F I N A L   T H E S I S

CONSTRUCTION SYSTEMS IN FINLAND AND THEIR APPLICATION IN A BUILDING SITE

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I N D E X

General Introduction to this work

The present work is the final thesis of the student Santiago Salvador Ferrando, of the Spanish degree program of “Arquitectura Técnica”. It has been made during an Erasmus exchange program in Tampere Polytechnic, under the degree programme of Construction Technology.

During the exchange program, the student had the possibility of visit the building site of a residential building, with the guide of the teacher Olli Kolkka. The knowledge of the student is due to personal observations and the teacher’s explanations during the visits or in office. This work analyzes the different building systems viewed in the building site during the four month exchange. Moreover, it tries to have a general view of the Finish construction technology, by talking about other systems, not present in the studied building site, but that are common in the Finish construction.

Some comparative are made along the work, between the systems used by the Finish and by the Spanish construction, to solve the same building element. That way, the work makes a special emphasis to the Finish systems very different than the Spanish ones, and tries to explain the reason of this difference.

The work is separated in four parts:

- The first part is a geographical introduction, about Finland, Tampere and Hervanta.
- The second part is an weather introduction. This part is important, because the weather conditions justify the use of some construction techniques.
- In the third part we analyze the construction systems viewed during the visits to the building site and some others. Not present in this building site, but common in the Finish construction
- The fourth part exposes some construction techniques, that are to emphasized because of being so different to the Spanish techniques. Some of them are used because of the climate conditions.

PART 1

GEOGRAPHICAL INTRODUCTION

Part 1
Geographical Introduction

1.1 Finland

Finland is a Nordic country situated in Northern Europe. It shares land borders with Sweden to the west, Russia to the east, and Norway to the north while Estonia lies to its south. Finland is bounded by the Baltic Sea, with the Gulf of Finland to the south and the Gulf of Bothnia to the west. The Åland Islands, off the southwestern coast, are an autonomous, demilitarized administrative province of Finland.

Img. 101.
The situation of Finland

Finland has a population of 5,282,583 people spread over 338,145 square kilometres (130,559 square miles) making it the most sparsely populated country in the European Union. Finland is a democratic republic with a semi-presidential system and parliamentarism.

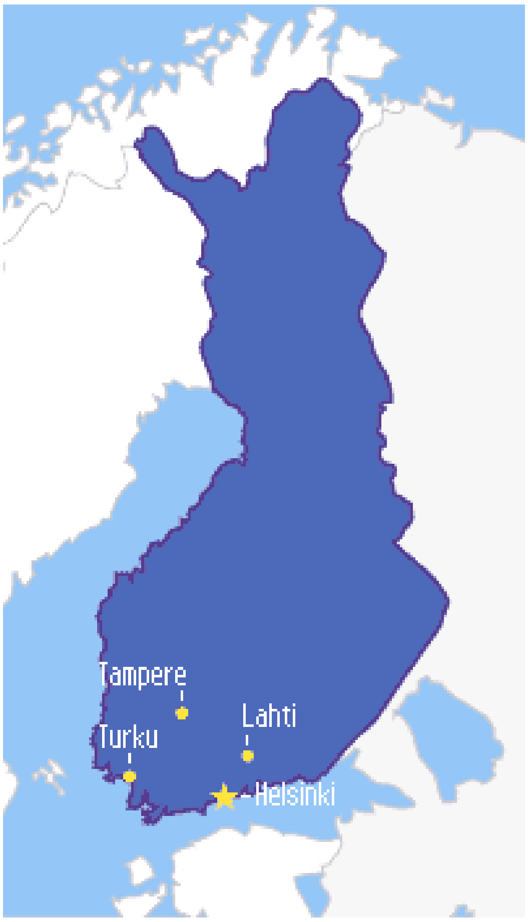
Finland was previously part of the Swedish kingdom and from 1809 an autonomous Grand Duchy in the Russian Empire, until it declared its independence on December 6, 1917. Finland is eleventh on the 2006 United Nations Human Development Index and ranked as the sixth happiest nation in the world by a subjective independent scientific study. According to the World Audit Democracy profile, Finland is the freest nation in the world, in terms of civil liberties, freedom of the press, low corruption levels and political rights.
The Republic of Finland is a member state of the United Nations and the European Union.

Along with Estonian, Hungarian and Maltese, Finnish is one of the few official languages of the European Union that is not of Indo-European origin. Finland's second official language is Swedish, spoken by a 5.5 percent minority.

1.2. Tampere

Tampere is located in southern Finland. It is situated between two lakes, Näsijärvi and Pyhäjärvi. Since the two lakes differ in level by 18 metres, the Tammerkoski rapids linking them have been an important power source throughout history, most recently for generating electricity. Railway tracks from many parts of the nation meet at Tampere railway station, making it an important junction on the VR system.

Tampere, with about 200,000 inhabitants in the city itself, and more than 300,000 including the neighbouring municipalities, is the second most important urban centre in Finland after the Helsinki region and the biggest inland city in the Nordic countries.
In terms of population, Tampere is the third largest city in Finland, and the largest city outside the Greater Helsinki area.



Img. 102. The situation of Tampere and other important cities of Finland

Img. 103. The Tammerkoski rapids, in the center of the city

1.3. Hervanta

Hervanta is a large suburb, or satellite city, of Tampere, located next to Hallila some 10 km south of the city centre. Home to a population of over 26,000, Hervanta is best known for its prefabricated blocks of flats. The total number of apartments is about 11,000. Nearly a fifth of the inhabitants (some 4,500 people) are students, many of them enrolled at the Tampere University of Technology (TUT) or the Police School. The largest student housing complex is Mikontalo, in fact nearly 3% of people in Hervanta reside there. Almost 8% of Hervanta's population is composed of foreigners from 75 different nationalities.
Hervanta currently covers an area of 13.8 km² and is continuing to grow. It was selected as Finland's top suburb in a survey conducted by the Helsingin Sanomat newspaper and published on 17 August 2003.

The complex of commercial buildings in the town center of Hervanta was designed by the Finnish architect Reima Pietilä.

Img. 104 - 106.
Some views of Hervanta

Hervanta is sometimes called the Silicon Valley of Finland, because of the high concentration of high tech companies in the area and the presence of the Tampere University of Technology. As well as the University, Hervanta is also home to the Hermia science centre and the VTT office complex. The world's first-ever GSM phone call was made in Hervanta in 1991, when Radiolinja started building its GSM network. Also Nokia Communicator was developed in there. Nokia and many other companies have offices in Hervanta.

PART 2

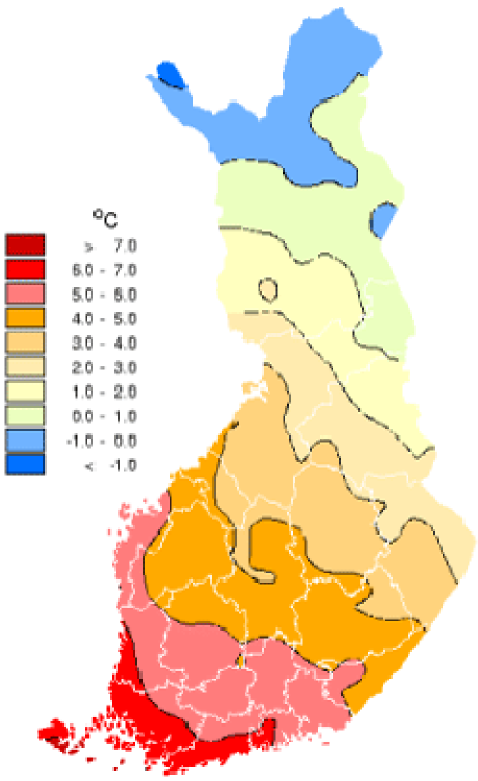
CLIMATIC INTRODUCTION

Part 2
Climatic Introduction

Finland's Climate

The main factor influencing Finland's climate is the country's geographical position between the 60th and 70th northern parallels in the Eurasian continent's coastal zone, which shows characteristics of both a maritime and a continental climate, depending on the direction of air flow. The mean temperature in Finland is several degrees (as much as 10°C in winter) higher than that of other areas in these latitudes, e.g. Siberia and south Greenland. The temperature is raised by the Baltic Sea, inland waters and, above all, by airflows from the Atlantic, which are warmed by the Gulf Stream.

When westerly winds prevail, the weather is warm and clear in most of the country due to the 'föhn' phenomenon caused by the Keel range. Despite the moderating effect of the ocean, the Asian continental climate also extends to Finland at times, manifesting itself as severe cold in winter and extreme heat in summer.



Since Finland is located in the zone of prevailing westerlies where tropical and polar air masses meet, weather types can change quite rapidly, particularly in winter. The systems known to affect Finnish weather are the low-pressure system usually found near Iceland and the high-pressure systems in Siberia and the Azores. The position and strength of these systems vary, and any one of them can dominate the weather for a considerable time.

According to Köppen's climate classification, Finland belongs wholly to the temperate coniferous-mixed forest zone with cold, wet winters, where the mean temperature of the warmest month is no lower than 10°C and that of the coldest month no higher than -3°C, and where the rainfall is, on average, moderate in all seasons.

Img. 201. Annual mean temperature in Finland in 2006. (Finish Meteorological Institute)

The winter in Finland

In winter, the mean temperature remains below 0°C, but warm airflows can raise the daily high above 0°C at times. Winter usually begins in mid-October in Lapland and during November in the rest of Finland, though not until December in the southwestern archipelago. It thus takes about two months for winter to proceed from Lapland to Åland. The sea and lakes retard the progress of winter. Winter is the longest season, lasting for about 100 days in southwestern Finland and 200 days in Lapland.

