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INTEGRATION OF LOCATION-BASED MANAGEMENT SYSTEM

INTO A SMALL CONSTRUCTION COMPANY'S PROJECT

Title page

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Synopsis:

This thesis investigates the planning, scheduling and onsite control of a small Icelandic construction company. The company implements activity based scheduling techniques and the onsite control is based on the experience of the management team.

Furthermore, this thesis reflects on how the planning, scheduling and onsite control could be performed through the Location-Based Management System (LBMS), by exploring the possibilities of optimising the use of the workforce, resources and reducing waste by implementing the system.

Currently the company has three ongoing projects. One of them was used to investigate the scheduling part, the other two to explore the onsite control.

The internal and external barriers of integration will also be investigated, as a part of exploring the possibilities of integration.

Additionally, further research avenues are suggested.

Acknowledgements

The author would like to start with thanking the people that helped during the writing of this thesis. Starting with my consultant Kjeld Svift for his advice and guidance. The employees of the company for participating in this project. All the professionals from the Icelandic AEC industry that answered the questionnaire. Then I would like to thank the people that read over the report, Kay Cook. Special thanks for my brother in law Jérôme Vadon for making the front page. Finally, I would like to thank my wife Augusta Ólafsson for all her help and support during my studies.

Abstract

This Master's thesis is written by Hákon Jónas Ólafsson as a part of the Management in the Building Industry course in Aalborg University, Department of Civil Engineering.

After working in the building industry as a mason for almost a decade, the author of this thesis has developed an interest in construction planning, particularly in the management of manpower, resources and waste reduction in construction processes.

This thesis will consider a small size construction company. Their planning is based on activity's based scheduling, which is the generally used scheduling technique in the construction industry these days. The method has been criticised by scholars, when implemented in construction projects.

It will investigate how the company conducts its planning, scheduling and control in its projects**.** Thereafter, a reflection is given on how it would be performed through the Location-Based Management System (LBMS), by investigating the possibility of optimizing the use of the workforce, resources and reducing waste by implementing the LBMS, through theoretical suggestion, by considering different articles and books written on the subject. Furthermore, the thesis will explore what kind of integration barriers can be found within the company.

The data used to analyse the internal factors of the company were collected through interviews and documents from the company. For the external factors, a questionnaire was formulated and sent out to professionals within the Icelandic AEC industry.

The findings reveal that considerable benefits can be achieved by implementing the LBMS within the company. Production is aligned and set in a continuous manner, which brings further optimisation in the use of resources and manpower. Furthermore, shortening of the project's time frame occurs, from 6.9-15%.

Barriers of integration were found to be the lack of knowledge about location-based scheduling theory and lack of skills in location-based software applications, within the company and the Icelandic AEC industry. Furthermore, Vico Office was found not to be in common use within the industry. It was found that the main application used for planning and scheduling among the respondents is MS Project and MS Excel. The internal barriers were found to be possible resistance to changes among the company´s employees.

For the LBMS to be properly integrated into the company, it was concluded that all parties involved in the production need to work together, both the company's employees and the subcontractors. Furthermore, all parties need to receive training which is suitable for their role in production.

Keywords: Location-Based Management System (LBMS), location-based scheduling, location-based control system, activity based planning, Vico Office.

List of Acronyms

Acronyms	Meaning
AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
BOQ	Bill of Quantities
CEO	Chief Executive Officer
CPM	Critical Path Method
ES	Early Start
EF	Early Finish
FF	Free Float
FS	Finish to Start
LBM	Location-Based Management
LBMS	Location-Based Management System
LBS	Location Breakdown Structure
LF	Late Finish
LOB	Line of Balance
LS	Late Start
IFC	Industry Foundation Classes
MEP	Mechanical, Electrical and Plumbing
MS	Microsoft
PERT	Program Evaluation and Review Technique
WBS	Work Breakdown Structure
SME	Small and medium sized enterprises
SS	Start to Start
TF	Total Float

Thesis structure

This thesis is setup in eight chapters as figure 1 illustrates. On the left side of the figure the chapters are listed, then on the right side there is a short description of their context.

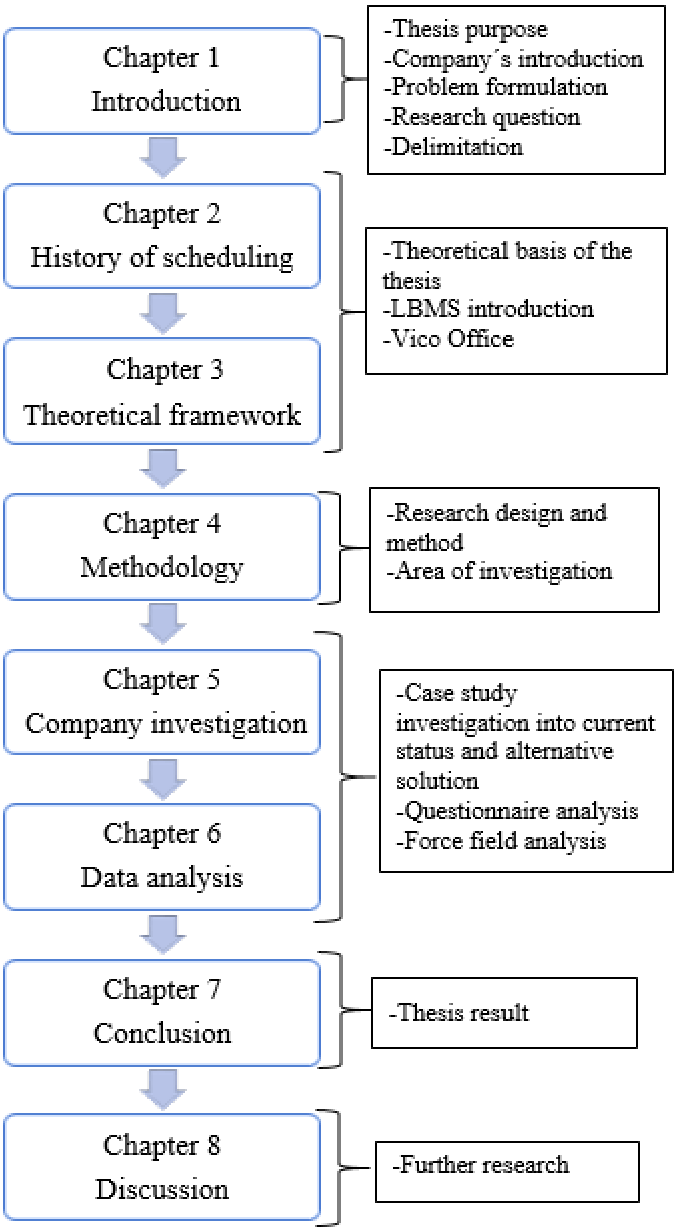

Figure 1: Report structure

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1. Introduction

The subject of this Master's thesis originated from the experience and personal interest of the author, whilst working as a tradesman in the Icelandic building industry. After working in the industry for a decade the author noticing large amounts of waste in the construction processes. A substantial amount of time went into waiting for materials, information and the location to be prepared for the work to begin. Furthermore, arriving at a worksite you sometimes just have to leave again because the presiding tradesmen have not finished their work. There is often the feeling that the managers in large construction projects lack an overview and status information related to the work about to be performed.

Another factor that had a significant influence on the choice of this subject was the author's interest, which emerged following a brief introduction to Location-Based Management System (LBMS) during his Master's studies. Even though the interest of the author is partly a reason for writing a thesis such as this, the fact remains that it still cannot be the only motivation.

Within the building industry there is an ongoing predicament when it comes to planning, scheduling and the control of construction projects. The schedules that are being produced are not being followed by the onsite crew and are just hung up on the wall, without being pursued (Kenley & Seppänen, 2010, p. 96). The building sites are often run by managers with extensive experience of building projects, but without much knowledge of planning methods, who are given unlimited control over the building sites. These seasoned managers often resist when enthusiastic, younger and inexperienced managers try to integrate new ideas (Arditi, 1983, p. 6) .

The topic of delays in construction projects has been a popular issue, whereas multiple researchers have found that poor project management has been the main reason for the delays (AlSehaimi, et al., 2013, p. 407). Another topic is the waste of time and rework within projects in the construction industry. This is a common factor when it comes to the building industry, along with delays and budget overruns (Büchmann-Slorup, 2012, p. V). Furthermore, a large portion of the tradesmen's time is spent on indirect work, such as collecting material, waiting, fixing errors etc. (Jongeling & Olofsson, 2007, p. 189).

Current techniques in scheduling have been criticised for their inability to support the onsite control of building projects. The insufficiency of the scheduling methods of including resources in planning has been discussed (Choo, et al., 1999, p. 151). Koskela has addressed the issue that project managers are not capable of getting the same results in large complex projects using the current project management methods, as in small projects. Furthermore, the lack of theoretical knowledge has hindered the integration of project management methods into practice (Koskela & Howell, 2002, p. 302). The subject of quality in construction projects has also been an issue within the scholarly community, where it is found to be insufficient (Koskela, 2000, p. 13).

Furthermore, researchers have implied that Location-Based Management (LBM) methods are better suited to planning and controlling construction projects than the traditional ones. The

LBM considers the continuous flow of work, resource limitation and location conflicts (Büchmann-Slorup, 2012, p. VII).

The author of this thesis intends to investigate the planning, scheduling and onsite control of a small construction company, and, furthermore, to compare it with the Location-Based Management System (LBMS).

1.1 The case studies

The thesis explores planning, scheduling and onsite control in a small construction company. The author contacted a small Icelandic construction company located in the capital area, which agreed to serve as a case study. The company has its own operations, building residential and industrial housing, along with undertaking projects from public and private parties.

Their scheduling is activity based, setup in a Gantt chart in MS Project and production control is executed based on the owner's experience. The company has employees with decades of experience in the building industry, and the highest level of education among the employers is master of a trade. The author intends to explore the work methods of the company, and explore the possibility of integrating the LBMS into its operations.

Another part of this thesis was to inspect the barriers to integration. The LBMS is relatively new, and evidently questions arose regarding the competences, knowledge and attitudes towards the system in the Icelandic AEC industry.

1.2 Problem formulation

The previous chapter introduced the chosen subject. Chapter 1.2.1 will introduce the problem statement and the research questions are defined. Then, in chapter 1.2.2, the problem delimitation is explained.

1.2.1 Problem statement

The common method for planning, scheduling and control in the construction industry, activity based planning, was developed in the 1950s. It is the foundation for such a system as the Critical Path Method (CPM). This method has been proven to be an effective method for planning, scheduling and control. Regardless, there has been criticism from scholars regarding CPM use in construction projects, especially regarding the flow of resources and insufficient management of construction projects (Andersson, 2007, p. 1).

Furthermore, there has been criticism about the level of detail in the CPM schedules. When it becomes too detailed, it gets difficult to update them during the construction process. As a result, the schedule becomes an inefficient planning and control tool (Jongeling & Olofsson, 2007, pp. 189-190).

An example of an alternative to the activity based planning system is the Location-Based Management System (LBMS), which covers the planning, scheduling and control in the construction process. This alternative method has started to be more commonly used in the construction industry. Its main function has been to reduce the duration and improve the use of resources, while implementing it in production, control and forecasting (OLLI SEPPANEN & JAKE EVINGER, 2014, p. 406).

Based on the introduction and concepts mentioned above, the following problem statement was formulated.

What are the advantages, opportunities and challenges of integrating the Location-Based Management System (LBMS) in a small construction company?

To further narrow the subject, the following research questions where defined:

- What effect, can implementing location-based scheduling have on optimization in planning and scheduling?

- Which possibilities are there in improving, utilization of resources and manpower in the control phase?

- Which specific barriers will influence the integration of LBMS?

Now that the subject, problem formulation and the research questions have been defined, it is time to specify the field of investigation in the problem delimitations.

1.2.2 Problem delimitations

The subject of integrating a management system into a company is a wide field of research which cannot be fully covered in a thesis as this. For that reason, the author has limited the scope of the thesis, and thus the aspects of financing, customer satisfaction, culture, safety, etc. will not be included in this thesis. Some consideration was given to risk during the transfer of the MS Project schedule into the flowline view.

The investigation is limited to the integration of the Location-Based Management System (LBMS) into a small construction company, but the financial aspect of the company will not be included when integrating the system. Following issues will only be included on a theoretical basis, loading cost into the schedule, cash flow and optimising cost.

Evidently, although activity based planning is implemented within the company, this thesis will not go into its theory, or activity based software in any depth.

As previously mentioned, the investigation will explore one company located in Iceland, where the planning, scheduling and onsite control was investigated within three current projects: a multi-storey house; a group home; and an industrial building. A new flowline master schedule was produced for the industrial house. The other two buildings offered the possibility of investigating onsite control procedures in the company. The production rates used in the thesis are based on data from the company.

The purpose of using a company as a case study is not to expose the work methods inside a specific company, rather it is to get an overview of the operation. For this reason, the names of those connected to the company have not been disclosed.

The chapter entitled History of Scheduling only explores a small fraction of the scheduling techniques. The author recognises that there are other varieties of repetitive sheduling methods such as the vertical production method, time-location matrix model, time space scheduling method, disturbance scheduling, horizontal and vertical logic scheduling for multi-story projects, repetitive scheduling method (RSM) (Robert B. Harris, 1998, p. 269) etc.. These aforementioned methods will not be discussed further in this thesis, neither will the activity based scheduling method Program Evaluation and Review Technique (PERT) be introduced in this thesis.

2. History of scheduling

This chapter investigates the literature written by scholars on the chosen subject. It´s main purpose is to establish an historical understanding of the scheduling techniques in the building industry. A rough overview of scheduling techniques is documented.

Furthermore, the chapter discusses the necessity for changes in the building industry, regarding planning, scheduling and control of building projects. Planning and scheduling are important aspect of the building process. Nevertheless, control onsite is equally important. For that reason the author disuses the control aspects of the Location-Based Management System (LBMS).

Articles and books were located, primarly by conducting searches in the Aalborg Univesity library databases. Secondary by internet search, for example, using Google Scholar.

Furthermore, the development of scheduling techniques takes place over an extended period of time. For that specific reason the investigation was not limited to a certain period in time. Rather, it pinpointed finding the leading scholar in the field, mixed with scholars who have contributed to the subject and have published articles in recognised journals and conferences.

This chapter will explore different aspects of planning, scheduling and control, with chapter 2.1 introducing a brief history of location and activity based planning. Chapter 2.2 introduces the Critical Path Method (CPM) and the criticism that it has received from scholarly society. Chapter 2.3 investigates the Line of Balance (LOB) scheduling technique. Afterwards, in chapter 2.4, the flowline method is introduced. Chapter 2.5 explores the Location-Based Management System, however, the chapter will not explain the method of Location-based management in any depth since that issue is addressed in chapter 3. Rather, it will investigate what scholars in the field have written about the system. Finally, chapter 2.6 will present a conclusion to the chapter.

2.1 Early days of scheduling techniques

Through the years, multiple variations of scheduling methods existed in the scholarly community. Some of them have become familiar, while others have acquired somewhat less attention. This chapter will explore some of the better-known scheduling techniques, utilised in the early days of scheduling.

Starting with the Gantt chart developed early in the 19th century by Henry Gantt and Frederick Taylor, probably one of the most widely recognised methods to visualise schedules. The Gantt chart has great graphical illustration and has become popular within the construction industry. The chart illustrates the construction process with a timeline and a list of activities (Kenley & Seppänen, 2010, p. 14).

Location-based scheduling methods are another example of a scheduling technique, which have been around for the last 100 years. Professor Karol Adamiecki developed a technique, called harmonogram. This technique is somewhat like the Gantt chart, with one significant difference through the inclusion of the location. Adamiecki's schedule illustrated the location where the work performed is placed on the Y axis and the timeline on the X axis. The activities are presented with bars. This method's objective is to optimise production efficiency (Kenley & Seppänen, 2010, pp. 50-51).

The Empire State Building is probably the most recognised building where location-based scheduling was implemented. The development of the building is described in "*Building the Empire State"* (Willis, 1998). The Starrett Brothers used harmonograms to illustrate the work flow and completed the 102-storey building in 18 months. The building was both completed in a relatively short time and under budget.

Even though the harmonograms implemented in the construction of the Empire State Building resemble Adamiecki´s work, no connection between them has been established (Kenley & Seppänen, 2010, pp. 54-55).

2.2 Critical Path Method

The Critical Path Method (CPM) is an activity based scheduling method, developed in the 1950s. It is by far the most popular within the construction industry (Andersson, 2007, p. 1). It was originally developed to minimise shutdowns in a chemical factory, occurring because of maintenance issues (Arditi, 1983, p. 3). The basis of the method is that all work should be in a well-defined sequence, as Kelley described it: *"Each job in the project is represented by an arrow which depicts (1) the existence of the job, and (2) the direction of time-flows from the tail to the head of the arrow). The arrows then are interconnected to show graphically the sequence in which the jobs in the project must be performed. The result is a topological representation of a project."* (JAMES E. KELLEY, 1959, p. 163).

Figure 2 is an example of a Critical Path Network. The Critical path represents the minimum duration of the project. The Critical path contains activities which are critical for the completion of the project (Büchmann-Slorup, 2012, p. 29). As figure 2 illustrates, the CPM uses Total Floats (TF), which is the differences between Late Start (LS) and Early Start (ES). Furthermore, Free Float (FF), which is the difference between the Late Finish (LF) and Early Finish (EF) (figure 2).

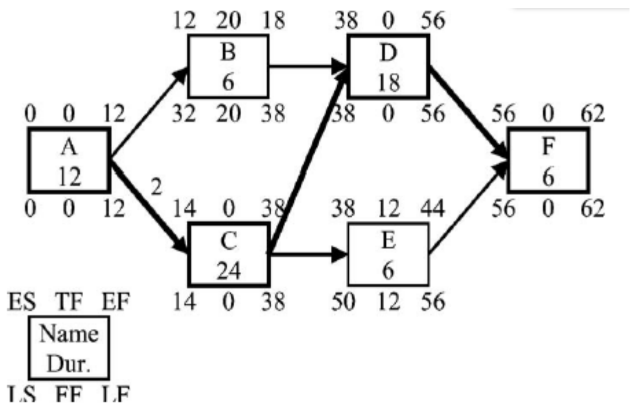


Figure 2: Critical path network (Gunnar Lucko, 2008, p. 712)

On the critical path, the activities Total Float (TF) and Free Float (FF) are equal to zero (Büchmann-Slorup, 2012, p. 31), as figure 2 demonstrates.

The CPM has been verified as an adequate method for planning, scheduling and the control of projects (Andersson, 2007, p. 1). It has been described as an effective method to control non-repetitive projects (Trietsch, 2009, p. 372).

Furthermore, it presents the information in a functional way. The CPM analyses the project in a way that makes information visible and makes a platform for communication within the organization's administration (Trietsch, 2009, p. 393).

According to Galloway, from experience over decades of use, it has been demonstrated that CPM can improve the prospect of a project finishing on time, or at least aid in agreements on extension of timescales (Galloway, 2006, p. 24).

In recent years, the method has had some criticisms among the scholarly community, including the inability of the CPM to manage the continuous flow of resources in the construction process (Robert B. Harris, 1998, p. 269) (Andersson, 2007, p. 1).

In addition, Seppänen criticised the CPM for constantly updating the schedule with new completion dates, instead of using control methods to handle the deviations in the scheduling (OLLI SEPPANEN & JAKE EVINGER, 2014, p. 608). Furthermore, the method has limits, as the CPM's priority is the timescale expected, instead of the workflow. This makes it difficult for the method to manage repetitive activities (Sua & Lucko, 2015). The next chapter will investigate the Line of Balance scheduling method.

2.3 Line of Balance

Line of Balance (LOB) is an example of a linear based scheduling method that emerged in the 1940s, from the Goodyear Company, thereafter further developed by the US Navy in the 1950s. Back then the method was primarily used in production control and industrial manufacturing (David Arditi, 2001, pp. 265-266).

Figure 3, is an example of a LOB schedule. The schedule is setup, with the time on the X axis and the amount unit produced on the Y axis. The start and finish are illustrated, by two parallel lines (Atilla Damci, 2016, p. 60). The space between the lines represents the time the unit takes. Whereas, the Activity on Arrow is used to create the network (Sua & Lucko, 2015, pp. 547-548). LOB method's objective is to make the production flow in a continuous sequence where it is performed in a systematic manner (David Arditi, 2001, pp. 265-266).

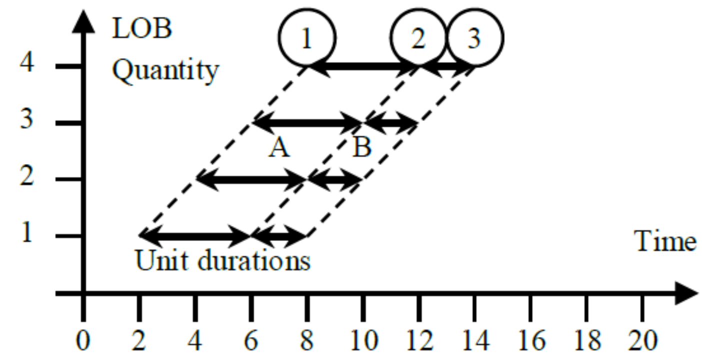


Figure 3: Line of Balance schedule (Sua & Lucko, 2015, p. 413)

The technique was developed as an alternative to activity based planning, which had been found to be insufficient in projects of a linear/repetitive nature (Atilla Damci, 2016, p. 58). The method has been implemented in various types of repetitive construction projects, including high-rise buildings, multi-storey houses and pavement projects (David Arditi, 2001, p. 265). Damci states that linear scheduling methods alone are insufficient to complete a project without problems. (Atilla Damci, 2016, p. 58)

Additionally, there is the need to manage resources. Whereas, the LOB method handles this issue, implementing resource allocation, where the goal is to minimise the duration of projects in accordance with resource constraints (Atilla Damci, 2016, p. 58).

The benefits of LOB include continuity in the construction process and optimum usage of work crews (Abdel Maged, 2017, p. 1). The optimum size of crew and natural rhythm, are implemented to reserve maximum productivity (Atilla Damci, 2013, p. 1109). The natural rhythm, principles state that to increase the production rate, the amount of work crews need to be doubled (tripled ...) (Atilla Damci, 2016, p. 60).

In recent years Björnfot and Jongeling performed an investigation into the benefits of combining LOB scheduling and 4D CAD in a timber multi-storey building. The findings were that the integration of 4D workspace simulation and LOB scheduling has a positive effect on the construction process, by balancing the work flow and assuring buildability. Furthermore, this increases the chance of finding waste in the operations (Jongeling, 2007, p. 209).

There has been uncertainty regarding the use of linear scheduling methods in the building industry, mainly regarding knowledge. According to Galloway, the main concern of owners, when it comes to linear scheduling is that it is not well known in the construction industry. Mainly, the contractors have a poor understanding of the method (Galloway, 2006, p. 27).

2.4 Flowline method

The flowline method, another variation of linear scheduling, it was developed in the 1970s. The method was named and documented by Mohr (Mohr, 1979). It was developed to *"handle normal construction projects"*, not building projects of receptive nature (Kenley & Seppänen, 2010, p. 72).

The technique resembles the Line of Balance method. The main difference is the use of locations rather than quantities. These locations are of a similar size. In the flowline method the activity is represented by a single line (figure 4), which flows through the locations. This is different from the LOB method, where the activities are portrayed by two parallel lines (figure 3) (Kenley & Seppänen, 2010, p. 71).

Figure 4, is an example of a flowline schedule, where the location is on the Y axis and the time on the X axis. The Tasks are represented by the black lines that flow through the locations. The dotted lines with an arrow at the end illustrate that when a Task is finished in a location the next Task can proceed, in the same location.

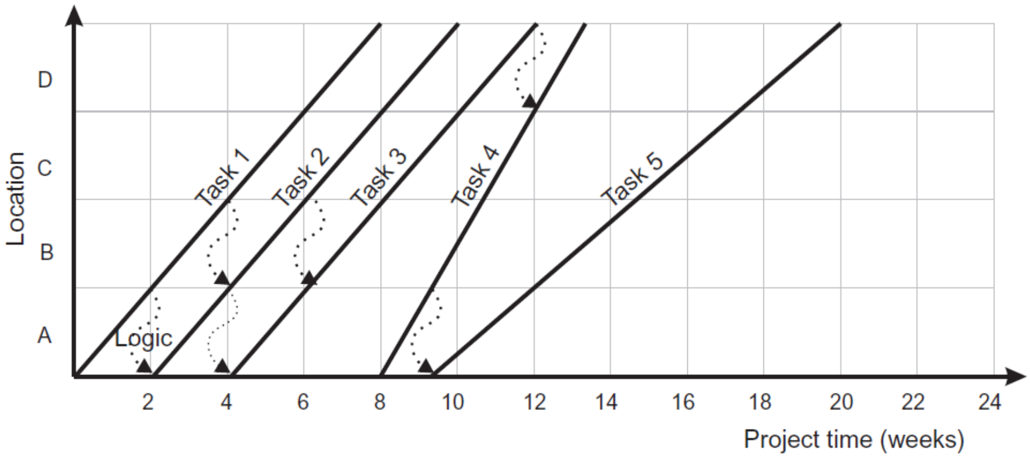


Figure 4: Flowline schedule (Kenley & Seppänen, 2010, p. 72)

2.5 Location-Based Management System overview

The Location-Based Management System (LBMS) is relatively new, the development dating to Finland in the 1980s. In the beginning, location-based planning methods were adapted to the construction industry by Kankainen and Kiiras, both professors at Helsinki University (Seppänen & Aalto, 2005, p. 272). The Finnish researchers based their system on a modified Line of Balance method (Andersson, 2007, p. 2). This research produced the location-based scheduling software called Dyna Project, which later was renamed Vico Office (Rezaei, 2015, p. 892).

LBMS affects all the stages of construction, from the design phase to the completion of construction (Kenley & Seppänen, 2010, p. 387). The system has been described as having two main parts: the location-based planning system and the location-based controlling system (OLLI SEPPANEN & JAKE EVINGER, 2014, p. 607).

The location-based scheduling is an example of a liner scheduling technique. It forms the foundation for the LBMS. The schedule breaks the construction project into locations, and where a Location Breakdown Structure (LBS) is established, it must be in a hierarchical structure (Kenley & Seppänen, 2010, p. 392). The structure forms the basis for the planning, scheduling and the control of the LBMS. In this way, location-based scheduling differs from the flowline method, which introduces locations of similar size.

The benefits of location-based planning involve different aspects, such as the planner reserves and a good overview of the flow of resources by implementing the method (Jongeling & Olofsson, 2007). Communication with the subcontractors and other parties involved in the constructing process has been known to improve. Also, the schedule makes sure that the flow of resources goes in a continuous way and there is no overlapping among the trades. location-based scheduling enhances the project's control by providing monitoring of the location of the work crews and the work they performed (Andersson, 2007, p. 10).

Furthermore, the system compresses the project time and improves the efficiency of resource utilisation by implementing production control and forecasting (OLLI SEPPANEN, 2014, p. 608). Kenley states that by managing resources through locations, this approach creates an improved management ability to control the handover of locations (Kenley, 2004, p. 1).

This chapter outlined a short introduction to the LBMS. In chapter 3, a more detailed explanation and further information is provided.

2.6 Chapter conclusion

This chapter has briefly explored the development of scheduling techniques. The Gantt chart was introduced, which represents an activity based visualisation of a construction schedule. The Critical Path Method (CPM) was presented and the criticisms by scholars noted, particularly its inability to assure the continuous follow of resources. Furthermore, the method is not suited to projects of a repetitive nature.

The history of the linear scheduling techniques has been explored from when Adamiecki introduced the harmonogram in the 1900s. Later, during the construction of the Empire State Building, harmonograms were used, with great results. The Line of Balance method was explored, and it was developed to handle production projects. Where instead of having activities on the Y axis as in the Gantt chart, it has units. Next, the flowline method was explored, where locations of similar size were introduced. Finally, the Location-Based Management System was introduced, which relies on a Location Breakdown Structure (LBS). This is explained in more detail in chapter 3.

In the next chapter the Theoretical Framework will introduce the Location-Based Management System and Vico Office application, a software which supports the system.

3. Theoretical framework

The last chapter reviewed the history of scheduling within the industry. The necessity for changes in the building industry was established. This chapter will introduce the Theoretical Framework. The Location-Based Management System (LBMS) is explored to set the frame for integration, into the case study.

This chapter, to a great extent, is based on the book "Location-Based Management for Construction, Planning, scheduling and control " (Kenley & Seppänen, 2010), by Russell Kenley and Olli Seppänen. The book is the main literature on the subject.

In chapter 3.1 the concept of the LBMS is explained. Thereafter, in chapter 3.2, Vico Office, a location-based software, is introduced. Then, chapter 3.3 contains the chapter's conclusion.

3.1 Location-Based Management System

The Location-Based Management System (LBMS) affects the complete construction process from the design to the construction phase. LBMS focuses on the planning, scheduling and control of projects. Its main efficacy is on locations, which form the basis for all stages of the system. The Location Breakdown Structure (LBS) gives a platform to store all the projects' data by locations. The planning, scheduling and controlling onsite are all coordinated by locations.

The system's efficacy is based on reducing the waste of time and materials. As such, it brings improved resource logistics, subcontractor's performance, reduces the production cost, increases quality in production and assists effective project reporting (Kenley & Seppänen, 2010, p. 3).

The Lean principles of workflow forms the foundation for the production philosophy. Lean principles include *Value*, where the need of the user is met. In the LBMS, this is implemented with a low level of risk. *Value stream* involves all the aspects necessary to deliver the product through design and the management of information. Within the LBMS, the emphasis is on improving logistics by locations. *Flow*, where the flow of work is secured, and locations are completed in a systematic manner. *Pull* is connected to the needs of the end user, where the user pulls the production to suit their requirements. In the LBMS, location pulls the resources. Finally, *Perfection*, which involves a virtual circle where all the previous principles are used to work towards perfection (Kenley & Seppänen, 2010, p. 390).

The pre-construction phase's necessity to maximise production efficiency through planning is recognised by the LBMS. Furthermore, the importance of controlling and monitoring these plans is acknowledged. Waste is reduced by implementing resources continuity. Implementing location management can generate the following: (Kenley & Seppänen, 2010, p. 389)

"

- *Continuous workflow wherever possible within project constraints*
- *Planned breaks or multiple crewing to achieve project objectives*
- *Alignment of production rates to achieve rhythmic production*
- *Space and time buffers between trades*
- *Reduction of interference or disturbance between trades*
- *Preventing cascading delays of the schedule*
- *Confidence in schedules, particularly for subcontractors*
- *Flexibility and variation in location requirements (repetition can be variable)."*

Furthermore, the flow of resoures goes in a continuous flow through each location, where all the tasks are finished before continuing to the next location.

Kenley & Seppänen have described the Location-Based Management System (LBMS) as having eight components (Kenley & Seppänen, 2010, p. 392): (1) Location breakdown Structure (LBS), (2) location-based quantities, (3) location-based estimating, (4) location-based planning and scheduling, (5) location-based control, (6) location-based reporting, (7) location-based quality management, and (8) location-based financial control. Each one of these components has its purpose in the system.

Additionally, the n D visualisation, which is not defined as a location-based method, will not be explored in the thesis. In the next eight sub-chapters, the eight components are elaborated further.

3.1.1 Location Breakdown Structure

The first step in performing the Location-Based Management System (LBMS) is to define the Location Breakdown Structure (LBS) (Kenley & Seppänen, 2010, p. 392), which is one of the system bases and breaks the project's structure down into locations. The breakdown structure should be hierarchical, where the top levels must include all of the locations that are beneath them. The construction sequences are optimised through the higher levels. The middle levels have the purpose of planning the structure's production flow, while the lowest levels have the purpose of planning the finishes and the details.

The LBS has great importance, because if the breakdown is not optimal then it will have a large effect on the quantity take off, which must fit with the LBS. This is in addition to the logistics, control based progress and flowline visualisation (Kenley & Seppänen, 2010, p. 204).

Figures 5 and 6 illustrate how the LBS can be performed on a multi-storey house. Figure 5 explains how the house can be divided both horizontally and vertically. Figure 6 demonstrates the same structure, using a diagram. The building is first separated into sections, with each section split into two risers, then floors and finally apartments.

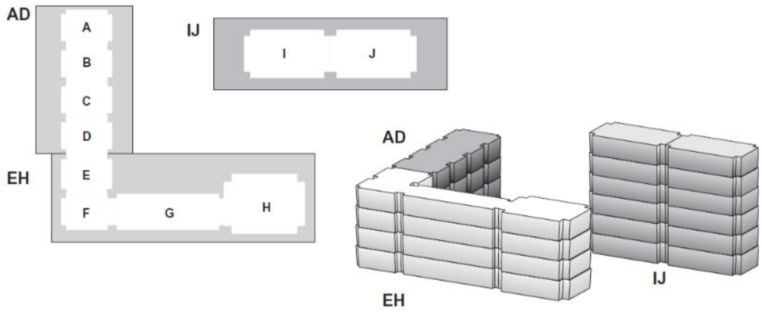


Figure 5: The hierarchy levels (Kenley & Seppänen, 2010, p. 126)

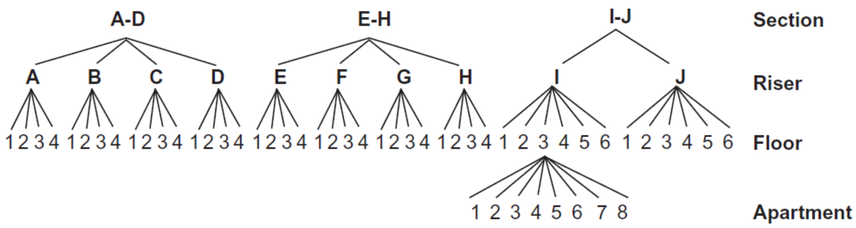


Figure 6: Location Breakdown Structure diagram (Kenley & Seppänen, 2010, p. 126)

3.1.2 Location-based quantities

After the Location Breakdown Structure (LBS) (Kenley & Seppänen, 2010, p. 393) is defined, the second component can be implemented, which is to extract the quantities according to their locations, called Bill of Quantities (BOQ). Quantities play a big role in the planning process. They are split up into packages by location. When defining these packages, it is necessary to make sure that sufficient manpower is assigned to perform the tasks and all the tasks in the same location that belong to the same work crew are in the packages. Work is finished before continuing to the next location. Furthermore, the same logic dependency is applied to the work outside the packages.

There are two ways of extracting the quantities. The first approach is the Manual method, where the quantities are estimated. The second method is by extracting from a 3D model, implementing software like Vico Office, which provides the quantities by location. It is preferred that the quantities are extracted using a 3D model. The reason for this is that the managers should be able to track variations in the quantities during the construction process.

Furthermore, supporting equipment, such as cranes and scaffolding, should be included in the quantities. They are measured along with the materials used in production.

3.1.3 Location-based estimating

The third component of the system is the cost control (Kenley & Seppänen, 2010, p. 394). When the quantities have been extracted, the next step is estimating their cost according to the locations. With the combination of the location-based quantities and the task formation, it is easy to perform a quick estimate of the cost and to locate errors in pricing. When estimating the cost, the cost of planning, manpower and other cost connected to the construction process must be included. This kind of calculation can easily be carried out with tools like Vico Office.

Implementing the location-based quantities ensures it is possible to integrate the cost into the project's schedule. By locating the amount of resources and manpower harnessed in individual locations, it is possible to generate the cost for each location. The next chapter will introduce location-based planning and scheduling.

3.1.4 Location-based planning and scheduling

Location-based planning (Kenley & Seppänen, 2010, p. 395) aims to make a schedule that can be performed and follows the principles of lean construction, where the tasks flow through the locations. This is done in a manner aimed at making the construction work efficient and the schedule suitable to follow and control.

The location-based scheduling, which forms the foundation for the LBMS, is not a new concept and has been around for around 100 years. As previously mentioned, the development was started by Professor Karol Adamiecki (Kenley & Seppänen, 2010, pp. 50-51).

When the quantities have been located, then it is possible to create a schedule, which is part of the fourth component. The production process must be planned to ensure production efficiency, aligning the rates of production to make the cycle planning, splitting the tasks and defining the crews that perform the actual tasks.

Figure 7 illustrates an example of a Location-Based Schedule, where on the x axis the location is placed and on the y axis the time. Thereafter, there is a black line that represents the start of the projects. The flow line is defined by the quantities and the consumption:

$$Total\ Hours = \sum_{k=0}^{i=n} (Quantity_{i\ x} * Consumption_{i})$$

(Kenley & Seppänen, 2010, p. 395)

In figure 7, the line named Task 1-4, represents the flow line, which in this case flows through all the locations represented by the tasks.

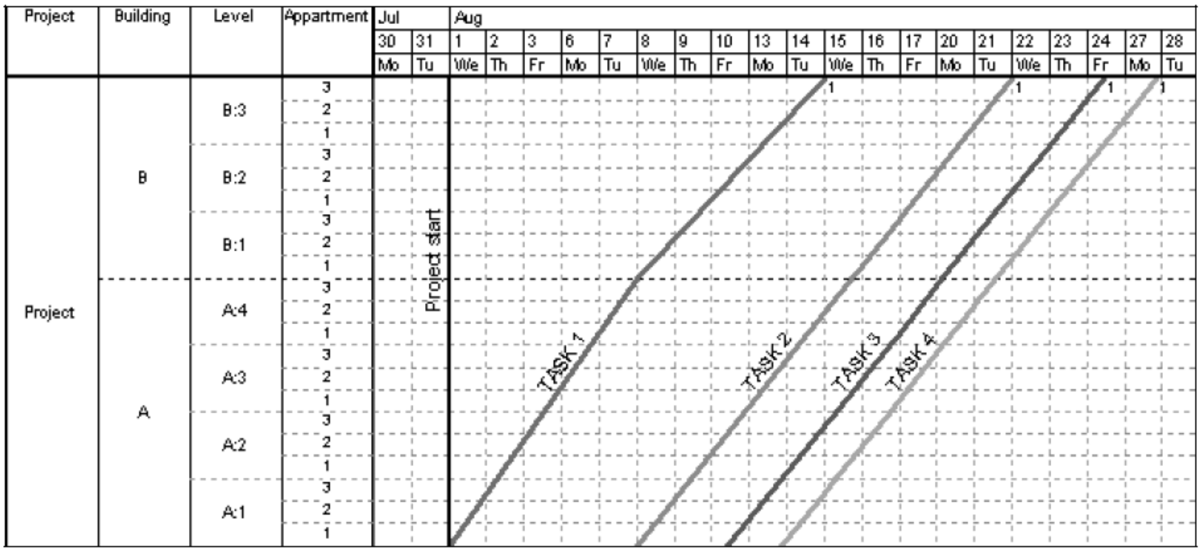


Figure 7: Location-based schedule (Andersson, 2007, p. 4)

Location-based scheduling implements CPM layered logic when it comes to the activities. Where (Kenley & Seppänen, 2010, p. 395):

"

1. *External logical relationships between activities within locations.*
2. *External higher-level logical relationships between activities driven by different levels of accuracy.*
3. *Internal logic between activities within tasks.*
4. *Phased hybrid logic between tasks in related locations (location lags).*
5. *Standard CPM links between any tasks and different locations."*

The location-based scheduling additionally implements lags and leads, which are used to determine the duration between the tasks. Furthermore, buffers time and location are used to meet the changes during the production period (Kenley & Seppänen, 2010, p. 396).

During the planning period, there are multiple points to consider, such as loading costs into the schedule, system cost, cash flow, and detail levels of the tasks. Furthermore, there is circular planning among critical activities, storage of materials, safety, quality, checks prerequisite for the tasks, and risks associated with the production and procurement process. The production process needs to be aligned and the resources assigned, and these plans then need to be run by the sub-contractor (Kenley & Seppänen, 2010, pp. 396-400).

The objection of the location-based planning and scheduling is to create a schedule that can maximise the productivity. This is done by using precise information concerning the project's scope, production rates, quantities and resources. The balance between risk and the project's duration is optimised. Now the planning and scheduling part of the LBMS has been explained. The next chapter will introduce the location-based control.

3.1.5 Location-based control

The previous parts of chapter 3.1 explained the planning and scheduling. Nevertheless, it is not enough to make good schedules if there is no sufficient tool to control them. This part explains the fifth component of the Location-Based Management System (LBMS), which involves the onsite control. At this point, it is expected that the schedule has been optimised, and a balance between time and risk found. The control system is designed to generate an early management response to deviations in production and create solutions (Kenley & Seppänen, 2010, p. 402).

By implementing location-based control, the management can commit to the subcontractors, ensuring that the work will proceed in a foreseeable and continuous way (Kenley & Seppänen, 2010, p. 402). The system uses the locations and visualisation to detect problems, before they take place. Forecast is used to remind the management that there are problems yet to be solved. The location-based control model will detect changes in quantity, delays in starting up, changes in production rates, and also, if trades are working out of sequence, changes in the production and the production prerequisite. This leads to improved efficiency in production.

In accordance with Kenley & Seppänen, the control stystem has four stages of production information: *"The location-based control model utilizes four stages of production information. The stages are: baseline, current, progress and forecast."* (Kenley & Seppänen, 2010, p. 403) There are two types of task used to establish the control of the schedule in the four stages: scheduled (baseline) tasks, which are the tasks present in the baseline schedule, and detailed (current) tasks, which demonstrates the current statuses of the scheduled tasks.

Figure 8, demonstrates the plotting of the stages of information, with baseline plans marked using a black unbroken line. The actual progress is represented by a dotted line and finally the forecast with the broken line.

The dot in the figure indicates that there is a clash between tasks. It is an early alarm system. (Seppänen & Kankainen, 2004, p. 4).

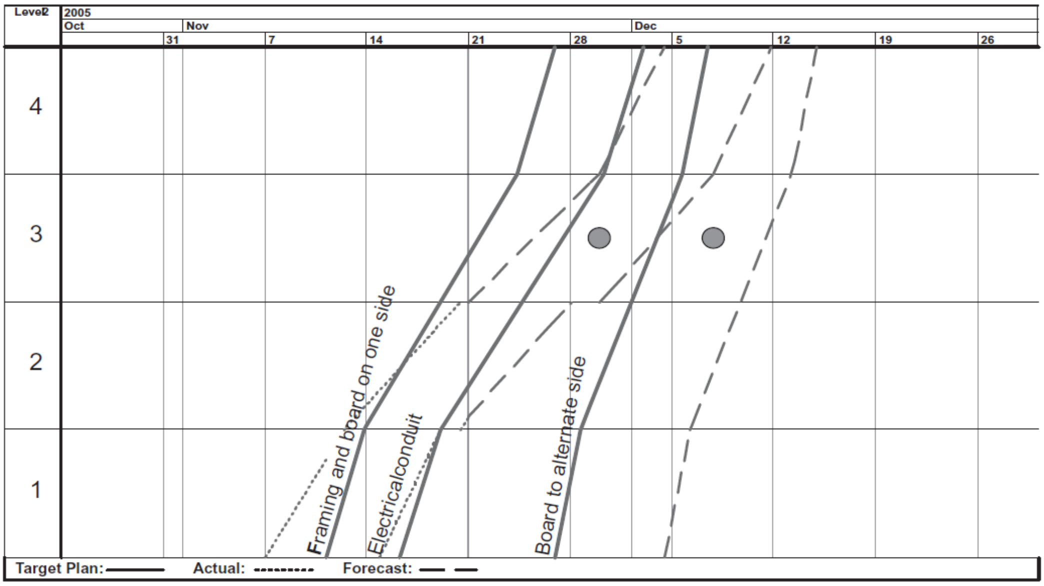


Figure 8: Baseline plans, actual progress, forecast and alarm (Kenley & Seppänen, 2010, p. 282)

The baseline stage, according to Kenley & Seppänen provides: "*The baseline stage provides the founding set of project data, such as the committed plan for the project, against which all subsequent performance is compared. It functions in the same way as a baseline in a schedule in CPM control systems.*" (Kenley & Seppänen, 2010, p. 403) The baseline cannot be changed except when a new baseline is initiated, and this only happens if there are considerable changes in the project. Within the location-based control model, the location-based quantities and the schedule task are used to produce the work plans. The baseline stage produces plans for procurement, forming commitments with the subcontractors and developing the tender schedule for the subcontractors. To be able to accomplish these issues, the start and finish dates need to be dependable.

