is possible to save energy and material costs in the building construction. Photovoltaic modules have been used successfully in many architectural projects, proving the possibility to be integrated in an aesthetically appealing way. Building integrated photo voltaics (BiPV) are used preferably for applications such as shader, ventilated facades, curtain walls and canopy. In this Project the integration of photovoltaic into a canopy is been examined see figure 7.23.

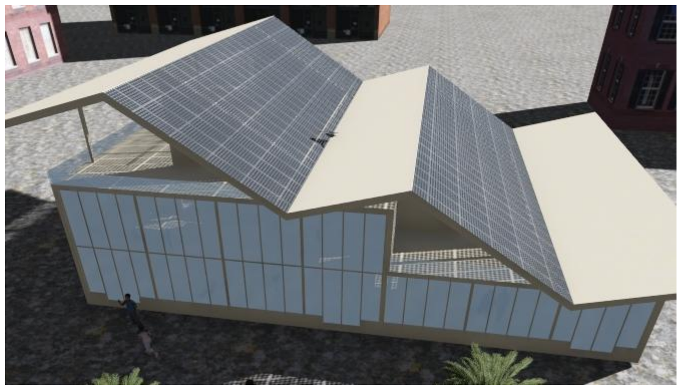


Figure 7.23 Bipv on the Roof

To access the solar resource the free software from the joint research center (JRC) PV GIS was used. In the figure 7.23, the horizon outline was controlled to avoid situations of solar shading and lack of direct sunlight. In Reinosa the horizon is almost completely flat, with distant shadows that never exceed 5° along the possible solar path, this means that the hours of sunlight are almost equal to the case of a flatland.

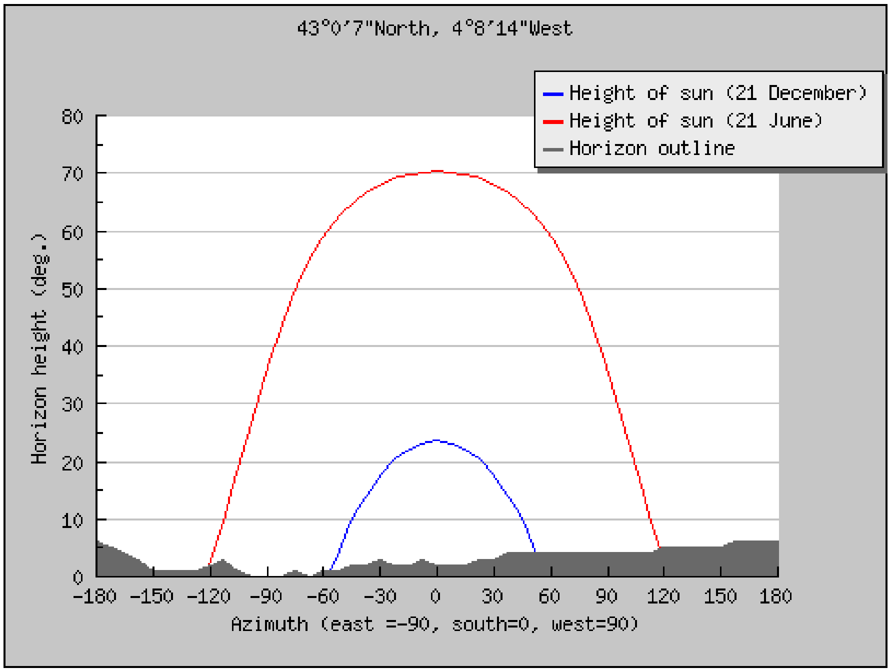


Figure 7.24 Horizon outline in winter(blue line) and summer(red line)

The GIS can find the optimal tilt and azimuth angle to maximize the production. In the location of the building the best tilt and azimuth angles would be inclination=35°, orientation=-3° i.e. tilted and slightly east oriented. With these properties, assuming an overall system efficiency of 12% (crystalline silicon technology with efficiency 17% and a performance ratio of 70%) there would be an annual average daily electricity production of 0.56 kWh/m2 of PV installed. Given the morphology of the building, the orientation of perfect south is not possible, for architectural reasons, to orient the modules 32 degrees est. The overall production is not affected consistently by the difference in orientation. The total area of the PV is 756m2, hence the annual average daily electricity production is 423kWh.

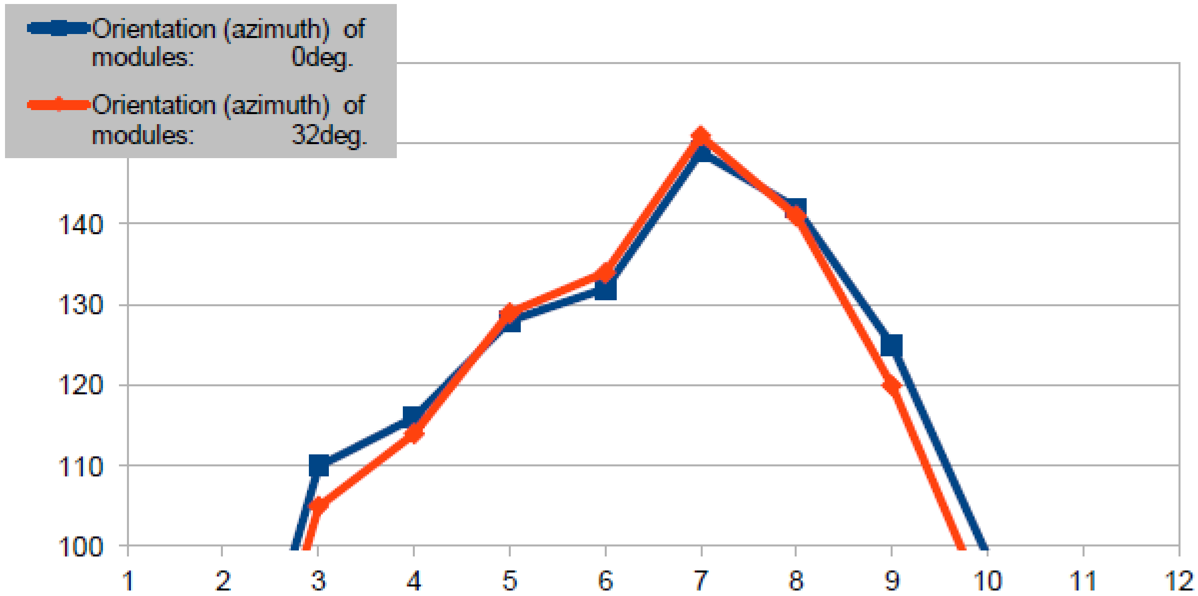


Figure 7.25 Compare Between 32deg and 0deg

7.3 Elements Data

U value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an "overall heat transfer co-efficient" and measures how well parts of a building transfer heat. This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behavior of an entire building element rather relying on the properties of individual materials.

The U value shall be calculated as:

$$U = \frac{1}{\frac{1}{h_i} + \sum_j \frac{d_j}{\lambda_j} + \frac{1}{h_e}}$$

Where:

h_i=internal convective coefficient in m^2K/W

h_e=external convective coefficient in m^2K/W

d=total thickness of the component in m

λ=thermal conductivity in W/m k

Thus U value for each building element is calculated as follows.

7.3.1 Vertical Elements

Internal Wall Dry/Dry -300mm				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	plaster board	0.35	15	0.043
2	ytong block/250*120*120mm	0.11	120	1.091
3	rockwool insulation between timber frame members	0.035	80	2.286
4	ytong block/250*120*60mm	0.11	60	0.545
5	plaster board	0.35	15	0.043
Internal	h_i			$0.13m^2K/W$
External	h_e			$0.04m^2K/W$
ΣR				$4.008m^2K/W$
U				$0.250W/m^2K$

Internal Wall Wet/Dry -300mm				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	ceramic tile with adherent	0.4	10	0.025
2	backerboard	0.35	10	0.029
3	Vapour barrier	0.17	5	0.029

4	ytong block/250*120*120mm	0.11	120	1.091
5	rockwool insulation between timber frame members	0.035	80	2.286
6	ytong block/250*120*60mm	0.11	60	0.545
7	plaster board	0.35	15	0.043
Internal	h_i			0.13m²K/W
External	h_e			0.04m²K/W
ΣR				4.048m²K/W
U				0.247W/m²K

Internal Wall Wet/Wet -300mm				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	ceramic tile with adherent	0.4	10	0.025
2	backer board	0.35	10	0.029
3	Vapour Barrier	0.17	5	0.029
4	ytong block/250*120*120mm	0.11	120	1.091
5	rockwool insulation between timber frame members	0.035	80	2.286
6	ytong block/250*120*60mm	0.11	60	0.545
7	Vapour Barrier	0.17	5	0.029
8	backer board	0.35	10	0.029
9	ceramic tile with adherent	0.4	10	0.025
Internal	h_i			$0.13m^2K/W$
External	h_e			$0.04m^2K/W$