Img. 202, 203.
The winter look of some streets of Hervanta. The snow covers everything

Img. 204.
The lake Näsijärvi and the start of the Tammerkoski rapids, frozen and covered with snow, in Tampere

North of the Arctic Circle, part of the winter is the period known as the polar night, when the sun does not rise above the horizon at all. In the northernmost extremity of Finland, the polar night lasts for 51 days. In southern Finland, the shortest day is about 6 hours long.

Img. 205. The snowed Tampere city centre by night

Permanent snow falls on open ground about two weeks after winter begins. The snow cover is deepest around mid-March, with an average of 60 to 90 cm of snow in eastern and northern Finland and 20 to 30 cm in southwestern Finland. The lakes freeze over in late November and early December. The ice is thickest in early April, at about 50 to 65 cm. In severe winters, the Baltic Sea may ice over nearly completely, but in mild winters it remains open except for the far ends of the Gulf of Bothnia and the Gulf of Finland.

The coldest day of winter comes well after perihelion, at the end of January everywhere except in the islands and coastal regions, where the slower cooling of the sea delays the coldest period until the beginning of February. The lowest temperatures in winter are from -45°C to -50°C in Lapland and eastern Finland; from -35°C to -45°C elsewhere; and -25°C to -35°C in the south, the islands and coastal regions. The lowest temperature recorded in Helsinki is -34.3°C (1987). The lowest temperature recorded at any weather station in Finland this century is -51.5°C (1999).

PART 3

STUDY OF THE BUILDING SITE

USUAL CONSTRUCTION SYSTEMS

Part 3
Study of the Building Site
Usual construction systems

In this third block, we will do first a presentation on the building under construction that has been visited. Exposing functions and characteristics.

On the other hand, we will analyze the construction systems used in this project, but we will talk about other different solutions also habitual in the Finnish construction, for the same phase of work.

A special mention will be done to the prefabricated elements that constitute structural horizontal and vertical elements, and the installations technical elements. This special mention is because the utilization of the prefabricated elements, is the bigger difference with the commonly used Spanish construction systems.

3.1. Introduction to the building

3.1.1. Utility of the building

During the time of making this work I have had the possibility of visiting a building site in the neighborhood of Hervanta. The direct environment is formed by apartment buildings, a new commercial center and the buildings of the university Tampere University of Technology.

Img. 301.
Sight of the complex on the side of the services building

Img. 302.
Sight of the complex on the side of the apartment buildings

Img. 303. Sight of the complex from the common court to all the buildings

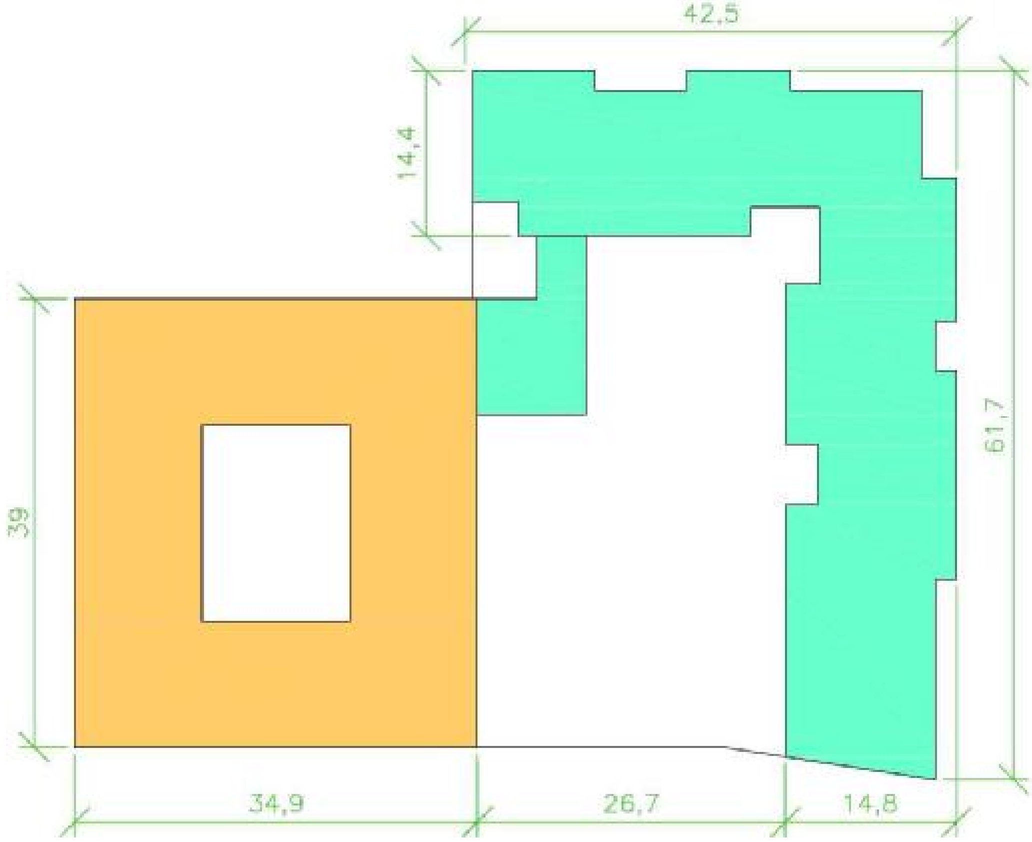
The building under constructions, consist on a complex destined for residence for major persons. The idea of this residential type complex, consists of having in the same place, apartments deprived for the residents, but that are inside a complex in which it offers to the customers, necessary services for the major persons. This concept of residential building, with assistance services for major persons is spreading in Finland in the last years.

3.1.2. Description of the building

The complex, is formed by three buildings. One of them is dedicated to the common services and other two, are the apartment ones.

The services building have an approximately square shape plant. There is a central court in its interior. It is composed by ground floor, basement floor and three floors. The ground floor is dedicated to parking and bomb shelters, at which we will dedicate a special section. The floors of the building are destined to the common services for the major, resident persons in the complex. These services would include services of medical character as consultations, centers of therapies, rehabilitation and treatments and services of social character and of leisure, as rooms of entertainments and organized activities.

The other two **apartment buildings** for residents have a rectangular shape and have not interior courts. They are connected by a corner between themselves and are connected with the services building by a corridor. There is a common court between the three buildings. The apartment buildings are composed by ground floor, the basement floor and three floors.



Img. 303. Schematic plane of the complex

3.1.2.1. Special characteristics: The bomb shelters

The building includes two bomb shelters for war times. The construction laws in Finland establish the obligatiry to build bomb shelters in the public and residential buildings of new construction.

The laws that establish the obligation to build the bomb shelters have been used in Finland from the Second World war.

The principal motives are:
- The intense warlike past of the place, as well as it is relatively recent.
- The conscience of the Finnish society of the potential risk that supposes being placed close to the border with Russia. Country of which, due to historical reasons it is not possible to trust, and from which it is necessary to expect for any thing, even the war.

Img. 304. Image of a bomb shelter under construction

The capacity for people or these bomb is established by means of a surface quantity by resident person in the building. Commonly they are constructed with prefabricated elements or in cast concrete. The normal thicknesses of the walls is about 30 cm. And the roofs approximately 40 cm.

This construction must be capable of supporting the weight of the whole building demolished over or it self. They must have reinforced doors made of steel and to be gas proof, besides other secondary doors of exit. Besides, they must have a special system of ventilation.

In times of peace, these refuges can be in use as storage, but they must can to be emptyings urgently in term of a few hours in case of need.

Img. 305.
Detail of the main door of a bomb shelter in the building site

Img. 306, Img. 307. Detail of the holes in the walls for the ventilation system.

Img. 308.
One of the emergency exits of of the bomb shelter

Img. 309. The emergency exits of the bomb shelters, goes outside through holes like those in the slab.

3.2. Construction systems applied in the building site and others of Finish construction

In this paragraph we will do a description of the different phases of the building site that I have been able to see during the period of visits to the building site.

I will try to explain the construction systems used in this building, but in addition I will try to give a global vision, of how these different parts of a building are solved habitually in the Finnish construction.

We will talk about the following phases of work in a building site:

3.2.1. The foundation (in a limited form, because it was finished and covered when I began to visit the building site).
3.2.2. Introduction to the structural system
3.2.3. The walls of basement.
3.2.4. Groundslab
3.2.5. Vertical elements of the structure: Load bearing walls and columns
3.2.6. Horizontal elements of the structure: Slabs and balconies
3.2.7. Stairs in prefabricated elements
3.2.8. Facilities and technical elements
3.2.9. Technical floors in bathrooms
3.2.10. Partitions
3.2.11. Roof
3.2.12. Carpentries

3.2.1. The foundation

Although have not had the opportunity to know the foundation phase, because it was made and covered the first time I visited the building site, I think that it is interesting, to do a brief introduction about the foundation system more usual in this kind of buildings.

First it is necessary to consider that the usual structure of these buildings is low bearing walls in the façade and isolated columns in the central area.

This type of structure determines the type of foundation. That way, the foundation uses to be a continuous foundation under walls, being this one the most habitual type. Another variant of the same system, also habitual, although less common, it is the construction of insolated foundations under the ends of the wall panels of the façade and to construct between them, foundation beams, that support the loads of the load bearing walls.

For the rest of supports or columns, there are usual isolated foundations, which can be or not joined with other foundations.

The typical soil in the Tampere region is the moraine. The area of Hervanta is very rocky. There, the soil is composed principally by granite, covered by a vegetable ground layer generally thin. That way, is common to have to realize the excavations for the construction of the building in the rock.

Img. 310. Excavation of a building site near to the studied one.

3.2.2. Introduction to the structural system

3.2.2.1. Structural prefabricated elements

The main characteristic of the construction in Finland is the use of big prefabricated elements. These systems provide to the building industry some benefits, which are important due to the conditions in what the construction works are made.