The current stage (Kenley & Seppänen, 2010, p. 403) considers new information that was not present when the baseline plan was produced. This information can comprise of changes in the project's planning. Adjustments are made to the current plan when new information is available. Still, the original baseline plan constrains the current plan on account of the completion date at individual locations.

The mapping between the two planning stages is implemented through the location-based control model. The current quantities and detailed tasks are used to control the deviations in the current stage of planning (Kenley & Seppänen, 2010, p. 403).

The baseline and the current plan are complemented with the information documented during production. This is performed to locate deviations in production and makes it easier to update the current plan. It is required to monitor the quantities, resources, length of shifts, off days, when tasks start and end in locations, during the production. This information is then used to calculate the rate of production for the detail tasks and the consumption of resources (Kenley & Seppänen, 2010, p. 403). *"Monitoring of these items should be made on the most accurate planning level. Effectively this is the chosen location level of the detail task. The mapping between the detail and baseline tasks allows progress data to be compared with either of the two levels of planning."* (Kenley & Seppänen, 2010, p. 404)

Furthermore, the actual time performance is monitored in the progress stage, using information from the detail tasks. The start and finish times of the tasks are measured at each location and the actual production rates can be calculated. Additionally, if there exists information about resources, it is possible to calculate the resource consumption rates.

The forecast (Kenley & Seppänen, 2010, p. 404) is performed by using the current and process data to locate possible changes in the schedule. These changes can include deviations in quantities, breakdown of trades, trades working out of sequence, production rates, production prerequisites and delays (Kenley & Seppänen, 2010, p. 256). By implementing the forecast, problems can be detected. Furthermore, it is possible to plan for control actions when the deviations in the forecast have been addressed. *"The forecasts combined with actual and planned scheduling data provide the management powerful tool with which it is possible to detect critical deviations in order to plan a timely and optimal control action plan to preserve project flow."* (Seppänen & Kankainen, 2004, p. 2) The control action can consist of changes to the number of resources, working hours, technical dependency, location, and starting date of a location. Furthermore, it can include the splitting of tasks and elimination of non-value adding tasks. No changes are made to the baseline (current) plan, rather the forecast is updated. The forecast uses the actual rate of production, instead of the planned one. This approach helps the management to take informed decisions, preventing problems in production. The look ahead plan is then formulated from the new forecast, and from there the weekly plans are formed, which are the lowest level of planning in the system. Deviations are reported; the system encourages clients to be informed of deviations in the production process (Kenley & Seppänen, 2010, p. 404).

The next chapter will explore location-based reporting, which includes the method of presenting the schedule along with the control charts.

3.1.6 Location-based reporting

The sixth component of the Location-Based Management System (LBMS) is the location-based reporting (Kenley & Seppänen, 2010, pp. 405-406). The project reporting is performed using Gantt-, flowline-, production- and control charts. The Gantt charts are mainly used for the construction planning. It is believed that it causes less resistance to the LBMS by representing the schedule in a Gantt chart (figure 9), which follows the principle of location-based planning (Kenley & Seppänen, 2010, p. 405). The first column illustrates the hierarchy and the second one the name of the tasks. This differs from the original Gantt chart which demonstrates work activities, and programmes such as MS Project demonstrate the activities in a Work Breakdown Structure (WBS).

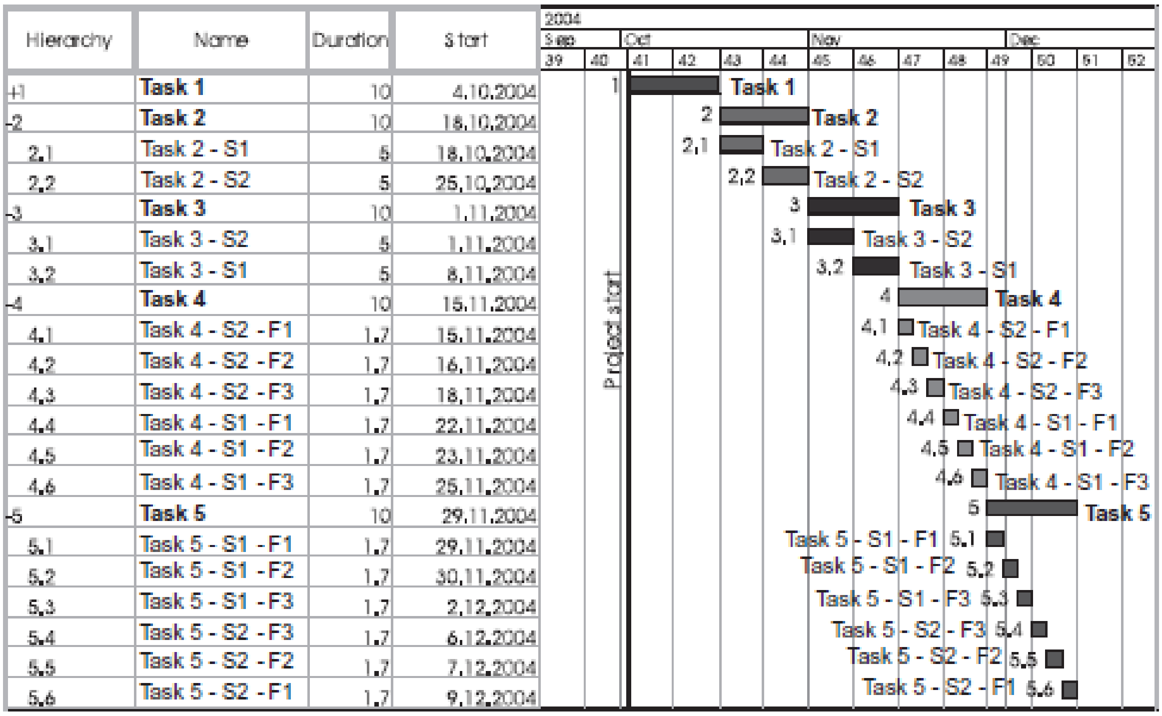


Figure 9: Gantt chart, based on the principles of location-based planning (Kenley & Seppänen, 2010, p. 140)

Furthermore, there is the flow line chart which was previously illustrated in figure 7 in chapter 3.1.4, which is the main method of communication in the LBMS. The user can read the chart as a floor plan, and it includes a great deal of information about the planned work. The chart is a powerful tool in the control phase, where it illustrates the history of the project and it is possible to analyse the future consequences.

Figure 10, illustrates an example of a control chart, which has the function of presenting the performance of individual tasks. The Y axis has the location structure and the X axis the task being monitored.

The chart is a highly effective tool when used at site meetings. The chart is like the flowline chart, as it is built around the location's structure. Instead of having a flowline through the location, the control chart has colour coding and the name of the location is entered instead of time. The status of each task in the locations is illustrated by using the colour coding, where green means that the task is finished. The blue colour indicates that the task in on track. Yellow shows that the task is behind schedule and red that the task will start late. Additionally, the start and end weeks of the locations are given. Also, the completion rate of each location that is under construction is given as a percentage. Furthermore, a production chart (Kenley & Seppänen, 2010) can be used to demonstrate the overall performance of the project.

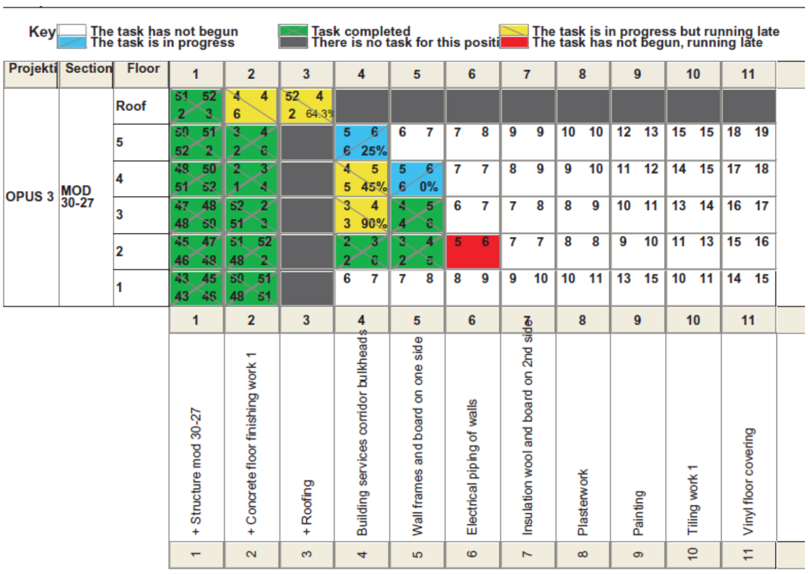


Figure 10: Control chart (Seppänen & Aalto, 2005, p. 276)

Next, this chapter will consider how the Location-Based Management System handles quality management.

3.1.7 Location-based quality management

This part of the system covers quality management (Kenley & Seppänen, 2010, p. 406), the Location-Based Management System's seventh component. According to Kenley & Seppänen, the main factors that can influence quality are if materials are damaged and if work is performed out of sequence. The work should be planned so it is not performed out of sequence. The important aspect is that the tradesmen can arrive at a location and all their predecessors are finished (Kenley & Seppänen, 2010, pp. 406-407).

Quality inspections should be implemented, then mistakes that have been made previously will not carry on to the next task. For this reason, it is recommended that after each task the location is inspected to avoid these complications (Kenley & Seppänen, 2010, p. 407).

3.1.8 Location-based financial control

The eighth component of the Location-Based Management System (LBMS) is the location-based financial control (Kenley & Seppänen, 2010, p. 407). The system has a different approach to the financial control, departing from the traditional method in the building industry. Subcontractors are paid with respect to their location, instead of finished work regardless of location as is the case today. This is a powerful tool, because it encourages the subcontractor to finish the location, because the contractor will not be paid until the location is finished.

Finally, all of the eight components of the LBMS have been explained. The next chapter will investigate Vico Office, software which supports the LBMS.

3.2 Vico Office application

The level of work process in the building industry has developed over the last two decades. New software applications have been developed to suit the needs of the industry. The concept of Building Information Modeling (BIM) has gained a considerable amount of attention in this period.

Building Information Modeling (BIM) has been described as one of the most promising developments in the AEC industry. With this technology, one or more virtual models are constructed with the purpose of improving the work process from the design phase throughout the life of the building. BIM affects the whole life cycle of the building process, including the design, construction and the facility management (Eastman, et al., 2011, p. 1).

The Location-Based Management System (LBMS) is not considered to be BIM, rather it has been described as interacting with BIM (Kenley & Seppänen, 2010). The main aspect, that the LBMS has been criticised for is the lack of a software application to support the system (Jongeling & Olofsson, 2007, p. 190). This is not considered to be an issue anymore following the development of the Vico Office software.

Vico Office is a planning, scheduling and control tool, and initially the application was called Dyna Project. The application was developed in Finland, by Olli Seppänen. It was created to suit the Location-Based Management System, with its development based on Finnish research. Furthermore, the application was first presented internationally at Stanford and Berkeley in 2003 (Seppänen, 2009, p. 7).

Figure 11, is an illustration of what Vico Office application offers to the industry regarding management, scheduling and control of projects. The information in this part were collected from the vicosoftware webpage (vicosoftware, 2016).

Figure 11: Vico Office (vicosoftware, 2016)

As previously mentioned, figure 11 illustrates what the Vico Office application offers. This starts with the document manager, where drawings and the models are compared to find variations and an accuracy check is performed. The application interacts with different BIM tools, including ArchiCAD, Autodesk Revit, Telka, CAD Duct, and AutoCAD MEP.

Vico Office offers integrated solutions in coordination and clash detection. The objective is to resolve problems before the start of the project.

Using the Takeoff Manager, the quantities are extracted from the building model. This is called the Quantity Takeoff, which is the fourth item in the sequence above. Next, comes one of the bases of the system, the Location Breakdown Structure (LBS). The location definition is performed in the LBS Manager. The creation of the schedule is performed using the Vico Schedule Planner. At this point, it is possible to connect the models, and the BIM components to the work crews, resources and materials. Another part of the system is the cost estimating, which is based on Target Cost Planning. In the Layout Manager, it is possible to map critical points in the model and worksite and compare them together. Then there is the production controller, where the production process is documented using information from the site. Additionally, forecasting is performed to predict the outcomes of the project. Then there is the 4D Manager, where a 3D replication of the project's timeline is performed.

This chapter has introduced Vico Office, the selected tool for integrating the LBMS into the case study. The next chapter will give a conclusion to this chapter.

3.3 Chapter's conclusion

This chapter has introduced the eight components of the Location-Based Management System (LBMS). The purpose of introducing the LBMS is to form the foundation for its integration into the case study. The Location Breakdown Structure (LBS) was introduced, where the building is split up into locations that make up the foundation for the LBMS. Then, the quantity Takeoff was explained, where quantities can either be extracted manually or by using the recommended method of using a Building Information Model. Next, the estimation was introduced, with this part involving the cost estimation. Thereafter, the planning and scheduling were based on the locations previously defined. After the schedule was created, the onsite control was discussed, including the introduction of the baseline, current, process and forecast.

Thereafter the location-based reporting was explained, with a location oriented Gantt chart, flowline schedules and control charts used as the reporting tool. Subsequently, the quality control was investigated, emphasising the important point that work is not performed out of sequence. Furthermore, it is important that mistakes in production are not carried over to the next stage. The location-based financial control was then explained, where the efficacy derives from the contractors getting paid by completing their location. Finally, Vico Office was introduced, as a software application based on the Location-Based Management System (LBMS).

4. Methodology

In all academic research, it is important to define the methodology, so the investigation has a clear objective. The following chapter will set the framework for the research method and its design. In so doing, it will define the direction of the research that is performed in the following chapters. In chapter 4.1 the research method will be introduced. Chapter 4.2 will illustrate the research design. Finally, chapter 4.3 will explain the data collection method.

4.1 Research method

At this stage, it is imperative to explain in more detail how the author intends to execute the research. To proficiently answer the problem formulation, it is necessary to investigate the sector that the problem formulation covers. This is conducted using a pragmatism research philosophy, by implementing mixed method research (Bryman, 2016, pp. 31-34) involving qualitative and quantitative methods.

Qualitative methods are used to investigate the company's internal factors, which will influence the integration of the Location-Based Management System (LBMS). In addition, the status of management, scheduling and control in the company's projects will be assessed by conducting interviews, observations and data gathered during the investigation.

A quantitative method is used to explore the external barriers concerning integration of the LBMS, by sending out a questionnaire. In addition, information was collected about material quantities and the number of employees working in the company's projects.

There was no possibility to collect quantitative information regarding the company's operation performance, so for that reason qualitative methods were applied.

4.2 Research design

The research was conducted as a case study, which consists of a single construction company located in Iceland; currently four projects are being executed. This thesis follows the design based approach to research explained by (Herrington, 2007), where the research starts with the hypothesis. However, because of limited time, the hypothesis will not be tested in the field. In this Master's thesis, the integration of the LBMS is primarily based on theory.

The aim of the research is to investigate the opportunities, advantages and challenges of integrating the LBMS into a small construction company. Furthermore, the study will answer the three research questions formulated in chapter 1.2.1.

Figure 12 illustrates the overall structure of the research and the order in which it was performed. The process that the figure illustrates was inspired by Kristensen's conceptual model (Kristensen, 2008, p. 26).

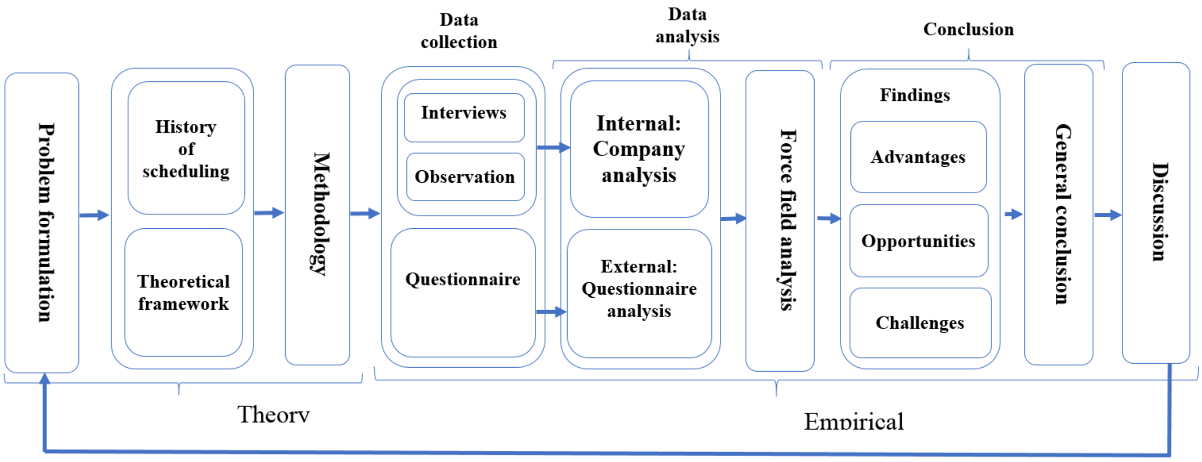


Figure 12: Research design

The work is composed of seven sections, as figure 12 illustrates, starting with the theoretical study. The first part includes the problem formulation, where the problem statement is developed, definition of research questions, and the formulation of problem delimitations.

Then the history of scheduling was explored, where the author reviews the work of scholars in the field, and both location and activity based methods were introduced. A theoretical framework, where information about the Location-Based Management System (LBMS) was formulated from books and articles, was composed by scholars on the chosen subject. This information was used to explore the possibilities of integration into the case study. Data about the scheduling techniques, where collected, is based on data obtained from Aalborg University´s Library and by internet searches.

The current part introduces the research method and defines its design. The next part will elaborate further on the data collection methods. In the upcoming chapters, the empirical study is performed. Where data collection is conducted, the current situation of the company is documented. Data is collected both internally and externally, internal data from the company and external from professionals within the construction field.

The current situation in the company's planning, scheduling and onsite control are compared with the LBMS procedures. Issues involving integration are explored. Thereafter, the findings from the questionnaire are introduced. A force field analysis is formulated, and the driving and resisting forces located.

The thesis thereafter lists the advantages, opportunities and challenges of integrating the system into the company. Finally, a conclusion is presented and suggestions for further research are outlined in the discussion.

4.3 Data collection methods

This chapter, will explain how data used in the investigation was collected. Three methods were implemented: interviews, observations and a questionnaire.

Semi-structured (Bryman, 2016, p. 10), explorative interviews were conducted with one of the company's owners and two of its employees, involving synchronous communication both in time and place. The questions were targeted on the collection of information about the company history and its future direction, its operations, employees, the internal situation of the company, technical information, work procedures, planning methods etc. The objective was to acquire the necessary information about the procedures implemented in the company during planning, scheduling and onsite control to support the solution for the problem formulation and research questions. The interview transcripts are placed in Appendix A, B and C.

The observations were performed over a week's period, during which the author of this thesis visited the company and observed their operations. Research activities included visiting a building site and collecting information and taking photos at different sites.

A questionnaire was sent out to experts in the Icelandic AEC industry to investigate the external barriers to integrating the Location-Based Management System (LBMS) into the company's project. The objective of this was to elaborate on the solution for part of research question three.

The questionnaire contained background questions. Thereafter, information about the work procedures were collected. Questions were asked regarding the respondents' use of Building Information Models (BIM) in their work and what kinds of software were used among the respondents when planning and scheduling. Additionally, the knowledge of theory and skills in the software applications used in construction management was investigated. The respondents were asked to evaluate their knowledge and skills on the scale from "Poor" to "Excellent".

The attitude of the respondents was measured on a Likert scale (Likert, 1932, p. 17) from "Strongly agree" to "Strongly disagree". The respondents were also asked to respond to a list of statements which assessed their opinion on the possibilities of improvements by implementing the LBMS and the barriers to its integration. The questionnaire design is located in Appendix D.

At this point, the thesis has come to a crossroads. The theoretical part is finished and from now on the empirical investigation will start. The next chapter will introduce the case study.

5. Company Investigation

Previous chapters introduced the theoretical studies, and now this one will explore and then elaborate on the empirical approach. This chapter will investigate the case study, which involves a small construction company. Integrating a management system into an organisation is a large task. For that reason, the work method and construction projects which the company is implementing need to be thoroughly investigated.

In chapter 5.1, the company's operations and employees are introduced. Then chapter 5.2 explores the planning and scheduling method adopted by the company. Chapter 5.3 demonstrates how the onsite control is performed. Thereafter, in chapter 5.4, the first of three projects that the company is currently implementing is introduced, and this project has been named "Industrial building". Chapter 5.5 will introduce the second project, "Group home project". The third project is explained in Chapter 5.6, the "Multi-storey house". The Industrial Building is used to demonstrate the scheduling part of the Location-Based Management System (LBMS) in the thesis, as well as the planning and onsite control. The Multi-storey house project and the Group home project will carry the function of demonstrating the operations of the company, as well as how the onsite control is coordinated. Finally, chapter 5.7 provides a short conclusion to the chapter.

As previously mentioned, the names related to this report have been kept anonymous. For that reason, company employees are named by their work title and the projects by their functions. It is common in this company for employees to have more than one function.

This chapter is based on information collected from interviews with three members of the company's management team. The first interview was with one of the Directors (CEO), who is educated as a Master of Carpentry and has over 30 years of experience working within the building industry. The owner (CEO) also serves as a Project Manager, where his duties are to oversee the work of the site managers. The transcript of the interview is provided in Appendix A.

The second interview was with a project coordinator/site manager, who is educated as a mason, has 12 years of experience working in the building industry and is currently pursuing higher education studies alongside work in the company. The project coordinator/site manager's duties are to perform the price calculation, plan for the projects and make the time schedule. This person is currently working as a site manager in the Multi-storey project. From now on the project coordinator/site manager is referred to as the Project Coordinator. The transcript of the interview has been provided in Appendix B.

The, third Interview, was performed at the Group house project building site with the project's Site Manager. The Site Manager is educated as a carpenter and has worked in the building industry for 24 years. The transcript of the interview is provided in Appendix C.

5.1 Company profile

The company is located in Reykjavík, which is the capital city of Iceland. It was established in the year 2000 by four educated tradesmen, three in the field of masonry and one was a carpenter. The history of the company could be explained in two periods. From 2000 to 2012, the company's primary function was to provide services within the field of masonry, both to individuals and construction companies as subcontractors. Additionally, they performed a few building projects over the years, on the side as a form of secondary production.

The second period commenced around 2011, when the owners decided to make changes to the company. These involved more focus on developing their own building projects, including residential and industrial housing. The reason for this change is they wanted to be more sustainable and independent. Currently the project portfolio consists of 70% development projects and 30% services. The owners see the future of the company trending more into development of their own projects and additionally building on demand for both private and public entities. Furthermore, they expect the service will reduce even more and perhaps close.

During the first interview, the Project Manager stated that there is no formal organisational structure. Still, by collecting information, the author has been able to structure an organisational chart as illustrated in Figure 13.

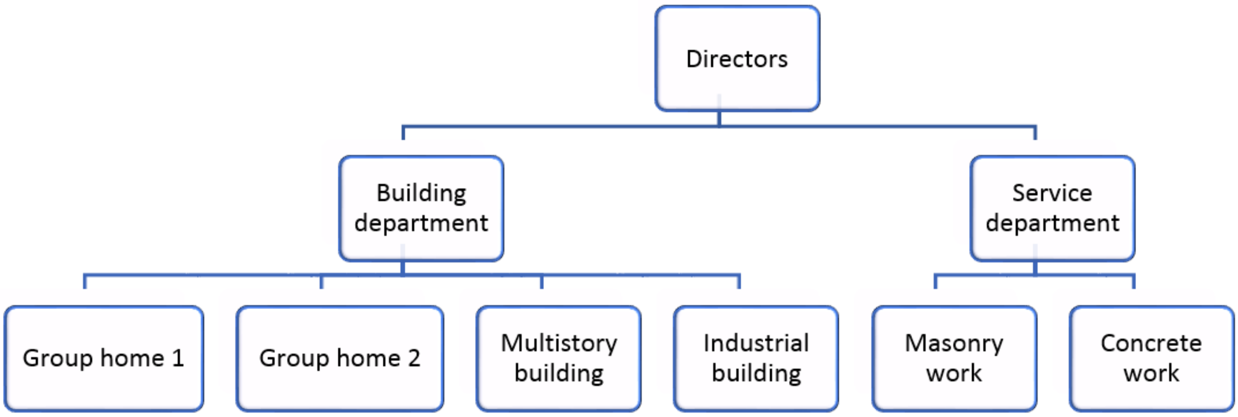


Figure 13: Organisational structure

As figure 13 illustrates, at the top of the organisation chart there are the Directors. Three of the owners are titled as Directors, as they all take part in the day to day running of the business and control of building projects. The fourth owner is working in the field, controlling the service department.

The company has two main departments as figure 13 demonstrates: the service and building departments. The service department is divided into two branches defined by their functions: masonry and concrete work. The branches focus on performing services for large construction companies. After the organisational changes, the company does not provide small-scale services for private entities.

The building department is controlled by the Project Manager previously introduced. Currently, there are four projects being constructed. Two of them are own production and the other ones are for a public organisation.

There are around 40 employees currently working in the company, mainly masons, carpenters and some helpers. The Project Coordinator previously introduced works within the building department, performing planning and scheduling. Furthermore, there are up to 30 workers employed by subcontractors, electricians, painters, etc. who work for the company on a day to day basis.

This chapter has introduced the organisation and its operations. The service department will not be discussed any further in this thesis. The next chapter will investigate the company's work methods within project planning and scheduling.

5.2 Companies planning and scheduling method

When it comes to planning and scheduling, the company's management team has recently started to develop time schedules and work according to them. This year and a part of last year was the first time projects were implemented using a time schedule. According to the Project Manager, they have not been strong in this field in the past. The practice has mainly been performed using feeling, rationalism and the experience of the management team in the company.

Times are changing, and the Project Manager realises that it is not possible to base the construction process mainly on feeling, rationalism and experience. The banks require a time schedule and a cost estimate of the projects in order for them to issue a loan for the construction projects. Additionally, it is expected from contractors that they will produce a schedule and demonstrate that it is being followed when executing public projects.

The planning is performed jointly among the management team, with the Project Manager and the Project Coordinator working together in the starting phase. Each project is evaluated by the management team with regards to different factors such as size, resources and manpower. The Project Manager has extensive work experience in the building industry and knows the expected duration of each task. After the Project Manager and Coordinator have made the plans for the projects, the Project Coordinator performs the cost estimation and the time scheduling digitally.

Figure 14 illustrates how the planning and scheduling is implemented within the company.

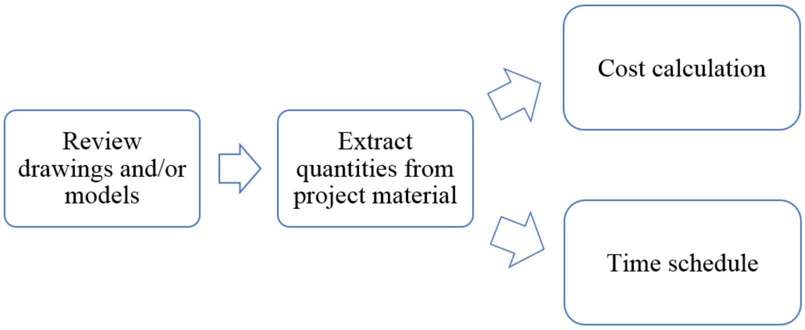


Figure 14: Planning and scheduling methods

When the Project Coordinator has reviewed drawings and documents concerning the construction projects, as illustrated in figure 14, the works start by going over the drawings and deliberating on the time frame for the project. Furthermore, it needs to be clear what demands are made to the company, so it is possible to make the plans. There are no risk analyses performed for any of the company's projects.

Thereafter, the quantities are extracted, and the work is performed by using tools such as Bluebeam Revu, IFC Viewer and MS Excel. The Project Coordinator takes the drawings and measures them in Bluebeam Revu to estimate the project's quantities. In cases where the company is working for the government, a list of quantities is received with the tender material.

Then the quantities are organised in an Excel spreadsheet, using the following seven-point project Work Breakdown Structure (WBS):

1. Work area
2. Earth work
3. Structure
4. Roof
5. Finishing outside
6. Finishing inside
7. Finishing grounds

The list is then further divided by activities within these seven categories, such as roof, walls, floor, painting etc.

After the quantities have been extracted, the cost calculations and scheduling are performed as figure 14 illustrates. According to the Project Coordinator, the only way to perform the cost calculation is by experience and feeling. The cost calculation is setup, similar to the previously mentioned WBS (Annex 2). Production cost is included in the cost estimate by adding a percentage to the project's total cost. In projects executed for the council, the calculated quantities are used to estimate the amount to bill the client in each period, with the activities calculated up to 100%.

Finally, the time schedule is setup in MS Project. This is conducted according to the project's Work Breakdown Structure (WBS), as previously mentioned. The number of workers used to perform the tasks are not included when the schedule is created. The Project Coordinator says that this is something they should include in the future. The schedule is formulated by using Finish to Start (FS) and Start to Start (SS) dependencies between activities with or without lags (Annex 1). The critical path is illustrated in a red colour in the project's schedule (Annex 1).

There have been some complications in producing dependable time schedules, with the main issues involving soil excavation, according to the Project Manager and Coordinator. It has been hard to estimate an accurate time for the soil excavation. Even though boreholes were executed, they have not accurately informed the situation of the soil condition accurately in every project. This has caused delays in production, resulting in customer dissatisfaction.

Furthermore, there have been difficulties in getting the subcontractors to follow the schedule. These difficulties are partially due to misunderstandings in communications. Perhaps the priorities have not been clearly stressed to the subcontractors, according to the Project Manager.

Now that the planning and scheduling procedures are explained, the next step is to investigate the project control method in the next chapter.

5.3 Project control methods

Now that the company's planning and scheduling methods have been explained, it is time to investigate the onsite project control.

The Project Manager is a registered building manager for all of the company's construction projects. It is not possible for him to be located at all places, therefore there are site managers employed at each location. Figure 15 illustrates the flow of communication in the onsite project work between the Project Manager, site manager, suppliers, company's employees and the subcontractors.

The onsite control work methods are performed in a similar manner as the planning and scheduling, based on the experience, rationalism and feeling of the management team. The Project Manager visits all the construction sites daily and conducts meetings with the site managers, as figure 15 illustrates. In these meetings problems in production are discussed and the two managers work together in finding solutions. The Project Manager does not interfere in the amount of work performed daily, but rather serves as a support network.

The, site mangers duties are to run the construction site, and communication with the subcontractors, suppliers and company's workers (figure 15) are a part of the duties. During the day, site managers coordinate the company's workers, which has been challenging due to language barriers.

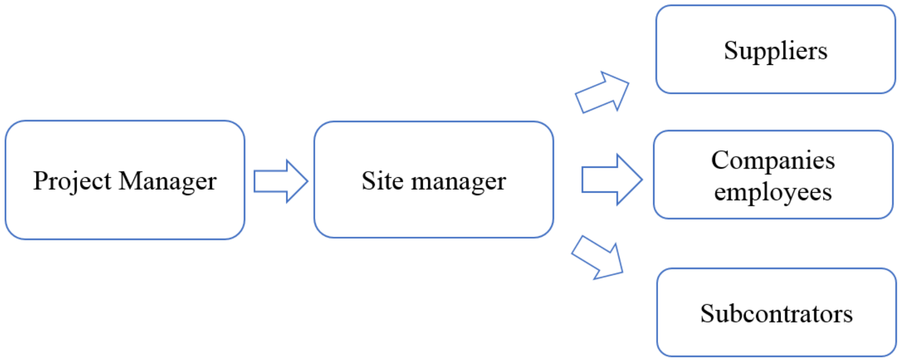


Figure 15: Project communication channels

Another of the site manager's duties is to be in contact with suppliers (figure 15) regarding materials used in production. The communication must be satisfactory, since suppliers will expect that managers always order the material at a suitable time. Furthermore, the time between the order and getting the material delivered cannot be too long because of storage issues.

The subcontractors are monitored and coordinated by the site manager. The Project Coordinator states that the communication has been satisfactory with the subcontractors. Still, the fact remains that most of the delays in the company's projects are caused by the failure of subcontractors to follow the time schedule. The problem is that when a subcontractor is late with tasks that need to be finished, this delays another contractor from starting their work. This has resulted to the firing of subcontractors in the past by the Project Manager, whilst the delays caused problems between the company and its clients.

When asked if there is any weekly planning implemented within the company projects, the Project Manager stated that every week there is a necessity to make plans involving what should be finished in the following week, so another task can start the week after. Furthermore, the plans are performed to give the next trade time to get ready. There is no documentation of weekly progress, within the construction projects performed, concerning their own production.

Figure 16, is from the Group house project. The time schedule is seen on the work shed wall and printed out drawings are on the table. The project's time schedule is used more as an overview than a control tool, according to the Site Manager.

The Project Manager stated that they are thinking about having a computer onsite to perform daily documentation and have access to the drawings digitally onsite. Also, they are going to start having an onsite clock, using a system called Tímon, so the employees can stamp in and out of work from their mobile phone. This will be done to get more out of the staff, through them being punctual and efficient.

Figure 16: Group home project, inside the work shed

There used to be a site meeting every two weeks with the subcontractors, which the three owners and the Project Coordinator attend. The company uses the same subcontractors in all their projects. A single site meeting occurred for all the combined projects, where the status of the projects was discussed. Since June 2017, there has not been any site meeting organised. When working for the public sector, there is an additional meeting with the client representative every two weeks to discuss the project's status.

There is no official work process when it comes to quality control. The company prides itself in using high quality materials for the internal finishes. The owners of the company are often present on the construction site monitoring, and according to the Project Manager not much goes past them. The Site Manager at the Group home project works alongside the carpenter from the company and oversees their work. Furthermore, the drawings are followed to ensure quality in the projects.

Additionally, inspections required by law are performed where a representative from the council comes to oversee all the iron in the structural parts and the plumbing. There are no inspection requirements regarding electricians, except the approval of material used in production. In addition, there is a possibility of an unexpected inspection from "Mannvirkjastofnun", a government agency.

Now that the planning, scheduling and control methods within the company have been investigated, it is time to introduce the current projects.

5.4 Industrial building project

As previously mentioned, the company has four ongoing projects. This chapter will introduce the first one, the Industrial house project. The building is located on the outskirts of Kópavogur, which is a town in the Greater Reykjavik area. Its function is to host businesses.

The house has two stories, each six metres high. These two stories then have additional levels, so altogether there are four levels. The building is a cast onsite concrete building, insulated from the outside with rockwool and aluminium cladding. Light internal walls are constructed with Gas concrete blocks. The floors and the roof slabs are hollow core concrete slabs.

5.4.1 Industrial building introduction

The Industrial building (figure 17) has a floor area of around 3600 m². The building has four levels, some of the levels are completely used, while other areas serve to increase the floor height for the lower levels.

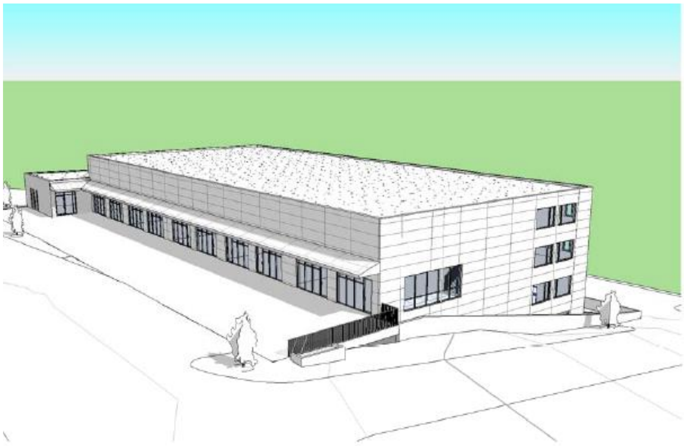


Figure 17: Industrial building project (Ragnarsson, 2016)

The first level has a floor area of 1200 m², and here there are three spaces which size from 230-500 m². These spaces are for various types of industrial businesses, such as carpenters, masons and plumbers. The floor height is six metres. In addition, there is one 250 m² space with a three-metre floor height.

Then, on the second level, there is only an office space, with a floor area of 240 m². Most of the space on this level serve as a floor height for the first level.

On level three, the complete floor area is used by businesses. There are five shops, each one of them 240-260 m². Parts of this level have a floor height of six metres, then there is one 84 m² office on this level.

Finally, level four has 460 m² of floor area. This level is comprised of offices, and there are five units, each 80-110 m² in size.

5.4.2 Onsite project hierarchy

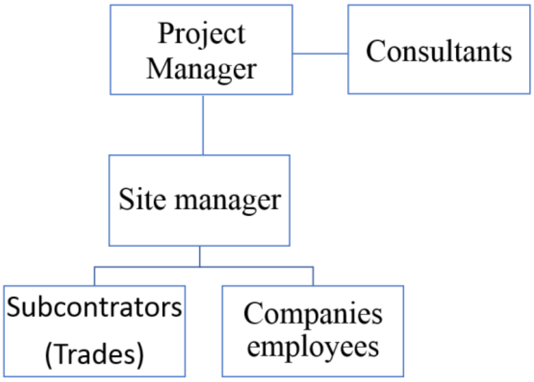


Figure 18: Onsite project hierarchy

The last chapter described the Industrial building's layout and functions. In the following chapter, the project's onsite hierarchy is introduced. Figure 18 illustrates how the onsite project hierarchy is planned to be organised, with the Project Manager at the top.

The company hires external designers to make the architectural, structural and installation drawings.

The site manager handles the daily running of the site. Among the site manager's duties is to coordinate the company's own workers and subcontractors, which consist of carpenters, plumbers, electricians, soil workers etc. In addition, the company hire an engineering office to perform the geological investigations.

5.4.3 Project schedule

Figure 19: Industrial building project November 2017, 15th of November 2017

The previous, chapter presented the planned project's onsite hierarchy, and in this chapter the project's time schedule is introduced. A copy of the schedule has also been provided in Annex 1. The planned time frame for the project was from 15 of March 2017 to 22 of June 2018. Figure 19 was taken during the onsite observation, and it demonstrates the status of the building on 15th of November 2017.

The project has been greatly delayed due to the problematic aspect of finding soil workers to perform the excavation. Finally, when a soil worker was hired, the work was more troublesome than expected. Information from the geological investigation did not indicate that the soil was as hard as it has turned out to be. It is not known why the geological investigation did not reveal these complications, however, it could be that the boreholes were not deep enough or there were too few boreholes drilled. The excavation finished at the end of September, and in the beginning of October the Project Manager expected the foundation work to start.

These problems have delayed the project for approximately five months, which is considerable for a project with an expected duration of 15 months. According to the Project Manager, this has caused the company some problems. They had made commitments with companies which expected to move into the building in the beginning of December. Figure 20 illustrates the schedule produced for the Industrial building project, prepared by the Project Coordinator.

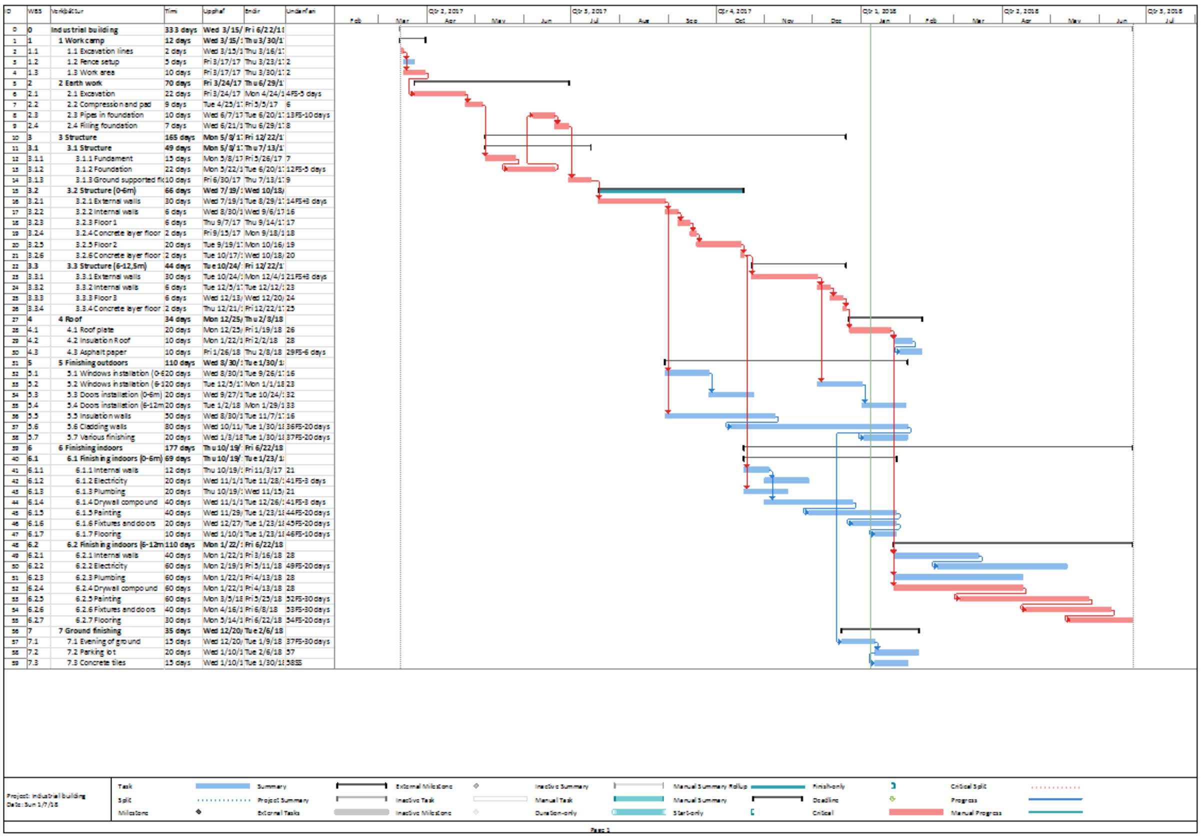


Figure 20: Industrial building project schedule (Annex 1)

5.5 Group home project

The previous chapter investigated the Industrial building project, and this chapter will now introduce the Group home project (figure 21), which is located Reykjavik. The project consists of two identical houses in separate locations in Reykjavík. For that reason, only one of them is investigated. Each house comprises around 575 m² of floor area, and they are designed for residential purposes. The project differs from the Industrial building. It is being constructed for a government agency, not developed by the company. The company participated in a tender and had the lowest bid.