ΣR				4.088m^2K/W
U				0.245W/m^2K

External Wall -500mm				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	concrete clading panel	0.42	30	0.071
2	supporting construction, horizontal suport battens with slip fixings(ventilated cavity)	-	40	-
3	wood fibreboard	0.15	10	0.067
4	vapour-permeanble and moisture-resistant	0.14	5	0.036
5	glasswool insulation between timber frame members	0.035	150	4.286
6	YTONG/600*250*250mm	0.11	250	2.273
7	plaster board,moisture-resistance both sides	0.35	15	0.043
Internal	h_i			0.13m^2K/W
External	h_e			0.04m^2K/W
ΣR				6.775m^2K/W
U				0.148W/m^2K

External Double Glazing Wall				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	Low-E glass	0.9	8	0.009
2	Argon	0.016	17	1.063

3	Low-E glass	0.9	8	0.009
Interna l	h_i			$0.13m^2K/W$
Extern al	h_e			$0.04m^2K/W$
ΣR				$1.080m^2K/W$
U				$0.926W/m^2K$

7.3.2 Horizontal Elements

Ground Floor				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	terrazzo tiles	1.5	10	0.007
2	screed laid layers	0.75	60	0.080
3	Separation Layer PET	0.03	5	0.167
4	extruded polystyrene insulation	0.035	150	4.286
5	damp proof membrane	0.17	10	0.059
6	Plastic Cast Concrete Ventilated Foundation with Metallic Net	0.42	400	0.952
7	concrete deck	0.42	20	0.048
8	earth	-	-	-
Interna l	h_i			$0.13m^2K/W$
Extern al	h_e			$0.04m^2K/W$
ΣR				$5.598m^2K/W$
U				$0.179W/m^2K$

1/F Typical Floor				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	terrazzo tiles	1.5	10	0.007
2	screed laid layers	0.75	60	0.080
3	Separation Layer PET	0.03	5	0.167
4	Light concrete	0.42	30	0.071
5	profiled steel decking	-	50	-
6	steel beam	-	-	-
7	ceiling hanger	-	-	-
8	service gap	-	550	-
9	rockwool insulation	0.035	30	0.857
10	Steel Ceiling Grid	-	10	-
11	plasterboard	0.17	15	0.088
Internal	h_i			$0.13m^2K/W$
External	h_e			$0.04m^2K/W$
ΣR				$1.271m^2K/W$
U				$0.787W/m^2K$

1/F Floor without Ceiling				
No.	Layer	λ (W/m k)	d (mm)	R (m^2k/w)
1	terrazzo tiles	1.5	10	0.007
2	screed laid layers	0.75	60	0.080
3	Separation Layer PET	0.03	5	0.167
4	Light concrete	0.42	30	0.071
5	profiled steel decking	-	50	-

6	plasterboard	0.17	15	0.088
7	steel beam	-	-	-
Internal	h_i			0.13m^{2}K/W
External	h_e			0.04m^{2}K/W
ΣR				0.413m^{2}K/W
U				2.421W/m^{2}K

Walkable Roof				
No.	Layer	λ (W/m k)	d (mm)	R (m^{2}k/w)
1	concrete flags	0.42	30	0.071
2	screed laid to falls	0.75	60	0.080
3	protective membrane	0.13	10	0.077
4	bitumen-based membrane 2-ply	0.5	10	0.020
5	extruded polystyrene insulation	0.035	200	5.714
6	Vapour barrier	0.17	10	0.059
7	reinforced concrete deck	0.42	100	0.238
8	steel beam	-	-	-
9	service gap	-	525	-
10	ceiling hanger	-	-	-
11	rockwool insulation	0.035	30	0.857
Internal	h_i			0.13m^{2}K/W
External	h_e			0.04m^{2}K/W

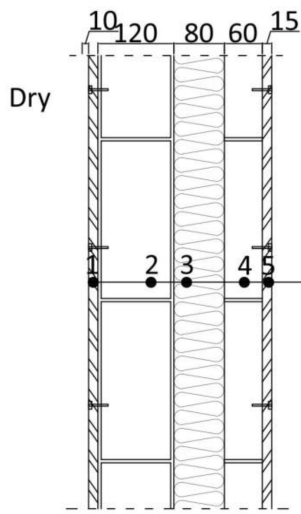
ΣR				7.16m^2K/W
U				0.14W/m^2K

7.3.3 Summary

Components		U-value W/m^2K
Vertical Elements	Internal Wall Dry/Dry -300mm	0.25
	Internal Wall Wet/Dry -300mm	0.247
	Internal Wall Wet/Wet -300mm	0.245
	External Wall – 500mm	0.148
	External Double Glazing Wall	0.926
Horizontal Elements	Ground Floor	0.179
	1/F Typical Floor	0.787
	1/F Floor without ceiling	2.421
	Walkable Roof	0.14

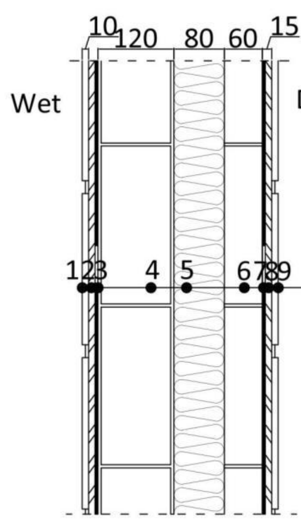
7.3.4 Detail Drawing

Internal Wall Dry/Dry -300 (Section)



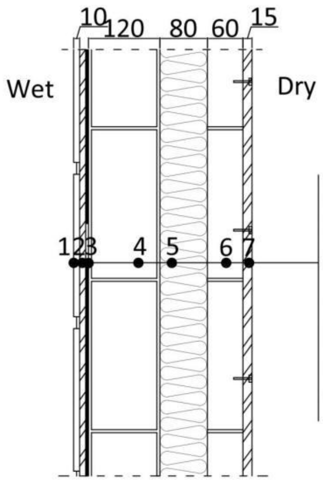
1-Plaster Board, 15mm
2-Ytong Block, 120mm, 600x250x120mm
3-Rockwool Insulation Between Timber Frame Members, 80mm
4-Ytong Block, 60mm, 600x250x60mm
5-Plaster Board, 15mm

Internal Wall Wet/Wet -300 (Section)



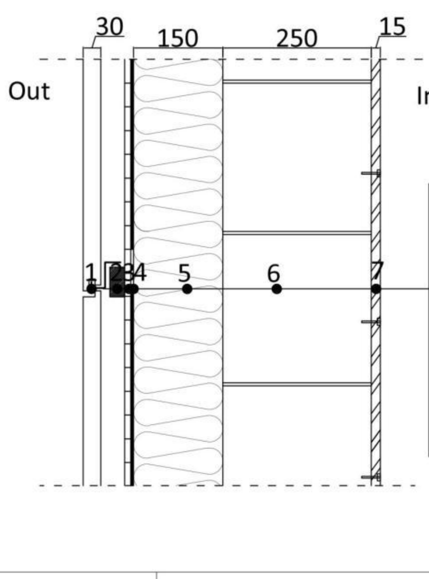
1-Ceramic Tiles with Adhesive , 10mm, 660x240x10mm
2-Backer Board, 10mm
3- Vapor Barrier, 5mm
4-Ytong Block, 120mm, 600x250x120mm
5-Rockwool Insulation Between Timber Frame Members, 80mm
6-Ytong Block, 60mm, 600x250x60mm
7-Plaster Board, 15mm
6-Ytong Block, 60mm, 600x250x60mm
7-Plaster Board, 15mm

Internal Wall Wet/Dry -300 (Section)



1-Ceramic Tiles with Adhesive , 10mm, 660x240x10mm
2-Backer Board, 10mm
3- Vapor Barrier, 5mm
4-Ytong Block, 120mm, 600x250x120mm
5-Rockwool Insulation Between Timber Frame Members, 80mm
6-Ytong Block, 60mm, 600x250x60mm
7-Plaster Board, 15mm

External Wall   -500 (Section)
U-value=0.148 w/m2K



1-Cement Panel, 30mm, 1000x1000x30mm
2-Supporting Construction, Horizontal Support Battens with Slip Fixings, 40mm
3-Wood Fibreboard, 10mm
4-Vapour-permeable and moisture-resistant, 5mm
5-Rockwool Insulation between timber studs,150mm
6-YTONG Blocks, 250mm, 600x250x250mm
7-Plaster Board, 15mm

