

Treball de fi de màster

Títol:

To Introduce the Lean Management philosophy as a way of thinking and acting to minimize waste in planning, organization and implementation processes, focusing in basic building constructions.

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1.-INTRODUCTION:

This work focusses on the field of Management in Civil Engineering.

In this context, it has been considered very interesting to introduce the professional aspects of construction projects in higher educational level. In fact, issues introduced in this Final Master project could be applied in training of higher production, civil engineering projects and work plans also.

Therefore the purpose then is to introduce a type of management planning within the set of elements involved in the preparation of a project and its subsequent execution.

The aim is introducing a new working unit into the "CFGS Projectes d'Edificació" within Module 10 (*Design and construction of buildings*) and Unit 2 (*Formative Elements in construction processes and building*). The unit is called "Lean, Planning and Efficiency" and wants to explain the Lean philosophy, as this concept applies to the construction process in order to obtain Lean Constructions: a production management-based approach to project delivery. This is a new way to design and build that maximizes value and minimizes waste. The aim is to bring the students the feeling of working together as specialists from the very beginning of the project, making a Lean project themselves, and finally giving them tools for real collaboration and communication which optimize the project, not the pieces.

Usually in the building industry there is a problem in the design and work on a project for lack of a clear plan of action. The thing is that all the players carry out make their part of the project without a clear goal or methodology.

The Lean process looks for minimizing the work from the root, introducing a more effective method of planning.

We assume that some students have none or very little contact with the professional market, which will be favorable for introducing a completely new methodology and to keep building them open minded to this new challenge. This method is introduced in several classes divided into a theoretical and a practical part.

In the theoretical part we would expose methodology, first as a general philosophy and then as a tool for our labor market. To achieve this, several lectures with presentations of the methodology will be created.

2.-BACKGROUND AND PROBLEM DEFINITION:

2.1.-Description:

There is still a significant lack of efficiency while solving a project in a lot of offices today. This is due to several factors:

- Hierarchy among participants in the project development. We could say that in the preparation phase of the project in most cases there is a team of architects, engineers, draftsmen, designers, etc., and interaction among all professionals is what supposedly generates the complete project to build. But in the real world there are always, doubts, mistakes, hesitation, lack of definitions...

- The industry is most directly getting involved in the implementation phase. They have the budget and its objective is to build the building as defined in the project, but here we are usually slow and indefinite, we change continuously, reorganize, we lack time...

- Normally the structures of the building are in place, usually there is no previous idea of how to construct the elements prior to reaching the goal and join them, even the most simple elements tend to waste of time in the execution phase.

- A very general issue is to plan the work schedules, which is not usually real because committing to finish on a given date is a difficult responsibility indeed, therefore the constructors only agree on parts of the project

- Lack of coordination is also a problem in the different phases of the project, as the people involved don't usually work together. They come from different companies with completely different jobs and usually don't know each other until they meet in the construction process. Sometimes it seems they want to "sabotage" the other's work just to justify their own deficiencies.

Among other reasons, this is why this work is focused on the Lean process and its philosophy in the field of Professional Training.

2.2.-What is Lean?

Lean is a term that became popular in the 1980's and 1990's to encompass a number of approaches to managing manufacturing companies. It includes the emphasis on systems producing exactly what the customer wants at the lowest cost and with no waste. Many of the ideas were developed after the Second World War by Toyota. Their imperative was, and remains, increasing profitability in low or no-growth markets. The focus was on producing cars of the best quality, at the lowest cost and in the shortest time by means of the systematic elimination of waste. As Toyota developed so many of the ideas associated with lean, the term "Toyota Production System" of TPS is used synonymously.

"How Toyota and their suppliers work was studied and popularized in the West by the book "The Machine that Changed the World, a study of Japanese car makers by Professors Womack and Jones of Massachusetts Institute of Technology (MIT). Their original book was published in 1990, but many of the ideas had already been current in the manufacturing and service sectors in different forms. What Womack and Jones did was to package these ideas for a European and American market.

Lean means a kind of management and process. It is a new way of thinking, planning and deciding, based on the final product as a main objective and focused on everything that creates value by reducing as far as possible a long series of activities conducted in all business areas in the traditional world, and which involve a cost but do not add value to the ultimate goal."

**Bibliography: www.lean.org*

It is a different way to look at and act in pursuit of the errors, to give them a solution, rather than hide them, with simple but effective techniques. Another major feature of Lean is teamwork, so for normal operations for solving problems, hierarchies disappear; great value is given to personal initiative to achieve the ultimate goal.

