Curso 2013-14

Trabajo Fin de Grado de la posible implantación de Last Planner System con Bybanen Utbygging AS en su proyecto “Bergen Light Rail - Workshop and Administration Building”

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PREFACE

This study has been a very important and rewarding experience. It has allowed me to grow up as a professional from research and delve in the Lean world, as much in the application of this in real case.

Being able to participate and know the hidden aspects of the construction of the workshop and administration building that form part of the huge project of Light Rail in Bergen, it has been one of the privileges I have enjoyed during this project elaboration.

It has allowed me to improve my knowledge and to compare the different techniques of project management used by the implicated parts in the project. Besides learning to utilize a great amount of tools and means that until the moment I did not have knowledge. Tools have helped me to carry out the study of the possible Last Planner System implementation.

One of the most important things I obtained from developing this of has been the learning of one of the control process methodology.

To achieve this I have had to apply all knowledge that I have developed during this five years of studies. Allowing me in addition, I learn to analysis, study, deduce and work with larger agility and professionalism in the future.

For all of these reasons, I would to thank the people who have helped me to obtain it:

- To my parents, because without them I would not be who I am.

- To Fernando Cerveró for his unconditional support and his excellent help.

- To Manu García for being always "ready for action" with a big smile.

- To Lluís Segarra and Felix Mesa for being always there.

- To Bybanen Utbygging, with special thanks to Martin Halvorsen.

- To Høgskolen I Bergen, with special thanks to Arve Leiknes.

SUMMARY

This research pursues to analyze the planned activities compliance regarding to the reality and understand the causes of non-compliance. Later, the fundamental reasons of why the Last Planner System implantation can be helped to obtain better results in the planning and compliance of it in the construction projects will be showed. The Last Planner System is a method based in Lean construction which makes possible the workflow control and the continuous learning in the construction projects. The participating agents, with this method, get a higher awareness of what is happening during the construction process of a certain project.

The construction of the workshop and administration building belonging to the new area that forms part of the third section in the huge project of the Light Rail in Bergen will be studied particularly. This project has already a management system which will be tested. In this way, the project Plan Percent Complete will be studied, over an estimated term of twelve weeks that the study last.

Finally, the Last Planner System implementation in this real project will be discussed, and the corrective actions found in this method will be presented, and will be fused with the already existent, and that will help to obtain better results.

RESUMEN

Este estudio persigue analizar el cumplimiento de las actividades planificadas respecto a la realidad y entender las causas de los incumplimientos. Más tarde, se mostraran las razones fundamentales de porque la implementación de Last Planner System puede ayudar a obtener mejor resultado en la planificación y cumplimiento de esta en los proyectos de construcción. Last planner systems es un método basado en la filosofía de Lean construcción, el cual posibilita el control del flujo de trabajo y el aprendizaje continuo durante los proyectos de construcción. Con este método se llega a alcanzar una mayor conciencia por parte de todos los agentes intervinientes de lo que pasa durante el transcurso del proceso constructivo de un proyecto determinado.

Se estudiara en concreto la construcción del taller y edifico de administración pertenecientes a la nueva área que forma parte de la tercera sección del gran proyecto del Tren Ligero en Bergen. Este proyecto ya cuenta con un sistema de gestión el cual va a ser puesto a prueba. De modo que se analizara el Porcentaje de Actividades Completadas del proyecto en un plazo estimado de doce semanas que durara el estudio.

Finalmente, se discutirá sobre la implementación de Last Planner System en este proyecto. Y se expondrán las medidas correctivas basadas en este método, que deberán fusionarse con las ya existentes, y que ayudaran a conseguir mejores resultados.

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS AND SYMBOLS

BU	Bybanen Utbygging AS
LPS	Last Planner System
WWP	Weekly Work Planning
PPC	Plan Percent Completed
IGLC	International Group for Lean Construction
EGLC	European Group of Lean Construction
*PAC	Porcentaje de Actividades Completadas

TABLE OF CONTENTS

1. INTRODUCTION

The present study pretends to examine the level of commitment and causes of non-compliance for the delays in the construction of the workshop and depot of the huge project of Light Rail in Bergen. In order to prevent possible delays in the construction before they happen.

One of the main issues for a project manager is to obtain the construction such as expected, avoiding out of the blue events. To get this, one of the most interesting methods is "Lean construction". It is a new point of view to understand the projects management, which develops the design and construction using Toyota's manufacturing principles applied to the construction process. And with one of the most widely used tools in lean construction, the last planner system.

For that reason, in this study the information from the chief contractor in charge of the construction is researched, and also his weekly planning and the causes of his delays (non-compliance). In order to analyse the commitment level of the contractor by way of the Plan Percent Complete calculation.

Therefore, through the Lean Construction philosophy it will be better understood what is happening in the project and the most frequent non-compliance reason will be detected. Thus applying Pareto's Principle most of the causes of non-compliance will be known and they should be attacked, in order to obtain the most efficient construction possible.

Finally, to understand the main reason of non-compliance in the Scheduling program is fundamental to present a methodology based in Lean Construction to improve the Plan Percent Complete, the Last Planner System. Exactly the perfect system to study the life cycle of the project and to improve the uncertainty, increasing the value of the product for the customer.

These kinds of research are very common, on account of the projects in the construction sector. It involves a lot of parts, and many problems can appear during the different phases of the project, altering the project efficiency, and also the cost, duration and quality, considering them all a loss. Then it is so important to take care of the projects planning.

1.1. MAIN GOAL

- The main goal of this research is to examine the level of commitment and causes of non-compliance for the delays in the construction of the workshop and depot of the huge project of Light Rail in Bergen. In order to prevent the possible delays in the construction before they happen.

- Understanding of the main reason of non-compliance in the Scheduling program. To present a methodology based in Lean Construction, the Last Planner System to improve the Plan Percent Complete (PPC).

1.2. SPECIFIC GOALS

- To detect the activities really executed of the activities planned.

- From the non-executed assignments,to obtain and analyze the causes of non-compliance.

- Theoretical and practical basis, prior concepts and the principal tools of Lean applied to the project.

- Proposal of implementation of the Last Planer System in a construction project.

- Proposing a methodology based on Lean philosophy to prevent the unexpected.

2. BYBANEN UTBYGGING AS

The first chapter is dedicated to the description of the company which cooperated with this thesis and to present the project to study.

FIGURE 1. BYBANEN UTBYGGING AS. [1]

2.1. ABOUT THE COMPANY

Bybanen Utbygging AS was created to provide a capable transportation system, the light rail, to the city and to expand to neighbouring municipalities in Bergen.

It is a public company in charge of the management of the huge project of Light Rail in Bergen. It is a division of Hordaland County Council with responsibility for planning, design and development. The planning subdivision of Bergen municipality will carry out the zone plan. [1]

BU has 60% of its employees internal, and the other 40% are external resources belonging to others companies associated.

The organizational structure employed by Bybanen Utbygging AS is called project organizational structure, which consists in the creation of an independent team for each project. [2] At the moment the company is performing five different projects into the huge project belonging to the third section of Light Rail. One of these is intended for the workshop and depot, and the four remaining for one of the different rail stretches. Of course, a specific working team has been assigned to each one.

In this kind of work structures, each project team is isolated from the parent organization. BU assigns certain resources for each project team that have their own management and technical staff. [2]

Especially the research is cooperating with the project team that is in charge of the construction of the new facility at Kokstad. This project team is formed by the project manager, the main constructor manager, the progress coordinator and the different construction managers. In particular the study is elaborated with the progress coordinator of the project.

2.2. BUSINESS AREAS OF BYBANEN UTBYGGING AS

[1] Bybanen Utbygging AS is accountable for the management, design and construction of the approved extensions to the system of Light Rail in Bergen. Hordaland fylkeskommune established Bybanen Utbygging AS to manage, operate and preserve its system´s infrastructure and to manage the vehicle fleet.

2.2.1. CONSTRUCTION. BERGEN LIGHT RAIL

The public transport system in Bergen, Bybanen Bergen Light Rail, is operating since 22nd June 2010. It is based on many similar systems which have been built with positive experiences during the past thirty years in Europe, Africa, Asia and North America. [1]

The Bergen Light Rail should be understood as both a physical construction and a dynamic element influencing many facets of the growth of the city of Bergen. It has become the sine of local area progress as well as the chief tool in Bergen's battle against air pollution. Without doubt, the design effort of the Bergen Light Rail pursues one clear target: to make public transport an attractive and realistic alternative to other means of transport. [3]

From the beginning in late 1970's when the first ideas were launched until the opening of the first stretch of the line in June 2010, the planning process of Bergen Light Railway has become an exceptionally long procedure. [3]

At the first moments the discussions were focused between road and rail, but finally the studies concluded that a light railway would be the correct choice, only a railway would have enough capacity for future passengers. Thereby the Bergen Light Rail is a mix of a tramway and a light rail line, driving in separate or priority lanes. [3]

The Bergen City Council decision of building a light-rail system was taken in 2000. The first section operates from Bergen city centre (Byparken) to the town centre of Nesttun. This section contains 15 stops in a length of 9.8 kilometres. [1]

In 2011 the second section was started with the construction to the shopping centre at Lagunen. The line was opened in 2013 and added approximately 3.6 kilometres with 5 more stops. [1]

FIGURE 2. LINE OF LIGHT RAIL BERGEN. [1]

To complete the line, a third section is being built now, which will connect the current rail from the city centre to the Bergen airport at Flesland. This research will focus specially in the workshop that this section will put into the system. Further, this 7 kilometre section will add 7 new stations. [1]

New extensions are now under planning to the northern and western areas of the city. [1]

FIGURE 3. THIRD SECTION OF THE LIGHT RAIL BERGEN. [1]

2.3. WORKSHOP AND DEPOT

In design and construction of light rail, as part of phase three a new workshop and depot between Bergen airport and Kokstad will be built in order to maintain a fully-developed rail network in Bergen. The research is going to settle down in this new area; especially the workshop and administration building are in it. [1]

The design of the new workshop and depot was carried out by Mott MacDonald Ireland Limited.

FIGURE 4. WORKSHOP AND DEPOT AT KOKSTAD. [1]

The site measures 110 000 m^2, of which approximately 80 000 m^2 will be used for workshop and depot.

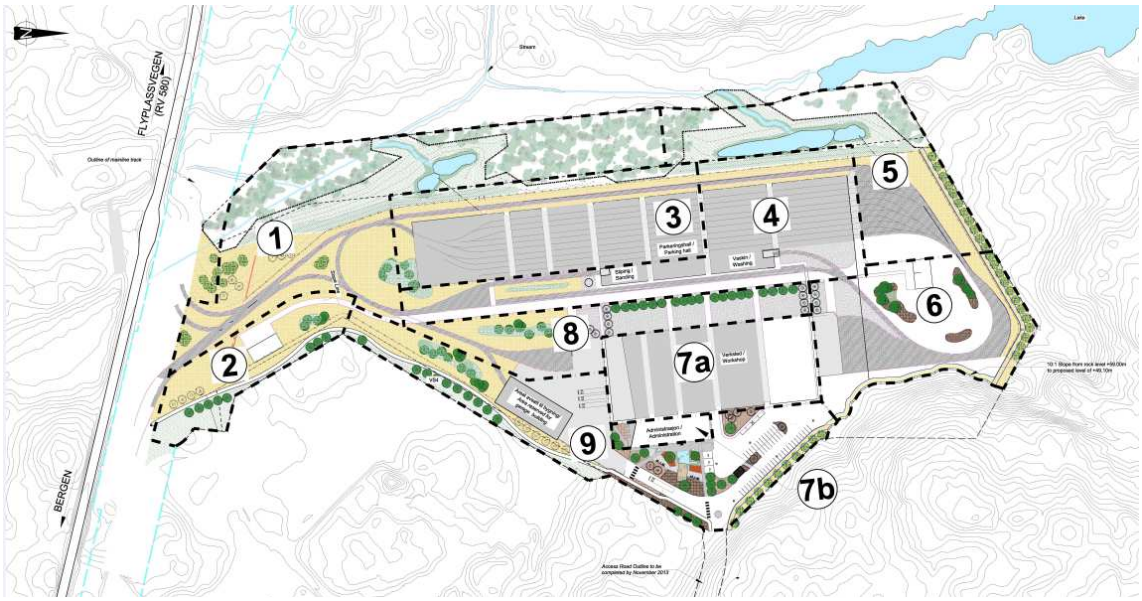

FIGURE 5. INDICATIVE CONSTRUCTION. [COMPANY DRAWING]

The current operating and maintenance facility at Kronstad will be partly replaced by this new facility. This will be home to 40 wagons. The new workshop and depot allow vehicles from 42 meter long from today's 32 meter long vehicles, broadening the vehicle passenger capacity considerably.

The workshop will be performed in phases, it is estimated that the construction of this area will finish at the end of 2015.

FIGURE 6. WORKSHOP AND ADMINISTRATION BUILDING. [1]

Workshop

The workshop is a building set aside for the repairing and cleaning of bybanen's vehicles, and has an area of 9800m^2. Most of the structure is of steel, although has some part with concrete walls and columns. The facade and the roof are made of sandwich panel with glass parts.

Administration building

The administration building is intended for skyss's offices, has an area of approximately $3000m^2$. It is a building with four floors. As the, it has most of the structure of steel but also has some parts of concrete. The facade is made of sandwich panel with glass parts but in the first floor has some wood panels. The roof is made of sandwich panels.

2.3.1. ORGANIZATION OF THE PROJECT

The organization of the project is very complex; given that there are many parts involved in the development of the project construction.

Hordaland fylkeskommune and Bergen kommunale bygg are the founders. These are departments of the government, institutes that command to build this project.