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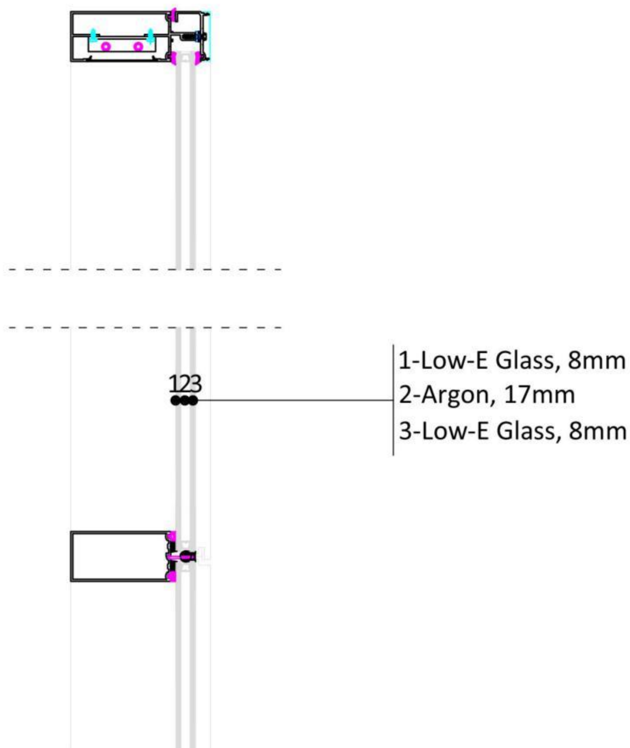
Final Submission 21-09-2015	PROJECT SOCIAL CENTRE REINOSA-SPAIN		Drawing Code Tecnology - Material - Internal wall - External wall T 102 Drawing Scale 1: 10

External Double Glazing Wall (Section)
U-value=0.926 w/m2K



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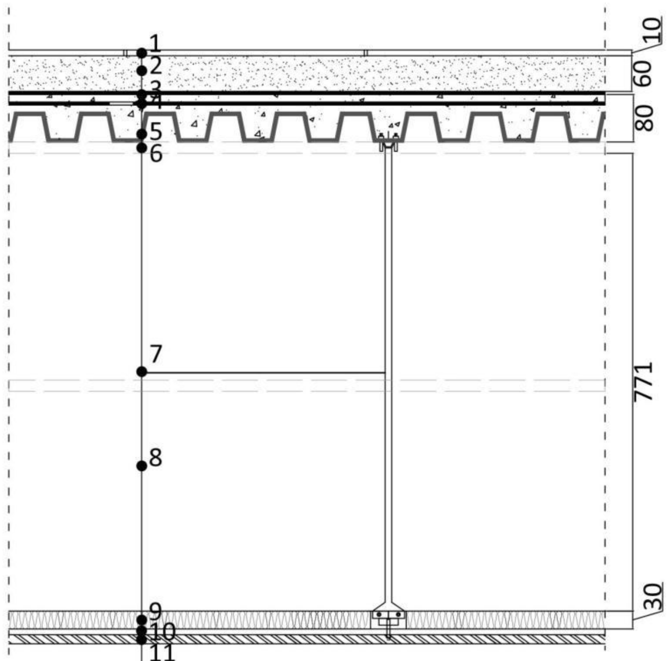
Typical Floor (Section)



1-Terrazzo Tiles,400x400mm, 10mm
2-Screed Layer, 60mm
3-Separation Layer PET, 5mm
4-Light Concrete, 30mm
5-Profiled Steel Deck, 50mm
6-Steel Beam
7-'Knauf' Aluminium Suspended Ceiling Hanger
8-Service Gap,771mm
9-Rockwool Insulation, 30mm
10-Steel ceiling grid, 10mm
11-Plasterboard, 15mm

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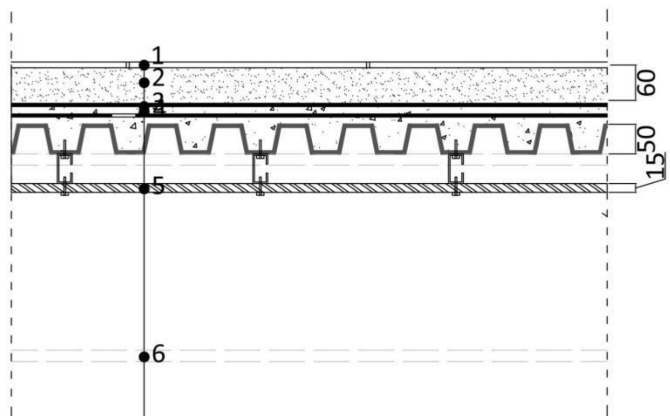
Floor without ceiling (Section)



1-Terrazzo Tiles, 400x400mm, 10mm
2-Screed Layer, 60mm
3-Separation Layer PET, 5mm
4-Light Concrete, 30mm
5-Profiled Steel Deck, 50mm
6-Plasterboard,15mm
7-Steel Beam

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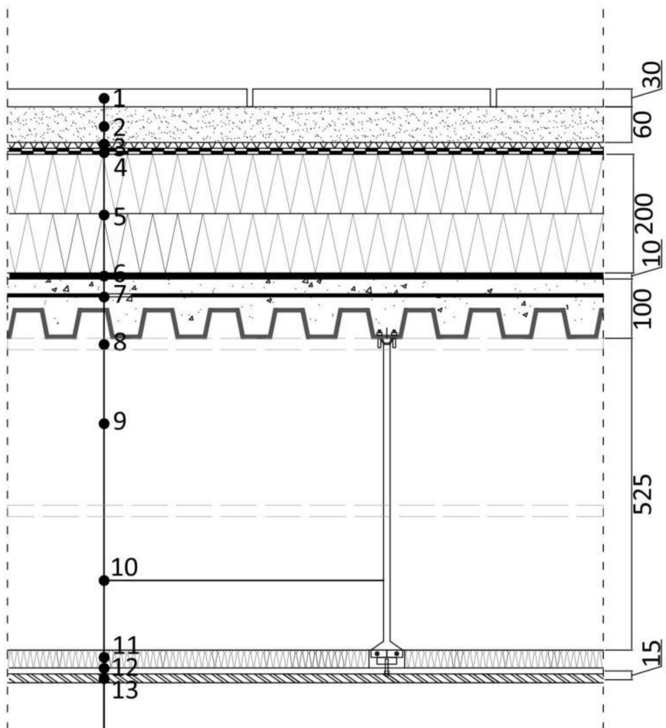
Roof (Section)
U-value=0.140 w/m2K



1-Concrete Flags, 800x800mm, 30mm
2-Screed Laid to Falls, 60mm
3-Protective Membrane, 10mm
4-bitumen-based membrane 2-ply, 10mm
5-Extruded Polystyrene Insulation, 200m
6-Vapour Barrier,10mm
7-Reinforced Concrete Deck, 100mm
8-Steel Beam
9-Service Gap, 555mm
10-'Knauf' Aluminium Suspended Ceiling Hanger
11-Rock Wool Insulation, 30 mm
12-Steel ceiling grid, 10mm
13-Plasterboard, 15mm

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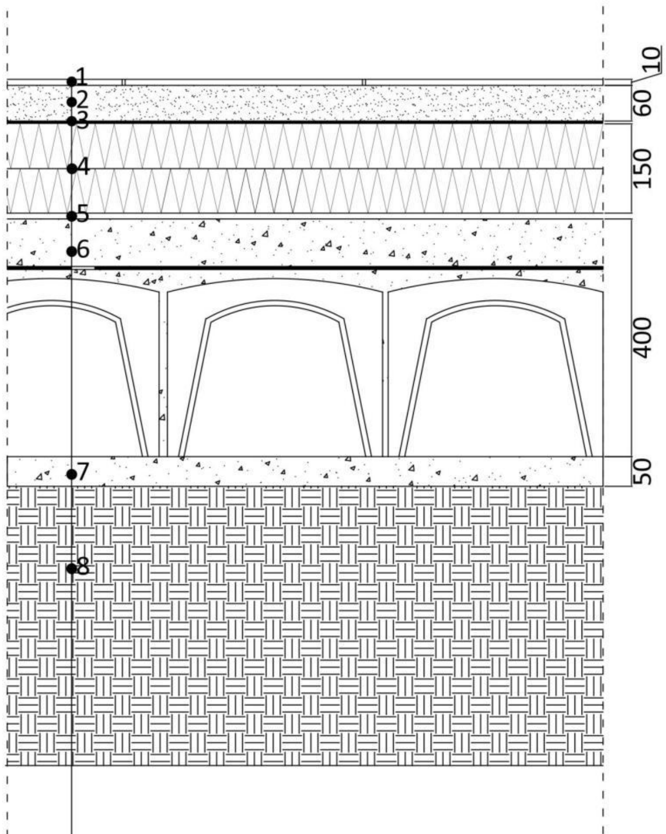
Ground Floor (Section)
U-value=0.179w/m2K



1-Terrazzo Tiles, 400x400mm, 10mm
2-Screed Laid Layer, 60mm
3-Separation Layer PET, 5mm
4-Extruded Polystyrene Insulation, 150mm
5-Damp Proof Membrane, 10mm
6-Plastic Cast Concrete Ventilated Foundation with Metallic Net, 400mm
7-Concrete Deck, 50 mm
8-Earth

