CHALMERS

Geotechnical working procedure

A case study based on three residential projects within the Gothenburg region

Master of Science Thesis in the Master's Programme Geo and Water Engineering

JOEL LILJENFEDT
DANIEL NORLING

Department of Civil and Environmental Engineering
Division of GeoEngineering
Geotechnical Engineering Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012

Master's Thesis 2012:84

MASTER'S THESIS 2012:84

Geotechnical working procedure

A case study based on three residential projects within the Gothenburg region

Master of Science Thesis in the Master's Programme Geo and Water Engineering

JOEL LILJENFEDT

DANIEL NORLING

Department of Civil and Environmental Engineering
Division of GeoEngineering
Geotechnical Engineering Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012

Geotechnical working procedure
A case study based on three residential projects within the Gothenburg region

Master of Science Thesis in the Master’s Programme Geo and Water Engineering
JOEL LILJENFELDT
DANIEL NORLING

Examensarbete / Institutionen för bygg- och miljöteknik,
Chalmers tekniska högskola 2012:84

Department of Civil and Environmental Engineering
Division of GeoEngineering
Geotechnical Engineering Research Group
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

Cover:
Figure text for the cover picture (if applicable), possibly with reference to more extensive information in the report.

Department of Civil and Environmental Engineering Göteborg, Sweden 2012

Geotechnical working procedure
A case study based on three residential projects within the Gothenburg region

Master of Science Thesis in the Master's Programme Geo and Water Engineering

JOEL LILJENFEDT
DANIEL NORLING
Department of Civil and Environmental Engineering
Division of GeoEngineering
Chalmers University of Technology

ABSTRACT

The concept of construction management as over the years been rather well studied, a wide range of literature has been produced. The same cannot be said about geotechnical project management which forms a small part of the construction management process. Relatively small amounts have been written about the subject. This could imply that the process thinking of geotechnical working procedure has potential to be developed. The aim of this thesis was to structure the geotechnical working procedure to enhance for new graduated engineers to adapt to the work as a geotechnical engineer as well as form a foundation for recommendations of improvement of the working procedure. Information was mainly collected through a case study of in-house residential projects, conducted by the construction company NCC. The study was performed through both interviews and a document study. The personnel interviewed in the study were either the client, geotechnical engineers or disciplines using the geotechnical recommendations. A result from the case study is that the geotechnical aspects are important in the beginning of a project in order to decrease the number of iterations needed to develop a profitable residential project. The best way to reach this target is to encourage a dialogue between the involved disciplines of a project. This would increase the possibilities to identify potential critical activities or alternative, more profitable, solutions in an early phase of the project. It is likely that a better solution have profitable outcome if it is detected early in the project when few features have been determined. For newly graduated geotechnical engineers employed at NCC the working procedure should be displayed in a process diagram together with an associated informative document. The process diagram, a flowchart, allows the new geotechnical engineers at NCC to get familiarized with the overall working procedure. A working procedure diagram also serves as a process control which is a commonly used tool to increase the effectiveness and quality of the process. The conclusion of this thesis is that we propose interdisciplinary meetings early in the design stage of projects. The meeting should increase the use of the different disciplines in wide issues which are affecting a project largely. From a geotechnical point of view questions regarding how the geotechnical aspects of the site affect the buildings and economics of the project. Furthermore we propose that a project-coordinator is involved in the projects from the beginning to the production, with experience from the production phase. This should decrease the gaps between the different phases and disciplines involved in a project.

Key words: geotechnical working procedure, process thinking, in-house projects, flowcharts, residential projects, Gothenburg region, NCC Project Studio

Contents

Appendices:

Preface

In this thesis, a case study has been conducted of residential projects within the planning phase. The case study focuses on the geotechnical working procedure within in-house projects performed by the construction company NCC. The cases are located in the Gothenburg region. The study has been done from January to June during 2012.

The thesis is performed as the final work in the master program Geo and water engineering at Chalmers University of Technology, Sweden. The project is carried out at the Department of Civil and Environmental Engineering, Division of Geo Engineering.

We would like to thank our supervisor Licentiate Helene Kennedy, NCC Technology, and our examiner Professor Claes Alén, Chalmers, for their support and involvement in the development of this thesis.

Obviously, this thesis could not have been done without the contribution from many employees of NCC, whom we sincerely want to thank.

Göteborg June 2012

Joel Liljenfeldt & Daniel Norling

1 Introduction

This chapter will introduce the thesis, the background, the aim and the delimitations are declared for.

1.1 Background

The economic profit of residential projects is decreasing mostly due to high competition for building companies and at present time, spring 2012, it is an unsecure housing market. This is because of the economic situation of, potential buyers and the society in general (RF-1, 2012). The contractor has to predict the income from selling the completed apartments and compare it with expenses for develop the residential area when planning to purchase a property. This prediction controls the budget of the project which the project manager has to keep and still have a profit left. This kind of predictions and risk evaluation is very important for the company's business. It is vital to identify the market situation at the time to find out if the forecast is positive and the project is profitable. On the other hand, if the prediction of the project's outcome is negative, measures are needed in order to generate a lucrative project.

In several projects nowadays the economic marginal between an economical successful and an unsuccessful project is small, therefore, the project is sensitive to mistakes. Changes and modifications in the design in the late stages of the project can adventure the total profitability of the project. Because of this it is necessary that the different departments and contractors involved in the project cooperate and that the project is efficiently managed. An efficient management process uses the competence and expert knowledge that are in the project at the right time in order to create an efficient and profitable project.

Several of different disciplines are working within the large building companies. This applies for the concern NCC AB and the concern's regional office in Gothenburg, Sweden. In this office several of subsidiary companies is located. NCC AB conducts residential projects for which the aim is to keep the projects "in the house" as much as possible. In these types of project the exchange between different NCC subsidiary companies are important for the effectiveness, it might be the difference between a negative or positive economic result, of the project.

In the in-house projects conducted of NCC different disciplines are involved and working at different stages in the project. Therefore, it is important that each personnel working within the project have an understanding of the project in general and its own role in the project team. In order to increase the efficiency of the project the different project members needs to have knowledge of each other's work. This is a vital task for the project manager to know the different professions and when to involve each profession in order to create the most efficient work flow. One method of accomplish this is to standardize the work to reduce the risk of missing out information.

1.2 Aim

The aim of this master thesis is to give recommendations for an efficient and standardized working procedure within geotechnics according to process thinking. By investigating and compiling the working procedure of the construction company NCC in residential projects. Furthermore, the thesis aims to present the developed working procedure in a clear and logical manner. This should provide assistance within the previously described type of projects, for new employees which are recently graduated or with little work experience of geotechnical design.

The work in this thesis is based on information from NCC residential in-house projects. However, the aim is that the result shall be possible to apply to geotechnical work in general but the thesis will be focused on the design phase of residential in-house projects.

1.3 Delimitations

The focus areas of this thesis are the working procedure of geotechnical planning, information usage and communication. The plan for production as well as the production phase is excluded.

The information used in this thesis derives entirely from three case studies described in the method. The interpretation of geotechnical information and the result will not be reviewed. However, the geotechnical aspects of information usage and communication within the project will be studied.

2 Method

This chapter describes the methods which are used in this thesis. First, the used general method and theoretical approach are presented. Secondly, the general methodology of the case study will be briefly described followed by descriptions of the specific methods included in the case study.

2.1 Theoretical approach

The principles of a deductive theoretical approach are to apply general methods that are commonly used in other business areas. The ideas are adapted to fit the studied process. This theoretical process used in this thesis is of deductive type, where conclusions are made from general principles and existing theories. (Patel & Davidsson, 2003)

A large number of questions will be answered through literature studies and a small number of interviews. Therefore, the methods used in this thesis are of a qualitative approach where interviews and literature studies aim is to get a deeper knowledge and understanding. In summary this thesis is based on a deductive approach in a qualitative research. (Olsson & Sörensen, 2007)

2.2 Case study

This thesis will be performed as a case study in which three different NCC residential projects will be studied. The projects are in-house projects with the contract form turnkey. In particular two types of information gathering methods will be used, literature study and oral interviews, which are further described below.

The case study will consist of the following steps:

- Literature study
- Determine relative correspondence groups and interview questionnaires
- Perform interviews
- Compile and sort information from interview results
- Establish the geotechnical working procedure
- Draw conclusions

2.2.1 Literature study

In order to develop an understanding of process thinking and project management a literature study is performed in three different areas, these are as follows:

- The very basics of conventional project management and the project process thinking within the construction industry.
- The fundamentals of the new production philosophy, often referred to as Lean.
- The essentials of the working methodology and concept NCC Project studio.

Furthermore, in order to get a background and understanding of the different cases the project documents and reports of general and geotechnical character are studied.

2.2.2 Interviews

The interviews have been performed through a dialog with both open and closed questions. The interviews are executed on separate respondent groups, geotechnical personnel and the client of geotechnical services in these types of projects. In total nine persons have been interviewed. The aim is to perform the interviews in two steps: first a briefing with the participants should be carried out to collect basic information. From this information specific questions will be formulated for the second interview. It is of importance that the questions for the second interviews are well prepared and focuses on areas that correlate to the aim of the thesis. The interviews are performed in Swedish, questionnaires in Swedish used during the interviews are presented in Appendix 1. The duration of each interview is about 1 hour.

The personnel that have been interviewed in this thesis are still working or have been working with at least one of the projects within the case study. Relevant personnel who are significantly involved or affected by the geotechnical design process have been interviewed. Those interviewed are geotechnical engineers, project managers and technical experts with senior status or less. No junior or new employee has been interviewed. In the thesis the sources will be referred to as RF- followed by a number, for example RF-3.

2.2.3 Geotechnical working procedure

The gathered information will constitute the basic data to establish a model of the geotechnical working procedure in residential projects. This will be done by comparing similarities and differences between the cases. From this information a preferable geotechnical working procedure will be established.

3 Conventional construction management

This chapter briefly presents several of important aspects of the conventional approach of construction management.

The traditional way of construction management is known with an initial idea, of a construction as a starting point. To reach and fulfil the idea the construction is first designed and then constructed. This chapter is giving a brief introduction to the conventional or traditional view of construction and its management focusing on the design phase process of a project.

Halpin & Senior (2011) describes the construction industry as oriented to create unique single units, this is referred to as the project format. Every project is unique to the fact of local conditions, design and production. The fact that the projects are seen as unique, may contribute to the known fact that many unnecessary or ineffective activities is repeatedly added in the projects.

In the construction industry both the design and construction of buildings is determined as a part of a project. The construction industry differ from other types of manufacturing businesses were focus is to fabricate large numbers of units, mass production, without redesign for each unit. The focus of construction management is instead the planning and control of resources such as personnel, time and machines within the framework of a project. The different projects may be unique in ways but the working procedure is similar and can, therefore, be organised and scheduled similarly.

3.1 The project life cycle

A facility is being created through the project creation process, when the facility is complete it is operated by the facility management. While the facility management gives the requirements which needs to be fulfilled by the project creation process. The life cycle of the project and eventually the facility is a symbiotic process, shown in Figure 1.

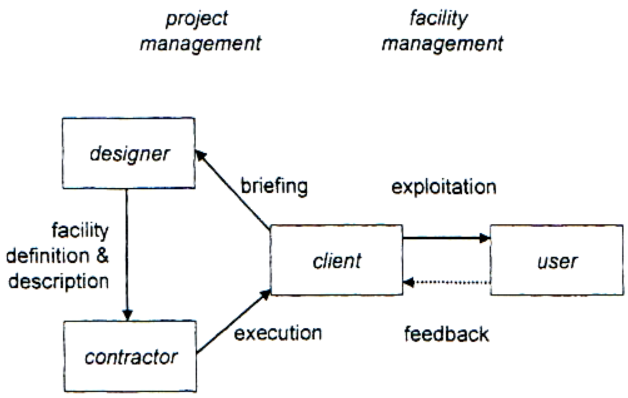

Figure 1. Illustration of the symbiosis between project and facility management. (Winch, 2007)

Winch (2007) further claims that to be able to create better facilities in the future it is vital to learn from the exploitation of existing facilities allowing a more detailed project mission definition.

3.2 General project development

The traditional project development process normally is sequential or linear fashion, see Figure 2 and Figure 3. A general project process has been summarized by Halpin & Senior (2011) as the following steps:

1. A client identifies a need of a facility.
2. Development of initial feasibility and cost projections.
3. A decision is taken to proceed with conceptual design and professional designers are engaged.
4. The conceptual design and scope of work is being developed to achieve an approximate estimate of cost.
5. The decision is made to advance to the development of the final design documents; this will define the project for purposes of construction.
6. Based on the final design documents, the project is presented and tender documents are given to construction companies.
7. The interested construction companies submit proposals are evaluated and a constructor is selected. The constructor is given a notification to proceed with the work. Both the proposal and the acceptance of the proposal of the owner constitute the establishment of a contract for the work.
8. The constructing of the facility is being initiated. When the construction is completed the facility is available for acceptance, occupancy and utilization.
9. Complex projects may require a period of testing to decide if the facility operates as designed and planned. This type of testing periods is common in industrial projects and is usually referred to as project start-up.

As this process symbolizes the project development is basically dependent on the step before, sequential system. Because of this more information is added along as the project proceed, which can cause problems for actors in the later phases, see Figure 2. The problem can be to have sufficient knowledge about earlier elaborated matters or being impact by earlier decisions. If the late participated actors would have had the possibility to affect the outcome by being involved in the earlier stages of planning.

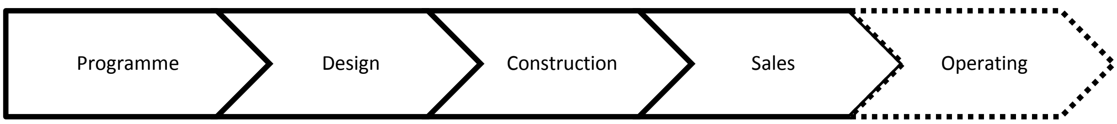

Figure 2. Schematic illustration of a conventional construction project process. (Nordstrand, 2008)

Since this thesis focuses on turnkey contracts a typical project process of this contract form is shown in Figure 2. In this contract form the client conducts the investigations which are needed in order to specify the requirements specification. The requirements can set the number of floors, wall shuttering, material and additional equipment. Furthermore, performance requirements such as strength, durability, ventilation and heat systems can be specified. These requirements are compiled to a general programme and provided to the construction companies as tender documents. This is followed by a procurement of a main contractor. It is then the main contractor's responsibility to realize the design and construction with its own project leader. The main contractor has the obligation to fulfil the requirements which were specified in the tender documents. The turnkey contracts are normally competitively procured. (Nordstrand, 2008)

3.3 Design process

The *Programme* and *Design* presented in Figure 2 is consisting of several of different activities, those two together are in this thesis called the *Design process*, see Figure 3. In Figure 3 it is noteworthy that the visualization activity is nowadays often being started before the *Programme phase* is completely defined. In order to manage the design work several of aids is frequently used such as time schedule, quality plan, environmental plan and cost control. (Nordstrand, 2008)

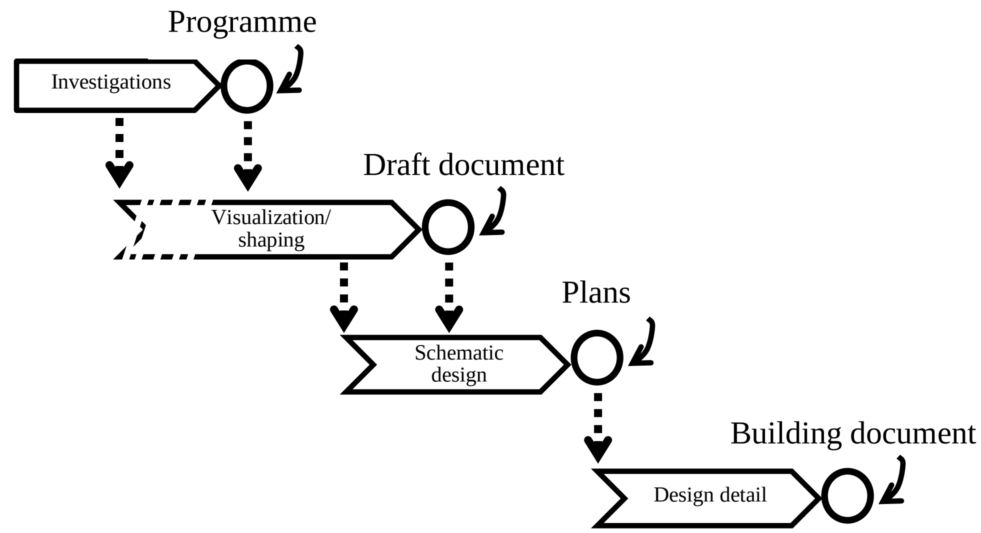

Figure 3. Schematic illustration of the Design process. (Edited: Nordstrand, 2008)

In Figure 3 a generalization of the *Design process* is shown, this process is varying slightly depending on the executing company. Therefore, the process implemented at the state client Akademiska Hus is presented in the Figure 4.

