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1 SUMMARY

In this final project it’s been implemented the design, computation and the structure project of a housing building located in Torredembarra. It contains the building’s presentation and description, its characteristics, environment, and its criterion and conditions. It also contains the process, approaches and finally, the choice of design for its structure. The proposed structure is basically for the construction of housing building based on an empty piece of ground in between two, already built, buildings. This building is distinguished for its geometry, that presents differences in every single storey. It’s been used a basic project and a geotechnical study to get enough information about the building. It’s been made and justified all the structural design process in order to develop all the written and graphic documentation needed for its right use. The basic project do not presents enough structural solutions for the case. In this project, I wanted to propose another solution a part from the initially given. I did it because I liked the challenge of finding another solution different from the given that works and fits better economical and environmentally.

In these pages, you will find the accurate explanation of all the calculus used for the project and a pre-sizing of all building’s elements. All the structure computation it’s been made using Tricalc. The modeling process, all data needed and all the decisions chosen to achieve the final resolution it’s been explained accurately and step by step.

This resolution will be presented as a project attached in the annex. Using the structure’s blueprints there is a reckoning project report that includes the methodology used in Tricalc to calculate the building’s structure, the whole sizes and finally, the material execution’s budget to get an estimated value of all the final structure designed. At last, it’s exposed an environment appraisement with all the energetic cost and the CO2 emissions during the whole process in order to rate the total repercussion of this construction in its surroundings.
2 INTRODUCTION

2.1 Project goals

The aim of this project is to contribute the executive part of a building structure destined for housing. The building contains four floors and it’s located in the city of Torredembarra.

The starting point and the initial goals are the revise of all documentation attached from a basic project and the geotechnical report.

I will start analyzing the structural system given in the basic project. Then, I will study if this is the best option for the final building structure resolution by doing all the changes and improvements needed an initial elements pre-sized score and finally, proposing new structural solutions better adapted for the building requirements in order to get the best results.

Right after I will analyze the terrain information given in the geotechnical report and I will study which is the best option for the basic structural system.

The principal goals needed to be resolved are below:

- The building structure
- The scale slab that binds the four different floors.
- The skylight structure used in the courtyard
- The pavement of ground floor.
- All the basil structural system.

In order to resolve the whole structure calculation I will use, as I mentioned before, Tricalc, where all the tested elements data will be introduced and will define the ultimate dimension. Right after, with the structure problem solved, I will make all the blueprints and details to get all the information needed to execute the structure process in the right way.

Through the blueprints I will make the mensuration, the material execution estimation and the reckoning of CO2 emissions to quantify the environmental impact and energetic expense.

To continue, it’s been taken as partial goals below:

- Look over all the documentation from the basic project.
- Look over the geotechnical report.
- Study and analyze all the various structural options

2.2 Building description

The building is located in a terrain in between two bordering buildings, between Reus Street, 14º, and Catalunya Avenue, 35º, in Torredembarra.

The precise location is shown below, in picture 1.1.
It has a 1130,47 m² built surface that fills a 241,48 m² parcel, with a flush height of 16,12 m. It’s a square building with a length of 20,25m, 11,97 and 11,88m wide in Catalunya Avenue and Reus Street respectively.

Right below, it’s been described in detail using table 1.1, the flush height and the surfaces of all different building floors:

<table>
<thead>
<tr>
<th>Name of the floors</th>
<th>Floor area</th>
<th>Flush Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground floor</td>
<td>241,48 m²</td>
<td>0,80 m</td>
</tr>
<tr>
<td>First floor</td>
<td>216,12 m²</td>
<td>4,35 m</td>
</tr>
<tr>
<td>Second floor</td>
<td>224,68 m²</td>
<td>7,30 m</td>
</tr>
<tr>
<td>Third floor</td>
<td>224,68 m²</td>
<td>10,25 m</td>
</tr>
<tr>
<td>Fourth floor</td>
<td>185,66 m²</td>
<td>13,20 m</td>
</tr>
<tr>
<td>Roof ladder</td>
<td>13,94 m²</td>
<td>16,12 m</td>
</tr>
</tbody>
</table>

Table 1.1: Heights and surfaces.