The main reasons for the prefabricated systems are:

- **Climatic conditions**: Due to the climatic conditions, is important to minimize the works made outside or in the building sites. It makes suitable the use of prefabricated elements, made by the industry and that need the minimum as possible works in the building site.

- **Quality**: The prefabrication of the elements in the industry, allows to reach high levels of quality, due to the mechanics production process of the factories. This quality levels would be not possible in the construction in situ.

- **Economy**: The use of the prefabricated systems allows to reduce the building site staff to the minimum necessary to place the prefabricated elements. Moreover, the use of these systems, avoids the mistakes in the construction process. This uses to be a important spent.

Moreover, that kind of construction makes possible a faster way of building, because the works in the building site, are limited in many times to put the elements in their places.

Img. 311. Wall element carried by the crane in the building site

The biggest part of these prefabricated elements, are structural parts. The use of these elements is very widespread, being the most common way of constructing. Nevertheless, also some structural elements are realized in situ, in cast concrete.

These cases are usually because the elements to build must have a difficult shape or dimensions, or they are in a place with difficult aces. Also in other cases, something can make the cast concrete more suitable and economic. .

In the building site, there are both cases. The greater part of the building parts are made with prefabricated elements, but some others are executed in situ. So, some slabs have been made in cast concrete

<u>3.2.2.2. Structural elements cast concrete</u>

As we said in the introduction of this paragraph, some elements are realized in cast concrete. The placing of the concrete is made basically in the same way that it is done in Spain.

Some differences exist, but they consist of precautions and special methods that are necessary due to the climatic particular conditions, we will study it in the specific block dedicated to this subject.

Img. 312. Casting concrete

3.2.3. The basement walls

The basement walls of the building are formed by prefabricated elements. They rest above continuous foundations. They are placed above some metallic plates in order to up them to the correct height and above a bed of fresh cement paste, that makes possible the correct support.

For making this system, is necessary to make an excavation with bank, for the exterior side of the building. In the case of this building site, it does not suppose problem, because it is an isolated building.

The most interesting characteristic of these basement walls, is the isolation of its exterior face. First, is added a bituminous sheet that avoid the pass the ground humidity. Over this sheet there are two sheets of EPS thermal insulation, with a total thickness of approximately 5-10 cm.

Img. 313. Exterior side of a basement wall of the building

3.2.4. The groundslab

I was able to see the building of the groundslab. The way of realizing the groundslab is basically like in the Spanish construction. The main difference is that in Finish construction is given a major attention to the thermal isolation against the ground temperature.

The first step to make the groundslab is spread a layer of big gravel with a thickness of approximately 20-30 cm. This gravel layer avoids the raise of the humidity into the building elements, because of the capillary effect. Above this gravel layer, once it is the correct level, they place some sheets of thermal insulation material, with a total thickness of about 10-15 cm. In some special low energy buildings, it can also have a thickness of even 25 cm.

On the sheets of insulating material, they place a few metallic joints with a few wings lined in plastic material. If there were a big concrete slab it would shrink a lot, and then it would make some cracks. These joints, works like motion joints, divides the great concrete slab into smaller slabs and avoid the cracks.

Once the joints and the reinforcement are in the correct place, the concrete of the groundslab can be cast. The concrete is cast with the necessary slopes in order that in the future, the possible waters of melt snow that enter the cars, can be evacuated by the sinks.

Img. 314, 315. Sight of the gravel layer and the insulation layer

Img. 316. Section of groundslab and its joint

Img. 317. Detail groundslab joint

Img. 318. Pieces of joint

Img. 319. After the harden one of the concrete, it is covered with plastic to support the humidity and get the concrete well treated

3.2.5. Vertical elements of structure: Load paring walls and columns

In this paragraph we will study the vertical elements of the structures. For this kind of structure, the predominant element is the load paring wall, generally in the fronts. Because of it, the wall elements make the double function of resistant element and closing. Besides for the interior zone of the building they can use walls of load. Finally columns are used also, to form porticoes with beams, but always inside the building, or in the exterior part for support balconies, but never forming a part of the front.

The bigger peculiarity of these structural vertical elements, is that they are solved always with only one element, from the floor to the roof. So much the walls of the front, as the internal load paring walls, even the columns.

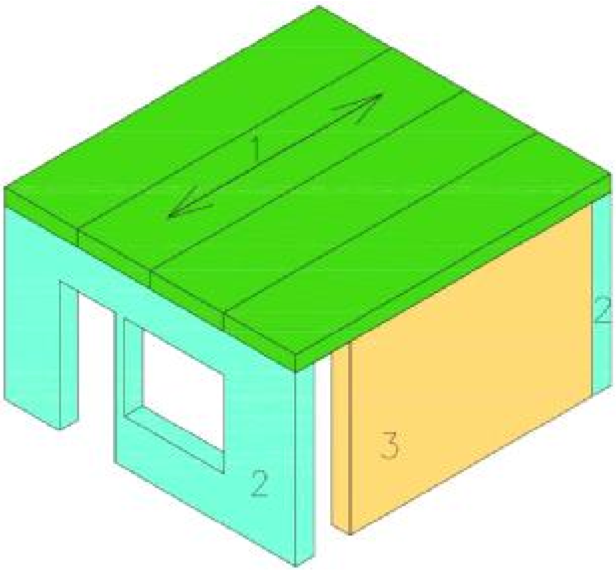
3.2.5.1. Load bearing and not load paring walls

The one of all the prefabricated elements, which characterize the residential Finnish construction, is the prefabricated element walls. This one is the most typical, for being the one that forms the urban landscapes of the residential zones in Finland.

These prefabricated panels of front can be of one of two types:

- Load bearing: In case of they make a structural function and support charges of the floors above or other elements.
- Non-load-bearing: It only supports its own weight but do not have a structural function, only the function of a wall.

The most common reason for this is that, if the wall is below the end of slab elements it will be load bearing, whereas the panels that are below the contour of the slab, will be non-load-paring.



Img. 320. Schematic representation of load bearing or not, where:

1. *Unidirectional slab and its direction of work*
2. *Load bearing elements*
3. *Not load bearing elements*

On the other hand, the structural panels or load bearing walls, can be exteriors or of front, or also they can be inside the building. From now on, we will centre on the exteriors, for being more interesting than the load bearing inside walls, and have the same way of place it.

The wall elements are prefabricated, made in a factory. The main reasons for this, are the easy way of putting it in their place and the economy of this system. The wall elements are made always, by order and following the specifications of a project. The project establish, dimensions, openings of front and its other characteristics

The prefabricated panels of front or façade are composed habitually by three different layer:

- The interior layer is made of reinforced concrete. The thickness uses to be 12-18 in load bearing elements and 8 cm in non-load-bearing elements.
- The central layer is made of the insulation material compacted rock wool. The usual thickness is 15 cm or more.
- The exterior layer is made of concrete and it is about 7 cm thickness.

Img. 321, 322. Sections of prefabricated panels of front

The final surface of the front wall elements can receive diverse ended. The ones used in this building site are, ended in the own concrete, re-dressed with washed stones or the most frequent case, covered with ceramics tiles making like an imitation of a brick wall. In the following images we will see different examples.

Img. 323. Ended in concrete

Img. 324. Ended in gray washed stone

Img. 325. Ended in washed stone of marble

Img. 326. Ended in a brick imitation wall

These prefabricated elements of front include the openings of doors and windows. Window and door openings are framed with impregnated timber, placed between the concrete layers. They remain compressed into the hollow of the insulation layer, and included between the interior concrete sheet and the exterior sheet. On this wood frame the carpentries will be screwed later.

Img. 327, 328. Detail of the wood frame, which fulfills the double function to close the hollow of insulating material in the perimeter of the hollows in the panel, and of using as support for the carpentry that will be screwed into it.

Another characteristic of these wall elements, is that they include inside of themselves, the necessary channelings, for the installations. Inside of them will be the electrical cables for the electricity. Besides, they include also, the boxes for mechanisms of the electrical installation.

Img. 329.
Boxes of the electrical installation included in the prefabricated panel

Transporting, stocking and placing the prefabricated wall elements

All the prefabricated panels of front are placed in the building site basically in the same way. So we will explain the way to place the load bearing façade wall elements that are those who have a bit more of complexity.

The panels are transported by trucks. Elements with openings are more fragile. To prevent the cracks of the most fragile parts, like the door openings, there are used reinforcement bars and timber blockings. The fragile parts of the elements are jointed with the rest of the element with an external prolongation of the reinforcement of the panel. These steel bars of the reinforcement are cut once the element is fixed in its place.

The wall elements must be always in vertical position, during the transport. While they are in stock they fill in vertical position with the help of a metallic substructures.

Img. 330.
Stock of front element walls

The element installing crew consists usually from carpenters and helpers. The wall elements are managed in the building site with the crane (Img. 331). They are placed by the workmen (Img. 332), above of fresh cement mortar bed (Img. 333) for making a correct joint. Once the element is in its correct place, it must coincide with the connection points of the lowest panel. Once the element is in its place it must be fixed with leaned supports (Img. 334). That supports must be fixed to the wall element and to the floor. Once the element is in the correct place and joined to the supports, it have to get in the correct vertical position by regulating the lengths of the different supports (Img. 335). Once placed, and put in vertical position, the placement finishes refilling with cement mortar the connection hollows (Img. 336, 337) between the panel below and the one that have just been placed.

In this hollows the cement mixture covers a part of the reinforcement of lowest panel and a part of the reinforcement of the higher

Img. 331.

Img. 332.

Img. 333.

Img. 334.

Img. 335.

Img. 336.

Img. 337.