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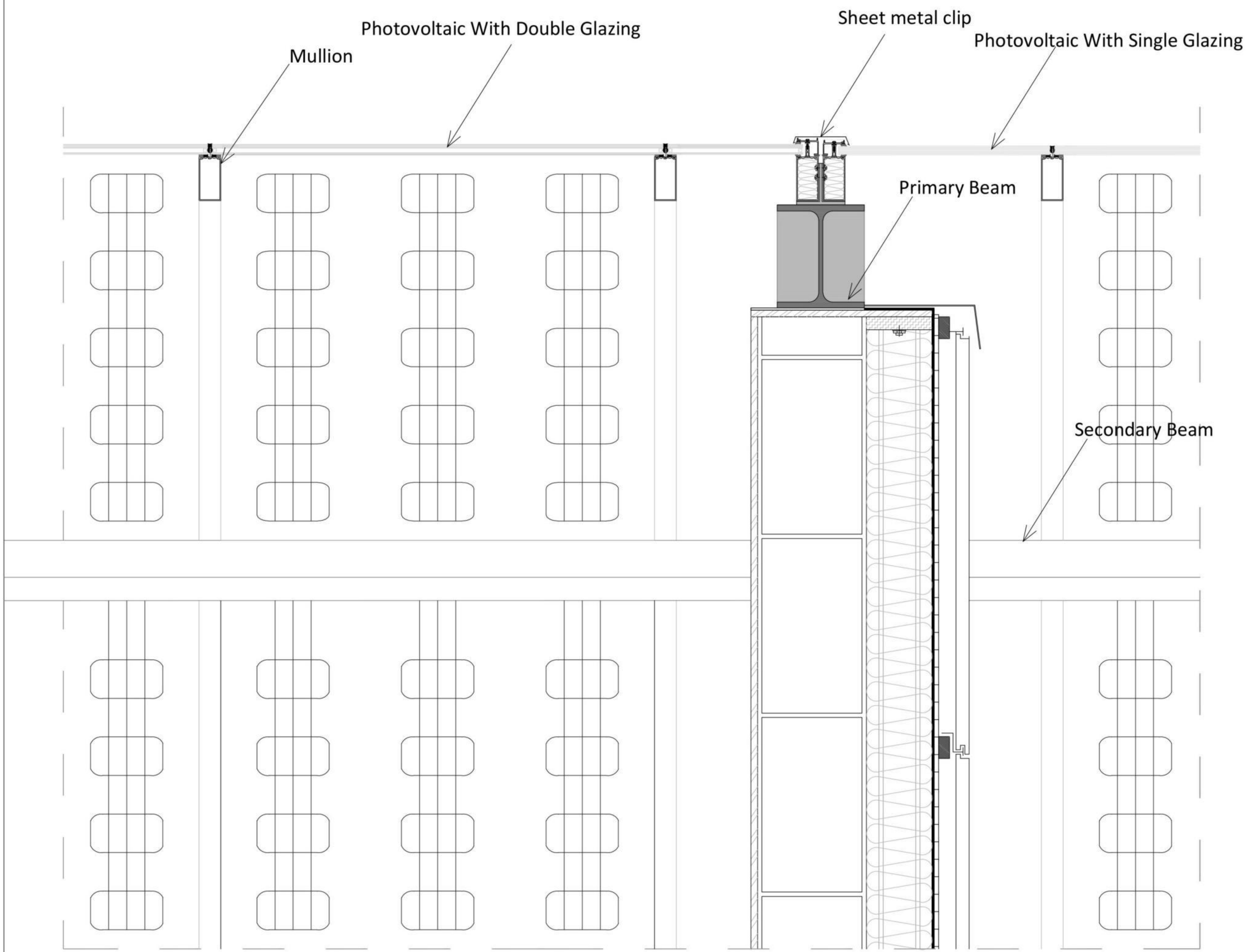
Final Submission 21-09-2015	PROJECT SOCIAL CENTRE REINOSA-SPAIN		Drawing Code Tecnology - Material - Groundfloor T 203
			Drawing Scale 1: 10



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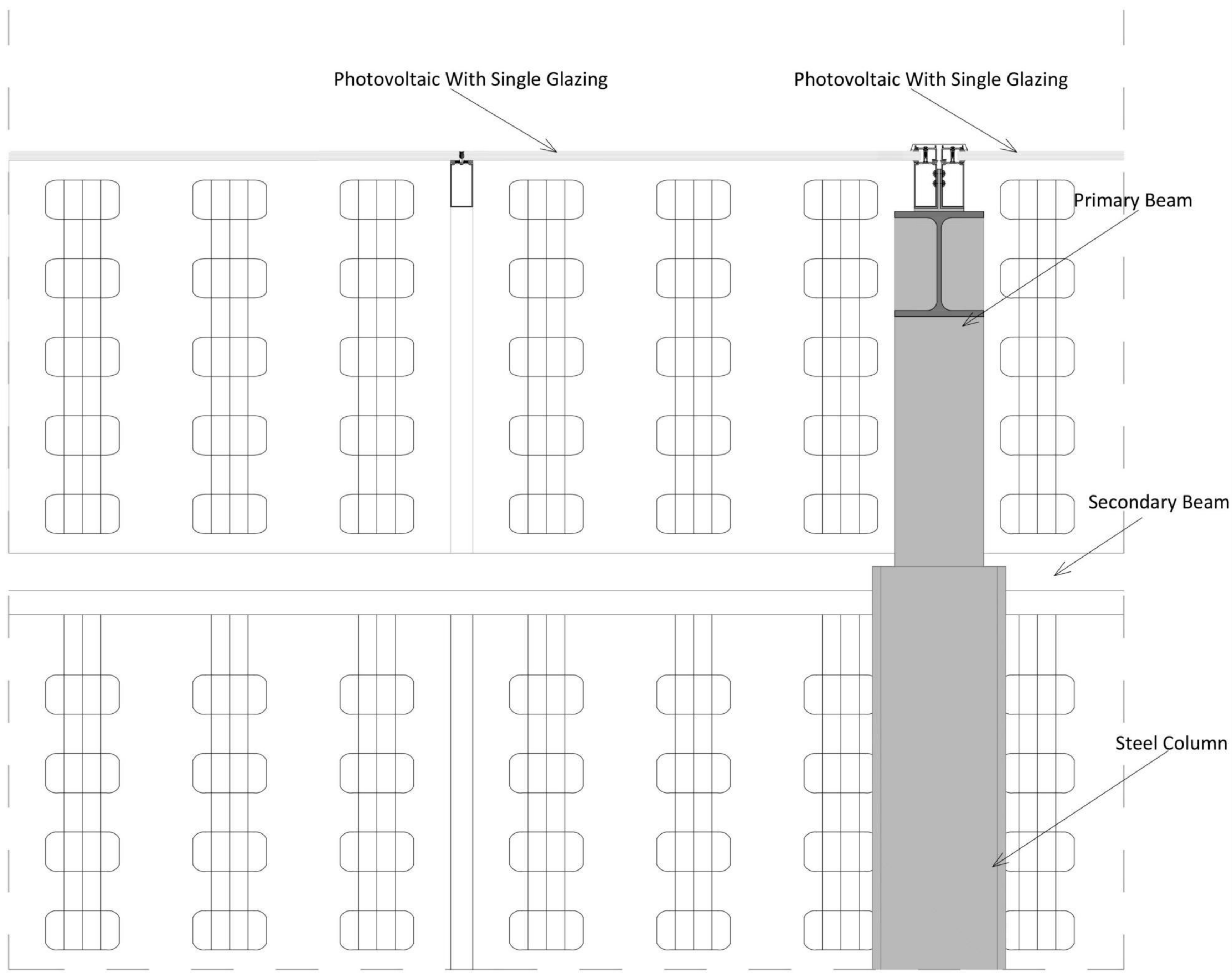
	PROJECT SOCIAL CENTER REINOSA - SPAIN			Drawing Scale 1: 10



