Escola Politècnica Superior d'Edificació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

DISSENY, CÀLCUL I PROJECTE D'ESTRUCTURES D'EDIFICACIÓ

ANNEX V – ENGLISH VERSION

SUMMARY

This Final Project consists of the design and the calculation of the structure of a residential building located in the town of Torredembarra with the help of the programme Tricalc.

This project is structured according to the guidelines established by the CTE. This document defines the elements that form the overall structure of the building, which is made of concrete.

The main objective is to strengthen the knowledge and skills acquired during the studies, as a specialization and preparation for professional practice in the field of building structures, thanks to the practical resolution of the structure of a building.

The project is based on an initial introduction, followed by the descriptive report. In this section, we explain and discuss different possible solutions before reaching a final solution.

We made the previous calculations to define the optimal structural solution for this building. We explained the operation and the steps needed to enter data in Tricalc programme.

Afterwards, we analyzed the calculation process made with the Tricalc programme and considering all the factors that affect one way or another in our structure.

Afterwards it introduced the budget and assessment of the cost and the environmental impact of the structure, with the help of the programme TCQ2000.

Finally, the project ends with the conclusions, the annexes and the plans required.

1 INTRODUCCION

1.1 Objectives of Final Project

The aim of the project is to solve the structure of a building in the town of Torredembarra.

We begin this project analyzing the structural system proposed in the Basic Project, including the geotechnical report, proposing changes that may be necessary and pre-measuring the elements.

In the second phase will solve the complete calculation of the structure with the help of the Tricalc program. Studying and analyzing various structural solutions. Once adjusted all the pre-measuring elements, we will edit all plans needed.

Finally, we will take the measurement and execution of the budget of the structure and also calculate their energy costs and CO2 emissions generated.

1.2 Description of the building

1.2.1 Location

The building is located in the northwest of the town of Torredebarra. This town belongs to the province of Tarragona. Torredembarra borders Creixell on the northeast, with Pobla de Montornés to the north, with La Riera to the northwest, with Altafulla to the south and with the Mediterranean Sea on the east.

Torredembarra is a tourist place of the Catalonian coast. In summer, the population increases up to four times more than the population in winter. In 2010, its population was 15.312 inhabitants, in summer this number increases to 60.000 inhabitants. The average altitude above sea level is 5 meters.

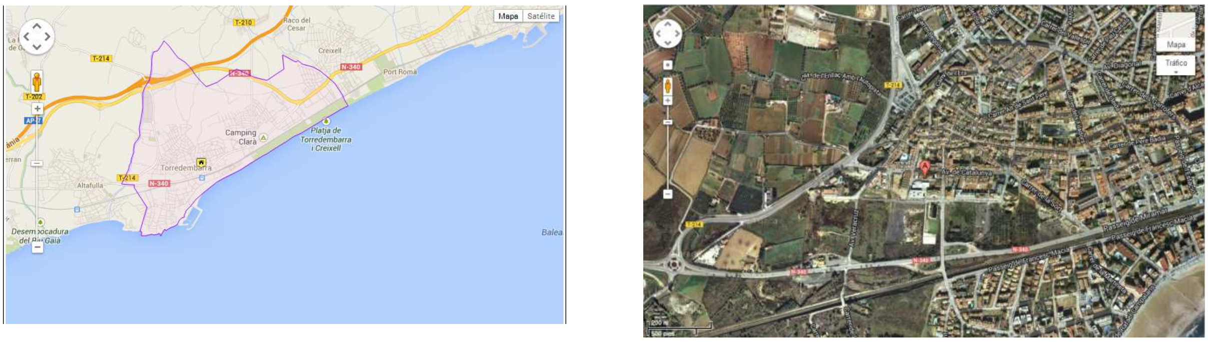

Figure 1.1: Areal view of Torredembarra

1.2.2 The site and its surroundings

The plot is located between the streets Reus 14 and Cataluña 35. There are two opened facades, and two façades between dividing. The plot is rectangular with an area of 240,6m2 cadastral according to the report.

As you can see in the screening plant, the building occupies the entire plot, and it has a rectangular shape with a depth of approximately 21, 50 meters and a width of approximate 12 meters. Straightaway, we can see the exact location and some photos to see how the building would be situated.