3.2.5.2. The colums

Columns are used for the construction of the interior porticoes, besides of the load paring walls. The peculiarity is that they use to be prefabricated.

The columns have connection system in its base and in its top. It usually is spike that has to get within of the piece that rests above.

The placement of the columns is done in a similar way that the element walls. It is placing them in its place, putting it inside of them the connection spike from the column below. For place the column in the correct height, are used metallic sheets. The column must be fixed with leaned supports. Later it must get in the correct vertical position by regulating the extension of the supports. Finally the joint between the column and the floor is refilled with grouting concrete.

Img. 338. Column with with leaned supports

Img. 339. Column supported on sheets

Img. 340. Final cement sand mixture recovered

3.2.6. Horizontal elements of structure: Slab elements and Balconies

This is the most usual system in the construction of slabs, by means of prefabricated elements. In spite of being the most habitual prefabricated system, in some cases, becomes more suitable to build some or some parts in cast concrete. This is the case of the building site that I have visited, where both systems have are used.

3.2.6.1. Slabs made of prefabricated elements

The system consists of the placement of prefabricated concrete panels side-by-side, forming this way the surface of the slab. The panels are longitudinal, have a standard width of 1’20 m and one changeable thickness, between 20 and 40 cm. They are made of pre stress concrete by means of pre stress cables in its low face. It has inside some longitudinal holes, which change in number and size depending on the singing of the panel.

These panels, as other prefabricated units, are made by order, with a singing and length determined by the project, and even with special forms or sections of reduced height, fixed all that by the project.

Img. 341, 342. Hollow core slabs

This system of prefabricated slab elements, rests on the load bearing walls or on beams. These beams can be made of concrete or steel according to the case. The difference is that the concrete beams stand out of the lowest face of the slab, whereas the metallic beams remain included in the thickness of the slab.

System with prefabricated concrete beams

In this slab system, the beams stand out under the slab. So, this system can be used only in places where is not need a smooth roof. The most usual places for this system are car parks and high load slabs, like for example central courts.

The system consists of reinforcement concrete beams with an inverted T section that rests on columns, generally also prefabricated.

Img. 343. Set of beams of the slab system

Img. 344. Detail of a beam resting over the column

The zone of supporting area between the column and the beam and the one between the beam and the slab elements includes a band of elastic material to favor a good seat and to avoid in the future the transmission of sonorous vibrations.

The connection between the column and the beam, includes a threaded bar that belongs to the column, that fits in a hole at the end of the beam. To fix both elements is screwed a nut into the threaded bar that, with help of a washer, immobilizes the beam.

Once placed the slab elements are put in the correct place, the joins between the all the elements of the system can be filled with concrete. It will fix and will immobilize the system.

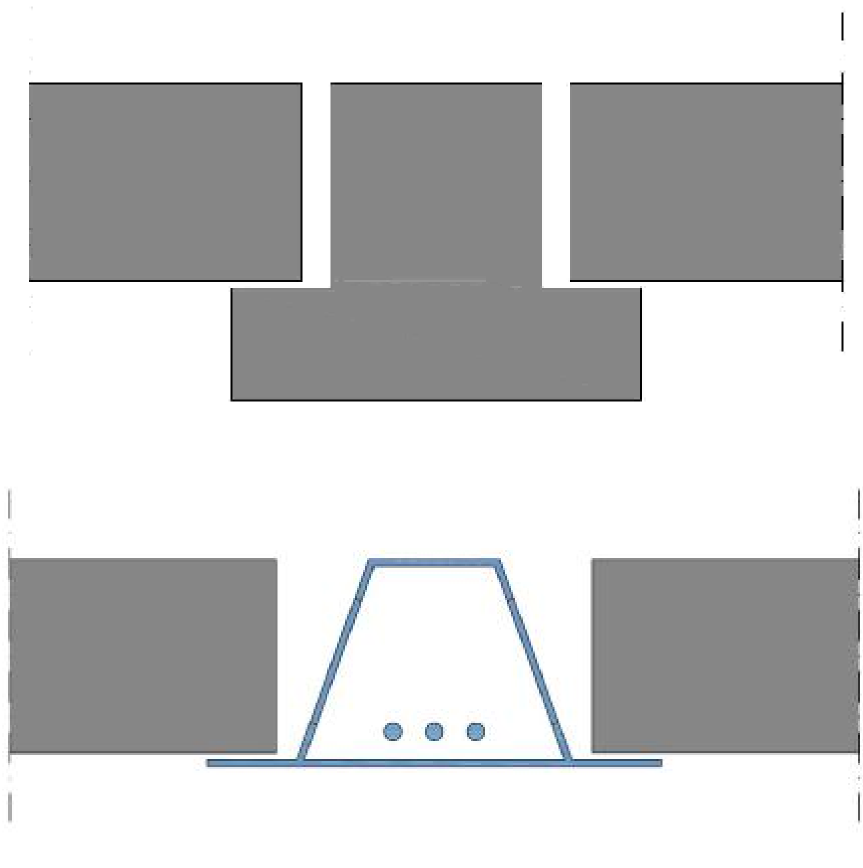
Img. 345.
The ends of the beams ready
For the concrete casting

Img. 346. Aspect of slab system after filling the joints with concrete

System with metallic beams

At the beginning is easy to think that the prefabricated concrete slab elements make impossible to include the beam inside the singing of the slab. Nevertheless, there exists a system of beams, made of metal sheets, which filled with concrete, that make this possible.

These beams are made of steel sheets. They have a horizontal base. The ends of the slab elements rest on that base. The shape of the beam is formed by other three sheets. The lateral sheets are inclined and have big holes. The purpose of those holes is to allow the concrete cast, which must fill the beam. It has inside of itself, in the low part, three reinforcement bars, which increase the loads resistance of the beam.



Img. 347. These cross sections of the beams of the different systems, show the differences between them:

- *System with concrete beam: The beam stands out under the slab.*
- *System with steel beam: The beam fits to the slab thickness.*

Img. 348, 349. Views of the metal beam system

Img. 350. Sight of the wing that supports the slab elements

Img. 351. Sight of the interior of the metal beam

Common characteristics to both systems of slabs made of elements

Filled of fissures of concrete joints

In any of the systems in which prefabricated panels are used, placed one together with other one, the joints between them must be filled with concrete. The habitual problem in these cases is that once the concrete gets dry, it makes some fissure. It happens usually between the concrete and one of the element of the joint.

This fissure could create in the future soundproofing problems. It is solved adding to the joint a second layer of a liquid cement mixture, which fill these fissures.

Img. 352.
Detail of retraction fissure

Img. 353. Workman spreading the liquid cement mixture

Img. 354.
Surface of a beam covered with the cement liquid mixture

Img. 355.
Joints between elements covered with the liquid cement mixture

Tops of the panels holes

The ends of the panels must be solid for resist the stress that appears in the supports of the slab elements. This stress depends of the loads that bears the panel and of its shape, and it is calculated in the project. That way, the project establishes what is the necessary solid long at the ends of the panels.

Img. 356. Plastic tops for concrete at the end of a slab panel

The way to get these solid long, is controlling the depth that the concrete reaches inside the holes of the slab elements when it is cast. Concrete can not spread all along the holes and neither can stop at the beginning of the hole. Concrete must reach the necessary depth inside the holes, which make sure the good work of the panel ends. For this purpose, they are used some plastic tops, that keep the depth that the concrete reaches. They are placed on the tops of the panel holes.

There are tops of different sizes and longs, according to the long that the concrete must reach inside the panel, which is established by the project.

Img. 357. Big depth plastic tops for concrete.
The ends of these elements will bear a big stress

3.2.6.2. Visit to hollow core slab factory

During the development of the present work we visited a factory of prefabricated slab elements. We will make here a small paragraph to make clear some aspects of the manufacture that we knew during the visit.

These panels are made of pre stress concrete by the method of the extrusion. They conform to pre stress cables in its low part. The panels have a standard section of 1.20m and one changeable singing, according to the model, approximately between 20 and 40 cm.

The interior of the section is lightened by means of longitudinal holes. The size and quantity of these holes depends of the singing of the element.

Manufacture

In the factory there are several big banks of work known as "beds" of more than 100 m of length (Img. 358). In one of the ends, there are the bobbins of cable (Img. 359), and in the opposite end, the cables get hooked up to be able stress them (Img. 360).

Img. 358

Img. 359

Img. 360

Once the cables are under stress, a big machine moves longitudinally, over the bed. It gets the concrete from a transport system and uses it make the panel. The machine advances slowly over the bed with the stressed cables and is forming the panel with the established section, which includes its exterior shape its inside holes (Img.361).

Img. 361

Once the machine leaves behind the section of panel newly executed, the concrete, is yet fresh, but it has reached already enough hardness as for maintain the its shape, even to support above the weight of a person. The resultant one of this process, is a great panel of more than of 100 m of length.

It is in this moment, when there are marked in this great block, the cutting marks to be cut transversely, to obtain the panels of different sizes. Besides, some panels are needed according to the project with complex forms. These forms can be basically, with minor width, in someone of its sections (Img. 362), with minor singing in some of its sections (Img. 363). This kind of slab is used for bathrooms areas. Other holes can be made for facilities (Img. 364).

Img. 362

Img. 363

Img. 364

Once this marked the great block with the specifications of every section, two more machines pass over it. The first one of these machines, is the one that reduces the thickness of the panel in the necessary sections (Img. 365). What it makes is to compress the still fresh concrete of the panel, removing the internal hollows and reducing the section this way. There is also the drilling machine, that drills small holes under the hollows to let water out from the hollow, if any.

Later there passes a third machine (Img. 366), that makes perforations. These perforations can be used to reduce the width of the panel cutting the unnecessary part, or be facilities holes.