Figure 21: Group home project, 17th of November 2017

5.5.1 Building introduction

The Group home project (Borgarsson, 2017) is a single-story building. The house is split up into three units, as figure 22 illustrates. The two areas coloured with green and blue in figure 22 contain accommodation for residents, and then the yellow area in the middle consists of a dining hall of 40 m², kitchen of 10 m², and a common area of 20 m².

The green area in figure 22 contains three studio apartments, 40 m² each. The apartments all include a sleeping room of 10 m², bathroom of 7 m² and a living room of 24 m². Then there are three storage rooms of 3 m² each. In shared areas there is an extra toilet of 7 m², bathroom of 25 m² and a laundry room of 10 m² for the residents. Additionally, there is accommodation for the employees, including a changing room of 7 m² and a toilet of 3.5 m². Furthermore, there is a 12 m² office for the administration and a technical room of 21 m².

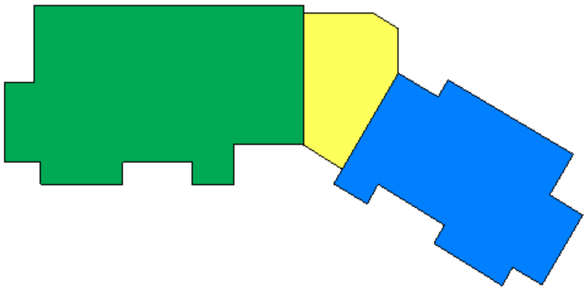


Figure 22: Group home project layout

Then, the blue area in figure 22 consist of three studio apartments of 40 m², designed in the same layout as the apartments in the green part. Also, there are three storage rooms of 3 m² and a technical room of 6 m².

Figure 23: Inside the Group home project, 16th of November 2017

The building is constructed out of prefabricated concrete elements, both the external walls and the foundations. The concrete, ground supported floor is cast onsite. Light internal walls are constructed from either gypsum wallboard or Gas concrete blocks (figure 23). The roof is constructed out of timber rafters and aluminium cladding.

5.5.2 Onsite project hierarchy

The project hierarchy (figure 24) is similar to the Industrial building project, with one exception. As previously mentioned, the project is being constructed for a government agency. The client has inspectors which monitor the progress of the projects, by conducting meetings with the company every two weeks.

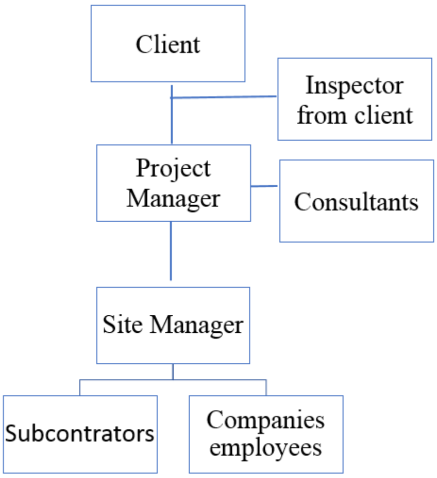


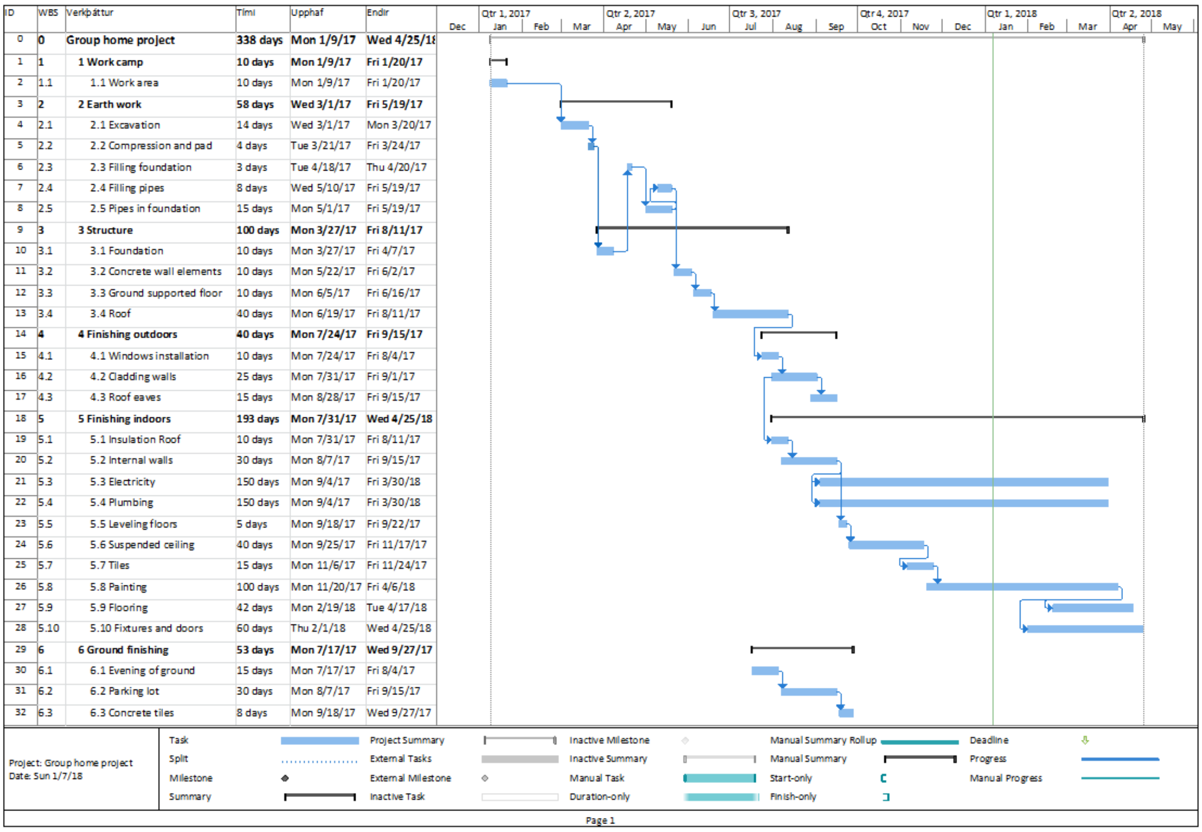
Figure 24: Onsite project hierarchy

As in the previous projects, the Project Manager is the registered building manager. Then, there is the Site Manager who handles the daily onsite control, which involves coordinating subcontractors and the company's employees. The next chapter will introduce the project's time schedule.

5.5.3 Project time schedule

The Group home project has a time frame of one and a half years. After that, the client expects the project to be delivered. The Project Coordinator formulated the project schedule (figure 25 and Annex 3) for the project. The schedule starts on the 1st of January 2017 and the expected end date was the 25th of April 2018. As previously mentioned, the company is expected by the client to follow the time schedule and deliver the project on time.

Unlike the Industrial building, this project is ahead of schedule. A subcontractor was hired to perform the work on the foundations, ground supported floor and to erect the prefabricated wall elements. The work took a considerably shorter time than estimated, which has resulted in the possibility of delivering the project by 1st of February. In the beginning of October, when the interview with the Project Manager was conducted, there were many trades working on the site.



ID	WBS	Verkþáttur	Tími	Upphaf	Endir
0	0	**Group home project**	**338 days**	**Mon 1/9/17**	**Wed 4/25/18**
1	1	**1 Work camp**	**10 days**	**Mon 1/9/17**	**Fri 1/20/17**
2	1.1	1.1 Work area	10 days	Mon 1/9/17	Fri 1/20/17
3	2	**2 Earth work**	**58 days**	**Wed 3/1/17**	**Fri 5/19/17**
4	2.1	2.1 Excavation	14 days	Wed 3/1/17	Mon 3/20/17
5	2.2	2.2 Compression and pad	4 days	Tue 3/21/17	Fri 3/24/17
6	2.3	2.3 Filling foundation	3 days	Tue 4/18/17	Thu 4/20/17
7	2.4	2.4 Filling pipes	8 days	Wed 5/10/17	Fri 5/19/17
8	2.5	2.5 Pipes in foundation	15 days	Mon 5/1/17	Fri 5/19/17
9	3	**3 Structure**	**100 days**	**Mon 3/27/17**	**Fri 8/11/17**
10	3.1	3.1 Foundation	10 days	Mon 3/27/17	Fri 4/7/17
11	3.2	3.2 Concrete wall elements	10 days	Mon 5/22/17	Fri 6/2/17
12	3.3	3.3 Ground supported floor	10 days	Mon 6/5/17	Fri 6/16/17
13	3.4	3.4 Roof	40 days	Mon 6/19/17	Fri 8/11/17
14	4	**4 Finishing outdoors**	**40 days**	**Mon 7/24/17**	**Fri 9/15/17**
15	4.1	4.1 Windows installation	10 days	Mon 7/24/17	Fri 8/4/17
16	4.2	4.2 Cladding walls	25 days	Mon 7/31/17	Fri 9/1/17
17	4.3	4.3 Roof eaves	15 days	Mon 8/28/17	Fri 9/15/17
18	5	**5 Finishing indoors**	**193 days**	**Mon 7/31/17**	**Wed 4/25/18**
19	5.1	5.1 Insulation Roof	10 days	Mon 7/31/17	Fri 8/11/17
20	5.2	5.2 Internal walls	30 days	Mon 8/7/17	Fri 9/15/17
21	5.3	5.3 Electricity	150 days	Mon 9/4/17	Fri 3/30/18
22	5.4	5.4 Plumbing	150 days	Mon 9/4/17	Fri 3/30/18
23	5.5	5.5 Leveling floors	5 days	Mon 9/18/17	Fri 9/22/17
24	5.6	5.6 Suspended ceiling	40 days	Mon 9/25/17	Fri 11/17/17
25	5.7	5.7 Tiles	15 days	Mon 11/6/17	Fri 11/24/17
26	5.8	5.8 Painting	100 days	Mon 11/20/17	Fri 4/6/18
27	5.9	5.9 Flooring	42 days	Mon 2/19/18	Tue 4/17/18
28	5.10	5.10 Fixtures and doors	60 days	Thu 2/1/18	Wed 4/25/18
29	6	**6 Ground finishing**	**53 days**	**Mon 7/17/17**	**Wed 9/27/17**
30	6.1	6.1 Evening of ground	15 days	Mon 7/17/17	Fri 8/4/17
31	6.2	6.2 Parking lot	30 days	Mon 8/7/17	Fri 9/15/17
32	6.3	6.3 Concrete tiles	8 days	Mon 9/18/17	Wed 9/27/17

Figure 25: Group home project time schedule

In October, the masons were putting up internal walls, and also the electricians, plumbers and seven of the company's workers were present onsite. Furthermore, the zink worker and painter is expected onsite soon, and the soil workers will lay down the concrete tiles outside. There have been some complications with the soil workers and it became necessary to hire a new subcontractor. During the onsite observation, it was noticed, as figure 21 illustrates, that the ground finishing was starting, which is a deviation from the original schedule, where the activity is set to start 17th July 2017 and end 29th September 2017. Putting up the internal walls was supposed to end on the 15th of October and the tile work was supposed to start on the 6th of November, but was not started during the observation. This supports the claims of the Site Manager (Appendix C) that the schedule is not being used as a control tool, but rather as an overview. Furthermore, the project is 2 months ahead of schedule and it has not been updated.

Now that the basic information on the Group home project has been introduced, the next chapter will investigate the Multi-storey house project.

5.6 Multi-storey house project

The prior chapter analysed the Group home project, and now this chapter will introduce the fourth project (figure 26), a Multi-storey house (Ragnarsson, 2015) located in Garðabær, a town in the Greater Reykavik area. The construction started in September 2016 and is expected to be finished in February 2018.

Figure 26: Multi-storey house project, 14th of November 2017

The building has five levels, and on the ground floor there are ten parking spaces and storage rooms.

Each floor contains three apartments of 70-100 m² in size. The fourth floor includes one 110 m² apartment.

Figure 27: Masonry work, 14th of November 2017

The building structure, external walls, floors, roof and part of the internal wall, are cast onsite concrete. The external walls are insulated on the inside with polystyrene insulation (figure 27), which is then plastered. All lightweight internal walls are constructed from Gas concrete blocks.

The onsite project hierarchy has the same build up as in the

Industrial building project. The Project Manager is the building manager and the Project Coordinator serves as a site manager and handles the onsite control.

A time schedule was formulated for the project by an engineering office. When the author asked the Project Coordinator for a copy of the schedule, the answer was quote "there is no schedule, if there was then it is lost". The control of the project has been going well. In the beginning of October, the masons were erecting the internal walls and plastering the house on the outside. Since there is no time schedule, it will not be possible to analyse it. Next, a conclusion is provided to this chapter.

When at the building site, the author of this thesis observed that the workplace was clean, and the work was performed in a synchronised manner where each task is finished before moving to the next floor. Next, a conclusion is given to this chapter.

5.7 Chapter conclusion

In this chapter, the company’s organisation and operations were introduced. The company was established in the year 2000 by four owners. Furthermore, the company has two main departments: services and building. The future ambitions of the owners are to reduce the services and focus more on developing their own construction projects.

The planning and scheduling was investigated. The company´s management team has been developing planning and scheduling for the company’s projects over the past year. Previously all the planning was performed based on feeling and experience. Currently, they have produced time schedules for all projects and they try to follow them, at least when working for a public organisation. The tools used in planning and scheduling are Bluebeam Revu, IFC Viewer, MS Excel and MS Project. Even though the planning and scheduling has been evolving, there still appear to be some complications, especially when it comes to the soil work and getting the subcontractors to follow the schedule. This has caused delays in the project schedules, and also problems for subsequent subcontractors.

The onsite control is performed based on the management team’s experience and feeling. There is a single building manager for all of the company’s projects, then a site manager in each location, who handles the daily running of the site.

Site meetings have not been conducted since June 2017, except with the inspectors from the Group home project. There are no formal work procedures within the company when it comes to quality checks, and instead these checks are performed by the owners as they go around the building site. Additionally, there is no risk analysis performed for any of the company’s projects.

Three of the projects under construction by the company were introduced. The Industrial building is a project that the company developed itself. The project is currently way behind schedule, which has made led to problems for the owners since promises were made to tenants to get the spaces delivered in December 2017.

In addition, the Group home projects were introduced, which the company is constructing for a public organisation. The project has advanced well from the beginning and is expected to be finished by 1st of February 2018, well ahead of schedule. However, it was found that the time schedule was not actually being followed in this project.

Finally, the Multi-storey house project was introduced, which is another example of the company's own production. The project is expected to be delivered in February next year. It was not possible to assess how the project was going according to the schedule, since the project is not using one.

Now that the company and its organisational structure has been introduced, the next step is to analyse the data. This analysis is performed in the next chapter.

6. Data analysis

The previous chapter introduced the company and its operations. This chapter's objective is to analyse the collected data and compare the planning, scheduling and onsite control method to the Location-Based Management System (LBMS). The data to be analysed was collected by a mixed method consisting of both qualitative and quantitative research methods. This chapter will investigate how the LBMS can optimise the operations within this chosen case study. In addition, the barriers of integration are explored, using a force field analysis.

In chapters 6.1, an internal analysis is performed, whereas the company's operations are compared to the LBMS. The LBMS has been described as having two main components: the Location-Based Planning (chapter 6.1.1-6.1.3) and location-based control (chapter 6.1.5) (OLLI SEPPANEN & JAKE EVINGER, 2014, p. 607). To be able to integrate the LBMS, it is necessary to compare the company's working methods with the LBMS, which is performed in the next two chapters. Then, chapter 6.1.6 explores the factors that have to be considered during the LBMS integration.

Then, in chapter 6.2, the external analyses are performed. These consist of a questionnaire which investigates competence, knowledge and attitudes within the Icelandic AEC industry. It is utilised to identify some external barriers to implementing the LBMS into a small construction company.

Chapter 6.3 will formulate a force field analysis, where the company's internal and external, and positive and negative forces of the implementation are explored.

6.1 Internal analysis

This chapter will investigate the possibilities of optimising the planning and scheduling in the company. In addition, the MS Project's Industrial building schedule is transferred into a flowline chart.

In chapter 6.1, the planning within the company is compared with location-based planning. In chapters 6.1.2- 6.1.3, the Industrial building time schedule is analysed by transferring the MS Project schedule, introduced in chapter 5.4.3, into a flowline chart. The purpose of this action is to investigate the possibilities of optimising the schedule and creating a new baseline schedule for the project. The reason the Industrial building schedule was chosen for the exercise is that it is larger than the Group home project and there was more information on the project. In chapter 6.1.4, the onsite control methods executed within the company's projects are compared to the Location-Based Management System's (LBMS) control methods. Then, chapter 6.1.5 will explore the factors that have to be considered during the LBMS integration.

6.1.1 Company's planning and scheduling analysis

The following chapter will analyse the company's work procedures when it comes to planning and scheduling. This is performed by comparing the summary of the Location-Based Planning procedures, which Kenley & Seppänen listed in their book, where the procedure has been explained in ten steps (Kenley & Seppänen, 2010, p. 401).

In table 1, the location-based planning work procedures are listed (1) – (10) on the left side and the company´s procedures one are on the right side.

Table 1: Company's planning and scheduling analysis

Location-Based Planning procedure	The company´s planning procedure
Defining the Location Breakdown Structure (LBS) (1). The building is divided up in a hierarchical manager, where the higher levels must contain all the lower ones. (Previously explained in chapter 3.1.1).	The project is split up into a Work Breakdown Structure (WBS), as previously introduced in chapter 5.2. The work is defined by activities in the Group house project. In the Industrial building, the structure is additionally divided by floors from 1-2 and 3-4.
Defining the location-based quantities (2). The quantities are extracted according to the Location Breakdown Structure (LBS). There are two alternative methods used to extract the quantities, either manually or from a Building Information Model (BIM) using Vico Office.	Quantities are estimated by measuring the drawings and models using software such as Bluebeam Revu and IFC Viewer, then listed in MS Excel according to the project WBS.
Building tasks from quantities and define them (3). The tasks are activities, built according to the quantities in each location, with the planner needing to decide what belongs to each task. Optimal crew size is found for each task. Duration is calculated by multiplying the quantities with consumption. layered logic is implemented to link the tasks.	The tasks are defined by the activities, according to the estimated quantities and the WBS, see Industrial building time schedule, Annex 1. Quantities and the number of workers are used to estimate the durations of the tasks, in accordance with the previous experience of the management team of their duration.

Next the schedule is aligned and optimised in terms of the sequence and duration (4). This part involves issues such as changing the production rates by changing the resource assigned to the task. It also includes changing the sequences that the locations are performed in, as well as breaking continuity and splitting tasks.	The number of workers is not included in the MS Project where the schedule is created. The schedule is formulated in MS Project, according to the WBS, using lags, Start to Finnish (SF) and Start to Start (SS) dependencies between activities.
Evaluate production system cost and risk (5). Production cost is evaluated by considering the working time, waste because of delays, logistics, etc. The production risk is further evaluated in accordance with issues related to weather, production prerequisites, adding resources, productivity rates, quantities, resource availability, locations and quality (Kenley & Seppänen, 2010, p. 398). (This part of the system is optional according to (Kenley & Seppänen, 2010, p. 401))	The project's cost is evaluated according to the quantities and services needed to perform the project, thereafter listed up in the WBS, using MS Excel. Production cost is accounted for by adding a [%] to the project's total cost. No risk analyses are made for any of the company's projects. The management team solves these issues by applying their previous experience.
Optimise cost and risk (6), by adding buffers, making changes to the production rates, altering the sequences and by breaking the continuity (Kenley & Seppänen, 2010, p. 401). (This part is optional according to (Kenley & Seppänen, 2010, p. 401))	There, is some optimisation of cost performed, since the management team needs to figure out how much cash is on hand to perform the work and how much resources should be used in each activity. Optimisation of risk is not performed in the company.
The schedule is cost loaded (7). The schedule is cost loaded according to the extracted quantities and the LBS, where both resources and manpower are accounted for. It is possible to use this method for calculating the cost for the entire schedule along with the	This part is not performed within the company. All cost calculations are performed in MS Excel, not integrated into the MS Project schedule.

timing of payments, the project's cash flow and the earned value.	
Optimisation of cash flow (8) is performed by making changes to the production and payment logic.	The project's cash flow is quantified in accordance with the construction project's process, where payments are made based on task completion rates. Paid out according to work performed.
Approve the Schedule (9). The schedule needs to be approved, both by the owner and the subcontractors (Kenley & Seppänen, 2010, p. 499).	The project's schedules need to be approved by the client, when performing official projects.
Planning procurement and design schedules, here pull scheduling techniques are used along with soft constraints. In addition, changes are only made to the schedule if they are necessary (10).	There are no specific techniques used for planning procurement and design schedules, and these issues are performed based on the experience of the management team. Schedules are normally not updated, even though there are large changes in production.
(Kenley & Seppänen, 2010, p. 401)	Information from chapter 3,5 and Appendix A, B and C.

In table 1, the company's planning and scheduling has been compared to the location-based planning. The company bases its schedule on activities and the LBMS is based on locations. In both cases, the scheduled tasks' time is estimated by quantities. The difference in estimating the quantities involves that the location-based planning system, defines the quantities in more detail through the Location Breakdown Structure (LBS), extracting the quantities either manually or using a Building Information Model (BIM) tool. The planning in the company is mostly based on the experience of the management team when it comes to planning for procurement, duration of activities, risk, cost calculations and planning of the schedule. Whereas, the location-based planning has procedures, as explained in table 1.

In the next chapter, the schedule from the Industrial building is transferred into a flowline chart, and then further analysis is performed in the following chapters.

6.1.2 Industrial building scheduling analysis

The last chapter analysed the planning and scheduling. In the following chapter, the analysis for the Industrial building, the time schedule is undertaken. The author of this thesis received a project schedule formulated in MS Project (Annex 1), an excel file with a list of quantities

(Annex 2), and additionally an Industry Foundation Classes (IFC) model (Ragnarsson, 2016) (figure 28). Unfortunately, there was no model for the MEP installation available. Additionally, information was gathered by conducting interviews with the company's owners and employees.

The initial intention was to use the IFC model to generate a schedule for the Industrial building project. The chosen tool to generate the schedule was Vico Office. The process of producing the schedule is described in this chapter.

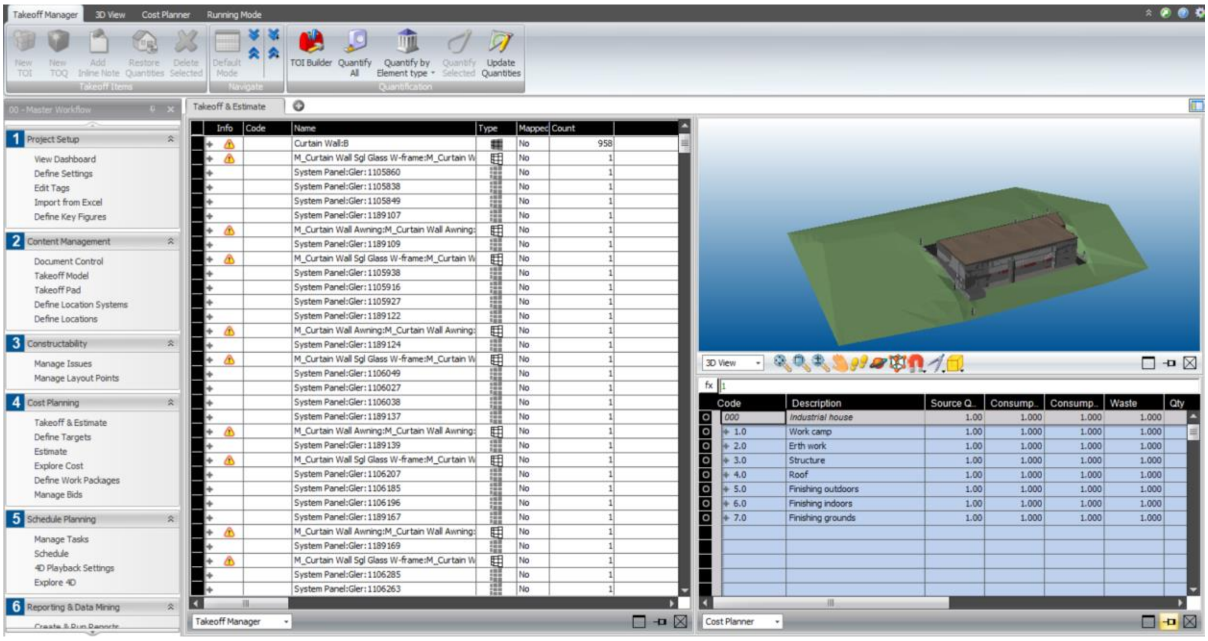


Figure 28: Location-based quantities (IFC model (Ragnarsson, 2016))

The first step after the project creation was the Takeoff & Estimate (figure 28). In this step, the quantities of each of the building components were extracted. Afterwards, it was possible to connect the quantities with the activities, by creating a list, as illustrated in the lower right corner of figure 28. This list has the same structure as the schedule presented in figure 20 in chapter 5.4.3.

At this stage it was possible to perform a cost calculation according to the extracted quantities, by adding the price of each activity in the list.

The next procedure was to create the project Location Breakdown Structure (LBS). The LBS is one of the bases of the Location-Based Management System (LBMS), where the Industrial building LBS are divided in a hierarchical level, with the top levels including the levels underneath them. The higher levels are used to optimise the construction sequences, and in this case, there is only one building. The middle level's purpose is to plan the construction flow. Finally, the lower levels plan the finishes and details as Kenley & Seppänen described (Kenley & Seppänen, 2010, p. 204).

Figures 29-30 illustrate the project's LBS, and the building levels were given the following names: Foundation, floor 1, floor 2, floor 3, floor 4 and roof. Then, floors 1-4 were split up into spaces which depended on the layout of each level. The foundation was defined as one space, and then floor 1 was divided into five spaces, all of them of similar size.

Floor 2 contains only one space, and there is only one office on that level. Floor 3 is divided into six spaces, containing five shops of similar size and one office. Floor 4 is divided into four office spaces, all around the same sizes.

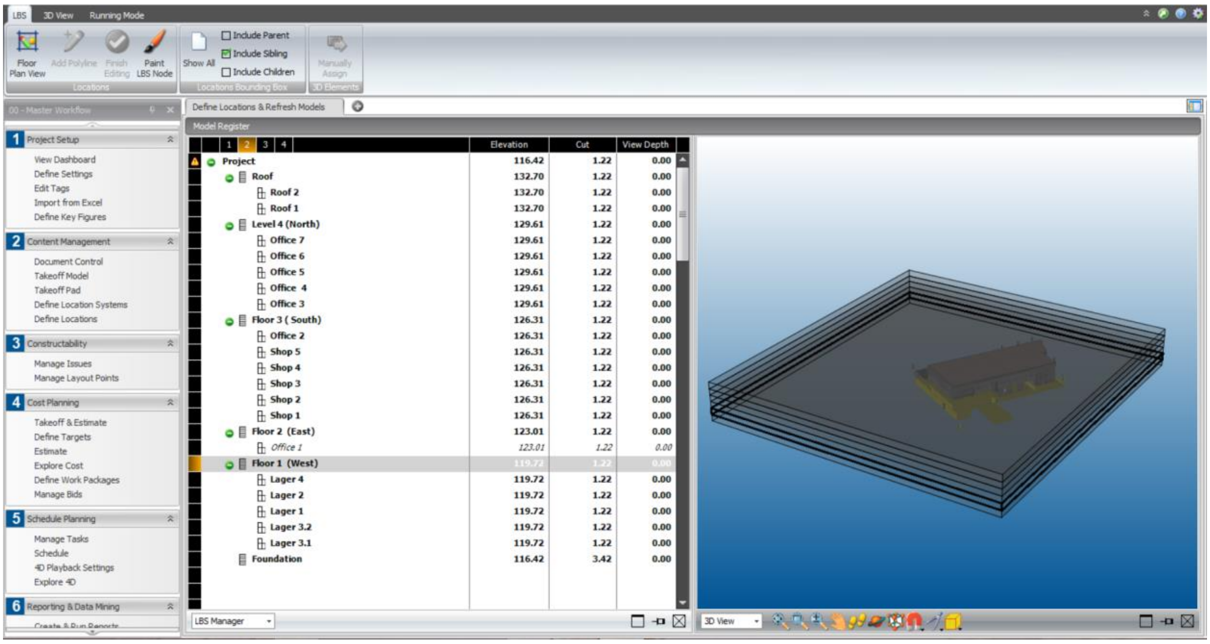


Figure 29: Location Breakdown Structure for the Industrial building project (IFC model (Ragnarsson, 2016))

Finally, the roof was divided into two equally sized spaces. The external finishing was divided into elevations: West, East, South and North. To make the project schedule simple, the elevations followed the floors 1-4, but in other construction projects this might not be possible. Figure 30 illustrates the Location Breakdown Structure (LBS) for the Industrial building project.

Levels (Elevations)	Spaces
Roof	Roof 2
	Roof 1
Floor 4 (North)	Office 7
	Office 6
	Office 5
	Office 4
	Office 3
Floor 3 (South)	Office 2
	Shop 5
	Shop 4
	Shop 3
	Shop 2
	Shop 1
Floor 2 (East)	Office 1
Floor 1 (West)	Lager 4
	Lager 3.2
	Lager 3.1
	Lager 2
	Lager 1
Foundation	Foundation

Figure 30: Industrial building projects LBS

After the LBS was defined. it became possible to start establishing the project's flowline schedule. The original project schedule presented in MS Project was transferred into Vico Office, and a flowline schedule created. The purpose of transferring the schedule into the flowline view was to locate waste in production. *"Consequently, CPM-based schedules, graphically represented by Gantt charts, may result in discontinuous resource usage that in turn will lead to interruptions in the production where each trade suffers from recurrent starts and stops during the project process."* (Andersson, 2007, p. 2). Furthermore, the flowline schedule gives the planner a better overview of the project (Seppänen & Kankainen, 2004, p. 1).

A list of 48 activities was created in the Schedule Planning in Vico Office. This list is the same as the Project Coordinator formulated in the company´s original time schedule (Annex 1). It was then connected to the list created in the Takeoff & Estimate.

An attempt to connect them to the extracted quantities was then attempted, but it did not go as planned because of the low level of component definition in the

IFC model. The model did not appear to be suitable for this kind of procedure. This deviation resulted in the quantities being entered manually into the programme according to the activities based structure previously mentioned.

The quantities are important factors in the system. The duration of each activity is calculated from them, by multiplying the quantities with the consumption (Kenley & Seppänen, 2010, p. 395). Thereafter, it is possible to define the production rate. At this point, a flowline schedule has been created containing the activities from the Schedule planner. Figure 31 illustrates the schedule after the schedule provided from the Company was transferred into Vico Office schedule planner. Each activity has the same start and end date as the schedule formulated in MS Project; quantities and manpower are not included in the schedule. The project starts on the 15th of March 2017 and ends on the 22nd of June 2018.

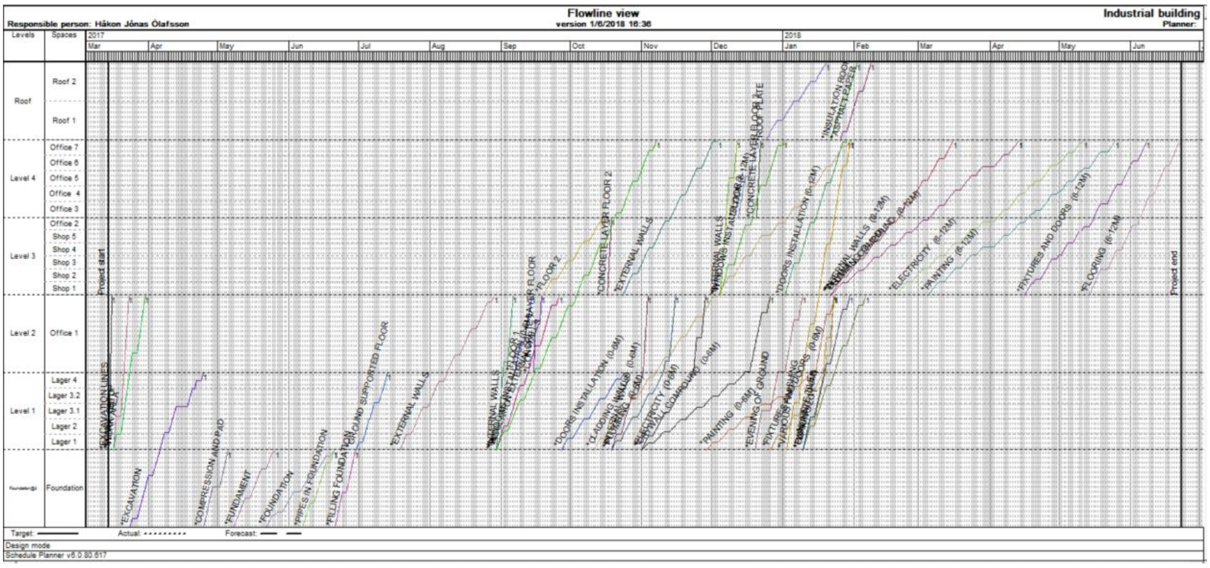


Figure 31: Industrial building flowline schedule, after transferring from MS Project and before changes (Appendix E)

The Location Breakdown Structure (LBS) for the Industrial house project, previously defined, is positioned on the Y axis and the time on the X axis (figure 31).

Each of the tasks created in the Schedule Planning flow through the locations as figure 31 illustrates. The duration of each activity is according to the Project Coordinator's estimate in the original schedule. Even though the initial plan was to make an identical schedule regarding the task time frame, there were some necessary changes to the original schedule regarding public holidays, since no consideration was taken to them when the schedule was created. All days off should be accounted for when the time schedule is formulated (Kenley & Seppänen, 2010, p. 243).

Figure 32 illustrates the project schedule after all holidays, manpower (Appendix F) and quantities (Annex 2) are included in the schedule, with the end date extended to the 11th July. The production rates were found by dividing the estimated hours to perform the tasks with associated quantities (Kenley & Seppänen, 2010, p. 395).

For the majority of activities there was information on the project's quantities, based on the Project Coordinator's estimation (Annex 2). Still, in some cases, such as the various finishing elements, electrical installations, plumbing, fixtures and doors, there was only data on the number of workers and the time the tradesmen were expected to use to complete the tasks. All shifts are 10 hours long.

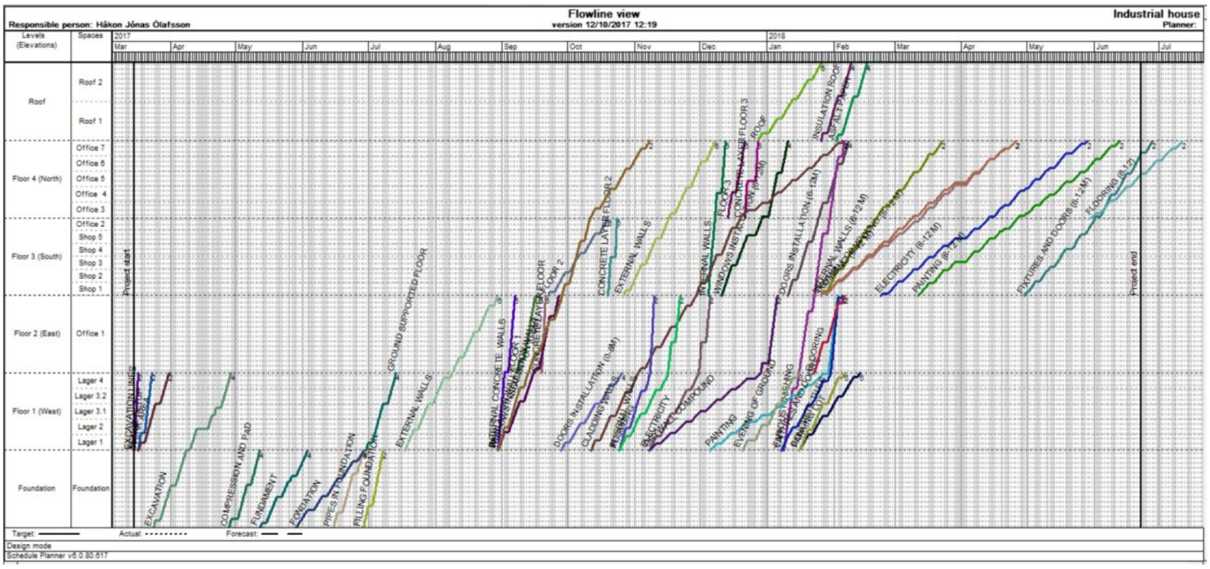


Figure 32: Project schedule after all holidays and quantities are included (Appendix F)

The number of workers estimated for each task was entered into the flowline schedule. Information about the number of workers was obtained during a visit to the company and provided by the Project Coordinator (Appendix G). Figure 33 demonstrates the number of workers onsite at each time, over the project's 18 months' time frame.

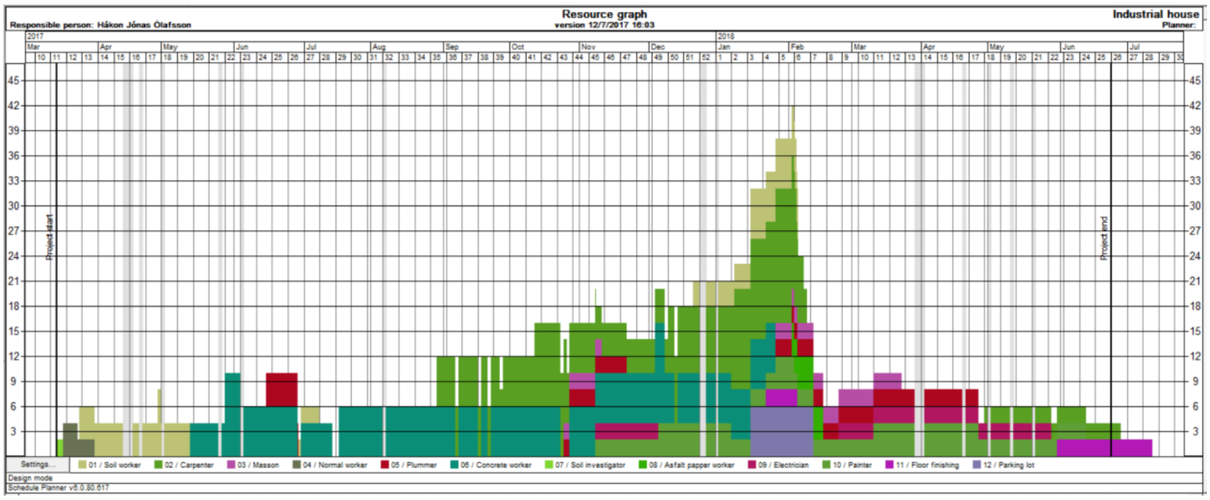


Figure 33: Resource graph after all holidays and quantities are included (Appendix F)

This chapter introduced the flowline schedule and resource graph for the Industrial building project, and the next chapter will investigate the possibility of optimising the schedule.

6.1.2 Possibilities of schedule optimisation

The previous chapter introduced the project flowline schedule, and now this chapter will investigate the possibilities of optimising the time schedule. Part of the problem formulation involves investigating how location-based scheduling can optimise planning and scheduling within the company's construction projects. To be able to perform this optimisation, it is necessary to locate opportunities to optimise the original schedule. Figure 34 illustrates the possibilities of optimising the original time schedule.

When the original time schedule was investigated in the flowline view, there were a few noticeable faults in the time schedule. Figure 34 demonstrates the problems and wasted time in the schedule, with red rings signifying the unused time in the time schedule. Furthermore, Figure 35 demonstrates how many workers are onsite at each time, and it is noticeable that in the period December 2017 until February 2018 there is a considerable increase in manpower onsite.

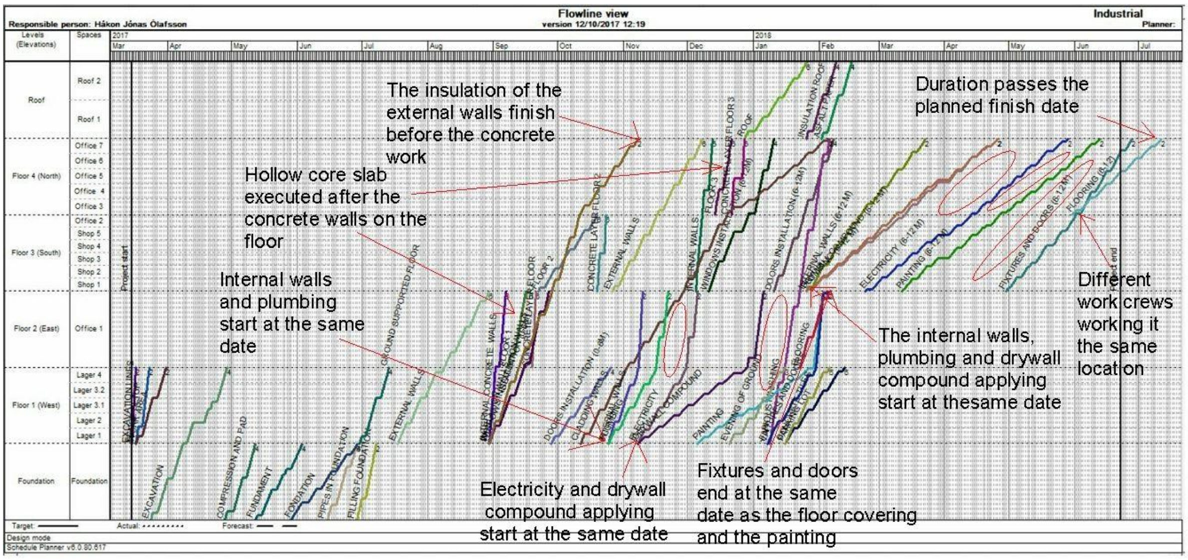


Figure 34: Possibilities of schedule optimisation

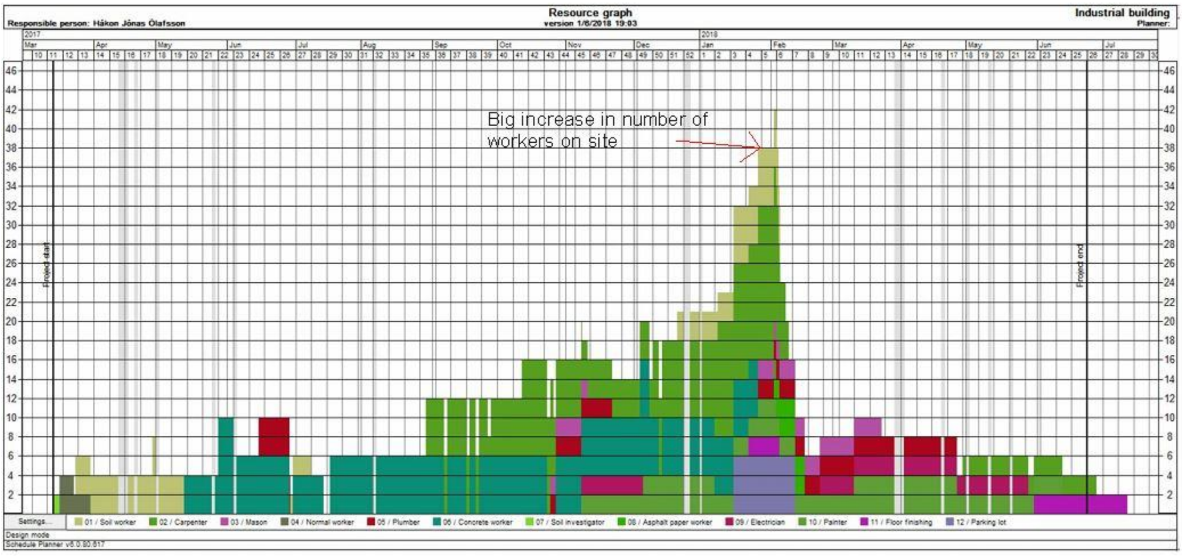


Figure 35: Resource graph before optimisation

The work in the structural part is executed by the same work crew the whole construction time and occurs in a continuous flow without any stops. There were some issues regarding buildability, the hollow core slabs are executed after the concrete walls in floors 2 and 4. This could be problematic, since the hollow core slabs are placed on the external wall and a prefabricated beam (Ragnarsson, 2016). One of the issues found in the external finishes was that the insulation of the external wall is supposed to be finished before the concrete work on the external walls (figure 34).

