CHALMERS


# Architecture and engineering in the conceptual phase of building projects

*Master of Science Thesis in the Master's Programme Structural Engineering and Building Technology*

STEFAN NYSTRÖM

Department of Civil and Environmental Engineering
*Division of Structural Engineering*
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ABSTRACT

One of the early phases in the construction process is the conceptual phase, where ideas are tested and preliminary design is performed. When the working procedure is clear, smaller and bigger problems can be dealt with, and in this early phase it is still easy to make changes. The information collected and developed will serve as input for subsequent phases.

Skanska of today has mapped the phases following the conceptual phase and has come up with a process map, which they intend to follow. For the conceptual phase there are many different suggestions on how to work and there is a need for a clear structure.

The aim of this project was to map the conceptual phase of the process, to find a perhaps more unified working procedure. It focused on the information needed for architects and engineers at Skanska's engineering consultant department. The department of project development also contributed with a description of how to work in the early stages.

When mapping a process, different methods could be used, and this project's choice fell on a combination of iterations built on discussions with staff, research and theory from literature.

Results of the project were a proposal of a process map to follow and a suggested approach for further development.

Key words: process map, conceptual phase, construction, architecture and engineering

Arkitektur och teknik i den konceptuella fasen av byggnadsprojekt

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## SAMMANFATTNING

En av de tidiga faserna i byggprocessen är den konceptuella fasen, där idéer testas och preliminär design görs. När arbetssättet är tydligt kan mindre och större problem hanteras och i denna tidiga fas är det fortfarande lätt att göra ändringar. Den information som samlas in och utvecklas kommer att fungera som en ingång till senare faser.

Skanska har idag kartlagt faserna efter den konceptuella fasen och har tagit fram en processkarta som de har för avsikt att följa. För den konceptuella fasen finns många olika förslag på arbetssätt och det finns ett behov av en tydlig struktur.

Syftet med detta projekt var att kartlägga den konceptuella fasen i processen för att hitta ett något mer enhetligt arbetssätt. Fokus låg på den information som behövs för arkitekter och ingenjörer vid Skanskas teknikkonsultavdelning. Avdelningen för bostadsutveckling bidrog med en beskrivning av hur man arbetar i ett tidigt skede.

När man kartlägger en process kan olika metoder användas och det här projektets val föll på en kombination av iterationer som byggde på diskussioner med medarbetare, undersökningar och teori från litteraturen.

Resultatet av projektet blev ett förslag till en processkarta att jobba efter och en föreslagen ansats för fortsatt utveckling.

Nyckelord: processkarta, konceptuell fas, byggprocess, arkitektur och teknik

# Contents

# Preface

This project has been carried out at Skanska during the spring 2014. It has been performed within the Master's Programme Structural Engineering and Building Technology at Chalmers University of Technology at the Department of Civil and Environmental Engineering.

I would like to express my gratitude to my supervisor and examiner Björn Engström, Professor/Vice Head of Department, Civil and Environmental Engineering, Structural Engineering, at Chalmers. He has fully supported this project from the start and given feedback when needed. I would also like to thank my supervisor Helena Burstrand Knutsson at Skanska for full support and showing the need for the project. The key persons for surveys and discussions at the engineering consultant department at Skanska also provided me with a wide range of knowledge and good spirit.

Finally, this thesis is performed as the conclusion of five years of study at Chalmers, which would have been impossible without the support from my family,

*Victoria*

*Siri, Alva and John*

Göteborg June 2014

Stefan Nyström

# 1 Introduction

## 1.1 Background

A process can be described as a collection of structured activities, producing a specific service for a particular customer. By dividing the whole process into phases, different issues can be dealt with along the timeline. These all contribute to the process as a whole. When preparation, planning and design are made for buildings, the process is called building construction. Typical phases of that process are, chronologically: formulation of a program, procurement, project management and production management. Within project management are the conceptual phase, followed by the general design phase and the detailed design phase. By having the work well organised and making it easy to apply changes, work performed in the conceptual phase should make it easy to find a design solution. Then the work can continue in next phase and go into details.

Skanska has developed a process map for the general design phase and the detailed design phase. Specific maps, with descriptions of actions along a timeline, can be found for every discipline, e.g. for the architects and the engineers, and with documents supporting the proposed actions. For making an input for these phases a wide understanding between the professions is needed. In this early design, or conceptual, phase there is today a lack in understanding of how the process should be structured and organised. There clearly is a need to investigate what information is needed when working in early design, how to develop it and, finally, how to communicate it as an input for the next stage.

## 1.2 Purpose

The purpose of this project was to develop a process map to follow when working in the conceptual phase. The project should be based on process models from literature and a formulation of the information needed between architects and engineers in the conceptual phase.

This project should propose a working method for the conceptual phase, with respect to the information that would be needed for the following phase. By using process maps in conceptual design, the different professions should be able to define the process together and use the outcome when communicating with others. The overall requirements were:

- A clear description of what should be done
- A structured way of working

## 1.3 Scope

In the engineering consultant department of Skanska, both architects and engineers can be found and in this project the architects approach should be most thoroughly investigated. Structural engineers, building physics engineers and architects should take part in surveys concerning the possible need of more interaction between professions.

Besides empirical facts, literature sources should be taken into account for the project. These should be selected among what are most used and referred to by other Swedish companies and organisations.

## 1.4 Method

A literature study should be carried out to get a deeper understanding of process management. The literature should be searched in books, in scientific articles and on web pages of companies and organisations, whose references in the subject were to be studied.

From the literature studies, information should be given on how to understand the process and where the conceptual phase would fit. By using tools from literature for analysing the process, it should be possible to present a way of how to map an on-going process in the investigated company.

By reviewing internal documents, having discussions with co-workers and having surveys sent to key persons, a mapping of Skanska's engineering consultant department's process work during the conceptual phase should be carried out. The surveys should be made to investigate the possible need for interaction between disciplines in an early design phase. Iterations of this project's process map had to be checked with co-workers of different departments and be compared to existing support documents describing how to work.

Based on the method of process mapping retrieved from literature, it should also be possible to make some suggestions for further development.

# 2 The conceptual phase

The process of adding structure to real property is called building construction. In the development projects Skanska is both owner and building contractor and also supplier. This way of working is referred to as design-build, where one single company can handle both design and construction services, Wikipedia (2014).

## 2.1 Timeline of a process

The construction process consists of different phases. Typical phases are, as presented in Section 1.1: formulation of the program, procurement, project management and production management, The Project Management Hut (2013). Within project management are the conceptual phase, followed by the general design phase and the detailed design phase. In this thesis the term conceptual phase is used in the meaning the phase where development of ideas and preliminary sizing takes place. In this early phase preliminary sizing can be estimated plans of buildings on the building site, volume models shown by 3D programs or physical models, early sectional drawings to show apartments with vent shafts. Most of the design problems should be solved to a certain level in this phase, so that changes do not have to be made later on. The more detailed phases are the general design phase and the detailed design phase and here dimensioning has to be carried out. In the end of the process there are the phases of handing over and operation. Finally, Swedish Wood (2011) states that the building should have a system of reuse and recycling of the parts after being demolished.

According to The Project Management Hut (2013), the construction process works as follows:

1. Specifying project objectives and plans including delineation of scope, budgeting, scheduling, setting performance requirements, and selecting project participants
2. Maximising the resource efficiency through procurement of labor, materials and equipment
3. Implementing various operations through proper coordination and control of planning, design, estimating, contracting and construction in the entire process
4. Developing effective communications and mechanisms for resolving conflicts

## 2.2 Conceptual design

Since the whole process is beyond the scope of this work, the conceptual phase is the one that was investigated. The conceptual design can be described as activities in the beginning of a building process used as a tool to learn what is needed in the project and then generate possible concepts, The Project Management Hut (2013).

### 2.2.1 Intuitive phase

The intuitive phase is the phase when goals are defined, e.g. the client's wishes are being transformed into a list of demands; design criteria considering current design codes are established; the making of concept solutions for different ideas are generated and evaluated, Swedish Wood (2011). The Project Management Hut (2013) states that there is merely a developed idea in the phase of initiation of a project. It will undergo refinement according to demands and suggestions will be tested and developed. A list will be needed that consists of minimum functions and tasks, demands and details. Some of them can be easily forgotten, such as alternative or obscure proposals and the technical team can help brainstorm with what the design team did not cover, The Project Management Hut (2013). According to Swedish Wood (2011), it is during the intuitive phase of most importance to understand the demands of the clients and information from all parties should be sought. Intuition and systematic methods are preferably combined when generating new concepts, since creative thinking often is of theoretical and practical descent. Possible combinations of structural materials, structural systems and production methods should represent ideas from the systematic and intuitive processes. Many ideas are better than too few. From many ideas the process goes on with narrowing them down in different steps using e.g. preliminary evaluation matrices and keeping record of why one solution was better than the other, Swedish Wood (2011).

### 2.2.2 Evaluation phase and choice of the final concept

In the evaluation phase, the various proposed concepts can be ranked and finally evaluated. Different requirements can be weighted and used when systematically comparing different concepts. Highest grade will get highest ranking. Risk analysis is important and should, according to Swedish Wood (2011), be included for each concept, including construction, transportation, production, economy, accidental risk or risk depending on weather. The best concepts should be evaluated with the risk analysis in mind, Swedish Wood (2011). An architect is hired to draw up a blueprint as a suggestion on how the house could look like in situ and with possible functions in it. The architect's blueprints become more detailed as the work progresses. In this development phase, it becomes clear how the design should be realised and the final concept can be chosen, Stockholms Byggmästareförening (2014).

### 2.2.3 Preliminary sizing

Swedish Wood (2011) states that by estimating preliminary dimensions of parts of the structural frame, it is possible to make early choices, e.g. how to carry vertical loads. The choices can be based on experience and estimations be verified by using not too advanced calculations, Swedish Wood (2011).

### 2.2.4 Benefits of collaboration in conceptual design

The benefit of the design phase is that it gives an opportunity to consider different solutions without spending the time that is needed for the detailed phase, Sobek II (2005). Addis (2007) shows that architects and engineers have collaborated since early nineteenth century to make better solutions together than on their own. The need

for collaboration was even greater when high-rise buildings were being designed. The aim of working together is great design, which is achieved by the teaming up of many different specialists. They, in turn, have to be aware of and interested in one another's framework and then make the right decisions on what to build, Addis (2007).

Architects and engineers may work in closer collaboration in conceptual design and need to train this as early as in exercises during education. To date, the students at the architectural programme at Chalmers are more often working to find an own design process for a project, whereas the students at the structural engineering programme have fewer projects where they can work with design process and the two programmes do not collaborate much except from voluntary courses at the advanced level. Though, more and more courses are held for creating a mix of students and interaction between the programmes and hence a perhaps better climate for open debate and collaboration in the design process will stem from this.