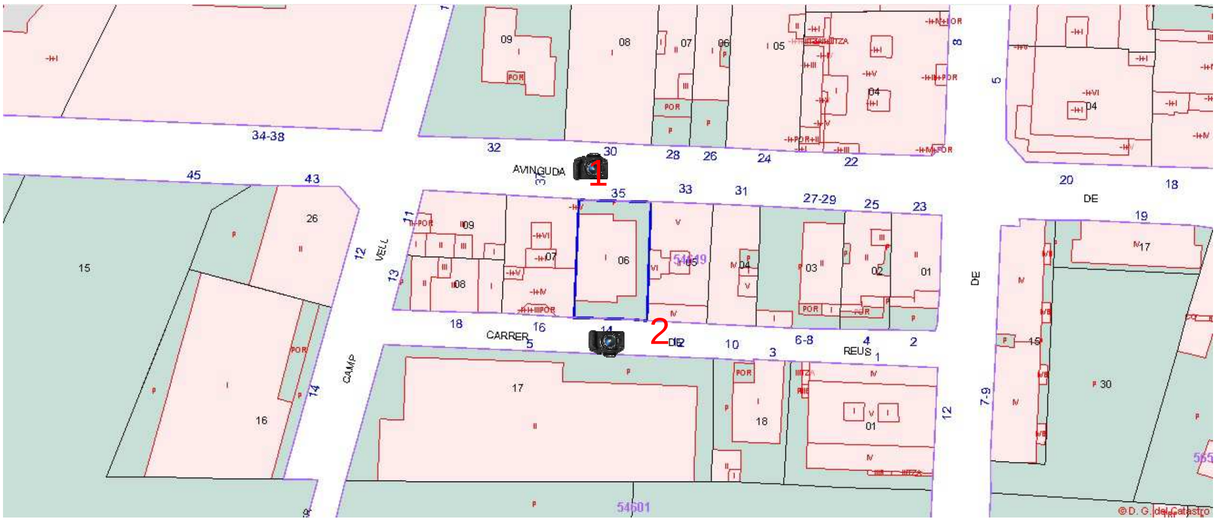

Figure 1.2: Cadastral map of the site

Picture 1

Picture 2

1.2.3 Characteristics of the building

The building would consist of ground floor, three further floors and one basement with a height of 12,50 meters above ground. The ground floor has a height between floors of 3,5 meters, while in the rest of floors will have the height of 3 meters.

It has two facades, the north faces the street Catalunya and the south faces the street Reus. Both have an approximate height of 12 meters. The building has a depth of approximately 20 meters. Both interior closings are divided. The whole building has walls made of exposed bricks.

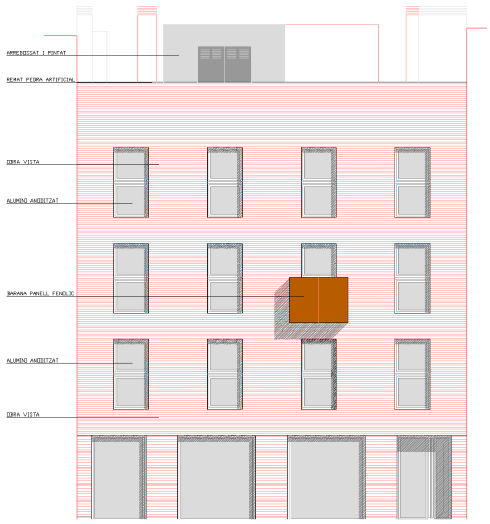

Figure 1.3: Façade Cataluña Street

Figure 1.4: Façade Reus Street

The main use of the building is intended as a house, except a part of the ground floor this will be a shop. The entrance to the building is located in Catalonia Street while the entrance to the shop is located in Reus Street. The basement is destined to become the store of the shop and is entered across private stairs. The height of this floor is 3 meters.

Below we can see a table with the surfaces constructed of every floor united with the uses and the heights between floors.

	Floor Area (m^2)	Height (m)	Use
Underground	88,49	3	
P-1	88,49	3	Shop store
Over ground	1165,22	12,5	
PB	240,6	3,5	Shop (5KN/m2), 1 housing of 3 bedrooms(2KN/m2)
P1	240,6	3	3 housings of 3 bedrooms(2KN/m2)
P2	240,6	3	3 housings of 3 bedrooms(2KN/m2)
P3	240,6	3	2 housings of 3 bedrooms(2KN/m2)
P.COBERTA	202,6		Roof and area of facilities, category G1(1KN/m2)
TOTAL	1253,71	15,5	

Table 1.1: Total floor areas.

Figure 1.5: Physical layout of the building

1.3 Methodology of work

For this TFG, I have read some recommended books by our teachers and I have reviewed the notes of my structure subjects, because I didn't make anything related with this matter some time ago.

Firstly, I have begun the previous work of comprehension and analysis of the Basic Project, taking into account the layouts, sections and geotechnical study of the ground.

The following step has been the pre-measuring of the whole structure valuing the actions that act on the building to determine the loads and the efforts and to establish some initial dimensions.

Then I calculated the structure of the building through the calculator program structures TRICALC to measure each and every one of the elements that compose it.

After defining the structure and analyzed the documentation generated with the program TRICALC, I make changes and adjustments.

Then I assess the economic cost (budged execution) and environmental impact (energy cost and CO2 emissions generated) of the project structure.

Finally to complete the work I start to write the memory of this project with reasoned justification of the decisions I have made.

1.4 Memory content

After all the introductory explanation of the building, its features and explaining the uses which will be aimed the building explained in section 1, then in section 2, we will explain the determining factors for the definition of the structural solution adopted; in section 3, we will show the calculations of loads and actions that must be taken into account as effort analysis, armed and foundations, etc.; in section 4, we will explain how to generate plans, calculation, memory and budget; finally in section 5, I will discuss everything related to the CO2 emissions. Then I will dedicate one page for the conclusions.