The general principles of the Lean philosophy are:

- * Get the **best quality-first**, in a constant search for defect detection and troubleshooting in order to give them the solution from source.
- * Elimination of all activities that do not add value, **optimization of resources** (capital, people and space)
- * Continuous-improvement: **reducing costs**, improving quality, increasing productivity and sharing information.

* Creation and maintenance of partnerships in long term relationships with inter relations in the project, to become **more creative and efficient**.

* **Settle** when and where each activity is accurate, with the necessary resources.

The Lean philosophy was born from the detection of change in the contemporary world. We could say that the new problems brought the need to seek new solutions:

Traditional Situation	New situation
Expansion markets	More offer over the demand.
Restricted products	Big variety in products
Standard Products	High level of customization.
Quality: another factor.	Totally quality: precondition
Undemanding customers.	High standards for the customer.
Delivery installments not restricted.	Very short delivery installments.
Irrelevant after-sale service.	Relevant after-sale service
Long life cycle.	Short Life cycle, depending on fast changes.

*Bibliography: "Lean Management: La gestión competitiva"

2.3. – Why and How “to Lean” in Construction education?

The purpose is to generate a new Formation Unit for Professional Education in Unit 2 (*Formative Elements in construction processes and building*). The unit is called "Lean, Planning and Efficiency". To do that, a year schedule and a evaluation chart have been created. Nowadays this new unit is needed in our Professional Education.

The aim is to apply a new management model building by fitting all the processes from project development to final execution of the works. The way to do it is through introducing lectures and a final practical course which will make the student create a small project in the Lean context, from the beginning to the end.

The characteristics of the management model, the efficiency and competitiveness of the results obtained give us a stark contrast with the traditional model which can be measured. Lean is important in the process due to several operations that must be coordinated and properly chained.

We could also say that the Lean model is basically doing exclusively what is necessary to obtain the objective from the source, quantity, price and time. This is achieved by avoiding unnecessary activities as far as possible.

The Lean method is based on two fundamental elements:

1.-Elimination of waste: unnecessary processes that doesn't add value to the ultimate goal. This means that any activity that is not valued as useful is a waste and should be avoided. Thus, for example, the Lean method would not sell products at high prices because of transport, as this cost has nothing to do with the final product so it becomes a waste. Residues play a very important part in minimizing the cost.

2.-Flexibility is very important because Lean aims at making the project and the amount claimed in a timely manner. This requires a highly flexible system, because of the same waste disposal it bears.

So in all Lean processes, and more specifically in what we are referring to in our study we find some important concepts:

The **value** is to design and deliver the product or service the customer expects and wants exactly. This will be achieved by a thorough analysis of work that must contain the project, under which conditions and for which functions it has been designed.

The Flow value defines the set of processes that fix the flow value for the customer, quickly and directly. This will be achieved if the construction process is fitted to the participants in each phase, and implies the development of joint "Last Planner" (annex 1).

The Flow of activities defines the activities that make the processes present in the flow of value, striving to always provide value. Closely linked to the flow of value are the activities that give value to flow, mainly for its highly effective contribution to the project.

Pull: once we have the right product, flowing through the flow of correct value, using processes that consume unnecessary resources, we have carried out the corresponding activity, but only insofar as they have needed a real demand. That is, the flow of activities neither more nor less than those required by the specific project.

Continuous improvement: all values above should be added to the continuous improvement since the Lean method requires constantly improvement and solution to the obstacles found on the road, giving special attention to error detection and avoiding their repetition.

Those topics must seem simple at first sight, but they include all the main handicaps we usually find in our buildings.

2.3.1.- Unit Description:

The unit is called "Lean, Planning and Efficiency" and wants to explain the Lean philosophy, as this concept applies to the construction process in order to obtain Lean Constructions: a production management-based approach to project delivery.

Lean methodology applies to the higher level of Building Projects, particularly in Module 4 (Planning for construction) in the training module 2 (Project planning and construction). This application will last for 30 hours, 1/3 of the total of the training module.