The area of the workshop and building administration is designed by Mott MacDonald Ireland Limited. It is an international consulting firm with over 14 000 employees. They are also in charge of the calculations of the technical facilities like the electricity, plumbing, ventilation, etc.

The project is led by the project management office Bybanen Utbygging AS as they are responsible for managing the huge project of Light Rail in Bergen. They decide the allocation of the main contractors and which contractor and architect get the work.

There is also a third party control company that is called Sweco AS, they check all the work that has been done by Mott MacDonald Ireland Limited and Multiconsult AS is doing the independent control of the entrepreneurs. There is a law in Norway, in which it is specified that all the construction work has to be checked by a third party control.

SKANSKA NORGE AS is the main contractor of the workshop and administration building. It is responsible for all structural deliveries and works related to the workshop and the administration building.

In this huge project, obviously, there are more contractors. But they are not important for this research and because of that, they are not mentioned.

2.3.2. ORGANIZATION CHART OF THE PROJECT

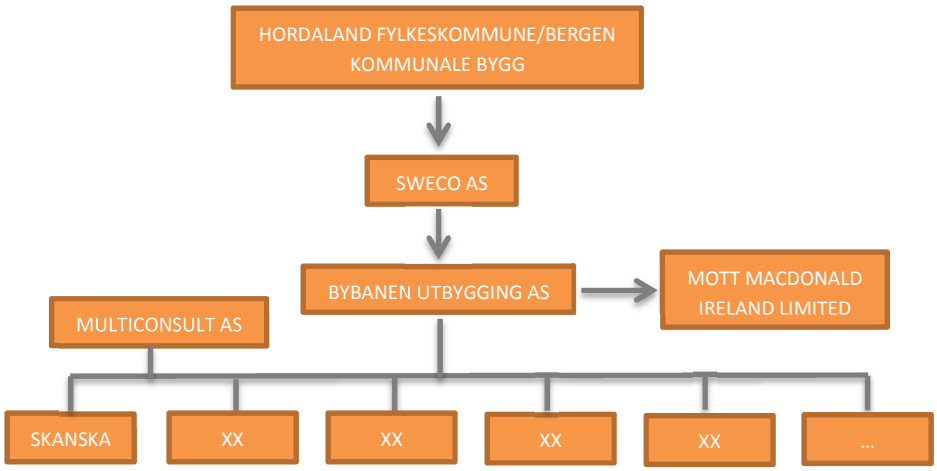

FIGURE 7. ORGANIZATION CHART OF THE PROJECT. [OWN COMPILATION]

2.3.3. ORGANIZATION ON THE CONSTRUCTION SITE

The project manager is the chief responsible person on the construction; he has the whole responsibility regarding the management and execution of a certain project. In other words, he is the person designated by the executing organization to reach the project goals.

The main constructor manager organizes all the work on the construction site and organizes the meetings with the sub-contractors. Also he coordinates the different constructor managers in charge of the parts of the site: constructor manager in structural work and proof building; constructor manager in exterior work; constructor manager in VSS; constructor manager in electro.

KU is the HSE-coordinator for execution on site. This is a role Bybanen Utbygging AS is responsible for. He is responsible to see that the production on site is done according to the Safety Health and Environment requirements in the project.

It exists another figure involved in the project and it is the progress coordinator, who directs and monitors the requirements, framework conditions and progress of short-term projects. He ensures the development of products and services according to customer requirements within the specified resources.

2.3.4. Organization Chart of Bybanen Utbygging AS on the construction site

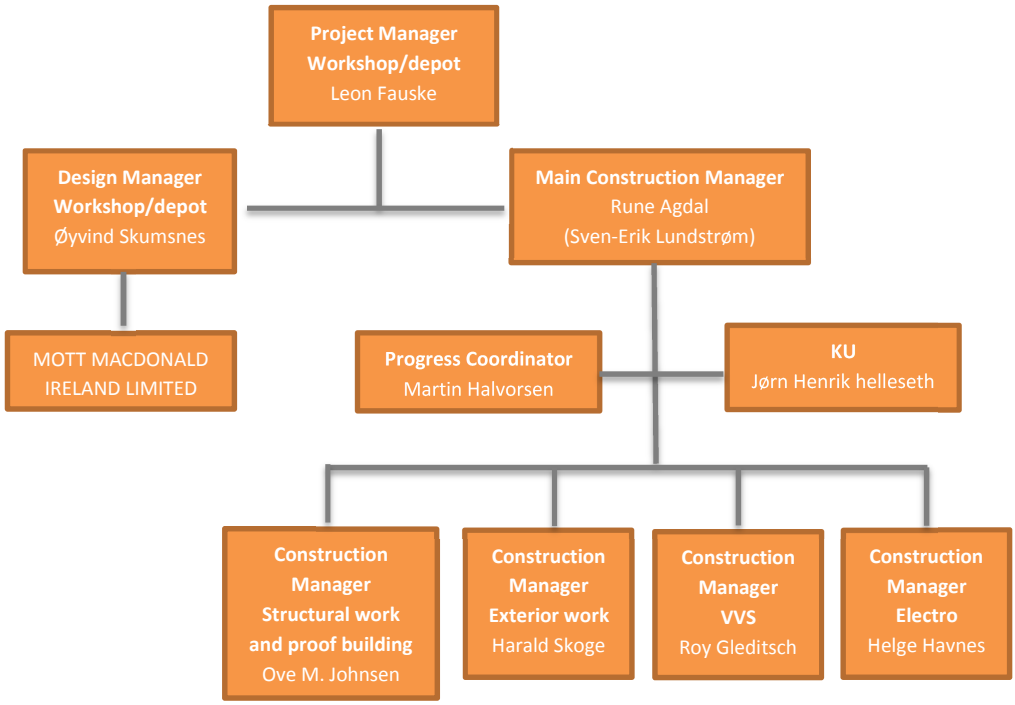

FIGURE 8. ORGANIZATION CHART OF BU ON THE CONSTRUCTION SITE. [OWN COMPILATION]

3. LEAN CONSTRUCTION. LAST PLANNER SYSTEM

To understand the main goal of this research it is necessary to know before what is Lean Construction based in and one of the most widely used tools in it, the last planner.

For this reason, the second chapter will give an overview of Lean Construction principles and knowledge, analysing fundamental aspects of this philosophy as theoretical base.

3.1. LEAN CONSTRUCTION

Lean Construction is a new point of view to understand the project management, based on management concepts of the Toyota production system. Lean develops the design and construction, applying the manufacturing principles to the construction process. Principles based on overspend reduction and adding value to the system customer [4]. Understanding the customer like all the participants involved in the process.

3.1.1. HISTORY

Toyota Motor's, the Japanese automobile factory, was founded in 1918. The principal idea in the Toyota production system is the abolition of inventories and other waste across small lot production, reduced set-up times, semiautonomous machines, co-operation with suppliers, and other techniques. [5]

It was developed by Taiichi Ohno, based in the 'common sense', although he didn't have any previous knowledge concerning automobile manufacturing. Without preconceived ideas it was the fundamental instrument of the unfolding of 'JUST IN TIME' philosophy. [6]

The Japanese factory was characterized by its tendency to encourage a bigger multifunctionality. To accomplish that, he divided the automobile's assembly works in less parts that required fewer specialization of the labours. At the same time the rotation was substantially prominent, and most of the tasks were performed in teamwork, in contrast to the occidental factories which rewarded the individual work. [6]

These kinds of patterns on the way of working established the difference between Toyota and the large US car manufacturers, it was outperformed by three factors: quality cost and time to market; the study was made in the 1980's. [4]

The ideas were developed and strained in an extensive process of trial and error; the establishment of a theoretical background and the wider presentation of the approach was not seen as necessary. As a result, in the West the information and understanding of the new approach was limited until the beginning of the 1980's. [5]

A lot of researches and books were published during the 1980's, which investigated and explained the approach in more detail. [5] In particular, with the publishing of the book "Lean thinking" (Womack y Jones, 1996) the basic principles and tools usage in

the production system without wastes were largely spread in the manufacturing industry. [4]

In the beginning of the 1990's, the emerging mainstream approach was the new production philosophy. In America and Europe, at least partially, it was practiced by dominant manufacturing companies. [5]

The management requirements have been adapted to others sectors, like in the construction industry, generally called 'Lean Construction'. In 1992 Koskela set up the bases for the application of lean production in the construction, analysing the growing production. [4] Lean Construction was a term used in 1993 for the first time by the International Group for Lean Construction. [6] Subsequently, Koskela in 2000 introduced a new view of the production as flow of information or materials, with three main goals: cost reduction, saving time and increase of the value to the client. [5]

They were revolutionary changes, nevertheless adapted to the necessities, thanks to the continued learning that covered decades. [5]

Nowadays LEAN is being adopted all over the world in almost every diverse industry and service from mining to manufacturing, hospitals to hotels, governments to grocers and now construction. [5]

3.1.2. LEAN PHILOSOPHY

The term 'LEAN' was coined to describe the way Toyota Production System sought to steadily identify and eliminate waste. It is essentially a different system "of thinking respecting how humans work jointly to add value". [7]

Without a doubt the techniques to obtain the mentioned above are ground in the 14 principles of Toyota's model carried out in the book "The Toyota way". [8] In it, the system takes life thanks to the people in it: working, communicating, resolving issues, and growing together. [9]

[9] The 14 principles of Toyota's model:

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.

2. Create a continuous process flow to bring problems to the surface.

3. Use "pull" system to avoid overproduction.

4. Level out the workload (heijunka). (Work like the tortoise, not the hare.)

5. Build a culture of stopping to fix problems, to get quality right the first time.

6. Standardized tasks and processes are the foundation for continuous improvement and employee empowerment.

7. Use visual control so no problems are hidden.

8. Use only reliable, thoroughly tested technology that serves your people and processes.

9 Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.

10. Develop exceptional people and teams who follow your company's philosophy.

11. Respect your extended network of partners and suppliers by challenging them and helping them improve.

12. Go and see for yourself to thoroughly understand the situation (genchi genbutsu).

13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (nemawashi).

14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).

Lean has been applied in a huge number of sectors. To get it, it must be understood, that it must be applied the philosophy, not the Toyota's tools. Using the philosophy it will have to be created new specific tools depending on the sector or company. [8]

3.1.3. LEAN CONSTRUCTION

Lean construction takes under consideration the causes of many of the problems that limit construction efficiency, and focuses attention on the reduction of losses throughout the productive flow. [4]

Lean Construction focuses its efforts to generate value in the final product, with removing the waste. The first step is to eliminate the wastes during the construction project, all of which do not generate value to the product and therefore create losses. [8]

The construction industry is particularly peculiar, given that each construction is unique with different characteristics, in contrast with the manufacturing industry, in which the same product is repeated once and again. In the construction industry it leads to many problems associated with the management.

The construction is a traditional sector and despite this, it has been introducing techniques of projects planning, control tools, organization methodologies... making a revision of the project management something necessary. [6]

Traditionally the construction is considerated as an activity whole directing to one certain exit. [6] That conventional view of production is called conversion model, and its associated concepts of organization and management. [5] Materials, works, etc., are put into a "black box" and come out as new products.

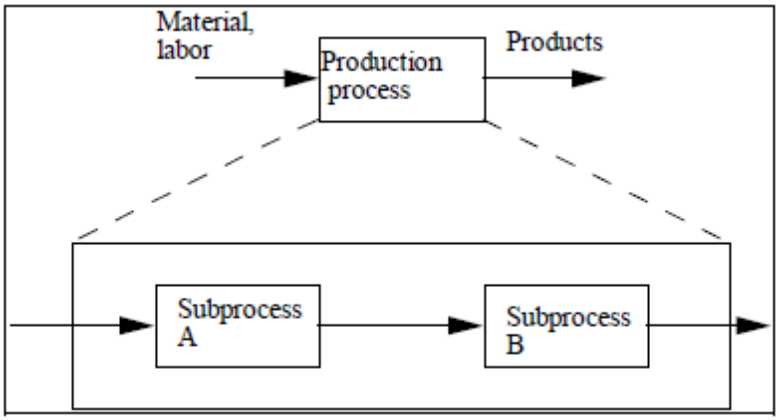

FIGURE 9. THE CONVENTIONAL VIEW OF A PRODUCTION PROCESS AS A CONVERSION PROCESS THAT CAN BE DIVIDED HIERARCHICALLY INTO SUBPROCESS. [5]

However, as employed to examine and manage productive operations, the conversion process model, is defrauding or even false. Because of this, it abstracts away physical flows between conversions; to the customer these activities are not required since they do not add value to the end product. These flows consist of moving, waiting and inspecting activities. [5]

The new production model, that Koskela proposed in his publication from 1992, can define the production as a flow of material and/or information from raw material to the end product. [5] In this flow, should be as a processes whole, where inspections can be introduced in each or the sub processes. [6]

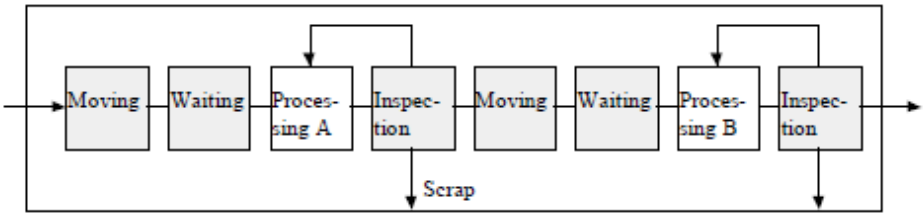

FIGURE 10. PRODUCTION AS A FLOW PROCESS: SIMPLISTIC ILLUSTRATION. THE SHADED BOXES REPRESENT NON VALUER-ADDING ACTIVITIES, IN CONTRAST TO VALUE-ADDING PROCESSING ACTIVITIES. [5]

In this way, an evolution has been produced, from progress in the construction phase, until reaching all the phases, the life cycle of the infrastructure, giving rise to the model “lean project delivery” (LPD). The mission of this model is to develop the best way to design and to build infrastructures. [4]

3.1.4. LAST PLANNER SYSTEM

One of the most widely used tools in lean construction is the last planner, inspired in Lean Production philosophy. This system just works in perfect surroundings of Lean culture. [8]

Foremost, the last planner system goal is to reach a continuous work flow and a decrease of the losses or tasks that contribute with no value. [6]

The last planner system suggests to modify the planning and control process in the construction with the purpose of creating a stable atmosphere in the job, protecting the production of the uncertain and the variability.