The ground floor of the building, in Catalunya Avenue, has got an entrance to a lobby used for a principal access, an apartment and a commercial local with an entry to both sides of the street, as suggested in picture 1.2.
In the first and second floor we can find three apartments in each floor. In the third floor, in return, we only got two apartments. So the building is composed with nine apartments and commercial local. All the roofs are different because they are conditioned for the street location regulation heights. They also got balconies and terraces that must be adapted for the minimum passing distances and all the urbanistic planning parameters in the region. In the first floor we can view, in Catalunya Avenue side, that there are not balconies, as you can notice in picture 1.3.
In the second floor, though, we can find, the balconies, as you can notice in picture 1.4:

![Figura 1.4: Planta Segona](image)

In the first and the second floor, you can see that there is a symmetry, just the difference, as said before, that the second has got the balconies. In the third floor you can watch there is only two apartments. The facade is recessed in order to have two terraces for a private use of each apartment. Instead of the balconies, there are concrete shelters that cover the second floor balconies, as you can noticed right below in picture 1.5.

![Picture 1.5: Third Floor](image)
In the cover, there is only one entrance through the roof ladder that links with the third floor through a scale. This is a community scale and only accessible for maintenance, where you can find air conditioners, an space reserved for sanitary hot water solar panels, one room and various cabinets used for installations, ventilation smokestacks.

In its central part we can notice there is a light cover where is the courtyard.

In its extreme we can watch the concrete shelters that protect from raining, the private terraces of third floor (Reus Street side) and all the balconies in the opposite side of the street. You can watch it in the next picture 1.6.

A two sectioned scale that adjoins all the floors and the covered floor.

The scale overture, through three different roofs, is protected with an small roof used as a Roof ladder, as you can notice in picture 1.7.

According to the basic project blueprints you notice structure is been designed to be made of reinforced concrete.

In them the basic project plans can be seen that the structure is designed to be concrete, and the pillars are not aligned, so to be with concrete pillars and two-way slab.

That decision was maybe chosen because of the complex floor distribution in order to not to make big changes and leave spaces free of pillars. Also, because the pillars not fill too much surface in the floor.

In this project, I wanted to propound another solution different from the given one, with pillars alignment, to make possible a stoop form, unidirectional forged and concrete pillars. I did it that way because I wanted to solve the challenge I proposed myself before which I think will fit better economical and environmentally.

On the other hand, the basic project proposed a light structure to cover the courtyard aperture.

If you want more information about it, you should consult the basic project blueprints in annex C. You can see next below all the building sections and elevations from different points of view, in the pictures 1.8, 1.9, 1.10, 1.11, 1.12, 1.13.
Picture 1.6: Covered floor

Picture 1.7: Scale transversal section
Picture 1.8: Courtyard longitudinal section

Picture 1.9: Principal entry longitudinal section
Picture 1.10: Local storehouse longitudinal section

Picture 1.11: Local storehouse transversal section
Picture 1.12: Posterior facade to Reus Street.

Picture 1.13: Principal facade to Catalunya Avenue
2.3 Project Methodology

At first, I revised the basic project blueprints to understand the exact situation, the form, the access, the floors openings and all the spaces all through the building.

After that, I read and revised the geotechnical study from Geotec Company in order to comprehend in what kind of terrain would be the building and resistant coat to decide which sort of foundation would be the appropriate.

During all the project realization I used the recommended bibliography and I searched information about the regulations, like the Technical Building Code and the Structural Concrete Instruction (EHE-08) to know all the information needed about the structural calculation.

I also have to admit that I started to control and enjoy all the function of Tricalc, (with a simpler structure example),

Having done the structural solution, I introduced all my structure data in Tricalc, helping myself in the blueprints using AutoCad, and deleting all I did not need and inserting all the floors templates, pillars location and all the apertures and perimeters.

With the bar structure done, I added the charges depending on the sector of the building. (Differentiating the permanents from the variables).

As I got all the building geometry right and complete, and the pertinent charges in every point and before the elements structure section, I did the pre-sized of the elements.

For example I estimate one of the unfavorable stoops and the more lighted forged stretch to have enough information to begin the elements section in order they accomplish the regulation EHE-08 and the Technical Building Code.

When the geometry was finished and completed, I calculated using Tricalc all the pillars, supports, forged and foundation with all the estimated options more suitable and solving that way all the errors caused by the bending beam or excessive fissuration.

Having all results, I could begin to draw the structure blueprints, obtaining from Tricalc the sketch of one-way slab, assembling beams and foundation.

With the measures I made an estimated budget, the energetic expense and CO2 emissions.