Img. 365

Img. 366

Once the great piece has been made and the unnecessary parts have been suppressed, it is left to harden the whole great block for approximately 24 hours. Past this term, the great panel is cut transversely into the diverse panels with its respective lengths. This cut is done with another machine with a great cutting disc (Img. 367).

Img. 367

When the pre stress cables are cut, they get shorter and pull the low part of the elements, producing a curved shape to the element

Img. 368.
Sight of the curved shape of the element

The last step to leave the piece in conditions of use, is to add plastic tops in the holes of the elements (Img. 365). These tops can be of different deep depending of the deep that will have to reach the concrete inside the holes of the element according to the project.

Img. 369

In the same factory we also observed the manufacturing process of other prefabricated elements of reinforced concrete. The interesting ones for this work are the concrete columns and beams.

The manufacturing process of both is similar, consisting simply to constructing wood concrete shaper over the floor, place inside the reinforcement and cast the concrete.

In both cases it is important to put a few hooks fixed to the reinforcement for be able later to handle by cranes these prefabricated elements. In the particular case of the columns, it must include the connection threaded bar on the top and bolt holes at the bottom.

Img. 370. Reinforcement and connection systems of columns

Img. 371. Connection systems of columns

Img. 372. Wood concrete shapers

Img. 373. Casting concrete

3.2.6.3. Balconies

In the Finnish construction it is very usual to build balconies, externally of the limit of the front. The form of sustentation of the balconies can be basically of two different ways, depending on the system of the slab.

Balconies Can be constructed without any columns. This one is the case of the building site that I have visited (Img. 374). For that kind of balconies it is necessary to build a concrete cast slab, to be able to fix the balcony. Another possible form, also usual in the Finish construction is constructing the balconies as continuation of the structure and with its own columns (Img. 375).

Img. 374

Img. 375

Here we will centre on the construction of the without columns, that are the ones that I have seen in the building site. These balconies are also prefabricated elements. For its placement, a holder system is prepared with supports and wood beams. It supports over the balcony below or in the ground.

Img. 376. Stock of balcony slabs

Img. 377. Temporary support for a balcony slab

For placing the balcony, It is hoisted with the crane and put above the holder system. The metal part of the element must be inside the casting concrete area, and later will be covered by the concrete.

Img. 378. Metal parts of the balcony element, placed inside the cast concrete

Img. 379. Hoisted of a balcony element

Img. 380 - 383. Sequence of the placement Of a balcony element

3.2.7. Stairs

We could say that, the most different building element, between the Finish and the Spanish construction industry, are stairs. They are manufactured in factory, transported to the building site, and the only work that it is necessary to do with them in the building site is to place them.

The prefabricated stairs elements include all the parts of some stairs. I want to insist on that, the manufacture of these elements include all the parts, and they become absolutely finished. The parts that include theses prefabricated stairs elements are:

- The structural reinforced concrete part
- The complete finished stairs
- The final surfaces of the low and lateral sides

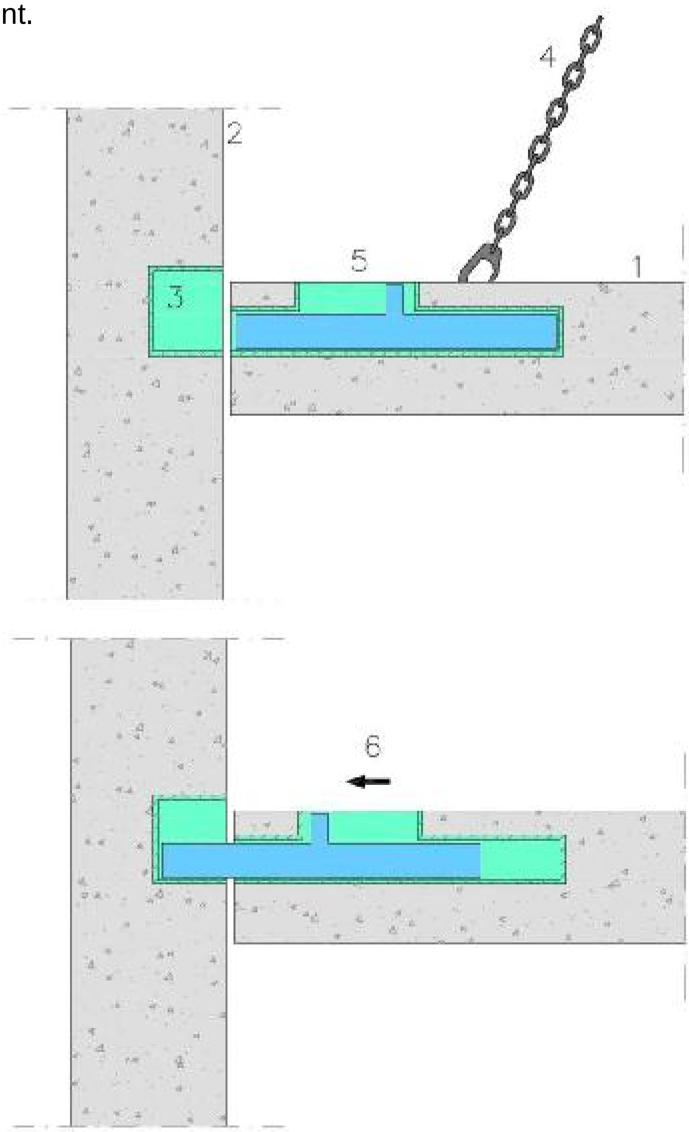
The stairs of the building site I visited are made in three strait elements: two stairs elements and an intermediate landing element. There is another very usual system: only one curved stairs element, which solves the stairs between two floors.

Img. 384.
Straight elements stairs

Img. 385.
Curved stairs in only one element

Here we will explain the system of the building site that I have visited, made with three strait elements. For making the stairs, is necessary that the floors and the stairs walls are finished.

The first steep is to place the intermediate landing slab. It is also a prefabricated concrete element. It must to be put in its place and fixed to stairs walls. The landing elements have four sliding steel parts, that fit in the special support holes in the stairs walls, fixing that way the element.



Img. 386. Schematic cross section of the sliding steel supports system and its placementre:

1: Prefabricated concrete landing slab

2: Concrete stairs walls

3: Special support holes in the stairs walls

4: The crane hoisting the landing element

5: Sliding steel support ready for use

6: The sliding steel support is placed in the support hole

Img. 387.
Intermediate slab placed, hold by the sliding steel supports to the walls

Once the intermediate landing slab is placed, it is possible to place the two straight stairs elements. One of them is put, between the floor below and in the landing intermediate slab, and the other, between the landing and in the upper floor.

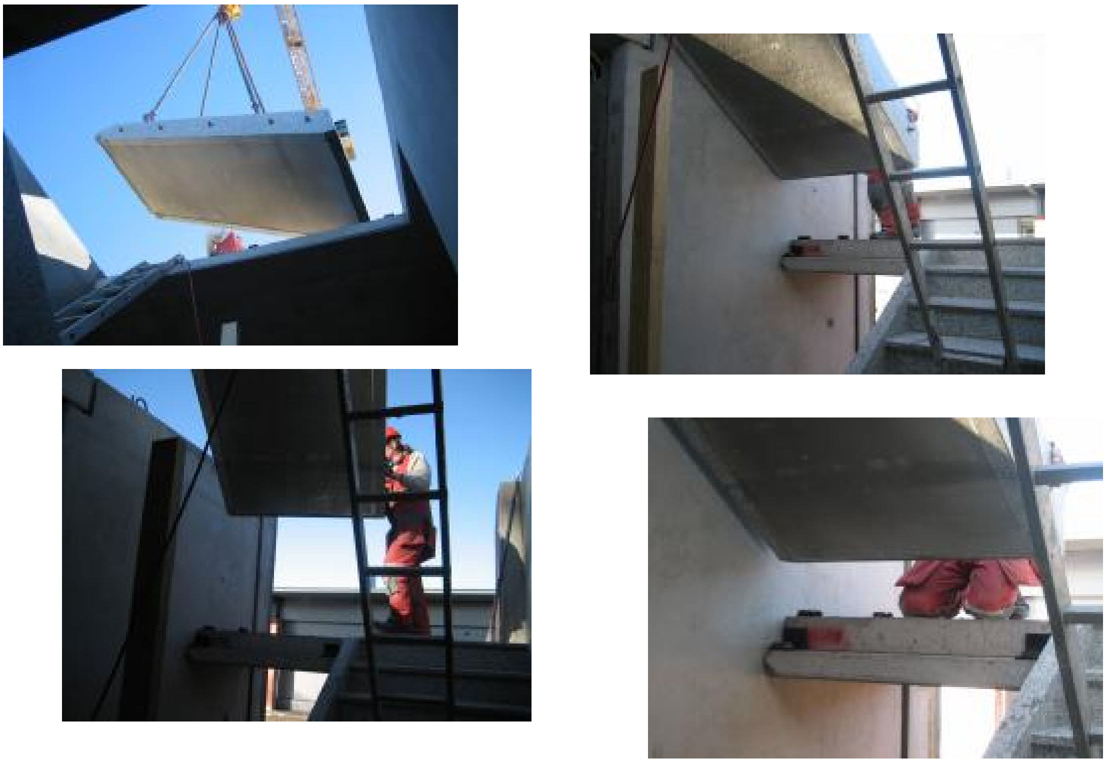
The stairs elements are not directly in contact with the surfaces where they rest. There must be a rubber element between two elements on contact (Img. 386), to avoid in the future, the acoustic transmission between the elements.

Img. 388

In case of, the stairs element is below of its correct height, some steel pates can be placed over the rubber element, to raise the support surface to its correct height (Img 387).