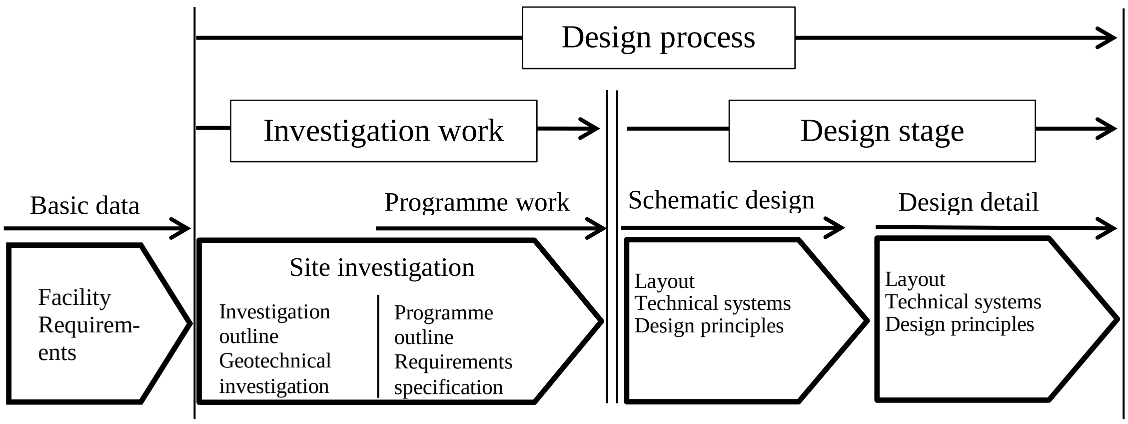

Figure 4. The Design process used by Akademiska Hus. (Edited: Nordstrand, 2008)

The two approaches of describing the *Design process* are containing the same subprocesses. The one used by Akademska hus is containing more information of what parts that should be included in the subprocesses.

3.3.1 Programme phase

In the beginning of a project it is vital to evaluate the need of a certain facility, see Figure 3. If a need can be established a conceptual definition of a facility which meets the needs can be designed. For commercial projects the need is usually defined from a market analysis which aims to determine the profitability of the planned project. This process is intended to ensure that the proposed project will be profitable. In this stage, factors as plant size, site location and availability to the site will be considered how they affect the project. This information is sometimes compiled and called a feasibility study.

This information must be acquired in order to enable the senior management of the company to make planning decisions. The information gathered in the feasibility study and a cost analysis constitutes the decision support for the board of directors whether the investment required to build the facility is acceptable. This is further described in chapter 3.3.7. (W. Halpin & A. Senior, 2011)

3.3.2 Draft document phase

The aim of the *Draft document phase* is to evaluate all the possible solutions which the buildings can adopt in order to fulfil the programme and narrow it down to one main alternative. This alternative is then being developed further in the following phases *Schematic design* and *Design detail.* Normally it is the architect which has the main responsibility during the *Visualization phase,* although, other technical disciplines is also needed. The architect and technical disciplines are needed so that a solution which corresponds with both the structural design and the architects draft of the building design.

Several of questions which largely affect the project is being asked and answered in the *Draft document phase*. Nordstrand (2008) addresses the following questions:

- Where and how will the buildings be located at the site?
- How will the buildings be placed according to the topography of the site?
- How will the communications in the area arranged?
- Where will the entrances be placed?
- Effective use of the site?
- Layouts of the ingoing buildings and spaces?
- Appropriate configuration of the site layout and levels at the site?

During the *Draft document phase* several of alternative models are proposed and weighted of advantages and disadvantages in order to choose one solution. The architect is very active in this phase and usually sketches many alternatives. One of these alternatives is then compiled to the main alternative which is how the project should be shaped, this is presented in the draft documents.

3.3.3 Schematic design phase

The *Schematic design phase* can be briefly described as the phase where the technical details of the programme is fulfilled. The structural design and the building services are planned so that all requirements specified in the programme is meet. In the end of the *Schematic design phase* the project should be determined so that the next stage *Design detail* can focus on the details. The structure of the project is presented in the schematic design plans. Whit these plans as a basis it is possible for the client to examine the development of the project, if the requirements are fulfilled. (Nordstrand, 2008)

During this phase the focus is to create the optimized technical solution which correlates with the draft documents and the programme.

3.3.4 Design detail phase

The *Design detail phase* shall result in building documents which the contractors should be able to make an estimate of cost as well as construct from. According to Nordstrand (2008) the *Design detail phase* is the most comprehensive of the different phases of the design process.

Through this phase the total design of the constructions and building services should be completed. The final determination of which building materials and building elements that should be used as well as the position of windows, doors, lighting fittings etcetera is done. Furthermore, the interior of the buildings is set, for example the surface structure of walls, floors and roofs.

When the *Design detail* is performed, there are many requirements, the programme, and laws to take into account. In addition to this the safety of building workers and possibility to construct the designed buildings needs to be taken into consideration.

3.3.5 Design aspects

If a project is accepted by the client it goes from ide to *Design phase*. Then the client obtains an engineer and, or an architect, these may be combined to one company. The design phase aims to develop an array of plans and specifications of how to construct the facility. The plans consists of schematic or graphical drawings of the proposed building while the specifications often is compiled in a descriptive document of how the construction work needs to be performed. This document is included as a legally binding part of the contract when the design is completed.

The design stage is normally divided into two phases, the *Schematic design* initiates the process and it is followed by the *Design detail*. Between these two design phases it is normally a time gap which allows the client to review the suggested solution. This review is usually done when about 40% of the total design is completed. (W. Halpin & A. Senior, 2011)

The methodology of the design phase usually follows one of two perspectives, the linear model and the conjectural model, which are shown in Figure 5. The linear model is based on that a decent design is obtained when certain key steps are being followed. While the conjectural model suggests that the designer iterates around problems several times to achieve a good solution.

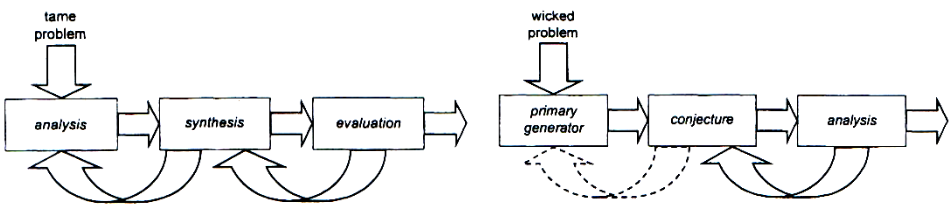

Figure 5. The linear model to the left and the conjectural model to the right. (Winch, 2007)

3.3.6 The briefing problem

In the early stage of a project it is a complex situation where the client wants to satisfy their vision of the project. It may exist several of possible options to fulfil this vision, which the client yet is unaware of. At the same time it is likely that several of possible realizations of the client's vision can be designed. This can be a problem for the designers who may have difficulties when trying to comprehend what the client actually wants. Misunderstandings can easily occur at this point because the actors are communicating information of very high level of uncertainty. The misunderstandings can be reduced by following the conjectural design approach, see Figure 5. (Winch, 2007)

This dilemma of information sharing in a project between the client and the designers can be presented within the so-called Johari Window, see Figure 6. Winch (2007) classifies the information as follows:

- **Public information**, is available and is usually understood by both actors.
- **Private information**, this information is belonging to the client but is not shared, or not understood, by the design team.
- **Blind information**, is the opposite of private information, it is known by the design team but not spread to, or understood by, the client.
- **Unknown information**, both the client and the design team are unaware of this type of information, it is the zone of uncertainty.

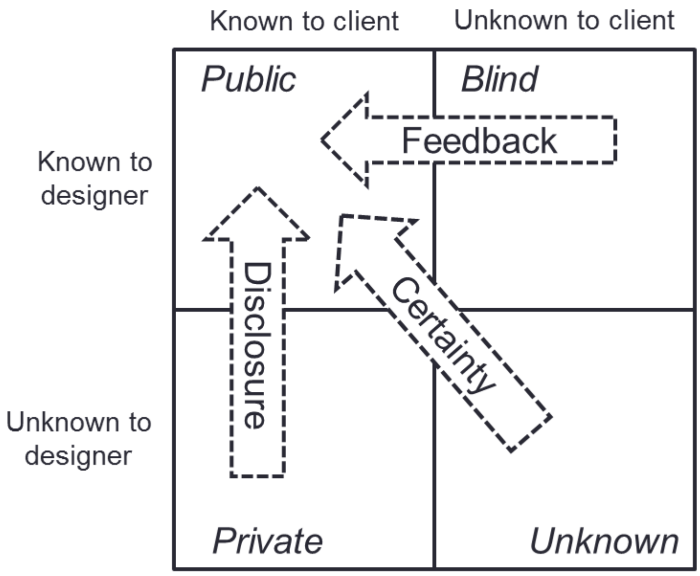

Figure 6. The Johari Window model. (Winch, 2007)

It is important to remember, when looking at models describing briefing problem, that this problem occurs during the first stage of the project where high levels of uncertainty is normal. In order to solve the briefing problem Winch (2007) is referring to "*disclosure and feedback*", see Figure 6. Disclosure is obtained when the client shares information with the design team, which the designers were uninformed about. For the client to be able to do this the client must internally have specified the project fairly thoroughly. Feedback is information going in the opposite direction, the design team communicates solutions and information to the client. As both parties are exchanging more information with each other the general uncertainty in the project is being reduced, indicated by the diagonal row in Figure 6.

The briefing problem occurs mostly because the parties have reasons for not communicating the information between each other. Winch (2007) suggests that the client can hold information privately for several of reasons, for example:

- The client evaluated the information as unnecessary for the design team.
- The client can have internal disagreements of the project which in some extent can be hidden by not providing sufficiently amount of disclosure information.
- Senior management wants to be in control and therefore the inferiors working within the projects are not given the authority to make decisions. This make the internal decision making slow and decisions that have been taken can be overruled later by senior management.
- The client may have inadequate organisational abilities to make the design team aware of which information that they needed.
- The client does not dedicate enough time and resources to fulfil its duties as a client.
- The information given to the design team is being reformed because the design team is not trusted.

Opposite from this scenario Winch (2007) explains that the design team can decide to keep information because of the following reasons:

- The design team presume that the information is irrelevant for the client.
- The design team may fail to communicate the message clearly, for example if it may be several of possible solutions.
- The design team needs more time in order to find proper solutions or justify identified solutions.
- Resources which are needed in critical moments are working in other projects.
- The information given to the client is being reformed because the client is not trusted.

One solution to improve the feedback and encourage information exchange is to become familiar with the other part’s method of working. If the client is working with the same design team for many projects reliance and understanding between the actors usually implies a more flexible working procedure.

Visualisation is another tool which can be used for helping the communication between the two parties. Normally, the client compiles its requirements through a descriptive document. The designers then transform this document into a visual context. At this point it is possible for the client to control that the visualisation matches the requirements while the designers have a good understanding about the project.

Another tactic to ease the briefing problem is to let the end user of the facility to be involved in the establishment of the building requirements. This approach supports the client to find and formulate the correct requirements needed for a certain purpose, which the client may have struggled to realise itself. (Winch, 2007)

3.3.7 Formal decision making

For a project to proceed, from one phase to the next, formal decisions are usually required at particular occasions during the project cycle. Winch (2007) suggests that three different tasks should be developed during the *Schematic design phase* to support the decision making, these are as follows:

1. An estimation of the cost based on the existing conceptual information.
2. A cost-benefit-analysis (CBA). For commercial based projects the CBA is a comparison of the expected income and the estimated costs over time. The value is back calculated to a net present value and compared with alternatives.
3. A graphical presentation of the project and a layout diagram of the buildings.

These three items serve as support for the decision makers when they evaluate whether the project should proceed.

3.4 Hierarchical levels

The disciplines working within construction companies can be distributed over a number of hierarchical levels, see Figure 7. It is a significant difference of management levels within a these companies. The levels are different for those handling general or global aspects of the construction company and for those handling precise or local aspects. In turn, it is possible to decompose the projects to more detailed levels. It is important to be familiar with these aspects of the construction companies to understand the project processes. According to W. Halpin & A. Senior (2011) four levels of hierarchy can be identified in the construction industry, these are:

- *Organisational*. At the organisational level questions regarding legal and business structure of the company are handled as well as managing of the different business areas. An important concern at this level is to support and contribute to the interaction between the head office and field managers.
- *Project*. At project level the projects are processed in terms of time and cost control as well as engaging and organising resources in the project.
- *Operation*. The construction and operation process level is dealing with the technology and specifics of how the construction is being executed. The global construction processes are typically rather complex, including several processes. Each of these processes is unique and is based on its specific methodology and work activities.
- *Task*. At the task level focus is to direct workflow of important assignments to the correct personnel at the work site.

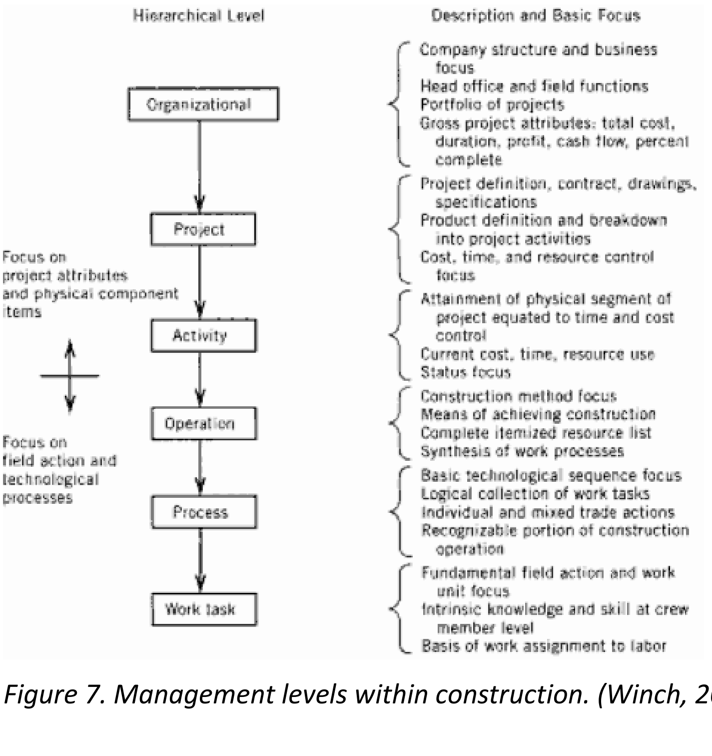

Figure 7. Management levels within construction. (Winch, 2007)

3.5 Conceptual basis of the conventional philosophy

Koskela (1992) is defining the conventional view of production as a conversion model and how it is related to ideas of organisation and management. Koskela presents four statements which represents the philosophy of conventional production. First an introduction of the term *production* is required. In this case *production* aims to describe the relation of the transforming activity of an input to an output. This can be applied on a wide range of disciplines not only the production industry but also engineering work, geotechnical work. Koskela's four statements are as follows:

1. A production process is defined as a conversion of an input to an output.

This idea is spread through several disciplines, economics and industrial engineering, to support the understanding of production, see Figure 8. It is rather easy to adapt appropriate measurements for this model, for example the ratio of input and output during a time frame gives the productivity.

2. One process can be divided into subprocesses which also are conversion processes.
3. Total cost reduction can be made by minimizing the costs of each subprocess.
4. Outputs of a process are being related to the total input costs of that process.

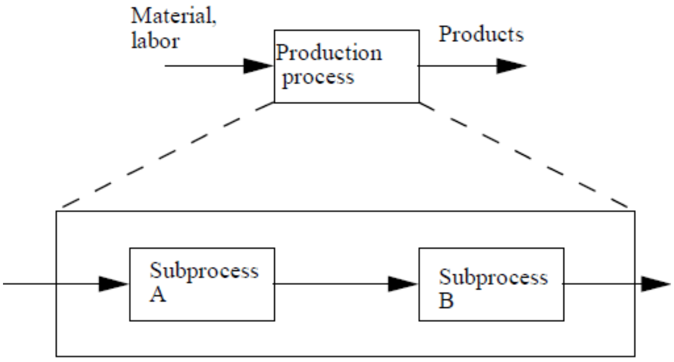

Figure 8. The conventional view of a production process. In this model main processes can be, usually is, divided into subprocesses. (Koskela, 1992)

Statements 2 and 3 are possible to relate to control within a hierarchical organisation. To be able to have this mode of control, conventional accounting theory is usually applied which is based on the following assumptions:

- The sum of all costs in operations in a production constitutes the total cost of the production process.
- The total cost for one operation, excluding material cost, is relative to the cost of direct labour of that operation.

This theory is also used reversed, for example in order to approximate the profitability of a device investment. This device makes the work of any operation easier, in other words reduces the work cost for one particular operation. The conventional accounting theory cause a reduction of both work cost and associated overhead cost, in order to determine the total financial impact of any particular change. Cost management can be focused on each department, operation or subprocess, making it easy for high levels of the hierarchy to get an overview while mid-level personnel trying to cut their own costs. (Koskela, 1992)

4 The new production philosophy

This chapter provides a brief description of the new production philosophy. The production term is described in chapter 3.5. The new production approach has several of names but is popularly known as Lean and is the philosophy which derives from the car manufacture company Toyota.

4.1 Background information

A change of production philosophy derived from Japan in the 1950's. One company, perhaps the most familiar, which embraced this new way of thinking about production was Toyota. Toyota implemented this new philosophy in their production system through a wide range of efforts; eliminated inventories and other matters by adopting small lot production, reduced set-up times, semiautonomous machines, co-operation with suppliers and other methods.

Meanwhile American consultants assisted the Japanese industry with quality issues. This resulted in a quality philosophy including tools for company development. These two ideas, the quality and production philosophy, were processed and refined over a long time. The ideas began to spread to America and Europe in the 1970's, particularly to the automobile industry.

