Design project of the structure of a residential building in the city of Castellón street Paseo Ribalta n◦1

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Trabajo Fin de Master Julio 2019

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Escuela Técnica Superior de Ingenieros de
Caminos, Canales y Puertos

UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA

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DOCUMENT N◦1 MEMORY

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1. Introduction

1.1. Purpose

The purpose of this Master Final Degree Project is a design of a structure of a residential building. This building has been located in the in the city of Castellón on the street Passeo Ribalta 1.

1.2. Situation and location

The building is located in the municipality of Castellón, belonging to the province of Castellón, in the Valencian Community (Spain).

Figure 1.1 Valencian Community in Spain

Figure 1.2 Localization of the province of Castellón

Figure 1.3 Location of the plot in Castellón

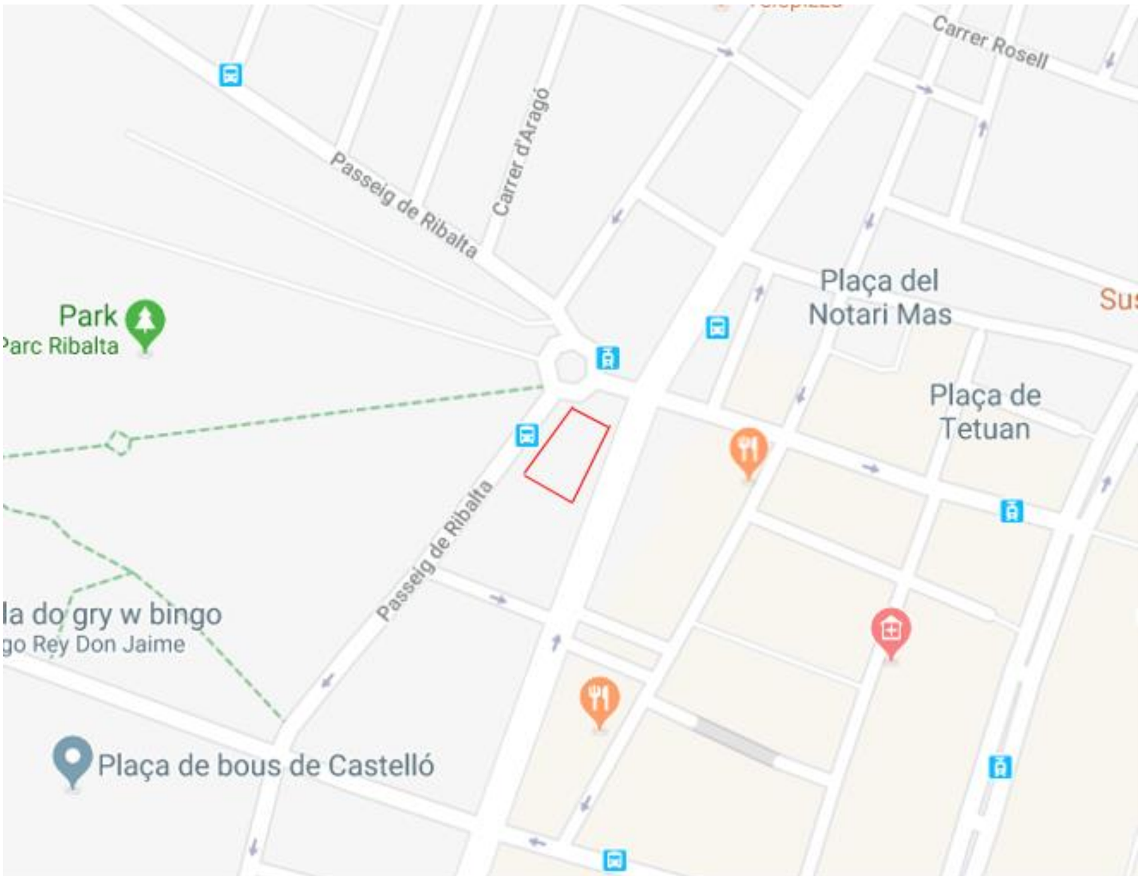

Figure 1.4 Detailed location of the plot in Castellón

2. Geotecnical study

For the construction of this building a geotechnical study was used that requested the Castellón de la Plana council for the work of Maset Blau. This report was made in 2006 by the company "Maestrat Global S.L." The detected soil have been sand-gravel mix.