There was some visible waste in the internal finishes, and in floors 1-2 the fixtures and doors ended on the same date as the floor covering and the painting. This will cause problems, since the fixtures and doors are dependent on painting to have finished in order for their installation to start. Also, the fixtures and doors need to be installed before work can commence on the floor materials. Electrical installations and applying the drywall compound start on the same date, however, this might not be a problem if the tradesmen start at separate locations.

The internal walls setup and the plumbing installations start on the same date, which could cause some issues. There are time gaps in production which could be worth investigating, since there is a two-week gap between the internal walls starting and the electrical installations. This time could be reduced. Overall, there does not seem to be any specific order applied to how the finishing tasks are performed in floors 1-2.

In floors 3-4, there are noticeable gaps in time between the trades. As an example of this, there is a two-week gap between the doors and the fixtures finishing until the flooring material is fixed.

Then there is a gap of two weeks between the painting and installing the doors and fixtures, as well as the electricity and the painting. In addition, there is a four-week period between the drywall compound applying finishes and the electrical work finishing. The plumbing, internal walls and drywall compound applying are supposed to start on the same date in floor 3-4 (figure 34), meanwhile the plumbing and drywall compound applying are supposed to finish on the same date in floors 3-4, which will cause clashing of trades since the plumber needs to be finished before the drywall compound applying starts. The fixtures and doors start around the same time in the fourth floor as the flooring materials. This could also become problematic because work crews could end up working in the same location. Finally, after the holidays were added, the schedule time frame changes. The finishing date was 22nd of June 2018, but now becomes the 11th of July.

Comparing the floors 1-2 with 3-4, production appears to proceed in a discontinuous manner. The trades need to leave the building site between the two sections, and this can cause problems later on in production. According to Seppänen, when subcontractors need to withdraw their work crews from the site, it can become difficult to retrieve them when the work starts again, because they have started working on another project (Seppänen, 2012, p. 2). Additionally, the internal finishing is not performed in the same sequence between floors 1-2 and 3-4, which is hard to explain.

Many of the issues listed above correspond to the findings of an investigation into a Danish company's construction projects, performed by Anderson and Christensen, where they transferred an activity based time schedule into a flowline schedule, It was found that: "*It was* *also observed in the original schedules that the planned work flow of activities through the different locations of the building was frequently discontinuous, i.e. the production was typically characterized by frequent starts and stops for the various working crews."* (Andersson, 2007, p. 6). Furthermore, they observed that activities were not balanced in accordance with the production rates, and this resulted in clashes between trades, since they ended up working in the same locations at the same time. Now that the time schedule is transferred into the flowline schedule, the next step is to explore the option of optimising the time schedule, which is considered in the next chapter.

6.1.3 Suggested project's flowline schedule

The last chapter investigated the faults and waste in the time schedule, formulated for the Industry building project. This chapter will make suggestions of optimisation to the project's time schedule. During this exercise, the fact that the project has been greatly delayed, because of the excavation and the work on the foundations being in process in November 2017, is ignored. The main purpose is to analyse the schedule and consider possibilities of optimisation within the project's time schedule. All production rates are the same as the Project Coordinator estimated when the schedule was formulated.
The early stage of the construction, which involves the soil work and the structure were found occur in a continuous flow (figure 36). However, the fact remains that the excavation work and the structure is a defining factor in the construction process and needs considerable care in the early stages of planning and scheduling (Kenley & Seppänen, 2010, pp. 457-459). The Project Manager (Appendix A) and the Project Coordinator (Appendix B) have confirmed their primary problem area in production is excavation. This is a known variable and, as Kenley & Seppänen have explained, needs to be specally investigated (Kenley & Seppänen, 2010, p. 457).
Layered logic (Chapter 3.1.4) (Kenley & Seppänen, 2010, p. 476) was implemented when the schedule was formulated, and figure 36 demonstrates part of these links.

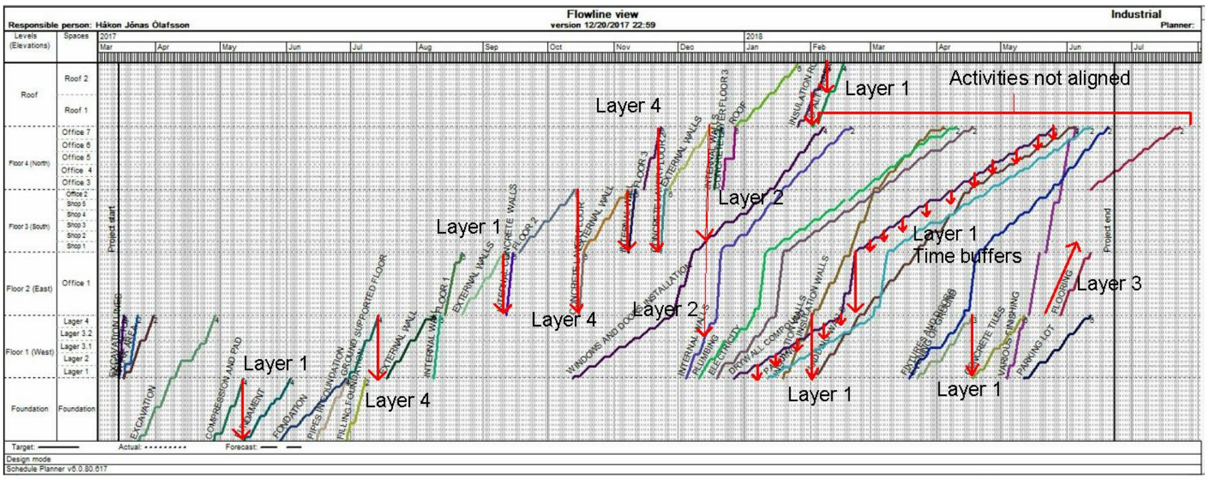


Figure 36: Project's suggested Flowline schedule after making the activities go in a continuous flow (Appendix H)

During the structural work, circular planning (Kenley & Seppänen, 2010, p. 231) should be implemented, where the activities can involve more than one task. This is the case during the structural part layer 1, layer 2 and layer 4 logic (Kenley & Seppänen, 2010, p. 134), where implemented, as figure 36 demonstrates, and finish to start links (FS) are applied.

By implementing the flowline schedule, it is possible to manage continuous workflow without different trades interfering with each other's work, thus reducing the waiting time (Andersson, 2007, p. 4). Figure 36 illustrates the schedule after the external and internal finishing has been set in a continuous manner, where the tradesmen are depending on the previous activities to finish in order to be able to start work in the location. Layer 1, 2 and 3 logics, previously introduced in chapter 3.1.4, are implemented with FS links, along with time buffers, as figure 36 illustrates. When one task is finished in the location, the next one can proceed. Only one trade works in a location at each time.

When the flooring was planned, layer 3 logic (Kenley & Seppänen, 2010, p. 476) was implemented. With the work only performed on the second and fourth floor (figure 36). If the task would have started as soon as possible, there would have been a stop in the work, because the fixtures and doors in the fourth floor would not have been finished on time. This would lead to the workers constructing the flooring ending up having to leave the site because of lack of work.

In addition, changes were made to the ground finishing where layer 1 logic (Figure 36) was implemented, and the activities were set in a finish to start (FS) sequence. Figure 36 demonstrates layer 1 logic links used to link together the insulation and asphalt paper on the roof.

When planning the work for subcontractors, they should be planned as using their own resources, or else it is impossible to plan the work flow (Seppänen & Aalto, 2005, p. 273). After this change was performed, the end date of the schedule was extended to the 23rd of July.

The list of activities has decreased from 48 to 41 after the discontinuous tasks from the floors 1-2 to 3-4 were combined. Time buffers of a minimum one day, from when a contractor finishes their location until the next one starts their work on the internal finishes, were inserted into the schedule (Kenley & Seppänen, 2010, p. 389). This gives the site managers time to inspect the location, to see if the location is ready for the next contractor and if the quality is adequate. The activities production rates have not been aligned in the schedule at this time, as the figure illustrates. The activities for the internal and external finishes are not aligned, and this causes time gaps in between the tasks.

As the flowline chart in figure 36 demonstrates, after these changes the project still goes over its planned duration, and the end date of the project is 23rd July. As the figure demonstrates, some of the lines are crossing, and that is because there are trades working on the internal and external finishing at the same time. These trades are not working in the same locations. This alteration to the schedule has made the activities flow in a continuous manner, however, there were still some time gaps in the construction process, as figure 36 illustrates.

The largest number of workers in a single day decreased from 42 to 28 workers (figure 37). The most significant change was that the number of workers towards the end of the project increased, because the internal finishes were set in a continuous flow.

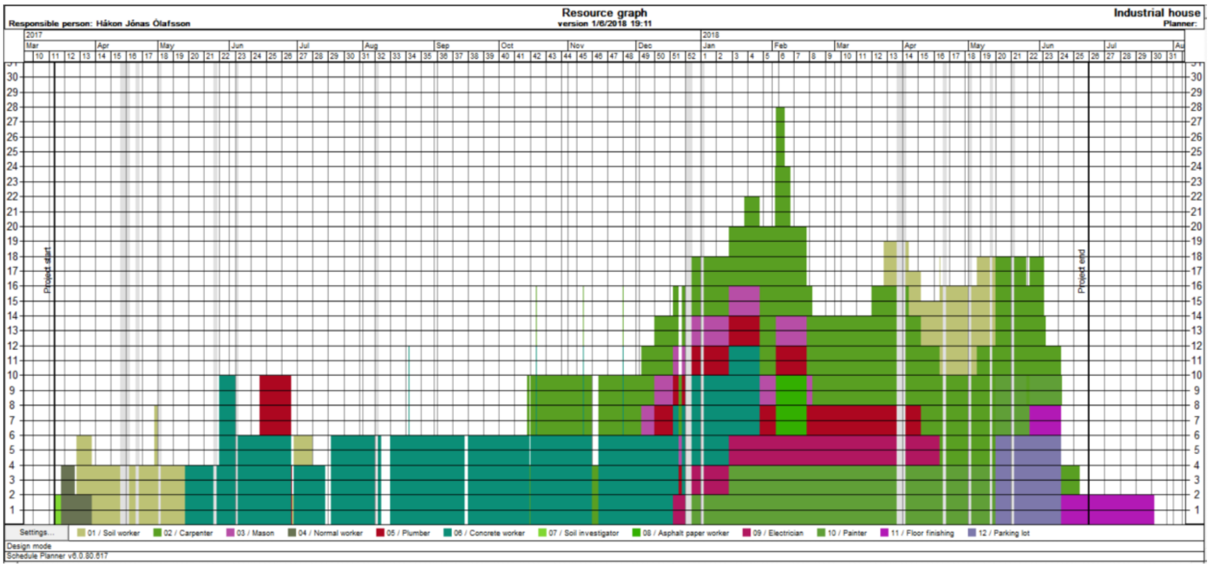


Figure 37: Resource graph, after making the activities go in a continuous flow (Appendix H)

Thereafter, the production rates were aligned as Kenley & Seppänen describe, as a part of the scheduling process, where changes can be made to the production rates by changing the resources. Additionally, it is possible to change the sequences which the locations are performed in, break continuity and by splitting tasks (Kenley & Seppänen, 2010, p. 401).

The Industrial building baseline schedule was aligned by adding resources to part of the tasks in the internal and external finishes. When adding resources, it is necessary to consider the resources available and whether there is space for more resources (Kenley & Seppänen, 2010, p. 241). Table 2 demonstrates the changes in number of workers, for the different activities.

Table 2: Changes in resources

Activity	Before	After
Internal walls (Floor 2)	2	1
Plumbers (Floors 1-4)	2	3
Electricians (Floors 1-4)	2	3
Painters (First floor)	2	4
Painters (Floors 2-4)	2	3
Flooring (First floor)	2	4
Windows and doors (Floors 1-3)	4	8
Windows and doors (Forth floor)	4	10
Insulation (West, East, South)	2	3
Insulation (North)	2	5
External cladding (West, East, South)	4	8
External cladding (North)	4	11

Figure 38, demonstrates the project baseline schedule after manpower has been added or reduced, in the internal and external finishes to reduce the time gaps in the time schedule. The result was that the schedule time frame was reduced, the new end date is the 3th of May, a total of seven weeks

This is a 15% decrease in time based on the schedule presented in figure 31 and 19.6% compared to the schedule in figure 32. According to the web page, vicosoftware (Vicosoftware, 2016), it is possible to optimise the time in the schedule by a minimum of 10% when transferring the activity based schedule to the flowline view.

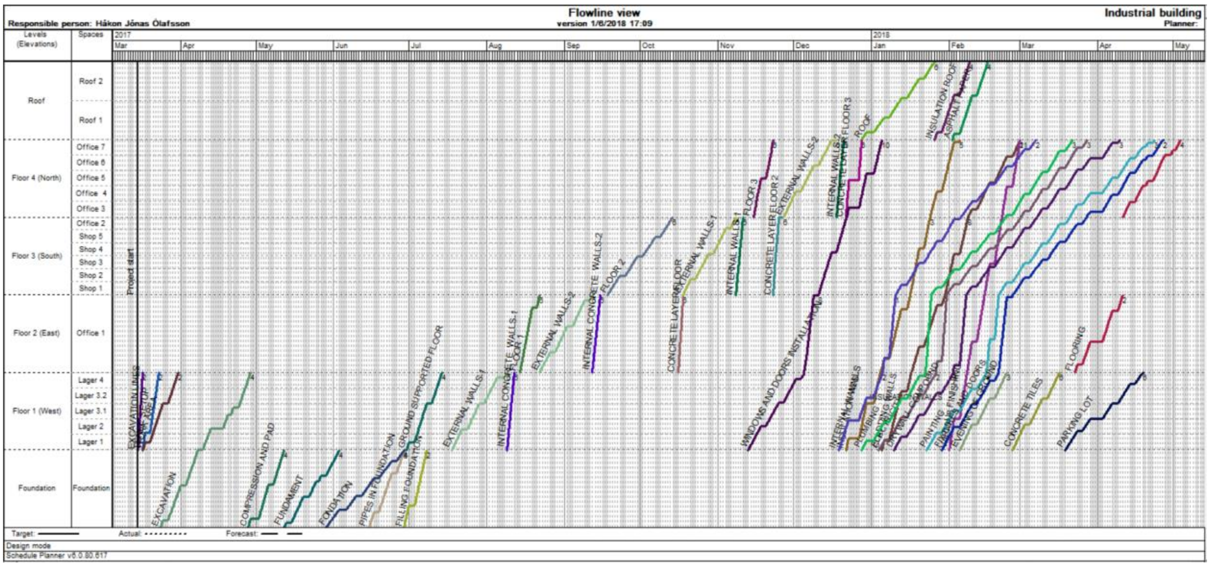


Figure 38: Projects suggested Flowline schedule after aligning activities (Appendix I)

After the activities were aligned, there were still some gaps in the schedule, which in some cases were necessary. For example, between the drywall compound and painting, the explanation for this gap is that there must be time between the activities to account for drying time, which is important to include in the schedule (Kenley & Seppänen, 2010, p. 242). In other cases, it was not reasonable to add more resources in the locations, because of lack of space.

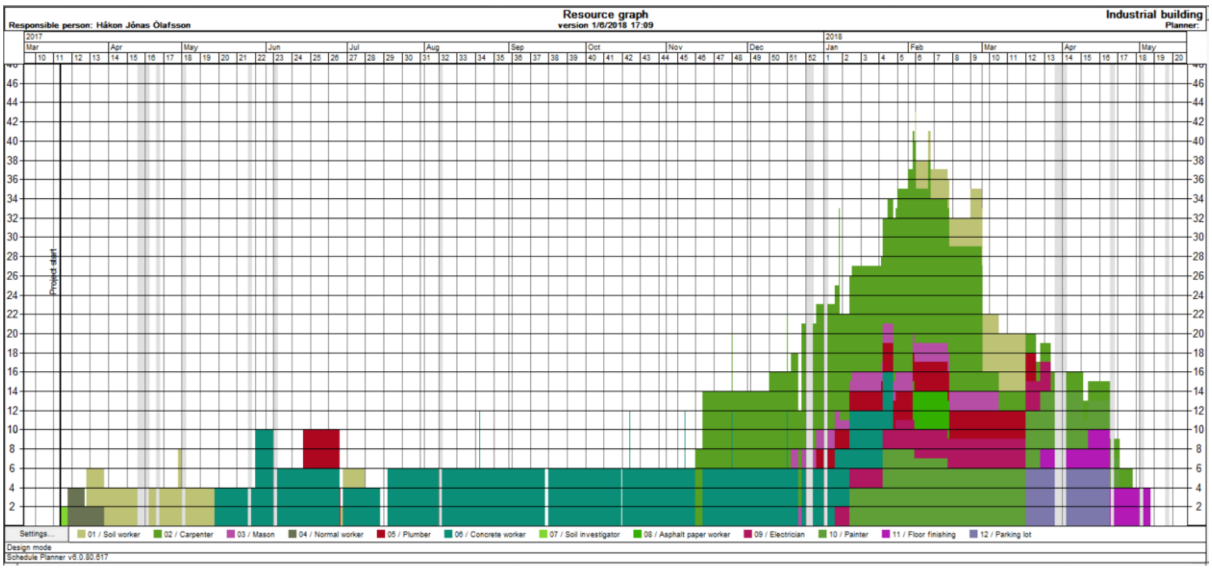


Figure 39: Resource graph, after aligning activities (Appendix I)

As figure 39 demonstrates, the largest number of workers onsite goes up to 41 workers for one day. For the last two months of production, the largest number of workers is 22, which is considerably more than in the original schedule.

Figure 40 illustrates another variation in the project schedule where risk of water damage is taken into consideration, and here the internal finishes have been pushed forward twenty-seven days. This gives an end date to the project of 30th of May. The reason for these changes is that the painting, fixtures and doors start before the asphalt paper on the roof has finished, which can be problematic in the winter time.

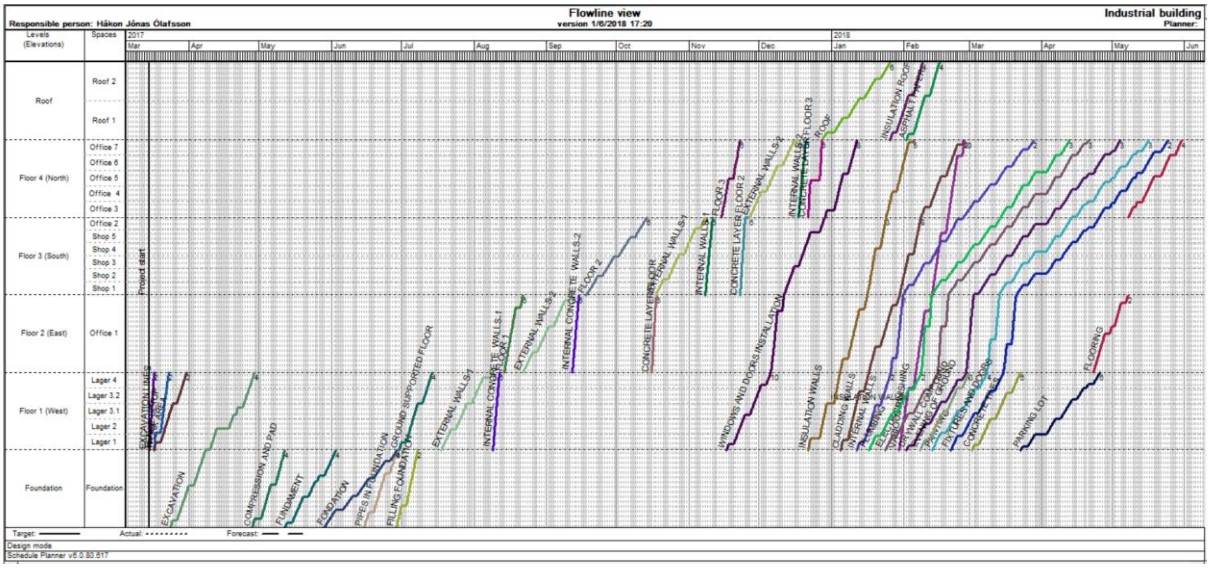


Figure 40: Project schedule, after aligning activities and risk has been taken into consideration (Appendix J)

Furthermore, the wall cladding is performed during the winter which can be problematic, but no other solution was found considering the project's constraints.

The project has been greatly delayed, so these issues might not be a problem if both the internal finishes and the external ones are executed during the summer time. Still, the fact remains that is safer to waterproof the roof before the internal fixtures and doors are executed.

The resource graph for the schedule is demonstrated in figure 41, and the largest number onsite is 35 workers. In the last month of production, the highest number of workers onsite is 10.

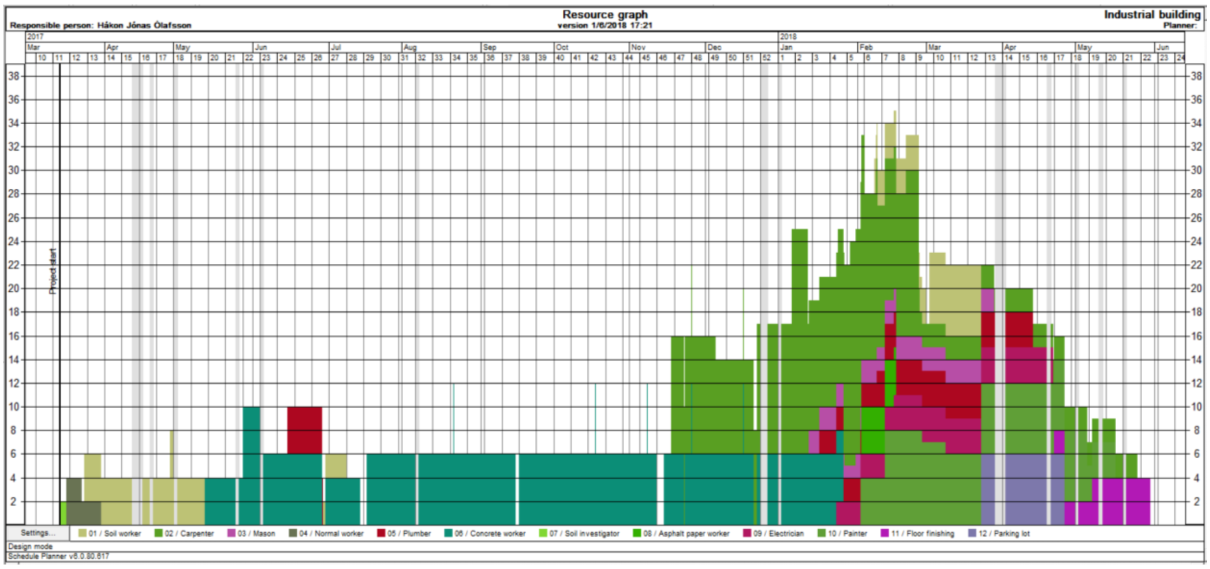


Figure 41: Resource graph, after aligning activities and risk has been taken into consideration (Appendix J)

This chapter has introduced the project's schedule, where the time frame was reduced by seven weeks and after risk is included the finishing date has changed from the 22nd of June 2018 to the 30th of May 2018. This is a 6.9% decrease in time compared to the schedule presented in figure 31 and 11.9% compared to the schedule in figure 32. This alternative schedule does not, perhaps, reduce the time as much but may still bring some benefits, as the roof has been waterproofed before the work on the internal fixtures and doors starts, and evidently the risk of water damage is minimised.

As the chapter has demonstrated, there are possibilities of optimisation in the project's schedule. The activities have been set in a continuous order and aligned. The benefits are that there has been reduction in the waste of time and the contractor's work occurs without clashes with other contractors.

"However, planning continuous flow doesn't guarantee that the project is implemented continuously. To achieve the benefits of flow, production must be controlled." (Seppänen & Kankainen, 2004, p. 2)

The next chapter will compare the company´s control method to the location-based control methods.

6.1.4 Control methods analysis

Previous chapters have analysed the company´s planning and scheduling, and now this chapter will analyse the possibilities of optimising the company´s control through the location-based control methods. This is performed by comparing the company´s control methods with the location-based control method. In table 3, on the left side the location-based control process has been listed as Kenley and Seppänen described the process in their book (Kenley & Seppänen, 2010, p. 337). Then, on the right side, there is information about how the company performs their control process, using the same issues as listed (1) - (10) for the Location-Based Management System (LBMS).

Table 3: Controlling process analysis

Location-based controlling process	Company´s controlling process
The first step is to monitor the project's current status (1). This requires that the statuses of tasks and locations are updated on the control chart and plotted on the flowline chart. The update is recommended on a weekly basis. The collection of the data can be performed by the main contractor, subcontractor or a combination of both. Start and end date of each location are documented, along with the actual resources and quantities used in production.	The monitoring of the project status is performed through visualising the process and by comparing the tasks in the planned schedule in MS Project to the project's current status.
Compare forecasts to plans to detect deviations (2). (Kenley & Seppänen, 2010, p. 337) The comparison can be performed by using flowline diagrams, production graphs and control charts. Here the current status of the project is compared to the detail and baseline plans.	No forecast is made for any of the company´s projects.
Control action planning (3). In this part, forecasts are used to detect warnings about deviations in production, within an appropriate timescale. If there is a difference in the original plans and the forecast, there is an opportunity to apply control actions before the issue becomes problematic.	Experience and feeling of the management team. The management team discusses and finds solutions to deviations in the construction process, either by themselves or in cooperation with the designers and clients.
The system requires an evaluation of resource needs (4), where the most important	The number of workers is evaluated using the experience of the management team.

subcontractors in the project need for resources is evaluated weekly. The subcontractors are informed in advance of the resources needed.	Then, subcontractors are notified the week before they can start their work.
Before the site meeting, managers need to create reports for the meeting (5). These include flowline figures, control charts, production graphs and resource diagrams.	Issues that are needed to discuss with the subcontractors are listed over the coming week and then presented at the meeting.
Site meeting (6). During the site meeting, the time should not be used to talk about what has been done, but rather to discuss the deviations in the schedule. All subcontractor will have previously received the reports form step (5). Furthermore, the plans for the next weeks should be discussed in the meetings, where issues that can delay starting locations should be addressed. Site meeting minutes should address the control actions and how to make the construction process run smoothly in the next weeks.	No site meeting has been held since June in the company's own projects. There is a meeting every two weeks in the Group home project where the process of the work is discussed. When needed, the site manager holds individual meetings with the subcontractors to discuss issues that come up in the construction process.
Management and client reporting (7). This part involves compering the baseline information to the current, actual and forecast information. The reporting can be implemented using production charts, control charts, end result forecasts, variation reports and completion rates reports.	Meetings every two weeks are held with the representative of the public client. The client's representative is provided with a report on the construction process. Additionally, in case of working for the council, the inspector comes every week to look around the site. The company´s management is informed by the site managers in daily meetings.
Detailed planning (8). This part involves updating tasks, so they fit with the current information and commitments. Furthermore,	This part is not performed within the company.

new detail tasks are planned (Kenley & Seppänen, 2010, p. 367).	If there are changes in the tasks, a solution is found in cooperation with the parties involved.
Monitor and prioritise prerequisites of production (9). The five flowing groups need to be monitored and prioritised. *(1)* "Availability of resources and equipment",(2) *"Design"*, *(3)* "Preceding tasks*"*, (4) *"Procurement and deliveries"*, and (5) *"Potential problems"* (Kenley & Seppänen, 2010, p. 377).	All monitoring is performed by visualising the production. Prerequisites are prioritised by the management team, based on their experience.
Weekly planning and communicating assignments (10). It is important for the workers onsite that there are enough assignments. This involves the management making sure that each work crew has assignments to keep them busy for the week. Also, tasks need to be prioritised.	Planning is performed to assure that everything is ready for the following week. The Project Manager goes through what needs to be done in the following week with the site managers, so they are ready.
(Kenley & Seppänen, 2010, p. 337)	Information from chapter 4 and Appendix A, B and C.

From the above information, it is possible to see that there are large differences between the control method performed by the company and the control methods described in the location-based planning. Whereas within the company the control is performed by the experience of the management team, the LBMS follows the location-Based control method. For the integration of the LBMS to be successful, the company's management team needs to familiarise themselves with its method.

6.1.5 Issues influencing LBMS integration

This chapter will go into the issues involved in influencing the integration. The system's integration into the operation should be implemented as Kenley & Seppänen suggested (Kenley & Seppänen, 2010, p. 418) as a thorough solution. The issuses analysed previously in this chapter should be intergrated into the company. For the Location-Based Management System (LBMS) to be integrated into the company, there are some topics that need to be addressed.

Among these topics, is the company ready for change? There are many parties that are involved in the integration process, and these parties need to work together for the integration to be successful. The management team in the company has expressed interest in new methods in planning, scheduling and onsite control (Appendix A, B, C). According to Kenley & Seppänen, a large barrier to integration is resistance among a company's employees: *"Even with a willing and supportive project team, there will still be barriers."* (Kenley & Seppänen, 2010, p. 409). The team within the company is used to working in a particular way.

Another significant challenge concerns acquiring the necessary data and the understanding of reporting and forecasts in the LBMS. Thus, the integrations are more likely to be a failure in the first project than not (Kenley & Seppänen, 2010, p. 409).

The employees need to be trained in the process, and this training needs to suit the different roles of the employees. It is especially important that the required training in location-based software applications is performed. There are subcontractors that need to receive training which suits their role in the production process. The planners need to be familiar with the principles of Lean Construction and the Location-Based Management System. Furthermore, the LBS must be considered during the design phase (Kenley & Seppänen, 2010, p. 419).

Now the company´s planning scheduling and control has been compared to the Location-Based Management System (LBMS), location-based planning and location-based control. The next chapter will investigate the external barriers to integrating the LBMS into the company, where the knowledge, skills and attitudes of professionals in the Icelandic AEC industry is explored.

6.2 External analysis

The last chapter analysed the company's planning, scheduling and controlling method. This chapter will introduce the questionnaire which was sent out to 839 individuals within the Icelandic AEC industry. The responses were anonymous. The questionnaire was designed to investigate the external factors of integrating Location-Based Management System (LBMS) into small construction companies. The main purpose is to identify barriers within the Icelandic AEC industry.

The questionnaire was sent out on the 24th of October and a week later there were 114 replies, then on the 30th of October a reminder was sent out. An additional 87 responses were submitted in the week that followed. On the 6th of November, the questionnaire was closed for answers. The questionnaire has been provided in Appendix D.

Chapter 6.2.1, introduces the background information of the respondents. Next, an investigation into how professionals use the Building Information Model (BIM) in their workflow is outlined in chapter 6.2.2. Furthermore, chapter 6.2.2 explores the tools used by professionals in Iceland for planning and scheduling. Thereafter, theoretical knowledge, skills in different software applications and attitudes towards new planning, scheduling and controlling methods are investigated in chapter 6.2.3. Finally, in chapter 6.2.4, the professional's attitudes towards new methods in planning, scheduling and controlling are evaluated.

6.2.1 Background information

The following chapter will explore the background information of the respondents. The questionnaire was sent by email to 839 individuals in the Icelandic AEC industry. A total of 201 responses were collected, which equals a 23,95% response rate.

The investigation targeted individuals with education connected to the construction field, including architects, engineers and constructing architects. Out of 324 architects listed in the web page of the Architectural Union in Iceland (Íslands, 2017), 52 answered, which equals a 16% return from the architects listed. It was not possible to send to all the architects, and 300 individuals received the questionnaire.

On the web page of the Constructing Architects Union (vefhönnun, 2012) in Iceland, there are 454 individuals listed. A total of 339 of them received the questionnaire, and 19.4% of the constructing architects listed on the union's webpage responded.

Information on the number of building engineers in Iceland could not be found. A total of 200 emails were sent out to engineers working in the AEC industry, and out of this group 54 answered, which equals a return rate of 27%.

The responses came from different age groups, as figure 42 illustrates. The age groups were categorised into four different groups (figure 42). The largest age groups are from 50 plus with 81 respondents, then 56 individuals from the age group of 40-49. From the age group of 30-39, there were 57 individuals who responded. The least number of responses came from the age group of 20-29, just 6 respondents. The small number from this age group could be explained by the fact that individuals typically finish their education at 23-25 years old in Iceland, and Master's degree studies normally finish around 25 years old.

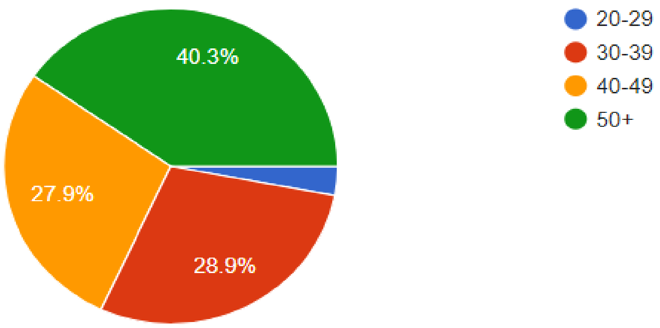


Figure 42: Respondents age groups division

Next, the experience among the respondents was considered. Figure 43 illustrates the years of experience among the respondents. The majority of them have an experience of 10 plus years. There were 22 respondents with 5-9 years of experience. Additionally, 15 respondents from the group had 2-4 years of experience. Finally, there were 3 responses from respondents in their first year of work within the building industry.

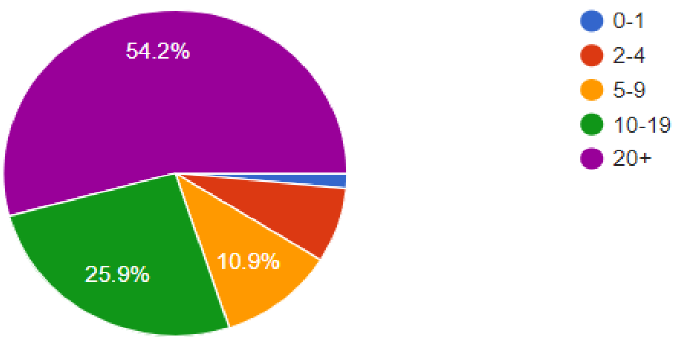


Figure 43: Years of experience among the respondents

As figure 44 illustrates, 43.8% of the professionals are educated as constructing architects, or a total number of 88. 26.9% of the answers came from engineers, with a total of 54 responses. In addition, 25.9 % were architects with 52 responses, and seven responses were received from professionals educated in connected fields, accounting for 5.7%, who were categorised as other in the questionnaire. Among these was an industrial engineer who was also a constructing architect, an architect with a BSc in Business and a civil engineer with a Master of Trade degree.

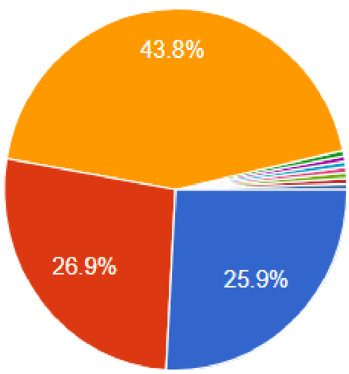


Figure 44: Field of education among the respondents

A similar number of respondents with a Bachelor´s and a Master's degree answered the questionnaire, as figure 45 illustrates. There were 98 respondents with a Bachelor's degree which amounted to 48.8% of the total number of respondents. The number of respondents with a Master's degree was 96 professionals, or 47.8%. In addition, 2% of the respondents held a PhD degree, 4 respondents. Finally, the category of others contained respondents with an AP degree and Master of Trade, totalling 3 responses, or 1.4%.

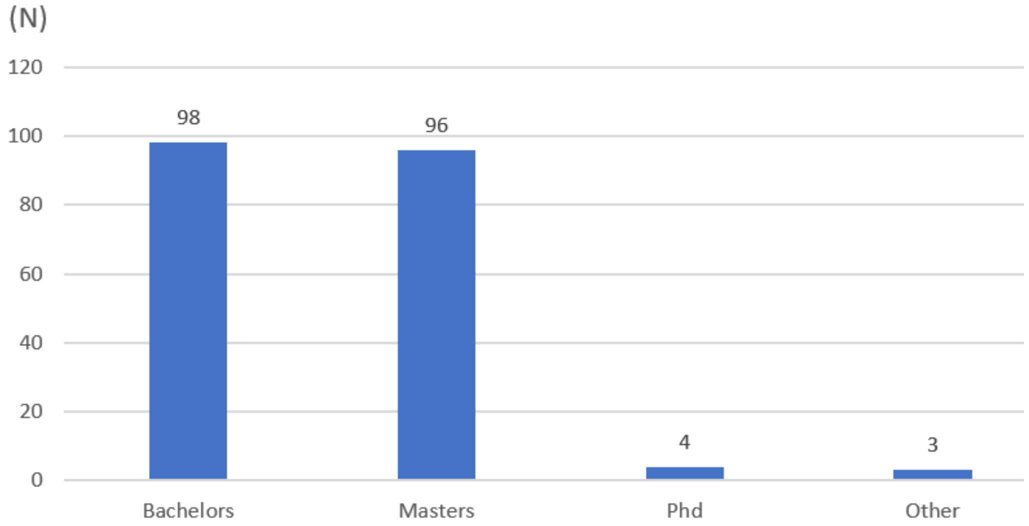


Figure 45: Highest level of education among the respondents (N stands for number of respondents)

Figure 46 illustrates the type of organisation the respondents worked for. The largest group worked in architectural offices, which included a total of 66 respondents. A high number of respondents worked within consulting companies, totalling 40 responses, engineering offices, 34, and government agencies, 26, construction companies, 24, and education, 1. Then, the other category contains 10 respondents who work in companies that are specialised in different lines of work, for example, facility management.

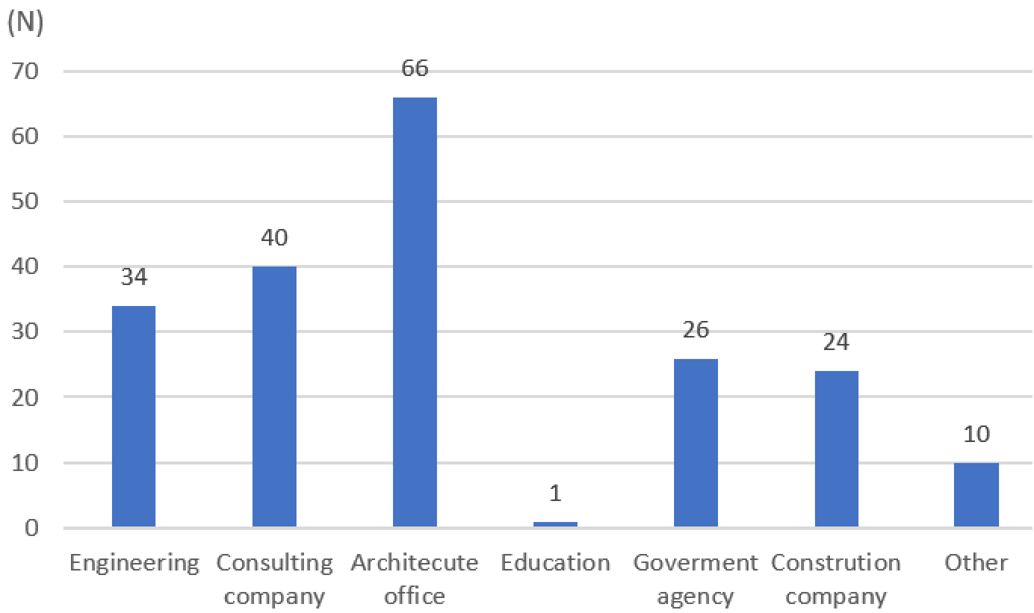


Figure 46: Field of work (N stands for number of respondents)

The sizes of the companies were categorised by small and medium sized enterprises (SME), where micro companies contained from 1-9 employees (Jedynak, 2015, p. 110), and small sized from 10-49 (Jedynak, 2015, p. 110). Medium sized included 50–199 employees and large companies with the number of employees, at 200 plus.

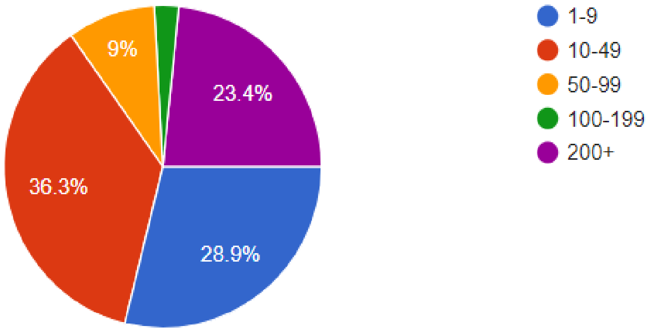


Figure 47: Number of employees in companies

The respondents came from different sized companies, as figure 47 illustrates. Overall, 65.2% worked in micro to small size companies, a total number of 131 individuals. There were fewer respondents from medium sized companies, a total of 23 individuals, or 11.5% of the total respondents. Finally, 47 respondents worked in large sized companies, or 23.4% as figure 47 demonstrates.

When asked if the respondents had worked in the field of construction planning and scheduling (figure 48), 27.9% had no experience from the field. The remaining 72.1% responded that they had worked in planning and scheduling.

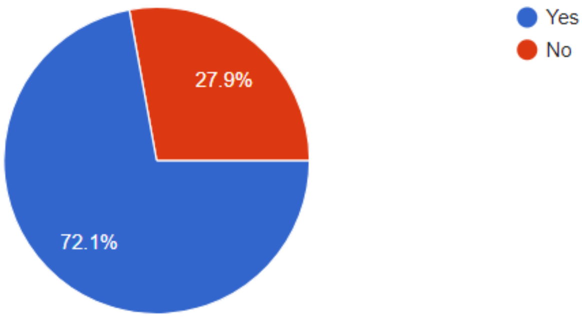


Figure 48: Have you worked in the field of construction planning and scheduling?

This indicates that there is an extended experience in the field of planning and scheduling among the respondents. The question was asked: ``Have you supervised construction projects onsite? ´´ The answers were almost equally divided: 46.3% answered that they had never worked in controlling projects onsite, and 53.7% had, as figure 49 illustrates.

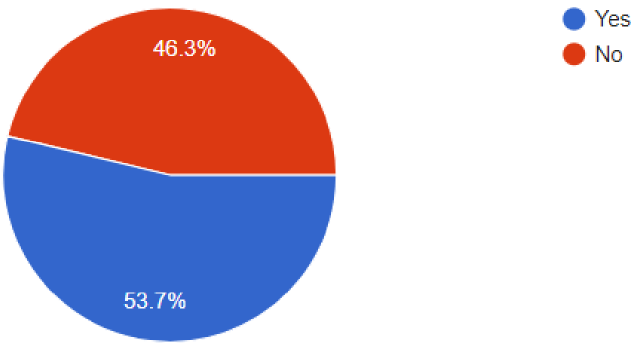


Figure 49: Have you supervised construction projects onsite?