In the early 1990's a long development process resulted in one mainstream approach under several names world class manufacturing, new production system and probably the most frequently used name today is Lean production. During this time large manufacturing companies in America and Europe introduced, at least partially, the new production philosophy. (Koskela, 1992)

4.2 The new production philosophy basics

This chapter aims to provide some basic knowledge about Lean production. The Lean concept develops constant, certain aspects are changed or replaced completely by updated strategies. Although, there are certain essential terms in the Lean concept which originate from the early episodes of the philosophy, these include:

- **Just In Time, JIT**. The general idea of JIT is reduction or complete elimination of inventories. To be able to perform this reduction several of measures had to be done, in general less material had to be handled at the plant during the same time. This resulted at Toyota in decreased lot size, redesign of layout, co-operation with suppliers and set-up time reduction. An overall rule of JIT is that nothing should be produced unless the consumer wants it. (Dennis, 2007)
- **Total quality control, TQC**. The quality thinking was initiated to inspect raw materials and products with statistical methods. The view of how quality aspect should be applied has progressed, to present time for focusing on how to design quality into the product or process. As the name reveals the quality should cover the total organisation. (Koskela, 1992)

- **Muda**, is the Japanese word for waste or an activity which is of non-adding value for the customer. It is the opposite of value which the customer wants to pay for. One of the initiators, Ohno (1988), of the new philosophy at Toyota, defines waste as:
    - Waste of overproduction
    - Waste of correction
    - Waste of material movement
    - Waste of processing
    - Waste of inventory
    - Waste of waiting
    - Waste of motion

The different type of waste will not be described further in this report but in order to proceed towards the Toyota production system it is elemental to identify wastes completely.

Several of new concepts have developed from the thoughts above for example Total Productive Maintenance, Employee involvement, Continuous improvement, Benchmarking, Time based competition, Concurrent engineering, Value based strategy (or management), Visual management, Re-engineering. These concepts show that many ideas originates from the basics of Lean, they will not be further described in thesis.

4.3 Conceptual basis of the new production philosophy

The new production model, as Koskela (1992) calls the philosophy which is strongly related to, or even goes by the name, Lean production. This model will be briefly described in this section.

In this approach production consists of a material or a information flow to the end product, see Figure 9.The flow is described by several of different activities all of which differ. The conversion aspect of production, see chapter 3.5, is represented by processing, while the flow aspect of production is being represented by inspecting, moving and waiting.

The flow aspects are likely to be characterized by time, cost and value. Value is created when fulfilling customer requirements, hence processing activities is almost exclusively value-adding. It does not matter if it is information or a material which is being conversed to a product. The flow activities are the channels which connects the processing activities.

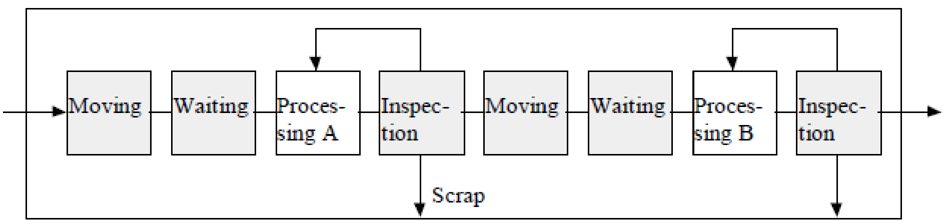

Figure 9. A Schematic illustration of a flow process forming a production. The shaded boxes in the figure represent the non-value-adding activities, unlike the value adding processing activities. (Koskela, 2000)

Since all activities, value-adding or non-value-adding, consume time and money but only the conversion activities contributes to the end product. In the pursuit to create a more efficient production, processing should be made more efficient while flow activities should be eliminated or reduced. This is the fundamentals of the *New production philosophy*, see Figure 10.

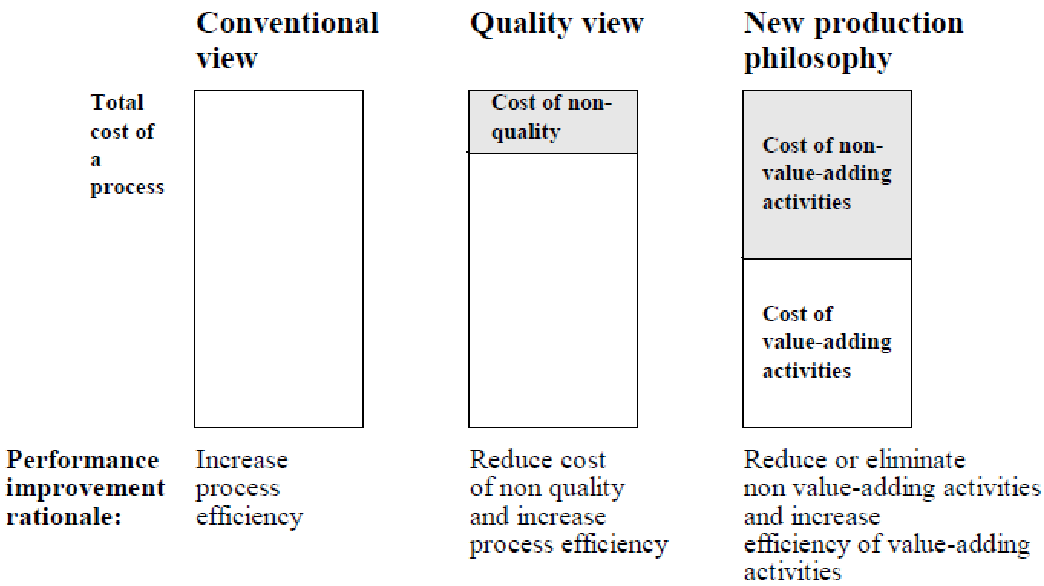

Figure 10. Comparison of three different production approaches. The figure present the performance improvement differences of three different production approaches. (Koskela, 1992)

4.4 Lean Construction

The new philosophy had to be adopted for the construction market in order to be useful. The first step was to take the core fundamental principles of Lean Production and adjust them to the Construction Industry. For the Lean construction to be useful its principles needed to be become operational. This was done through a new project delivery system which includes all of the core principles of Lean Construction. The Lean Construction delivery system does not consist of a certain set of tools that can be implemented directly. However, it should supply a structured, controlled and improved method of conduct projects in the quest of maximising the profit and workflow consistency on construction sites. (C2P2ai/SPDC, 2008)

4.4.1 The Lean Project Delivery System

A conceptual framework for the purpose of assisting with implementation of Lean construction on project based production systems has been developed by Ballard (2000). The framework is called The Lean Project Delivery System, LPDS, and it comprises a set of interdependent functions, how decision making should be done, methods for execution of functions, and aids and tools for implementation.

The LPDS can be illustrated as in Figure 11 by five overlying triads which in turn consist of subprocesses. The first three triads and the processes within are of interest for the design of the project, these are as follows:

- The **project definition** phase contains the modules: Needs and Values Determination, Design Criteria, and Conceptual Design.
- **Lean design** includes Conceptual Design, Process Design, and Product Design.
- **Lean supply** consists of Product Design, Detailed Engineering, and Fabrication/Logistics.

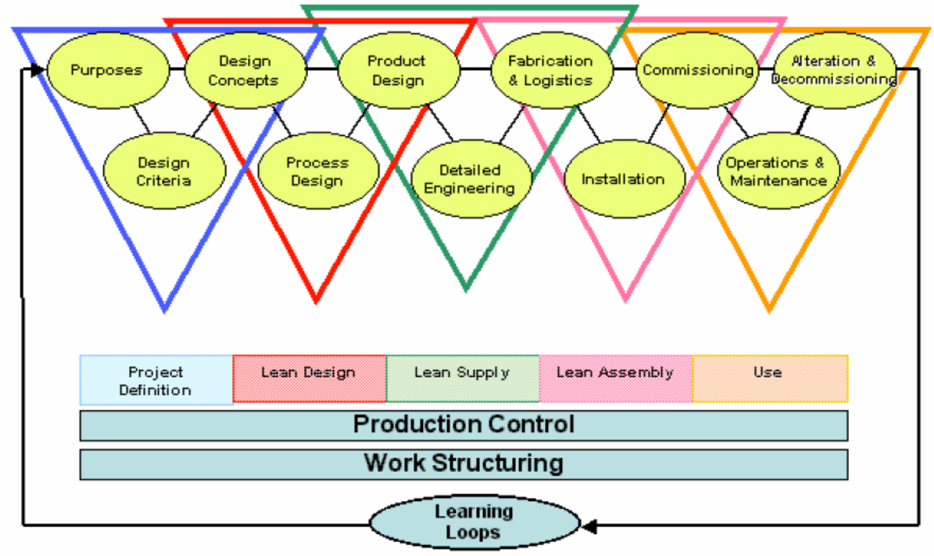

Figure 11. Illustration of The Lean Project Deliver System. (Ballard, 2000)

Important elements of the LPDS are the Production Control and Work Structuring. The aim of Work Structuring is to structure site operations flow in a reliable and quick manner while value is delivered to the customer. The Production Control purpose is to manage the production plans through the whole process. A vital concept of the Production Control is the Last Planner System. The idea of this concept is to involve disciplines who will execute production or design in later phases of the process in early phases. This is done in order to draw conclusions of problems of design and manufacturing as early as possible where it is less expensive to correct the fault. (C2P2ai/SPDC, 2008)

5 Standardization

This chapter briefly describes the standardization concept.

Standards in different context are widespread all over the world today. It is facilitating communication between people so that both parties have the same frame of references. The target for standardization within the industry is to make the whole organisation more effective and increase or maintain good quality. (SIS, Swedish Standards Institute, 2011)

In companies or departments which are specialised in design and knowhow standards are primary used by providing solutions to common problems; ensure safety and capacity of the design. Furthermore, standards can be used for quality assurance and improvement of effectiveness of the working procedure. (ISO, International Organization for Standardization, n.d.)

One type of commonly used standardization is the use of standardized working procedures. These working procedures should include predefined areas of concern, therefore, the risk of missing out information is reduced. Furthermore, a standardized working procedure gives recommendations and examples of which information that should be included. If the responsible personnel, choses to neglect or leave out information, it has made an active choice and the risk of missing out information by mistake is reduced.

5.1 Standardization in Sweden

The organization which is responsible for standards which among other businesses focus on construction is the Swedish Standards Institute, SIS. SIS is a member of the International Organization for Standardization, ISO, and the European Committee for Standardization, CEN, where the latter has been developing the Eurocodes.

To support the implementation of the geotechnical Eurocodes in Sweden, an implementation commission has been established called Implementerings-kommisionen för Europastandarder inom Geoteknik, IEG. IEG has released several of reports which aim to describe how to apply the geotechnical part of the Eurocodes.

5.2 The process concept

Within a company it is many different processes running during the same time at different levels of the organisation. It is essential for larger companies to have a good structure and order of the labour which is performed. A proven method to define the working procedure is to make flowcharts of the process, this can be done at various levels of the organisation, see Figure 12.

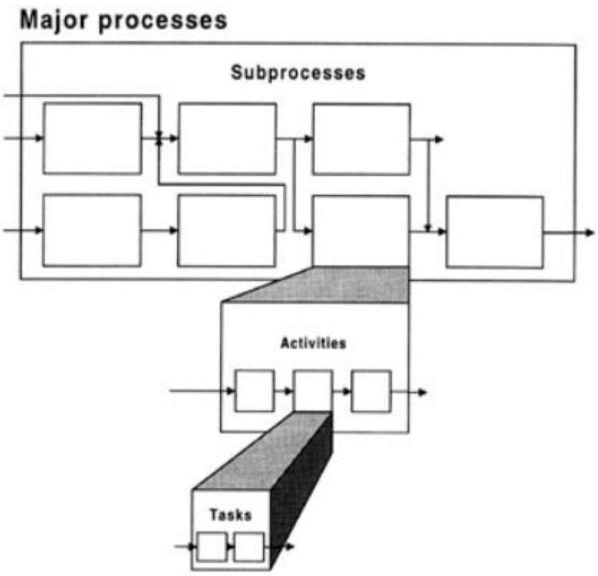

Figure 12 Schematic model of process hierarchy. (Harrington, et al., 1997)

Harrington , Esseling, & van Nimwegen (1997) have defined factors which are likely to be used in process diagrams, as following:

- A **process** is a set of logical, related, sequential (connected) activities which converse, an input from a supplier to an end product for the customer.
- A **major process** is a process that usually involves more than one function within the organizational structure. Major processes are likely to be rather complex, difficult to flowchart at the activity level. It is regularly divided into subprocesses.
- A **subprocess** is one part of a major process which achieves a specific objective that supports the major process.
- **Activities** are the actions within a process or subprocess. They are usually performed by single personnel or departments. An activity is usually documented in an instruction.
- **Tasks** are individual elements and/or subsets of an activity. Normally, tasks relate to how an item performs a specific assignment.

To present a clear overview of the process it is important to use an appropriate organizational structure diagram. Harrington, Esseling, & van Nimwegen (1997) suggest several of different diagrams to present this matter from which two were selected, as following:

- **Detailed process diagram**, gives insight to the sequence of activities and the flow of documents in a process. The process diagram is particularly suitable for obtaining an understanding of and analysing the processes. The process diagram is also referred to as a flowchart.
- **Instruction diagram**, consists of a detailed process diagram with associated instructions, see Figure 13. It provides the staff members in an organization with understanding of the processes how it should be carried out and the rules that must be followed. The instruction diagram can be a unique tool for transferring knowledge if the documentation is proper formed. Each instruction in the documentation should convey only one clear meaning.

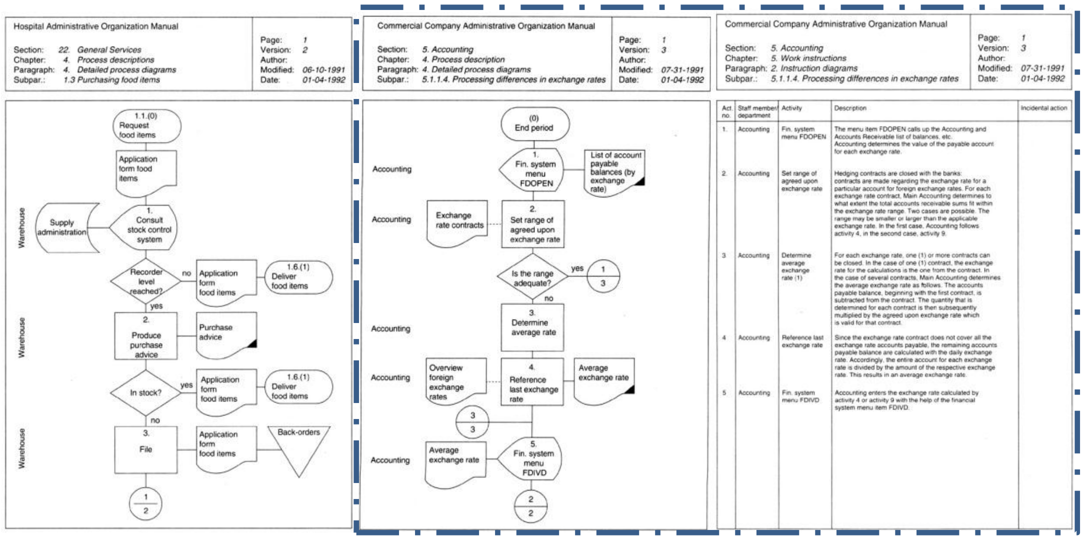

Figure 13. Examples of process diagrams. The figure shows a detailed process diagram, also known as a flowchart, to the left. To the right in the dash-dotted box are an instruction diagram and its related instruction form. (Harrington, et al., 1997)

5.3 Choosing conceptual model of working procedure

It is necessary to choose a suitable model to display the process in order to make it useful. The selected type of model of the working procedure should be able to be used as a foundation for recommendations of improvement and providing assistance for new employees.

A suitable method of sorting information is a detailed process diagram, flowchart. Through a flowchart it is possible to present an overview of the process along with more detailed information in the same diagram. The diagram and an associated document with further information and instructions will, if carried out properly, facilitate the adaptation of recently graduated new employees. Therefore, these two supports will be used to describe the geotechnical working procedure.

6 Organization

This chapter describes the organization of the participants involved in the NCC in-house residential projects.

6.1 NCC

NCC AB, Nordic Construction Company AB, is a building and a real property company. The NCC group includes the following affiliated companies NCC Construction Sweden, NCC Housing and NCC Property Development, see Figure 14. NCC Construction is responsible for the construction work and is divided into four geographical areas depending on Nordic country, NCC Construction Sweden, Denmark, Finland and Norway.

