Industrialised house building

-fundamental change or business as usual?

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Abstract

Criticism concerning quality deficiencies and high production costs for housing has made many construction companies make efforts to improve performance, inspired by ideas from the manufacturing industry and in particular the car industry. This is often referred to as industrialised building. The ideas are not new but so far their spread has been limited. This study covers two years of one current effort to industrialise house building in a Swedish construction company, the Peab group. An investment in a new factory for automated production of concrete building elements had been made and start up of production in the factory took place during the time of the study. Two subunits, a contractor and a structural building element supplier were involved in the industrialisation effort and the study is confined to these. To improve performance, a prefabricated building system including Peab standards was to be developed and used across the organisation, instead of the existing local solutions. A project, Peab Gemensamt System concept (PGS), was established to conduct the task. The focus for the study is on the facilitators and barriers to make organisational changes for the purpose of industrialising house building in a construction company. Observations were made at meetings with the PGS core team and the involved Peab group staff was interviewed. Notions of organisational competence and embedded knowledge and action were applied to describe the studied company’s specific organisational context and to identify facilitators and barriers. Conclusions concern how organisational context, content of change and the change process interrelated and formed the outcome. In this case, fundamental ideas for change became local attempts. Establishing a project, PGS, for conducting change was new to the target organisation. Facilitators were not created to allow the organisation to learn to change in this new way. The PGS project could therefore not contribute directly to change. One building project introduced a prefabricated building system. It was beyond the team’s control to make necessary changes to benefit from it. Therefore, temporary adaptations to prevailing organisational conditions were made. Another building project introduced a new way of working during the detail design stage. It was within the team’s control to make necessary changes to benefit from it. Existing organisational competence could therefore be enhanced. The new factory had the potential to rationalise production of building elements, but it did not automatically solve problems related to the collaboration between the building element supplier and the contractor. Issues for improving performance through the studied ideas for industrialisation emerge from this. These concern combining the contractor’s and building element supplier’s different ways of working; meeting customer requirements while realising certain industrialisation ideas; and the roles of the permanent and temporary organisations for embedding knowledge without losing flexibility.

Keywords: Industrialised house building, organisational change, organisational competence, embedded knowledge and action
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1 In search for improved housing production methods

1.1 Car manufacturing – a source of inspiration

“It can be described as an effort to develop 100 Lego blocks. 80 of them will be blue, the rest will be red. But it requires that everybody can agree that the blue ones can be used for 80% of the production.”

This quotation is collected from the Swedish construction company Peab’s corporate information magazine in December 2002. The man behind it is the project manager for a newly started effort to industrialise house building, the PGS project, with the aim to develop a building system and spread it across Peab. The effort had actually started several years earlier with the decision to invest in a brand new factory for automated production of concrete building elements to be used for the structural frames for houses. This factory was the trigger for Peab top management to initiate the PGS project to develop a structural building system for multi family housing to be used across Peab’s organisation, instead of the current local solutions. The blue and red Lego blocks, which the project manager talks about, represent how he saw the building system to be developed. Inspiration was found in how car producers provide product variety by using a modular approach and product platforms. The blue Lego blocks were the common elements or the platform he imagined. The red blocks were seen as the variety modules which could be used to create different housing variants.

Peab top management initiated the PGS project less than a year before the new plant was ready for production. Resources were allocated for the project and the PGS project members gathered together and went to work. Finally, they thought, someone could start defining company product standards and make efforts to increase the use of factory produced parts and in turn decrease production taking place on the construction site. The team believed that production costs could be reduced by at least 30% this way. They also claimed that the houses would not have to look the same. Two years later the PGS core team who was supposed to lead Peab’s change work, found itself more or less isolated from the target organisation. The new factory was up and running, but it did not produce the imagined set of Lego blocks. It produced products, which were considered to belong to the past by the advocates of Lego blocks. The products supported what they found to be traditional construction methods. Moreover, Peab made good profits.

Is this a successful failure? Or would Peab have earned even more money with the PGS core team’s Lego system? Or did Peab discover that product platforms are
inappropriate in the context of construction while automated production is suitable? Or is it something else? The issue of whether it is possible to adopt similar production methods as the manufacturing industry and in particular the car industry has been a subject for debate and full-scale effort over the last century. There is a long tradition of seeing the manufacturing industry, in particular the car industry, as a model for improving performance in the construction industry and frequent attempts to adopt concepts have been made. This is often referred to as industrialised building. In the early 1900s, influential architects developed houses for factory production inspired by Ford’s methods (Gann 1996). After the Second World War, mass production became the answer to the great need for housing in Europe where building materials and labour were scarce (Adler 2001). Governments in many European countries encouraged mass production of housing through launching various mass housing programmes during the 1950s and 1960s.

By the mid 1970s, mass production of housing decreased in many Western European countries as a result of, among other things, changes in demand. For instance, the choice of materials and design of the mass produced houses did not meet users’ and society’s requirements. The end of the mass housing era, meant a decrease in large scale mass production in favour of more traditional construction methods, where more of the construction work was done on site.

Lately, the construction industry has been criticised for, among other things, producing low quality, expensive housing. Newspapers have talked about mould, non working ventilation systems and other problems with newly constructed buildings (see e.g. Dagens Nyheter August 30, 2002; Svenska Dagbladet September 9, 2002). Such criticism has also been forwarded in government assessment reports. In 2002, such a report was published, where the government criticised the Swedish construction industry for high production costs, low quality products and unwillingness to change (SOU 2002:115). Sweden is not the only country where the construction sector is being criticised in this way. In 1998, the report Rethinking Construction criticised the UK construction industry. It pointed out that the UK construction industry’s performance sometimes is very good, but the report concluded that most of the industry did not perform satisfactorily, particularly in terms of cost, quality and time.

Following the criticism, now as well as during the mass housing era in the 1960s, government and industry initiatives to encourage improved construction performance have been launched in Sweden as in other countries. Such initiatives include the Swedish Construction Cost Forum and the Swedish Council for Constructing Excellence (BQR). While large-scale housing projects were encouraged by economic
incentives to local authorities during the mass housing period in Sweden, BQR is a non-profit organisation with members from the construction sector. These members decide on the focus for the work. One example of an ongoing activity is development of a model for evaluation of construction projects.

An important source of inspiration is still the car industry, which is illustrated by what the project leader for the Swedish Construction Cost Forum, Sonny Modig, who is now also the coordinator of BQR said in 2004. “I am convinced that in 8-10 years, “lean” thinking will be rooted throughout the Swedish construction sector. It is not impossible that the main part of the components for houses will be produced indoors by then. Lean Construction incorporates a core idea which is that quality should be produced throughout the process. A big problem in the construction sector is the large number of mistakes, and I think we have much to learn. Mistakes not only cost money, they also injure the reputation of the Swedish construction sector. A holistic view is needed and each company must challenge itself, its processes and its employees. (Author’s translation from Planera Bygga Bo 5/04)

Construction companies also take their own initiatives to respond to criticism and also to increase their profits. Many construction companies are currently reconsidering their work organisations and working procedures, which are seen as a contributing reason to the problems. Again industrialised building is seen as a promising way forward.

1.1.1 A new try or trying something new?

Peab is not the only one to make efforts to improve its performance by using the manufacturing industry as a source of inspiration. Daily newspapers and construction industry magazines report how other big Swedish construction companies such as Skanska, NCC and JM also are making efforts to increase quality and reduce production costs on newly produced housing. For all of them, industrialisation is a key word, even though their approaches differ. Some of them have invested in their own factories, while others focus on developing specific guidelines for housing design to increase the use of standardised parts. Even though their approaches differ, there are some common ingredients in their approaches; increased control over the design of the buildings, longer term relations with other actors and increased degree of prefabrication.

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1 Research related such industrialisation efforts are being carried out. One example is Lessing (2006) who deals with implications of industrialisation on process structure and on project management.
This is not at all a unique Swedish trend. For instance, EU research funds are spent on efforts to improve housing production across Europe. Between 1999 and 2001, FutureHome, a project which brought together universities and companies from six different EU countries was carried out (Atkin and Wing 1999). It aimed at developing know-how for housing production using advanced manufacturing methods. A more recent example is Manubuild, a consortium of companies and research institutes from ten European countries whose vision includes industrialised processes in factories as well as on site to produce flexible housing designs (www.manubuild.org).

Why do construction companies want to do this again? There must have been some reason for earlier efforts to fade away? By talking to practitioners, researchers and reading literature on the issue it was found that there is no consistent answer. There seem to be different understandings of how to consider experiences from the past and new efforts to improve performance by learning from other industries.

Those who were sceptical about transferring ideas from manufacturing or car production, as pointed out by Gann (1996), argued that housing production and car production are too different. Past efforts have shown what transferring production ideas can lead to. Houses and cars are different products and the way to produce them must therefore be organised in different ways. For example, cars are shipped to the market from the factory, while houses are consumed at the same place as they are produced (Reichstein et al. 2005). Therefore the construction work organisation is designed to manage a large number of independent and often local actors who meet in individual projects to conduct sequenced activities to create a unique product. In car production, large volumes of similar cars are assembled by the same people at the same place. This implies differences in how labour supply and logistics need to be considered. Such differences affect the type of production principles that are possible and feasible to transfer.

In housing production it was claimed that a trade-off must be made between the use of standardised factory produced parts and unique parts, to meet customers’ and society’s requirements. One lesson from earlier attempts to industrialise house building, both from the early attempts in the 1930s and during the mass housing era in the 1960s concerned how standardisation contributed to monotone buildings which did not meet customer demands (Hounshell 1984 and Adler 2001). Furthermore, too extensive standardisation of building systems was found to be a barrier to adapting the buildings to site specific conditions. Therefore, standardisation as a way to achieve large volume production was not seen as a feasible way forward.
It was also discussed whether it is possible to reduce production costs through standardisation and factory production of building systems and components. Advocates of prefabrication as an ingredient in industrialised building claim that there is great potential to reduce costs as a result of reduced construction time and large production volumes. However, it has proven difficult to make comparison between projects constructed with traditional methods and those where prefabricated parts are used. One reason is that it is difficult to tie cost reductions or increases in individual projects to a particular building element. In Sweden, Adler (2001) claims that mass produced houses, made during the one million programme (the Swedish mass housing programme) were not cheaper than those constructed with traditional methods at the time.

Such disadvantages were described to be contributing reasons why prefabrication and mass production decreased after the mass housing era. Those who were sceptical considered creating a better understanding of conditions for construction work and make that a starting point for improvement work, as a better way forward than making attempts to learn from the manufacturing industry or more specifically the car industry.

Winch (2003) elaborates on this and suggests that the history of manufacturing often is presented more or less as that of one specific industry i.e. the auto industry. Development of mass production and later lean production has therefore tended to be seen as a good model for others to follow. However, there is also a parallel development which concerns infrastructure and related systems i.e. complex systems, which are different to mass market products. Complex systems industries and volume industries show big differences in how they organise manufacturing. The logic of how they organise is closely related to the markets they serve, and can therefore not be taken away with for example a re-engineering programme. Complex systems industries are described to be characterised by a design-to-order strategy, tendering against customer specification and low volume materials flow. This is different to a make to order strategy with an existing design that can be configured to fit specific customer requirements and where new product developments take place based on market research instead of through a contractual relationship with a customer.

A problem that Winch mentions is that many attempts to re-engineering the construction process have used the mass production and lately the lean production models as templates, rather than complex systems models. It is suggested that the lean production model, based on mass customisation is most likely to apply to housing with high enough volumes, rather than construction in generally.
Others, who were in favour of improving performance in construction by learning from the car industry, claimed that an updated understanding of how to apply the ideas is required. If this can be achieved it was claimed that there are great potentials to reduce costs and improve quality in housing production. The arguments concerned for instance a reconsideration of standardisation and prefabrication as ingredients in industrialised building. New efforts can make use of standardisation and prefabrication if the understanding of the concepts is updated, it was claimed. Other industries have long been thinking beyond mass production. It was pointed out that standardisation does not necessarily have to be maximised and there are ways to provide product variety from standardised components, as shown by the examples in the car industry (Gibb 2001).

An example of what is seen as an updated understanding is Adler (1995) and Sarja (1998) who argue for open system building. The use of open system building instead of closed systems, as used during the mass housing era is argued to be a way to create smaller scale housing projects, which are adaptable to various conditions and various requirements. Open system building refers to buildings that are assembled with components from independent producers, while closed systems are controlled by a single company which the client has to deal with. Producers of closed systems are dependent on large-scale production in single projects. Independent producers of components for open system building on the other hand, achieve large-scale production by selling components to many different projects. In a market where open system building is predominant, there will be a wide choice of different components to combine into different housing projects, it was argued.