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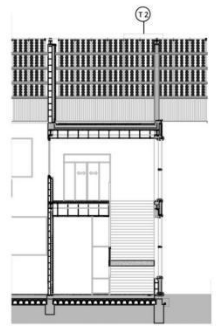
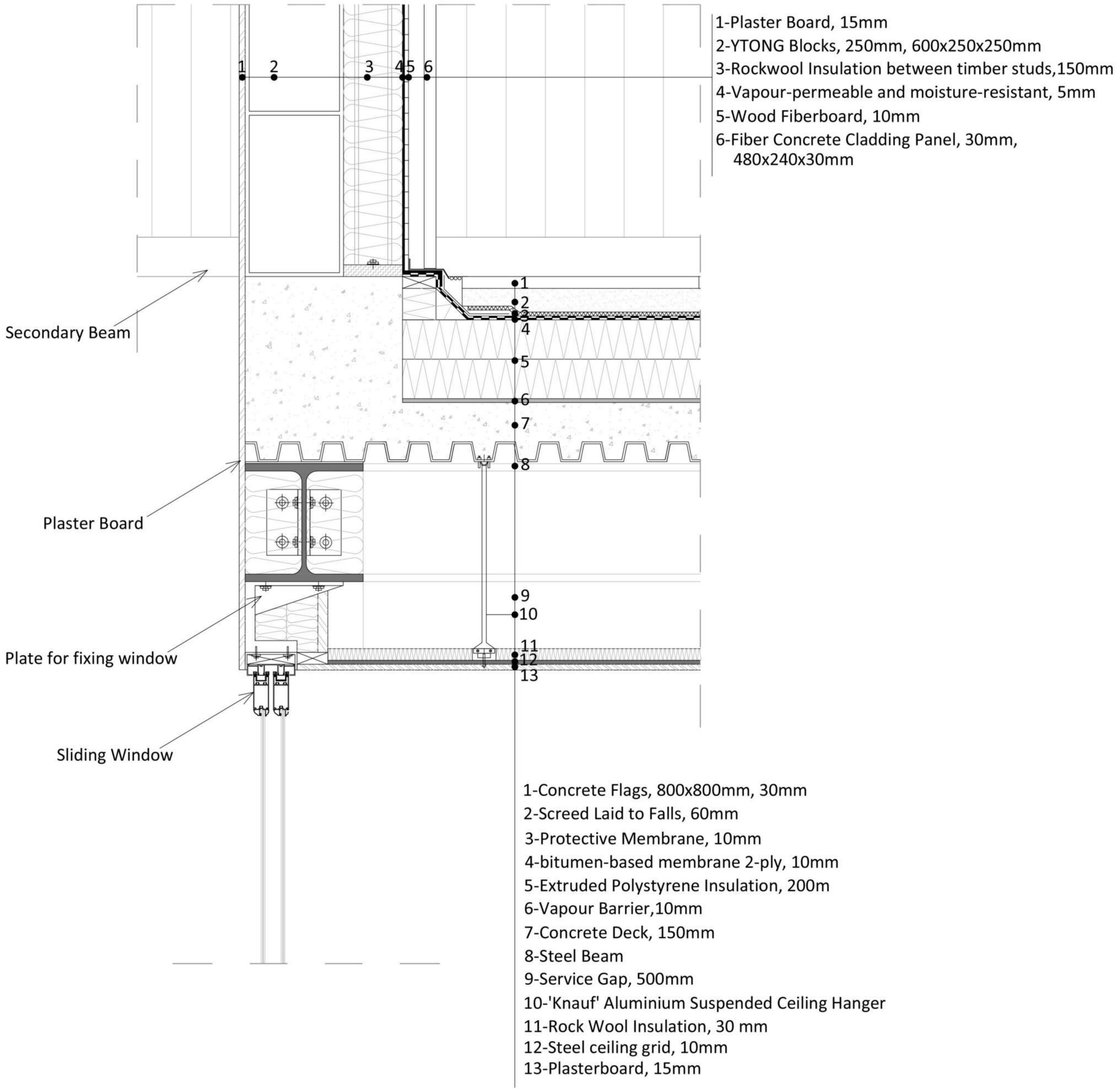


Drawing Code
Tecnology - Joint 2
T 2

Drawing Scale
1: 10



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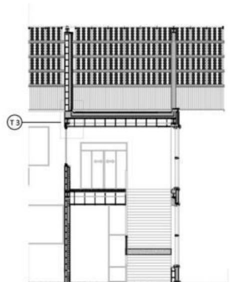
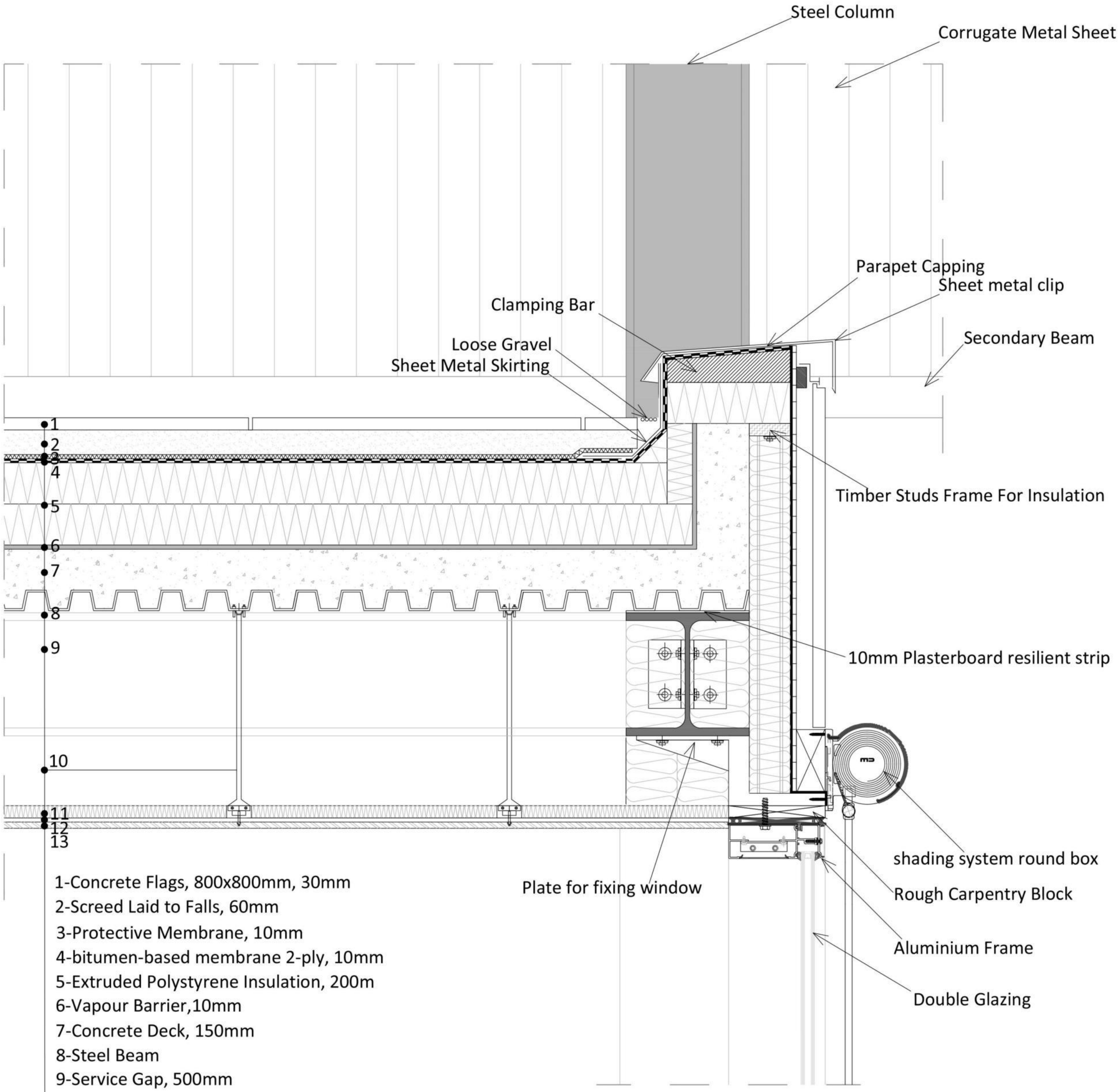
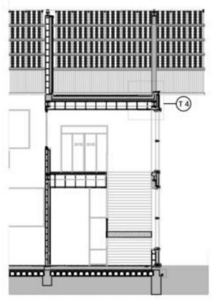