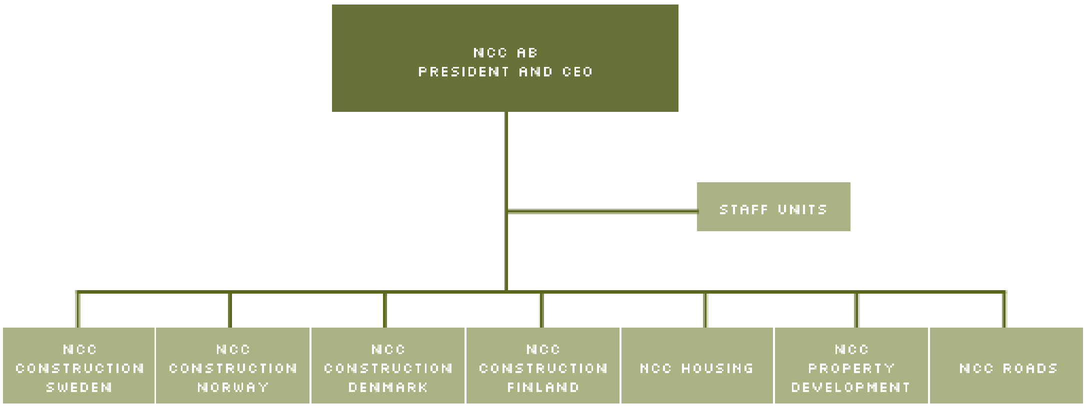

Figure 14. Organization chart of NCC AB. (NCC AB, 2012)

NCC is together with Skanska the largest actors on the Nordic construction market with 6 % market share, see Figure 15. In the area of development of residents in Sweden JM is one of the largest rivals. (NCC AB, 2011)

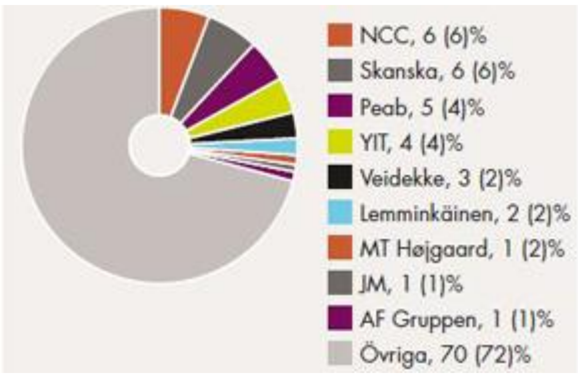

Figure 15. The Swedish construction market shares. The figure shows the market share different companies has of the Nordic construction market the year 2010. The largest part "Övriga" refer to "other, smaller companies". (NCC AB, 2011).

6.2 NCC Housing

NCC Housing AB, a subsidiary company to NCC AB, is the contractor of the resident projects and the client of the geotechnical work. NCC Housing is developing and selling residences, operating in certain parts of the Nordic region, Germany, the Baltic countries and St: Petersburg market (NCC AB, 2012).

6.3 NCC Engineering

NCC Engineering AB, NCC Teknik, is a consultant company which focus on supporting NCC Construction Sweden with technical advice and design. NCC Engineering is divided into regional departments. The southern department consist of different departments with focus on energy, installation, structural design, geotechnics and infrastructure. The section which is performing the geotechnical work in NCC in-house resident projects is called NCC Engineering, NCC Teknik Geo/Infra.

6.4 Hercules Grundläggning AB

Hercules Grundläggning AB is a subsidiary company to NCC Construction which design, manufacture and install ground improvements, different types of piles and structural support. Hercules is subsidiary company under NCC Construction Sweden, however not guaranteed to receive the foundation work contracts from NCC Construction. Hercules needs to compete, compile tender documents like, other competing companies. (HERCULES Grundläggning AB, 2012)

7 Present project process at NCC

This part presents the current project process at NCC. First, the general aspects of the project process are described, followed by more detailed descriptions of the phases Business development and Project development.

The NCC residential in-house projects are symbolised by the fact that NCC is both the responsible customer who owns the project and the company that conducts the project. The projects are owned by NCC housing in the early stages and later in the projects by NCC Construction, see Figure 16. For NCC to be able to perform this type of projects NCC consists of several NCC subsidiary companies which have their own expertise, see Figure 14.

In these residential projects several of disciplines are working in the *Design process* within certain predefined stages; as described in chapter 3.3, see Figure 16.

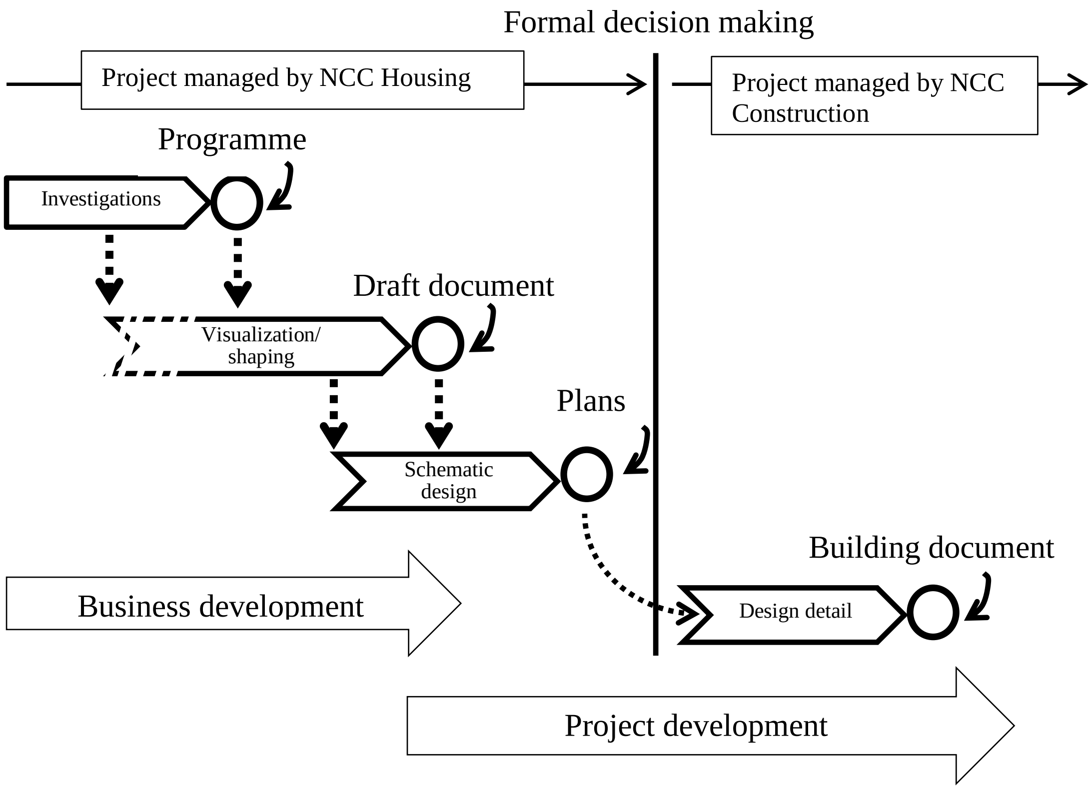

Figure 16.The main stages of a project in relation to the phases of the project.

As Figure 16 shows that a formal decision should approve the project, for the project to proceed into the production phase. This decision is taken by the NCC board of directors. If the decision is taken to proceed to constructing, the managing company of the project is changing from NCC Housing to NCC Construction. (RF-6, 2012)

The flow, the stepwise chronological order, is similar for most projects while the project's content and the time required to accomplish the steps differs.

During the *Design process* the two concepts Business development which is followed by the Project development are established, these are further described hereafter.

7.1.1 Business development

The first phase of a residential project is called Business development, it is managed by NCC Housing, see Figure 17. From a geotechnical view the two right columns are of interest. NCC Housing is ordering the geotechnical investigation from NCC Engineering. The phase is called Business development because it aims to evaluate the possibility for a profitable business of a specific site. The features during the beginning of the phase are technically course and NCC Housing is working with visions about the site. (RF-1, 2012)

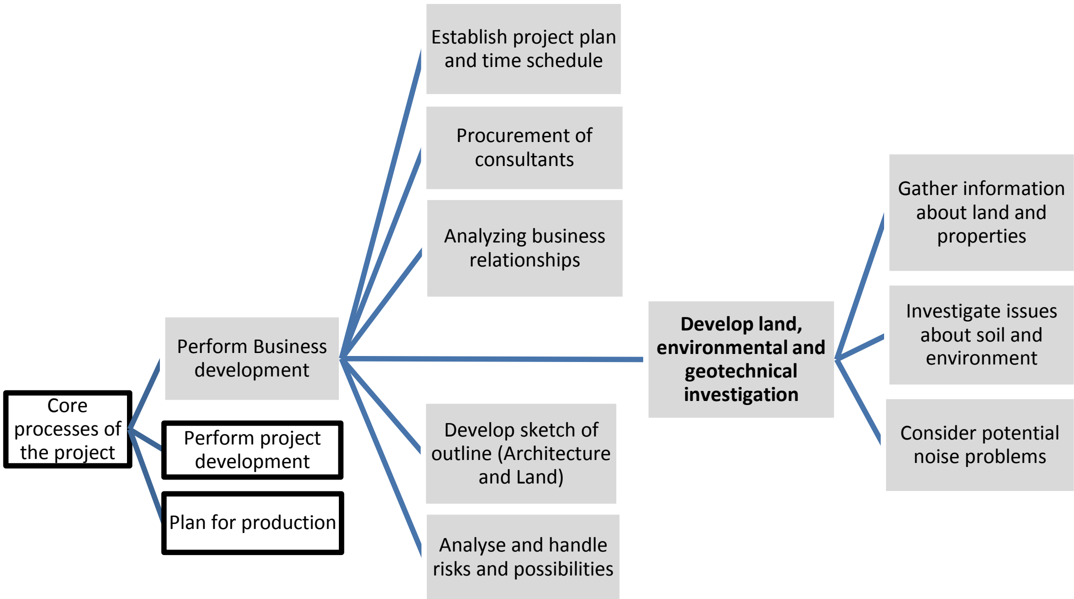

Figure 17.The Business development process. The shadowed boxes in the picture represent the main activities of the business development process which is managed by NCC Housing.

7.1.2 Project development

The second phase of the total project procedure is called the Project development, see Figure 18. As NCC Housing is the owner of the project, therefore, in charge of the Project development phase. This phase is usually beginning while the business development is running, see Figure 16. Because of this, the link between the phases is significant. The Project development focus is to develop the concepts that have been established in the earlier phase. The aim is to perform a detailed design of the project. To be able to accomplish the aim, accurate and precise information are required. This implies that a majority of the project must be defined. Large changes in the later stages of this phase will probably cause second round effects and be rather costly to correct. (RF-2, 2012)

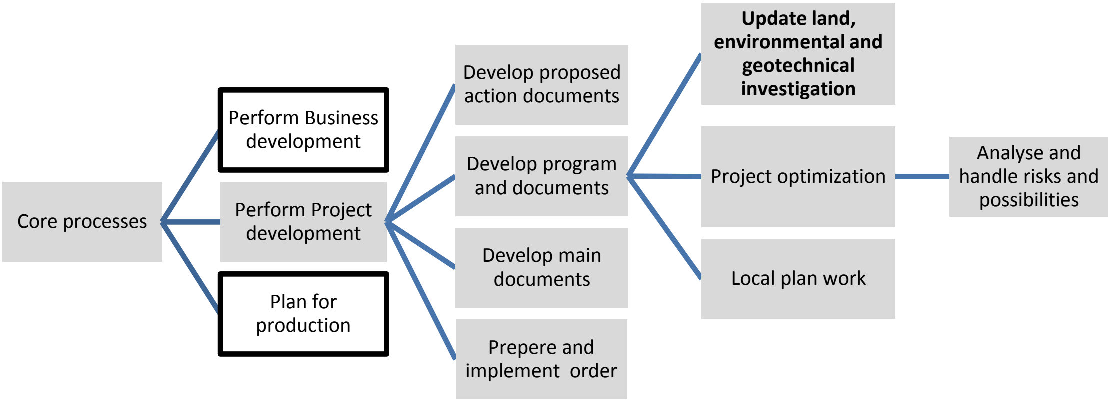

Figure 18.The Project development process. The shadowed boxes in the figure constitute the project development process which is managed by NCC Housing.

7.1.3 Geotechnical process approach

The methodology of geotechnical work is an iterative process containing planning, information gathering, evaluation, stating a recommended solution and design of the construction. The start is normally to obtain an understanding of the site and to identify which information that is needed. The level of accuracy in the information needed defines how much testing that is required. It is rather usual that geotechnical engineers prefer to have a low-resolution understanding, the information increase over time, of the site to be able to determine the factors of importance in more detail. (RF-8, 2012)

NCC Construction has established a total project process map, from these the design of the foundation is interpreted to be a part of both the Business and Project development by the authors. One of the first tasks in the early stages of the Business development is to identify if there is a potential significant risk of having extra ordinary costs for design of foundation (NCC Construction Sverige, 2010). To answer that question the geotechnical engineers needs to be informed early about the project and continuously updated about any changes that could affect the design of the foundation. If this communication is well functioning and continues, the whole project are increasing its potential to have a well-designed foundation. The opposite, a badly-communication or usage of expertise, can make a potential successful project end up unsuccessful.

Furthermore, the authors of this thesis get the impression that the geotechnical engineers are in the project to answer a few specific questions. This means that their view and impact of the overall project is limited.

7.1.4 NCC Project Studio

NCC AB has recently developed and introduced a concept called NCC Project Studio. The goal with NCC Project Studios is to do "*everything correct*" in project planning (NCC Starnet, 2012). This is mostly done by benefitting from several of disciplines during the design stage in order to reduce the amount of bad decisions. This is done by having the personnel working together in one studio, at the same time and place.

In practice, a meeting should be held between those disciplines before they have started their individual work on the project, called start-up meetings in this thesis. Later in the project when the work has started on individual level the meetings needs to be continuously planed and scheduled by a project coordinator. While the information sharing between the disciplines also should be maintained through direct or indirectly dialogue in the studio.

By doing *everything correct* the mistakes should be identified and dealt with as early as possible in the project planning, faults should not be discovered later in the production phase. A later discovered mistake will have a larger impact when already designed features need to be redesigned. These changes will often be complex and costly compared to if they were done in an early stage instead, see Figure 19 (RF-10, 2012).

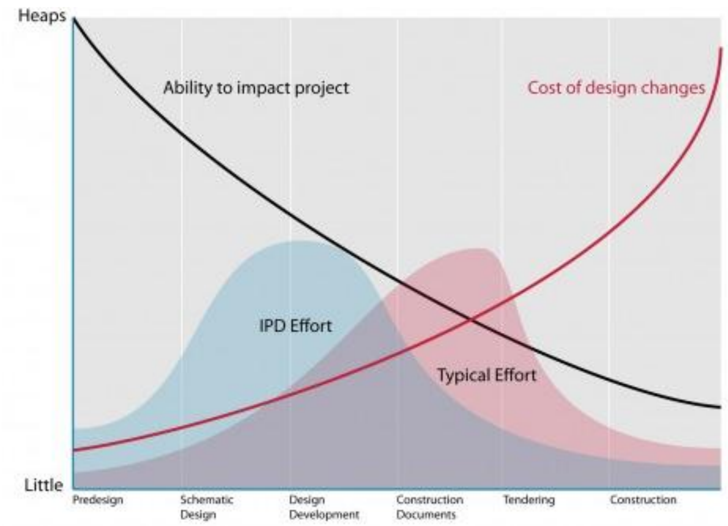

Figure 19. MacLeamy graph illustrates costs of design changes (MacLeamy, 2011)

The NCC Project Studio engages a wide competence which enables personnel from each discipline to reflect of aspects correlating badly with their area of expertise. In some situations, when a mistake is being identified in a late phase, a change of plan has to be made. At that stage it is important to choose the best alternative from the total perspective of the project. By working with NCC Project Studio it is possible to identify alternative solutions and compare them from a wider range of parameters such as time and resources within the total project.

There is a risk that personnel are attending the Project studio where it does not benefit at maximum. This appears when personnel are present in meetings and working with tasks that are to fare away in project time or technical area. The problem is to use and direct the resources, personnel and time, as beneficial as possible - the personnel need to attend the right parts of the project. This is based on Lean process thinking, see chapter 4.

In Project Studio different technical expertise are represented. One of the disciplines is geotechnical engineering and should be present. The Project Studio has the potential to develop the communication and interdisciplinary understanding. The next step in the implementation of NCC Project Studio should be to introduce the concept in early planning and design stage. By introducing NCC Project Studio early in a project more benefits can potentially be achieved.

8 Case and object description

This chapter presents a brief overview of the location and the geology in the area followed by a description of the studied cases. For each case, site specific factors will be described regarding the geotechnical aspects of the ground, the previous activities and planed buildings.

8.1 Regional location

The case projects are all in the Gothenburg area. The project Marconi Park is in Frölunda, Åby Stallbacke in Mölndal and Tölöbergs Terrass in Kungsbacka see Figure 20.

Figure 20. Site locations in the Gothenburg region. The figure shows the site locations of the cases. (Google, 2012)

8.2 Regional geology

The typical ground profile in the Gothenburg area has sediments which are of small size, have settled in water and often constitute different clays. The clay covers over large lowland areas, over layering the bedrock, which can be as thick as about hundred meters. Areas with deep clay layers are often located in valleys, for example the Götaälv valley. Because all cases are situated in the Gothenburg area the geotechnical aspects are generally rather similar. Thus, the ground profile is consisting of a friction material covered by clay and a layer of fill or friction material on top of the clay. However, geometrical and technical conditions and behaviour of soil properties are varying. The geometrical aspects are layer thickness of clay and friction material. The soil properties have a variation of content, deformation and strength characteristics. (Bergdahl, et al., 1993)

8.3 Marconi Park, Järnbrott Frölunda

In the year 2007 NCC Teknik performed a geotechnical survey for NCC Housing at the location Järnbrott in Frölunda, see Figure 21. The plan was to build six houses with four or five floors each. An underground garage was planned to be built, but the location and size were changed late in the design stage. The project is being constructed at present (NCC Engineering, 2007).