# 3 Definition and management of a process

## 3.1 The process

A process is a series of continuous activities. It can refine a service to meet customer needs. At least one supplier delivers input and one customer receives output. It should be an even flux; it could be compared to rails on a railroad, where the trip of the train is a project. When taking part in that journey you do not want the rails to be broken, Dicander Alexandersson et al. (1998).

### 3.1.1 Different processes

ISO (International Organisation for Standardization) has a standard in which they describe a process approach as a method that can be applied when managing a system of an organisation of any size, ISO (2008). A process always exists in a company or an organisation and each company has to define where it should start and stop. Some processes are overall and go through the whole company, starting with customer needs and end with delivery of what the customer wants, Dicander Alexandersson et al. (1998). The activities need both people and material in the right place at the right time to interact, when going from the needs to the deliveries. The inputs and outputs can be of material or informational nature. The different processes can have participants and internal or external customers with different needs. One process can give outputs that will form a list of inputs into other processes. An example of a simple process can be seen in Figure 3.1.

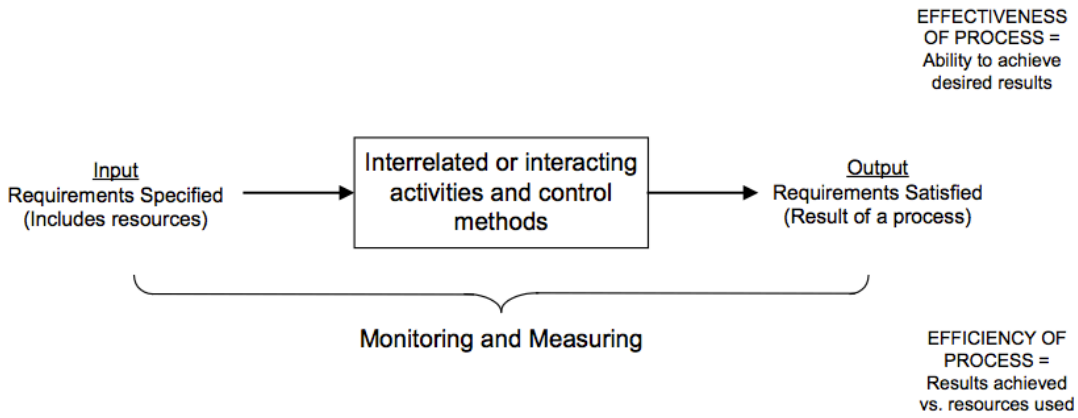


*Figure 3.1 A generic process, according to ISO (2008).*

By adjusting the process according to goals and matter of complexity value could be added to the organisation. The organisation has to decide how many processes there should be and of what kind to reach the goals of the business. These vary between different organisations, but some typical processes can be identified. ISO (2008) defines them as follows:

- *Processes for the management of an organisation*. These include processes relating to strategic planning, establishing policies, setting objectives, ensuring communication, ensuring availability of resources for the other organisation's quality objectives and desired outcomes and for management reviews.

- *Processes for managing resources*. These include all the processes that are necessary to provide the resources needed for the organisation's quality objectives and desired outcomes.

- *Realisation processes*. These include all processes that provide the desired outcomes of the organisation.

- *Measurement, analysis and improvement processes*. These include the processes needed to measure and gather data for performance analysis and improvement of effectiveness and efficiency. They include measuring, monitoring, auditing, performance analysis and improvement processes (e.g. for corrective and preventive actions). Measurement processes are often documented as an integral part of the management, resource and realisation processes; whereas analysis and improvement processes are treated frequently as autonomous processes that interact with other processes, receive inputs from measurement results, and send outputs for the improvement of those processes.

### 3.1.2 Different views

Typically, an organisation is divided into different departments. It is called a line organisation and the areas of responsibility are clearly defined, like who is in charge. However, there is some risk of sub-optimisation and energy spent on the rivalry between departments. This is not beneficial for the customer and can be very costly, Dicander Alexandersson et al. (1998). There is often a hierarchical structure within an organisation with different units of different functions. The management of this system is often acting vertically and the different units are responsible only for their part of the output information. Not all units, or participants, always see who the end customer is. Therefore it can often be an insufficient interest in solving problems found between different phases and the own unit's well-being is prioritised. From this follows only small enhancements when the work is finished with units not seeing the bigger picture and merely focusing on one task, ISO (2008).

The process can be seen from the customer's or the management's side of view. As a customer you may not see the process as something going through several activities. Dicander Alexandersson et al. (1998) give the airport as an example. Imagine yourself going to the airport and wondering about all those questions; whether or not you are in time, have parked the car correctly, can pass security gate or may enter the lounge. All those activities should be the same for each of us and you are following a process where many participants are involved. Your satisfaction will depend on how skillful these actors are, their cooperation and how they put different parts together in a process for you to follow as a customer. Depending on which side you represent you may react differently to the same event. This is something to be considered when improving the way of working. The transmission between different steps in the process has to work seamlessly and all steps have to work individually or else they have bad influence on the others. By working cross-functionally, it is easy to find bottlenecks and things that is blocking between the different steps or phases, Dicander Alexandersson et al. (1998).

## 3.2 Process management

### 3.2.1 What to achieve

When going into processes and improving them process management has started. By working with process management the aim is to enhance the overall efficiency and secure that goals will be reached. Customer requirement is the input that will be converted into customer satisfaction, ISO (2008). Dicander Alexandersson et al. (1998) define process management in three main categories:

1. Focus
   Map the processes going on in the organisation, analyse and discover deficiencies and improvement opportunities.
2. Control
   To get stability deficiencies and problems have to be eliminated and processes be run so that results do not vary. By then the process is reliable and we can get the result expected.
3. Improve
   Based on a sound process, even tougher targets are set, aimed at increased efficiency and customer value. Some improvements may be done and co-workers are beginning to get used to the thought of improvement. The process is continuously developing with small and large improvements.

The result of process management according to ISO (2008) is:

- Integration and alignment of processes to enable achievement of desired outcomes
- Ability to focus effort on process effectiveness and efficiency.
- Provision of confidence to customers and other interested parties about the consistent performance of the organisation.
- Transparency of operations within the organisation.
- Lower costs and creation of shorter cycle times through the effective use of resources.
- Improved, consistent and predictable results.
- Provision of opportunities for focused and prioritised improvement initiatives.
- Encouragement of the involvement of people and the clarification of their responsibilities.

### 3.2.2 Leadership

A *process owner* is chosen as early as possible and is someone who can review and set targets in the development of the process and be responsible in the work towards customer satisfaction. It can be a group manager with responsibility over a bigger part of the process, Dicander Alexandersson et al. (1998). A process owner is, according to ISO (2008), someone who is given the responsibility for "implementation, maintenance and improvement of each process and its interactions".

*Group managers,* responsible for resources and functions, may experience loss of power when working with a process and see the process owner as a competitor. It is not beneficial for the business with rivalry and the group manager should rather see

the process work as a way for succesful cooperation and development. A good thing for both customer and business is when the process owner and group managers work together with open communication, Dicander Alexandersson et al. (1998).

The *management team,* or top management, is also responsible for being engaged in the process work and their engagement will affect how successful the work will be. This team must have the knowledge about how to ease and support the work for group managers and the process owner. The team also has to create conditions for setting up a process team consisting of co-workers of different areas. By making clear priorities of the process work, setting the demands for what to accomplish and take the time needed for process team meetings, the management shows its engagement. It is very important to question and follow up the result of the process team's efforts. The work with change of a process is also affected by internal and external relationships and trust for the management, Dicander Alexandersson et al. (1998). Those in top set policies for how to work towards the market for the organisation and then goals are set for results, ISO (2008).

A *supervisor* could be a good help for the process owner, with responsibility for leading and keeping the process team alive, discussing and evolving. The supervisor should be someone who perhaps is not aware of the whole process, but has got the methods for carrying out this work. The person should let everyone tell their opinion and let everyone ask the most important questions. The supervisor could be someone from a different department, who after some time leaves the whole responsibility to the process owner, Dicander Alexandersson et al., (1998).

## 3.3 Development of a process map

Using process maps along the way, i.e. during the whole timeline of a certain project, should help bringing out information among disciplines and make it easier to take decisions.

### 3.3.1 Basic principles

Making things simple is maybe not the simplest thing. However, with a short manual that is easy to understand, it should be possible to describe a working process that gives results. According to Dicander Alexandersson et al. (1998) it can be hard to simplify instead of complicating things. The authors come from different companies and they have all had different roles in their jobs. Their way of describing a process model is based on experience from years of improvement work. Something that gives quick result, according to the authors, is to dare making a practical and easy-to-understand description for the co-workers, with hints on how to manage improvements to the executives and a very clear manual for the ones leading the work, i.e. owners of the process. A common and wasteful way of using money is to keep and monitor inefficient bottleneck situations. Neither managers nor co-workers can find the illness. In such a scenario cuts of costs are evenly distributed when it would have been more appropriate to make a change that really improves the outcome. It is easy to forget the old truth, saying that it costs money to earn money. The authors list three basic principles to build a process model upon:

- Simplicity – get started
  The process model is based on a simple manual with down to earth

instructions, directly from reality. The effort should be made in change management, not in trying to grasp a difficult manual with obscure print and trees no one is reading. Simplicity is crucial.

- Inclusion – those who know best do best
  Simplicity is a prerequisite for inclusion. The people who should map the process are the ones who are actually working in it, because they probably best know about how to work. They can discover bottlenecks and disturbances and be responsible for creative solutions improving the situation. It is easier to make changes when you are involved in decision-making.
- Leadership – everyone is pulling in the same direction
  Full engagement is necessary to achieve prosperity. The management sets the overall goals for the company's direction and helps co-workers to understand the process work, increase the level on a personal plan, expand boundaries and use the engaged leadership as a pioneer for continuity and perseverance. Credibility comes with doing what you are saying you are doing.

To sum up, process management is good for the customers, the co-workers and the company. Dicander Alexandersson et al. (1998) states that the process is based on the customers needs; it is working on its way to the customer with engaged participants, who understand the whole picture as well as details; co-workers can see consequences directly from the work being done; the work approach enhance communication between co-workers, departments and functions; finally it can lead to enhancement encouraging competitiveness and thus increase profitability.