As the above information demonstrates, the respondents came from a wide range of backgrounds, involving all age groups and experiences ranging from 1 to over 20 years. Education levels ranged from Master of Trade up to PhD degree. In addition, the professionals worked in various types of enterprises that are both private and public.

Even though the questionnaire covered a wide range of professionals, the fact remains that a much larger number are working in the AEC industry and this is just a portion of them, and so the results might give only an indication on what is going on in the industry.

6.2.2 Work methods in the Icelandic AEC industry

The following chapter will investigate the current work methods in the Icelandic AEC industry where the two following issues are investigated: how the respondents use BIM in their workflow and what kind of software applications are used in Iceland for the planning and scheduling of construction projects.

The question "Do you use BIM (building information modelling) for one or more of the following tasks in your workflow?", was asked. The respondents had ten different options to choose from; also, the possibility of filling in their own comments as "other", as figure 50 illustrates.

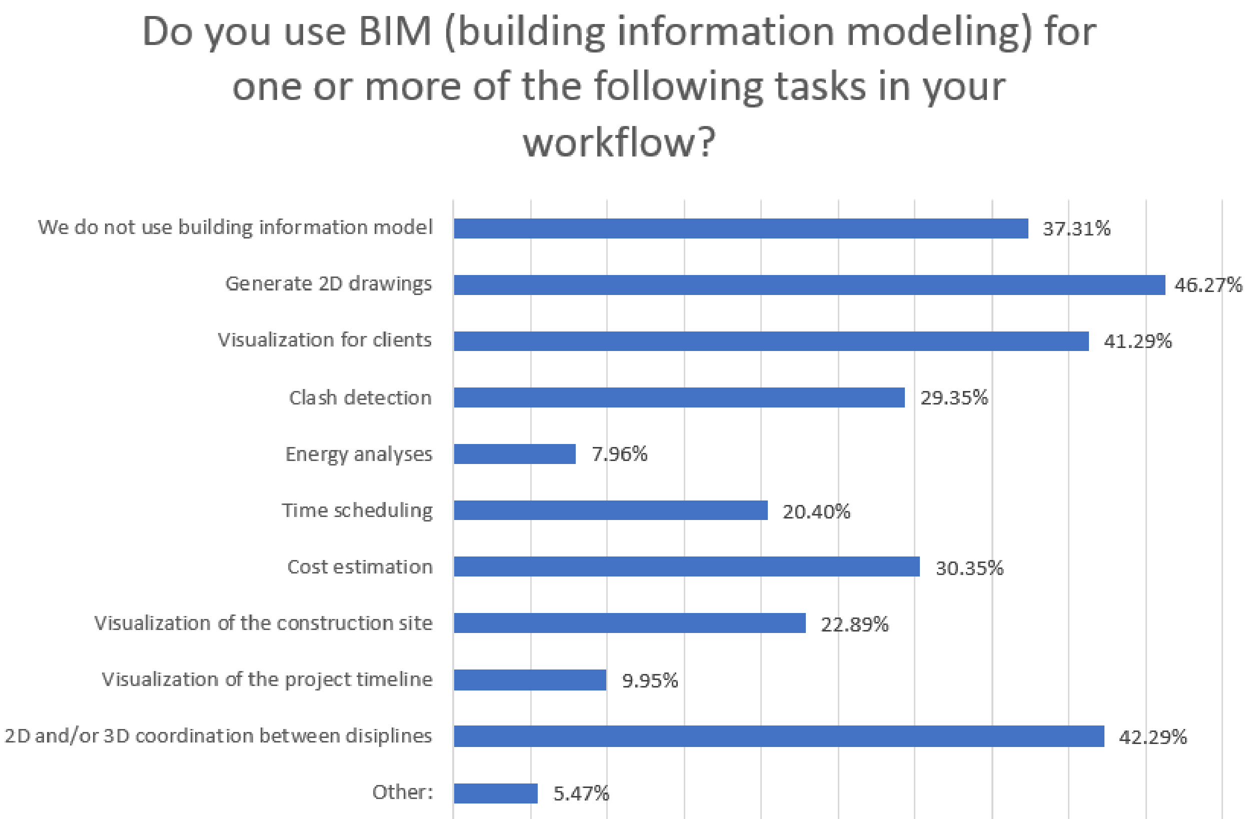


Figure 50: Do you use BIM (building information modelling) for one or more of the following tasks in your workflow?

As previously mentioned, there were 201 responses to the questionnaire, and out of that group 37.31% (figure 50) stated that they do not use BIM in any part of their workflow, or 75 respondents. This means that 62.69% of the respondents use BIM in one or more tasks in their workflow. The number of respondents who use BIM to generate 2D drawing was 93, or 46.27%, as figure 50 demonstrates. Then, 41.29% stated that they use BIM for visualisation for clients. When it comes to energy analysis, 7.96% use BIM in their workflow.

Generating time schedules using information from BIM was performed by 20.4% of the respondents, based on 41 individuals. Cost estimation is carried out using BIM, according to 30.35% of the respondents, based on 62 respondents.

Additionally, 22.89% of the respondents stated that they use information from BIM to make visualisations of their work site, a total of 46 respondents. The visualisation of the project timeline was performed by 9.95% of the respondents. Furthermore, 42.29% use information from BIM for 2D and/or 3D coordination between disciplines, a total of 85 individuals. Finally, 11 responded using the other category, which was 5.47% of the respondents.

Another question asked, “Which software/s have you used for planning and scheduling?”, as figure 51 illustrates.

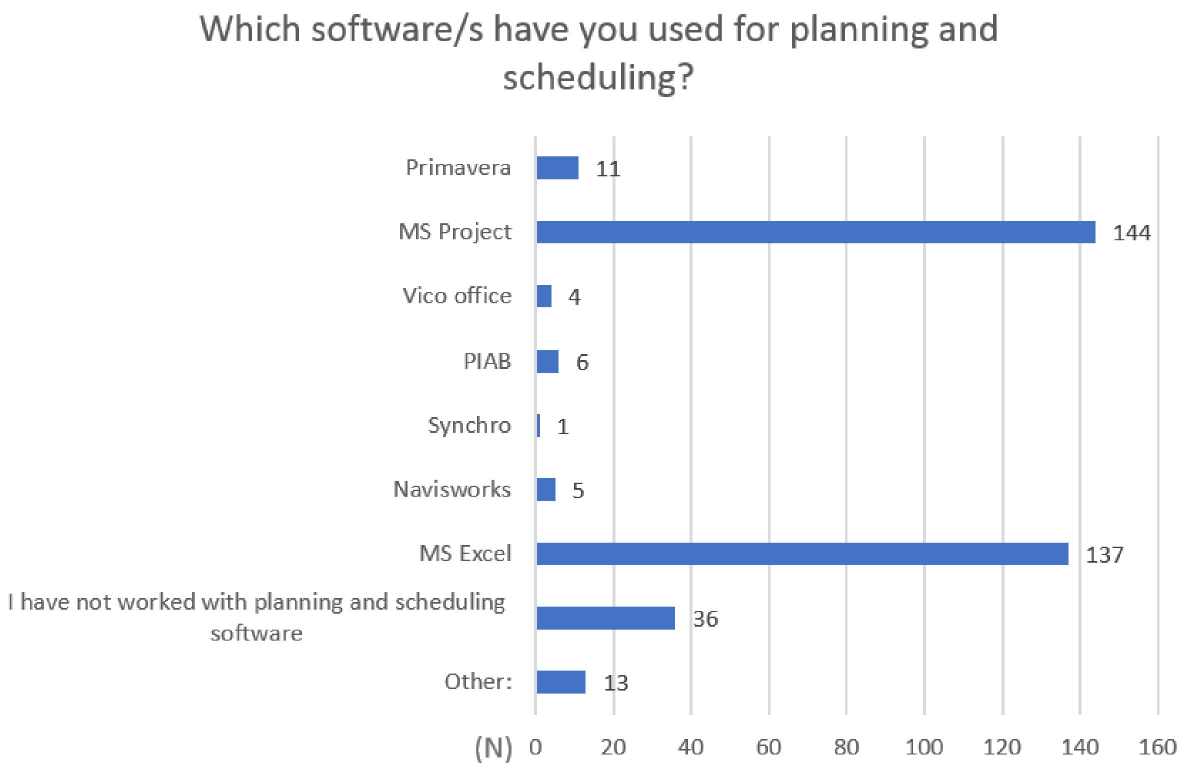


Figure 51: Which software/s have you used for planning and scheduling? (*N stands for number of respondents)

As figure 51 demonstrates, 36 of the respondents have not worked with planning and scheduling software applications, therefore 165 of the individuals have used planning and scheduling software in their work. From these 165 professionals, 144 have used MS Project in their work, and this indicates that 87.3% of respondents that work with planning and scheduling software use MS Project in their work. A similar number of respondents use MS Excel, working in planning and scheduling, or 137 of 165, which equals a rate of 83%.

When it comes to Vico Software, only 4 of these 164 individuals, 2.4%, indicated that they use the software application in their work. Primavera is used by 11 respondents, PIAB by 6, Synchro by 1, and Navisworks by 5. Finally, 13 respondents marked the ``others´´ category, and all of them use different planning and scheduling software applications.

6.2.3 Skills and knowledge

The last chapter introduced the work methods of the professionals that responded to the questionnaire. This chapter will investigate the skills in software applications among the professionals in the Icelandic AEC industry. Additionally, the chapter will explore the theoretical knowledge of the professionals.

The respondents were asked to evaluate their skills on a scale (1-5), from none to excellent as table 4 demonstrates, in eighteen different types of software applications. The table also includes the calculated mean *"Is the arithmetic average of the observations"* (Moore, et al., 2012, p. 45) and standard deviation" The *standard deviation measure spread by looking at how far the observations are from their mean"* (Moore, et al., 2012, p. 39).

Table 4: Skills in software applications (N stands for number of respondents)

	N	None	Poor	Good	Very Good	Excellent	Mean	Standard Deviation
Autodesk Revit	201	53	68	47	25	8	2.338	1.116
Autodesk AutoCAD	201	14	44	63	58	22	3.149	1.099
ArchiCAD	201	138	48	9	5	1	1.423	0.738
Microstation	201	140	32	15	7	7	1.552	1.014
SketchUp	201	47	73	45	25	11	2.403	1.137
Autodesk 3ds Max	201	160	34	3	2	2	1.269	0.638
Autodesk Civil 3D	201	147	30	16	6	2	1.438	0.841
Vectorworks	201	164	15	6	12	4	1.393	0.949
Tekla	201	178	15	7	1	0	1.159	0.484
AutoCAD MEP	201	176	15	7	2	1	1.194	0.589
Solibri	201	174	15	10	2	0	1.204	0.568
CAD Duct	201	193	5	2	0	1	1.065	0.375
MS Project	201	57	27	66	37	14	2.622	1.263
Primavera	201	179	13	6	2	1	1.174	0.570
PIAB	201	189	5	4	2	1	1.114	0.512
Synchro	201	198	2	0	1	0	1.025	0.233
Vico Office	201	187	9	1	3	1	1.119	0.515
Autodesk Navisworks	201	168	24	7	0	2	1.229	0.606

This was performed to evaluate the skill levels among professionals in Iceland, and also to find out how strong their skills are in software that interacts with Vico Office.

Among the respondents, the skill level appears to be highest in the three-following software applications, as table 4 and figure 52 demonstrates. AutoCAD was 71.1% evaluating their skills as good to excellent. Then, Revit, where 39.8% stated that they are good to excellent. In SketchUp, 40.3% of the respondents evaluated themselves as good to excellent.

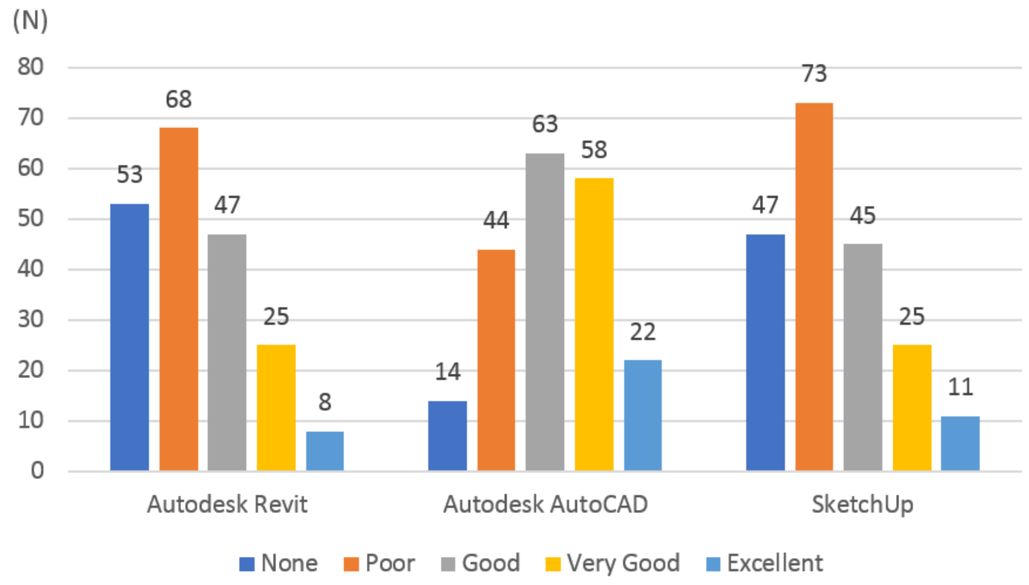


Figure 52: Software application (N stands for number of respondents)

As figure 52 indicates, there appears to be a higher level of skill when it comes to AutoCAD than Revit among the respondents within the Icelandic AEC industry.

MS Project was the scheduling software where the largest proportion of the respondents evaluated their skills as good to excellent (figure 53 and table 4), or 58.22 %. Only 2.49 % of the respondents rated their skills as good to excellent in Vico Office.

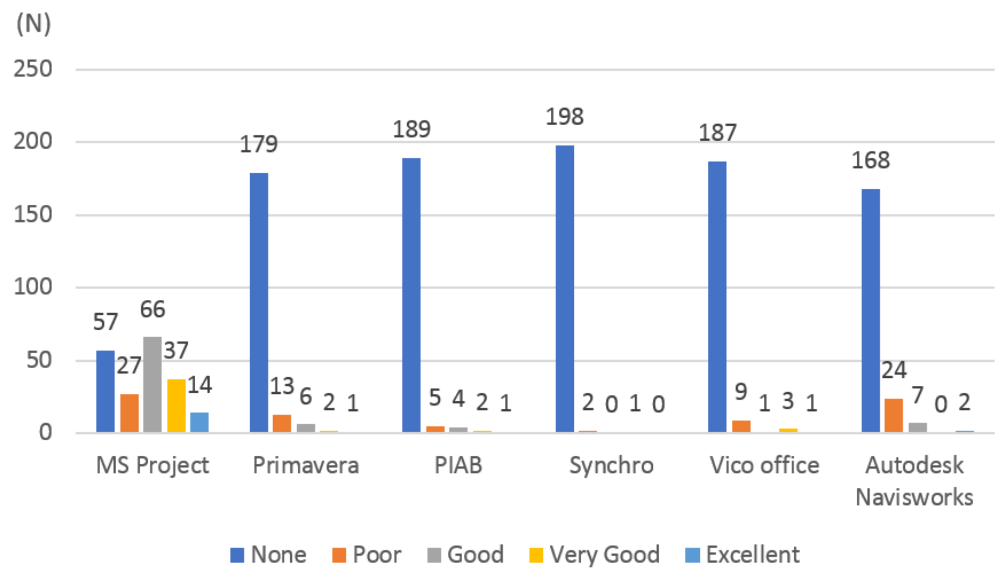


Figure 53: Scheduling software application (N stands for number of respondents)

In other software application, the skills level was quite low, and in those cases the explanation could be that the software is not used by all the professionals but is more specialised. Examples included Tekla, CAD Duct and Solibri.

In addition, self-evaluation was formulated in the following subjects using a five-point scale, and the results are demonstrated in table 5.

Table 5: Theoretical knowledge among the respondents (N stands for number of respondents)

	N	None	Poor	Good	Very Good	Excellent	Mean	Standard Deviation
Gantt chart	201	64	29	63	28	17	2.527	1.296
Critical Path Method	201	78	30	55	26	12	2.323	1.273
Line of Balance	201	109	57	24	10	1	1.672	0.873
Lean Construction	201	91	60	35	11	4	1.900	0.967
Location-based scheduling	201	114	55	24	5	3	1.647	0.894
Location-Based Management System	201	125	54	19	2	1	1.507	0.749

The theoretical knowledge of professionals in Iceland appears to be higher when it comes to theory connected to activity based scheduling than location based, as table 5 and figure 54 demonstrates.

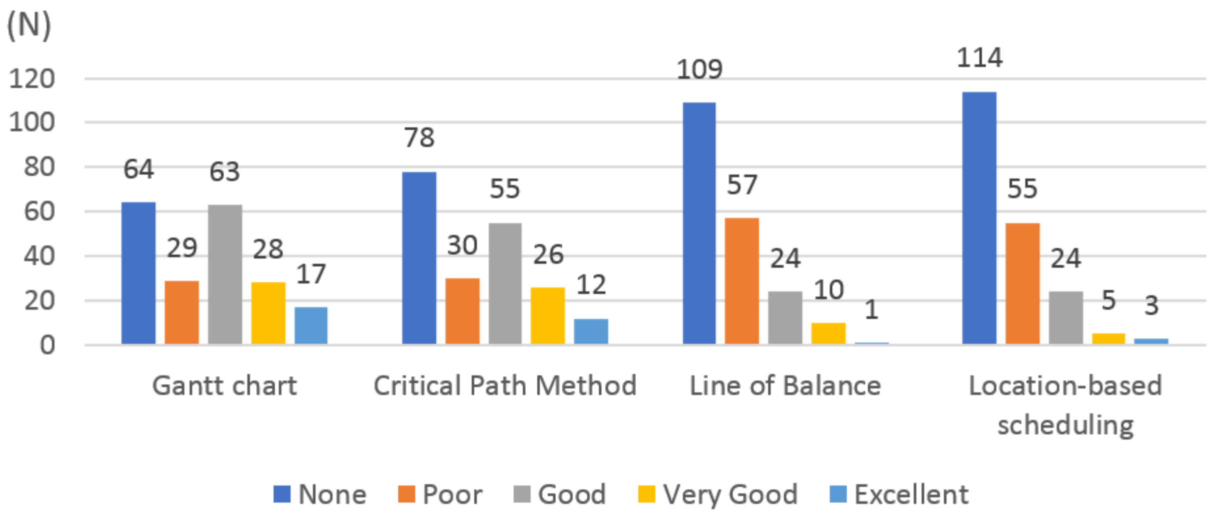


Figure 54: Activity vs. Location-based scheduling (N stands for number of respondents)

The percentage of the professionals that rated their capability as good to excellent in the Gantt chart was 53.73%. In the Critical Path Method (CPM), 46.27% rated their knowledge as good to excellent.

The respondents have rated themselves lower when it comes to linear scheduling methods. In the line of balance, 17.41% stated understanding of the method in the range good to excellent. Regarding location-based scheduling, 15.92% stated that they have a good to excellent knowledge concerning the method.

As figure 54 illustrates, higher numbers of professionals rate their knowledge as good or higher when it comes to activity based scheduling methods than location based. From the sample of 201, 93 respondents rated their knowledge in the CPM as good or higher, whereas 32 respondents did so when it came to location-based scheduling.

In Lean Construction, 24,87% rated their understanding as good to excellent. Finally, 10.95% stated that they have a good to excellent knowledge in the Location-Based Management System (LBMS).

This chapter has investigated skills, knowledge in selected software applications and theory. The next chapter will investigate attitudes towards planning, scheduling and controlling methods among the professionals.

6.2.4 Attitude towards planning, scheduling and control methods

This chapter's objective is to investigate attitudes among the Icelandic AEC industry towards current and new methods in scheduling, planning and onsite control. Additionally, the chapter will investigate the opinions of the professionals regarding optimisation of the Location-Based Management System (LBMS) and what this can bring to small construction companies and the barriers to integration. Upcoming questions were asked to establish whether there are external barriers to integration, when considering the attitudes of professionals in the Icelandic building industry towards planning and scheduling methods.

Figure 55 demonstrates the opinions of the respondents to question 1: "I find the Critical Path Method sufficient for scheduling", and question 2: "I am satisfied with the current methods used for planning and scheduling".

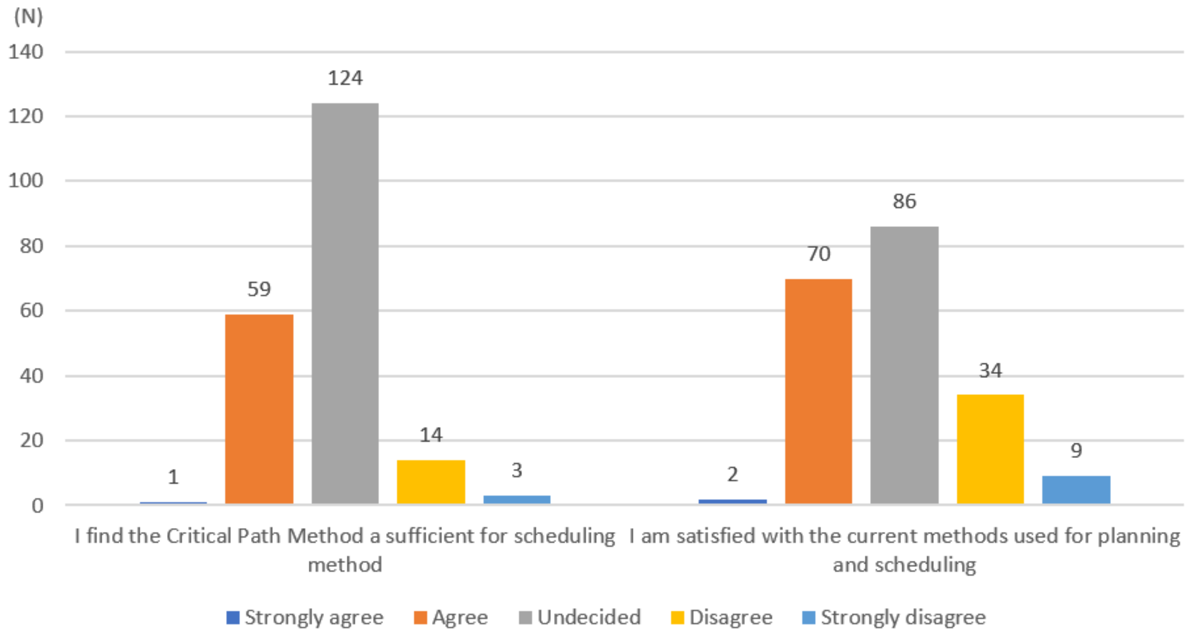


Figure 55: Attitudes toward current scheduling method (N stands for number of respondents)

The majority of the respondents were undecided regarding question 1, as the graph in figure 55 illustrates. Among the respondents, there were more that found the Critical Path Method to be sufficient for scheduling than insufficient, as figure 55 identifies.

When asked if the respondents were satisfied with the current methods used for planning and scheduling, a majority of the respondents were undecided, and out of the remainder a higher number of respondents were satisfied with the current methods in scheduling and planning than unsatisfied, as figure 55 demonstrates.

Thereafter, the following question 3 was asked: “I am interested in new methods for planning and scheduling”, and question 4: “I believe that the disciplines in the Icelandic AEC industry ae open minded when it comes to new methods for planning, scheduling and control?”, as figure 56 demonstrates.

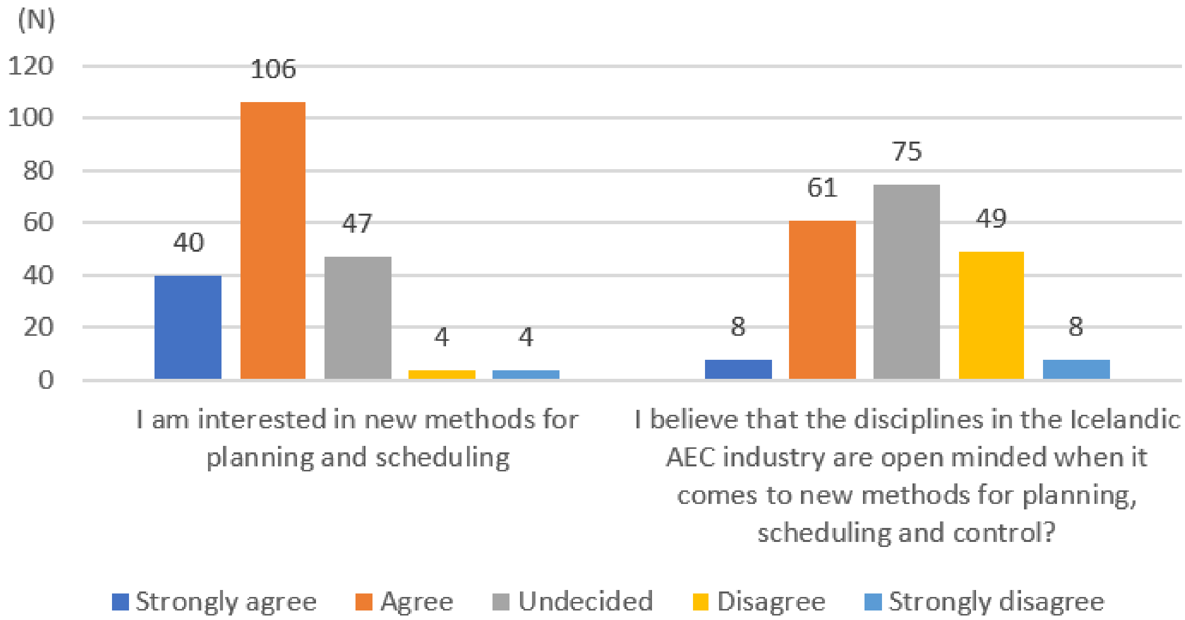


Figure 56: Attitudes toward new scheduling method (N stands for number of respondents)

The findings to question 3, as the graph in figure 56 illustrates, show that the majority of the respondents are interested in new methods in planning and scheduling. Close to 25% of the respondents were undecided when it comes to new methods. Only eight respondents indicated that they were not interested in new methods in planning and scheduling.

Thereafter, question 4 (figure 56) investigated the opinions of the professionals when it comes to whether the Icelandic AEC industry is open minded concerning new methods in planning scheduling and controlling. The largest group were undecided regarding this question, and thereafter a slightly larger group stated that the AEC industry is more open minded then not, as the graph in figure 56 demonstrates.

Table 6 contains the information about number of respondents, the mean and standard deviations for the four questions discussed above.

Table 6: Attitudes toward current scheduling method (N stands for number of respondents)

	N	Mean	Standard Deviation
I find the Critical Path Method sufficient for scheduling method	201	2.796	0.635
I am satisfied with the current methods used for planning and scheduling	201	2.891	0.853
I am interested in new methods for planning and scheduling	201	2.134	0.823
I believe that the disciplines in the Icelandic AEC industry are open minded when it comes to new methods for planning, scheduling and control?	201	2.940	0.931

Furthermore, the professionals where asked: “Do you believe that Location-Based Management Systems could improve, following methods within small to medium size construction companies?”. The response options are listed in figure 57, and the respondents were also given the choice to provide their own opinion.

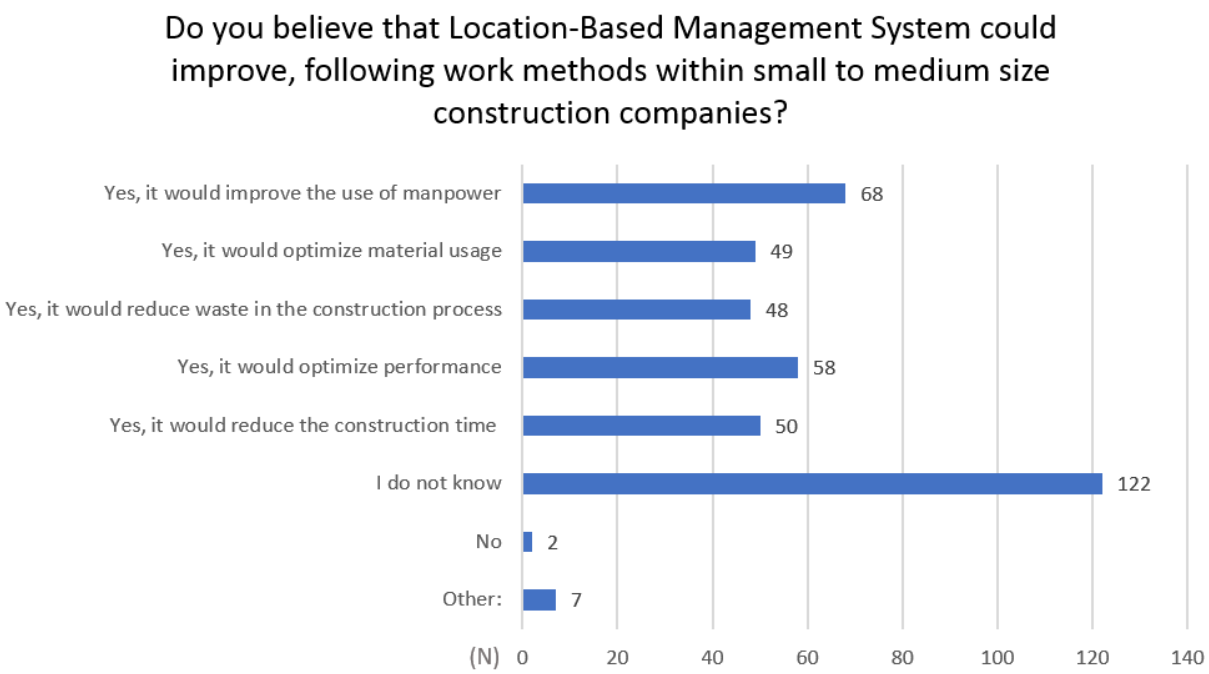


Figure 57: Do you believe that the Location-Based Management System could improve, following work methods within small to medium size construction companies? (N stands for number of respondents)

The findings, as figure 57 demonstrates, were that the majority stated they did not know whether the LBMS can improve work methods within small to medium sized construction companies, 60.7% of the total number. The remaining 79 respondents had an opinion on the matter. Two of these stated that the system would not improve the work method. Of the remaining 79, who chose from the first five options, most found the LBMS would improve the use of manpower. Then there were seven respondents who gave their own opinion, among them were that the LBMS would be better suited to large construction companies.

The final question asked (figure 58), was: “What do you consider the main barriers are for small and medium sized construction companies to implementing LBMS?” Five options were given along with the option of adding an own opinion, as figure 58 demonstrates.

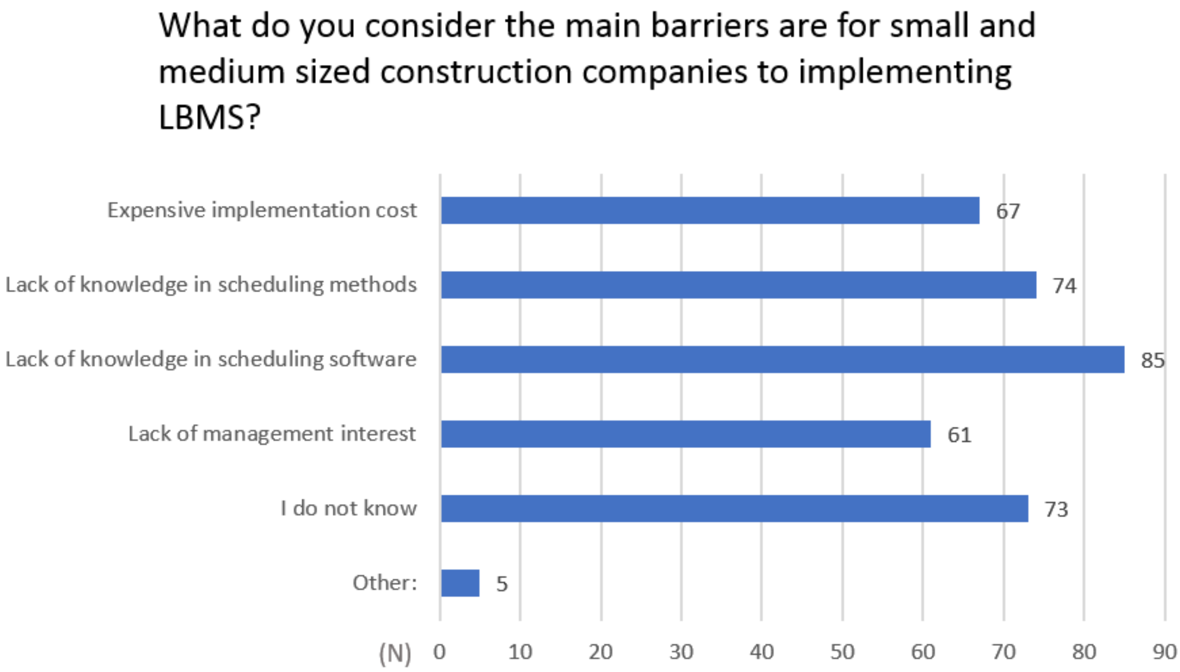


Figure 58: What do you consider the main barriers are for small and medium sized construction companies implementing LBMS? (N stands for number of respondents)

Of the 201 respondents, the main answers were that, ``there is a lack of knowledge in scheduling methods and software´´, as figure 58 illustrates. Then, 73 respondents stated that they did not know what the main barriers are. A large number found that, ``a high implementation cost and lack of management interest were barriers of the integration´´. Additionally, in the other category, there were comments regarding the ``time factor or the lack of it´´.

The purpose of this questionnaire was to locate some of the barriers to integrating the LBMS into the case study. In the next chapter, the barriers are further investigated by formulating a force field analysis.

6.3 Driving and resisting forces of integration

Previous chapters introduced the company's planning, scheduling, control and the questionnaires distributed among professionals in the Icelandic AEC industry. This chapter will investigate the driving and restraining forces of integrating the Location-Based Management System (LBMS) into the case study.

The chosen method to investigate the driving and restraining forces is the force field analysis: *"A force field analysis can be helpful in providing a view of forces at work in an organization that act to prevent or facilitate change."* (JOHNSON, et al., 2014, p. 475). Figure 59 illustrates the force field analysis created for the integration of the Location-Based Management System into the case study. The information collected from the interviews and questionnaire have been utilised to perform the analysis.

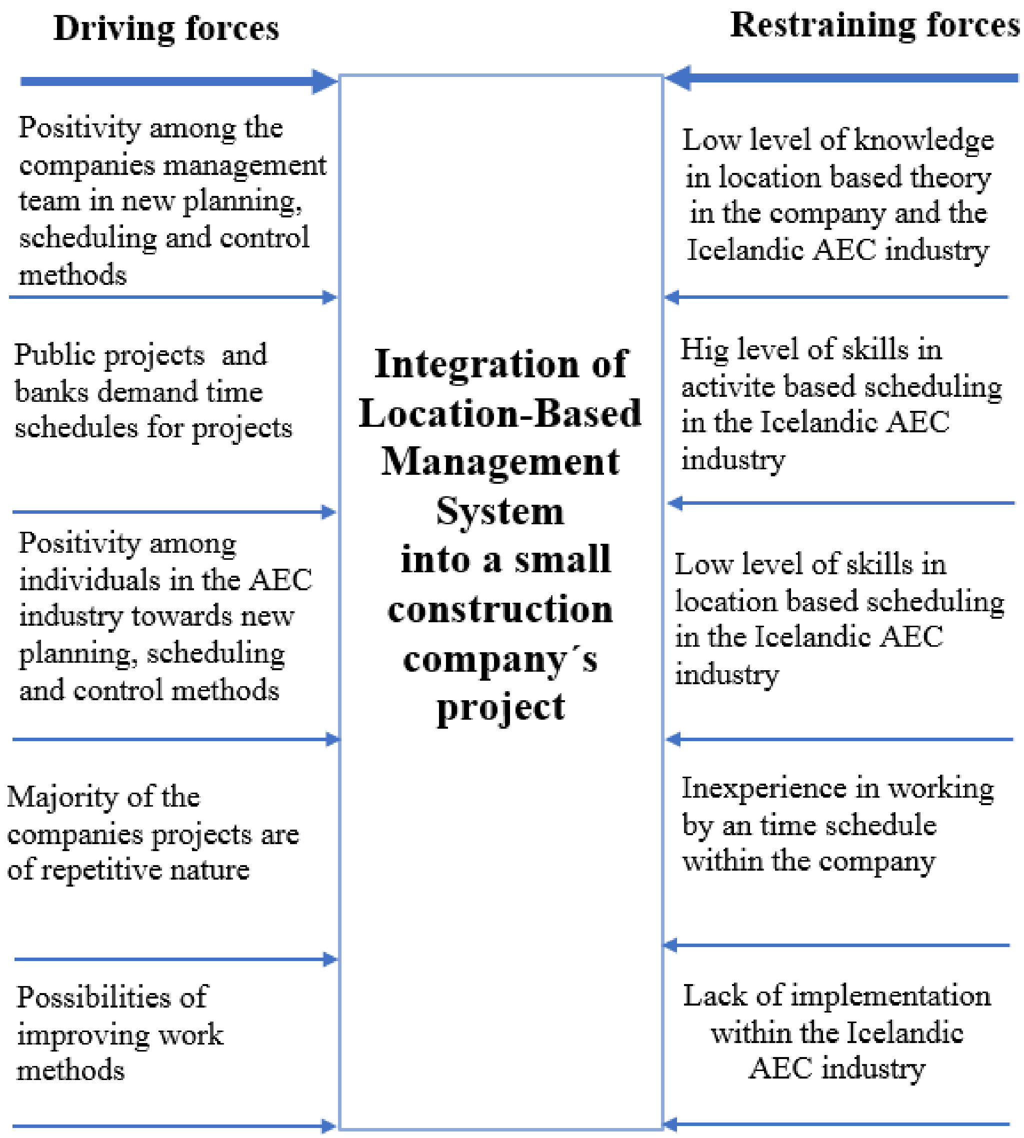


Figure 59: Force field analysis

As the information in figure 59 illustrates, there are numerous factors which influence the integration of the LBMS. The driving forces are, among others, positivity among the management team of the company when it comes to new methods in planning and scheduling, as the Project Manager indicated in the first interview. (Appendix A)

The company's main production is constructing residential houses, whereas multi-storey housing involves mostly tasks of a repetitive nature. Projects of a repetitive nature have been described as being suitable for location-based scheduling (Seppänen & Aalto, 2005, p. 271). Another driving factor for the company to integrate a management system is that the banks and public entities expect contractors to produce a time schedule for all projects.

Furthermore, as chapter 6.1, demonstrated, by implementing location-based scheduling, the company can improve the work methods, utilisation of manpower, reduce time gaps in production and make the performed tasks flow in a continuous manner, where the subcontractors do not have breaks in their work where it is necessary to leave the building site due to lack of work. The flowline view gives the planner an improved overview of the project's schedule, as previously addressed by Andersson (Andersson, 2007, p. 10). Finally, the professionals in the Icelandic AEC industry have indicated that they are interested in new methods of planning, scheduling and controlling (chapter 6.1.4).

Then there are the restraining forces of integration, illustrated in figure 59. There is a gap in the Icelandic AEC industry, when it comes to theoretical knowledge in location-based scheduling methods (chapter 6.3.3) and skills in software applications based on the locations (chapter 6.3.3), according to the questionnaire.

The responses from the questionnaire demonstrate that MS Project and MS Excel are the dominant software applications when it comes to planning and scheduling, according to the sample of 201 respondents. There was a lower level of skills in scheduling software applications which interact with Building Information Model (BIM). This could indicate a barrier, which involves resistance to new applications. The questionnaire indicated that Vico Office, which is based on the Location-Based Management System, is not in general use within the Icelandic AEC industry, as it is only used by 2,49% according to the analysis.

These findings correspond to research conducted in the United Kingdom involving BIM and 4D planning, where educational gaps, lack of experience, lack of use in the industry and resistance to change, were found to be parts of the barriers to implementation (Kassem , et al., 2012, p. 9).

Finally, a significant factor is that the majority of the management team is not used to work using a time schedule, and this could indicate that a cultural change is needed within the company for the integration to work properly. As the Project Coordinator (appendix B) indicated in their interview, the problem is to get the team to follow the schedule, and the Site Manager (appendix C) confirmed that the time schedule is not followed in the Group home project. This is not a new dilemma, as Arditi has previously documented, regarding integrating the network planning into construction projects: *"First, because the older generation of engineers are not familiar with network techniques, the necessity arises of forming a central planning unit staffed with planning experts. Contracting companies who have been traditionally organized in a vertical "project management" structure with autonomous project managers at the head of each project, are this way subjected to a new horizontal dimension in their organizational structure, with planners reporting to higher management and thus reducing the project managers' autonomy."* (Arditi, 1983, p. 6). Furthermore, Arditi addressed the issue that site managers of the older generation, with an extensive experience, have been given unlimited control onsite, and these managers often have little or no experience of working with network planning.

Chapter 6 has analysed the planning, scheduling and onsite control within the company and the internal and external barriers to integration. The next chapter will present the thesis findings.

7. Conclusion

The following chapter gives a conclusion to the report in chapter 7.1. The findings are presented, with answers provided to the problem formulation. Then, chapter 7.2 gives a general conclusion to this thesis.

7.1 Findings

The last chapter analysed the data collected on the case study and compared it to the Location-Based Management System's (LBMS) two main components: the location-based planning and the location-based control. This chapter will answer the problem formulation and the research questions. It will explain the advantages, opportunities and the challenges of integrating the LBMS into the company. In chapter 1.2.1, the problem formulation was introduced:

What are the advantages, opportunities and challenges of integrating the Location-Based Management System (LBMS) in a small construction company?

What effect, can implementing location-based scheduling have on optimisation in planning and scheduling? After the company´s MS Project schedule was transferred into a flowline view, it was noticeable that the activities in the schedule are neither in a continuous manner nor aligned. The main advantage is that the location-based schedule brings a better overview of the time schedule. Integrating the LBMS would bring opportunities to optimise the planning of the activities within the time schedule. By doing so, it could derive the advantage of shortening the project's duration, as it was found that the company's original schedule could be reduced by 6.9-15%, depending on the level of risk the contractor is willing to take. This makes it possible for the company to move their manpower at an earlier time to other projects and optimise their production.

Which possibilities are there in improving, utilisation of resource and manpower in the control phase? Implementing the controlling of project, utilising a location-based schedule can give advantages by improving the use of resources. The company can use the planned current and forecast to take control actions when there are deviations in production within appropriate time. The planning of logistics becomes more reliable, where the quantities for each location and the location the trades are working in at each time are known. The location can be ready before the tradesmen start their work, clean and the materials are delivered onsite. Furthermore, the company has the opportunity to standardise their work method, instead of primarily relying on experience.

Which specific barriers will influence the integration of LBMS? During the investigation, there were some signs of integration barriers, both internal and external. Starting with the internal barriers, there could be some resistance among the workers, when they are used to working in a certain way and it could be challenging to change the mindset within the company. Still, this factor would involve both integrating activity as well as location-based planning, since the company has just in the last year starting to integrate time schedules into their project. At this point, there could be an opportunity to consider location-based planning. Another significant challenge is the lack of knowledge and skills in theory and software connected to location-based planning.