8.3.1 Location

On the planned construction site for the residential area a gas station and a football field was situated, see Figure 21. Along the site it is a rather heavily used access road, on the other side there a residential area is located. The top surface is covered by a layer of gravel covering a clay layer.

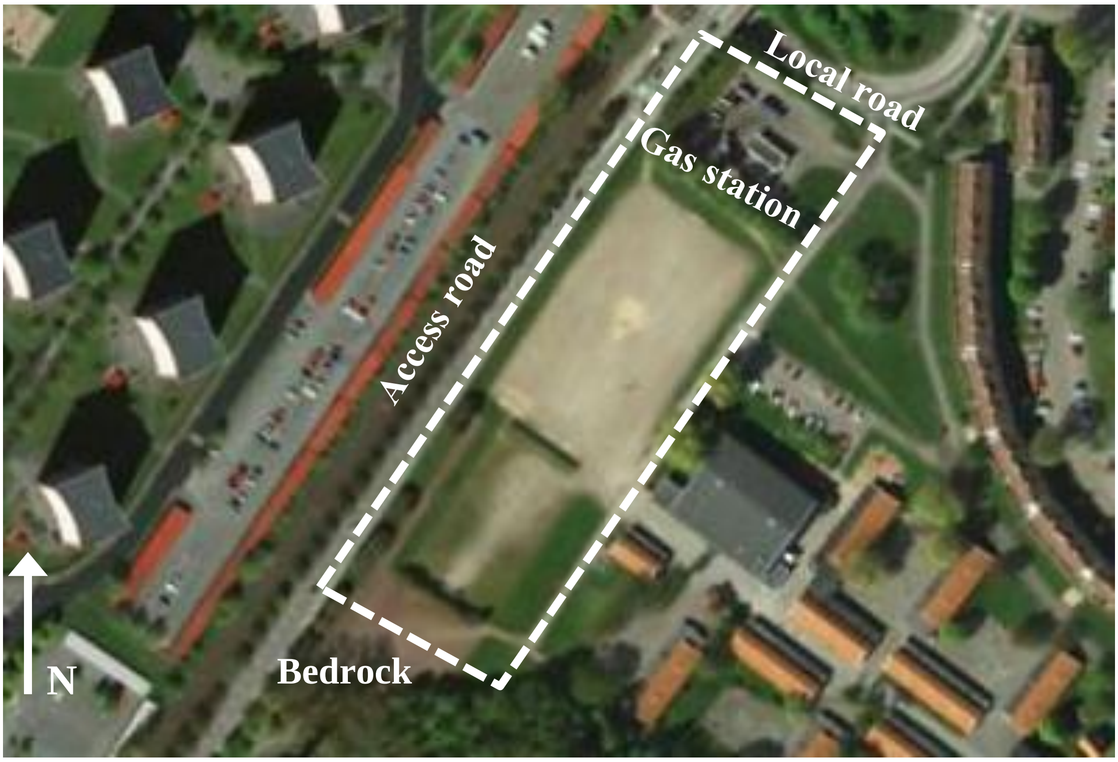

Figure 21. Site overview of Marconi Park, situated in Frölunda, Göteborg. The dotted rectangle marks the location where the apartment blocks and the ice arena are planned to be constructed. (Hitta.se, 2012)

8.3.2 Field investigations

The field investigation was divided in to two different occasions. The first was performed in August 2007 and the second in September 2007. Tests conducted at the site were Standard Penetration Test, SPT, and Vane Test. Disturbed and undisturbed soil sampling was also made at the site (NCC Engineering, 2007).

From the field investigation in 2007 the ground conditions was determined for the site. In the south- east part of the site there is bedrock at the surface, the bedrock declines to the north-west and is covered by varying thickness of clay. This implies that the thickness of the clay varies in the area from about 20 meters to no existence of clay, see Figure 22. Therefore, different alternative foundation methods are possible to use, to some extent depending on where the houses are located within the area. (NCC Engineering, 2007)

A second round of field investigation was performed in April 2010. This survey was done in order to determine the shape of the bedrock in the south-west of the site. An underground garage was planned to be constructed in this part of the area.

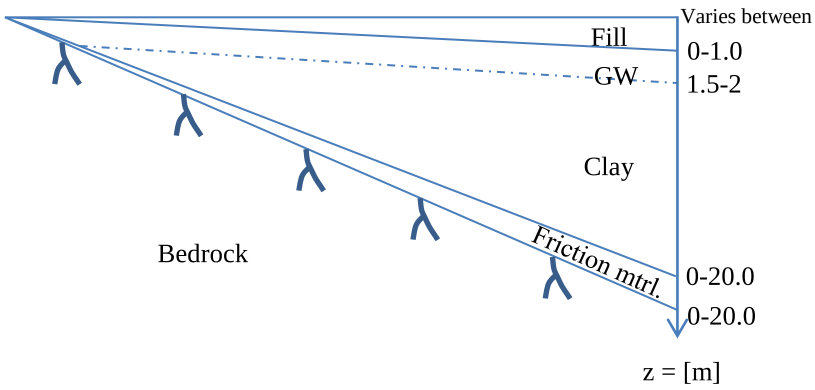

Figure 22. Ground profile model of Marconi Park.

The groundwater level is observed at about 1.5-2.0 meters below the ground surface and the pressure is estimated to be hydrostatic. The clay is slightly over consolidated in the upper layers and the degree of over consolidation decreases with depth at depth.

8.4 Åby Stallbacke, Åby

NCC Teknik performed in the year 2009 a geotechnical survey for NCC Housing at the site located in Åby, which is a part of Mölndal, see Figure 23. The projects consists of building a residential area including two slab blocks, F7 with five or seven floors and F8 with either three or five floors both alternatives includes basement. Later stages of this residential project is planned to contain several of tower blocks. The project is currently waiting to for the formal decision to continue to the construction phase. (NCC Engineering, 2011)

8.4.1 Location

On the site where the residential houses is planned to be built is next to the horse racetrack, Åby Travet. The land currently used to house horses for the racetrack and the top surface is covered by a layer of gravel covering a clay layer.

Figure 23. Site overview of Åby Stallbacke, situated in Mölndal. The dotted rectangle, west of the horse racetrack, marks the location where the slab blocks are planned to be constructed the land are planned. (Hitta.se, 2012)

8.4.2 Field investigations

One geotechnical field investigation was performed in this project. Standard Penetration Test, SPT, and Vane Test were conducted at the site. Soil sampling in terms of disturbed and undisturbed, was performed at the site (NCC Engineering, 2011).

From the performed field investigation a soil profile was determined, see Figure 24. The soil profile has a covering top layer of 0.3-0.7 meters consisting of gravel which superposing a clay layer. Under the clay is a friction material layer which covering the bedrock. The clay layer is 50-60 meters thick and the friction layer is estimated to be more than 5 meters, see Figure 24. (NCC Engineering, 2011).

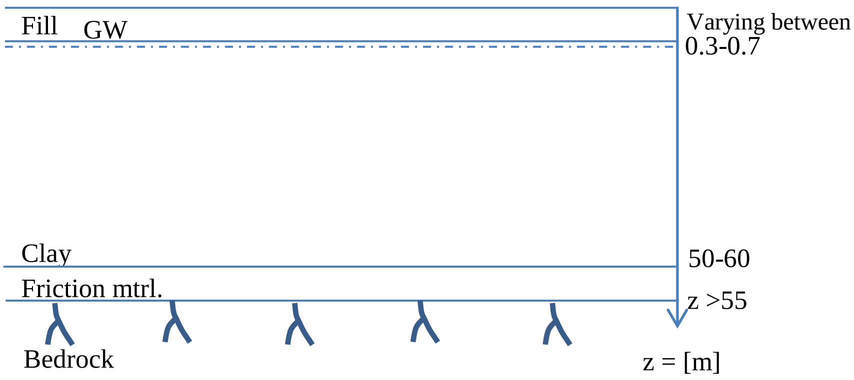

Figure 24. Ground profile model of Åby Stallbacke.

The groundwater level is observed at about half a meter below the ground surface and the pressure is estimated to be hydrostatic or slightly artesian. The clay is slightly over consolidated in the upper layers and normal consolidated at deeper layers.

8.5 Tölöbergs Terrass, Kungsbacka

NCC Teknik performed in January 2012 a geotechnical survey for NCC Housing at the location Tölöberg in Kungsbacka, see Figure 25. The plan was to build seven apartment blocks with 4-6 floors each. Some of the houses are planned to be built with basement and some with attic apartments (NCC Engineering, 2012). The project is currently in construction phase.

8.5.1 Location

The site for the planned residential area was previously used for industry activities. Close to the site, railway tracks are located while some existing houses surround the site on other sites. Because of the former activities contaminated the soil within the site remediation of the soil has to be done.

Figure 25. Site overview of Tölöbergs Terrass, situated in Kungsbacka. The dotted rectangle marks the location where the apartment blocks are planned to be constructed (Hitta.se, 2012)

8.5.2 Field investigations

The field investigation was performed at one single time. Test that was performed was Standard Penetration Test (SPT) and Vane Test. Soil sampling, disturbed and undisturbed, was performed at the site. (NCC Engineering, 2012)

The results from the field investigation show that the top layer is 0.4-1.7 meters of fill that over layers 2-14 meters of clay. The bottom layer is friction material on top of bedrock, depth unknown. The upper layers, 0.5-0.8 m, of the clay is a dry crust and in some regions the clay has a layer of mud, see Figure 26 (NCC Engineering, 2012).

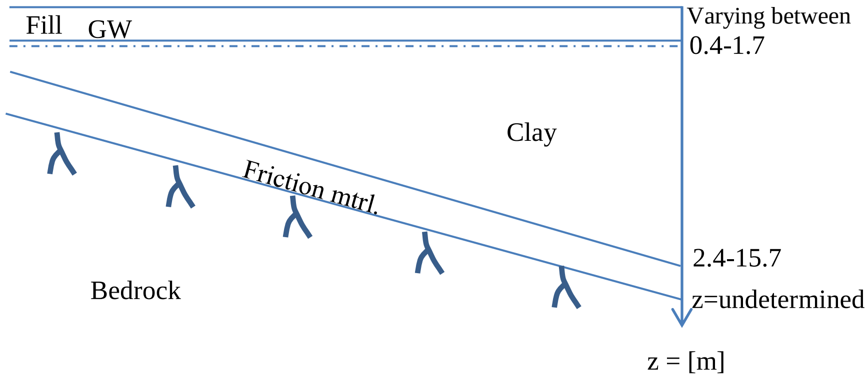

Figure 26. Ground profile model of Tölöbergs Terrass.

The groundwater table have been observed in the boundary between the fill and the clay and are estimated to be hydrostatic. The pre-consolidation is estimated to be slightly over consolidated in the upper layers and normally consolidated deeper down. (NCC Engineering, 2012)

9 Interviews

This chapter will present the interview results from the case study. Since the interviews have been performed in Swedish, the Swedish questionnaires used during the interviews can be found in Appendix 1. The interview result is presented under each case study.

9.1 Marconi Park

The project Marconi Park is at present, spring 2012, in the construction phase. A main part of the geotechnical work in this project was related to the underground garage. The undetermined position of the garage caused additional work for the geotechnical engineers.

The geotechnical engineers in this project suggested a floating standalone garage, a compensation foundation method. In this case no pilling was needed because the excavated clay is compensating the garage construction. This is resulting in a rather cost efficient foundation. These aspects were discussed between the geotechnical engineer and NCC Housing, the project leader agreed to further investigations (RF-8, 2012). The question was how large the underground garage could be. Because of the fact that the surrounding houses and the bedrock was delimiting the possible garage expanse. Therefore, detailed knowledge about the level of the bedrock was important, because rock excavation would make the cost reduction measure unprofitable. The question was narrowed to: how far in the direction south-east could the garage reach before the bedrock is interrupting? Because of this specific problem, second round of surveys was performed at the site. From the second survey a rather detailed model of the bedrock at the site could be evaluated.

The foundation of the residential houses was recommended to be slab block with piles driven to bedrock. The garage was built underground next to the houses, not directly under them. The foundation of the garage was, because of its low weight, recommended to be a compensated foundation. Between the garage and the apartment houses underpasses needed to be constructed. The fact that the garage and the slab blocks were made with different types of foundation works complicated the underpasses between them.

At the same time as the planning of the residential area Marconi Park were carried out, the planning of an ice arena in the same area was done, managed by NCC Construction. In the planning phase there was a discussion about where the two objects should be built in relation to each other. The adjacent access road to the site was planned to continue to supply the local road in the north of the site, see Figure 21. The local road network of course have to give access to the buildings in the area, which meant that if the resident areas where built in the north part all the visitors to the ice arena would have to pass through the residential area. Therefore, NCC Housing recommended that the residential area should be located in the south of the area (RF-2, 2012). This alternative was accepted for giving most value for the costumers for both the ice arena and the resident. The precise location of the houses was not set until late in the planning. This had the effect that an exact design of the foundation support, depending on the ground variations, had to be done later in the project.

The structural designer calculated the loads of the garage and distributed the results to the geotechnical engineers. As mentioned before, the clay thickness to firm bottom varies significantly in the area of Marconi Park. This gives different alternatives of type of foundation support. At some spots the garage could build direct on bedrock, by natural inclination of the rock mass or by blasting. An alternative method is to have columns that reaches firm bottom, this would be used at areas with thick layers of clay and longer distances to firm bottom. The last alternative is to have a construction with a combination of foundation support, direct on bedrock on one side and supporting columns at the other. A discussion about different foundations alternatives was held during the phase of Business development lead by NCC Housing.

The involved personnel in Marconi Park are satisfied with the overlapping communication between project management and the geotechnical engineers. Both parts were positive about the chosen solution but without a close and frequent discussion with geotechnical engineers the cost for foundation work could have been much more.

9.2 Åby Stallbacke

The project of Åby Stallbacke is currently, spring 2012, on hold before the production has begun because the NCC board of directors have decided to begin with the development of other sites in the same area (RF-4, 2012).

The ground profile indicates that the most economic type of foundation within this area for heavy constructions is piled raft with cohesion piles. This was known by NCC when acquired the land. Cohesion piles are typically a type of deep foundation which is relatively sensitive to changes of the design of the planned houses. For example larger loads will affect the pile dimensions, lengths and amount. If the design of house F8 would change and generate higher loads the foundation method might change from cohesion to supporting piles (RF-9, 2012). An alternative foundation method could be to use a compensated foundation. This would require a deep excavation in order to reduce the effective stress sufficiently or a higher degree of pre-consolidation and are therefore not an alternative in this case.

The foundation of the residential houses was recommended to be done with piled rafts for both houses. House F7 is designed with a base slab and supporting piles and house F8 with a base slab and cohesion piles. The different types of piles used is because of house F7 consists of two more floors than house F8, generating higher loads. Cohesion piles can be used for house F8 because of the less number of floors. The deep clay layer enables long piles which can generate adequate cohesion.

If a bearing base slab is used together with cohesion piles, as in this case, it is important which level the buildings are in relation to the ground surface. This is normally a question which several of disciplines have opinions of, for example architects, land planners and for this foundation type geotechnical engineers. To be able to design an inexpensive foundation works the lowest level of the building, basement or ground floor, should be located at ground surface or deeper. Otherwise, it will cause costly measures. In this project the involved disciplines agreed to a solution favourable from a geotechnical point of view (RF-7, 2012).

At present time it is potential occurrence of lead in the ground. If lead are identified there might be a demand to remediate and excavate soil (RF-4, 2012). If big volumes of masses are removed the soil properties will change and this could have a change in foundation design or method.

To the fact that the project is on hold could have the effect that the project is redesigned to become less expensive to build. This can be done by designing another type of residential house with other material characteristics making it less expensive. Another alternative is to reduce the load making the foundation work less expensive. (RF-5, 2012)

9.3 Tölöbergs Terrass

The project of Tölöberg Terrass is currently, spring 2012, in the beginning of the construction phase. The ground conditions are similar to those at Marconi Park with a fairly large variation in clay depth to bedrock.

As a foundation method a base slab in combination with supporting piles and plinths was recommended. The supporting piles should be used where the depth is larger than five meters. If the depth is less than five meters plinths shall be used instead.

To construct the basement soil excavation was needed, this was done with sheet pile walls to ensure a safe and stable temporary construction (RF-8, 2012). To install a stable sheet pile wall it has to be driven deep enough, thus, the wall is at force- and moment equilibrium. If, for some reason the sheet pile wall cannot be driven deep enough, not generating sufficient restraining pressure alternative measures has to be used.

At Tölöbergs Terrass the sheet pile wall had to be fixed to the bedrock because piles with sufficient length could not be used due to the shallow clay depth to bedrock (RF-8, 2012). The consequence of this was that the work needed to an unwanted standstill where the geotechnical engineers redesigned the work. This was a consequence of lack of prediction in early design stage of the project. The geotechnical programme could have been better performed in order to identify this aspect. If so, the knowledge would have eliminated the interference of a geotechnical survey needed to be done at the site before the excavation work could continue.

Since the area is an old industrial ground which the municipality wanted to transform into a residential area, a new local plan for area was required. This created the opportunity for NCC Housing to influence the municipality when determine the detailed development plan Tölöberg Terrass (RF-1, 2012).

10 Interview evaluation

This chapter summarizes the geotechnical and the project management aspects identified from the interviews. The project management issues are oriented towards relevant matters for geotechnical engineering.