NF1: Planning into Lean Process					
Teaching and Learning Activities			RA	Evaluation	
				CA	Evaluation tools
A1: Introduction to LEAN		3h	1,2,3		-It is an approach to general knowledge.
Description	Explanation of Lean concept and how to apply it into a construction process.				
A2: Concepts		3h	1,2,3		-It is an assessment of knowledge specific to the introduction of Lean
Description	Lean-analysis method in the				

	construction, explanation of evidence for and against the elements.			Construction, orally
A3.- Start and development	3h			-It is an oral evaluation once the contents have been exposed to the students.
Description	Lean-analysis method in the construction, explanation of evidence for and against the elements.	1,2,3		

NF2: Application of the method in a Lean project.				
Teaching and Learning Activities		RA	Evaluation	
			CA	Evaluation tools
A1.- Lean implement	3h	4,5,6		-Evaluation through a question about the possible shortcomings of the project.
Description	Detailed and thorough analysis of the project.			
A1.- Lean implement	3h	4,5,6		-It is an assessment on planes adapted to the original proposal after the student applies the Lean method.
Description	Adaptation of the project drafted in the Lean method.			
A1.- Lean implement	3h	4,5,6		-It is an assessment on planes adapted to the original proposal after the student applies the Lean method.
Description	Adaptation of the project being drafted in the Lean method.			

NF3: Application of the method in a Lean project.				
Teaching and Learning Activities		RA	Evaluation	
			CA	Evaluation tools
A1: Lean Development	4h	7,8		Evaluation of the planning progress of equipment (half part).
Description	Development of a complete Last Planner of the project. Focus on the equipment part			

A2: Lean Development		4h	7,8	Evaluation of the planning progress of side works (half part).
Description	Development of a complete Last Planner of the project. Focus on side works (pladur, paint, floor)			
A3: Lean Development		4h	7,8	Evaluation of the final plan presented.
Description	Development of a complete Last Planner of the project. Managing all the different building parts.			

As we can see in the chart, class participation is a very important part of the rate to evaluate, due to the "Last Planner" concept which needs to be analyzed deeply in order to get the best result.

2.3.2.-Unit evaluation:

Ratings	EVALUATION TOOLS						
	(CP) Class participation (30%)			(PE) Practical Exercises (70%)			
Learning	CP NF1	CP NF2	CP NF3	PE1	PE2	PE3	PE4
RA1	10%	10%	10%	Contents 20%	Solution 15%	Constructive Solutions 20%	Last Planner 15%

Learning outcomes and assessment criteria will be determined by:

- Identification of the development activities of construction projects, relating them to the phases and planning procedures.
- Determination of common work and procedures involved in designing a project, establishing its development over time.
- Collecting and analyzing relevant data for planning
- Decomposing the process into phases and relating them to different lengths.
- Analyzing methods of collaboration on the project with external equipment
- Assessing the effects and implications of their decisions regarding the project.
- Identifying activities to execute construction works, relating them to the phases and planning procedures.
- Relating the different activities to their duration.
- Preparing a box with the description of the activities, the participants, time and activities.
- Representing the relationship between activities.
- Use of ICT in collecting and processing data, pictures and prices of income.
- Identification of human resources for each of the planned activities.
- Elaborating programs for

project development, contracting and monitoring of work, setting goals and identifying the agents involved and the procedures. m) Identification of the project phases with the appropriate level of detail. n) Sequence of the stages required for the project. o) Identification of activities that can share resources. p) Identification of the teams involved and the expected return. q) Calculating a network of sources to process daily, with one representing the "Last Planner" and solving its duration. l) Identifying the causes of problems and proposing solutions to solve them. m) Tracking planning.

3.-APPLY LEAN MANAGEMENT:

3.1.-Development of the theoretical part:

3.1.1.- Introduction:

A Lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

To accomplish this, lean thinking changes the focus of management from optimizing separate technologies, assets, and vertical departments to optimizing the flow of products and services through entire value streams that flow horizontally across technologies, assets, and departments to customers.

Eliminating waste along entire value streams, instead of at isolated points, creates processes that need less human effort, less space, less capital, and less time to make products and services at far less cost and with many fewer defects, compared with traditional business systems. Companies are able to respond to changing customer desires with high variety, high quality, low cost, and with very fast throughput times. Also, information management becomes much simpler and more accurate.

The goal of Lean in the construction and what makes it effective is the reduction of time. This is proved in practice but we'll start to explain what the method is based on. The key to successful implementation of the Lean methodology is to find the problem, so that's what we are going to do first. We could say that the current problems in construction are:

Information on most projects is not complete.

The preparation time is too short.