Then, I pursued doing the project report redaction and the project confection.

2.4 Project report content

Right after, there is chapter two, where it’s explained and defined the structural solution chosen, with its criterion and conditions.

In chapter three there is the explanation of all the steps and calculations done with Tricalc.

In chapter four, I explicate the blueprints making method, the calculus of project report and the budget realization from the measurements.

At last, in chapter five, I will explain how I put together all the information to obtain all final project data about energetic expense and CO2 emissions.

Finally, there are conclusions summarizing all the chapters explained before in this project report.
All the annex attached in this project report are:

- Annex A – Geotechnical Study
- Annex B – Calculation project report
- Annex C – Basic project blueprints
- Annex D – Blueprints
- Annex E – Measurement and costs
- Annex F – Energetic expense and CO2 emissions
- Annex G – English version
3 DEFINITION OF STRUCTURAL SOLUTION

This chapter defines the structural solution adopted. The criteria taken into account based on the study of the basic characteristics of the project, as well as the report of the geotechnical field. Here are the criteria and conditions applied.

3.1 Criteria and conditions

This project is intended to achieve the objective of defining the best structural solution that best meets the economic criteria of sustainability and functionality; for such is discarded the structural systems that hinder its implementation. Here are some important features of the blueprint provided.

You can see how plants are quite complex due to their distribution, and the pillars are not aligned. The spaces are fairly small plants so the solution is to be designed with fewer pillars. It appears that the solution proposed is a basic structure with concrete pillars with two-way slabs.

Facilities pass through ceilings and the pillars are touching. These are over the perimeter of the floor. This is not recommended. The area is on solid pillars, if the structure was made with two-way slabs. The structure is weak, and this increase the amount of iron needed.

The height between floors is 2.55 m. Requires the use of curved concrete plans in two-way slabs.

3.1.1 Factors Design

All roofs are not equal. The building is conditioned on the maximum heights. For example, affects the corner of the first floor in Catalonia Avenue. There are not balconies. The building is between two roads that have different levels, so the regulatory maximum height of 13.20 meters which is conditioned on both streets the maximum height of the building and therefore the top floor, which is the ground cover is found to limit the height on Reus Street lower level than Catalonia Avenue. Also facade and wrought on the Reus Street is behind a terrace giving way to the third floor, making the floor of the deck is shorter in this part of the building.

The number of floors is not the same as the number of floors, since the structure of the ground floor is a concrete slab ventilated using the slab system called Càviti. This solution was chosen because the basic design is not defined, and this achieved the required level of the ground and is not in contact with the ground.

For so, we will count the floors from the ground first, then the second floor, third floor, the ground cover and ending with a small wrought that will cover the stairwells.

There are four balconies on the first floor in Reus Street. At Catalonia Avenue there are not balconies because is affected by the parameters of urban area. On the second floor we have four balconies on the street Reus. At Catalonia Avenue there are two. On the third floor four balconies overlapping the street Reus become shelters. There are concrete overhangs to protect from the rain balconies on the second floor. On the ground the roof overhangs Avenue Catalonia become concrete shelters to protect them from the third floor balcony. At Reus street there are two wider overhangs, as well as
concrete overhangs to protect openings, the front wall and leaving the two terraces on
the third floor.

There are two openings in floors that are repeated in all. These openings are the
courtyard and stairwell. The first will cover the forged to the stairwells and the second a
light frame structure that will happen fairly light and ventilation, but will be protected
from rain and wind.

The height between floors, counting the floor is 2.55 meters less than the height of the
ground floor to the ceiling of the first floor which is 3.15 meters and the height from the
landing of ladder to the roof of the stairwells is 2.60 meters.

The building has an occupancy rate of 100%, with an area of approximately 241.48
square meters. The shape of the plot is almost rectangular with 20.25 meters long,
11.97 meters to the top, Catalonia Avenue, and 11.88 meters at the bottom, in Reus
Street.

The land has an area roughly flat at the level of Reus Street. This street is the lowest
level. Will be taken as a reference, so will be level 0. The highest point of the place is
found in Catalonia Avenue, which has an upward slope and is 0.80 meters above the
level 0 from Reus Street. So the land has a slope of 3.95% upward slope.