### 3.3.2 Identification and planning

Both ISO (2008) and Dicander Alexandersson et al. (1998) suggest similar methods to follow when managing a process. The idea is to improve business by letting all participants know what is expected from them. Then it should be more likely that everybody aims at the same target. The ten following steps are retrieved from Dicander Alexandersson et al. (1998):

*Step 1. Start with management*

Necessary decisions have to be taken on how to direct the work and unite around a vision. The goal should here be clear before the start of the change efforts. The destination image is important when choices are made and also for convincing other participants of the fact that following the road map is worth the effort. The management has the responsibility for the co-workers' understanding of the map. The process owner and the process team should be chosen in this step.

*Step 2. Involve co-workers*

It is important that everybody understands what has already been achieved with improvements and the process work that remains to be done. Most important is that everybody can see what process work means, what kind of processes the company consists of and why engage in working with processes.

*Step 3. Map the process*

Start the mapping with writing down what is actually done today and not what should be done. Then potential issues and obstacles can be shown. All activities should be written on post it notes. The participant's roles of a process can be written on notes

and hung vertically on the side. In Figure 3.2 relations of different processes are shown.

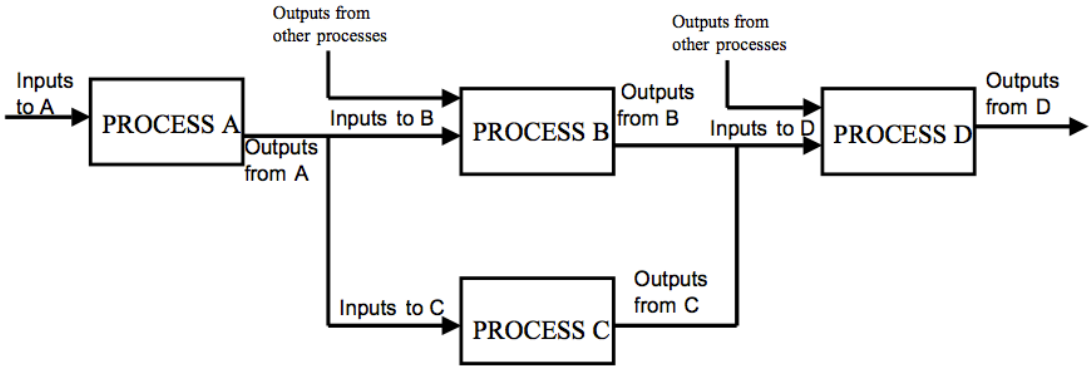


*Figure 3.2 Example of different processes and their relations, ISO (2008).*

The technique of mapping should be easy; make a square for activity and if it stands on its end it could be a stop where something must be chosen. With verb and noun on each note, e.g. "plan coordination", it should be easy to follow the timeline and how it is divided between different roles of a process. The customers view and need are central in the process work and must be fully understood and requested.

*Step 4. Reconciliation*

This step should come after the meeting of the process team to get things right. This should be a recurrent event in two groups; one with a participant from a process checking things with colleagues and giving them opportunity to get influence; the other group should consist of the process owner and the management and discuss e.g. the purpose, group dynamics, dominance, free speech, participation from managers, how the process owner is acting, if some competence is needed, and so on.

*Step 5. Inventory of problems*

By going through the whole map of the existing processes there is then a new opportunity to identify problems and make additions. The process team should choose some areas of problems to start with and the process owner should ask the group who is willing to be responsible for each of those. To succeed it is important that there is a true willingness to take responsibility for a problem and those who want can form a problem solving team. The problem solving team should involve co-workers who are affected by the problem to secure engagement.

*Step 6. Solution proposals*

The problem solution team has to find the cause of the problem, not just make the symptom disappearing. A session of brainstorming is a powerful tool and all ideas should be written down so everybody can see them. This is done to create even more new ideas and creativity.

*Step 7. Decision on the implementation*

The process team should gather the suggestions for improvement, from the problem solving team, and make use of their overall view to see how this may affect other functions and departments. Some proposals can be accepted and implemented as a

new routine. The process team takes the decision to go ahead and makes a plan for implementation. It can be reasonable to test the new routine in small scale and see whether the outcome is the expected.

*Step 8. Evaluation*

Now it is time to answer questions about improvements, adjustments and unforeseen consequences caused by the changes made. If everything works in a first version then it can be time for full-scale implementation. It is important to listen to co-workers to not forget inclusion and maybe further education is needed.

*Step 9. Documentation*

Writing routines, to ensure that the change will be executed and not only a theory, should document the process.

*Step 10. Work with continuous improvements*

The process owner can carry the team's work further by summoning the team directly towards vision and goal, monitoring metrics and reconciling implemented improvements. The process team should not only keep an on-going open discussion with customers, but also with colleagues to encourage contributions of improvements for the process. New members may be drafted to the team. In that way there could be full engagement of new thoughts and ideas that will grow in the constant mix of experienced and inexperienced members.

Those who know best do best, as stated in Section 3.3.1, and this is true for the inclusion of co-workers in the mapping of a process. Since forming of a process team is costly and must be performed with a mandate from the management, it is also beyond the scope of this thesis to carry out all steps suggested by Dicander Alexandersson et al. (1998). However, variants of Step 2 through Step 6 could be performed with co-workers in interviews and discussions and the answers could be compared with internal documents. Step 7 could be carried out with the help of a process map proposal, which is the final aim of this project.

# 4 Mapping of present process

In internal documents a section concerning Skanska's engineering consultant department and its way of working are described. This description should act as a tool for guiding operations towards more satisfied customers, dedicated, competent and focused employees who are satisfied, and increased profitability. In these documents the roles of architects and engineers are described together with their interaction.

From the internal documents it is possible to identify the main steps of the building construction process within Skanska's engineering consulting department. An interpretation of the process is shown in Figure 4.1.

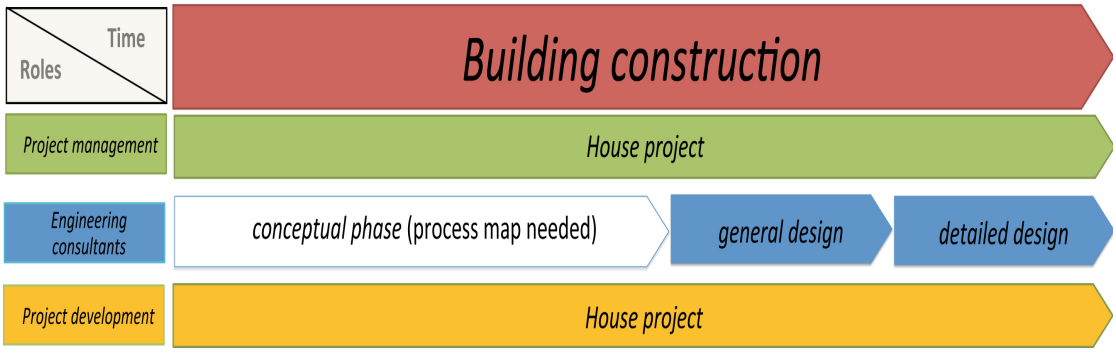


*Figure 4.1 An interpretation of Skanska's description of the process.*

The figure indicates the generic process of building construction where the second row represents the project management's process for a house project. The third and fourth rows represent the processes of Skanska's engineering consulting department and the project development's department respectively.

For the general design phase, Skanska's engineering consultant department has mapped how they are working and recently developed a process map to follow. Today there is no process map for the conceptual phase of the building construction process and the white coloured phase is meant to show that the map is missing. A process map proposal for this part is the assignment of this thesis.

## 4.1 Existing situation

Figure 4.2 shows a highlighted area in the third row. The first is the general design phase, which follows the conceptual phase and can be defined as where to produce compiled investigative material that describes all the building's technical systems. This phase is in turn followed by the detailed design phase, which can be defined as where documents such as descriptions and drawings are produced that recognise a project's design, construction and quality. Those documents form the basis for project execution. The two phases are highlighted in Figure 4.2. They are well documented in Skanska's internal documentation and a process map is at hand.

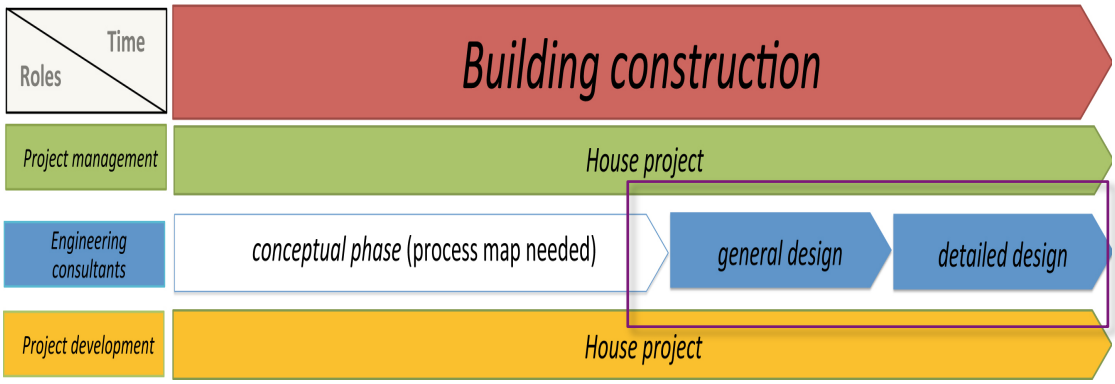


*Figure 4.2 The two phases general design phase and detailed design phase.*

When Skanska's engineering consultant department mapped the general and detailed design phases, the process approach including tools as described in Section 3.1.1 was applied. These tools should support planners and project managers to plan, direct and monitor activities, clearance and delivery of the design process. Each step of the process has an associated document with activity descriptions. Please note that this process map now exists and describes the process from general design through detailed design phase and does not include the conceptual phase. The approach aims to describe process flows and activity descriptions on a discipline level, including input/output data and resources per activity and definitions of consensus on the final delivery.

### 4.1.1 Activities during general design and detailed design

During the general design and detailed design phases architects and engineers are producing the basis for building permits and start of production. Architectural drawings are also transformed to a more detailed level. The existing process map for these phases, from Skanska's engineering consultant department, will serve as a model of layout and function for the project of this thesis. The input needed in the beginning of the first of these two phases, i.e. the general design phase, will serve as a goal to where the preceding phase, the conceptual design phase, must deliver output.

As an example of the increasing level of detail achieved in the general design and detailed design phases it can be shown with what activity the different professions, such as architects and structural engineers, are working in the different phases, respectively.

General design phase: architects work with land, 3D-model and façades; structural engineers work with structural design, 3D-model and plans.

Detailed design phase: architects work with plans and details including relations to existing buildings and also 3D-model, kitchen setups, ceilings and walls; structural engineers work with 3D-model, elevations and details.