10.1 Geotechnical aspects

This chapter will summarize the geotechnical aspects identified as having a significant effect of the foundation design. A brief description how the ground conditions at the site and the planned construction govern the designed foundation method.

The foundation methods chosen in the projects of the case study are all based on a base slab in combination with piling, see Table 1. The base slab is conventional used to spread the loads, generated by the building, over a larger area. If more ground support is needed the design will include piles. This is commonly used when constructing in areas with a ground profile consisting of clay, like the Gothenburg area.

Table 1. The Table illustrates similarities and differences for the three cases.

	Marconi Park	Åby Stallbacke	Tölöbergs Terrass
Ground conditions	Clay layer varies from 0-20 m thick	Clay layer varies from 50-60 m thick	Clay layer varies from 2-14 m thick
Foundation method	Base slab with supporting piles	Base slab with cohesion and supporting piles	Base slab with supporting piles
Progress	Constructing	Waiting	Constructing
Important aspects	• Change of location between ice-arena and residential area. • Change of garage construction.	• Building level in relation to ground surface. • Comprehensive remediation of soil, change of soil parameters.	An excavation was overlooked in the planning phase, creating standstill in the production phase because of further geotechnical survey.

The parameter that has the largest impact on the type of piles needed for the case studies is the depth to firm bottom, bedrock. Supporting piles are used when the depth is approximately less than 20 meters, see Table 1. By having supporting piles no or negligible differential settlements are developed and therefore negligible deformation. For deeper clays cohesion piles are used.

By having a garage or basement under the construction enables more space for the residents but is also a costly alternative compared to normal parking lots above ground. The total costs for the project are likely to be more expensive with an underground construction but the cost for the foundation is potentially reduced. A garage or basement under any construction demands soil excavations. By removing soil the ground are unloaded which is reducing the effective stresses in the soil. This reduction of effective stresses affects the foundation design and its support, reducing the additional load from the building, reducing the amount of required bearing capacity from piles.

To be able to choose pile design or to design an underground garage, the depth to bedrock is of importance. Based on the case study of this thesis three scenarios can be distinguished, if the clay depth have been observed:

- Shallow depth: approximately less than 3-5 meters, depending on design and new ground elevation.
  - Expensive bedrock excavation needed if constructing underground
  - Supporting piles applied
- Intermediate depth: approximately less than 20 meters
  - Risk of discover bedrock if constructing underground, requiring expensive bedrock excavation
  - Supporting piles applied
- Deeper depth: approximately more than 20 meters
  - Low risk of discover bedrock if constructing underground blasting
  - Cohesion piles applied,

During the early phase of a residential project for a geotechnical engineer the work is being performed in a brief and general way. This is done in order to evaluate the risk of having significantly complex ground conditions, which thereby will cause an expensive foundation. This risk control is performed without having all pieces of information, in the stage of Business development usually small amounts of site specific geotechnical information represents the knowledge. Furthermore; the positioning and design of the planed buildings may be changed within the frames of the detailed development plan during this stage. The building design may differ in number of floors and type of building material used, probably causing changes of the loads affecting the foundation.

10.2 The management of geotechnical working procedure

This chapter will summarize the management aspects identified which have a substantial effect of the foundation design.

The studied projects have been managed by the conventional construction management method, similar to what is described in Chapter 3, from what the authors of this thesis are able to construe. The project is somehow being shaped by the sequential order in which the different experts are being engaged by NCC Housing. The architect is given conditions which follows the detailed development plan, if determined, and the vision that NCC Housing has about the area. The architects create a site plan, a layout of the area, and the appearance of the buildings. Meanwhile the geotechnical engineers are connected to the project and begin to work from their point of view. This situation can cause problems if the architects place the buildings in a way that correlates poorly with the ground conditions, affecting the foundation to become expensive. If a geotechnical engineer was involved in the creation of the detailed development plan this could have been avoided.

The working procedure conducted in the three NCC in-house projects studied in this thesis is similar but due to the fact that every project is unique according to local ground conditions the working procedure is varying some between the projects.

During the phase when NCC Housing has been in charge of a project NCC Housing had a project leader responsible for the project group. The link from NCC Housing to NCC Teknik and its subinstances has been through a representative from NCC Teknik. This person has the responsibility over technical aspects. If, for example, the project group needs more information about possible foundation methods, risk estimations and expert judgements more instances are contacted.

The most distinguished similarities are identified in the early stages of planning held by NCC Housing. In this stage the work focuses on, to identify a profitable business without having access to detailed information about the planned project. NCC Housing is evaluating many parameters and determines rough economic values of income and expenses in the project to be able to make a first prediction of the profitability of the project. If this approximation has a positive outcome this process is being repeated with more information for each repetition. This information is being distributed from the different technical experts involved in the project, for example architects, structural design engineers and geotechnical engineers.

A large part of the land areas which are easy to develop within Gothenburg, according to location, geotechnical and environmental aspects, have already been constructed at. This situation in addition with the fact that the market situation is rather unstable has led to decrease the economic marginal for the residential projects. Therefore, it is becoming more important to reach an accurate budget earlier in the project. This was not the case a few years back in time, when the marginal was higher it was unnecessary with early accurate budgets (RF-1, 2012). At the available sites for development where the geotechnical and environmental aspects might be relatively tough the risks of unpredictable costly measures increases. This implies the importance of having a well-developed working plan and communication flow where people easy can contact and getting further information or contribution to the knowledge in the project.

The management of a project is of great importance; with insufficient management in projects of many involved parts the working procedure normally is affected. Information is not provided and questions concerning several of disciplines cannot be resolved the formal way. If this standstill continues for a long time, the waiting disciplines are feeling the urge to take a decision themself. This is creating decisions which are not established through the project management. It is a risky situation if the project management finally disagree of the taken decision. The scenario is preventing engineers to make creative solutions, because of lack of guidelines.

At Marconi Park NCC developed two properties at the same time. When the precise location of the two objects was determined by NCC Housing and NCC Construction, it was possible to form the detailed development plan according to this. This suggests that if the project management is noticed about the profitability of positioning a construction at a certain location it may be possible to adjust the detailed development plan. In other cases it is possible to develop the detailed development plan in collaboration with the authorities, which was the case for the project Tölöberg Terrass. This creates the opportunity to affect the size, position and type of allowed constructions.

11 Standardized working procedure

Through the information gathered in the case study the authors of this thesis have established working procedure diagrams. This means that the working procedure in this thesis is based on NCC in-house residential projects. This chapter describes the created working procedure, presented and described through the following items:

- **Flowchart: Geotechnical working procedure**, this flowchart represents the activities which are performed by geotechnical personnel in the projects. The flowchart has been made to contain as much relevant information as possible without becoming cluttered. The flowchart contains one activity, design and handling of geotechnical investigation, which constitute a subprocess presented in:
- **Flowchart: Design and handling of geotechnical investigation**, this flowchart present the activities included in the development of a geotechnical survey. This flowchart is covering aspects of geotechnical survey.
- **Description and instruction document**, excluded from this master thesis work this document was established to give further information about the different parts of the geotechnical working procedure. The additional information consists of advice regarding appropriate approaches and references to commonly used material. This document has been created in conjunction with the thesis but as an independent part and is not included in the thesis.

In order to suit the conventional language at NCC in Sweden these items are written in Swedish and translated to English, the full versions can be found in Appendix 2-3.

11.1 Flowchart of geotechnical working procedure

The geotechnical working procedure is a subprocess to the major project process. It is containing a relatively large amount of activities. Therefore, the scheme of the procedure is organised in two dimensions where main activities progress vertically downwards, see Figure 27. An example of one subprocess, horizontal direction in Figure 27 is the design and execution of the geotechnical survey, see chapter 11.2.

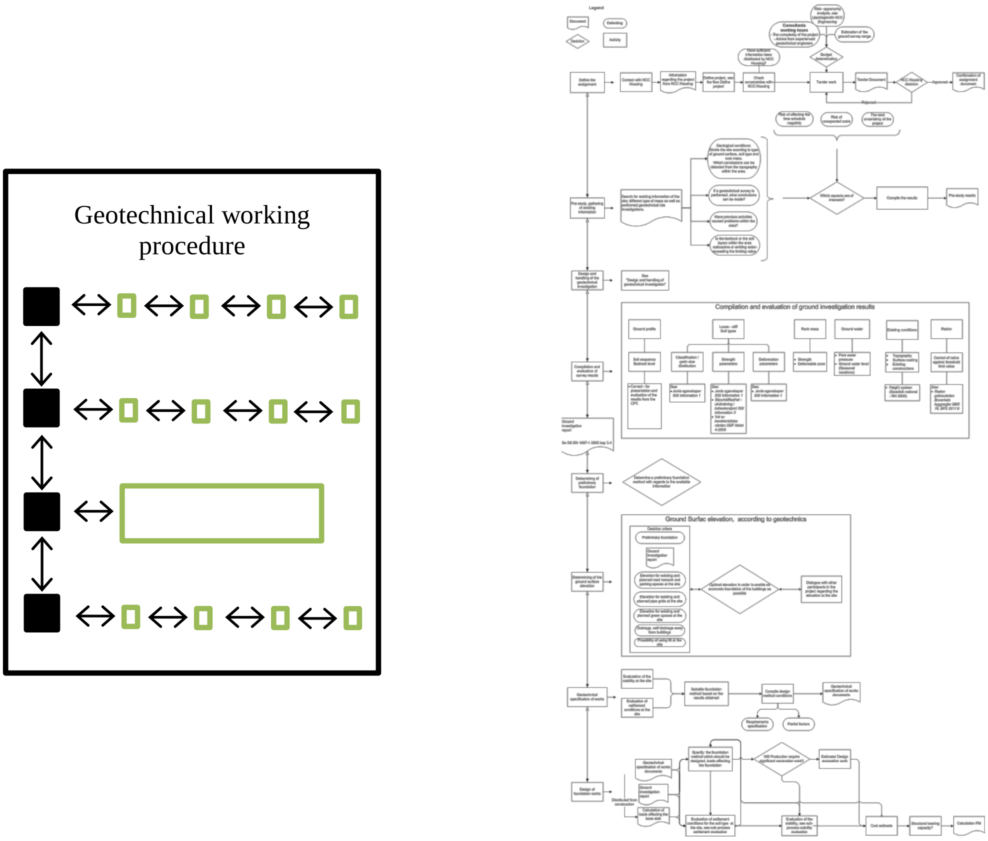

Figure 27. Models of the flowchart: Geotechnical working procedure. To the left a schematic layout of the model is shown and to the right a miniature of the diagram is presented.

The fact that the arrows are pointing in both directions in Figure 27 indicate that the geotechnical working procedure adapts *the conjectural approach*, see chapter 3.3.5. A more common method to illustrate the iterations is to draw a circular workflow. This however requires that you are aware of which activities to iterate around. In the studied projects it is difficult to know exactly in which route iterations are being conducted. This is due to the fact that the total residential project is being developed at the same time as well as complex information sharing between different designs disciplines, and between designers and the client, see chapter 3.3.6. Information is being acquired continuously at different times during the project. Iterations can be done anywhere in the process because of changed conditions or to create more detailed results. Therefore, no stated laps have been used. Also, this layout enables using of the engineers who prefer the linear approach as well.

The main activities in the geotechnical working procedure, from *Define the assignment* to the *Design of the foundation works*, are shown in Figure 28. For the whole model of the working procedure see Appendix 2.

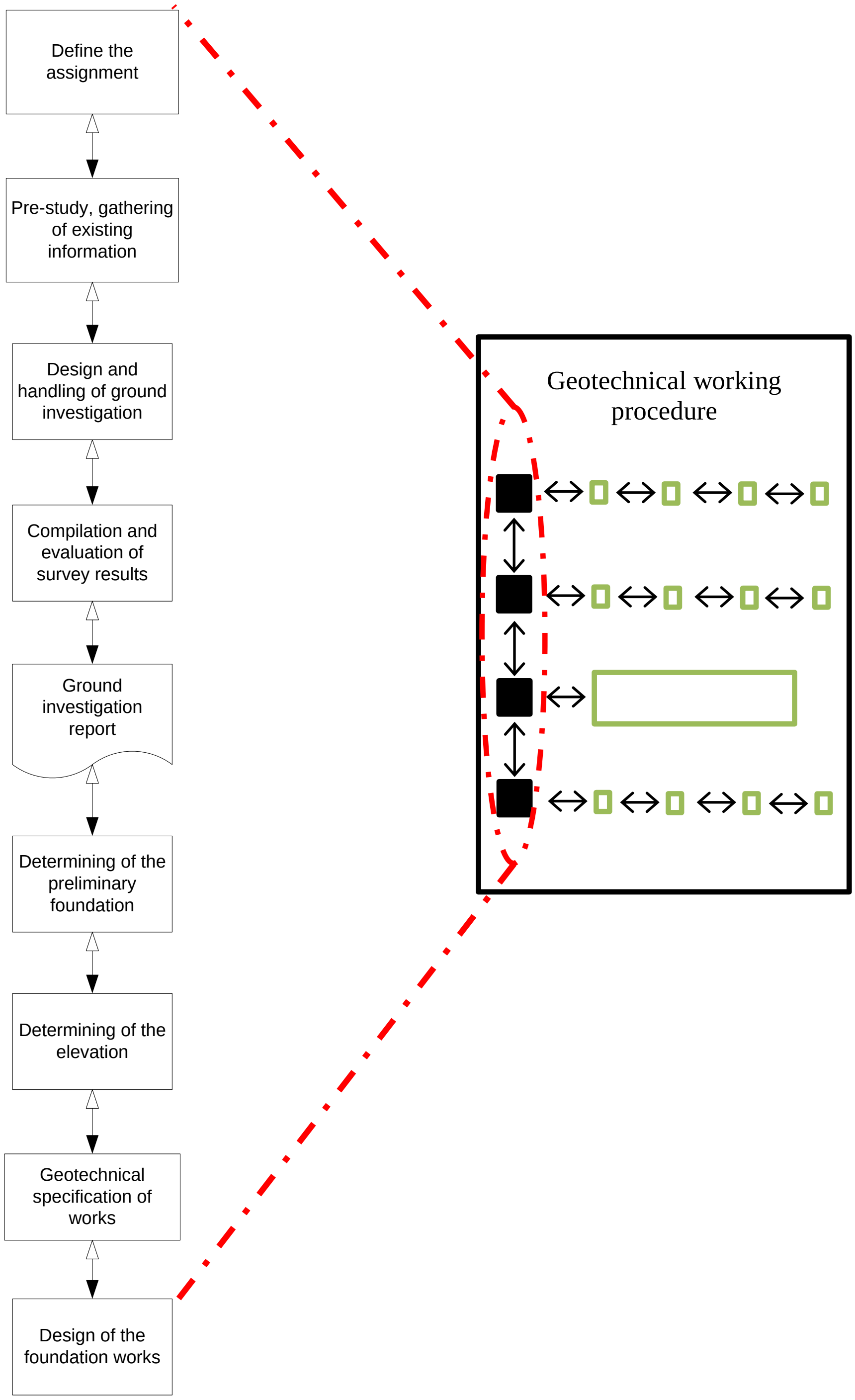

Figure 28. Main activities of the geotechnical working procedure. The figure also describes the context of the total model.

The first two main activities of the working procedure are shown in the Figure 29. The activity which initiates the process is *Define the assignment*, the subprocess connected to this activity begins with communication and obtaining information regarding the project from NCC Housing. These activities are followed by *Define the project* which also composes a subprocess, presented in Appendix 2. This activity is rather important because it aims to define the framework for the geotechnical part of the project. Without a well-specified assignment questions may arise through the whole project, which can influence the workflow negatively. The subprocess *Define the assignment* continues with tender work and to obtain a conformation of the assignment from NCC Housing. The second main activity is *Pre-study, gathering of existing information*. This subprocess addresses typically important aspects which should be assessed during a pre-study. When these aspects are evaluated it may be necessary to set this into relation to risks connected to the project. The results should be summarized, to be used during the planning of the geotechnical ground investigation.

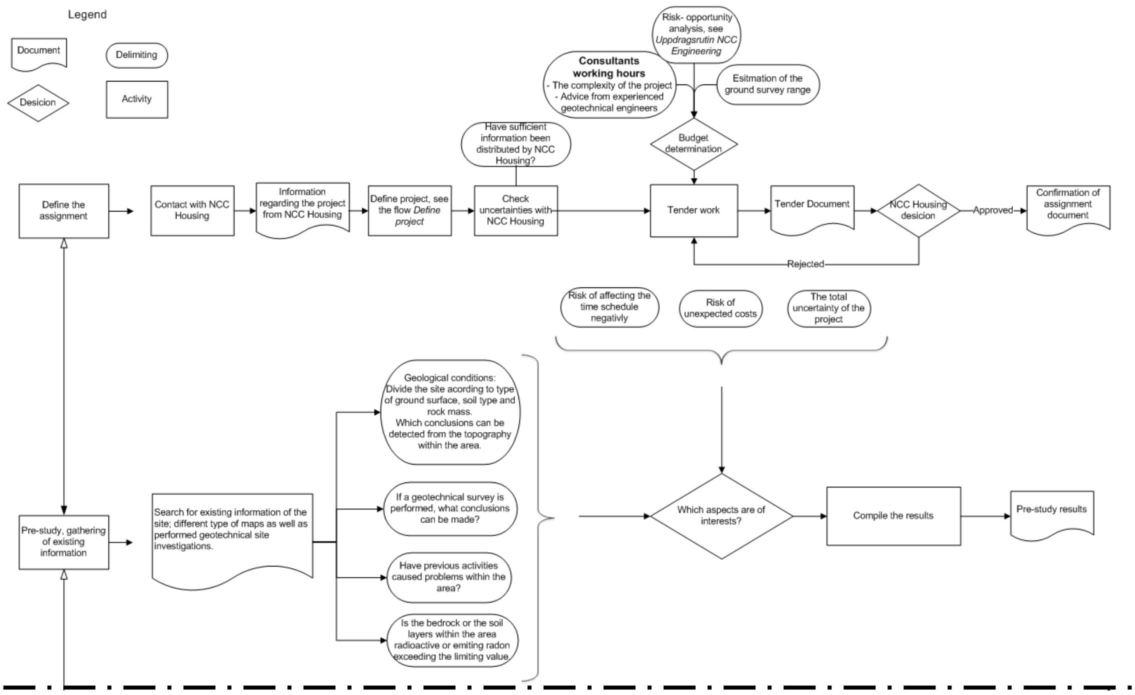

Figure 29. The first two main activities of the geotechnical working procedure; Define the assignment and Pre-study.