Another example is lean construction. Many researchers are engaged in examining how notions from lean production\(^2\), applied successfully in the manufacturing industry, can be applied to construction. There is a network for professionals and researchers, International Group for Lean Construction (IGLC), who among other things, arrange annual international conferences on this topic. IGLC describe a number of research themes, which point to that professionals and researchers have taken interest in applying “lean ideas” to many areas and aspects of construction. The research themes include theory; production planning and control; product development and design management; supply chain management; prefabrication, assembly and open build, as well as people, culture and change.

\(^2\) Lean production concerns ideas for design of a production system as a flow with no waste. The concept of lean production is based on studies of Japanese car producers (Womack et al 1990).
Vrijhoef and Koskela (2005) describe that different ideas about how lean construction can be realised have been presented. Some, such as the Egan Report, have argued that for this to occur, construction must turn into a manufacturing process. There are also many who take the prevailing production system and its context as a starting point for finding ways to improve current practice. Within the IGLC community, Ballard (2005) claims that lean construction is broadly considered based on the idea that the project is a more fundamental form of production system than the factory.

Advocates of industrialised building also point to some examples which are labelled as successful transfers of knowledge from the manufacturing industry to housing production, for instance in Japan. Prefabricated-housing companies in Japan produce detached houses using factory-produced parts, in a way that can be compared with the automobile industry. Some of the companies produce over 10,000 units per year (Sawada, 1997). These are Sekisui Heim, Daiwa House and Toyota Homes, and are described to produce houses in a similar way as cars are produced. None of them have developed from traditional house building firms (Gann 1996). Sekisui Heim was established as a subsidiary to Sekisui Chemicals, Daiwa House was established by Daiwa, a tubular steel fabricator, and Toyota Homes was established by Toyota, the car manufacturer. All of these companies therefore had access to large R&D departments and knowledge from other parts of the original organisations. This helped cross-industry learning to occur. If these companies have done it, there must be a way for others to do it as well, advocates say.

Thus, these ideas do not seem to be all new. Sceptics argue for exploring other ways to improve performance instead. Advocates claim that there are potential benefits for those who can update their understanding of the old ideas. Many people are obviously engaged in making efforts to do this from various perspectives. There are some construction companies which are described as already being there, and many others are attempting to get there. Assume that the advocates are right, how come that not all construction companies are there already? What takes them so long? Why is it difficult to transfer production and management notions from the manufacturing industry to the construction industry? How come Peab could introduce modern factory production to support traditional construction methods? What happened to the PGS project and the idea of creating Lego blocks?

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3 Rethinking Construction is the title of a report by Sir John Egan’s Construction Task Force, published in the UK in 1998. It argues that through the application of best practices, the construction industry and its clients together can improve their performance.
1.1.2 Research question and scope

From what has been said earlier, it seems as if industrialisation of house building can concern many different aspects of construction work and organisation. It is clear though, that it is about changing something from a current state to a desired state. Therefore, I have chosen to think about individual companies’ efforts to industrialise building, in terms of change in an organisation. In the context of business and organisations today, the word change is used to describe changes that concern the conditions for business such as technology, customers, competitors, market structure, social and political environment (Senge 1999). The word also refers to internal changes aiming at adapting to such external changes. Change can be an intentional effort initiated by managers, for example in order to adapt to new external conditions. It can also happen slowly as a result of successive replacement of old equipment. Changes can have an effect on any aspect of the operation and functioning of an organisation (Mullins 1993).

While change can concern numerous things, this study focuses on specific changes, labelled industrialisation of house building. One specific research question has been formulated for this thesis:

What are the facilitators and barriers to making organisational changes for the purpose of industrialising house building in a construction company?

Since ideas for industrialisation can focus on different things, as pointed out above and the organisations where they are conducted in turn are different, I have chosen to use theoretical notions which can support understanding of facilitators and barriers to achieving specific changes in a specific organisational context. These notions concern, organisational competences or more specifically, embedded knowledge and action, related to individual companies as well as the industry or society in which they operate. This approach can support an understanding of why it may be possible or difficult to make changes in the organisation.

Choosing this perspective means that certain things are put in the foreground while others are put in the background. That is to say that the chosen perspective contributes to define the scope of the study. Obviously many theoretical perspectives could provide interesting insights about facilitators and barriers to industrialising house building. In this case, such things as how various stakeholders’ interests and control over resources influence the change process also would have provided interesting insights. While recognising this, a choice had to be made since, as in most research endeavours, resources were not available to cover all potentially interesting aspects.
The purpose of choosing this particular approach was that it is believed to provide useful insight to issues relating to industrialisation of house building from the individual construction company’s perspective. Many earlier studies have dealt with facilitators and barriers related to change, learning, and innovation in construction projects and companies (see e.g. Barlow 2000; Gann 2001, Larsen and Ballal 2005 and Huemer and Östergren 2000). Barlow studies partnering as a mean for improving performance in a project and corresponding innovation and learning benefits at the organisational level. Gann examines mechanisms and constraints for absorbing knowledge created by academics in construction companies. Larsen’s and Ballal’s study deals with how innovations can be spread in the UK construction industry. Huemer and Östergren (2000) describe how a changed perception of being local in two Swedish construction companies implies openings for improved learning.

This study contributes to knowledge by identifying facilitators and barriers to industrialising house building according to specific ideas in a Swedish construction company, i.e., a specific organisational context. This can contribute to the discussion about individual construction companies’ ability to achieve certain changes and hence increase the understanding of possible ways to improve performance in construction.

Facilitators and barriers to making organisational changes for the purpose of industrialising house building are studied through a case study of the Swedish construction company Peab’s effort to industrialise house building. Findings presented here represent two years study of the ongoing effort, i.e. autumn 2002 to autumn 2004. During the time of the study, the industrialisation effort mainly involved two entities within the Peab group, i.e. Peab Sverige AB (contractor, from now on referred to as Peab) and Skandinaviska Bygglement AB (supplier of prefabricated building elements, from now on referred to as SBE) and therefore the study is confined to these two entities.
1.2 Introduction to the Peab group and its industrialisation effort

Peab is one of the largest construction and civil engineering companies in Sweden\(^4\). Company group turnover is SEK 25.5 billion (2005) and the number of employees is 11,000. The company group business is divided into two main areas, construction and civil engineering/industry. The construction area consists of three construction companies, one in Sweden (Peab Sverige AB), one in Norway (Peab AS) and one in Finland (Peab Suomi Oy). The civil engineering and industry area consists of companies which operate within the business areas: asphalt, crane hire, rock engineering and geotechnics, concrete and prefabricated elements, as well as transportation and plant hire.

Peab was founded in 1959 by the two brothers Erik and Mats Paulsson. For a start, the company helped farmers in Skåne, in the south of Sweden with transportation of waste (www.peab.se). Through buying other businesses, the company grew and its business changed character. During the 1960s, export of macadam was of importance for Peab. Furthermore, in 1967, its first office was built in Förslöv in Skåne. This is still today its head quarters. In the following decades, Peab grew through buying a number of other construction and civil engineering companies in different places. This turned Peab into a nation wide construction and civil engineering company and it has become one of Sweden’s largest construction companies. It also does business in Finland and Norway. The Paulsson brothers are still influential in the company group through their ownership. Furthermore, Mats Paulsson is the company group CEO.

The drivers behind Peab’s decision to start an industrialisation effort concerned a will to reduce production costs for housing and thereby increase competitiveness. Again, the idea of adopting methods and concepts developed outside the construction industry was seen as the way forward by Peab as many other construction companies.

\(^4\) The Swedish construction industry is characterised by its numerous and small companies. Companies that belong to the construction industry are those that are directly involved in building and civil engineering works, refurbishment and rebuilding. Construction investments in Sweden amounted to 6.2% of GDP in 2004. The industry employs 5.8% of the total number of employed people in the country (Fakta om byggande 2005).

In 2004, the industry consisted of about 60,000 companies, but only 12% of them had more than 4 employees (Fakta om byggandet 2005). While only 1% of the companies had 50 or more employees, their turnover from work by contract was 64% of the country’s total. These companies employed 53% of the industry’s employees. The three largest construction companies, both in terms of turnover and number of employees in 2004 were Skanska, NCC and Peab.
This effort had actually started some years earlier with a decision to invest in a new production plant for automated production of concrete building elements. The construction of the new plant was to be managed within a newly founded subsidiary, Skandinaviska Byggeelement AB, with origins in the civil engineering and industry part of the Peab group. Among some of the staff that had worked many years in the prefabricated concrete element business, the thought of such a factory was not new. In the 1980s there were plans to establish one, but due to the recession in the early 1990s the plans were not realised. With renewed focus on affordable housing and an increasing demand for housing about a decade later, the decision to go ahead with the factory investment was taken. To allow for conveniently reaching the main Swedish housing market areas, the factory was located in Katrineholm, approximately 110 km Southwest of Stockholm, where Scania (a truck manufacturer) had just closed down a factory. The location provided new opportunities for work in Katrineholm and thus implied a good position for negotiating with authorities about improvement of the road connecting the factory with regional and national roads.

The factory investment was considered by top managers as a trigger for a wider renewal effort and therefore, during the autumn of 2002, one year before the factory was ready for production, top management launched a project with the aim to join forces between the construction side of the company (Peab) and the building element manufacturing side of the company (SBE). The project was part of Peab top management’s work to unite the different local entities and subsidiaries in the company group to allow for making use of resources in a more efficient way. Housing production was expected to become more efficient if a system with certain standardised parts could replace the prevailing practice of applying different systems across Peab’s local entities.

A former Peab employee accepted the offer to come back and manage the project. Together with top management, the project manager appointed seventeen core project team members to work with the renewal effort. The effort was referred to as Peab’s industrialisation effort. The building system to be developed and the project and its team were named PGS, referring to Peab Gemensamt Systemkoncept (common system concept for Peab). The task given to the PGS team by top management was to develop a common structural system for the company as indicated by the name PGS. The idea was to reduce production costs for housing through developing a building system including Peab standards for certain parts. Project duration was planned from 2002-2007.

To indicate the formal start of the Peab and SBE joint effort, a kick off meeting with the company group top management was held. The meeting was arranged by the
newly appointed manager for the PGS project and external consultants, contracted to support the project manager. These external consultants specialised in lean growth, i.e. ideas with origins in the notions of lean production. Involving them in the PGS work was seen as way to incorporate lean ideas to the industrialisation work. The kick-off meeting served the purpose of collecting top managers’ views and establishing a common view of the direction of the work. Target levels for such things as reduction of lead times, production costs and future production volumes as well as a vision and strategy for the joint effort were confirmed. The target for cost reduction was set at 30% and lead time reduction at 40%. Shortly after the meeting, articles in company internal papers informed the organisation about the launch of the joint effort. In addition to the emphasis on reducing production costs through an industrialised approach to production of multi family housing, the message sent to the organisation underlined that this effort was an important part of uniting Peab’s many local entities and subsidiaries that operated more or less independently.

The idea of prefabrication was not new to the organisation. In accordance with the general development of housing production, Peab used to have its own factory production of housing in the 1970s. Through the years after the mass production period, the idea of an industrialised housing production process remained in the minds of some people in the organisation in a similar way as among practitioners and researchers in general. The construction side of the company saw local efforts in the organisation to develop building systems for multi family housing production over the years, of which some were considered promising. However, spreading such results across the organisation only occurred to a very limited extent. As a result of the investment in the new factory and a general perception about the need to reduce production costs for housing, a working group within Peab Sverige AB was established not long before the launch of the PGS project. The group aimed to develop a building system concept suitable for rational production. Furthermore, they wished to make the voice of the “construction side” heard regarding the requirements of products produced by the new factory. The start of the PGS work included reforming the organisation for the development project and the original group became the steering group of the new PGS core team.

The case study presented in this thesis is a glimpse into some events taking place during two years of a several years long change process in Peab AB and SBE AB, seen through the eyes of a researcher who has interviewed involved individuals and observed events in real time during two years. While the process started some years earlier with the decision to invest in a new and automated factory for production of structural building elements, the story told here begins in September 2002 when the
company’s top management launched a project to join forces between the construction side and the building element manufacturing side in the company.