From this study the following conclusions are drawn:

Table 2.1 Basic fundation and soil information

Foundation support height	-4,10m
Attack on concrete	No
Affectation of the water table	No
Affection of the earthquake	No

With the data of the geotechnical study a mat fundation of 0,8m have been dimensioned. Firstly, the spread footings for each column were designed, but their area was bigger than 50% of the buliding area so it was decided to change for the mat fundation.

The ballast coefficient was calculated.

Knowing the loads that arrive from the columns to the mat foundation, its dimensions was decided in order not to overcome ground sinking stress.

All these calculations are developed in "Annex 2. Geological and geotechnical study ".

3. Description of the building

3.1. Utility function of the building

The building is going to be a student residencial complex. It is situated 2,5km from Universitat Jaume I in Castellón. On the gound floor there are going to be an auditorium, 4 small conference rooms, 4 study rooms of different sizes and 3 offices. On the floors 1 to 4 there will be accommodations for the students that includes dormitory, kitchen, bathroom and living room. On the 5th floor will be a utility roof with a terrace and a swimming pool.

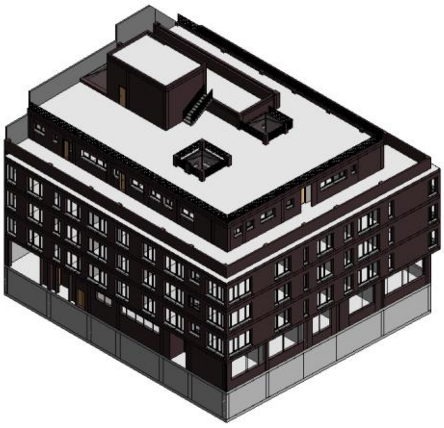

Figure 3.1 3D view of the building

3.2. Dimensions of the building

The bulding is in the shape of a trapezoid. The north-eastern and south-western sides aren't perpendicular. The bulding has 7 foors including underground garage and utility roof, on which will be located swimming pool with dimensions of 15,7m x 4,6m x 1,5m. The floors have variable dimensions that are indicated in the annex 2 Structural Calculations. The ground floor has the dimensions of 30,12m x 25,80m x 29,00m x 25,83m. The height of the buildings and its relative hights are shown in the following table:

Table 3.1 Height of the floors

Nº	Name	Height (m)	Relative height (m)
-1	Undergroud garage	3,15	-3,15
0	Ground Floor	4,04	0,00
1	First Floor	2,95	+4,04
2	Second Floor	2,95	+6,99
3	Third Floor	2,95	+9,94
4	Fourth floor	2,95	+12,89
5	Utility roof	2,95	+15,84
6	Roof of staircase	-	+20,48