We also have some appendices accompanying this report and are the following documents:

- Report of calculation.
- Specifications.
- Plans.
- Measurements and budget.
- English version.

2 DEFINITION OF THE STRUCTURAL SOLUTION

In this section I try to explain the procedures followed to choose and define the most appropriate structural typology for this project.

2.1 Criteria and conditions of the land

This section is an important part of the project. According to the geotechnical report previously provided by teachers, we can begin to set the foundation necessary for the type of terrain that exists in this building. The report says that the most appropriate foundation solution for this type of construction is based on a semi-deep foundation or foundation pits to arrive at the level of tough terrain and avoid problems of differential settlements, etc.

From the data obtained in the tests performed in situ, it could lay the foundations from approximately of 3.5 to 4.3 meters deep, in the carbonate sections of level 2. In this point, are calcareous crusts and conglomerated intercalated in clay silt and sand.

It is necessary to go through the organic layer. Also we have to go through the stratum number 2 which is formed by clays and sands of low resistance.

As for the type of foundation, the report geotechnical recommends to make the foundation with spread footings and continuous spread footings in the final of level 2. We will make caissons to reach the level of the subsoil resistant. These caissons will be maintaining its dimension along its dept. The allowable stress is 2,0 kg/cm^2.

Then we can see the section of the soil where the building will be build. Furthermore, we can see the characteristics of the layers of the soil as the geotechnical study.

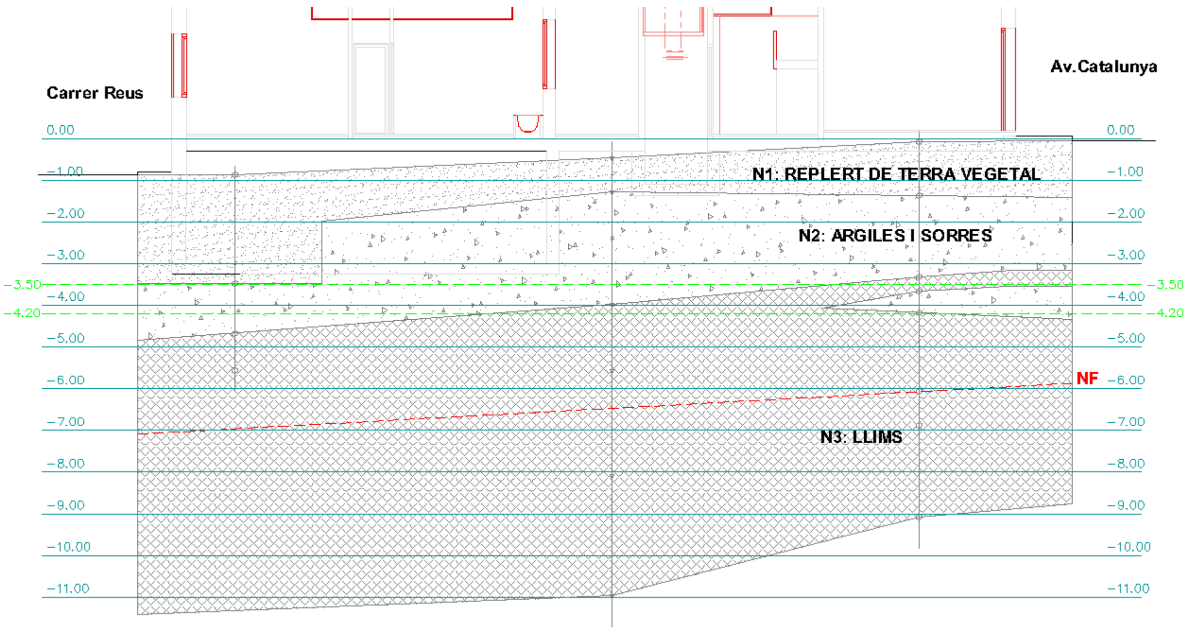

Figure 2.1: The soil layers.

Level 1: Tops oíl	
Dry density (t/m3)	1,43
Apparent density (t/m3)	1,73
Submerged density (t/m3)	0,92
Compression strength (t/m2)	1,02
Internal friction angle (degrees)	25
Foundations-Land friction angle (degrees)	16,67
Foundations-Land friction coefficient (degrees)	0,31
Vertical coefficient, sheet 30x30 (kg/cm3)	4,59
Horizontal coefficient, active pressure (kg/cm3)	4,33
Horizontal coefficient, passive pressure (kg/cm3)	4,08

Level 2: Clays	
Dry density (t/m3)	1,78
Apparent density (t/m3)	1,89
Submerged density (t/m3)	0,92
Compression strength (t/m2)	15,3
Internal friction angle (degrees)	22
Foundations-Land friction angle (degrees)	14,67
Foundations-Land friction coefficient (degrees)	0,27
Vertical coefficient, sheet 30x30 (kg/cm3)	4,59
Horizontal coefficient, active pressure (kg/cm3)	3,31
Horizontal coefficient, passive pressure (kg/cm3)	2,04

Level 3: Silts	
Dry density (t/m3)	1,63
Apparent density (t/m3)	1,89
Submerged density (t/m3)	0,92
Compression strength (t/m2)	6,12
Internal friction angle (degrees)	28
Foundations-Land friction angle (degrees)	18,67
Foundations-Land friction coefficient (degrees)	0,35
Vertical coefficient, sheet 30x30 (kg/cm3)	3,06
Horizontal coefficient, active pressure (kg/cm3)	2,8
Horizontal coefficient, passive pressure (kg/cm3)	2,55

Tarragona area is located on the Cretaceous and Tertiary materials formed by clays conglomerates. This substrate is covered by Quaternary sediments in the form of fans and floodplains constructed by granular and cohesive packages of variables powers and from the erosion of the littoral mountain chain.