The LPS is focused in the execution period, concretely in the construction site. The last Planner System does not replace or compete with the traditional systems of planning, otherwise LPS complement and enriches to ameliorate the variability and the workflows. [10]

This system pretends to increase planning trustworthiness and consequently increment performance in the construction; to reach this, the system provides effective planning and control tools. The Last Planner System is specially designed to improve the control of the uncertainty in the sites; this is achieved by applying definite actions in the different planning levels. [10]

The utilization of LPS has allowed contractors to decrease the delivery time of a project, all the while it enables the contractors to ameliorate the employment of their resources. By way of a series of planned conversations, meetings, LPS originates commitments between project participants. [7] Due to learning to keep and make these commitments, the work environment is stabilized. It is expected that these commitments are assumed by the Last planners, to do what SHOULD be done, insofar as is possible it CAN be done. [11]

3.1.4.1. CAN, SHOULD, WILL

Generally the most used way to plan is just considering the transformations, ignoring the flow activities, in contrast with what the Last Planner does. Transportations, waitings, inspections, etc. are flow activities and have value, duration and consume resources, but are not always planned. However, they constitute the biggest part of production time. Caused of it, the Last Planner System establishes a planning method that takes it into account and manages the flow.

The Last Planner System is based in a Pull system, where the planning is made from the back to the front. [8] One of the huge changes Last Planner introduces is the weekly planning, with the commitment between team members, the last planners, to complete their activities as scheduled and it is the foundation for the incremented predictability and reliability of work flow on a project utilizing LPS. It can be understood as a transformation mechanism of what SHOULD be done in what CAN be done. [7]

In contrast to it, the traditional management is a push system where the tasks are planned starting from the first one, and then moving forward to the next task as a consequence of the previous to accomplish deadlines. [8] The execution tasks are directly planned depending on what SHOULD be done, independently if it has enough resources to do it. In the next figure it shows how the work planning is performed keeping in mind the previous information and the projects goals, but the available resources are considered a posteriori. [6]

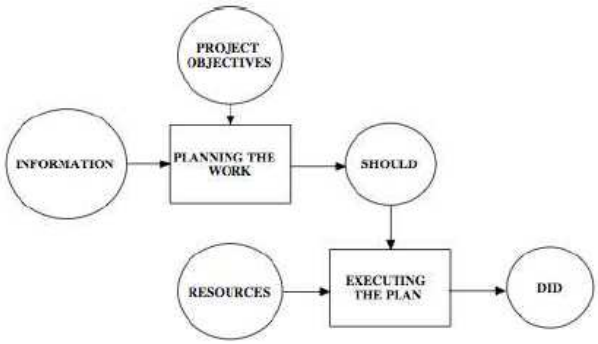

FIGURE 11. TRADITIONAL (PUSH) PLANNING SYSTEM. [12]

In the other way, the LPS makes planning of what SHOULD be done considering what it CAN be done according to the resources, prerequisites, etc. reaching what WILL be done, it will be exactly executable. In the following figure it is observed how the planning takes into account what is possible to execute before deciding what will be done.

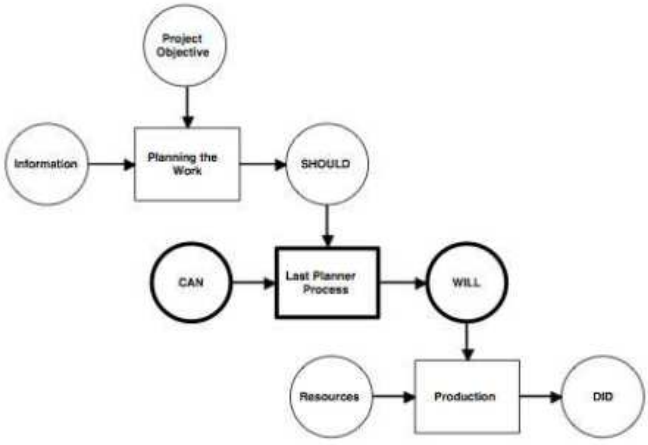

FIGURE 12. SYSTEM PULL.[12]

In the figure it can be seen, like in the traditional way, the interaction among the planning activities, where what CAN be done and WILL be done are two subset of SHOULD be done, caused by the plan (WILL be done) is developed without knowing what it can be done. [6]

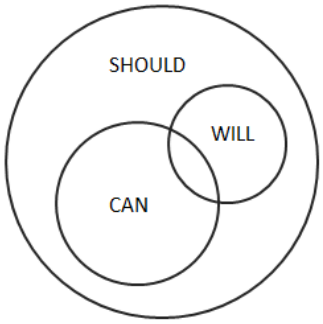

FIGURE 13. SHOULD-CAN-WILL. [13]

The aim of the Last Planner System is to generate a real planning, instead of an unreal and sometimes optimist planning. [8] To establish before what WILL be done is fundamental to have an appropriate knowledge about what CAN be done. In this way it is avoiding the activities to be stopped because some restrictions are not freed. The planning process should be principally focused in the management of what CAN be done, while the more it can be enlarged it, the greater the progress possibility will be. [11]

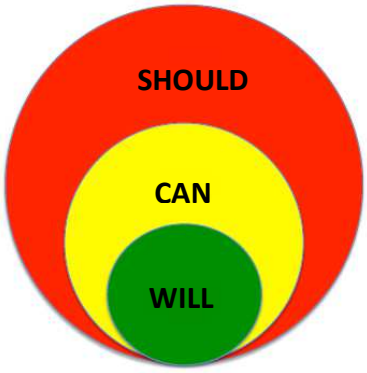

FIGURE 14. LPS. SHOULD-CAN-WILL. [13]

Regarding procedures, the system has two components: the production control and the work flow control. The first's work is to make better assignments to the workers, with the continuous learning and corrective actions. The work flow control function is to obtain the work flows actively through production units to reach easier objectives. [8]

The advantage of this system is that activities start when it is really necessary, getting to know in advance the possible problems that may arise amongst activities.

3.1.4.2. PREREQUISITE AND RESTRICTIONS

As mentioned above, the LPS's objective is reached to increase the work flow and that the planning is about the really work, and it is possible. For that it is necessary to define first what the meaning of prerequisites and restrictions is, and how these influence the planning.

The prerequisites are actions, states or activities that should take place before performing the tasks. These can depend on other agents or on the same production unit that is to execute the task. Until the prerequisites are "free", the task cannot be planned.

The constraint’s also impede the task execution. They can be: absence materials or workforce, design definition lack....

A constraints control mechanism is to make a list, in which it is reflected each of that is appeared during the planning process. The list will count on the restriction, the affected sector and task, which restriction it is, a short description, who is responsible for the liberation of it, in which date will be the liberation and finally the real date of the liberation.

3.1.4.3. THREE PLANNING LEVELS

To reach a real planning, the Last Planner System uses a waterfall planning in this; the planning process is divided in stages. This planning goes from the general to the specific, from the project idea until the execution in the real construction. From the main planning where the activities are general with long duration, the detail grows and reduces the duration, during the next levels, planning a medium term and a short term.

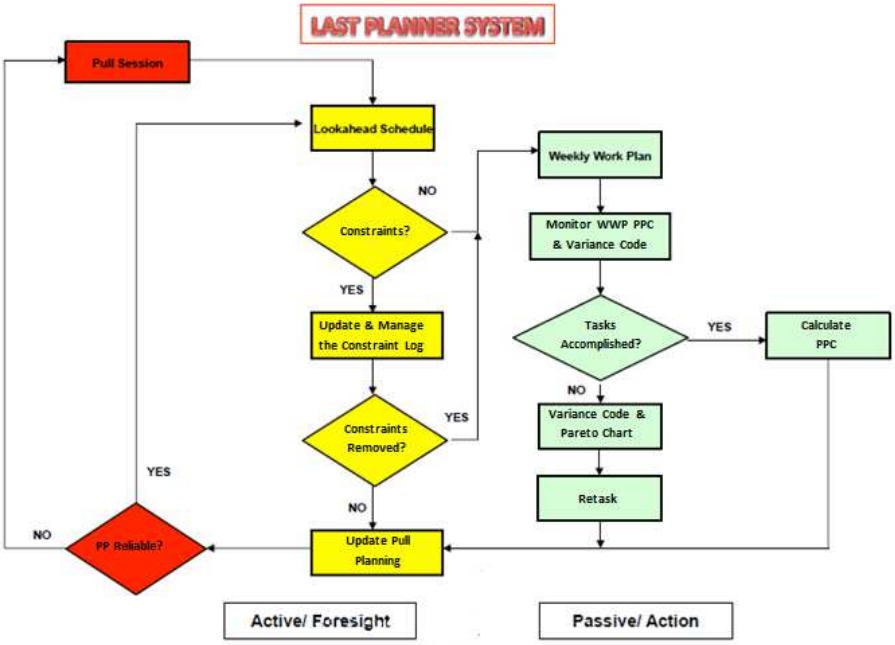

FIGURE 15. LPS PROCESS DURING THE IMPLEMENTATION. [12]

The planning for a long term indicates what SHOULD be done, the planning for a medium term or Lookahead prepares the work and carry out the restriction revision, allowing to know what CAN be done and the weekly planning programs activities series of which can be executed, committing all the participant of the planning compliance (what WILL be done). [8]

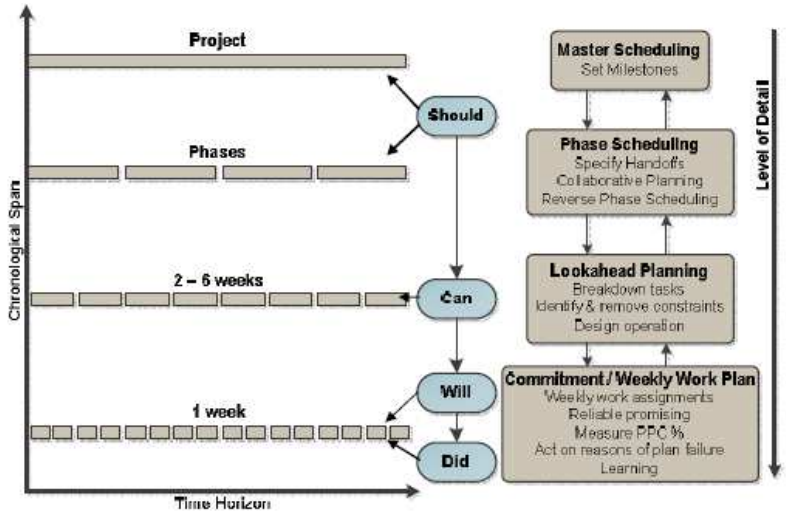

FIGURE 16.PLANNINSTAGES/LEVELS IN THE LAST PLANNER SYSTEM. MODIFIED FROM BALLARD, 2000. [13]

3.1.4.3.1. MASTER SCHEDULE

The master schedule is the initial planning, which define what SHOULD be done. It provides a general view of the project, which possesses few detail levels. It is describing the work to be carried out over the duration of the project; thereby the responsible for the project thinks that the work can be ended as planned. It identifies major milestone dates demanded by the customer or other causes; and add critical path method (CPM) logic to determine entire project duration. [8, 11] In this way, the Last Planner System can be applied and obtained the project execution in time and form. [6]

3.1.4.3.2. PHASES PLANNING: PULL SESSION

When the projects are huge and complex, there is another stage where a project team in a collaborative fashion prepares phases, pull plan, to display the essentials activities to conclude a phase of work and determine the best sequence to complete those activities. [7, 10]

It is called Pull Session, because the participants on it will be one agent of each company or specialist who works in the phase. [6] The master schedule of the project into logical phases, basing the actual time or durations of a phase on it. [10, 11] Hence, the phase scheduling creates a detailed schedule including each project phase.