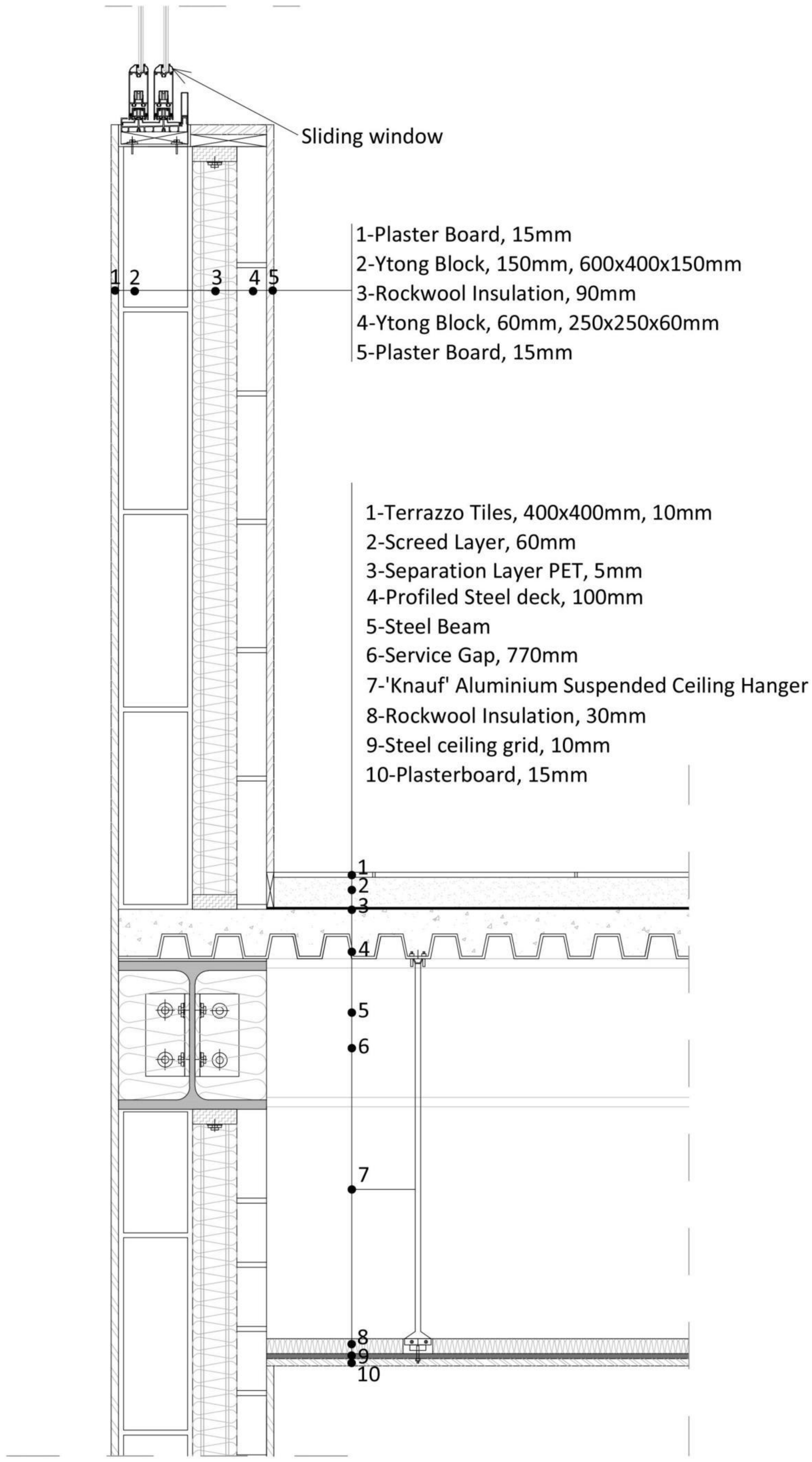
Drawing Code
Tecnology - Joint 3
T 3

Drawing Scale
1: 10



1-Concrete Flags, 800x800mm, 30mm
2-Screed Laid to Falls, 60mm
3-Protective Membrane, 10mm
4-bitumen-based membrane 2-ply, 10mm
5-Extruded Polystyrene Insulation, 200m
6-Vapour Barrier,10mm
7-Concrete Deck, 150mm
8-Steel Beam
9-Service Gap, 500mm
10-'Knauf' Aluminium Suspended Ceiling Hanger
11-Rock Wool Insulation, 30 mm
12-Steel ceiling grid, 10mm
13-Plasterboard, 15mm

POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	AUTHORS CHEN CHI		Drawing Code Tecnology - Joint 4 T 4
PROJECT SOCIAL CENTER REINOSA - SPAIN			Drawing Scale 1: 10



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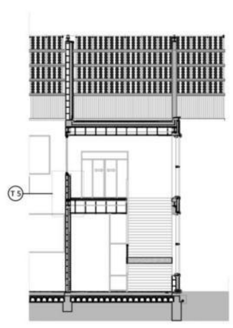

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T 5

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Drawing Scale
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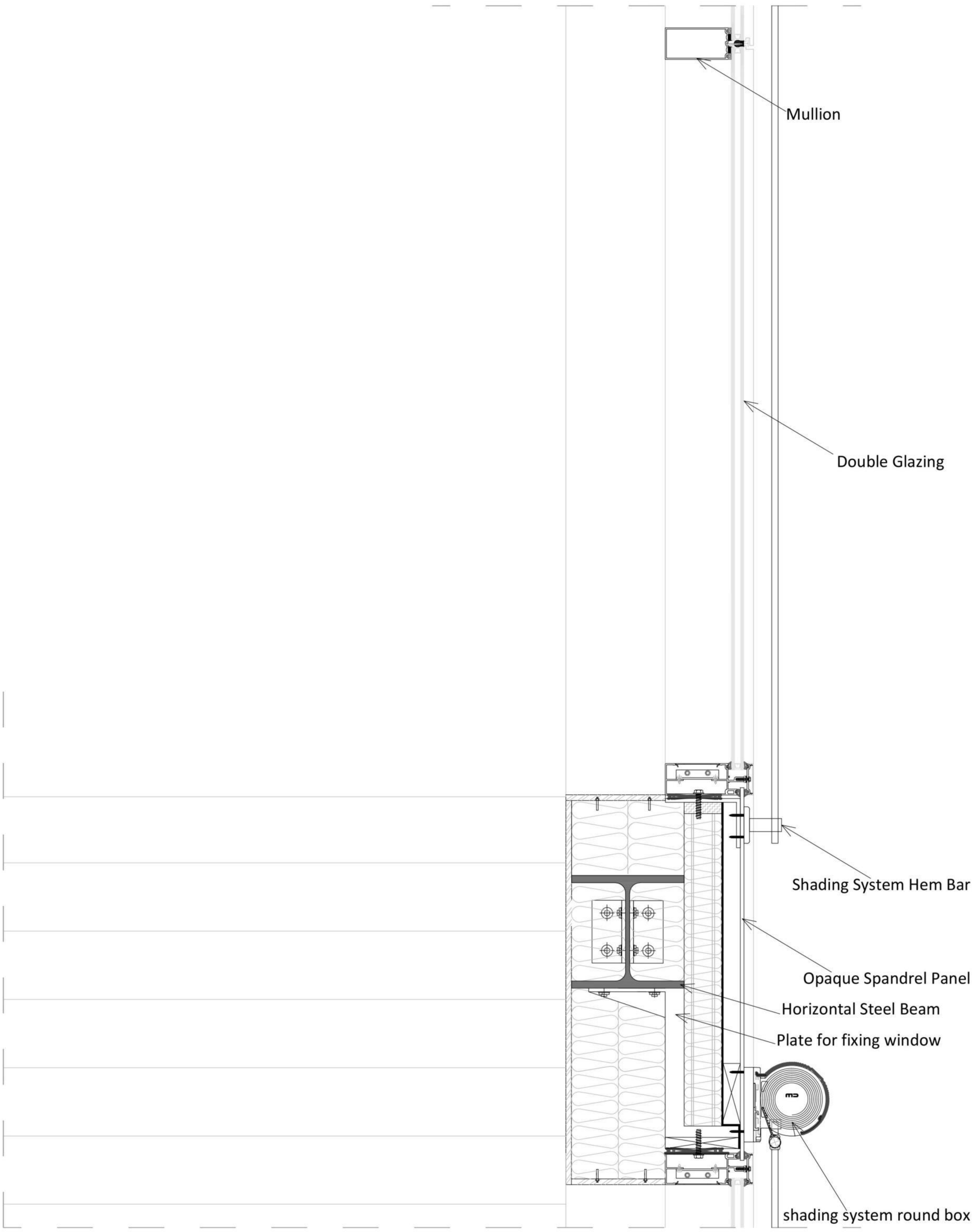

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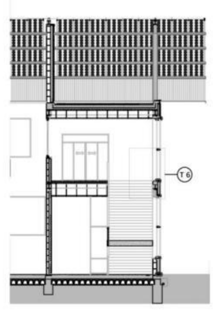