To study the layers of the ground, experts used the standard penetration test (SPT "standard penetration test") that is nailed, over 30 centimeters spoon cam normalized samples consisting of a cylinder of 35 mm inner diameter and 51 outside diameter.

The groundwater level is between 6 and 7 meters of depth. This means that will not affect in any way to do the foundations of the basement because it goes below the foundation level.

Regarding the chemical quality of the groundwater, analysis has been done with the data obtained by reference to the standard EHE-08, Statement of Structural Concrete; mandatory, underground water does not have a high level of aggressiveness to concrete.

To understand the potential aggressiveness of subsurface materials in concrete has been done in the determination of soluble sulfates. In view of the results, we define the degree of aggressiveness of the concrete flooring is NULL, so no need to take special precautions in this respect (as Norma EHE-08: Statement of Structural Concrete, below 2.0 mg/kg soil is not aggressive).

2.2 Solution structure adopted

The aim of this chapter is to justify the solution adopted including foundations, vertical and horizontal structure.

2.2.1 Foundation.

We can see in the geotechnical report that the topsoil level reaches 2,5 meters deep. It’s necessary to surpass this level to do the foundations. The basement level is located 3 meters deep. This thing doesn’t suppose a problem. The foundation of the wall of basement will be done by continuous spread footing whereas the foundation of the pillars will be done by spread footing with caissons to reach the most resistant layer.

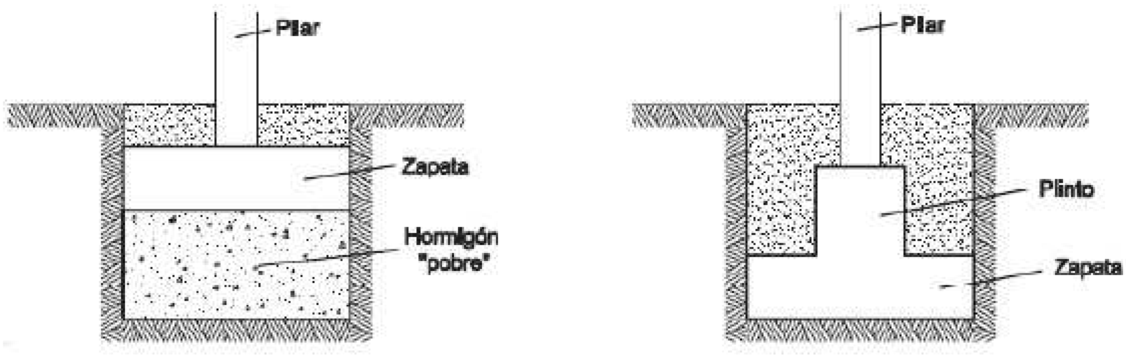

Figure 2.2: Principal kinds of caissons.

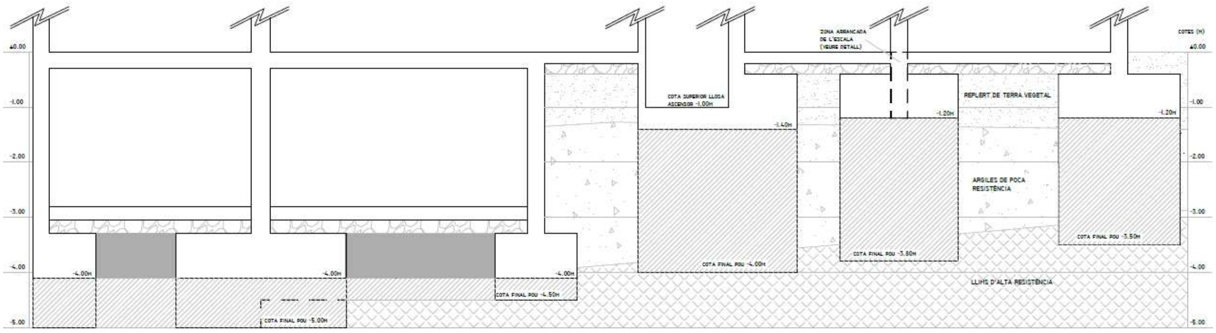

Figure 2.3: Drawing of the foundation of the structure.

2.2.2 Vertical structure

Analyzed the geotechnical report and the basic project, it was considered appropriate that the structure of the building is made with reinforced concrete frames. The decision to use this material for their accomplishment comes from several factors.

We changed the layout of some pillars because the distance between them was excessive.