The Pull Session results in a White Paper, board where once that are determined the phases and activities, post-its are used, one colour for each representative, to identify their commitments and necessities. The milestones are marked on it and the representatives will analyse the real possibilities to reach the terms and the necessities that can arise. [6] In this way, the schedule employs reverse phase scheduling, working from the phase end to the beginning, freeing activities for other team members. [11] Finally, the post-it configures a logic work network. It is possible to add more information in the post-it as task durations, resources, etc. The White Paper has contractial character. [6]

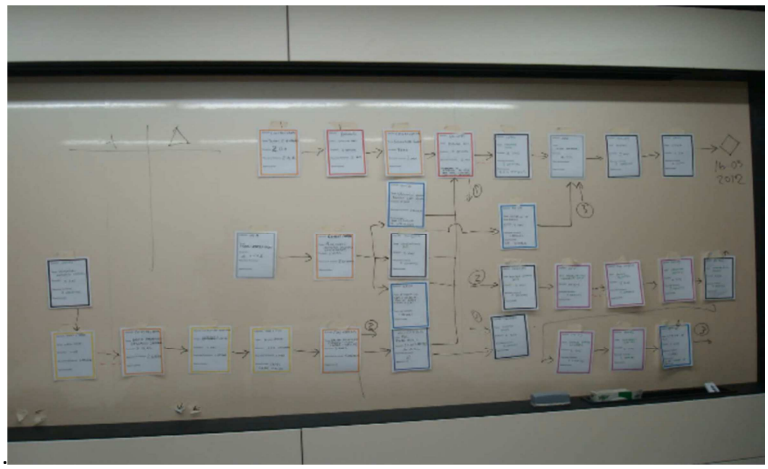

FIGURE 17. WHITE PAPER EXAMPLE. [16]

Pull Planning, thanks to its discussion and collaborative development, permits the agents to have ownership of the planning as well as supplying the most realistic

information as to the actual sequence and duration of the assignments on the schedule. [7]

3.1.4.3.3. Lookahead Program

Look-ahead planning is the first step of production planning with a medium time term, usually embracing among two to six weeks, determination of this period is according to the project necessities and characteristics, schedule system reliability, etc. [8,11]

At this stage, the activities included in certain definite interval of the master schedule are broken down into the level of processes/operations, constraints are identified, responsibilities are assigned and the necessary resources are computed. In other words Lookahead obtains activities combination in a definite term, and constrains group of each of this which demarcate if it is possible to execute the task or not. [6, 11]

After identifying each activity and what their constrains are, the assignments should subdue to a preparation process, in which it is proceeded to make an analysis of the constraints, to subsequently eliminate them, leaving the activity ready to be executed. [8]

3.1.4.3.4. Analysis constraints

Once the assignments or tasks are identified, some constraints are detected that do not work as shown on the Phase Pull Schedule that are required to start and complete tasks. The activities will be subdued to constraints analysis that may be of: design, previous work executed, space, equipment, etc; to eliminate them. [8, 11]

After the revision, a constraints log will be performed, where it will be reflected the state of request, the responsible to avoid it, and when it will be freed. [11]

TABLE 1. CONSTRAINT LOG. [11]

CONSTRAINT LOG										UPDATE DATE:	11-Aug-11	
PROJECT:			UT Arlington College Park									
PHASE:			Stage 1 & 2									
RESPONSIBLE INDIVIDUAL:												
CONST ID	CONST REF. #	Activity ID	ACTIVITY EFFECTED BY CONSTRAINT	CONSTRAINT DESCRIPTION	RFI #	CUSTOMER	STEWARD	PERFORMER	DATE IDENTIFIED BY CUSTOMER	DATE REQUIRED BY CUSTOMER	DATE PROMISED BY PERFORMER	DATE ACCEPTED BY CUSTOMER

3.1.4.3.5. WEEKLY WORK PLANNING

The system of Last Planer pretends to increase the quality in the weekly work that, combined with the medium term planning process, generates a workflow control. [8] The Weekly Work Plan exemplifies the most detailed plan in the system before executing some work, showing interdependence among the works. [11] It should be carried out by construction manager, foremen, site manager... and the rest of people in charge of supervising the work execution. [6]

The Weekly Work Plan is in charge of defining what WILL be done, during the entering week depending on the aims achieved in the ending week planning. [10] To elect the assignment that will be executed in the coming week from the knowledge of what CAN be executed is called "quality assignment". Just the "quality assignment" may be executed in the WWP, whereby the flow is protected of uncertainty. The Weekly Work Plan is effective when the assignments have these following quality criterions: definition, consistency, sequence, size, feedback or learning. [6]

For the realization of this planning it is convenient to ascertain a meeting, in which it is developed a first analysis work about compliance of last planning and a second work of planning to the coming week, with all of the components implicated in the execution (the last planners). In the first analyse of the compliance of last planning it is pretended to detect the non-compliance causes to adopt the measures necessary to correct the imbalances. [10] The production system and reliability of planning measurement will be made after the tasks have been reviewed at the end of each plan period. Analysing reasons for plan failures and acting on these reasons is used as the basis of learning and continuous improvement. [11] In the second analyse, as it was previously mentioned, the activities will be established, based on the results of the planning compliance of the prior week, on the expected in the medium term planning and on the existing constrains eliminated, always keeping in mind the work period executable. [10]

This weekly iterative process causes a feedback with the conclusions obtained from the weekly performance analysis that may introduce modification in the master schedule and in the look-ahead program. A basic facet of Lean Construction philosophy that reaches its maximum expression in the Last Planner System is the commitment of all participants in the construction execution. The commitment is reinforced with the public visibility of the weekly reached results. [10]

3.1.5. PLAN PERCENT COMPLETE

The LPS needs to measure how its system is working, the performance of each weekly working plan to estimate its quality. This measure that is the first step to learn from mistakes and implement improvements is realised through the Plan Percent Complete that is the number of assignments completed planning divided by the number of assignments made for the week.

EQUATION 1. PLAN PERCENT COMPLETE. [11]

$$Plan\ Percent\ Complete = \frac{number\ of\ completed\ tasks}{number\ of\ asigned\ tasks} \times 100$$

In this way, the PPC evaluates until where the LPS was able to plan ahead for the work that will be done next week, in other words it compares what will be done according to the weekly working plan with what really was done, reflecting the trustworthiness of the planning system that is directly related with the productivity. [8, 11] The causes of non-compliance are also researched weekly, in order to avoid them in a future. [10]

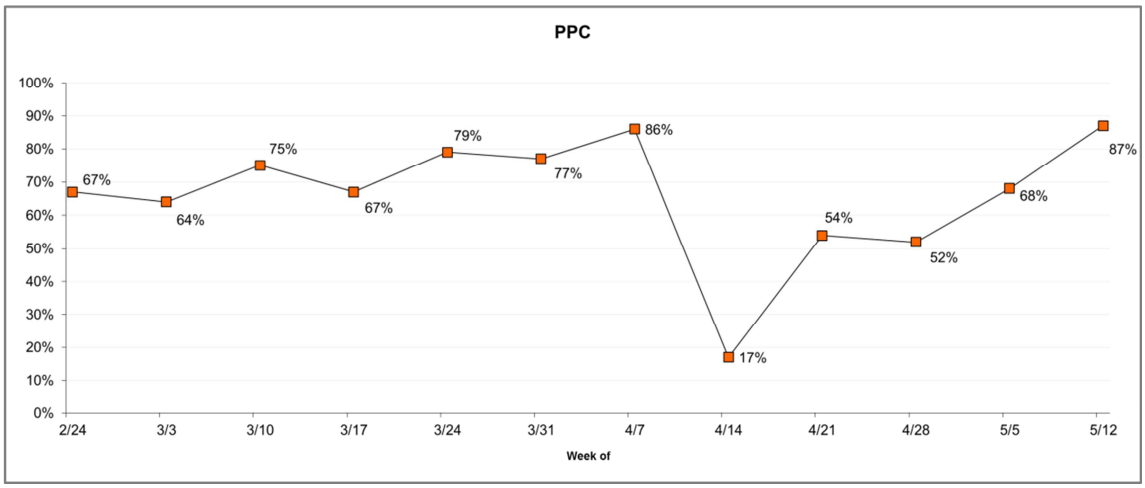

FIGURE 18. EXAMPLE GRAPH PPC. [OWN COMPILATION]

It is important to emphasize that PPC measures the planning compliance, does not the progress in the construction, it means how was the commitment adopted, correct or not, the constraints handling, etc. So the results are measured by binary way: 1 the adopted commitment is achieved and 0 if it was not reached. [6]

A good execution achievement is positioned above 80%; a poor achievement under 60%. In most cases the PPC will be less than 50% when a project starts to control the PPC that will grow to 80 or 90% as the team becomes conscious of the need to actually perform work as planned. Teams with broad experience in the system keep an achievement above 85%. [8, 11]

3.2. PARETO'S PRINCIPLE

[14] All problems have a great number of causes, so that it is not worth the effort isolating a few chief causes. There are many problems with no relevance facing a few serious. Thus Pareto's principle although counterintuitive, it affirms that a majority of the results, outputs or rewards, are usually in the minority of causes, inputs or efforts. It is located in the most representative elements, and just are controlled these, extrapolating the results to the rest of the other controllable elements to obtain the information needed. The 80/20 rule helps to reach much more, with much less effort.

Therefore for all practical effects, four-fifths of the effort are greatly irrelevant. This is opposite to what people generally expected. Usually it is tended to assume that 50% of the causes or inputs will record for 50% of the results or outputs, or it seems natural, eagerness that causes and results are for the most part equally balanced. Sometimes that is true, but it is inaccurate and harmful.

As a consequence, this study focuses in the 20% of more frequent causes that have appeared in the construction during the comprised period, considering that the elimination of these lead to resolve the 80% of the problems.

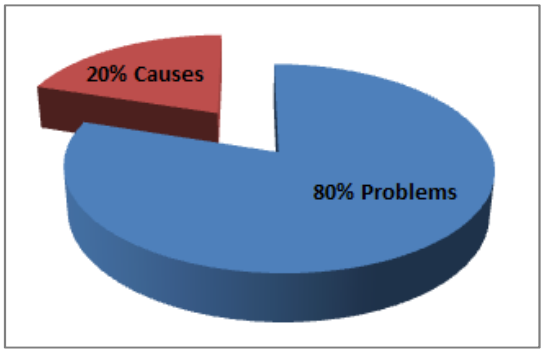

FIGURE 19. PARETO'S PRINCIPLE. [OWN COMPILATION]

Using the 80/20 principle our daily lives can be largely raised and the profitability and efficiency of any organization can be multiplied. It can even raise the quality and quantity while reducing the cost.

4. STUDIES ABOUT THE PLANNING

To study the effectiveness of the project management it is required to carry out a control of it. In this research, the control will be performed using the Last Planner methodology, which will be done by means of PPC inspections that, as explained previously, it consists in checking if the promises have been fulfilled or not, by the implicated Last Planners. The research will analyse the information obtained from the schedule in a term of twelve weeks.

This information will be selected through the Pareto's Principle, to deal with the truly important causes. Hence, knowing the causes that created the majority of the problems will help to focus, the efforts in solving these as a priority.

In this chapter, the control process of the project management will be developed, starting from the data collection until the analysis of them. It has been gathered information about the planning from the main contractor in this project, Skanska AS, so that its PPC can be calculated.

Throughout the period studied, two outsources of the chief contractor have participated in this phase, have been in charge of the execution some works: Bravida and Halvorsen Group. Thereby, their PPC will also be computed.

4.1. WAY OF MANAGE COMPANIES BY BYBANEN UTBYGGING AS

The management company of the project, BU, has installed a planning system and control method, where they established a series of meetings where they meet with the different participant agents in the project. Despite this, they keep the right to convene extraordinary meetings at their will.

They have two kinds of weekly meetings with distinct participants of the project. The first meeting is every Monday to coordinate the construction site, with the production managers of the contractors and the management company, BU. The second one is destined to the issues connected with the construction and it is every Tuesday. The participants in it are the BU, the design team, Mott MacDonald, and the project managers representing each contractor.

Also they have a third meeting every two weeks, with BU and the contractors to establish Time Plannings.

All of these meetings are essential to the good operation and coordination of the construction process.

4.2. MAIN CONTRACTOR PLANNING WAY

The main contractor of the Workshop and Administration building construction is being built at the moment at Krostad, Skanska AS. His planning system is based on the initial plan elaborated by the management company, BU, where the main contractual milestones of this project are reflected.

In such a way, he developed a first general plan in which the length and precedence of the activities according to the contractual milestones are established. This plan has been already recalculated, at the beginning of May, owing to the impossibility to compliance, moving the date for the first milestone.

The company counts on a second level plan that include three weeks' sight. It tends to bring up to date the majority of the weeks, but this does not happen invariably. There are some weeks missed. In the updates, the activities that could not be executed are reallocated.

Lastly, the contractor has a meeting every Friday with his workers where they plan the work for the next week. Hence, to a certain extent, the verification of the work compliance is produced at these meetings.

These three levels of planning can be similar to the three levels of the Last Planner System. But these are developed just by the main contractor and not by all of the participants of the project as The LPS defends, by means of collaboration.

4.3. COMMON CAUSES OF NON-COMPLIANCE BY LAST PLANNER SYSTEM

Based in the Last Planner System it is presented a list of the most usual causes for delays, non-compliance, these happen in the building works:

1. Contracts/CO's
2. Preparatory works – others
3. Preparatory works – owns
4. Information or available data
5. Design /design team clarification
6. Personal availability
7. Materials availability
8. Owner protocol
9. Acceptance conditions
10. Timetable/sequence
11. Incorrect time estimation
12. Request not included in the project
13. Climatology
14. Public administration technician
15. Owner decision
16. Unexpected event

The causes of non-compliance that form the list were fixed with a Lean Construction expert, Fernando Cerveró Romero.

This list is what has been provided to the contractor so that he can detect and choose the reason of non-compliance of the activities in his planning. The data gathered from him, will be processed with Pareto's Principle; it focuses in the inspection of the most habitual.

4.4. INFORMATION OBTAINED FROM PLANNING

For the data collection from the main contractor, an excel document is carried out where the activities of each week are reflected. That document is elaborated from the planning made by the contractor that includes three weeks. The plan activities for the entering week are extracted from the updates the contractor does each week. However, there are some weeks that the contractor does not prepare the updates, consequently the activities are extracted from the last updating. That

happens in week fifteen (07.04.2014), seventeen (21.04.2014), nineteen (05.05.2014) and twenty (12.05.2014).

The document tries to simulate thus the work that would be made for WWP of Last Planner, but without the created commitments by the agents that are generated when they promised to execute a definite number of activities that they can really do.

The contractor assumes the commitment to fill in, at the end of the week, the document created with the week assignments, specifying if the tasks have been done or not and choosing one of the prior causes for the non-compliance of those activities which have not been done.