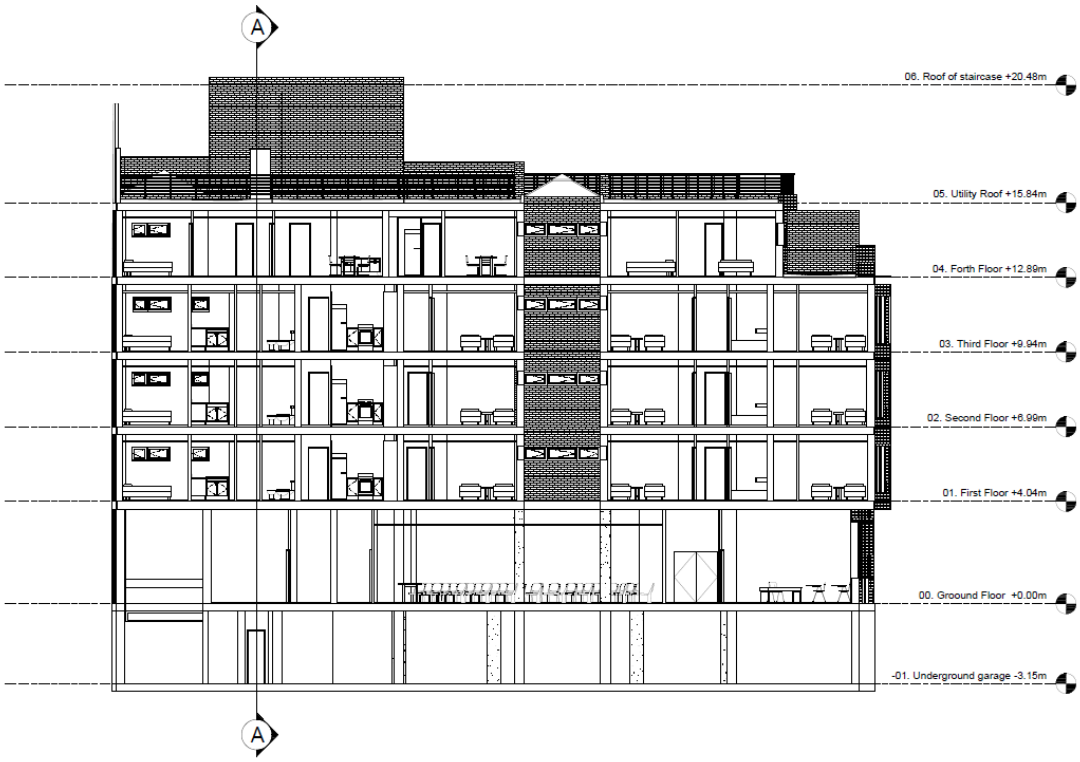

Figure 3.2 Section of the building

Figure 3.3 Plan of the ground floor

4. Enviromental condition and structural materials

Design working life 50 years -> Chosen category: S4

Materials:

Concrete

Strength class of concrete: C25/30

Consistency: Soft

Max size of aggregate: 20mm

Load factor: $\gamma_c = 1,5$

Structure exposure class: XC1

XC1: Concrete inside buildings with low air humidity.

Fundations exposure class: XC2

Concrete cover:

Fundation -> c_{nom}=35mm

Structure -> c_{nom}=30mm

Steel

Class of reinforcing steel: B500SP with C ductility class

Load factor: $\gamma_s = 1,15$

5. Actions taken for the calculation

5.1. Permament actions

- Self-weight load
- Dead load

This structure is subject to different loads in different places. The dead loads of the leyers that compose the floors are shown in the table below. The total load for each floor and the load of the walls are showed in "Annex 2: Structural Calculation".

Table 5.1 Dead load of the floor layers

Dead Loads	Weght kN/m³	Load characteristic value kN/m²
Concrete screed 10mm	20.00	2.000
Gres tiles 2mm	21.00	0.420
Flexible mineral insulation	-	-
The reinforced inheritance layer 8mm	22.00	1.760
Polyethylene sheathing	-	-
Styrofoam hard 2mm	0.45	0.090
Polyethylene sheathing	-	-
Cement screed 4mm	21.00	0.840
Steel grate for suspended ceilings	-	0.020
Plasterboard 2 * 12,5mm	12.00	0.300
Laminate floor panels with HDF 8 mm	10.00	0.080
Spring mat made of PE 3 mm	0.30	0.001
Self-leveling undercoat 20 mm	16.00	0.320
Floor mesh	-	0.002
Geotextile	-	0.002
Mineral wool 20 mm	1.61	0.032

Table 5.2 Dead load of the floors

Floor	Load characteristic value kN/m²
Underground garage	3,00
Ground Floor	0,44
Floor 1,2,3,4	0,76

Utility Roof	3,36
Roof of Staircase	3,04

5.2. Variable actions

- Live load

The category and value of imposed loads are showed in the table below:

Table 5.3 Live load of different zone of the building

Name	Category	Load q_k [kN/m^2]
Garage	F	2
Ground floor	C2	3
Floor 1,2,3,4 and utility roof	A	2
Stairs	A	3

- Wind

The following data are used to calculate the wind actions:

- Basic wind velocity: $v_b = 26\frac{m}{s}$
- Terrain category: Category IV, Urban zones with buildings on, at least 15% of their surface area with a mean height greater than 15m.

8 cases of wind load were applied: pressure and suction from 4 directions.

Table 5.4 Wind cases

N◦	Wind load case
1	Wind +X ecc.+
2	Wind +X ecc.-
3	Wind -X ecc.+
4	Wind -X ecc.-
5	Wind +Y ecc.+

6	Wind +Y ecc.-
7	Wind -Y ecc.+
8	Wind -Y ecc.-

ecc.+ - pressure

ecc.- - suction

- Snow

The designed building is in "zone 5" of climatic zones in winter in Spain and at sea level so the value that is applied is: 0,2 kN/m^2.