Regarding the external barriers, the questionnaire indicated there is a knowledge gap when it comes to location-based planning theory within the Icelandic AEC industry. There is a low level of skills in Vico Office and software that it interacts with, such as Cad Duct and Tekla. A low number of respondents use Vico Office in their work, only four. This could indicate that it will be a challenge to find professionals to help with the integration of the LBMS. Furthermore, within the Icelandic AEC industry, there seems to be a trend to use MS Project and MS Excel in planning and scheduling, and this too could become a barrier when finding qualified workers.

7.2 General conclusion

This thesis has investigated the planning, scheduling and control of a small Icelandic construction company. Their scheduling is activity based and the control of projects based on the management experience. Currently, the production consists of three projects, the Industrial building Group house project and the Multi-storey house. The Industrial building project was used to demonstrate the possibilities of optimising the time schedule. The other two projects had the purposes of investigating the onsite control.

After the Industrial building project schedule was transferred into Vico Office, opportunities for optimisation were explored. The transfer increased the overview of the project. The transfer revealed that work in the internal finishes and part of the external finishes are not performed in a continuous manner, and waste in time was also located and clashes between trades. After the activities were set in a continuous manner and some minor changes made, the schedule exceeded the project's time frame. Thereafter, the schedule was aligned by adding resources, which shortened the time frame by seven weeks. When risk was considered, further changes were needed to the schedule, including the painting, fixtures and doors starting before the waterproofing of the roof has finished. After taking this into consideration, the internal finishes being pushed to a later date, but nevertheless the time frame was three weeks shorter than the planned duration.

The onsite control was also addressed, and this analysis was performed by comparing the method implemented in the company to the location-based control, since it was not possible to perform it in practice. There is an opportunity for the company to organise the flow of workers and the logistics within the work site by implementing the location-based control method. The company can make more reliable plans in production and better optimise manpower and resources.

For the company to integrate the LBMS, all parties involved in the construction process must work together. Furthermore, it is necessary to train the employees.

A questionnaire was sent out to 839 professionals in the Icelandic AEC industry, and 201 responded. The questionnaire revealed that 62.69% of the respondents use BIM in some part in their workflow. There among, 20.4% to generate time schedules and 30.35% for cost estimation. The respondents rated their highest skill levels in software applications, such as Autocad, Revit, Sketchup and MS Project. When asked what kind of software application the respondents used for planning and scheduling, the majority replied MS Project and MS Excel, whilst only four used Vico Office. When it comes to theory, the answers indicated that there is a higher knowledge about activity based planning than location among the respondents. The respondents appeared to have interest in new methods in planning and scheduling.

The main barriers to integration were found to be the lack of skills in location-based scheduling software and knowledge of theory in the subject within the company and the AEC industry. Furthermore, there was a lack of use of Vico Office within the Icelandic AEC industry.

Overall, the company appears to follow the trend within the Icelandic building industry when it comes to planning and scheduling, with the main tools being MS Project and MS Excel. In addition, there is use of Bluebeam Revu and IFC viewer for determining quantities.

After making the analysis in this thesis, the author believes that the LBMS would bring benefits to the company, within its planning, scheduling and onsite control. The next chapter will consider further potential research on the subject.

8. Discussion

The literature on the implementation of the Location-Based Management System (LBMS) the author of this thesis has reviewed on the subject has mainly involved large construction companies. These companies might not have unlimited resources on hand but still considerably more than small construction companies. The construction industry consists of many small companies, which after writing this thesis the author assumes could achieve considerable benefits through implementing the LBMS.

Therefore, the suggestion for future research, would be to integrate the LBMS into a company with a similar production level as the company in the case study, where production consists of projects of a repetitive nature. This thesis has only been able to bring possibilities of optimisation through a theoretical framework. Even though the thesis is based on an existing company in the Icelandic building industry, the process was not performed in the field, in an ongoing project.

Furthermore, there is a need to document the integration of the LBMS into the company. This is an efficient way to properly measure the benefits the company can achieve by implementing the LBMS. Even though planning and scheduling are important parts of the construction process they are only plans, which need to be properly controlled onsite for the benefits to be achieved.

Also, it would be interesting to investigate how the older generation will react to the cultural changes. For the LBMS to be properly implemented, it is necessary that all the parties involved are working together. The training of the company's employees should be monitored to ensure that the employees have the "tools" to be able to successfully implement the LBMS.

Table of figures

Tables

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Appendices

Appendix A: First interview-Project Manager

This appendix contains an interview performed through skype with the project manager on the 4th of October 2017.

Project Manager information:

Researcher: What is your position in the company?

Project Manager: I am a director and a construction manager.

Researcher: What is your education?

Project Manager: Master of trade.

Researcher: What kind of certification do you have?

Project Manager: I have certification in building manager and master of trade

Researcher: How long have you been working in the building industry?

Project Manager: I have been working for 34 years.

Researcher: How would you describe your work in the company?

Project Manager: construction control and financial aspect are my job description.

Information about the Company.

Researcher: Which projects are you currently working on?

Project Manager: Supervising four building projects which include an Industrial building, Multi-storey house no 41-43, Group home projects 1 and 2. The projects are well underway, also controlling manpower in a project that they are casting the foundation and another that the kitchens is being put up and everything in between.

Researcher: When was the company established?

Project Manager: The company was established in the year 2000.

Researcher: How would you describe the history of the company? Operations

Project Manager: I would describe the history as: We are four working owners. To start with we provided service to companies in the building industry in Iceland that have been building and selling. Also, individuals (private). We have provided service for everything around the masonry trade and more. But still we have had a few building projects on the side through the years. Until 6 years ago we decided to focus on building projects where we are selling apartments and performing building projects and not providing servicing for others. This approximately how the operations are today. Still we are servicing big building contractors, that is around 25-30 % of the operation today.

Researcher: How would you describe the company's structure? Departments, number of employees …

Project Manager: We don't refer to ourselves as CEO, we are four owners as I mention before. Three of us are involved in the project control and running the business, the forth one is more of a working employee. We have today around 40 employees that are mostly carpenters and masons, also some helpers. Then there are around 30 that work for subcontractor which are other trades that are involved in the projects, electricians, painter, plumbers and others.

Researcher: How do you see the future of your company?

Project Manager: The future, I see the future like what we are doing today, I still think we will reduce the service in the next years and be more self-sufficient in projects and will focus on our own projects up to 100%, the service department will fall out in some ways.

Schedules and planning:

Researcher: How would you describe the work procedures when planning and scheduling?

Project Manager: Therefore, I found it so interesting to hear from you and to do this project, we have not been strong in this field through the years in this work to do time schedules. As you might know the Project Coordinator is studying the same course as you and he has lifted us slightly up to a new level in scheduling. This year we have been working after schedules that we have made, before this we have mostly been working from schedules others have made, in the service. So, this is the first year and part of last year also that we are working from schedules, we like to use it and we rely also on it.

Researcher: What kind of software do you use to make time schedules and cost estimates; do you find this sufficient?

Project Manager: I do not know anything about that, you may ask, Project Coordinator about that.

Researcher: How do you estimate the cost and quantities?

Project manager: I do not make the estimates myself, but I do have a lot of experience and can tell Project Coordinator how long the task will take. Each project must be analysed by itself, regarding size and other factor. It is done in some ways from feeling and experience, though you cannot just really on that. Still the schedules we have made are based on rationalism, feeling and experience that tells how long each task will take.

Researcher: Do you estimate at this stage how much manpower you need, to perform the task?

Project Manager: Yes, you are just talking about time scheduling not cost estimates. I estimate the manpower we need for each task, so we can stand by the schedule we have made.

Researcher: Is there anything in the planning and scheduling you would like to improve?

Project Manager: Good question, that I cannot answer now, no there is nothing right now that I can see, that I would like to improve.

Researcher: How would you describe the work procedures when controlling onsite? Starting with the Multi-storey house

Project Manager: I have some employees working under me and one site manager at each work place. Each day I go to every site. For example, Multi-storey house where, Project Coordinator is controlling, every day I go over tasks with him. I do not involve myself in how much he will do today, rather advise him in how we solve different tasks which are many, an example could be this morning he need help how the "zinc" trade should finish this and how to solve a structural issue around a balcony "shade". Then I go over it with him and solve it, then he takes it into the day and buys what is needed and makes the employees do these tasks. This is at Multi-storey house.

Then the Group home project 2, there I also have a site manager, yes a guy that I meet every day and go over the task that are ongoing there. This is my role in each work place, this is the process for me every day, make sure that they have what they need and solve how it is best and quickest to perform each task. This is how I go through things with my employees over the day in all work places.

Researcher: Do you make weekly plans

Project Manager: By planning ahead, for example, to the guy that puts the asphalt on the roof that they should come tomorrow, I make plans with the employees that we need to finish a task, this week so someone else can start next week. We always have plans that are not necessary on paper or in any project management, I fix expected time for tasks and want the task finish then, so another task can commence.

Researcher: What is the schedule time frame for starting and finishing a project?

Project Manager: We made plan for Industrial building early in the spring, where we planned to start in the spring and finish the concrete work by new year, and complete the project by the end of next year. Then it took a long time to get the soil worker, finally when we got the soil worker and he was able start, the job took two months longer then he planned, because we needed to remove 20,000.00 m3 and the soil was harder than he expected, that is why there was a delay, so we are now able to start with the foundation, so you can see that we are far behind the plan we made this spring, so now we need to make a new plan whereas the soil work has an great influence on the time for all tasks, but from here on we are able to make a plan that we can stand by. Then we are not depended on any external condition like material that is harder or need to explode or hammer.

Researcher: Are there any technical workers that take out the soil?

Project Manager: Well like in the Industrial building, the decision was taken to make a house in two floors, which means that we decided to go so deep, so we would be able to have a house in two floors, and took a few bore holes and they looked good, but when there were 2 meters left down, there was soft soil Rhyolite in the top layers, but as I said when there were 2 meter left we came to such an hard Rhyolite that we had to hammer it. The bore holes we made was not deep enough or it was just so soft were we tested. That is why there was a delay but of course we could have made a lot deeper bore holes to go down to that hard layer we went down to the last two meters.

Researcher: In months, how long is the estimated project time for Industrial building

Project Manager: Concrete work is expected to finish in 6 months and remaining tasks in eight to ten months.

Researcher: How long did the soil work take?

Project Manager: It started in May and just finished in the middle of September, around end of august, took a lot longer than we expected.

Researcher: Have you started with the foundation

Project Manager: Not yet, the company carrying out the position point measurement has promise to give us position today. I have hired a subcontractor to do the foundation, so many delays has occurred in the project, so as to avoid other delays I decided to bring in a subcontractor that has six carpenters that will finish the fundamental foundation in 3 weeks.

Researcher: Anything more you have to say about Industrial building.

Project Manager: About Industrial building it is always bad about this kind of delays because we have rented out a part of the house and promised to deliver at the end of the year. On the lower floor which would have been ok if the soil work was finished in Jun or July. What I would like to say about Industrial building is that I am not happy about being behind the schedule, but we are going to, put into full speed now so we will not have problems with it all winter. We are not coming into the best time of the year to start concrete work on a big house but. We know and you also that we can get a good autumn without frost. But Industrial building is exciting project, we have been asked why we do not make steel frame house, that it is a lot faster. But we decided to go this way to use your expertise, workforce, machines and tool to make a concrete house and have a more valuable house, one year we might want to sell then we have a big and beautiful concrete house, instead of a steel frame house, one that with the years become more tired and will not keep their value. So that is the idea of making a big concrete house.

Researcher: How do you plan the management on site?

Project Manager: In the Multi-storey house project, which I sent you the drawing, we started the project a few years ago. There are 2 houses, Multi-storey house no 41 we are finished on the inside and out, and its be occupied, then Multi-storey house no 43 is starting. It is a concrete house, the Icelandic building style, where the concrete work is cast onsite, then insulate on the inside and plastered. But if I would like to make some changes from what it would be to make all the companies project, with insulation from the outside, then some kind of system timber, tiles or aluminium or zinc whatever it is called, Multi-storey house is the last project we will insulate from the inside and plaster. Else with the Multi-storey house we have kept your schedule well, we have finished the concrete work and are doing the plastering work, in the next months we will put it for sale and they are delivered in February next year. This is basically the Multi-storey house project.

Researcher: Did you make a detailed time schedule for Multi-storey house?

Project Manager: We did yes, we have it.

Researcher: Have you been able to keep the schedule?

Project Manager: Yes, I think we have been able to keep it.

Researcher: No delays you can remember?

Project Manager: No nothing big. Talking about schedules we are building a group home in Group home project 1 and 2. There we used concrete elements in the external and part of the internal walls. There we made a time schedule and where far ahead of the schedule, so we had to change it. The work was so fast the we were on the other side “too fast” In the schedule.

Researcher: When did the work start and expected to finish Multi-storey house?

Project Manager: In number 43 it started in September last year. For the whole project, we made a time schedule. Today the banks made a demand to have a time schedule so if I want to borrow money from them I need to have a time schedule and a cost estimate. So, for no 41 I got an engineer consultant, he made a time schedule and I made the cost estimate for 41 and if I remember right, there was three months delay from the time schedule. Which was supposed to take one and a half year, we went three months over the time.

Researcher: Could we have a similar oversee of Group home project 2.

Project Manager: In Group home project 2 is a different project for the company then we usually perform, it is a public project. Which was a tender, in the tender there were two that made an offer, we had a little bit lower price and got the job. So, the client made a contract with us. In the tender documents, the time is stated that we had to finish the projects, one and a half year for both the projects and they asked at the signing that we make a project schedule for the project. Of course, it must be inside the time frame they give one and a half year, so we planned the project inside that one and half year. Turned the schedule in at the signing, what happened was we here ahead of schedule with erecting the concrete elements. Both houses are around 600 m2. They are similar, there is a five weeks difference between the projects. We are supposed to deliver these two projects 1 April next year, it looks like we can deliver Group home project 1 then, 1 February and Group home project 2, one month later 1 of April. These two projects are ahead of schedule and the client is happy. So, it is exciting to see if it will happen.

Researcher: How much manpower do you have in these places and what is performed by subcontractors?

Project Manager: This was a nice project because we did not need much manpower to start with because of other projects we were finishing a townhouse and other projects, this was a concrete element house which we had to do the soil work, the foundation were also precast concrete elements. So, we made a contract with “Loftorka” so when we had made the soil work the projects was in the subcontractor’s hands for some months, when they had put up the house I brought in my own manpower and have had around 6 to 7 men on each site in average. Subcontractors onsite, are masons that have been putting up the internal walls. Electrics and plumber have been with us there quit a lot, now the zinc guy is coming, and the painter will come soon. The soil worker also, is back in Group home project 1 to do the ground and the concrete tiles. That work is starting in Group home project 1 so there is a lot of manpower there now, all the staff from the company and the subcontractors.

Researcher: How much manpower do the subcontractors have there?

Project Manager: They have starting with electrician, two guys. Plumber has two to three. There are two painters, because the pipes are external we have been applying drywall component and painting behind the radiators and pipe paths for the radiators, so there are two painters. Then one soil worker, two concrete tile guys. These are the guys working in Group home project now.

In Group home project 2 I have six guys from the company, which just finished the cladding on the roof and are insulation it, also installing the windows which is almost finished. Right now, they are putting asphalt paper on the roof of which four men are doing. No electric´s or Plummer's are there now, but we expect them in another two weeks.

Researcher: In Multi-storey house, how much manpower do the subcontractors have there?

Project Manager: There are many things going on there, we have 7 employees of the company and there are 2 plummer´s,3 electricians, 2 zinc guys. The painter has not started there he will start after next week. The floor levelling will start tomorrow. Yes, then there are a lot of masons, a subcontractor with around 4 or 5 guys doing plastering inside and out.

Researcher: Could we have a similar oversee of the Industrial building

Project Manager: Right now, nobody is working there we are finished with putting up 2 cranes, have set up the work camp and have gotten the cold water in it and got the electric connection today. Hopefully after today there are 6 carpenters., but I am waiting for a call from the measurement guy.

Researcher: How do you conduct and get ready for site meetings?

Project Manager: There are no site meetings

Researcher: What kind of software do you use to monitor the status of the project?

Project Manager: The company do not use any software in monitoring projects.

Researcher: How do you have site meetings with subcontractors?

Project Manager: No, we don't have them now, we started in the spring. Then the summer holidays started. We will start it again. The only site meeting we have is with the client every other Tuesday. Then there are inspectors and designers and we go over the projects Group home 1 and 2. We started this spring with meeting in our own projects with the subcontractors. Somehow it stopped we should start it again. Somehow lack of time lead to not keeping it on.

Researcher: Do you update the time schedule, during the construction phase?

If yes, how often? if no why?

Project Manager: No, we have not done it

Researcher: So, you follow the original plan?

Project Manager: Yes, but as I said before. In Group home project 1 and 2 we changed them slightly. It was once updated.

Researcher: Do you find that the time scheduling is sufficient control tool during the construction process?

Project Manager: Yes, I would say, I think it is completely justifiable and all managers I know in the construction industry should use. Even though I am of the old school and want to have it all in my mind, then it is not always possible, and we need to have it ok, the project schedules.

Researcher: How do you assure quality in the projects?

Project Manager: It is like that in the industry we are depended on inspection from the city and they come and look at everything with the structural, all the iron is taken out in the houses. Another part is that needs to be inspected is everything connected to plumbing, so you need to install all the pipes and test, according to the drawing so it will pass the inspection. This is of course always fulfilled in each work place. Electricians in Iceland do not need any kind of inspection during the construction process. But it is like that with the electricians that they finish the work, with recognized material that has been certified. When they finish the work, they report it to "Manvirkjastofun" a government agency which then goes randomly for inspection, there to say they come to these places when the work is done and inspects them. Then the electrician collects points and if there are a lot of problems "Manvirkjastofun" will inspect all their work. If there are few faults they do not inspect as much the individual electrician. That is the quality control for the electrician.

Regarding other tasks like putting up the kitchens, internal walls and other. There we have our own inspection, how far you what to go with quality, do you want to want to turn in a job with a crooked window sill or and leaning radiators, or badly put up cabinets. This is more connected to the company quality control. We have today a quality system, in the company there are high demands to all the work and how the apartments are delivered, we go a little further then our competitors in quality in kitchen cabinets, finishing and tiles, we are proud of that we can flag that we go further than others.

Researcher: How do you perform the quality checks is it inside the time schedule?

Project Manager: Of course, you can say that we do not have it inside the time schedule, rather it is the managers that inspect each task. For example, if the mason is putting up internal wall, we do not use gips plates that is part of the quality, then they will put up the walls then we inspect the if they are ready for the painter, but we do not write it down, this is the human part in the building industry that I also need trust the employees that they are doing a good job. Don't know how to explain it differently. By being onsite every day us the directors and the site managers there is not much that we do not see.

Researcher: How would you describe the communication and coordination with the subcontractors?

Project Manager: The communication is pretty good, of course there are things that come up we have had subcontractor that have not fulfilled their part and not followed the timeframe we give them. Talking about that we were building a townhouse this summer and we had a painter that basically "painted us in a corner" you could say, he did not follow the time frame, and because of that we were far behind the schedule. Which caused us having unhappy clients which were supposed to get their apartments, at a certain time which was not possible, then we needed to fire him, we also fired the one before him. Now we have three painters, one for Multi-storey house project, Group home project 1 and 2, so we have 3 painters now and we will see how they will perform. But regarding the electrician and plumber, we have had the same electrician from the beginning, every good company and has done a really good job, all communication good. Then we have a Plumber he on the edge with keeping the time schedule in all the projects. He is our main "Achilles heel" he has not performed good in most of the project, so we are starting to look for another plumber to have on the starting line and maybe when we are up to this size we need to have two plumbers and split the projects. He cannot follow the time schedule. He normally has too few workers.

Researcher: Are there delays in the production because tasks are not finished in the right time?

Project Manager: Yes, that happens when they do not do their part, for example when the plumber does not finish his part, so another can start. Yes, that happens.

Researcher: How is the communication and coordination with the suppliers?

Project manager: They are good we shop with "Húsasmiðjan" they are our biggest supplier today and they have performed good, but of course sometimes there has being issues, with the suppliers something that was supposed to come today won't come into the country until in one week and so on that will always happen, sometimes it has an affect and sometimes not. But I have learned with years and have stated to make sure these things do not happen, it is normally expensive and is bad for all the plans if the supplier does not have to product I am expecting. There is always something that will happen that is just how it is. The communication is fine, in other way.

Researcher: Do you have any problem currently in your production?

Project Manager: This is a good question, I think after we started the work that was strictly by time schedules, like in Group house project 1 and 2. I think the subcontractors do not realize the importance to follow the time schedule.

Then I am referring to the plumber and painter in the last projects, they have been careless. This could be put on us that we have not made it clear that it is important. This is things that I need to improve to make it clear, to be more effective and work better with me in with the time schedule.

Researcher: Is there anything in the onsite control you would like to improve?

Project Manager: We can always do better, We are thinking about having a computer that has an internet connection where we can get all the material, changes in drawing have daily documentation on tasks, these are thing we have been thinking of, maybe you could come with a solution to it, I don't know, we have been thinking of it, would be something we could do to let the subcontractors and all know the importance of following the time schedule, even ourselves that we follow the time frame and cost estimates that we make.

Researcher: How open are you to trying a new management system?

Project Manager: I am open to consider anything in these matters especially since we have not come further than this. Especially if I can have like I said in the last question. If I could have something on site whether it is a computer or a laptop or something else, that I can have a daily register of everything. That is exciting to consider anything regarding that. We are starting with a system in the end of the month for the first time, a clock to for workers to register in and out of work, in all work places of the company from 1 of November. That is a system called Tímon which goes through a Mobil phone. From first of November all employees need to register, every day in, then we can see where they are working, also we will have documentation, and less writing after that and maybe we will get more out of the staff they will come early and won't quit 10 minutes before.

Researcher: Have you heard of the Location-Based Management System?

Project Manager: I think so.

Researcher: Is there something you would like to add?

Project Manager: No

Appendix B: Second interview- Project Coordinator

This Appendix contains an interview performed through skype with the project manager on the 11th of October 2017.

Researcher: What is your position in the company?

Project Coordinator: I don't have any title, but I do the job of a coordinator, site manager, with insight into all projects. Then I control Multi-storey house with 10 apartments.

Researcher: What is your education?

Project Coordinator: I´m a mason, but also a student of construction technology in the University of Reykjavik.

Researcher: What kind of certification do you have?

Project Coordinator: Masonry and for fireproofing.

Researcher: How long have you been working in the building industry?

Project Coordinator: For 12 years.

Researcher: How would you describe your work in the company?

Project Coordinator: Makes project time schedules, takes material quantities and a site manager at Multi-storey house, where I handle taking quantities for material ordering and daily planning

Researcher: Which projects are you currently working on?

Project Coordinator: Multi-storey house, Group home project 1-2 and Industrial building.

Researcher: How would you describe the operation of the company?

Project Coordinator: Building contractor and service in the building industry.

Researcher: How would you describe the work procedures when planning and scheduling?

Project Coordinator: Start with going over the drawings and the time frame we have for the job. What demands are made towards us regarding time and what demands we make to ourselves. What is realistic to do. How much financing we are going to put into the job, how much manpower we have. Then I try to see how much time each activity will take, especially regarding tender projects. There you are working for a client with a deadline for the job and you need to show him how you are going to deliver in the right time it is not enough to say you are going to do it. You try to analysis what you are doing, spilt it down to activity's, in tender we get a list of quantity's. When we are making planning, we split into for example the structure into foundation, wall units, floor and roof. We try to spit it into units that can be finish.

Researcher: Do you use any kind of methodology in your planning?

Project Coordinator: No, use the experience in the company, do it together. Of course the plans are not doable if we do not follow them and the experience has shown that it has been hard to follow them. Use the experience.

Researcher: Do you use buffers in your scheduling?

Project Coordinator: No, don't know what concept.

Researcher: What kind of software do you use to make time schedules and cost estimates; do you find the sufficient?

Project Coordinator: Bluebeam Revu, IFC Viewer, MS Excel files, MS project. Bluebeam is a device you can use for take-offs. Just take one measurement from the drawing and from it I can measure everything else in scale. Then I use excel to document the information and finally put it up in Ms project.

Researcher: How do you estimate the cost and quantities?

Project Coordinator: Cost is an offer, feeling and experience you cannot do it other way.

Researcher: Is the production cost included in the project's cost estimation?

Project Coordinator: The production cost is accounted for by adding a % to the total projects cost.

Researcher: Do you make any kind of risk analysis?

Project Coordinator: No

Researcher: How do you estimate the production rate?

Project Coordinator: We know how long it will take to put up an internal wall and how long it will take two guys to put up certain amount of formwork in one day. We get a square meter number and the work environment, if are we on the floor or in a ditch. Then it is just calculation.

It is normally everything but the earth work that is fine. Then for example the plumber must wait for the earthwork combination, then it can start to be problematic.

Researcher: Do you estimate at his stage how much manpower you need, to perform the task?

Project Coordinator: We do not put it in the MS project as it is, but we should do it in the big projects.

Researcher: Is there anything in the planning and scheduling you would like to improve?

Project Coordinator: Yes, to follow it up and I would need more time to make a more exact planning that will come with experience. Can always improve but it must be taken more serious that manpower is put on a project and no changed after that.

Researcher: How would you describe the work procedures when controlling on site?

Project Coordinator: Everyone needs to have work to do but not too much, they must be able to see the end of the day. You should consider that not everyone can work together. You must train workers into some tasks. If there are many workers then I write down what they should do, and make them monitor one another.

Researcher: How do you plan the management on site?

Project Coordinator: For example, we will level the floors on Friday, then we need to order material and get the floor ready, that goes into to plan. Then on Thursday I close the areas and guys need to walk on the scaffolding. Also, I must make sure that the workers have enough material.

Researcher: What kind of software do you use to monitor the status of the project?

Project Coordinator: In the Group home house, we use ahead calculations to see how much have been paid. That is taking out by an expert from the client. Then we have the quantities that we get paid from in percentage, each part can be billed up to 100%, then it is out.

Researcher: Do you have any connection between the finished quantities and the plan you have made?

Project Coordinator: I have tried to put it together, but the thing is a list of quantities can have hundreds or thousands of items, so I must find some simple way to connect these items, it is possible, but I am not there yet.

Researcher: How do you conduct and get ready for site meetings?

Project Coordinator: On site meeting I take notes then I put the notes up in a list in word, then I bring it up in the meeting. If we need to go over drawings, then I bring it in A4. Which I can refer to when discussing the tasks in the project , then I take that one with me to the meeting.

Lately, we haven't be meeting with the subcontractors, but with the client every second week or son.

I will send you a copy of a meeting. The goals for the next meeting are put in the meeting agenda. Instead of having a meeting at all the sites we make one meeting. Since we have the same subcontractors at all places.

Researcher: Do you update the time schedule, during the construction phase?

If yes, how often? if no why?

Project Coordinator: Yes regrettable, constantly. There is always something either delayed or too fast. It is hard to foresee the earth work; the quantities are estimated, and you never know what is in the soil.

For example, you have the earth contractor that starts on the 10 of January and you have a concrete contractor that is supposed to start at 11 February. Then when digging starts there is frost down to the rock, which then affects the estimated time for foundation work to commence, which now result in delays of project being ready on time. It's mostly the earth work that causes delays. Not except you want to drill 100 bore holes you do not know what is underneath.

Researcher: Have you been able to follow the time schedule? If not, why?

Project Coordinator: Yes, and we are on plan in the Group home projects 1 and 2. We are close to what we estimated in the activities. It is fun to tell about that.

Researcher: What about the Multi-storey house?

Project Coordinator:

There is no time schedule there, but we are in full swing, the windows are being installed, plastering almost finished, the painter will come on Monday and we are levelling the floors in the first two floor. It well underway since my supervision.

Researcher: Has there been delays in the work? If yes, why?

Project Coordinator: There has been some, mainly because of the subcontractors. blacksmiths and plumbers, it is mainly that. As the situation is today there are so many that want to employ them, and they can't get over all the work. All the delays are because of subcontractors. In these kinds of activities where one task finishes for other to start.

Researcher: Do you find that the time scheduling is sufficient control tool during the construction process?

Project Coordinator: Yes, I like it, these are the first two projects we have used it in, with supervision from the client. Which goes over the time schedules, yes, I am happy with it. Especially good for ordering material, these projects are 14 months from the earth work until handover and the floor are 1300m2 for handicapped with all kind of special solutions. Without these schedules, we would never be able to order for it, berceuse we have order far ahead.

Researcher: How do you assure quality in the projects?

Project Coordinator: By following the projects drawing and constantly monitoring the work onsite.

Researcher: How would you describe the communication and coordination with the subcontractors?

Project Coordinator: Through the site meeting and we have worked much together there are no new subcontractors as it is, and they get the schedules to follow I must be more persistence on it. In that way, we try to coordinate it. Most of them want to be able to follow the schedule.

Researcher: How is the communication and coordination with the suppliers?

Project Coordinator: Good, they are happy that we order in time. But also, you cannot be too early, so they do not end up storing lot of material for us, that we are going to use I three months. We need to coordinate well with them.

Researcher: Do you have any problem currently in your production?

Project Coordinator: No of course not.

Researcher: Is there anything in the onsite control you would like to improve?

Project Coordinator: Yes, communication but that will not be done except I learn polish or they Icelandic.

Researcher: How open are you to trying a new management system?

Project Coordinator: Are you trying to sell me something, I am open?

Appendix C: Third interview- Site Manager

The following interview was performed on 15 of November 2017. Where the researcher went to meet the Site Manager from the Group home project, at the projects location.

Researcher: What is your position in the company?

Site Manager: I am Site Manager over Group home project 1 and partly over Group home 2, the Project manager is mainly taking care of the second one. Then I have been doing carpentry work also, windows and roof.

Researcher: What is your education?

Site Manager: Journeyman's certificate in carpentry.

Researcher: What kind of certification do you have?

Site Manager: None.

Researcher: How long have you been working in the building industry?

Site Manager: Since 1993, that is 24 years.

Researcher: How long have you been working in the company?

Site Manager: For seven months.

Researcher: How would you describe your work in the company?

Site Manager: I am doing carpentry half the day then, controlling the work the other half.

Researcher: Which projects are you currently working on?

Site Manager: The Group house projects 1 and 2.

Researcher: How would you describe the work procedures when controlling on site?

Site Manager: The Project Manager is the building manager and he come to me every other day and looks over the finishing tasks and if there are some issues, sometimes everyday depending on if I ask him. Everything I do consult with the project manager. I make sure the staffs perform their work.

Researcher: How do you plan the management on site?

Site Manager: Mainly, at the end of the day I check what is needed for the next 2-3 days. Then one of the staff delivers the materials to the site. This is a small project and perhaps not so much to look into.

Researcher: What is the schedule time frame for starting and finishing a project?

Site Manager: We want to be finished in January, it is supposed to finish in April, but we are going to finish in January. The painting job will finish in December, then we will put up the internal fixtures.

Researcher: What kind of software do you use to monitor the status of the project?

Site Manager: None, we just have an inspector that monitors the process, then onsite clock registers the time for the companies staff. The Project Manager handles all the computer work around this, I do not perform any of that work.

Researcher: How do you conduct and get ready for site meetings?

Site Manager: Every other week, with the architect onsite, and if necessary the client is included, I take notes that I review to see any concerns or problems that can arise.

If there are issues that cannot work out, then the meeting is here. I often talk to the architect if it is about the details. If it is about the process of the work, then the meetings are at the company's office.

Researcher: Do you update the time schedule, during the construction phase?

If yes, how often? if no why?

Site Manager: No, we have a time schedule, but we have not updated it, but can see that we are two months ahead of time. It's hanging up here in the shed and we have not updated it. We are ahead of it, so we do not try to follow it. For example, the soil workers are behind. The time schedule is more on the side and it is possible to see how it is supposed to go but I do not look at it so much. I can see that the painter will start now and in a month, it is possible to put up the internal fixtures.

Researcher: What are the reasons for not using the time schedule?

Site Manager: The project will be ready on time, so I don't see it necessary to follow the time schedule.

Except with the soil worker delay.

Researcher: You do not use the schedule as a control tool?

Site Manager: No, not in a small project like this, in the Multi-storey house project that we are about to start it is more necessary, because of the size, then you need to register more.

Researcher: Do you find that the time scheduling is sufficient control tool during the construction process?

Site Manager: Yes, the schedule is more necessary in larger projects.

Researcher: How do you assure quality in the projects?

Site Manager: The Project Manager monitors the quality of the project, the inspector from the client comes two times a week also. I do not have any register system. I supervise with the trades to see if tasks are completed, for example if the electricity setup is finished before the wall is closed. Then we need an inspector to take out the plumbing then the Project Manager is also present, and they inspect the work. They came today and took out the fire control and plumbing, so now these tasks are finished. It is possible now to close all walls and ceiling.

Then I monitor what the workers are doing but I do not have any check list. I´m working with my guy´s and make sure they do the work well. Then when the trades say they are finished somewhere then I go with them and look the work over. No formal process except with the ones that need inspection for the council.

Researcher: How would you describe the communication and coordination with the subcontractors?

Site Manager: They are good onsite meetings and in general onsite. If there are some issues with the trades, then I have a meeting with them and sometimes the architects join. I do not sit the meeting where they go through the process of the project or the financing.

Researcher: How is the communication and coordination with the suppliers?

Site Manager: We have one supplier, that we buy everything from. I try to order the material within good time. We have a coordinator from the supplier which handle our supply.

Researcher: Do you have any problem currently in your production?

Site Manager: No, only the soil work. The Plumber has also been behind, but it is not really affecting us.

Researcher: Is there anything in the onsite control you would like to improve?

Site Manager: No, everything has been going well and it has been good to work with the architect. If the communication is good, then the work normally goes well.

Researcher: How open are you to trying a new management system?

Site Manager: I am open

Researcher: Have you heard of the Location-based management System?

Site Manager: No.

Researcher: Is there something you would like to add.

Site Manager: No.

Appendix D- Questionnaire

This appendix contains a questionnaire which was sent out to professionals in the Icelandic AEC industry by email using google forms. The following text was used to introduce the questionnaire:

Kæri viðtakandi

Ég óska eftir þinni aðstoð.

Ég heiti Hákon Jónas Ólafsson og stunda mastersnám í Framkvæmdastjórnun við Verkfræðideild Háskólans í Álaborg. Ég er í augnablikinu að vinna að lokaritgerð minni sem fjallar um innleiðingu LBMS kerfis í lítil og meðalstór fyrirtæki („Integration of Location Based Management System into a small construction company project"). Ég hannaði eftirfarandi spurningalisti til að leita svara við rannsóknarspurningunni, „Which specific barriers will influence the integration of LBMS?". Rannsóknarverkefnið er miðað við íslenskar aðstæður.

Location-Based Management System (LBMS) er svæðismiðað stjórnunarkerfi, sem hefur áherslu á áætlangerð og stjórnun framkvæmda. Dæmi um svæðismiðaðan hugbúnað til áætlangerða er Vico office. LBMS hefur áhrif á allt framkvæmdaferlið, frá hönnun til framkvæmda. þess vegna hef ég sent spurningalistann til arkitekta, bygginga-, verk- og tæknifræðinga á Íslandi, með von um góðar undirtektir.
Könnunin er stutt, tekur einungis um það bil 5- 10 mínútur. Það er nauðsynlegt að svara öllum spurningunum, sumar þeirra gefa möguleika á fleira ein einu svari. Könnunin er algjörlega nafnlaus.

Vinsamlegast smellið á linkin hér fyrir neðan til að svara.

Með fyrir fram þökk.

Kveðja

Hákon Jónas Ólafsson

Questionnaire

*Required

Part 1: General questions

1. **Your age? (Aldur þinn?)** *

Mark only one oval.

- 20-29
- 30-39
- 40-49
- 50+

2. **How many years have you been working in the building industry? (Hversu mörg ár hefur þú unnið í byggingariðnaði?)** *

Mark only one oval.

- 0-1
- 2-5
- 5-9
- 10-19
- 20+

3. **What is your education? (Hver er menntun þín?)** *

Mark only one oval.

- Architecture (Arkitektúr)
- Engineering (Verkfræði/tæknifræði)
- Constructing architecture (Byggingafræði)
- Other: ______________

4. **What is your highest level of education? (Hvert er þitt hæsta menntunarstig?)** *

Mark only one oval.

- Bachelor degree (BS/BA gráða)
- Master degree (Meistara gráða)
- Phd degree (Doktors gráða)
- Other: ______________

5. **What is your profession (field of work)? (Hvert er þitt starfssvið?)** *
Mark only one oval.

- ◯ Engineering (Verkfræði, burðarþol, lagnir..)
- ◯ Consulting company (Ráðgjöf)
- ◯ Architecture office (Arkitektastofa)
- ◯ Education (Menntastofun)
- ◯ Government agency (Ríkisstofun/bæjarfélag/sveitafélag)
- ◯ Construction company (Verktakafyrirtæki)
- ◯ Other: ______________________

6. **How many employees does your company have? (Hversu margir starfsmenn vinna hjá fyrirtækinu?)** *
Mark only one oval.

- ◯ 1-9
- ◯ 10-49
- ◯ 50-99
- ◯ 100-199
- ◯ 200+

Part 4: Software application and knowledge

7. **Do you use BIM (building information modeling) for one or more of the following tasks in your workflow? (Notast þú við upplýsingalíkan (BIM) við eitthvað af eftirfarandi í þinni vinnu?) (Hægt að velja fleiri en einn valkost)** *
Tick all that apply.

- ☐ We do not use building information model (Nota ekki upplýsingalíkan (BIM))
- ☐ Generate 2D drawings (Gerð tvívíddateikninga)
- ☐ Visualization for clients (Þrívíddar framsetning fyrir viðskiptavini)
- ☐ Clash detection (Árekstargreiningu)
- ☐ Energy analyses (Orkugreiningar)
- ☐ Time scheduling (Tímaáætlanir)
- ☐ Cost estimation (Gerð kostnaðar áætlunar)
- ☐ Visualization of the construction site (Þrívíddar framsetingu af verkstað)
- ☐ Visualization of the project timeline (Þrívíddar framsetingu af framkvæmdaferlinu)
- ☐ 2D and/or 3D coordination between disiplines (Samræmingu hönnunargangna)
- ☐ Other: ______________________

8. **How would you rate your skills? (Hverning myndir þú meta hæfni þína?)** *
Mark only one oval per row.

	None (engin)	Poor (lítil)	Good (góð)	Very Good (mjög góð)	Excellent (framúrskarandi)
Autodesk Revit					
Autodesk AutoCAD					
ArchiCAD					
Microstation					
SketchUp					
Autodesk Civil 3D					
Vectorworks					
Tekla					
AutoCAD MEP					
Solibri					
CAD Duct					
MS Project					
Primavera					
PIAB					
Synchro					
Vico office					
Autodesk Navisworks					
Autodesk 3ds Max					

9. **How would you rate your knowledge? (Hverning myndir þú meta þekkingu þína?)** *
Mark only one oval per row.

	None (engin)	Poor (lítil)	Good (góð)	Very Good (mjög góð)	Excellent (framúrskarandi)
Gantt chart (Gantt riti)					
Critical path method (Bundna leiðin)					
Line of balance (Tegund af flæðilínuriti)					
Lean construction (Lean straumlínustjórnun)					
Location based scheduling (Svæðismiðuð áætlanagerð)					
Location Based Management System (Svæðismiðað stjórnunarkerfi)					

Part 3: Planning, scheduling and control

10. **Have you worked in the field of construction planning and scheduling? (Hefur þú unnið við áætlanagerð fyrir byggingaframkvæmdir)** *
Mark only one oval.

11. **Have you supervised construction projects onsite? (Hefur þú haft yfirumsjón á verkstað?)** *
Mark only one oval.

- ◯ Yes (Já)
- ◯ No (Nei)

12. **Which software/s have you used for planning and scheduling? (Hvaða eftirfarandi hugbúnað hefur þú notað við tímaáætlanagerð?)(Hægt að velja fleiri en einn valkost)** *
Tick all that apply.

- ☐ Primavera
- ☐ MS Project
- ☐ Vico office
- ☐ PIAB
- ☐ Synchro
- ☐ Navisworks
- ☐ Ms Excel
- ☐ I have not worked with planning and scheduling software (Ég hef ekki unnið með hugbúnaði tengdum áætlanagerð)
- ☐ Other: ____________________

13. **To what extent do you agree with the following statements? (Hverning myndir þú meta eftirfarandi staðhæfingar?)** *

Mark only one oval per row.

	Strongly agree (mjög sammála)	Agree (sammála)	Undecided (hlutlaus)	Disagree (ósammála)	Strongly disagree (mjög ósammála)
I find the Critical path method a sufficient for scheduling method (Mér finnst, Bundna leiðin fullnægandi aðferði til áætlunargerðar)	⬭	⬭	⬭	⬭	⬭
I am satisfied with the current methods used for planning and scheduling (Ég er ánægð/ánægður með núverandi aðferðir til áætlunargerðar)	⬭	⬭	⬭	⬭	⬭
I am interested in new methods for planning and scheduling (Ég hef áhuga á nýjum aðferðum til áætlunargerðar)	⬭	⬭	⬭	⬭	⬭
I believe that the disciplines in the Icelandic AEC industry are open minded when it comes to new methods for planning, scheduling and control? (Ég trúi því að íslenskir fagaðilar innan byggingargeirans, séu víðsýnir þegar kemur að nýjum aðferðum í áætlunargerðum og framkvæmdastjórnun)	⬭	⬭	⬭	⬭	⬭

14. Do you believe that Location Based Management System could improve, following work methods within small to medium size construction companies? (Trúir þú að Location Based Management System gæti bætt eftirfarandi verklagsaðferðir innan lítilla og meðalstórra byggingarfyrirtækja?)(Hægt að velja fleiri en einn valkost) *

Tick all that apply.