These are data that will be used later to compute the PPC, knowing in that way if the planning of this construction is productive or not.

Furthermore, it is important to mention that the contractor executes assignments during the week that are not referred to in his planning if this is possible. It is called the workable backlog. Even though the completed work of this activities does not compute for the PPC calculation. By this reason, they are not taken into account in this research that studies the plan trustworthiness.

4.4.1. FREQUENT CAUSES

Despite the Last Planner System lays down sixteen common causes of non-compliance, it does not mean that they all appear in a certain construction process. Thereby, after analysing the information facilitated by the contractor, about the causes of non-compliance of his plan, it is observed that in the time period researched, seven out of the sixteen common causes introduced by Last Planner have occurred in the construction.

- Preparatory works – owns
- Information or available data
- Design /design team clarification
- Personal availability
- Materials availability
- Timetable/sequence
- Unexpected event

Not all of the non-compliance causes have happened in the same amount of times. This is an important point to keep in mind, since when it comes to reach the construction efficiency, such as the Pareto's Principle established, it should intervene in the most frequent.

In the next figure, the difference among the frequent of each non-compliance can be perceived.

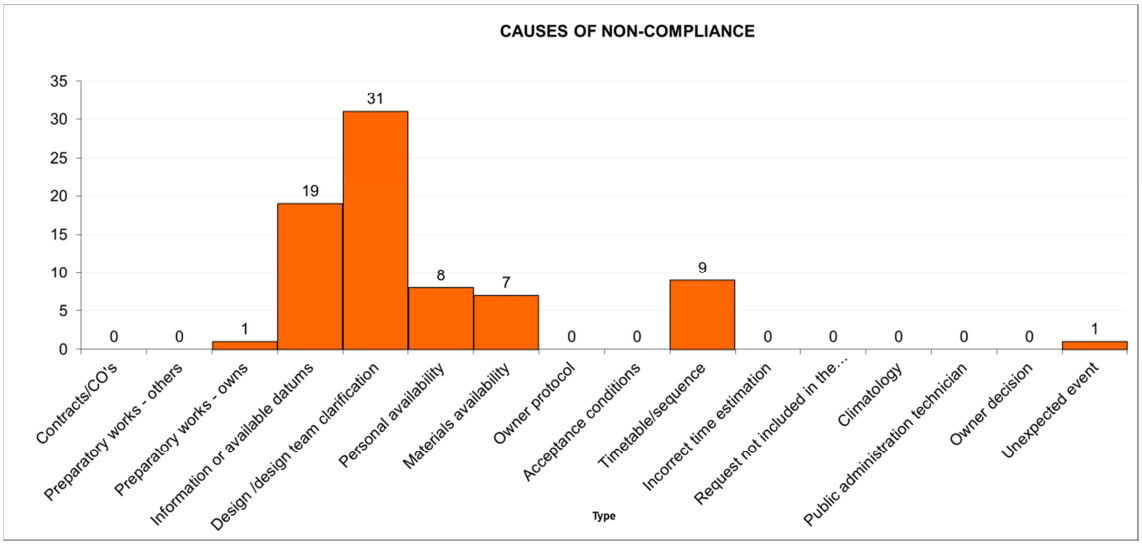

FIGURE 20. GRAPH OF CAUSES OF NON-COMPLIANCE. [OWN COMPILATION]

To examine the non-compliance graph is essential; it will provide a clear view of what the main problems in the execution are. Also it allows to detect which are the more frequent causes, and consequently measures to palliate the problems can be taken.

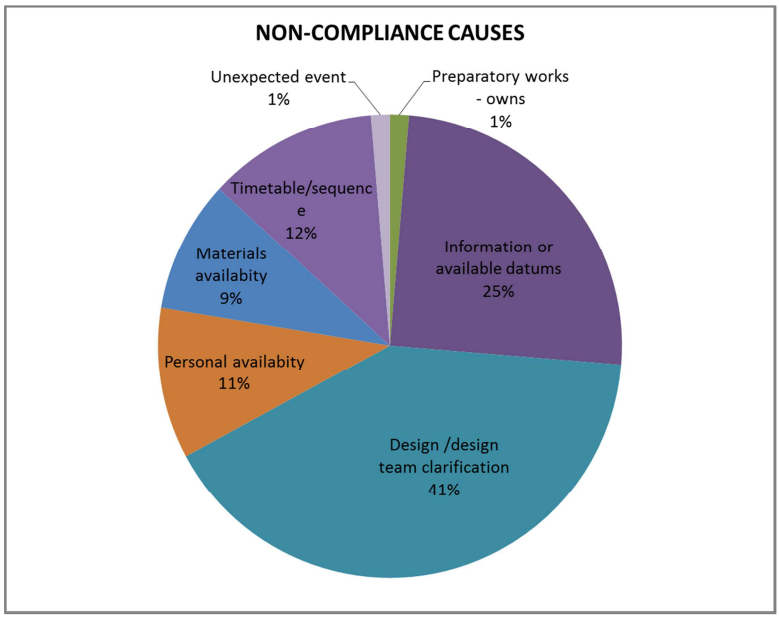

FIGURE 21. GRAPH OF NON-COMPLIANCE CAUSES. [OWN COMPILATION]

Following Pareto's principle, which defends, as mentioned before, that the 20% of the causes originate the 80% of the problems, it is deduced that avoiding the 20% of the non-compliance causes, will resolve the 80% of the problems that happen in the construction. Specifically in this project the 20% of the causes belong to: "Information or available data" and "Design /design team clarification".

In the Figure 21, the causes belonging to the 20% established by Pareto are represented in orange. The two most common are marked, because they are 20% of the seven. The rest are depicted in grey.

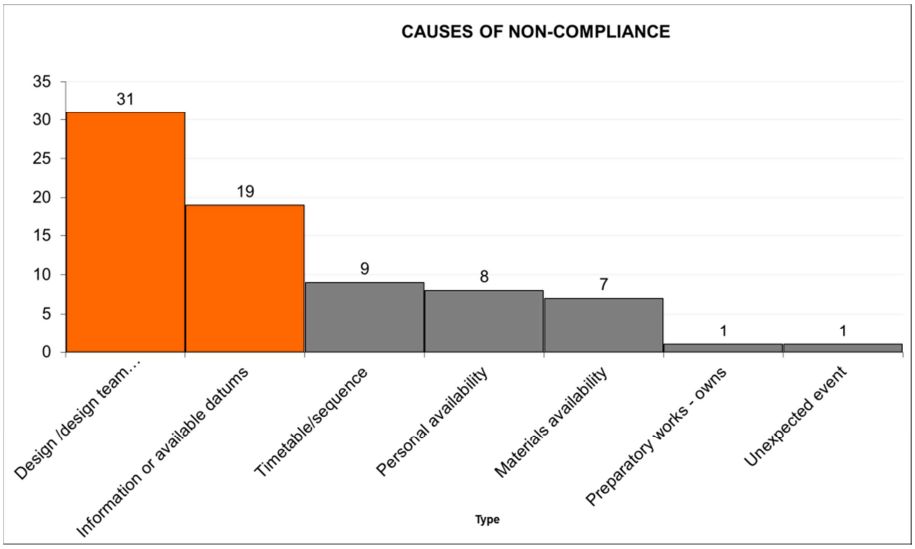

FIGURE 22. GRAPH APPLYING PARETO'S PRINCIPLE. [OWN COMPILATION]

Such a way, focusing in the effort to solve the constraints that bring about these non-compliance causes (orange), will provide a predictable schedule.

4.5. CALCULATION PLAN PERCENT COMPLETE

Such as it was exposed beforehand, the Plan Percent Complete of the construction measures if the activity's execution has been followed according to the established plan to each week or not, in other words, it measures how the system is working, the performance of each weekly plan to estimate its quality. Hence, it is also about checking if the promises realized by the Last Planners at the beginning of the week, have been really achieved during the course of it.

Below it is exposed an example of how the PPC of the first study week is calculated, week 9 (24/02/2014-28/02/2014), across the collected information by the contractor.

EXAMPLE of PPC for week 9 (24/02/2014-28/02/2014:

TABLE 2. WEEKLY WORK PLAN. WEEK 9. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 67%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			24-feb-14				PPC ANALYSIS	
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?	LEARNING
					2/24	2/25	2/26	2/27	2/28	3/1	3/2	YES / NO/CAT.	NON-COMPLETION
			Excavation for pumping waste water pipe										
			Excavation for wastewater pumping station										
			Gravel / leveling point for foundations axis 6.4 / KV (workshop)										
			Gravel / leveling of strip foundations (workshop)										
			Excavation for the foundation to the mountain axis 14-15/EE-HH, 16-17/EE-HH										
			Excavation for the foundation to the mountain axis 16-17/AA										
			Excavation for objection stormwater axis 1-1a/KL									4	Information or available datums
			Installation of pump wire to wastewater pumping station									5	Desing /desing team clarification
			Casting anchor plate for waste water pumping station									4	Information or available datums
			Lean for rock bolts office										
			Drilling for rock bolts									10	Timetable/sequence
			Prefab reinforcement foundation F3 and F4 (workshop)										

EQUATION 2. EXAMPLE CALCULATION PPC. [OWN COMPILATION]

$$Plan\ Percent\ Complete = \frac{number\ of\ completed\ tasks}{number\ of\ asigned\ tasks} \cdot 100 = \frac{8}{12} \cdot 100 = 67\%$$

The PPC is represented in a cumulative graph, where the scheduling compliance is represented weekly. It is developed one chart for each project, building work, in which the percentage per week are reflected.

Especially the graph of PPC for this project, it is created with several data that were collected each week from 24/02/2014 through 16/05/2014, the term that covers twelve weeks is the next:

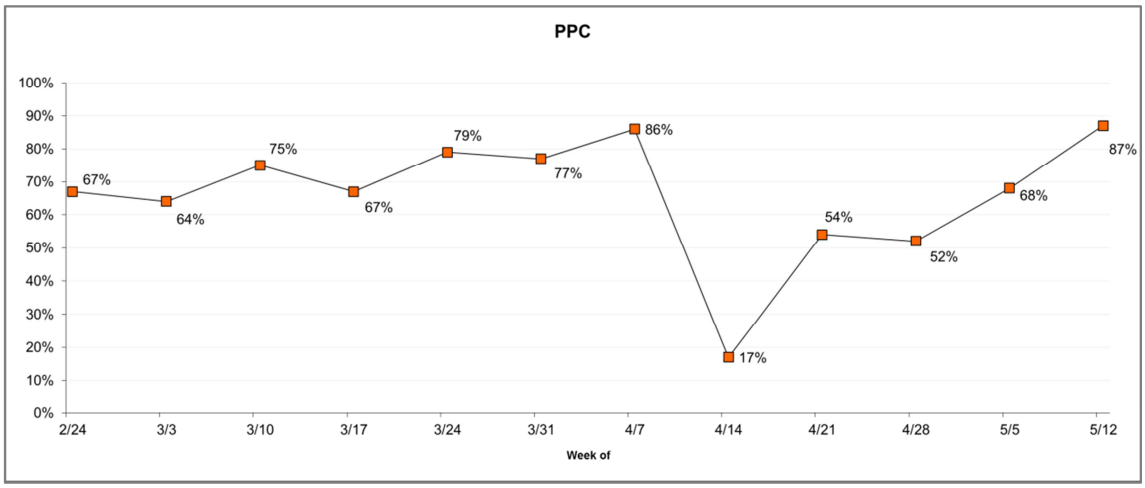

FIGURE 23. PLAN PERCENT COMPLETE OF THE PROJECT. [OWN COMPILATION]

It can be observed that the PPC of the full project is very variable. In most of the cases it is found a PPC relatively high above 60%. However, sometimes, as the case of the week sixteen, corresponding with the Easter holidays, the PPC falls until 17%. Affecting even the PPC of the two subsequent weeks that the PPC borders a 50%. In this data it is reflected a large instability in the project at planning level of the project. Give that the PPC changes in a rank of 70%.

Also it has been proceeded to make a chart of each of the outsources PPC are in the moment of the period studied in the construction site in charge of the construction of workshop and building administration, including one for Skanska, chief contractor.

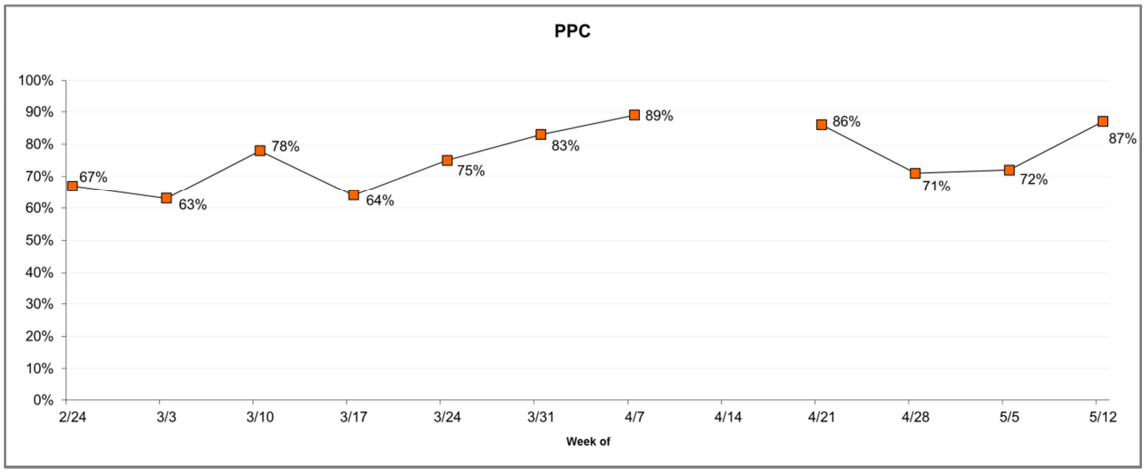

FIGURE 24. PLAN PERCENT COMPLETE OF CHIEF CONSTRACTOR. [OWN COMPILATION]

The chief constructor of the project gives highs PPC, always above 60%, arriving to reach a 90% in the fifteenth week. This is owing to the planning system that is developed by the company, as disclosed above, that allows to make a correct planning of their works, reaching a high amount of commitments.