3.1.2 Determinants of the land

The land, according to the geotechnical study, is formed on top of a base of filling
debris and remains from different backgrounds and / or land removed. The second
level is silt sandy clay with varying proportions of orange colorings gravel and different
degrees of carbonation forming sections of interspersed limestone crusts and / or
conglomerates. It is here, where we can to see the hard terrain layer from depths of
approximately -3.5 and -4.2 m.

It is why the firm ground is at these levels, which are easily attainable from a basement.
This option can not be considered because water level is very near, the level at -6.0,
and complicate the very foundations if it not reach a resistant layer.

3.1.2.1 Study of direct foundation

So the solution, according with the geotechnical study, we must arrive with our
foundations until the hardest land in order to obtain a land with a resistence of 2
kg/cm².

There is also another possibility, as the slab foundation, so get one Kg / cm² allowable
resistance of the field, taking into account not based on any point on highly deformable
materials Level 1, since this could lead to significant differential settlements that may
damage the structure of the building. In the same vein, it is also recommended to
overcome the stretches of limestone crusts.

Settlements for the foreseeable foundation solutions will be given below:

S<2,5 cm option for shoe
S<5,0 cm option for slab foundation
3.1.2.2 Study of a deep foundation

The deep foundation piling which can work using materials in Level 2, the three points polled, from the depths of 2.6, 0.8, and 1.3, which can be observed by the geotechnical study.

The foundation could work with the materials intercalated of limestone crusts of Level 2, provided that thickness of safety plan required under the deep foundations of these elements.

By choosing the method of execution and types of deep foundations, or the choice of execution the concrete screens should be considered:

- Shares of Level 1 materials produced by a negligible cohesion.
- The presence of highly carbonated layers or cemented calcareous crusts mode, taking into account the varying thickness of these collations erratic, so that they have adequate security thicknesses below the foundation level. Furthermore, to calculate the resistance value of the screens must consider sections of limestone crust as thin layers supported on ground of least resistance, taking into account the resistance value of hotspots upper and lower elements concrete screen to prevent breakage.
- If the poll conducted deep research was not enough for the proper design of foundations, new wells would be required to characterize the ground to the required depth.
- Values of shaft resistance is given by considering only the concrete screen display area below the bottom of the excavation acting on both sides. Loads that resistance is provided in this section are uniform and must be considered for each of the two sides of the screen.
- The deformations will be due to the effect of group.
- Shares of neighboring foundations.
- Possible side drives and friction caused by the filling material.
- The presence and possible fluctuations in the groundwater level is detected from the depths of 6.0 and 6.1.

These considerations should be taken into account if you choose either of the two solutions, to ensure a proper foundations operation.

(See the situation, records of surveys and interpretation cuts in Annex A geotechnical study).

To calculate the load capacity of both should consult Appendix A of the geotechnical study.

The solar neighboring buildings are built with similar characteristics, which will be located in the building of this project.

3.1.2.3 Earthworks

The earthworks for the excavation of foundation of the trenches not present difficulties from the point of view of resistance in the Level 1 material. Can perform the work of earthmoving machinery such conventional soil if However, the presence of highly carbonated mode of stretches of limestone crusts and / or conglomerates intercalated
materials in Level 2 may require the use of machinery aided by powerful hydraulic hammer or digging.

Moreover, the low lateral stability that can present Level 1 materials could hinder the excavation of these materials. Must be kept in mind in choosing the method of excavation because the presence of roads, neighboring foundations and nature of the materials excavated, so that during the execution of earthworks not develop possible pathologies in the adjoining buildings and/or roads.

3.1.2.4 Slope stability in the short term

For banks that may remain on the site for the work of preparation of the land for short spaces of time in normal construction, could leave the following relationships:

Level 1 materials: they can appear in areas where this material level to altitudes below 3.0 meters long and short common areas in the building, and must not be left berm slopes above the assumed ratio 3: 2 (H: V) and build a retaining wall which stretches the width will be determined by the coronation overload caused by roads and neighboring buildings.

Materials Level 2: For banks that may remain in these materials, heights lower than 3.0 m long and short common spaces in the building, you can leave a berm and slopes with a ratio of approximately 1: 2 to 1: 3 (H: V), then build a retaining wall which stretches the width will be determined by the coronation overload caused by roads and neighboring buildings.

If you wish to dig underneath plans foundations neighbors, and there are indications of instability in the early stages of the excavation or embankments intended to leave a permanent, would change the relationships described or studied a solution by perimeter walls.