In this case, the most suitable option is to build the concrete structure of the building has a remarkable ability to withstand compression forces and a nice clean look of strength and that presents a whole structure columns, walls and beams, once removed the formwork.

We keep in mind the maintenance costs. In purely metallic structures we need painting periodically iron to prevent oxidation and wear. While in reinforces concrete, iron, surrounded and protected by a mass of concrete remains intact and in perfect condition.

However, concrete is a very insulator of head, so when protect users from any mishap we will have time to evacuate the building.

For all these reasons, we have chosen to make the structure of concrete.

2.2.3 Horizontal structure

The basement floor slab will have a thickness of 20 cm and under there will be a layer of gravels.

The floor slabs are resistant elements that form a continuous slab floors and constitute each plant. Function is to serve a floor to ceiling in the basement of the same, and ceiling to floor. So, between two floors of a building. There may be the case that it is the roof, so the roof will serve and support the roof.

The curved concrete slabs will be relieved of 30 cm with a depth of 5 cm layer of compression, with coffered wood boards.

2.2.4 Elements of vertical communication

2.2.4.1 Stairs and ramps

There are stairs that communicated the shop and the store in the basement. The scale of the building that connects the different levels is also of concrete slab 20 cm thick.

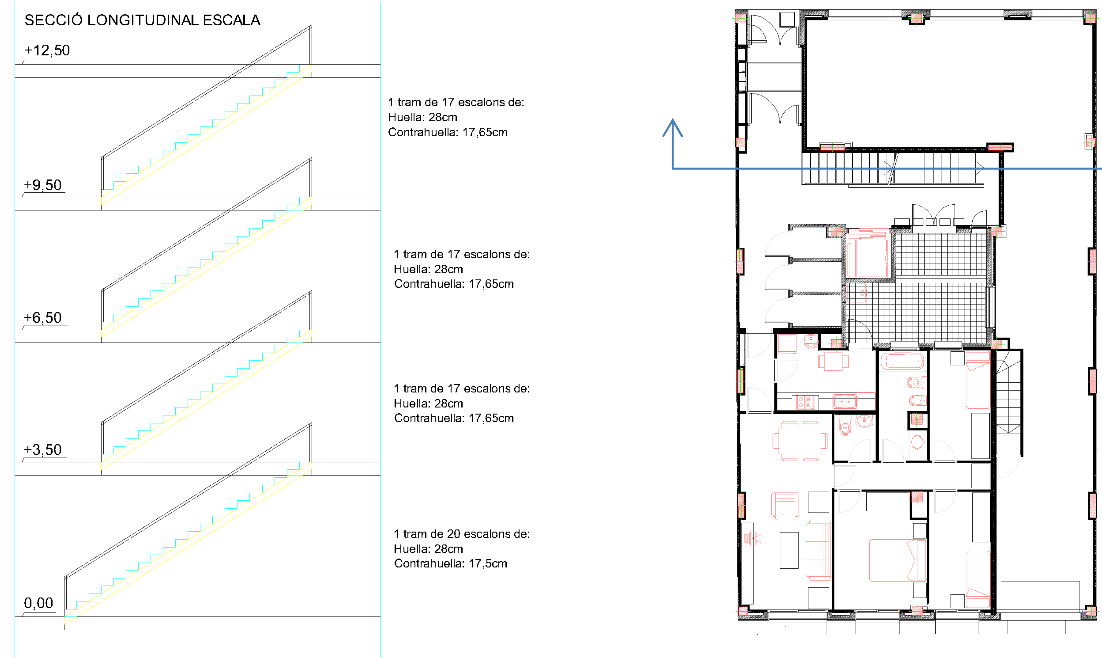

Figure 2.4: Longitudinal section of the main stairway

2.2.4.2 Resistant walls

The basement wall is made of reinforced concrete 30cm thick and 3 meters high. We don't need to have any special protection in the concrete in the face of humidity because the groundwater level is located below the wall foundation level. This foundation will be done with countinuous spread footing.

2.3 Materials used in the structure

Once we have defined the structural solution of the structure, we have to define the materials used.

Steel:

We use the same steel bars for the entire structure.

B 500 S

Steel Type B (for concrete)

Nominal yield strength: 500MPa

Weldable

Concrete:

We use the same type of concrete for the entire structure.

HA – 30/B/20/IIIa

Type: Reinforced concrete

Characteristic compressive strength: 30N/mm^2

Consistency: Adobe

Maximum size of aggregate: 20mm

Type of setting: IIIa

2.4 The pre-measured

The following is the procedure to make a first approach to the dimensioning of the structure.