### 4.1.2 Definition of milestones

As stated in Section 3.3.2 all activities should be written on post it notes. The technique of mapping should be easy; make a square for activity and, according to Dicander Alexandersson et al. (1998), if it stands on its end it could be a stop where something must be chosen. Skanska is working with milestones in that manner, defined as clear stops, starting points or control points, where a decision is irreversible and next step is the following step. Two examples of milestones according to Skanska's existing process map can be found in Table 4.1.

*Table 4.1* *Two of the milestones used in the process map of general design and detailed design,* Skanska (2013).

|  | Milestones | Definition |
|---|---|---|
| 10 | Locked main layout and structural frame (*from general design phase*) | Layout should be so clear that the structural frame could be locked. Space coordination has been performed by the disciplines participating in the project. |
| 70 | Joint examination Installations + Architect (*from detailed design phase*) | The purpose is to secure that all guiding information that affects architectural and installation design is in the 3D-model. Examination is performed with the aid of checklists and is preceded by internal reviews. All notes should be implemented before dispatching. |

### 4.1.3 Input from the conceptual phase

Before entering the general design phase the disciplines need, in the conceptual design phase, to develop the input to the general design phase. Today two main prosesses can be found, one at the engineering consultant department and one at the project development department. The reason for introducing the latter is that when going through the internal documents, most of the information concerning when architects are consulted can be found there. This is also where references to planning handbooks for architects can be found. The department of project development is where houses are being planned and customers groups are targeted. In order to understand where and how the different departments intersect in time, the process must be clarified. In Figure 4.3 the project developers' activities are briefly presented.

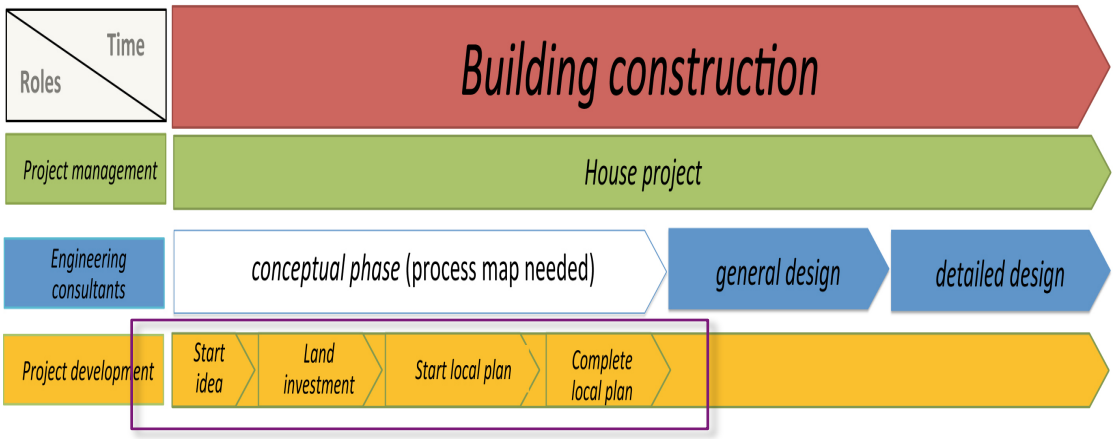


*Figure 4.3 Project developers' process in the conceptual phase.*

The purpose of the phase before the general design phase is to actually prepare and plan design as well as possible. In general, a project manager controls most of when and for how long time work is executed, while a design leader is responsible for preparing and developing major design. In practice, the project manager and a project leader are usually working together. It is also an advantage, if the people involved in the bidding process are involved. Project developers are stating that they have an early collaboration with architects.

After completing land investment in most cases the local plan process will begin. The detailed development process of local plans can take several years depending on politics and community.

In Table 4.2 one example is shown of a step in local plan work with regard to activity and participant.

*Table 4.2 An example of a step along the project developers' process.*

| Activity | Participant | Definition |
|---|---|---|
| Staffing the project | District manager | The project manager and the project leader are appointed and then other roles are staffed gradually. For larger or more complex projects consultations are held with the regional manager. |

The department of project development has a carefully crafted process, from a manager's view, and the internal documents are showing that architects are present, yet not exactly how and when.

### 4.1.4 Input for architects

In order to prepare the input needed at the start of the general design phase the different disciplines in a project should contribute with information.

Two input lists are specified on the existing process map for each profession in the general design phase. One is for common input and one describes the input for the actual discipline. The following example as described by Skanska (2013), is the specific input list for architects during general design phase and should preferably coincide with the output list of the conceptual phase, yet tasks can be added from e.g. project management.

Input list for architects:

- land - the ground can be more or less suitable for high rise buildings and has to be considered when house types are chosen. Furthermore, the ground properties will influence whether garages or basements will be built: the increased living area should provide higher revenues than the cost of the basement.
- environmental inventory – this can be performed in terms of waste from previous buildings on the site that first have to be demolished or regarding existing pollutants from the air or ground within the surroundings.
- moisture description – a first moisture check is done when façade materials are chosen: there is an increased risk of moisture problems when e.g. small areas of different materials should fit together. The work with further risks of moisture should have been initiated.
- fire and sound – a first check with evacuation routes, distance between buildings and whether ladder appliance from fire department can be used or not and how that will affect the orientation of apartments with respect to evacuation. Apartment separating walls and slabs and building services must be built so that the sound class complies with the requirements set by the department of project development against e.g. traffic noise.
- architectural model – physical or digital 3D-model showing site with vegetation and buildings' orientation and, to some extent, apartments and their orientation.
- preliminary energy estimates – e.g. check if district heating is available and if not, what system can be used. Estimation of the ratio between window frame area and window areas must also be performed and the need for sun protection should be investigated.

Tasks added from project management and project development

- program document - a description of the proposed design should accompany the drawings made in the conceptual phase.
- mission plan - a description of what is still to be done within the discipline.
- mission schedule - a preliminary time schedule for the work that should be carried out must be presented.
- notification schedule - information flow between designers and builders in the project for the production of construction documents as specifications for subcontractors.

As help for architects, as referred to by the project developers, planning handbooks are proposed as guidance when working with a standard solution. What to prepare, considering the input list and the additional tasks, could easily be interpreted and worked through with the aid of those supporting documents.

### 4.1.5 Conclusion

At the department of consulting engineers Skanska today uses a process map for the general design phase and detailed design phase. The process map should be extended to also include the conceptual phase. The existing map is mainly based on the standard process model of ISO (2008) as described in Section 3.1.1. There is today a process described for the conceptual phase in another department, the department of project development. To understand when architects are consulted, most of the information can be found from internal documents of that department. There are also planning handbooks for architects to follow when working with prescribed activities.

During the timeline of a house project, the level of detail increases. As an example, input lists are formulated in the beginning of the general design phase: one common list with contributions from different disciplines and also one for each discipline. To formulate those lists issues must be worked through during the conceptual phase within the different disciplines respectively and output could be e.g. energy estimates, which in the following phase will be calculated to give more exact figures before production starts.

There is today a wish for a process map for the conceptual phase of the consulting engineers' department and this should be synchronised with activities in the process of the department of project development.

## 4.2 Forming a focus group

Apart from informal discussions with co-workers a series of four surveys was carried out to key position co-workers among the project developers and consulting engineers. This was carried out to better understand the perception of how work is organised in reality. Forsell and Obert (2000) define a focus group as a group of people that focuses on a common problem. It can also be formulated as a kind of group interview, due to the participants' view and values concerning specific problems. In the work of mapping a process the focus group is used when making the surveys. Since there is no process team as is suggested by Dicander Alexandersson et al. (1998) and referred to in Section 3.2.2, this focus group will be used instead of such a team. The aim was to find out what the co-workers define as problems or obstacles when working in the conceptual phase in collaboration with people of different professions and how an improvement of the process could be performed.

### 4.2.1 Survey 1

In the first survey four questions were formulated to get the informants general view upon possible collaboration between architects and engineers. The questions were answered by developer A among the project developers, and from the consulting engineers department: structural engineer A, building physics engineers A and B and finally architects A and B. The answers are presented in Table 4.3 through Table 4.6.

*Table 4.3 First question of Survey 1.*

| | 1. Is the architect involved in the development of the best solution during the conceptual phase? |
|---|---|
| Skanska project developers<br>*Developer A* | ”During development of local plans the architects are there. In this early phase volumes of a building are mostly studied. Also when investigating possibilities to buy land or real estate an architect is there. It is not sure that it is the same person that will have the job in a later phase. At the stage when it is time to start work on a specific product the architect is among the first professions to enter the project and conditions such as geotechnics, noise, etc. are then already mapped.” |
| Skanska consulting engineers<br>*Building physics engineer A* | ”Yes an architect has an important role here to design the building so that it can be produced and maintained in a moisture-proof manner. The architect needs to have a basic understanding of moisture risks associated with choice of finishes, but also the placement of such wet areas and the design of them; eaves, roof pitches, connections to the ground and so on. There are many points to touch on here.” |
| Skanska consulting engineers<br>*Building physics engineer B* | ”It is difficult to build so that the most sensitive person does not need to feel bad according to the precautionary principle. A zero tolerance for mold (i.e., fewer cases with mold than collapsed houses...) is not practical, so you end up with some kind of compromise already in this phase. Otherwise, it is definitely a conflict between moisture safety, availability, economics and architecture. I have seen so many examples of solutions that probably are not making any of the professions happy.” |
| Skanska consulting engineers<br>*Structural engineer A* | ”In a good project the architect develops a plan that make structural engineers juggle and have a discussion about stability and possible solutions. In a bad project the architect develops a plan too far and then the work with finding solutions can become tedious and not rational.” |
| Skanska consulting engineers<br>*Architect A* | “Yes, the architect is involved with gross area analysis, division of zones, the shape of buildings, sketches and layouts.” |
| Skanska consulting engineers<br>*Architect B* | “Yes, that should be the case in my opinion.” |

*Table 4.4 Second question of Survey 1.*

| | 2. Could the architect in closer collaboration with engineers develop an even better solution? |
|---|---|
| Skanska project developers<br>*Developer A* | ”Of course it is positive if the architect has someone to talk to regarding technical issues during the conceptual phase.” |
| Skanska consulting engineers<br>*Building physics engineer A* | ”Yes, if the engineer has knowledge of moisture and production. Already in the conceptual phase should e.g. availability questions be aroused, but moisture and availability requirements often collide. There are only advantages in considering production and management early.” |
| Skanska consulting engineers<br>*Building physics engineer B* | ”On the contrary, I believe that certain issues must be addressed in a broader forum. It is not just architects and engineers that should interact. Also the engineers need to interact with each other ... structural engineers and building services engineers, designers and practitioners.” |
| Skanska consulting engineers<br>*Structural engineer A* | ”YES!” |
| Skanska consulting engineers<br>*Architect A* | “You need to work with spans, the column positions in the garage, fan room sizes, shaft sizes, thickness of floors and more.” |
| Skanska consulting engineers<br>*Architect B* | “Yes, an early cooperation and overview can solve many old grudges; for example, there is an internal document that gives hands-on examples of estimated dimensions and measures to get the architect to think of the structural engineering, early, as structural engineers, sort of.” |