1.2.1 Peab’s ideas for industrialisation - What is PGS?
Already before the PGS project commenced its work, there was an idea about the building system to be developed to be a system with a not yet specified degree of prefabrication. Since cast in situ and semi prefabricated structural systems were commonly used within the organisation at the time for the start of the PGS project, it was considered desirable to increase the use of prefabrication by introducing the new building system. The desire to increase the use of prefabricated parts, was based on a desire to benefit from an number of potential advantages, which were also emphasised by advocates of off-site fabrication

Prefabrication implies several potential benefits compared to on situ construction according to Gibb (1999). First, there is a perceived potential to save time by reducing time on the construction site. Prefabrication allows for foundation work to be done on site concurrently with manufacturing of elements in factories. This saves time compared to in situ construction where these activities must be done in sequence. Second, there is a perceived potential for cost reduction by allowing for earlier income generation mainly through the shorter construction time. Third, there is a perceived potential to improve quality since factory environments are more favourable than outdoor conditions. Fourth, there is a potential to increase predictability by applying off-site fabrication since items must be produced before they are required on site. Finally, off-site fabrication is considered to have the potential to increase productivity in a way that is not possible on the construction site since in the factory operations can be sequenced in the best possible way, work stations can be adjusted and so forth in a way that is not possible on the construction site. Additionally, the possibility of benefiting from economies of scale for suppliers of building systems as well as smaller components is another potential advantage (Gann 1996).

To find out more about what the emerging PGS core team expected the common system concept to be, the initial team members were interviewed before they started working together. Their replies together with the observations at the kick-off meeting in September 2002 provide insight into prevailing ideas about how to improve performance in the Peab group house building process.

Descriptions of what the common system concept would be included expectations, requirements as well as physical solutions. The requirement on the common system concept that generally was considered to be the most important was cost
effectiveness. There were many ideas about requirements that the system has to fulfil to be cost effective and even more ideas about cost-effective solutions. Some talked about developing a number of type-houses or concept-houses by using this system and emphasised that these houses must be adaptable to various requirements and continuously developed not to become obsolete. Others said that they found the idea of type-houses too limited and argued for developing a system that could be applied to different variants instead.

'I don't think that we are going to develop one house that looks the same everywhere. It must be a system that can include various requirements. There must be a certain flexibility that allows for designing the house in a way that it will not be possible to say in 30 years that, yes, that is a typical Peab-house that looks the same in Stockholm, Sundsvall and Gothenburg.' (Purchaser, Peab)

'Some people think that we should have type-houses, but I think that we should have a system with certain flexibility. I mean, we must have a system that can be adapted to what is in fashion at the moment. If well-known architects start going in one direction, the others will soon follow. After a while they change direction.' (Design co-ordinator, Peab)

"I think we need to develop 4-5 different type solutions. Sometimes you wish to build a house shaped as a long loaf of bread, sometimes you wish to build a tower block. Sometimes you wish for a tall building and sometimes a lower one and sometimes you need to be able to build in slopes and adapt the building to hilly terrain, sometimes to flat terrain. I don’t think that it is possible to stubbornly present two houses and say "Here you go. Take it or leave it". I rather think we should use the same base components which can be assembled in different ways like a leggo system to allow for meeting all these requirements." (Technical manager, SBE)

The need for a complete building system was emphasised by most of the PGS core team members from Peab, as opposed to producing separate elements. A manager at the regional level took the view that SBE should have the right competence in their factory to allow for the “construction side” to send architect drawings and in reply receive a suggestion for a structural solution including price. The structural solutions coming from the factory should be possible to apply in different places in Sweden. A contracts manager and a design co-ordinator argued for SBE to get the right competence to be able to supply a complete system. It was not considered necessary that all parts should be manufactured by SBE but since it is likely that they can buy larger quantities than Peab, they would probably get better prices. SBE can then offer the complete system to Peab, they argued. Others talked about how important it was that SBE took a holistic view of a structural system, rather than manufacturing separate elements. SBE interviewees also found it feasible that they would take a
larger responsibility than what was customary at the time for the structural system. At this point, it was not yet clear exactly what this larger responsibility would include.

Another argument for developing a complete system mentioned, especially among Peab interviewees, was that to benefit from using prefabricated elements, the use of them should be maximised in a project. It was explained that if prefabricated beams and floor slabs are used, while the staircases are cast in situ the whole assembly process would stop every time a staircase is casted. Everyone has to stop and wait for it to be finished, which increases the time and cost on site.

The aesthetic aspect was in addition to cost effectiveness claimed to be of great importance. The significance of not repeating the “the one million programme” (Swedish mass housing programme) was pointed out during the kick-off meeting as well as by several of the interviewees both from Peab and SBE. It was stressed that one basic requirement that had to be fulfilled in order not to repeat the one million programme was the possibility of applying the system to various variants of housing designs. Leaving the right degree of freedom in the system to the architect was believed to be a way to deal with the aesthetic aspect and allowing for the system to be applicable to various variants. The right degree of freedom was not yet defined, and was seen as part of the PGS project to deal with by including architects in the work.

'Maybe we have, say four or five types of staircases and we have standardised the elevator function, the canalisation for electricity, ventilation, water in connection to the staircase and then for the rest of the structural system we could perhaps leave the sizes of the elements as questions for the architect. The sizes of the elements would be limited in accordance with what our factory can produce.'

(Design co-ordinator, Peab)

Several respondents, both from Peab and SBE, mentioned that a Peab-design book, a data base, would be useful to develop. This book should include feasible design solutions that designers should use in order to be sure to achieve desired quality in the final product. The Peab design book should serve as a guide for the architect.

1.2.2 Economies of scale
To allow for cost effectiveness without repeating the one million programme in terms of producing housing with an unacceptable appearance, the common system concept was imagined to be designed for applying ideas from among others, the car industry. The design principles top management and the PGS core team members expressed were inspired by the application of a common platform which can be combined with varied parts to distinguish different product variants. The use of certain standards was
seen as a way to benefit from economies of scale in production as well as increasing repetition in work, which would increase speed and predictability.

SBE’s managing director and technical manager explained their thoughts of the development of Peab-houses or a Peab-concept as perhaps four or five type solutions. The Peab-houses should have common parts but be allowed to vary in shape and other external features such as the facade. The system was described to include a platform which constitutes 60-70% of the system. It should also be possible to have a standard level that can be extended according to how much the customer is willing to pay. Several of the Peab interviewees expressed similar thoughts in saying that the type houses or flexible system should be applicable to different variants, as described above under 1.2.1. Furthermore, they also talked about a basic concept, which could be extended with optional items for customers who wished for a higher standard. It was believed that most customers would be pleased with the standard selection, provided it was carefully selected and continuously developed. These ideas included a wish to benefit from economies of scale.

To allow for efficient production, most of the Peab interviewees pointed out that design solutions for shafts, stair-cases, bathrooms, and kitchens should be set early during the process. Some mentioned that perhaps there should be 4-5 standard solutions with certain optional items for kitchens and bathrooms. Many respondents thought it necessary to be clearer about what the customer can choose and what is not optional. Floor plans were considered by some as a non-optional item, while others thought that in the future most end-users would demand the power to influence the floor plan. The importance of getting the product right from the start and specialising on optional items that generate a profit was emphasised, especially by the contracts managers. However, most respondents also claimed that what the customers demand and what they wish to influence varies from one project to another. It may also vary over time, since peoples’ habits change. That what the customers value depends on many things, such as age and income, was pointed out by many respondents. By deciding about certain standard solutions, it was believed that larger quantities could be bought from fewer suppliers, and thereby more favourable prices would be achieved.

Economies of scale were also believed to be achievable by re-using drawings for certain technical solutions for the type-house, concept houses or flexible system to be developed. These could be stored in the factory computer system and re-used by “pushing the button”. By not redesigning everything for every new project, as is done today, time and money could be saved.
Another important requirement mentioned several times was that assembly of the building system must be easy. Easy assembly was said to be achieved by making sure that the principle for assembly is the same irrespective of the shape of the building. The repeatability was considered important.

Even though interviewees both from Peab and SBE claimed that cost estimates currently normally showed that prefabricated structural systems are not less expensive than cast in situ structural systems, they agreed based on the logic of economies of scale, that large volume production is one important way to reach lower costs than would be possible with cast in situ production. It was claimed by two contracts managers and a manager at the regional level, that a team that is skilled in producing in situ structural systems can produce a house at the same or at a lower cost than costs implied by a prefabricated system today. However, it was not possible to present any clear evidence of differences in production costs. It was claimed, both by Peab and by SBE interviewees, that current models for cost estimates are not well suited for prefabricated structural systems since they were developed to suit cost estimates for cast in situ constructed buildings.

Cost estimates for buildings with prefabricated structural systems were said to be based on estimates for cast in situ structural systems. Then the structural parts were taken out and replaced with the cost estimate provided by the prefabricated structural system supplier. This resulted in that the shorter construction time, lower costs for supervisors, shorter costs for cranes, etc which SBE staff claimed to exist were not regarded. This contributed to a prefabricated structural system appearing as expensive or sometimes more expensive than the cast in situ alternative and SBE did not have the tools to prove the opposite. A great potential was seen in the possibility of estimating costs with higher certainty than today by using a common system concept.

The SBE managing director explained that a basic condition for SBE’s business activities is that the production equipment implies fixed costs which means that a certain production volume needs to be reached to allow for profits to be made given the market price for the products. All Swedish building element manufacturers experience problems due to the limited volume of new housing construction from time to time. The continuity is sometimes interrupted when demand is low and the factories have to close for some time. This causes loss of competence and money. Therefore large and continuous production volumes were considered important in the context of the renewal project and Peab was considered as an important customer for SBE, even though the products were going to be sold to the external market as well.
A project leader from SBE expressed this by saying that since there is no demand for the type of houses that were produced in the 1960s, the standardisation should be in the production process and the technical specification of the elements. In accordance with the managing director, he emphasised that the elements that SBE can produce and their production system allow for a wide variety in the design of the buildings and at the same time rational production can be achieved. For the new factory in Katrineholm, changing between production of different elements and changing shape of elements is automated, which makes it quick and easy. In the Uppsala factory, which is older and less automated, such changes were possible but more time consuming.

1.2.3 Why PGS?

"The difficult part is to build cheap houses and somehow we have got used to that it is nothing strange that it becomes too expensive, much more expensive than estimated. In fact, we are more surprised when we stick to the initial cost estimate." (Contracts Manager, Peab)

A useful basis for understanding top management’s and the PGS members’ ideas of why the common system concept would be a way to reduce production costs for housing, is their explanations as to why too high production costs occur. The reasons mentioned, have a lot in common with general descriptions of drawbacks implied by current work organisation in construction. Construction can be described as a project based business, where independent actors meet in the individual projects (Dubois and Gadde 2002; Walker 1996). Feedback between the actors and the different phases of the project is often lacking. There are few incentives to spend resources on improving work, since it is not certain that newly gained knowledge can be re-used in coming projects with other actors.

It was said that today there is relatively little co-ordination and exchange of knowledge and experience between the different units within Peab and each one has developed their skills dealing with different types of building systems and methods. Furthermore, it was perceived that there is also little re-use of experience between projects within the same organisational unit. Often suppliers and consultants are contracted based on lowest price, which leads to new ones being hired for each new project. Treating almost every project as unique by hiring new designers and not re-using experiences gained from someone in the organisation that already was involved in building a similar house earlier was said to lead to repeating work that need not have been repeated and also repeating mistakes that someone else has already made. Often new designers are appointed to design a house that may well be similar to a house that someone else in the organisation built earlier, it was pointed out. A design
coordinator explained that by not taking advantage of earlier experiences, the organisation keeps “inventing the wheel” over and over again.

It was claimed by all SBE respondents that it is only possible to benefit economically from using a prefabricated building system if the design stage is finished earlier than what is customary today when in situ concrete is used. Peab interviewees agreed with this. Problems when prefabricated structural systems are applied occur when drawings are not ready in time for production in factory to start in due time and changes are made during the course of the construction stage when the building elements have already been manufactured. The potential economic benefit is then lost. Problems also occur because of lack of co-ordination between the design of the prefabricated building elements and the design of services. The two project leaders and the managing director especially emphasised that today there seems to be no systematic approach to the design of services. SBE receives documents that include mistakes and are delayed. Over all, co-ordination between the manufacturer of prefabricated elements and other parties during the design stage was perceived to be lacking. Disturbances in the continuity of production in the factory were described to occur sometimes because of this. It happens that production has to stop partly or completely for some time because of this.