Img. 389, 390. Metallic sheets to increase height

The placement of these stairs elements, is made with the crane. A workman manipulates the stairs in suspension, and directs it to its correct place and position.



Img. 391 - 394. Sequence of placement of a stairs element

Finally and for the definitive fixation of the stairs elements, the joints between the elements are filled with a grouting concrete. The lateral joints with the walls and the low part of the joints between the elements are filled whit polyurethane, to stop the spilling of the liquid grouting concrete. The polyurethane is removed later.

Img. 395. Upper joint

Img. 396. Low joint

Img. 397. Low side of the upper joint

Img. 398. Lateral joint

Once the stairs are correctly placed, they must be covered with some protection element, to protect them during the works (Img. 399)

Img. 399.
Glass fibre covers

<u>Comparative with the usual Spanish stairs system</u>

This is the one of all the construction systems studied in this work, that supposes the bigger difference, to the systems used in the Spanish construction to solve the same building element. This system supposes the biggest advantage from the stairs construction systems commonly used in the Spanish construction.

In the Spanish construction, the construction of stairs of reinforcement concrete supposes diverse works:

- First, project phase must have been calculated and distributed well the stairs. It now always happens.

- Then it has to be marked in the building site the shape of the stairs, with the risk of mistake that this implies.

- Then, there has to be done an concrete former which makes the forms generally complicated of the stairs.

- Then, it is necessary to adapt the reinforcement to the concrete former. The workers are working in difficult conditions, due to having to work on own concrete former.

- Later, it has to be filled with concrete, also working in difficult conditions.

- Finally and in the endings, a specialist workman in coatings, has to make re-dress the whole stairs, making all the stairs of just the same dimensions, squared and whit the correct vertical positions.

Due to all these works, and because of the big amount of time and different workers that it is necessary to build the stairs, it becomes a difficult work. And it makes easier the possibility of making mistakes.

All that, remains enormously simplified, if the stairs comes perfectly manufactured from factory. And the only works in the building site, are limited to placing it in its correct place.

3.2.8. Facilities and technical elements

Another peculiarity very distinguished from the Finnish construction, is the utilization of the called " technical elements ".

These prefabricated elements consist of big concrete blocks. They are a similar shape and dimensions to the columns. Its height is between two floor slabs. They do not have any structural function. They have inside of them, the vertical pipes of the facilities, and also include the access and the exits of these facilities pipes from the floor facilities.

These prefabricated elements, like the other kinds of prefabricated elements, do not correspond with any standard model. They are made by ordering them, and their designs are established by the project of the building.


Img. 400, 401 Stocks of technical elements

Img. 402. A technical element hoisted by the crane

These technical elements can contain inside of them several types of facilities at the same time. The most usual are:

- Plumbing
- Drainage
- Ventilation
- Water for the heating system
- Water for the fire extinction system.

It is interesting to point up that, when the ventilation system is included inside a technical element, concrete forms a good fire protection around the ventilation channel.

Img. 403.
Detail of some facilities of a technical element

Img. 404.
Head of a technical element to be fixed inside the cast concrete

3.2.9. Technical floors in the bathrooms

When the floor slabs are made of hollow core elements, two important problems appear in the bathroom areas. This slab system do not allows the placement of facilities inside of itself, and in the other hand, a hollow core slab, do not give enough soundproofing against the noise that the drainage facilities produce.

These problems are solved by using the low thickness slab elements. They are the ones of the compressed type, without holes, of which we talked about in the paragraph dedicated to the slab elements manufacturing.

The use of these thin and solid elements allows the placement of the drains, the other elements of the drainage facilities and, in case, other facilities. Moreover, the solid slab elements provides the necessary soundproofing against the drainage facilities noises.

Img. 405. The bathroom areas are solved with thin slab elements that allow the placement of the drainage facilities on them

In the visited building site, the heating system for the bathrooms is constructed by a radiant floor system. The particularity that makes it different from the usual systems on the Spanish construction, is that it is made of electrical cables instead of a hot water pipes circuit.

To be able to place the heating cable system, they are put some reinforcement nets. They are used to joint the cables to them and make that the cables keep the net like shape. Once electrical cables are correctly placed, the system is ready to be filled with concrete. The heating electrical cables circuit will be connected to heating system devices.

Img. 406, 408
Different sights of the floor electrical heating system

3.2.10. Partition walls

In this paragraph we are talking only about the non-load-bearing walls. Inside the building there are some double function walls, structural or load bearing and partition. We talked about the structural walls in the specific previous paragraph. So, here we will show only the ones with only partition function.

We could say that in the studied building site, there are three different types of partition walls, depending of the material that they are made of. The use of these different kinds of partitions depends of their acoustic isolation and their resistance against fire. These kinds of partition walls are:

- Thick lime sand blocks wall
- Thin lime sand blocks wall
- Light weight steel frame and gypsum board

Thick lime sand blocks wall

These partitions are made of white lime sand blocks of approximate dimensions of 40x20x17 cm. The prominent peculiarities of this system are that exist special pieces for the formation of lintels over the doors.

Img. 409. Sight of the thickness of the wall

Img. 410. Lintel solved with special piece

Img. 411. General aspect of the thick lime sand blocks wall

Img. 412. Detail of the lintel

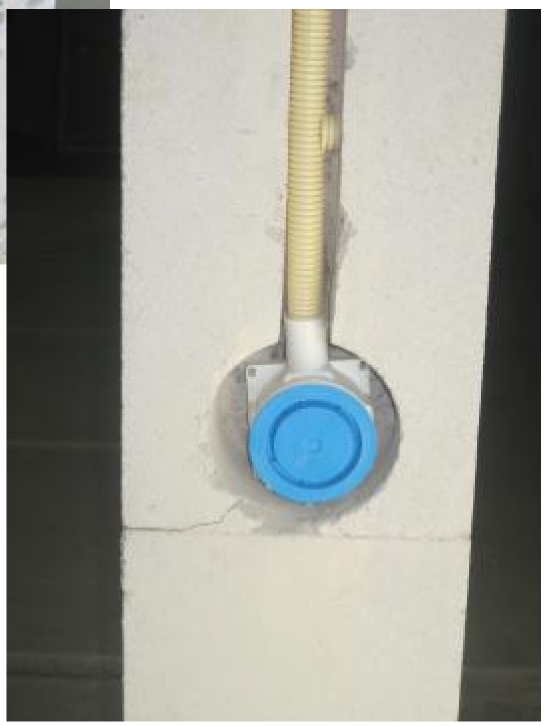
Thin lime sand blocks wall

These partitions are made in white concrete blocks, as the previous ones but of smaller thickness, of approximate dimensions of 40x20x12 cm. This system also has special composed prefabricated pieces. They are lime sand block beams, to support the part of the wall that is above the opening.

Img. 413. Assembly of a small format block wall

Img. 414. Assembly of a small format block wall and the wood opening frames

Img. 415. Stocks of blocks and piece lintel



Img. 416. Installation holes and electrical material

Dry and light partitions

The third type of partitions, is the light weight steel frame and gypsum board. It is used for making light partitions for inside of the apartments. Inside of one apartment it is not necessary the fireproofing of the heavy partitions systems showed before.

This system is made of an inside metallic profiles structure covered whit sheets of carton plaster. The inside of the system can be filled with insulating material in case of it is necessary. The joints between the surface sheets of this system are filled and covered with plaster. The system must include elastic joints with the other building elements. To close this joint is necessary to avoid the pass of the fire in case of it.

Img. 417, 418. Views of the system

Img. 419.
Electrical installations
fixed in the system

3.2.11. The roof

In the building site I have been able to see the timber system for the formation of roof and its inclinations. This system is very common in the Finnish construction.

The system consists of the construction above the last floor slab of a timber structure, which is covered by a timber board, which forms the earrings for the evacuation of the water of the roof. The main reason for the existence of this timber structure, is that the space below the timber board, is used to place there, lots of air installations, with tubes of big dimensions.

The system this composed by a timber load paring structure, and on the top of it, a timber board. The structure is formed as a series of porticoes made of 2 by 4" or 2 by 5" timber. The timber board is made of thin wood strips, joined one close to the other.

The timber is made of spruce wood, generally of the own country, and it does not have any kind of treatment against insects, against the humidity or against the fire. Wood is used in natural form, that is to say, it is not in used any kind of composed timber material. Even the board on the top, is made of tables of natural wood.

Img. 420. Sight of the timber system

Img. 421. Sight of the interior of the system. Low side of the board that forms the surface

Img. 422. General view of the roof, after placing the first bituminous sheet

The timber system is usually covered with two or three layers of bituminous sheet. The final surface of this layers is made with a protection of slate small gravel. Some peculiarities of this roof are:

- The drain elements have a self regulating heating cable installed outside it to prevent freezing.

- There are some special smog vents, which allow the exit of the smog in case of fire.

Img. 423. Joint of the roof with a wall *Img. 424. Joint of the roof with a an access hatch*

Img. 425,426. Detail of the drain its anti freezing electrical cable system

Img. 427. Placed drain

Img. 428
Special smog exit

3.2.12. Carpentries

The elements of carpentry, ready made windows and doors, are delivered in the building site, manufactured and packed. Those windows and door can be made of different materials. In the case of the visited building site, there are two kinds, painted aluminum and natural wood.

Because the carpentry elements arrive in one complete piece, the only necessary work to do in the building site, is to place them. Placing consists en put them into the correct place and position inside the wood frames. This work is made with the help of wedges. When the doors and windows are in the correct position they are joint to the wood frames with screws. After that, the space between the wall element and the door or window piece, is filled whit some polyurethane foam.

The finish consists on a flashing in the low part of the exterior side to dump the rain water, and maybe any flashing or timber board that covers the joint between the carpentry element and the wall element.