2.4.1 Slabs

2.4.1.1 Slabs between floors

We consider for the pre-measured:

Loads considered:

- Permanent
  - Weight own: 5 KN/m^2
  - Partitions: 1 KN/m^2
- Use
  - Ground (Trade Area): 5 KN/m^2
  - Floors 1, 2 and 3 (Housings): 2 KN/m^2

We consider the most unfavorable situation (Ground): 5 KN/m^2

Total charge: q = 5+1+5 = 11 KN/m^2

According to Article 50.2 of the EHE, the edge $h_{min} = \delta_1 \cdot \delta_2 \cdot L/C$, where:

$\delta_1 = \sqrt{q/7} = \sqrt{11/7} = 1{,}25$

$\delta_2 = (L/6)^{1/4} = (5{,}80/6)^{1/4} = 0{,}99$, where the distance is more large L = 5,80m

C = 24, according to the coefficient table 50.2.2.1b

$h_{min} = \delta_1 \cdot \delta_2 \cdot L/C = 1{,}25 \times 0.99 \times (5{,}80 / 24) = 0{,}30$ m

It establishes a thickness of 25+5.

2.4.1.2 The roof slab

Loads considered:

- Permanents (roof weight own): 5KN/m^2
- Use overload(passable only privately accessible): 1KN/m^2
- Snow overload:

According to section 3.5 of the CTE DB SE-AE, snow load is calculated using the following formula: $q_n = \mu \cdot S_k$

Where: μ = coefficient of roof shape; S_k = characteristic value of snow load

In the case of Torredembarra, with an altitude of 10m above sea level → Sk = 0,4

The roof is flat and we haven't impediment sliding snow → μ = 1

➔ $q_n = \mu \cdot S_k = 1 \times 0{,}4 = 0{,}4$ KN/m^2

Total charge: q = 5 + 1 + 0,4 = 6,4 KN/m^2

According to Article 50.2 of the EHE, the edge $h_{min} = \delta_1 \cdot \delta_2 \cdot L/C$, on:

$\delta_1 = \sqrt{q/7} = \sqrt{6{,}4/7} = 0{,}96$

$\delta_2 = (L/6)^{1/4} = (5{,}80/6)^{1/4} = 0{,}99$, where the distance is more large L = 5,80m

C = 24 according to the coefficient table 50.2.2.1b

$$h_{min} = \delta_1 \cdot \delta_2 \cdot L/C = 0,96 \times 0.99 \times (5,80 / 24) = 0,23 \text{ m}$$

It establishes a thickness of 25+5 cm.

2.4.2 Pillars

To make the pre-measured of the pillars, we consider the most unfavorable situation.

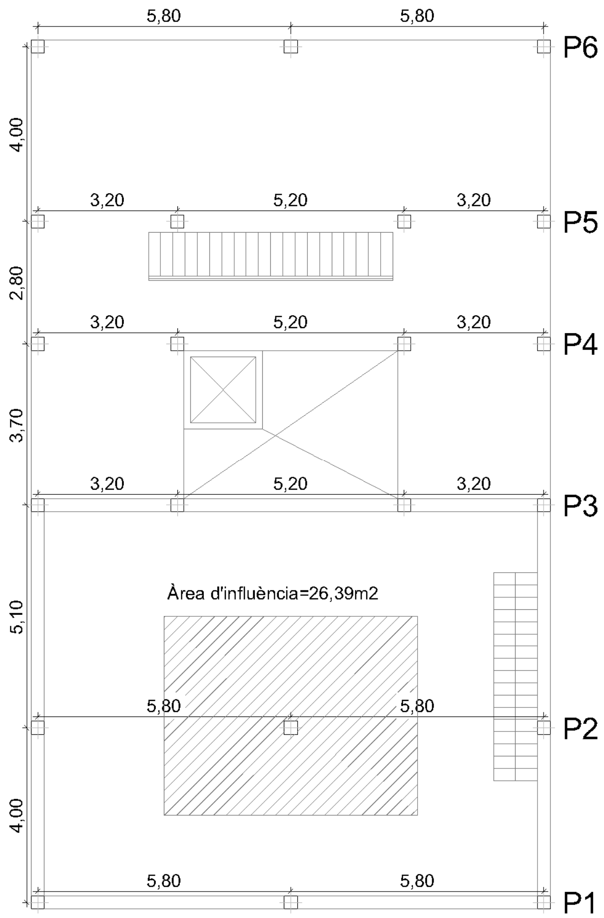

Figure 2.5: Situation of the pillars.

Loads considerated:

- Permanent loads:
  - o Weight own floor slabs: 5 KN/m^2
  - o Weight own roof: 5 KN/m^2
  - o Partitions: 1 KN/m^2
- Use overload:
  - o Ground: 5 KN/m^2
  - o Floors 1, 2 and 3: 2 KN/m^2
  - o Roof: 1 KN/m^2
- Snow overload (calculated in the previous section): q_n = 0,4 KN/m^2

Permanent loads: (5 + 1) KN/m^2 x 5 floors = 30 KN/m^2

Overloads: 5 + 2 + 1 + 0,4 = 8,4 KN/m^2

It is consider a total charge of q = (30 x 1,30) + (8,4 x 1,50) = 51,60 KN/m^2

Area of influence of unfavorable prop = 26,39m^2

Total: N_d = 51,30 x 26,39 m^2 = 1353,81 KN

We have a concrete HA-30, so f_{cd} = 300 kg/cm^2

σ_{adm} > N_d / A > 1353810N / 30 N/mm^2 → A > 45127 mm^2 = 451,27 cm^2

So, $\sqrt{451,27}$ = 21,24 cm

The pre-measured gives values of 25cm, but for the security and distribution plans the pillars will be 30x30cm.