The PGS ideas were seen as a way to overcome the perceived problems. In the longer run, SBE wished to develop from a building element supplier into a building system supplier. This implied that SBE would take a larger responsibility for design and assembly of the entire structural system as opposed to supplying separate elements to customers. An SBE project leader pointed out that if SBE takes care of the design of the structural system, experiences may be re-used better than today since SBE will be able to take with them new knowledge from every project that is done. The local contractor often builds such projects with many years between them and in addition there is generally very little contact between site managers, which could be a useful way to learn from other's experiences.

'One idea behind these building elements is to develop a concept so we can take a holistic responsibility for the structural system.' (Project leader, SBE)

Since work on the construction site can be physically demanding, a great potential in improving working conditions by moving the work into a factory was seen both by top management and the PGS core team members. Working conditions on site could also be improved. An important requirement in the common system that most respondents mentioned concerned the working conditions on site. Assembly work must be safe and should not include heavy lifts. A great potential was seen in
reducing man-hours on site by using prefabricated elements. The new factory was also less labour intense than the traditional concrete element factories and the working environment was perceived to be improved by moving work from the construction site to the factory.

Another advantage that was considered to be achievable through the common system concept, especially emphasised by Peab respondents, was more efficient purchasing procedures. For a large contractor like Peab, with a large amount of building projects every year, great potentials were seen in co-ordination of purchases between these and also longer-term relationships with certain suppliers. Today there are certain purchasing agreements for the Peab group, other purchasing agreements on a local level and still more purchases are made on a project basis. Furthermore, without knowing about each other, purchasers from different Peab building projects use the same suppliers without co-ordinating their orders. The amount of purchasing done on a project level was considered as too big and it resulted in unnecessarily high costs since only small amounts are bought from each supplier. A general view was that the choice customers were given regarding finishes, kitchen equipment and bathroom equipment were too wide in terms of numbers of suppliers to supply the selection. The cost for providing such a wide variety was considered to exceed the profit since it generated more administration for handling invoices and different procedures concerning for example complaints and warranties.

'To become a national construction company and stop inventing the wheel over and over again, we have to have a standard selection.' (Purchaser, Peab)

In addition to unfavourable prices, the possibility of developing a certain product together with a supplier was considered difficult when only small volumes are bought each time. Today the suppliers offer certain products and when these are purchased on a small scale for a single project, there are limited chances to influence the development of the products to better suit their own purposes.

'It is possible to work with the suppliers in a different way. If we have problems with one, we can discuss the problem. If we have made one single purchase from one supplier, then we only solve the problem for that particular project, but we don’t solve the problem in a long term perspective.' (Purchaser, Peab)

1.3 What is industrialised house building?

There are obvious reasons to make efforts to overcome problems which were pointed out through the criticism of the construction industry. To overcome those problems that are related to house building, industrialised building is seen as a way
forward by many companies currently. The ideas expressed by Peab and SBE employees, described above are an illustration of how they envisioned the key to industrialised building; a prefabricated building system with certain standards applied across Peab’s organisation. Such a system was believed to be a feasible way to overcome perceived problems with high production costs and mistakes. The problems were explained as caused by the way work is conducted and organised.

So far, in this thesis, the expression industrialised house building has been used as if it was the same thing as adopting production and management principles developed and applied in the manufacturing industry. Is this to say that there was no (or only minor) development before the efforts to learn from Ford’s way of producing cars 100 years ago? Did development stop after the mass housing era, and has it started again with the new efforts to industrialise?

When talking about industrialised house building, many people imagine concrete slabs being mass produced in factories and assembled in monotone large-scale housing projects. Looking into the literature on the area, it can be found that mass production and prefabrication was an important ingredient at certain times. There is also evidence in the form of houses at various places in our cities that reveal that this was the case. While such mass housing approaches seem to be the symbol of industrialised building, historical descriptions of developments in construction point to the fact that it was one of numerous development steps in the history of construction. Construction has developed in many other ways as well and also made use of other knowledge than ideas of mass production in factories, developed outside the sector. Developments in the construction industry have taken place parallel to developments in society and other industries in general. This development often seems to end up in the shadow of discussions of the construction industry’s ability or as it is sometimes described, inability, to improve performance by adopting similar management and production principles as the manufacturing industry.

Despite actual development, the construction industry is often accused of being stiff and conservative when it comes to adopting new and improved production techniques, management philosophies, etc as pointed out by Bröchner (1997). On the one hand it is admitted that there is a gradual development going on in construction, and that this development turns construction into a modern industry (Sebasyén 1998). On the other hand it is claimed that the pace of development is slower in construction than in other industries. More, the construction process and its management processes are claimed to have changed little compared to corresponding processes in other industries (Sarja 1998).
1.3.1 Interrelated development in construction and other industries

Before the 18th century, construction relied mostly on empirical experiences and the expertise of master builders, masons and carpenters (Sebestyén 1998). McClellan III and Dorn (1999) describe the significant changes that started in England in the 1780s as the effects of the development of major industries. These changes included the construction industry as well. Important for the development was that iron began to be smelted with coal. In this way, development of the coal industry was triggered, which also triggered the development of the steam engine to clear the coal mines. This in turn supported the development of railways to transport the coal and thus an increased demand for iron stimulated the development of the iron industry. As a result, great changes in society took place, which are illustrated by the authors by pointing to that rural farmers became urban factory workers and horses and dirt roads were replaced with locomotives and railway tracks. Furthermore, iron and steel started to replace wood and stone as structural material and steamships replaced sailing boats. Starting in the 18th century, significant changes that transformed the character of construction work also took place. Increased use of iron in construction contributed to this.

During the 19th century, several factors contributed to the increased speed of technological change in construction (Sebestyén 1998). Among these, the inventions of Portland cement and reinforced concrete, the use of steel instead of iron and mass-production of glass are of importance. Industrial development and urbanisation in general and the construction of railways in particular resulted in the emergence of large international contractors. However, the largest part of the building contractors remained national players and went on producing for their respective domestic markets. Between the two world wars, the use of trains, cars, aeroplanes, telephones and radio increased. The increased possibilities for mobility of people and goods together with better possibilities for communication opened up new international business opportunities for industry. It also provided new opportunities for the construction industry, which could produce such things as highways and airports, which in turn was a prerequisite for other sectors’ development. Technical progress in construction took place to respond to demands for skyscrapers, long-span domes and bridges, for instance.

Between the two wars, the character of buildings changed, both on the inside and the outside. This included development of materials and structures. For example, cast concrete allowed for curved forms to be produced. Pre-stressed, lightweight and decorative concrete was added to structural reinforced concrete. The introduction of framed structures was made possible by steel and reinforced concrete. During this period, there were changes inside the buildings as well. Partitions and ceilings were
detached from the structural parts and new types of services such as heating, air-conditioning, electric lighting, mains water and elevators became common. With the adaptation of components for specific purposes there followed specialisation in the professions. This made it necessary for architects and engineers with different skills and specialities to cooperate in the design process. Furthermore, during the construction phase, the contractor responsible for the structural parts of the building also had to cooperate with specialist firms working with the services. As technical development carried on, contractors mechanised and such equipment as excavators, bulldozers, cranes and mixers became common.

Such developments and innovations as those described above, contributed to development in the manufacturing industry (Biggs 1996). One such innovation is reinforced concrete, which contributed to some specific improvements for factory buildings compared to traditional wooden factory buildings. First, it made buildings with several floors possible to use, since it reduced vibration from machines. It also opened the floor space on the shop floor, since fewer columns were needed. Increased strength of the outer walls allowed for window areas to be increased, which in turn allowed for daylight to enter the building in a better way. The buildings could also be made larger than the traditional wooden ones. A further important improvement made was the decreased risk of fire. Fire was a great concern for owners of factories which were housed in wooden buildings. In case of an accident, their entire plants and even neighbours’ properties could be eliminated by fire.

One company, among many, that made use of these developments in order to become successful was Ford. As Ford and his engineers developed the production process and production volumes increased, the requirements on the factory buildings also increased. Biggs describes that in the early 1900s, car producers assembled components from supplying manufacturers. The assembly of a car required skilled workers, who could use standard machine tools. All the different parts of the car had to be cut and fitted since there were not yet any standards developed. Each car was assembled by a team of skilled workers, who shared the shop floor with other similar teams. Management often consisted of the owner and a foreman, who were skilled in the trade themselves. Ford’s first factory is described to be of this type and this was also how other goods such as wagons and machinery were made at that time.

By the end of 1905, when Ford established separate factories for production of engines and rear axels, he and his foremen began to think about rearranging work organisation. Efforts to produce interchangeable parts were made, which required precision, and machine tools were developed to better meet the new requirements. Further, to increase the pace of production, the machines were placed in sequence
according to the order in which they were used, instead of in groups as earlier. As Ford introduced the model T, business boomed and he decided to invest in a new factory, where the experience and knowledge he and his engineers had gained could be combined. In Highland Park, Ford first built one new plant and later an even bigger and more modern one. The first one operated from 1910 and the second one from 1914. As a further step, Ford bought a large area of land and established the River Rouge plant in 1919, which was even bigger than the previous ones.

Ford and his engineers worked closely together with the architect Albert Kahn and his brother, the structural engineer Julius Kahn for design and construction of the Highland Park plants as well as the River Rouge plant. The Khan brothers made use of the modern technologies in construction available at the time, to meet the requirements set by Ford’s fast developing production system and increasing production volumes. As production volumes increased, the plant became more and more crowded with machines, workers and cars in process. Therefore, material handling became more and more essential to keep production times and costs down. To be able to handle the flow of material efficiently, shop floor lay out became essential and also the specific location of the different buildings which made up the entire plant. The buildings were designed to let in daylight, as were most modern factory buildings at the time. They were also designed to house the assembly line, which Ford introduced in the first factory in Highland Parks. To make the logistics of the production system work, the buildings made use of the continuously improved reinforced concrete technology, which allowed for factory buildings with several floors. The reinforced concrete made it possible to put heavy machinery on other floors than the ground floor.

The period after the Second World War has also involved development in many areas for construction. For instance mechanisation as well as prefabrication and system building developed as well as building codes and standards. As technology has progressed, peoples’ requirements on comfort and other things have been met through more and more advanced solutions for such things as heating, ventilation and telecommunications. Such development builds on development in several areas (Sebestyén 1998). For instance, design of buildings takes advantage of knowledge in mathematics and physics. Further, computers are used in different parts of the building process. Wikforss (2003) describes how computers were introduced in the construction and real estate industries 30 years ago. At that time, 30 years ago, a big concern was how to get access to sufficient computer capacity at a reasonable cost. Today a concern is how to structure data and information concerning buildings throughout their life cycle to allow for communication between users with different system needs. Research has improved knowledge in areas such as heating, ventilation
and energy conservation. Fire, sound and noise in buildings are other examples of areas where knowledge has advanced. Studies of, for example maintenance, repair and environmental impact are conducted with the aim of achieving the best possible performance over a life cycle. Construction also takes advantage of new materials, equipment and production processes. The use of new materials refers to, for example, taking advantage of developments in steel technology and the development of various types and qualities of concrete. Other examples are the use of glass produced with properties suitable for the effects of sunshine and energy conservation. New machines include the use of robots in the construction process.

1.3.2 System building

One area of development in construction which receives much attention currently and has received much attention at certain times during the last century is the development of prefabrication and system building. This development is closely associated with the expression “industrialised building” and has bearing on current ideas. System building was applied broadly in the 1950s and 1960s, but its development started earlier. It means that different types of building systems are used as a basis for constructing housing. A building system can be referred to as "a set of components for a particular type of building, together with their production and erection procedures" (Sarja 1998). While Ford is one of many companies that made use of advances in construction which made factory production successful, housing producers took interest in adopting his production principles. Current housing producers still take interest in learning from car manufacturing. Now an important source of inspiration is Toyota, which is shown for instance by research on “lean construction”, as previously mentioned. The development of system building provides insights into where the ideas of Peab’s common system concept come from.