- [ ] Yes, it would improve the use of manpower (Já, myndi bæta nýtingu á mannafla)
- [ ] Yes, it would optimize material usage (Já, það myndi auka nýtingu byggingarefna)
- [ ] Yes, it would reduce waste in the construction process (Já, myndi minnka sóun í byggingaferlinu)
- [ ] Yes, it would optimize performance (Já, það myndi auka afkastagetu)
- [ ] Yes, it would reduce the construction time (Já, myndi stytta byggingartímann)
- [ ] I do not know (Veit það ekki)
- [ ] No (Nei)
- [ ] Other: ____________________

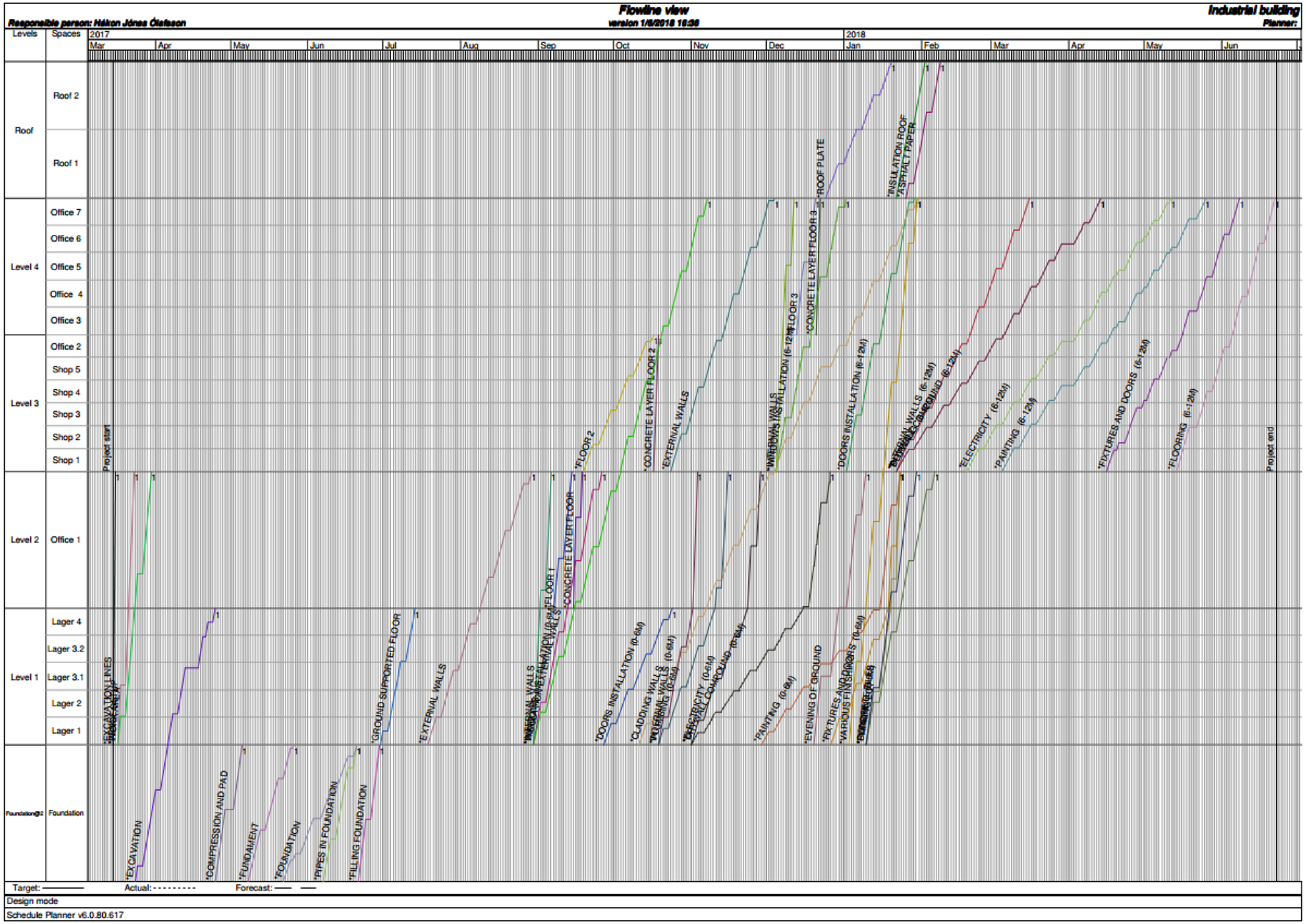
15. What do you consider the main barriers are for small and medium sized construction companies to implementing LBMS? (Hvað telur þú að muni helst standa í vegi fyrir því að lítil og meðalstór byggingarfyrirtæki innleiði LBMS hjá sér?)(Hægt að velja fleiri en einn valkost) *

Tick all that apply.

- [ ] Expensive implementation cost (Of hár innleiðingarkostnaður)
- [ ] Lack of knowledge in scheduling methods (Vanþekking á aðferðum í tímaáætlanagerð)
- [ ] Lack of knowledge in scheduling software (Vanþekking á hugbúnaði)
- [ ] lack of management interest (Áhugaleysi stjórnarmanna)
- [ ] I do not know (Veit ekki)
- [ ] Other: ____________________

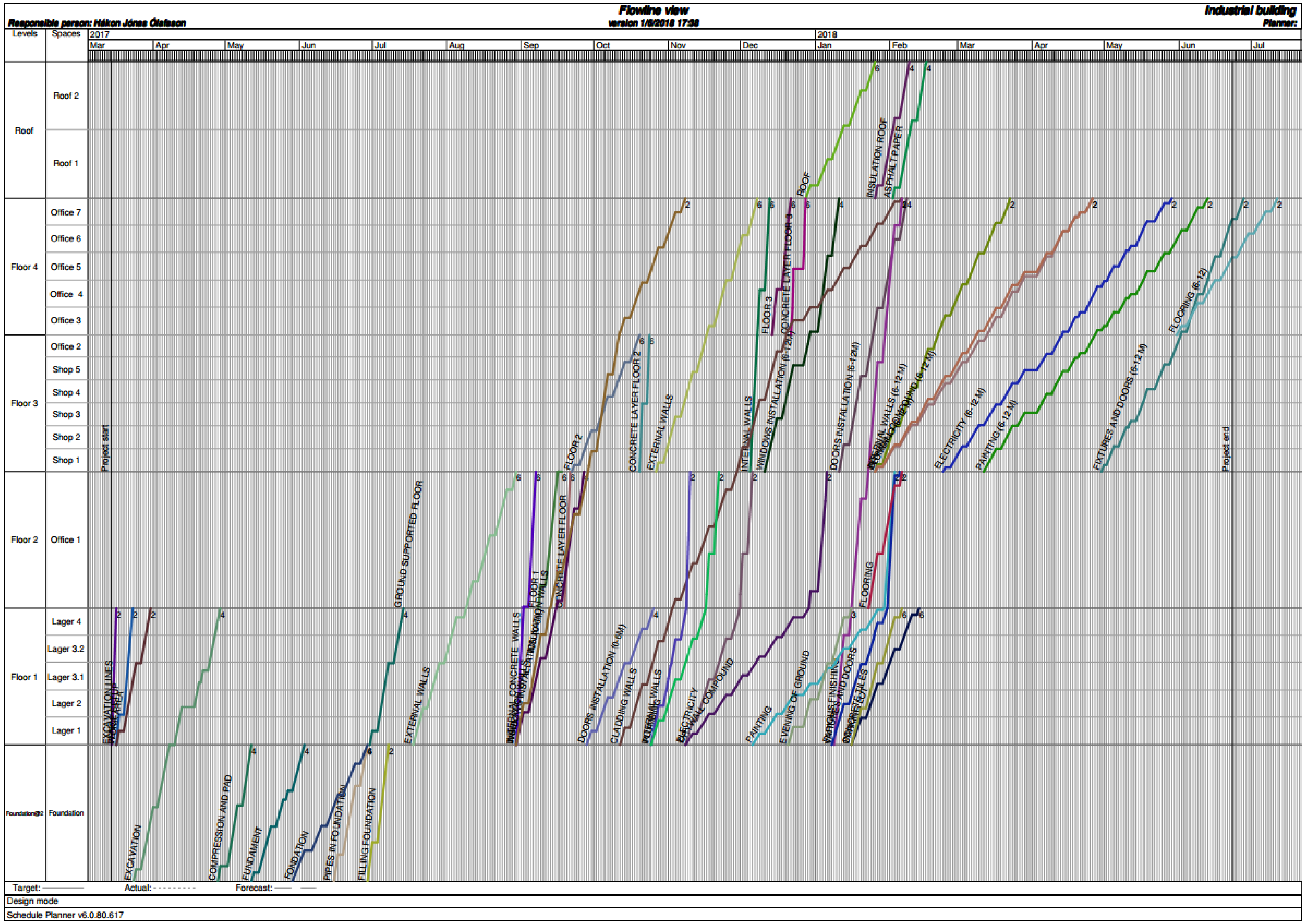
Appendix E-Industrial building flowline schedule, after transferring from MS Project and before changes

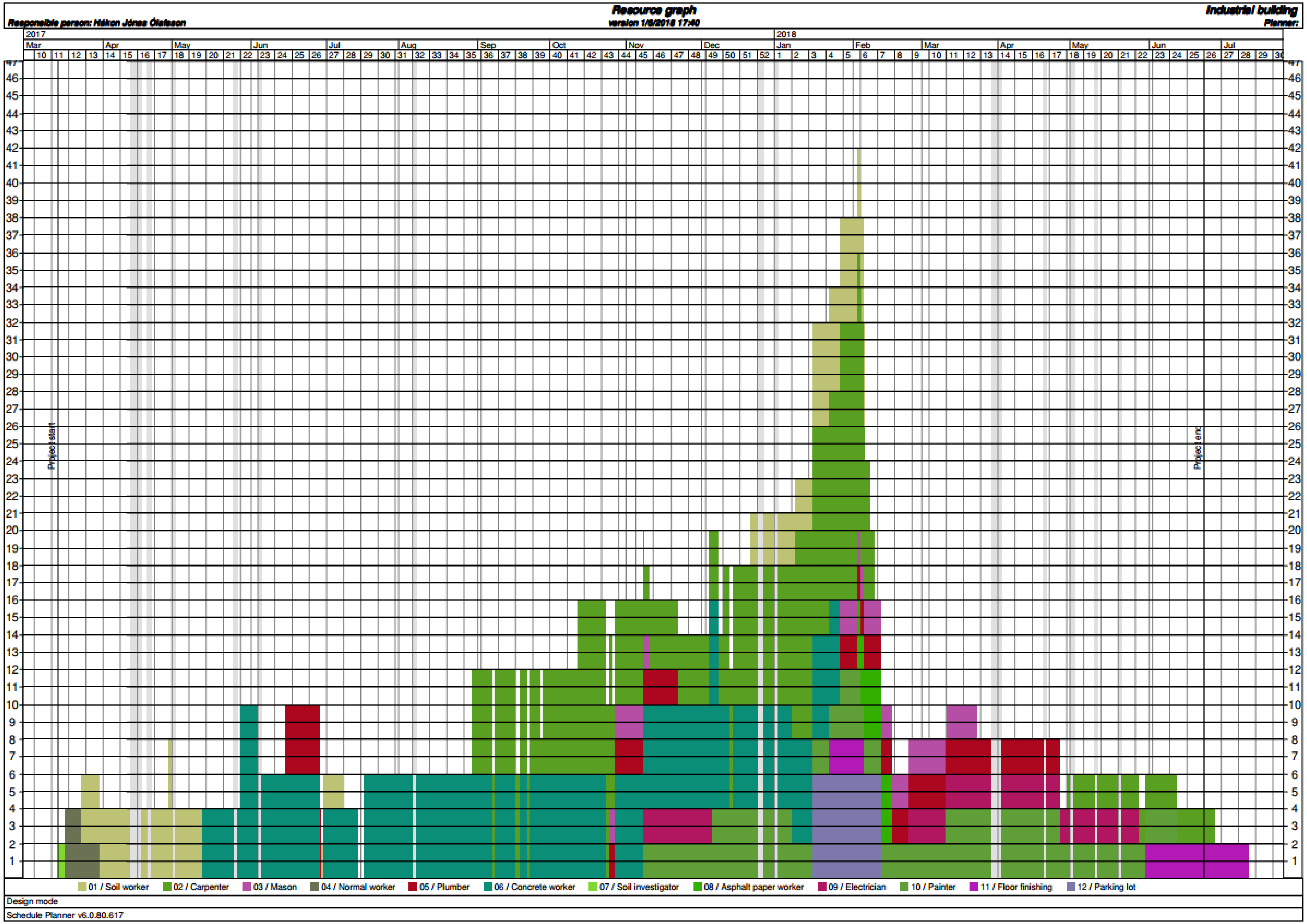
This appendix contains the Industrial building, flowline schedule, after transferring from MS Project and before changes.



Appendix F- Industrial building project schedule and resource graph after all holidays and quantities are included

This appendix contains the Industrial building, project schedule and resource graph after all holidays and quantities are included.




Resource graph
version 1/6/2018 17:40
Responsible person: Hákon Jónas Ólafsson
Industrial building
Planner:
2017
2018
Project start
Project end
01 / Soil worker
02 / Carpenter
03 / Mason
04 / Normal worker
05 / Plumber
06 / Concrete worker
07 / Soil investigator
08 / Asphalt paper worker
09 / Electrician
10 / Painter
11 / Floor finishing
12 / Parking lot
Design mode
Schedule Planner v6.0.80.617

Appendix G- Number of workers Industrial building

Following appendix contains information concerning number of workers implemented in the Industrial building project. The information where collected during the "observation", visit to the company in November 2017. Source of information is the Project Coordinator.

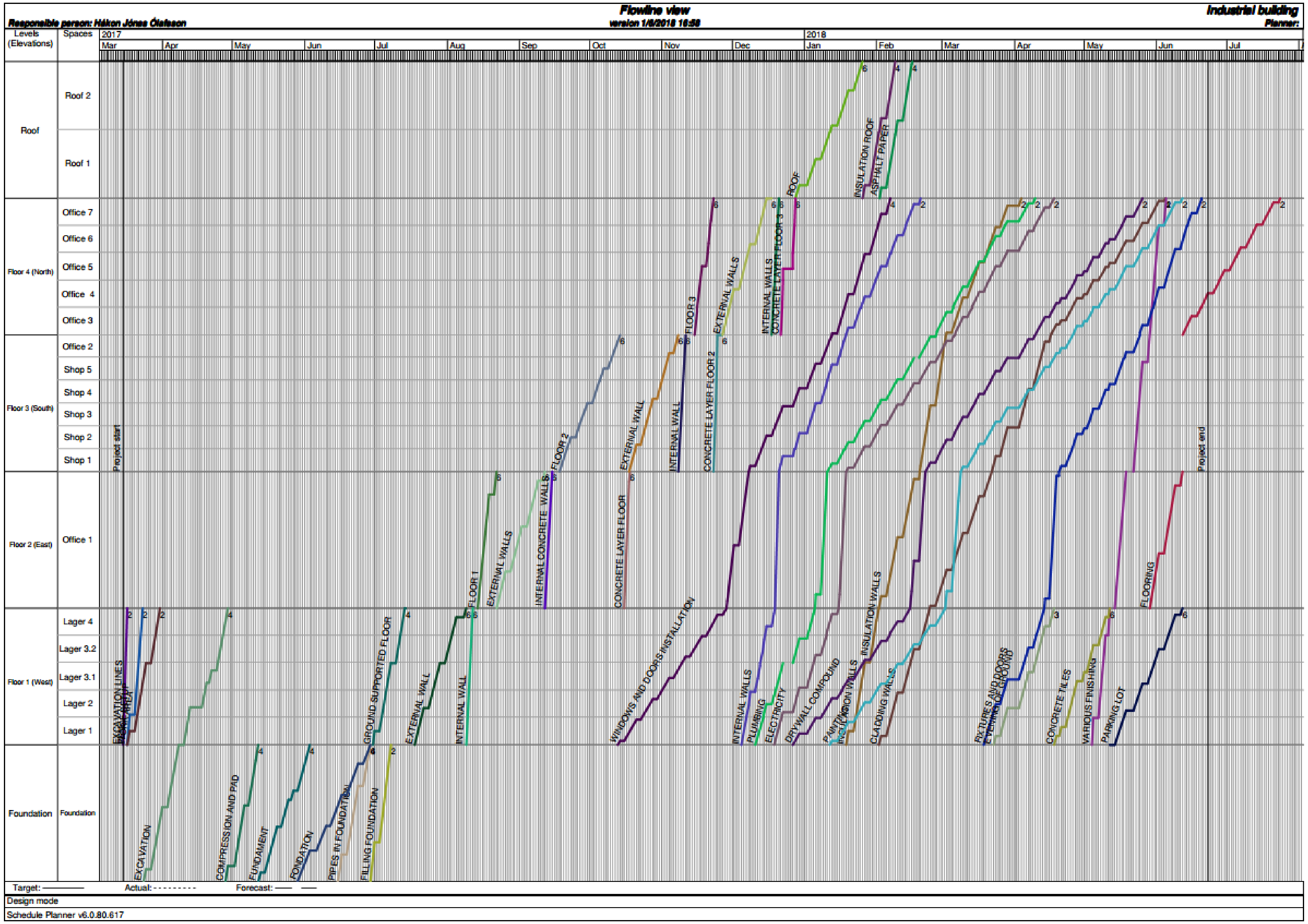
Task	Number of workers
Excavation lines	2
Fence setup	2
Work area	2
Excavation	4
Compression and pad	4
Pipes in foundation	4
Filling foundation	2
Fundament	4
Foundation	6
Ground supported floor	4
External walls	6
Internal walls (Floor 1-2)	6
Floor 1	6
Concrete layer floor 1	6
Floor 2	6
Concrete layer floor 2	6
External walls (Floor 1-2)	6
Internal walls (Floor 1-2)	6
Floor 3	6
Concrete layer floor 3	6
Roof plate	6
Insulation Roof	4
Asphalt paper	4
Windows installation	4
Doors installation	4
Insulation walls	2

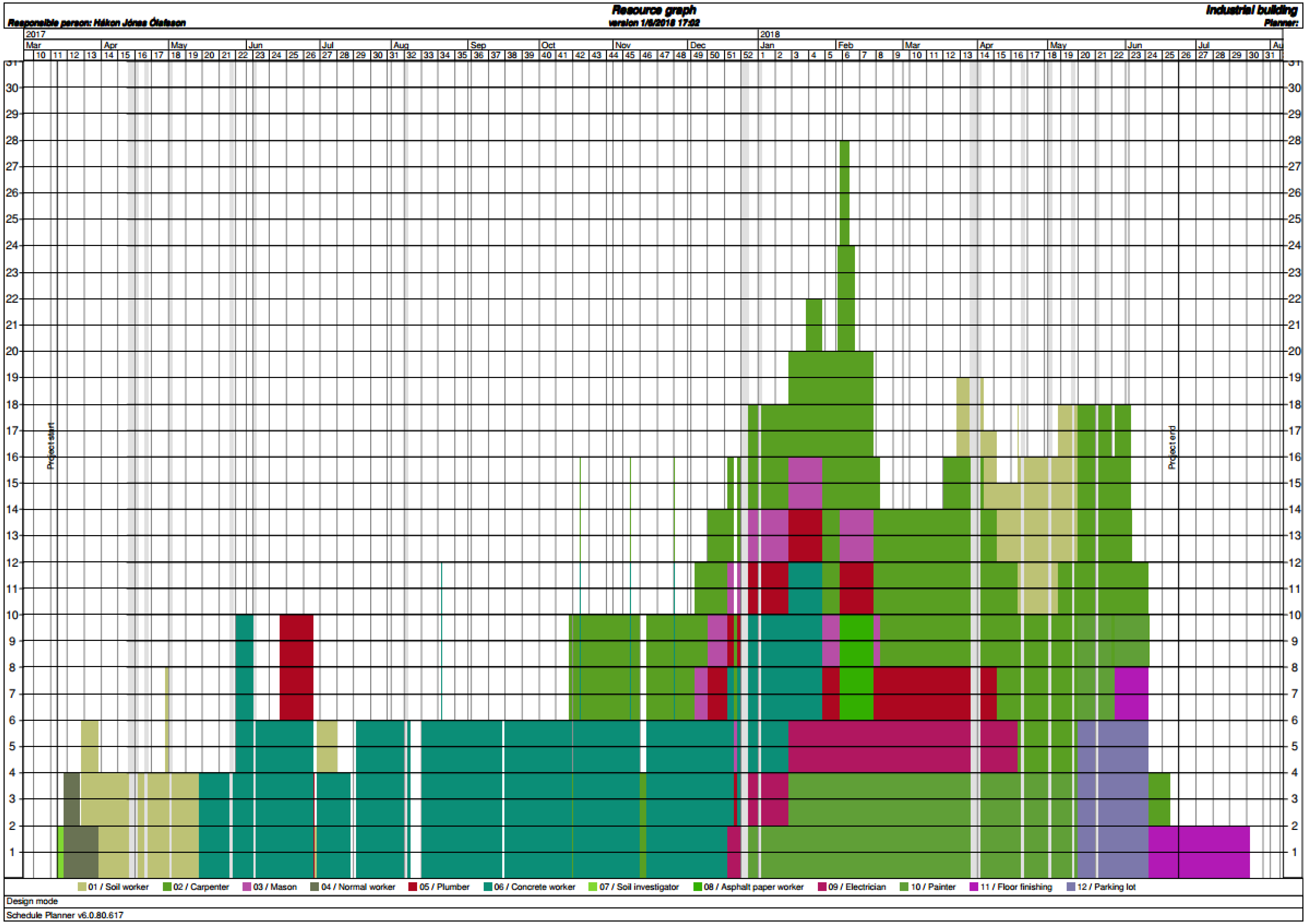
Cladding walls	4
Various finishing	2
Internal walls	2
Electricity	2
Plumbing	2
Drywall compound	2
Painting	2
Fixtures and doors	2
Flooring	2
Evening of ground	3
Parking lot	6
Concrete tiles	6

Table 7: Number of workers Industrial building

Appendix H- Industrial building project schedule and resource graph after making the activities go in a continues flow

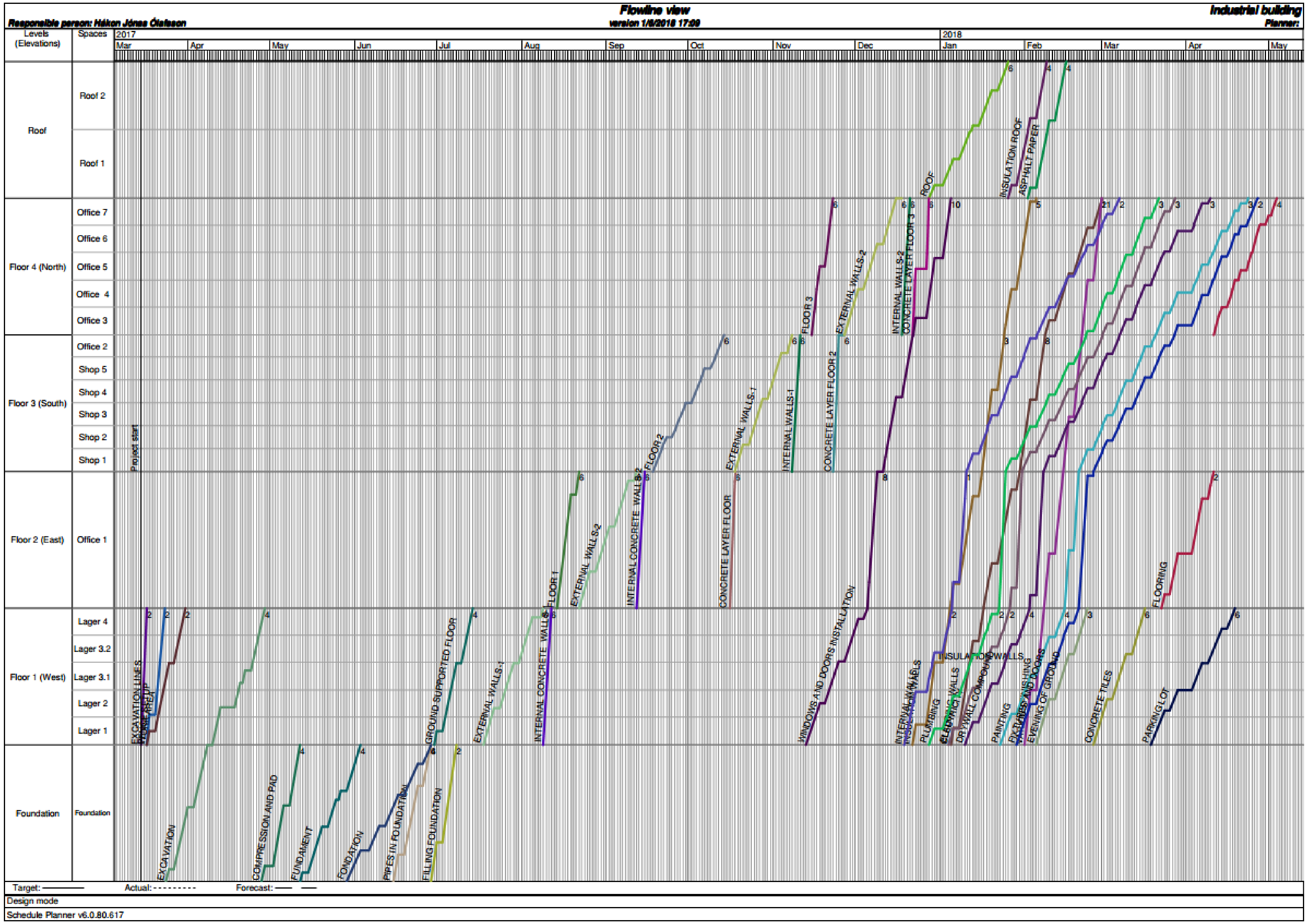
This appendix contains the Industrial building, project schedule and resource graph after making the activities go in a continues flow.

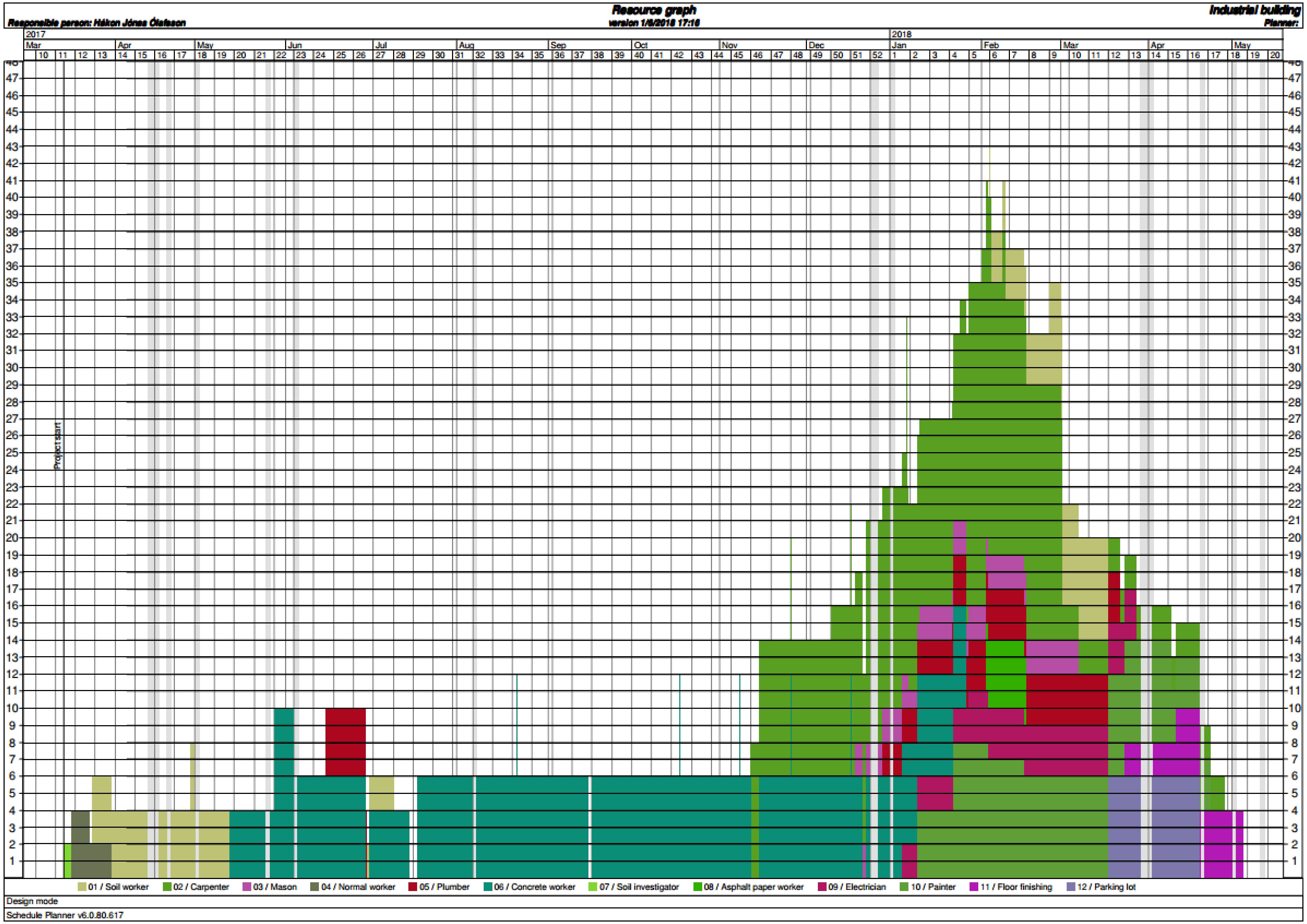



Responsible person: Hákon Jónas Ólafsson
Resource graph
version 1/6/2018 17:02
Industrial building
Planner:
2017
2018
Project start
Project end
01 / Soil worker
02 / Carpenter
03 / Mason
04 / Normal worker
05 / Plumber
06 / Concrete worker
07 / Soil investigator
08 / Asphalt paper worker
09 / Electrician
10 / Painter
11 / Floor finishing
12 / Parking lot
Design mode
Schedule Planner v6.0.80.617

Appendix I- Project schedule and resource graph after aligning activities

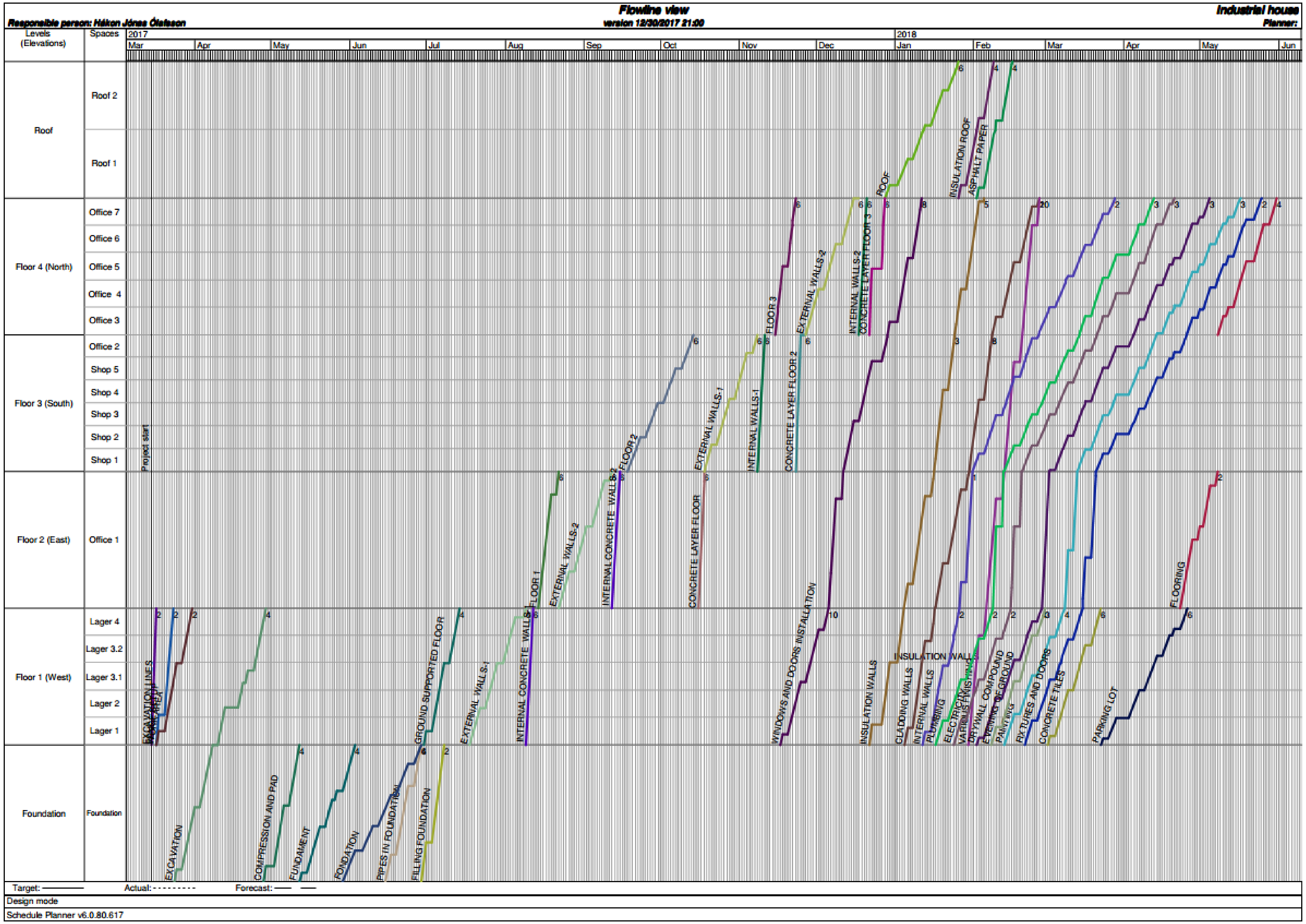
This appendix contains the Industrial building, project schedule and resource graph after aligning activities.

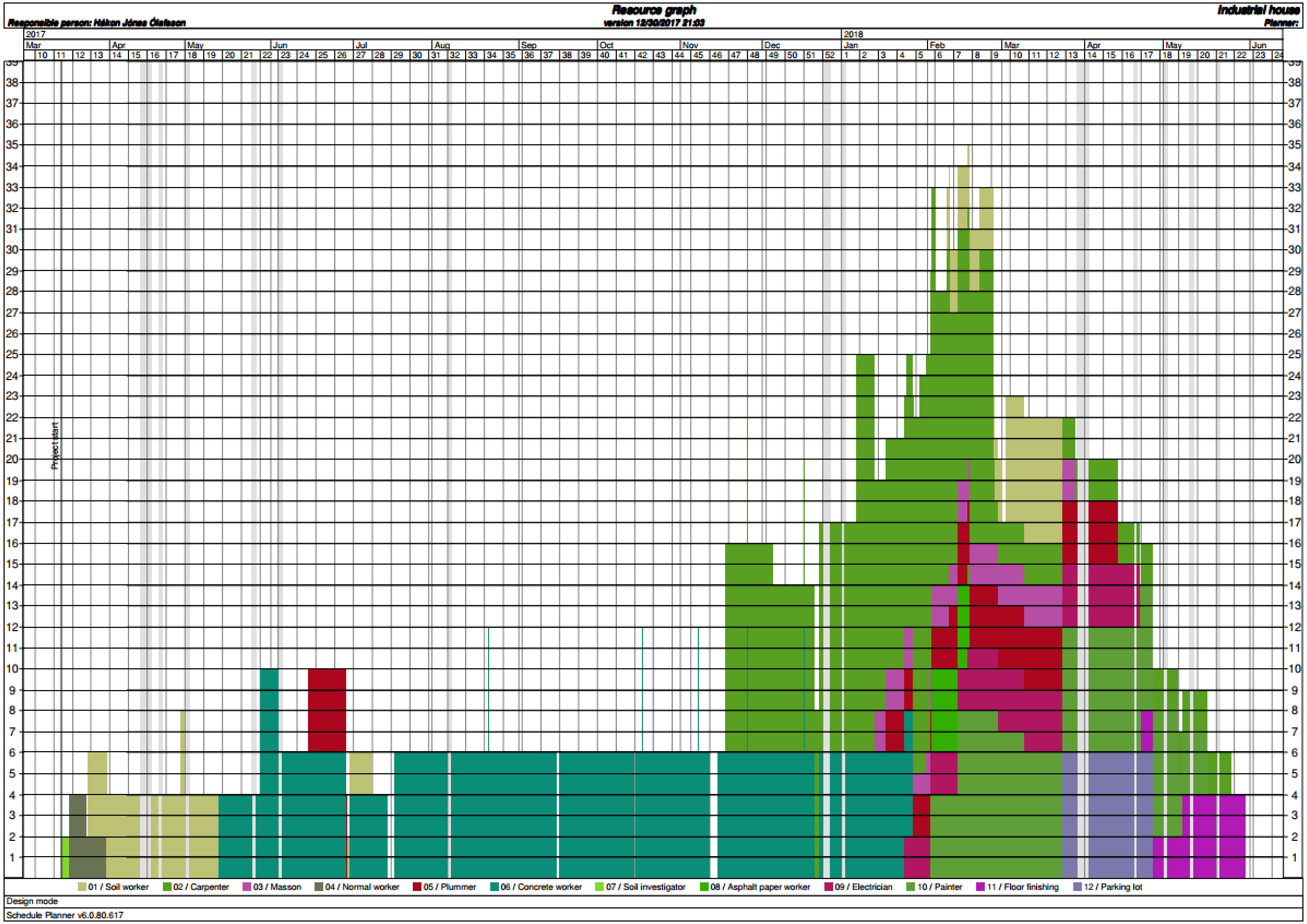



Resource graph
version 1/6/2018 17:16
Industrial building
Planner:
Responsible person: Hákon Jónas Ólafsson
2017
2018
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Project start
01 / Soil worker
02 / Carpenter
03 / Mason
04 / Normal worker
05 / Plumber
06 / Concrete worker
07 / Soil investigator
08 / Asphalt paper worker
09 / Electrician
10 / Painter
11 / Floor finishing
12 / Parking lot
Design mode
Schedule Planner v6.0.80.617

Appendix J- Project schedule and resource graph after aligning activities and risk has been taken into consideration

This appendix contains the Industrial building, project schedule and resource graph after aligning activities and risk has been taken into consideration



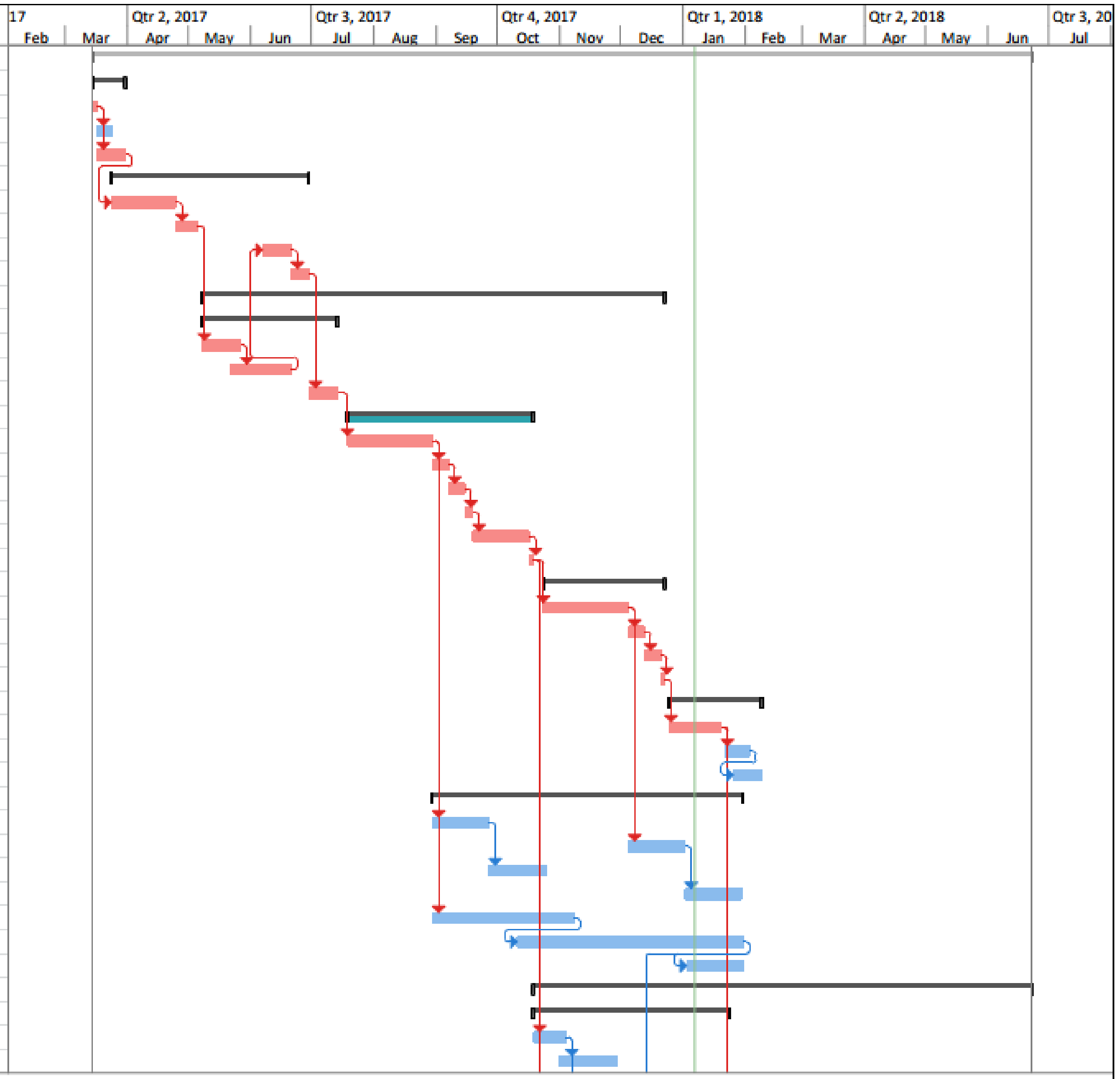

Resource graph
version 12/30/2017 21:03
Industrial house
Responsible person: Hákon Jónas Ólafsson
Planner:
2017
2018
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
Project start
01 / Soil worker
02 / Carpenter
03 / Masson
04 / Normal worker
05 / Plummer
06 / Concrete worker
07 / Soil investigator
08 / Asphalt paper worker
09 / Electrician
10 / Painter
11 / Floor finishing
12 / Parking lot
Design mode
Schedule Planner v6.0.80.617

Annexes

Annex 1- Industrial building project schedule

This annex contains a translation of the Industrial building MS Project time schedule provided by the Project Coordinator, from Icelandic to English. Also, the original time schedule.