Drawing Code
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T 6

Drawing Scale
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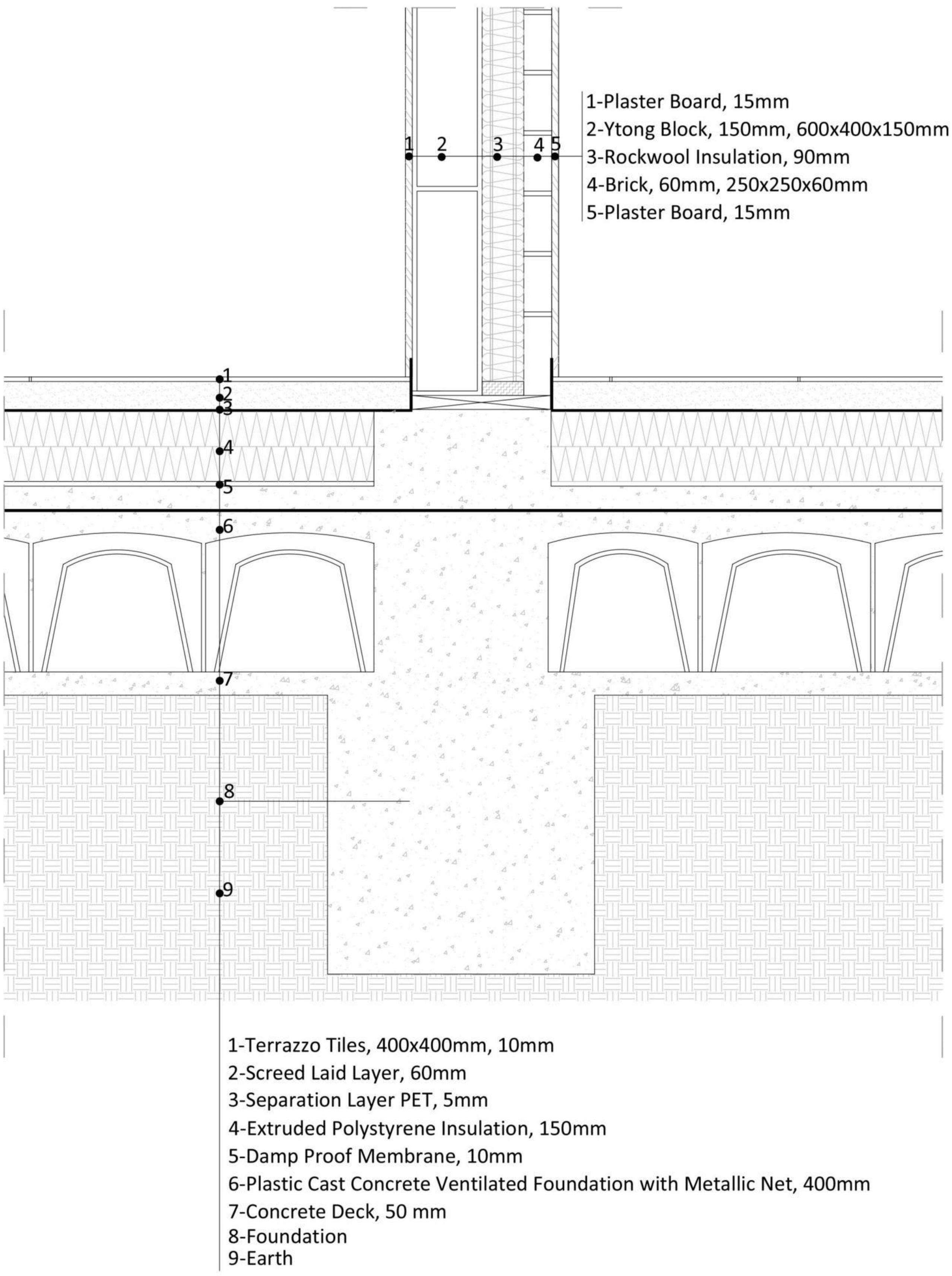

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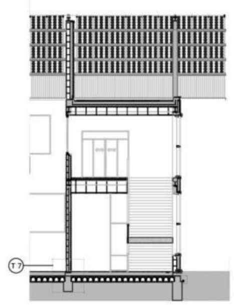

Drawing Code
Tecnology - Joint 7
T 7

PROJECT
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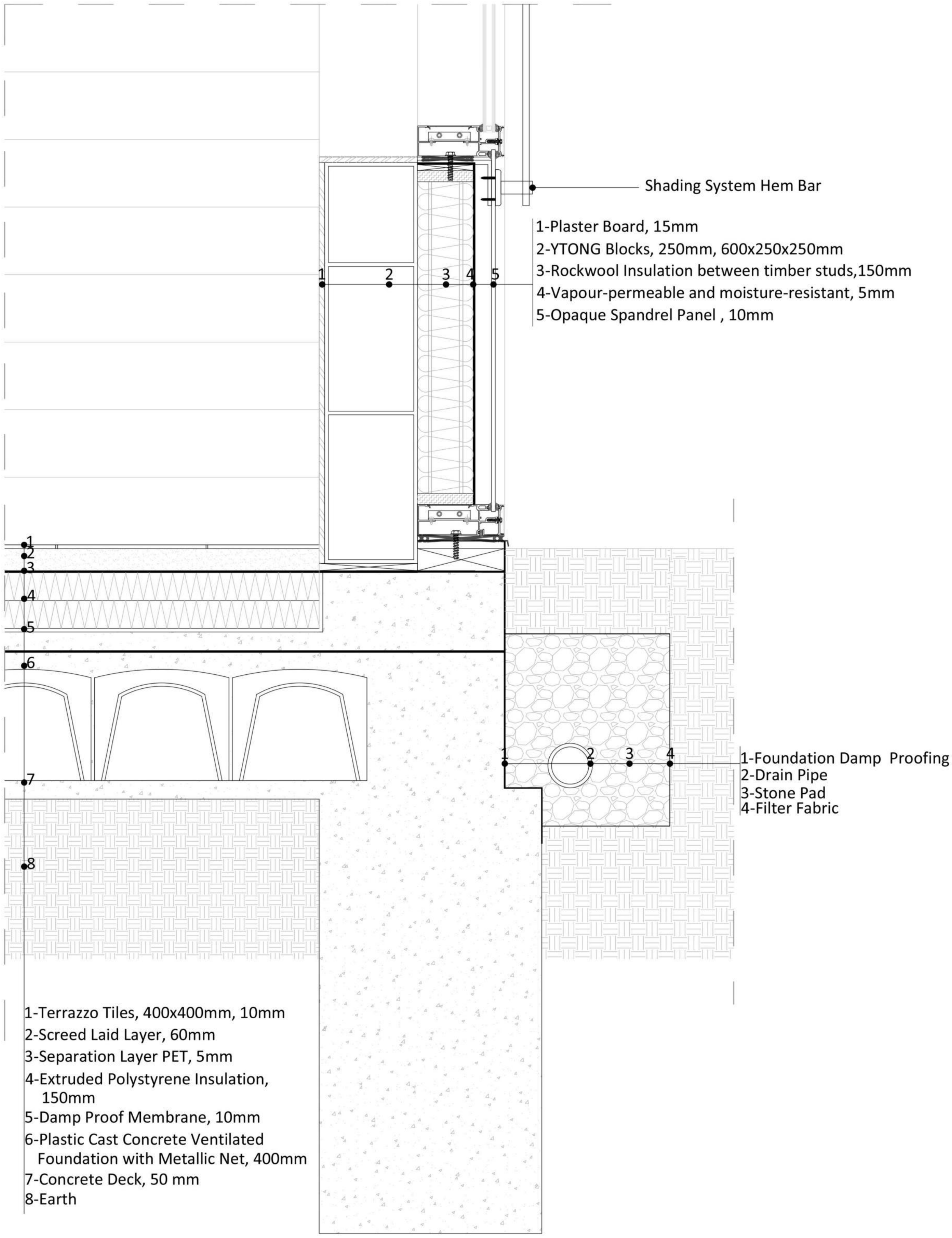
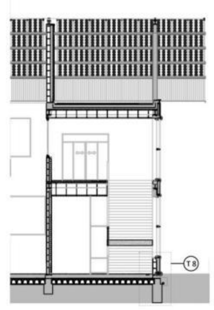
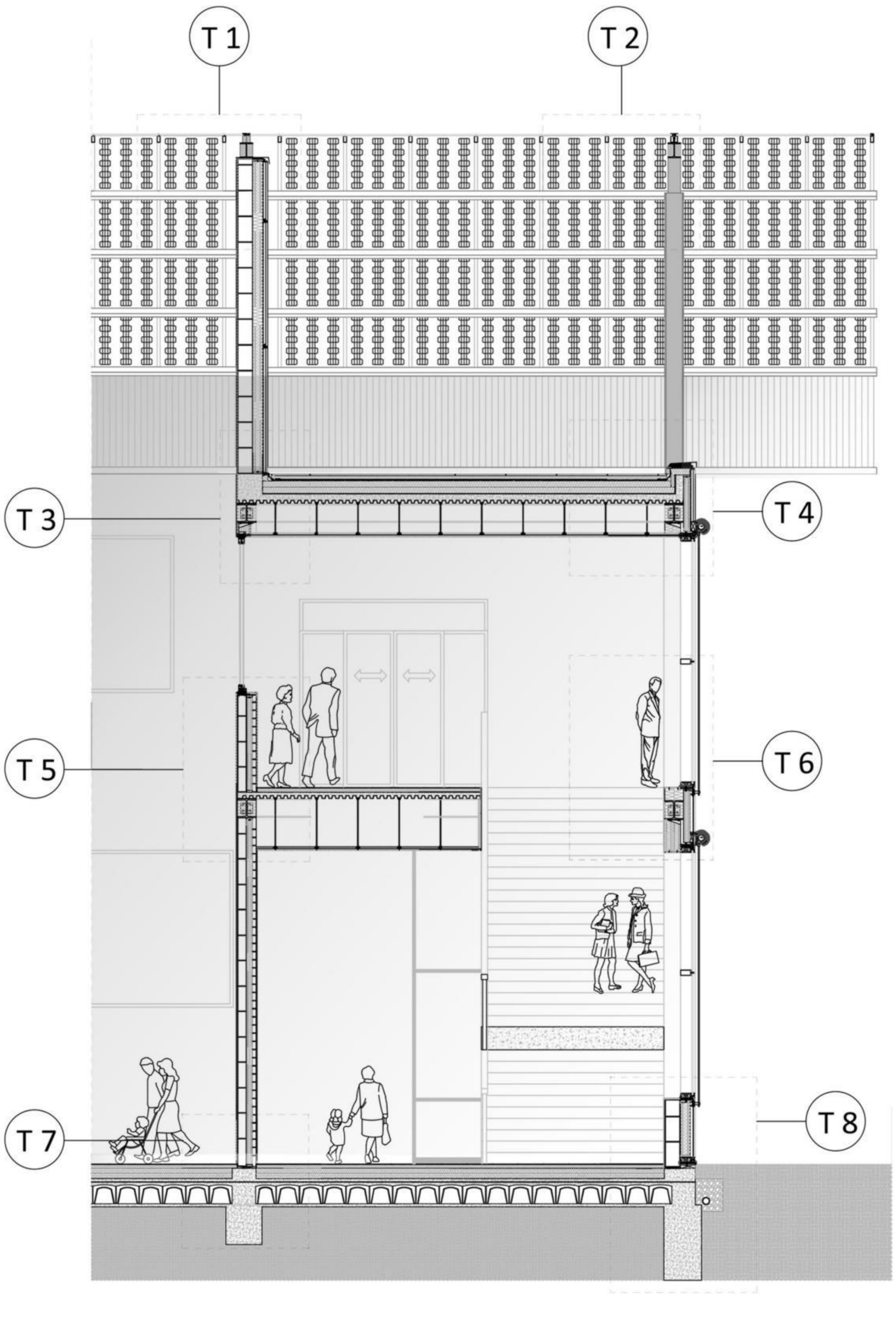
REINOSA - SPAIN