From the time when Ford developed the standard production line for car manufacture, actors in the European and North American house building sectors as well as politicians have been attracted by the idea of producing houses in factories like cars (Gann 1996). During the early part of the 20th century, leading architects, for example Le Corbusier and Walter Gropius aimed at improving efficiency in construction by rationalising the process by using scientific methods. Walter Gropius, founder of the German Bauhaus School, became a promoter the ideas of Henry Ford and Frederic Taylor (Biggs 1996). He introduced Ford’s principles for mass production to the architects of the Bauhaus school, who designed buildings that could be produced according to these principles. In brief, Ford’s production system was built around a few ideas which included production of a single model at a low price, in large quantities with a small profit margin. A key characteristic of Ford’s production system was the assembly line. For the production system to work,
standardisation, mechanisation, speed and control of the entire system and its workers were needed. Division of labour and specialisation of work were essential ingredients. The ideas of Le Corbusier, Gropius and others led to new construction methods that later on influenced the evolution of system building in the 1960s.

After the Second World War, there was a great need for new housing in many European countries. Adler (2001) points out that at this time construction methods were to a great extent craft production, which forced governments and housing producers to search for more efficient and faster methods to be able to cope with the situation. In many European countries there was a lack of labour as well as building materials. Industrialised mass production was therefore seen as a way to improve productivity to be able to meet the enormous need for housing. During the 1950s, the search for new building methods started on a broad base and designers as well as other actors such as manufacturers and contractors contributed to the development of factory produced housing. In many European countries, the governments encouraged the development of system building by extensive mass housing programmes.

The development was supported by three principles; standardisation, prefabrication and system building (Gann 1996). Standardisation was a prerequisite for production of components in factories. Production of components in factories and their assembly on site, aimed at reducing costs, increasing the speed of construction and improving quality. Prefabricated components became commonly used during this period, and new ways of working were introduced such as new relations with manufacturers, and quality controls. Dimensional coordination, i.e. coordination of the size of factory-produced components with the design of buildings, was introduced. Two main types of prefabricated components were developed; the first type was produced without knowledge about the building and the second type was produced for a specific building.

The development of system building is described by Adler (1998 and 2001) as a system development of three generations. The first generation constituted prefabricated concrete elements, specific for a particular system, that were mass produced. The production methods led to standardisation of components as well as entire buildings. In Sweden, as well as other countries where industrialised house building was seen as a means for rational production, the question whether closed or open systems should be developed was discussed. The closed systems were most suitable for large-scale projects with standardised buildings on green land. Design and building contracts were applied where the contractor, the owner of the system, took on necessary technical development to adapt the system to the specific project.
Technical information about the closed systems as well as their production techniques were considered as business secrets, to be kept within the large construction companies who owned the production facilities.

For these systems to be used rationally, large volumes of system specific elements preferable for large projects were required. Large-scale house building was criticised in many places in the 1970s and as a result, new types of requirements on housing were formulated. The new requirements concerned users' opportunities to influence the design of the dwellings initially and over time, as well as adaptation of design to different local needs. Environmental requirements on production methods were also included in the requirements. The closed systems were not adaptable to external conditions to the extent which the new requirements demanded, and were therefore replaced with other building techniques. Such development took place in many European countries, e.g. the UK, Germany, France and Poland.

By the mid 1970s there was a decrease of use of prefabrication in many western European countries since the design, layout and choice of materials of the products which these factories produced no longer corresponded to the preferences of users and society in general. In addition, many of the systems used during the mass production period, were closed and were therefore not suitable to combine with products from different manufacturers and they were also mostly suitable for construction on green land (Adler 2001). By the mid 1970s, the demand also changed for systems suitable for construction in already exploited areas.

In Eastern Europe and the Soviet Union, Sebestyén (1998) points out that the development was similar, but system building continued into the 1980s. Big residential areas were built by state owned organisations that handled design and contracting. The largest part of new housing in cities was realised through direct or indirect government interference. Significant investments were made in mechanisation and prefabrication.

However, as described earlier, this does not mean that development in construction started and ended with the efforts to apply Ford’s production principles. The so-called traditional construction methods have also developed over time. For instance, construction on site has gradually increased its use of components and systems produced off-site, i.e. prefabricated parts. This development started long before Ford, and an early example is the brick, which was used in Egypt 1500 years B.C (Adler 2001). Later examples of items produced in factories off-site are doors, windows, electrical systems and sanitary equipment. The construction process also makes use of different types of modern machinery on site and computers during design.
The new requirements implied new demands on building techniques as well as the building process, which opened up for new development paths for system building. Building projects changed to smaller scale and were located within or adjacent to already built areas, i.e. on brown land. During a transition period in the 1970s and 1980s, for example Denmark and Finland developed and tried a more open approach to system building, i.e. what Adler calls the second generation of building systems. The second generation of building systems could be procured by smaller contractors. This led to the development of component-building technology or "catalogue building". Dimensional co-ordination of components from different suppliers turned out to be necessary but not sufficient for a rational open market. In practice the features of the building components and their connecting interfaces were crucial for the opportunity to combine products from different suppliers. The need for easily accessible product information was needed and a framework for product information was developed. However, experiences pointed to that the rules of co-ordination must be accepted and practised by all parties in the building process to allow for making use of potential benefits of this type of prefabrication.

Different variants of the open approach have been developed. An early example is the Dutch architect John Habraken who developed Open Build (OB), as a response to lack of user involvement in the mass housing era of the 1960s. A central idea of OB is distinguishing between levels. The three levels of decision making are tissue level (planning and neighbourhoods), support level and infill level (Gann et al. 1999). The support level, or base building is, according to Kendall and Teicher (2000) common to all occupants and it may last for 100 years or more. In a multifamily house the support level is the load bearing structure, common mechanical and conveyance systems, public areas and most of the outer skin. Individual tenants should not touch the support level. The infill level refers to all components specific to the individual dwelling unit. For a multi-family dwelling those are partitioning, kitchen and bathroom equipment, unit heating, ventilation and air conditioning system, outlets for power, communication for security, ducts and pipes and cables which individually service facilities in each unit. For a detached dwelling, open build distinguishes changeable interior fit out from more durable structure and skin.

The idea of OB is well developed but it is not widely used in practice. Gann et al. (1999) mention some of the reasons for this. There is not an effective medium or large-scale industrial delivery system with supply-chain linkages through design and manufacture to component and sub-system assembly. One reason for the slow commercialisation of the existing infill systems may be difficulties adapting design and construction of the structure to the particular needs of a particular infill system.
Adler (2001) claims that the view of industrialised building changed by the end of the 1980s, and that we now see the emergence of what he labels the third generation of systems. The requirements are said to have moved away from standardisation and instead focus on human and environmentally friendly design of components and entire buildings. To meet these requirements production techniques in his view need to be industrialised in combination with rational craft work and open flow of information. Therefore open industrialised building is described as "integrated and systematic exchange and implementation of products, services and information between the parties of a building process nationally and internationally between countries and regions which have major differences in the structure of their building industry".

Both open and closed approaches to system building can be found in the market today and it is not always easy to tell them apart. These exist side by side with cast in situ construction. Combinations between cast in situ and prefabrication are commonly applied. For instance, since Peab owns factories, the company prefers to develop a closed structural system, and certain standards for other components which are bought from other suppliers to create a Peab-concept as part of its industrialisation effort. This implies a limitation in openness in the sense of being free to choose any supplier of sub assemblies. However, Peab’s or rather SBE’s structural elements can be sold to other contractors who combine it with components from other suppliers. In this way, SBE’s products can be used in a more open approach. There are also so-called Construction Management companies in the market. These companies manage the building project on behalf of a client from design to construction. Such companies can choose to combine subassemblies from different suppliers, which could be seen as an open approach.

1.3.3 Industrialisation as state of the art and organisational competence

While prefabrication and system building is one of many development steps in the history of construction, they are sometimes labelled industrialisation of building. More, industrialisation is a label put on efforts which many companies have started recently to improve performance in housing production. What is the actual meaning of industrialised building? Is there a difference between a general development in construction and industrialisation after all?

A look into the literature on the topic shows that there is no single definition of the term industrialised building. Instead, several more or less similar explanations to the expression, produced by different authors, can be found. For instance, the original
meaning of the expression to industrialise building was to transfer manufacturing of building components and elements from the construction site to factories (Adler 2001). The buildings were then to be assembled on site. Today the expression is focused on the entire building process and incorporates many perspectives. Sebestyén (1998) exemplifies this by describing that prefabrication can be considered as one form of industrialised building. In his view, industrialisation is also the application of modern technologies, such as modern in situ processes (modern processes on site as opposed to off site fabrication) as well as the use of modern design methods based on scientific knowledge about, for example, building physics. A further example is Sarja (1998), who describes industrialisation of building as “the application of modern systematised methods of design, production planning and control as well as mechanised and automated manufacturing processes”.

These definitions are quite general and can almost cover any change that modernises construction work. They are not specifically confined to standardisation, prefabrication or any other specific technology, production principle or anything else. Neither do they specifically say that industrialisation concerns learning from other industries or developing new knowledge within the sector itself. In this thesis, industrialised building is seen as a state of development, which changes over time. It is the result of continuous development taking place in construction, both as a result of knowledge developed within the construction industry itself and elsewhere, in line with the historical overview presented above. Such development may not always be seen as clear changes from one day to another or even from one year to another, but it can be distinguished by examining various aspects of construction work over a longer period of time. That is to say that industrialised building today is the sum of earlier and current developments, i.e. it is the state of the art.

Against the discussion presented earlier in this chapter, where industrialised building is seen as the remedy against quality deficiencies in constructed houses and low productivity for construction companies, one gets the impression that modern technologies or standardised products and processes in themselves are the solution. However, such things as modern production equipment and product standards in themselves cannot improve quality and productivity. The organisation must also have the ability to manage them in a way that leads to fulfilment of its goals. These abilities must be incorporated into the organisation and can be described as organisational competences. Such and other organisational competences reside in e.g. employees, routines and physical equipment. Therefore, in addition to being a development state, industrialised building is also seen as an organisational competence. Industrialising building by adapting a new production technique or a new working procedure thus involves building new or enhancing existing organisational competence.
1.4 How can PGS be realised?

Do the initial ideas of how to realise PGS reveal anything about facilitators and barriers? PGS core team members’ views on realisation before starting the work showed that they considered the aspect of development through learning and collaboration with other actors important. They were also well aware of the great changes the ideas implied to the organisation, but considered the established way of creating new knowledge in individual building projects as the way to go about it. If good results could be shown, this would attract interest among others as well and in this way the spreading of ideas would happen.

1.4.1 Development through collaboration

Collaboration and improvements in current working practice were mentioned by all interviewees, both from Peab and SBE, as important for the development of the common system concept. The collaboration concerned Peab and SBE as well as their collaboration with other actors in the building process. Such collaboration and improvements of working practice were considered important to allow for creating a feasible solution, to allow for continuous development and to benefit from the advantages of the system to be developed.

The PGS project and its core team was appointed coordinator of inputs from various stakeholders with different skills relevant for the development of the new building system. The building system was intended to be continuously developed through applying prototypes and/or early versions of the system in pilot building projects. Experiences from such pilot projects would then be used for further improvements.

Collaboration, especially with service suppliers and architects was considered necessary to come up with good solutions for the system, both for the initial development and for continuous improvement. However, as pointed out by some respondents, it is important to understand that in such collaboration everyone wants to earn money. To allow for all involved to earn money, trust and open attitudes were described as necessary. However, trust and openness were described to be limited many times. While different actors work closely together in individual projects, they are often independent and therefore they may well have competing interests (Walker 1996).

"They (suppliers) are specialists in their area and I don’t think we need to be so afraid of getting cheated, because every one must earn money. If we know what we want and become good at doing what we do, we can say that it is okay. They earn money and they are also part of this." (Purchaser, Peab)
'I think that it is important that we involve architects in the development of our system, to avoid technocratic thinking.' (Technical Manager, SBE)

Similar thoughts were expressed concerning the collaboration between Peab and SBE. It was emphasised that the collaboration within the framework of the common system concept must allow for both parties to earn money.

'I don't have a problem with Skandinaviska Byggeelement making profit on their building elements as long as we can build our houses and earn money at the other end too. There can't be any imbalance between us. It is about open attitudes, and that is a must, otherwise this will not happen. We must play with open hands. After all, we are one company.' (Purchaser, Peab)

1.4.2 Spreading PGS

Top managers as well as interviewees, both from Peab and SBE expressed an awareness that that the renewal ideas implied a great difference as to how things worked at the time for the start of the PGS project. A manager at the regional level from Peab expressed it as “we have a long way to go”. The way in which Peab was organised and the way in which authority to decide about the construction methods to apply in individual projects at the time for the first interviews, during the autumn of 2002, implied that it was not possible to just force the organisation to use a system developed within the PGS project. Managers at local units were entitled to decide about construction methods, suppliers, etc to a great extent. This is further explained in the next chapter. Therefore, the people in the organisation were seen by most respondents as the key to success for implementation of the common system. An SBE project leader expressed it as “making the organisation work with you is a basic requirement for success”.