3.2 Loads and actions considered

To calculate the loads and actions that are in the building has been used Basic Document Security Structural Actions in Building Technical Code (CTE DB SE-AE).

To better define the structural solution, has made the calculation of all loads and actions. Before doing any calculations, we checked whether the earthquake consider when sizing the structure. The geotechnical study tells us that the best solution is to make a shallow foundation, either slab or through shoes isolated wells.

To better understand the loads and actions, ordered by plants.

3.2.1 Permanent actions

Permanent actions always act in the life of the building. They are the self weight of the structure of the building and the actions of the land. To define the constructive elements were analyzed in each area of the building and all were decomposed in the following tables. For surface charges, we will use the units kN/m, and the linear kN/m.

The ground floor consists of the areas of housing and commercial shop; Table 2.1 lists the permanent loads on the floors.
<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Concrete pavement</td>
<td>Slab</td>
<td>2,76</td>
</tr>
<tr>
<td></td>
<td>Concrete pavement ventilated</td>
<td>Formwork with 70 cm and 10 cm layer compression</td>
<td>5,05</td>
</tr>
<tr>
<td></td>
<td>Pavement</td>
<td>Terrazzo on mortar</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partition</td>
<td>Light evenly partitions</td>
<td>1</td>
</tr>
<tr>
<td>Linear</td>
<td>Facade</td>
<td>Partitions of the facade</td>
<td>10,2</td>
</tr>
<tr>
<td></td>
<td>Walls</td>
<td>Partitions between housing and local</td>
<td>6,5</td>
</tr>
</tbody>
</table>

*Table 2.1: Permanent loads on Ground Floor*

The first and second floors consist of areas and homes; Table 2.2 lists the permanent loads in the plant.

<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Own weight of slab</td>
<td>way slab</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pavement</td>
<td>Terrazzo on mortar</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partition</td>
<td>Light evenly partitions</td>
<td>1</td>
</tr>
<tr>
<td>Linear</td>
<td>Facade</td>
<td>Partitions of the facade</td>
<td>10,2</td>
</tr>
<tr>
<td></td>
<td>Walls</td>
<td>Partitions between housing and local</td>
<td>6,5</td>
</tr>
</tbody>
</table>

*Table 2.2: Permanent loads on First Floor*

The third floor consists of the common areas and homes; Table 2.3 lists the permanent loads in the plant.

<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Own weight of slab</td>
<td>way slab</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pavement</td>
<td>Terrazzo on mortar</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partition</td>
<td>Light evenly partitions</td>
<td>1</td>
</tr>
<tr>
<td>Linear</td>
<td>Facade</td>
<td>Partitions of the facade</td>
<td>10,2</td>
</tr>
<tr>
<td></td>
<td>Walls</td>
<td>Partitions between housing and local</td>
<td>6,5</td>
</tr>
<tr>
<td></td>
<td>Barana</td>
<td>Barana d'obra</td>
<td>3,45</td>
</tr>
</tbody>
</table>

*Table 2.3: Permanent loads Third Floor*
The cover floor and stairwells consist of only passable areas for maintenance; Table 2.4 lists the permanent loads in the plant.

### 3.2.2 Variable actions

The variable loads are those that act in a certain time on the building during its lifetime. We have different types of usage such as overloading, wind and snow.

Analyzing the elements of our building and adopting the values characteristic of the overload of use set out in Chapter 3. Shares variables CTE DB SE-AE obtained the following variables summarized and distributed plants in tables 2.5, 2.6, 2.7. The values of the overload of snow and wind were obtained by performing the calculations indicated in the technical code.

<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Overloading of Use</td>
<td>Housing and Local</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Overloading of Use</td>
<td>Access areas and evacuation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 2.5: Variable loads on the ground Floor*

<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Overloading of Use</td>
<td>Housing</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Overloading of Use</td>
<td>Access areas and evacuation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 2.6: Variable Loads First Floor, Second and Third*

<table>
<thead>
<tr>
<th>Type</th>
<th>Item</th>
<th>Description</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Overloading of Use</td>
<td>Cover</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Overloading of Use</td>
<td>Access areas and evacuation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 2.7: Variable loads Covers Floor*

The calculations overload of snow and wind are calculated from the points 3.5 Snow and 3.3 Wind, CTE DB SE-AE.