Img. 429.
Windows ready for its placement

Img. 430.
Joint between the carpentry and the frame in the lintel

Img. 431.
General aspect of the frame of a door hollow

Img. 432. Support of the carpentry

Img. 433. Detail of the screw connection

PART 4

PARTICULAR TECHNIQUES IN THE BUILDING TECHNOLOGIES

Part 4
Particular techniques in the building technologies

In this fourth block we will describe some particular techniques that I have been able to see during the visits to the building site. They are specially interesting because of they are not usual in the Spanish construction.

We will expose three technologies. Two of the are motivated because of the usual hard climatic conditions. And the third is possible thanks to the advanced technological development. These technologies are respectively:

- Concrete casting techniques
- Heating the building during the construction
- Surveyor marks the necessary guidelines and points to the floor etc

4.1. Casting concrete techniques

The most usual in the Finnish construction, for making slabs, is to use the prefabricated elements system. But there are some cases where is necessary or simply more convenient to cast the reinforced concrete in situ.

Description of the system

In the Spanish construction, the most common system for cast concrete is made with small pre stress beams, and blocks that fills the space between these beams. The concrete is cast above this system.

The Finish construction do not use that kind of pieces slab when it is made of cast concrete. The normal solution is making a reinforcement concrete slab in all its thickness. It is neither used the light slab system, composed of concrete nerves, and hollows inside.

To be able to construct this type of slab, is needed a total concrete form-work. The habitual thing is to this concrete shaper with a continue wood board, which uses as base for cast the concrete.

Img. 501, 502.
Low face of the total concrete shaper

The own prefabricated panels of the front, make also the function of concrete shaper, and at the same time, they get hold with the cast concrete. Besides of this, the cast concrete holds with the other load bearing walls, on the central area of the floor. In the higher part of these walls, there are vertical steel bars that allow the connection between the wall element, and the cast concrete, and later, to the wall element above.

Img. 503.
Connection of the cast concrete slab and the wall elements

Img. 504. There are hooks in the top of the load bearing element wall. They are only for be able to hoist the element. The connexion of these wall elements to the cast concrete is provided by the vertical steel bars. These bars also later will be the connexion with the wall element above.

Img. 505.The top of some load bearing elemens that will be jointed with the cast concrete

Another important thing that gets included inside cast concrete are the ends of the technical installations elements. Also made of concrete, they get fixed to the slab.

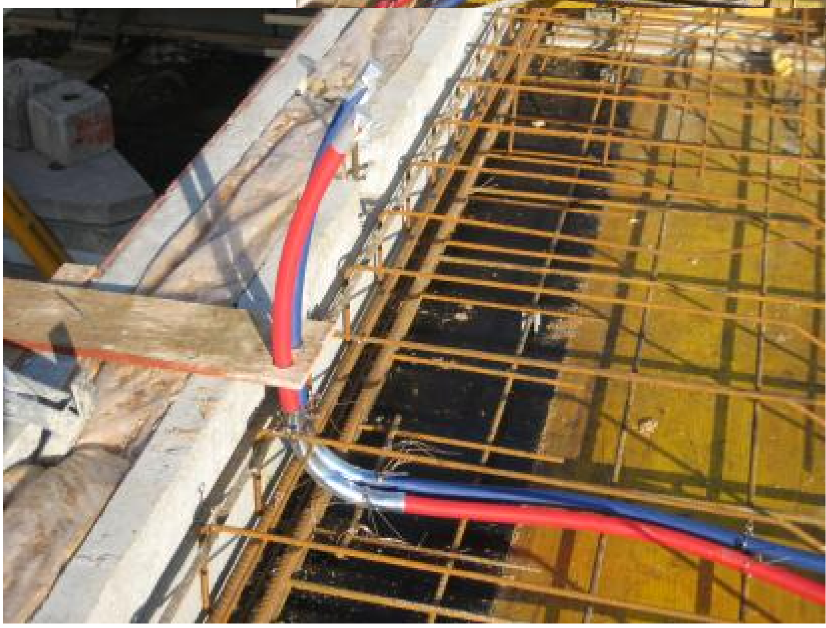
The bigger particularity and difference of these concrete slabs with the Spanish construction, is that these slabs include inside themselves all the facilities pipes necessary to fit inside of them. The usual facilities are:

- Drainage
- Plumbing
- Heating system water
- Tubes for the electrical installation.

Img. 506, 507.
Heads of technical elements, connected with the drainage installation

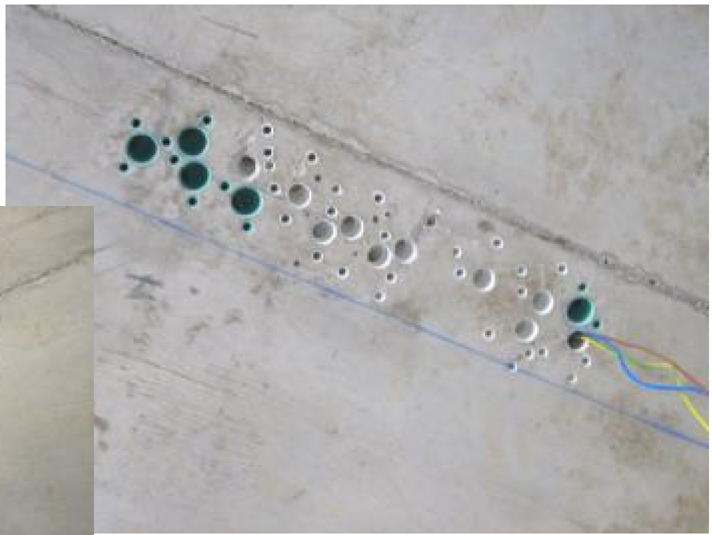
Img. 508
Facilities of drainage and the drain of a bathroom


Img. 509, 510.
Pipes for the electrical installation and the plumbing installation



Img. 511.
Special piece of the pipes for getting inside the slab

The aspect of the surface of the concrete shaper of the slab, results very surprising, because of some areas are full pipes of different facilities, materials, forms and sizes. Is the same of surprising the view of the surface of the final concrete slab, because some areas are replete of orifices for allow the pass of the facilities.



Img. 512, 513. Aspect of the full area of electrical installation pipes. These are above a partition wall where the pipes will continue

The casting of concrete

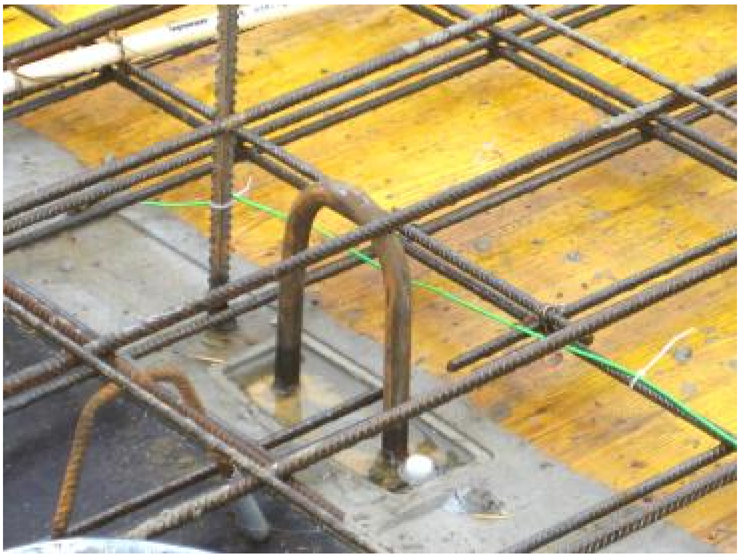
The techniques of casting concrete totally determined because of the usual hard climatic conditions. The concrete even can be provided to the building site hot, to an approximate temperature of about 30ºC.

Img. 514. Casting concrete

Img. 515. During the spread, the concrete detaches great quantity of steam, due to the hot temperature that it is

During the concrete casting, the temperature of the concrete is measured with a temperature gauge. It permits to know what is the temperature of the concrete. Even, in winter, is possible to put inside the cast concrete, an electrical cables heating circuit. It can be switched on in case of the concrete goes down of the necessary temperature, and that way, to heat the concrete.

Img. 516. Supervisor installing the wires of the temperature gauge.

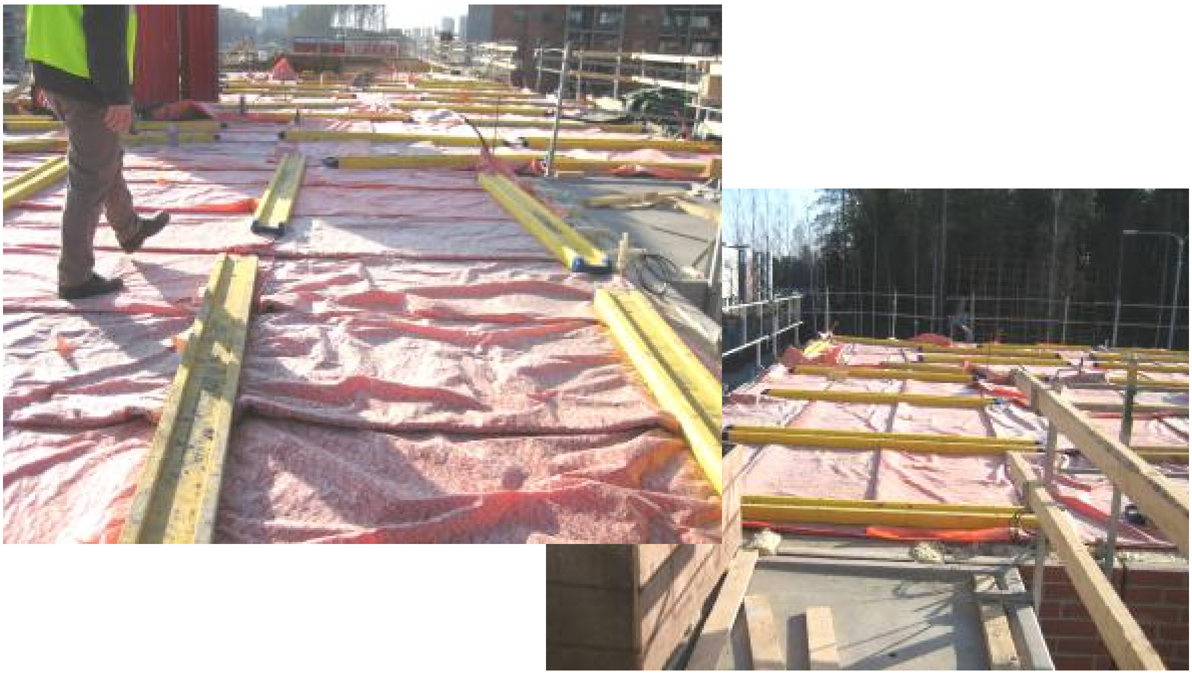


Img. 517. Detail of the temperature gauge system cable for measuring the temperature of the fresh concrete

After the concrete casting, when it gets enough hardness to resist the weight of a person, the concrete slabs are covered. They can be covered depending of the weather temperature:

- Only with plastic, to stop evaporation, or
- With blankets, that also to stop heat loss.