To make people in the organisation use the common system, all respondents advocated demonstration of good examples. By testing the system, or prototypes in individual projects, it would be possible to show that the system has the potential to meet requirements of good quality, cost reductions and shorter lead times. It was claimed that the more it is used, the more it can be improved from gained experiences. However, SBE’s managing director pointed out that pilot projects must be conducted by people who are interested in developing improved ways of working, because if the pilot projects are run as normal projects, they will fail. A Peab project developer emphasised that there must be a general understanding within the organisation that development projects are not for free and increased costs must be accepted for development to take place.
The Peab project developer further expressed an anxiety that the lack of the habit of testing and evaluating could affect the PGS project in a negative way. If an incorrect evaluation of a new idea is made, the idea may be rejected by mistake. Several interviewees, among them the PGS project leader, and two SBE project leaders, pointed out that it was also very important to continuously inform the organisation about the PGS-work and how it is progressing. Picking up ideas from everywhere in the organisation was also considered as necessary to come up with a feasible solution that people in the organisation approve of. The project manager was travelling around Sweden to meet people at various positions in the organisation and include them in the dialogue with the PGS core team, starting before the formal start of the work in the PGS core team. The project manager’s idea was that through the PGS core team members, information will be further spread and ideas picked up from various places in the organisation. The idea was in line with views expressed by an SBE project leader who emphasised the importance of involving people at all levels in the development work. If the project goes on behind closed doors and certain ideas are forced on the organisation, there will be problems with acceptance it was pointed out. It is necessary to keep people at the sites informed and listen to their ideas, since there is a lot of valuable knowledge among people who have long experience of site work.

The PGS team had ideas about the realisation of the PGS ideas that were based on their experiences of how changes had occurred earlier. Some hints about potential facilitators and barriers came up in their descriptions of how to make PGS become real. For instance, collaboration and learning seemed to be considered as important facilitators. Barriers that were mentioned included trust among actors, the current distribution of authority in Peab and a lack of habit to follow up and evaluate experiences. If they knew about these facilitators they would surely make sure to use them? Similarly, if they knew about these barriers, they would surely be able to overcome them? How come then the PGS project became relatively isolated while the new factory was up and running two years after the launch of the PGS project? The following chapters will look into these issues.

1.5 Structure of the thesis
This thesis consists of five chapters, an epilogue and a reference chapter. This section is part of Chapter 1, In search for improved housing production methods, which presents the background and the context for this study. The company and the industrialisation effort which is the subject for the case study in this thesis are introduced. Research question and the scope of the study are also presented.
Chapter 2, Research method, describes the chosen research method for this thesis. The chapter deals with how the research was conducted. This is done through describing the main activities of generating research questions, selection of research method, data collection and analysis. It also deals with how criteria for trustworthiness were fulfilled.

Chapter 3, Conditions for change in a construction context, deals with how and why construction work is organised the way it is. Peab’s and SBE’s particular organisational contexts are described. Central theoretical concepts such as organisational competence and embedded knowledge and action are presented and finally the approach of identifying facilitators and barriers applied in the thesis is described.

Chapter 4, Change efforts in Peab and SBE, presents findings from the ongoing industrialisation effort. Facilitators and barriers to achieving desired changes are identified in Peab’s and SBE’s particular organisational contexts.

Chapter 5, Conclusions, presents a summary of findings along with the thesis’ conclusion. It also contains a discussion about applied research methods and recommendations for future research.

1.6 Summary

To meet the requirements for better quality and reduced production costs, many construction companies, in Sweden and other countries, are making efforts to improve performance in housing production inspired by ideas from the manufacturing industry. This is often referred to as industrialised building. Efforts to industrialise house building by learning from the manufacturing industry are not new. In the early 1900s, influential architects developed houses for factory production inspired by Ford’s methods. After the Second World War, industrialised house building became the answer to the great need for housing in Europe where building materials and labour were scarce. By the mid 1970s industrialised housing production decreased in many western European countries as a result of, for example, new requirements on adaptation of housing design to local needs and users’ possibilities to influence design of dwellings.

Even though earlier efforts to industrialise house building by extensive use of factory produced building systems more or less have faded away, many construction companies are currently making a new effort. This research studies one such effort in one of the major Swedish construction companies, the Peab group. Focus is on facilitators and barriers to achieve the specific ideas for industrialisation which Peab
aims for. Similar ideas prevail in other construction companies as well. The study concerns two units within the Peab group, Peab Sverige AB (contractor) and Skandinaviska Byggelement AB (supplier of prefabricated building elements) and it covers two years of the industrialisation process.

In this study, industrialised house building is seen as a development state, representing state of the art, concerning how work is organised and conducted. It is also seen as an organisational competence, which allows companies to manage and apply state of the art technologies, working procedures, etc to fulfil organisational goals.

Peab’s industrialisation ideas concerned developing a common building system to be used across Peab’s organisation, instead of the different local systems and methods applied at the time. The system was intended to be prefabricated and to include certain standards. Furthermore, to be able to create and further develop such a system, longer-term relations with other actors were seen as important to develop. A project, PGS, was established to conduct this task. The project core team saw the use of good examples of application of early versions of the building system as a feasible way to spread it across the organisation. Chapters 4 and 5 of this thesis deal with how PGS was able to manage this task.
2 Research Method

This chapter deals with how the research presented in this thesis was conducted. The different activities, literature review, data collection, generation of research questions, evaluation and selection of research methods, and analysis are described. Finally, measures taken to establish trustworthiness of the study are presented.

2.1 Point of departure

I started my work at KTH as researcher at the division for Construction management and economics, for an EU funded project which dealt with industrialisation of house building. As the EU project was finished, I was interested in continuing as a PhD student, working with this topic. At this particular time, Peab was about to launch its change effort. Discussions with a representative of the company group top management resulted in an agreement to cooperate in a PhD research project. Funding was granted jointly by Peab, Competitive Building (national research and development programme in the Swedish building sector) and SBUF (Development Fund of the Swedish Construction Industry).

The focus for this study comes out of a real problem experienced in a construction company at the time when the study was conducted. It is the result of what I learned about the ongoing industrialisation effort at Peab by actually being there. Focus also emerged from my own interests, as well as inspiration I got from talking to my academic supervisors and colleagues. Thus, the study’s starting point is a question relating to a real perceived problem, rather than a question based on theoretical assumptions. As pointed out by Ghoshal (2005), this starting point contributes to the relevance of the study by avoiding reliance on theoretical assumptions which may lack empirical support. My approach to investigating facilitators and barriers to industrialising house building in the studied company was process-based. This was considered feasible since time is of importance to grasp a change effort which is an ongoing process, rather than a one off event. Such approaches are common among researchers aiming at understanding issues related to management and organisations (Ropo et al. 1997). I followed the ongoing industrialisation process in Peab for two years and continuously collected data through observations and interviews.

My study is formed by the academic and industrial context in which I have worked during my time as a PhD student. This goes for the choice of focus for the research as well as how I chose to conduct it. The early part of my work was inspired by colleagues and traditions at the division for Construction management and economics. As ideas for industrialisation of house building often are inspired by how the manufacturing industry works, I found that I had to broaden my knowledge and
learn more about this. I contacted the department for Industrial Production at KTH (now part of School of Industrial Engineering and Management) and joined the weekly PhD seminar group there. I attended these seminars for two years. Since I started this study, my base at KTH has been the department of Industrial Economics and Management, Indek (now part of School of Industrial Engineering and Management). Academic supervisors and colleagues at Indek have inspired my choice of theoretical framework as well as my research approach.

2.2 Research Design

One way to describe how this study was conducted is by describing it as activities. The activities I have chosen to deal with here are similar to those that are often described in books on research methods (see e.g. Fellows and Liu 1997 and Yin 1994).

Five main activities are described in this chapter:
- literature review,
- data collection,
- generation of research questions,
- evaluation and selection of research method
- analysis

Three of the activities; literature review, data collection and analysis have been ongoing concurrently with different intensity and character almost throughout the process. While the activities mostly took place iteratively throughout the process, some were emphasised in the early part of the study. Generation of research questions and selection of research methods were stressed during the early part of the study. Data collection was finished some time before the literature review and analysis were finished. The picture below shows the time plan which was used during the work. It may give the impression that the activities were more or less independent and easily distinguishable from each other. In practice, however, the process mostly involved iterating between the activities and their content emerged during the course of the process.

The rest of this chapter attempts to provide a more detailed description of how the study was done. It shows that the process had more of an emergent character than implied by the picture.
2.2.1 Generating the research questions

I started this research with some earlier experiences on the topic of industrialised house building, some ideas of possible research questions and only a little knowledge about Peab’s industrialisation effort. At the time when my study started, there was no detailed information to be obtained about the industrialisation effort, since it had not formally started and the project manager was in the process of leaving his earlier employment and starting working with the Peab group. Concurrently with the project manager starting the process of appointing the members of the team to be primarily involved in the PGS core team, I interviewed these individuals to find out more about their views on this effort and why they perceived it necessary, along any new “facts”, such as project plans, that may have emerged. As the PGS project started formally, I made observations at project meetings and conducted further interviews.

As the PGS core team started working, I noticed the difficulties it had to contribute to change in the Peab group. While the PGS core team was more or less unable to contribute to change, changes occurred at other places in the organisation. This issue was in one way or another always present during the course of the change work I studied. During my research process, working questions for the study were used. As time passed, the ever present issue of why it was more difficult to pursue some changes than others turned out to be central for my study. This formed the basis for the formulation of the study’s research question as mentioned under section 1.1.2:
Parallel to the initial interviews and observations I reviewed the existing literature. The literature review served as a help to create a preliminary understanding of the findings from interviews and observations and it also served as a basis for confirming the general relevance for the study. As the research question emerged, it was possible to focus the study and select research strategies and methods. The next section describes how the research method was selected. In practice the process of generating research questions and selecting research strategy and method took place concurrently as an iterative process.

2.2.2 Evaluation and selection of research methods

The formulation of the research question determines the focus for the study. Wing et al. (1998) and Yin (1994) presents a pragmatic view on selection of research methods in pointing out that different methods have their own advantages and disadvantages and are suitable in different contexts for different types of research problems. The key is to select the method that best suits the problem at hand. A literature review of different research strategies was conducted to find one that would suit the research problem at hand. Methods and approaches that seemed suitable were evaluated and finally my own approach was chosen.

Survey

A survey aims at obtaining information which can be analysed and patterns extracted and comparisons made (Bell 1993). Surveys work on the basis of statistical sampling and much attention must be paid to making sure that the sample population is representative. Fellows and Liu (1997) point out that only rarely are full population surveys possible, practical or desirable. It is pointed out that often questionnaires or interviews are used to survey the sample. Special consideration must be given to the response rate and responses obtained for a given sample size of responses required. All respondents are asked the same questions and it is important to ensure that questions are understood in the same way by the respondents. Piloting is suggested as one way to approach this issue.

At the early stages of the research project, a survey was considered as a possible approach for gaining an initial understanding of the Peab group industrialisation effort. Since only a few people within the organisation had knowledge about the effort at that point, the idea of doing a survey was rejected since it was possible to conduct interviews with all of these individuals. It was also considered important to get an idea of the interviewees’ opinions which would be more difficult to obtain
through a survey than through interviews. Interviews with all relevant individuals at that point were therefore considered to be more suitable than a survey.

Ethnographic study
Ethnographic studies are described by Baszanger and Dodier (2004) to be useful in three particular situations. The first is when there is a need for empirical observations i.e. when the phenomena of interest cannot be inferred logically. The second situation is described to be when there is a need to remain open to elements that cannot be codified at the time for the study. To allow for finding new data that represent the studied phenomenon, the field worker must remain open, as opposed to studies when activities are observed according to predetermined schedules based on predefined rules. The third case is when there is a need to ground observed phenomena in the field. When observed facts are tightly connected to the features of the historical and cultural context in which they occur, the study can be characterised as an ethnographic study as opposed to other formal studies that disconnect the facts from their context, the authors claim. Such an approach is applied in, for example, studies in philosophy of language and phenomenology.

An ethnographic study would surely lead to interesting insights for this research problem. However, the ethnographic study was rejected due to the resources available for the study. To allow for observing all necessary events to create an understanding of the change process would be far too time consuming given the time and manpower available.