The calculations obtained with respect to the action variable overhead Snow is:

The formula to calculate the snow load per unit area in horizontal projection is the following:

\[
q_n = \mu \cdot s_k
\]

\(\mu\) is the coefficient for cover as Figure 3.3 in Chapter 3.5.3 of the CTEDB SE-AE. Having a flat roof with a disability will take \(\mu = 1\).

\(s_k\) is the characteristic value of snow load on the ground horizontally, depending on location and altitude, according to Table 3.8 in Chapter 3.5.2 of the CTE DB SE-AE.

The building is located at a height above sea level of 9 meters in a climate zone 2 shall be adopted \(s_k = 0.4\). For so \(q_n\) is equal to 0.4 kN / m, as shown in Table 2.8.
Table 2.8: Overload of snow on the ground horizontally depending on the altitude and climate zone

To calculate the wind overload, we have the formula of equivalent strength, perpendicular to the exposed surface as follows:

\[ q_e = q_b \cdot C_e \cdot C_p \]

\( q_b \) is the dynamic pressure of the wind that depends on the geographic location, knowing that you get the wind zone. As Torredembarra is within the wind zone C is assigned a pressure of 0.52 kN/m². As shown in Figure 2.1.

\( C_e \) is the coefficient of exposure that varies according to the height of the point under consideration, obtained from Table 2.9.

---

**Table 2.8:** Overload of snow on the ground horizontally depending on the altitude and climate zone

<table>
<thead>
<tr>
<th>Altitude (m)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</table>

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**Figure 2.1:** Map of wind areas of Spain and the wind speed, taken from appendix D of the wind CTE DB SE-AE
Table 2.9: Values of coefficient $C_e$ exhibition, taken from chapter 3.3.3 Coefficient of exposure

CTE DB SE-AE

$C_p$ is the coefficient of wind or pressure depending on the shape and orientation of the surface with respect to the wind. In buildings up to eight plants is calculated slenderness ratio and seeks wind, as shown in Table 10.2.

<table>
<thead>
<tr>
<th>Grado de aspereza del entorno</th>
<th>Altura del punto considerado (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Borde del mar o de un lago, con una superficie de agua en la dirección del viento de al menos 5 km de longitud</td>
<td>2,4 2,7 3,0 3,1 3,3 3,4 3,5 3,7</td>
</tr>
<tr>
<td>II Terreno rural llano sin obstáculos ni arbolado de importancia</td>
<td>2,1 2,5 2,7 2,6 3,0 3,1 3,3 3,6</td>
</tr>
<tr>
<td>III Zona rural accidentada o llano con algunos obstáculos aislados, como árboles o construcciones pequeñas</td>
<td>1,8 2,0 2,3 2,5 2,8 2,7 2,9 3,1</td>
</tr>
<tr>
<td>IV Zona urbana en general, Industrial o forestal</td>
<td>1,3 1,4 1,7 2,1 2,2 2,4 2,6</td>
</tr>
<tr>
<td>V Centro de negocio de grandes ciudades, con profusión de edificios en altura</td>
<td>1,2 1,2 1,4 1,5 1,6 1,9 2,0</td>
</tr>
</tbody>
</table>

Table 2.10: Wind coefficient in residential buildings

For such, the results of the wind are the following:

Pressure = 0,52x2,1x0,8 = 0,874 KN/m²

Sucking = 0,52x2,1x0,4 = 0,437 KN/m²

Here the calculations necessary to implement the action of the wind in the program Tricalc. Calculate the value of the wind at each of the plants, according to the area of household in each of them. The results of these actions should be applied at the slab that transmitted the actions to the pillars, and the pillars at the ground. By introducing these loads in the program, you should consult Tricalc chapter 3.2.1 Wind. Here are the hypotheses of the actions of wind in Figure 2.2.

- Slab of ground Floor: Distance to apply = 3,45/2 (lower altitude of the facade) + 2,95/2 (upper altitude of the facade) = 3,2m
- Pressure: 3,2m x 0,874 KN/m² = 2,8 KN/m;
- Sucking: 3,2m x 0,437 KN/m² = -1,398 KN/m
- Slab First Floor: Distance to apply = 2,95 m
- Pressure: 2,95m x 0,874 KN/m² = 2,58 KN/m;
- Sucking: 2,95m x 0,437 KN/m² = -1,289 KN/m;
- Slab second Floor: Distance to apply = 2,95 m
- Pressure: 2,58 KN/m; Sucking: -1,289 KN/m;
- Slab third Floor: Distance to apply = 2,95/2 (lower altitude of the facade) + 1,30 (cover parapet) = 2,775m
- Pressure: 2,775m x 0,874 KN/m² = 2,43 KN/m;
Annex G – English Version