Figure 24 corresponding to outsource A, it is in charge of the earthworks.

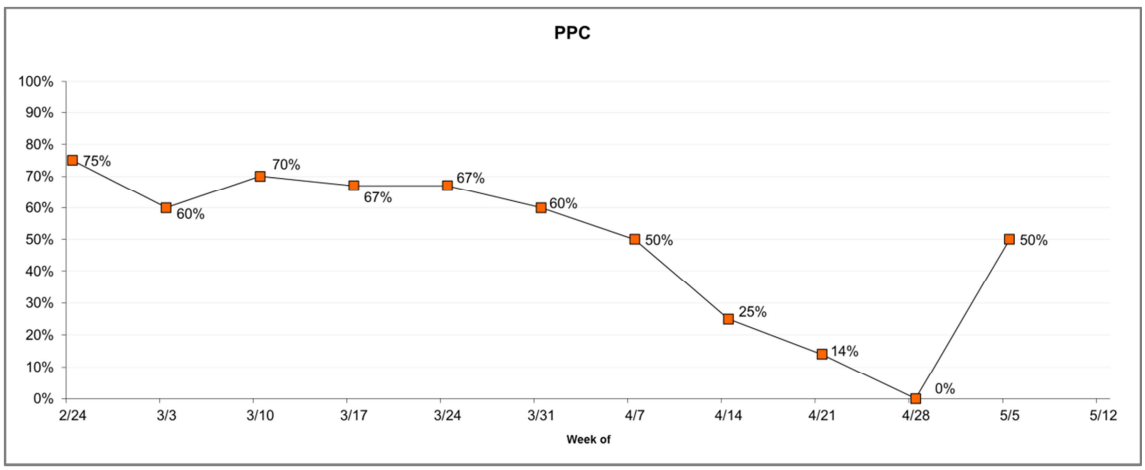

FIGURE 25. PLAN PERCENT COMPLETE OUTSOURCE A. [OWN COMPILATION]

The outsource A, has a variable PPC. Its PPC fluctuates between 0% and 75%, with a low PPC average of 48, 9%.

Figure 26, belonging to outsource B, it is assigned for plumbing works.

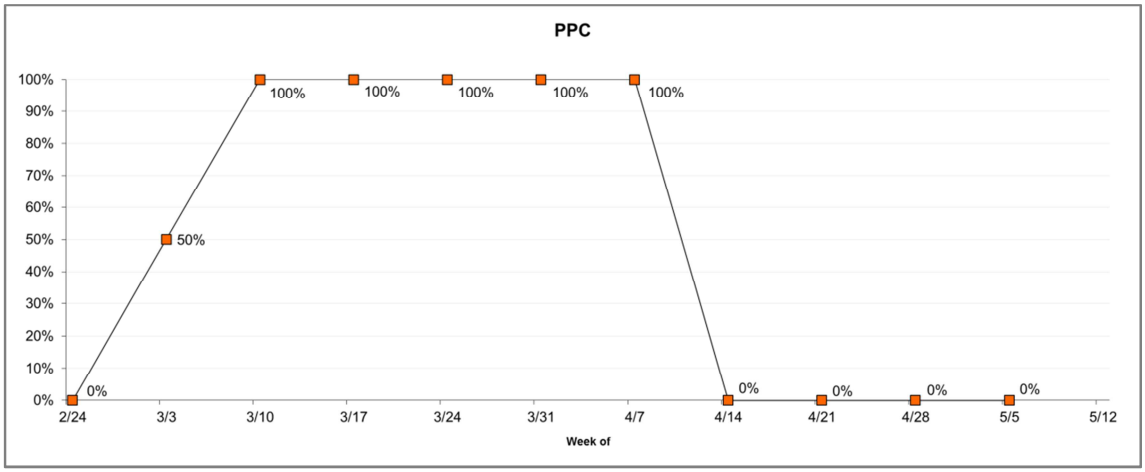

FIGURE 26. PLAN PERCENT COMPLETE OUTSOUCE B. [OWN COMPILATION]

The outsourcer B, has a high commitment, although during four weeks consecutive, it cannot carry out their assignments because of external problems of him. The PPC average is 50%, due to that five of the weeks is reached a 100% and five a 0% and a week a 50%. It is observed that the outsource B is which suffers the biggest variability in their PPC.

Particularly in this building work it is found a quite high and acceptable PPC, though not all of the weeks the PPC is very variable. But there is no doubt that by means of the use of the Last Planner System methodology the PPC could be increased. Now that, it is carrying out a process control more complete and only the freed activities are planning to be executed, thus it should not exist non-compliances. Thereby when the PPC is controlled, this will be enlarged until 80% or 90%. Reaching with these good results in the construction process.

4.6. MAIN DELAYS ON THE PROJECT.

The non-compliance in the contractor schedule sometimes does not affect to the normal course of the construction or to the main planning. Since the activities are not part of the critical path and the non-compliance does not lead to delays in the next assignments, therefore does not produce changes in the planning. Nevertheless normally, most of the times this suppose hold-ups, causing that the dead line of the construction has to be postponed.

In this project, the non-compliance of the planned activities has caused the building works to be delayed, whereby the finalization date of the works of this phase has been moved one month and a half later from the 23/10/2014 to the 16/12/2014. This means exactly a delay of 38 days so far. Due to this, the contractor has been forced to rebuild his planning with these consequences.

As it has already been mentioned previously, most of the times, the causes that have originated that the activities cannot be executed are: "Information or available datum" and "Design /design team clarification".

In the case of "Design /design team clarification", the replay of it has gone to such extent that in the sixteenth week, just one activity could be executed and it reached to be the unique cause of non-compliance during two consecutive weeks, sixteenth and seventeenth week.

On one hand, it has been, as a result of the construction works that had been started before that the project design is totally completed, and it still exists parts that have not been designed. Hence the design team has not been able to deliver the requisite information to the contractor. On the other hand, the hold-up in the information for the contractor from the design team is owing to that the information should be accepted first by: BU, the final users and the administration.

5. CONCLUDING REMARKS

The real implementation of the Last Planner System based in the construction of the Workshop and Administration building that are being built at the moment at Krostad and form part and complement the huge project of Light Rail in Bergen is physically impossible. This is due to the fact that the company that is in charge of the management of this project, BU, has their own techniques and tools to manage the project. And the project has already started.

Although what is viable for this project is to analyze the effectiveness of the present construction management, and to explain how using the LPS would increase that.

In spite of having studied the Plan Percent Complete from the chief contractor, the Last Planner System implementation should be performed by the BU, since the company is in charge of the project management of this project.

As it has been observed the materialization of this project has a high PPC, symptom that the planning is as expected at least in most of the cases, however that does not proof anything about the construction real progress. Nevertheless the main contractor see himself forced to plan again all of the left over works of this phase, four months later from the beginning of them, with a delay of one month and a half more or less of the forecast date.

Thereby in this chapter it will be discussed about the advantages of Last Planner System implementation, and how it would improve the construction with LPS.

5.1. HOW TO IMPROVE THE MANAGEMENT OF THIS PROJECT?

In front of the question how to improve the management of this project, it can be made the mistake of accepting that as the planning is going as expected and it has been obtained good results in the research carried out, it would not need to introduce improvements in the management of this. However, it is clear evidence, after presenting LPS methodology that by means of the implementation of this it can be obtained even a better performance.

Whereby from the base the continuous improvement that introduces Last Planer System, through the constant learning about our errors. With the previously presented methodology's application, it can always be reached the highest results, achieving thus greater value of the final product.

Before, it is essential to have clear the principal difference that presents the Last Planner System, in front of the other management systems, it is that is in charge of managing persons, in exchange to manage activities as the conventional methods produce. These people will be later the responsible and in charge of managing the activities. This means that the Last Planner works with a team of people, which in joint they are entrusted to manage the assignments of the works, responsible, etc, and that the activities can be developed in the expected moment, that having been freed beforehand to make this possible. The team is composed by the implicated parts in the project, being all represented, from the design team, architect, until the site manage.

Affording that the complete team will have full knowledge of all of the necessities of each of the components, being able to facilitate the work among them. All components produce a value chain.

Therefore with this method the whole management belongs to the implicated parts and it is not a result imposed by only one whole group part of those involved in the project. Helping the participants to assume their responsibilities with the largest predisposition, given that they have been themselves who have imposed them. Creating a biggest tie among the participants because it has been built in common looking for the public good, it has been created by them and for them. The management is elaborated through the collaboration and cooperation of all and each one of the participants involved. In this way a large number of problems that appear due to the lack of collaboration and cooperation disappears.

5.2. Possible implementation of the Last Planner System in the Project

As explained before, the Last Planner implementation in the studied project is not possible in its whole magnitude, since the project is currently developing its construction phase. Once the projects have started, it turns out difficult to create the gained commitments from the agents, during the initial planning elaboration that helps the good planning operation, given that they have not participated in this. Hence the responsibilities have been imposed by third people, in the absence of that the commitments have been gained by themselves.

That does not mean that the greatest performance in the construction cannot be obtained. Even so, improvements could be obtained with the implementation of part of the Last Planner adapted methodology for the rest of the project. It can be complemented with ideas and tools that present LPS to the existents already in the construction of this project. However, these should be assumed and acquired by all team members.

Thereby, in the project of the construction of the Workshop and administration building at Kokstad that forms part and complements the huge project of Light Rail in Bergen, it is proposed to be applied for the planning control through the LPS three levels, in its waterfall planning. In particularly, the proposal can be just developed in the last two, considering that just these can be still modified.

In the first level where the manner is prepared collaboratively by all participants, it is already done, but not in this way by collaboration, just by the management team involved in the elaboration of it, in this case BU. At this level, it is where the commitments network would be created by the participant agents, since they would carry it out by themselves. This level belongs to the Master Schedule presented earlier.

In the second level, called lookahead, although already elaborated, it should be intervened and carried out again for the remainder of the project. It is here when the workflow is supplied, analyzing the constraints, and obviously developed collaboratively by all the implicated parts. In this level the constraints should be detected 6 weeks ahead of the beginning of the activities, in order to have a large

action scope, being laid given this period of 6 weeks to solve the assignments constraints. For the constraints to be solved, a responsible for their elimination should be assigned. Therefore, the parts of this project should meet up collaboratively. To explain what they need to happen before they perform their activities in order that the task can be executed. And the remaining components to commit that when the activities start, have all been solved. In this case that the majority of the delays are due to the lack of information, the contractors could show six weeks in advance what information they need for the future assignments, and the design team would focus in providing and having ready this information, giving priority to the critical work.

These issues could be treated in the already existing meetings established by Bybanen Utbygging AS, that are being developed every two weeks approximately, where they discuss about the time planning. The changes to be introduced in these meetings would be the following:

- The term should be established, approximately six weeks, in which the activities of these 6 weeks are managed.

- In this meeting, everybody implicated in this period should be present, not just those participating in the construction site at present.

- The constraints should be managed determining a responsible, the freed date, the real freed date of it, etc. To obtain that it is very common to use tables where all of this data is specified.

And the third level, the Weekly Week Plan that consist in weekly meetings, at the beginning of the week or at the end indistinctly. They develop a first work that analyses the compliance of the planning, if the promises done the previous week have been completed during the week. And a second work planning the entering week, of the activities to be executed during the week.

At the moment BU carries out two kinds of weekly meetings with distinct participants of the project. One devoted to the coordination and the other to the issues connected to the construction. Consequently, it would have to adapt one of these meetings, including the following modifications:

- It is fundamental that all participants involved in the construction, from the direction representatives, suppliers and subcontractors implicated, to the site manager (the Last Planners), attend this meeting.

- The planning work and commitments should be established in presence of the whole team.

- The participants should receive feedback regarding the prior week, analyze the completed work and the reasons of non-compliance.

In summary for the LPS implementation in this construction project of the workshop and administration building, it is needed more active participation by every member at the moment of the planning. Because in this way it is obtained a greater understanding of what is happening in the project, and there are better conditions for providing

information on the situation of the restrictions. The exchange of information among the participants boosts the workflow.

5.2.1. LEARNINGS

The possibility of the Last Planner System implementation will allow an improvement of the plan trustworthiness. Nevertheless, it is required to reach a good implementation and good understanding about what LPS is. Therefore, it is necessary to take out the knowledge learnt that can be applied.

The project management should be elaborated through understanding the control production process and its goals. In phase scheduling an intensive participation by the agents involved should be incorporated by means of collaboration and cooperation amongst them.

In the intermediate planning a certain time term should be adopted. The assignments contained in this term and its constrains will be analyzed. Thereby it focusses in the elimination of these constrains, assigning a responsible of the task and constraints.

To study the weekly planning cycle it is essential that each week the tasks selected are free of constraints. Introducing the checking plan in each week for measuring PPC identify and acting on reason.

[4] Therefore, the Last Planner System can be summarized in four basic principles:

1. Personal commitment of the Last Planners.
2. Last Planners coordination by regular meetings.
3. Using a basic control indicator called Plan Percent Complete (PPC).
4. Public visibility of the weekly results obtained.

With the application of this way of working, the Last Planner System, it is possible to achieve a PPC above 90%, reaching a good result in the construction process.