*Table 4.5 Third question of Survey 1.*

| | 3. What is the situation during the conceptual phase today? |
|---|---|
| Skanska project developers<br>*Developer A* | ”I am not really sure if everybody is following the same line - different parameters are of different importance depending on the actual project. In the conceptual phase the process is iterative and has to fit into the budget. Then the reconciliation with respect to costs is performed together with the project manager, who is running the project during the building phase and with calculation engineers. Structural engineers are also consulted. As soon as we have set the direction for the project and drafters from other disciplines are engaged, the structural engineers become involved.” |
| Skanska consulting engineers<br>*Building physics engineer A* | ”I don’t know.” |
| Skanska consulting engineers<br>*Building physics engineer B* | ”However, it is also important to remember that a client company is hardly any democracy. Someone must have power and authority to decide and a clear and explicit goal or vision.” |
| Skanska consulting engineers<br>*Structural engineer A* | ”Different in all projects. In proprietary projects, we are often in early and can discuss product.” |
| Skanska consulting engineers<br>*Architect A* | “We ask others if needed, mostly engineers. Otherwise, there are various internal documents as support.” |
| Skanska consulting engineers<br>*Architect B* | “I believe that cooperation today is minimal in this early phase, when not even the architect is an obvious actor.” |

*Table 4.6 Fourth question of Survey 1.*

| | 4. What pros and cons could there be with a closer collaboration? |
|---|---|
| Skanska project developers<br>*Developer A* | ”A close collaboration is always good. In the early phase where I work, we always try to find the point where we can optimise profitability from maximising customer quality and minimise production cost. By customer quality I also include making the city happy. The best thing would of course be to get all professions involved to understand where to reduce costs but improve customer quality. To succeed requires a good climate of cooperation, respect and trust for each other and for the end customer. Disadvantages of being many involved are that it can be too many people involved in a stage where you need to take many decisions. It then becomes very important to find a quick and easy way to exchange information. It is also important that project developers mediate all communication. It can be difficult to get that working well at a late stage and give priority to work at the beginning. When many people do have opinions but do not prioritise the project, it becomes very time consuming and blunt to cooperate.” |
| Skanska consulting engineers<br>*Building physics engineer A* | ”Plus sign for increased team spirit, commitment, increased understanding of the various disciplines’ requirements or preferences and early solved problems areas cost less than if you come to it late. Minus sign for easily getting caught up in details in a premature stage.” |
| Skanska consulting engineers<br>*Building physics engineer B* | ”To know which questions are big and require everyone involved and which ones are not so big and can be solved anyway. Collaboration depends on a respect and understanding for each other’s skills; involvement of the right things, which are in line with the mission and not their own agendas.” |
| Skanska consulting engineers<br>*Structural engineer A* | ”Great benefits for understanding the work of both. What is important are what can cost, the ability to build and the technology.” |
| Skanska consulting engineers<br>*Architect A* | “It is an advantage to have a project team early with all disciplines to consult.<br>A disadvantage could be that you end up in detail discussions instead of starting with the general guidelines.” |

| | |
|---|---|
| Skanska consulting engineers<br>*Architect B* | "Cost effectiveness. Everything results in that. Better architecture. Focus on problems that are possible to handle with a greater understanding between architecture, structural engineering and building services engineering, instead of drawing up each discipline's own solution early, which usually leads to very inefficient solutions or housing. Communication and collaboration between disciplines ensure that a project can be well carried." |

### 4.2.2 Survey 2

Skanska has developed a platform, or standard solutions, to be used when building apartment houses. A planning handbook is proposed as an aid to guide architects when working with the standard solutions. On the other hand, an architect wants a problem to solve and should be trusted for her or his competence. What is obvious, despite the fact that some guidance for how to work is proposed, is that from an external point of view, architecture as an own discipline is missing at Skanska and architects have not much influence on the process of building projects. The planning handbook is perhaps more suitable when it comes to internal drafters, who are preparing architectural drawings. Of these reasons an additional question was sent to structural engineers A, B and C; building physics engineer A; process manager A and architects A and B. At this time they were also asked to make four suggestions and rank them with number 1 as the most important. The answers are presented in Table 4.7.

*Table 4.7 Survey 2.*

| | What creates an effective collaboration between architects and engineers during the conceptual phase – what is most important? |
|---|---|
| Skanska consulting engineers<br>*Process manager A* | "(1) Use Skanska Sweden Housing platforms as starting material, in particular the engineering handbook for architects at hand.<br>(2) Requirements for the project shall be clarified so that architects and engineers can collaborate effectively, e.g. which target group customers are in, their affordability and corresponding economic framework.<br>(3) Do not just rely on the architect's mission to do 'good layout' but handle also concrete technical issues, such as plot design, garages, technical areas, incoming media shafts, etc., in collaboration with the consulting engineers.<br>(4) It is important to carry out risk and opportunity analyses for alternative potential solutions." |

| | |
|---|---|
| Skanska consulting engineers<br>*Structural engineer A* | "(1) It is important to have production ideas, that it is possible to build streamlined and simple so you do not build in complex functions that do not provide much value in the end.<br>(2) Try to perceive who the customers are, i.e. who buy the apartments.<br>Is there an advantage with 2,5x3,0 m large window or does it just become annoying transparency in the bedroom? Can you provide less transparency? Is it good to place a convector in front of a window that starts from floor height?<br>(3) It is important to weight what customers will notice in terms of artistic expression versus what they think is worth the money.<br>(4) It is important to keep visions and ideas open so you can have a dialogue, and that the design is not locked too early." |
| Skanska consulting engineers<br>*Structural engineer B* | "(1) Work together to find a structural system that works. Bearing walls and columns should be in the same position in all floors. Otherwise, complicated lintels will likely be required.<br>(2) Spans must adapt to joist plan solutions. Span limits depend in turn on the subdividing and location of apartment separating walls. Depending on whether hollow core floors, solid slabs or flat slabs are to be used, there will be various ranges for the suitable spans.<br>(3) It is important to solve difficult problems early. Where architecture requires extraordinary solutions, one should early find the best possible solution so that it will not be more expensive than necessary. For example, in lobbies where you do not want to have interfering columns, a smart plan for the floors above can facilitate.<br>(4) It is important to discourage frivolous architecture. This refers to fighting architectural fads that lead to inappropriate solutions. For example, corners with large windows and no columns. It is also common with non-existing overhangs and windows that are placed too far from the facade. Both of these phenomena increase the risk of leakage." |

| | |
|---|---|
| Skanska consulting engineers<br>*Structural engineer C* | "(1) It is important that the architect collects data on suitable spans and beam lengths to get cost-effective solutions. Even a rough estimate for the stability of the building is needed.<br>(2) The architect should have an understanding of fire, sound and moisture already in the early stages. Example: if the building is high, fire evacuation may be required that affects the layout.<br>(3) It is important to establish a good cooperation in the early stage where the roles are clarified. This facilitates the initial and continued cooperation.<br>(4) It is important that the architect is clearly informed of the conditions that apply. This can for example be given measurements on the stairwells to be applied in the project." |
| Skanska consulting engineers<br>*Building physics engineer A* | "(1) It is important to have a common vision.<br>(2) It is important to have a mutual understanding of each other's expertise.<br>(3) It is important to see the whole picture of the final product with respect to quality and economy.<br>(4) It is important that the different professions have good knowledge of their own area of responsibility." |
| Skanska consulting engineers<br>*Architect A* | "(1) It is important to sit in the same place or have frequent meetings.<br>(2) It is important to check ideas with each other." |
| Skanska consulting engineers<br>*Architect B* | "(1) It is important to communicate.<br>(2) It is important to sit down together, not only to communicate via e-mail.<br>(3) It is important to have knowledge regarding ones own discipline.<br>(4) It is important to have understanding of the other discipline's need. |

### 4.2.3 Survey 3

A problem solving team should focus on finding the causes of a problem, when working with a process, as stated in Section 3.3.2. The next question was therefore sent to structural engineers A and B and architects A and B of the focus group to

define problems and they were also asked to come with suggestions of improvement. The answers are presented in Table 4.8.

*Table 4.8 Survey 3.*

| | Define some typical bottlenecks in the conceptual phase and give suggestions on how to get rid of these. |
|---|---|
| Skanska consulting engineers<br>*Structural engineer A* | "There is typically no coordination of the floors in the architectural sketches.<br>- To get rid of this obstacle you need to remind architects that the walls come above each other and the shafts go straight up. Nothing disappears halfway up.<br>Fire engines should be able to enter the garage deck.<br>- Try to consider this immediately.<br>Typically, you design with too efficient measures, e.g. if measures must be increased later due to accessibility, it does not work because all the dimensions are locked already.<br>- You need to have a little margin in the measurements, so you do not start with locked measure ratios.<br>The prerequisites have not been figured out.<br>- Think clearly first. It is hard to turn something into 'Green Building Gold' [grade of environmental certificate] late in a project, but if you are aware of the environmental expectancies from the beginning it is easier to take it into account." |

| | |
|---|---|
| Skanska consulting engineers<br>*Structural engineer B* | Typically, the layout is not determined when general design begins.<br>- Let the conceptual design phase be completed before the planning begins for real.<br>The space needed for installations may not be known, when the structural frame is to be designed. The guesses concerning holes in slabs are not enough. Fan rooms, where they exist, must perhaps be made larger.<br>- Make sure to investigate the needs for installations a little better and a little sooner.<br>There is typically no design loads available, when the foundation must be designed.<br>- We can simply procure core providers even earlier. This applies to all subcontractors, whose solutions affect the design.<br>There are participants who do not master the software to be used. '3D? All right - no problems, we'll fix that'.<br>- If you cannot trust that the planners or architects have the right skills, you need to hire someone else, even though it would be more expensive." |
| Skanska consulting engineers<br>*Architect A* | "Typically, there are too many little picky changes to layouts before the developers are pleased. This means that everything may be delayed.<br>- You may educate the developers in availability and required standard dimensions according to Swedish standards.<br>There are typically too few people when you need help.<br>- Recruit staff. Get help from other departments and branches." |
| Skanska consulting engineers<br>*Architect B* | "There are typically too few shafts.<br>- The building services team can be consulted early to give an opinion concerning the architectural plans.<br>Typically, there is too little time for conceptual design sketches.<br>- Let projects mature. The opposite will cause a risk of copy-paste architecture. Sketching should occur in groups over time." |

### 4.2.4 Survey 4

To get a chance to give a personal opinion on how a good process for the conceptual phase should look like, all participants in the focus group where sent the same question. Only Structural engineer B, and architects A and B answered the final survey, though. The answers are presented in Table 4.9.