Case study
A case study is described by Yin (1994) as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. Yin suggests that a case study should comprise five components; the study’s questions, its propositions (if any), its unit(s) of analysis, the logic linking the data to the propositions and criteria for interpreting the findings. Eisenhardt (1989) describes the case study as a research strategy that focuses on understanding the dynamic present within single settings. Case studies can be used to accomplish different aims as pointed out by Eisenhardt (1989): to provide a description, to test a theory or generate theory.

Lincoln and Guba (1985) describe an approach to case studies (it can also refer to studies labelled ethnographic studies, hermeneutic, subjective etc) that take place in a natural setting. Such studies are claimed to require a human instrument that can respond and adjust to a context which cannot be ascertained. The human instrument
is described to be able to draw on explicit and tacit knowledge. Tacit knowledge can only be used by the human instrument and it is claimed to be a useful basis for gaining insights and elaborating hypotheses during the course of the study. Data is collected in ways that are suitable for the human instrument such as interviews, observations and reading of documents. The field procedure is suggested to consist of iteration between four main components; purposive sampling (by allowing for emergent sampling to collect as much information as possible), inductive data analysis, elaboration of a grounded theory based on the analysis and planning of subsequent steps. The iteration goes on until results are considered satisfactory and the emergent design is fulfilled given available resources. Obtained information is then put together in a case study report which is “an interpretative instrument for an idiographic construal of what was found”.

The focus for a case study can be various things, for example processes, decisions, individuals, neighbourhoods and organisations. As pointed out by Lincoln and Guba, various data collection methods can be combined in a case study. Yin (1994) mentions six commonly used data sources. These are documentation, archival records, interviews, direct observations, participant observations and physical artefacts. All of these have strengths and weaknesses and therefore the possibility to combine them is useful. A discussion about strengths and weaknesses with data sources applied in this study is presented under the section Data collection.

The case study approach was considered to be the best suited research strategy for the research problem at hand for the following reasons. The study takes place in what in Yin’s (1994) terms would be a “real-life context” or in the field as Lincoln and Guba (1985) describe. The focus for the study is facilitators and barriers related to deliberately initiated changes in an organisation. To identify such facilitators and barriers, I had to study the ongoing industrialisation process, which included numerous events taking place over several years. It involved two different subunits and many individuals in a company group. Thus, information had to be gathered about events over time involving different people. To allow for capturing enough information on the process, given available time and manpower, several data sources and data collection techniques were needed. Interviews with a selection of individuals combined with observations of selected events and study of relevant documentation were seen as a possible way to collect data. This also allowed for data collection at different points in time during the course of the study.

It has already been noted that this study is confined to an industrialisation effort in a single company group. The process involved two company group entities, Peab Sverige AB and SBE AB. According to Yin’s (1994) way of labelling cases studies,
this one is a single case embedded study, where the overall industrialisation process is the main case and the processes in Peab and SBE constitute the embedded cases. The option of going for a single case study was based on the funding arrangements, but also the belief that the insight into the Peab group effort would generate valuable insights about such a company’s ability to industrialise. Dyer and Wilkins (1991) support the argument in stating that case studies do not necessarily have to use multiple cases. Thorough studies of single cases can generate new theory and question old ones.

The approach taken for the case study in this thesis, as will be further described below, does not follow any of the above described approaches strictly. Instead it combines notions from the different authors.

2.2.3 Data collection

Once the focus for the study was set, it was possible to concentrate on the data collection. To get hold of relevant data, it had to be collected, to a large extent, in real time. This situation made it impossible to predefine from whom and from where relevant information could be collected. Therefore, I had to let the sampling develop as more information became available. Furthermore, information provided by one source gave clues as to where to go next to find out more on a certain issue. As more information become available, it also became clearer where to find the most relevant information. This way of collecting data is in line with what Lincoln and Guba (1985) label purposive sampling.

I studied Peab’s industrialisation effort for approximately two years. During this period, data was collected mainly through interviews and observations at meetings, and visits to construction sites and factories. Since interviews mainly took place at the interviewee’s offices and since construction sites and factories were located at different places, I had to travel around Sweden. Other forms of complementary data collection such as reading of related documentation and studies of pictures also took place. I started the data collection with an initial round of interviews to gain initial understanding of Peab’s industrialisation efforts in terms of why they perceived change necessary and their views and expectations of the effort. The process of choosing persons to interview was simple in this case. Since the only ones in the organisation who had knowledge about the effort at that time were those appointed as PGS core team members, these persons were the ones that were relevant to interview. A total number of 17 interviews were conducted in this first round. The interviewees represented the following positions:
For the continuation of my study I had to collect data on an ongoing process, which meant finding out where and when relevant events took place, along with who the events involved. A key source to finding out such information was the monthly meetings with the PGS core team, which I observed. During these meetings, I also had the opportunity to chat informally with team members to find out more about ongoing activities and their views about things. The meetings were organised as working meetings where team members conducted work and informed each other about the results and also about ongoing events of relevance taking place in their respective parts of the organisation. Obviously many events relevant to my study of the industrialisation effort took place outside the monthly meetings, and there was no way that I could be present and collect real-time data everywhere. Therefore I chose to focus my data collection outside the monthly meetings on those events that had the highest priority for the team and/or seemed important for my study. These included observations meetings with top management, external consultants, visits to construction sites and factories. Thus, I selected the events for observation and persons to interview based on perceived important events.

A total number of 28 observations at meetings were conducted. A total of 26 interviews, were conducted.
1 purchaser, Peab
2 purchaser/project coordinators, Peab
1 full time renewal project member, Peab
1 architect, consultant for Peab
1 marketing/business development manager, SBE
1 assembly manager, SBE
2 project leaders, SBE
2 production managers, SBE
1 purchaser/team leader, SBE
1 team leader, SBE

I got access to the monthly PGS core team meetings through the project manager, who was also my main contact person at Peab. He also introduced me to people in the organisation, which made it easier for me to get appointments for interviews and visits to factories and sites.

2.2.4 Advantages and disadvantages with applied data collection methods

What are the advantages and disadvantages with the data collection methods used in this study? Interviews can, if properly conducted, provide valuable insights on the studied topic. Facts as well as opinions can be obtained from the interviewees. Interviews can be of different types as pointed out by Gillhan (2000) who illustrates this with a scale. At one end of the scale the unstructured interview which uses the “natural conversation to ask questions” is found. At the other end of the scale the structured questionnaire with straightforward, specific closed questions is found. In between there are a variety of open-ended and semi structured interviews. The open-ended interview makes use of open questions, i.e. questions without predefined alternative answers while the semi structured interview makes use of both open and closed questions. Closed questions have predefined alternative answers.

However, there are also some difficulties and disadvantages with this form of data collection. As pointed out by Miller and Glassner (2004) interviewees may for example adapt their replies depending on who the interviewer is, i.e., the reply provided to different listeners may differ. Furthermore, the authors mention that respondents may not trust the interviewer and therefore be selective in their responses. Other issues that may occur are that the respondents do not understand the questions or purposely mislead the interviewer.

The interviews made for this study were mainly open-ended and semi structured, i.e., an interview guide with questions covering the main areas of interest was used.
Follow up questions for clarification and detailed information were decided on during the course of the interviews. Interviews were, with a few exceptions, conducted at the respondent’s office and took about one hour each. A tape recorder was used in all cases. For the first round of interviews the same questions were used in all interviews. For the later interviews the questions changed to some extent depending on the interviewee’s position and the issues of interest for the interview. However, in all cases the focus for the interviews was the ongoing renewal process.

What difficulties and disadvantages did I come across during my interviews? From the interviews made, I recognise that some interviewees adapted their replies according to their perception about me as a researcher as well as to my background. This concerned such things as explaining certain technical issues in a more ”popular” way than it had been discussed among themselves during meetings I had observed. Another thing I noticed was a sort of loyalty towards colleagues. At certain stages of the studied process problems of different types occurred. Even though these were discussed vividly during the observed meetings, people would refer to them in more general terms in interviews and always make sure they did not mention a colleague or group of colleagues in a negative way. In only two cases I felt that the interviewees did not trust me as an external researcher. In one case this was solved by, on request of the interviewee, skipping questions on a certain issues and in the other case, it was solved by turning off the tape recorder. As far as I am concerned, there was no respondent who deliberately provided me with misleading answers.

Observations also have their own advantages and disadvantages. Yin (1994) distinguishes between direct or participant observations. As indicated by the names, participant observation means that the researcher is involved and direct observation means that the researcher observes from the outside. An advantage with observations pointed out by Gillham (2000) is that they provide direct data on what people actually do and say in a certain situation, as opposed to interviews and written documentation. The author also points out that observations may seem easy, but it may be a source of selective and unreliable information.

The observations made in this study were direct. I observed the monthly meetings with the renewal effort core team as well as meetings with top management and external consultants. Furthermore, I made visits to construction sites and factories. During the observations, I continuously took notes. The issue of being selective in my data collection was a difficulty I experienced. Being right in the middle of an ongoing course of events, sometimes made it difficult to distinguish the important issues for my study from the total flow. Some events were easily identifiable as key events once they occurred, while others that seemed less important at the time when
they occurred, later turned out to be of importance for the overall development of the events. Through taking notes continuously during the observations, chatting with people, making interviews and with some months delay looking back on earlier events and relating them to the current situation, it was possible to identify what in my view and for my study seemed to be the “main stream” of events. In some cases I had to find out more about previous events by talking to those who were involved to understand the cause of the course of events.

As already hinted above, the main strategy for overcoming the difficulties related to the applied data collection methods was the use of multiple data sources. By making interviews, observing meetings and making visits I obtained different perspectives on the events taking place, which provided me with a better understanding of what was going on. By comparing information on the same issue from different data sources I believe my understanding of the events became more nuanced than would have been the case otherwise.

Data collection was finished in October 2004 as a new project leader took over the management of the studied renewal project. The choice of this end point was based on availability of resources for the research project and also that the change of project leader indicated a natural ending of the first phase of Peab’s change effort.

2.2.5 Analysis

Theory provides different suggestions on how to analyse data in the context of case studies. Some authors advocate the use of theoretical propositions as the basis for data collection and analysis (Yin 1994), while others suggest that neither theory nor type of data and hence analytical procedures are given in advance but emerge as the study evolves (Lincoln and Guba 1985). A third example, which is somewhere in between the previously mentioned two, is Eisenhardt (1989) who suggests that after the initial broad definition of the research question(s), a prior specification of constructs can help focus the study. However, as the study progresses, research questions and constructs may need to be exchanged. The author argues that even though it is difficult to achieve, theory building from case studies should start without consideration of certain theories and without hypotheses to test. The data analysis strategy suggested is iterative hypothesis shaping in a way that leads to internal validity, replicative logic across cases and possibility to generalise.

In this study, I started with preliminary research questions which were elaborated during the course of the study. I did not enter the field without any influences from existing theory, but neither did I have theoretical propositions. As a result of the emergent character of the data collection, it was found necessary to conduct
preliminary analyses during the course of the study in order to be able to build up knowledge about the case and decide on the next step. As already mentioned, data collection and preliminary analyses took place concurrently and iteratively. The analysis was tentative in the beginning and got more focused as the study evolved.

The collected data was first sorted based on themes, statements and key words. By reading and comparing transcriptions of interviews and observation notes, key words and themes emerged. Categories were then created to put together data referring to similar key words and themes. Central concepts and themes from theory were used to support the creation of preliminary categories and also to increase understanding of the findings. The preliminary analyses were used to guide further collection of data. The analysis also included making preliminary case reports during the course of the study. Texts that described the findings were written based on the created categories. This provided insights into the issues relevant to the research problem and was considered as necessary to allow for grasping the data during the course of the study.

My description of the studied situation was created using the categories. Data from different sources was continuously compared and finally the presented description emerged. By comparing data continuously, as it became available with the emerging description, the final description emerged. Analysis was finished when I felt it was possible to create a comprehensive description of the studied situation, i.e., the case study description presented in this thesis.

2.2.6 Trustworthiness
There are several prejudices against the case study strategy. For instance, Yin (1994) points out that there has been great concern over the lack of rigor of case study research. A second common concern is that case studies provide little basis for generalisation. According to the author case studies, like experiments, are generalisable to theoretical propositions, but not to populations or to universes. Literature on case study research provides suggestions on how to deal with these issues.