5.3. LEAN CONSTRUCTION IN NORWAY

The next 23rd of June, the 22nd conference of the International Group for Lean Construction will take place in Oslo, Norway. The principal issue of the 22IGLC is “Understanding and improving project based production”.

[15] The schedule of the 22nd conference covers from the 23rd to the 27th, when conferences and workshop will be developed. The first day will be destined to the industry where a general view of Lean Construction will be given and there will be exchanges of experiences among companies. In the second day, there is a list of interesting workshops to be developed during the day. And the last three days there will be conferences that will consist of plenary and parallel sessions, and include the presentations of all accepted papers. Also they organize journeys for the students where they can present their projects, between 28 and 29 of June. In short, it offers an endless amount of interesting activities related with Lean Construction.

Scandinavian contractor Veidekke that already applies Lean Construction in its projects and University of Agder (UiA) form the Conference Organizing Committee.

But it is not the first event of this nature that is developed in Norway, about Lean Construction. In 2012 it was celebrated the yearly meeting of the European Group of Lean Construction in Oslo. It was organized by FAFO and in this it was also involved Veidekke. The following year, 2013, the meeting was celebrated in Valencia, Spain. It was organized by the Spanish Group for Lean Construction that was founded in 2010. [16]

Undeniably it is an excellent chance to take and spread Lean Construction to Norway, its advantages and the needed knowledge for its application.

As it can be observed, Veidekke is an influential Lean Construction company in Norway. Veidekke has been using the Last Planner (or Collaborative Planning as they call it) since 2006. They first tested it in a few pilot-projects. Thereafter, a revised version of the concept was applied in several learning-projects. From 2010, the ambition in Veidekke has been to use collaborative planning in all of their projects. [17]

It exists a Lean Construction group in Norway; some companies as Kruse Smith or AF Grouppen belong to their LC network. [18] Nevertheless other sectors in Norway, like electricity industry that takes more time using Lean Thinking. [19]

5.4. CONCLUSION

In the carried research it is has been obtained two types of results. First, those related to the percent of the plan complete (PPC) per week. Seconds refers to cause of non-compliance.

From the PPC obtained data during the studied weeks of the project, it is found very variable PPC of the full project. In most of the cases it is found a PPC relatively high above 60%. However, sometimes as the case of the week sixteen, corresponding with the Easter holidays, the PPC falls until 17%. Affecting even the PPC of the two subsequent weeks when the PPC borders 50%. In this data it is reflected a large instability on a planning level of the project. It has produced a one month and a half delay in relation with the expected plan because of the non-compliances.

To understand what is happening in the construction it is important to visualize and understand the PPC of all the contractors participating in the construction during the term studied. Hence it is calculated the PPC for the chief contractor and for each of the outsourcers.

The chief constructor of the project gives high PPC, always above 60%, arriving to reach a 90% in the fifteen week. This is owing to the planning system that is developed by the company, as disclosed above, that allows to make a correct planning of their works, reaching ahigh amount of commitments. Nevertheless, it does not allow to control outsourcers planning level.

The outsourcer A, has a variable PPC. Its PPC fluctuates among 0% and 75%, with a low PPC average of 48, 9%. Concretely, the cause of non-compliance is the number 5: Design /design team clarification.

Regarding the outsourcer B, it has a high commitment, although during four consecutive weeks, it cannot carry out its assignments because of the same cause as outsourcer A, the number 5. The PPC average is of 50%, due to that, five of the weeks is reached a 100% and five a 0% and one week a 50%. It is observed that outsourcer B is who suffers the biggest variability in their PPC. Thanks to the causes analysis, the author of this project, concludes that the compliance variability in the activities is not related with the commitment degree in the company. When the company had all the information that achieved the 100% and by external causes, its compliance was 0%.

On the other hand, the author thinks that the PPC measures for each company without the total and complete application of LPS, the data are not reflecting a commitment degree of it.

In the end, applying the LPS in the project, the data provided by the PPC calculation for each company is more reliable than if LPS were not applicated. Without the LPS application, the constraints are not managed, due to this the PPC for each company can be lessened owing to external causes of it.

As far as the causes of non-compliance, during the period studied only were appeared seven of the sixteen proposals. Still, it should be concentrated in avoiding the causes that occur 20% of the times. Once eliminated these, it will be solved the most of the problems. That is to say, in this certain case it should be attacked the "Information or available data" and "Design /design team clarification". These two causes that come from more or less the same fount, the design team, are as a result mainly of the design phase is not finished yet and the information from the design teams should be accepted by all of the projects parts, before it can be executed.

Lastly, there is no doubt that the best system to achieve a significant increase in this project and improve the previous results is the Last Planner System implementation, which is committed to carry out the assignments that really can execute, throughout the commitments and an exhaustive control of the process.

This system, besides, presents many other advantages. It generates a commitment network between the Last Planners by means of the Pull Planning. The flow is managed through the constraints log; in this way, the constraints that hinder the activities execution are detected within six weeks in advance. Weekly, the Last Planners make their promises and the project advance is controlled.

In addition to this, it is generated a continuous improvement culture analyzing the causes of non-compliance. The members share the knowledge among them through the conversations.

Finally and very important, the group become to a team, considering that they understand they are part of a system and the actions of one affect the others. All of that, to protect the production of the uncertainty.

5.4. CONCLUSIONES

En el estudio realizado se han obtenido dos tipos de resultados. En primer lugar, los relacionados con el porcentaje de actividades completadas (PAC) por semana. Y en segundo, los referidos a las causas de incumplimiento de esas actividades.

De los datos obtenidos del PAC durante las semanas estudiadas, se encuentran PAC del proyecto global muy variables. En la mayoría de los casos se encuentran PAC relativamente altos por encima de 60%. Sin embargo, en ocasiones como en el caso de la semana 16, correspondiente a la semana de vacaciones de pascua, baja de manera estrepitosa a un 17%. Viéndose afectado incluso los PAC de las dos semanas posteriores, que rondan por el 50%. En estos datos se refleja una gran inestabilidad a nivel de planificación del proyecto, puesto que los PAC varían en un rango de 70%. Lo que produce un mes y medio de retraso en relación con el plan esperado debido a los incumplimientos.

Para entender lo que está pasando en la obra también es importante entender y visualizar los PAC de todos los contratistas que están participando en la obra durante el momento del estudio. Por lo tanto se realiza un cálculo del PAC del constructor principal y uno para cada uno de los subcontratistas.

El constructor principal del proyecto presenta PAC altos, siempre por encima del 60% llegando a obtener un 90% en la semana 15. Esto se debe a que el sistema de planificación que desarrolla la empresa, anteriormente expuesto, le permite realizar una planificación correcta de sus trabajos, alcanzando un grado de compromiso alto. Aunque no le permite controlar la planificación de los subcontratistas.

El subcontratista A, comprobamos que tiene unos PAC muy variables. Sus PAC fluctúan entre 0% y 75%, teniendo una media de PAC baja, de un 48.9%. En la mayoría de los casos, los incumplimientos se han debido a la causa número 5: Diseño / aclaración por parte del equipo de diseño.

En cuanto al subcontratista B, tiene un grado de compromiso alto, pero durante 4 semanas consecutivas, no pudo realizar sus asignaciones por la misma razón que el subcontratista A, la número 5. La media del PAC de este, es del 50%, esto se debe a que cinco de las semanas logra un 100%, otras cinco un 0% y una semana un 50%. Se observa que el subcontratista B es el que sufre una mayor variabilidad en su PAC. Gracias al análisis de las causas, el autor de este proyecto, concluye que la variabilidad del cumplimiento de las actividades no está relacionada con el grado de compromiso de la empresa. Ya que cuando la compañía cuenta con toda la información necesaria para desempeñar su trabajo, logra el 100% de cumplimiento y el 0% se obtiene por causas externas.

Por otro lado, el autor piensa que los datos obtenidos del cálculo del PAC para cada empresa sin la aplicación total y completa de LPS, no están reflejando el grado de compromiso de las mismas.

Con la puesta en práctica de LPS en el proyecto, los datos proporcionados por el cálculo de PAC para cada empresa serían más fiables y reales que si LPS no se pone en práctica. Sin la aplicación de LPS, las restricciones no son gestionadas, lo que provoca

que el PAC para cada empresa pueda verse reducido debido a causas externas de la misma.

En lo que respecta a las causas de no cumplimiento, durante el periodo estudiado solo se han presentado 7 de las 16 propuestas. Pero se deben concentrar los esfuerzos en abolir las causas que suceden el 20% de las veces. Ya que eliminando estas resolveremos la mayoría de nuestros problemas. Es decir, en este caso en concreto, se deben atacar la "Información o disposición de datos" y el "Diseño / aclaración por parte del equipo de diseño". Estas dos causas que provienen más o menos de la misma fuente, del equipo de diseño, se debe principalmente a que la construcción empezó antes de que la fase de diseño estuviera acabada y a que la información que el equipo de diseño proporciona antes de poder ser puesta en marcha debe ser aceptada por todas las otras partes del proyecto

En definitiva, no cabe duda que el mejor sistema para conseguir una mejora significativa en este proyecto y en los resultados anteriormente expuestos es la implementación de Last Planner, el cual se compromete a realizar lo que realmente se puede ejecutar, a través de los compromisos y un control exhaustivo del proceso.

Este sistema, además, presenta otras muchas ventajas. Se genera una red de compromisos entre los últimos planificadores (the Last Planners) a través del Pull Planning. El flujo se gestiona a través del análisis de las restricciones; de manera que, las restricciones que dificultan la ejecución de las actividades se detectan con seis semanas de antelación. Y semanalmente, los últimos planificadores realizan sus promesas y se controla el avance del proyecto.

Asimismo, se genera una cultura de mejora continua, al analizar las causas de incumplimiento. Los miembros comparten el conocimiento entre ellos a través de las conversaciones y la comunicación que establece el sistema.

Por último y muy importante, el grupo se convierte en un equipo, teniendo en cuenta que se sienten parte del sistema y las acciones de uno afectan a los demás. Todo eso, para proteger la producción de la incertidumbre.

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APPENDIX I. DOCUMENTATION WEEKLY REVIEW

Collected information from the main contractor of the workshop and building administration about his weekly plan and non-compliance of it. The information was collected during twelve weeks and these reflect the PPC of the process construction of this project.

PPC TABLES OF EACH WEEK

TABLE 3. WEEK 9. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 67%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			24-feb-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					2/24	2/25	2/26	2/27	2/28	3/1	3/2	YES	NO/CAT.	NON-COMPLETION
			Excavation for pumping waste water pipe											
			Excavation for wastewater pumping station											
			Gravel / leveling point for foundations axis 6.4 / KV (workshop)											
			Gravel / leveling of strip foundations (workshop)											
			Excavation for the foundation to the mountain axis 14-15/EE-HH, 16-17/EE-HH											
			Excavation for the foundation to the mountain axis 16-17/AA											
			Excavation for objection stormwater axis 1-1a/KL										4	Information or available datums
			Installation of pump wire to wastewater pumping station										5	Desing /desing team clarification
			Casting anchor plate for waste water pumping station										4	Information or available datums
			Lean for rock bolts office											
			Drilling for rock bolts										10	Timetable/sequence
			Prefab reinforcement foundation F3 and F4 (workshop)											

TABLE 4. WEEK 10. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 64%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			03-mar-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					3/3	3/4	3/5	3/6	3/7	3/8	3/9	YES	NO/CAT.	NON-COMPLETION
			Excavation for pumping waste water pipe											
			Gravel / leveling point for foundations axis 4.5 / KV (workshop)											
			Gravel / leveling of strip foundations axis 6/RN (workshop)											
			Installation of pump wire to wastewater pumping station											
			Casting anchor plate for waste water pumping station										4	Information or available datums
			Drilling for rock bolts										7	Materials availability
			Prefab reinforcement strip foundations 1/M-W											
			Prefab reinforcement foundation F3 and F4 (workshop)											
			Lean for foundations (workshop)											
			Formwork / reinforcing axis 6/V-S											
			Formwork / Reinforcement in transformer											
			Slab foundations axis point SW/1a - (workshop)										10	Timetable/sequence
			Laying of strip foundation 1/M-W (workshop)										10	Timetable/sequence
			Excavation / assembly for pumping out of water from excavation										6	Personal availability

TABLE 5. WEEK 11. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 75%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			10-mar-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					3/10	3/11	3/12	3/13	3/14	3/15	3/16	YES	NO/CAT.	NON-COMPLETION
			Excavation for wastewater pumping station										4	Information or available datums
			Gravel / leveling point for foundations axis 3 and 2b (workshop)											
			Excavation for foundations point to the mountain (office)										16	Unexpected event
			Excavation for interior basins										4	Information or available datums
			Reinforcement strip foundations axis 6 workshop											
			Prefab reinforcement foundation F3 and F4 (workshop)											
			Reinforcement strip foundation axis 14-15/EE-HH, 16-17/EE-HH											
			Lean for foundations (workshop)											
			Formwork / reinforcing axis 6/V-S											
			Formwork / reinforcing axis 6/V-S											
			Shuttering strip foundation axis 14-15/EE-HH											
			Shuttering of strip foundation axis 6/R-N											
			Foundation axis AA/16-17											
			Shuttering of plinths PD2										6	Personal availability
			Reinforcement of the plinths PD2										6	Personal availability
			Fill in around foundation engineering point of axis V											
			Excavation / assembly for pumping out of water from excavation											
			Exterior storm water / sewage / water pipeline											
			Excavation for external stormwater											
			Excavation for exterior sewage at workshop											