Drawing Scale
1: 10



POLITECNICO DI MILANO MASTER OF SCIENCE IN ARCHITECTURE ENGINEERING GRADUATION THESIS	AUTHORS CHEN CHI		Drawing Code Tecnology - Joint 8 T 8
PROJECT SOCIAL CENTER REINOSA - SPAIN			Drawing Scale 1: 10



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GRADUATION THESIS

AUTHOR
CHEN CHI

Drawing Code
Tecnology - Section

PROJECT
SOCIAL CENTER
REINOSA - SPAIN

Drawing Scale

7.3.5 HVAC Design

The objective of an HVAC (Heating, Ventilating, and Air-conditioning) system is to control the temperature, humidity, air movement, and air cleanliness, normally with mechanical means, to achieve thermal comfort. Load estimation is to calculate the peak design load (cooling/heating), estimate likely plant/equipment capacity or size, as well as form the basis for building energy analysis. In Reinosa, cooling load estimation is the goal to achieve before HVAC design process.

7.3.5.1 Design Condition

From <Energy efficiency requirements in building codes, energy efficiency policies for new buildings> issued by European Commision, the design condition for both indoor and outdoor at summer time is recommended as below.

Summer Condition	Indoor	Outdoor
Temperature	27℃	32℃
Relative Humidity	50%	80%

Table 7.1 Design Condition

7.3.5.2 Central Air Conditioning System

Air and water conditioning system offers whole-house or large space cooling, and often offers moderate multi-zone temperature control capability while be controlled by local units. In Reinosa, the substantial heating is often required at the perimeter walls in winter. Therefore, in this situation, a hot-water-heating system can be installed around the perimeter of the building while a central air system provides cooling and ventilation. Furthermore, the air units could be installed in ceiling plenum, does not require additional space.

For the arcades, where is large space without ceiling, to supply the new air to get comfort condition, high sidewall air supply is applied. The following shows the layout of the air conditioning system.

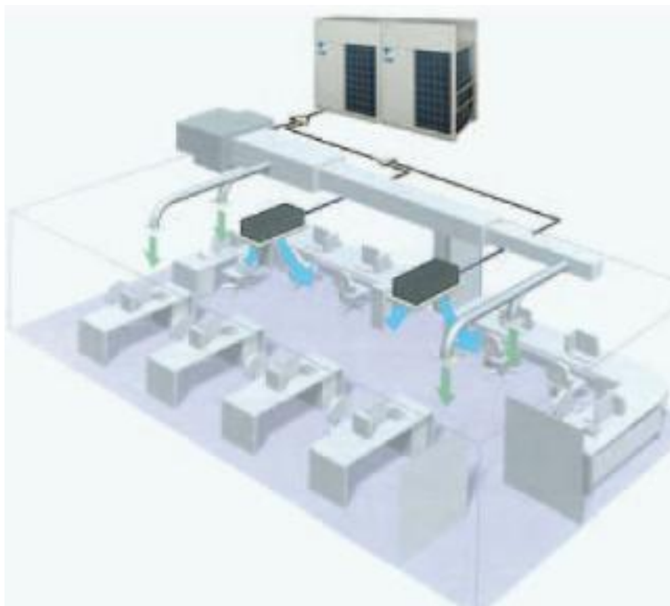

Figure 7.26 Scheme of All Air System with VRV System

7.3.5.3 Air Handler Unit Choose

Function	Indoor design temperature ℃	Cooling load
Bedroom	26	90-145W/m^2
Study room	26	80-145W/m^2
restaurant	26	350-465W/m^2
Bars	26	230-350W/m^2
Club	26	260-380W/m^2
Corridor	27	70W/m^2
Hall	27	210-320W/m^2

Table 7.2 Cooling Load

According to the table shows below, the cooling load is estimated.

	rooms	Area (m^2)	Cooling load (kw)	Air flow (m^3/h)	AHU Air flow (m^3/h)
Ground Floor	Corridor	300	60	30000	
	Arcade(lower)	424	84.8	42000	
	Market	133	26.6	13000	
	Cafeteria	60	12	6000	
	Cafeteria/Fast food	36	7.2	3000	
	Arcade(higher)	159	31.8	16000	
	Exhibition Room	160	32	16000	
	Auditorium Room	83	16.6	8000	
	Total			134000	70000*2
First Floor	Corridor (south)	163	32.6	16000	
	Workshop Room (big)	164	32.8	16000	
	Workshop Room (small)	44	8.8	4000	
	Workshop Room (small)	44	8.8	4000	
	Workshop Room (small)	44	8.8	4000	
	Workshop Room (small)	44	8.8	4000	
	Corridor (north)	78	15.6	7000	
	Total			55000	40000*1

Table 7.3 Air Flow per room

7.3.5.4 Layout of the Pants

Figure 7.27 Air Conditioning System scheme in Ground Floor

Figure 7.28 Air Conditioning System scheme in First Floor

CONCLUSION

To provide a multi-functional public space for the citizens in Reinosa, the Socio-cultural Center plays an important role, while recall the memory of the previous market. By understanding it as one opportunity to challenge myself, I decided to choose this archaeology project in Reinosa.

Finding the solutions to meet the practical problems, the very first thing that I did was to do research and case study to understand the feature and history of the town, site situation, archaeological typology, etc. the concept was then gradually outlined, leading to the final form of two arcades with one square and one orchard garden.

The different large spaces inside and outside of the building were designed to create a pedestrian connection and a relaxing experience to appreciate the bridge ruins. It was a subject not only about urban design, but also about orchard garden design which brings the visitors to a food market sources.

The two internal public spaces differ in height and are surrounded by different environments in an effort to create the two main type of arcade. The building acts as a bridge between the small garden square in front of the theater, and a new square that built in direction of the city center. The visitor will have the possibility to go through a series of square: the modern one close to the south facade, the internal one with the arcade, and the existing compact one between the north facade and the theater.

The regular steel frame structure is applied to support the two levels' building. Besides, building integrated photovoltaics were applied on the roof, to approach net-zero-energy concept as well get more natural light to the large spaces.

Overall, solutions reached me progressively along with more and more practical problems in each step, from urban analysis to form determination, from local site study to global development strategy, from case study to element extraction and from architecture shaping to structure and technology detailing. I had integrated my knowledge and past experience into the application, while at the same time seeking for a better result in new subjects. What I have learned from this project has gone beyond the pages. I am deeply indebted to all of my

professors and tutors for their direct and indirect help to me. Special thanks should go to my friends and classmates for all help, support and interest. I should finally like to express my gratitude to my beloved parents who have always been helping me out of difficulties and supporting without a word of complaint.

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