*Table 4.9 Survey 4.*

| | What creates a good process and how should it look like in the conceptual phase? |
|---|---|
| Skanska consulting engineers<br>*Structural engineer B* | "A good process requires a skilled management from a project leader or equivalent.<br>- One should appoint a person with the right skills and who can dedicate enough time. Sometimes the project or production manager executes the job nonchalantly." |
| Skanska consulting engineers<br>*Architect A* | "A good process is when everything runs.<br>- One should have frequent meetings with the project management. Both residential developers and Skanska's production department should participate in order to get the best buildable product." |
| Skanska consulting engineers<br>*Architect B* | "A good process needs to take time.<br>- The process should have a time schedule to allow the project to be properly worked through and to be open for changes.<br>The participants during the conceptual phase must come from disciplines with adequate and proper staffing.<br>- The project should have a dedicated client.<br>Usually the process becomes successful, if the client and design disciplines understand each other's needs.<br>- It should be time for pondering before entering next phase." |

### 4.2.5 Summation of the survey answers

When working with this project at Skanska there has not been a possibility to gather participants of different professions in a process team to perform a mapping of the conceptual phase of today. The mapping of how work is performed today and the opinions on how work should be performed has instead been investigated by going through internal documents and by having discussions with co-workers of different professions. The informants were chosen due to their experience as senior engineers or as someone having the best knowledge in their field. The forming of a focus group to answer survey questions has been of great importance for this project.

When making survey questions with only a small number of participants the uncertainties from a statistic point of view are obvious. However, the answers could perhaps be interpreted as somewhat characteristic for each of the represented professions, since there is often more than one participant that answers individually from each profession. Furthermore, considering the size of the departments they represent, the answer frequency is high.

From Survey 1 through Survey 4 the questions ranged from specific questions, which could have short or long direct answers, to more open questions where the participants could formulate themselves more freely. The four surveys were constructed to correspond to the work of a process team, as described in Section 3.3.2, ranging from mapping existing work to the implementation of ideas.

Survey 1 was made with four questions. The first two questions were formulated to investigate the perceived situation of how much architects participate in finding design solutions and whether collaboration with engineers could be beneficial. The questions could have short answer, but the majority of the informants chosed to answer more freely. The aim of questions three and four was to make the participants reflect on the current situation and formulate a personal view of advantages and disadvantages of collaboration. Both questions would be answered freely.

Survey 2 was made with one question about the importance of collaboration. The answers could be given as a list of aspects. The aim was to make the participants address the importance of collaboration and what influence on the process it may have.

Survey 3 was made with one question. The participants were asked to first define a problem and then come up with a suggestion of improvement.

Survay 4 had one question. Here the answer would be to set up conditions for a good process and formulate a wish of implementation.

*Analysis and evaluation*

In the first question of Survey 1 the participants had somewhat similar answers. Project developer A and architect A could confirm that the involvement of the architect already is the case, whereas the other informants were convinced that it should really be the case. The latter also revealed in their answers an opinion of what they think an architect should know and what is bad by not knowing. In the second question all participants shared the same view that early collaboration can only be positive and should be used between and among disciplines. From the answers of the third question, about the present way of working during the conceptual phase, a possible interpretation is that collaboration is not carried out by routine but performed when needed and differs with the budget and size of a project. In the answers of the fourth question the participants defined pros and cons of a closer collaboration. Among the advantages mentioned were: respect and understanding between professions, understanding for economy and finding cost efficient solutions early, ‘better’ architecture and increased team spirit. Disadvantages according to the participants were: a risk to slow down the decision taking by having too many professions involved and the risk of going into details too early with too much focus on specific problems concerning their own profession.

In Survey 2 the participants were asked to list what is important for collaboration. The process manager along with structural engineers emphasised the importance of clear production ideas and simple plans so that the function of the building do not become

too complex. The architects had same vision and mentioned that sitting and working together is important for efficient collaboration. The structural engineers tended to focus on architects' ability to understand structures, yet the focus of this question was how to collaborate.

Survey 3 asked the participants to define problems and suggest improvements. Here they shared the opinion that the conceptual phase is too short and that this is not beneficial for the general design, when the main layout is still not set. It may be improved by earlier collaboration to solve problems according to prerequisites, but still having margins in the measurements.

In the answers of Survey 4, about how a good process should look like, the participants asked for clear project management and time enough for working through the project properly.

*Conclusions*

The survey answers show that collaboration today exists only when needed and is depending of size and budget of a project. The informants stated that a process with even more collaboration is mostly beneficial with regard to improved customer quality and co-workers understanding of where to reduce costs, a better team spirit and mutual understanding between professions. More time to work in the conceptual phase should along with collaboration also be prioritised, since it is easier to make impact on decision taking when the costs are still low and the plans are still not locked with exact measures.

# 5 Suggested process

Both Dicander Alexandersson et al. (1998) and ISO (2008) explain a process as such in Section 3.1.1 and suggest methods for managing it as presented in Section 3.2.1. The benefits of process management are e.g. the transparency of a process and the ability to reach set goals. When co-workers understand not only what they are performing at the moment, but also understand what has been done and what will be done, the working approach could be called horizontal. What can be found today at Skanska is a wish for a horizontal way of working in processes for each project, preferably with the change of the remnants of a perhaps more hierarchical line organisation.

## 5.1 Relevant information

The aim of this project was to develop a process map to follow for architects and engineers. When a process map was developed for the conceptual phase at Skanska the approach used deviated somewhat from that proposed by Dicander Alexandersson et al. (1998). During this project a search among the numerous internal documents was made to find where the conceptual phase for architects and engineers would fit.

At Skanska the project developers, in discussion and from the surveys, claim that they are working in close collaboration with architects, especially in early stages. The process is to some extent possible to follow at the project developer's level, as is explained in Section 4.1.3. In internal documents it is also possible to find the occasions when architects are consulted. The department of project development provides documents that define a basis for the architects to follow and here the underlying process for the conceptual phase should be found. There are references to many different support documents, each with detailed descriptions on what to perform at a certain step in the process, but no documents or maps are describing the whole process for a certain profession. By discussions with co-workers, process managers and project developers it was understood that a process map for the conceptual phase was desired to give horizontal transparency.

The conceptual phase, where early drawings are prepared and only preliminary sizing of structural members is performed, at Skanska fits on the whole period before the general design phase, see Figure 4.1.

In this thesis the way of working in the conceptual phase of the building process was investigated with the help of architects, engineers, project managers and by internal documents. This was performed in discussions and surveys in order to find different views from different professions. Those who took part in the surveys have in common that the aim of their work should be to find the best design solution. Since there is today only a statement on the mere existence of interaction between project developers and architects, but no documentation, there is a need to describe when and how the interaction may occur in the conceptual phase.

## 5.2 A process proposal

The development of the process was performed on the basis of the theory in Dicander Alexandersson et al. (1998) and ISO (2008). A process map for the general and detailed design phases was at hand at Skanska when this project started. That map is

explained in Section 4.1. For every step on this map there is an activity description about the actual step, its co-actors and information about whether a support document exists or is not. Then there is an associated document, at Skanska, describing what should be done and a suggestion of how. A desire to give the same kind of layout with its functionality in this project was formulated from the start.

The structure was developed partly by mapping how architects are working and interacting with engineers during the conceptual phase today and comparing with what is needed on the input list of the following phase. The different activities were arranged to follow the project developers' process that was at hand. Working methods were taken from internal documents, which already are being used, and these were compared with requests from co-workers of different professions.

The resulting process map proposal is presented in full scale in Appendix A and should for visibility reasons be used to make the map more legible. A simplified overview of the process proposal is shown in Figure 5.1.


*Figure 5.1. Process proposal for the conceptual phase.*

The roles of the participants can be seen on the left side in Figure 5.2: architects, structural engineers, building services engineers and project developers.

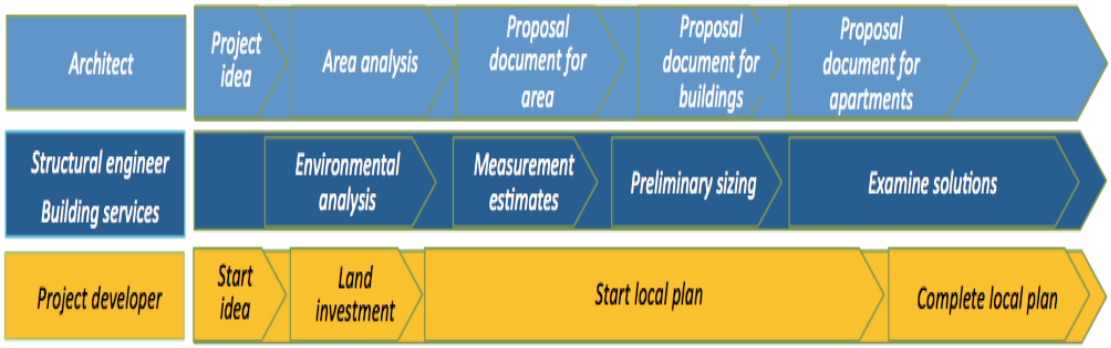


*Figure 5.2 Three integrated processes.*

First row in light blue colour refers to the process for architects, darker blue in row two for engineers and yellow colour in row three for project developers. The process described by the yellow row is a shortened and simplified version of an existing process map from the department of project developers and was established according to how often architects are mentioned in internal documents, regarding the conceptual phase, of that department.

In Figure 5.3 to Figure 5.7 the five main steps of the proposed process are highlighted and explained more in detail.

In Figure 5.3 the step ‘project idea’ is shown.