TABLE 6. WEEK 12. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 67%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			17-mar-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					3/17	3/18	3/19	3/20	3/21	3/22	3/23	YES	NO/CAT.	NON-COMPLETION
			Excavation for wastewater pumping station										4	Information or available datums
			Excavation for interior basins										6	Personal availability
			Filling around foundation engineering point of axis V											
			Exterior storm water / sewage / water pipeline											
			Excavation for exterior sewage at workshop											
			Excavation for exterior water pipe at the workshop											
			Excavation / assembly for pumping out of water from excavation											
			Casting anchor plate for waste water pumping station										4	Information or available datums
			Casting anchor plate for tanks / wastewater										4	Information or available datums
			Formwork point foundation F9										6	Personal availability
			Prefab reinforcement point foundation F9 - F8											
			Shuttering of strip foundation axis 6-R / N											
			Reinforcement strip foundations axis 6 - R / N											
			Formwork / Reinforcement in transformer											
			Shuttering of plinths PD2										6	Personal availability
			Reinforcement of the plinths PD2											
			Lean for foundations (workshop)											
			Lean between point foundations axis 4/5 - V / N											
			Lean mellim point foundations axis 3/4 - V / N											
			Lean mellim point foundations axis 5/6 - V / N											
			Insulation / membrane and radon 3/6 - V / N										7	Materials availability

TABLE 7. WEEK 13. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 79%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			24-mar-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					3/24	3/25	3/26	3/27	3/28	3/29	3/30	YES	NO/CAT.	NON-COMPLETION
			Excavation for wastewater pumping station										4	Information or available datums
			Gravel / leveling point for foundations axis 3/2 - VR (workshop)											
			Excavation for internal trench axis 2C-L / R											
			Installation of internal pump wire axis 2C											
			Excavation for foundations point to the mountain (office)											
			Exterior storm water / sewage / water pipeline											
			Excavation for exterior sewage at workshop											
			Excavation for exterior water pipe at the workshop										10	Timetable/sequence
			Casting anchor plate for waste water pumping station										4	Information or available datums
			Casting anchor plate for tanks / wastewater										4	Information or available datums
			Reinforcement strip foundation axis 14-15/EE-HH, 16-17/EE-HH											
			Formwork point foundation F9											
			Shuttering of strip foundation axis 6-R / N											
			Shuttering of strip foundation axis 6 - M / G											
			Reinforcement strip foundations axis 6 - M / G											
			Shuttering of plinths PD											
			Reinforcement of the plinths PD2											
			Lean between point foundations axis 4/5 - V / N											
			Lean between point foundations axis 3/4 - V / N											
			Lean between point foundations axis 5/6 - V / N											
			Insulation / membrane and radon 3/6 - V / N										6	Personal availability
			Formwork and reinforcement point foundations adm.build											
			Lean axis V / R - 2/3											
			Shuttering of stripe / dot foundation axis V / R -2 / 3											

TABLE 8. WEEK 14. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 77%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			31-mar-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					3/31	4/1	4/2	4/3	4/4	4/5	4/6	YES	NO/CAT.	NON-COMPLETION
			Excavation / Blasting for wastewater pumping station										4	Information or available datums
			Grading for tanks										4	Information or available datums
			Excavation for the elevator sync workshop axis 2a - R / S											
			Filling of inner trench axis 2C-L / R											
			Excavation for internal sump axis 2C											
			Filling of point foundations Office											
			Filling around foundation engineering point of axis V											
			Filling of elevator / stairwell office										6	Personal availability
			Exterior storm water / sewage / water pipeline											
			Excavation for exterior sewage at workshop											
			Excavation for exterior water pipe at the workshop										10	Timetable/sequence
			Casting anchor plate for waste water pumping station										10	Timetable/sequence
			Grouting of rock bolts											
			Shuttering strip foundation axis 14-15/EE-HH											
			Reinforcement strip foundation axis 14-15/EE-HH											
			Formwork Foundation axis AA-16/17											
			Reinforcing foundations axis AA 16/17											
			Shuttering of strip foundation axis 6 - M / G											
			Shuttering of plinths PD2											
			Reinforcement of the plinths PD2											
			Slab base plate for engraving 3/6 - V / N											
			Reinforcement of the base plate for engraving 3/6 - V / N											
			Lean between point foundations axis 4/5 - V / N											
			Lean between point foundations axis 3/4 - V / N											
			Lean between point foundations axis 5/6 - V / N											
			Insulation / membrane and radon 3/6 - V / N											
			Shuttering of group 2 axis 3/4 - M / U											
			Reinforcement of group 2 axis 3/4 - M / U										3	Preparatory works-owns
			Formwork and reinforcement point foundations adm.building											
			Shuttering of stripe / dot foundation axis V / R -2 / 3											
			Reinforcing strip / dot foundation axis V / R -2 / 3											
			Shuttering of strip foundation axis 6 - G / B											
			Reinforcing strip foundation axis 6 - G / B											
			Formwork walls axis 6 - V / N										4	Information or available datums
			Reinforcement of walls axis 6 - V / M										4	Information or available datums

TABLE 9. WEEK 15. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 86%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			07-abr-14				PPC ANALYSIS	
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?	LEARNING
					4/7	4/8	4/9	4/10	4/11	4/12	4/13	YES / NO/CAT.	NON-COMPLETION
			Installation of manhole 118 and 119									10	Timetable/sequence
			Excavation for foundations point to the mountain (office)										
			Exterior storm water / sewage / water pipeline										
			Casting anchor plate for tanks / wastewater										
			Shuttering of plinths PD2										
			Reinforcement of the plinths PD2										
			Slab base plate for engraving 3/6 - V / N										
			Armering av bunnplate for graver 3/6 - V/N										
			Reinforcement of the base plate for engraving 3/6 - V / N										
			Reinforcement of group 2 axis 3/4 - M / U										
			Installation of bolt groups in group 2										
			Formwork and reinforcement point foundations adm. building										
			Formwork walls axis 14-15/EE-HH, 16-17/EE-HH										
			Reinforcing walls axis 14-15/EE-HH, 16-17/EE-HH										
			Shuttering of stripe / dot foundation axis V / R -2 / 3										
			Reinforcing strip / dot foundation axis V / R -2 / 3										
			Shuttering of strip foundation axis 6 - G / B										
			Reinforcing strip foundation axis 6 - G / B										
			Slab foundation point axis 6 - A										
			Formwork walls axis 6 - V / N									4	Information or available datums
			Reinforcement of walls axis 6 - V / M									4	Information or available datums

TABLE 10. WEEK 16. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 17%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			14-abr-14				PPC ANALYSIS	
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?	LEARNING
					4/14	4/15	4/16	4/17	4/18	4/19	4/20	YES / NO/CAT	NON-COMPLETION
			Installation of manhole 118 and 119									5	Design/Design team clarification
			Excavation for the elevator sync workshop axis 2a - R / S										
			Exterior storm water / sewage / water pipeline									5	Design/Design team clarification
			Excavation for exterior sewage at workshop									5	Design/Design team clarification
			Excavation for storm water and water in area 1 and 2									5	Design/Design team clarification
			Installation of storm water and water area 1 and 2									5	Design/Design team clarification

TABLE 11. WEEK 17. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 54%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			21-abr-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					4/21	4/22	4/23	4/24	4/25	4/26	4/27	YES	NO/CAT.	NON-COMPLETION
			Invnvendig ditches acodrain including mounting										5	Design/Design team clarification
			Exterior storm water / sewage / water pipeline										5	Design/Design team clarification
			Excavation for the exterior surface water by crane # 1										5	Design/Design team clarification
			Excavation for exterior sewage at workshop										5	Design/Design team clarification
			Excavation for exterior water pipe at the workshop										5	Design/Design team clarification
			Filling graves axis 5-6											
			Excavation for KL master area 1 and 2										5	Design/Design team clarification
			Excavation for pull manholes area 1 and 2										5	Design/Design team clarification
			Grouting of rock bolts											
			Formwork walls axis AA-16/17											
			Reinforcing walls axis AA 16/17											
			Shuttering of plinths PD2											
			Reinforcement of the plinths PD2											
			Slab base plate for engraving 3/6 - V / N											
			Reinforcement of the base plate for engraving 3/6 - V / N											
			Formwork / reinforcing pumpekumme axis 2C-N										5	Design/Design team clarification
			Lean between point foundations axis 5/6 - V / N											
			Insulation / membrab and radon 3/6 - V / N											
			Installation of bolt groups in group 2 axis 3/4 - M / U											
			Formwork walls axis 6											
			Reinforcement walls axis 6											
			Formwork and reinforcement point foundations adm.building										5	Design/Design team clarification
			Shuttering of stripe / dot foundation axis V / R -2 / 3										5	Design/Design team clarification
			Reinforzament of stripe / dot foundation axis V / R -2 / 3										5	Design/Design team clarification

TABLE 12. WEEK 18. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 52%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			28-abr-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					4/28	4/29	4/30	5/1	5/2	5/3	5/4	YES	NO/CAT.	NON-COMPLETION
			Filling of point foundations Office										5	Design/Design team clarification
			Exterior storm water / sewage / water pipeline										5	Design/Design team clarification
			Excavation for exterior sewage at workshop										5	Design/Design team clarification
			Excavation for storm water and water in area 1 and 2										5	Design/Design team clarification
			Excavation for KL master area 1 and 2										5	Design/Design team clarification
			Excavation for pull manholes area 1 and 2										5	Design/Design team clarification
			Reinforcing walls axis 14-15/EE-HH											
			Formwork walls axis AA-16/17										10	Timetable/sequence
			Armering vegger akse AA- 16/17										10	Timetable/sequence
			Reinforcing walls axis AA 16/17											
			Slab base plate for engraving 3/6 - V / N											
			Reinforcement of the base plate for engraving 3/6 - V / N											
			Formwork/reinforcing pumpstation axis 2C-N										5	Design/Design team clarification
			Isolation basin AC4, AC5, IC6, AC8, AC6, AC10, AC11, AC12											
			Lean for foudations (workshop)											
			Lean between point foundations axis 5/6-V/N											
			Insulation/membrane and radon 5/6-V/N											
			Formwork walls in group 2 axis 3/4 - M / U											
			Reinforcement walls in group 2 axis 3/4 - M / U											
			Formwork walls axis 6											
			Reinforcement of the wall axis 6											
			Formwork walls transformer yard										5	Design/Design team clarification
			Formwork and reinforcement point foundations administration building										5	Design/Design team clarification

TABLE 13.WEEK 19. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 68%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			05-may-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					5/5	5/6	5/7	5/8	5/9	5/10	5/11	YES	NO/CAT.	NON-COMPLETION
			Excavation for foundations point to the mountain (office)											
			Filling around foundation engineering point of axis 3 -2/AJ											
			Filling walls stairway / elevator adm building											
			Invnvendig ditches acodrain including mounting										5	Design/Design team clarification
			Excavation for Dibo thoughts of crane No. 2										7	Materials availability
			Excavation for exterior water pipe at the workshop										7	Materials availability
			Lean for KL foundation										5	Design/Design team clarification
			Formwork KL foundations										5	Design/Design team clarification
			Formwork walls axis 14-15/EE-HH											
			Reinforcing walls axis 14-15/EE-HH											
			Formwork walls axis AA-16/17											
			Reinforcing walls axis AA 16/17											
			Shuttering of plinths PD2											
			Slab base plate for engraving 3/6 - V / N											
			Reinforcement of the base plate for engraving 3/6 - V / N											
			Formwork / reinforcing pumpekumme axis 2C -N										7	Materials availability
			Isolation basin AC4 , AC5 , IC6 , AC8 , AC6 , AC10 , AC11 , AC12										7	Materials availability
			Formwork basin AC4 , AC5 , IC6 , AC8 , AC6 , AC10 , AC11 , AC12										7	Materials availability
			Lean for foundations (workshop)											
			Lean between point foundations axis 4 /5 - V / N											
			Lean between point foundations axis 3 /4 - V / N											
			Lean between point foundations axis 5/6 - V / N											
			Insulation / membrab and radon 5/6 - V / N											
			Formwork walls in group 2 axis 3 /4 - M / U											
			Reinforcement walls in group 2 axis 3 /4 - M / U											
			Formwork walls axis 6											
			Reinforcement of the wall axis 6											
			Formwork walls transformer yard										5	Design/Design team clarification
			Formwork and reinforcement point foundations adm.bygg										5	Design/Design team clarification
			Shuttering of stripe / dot foundation axis V / R -2 / 3											
			Reinforcing strip / dot foundation axis V / R -2 / 3											

TABLE 14. WEEK 20. [OWN COMPILATION]

WEEKLY WORK PLAN

PPC 87%

ID de TASK	Area	Responsible party	ACTIVITY	Responsible individual	STARTING ON			12-may-14				PPC ANALYSIS		
					Mon	Tue	Wed	Thu	Fri	Sat	Sun	¿DONE?		LEARNING
					5/12	5/13	5/14	5/15	5/16	5/17	5/18	YES	NO/CAT.	NON-COMPLETION
			Formwork walls axis 14-15/EE-HH											
			Reinforcing walls axis 14-15/EE-HH											
			Formwork Wall axis DD-16/17											
			Slab base plate for engraving 3/6 - V / N											
			Reinforcement of the base plate for engraving 3/6 - V / N											
			Isolation basin AC4, AC5, IC6, AC8, AC6, AC10, AC11, AC12											
			Formwork basin AC4, AC5, IC6, AC8, AC6, AC10, AC11, AC12											
			Lean between point foundations axis 4/5 - V / N										4	Information or available datums
			Lean between point foundations axis 5/6 - V / N										4	Information or available datums
			Insulation / membrab and radon 4/5 - V / N											
			Formwork walls axis 6											
			Reinforcement of the wall axis 6											
			Formwork walls transformer yard											
			Shuttering of stripe / dot foundation axis V / R -2 / 3											
			Reinforcing strip / dot foundation axis V / R -2 / 3											