6. Description of the elements of the structure

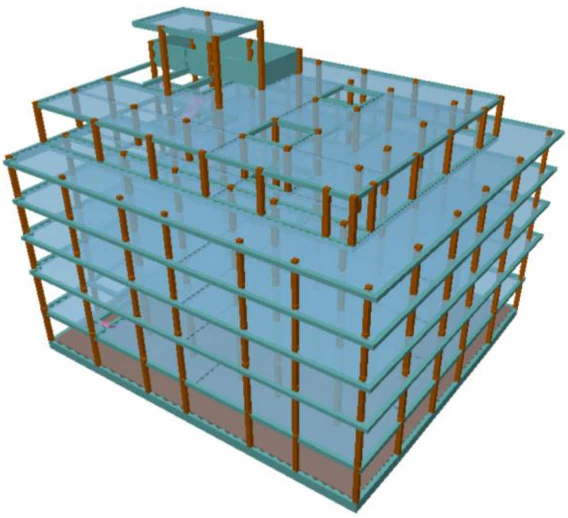

Figure 6.1 Complete structure 3D view

6.1. Foundations

Foundation is composed of:

- Mat foundation of 80cm thick of concrete C25/30
- Foundation beams of dimensions 30x80cm of concrete C25/30

6.2. Columns

The building is composed of 66 columns. Their dimensions are variable depends on which floor they are and the position of the columns in the building. The range of the dimensions is between 30x30cm to 45x45cm. Detail description of all columns is developed in “Annex 2: Structural Calculation”.

6.3. Beams

Similarly to the columns, there are different sizes of beams depending on the area of the building. In most cases the beams have dimensions of 30x30cm around slabs, but in some more loaded areas the depth of the beam incrise to 35cm, 40 or 45cm and the width incrise to 35cm.

6.4. Slabs

The slabs that form the floors are bidirectional slabs of reinforced concrete with the depth of 30cm.

A base reinforcement has been arranged and addictional reinforcement has been added around the columns and in more loaded areas. Around some columns the addictional puching shear reinforcement has been arranged.

7. Structural Analisis with Cype

The entire dimensioning and calculation process has been carried out with the help of the Cype calculation program.

In the "Annex 2. Structural Calculation" of the present work the following extracted lists of the program are presented:

- List of combinations

- Frames reinforcement

- Worst cases of forces of columns

- Columns reinforcement

8. Calculation by hand (with verification with Cype)

In this section the dimensioning of some of the elements of the structure is carried out, in order to verify that the results extracted from the Cype calculation program are reasonable.

The calculation of some elements or parts is performed, which are done entirely by hand.

The elements that are calculated are beams, pilars and fundations.

All these calculations are developed in "Annex 2. Structural Calculation".

9. Economic Valuation

		Amount (€)
1 Fundations		
1.1 Basement excavation		8.996,56
1.2 Blinding concrete layer		5.396.10
1.3 Fundation slab		103.229,04
1.4 Basement walls		24.767,75
	Total 1 Fundation:	142.389,48
2 Structure		
2.1 Slabs		321.333.20
2.2 Pilars		55.122,25
2.3 Beams		61.734,11
2.4 Stairs		20.413,17
	Total 2 Structure:	458602,73

Budget of material and labor execution	600.992.22
13% de general costs	78.128,99
6% de industrial benefit	36.059,53
Contract execution budget	715.180,74
21% VAT	150.187,96€
Contract execution budget with VAT	865.368,69€

Increases the contract execution budget with VAT to the expressed amount of "EIGHT HUNDRED SIXTY FIVE THOUSAND THREE HUNDRED SIXTY EIGHT EURO AND SIXTY NINE CENTS".

Once obtained the approximate budget, the cost of the work per m^2 can be calculated to have an order of magnitude of the cost:

- Contract execution budget with TAX = 865.368,69€
- Area of m^2 of the floor = 3934,05 m^2

Therfore the cost per m^2 of the floor will be 219,97 €/m^2.

10. BIM Implementation

Along with the dynamic development of the technology in the world, the construction industry is also constantly developing and trying to use the inventions in its problems.

The new revolution is the construction disign is called BIM, or Building Information Modeling.

BIM is not only a tool that allows to transfer design from 2D to 3D and to create a spatial object model, but also allows to include spatial geometry, geographic (climatic) information and the number and properties of building components.