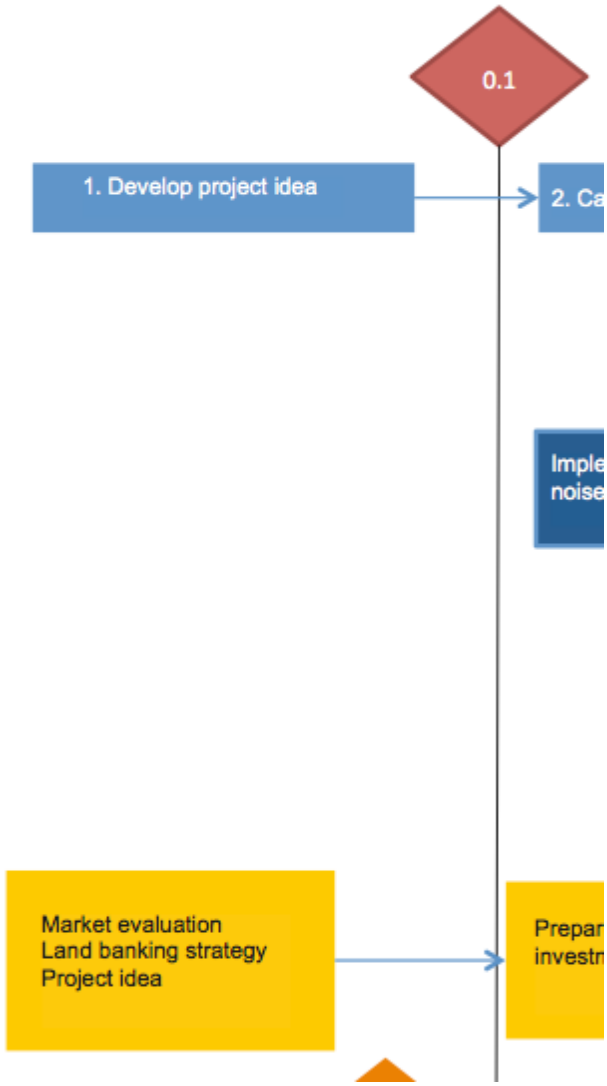


*Figure 5.3 Project idea, the first step of the process map proposal.*

Activity here is

1. ‘Develop project idea’ with the definition ‘Provide architectural aspects for project idea proposal’.

Market developers and business analysts primarily perform this first step. Here it is perhaps too early to take part in for an architect, or it could be as consultant for a specific issue. According the survey answers the architect is involved when investigating possibilities to buy land or real estate.

The concluding milestone (0.1) is ‘Approve idea’ with the definition ‘Take part in idea proposal before the start of area analysis’.

In Figure 5.4 the step ‘area analysis’ is shown.

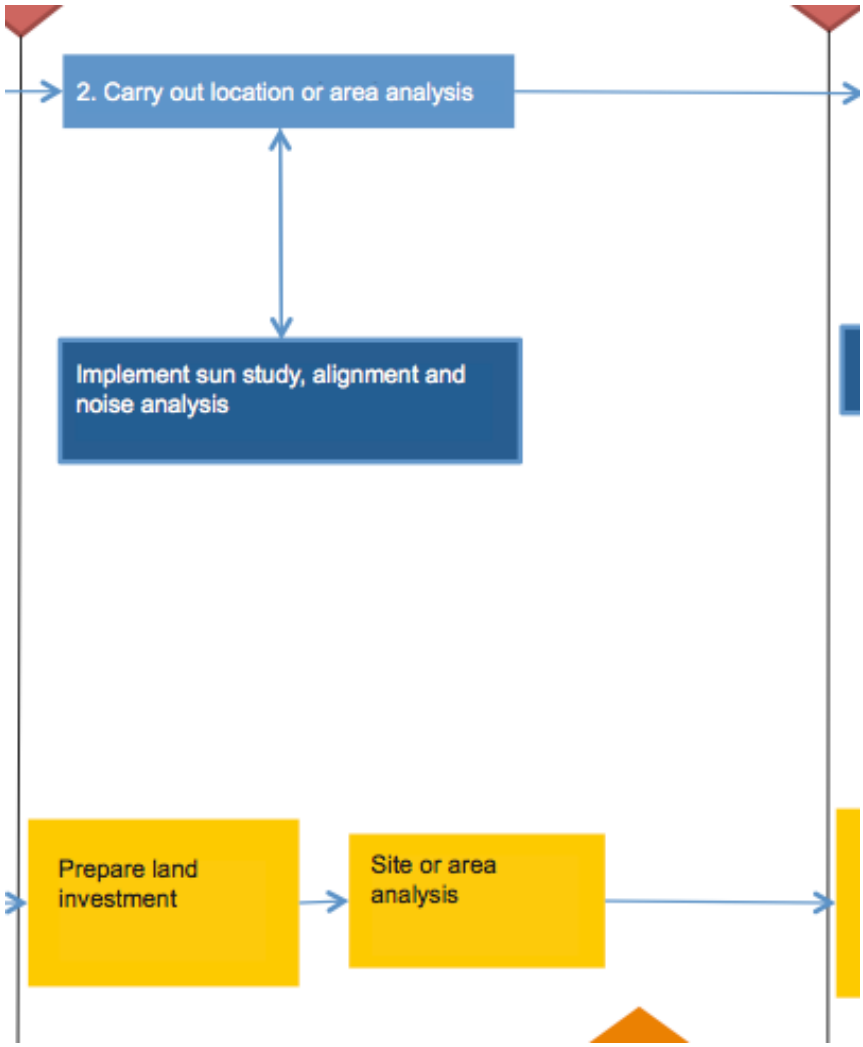


*Figure 5.4 Area analysis.*

The activity is

2. ‘Carry out location or area analysis’ with the definition ‘Implement sun study, alignment and noise analysis’.

The main activity in this step is to perform a site analysis in collaboration with engineers to implement sun study, orientation of buildings and noise analysis before the start of local plan. From internal documents and according to participants in the surveys the architects are involved here.

In Figure 5.5 shows the step ‘proposal document for area’.

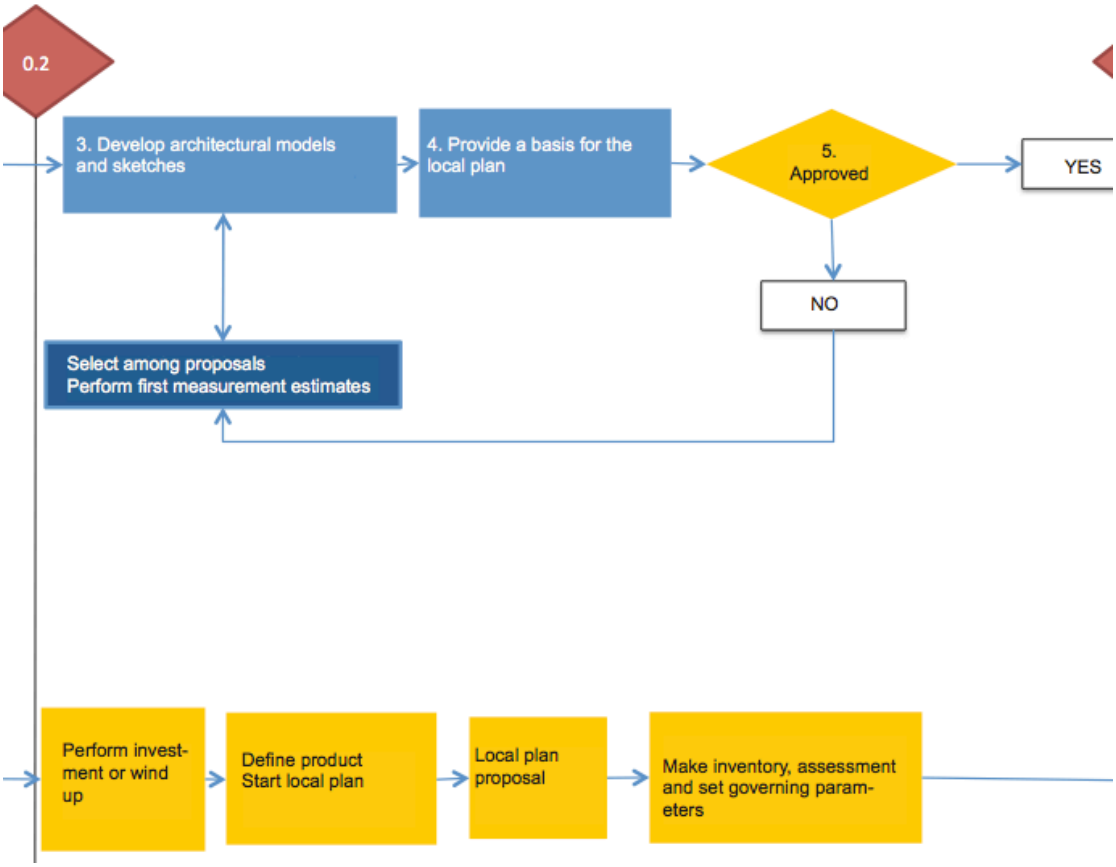


*Figure 5.5 Proposal document for area.*

The initial milestone here (0.2) is ‘Start local plan’ and the definition is ‘The purpose is to work on a new project with a new or existing local plan in the municipality’.

The activities are

3. ‘Develop architectural models and sketches’ with the definition ‘Develop the first volume models - engineers select among the proposals and perform first measurement estimates’.
4. ‘Provide a basis for the local plan’ and the definition is ‘Examine legal requirements and develop an efficient proposal with efficient use of land’.
5. ‘Approve model if suitable for local plan’ with the definition ‘This is performed according to project developers; if no, go back to Step 3 and 4 and adjust, if yes, go on’.

The overall activity in this third step is to develop a basis for a local plan by examining legal requirements and developing an efficient proposal with efficient use of land. The project developers in the survey stated that the architect is among the first professions to enter the project and when direction for the project is set the structural engineers become involved.

In Figure 5.6 shows the step ‘proposal document for buildings’.