The detailed planning is not included, neither is the schedule of deliveries.

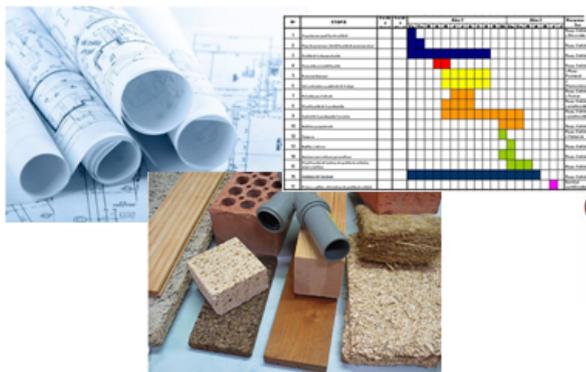
Prefabrication does not run all the work

Deliveries are not provided "Just In Time"

No collaboration / partnership between the client, the designers and manufacturers.

Current projects are not executed in the estimated time, really run in a term than had previously been established.

Solutions of prefabrication and preassembly are not found in our buildings.



3.1.2.- How to apply Lean:

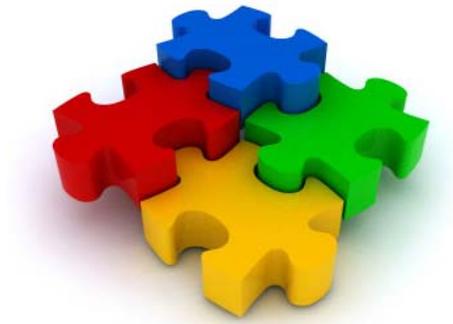
The goal of Lean is thus to reduce time, increase quality and reduce cost, to achieve more favorable results; We need to achieve the four most important assertions:

A) Creating a collaborative agreement with the contractor, knowing the final quality standards and encouraging their growth, which benefits both parts.

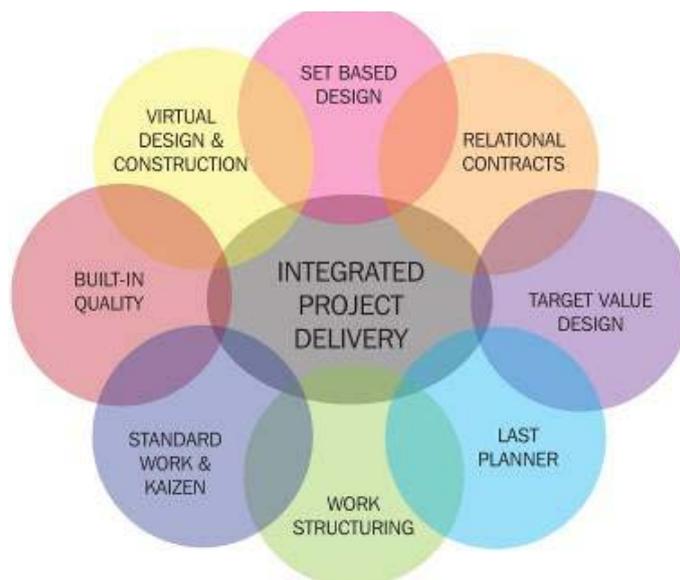
B) Planning: Project planning is done jointly with the contractor and its subcontractors for the joint undertaking. Creating a detailed planning "day by day". The ultimate goal is that all subcontractors know exactly what and when work should be done every day.

C) Preparation of material and external ACOP: Preparation of all the materials needed for building in a warehouse of the external contractor. Everything needed everyday has to be prepared. This also avoids the generation of waste in the workplace.

D) Prefabrication: Some material may be fabricated prior to their placement in the workplace in order to reduce time and waste. Today most of the information is not complete in the projects and the preparation time is just too much. Usually the plans that are developed are quite general and do not include delivery date. They are very poorly defined.



How can we get a new way of working?



*Bibliography: "Lean Management: La gestión competitiva"

Joining and making more effective all necessary resources make cooperation, collaboration and real facts a need to establish project delivery.

Creating and working hand in hand with a team made out of architects, engineers, contractors and specialists from the beginning of the project.

The members of this team should be selected based on experience, technical knowledge and skills to communicate and work together in collaboration with other members. Engineers / architects and contractors and selected specialists should also be part also of the team that will prepare the project delivery work.