2.5 Fire resistance of the structure

The main objective of this chapter is to check whether the project meets the basic requirements of security in the event of a fire set in the Basic Document of the Technical Building Code, CTE DB-SI. The principal use of the building is basically Residential Housing.

2.5.1 SI.2 Exterior propagation

<u>Dividing facades</u>
The dividing facades have a fire resistance of EI-120 and accomplish the distances to limit the risk of horizontal exterior fire propagation of 0,50m for angles of 180º.
The facades have a fire resistance of EI-60 and the separation with the windows is > 50 cm of horizontal distance and >100 cm of vertical distance.

<u>Roof</u>
The roof of the building will have a fire resistance of REI 60 in a strip of 50cm as minimum, that guarantee the non-propagation of the fire between the two fire sectors of the building use that where explained before and with other buildings.
The roof final materials as well as the final materials of the cantilever solid floor over the balconies will be of the reaction fire class B roof (t1).

2.5.2 SI.6 Fire resistance of the structure.

It is considered that the fire resistance of a principal structural element of the building (including floors, beams and supports), are enough if:

a) They achieve the indicate class in the following tables (3.1 and 3.2 del DB-SI), that represent the time in minutes of resistance in front of the action represented by the normalized curve time temperature, or
b) Supporting this action during the time equivalent of fire exposition indicating the annex B of the DB-SI.

Tabla 3.1 *Resistencia al fuego* suficiente de los elementos estructurales

Uso del *sector de incendio* considerado [1]	Plantas de sótano	Plantas sobre rasante *altura de evacuación* del edificio		
		≤15 m	≤28 m	>28 m
Vivienda unifamiliar [2]	R 30	R 30	-	-
Residencial Vivienda, Residencial Público, Docente, Administrativo	R 120	R 60	R 90	R 120
Comercial, Pública Concurrencia, Hospitalario	R 120 [3]	R 90	R 120	R 180
Aparcamiento (edificio de uso exclusivo o situado sobre otro uso)	R 90			
Aparcamiento (situado bajo un uso distinto)	R 120 [4]			

[1] La *resistencia al fuego* suficiente R de los elementos estructurales de un suelo que separa *sectores de incendio* es función del uso del sector inferior. Los elementos estructurales de suelos que no delimitan un *sector de incendios*, sino que están contenidos en él, deben tener al menos la *resistencia al fuego* suficiente R que se exija para el uso de dicho sector

[2] En viviendas unifamiliares agrupadas o adosadas, los elementos que formen parte de la estructura común tendrán la *resistencia al fuego* exigible a edificios de *uso Residencial Vivienda*.

[3] R 180 si la *altura de evacuación* del edificio excede de 28 m.

[4] R 180 cuando se trate de *aparcamientos robotizados*.

Table 2.1: The table 3.1 del CTE DB-SI

According to Table 3.1 CTE DB-SI, requires a fire resistance of EI 120 in the walls, ceilings and doors of the plant below ground and EI 60 in the exterior of the plant above ground, as the height less than 15 meters (h≤15m).

As for areas of special risk, table 2.1 CTE DB-SI, classifies the areas of special risk integrated in the building, we consider the following areas:

1) The store has a volume greater than 200m3, is a high-risk area. Because of this, the fire resistance is R180.
2) In the closings of the shop, the fire resistance will be R120 because this area has a surface smaller than 300m^2.

Table 2.2: The table 3.2 of CTE DB-SI

Tabla 3.2 *Resistencia al fuego* suficiente de los elementos estructurales de zonas de riesgo especial integradas en los edificios [1]

Riesgo especial bajo	R 90
Riesgo especial medio	R 120
Riesgo especial alto	R 180

[1] No será inferior al de la estructura portante de la planta del edificio excepto cuando la zona se encuentre bajo una cubierta no prevista para evacuación y cuyo fallo no suponga riesgo para la estabilidad de otras plantas ni para la compartimentación contra incendios, en cuyo caso puede ser R 30.

La *resistencia al fuego* suficiente R de los elementos estructurales de un suelo de una zona de riesgo especial es función del uso del espacio existente bajo dicho suelo.

2.5.3 Design criteria regarding the structure of the fire resistance

2.5.3.1 Waffle slab

In the case of the waffle slab that forms the building structure, it is about to consider the following considerations in order to their dimensions.
With the table C.5 of the CTE DB-SI, it can be obtained the fire resistance of the reticular slab sections, which refers to the minimum wide of the nerve and to the minimum equivalent distance from the edge of the lower rain-force in traction. It can be

considered as thickness the pave or any other element that maintain its isolation

Tabla C.5 Forjados bidireccionales

Resistencia al fuego	Anchura de nervio mínimo $b_{mín}$ / Distancia mínima equivalente al eje a_m [(1)] (mm)			Espesor mínimo h_{min} (mm)
	Opción 1	Opción 2	Opción 3	
REI 30	80 / 20	120 / 15	200 / 10	60
REI 60	100 /30	150 / 25	200 / 20	80
REI 90	120 / 40	200 / 30	250 / 25	100
REI 120	160 / 50	250 / 40	300 / 35	120
REI 180	200 / 70	300 / 60	400 / 55	150
REI 240	250 / 90	350 / 75	500 / 70	175

(1) Los recubrimientos por exigencias de durabilidad pueden requerir valores superiores.

function during the fire resistance period.