To keep the correct humidity and, in case, the correct temperature, is necessary for a good making compact and hard of the concrete.

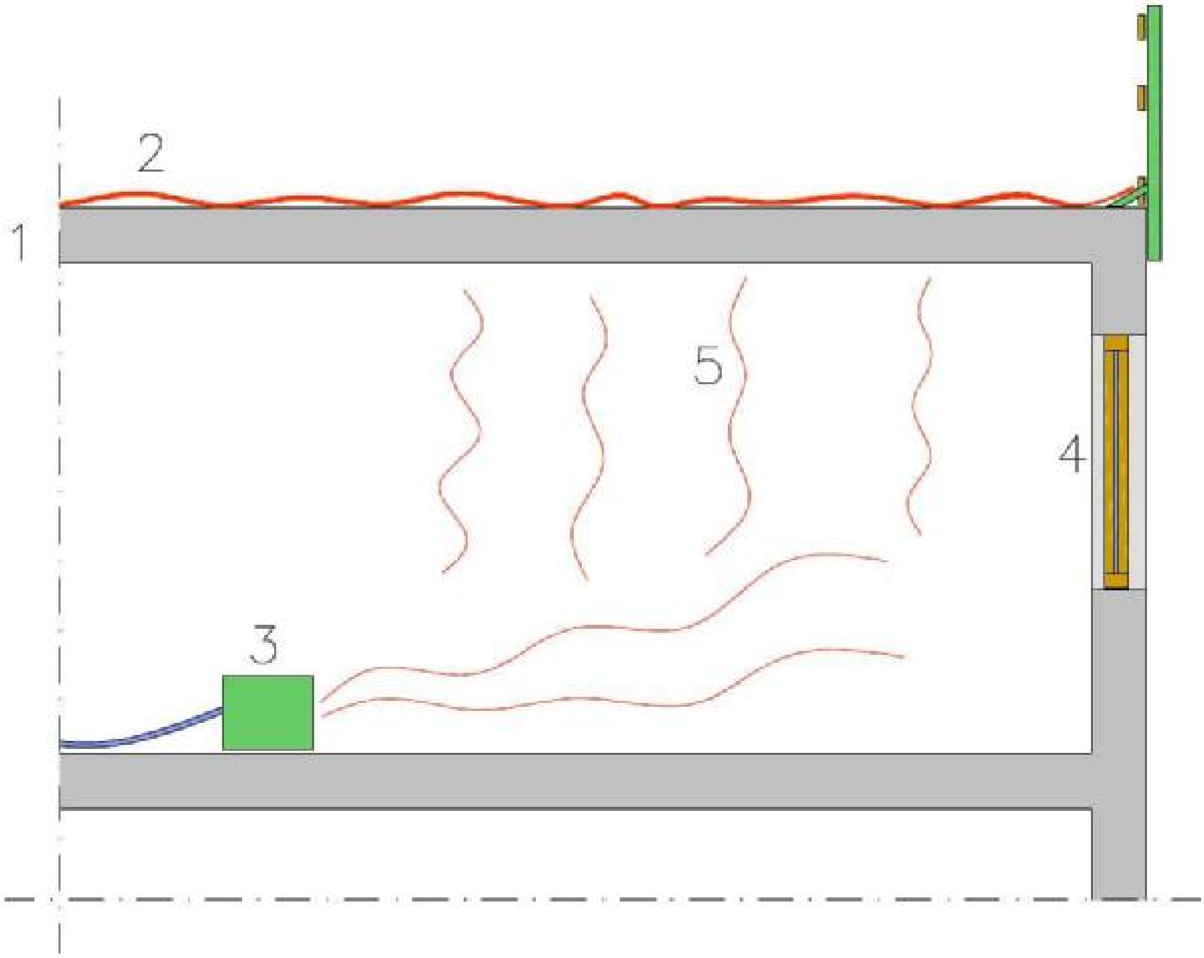


Img. 518, 519. Cast concrete slabs covered with blankets to keep the humidity and the heat

4.2. Temporary heating techniques for keep warm the inside of the building site

Another habitual technique in the building sites, is to use a heating system. The technique consists on the temporary heating of the inside space of the building. This heating uses to be applied on the last floor under the last slab that has been made.

This heat avoids the freezing of the water in fresh concrete of the just cast slab. It also avoids the freezing of the dampness that exists inside the building, and helps to the correct hardening and dried of concretes and other mixtures.



Schematic representation of the heating of the last cast concrete slab, where:

1. *The last made cast concrete slab*
2. *Thermal blankets cover the slab*
3. *Gas burning heater fan*
4. *Wood frames with plastics, closes the façade openings*
5. *The heat produced is spread in the inside space and rises to the slab*

To achieve the warming of the building, all the front hollows must be closed, with wood frames closed with plastic. This avoids the exiting of the building heat.

To produce the heat there are used different types of heaters. Those that there was in the building site was a gas burner with a fan that helps to distribute the heat. Also are used gas burning infrared heaters.

Img. 520. Stock of frames

Img. 521. Hollows of window and door closed with plastic

Img. 522. Gas burning heater fans

Img. 523. This is a gas burning infrared heater

4.3. Surveying works

Another more advanced technique to the conventional methods in the Spanish construction is the way of drawing the main lines of the plans on the floors. The technique I will explain here is made by a surveyor with a total station.

This work is realized by specialized workers. The equipment of work in the building site consists on, a total station, a radiolink remote control to handle, and a prism. The technician manipulates the remote control and the prism. The total station is automatically orientated towards the remote control. The total station machine moves by itself, turning and changing its inclination to be automatically orientated always towards the remote control.

Img. 524.
The surveyor and his total station equipment

Img. 525.
Placing the prism

The marking process is approximately this one:

- The data of the plans is introduced into the topographic machines before of starting the marking works.

- The surveyor, chooses what point is going to place, and indicates it to the total station trough the remote control.

- Then, he goes to the approximately place where he thinks the point will be, and places the prism on the floor.

- The total station finds the correct place for the point, and trough the remote control, indicates to the surveyor where he has to move the prism to reach the correct place of the point.

- Once the point is located by the prism, the surveyor marks it. It can be marked directly on the floor surface, or in some cases, the surveyor fixes a small wood sheet on the floor and marks the point on it.

With this technique are marked only the main points. The main lines of the floor, will be reached by making lines between these points.

Img. 526. Surveyor and the remote control of the total station with a radiolink

Img. 527. Surveyor placing the prism

Closing

I would like to talk about some personal impressions, before of to close this work. This will be about the contents of the work and about the things that I have leant by doing it.

At the beginning I was talk about the possibility of making a work about the Finish traditional construction. Something related with traditional wood houses or other more modern kind of timber buildings. That one, was the subject that other students of my university, developed during these last years, for their Final Thesis works in the Tampere Polytechnic.

When I arrived to Finland, I was talked about the possibility of visiting a building site of a modern residential building. It would mean to know the current construction methods in the Finish construction market. That way, we finally reject the idea of to talk about the traditional timber construction.

After some weeks visiting the building site, and despite some initial doubts about the subject of the work, it began to get its shape. It happened by analyzing one by one, the different construction systems of the Finish construction, that I had seen in the building site. The method I tried to follow was, to explain the systems, explain the reason for their use and to talk about their placing techniques in the building site. I think that this analyzing system, allowed me to know and understand these systems and also to get a different way of understand de construction process.

I think that the knowledge of these construction systems and techniques could be useful for my professional future, like a construction technician. Despite some of these systems could not be used in the current Spanish construction, the knowledge of them, will allow me to analyze the technical problems with new points of view. Also in some cases, some systems could be interesting for the Spanish construction.

Finally I would like to talk about my personal impressions. I consider that doing my final thesis abroad, was a very interesting experience. It allowed me to know the daily live of a society different than mine. I had to face to live in a new place, have new responsibilities and I had the opportunity of meeting new people of different countries. I think also, that this kind of experiences I had, will help me in the future to face new challenges.

I would like to give some thanks before of finish this work. I want to say thanks to my teacher in Finland, Olli Kolkka. Thank you for the time you dedicated to me and for your patience with me. Thanks for my teacher in Valencia, Jose Ramón Albiol. His indications and encourage did not by missing during the developed of this work. And finally to my family, specially to my parents. They support me before and during this Erasmus period, and made it possible. And they support me, all along my studies, which end here with these lines.

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