ID	WBS	Verkþáttur	Timi	Upphaf	Endir	Undanfari
0	**0**	**Industrial building**	**333 days**	**Wed 3/15/**	**Fri 6/22/18**	
1	**1**	**1 Work camp**	**12 days**	**Wed 3/15/1**	**Thu 3/30/1**	
2	1.1	1.1 Excavation lines	2 days	Wed 3/15/1	Thu 3/16/17	
3	1.2	1.2 Fence setup	5 days	Fri 3/17/17	Thu 3/23/17	2
4	1.3	1.3 Work area	10 days	Fri 3/17/17	Thu 3/30/17	2
5	**2**	**2 Earth work**	**70 days**	**Fri 3/24/17**	**Thu 6/29/1**	
6	2.1	2.1 Excavation	22 days	Fri 3/24/17	Mon 4/24/1	4FS-5 days
7	2.2	2.2 Compression and pad	9 days	Tue 4/25/17	Fri 5/5/17	6
8	2.3	2.3 Pipes in foundation	10 days	Wed 6/7/17	Tue 6/20/17	13FS-10 days
9	2.4	2.4 Filling foundation	7 days	Wed 6/21/1	Thu 6/29/17	8
10	**3**	**3 Structure**	**165 days**	**Mon 5/8/17**	**Fri 12/22/1**	
11	**3.1**	**3.1 Structure**	**49 days**	**Mon 5/8/17**	**Thu 7/13/1**	
12	3.1.1	3.1.1 Fundament	15 days	Mon 5/8/17	Fri 5/26/17	7
13	3.1.2	3.1.2 Foundation	22 days	Mon 5/22/1	Tue 6/20/17	12FS-5 days
14	3.1.3	3.1.3 Ground supported flc	10 days	Fri 6/30/17	Thu 7/13/17	9
15	**3.2**	**3.2 Structure (0-6m)**	**66 days**	**Wed 7/19/1**	**Wed 10/18/**	
16	3.2.1	3.2.1 External walls	30 days	Wed 7/19/1	Tue 8/29/17	14FS+3 days
17	3.2.2	3.2.2 Internal walls	6 days	Wed 8/30/1	Wed 9/6/17	16
18	3.2.3	3.2.3 Floor 1	6 days	Thu 9/7/17	Thu 9/14/17	17
19	3.2.4	3.2.4 Concrete layer floor	2 days	Fri 9/15/17	Mon 9/18/1	18
20	3.2.5	3.2.5 Floor 2	20 days	Tue 9/19/17	Mon 10/16/	19
21	3.2.6	3.2.6 Concrete layer floor :	2 days	Tue 10/17/1	Wed 10/18/	20
22	**3.3**	**3.3 Structure (6-12,5m)**	**44 days**	**Tue 10/24/1**	**Fri 12/22/1**	
23	3.3.1	3.3.1 External walls	30 days	Tue 10/24/1	Mon 12/4/1	21FS+3 days
24	3.3.2	3.3.2 Internal walls	6 days	Tue 12/5/17	Tue 12/12/1	23
25	3.3.3	3.3.3 Floor 3	6 days	Wed 12/13/	Wed 12/20/	24
26	3.3.4	3.3.4 Concrete layer floor :	2 days	Thu 12/21/1	Fri 12/22/17	25
27	**4**	**4 Roof**	**34 days**	**Mon 12/25/**	**Thu 2/8/18**	
28	4.1	4.1 Roof plate	20 days	Mon 12/25/	Fri 1/19/18	26
29	4.2	4.2 Insulation Roof	10 days	Mon 1/22/1	Fri 2/2/18	28
30	4.3	4.3 Asphalt paper	10 days	Fri 1/26/18	Thu 2/8/18	29FS-6 days
31	**5**	**5 Finishing outdoors**	**110 days**	**Wed 8/30/1**	**Tue 1/30/1**	
32	5.1	5.1 Windows installation (0-6	20 days	Wed 8/30/1	Tue 9/26/17	16
33	5.2	5.2 Windows installation (6-1	20 days	Tue 12/5/17	Mon 1/1/18	23
34	5.3	5.3 Doors installation (0-6m)	20 days	Wed 9/27/1	Tue 10/24/1	32
35	5.4	5.4 Doors installation (6-12m	20 days	Tue 1/2/18	Mon 1/29/1	33
36	5.5	5.5 Insulation walls	50 days	Wed 8/30/1	Tue 11/7/17	16
37	5.6	5.6 Cladding walls	80 days	Wed 10/11/	Tue 1/30/18	36FS-20 days
38	5.7	5.7 Various finishing	20 days	Wed 1/3/18	Tue 1/30/18	37FS-20 days
39	**6**	**6 Finishing indoors**	**177 days**	**Thu 10/19/1**	**Fri 6/22/18**	
40	**6.1**	**6.1 Finishing indoors (0-6m)**	**69 days**	**Thu 10/19/1**	**Tue 1/23/1**	
41	6.1.1	6.1.1 Internal walls	12 days	Thu 10/19/1	Fri 11/3/17	21
42	6.1.2	6.1.2 Electricity	20 days	Wed 11/1/1	Tue 11/28/1	41FS-3 days

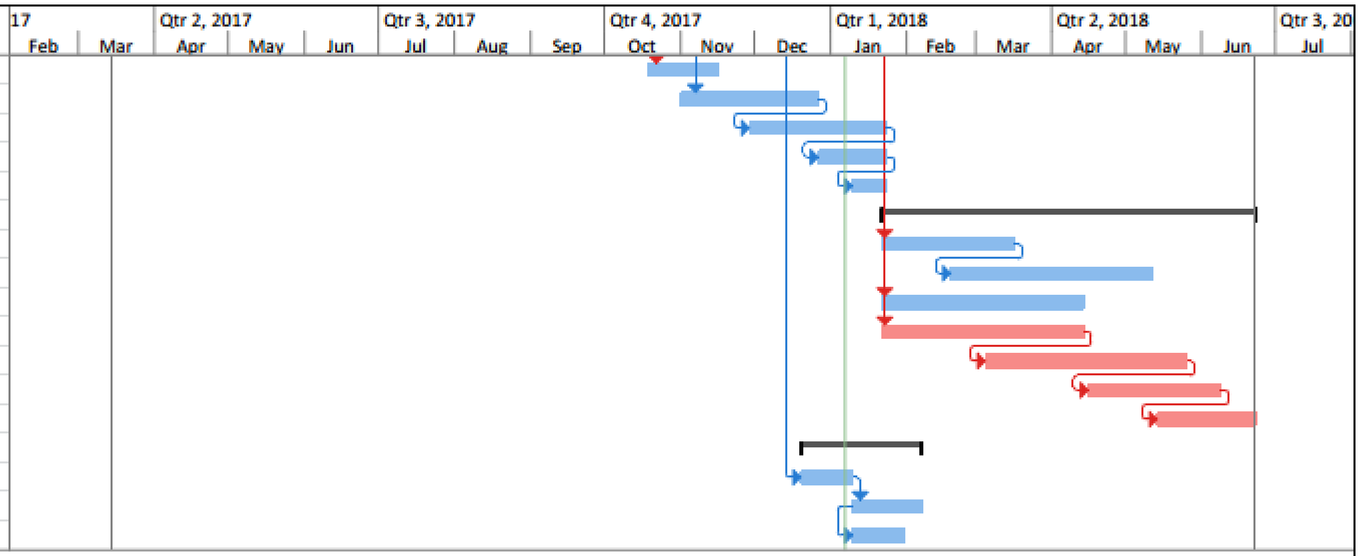


Project: Industrial building
Date: Sun 1/7/18

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Critical | Critical Split | Progress | Manual Progress

Page 1

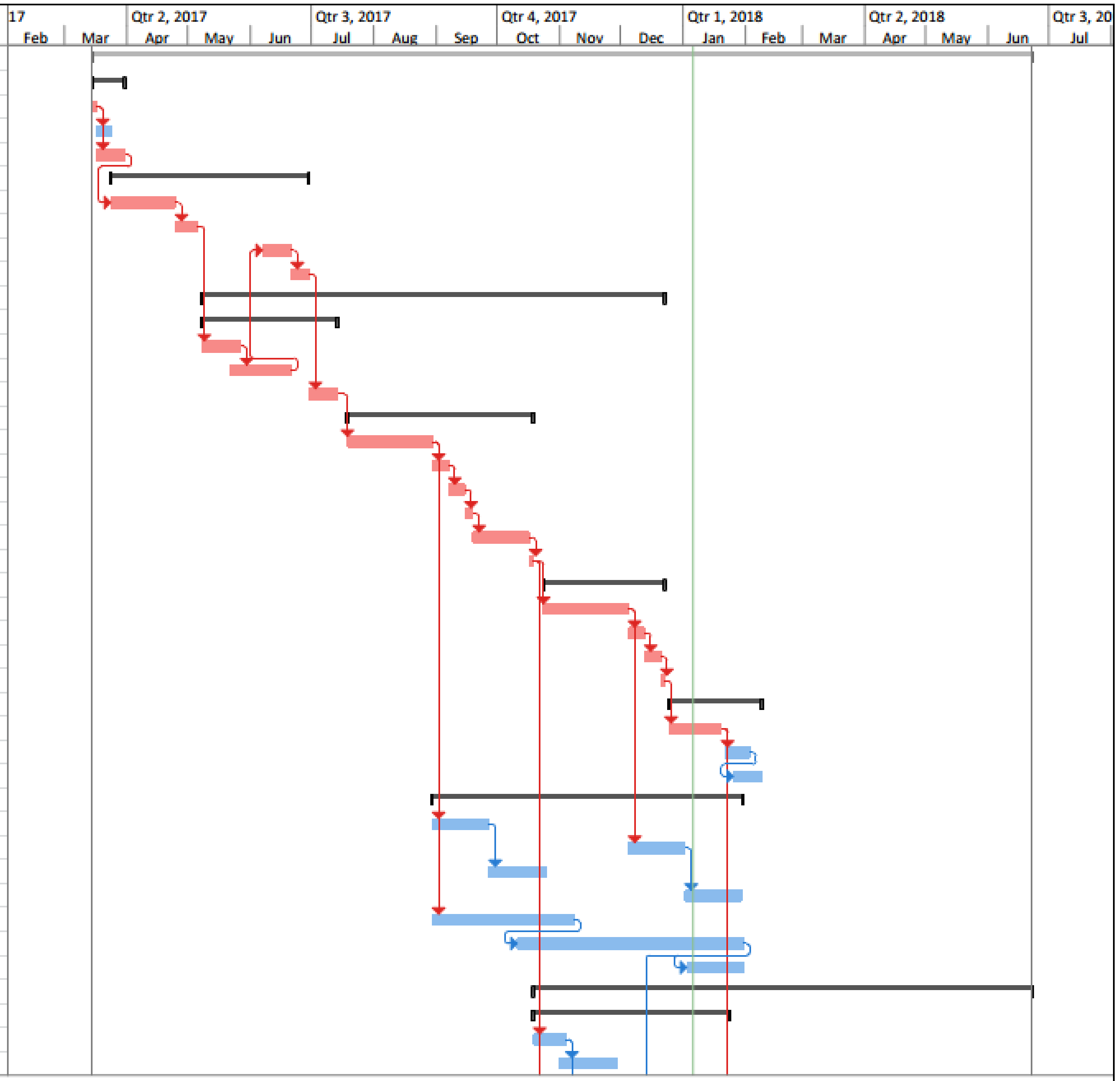
ID	WBS	Verkþáttur	Tími	Upphaf	Endir	Undanfari
43	6.1.3	6.1.3 Plumbing	20 days	Thu 10/19/1	Wed 11/15/	21
44	6.1.4	6.1.4 Drywall compound	40 days	Wed 11/1/1	Tue 12/26/1	41FS-3 days
45	6.1.5	6.1.5 Painting	40 days	Wed 11/29/	Tue 1/23/18	44FS-20 days
46	6.1.6	6.1.6 Fixtures and doors	20 days	Wed 12/27/	Tue 1/23/18	45FS-20 days
47	6.1.7	6.1.7 Flooring	10 days	Wed 1/10/1	Tue 1/23/18	46FS-10 days
48	**6.2**	**6.2 Finishing indoors (6-12m**	**110 days**	**Mon 1/22/1**	**Fri 6/22/18**	
49	6.2.1	6.2.1 Internal walls	40 days	Mon 1/22/1	Fri 3/16/18	28
50	6.2.2	6.2.2 Electricity	60 days	Mon 2/19/1	Fri 5/11/18	49FS-20 days
51	6.2.3	6.2.3 Plumbing	60 days	Mon 1/22/1	Fri 4/13/18	28
52	6.2.4	6.2.4 Drywall compound	60 days	Mon 1/22/1	Fri 4/13/18	28
53	6.2.5	6.2.5 Painting	60 days	Mon 3/5/18	Fri 5/25/18	52FS-30 days
54	6.2.6	6.2.6 Fixtures and doors	40 days	Mon 4/16/1	Fri 6/8/18	53FS-30 days
55	6.2.7	6.2.7 Flooring	30 days	Mon 5/14/1	Fri 6/22/18	54FS-20 days
56	**7**	**7 Ground finishing**	**35 days**	**Wed 12/20/**	**Tue 2/6/18**	
57	7.1	7.1 Evening of ground	15 days	Wed 12/20/	Tue 1/9/18	37FS-30 days
58	7.2	7.2 Parking lot	20 days	Wed 1/10/1	Tue 2/6/18	57
59	7.3	7.3 Concrete tiles	15 days	Wed 1/10/1	Tue 1/30/18	58SS



Project: Industrial building
Date: Sun 1/7/18

Task	External Tasks	Manual Task	Finish-only	Manual Progress
Split	External Milestone	Duration-only	Deadline	
Milestone	Inactive Task	Manual Summary Rollup	Critical	
Summary	Inactive Milestone	Manual Summary	Critical Split	
Project Summary	Inactive Summary	Start-only	Progress	

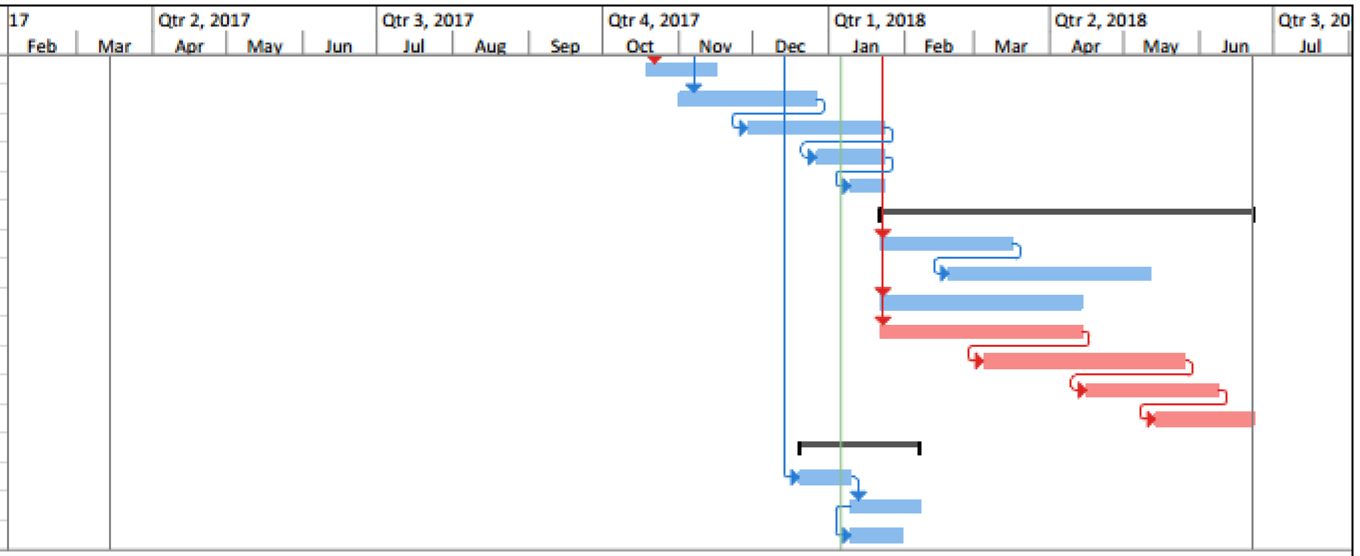
ID	WBS	Verkþáttur	Tími	Upphaf	Endir	Undanfari
0	**0**	**Tóna**	**333 days**	**Wed 3/15/**	**Fri 6/22/18**	
1	**1**	**1 Aðstaða**	**12 days**	**Wed 3/15/1**	**Thu 3/30/1**	
2	1.1	1.1 Útsetning graftarlína	2 days	Wed 3/15/1	Thu 3/16/17	
3	1.2	1.2 Uppsetning Girðingu	5 days	Fri 3/17/17	Thu 3/23/17	2
4	1.3	1.3 Uppsetning vinnusvæðis	10 days	Fri 3/17/17	Thu 3/30/17	2
5	**2**	**2 Jarðvinna**	**70 days**	**Fri 3/24/17**	**Thu 6/29/1**	
6	2.1	2.1 Gröftur	22 days	Fri 3/24/17	Mon 4/24/1	4FS-5 days
7	2.2	2.2 Þjöppun og púði	9 days	Tue 4/25/17	Fri 5/5/17	6
8	2.3	2.3 Grunnlagnir	10 days	Wed 6/7/17	Tue 6/20/17	13FS-10 days
9	2.4	2.4 Fylling sökkla	7 days	Wed 6/21/1	Thu 6/29/17	8
10	**3**	**3 Burðarvirki**	**165 days**	**Mon 5/8/17**	**Fri 12/22/1**	
11	**3.1**	**3.1 Burðarvirki**	**49 days**	**Mon 5/8/17**	**Thu 7/13/1**	
12	3.1.1	3.1.1 Fundament	15 days	Mon 5/8/17	Fri 5/26/17	7
13	3.1.2	3.1.2 Sökklar	22 days	Mon 5/22/1	Tue 6/20/17	12FS-5 days
14	3.1.3	3.1.3 Botnplata	10 days	Fri 6/30/17	Thu 7/13/17	9
15	**3.2**	**3.2 Burðarvirki (0-6m)**	**66 days**	**Wed 7/19/1**	**Wed 10/18/**	
16	3.2.1	3.2.1 Útveggir	30 days	Wed 7/19/1	Tue 8/29/17	14FS+3 days
17	3.2.2	3.2.2 Innveggir	6 days	Wed 8/30/1	Wed 9/6/17	16
18	3.2.3	3.2.3 Milliloft	6 days	Thu 9/7/17	Thu 9/14/17	17
19	3.2.4	3.2.4 Ásteypulag milliloft	2 days	Fri 9/15/17	Mon 9/18/1	18
20	3.2.5	3.2.5 Plata 2	20 days	Tue 9/19/17	Mon 10/16/	19
21	3.2.6	3.2.6 Ásteypulag plötu 2	2 days	Tue 10/17/1	Wed 10/18/	20
22	**3.3**	**3.3 Burðarvirki (6-12,5m)**	**44 days**	**Tue 10/24/1**	**Fri 12/22/1**	
23	3.3.1	3.3.1 Útveggir	30 days	Tue 10/24/1	Mon 12/4/1	21FS+3 days
24	3.3.2	3.3.2 Innveggir	6 days	Tue 12/5/17	Tue 12/12/1	23
25	3.3.3	3.3.3 Milliloft	6 days	Wed 12/13/	Wed 12/20/	24
26	3.3.4	3.3.4 Ásteypulag milliloft	2 days	Thu 12/21/1	Fri 12/22/17	25
27	**4**	**4 Þakvirki**	**34 days**	**Mon 12/25/**	**Thu 2/8/18**	
28	4.1	4.1 Plata (þak)	20 days	Mon 12/25/	Fri 1/19/18	26
29	4.2	4.2 Einangrun	10 days	Mon 1/22/1	Fri 2/2/18	28
30	4.3	4.3 Asfalt pappi	10 days	Fri 1/26/18	Thu 2/8/18	29FS-6 days
31	**5**	**5 Frágangur utanhúss**	**110 days**	**Wed 8/30/1**	**Tue 1/30/1**	
32	5.1	5.1 Ísetning glugga (0-6m)	20 days	Wed 8/30/1	Tue 9/26/17	16
33	5.2	5.2 Ísetning glugga (6-12m)	20 days	Tue 12/5/17	Mon 1/1/18	23
34	5.3	5.3 Ísetning Hurða (0-6m)	20 days	Wed 9/27/1	Tue 10/24/1	32
35	5.4	5.4 Ísetning hurða (6-12m)	20 days	Tue 1/2/18	Mon 1/29/1	33
36	5.5	5.5 Einangrun	50 days	Wed 8/30/1	Tue 11/7/17	16
37	5.6	5.6 Klæðning	80 days	Wed 10/11/	Tue 1/30/18	36FS-20 days
38	5.7	5.7 Ýmis frágangur	20 days	Wed 1/3/18	Tue 1/30/18	37FS-20 days
39	**6**	**6 Frágangur innanhúss**	**177 days**	**Thu 10/19/**	**Fri 6/22/18**	
40	**6.1**	**6.1 Frágangur innanhúss (0-6**	**69 days**	**Thu 10/19/**	**Tue 1/23/1**	
41	6.1.1	6.1.1 Milliveggir	12 days	Thu 10/19/1	Fri 11/3/17	21
42	6.1.2	6.1.2 Rafmagn	20 days	Wed 11/1/1	Tue 11/28/1	41FS-3 days



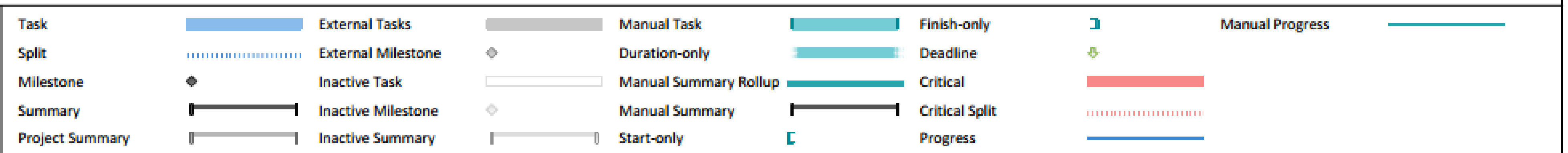
Project: Tóna
Date: Sat 1/6/18

Task	External Tasks	Manual Task	Finish-only	Manual Progress
Split	External Milestone	Duration-only	Deadline	
Milestone	Inactive Task	Manual Summary Rollup	Critical	
Summary	Inactive Milestone	Manual Summary	Critical Split	
Project Summary	Inactive Summary	Start-only	Progress	

ID	WBS	Verkþáttur	Tími	Upphaf	Endir	Undanfari
43	6.1.3	6.1.3 Pípulagnir	20 days	Thu 10/19/1	Wed 11/15/	21
44	6.1.4	6.1.4 Spörtlun	40 days	Wed 11/1/1	Tue 12/26/1	41FS-3 days
45	6.1.5	6.1.5 Málun	40 days	Wed 11/29/	Tue 1/23/18	44FS-20 days
46	6.1.6	6.1.6 Innréttingar og hurði	20 days	Wed 12/27/	Tue 1/23/18	45FS-20 days
47	6.1.7	6.1.7 Gólfefni	10 days	Wed 1/10/1	Tue 1/23/18	46FS-10 days
48	**6.2**	**6.2 Frágangur innanhúss (6-1**	**110 days**	**Mon 1/22/1**	**Fri 6/22/18**	
49	6.2.1	6.2.1 Milliveggir	40 days	Mon 1/22/1	Fri 3/16/18	28
50	6.2.2	6.2.2 Rafmagn	60 days	Mon 2/19/1	Fri 5/11/18	49FS-20 days
51	6.2.3	6.2.3 Pípulagnir	60 days	Mon 1/22/1	Fri 4/13/18	28
52	6.2.4	6.2.4 Spörtlun	60 days	Mon 1/22/1	Fri 4/13/18	28
53	6.2.5	6.2.5 Málun	60 days	Mon 3/5/18	Fri 5/25/18	52FS-30 days
54	6.2.6	6.2.6 Innréttingar og hurði	40 days	Mon 4/16/1	Fri 6/8/18	53FS-30 days
55	6.2.7	6.2.7 Gólfefni	30 days	Mon 5/14/1	Fri 6/22/18	54FS-20 days
56	**7**	**7 Lóðafrágangur**	**35 days**	**Wed 12/20/**	**Tue 2/6/18**	
57	7.1	7.1 Gróf jöfnun lóðar	15 days	Wed 12/20/	Tue 1/9/18	37FS-30 days
58	7.2	7.2 Malbik	20 days	Wed 1/10/1	Tue 2/6/18	57
59	7.3	7.3 Hellulögn	15 days	Wed 1/10/1	Tue 1/30/18	58SS



Project: Tóna
Date: Sat 1/6/18



Annex 2-Industrial building quantity list

This annex contains quantities calculated by the company for the Industrial building project. The quantities were provided by the Project Coordinator.

Table 8: Industrial building (Quantities)

No		Task	Unit	Quantities
		Work camp		
1		Fence set up	m	300
2		Work area	no.	1
		Erth Work		
3		Excavation	m3	13000
4		Compression and pad	m3	4000
5		Excavation pipes	m	800
6		Pipes in foundation	m	800
7		Filling pipes	m	800
		Foundation and Ground supported floor		
8		Foundation formwork	m2	168
9		Foundation Iron	kg	2720
10		Concrete Foundation	m3	34
11		Ground supported floor formwork	m2	1950
12		Ground supported floor iron	kg	26550
13		Ground supported floor concrete	m3	295
14		Insulation	m2	1950
15		Fundament	no.	12
		Floor 1 -2 (0-6m)		
16		Formwork walls	m2	1332
17		Concrete walls	m3	240
18		Iron walls	kg	19200
19		Formwork internal walls	m2	400
20		Concrete internal walls	m3	95
21		Iron internal walls	kg	7600
22		Other Concrete walls formwork	m2	64
23		Other Concrete walls concrete	m3	13
24		Other Concrete walls iron	kg	1040
25		Concrete column Þ45cm	no.	12
26		Concrete in columns	no.	12
27		Iron in columns	kg	1440
28		Internal walls	m2	886
29		Internal doors EI60-CS IH-H6	no.	5
30		Internal doors EI30-CS IH-H5	no.	1
31		Internal doors IH-H4	no.	9
32		External doors ÚH-H1	no.	8

33		Windows ÚG-G9	no.	7
34		Garage Doors BHB1	no.	5
35		Windows ÚG-G2	no.	3
36		Windows ÚG-G8	no.	2
37		Window ÚG-G7	no.	2
38		Window ÚG-G1	no.	3
39		Concrete steps (3m)	no.	2
40		Spiral staircase (3m)	no.	1
		Floor 2		
41		Hollow core slab	m2	275
42		Concrete layer floor 2, 6 cm	m3	17
43		Iron concrete layer	kg	1530
44		Internal walls	m2	140
45		Internal doors EI30-CS IH-H5	no.	1
46		Internal doors IH-H4	no.	4
47		Windows ÚG-G1	no.	3
48		Windows ÚG-G2	no.	3
49		Window ÚG-G4	no.	2
50		Windows ÚG-G5	no.	2
51		Iron railings	m	27
		Floor 3-4 (6-12,5 m)		
52		Hollow core slabs	m2	1390
53		Concrete layer (6cm)	m3	84
54		Floor iron	kg	7560
55		Balconies formwork	m2	80
56		Balconies concrete (18cm)	m3	15
57		Balconies iron	kg	1350
58		Formwork external walls	m2	1287
59		Concrete external walls	m3	258
60		Iron external walls	kg	20640
61		Concrete column Þ45cm	no.	12
62		Concrete in columns	no.	12
63		Iron in columns	kg	1440
64		Internal walls	m2	542
65		Other Concrete walls formwork	m2	52
66		Other Concrete walls concrete	m3	10
67		Other Concrete walls iron	kg	800
68		Window ÚG-G1	no.	2
69		Window ÚG-G2	no.	2
70		Window ÚG-G3	no.	1
71		Window ÚG-G4	no.	7
72		Window ÚG-G5	no.	10
73		Window ÚG-G6	no.	3
74		Window ÚG-G10	no.	1
75		Window ÚG-G11	no.	6
76		Window ÚG-G11 (a)	no.	4
77		Window ÚG-G12	no.	2

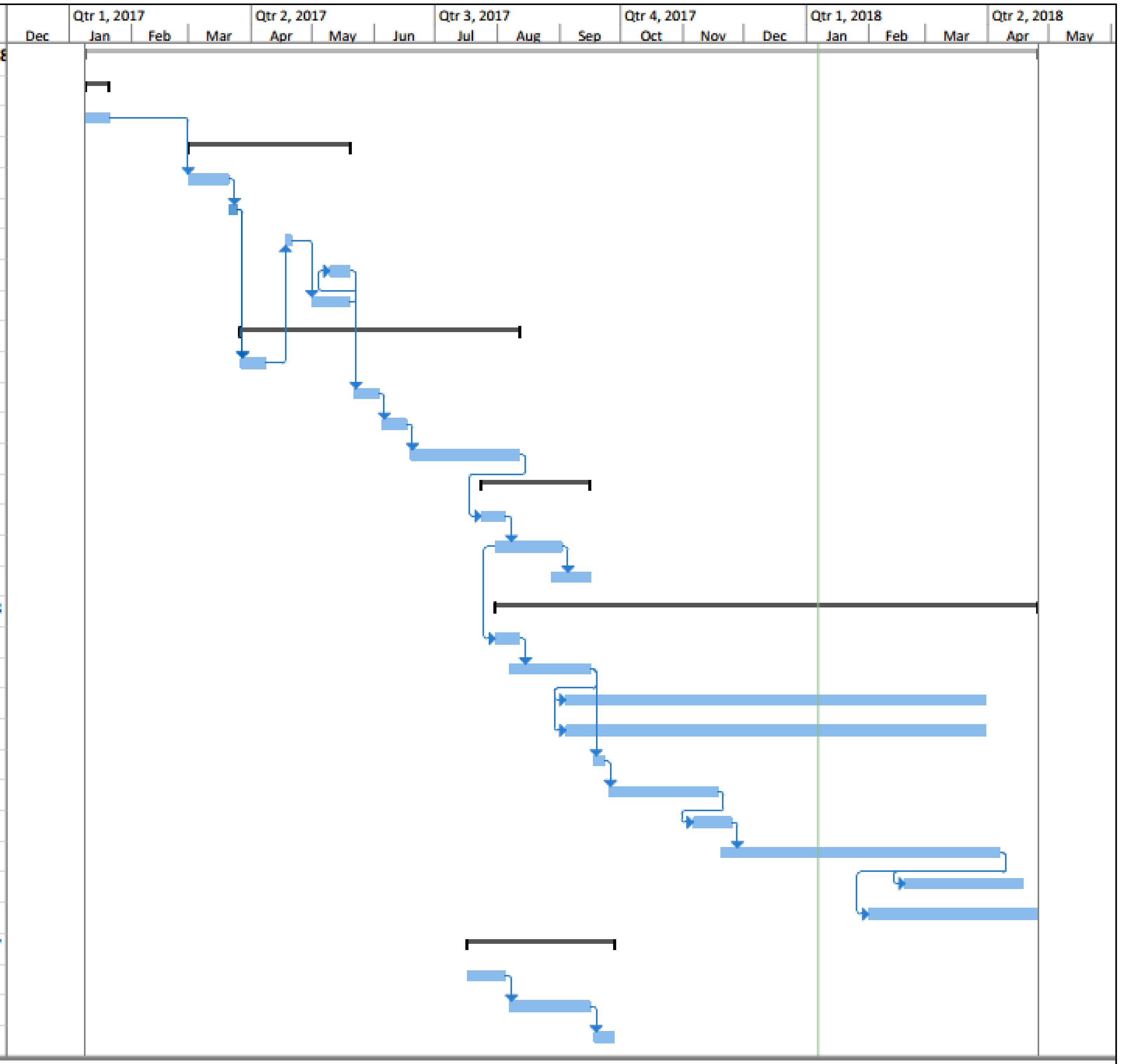
78		Window ÚG-G13	no.	1
79		Window ÚG-G14	no.	1
80		Window ÚG-G15	no.	1
81		Window ÚG-G16	no.	1
82		Window ÚG-G17	no.	1
83		External doors ÚH-H2	no.	2
84		External doors ÚH-H3	no.	3
85		Internal doors IH-H4	no.	1
86		Internal doors IH-H5	no.	1
87		Concrete steps (3m)	no.	6
		Floor 3		
88		Hollow core slab	m2	560
89		Concrete layer (6cm)	m3	34
90		Floor iron	kg	3100
91		Balconies formwork	m2	65
92		Balconies concrete (18cm)	m3	10
93		Balconies iron	kg	900
94		Internal walls	m2	670
95		Internal doors IH-H4	no.	30
96		Internal doors IH-H5	no.	5
97		External doors ÚH-H2	no.	2
98		External doors ÚH-H3	no.	3
99		Window ÚG-G1	no.	2
100		Window ÚG-G2	no.	2
101		Window ÚG-G4	no.	7
102		Window ÚG-G5	no.	10
103		Window ÚG-G6	no.	3
		Roof		
104		Hollow core slab	m2	1666
105		Concrete layer (6cm)	m3	81
106		Floor iron	kg	7290
107		Asphalt paper	m2	1354
108		Rockwool	m2	1354
109		EPS inslulaiton	m2	1354
		External finishing		
		West		
110		Insulation walls	m2	324
11		Cladding walls	m2	324
		East		
112		Insulation walls	m2	383
113		Cladding walls	m2	383
		South		
139		Insulation walls	m2	293
140		Cladding walls	m2	293
141		Cloth under Insulation	m2	430

		North		
114		Insulation walls	m2	635
115		Cladding walls	m2	635
116		Glas font	m2	201
117		Fire staircase (10m)	no.	1
		Indoors finishing		
		Floor 2		
118		Drywall compound	m2	280
118		Painting	m2	280
120		Flooring	m2	270
121		Toilet	no.	1
		Floor 4		
122		Drywall compound	m2	1850
123		Painting	m2	1850
124		Flooring	m2	559
125		Toilet	no.	5
		Floor 4		
126		Drywall compound	m2	185
127		Painting	m2	185
128		Flooring	m2	106
129		Toilet	no.	1
130		Electricity	no.	1
131		Plumbing	no.	1
		Ground finishing		
132		Evening of ground	m2	2700
133		Parking lot	m2	2700
134		Concrete tiles	m2	220

Annex 3-Group home project schedule

This annex contains a translation of the Group home MS Project time schedule provided by the Project Coordinator, from Icelandic to English. Also, the original time schedule.

ID	WBS	Verkþáttur	Tími	Upphaf	Endir
0	**0**	**Group home project**	**338 days**	**Mon 1/9/17**	**Wed 4/25/18**
1	**1**	**1 Work camp**	**10 days**	**Mon 1/9/17**	**Fri 1/20/17**
2	1.1	1.1 Work area	10 days	Mon 1/9/17	Fri 1/20/17
3	**2**	**2 Earth work**	**58 days**	**Wed 3/1/17**	**Fri 5/19/17**
4	2.1	2.1 Excavation	14 days	Wed 3/1/17	Mon 3/20/17
5	2.2	2.2 Compression and pad	4 days	Tue 3/21/17	Fri 3/24/17
6	2.3	2.3 Filling foundation	3 days	Tue 4/18/17	Thu 4/20/17
7	2.4	2.4 Filling pipes	8 days	Wed 5/10/17	Fri 5/19/17
8	2.5	2.5 Pipes in foundation	15 days	Mon 5/1/17	Fri 5/19/17
9	**3**	**3 Structure**	**100 days**	**Mon 3/27/17**	**Fri 8/11/17**
10	3.1	3.1 Foundation	10 days	Mon 3/27/17	Fri 4/7/17
11	3.2	3.2 Concrete wall elements	10 days	Mon 5/22/17	Fri 6/2/17
12	3.3	3.3 Ground supported floor	10 days	Mon 6/5/17	Fri 6/16/17
13	3.4	3.4 Roof	40 days	Mon 6/19/17	Fri 8/11/17
14	**4**	**4 Finishing outdoors**	**40 days**	**Mon 7/24/17**	**Fri 9/15/17**
15	4.1	4.1 Windows installation	10 days	Mon 7/24/17	Fri 8/4/17
16	4.2	4.2 Cladding walls	25 days	Mon 7/31/17	Fri 9/1/17
17	4.3	4.3 Roof eaves	15 days	Mon 8/28/17	Fri 9/15/17
18	**5**	**5 Finishing indoors**	**193 days**	**Mon 7/31/17**	**Wed 4/25/18**
19	5.1	5.1 Insulation Roof	10 days	Mon 7/31/17	Fri 8/11/17
20	5.2	5.2 Internal walls	30 days	Mon 8/7/17	Fri 9/15/17
21	5.3	5.3 Electricity	150 days	Mon 9/4/17	Fri 3/30/18
22	5.4	5.4 Plumbing	150 days	Mon 9/4/17	Fri 3/30/18
23	5.5	5.5 Leveling floors	5 days	Mon 9/18/17	Fri 9/22/17
24	5.6	5.6 Suspended ceiling	40 days	Mon 9/25/17	Fri 11/17/17
25	5.7	5.7 Tiles	15 days	Mon 11/6/17	Fri 11/24/17
26	5.8	5.8 Painting	100 days	Mon 11/20/17	Fri 4/6/18
27	5.9	5.9 Flooring	42 days	Mon 2/19/18	Tue 4/17/18
28	5.10	5.10 Fixtures and doors	60 days	Thu 2/1/18	Wed 4/25/18
29	**6**	**6 Ground finishing**	**53 days**	**Mon 7/17/17**	**Wed 9/27/17**
30	6.1	6.1 Evening of ground	15 days	Mon 7/17/17	Fri 8/4/17
31	6.2	6.2 Parking lot	30 days	Mon 8/7/17	Fri 9/15/17
32	6.3	6.3 Concrete tiles	8 days	Mon 9/18/17	Wed 9/27/17



Project: Group home project
Date: Sun 1/7/18

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only		Manual Progress	
Summary		Inactive Task		Duration-only		Finish-only			

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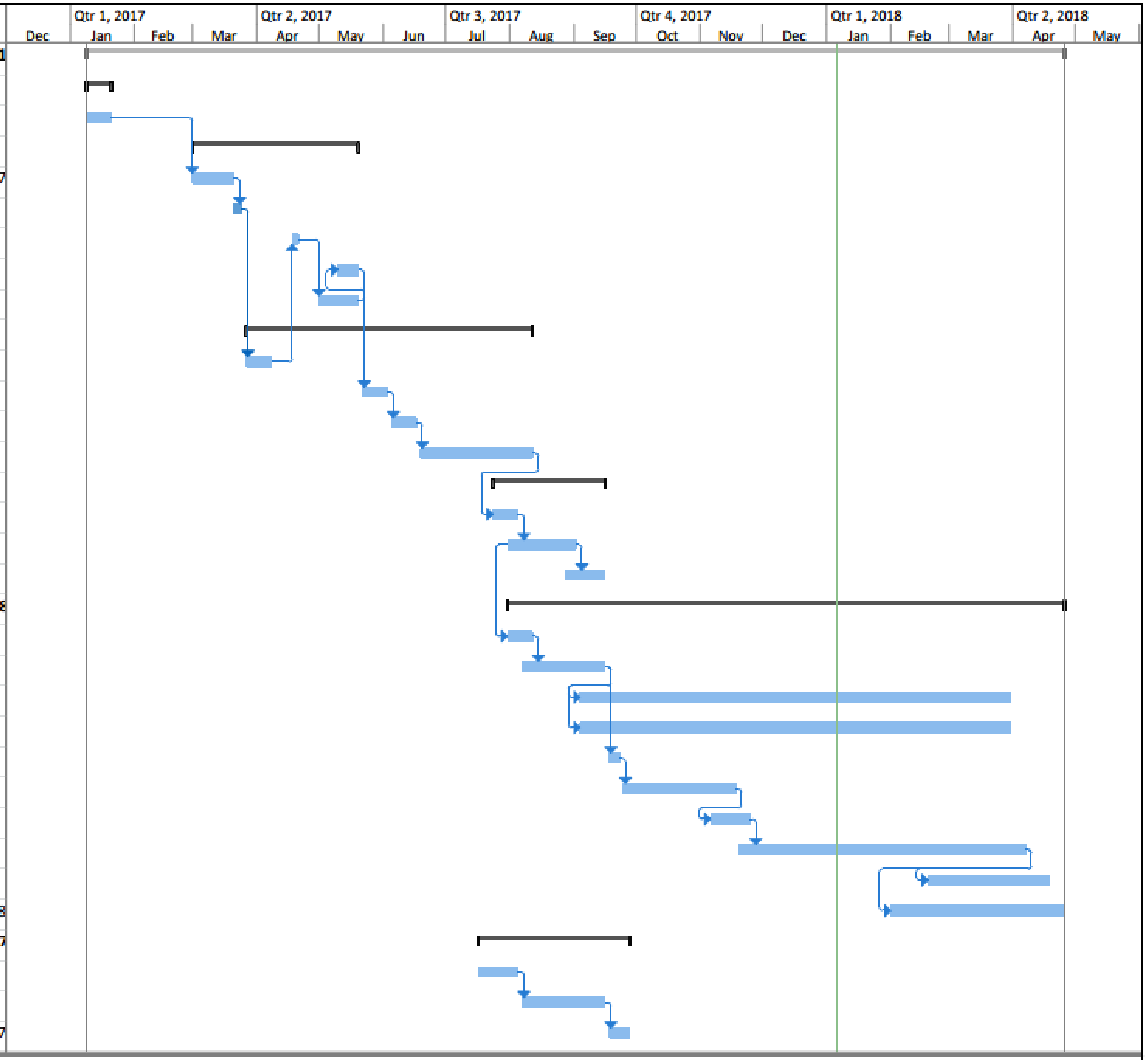
ID	WBS	Verkþáttur	Tími	Upphaf	Endir
0	**0**	**Kamb**	**338 days**	**Mon 1/9/1**	**Wed 4/25/1**
1	**1**	**1 Aðstaða**	**10 days**	**Mon 1/9/17**	**Fri 1/20/17**
2	1.1	1.1 Uppsetning vinnusvæðis	10 days	Mon 1/9/17	Fri 1/20/17
3	**2**	**2 Jarðvinna**	**58 days**	**Wed 3/1/17**	**Fri 5/19/17**
4	2.1	2.1 Gröftur	14 days	Wed 3/1/17	Mon 3/20/17
5	2.2	2.2 Þjöppun og púði	4 days	Tue 3/21/17	Fri 3/24/17
6	2.3	2.3 Fylling innan sökkla	3 days	Tue 4/18/17	Thu 4/20/17
7	2.4	2.4 Fylling undir lagnir	8 days	Wed 5/10/1	Fri 5/19/17
8	2.5	2.5 Grunnlagnir	15 days	Mon 5/1/17	Fri 5/19/17
9	**3**	**3 Burðarvirki**	**100 days**	**Mon 3/27/1**	**Fri 8/11/17**
10	3.1	3.1 Sökklar	10 days	Mon 3/27/1	Fri 4/7/17
11	3.2	3.2 Einingar	10 days	Mon 5/22/1	Fri 6/2/17
12	3.3	3.3 Botnplata	10 days	Mon 6/5/17	Fri 6/16/17
13	3.4	3.4 Þakvirki	40 days	Mon 6/19/1	Fri 8/11/17
14	**4**	**4 Frágangur utanhúss**	**40 days**	**Mon 7/24/1**	**Fri 9/15/17**
15	4.1	4.1 Ísetning glugga	10 days	Mon 7/24/1	Fri 8/4/17
16	4.2	4.2 Klæðning utanhúss	25 days	Mon 7/31/1	Fri 9/1/17
17	4.3	4.3 Þakkantur	15 days	Mon 8/28/1	Fri 9/15/17
18	**5**	**5 Frágangur innanhúss**	**193 days**	**Mon 7/31/1**	**Wed 4/25/18**
19	5.1	5.1 Einangra þak	10 days	Mon 7/31/1	Fri 8/11/17
20	5.2	5.2 Milliveggir	30 days	Mon 8/7/17	Fri 9/15/17
21	5.3	5.3 Rafmagn	150 days	Mon 9/4/17	Fri 3/30/18
22	5.4	5.4 Pípulagnir	150 days	Mon 9/4/17	Fri 3/30/18
23	5.5	5.5 Flotun gólfa	5 days	Mon 9/18/1	Fri 9/22/17
24	5.6	5.6 Taka niður loft	40 days	Mon 9/25/1	Fri 11/17/17
25	5.7	5.7 Flísalögn	15 days	Mon 11/6/1	Fri 11/24/17
26	5.8	5.8 Málun	100 days	Mon 11/20/	Fri 4/6/18
27	5.9	5.9 Gólfefni	42 days	Mon 2/19/1	Tue 4/17/18
28	5.10	5.10 Innréttingar og hurðir	60 days	Thu 2/1/18	Wed 4/25/18
29	**6**	**6 Lóðafrágangur**	**53 days**	**Mon 7/17/1**	**Wed 9/27/17**
30	6.1	6.1 Gröfjöfnun lóðar	15 days	Mon 7/17/1	Fri 8/4/17
31	6.2	6.2 Malbik	30 days	Mon 8/7/17	Fri 9/15/17
32	6.3	6.3 Hellulögn	8 days	Mon 9/18/1	Wed 9/27/17



Project: Kamb
Date: Sat 1/6/18

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only		Manual Progress	
Summary		Inactive Task		Duration-only		Finish-only			

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