3.1.3.- Achievements:

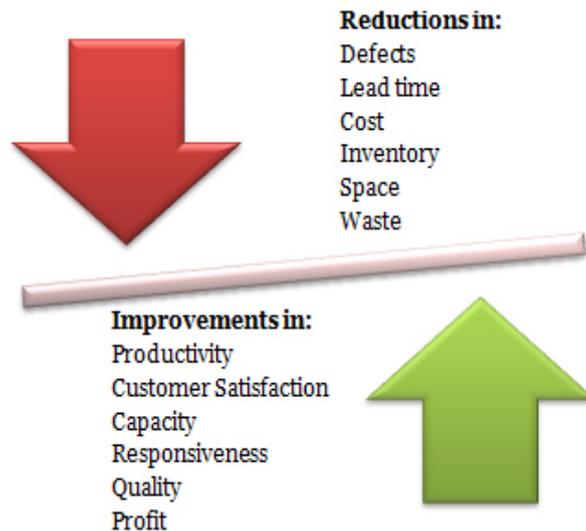
Our goal is the elimination of useless contributions or so-called "junk". To get that we need to:

- Filter and sort.....ORGANIZER
- Steady.....ORDER
- Shining.....CLEANING
- Standardize.....PREFABRICATION
- Maintaining.....SELF DISCIPLINE



*Bibliography: "Lean Management: La gestión competitiva"

Reducing Defects, Costs, Decision Time, Inventories and garbage area, we improve:
Productivity, Capacity, Responsibilities, Qualities and Benefits.



**Bibliography: "Lean Management: La gestión competitiva"*

3.2.- Development of the practical part.

Having explained the theory, we are going to study Lean process in the classroom. From a small project for a local business, for which we run the plans, memory and measurements, we will consider this project to transform it into method Lean. This will include thorough use of the tool of the "Last Planner", such as the prefabrication of elements and the preparation of the project of delivery.

There will be three groups in each classroom with the same information; they should be put in the roles of different heads in the Lean real process, to achieve the purpose of executing the project in the shortest time possible.

The goal of this practice is that students go through all steps for each role (arquitect, engineer, plumber... before building. To practice this, they must have some advanced knowledge on construction and its facilities.

The most important part is to make the contents learnt become the practical part of the course. In this practical part. The theoretical concepts will be mixed so as to become practice.

In order to properly deal with the practice raised during the whole course of transformation and development of a basic project for a Lean project has to properly be dealt with and to this end, students will have to prepare:

- 1.-Maps (Floor, sections and facilities).
- 2.-Report.
- 3.-Study of Safety and Health.
- 4.-Measurements.

Once you have all the material, students must carry out two main activities that will result in a third one called Lean Planning Project.

A: Application of Lean: Detailed analysis of the project:

Students will become familiar with an existent project of a simple commercial construction. In this phase must be already grouped to analyze the project in detail. In this first phase they must demonstrate that they have full knowledge of the project assigned. At this stage, with the Lean method explained but not yet dealt with, they should start thinking about possible shortages in the future which could become a problem

B: Application of Lean: Adaptation of the project drafted in the Lean method.

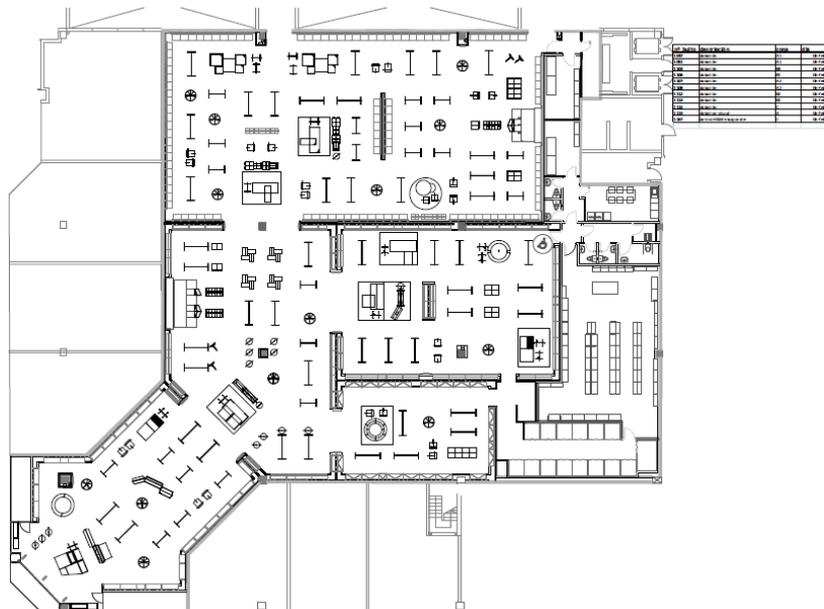
Students at this stage, and again in groups, will have to adapt the plans to draft a set of plans in Lean executables. This is the most important application of the methodology because from there the students begin to think about the project as a possible lean project. The most important part of this phase are the facilities. As they will have been explained in the theoretical part, those will be the first ones to be divided into phases establishing the all the levels, is fragmenting all existing facilities in phases in order to mount them when executing the work.