The main improvement introduced by BIM in relation to CAD is starting to manage not only the graphics itself, but also information that can be used throughout the life cycle of the building - from the concept through the preparation of the project, the construction process, the period of use of the object, even to its demolition. Thanks to BIM, once the virtual model has been generated with its database, all the plans, budgets, measurements, etc. can be obtained in a simple way.

The implementation of the BIM technology in this project allows it to be more complex and to generate more accurate plans and calculations. It gives the ability to easily obtain any section at any time without additional work. Futhermore, in the future the BIM model can be use to design the sanitary instalations, to obtain the quantity of structural elements and to plan the construction work.

11. Constructive Process

The type of falsework used during the construction of the slabs was designed and the necessary time of use of the falsework for each floor was calculated.

The solution of 2 shored floors with 2 reshored floors was applied.

The reshoring operation consists of form removal on certain floors freeing of corresponding punctual loads and redistributing the loads between the slabs, and then propping up again, ensuring the contact between struts and slab, so that these struts collaborate in future load increases. The following figure shows the scheme of the operation. In each operation cycle, the first phase is to reshore the lower floor plan (operation a). Afterwards, the shoring of the lowest reshored floor is dismantled and moved to its new location in the new floor under construction (operation a'), and then it is concreted (operation b).

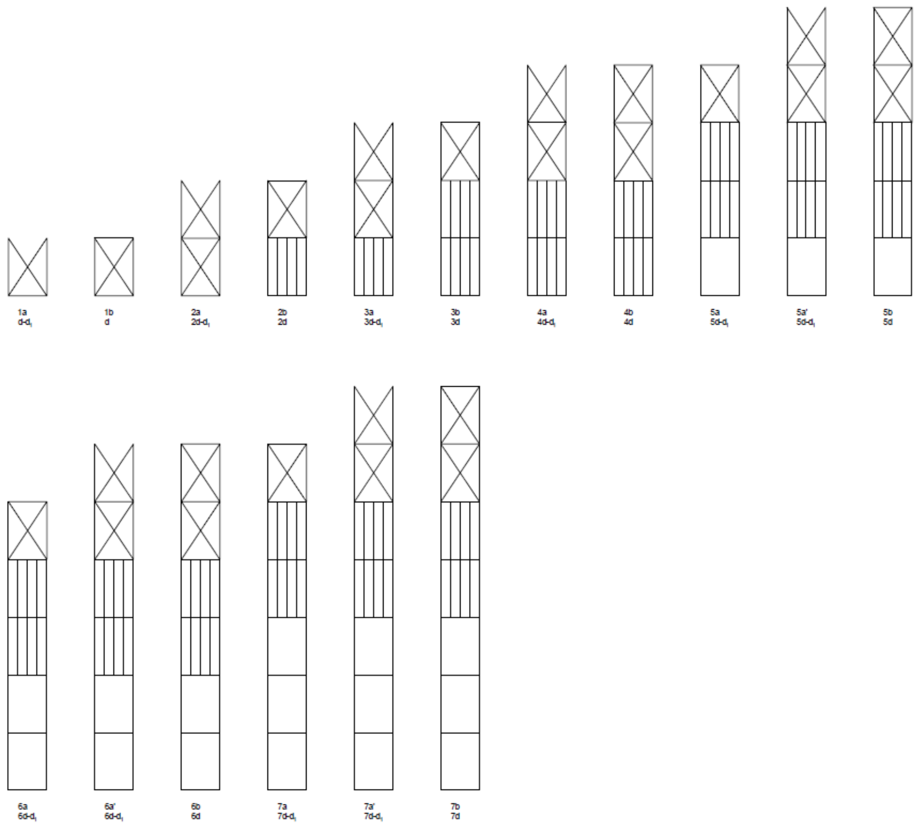

Figure 11.1 Diagram of cycle and time for the construction of the floors

Table 11.1 Constructive cycle time for the floors

Floor	Constructive cycle time [days]
Ground Floor	7
First Floor	15
Second Floor	23
Third Floor	23
Fourth Floor	23
Utility Roof	22
Roof of staircase	22

The cycle time corresponds to the form removal from floor.

The total period of time of the constructive process is the sum of the cycles for all floors.

$$7 + 15 + 23 + 23 + 23 + 22 + 22 = 135\ days$$