The two main activities initiating the working procedure are followed by four main activities presented in Figure 30. The third main activity is *Design and handling of the geotechnical investigation*, which constitutes a subprocess, further described in chapter 11.2. After the geotechnical ground investigation has been performed the results obtained should be compiled and evaluated. In the working procedure aspects and parameters of different materials are provided with addition to relevant information of how to interpret and evaluate the obtained results. The information gathered at this point should be sufficient to compile the *Geotechnical ground investigation report*. When this is done a preliminary foundation method should be determined with regards to the available information about the site.

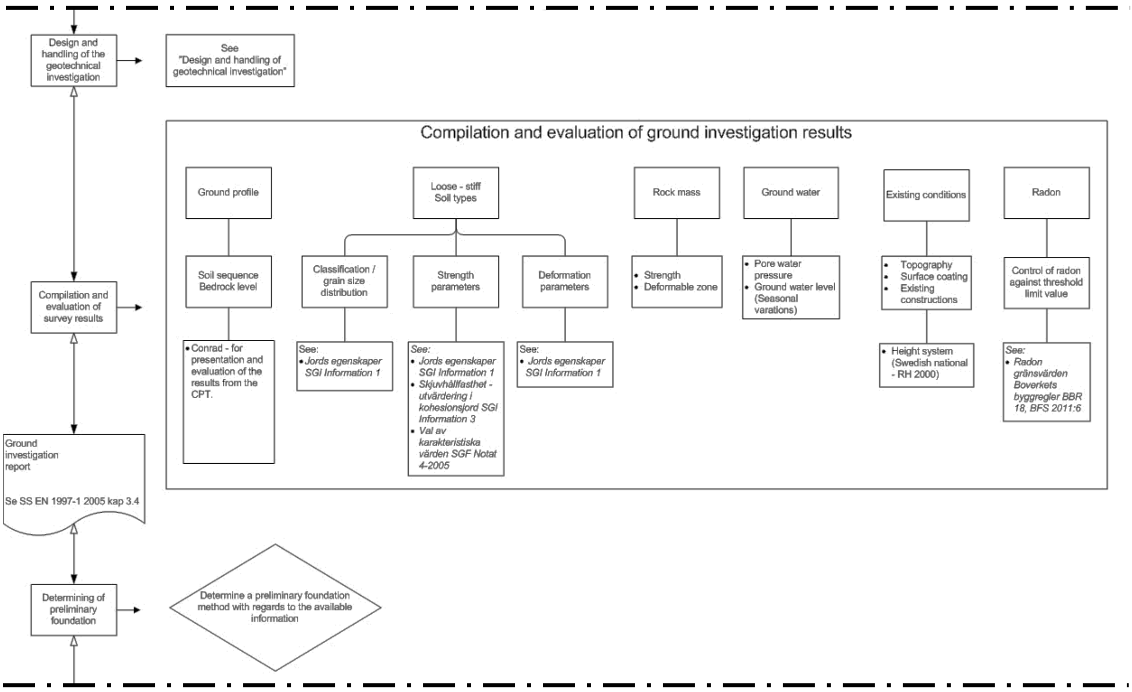

Figure 30. The four main activities following after the initiating two main activities of the geotechnical working procedure.

The three main activities in the end of the working procedure are shown in Figure 31. Following after *Determining of preliminary foundation* is the activity *Determining of the ground surface elevation* which subprocess begins with stating essential decision criteria. This is followed by decision making of the ground elevation according to geotechnical aspects. This should be done with the aim to decide the most optimized solution for the project. A dialogue with the other involved relevant disciplines in this subject should be held to reach the best solution for the total project.

The next step in the working procedure is the main activity *Geotechnical specification of works*, see Figure 31. The subprocess associated to this main activity contains several of aspects that should be covered in the Geotechnical specification of works documents. This includes evaluation of the stability and settlement conditions at the site. When this is done an update the preliminary foundation method should be performed, so that the foundation method is corresponding with the new information obtained. For the chosen foundation method the required design conditions should be determined. This information should be summarized in the Geotechnical specifications of work documents. The information from these documents is relevant for several of disciplines, structural design engineers, architects and land planner. Therefore, a good dialogue with these disciplines is usually important in order to allow an efficient project process.

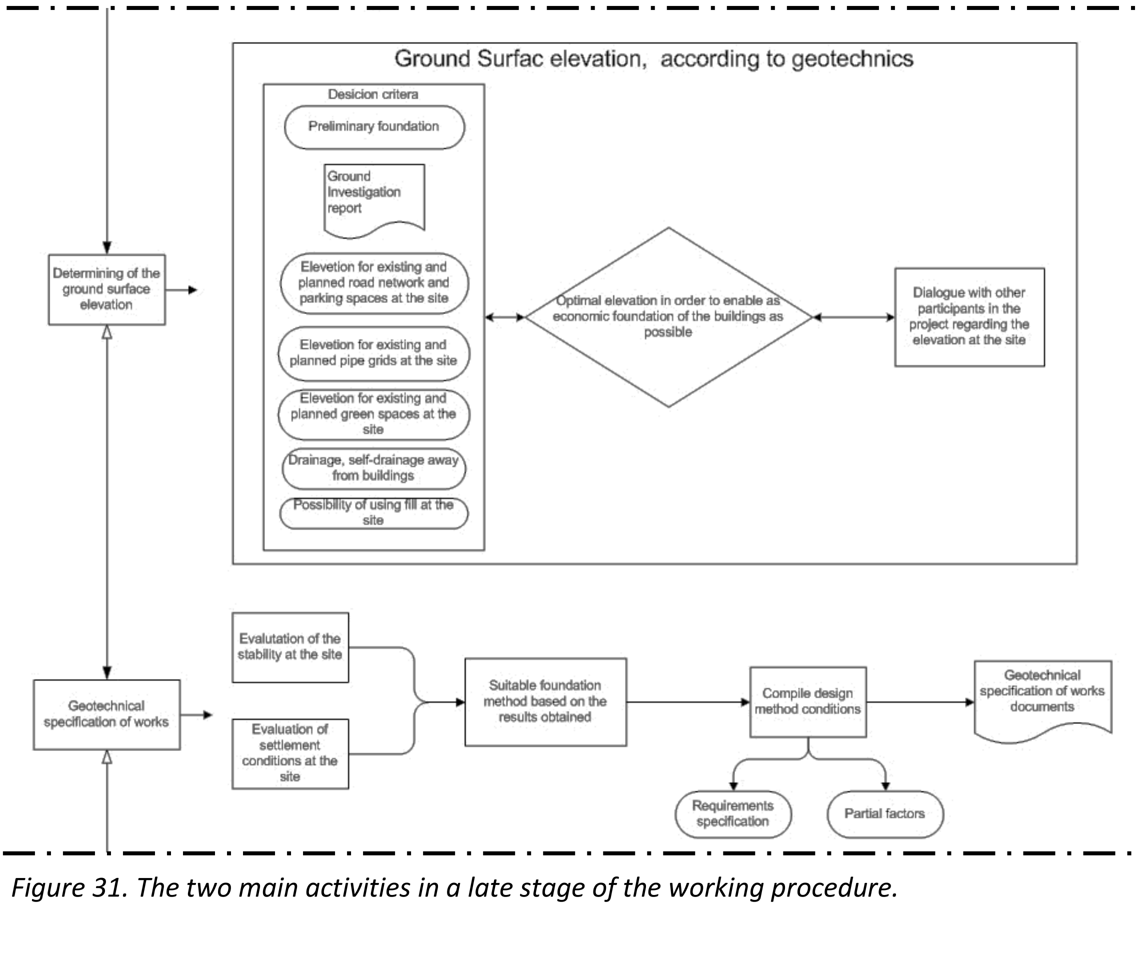

Figure 31. The two main activities in a late stage of the working procedure.

The main activity which completes the working procedure is *Design of foundation works*, see Figure 31. The subprocess to the main activity *Design of foundation works* is initiated by specifying what type of foundation that should be designed and the loads affecting the structure. The next step in the working procedure is to evaluate if the results obtained requires retaining structures in the production phase. Following after this are the evaluations of the settlement and the stability of the site. The stability evaluation comprises the total site stability and the stability of the foundation works. It is also important to make an estimation of the stability for the required retaining structures during the production phase and how this adopts to the geology at the site. When this is done a cost estimation of the foundation works design and required measures should be done. From the cost estimation it is possible to evaluate the economic situation of the project, if the foundation works becomes too expensive.

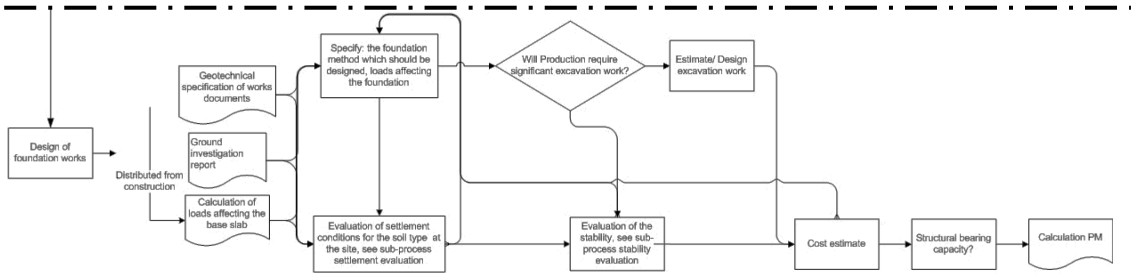

Figure 32. The last main activity of the working procedure, Design of foundation works.

11.2 Flowchart of design and handling of the geotechnical investigation

In the geotechnical working procedure the main activity *Design and handling of the geotechnical investigation* is included, containing numerous tasks forming a subprocess. This process has been modelled in this thesis as an iterative process with a predefined "lap", see Figure 33. This is due to the fact that the process usually contains the same steps in a similar sequence. A brief summary of the containing tasks in the process are presented in this chapter, for the total flowchart see Appendix 3.

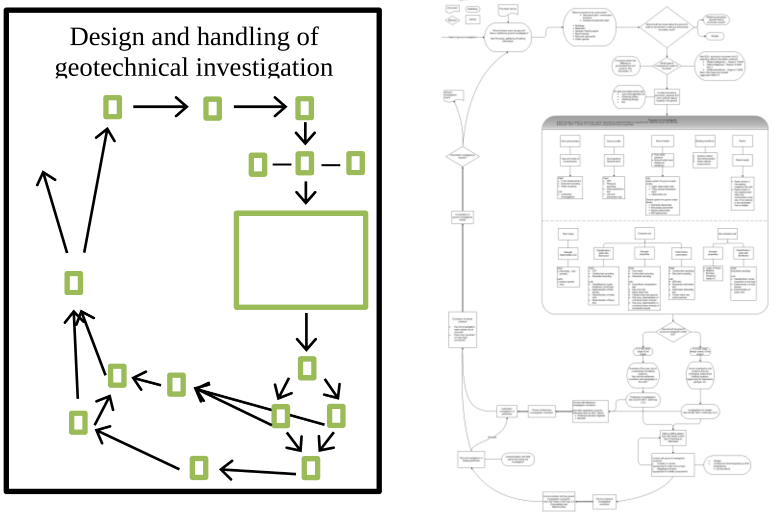

Figure 33. Models of the flowchart: Design and handling of the geotechnical investigation. To the left a schematic layout of the model is shown and to the right a miniature of the diagram is presented.

The first section of the flowchart *Design and handling of geotechnical investigation* is presented in the Figure 34. The first task in the process is to compile the existing knowledge about the geotechnical aspects of the site. The next step is to evaluate which kind of information that is required to be able to give recommendations and performing the design of the foundation works. From these findings it is possible to design the geotechnical investigation. When the survey programme is designed the execution phase needs to be prepared. This includes purchasing of the ground survey and laboratory services as well as communicating the programme to the operational personnel. After the survey is carried out the information is compiled and documented in the ground investigation report.

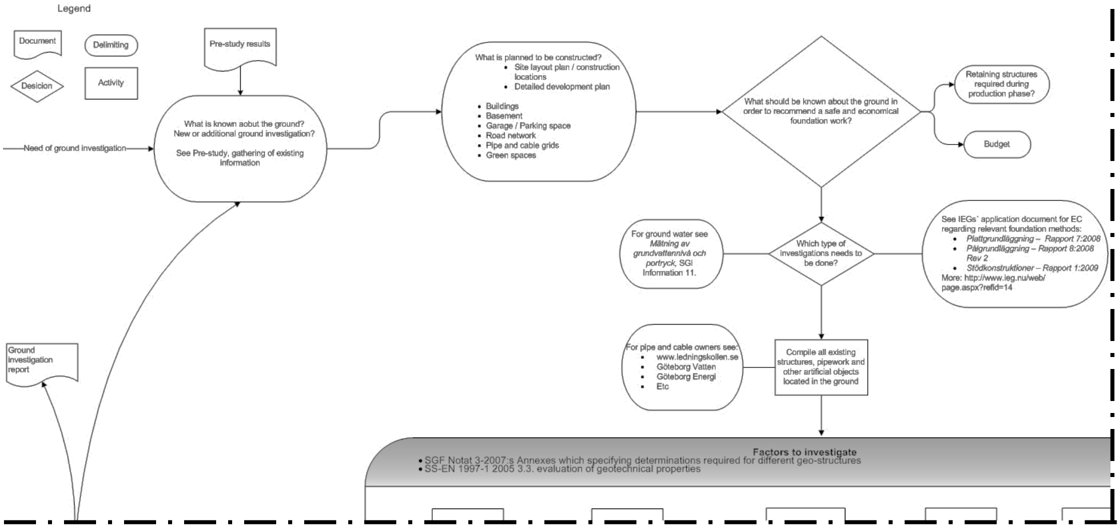

Figure 34. The upper part of the subprocess Design and handling of the geotechnical ground investigation flowchart.

12 Conclusions

We propose a project process in which relevant actors in the early stage of a project exchange ideas frequently, in order to reduce the number of mistakes and find the most beneficial solution for the entire project. These ideas are primarily adapted for larger residential projects. In practice, meeting should be held between disciplines before they have started their individual work of the project, called *Start-up meeting* in this thesis, with addition of *Follow-up meetings*. The meetings shall be multi-disciplinary and discuss major questions of great importance of the total project. We recommend that the following type of personnel shall attend the meeting:

- Project leader of the client - NCC Housing
- Responsible architect
- Responsible geotechnical engineer
- Responsible structural designer
- Project-coordinator, with production experience

Although, other disciplines may be needed depending on which project phase the meeting is held during as well as the complexity of the project.

At the start-up meeting a project-coordinator is leading the multi-disciplinary work to enhance the interdisciplinary communication and understanding. The project-coordinator shall have the knowledge and experience from the production phase. The technical expertise areas should be represented by the responsible personnel at the meetings. This is essential for each expertise area to be able to provide direct feedback of issues instead of being asked specific questions by a project leader or project coordinator.

As mentioned earlier, the questions which should be discussed during the meetings are of wide character, concerning the total project. Questions which are deals with several of areas of competence can have a large effect of profitability of the project and should, therefore, be discussed with the responsible personnel. The questions should be of the kind stated in chapter 3.3.2 Draft document phase. From a geotechnical point of view these questions can be:

- Which type of buildings can be constructed at the site depending on foundation method? Evaluate the risk of having significantly complex ground conditions.
- Are any areas at the site preferable for heavy constructions? If it is possible to impact the detail development plan, this could be very important.
- Is it appropriate to place garages underground, to which costs? Evaluate the risk of having expensive bedrock excavation.

The described ideas correlate with some aspects contained in the concept NCC Project Studio.

In align with this it is of importance to have a standardized working procedure of the activities and tasks that should be performed during a project. If all the involved persons of the different disciplines have the same working procedure everyone will know what the others are supposed to do. This type of process control would prevent the disciplines from doing unnecessary, waste, activities. The chain of command wold also be stated preventing decisions to be taken incorrectly.

13 Discussion

The working procedures of the NCC in-house projects which are studied in this thesis have common and divergent conditions. The working procedure described is of a general character, not project specified. It is desirable for NCC to have a pre-set working procedure in order to handle large amount of geotechnical information in an organised and effective way, while fulfilling actual standards and regulations. An essential factor of the geotechnical work is that it is required to be in alignment with the client’s total working process and other involved disciplines. Because of the large variation in these aspects between the projects there has been a challenge for us to include it in the report.