Table 2.3: The table C.5 of CTE DB-SI

If the slabs have beam fillings ceramic or concrete elements and inferior coverings, for a fire resistance R 120 or lower it will be enough with the accomplishment of what is said in the point 1 of the section C.2.3.5. Of CTE DB-SI, C4 table showed right after.

Tabla C.4. Losas macizas

Resistencia al fuego	Espesor mínimo $h_{mín}$(mm)	Distancia mínima equivalente al eje a_m (mm) [(1)]		
		Flexión en una dirección	Flexión en dos direcciones	
			l_y/l_x [(2)] $\leq 1,5$	$1,5 < l_y/l_x$ [(2)] ≤ 2
REI 30	60	10	10	10
REI 60	80	20	10	20
REI 90	100	25	15	25
REI 120	120	35	20	30
REI 180	150	50	30	40
REI 240	175	60	50	50

(1) Los recubrimientos por exigencias de durabilidad pueden requerir valores superiores.
(2) l_x y l_y son las luces de la losa, siendo $l_y > l_x$.

Table 2.3: The table C.5 of CTE DB-SI

The reticular slabs used in the structures of this memory are of thickness 25+5cm, the nerves width 15cm, inter-edge of 85cm, concrete lighten blocks, and its inferior reinforced minimum with bars of Ø12.
The fire resistance is REI 90. The minimum width of the nerve must be of 12cm and the minimum distance equivalent to the edge of 40mm. The reticular slabs used accomplish an REI 90, with re-covers for an ambient IIa.
The fire resistance is REI 120. The minimum width of the nerve must be of 16cm and the minimum distance equivalent to the edge of 50mm. If we consider the collaboration of the inferior plaster and of the superior pave, there can be used the reticular slabs described before.

2.5.3.2 Resistant walls and pillars

Using Table C.2 can obtain the fire resistance of the support offered for three or four sides, and the bearing walls exposed for one or both sides, which refers to the minimum distance equivalent to the axis of the reinforcement of the faces exposed.

Tabla C.2. Elementos a compresión

Resistencia al fuego	Lado menor o espesor $b_{mín}$ / Distancia mínima equivalente al eje a_m (mm) [1]		
	Soportes	Muro de carga expuesto por una cara	Muro de carga expuesto por ambas caras
R 30	150 / 15 [2]	100 / 15 [3]	120 / 15
R 60	200/ 20 [2]	120 / 15 [3]	140 / 15
R 90	250 /30	140 / 20 [3]	160 / 25
R 120	250 / 40	160 / 25 [3]	180 / 35
R 180	350 / 45	200 / 40 [3]	250 / 45
R 240	400 / 50	250 / 50 [3]	300 / 50

[1] Los recubrimientos por exigencias de durabilidad pueden requerir valores superiores.
[2] Los soportes ejecutados en obra deben tener, de acuerdo con la Instrucción EHE, una dimensión mínima de 250 mm.
[3] La resistencia al fuego aportada se puede considerar REI

Taula 2.4: La taula C.2 del CTE DB-SI

The minimum dimension of one pillar is of 25cm according to the instruction EHE, and the minimum distance equivalent to the edge for an ambient IIa and a minimum reinforced of Ø12 bars is of 40mm, therefore the pillar always accomplish with an R120

2.5.3.3 Beams

In the table C.3 CTE DB-IF you can get the rife resistance of sections of beams supported at the ends with three sides exposed to fire, referring to the minimum distance equal to the armature axis.

Tabla C.3. Vigas con tres caras expuestas al fuego [1]

Resistencia al fuego normalizado	Dimensión mínima $b_{mín}$ / Distancia mínima equivalente al eje a_m (mm)				Anchura mínima[2] del alma $b_{0,mín}$ (mm)
	Opción 1	Opción 2	Opción 3	Opción 4	
R 30	80 / 20	120 / 15	200 / 10	-	80
R 60	100 / 30	150 / 25	200 / 20	-	100
R 90	150 / 40	200 / 35	250 / 30	400 / 25	100
R 120	200 / 50	250 / 45	300 / 40	500 / 35	120
R 180	300 / 75	350 / 65	400 / 60	600 / 50	140
R 240	400 / 75	500 / 70	700 / 60	-	160

[1] Los recubrimientos por exigencias de durabilidad pueden requerir valores superiores.
[2] Debe darse en una longitud igual a dos veces el canto de la viga, a cada lado de los elementos de sustentación de la viga.

Table 2.4: The table C.3 of CTE DB-SI

For fire resistance R180, the beams must have a minimum dimension of 300mm and the minimum distance between the plates is equivalent to 75mm. The negative reinforcement of the beams extends to 33% of the length of the section to an amount not less than 25% of that required at the ends.