This is the hardest part of the course but will also undoubtedly be the most rewarding one for the student, because here is where they will learn how to think about facilities in terms of design rules and then plan their fitting in an efficient manner.

Some example for "Preparation of project plans adapted to Lean":

Ex1: Practical Exercise 1 : First of all, students have basic layout plans.

"You have to organize the store in phases to be built as quickly as possible, including the division of the main facilities of water, air conditioning, fire protection and electricity"



C: Application of Lean: Preparation of a complete planning project "Last Planner"

In this phase the students break up groups and work with the whole class. The objective of this phase is to bring together all the knowledge learned so far. To make the activity more realistic and rewarding each student is given a role in the planning Lean. Depending on the number of students in each class they will be assigned individually or in groups.

The essential roles that will have to make the most careful planning will be: Architect, Engineer, Builder (New Work), installer of air conditioning, Fire Protection Installer, Electricity, Plumbing and Sanitation, metalwork and carpentry (doors and furniture).



After making groups, the "Last Planner" explained in the theoretical phase, the students will consider their role and start work. Taking into account the most important thing in "Last Planner: " Who you know? / How?/ Where? /What? To properly draw the Last Planner, each participant must commit to work paying attention to these questions.

Using a template that will hang in each class considering the division that was made in earlier phases will bring in the planning (*annex 1*) Thus the debate at this stage will be how many people are really necessary, what stage of the work and so on?

The result of the Last Planner is the result of applying the Lean methodology in construction. Once garbage has been removed, all the time used will be really necessary. All decisions must be taken prior to starting work

4.- CONCLUSIONS:

The main objective of introducing the methodology is to reach the practical project of Lean. Students must turn a small project for a local business in the Lean methodology. The student work have to be based on premises that have been exposed into Lean class to minimize the time and get the planning goal. They should make a thorough analysis of the project and all its elements, the industrial materials, installations... in order to unconsciously generate a deep understanding of a work and its facilities before build it.

So we could say that the main objectives of introducing the Lean methodology in the Profesional Education is closely linked to various competencies that are already part of the methodology. Those objectives are:

- a) Prepare for team members to work together with each other, discuss the details well before the execution of work.
- b) Fix sequence and all questions that in ordinary work would be difficult to solve.
- c) Allow team test different options to improve workflow, and create capacity for work time reduction.
- d) Identifying details of the design that are not clear.
- e) Build commitment on planning among all team members and reduce the overall planning program time.
- f) Build confidence, commitment and sense of team, leaving behind hierarchies and positions.

For the methodology to be truly applicable, there must be particular interest and knowledge in the preparation of the Last Planner fairly specialized knowledge of the facilities.

Given that this method is thought especially for introducing students to generate discussion and provoke the search for solutions taking into account the adjustment of time and effectiveness. The Lean method is giving us very high analyzing context as we saw in the explanation of the practice.

Students not only develop a plan that usually traditional methods such as Gant diagram should got. Lean method want the student to go further and really make a comprehensive analysis of the project, sectioning it, thinking of it, with the premise of time as a primary objective.

This peculiarity is the fact that why I consider this as a final project because I think this will really work and this type of construction, with this students, and at the end to get more efficient and sustainable construction.

It also gives us tools for evaluating and measure students knowledge in many other ways. With the Lean method students are required to optimize their project from design and production planning untill building it.

Another important contribution of the proposal is the fact of the possible prefabrication of various elements of the project and precast standards are considered. Students should consider the different parts of the project to be prefabricated before assembly on site. This part of the course provides real and effective solutions in construction.

The goal is introducing a methodology that professionalize students. It was intended from the beginning and gives tools for further learning of a real building, forced them to think how to make that, the project exhaustively which brings them a very professional support for the future.

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