In this thesis we have studied three projects by interviewing several of personnel involved. It is important to notice that the result is not likely to be representative for all projects or personnel at NCC. We think that the result provided in this thesis can be used as an indication of the situation and as a foundation for further standardizing of geotechnical work.

There is a risk that project leaders tend to see the initial costs of start-up meetings and missing out to see how it can affect the total budget for the project. This is understandable because this approach is rather unproven. The goal is to make needed changes in early stages where the related costs are low rather than late changes that are costly. If this should benefit the total projects economic outcome these savings should be larger than the required extra effort in the beginning of the project. It is up the client to the client to be brave enough to implement this in pilot projects. Our perception is that the effort spent in the beginning of the project will pay off in the end if it is done in an efficient manner.

The risk when implementing the concept of start-up meetings is that resources, personnel and time, are used in an ineffective manner. The meetings should be kept as brief as possible with the right type of personnel present, dealing with important project related questions. To be able to make this as efficient as possible follow-ups whit feedback needs to be done after every project. Furthermore, it is hard to say that the total project process is benefiting from the studio approach where the disciplines should sit together in one large room during the project. It may be the coincidence that people overhear what people are saying and begins to reflect about that aspect. Even though, the coincidence may be higher because of more chatting in one room. This is one aspect as well, as people work differently, some people perform good in such environment while others need quietness in order to produce.

The project-coordinator and project leader can be the same person, but we recommend that the disciplines should be separated. Where, the most important work for the coordinator is to lead the multi-disciplinary work to enhance the interdisciplinary communication and understanding between disciplines and phases. A condition of is that the project-coordinator has the knowledge and experience from production phase to bring this aspect in the *Design phase*. While the project leader has the task to lead the entire project, be in charge of administration and dealing with a wide range of aspects of the project.

The flowcharts, *Geotechnical working procedure* and *Design and handling of geotechnical investigation*, need some adjustment in order to be applied for different types of projects than residential projects. If the flowcharts shall be used for other regions than Gothenburg the chart the flowcharts need to be changed according to local geology.

References

Ballard, G. H., 2000. *Leanconstruction.* [Online]
Available at: http://www.leanconstruction.org/lpds.htm
[Accessed 22 05 2012].

Bergdahl, U., Ottosson, E. & Stigsson, B., 1993. *Plattgrundläggning.* Linköpig: Statens geotekniska institut .

Boverket, 2012. *Myndigheten för samhällsplanering, byggande och boende.* [Online]
Available at: http://www.boverket.se/Bygga--forvalta/Bygg--och-konstruktionsregler-ESK/Konstruktionsregler-EKS/
[Accessed 16 May 2012].

C2P2ai/SPDC, R. T., 2008. *C2P2ai/SPDC Research Team.* [Online]
Available at: https://www.msu.edu/~tariq/C2P2AI_LeanConstruction_WhitePaper.pdf
[Accessed 21 May 2012].

Dennis, P., 2007. *Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System, 2nd Edition.* s.l.:Productivity Press.

Google, 2012. *Google Maps.* [Online]
Available at: http://www.maps.google.se
[Accessed 11 May 2012].

Harrington, H. J., Esseling, . E. K. & van Nimwegen, H., 1997. *Business Process Improvement Workbook.* s.l.:McGraw-Hill.

HERCULES Grundläggning AB, 2012. *Om Hercules.* [Online]
Available at:
http://www.hercules.se/templates/GenericPage____5114.aspx?T=TOPNAV
[Accessed 28 May 2012].

Hitta.se, 2012. *Hitta.se.* [Online]
Available at: http://www.hitta.se/karta
[Accessed 11 May 2012].

ISO, International Organization for Standardization, n.d. *International Standards for Business, Government and Society.* [Online]
Available at: http://www.iso.org/iso/about/discover-iso_what-standards-do.htm
[Accessed 12 May 2012].

Koskela, L., 1992. *Application of the new production philosophy to construction,* s.l.: Stanford university.

Koskela, L., 2000. *An exploration towards a production theory and its application to construction,* Finland: Valtion teknillinen turkimuskeskus (VTT).

MacLeamy, P., 2004. *MacLeamy Graph,* u.a: u.a.

MacLeamy, P., 2011. *MacLeamy Graph.* [Online]
Available at: http://www.nzarchitecture.com
[Accessed 2 June 2012].

NCC AB, 2011. *Om NCC/"About NCC".* [Online]
Available at: http://www.ncc.se/sv/OM-NCC/NCC-koncernen/Marknad-och-konkurrenter/Om-vara-konkurrenter/
[Accessed 16 03 2012].

NCC AB, 2012. *Vår organisation.* [Online]
Available at: http://www.ncc.se/sv/OM-NCC/NCC-koncernen/Organisation1/
[Accessed 07 03 2012].

NCC Construction Sverige, 2010. *Verksamhetssystem.* [Online]
Available at: http://verksamhetssystem.ncc.se/
[Accessed 12 April 2012].

NCC Starnet, 2012. *NCC Projektstudios.* [Online]
Available at:
http://starnet.ncc.se/templates/ContentPage.aspx?id=90716&epslanguage=sv
[Accessed 08 May 2012].

NCC Teknik, 2007. *Geoteknisk undersökning Järnbrott- Marconigatan,* Göteborg: NCC Boende.

NCC Teknik, 2007. *Geoteknisk utredning -Projekteringsunderlag Järnbrott marconigatan,* Göteborg: NCC Boende.

NCC Teknik, 2011. *Geotekniskt projekteringsunderlag - Hus 7 och hus 8,* Göteborg: NCC Construction Sverige AB, NCC Teknik.

NCC Teknik, 2012. *Geotekniskt Projekteringsunderlag -Tölöbergs Terrass,* Göteborg: NCC Boende Väst.

Nordstrand, U., 2008. *Byggprocessen.* s.l.:Liber.

Olsson, H. & Sörensen, S., 2007. *Forskningsprocessen - kvalitativa och kvantitativa perspektiv.* Stockholm: Liber.

Patel, R. & Davidsson, B., 2003. *Forskningsmetodikens grunder.* Lund: Studentlitteratur.

Per-Erik Josephson, L. S., 2005. *Slöseri i byggprojekt, Behov av förändrat synsätt,* Göteborg: FoU-Väst.

RF-10, 2012. [Interview] (08 May 2012).

RF-1, 2012. [Interview] (06 04 2012).

RF-2, 2012. [Interview] (2 February 2012).

RF-3, 2012. [Interview] (24 April 2012).

RF-4, 2012. [Interview] (29 Mars 2012).

RF-5, 2012. [Interview] (23 May 2012).

RF-6, 2012. [Interview] (21 February 2012).

RF-7, 2012. [Interview] (13 Februari 2012).

RF-8, 2012. [Interview] (26 Mars 2012).

RF-9, 2012. [Interview] (29 Mars 2012).

SIS, Swedish Standards Institute, 2011. *SIS.* [Online]
Available at: http://www.sis.se/en/content/about-sis/The-world-needs-SIS/
[Accessed 23 May 2012].

Skredkommissionen -Commission on slope stability, 1995. *Anvisningar för släntstabilitetsutredningar Rapport 3:95,* Linköping: Statens geotekniska institut.

Swedish Institute Standards, S., n.d. *Swedish Standards Institute.* [Online] Available at: http://www.sis.se/tema/eurokoder/ndp/

SWEDISH STANDARDS INSTITUTE, 2009.a. *SVENSK STANDARD SS-EN 1997-1:2005 Eurocode 7: Geotechnical design- Part 1:General rules,* Stockholm: SIS Förlag AB.

W. Halpin, D. & A. Senior, B., 2011. *Construction management, fourth edition.* Jersey City: John Wiley & Sons.

Winch, G. M., 2007. *Managing construction projects.* Malden: Blackwell Science Ltd..

Appendix 1 – Interview questionnaires

There are essentially two different questionnaires that have been used in the oral interviews. This depends on subject area and the area in which the interviewees are working within, "*1 Technical competence*" and"*2 Project management*". Please note that project-specific parameters are marked with *. The interviews have been performed in Swedish.

Interview questionnaire: 1 Technical competence

Projektprocessen

1. Beställarsituation
   1.1. Hur ser beställarsituationen ut?
   1.2. I början av projekten är det boende som är beställare, när gick det sedan över till Construction?
   1.3. Hur tycker geo att projektledningen fungerar, är ansvarsfördelningen tydlig?
   1.4. Om inte; i så fall när i processen?
   1.5. Hur fungerade dialogen med boende när de upphandlade geoarbetet?
2. I ”Förslag uppdragsbekräftelse” står det att projektet utfördes med ett rörligt arvode med budget * kr, stämmer detta?
3. En allmän fråga: Hur fungerar det med avsikt på de olika skedena i projektet, affärsutveckling, projektutveckling. I början av projekten, affärsutvecklingsskedet, vill geo skapa sig en uppfattning om tomten som är aktuell. Genom en lite mer översiktlig undersökning eftersom ni vet av erfarenhet att byggnadslägen och tomtutformning mycket väl kan ändras i detta skede?
4. Görs det i detta skede en utvärdering och ett ”överskattat” rekommenderat grundläggningsförslag? Vilket Boende ser och blir fundersamma över hög grundläggningskostnad?
   4.1. Vid upprättandet av uppdragsbekräftelsen, fanns det behov eller utrymme att övertyga beställare om varför vissa undersökningar eller konsulttimmar behövs?
   4.2. Eller resonerar ni så att vi får be om mer pengar när vi har något konkret som vi behöver undersöka?
   4.3. Ändringsarbeten
      4.3.1. Preliminär grundläggningsmetod:
      4.3.2. Skedde några ändringsarbeten som hade stor betydelse för den geotekniska utformningen?
      4.3.3. Vilken typ (t ex byggnadsförflyttningar, total omplanering av tomten). När i processen?
      4.3.4. Skedde det någon dialog från beställare (boende) om angivna förändringar. När i processen?
5. Gäller detta även gentemot konstruktion?
6. Projektledning
   6.1. Har det varit regelbundna möten med de olika teknikområdena?
   6.2. Olika ofta i projektet

6.3. Vem har haft ansvaret för möten?
6.4. Generell uppfattning av dessa
6.5. I vilken del av projekteringen har dessa ägt rum?
6.6. Samverkan mellan avdelningar
6.6.1. När grundläggningen är dimensionerad med hänsyn till den geotekniska bärförmågan lämnas den i många fall vidare till Hercules för dimensionering av den strukturella bärförmågan, hur ser geo på kommunikationen i detta skede?
6.6.2. Fick Hercules ansvaret för grundläggningens strukturella bärförmåga i det här projektet?
6.6.2.1. Varför eller varför inte?
6.6.3. Sitter någon från teknik med på de styrgruppsmöten som finns för samverkansprojekt?

Markundersökning

Förklaring: Arbetet med att planera och utföra provtagning och dokumentation och att fastställa markegenskaper.

1. Vad vet vi om marken från förundersökning?
2. Vilken typ av information saknades och eftersöktes?
3. Erhölls den typ av information som efterfrågades eller beställts?
3.1. Om inte, varför då? Fel provtagningsteknik eller bristfällig utrustning alernativ kunskap? (hört om jordberg sonderingar som inte visat utförts korrekt på grund av felaktig utrustning)
3.2. Provtagningsmetod
3.2.1. JB, Kolv, vinge, portryck etc.
3.2.2. Till vilken hjälp var den förkunskap (t ex från förundersökning) som du hade när du bestämde vilka provtagningsmetoder som skulle användas?

Borrplan:

1. Hur bestämdes borr och provtagnings- planen?
1.1. Provtagningshål densitet/frekvens
1.2. Metod
2. Ekonomisk kostnad
2.1. Budgeterad markundersökningskostnad → *kr, labbförsök → * kr
2.1.1. Fältundersökningar och labb
2.2. Borrplan och provtagningsschema satt av 1 eller 2 personer?
2.3. Faktisk kostnad
2.4. Hur väl stämde budgeten?
2.4.1. Om budgeten var för snålt tilltagen: Skulle en ökad budget ge bättre svar på den information som eftersöks, i vilken mån?
2.4.2. Om JA: Skulle det ökade medlen lagts på en meromfattande fältundersökning eller på fler konsulttimmar för en bättre utvärdering av provresultaten eller bättra val av provpunkter.

2.4.3. Om NEJ: Varför inte?

3. Skulle det avsättas mer pengar om det efterfrågades?
    3.1. Internfakturering – Vilken avdelning gjorde beställningen
        3.1.1. Anlitades underkonsulter:
            3.1.1.1. Om JA: För vilka delar och varför: resurs- eller kapacitetsbrist

Framtagande av projekteringsunderlag

1. Tabellen visar ekonomiuppgifterna från uppdragssystemet, hur väl stämmer dessa uppgifter?
    1.1. Arbetades det mer? Går det att uppskatta i timmar?
2. Budgeterad
    2.1. Vilka geotekniker var inblandade och hur såg deras timfördelning ut dem emellan?
        2.1.1. Fördelning: upprättande av rapport och granskning
    2.2. Jämförelseprojekt eller schablonvärde
3. Faktisk kostnad
    3.1. Internfakturering – Vilken avdelning gjorde beställningen
        3.1.1. Anlitades underkonsulter:
            3.1.1.1.1. Om JA: För vilka delar och varför: resurs- eller kapacitetsbrist

4. Tidsaspekter
    4.1. Projekthändelser
    4.2. Kritiska aktiviteter eller gates
    4.3. Höjdsättning
        4.3.1. Är detta gjort i samband med övriga teknikområden. Exempelvis väg, anläggning VA etc?
        4.3.2. När i processen sattes den preliminära och hur mycket ändrades den efter hand? Vilka aktiviteter eller processer förvårade mest för geo med avseende på grundläggning.
5. Ändringsarbeten
    5.1. Slutgiltig grundläggningsmetod:
    5.2. Påverkades den slutgiltiga grundläggningsmetoden av ändringsarbeten?
        5.2.1. I så fall vilka?
        5.2.2. Skedde det någon dialog från beställare om angivna förändringar?
6. Samverkan mellan avdelningar
    6.1. Vilken är den generella uppfattningen av sammarbetet mellan GEO och Hercules i denna fas (om Hercules fick jobbet tidigare i projekteringen)?
    6.2. På samma sätt, sammarbetet mellan GEO och Construction.

Interview questionnaire: 2 Project management

Projektledning

1. Projektförlopp
   1.1. Vilken ”gate” var det som gjorde att ni på Boende tog första kontakten med geo i projektet *?
      1.1.1. Fall där geo har varit inblandade i miljöutredning av fastigheten
      1.1.2. Fall där geo inte varit inblandade
   1.2. Vilken information får geo av er i detta tidiga skede, allt tillgängligt material om maken, ritningar på tänkt utformning av tomten alternativa lösningar?
   1.3. I vilket skede görs geoteknikarbetet under det totala projektförloppet? Under affärsutveckling, svårt att definiera noggrannare än så, Se 1.
   1.4. Tidsmässigt så är det förhållandevis lång tid från början av affärsutveckling till början av projektering, är geoteknikarbetet beroende av andra deadlines?
2. Övergången till Construction
   2.1. Enligt ORGANISATIONSMODELL SAMVERKANSPROJEKT Projekteringsgrupp (Förslags- och Huvudhandlingsskedet) så tillsätts en projekteringsledare från Construction, fungerar det så vanligtvis? Om inte; vilka andra avdelningar representeras med fördel?
3. Ekonomi Budgeterad kostnad: *kr
   3.1. För att möjliggöra en förmånlig grundläggning rent ekonomiskt, krävs ett detaljerat geoteknikarbete. Hur upplever ni diskussionen med geoteknikerna angående den geotekniska utredningens omfattning och relevans. Exempelvis antalet timmar samt undersöknings metoder? Det vill säga den avsatta budgeten för uppdraget.
   3.2. Vad vi har förstått så vill ni gärna ha fast pris på geoarbetet/markundersökningarna? Varför inte löpande fakturering med tanke på att det finns ett ömsesidigt vinstintresse i dessa in-house projekt?
   3.3. Efter en uppskattad budget av geo-avdelningen skulle en löpanderäkning upprättas med regelbunden avstämning.
   3.4. Resonemang om omfattning av markundersökning och kostnadsuppskattning av grundläggningskostnader för projektet.
   3.5. Projektoptimeringen ska enligt samverkansdokumentet ske ur såväl kundnytta som ekonomiskt och tekniskt perspektiv. Har du varit med på dessa styrgruppsmöten? Vilka ingår i denna styrgrupp?
4. Ändringsarbeten
   4.1. När ni från Boende kommer fram till att utformningen av tomter, främst huslägen, behöver förändras så är geo ett av de teknikområden som påverkas markant. Hur hanteras detta från Boendes sida, får geo information om förändringar av huslägen som ni har börjat undersöka?
5. Markförhållanden
   5.1. Det finns en checklista ”MARK- OCH MILJÖUTREDNING” som behandlar då ganska kortfattat några geofrågor. Används denna, när i så fall?

5.2. Vem är det som utvärderar dessa frågor och svarar på detta? Det vill säga kompetensnivå och detaljnivå i beskrivning och svar.
5.3. Vi förstår att det är ett behov av korta och koncisa frågor, dock är dessa förhållandevis subjektiva eller finns det definitioner till dessa?