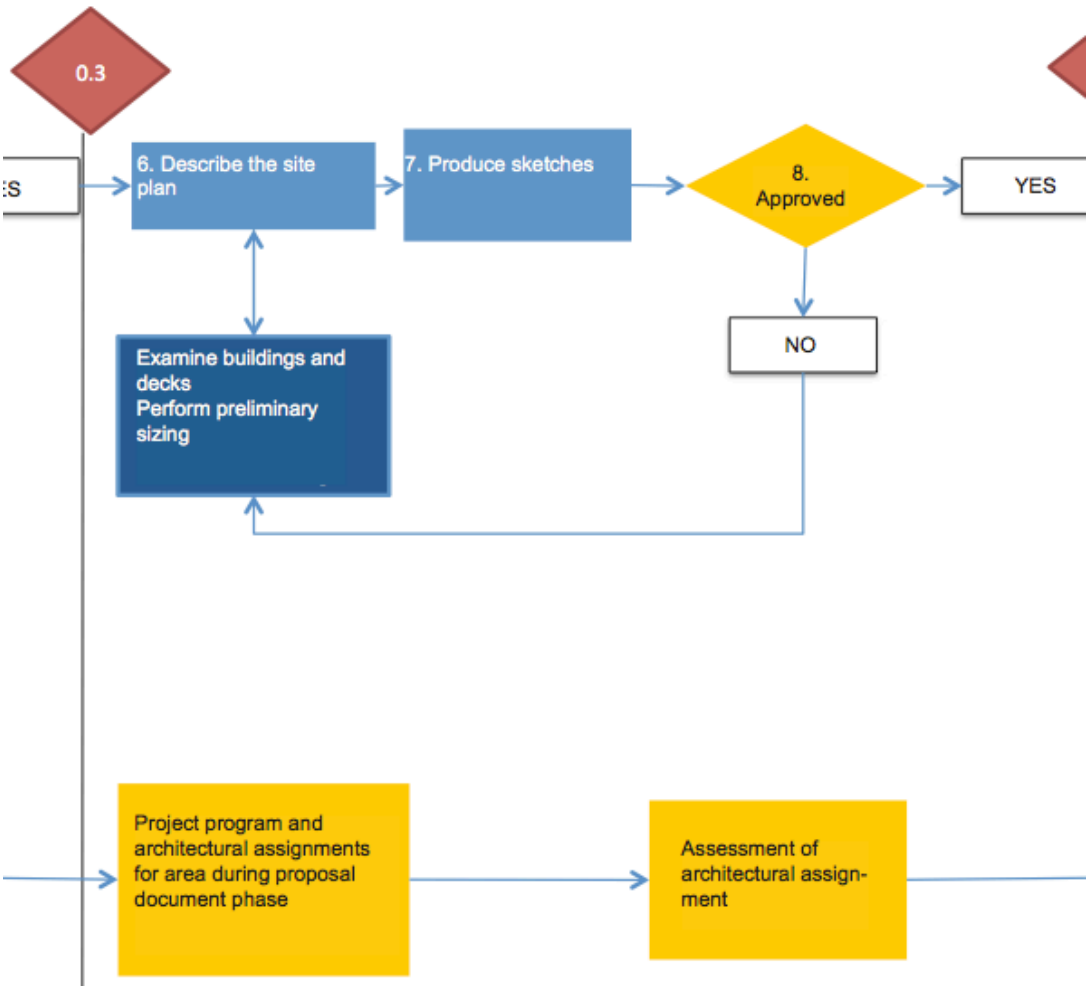


*Figure 5.6 Proposal document for buildings.*

Milestone in this step (0.3) is ‘Start architectural proposal document for area’ with the definition ‘Preparation of site plan’.

Activities are

6. ‘Describe the site plan’ and the definition is ‘Propose screening, local roads, vegetation’.
7. ‘Produce sketches’ with the definition ‘Sketches concerning site and buildings’.
8. ‘Approve site plan’ and has the definition ‘This is performed according to project developers; here architecture is being evaluated. The same or new architects will proceed in the next step’.

Engineers examine buildings and decks and perform preliminary sizing

The main activity in the fourth step is to develop a basis for site plan and this is performed according to project developers; here architecture is being evaluated. The same or new architects will proceed in the next step. The process manager who participated in Survey 2 referred to the planning handbook for architects and stated that architects should handle plot design, garages, technical areas, incoming media shafts, etc., in collaboration with the consulting engineers.

In Figure 5.7 the fifth step, ‘proposal document for apartments’ is shown.

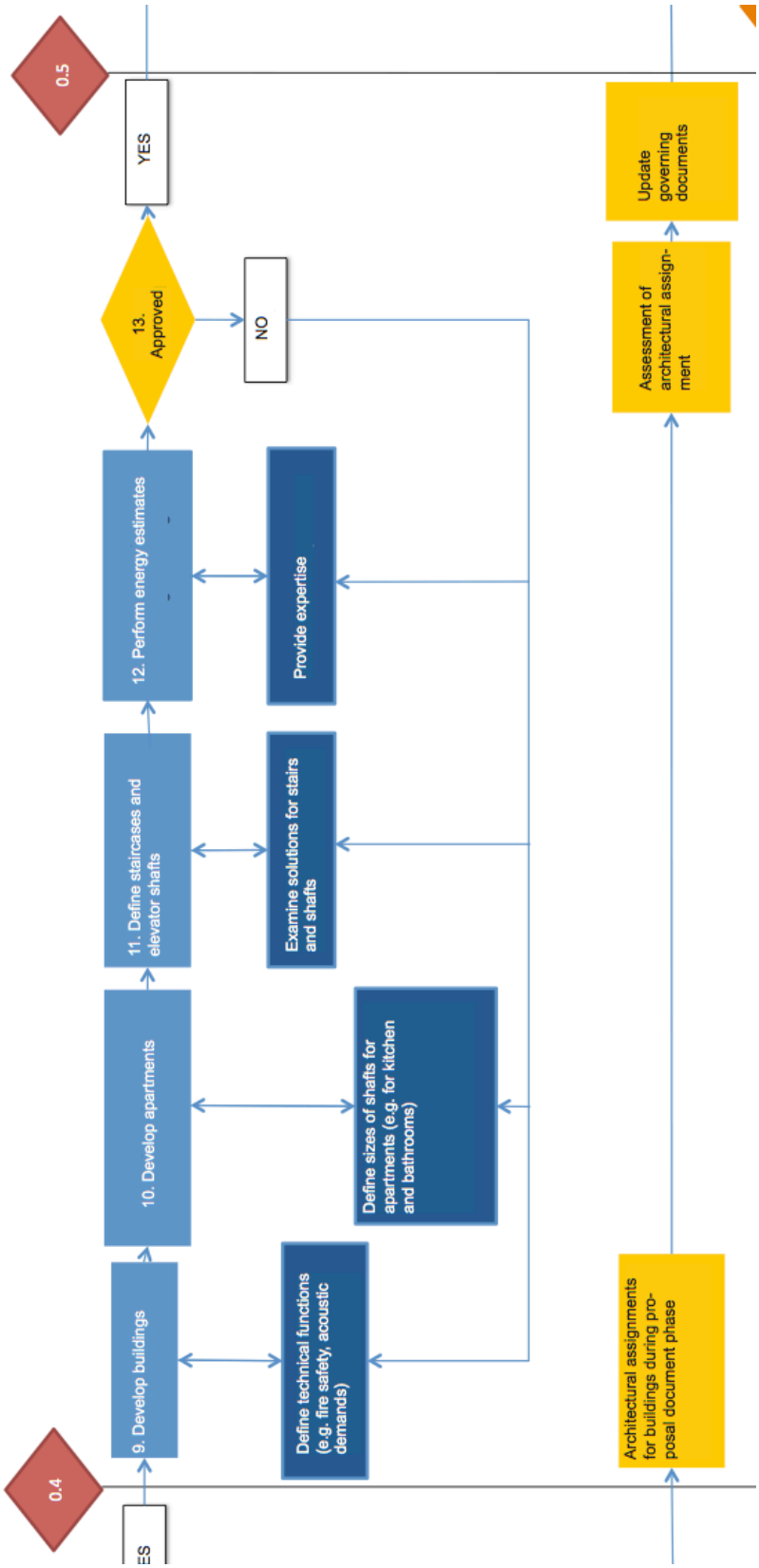


*Figure 5.7 Proposal document for buildings and apartments.*

The initial milestone here (0.4) is ‘Start architectural proposal document for buildings and apartments’ and has the definition ‘Preliminary sketches and drawings of houses and apartments and their functions’.

Activities here are

9. ‘Develop buildings’ with the definition ‘Here the first technical functions of the buildings are defined in collaboration with engineers; fire safety, acoustic demands’.
10. ‘Develop apartments’ and has the definition ‘Sizes of shafts for apartments, e.g. for kitchen and bathrooms, are defined in collaboration with building services engineers’.
11. ‘Define staircases and elevator shafts’ with the definition ‘Stairs and shafts are defined in collaboration with structural engineers’.
12. ‘Perform energy estimates’ with the definition ‘Engineers provide expertise when performing preliminary energy estimates’
13. ‘Approve architectural assignment for proposal document for buildings’. This last activity has the definition ‘This is performed according to project developers; here architecture is being evaluated. The same or new architects will proceed in the next phase, i.e. the general design phase’.

In this fifth and final step of the conceptual phase buildings and apartments are developed and the first functions of the buildings are defined in collaboration with engineers. The architect should, according to survey answers, during the conceptual phase have an understanding of e.g. fire, and because fire evacuation may be required that affects the layout. Before proceeding to the next phase an approval is carried out according to project developers; here architecture is being evaluated. The same or new architects will proceed in the general design phase.

The final milestone (0.5) of this process proposal is the concluding ‘Approved architectural proposal document’ and has the definition ‘Outcome is summed up in a list that can be delivered as a part of the input for the next phase’.

Output lists for architects and project developers consists of issues addressed in the conceptual phase. They will be taken to the next level of detail for further development, e.g. the list for architects will be a part of the input to the general design phase, as explained in Section 4.1.4, and there should preferably not be a need to go back and make changes.

# 6 Conclusion

## 6.1 General conclusion

The proposed process map for the conceptual design phase can be seen as a contribution to a larger on-going mapping of working methods at Skanska and an attempt to describe a structured way of working. The project development department and the consulting engineering department have different processes in different projects and a horizontal transparency, i.e. openness between the people performing the different steps in the process, would be of interest when searching for a unified working method. The map was based on the on-going process from the project development department, and the collaboration among architects and engineers within the consulting engineers department. The resulting process map may serve as a pilot process.

Co-workers of different professions and departments have all had different methods when working, depending on project and experience. From discussions and the surveys made the different professions' look upon the same phase of the process has been compiled and it could be shown that both architects and engineers have similar opinions on what collaboration is good for. Yet, so far, it has only been expressed that a closer collaboration is needed and this project suggests a way to make that collaboration to a unified routine by clarifying the process.

Internal documents have been a great support for the completion of the proposed process map and the most relevant, from an architect's point of view, can be found in the department of project development. Those documents have to be open for updates on how work is actually performed.

Given the conditions as mentioned in Section 4.1, the map was produced with deviation from theory given by Dicander Alexandersson et al. (1998) and ISO (2008) but may serve as a ground for future work.

## 6.2 A proposal for future work

There is today a large difference in size of different projects, when work is done depending on project or when a process is being performed in parallel with other departments. Though, among the informants in this thesis there is still a somewhat shared view upon a possible collaboration in the conceptual phase of building projects.

The recommended steps for further collaboration in the process are:

- Start with synchronising the processes of the different departments and make a unit timeline where each profession can see their own process
- Reorganize the internal documents and let e.g. architects have no more than one source
- Follow the the five steps of the process map as a pilot including the departments concerned
- Reconcile, find obstacles and improve
- Use experience feedback for making improvement a routine

By working together early, it may increase the understanding for other professions. When forming a team and implementing the given theory, the time invested could be a base for future success in process work. By including the co-workers and their further training in process work a better understanding for the whole process could be gained and the benefits of collaboration between disciplines and departments could be received.

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# Appendix A – A process map proposal