- Sucking: 2,775m x 0,437 KN/m² = -1,21 KN/m;
- Cover stairs slab: Distance to apply = 2,45/2 (lower altitude of the facade) + 0,32 = 1,545m
- Pressure: 1,545m x 0,874 KN/m² = 1,35 KN/m
- Succió: 1,545m x 0,437 KN/m² = -0,675 KN/m

Figure 2.2: Designation of wind facades

3.2.3 Accidental actions

These are actions that occur accidentally, their acting can cause damage to the structure. These actions are fires and earthquakes.

For fires, program structures Tricalc already takes into account the coatings required for each structural element.

For earthquakes, we can analyze the "earthquake resistant construction standards" (NCSE-02). We note that it must be applied according to the calculations. The area where the building is within the "Seismic Zone 1" seismicity implies lower middle grade VI. For the town Torredembarra is considered a basic seismic acceleration values of 0,04g ab, g is the acceleration of gravity, and a coefficient K= 1 contribution. Depending on the type of terrain, we adopted a coefficient of soil type (C). The foundations arrive to cemented reach land classification type 1, with a risk ratio of ρ=1, the field amplification coefficient (E) is calculated with 0.8, so for the acceleration of the calculation we obtain the formula a_c = S·ρ·a_b = 0,8·1·0,04= 0,032. It can be seen in Figure 2.3.
ANNEX G – ENGLISH VERSION

FITXA D’APLICACIÓ DE LA NORMA NCSE-02
norma de construcció sismoresistent

IDENTIFICACIÓ DE L’EDIFICI
Situació: Aragunya Catalunya. 35
Municipi: Toremedrera
Número de plantes sobre rasante: 4

CARACTERÍSTICHES DE LA CONSTRUCCIÓN
Claseificació de l’edifici en funció de la seua importància: (Art. 1.2.2)
- Normal
- Especial

Acabaturament bàsic $a_b$ (m/s²)
- En funció del municipi d’acord a l’annex I de l’INCSE-02
$$a_b = 0.12$$

Acabaturament de càrrec $a_c$
- Coeficient de càrrec normal $a_c = 0.6g$
- Coeficient de càrrec especial $a_c = 1.3$

Tipus d’estructura: Parquets estructurals

CRITERI D’APLICACIÓ DE LA NORMA
Edificis d’importància moderada
- No cal aplicar l’INCSE-02

Edificis d’importància mitjana
- No cal aplicar l’INCSE-02

Edificis d’importància alta
- Cal aplicar l’INCSE-02

NOTA: NO CAL APLICAR LA NORMA NCSE-02

En virtut de la dicotomia entre les edificacions considerades, les hipòtesi i les conclusions adoptades, i en els plantejaments, es fan constar els nivells de certaintat utilitzats en el càlcul.

Notes:
1) Les edificacions de fàbri de màs, de blocs de morter, o similars, o $0.05g < a_c < 0.12g$ tindran 4 plantes com a màxim. I si $a_c > 0.12g$ en tendran, com a màxim, de 2 plantes.
2) Quan $a_c < 0.04g$, no s’executen estructures de parets, tapes o tores.
3) Coeficient del terreny $C$: en funció del tipus de terreny:
   - Terreny I: (Sol sobre nivell, sol calcí amanitat o granular molt densa) $C = 1$
   - Terreny II: (Sol sobre nivell, sol calcí amanitat o granular densa) $C = 1.2$
   - Terreny III: (Sol granular de comprovat mitjà, sol calcí amanitat o granular mitjà densa) $C = 1.6$
   - Terreny IV: (Sol granular de comprovat basa, sol calcí amanitat o granular mitjà) $C = 2$
4) Les estructures de murs de fàbri, o $0.05g < a_c < 0.12g$, l’alçada màxima serà de 4 plantes. I $a_c > 0.12g$ l’alçada màxima serà de 2 plantes.
5) En el cas d’edificacions de públics, no importa on es construeixin, els estimats i els amuntens són els mesos de les direccions de la direccional de l’INCSE-02 (C.1.2.2).

Figure 2.3: Application profile of the rule NCSE-02