In this thesis, mainly the notions on credibility, transferability, dependability and confirmability as suggested by Lincoln and Guba (1985), are applied to meet the requirements on trustworthiness. First, credibility, is suggested to be a way to deal with the issue of making the findings of the inquiry “credible to the constructors of the original multiple realities”. This is described as being done by conducting the inquiry in a way that increases the prospect of generating credible discoveries and interpretations. Five techniques to achieve this are proposed.
(a) Prolonged engagement, persistent observation and triangulation are suggested means to increase the probability of producing credible findings. Prolonged engagement means spending enough resources to accomplish something such as learning a culture or building trust. Persistent observation aims at pinpointing those issues in the studied situation that are most relevant for the inquiry and concentrating on them. Finally, triangulation which can refer to sources of information, methods, investigators and theories.

(b) Peer debriefing is suggested for looking into issues such as inquirer’s biases and as the basis for interpretations of findings. It should also be used for testing working hypotheses and it is also said to be an opportunity for the inquirer to release his/her mind of emotions that may prevent clear thinking.

(c) Negative case analysis is suggested for reducing the number of exceptional cases, preferably to zero. This is done by continuously comparing a hypothesis with data and adjusting the hypothesis until there is a perfect match.

(d) Referential adequacy refers to keeping of raw data and is suggested as a good way of proving credibility.

(e) Member check is suggested as a key method to create credibility. It should be conducted through representatives from the groups from which the data was collected, get the opportunity to check and react on analytic categories, interpretations, conclusions etc.

Several measures to establish credibility were taken in this study. Some of these have already been mentioned in the section 2.2.3, i.e., the use of multiple data sources and how key issues were pinpointed during the course of the study. Prolonged engagement and persistent observations were conducted by following the studied change effort during two years. Numerous interviews, observations and visits were accomplished during this time. It is considered that this provided sufficient breadth and depth to the study. Triangulation in terms of data sources and modes of data collection was also conducted. By comparing information on the same issue from different data sources, different perspectives were obtained. For example, in the interviews certain conditions in the organisation that could make renewal work difficult were mentioned. During the observations, these conditions proved to work as the interviewees had described. I was then able to obtain a better understanding of how these conditions work.
Peer briefing was conducted through meetings with academic supervisors and my industrial contact person at Peab. My industrial contact person at Peab, who also was the PGS project manager during the time of my study, took part in meetings with me and my academic supervisors on a regular basis. During these meetings, among other things, drafts of the case study report were discussed and I received comments on various issues. The comments helped me to clarify my description of the case and also verified the text as being an acceptable representation of the case.

Referential adequacy is achieved by safe keeping of raw data, such as taped interviews and field notes. Finally, member check was conducted through allowing renewal project members, who were providers of data, to read and comment on my draft case study reports. I also made presentations of preliminary results during meetings with the PGS project team.

The second trustworthiness criterion is transferability. According to Lincoln and Guba (1985), it is only possible to extract “working hypotheses” that describe a certain case. This implies that the working hypothesis are valid in the context they were found. The authors claim that whether they are valid in another context depends on the similarity between these contexts. The means to achieve transferability should be a thick description which allows for someone else to compare the described context with another context. Thus, the task of the inquirer is to provide enough information to allow for a comparison with other contexts. Payne and Williams (2005) on the other hand argue that it does not necessarily have to be up to the reader to judge if it is possible to generalise findings to another context or not. The researcher himself or herself can also make what the authors call “moderatum generalisations”. This means that the claimed scope of the generalisations is moderate and that they are moderately held in terms of being open to change. In this way, the authors point out, the generalisations are like testable propositions that can be confirmed or rejected in case other evidence emerges.

In this study, transferability was aimed for through providing a description of the context in which the studied change effort took place. The level of detail of the description is considered to be sufficient for someone else to be able to make a comparison with the context for his or her study. Moderate generalisations are also made by claiming that some findings may also be valid in other construction companies with similar organisational contexts.

Dependability refers to methods to account for changes referring to the studied object and its context as well as changes in study focus and corresponding procedures. This should be dealt with through auditing, where the auditor goes through the process as
well as the product of the study. Another suggested way to deal with dependability is through a reflexive journal. Such a journal should include daily schedule and logistics of the study, personal diary and methodological log.

Finally, confirmability deals with whether the data are confirmable. This should be done through auditing or a reflexive journal as described above. An auditor would examine the data, findings, interpretations, and recommendations to find out that the results of the study are logical results of the collected data.

In this study, dependability and confirmability have been taken into account by safe keeping of raw data, keeping of notes which include reflections on research questions and methods as well as a number of draft reports on case study findings. These can be used, together with this final report, to trace the process as well as the product of this study.

2.3 Summary

The way in which this research was conducted can be described through the five main activities: literature review, data collection, generation of research questions, and analysis. While iteration between the activities took place throughout the process, some were emphasised in the early part of the study. During the early part of the study, generation of research questions and selection of research methods were stressed. Literature review, data collection and analysis took place concurrently with different intensity and character almost throughout the process.

The study’s research question is a question relating to a real perceived problem, rather than a question based on theoretical assumptions. It was generated, via working questions, during the course of the study as I was collecting data and reviewing literature. The study takes place in “a real-life-context” and focuses on an ongoing process including numerous events and people over a several year period. Therefore several data sources and data collection techniques had to be used. A case study was considered as the most suitable research approach for this study.

Data was collected mainly through observations and interviews. Since the process I was studying was ongoing, it was not possible to predefined from where and from whom relevant data could be collected. Sources of information had to be developed as more information became available. A key source of data and information about where to go next to collect relevant data was the monthly meetings with the PGS-core team. Multiple data sources were thus used. This allowed for obtaining different perspectives of the events taking place, which provided me with a more nuanced understanding of the process than what would have been possible otherwise. Data
was analysed by categorising data according to themes, statements and key words. This was used to write texts about the findings. The text was continuously refined and until a comprehensive description of the studied case could be done.

Several measures to establish trustworthiness have been made. Credibility was established through the use of multiple data sources, prolonged engagement, peer briefing and safe keeping of raw data. Transferability was established through a detailed enough description of the studied case. Dependability and credibility have been taken into account by safe keeping of raw data, notes and draft reports.
3 Conditions for change in a construction context

What conditions do Peab and other construction companies face when they make efforts to industrialise house building? In what way do these conditions influence facilitators and barriers to make the specific changes they aim for? This chapter deals with how work is organised in construction in general and in Peab and SBE in particular. By using the notions of embedded knowledge and action, potential facilitators and barriers in this particular context are pointed out. Finally, the approach taken to identify facilitators and barriers in this study is presented.

3.1 Combining individual actors’ skills

The construction sector consists of different types of companies with different types of businesses. These can be, for example, professional clients, consultants such as service consultants, architects, structural engineers, as well as contractors and material suppliers. The actors meet in building projects which are managed by the client or a contractor depending on the type of contract at hand. Building projects are often conducted by actors representing separate organisations with no formal connection to each other outside the contracts of the building project (Walker 1996). The representatives, or individuals, are expected to contribute with their special skills to the totality. A building project often constitutes a new combination of actors.

![Figure 2. Construction involving both firm and project management. (Adapted after Walker 1996)](image-url)
The actors do not only differ in what their special skills are. Some firms only have a few employees, while others are larger and some are even multinational. Their respective organisations also have different features to house their skills. For instance, a consultancy firm that conducts geological examinations and an elevator supplier firm have quite different skills. Their respective production systems can differ in several ways, e.g. by type of required production equipment. While the geologist needs maps and measuring equipment, the elevator supplier needs specific machinery for manufacturing and assembly of the different components that make up an elevator. More, the individual geologist may be the main carrier of the knowledge that his/her firm offers in its services to customers, while the elevator supply firm relies more on its machinery to offer products to customers. Yet theirs and other actors’ skills are combined directly or indirectly in individual building projects.

Actors’ relations are based on contracts in individual building projects. Contracts may include different terms not only regarding time of engagement, but also concerning incentives for encouraging certain behaviours. Traditional contracting implies that the client contracts independent professionals such as architects and engineers to design the building (Sebestyén 1998). A separate building contract is then made with a contractor for the construction of the building. Traditional contracting is still applied, but it has been described as a contributing reason for confusion about areas of responsibility and the occurrence of conflicts. For several decades new methods for contracting have emerged. There are, for example, different variants of so-called design and build methods, which provide the contractor with full or shared responsibility for design and construction. There are also different variants of relation contracting, also referred to as long-term partnering. The evolution of system building for instance led to development of some new contractual forms that were also used for traditional construction (Finnimore 1989).

Some actors are only engaged in the building project at its very beginning and disappear when their task is finished, while others commence their task when the project has been ongoing for some time. Some are engaged over a longer period of the project and take on different roles at different stages. The scope of the task a firm conducts can also vary between different projects. For example, in one project a firm can conduct design, production and assembly of a subsystem and in the next project the same firm only takes on production. The actors may be engaged in more than one project at the same time, with other actors. All together, this results in that building processes may differ between projects.
3.2 Organisational knowledge and action

It is sometimes said that a certain spirit or even knowledge reside in the walls of a company. This saying refers to that there is something more in a company than the sum of what the employees know: there is also knowledge that “survives” or stays in the organisation, even though a key person leaves. Knowledge itself is a complex concept which has been elaborated by many philosophers already among the ancient Greeks. However, it is beyond the scope of this thesis to go into different philosophers’ writings on the concept of knowledge. Instead the focus here is on presenting some writers’ views on organisational knowledge and to describe how organisational knowledge is dealt with in this study. A look into literature shows that authors use different concepts and notions to describe organisational knowledge. Blackler’s (1995) five images of organisational knowledge provide insight into the complexity of organisational knowledge and the different approaches taken to studying it.

The five images on organisational knowledge are based on approaches found in a literature survey. The first image is *embrained* knowledge. It is described as abstract knowledge that relies on conceptual skills. It includes notions about abilities to create and understand complex rules and causations. Argyris’ concept double-loop learning, which concerns assumptions and beliefs which form implicit patterns of action, is pointed to as a good example of this type of organisational knowledge. The second type mentioned is *embodied* knowledge. This type of knowledge can only be expressed explicitly to a limited extent. It is exemplified as practical thinking in terms of problem solving practices which rely on deep knowledge about a situation, rather than abstract rules.

*Encultured* knowledge is the third image described. It concerns the development of shared understandings and is closely related to processes of socialisation. Language plays an important role for this type of knowledge. The fourth image is *embedded* knowledge. This type of knowledge resides in routines and can be analysed in system terms through the relation between technologies, roles and formal procedures. Organisational competences as presented by Prahalad and Hamel (1990) are mentioned as an example of this type of organisational knowledge. The authors describe organisational competence as a collection of skills and technologies. The fifth image of organisational knowledge is *encoded* knowledge. It refers to information communicated through symbols and signs. Books are a traditional form of encoded knowledge, while information encoded and spread electronically is a more recent example.
An issue, which is mentioned among Blackler’s images is the distinction between tacit and explicit knowledge. Nonaka (1994) describes the difference between tacit and explicit knowledge by pointing to that not all knowledge that exists in organisations can be expressed explicitly. There is also tacit knowledge, which has personal features and is difficult to formalise and communicate. It is embedded in action, participation and devotion in a certain context. It incorporates technical as well as cognitive elements. Spender (1994) uses the distinction between tacit and explicit knowledge in describing his view on types of organisational knowledge. According to Spender, there is likely to be a difference between individual and collective knowledge in organisations. Collective knowledge can be embedded in institutional collective practices and in this way, it concerns the relations between individuals’ practice, rather than being something they can express explicitly. Thus, it is likely to show through practice rather than explicit analysis. It is likely to develop as individuals begin to involve themselves in common practice.

Based on the view that there is a difference between individual and collective knowledge, Spender suggests four types of organisational knowledge. The first two types, conscious and automatic are held by individuals. Conscious knowledge can be expressed explicitly by individuals. Automatic knowledge is used in practice but cannot be expressed explicitly. The third and fourth types, objectified knowledge and collective knowledge are social. Objectified knowledge can be expressed explicitly and spread through the organisation. It can be, for example scientific knowledge, company rules and operating guidelines. Finally, collective knowledge was described above as embedded and not possible to express explicitly. Hodgkinson and Sparrow (2002) claim that cognitive psychologists, who have done work on the development of individual-level knowledge, argue that tacit knowledge is not just knowledge that cannot be expressed explicitly. It is a different kind of knowledge and intelligence. For instance, people can make decisions using knowledge that they are unaware of. This is, according to the authors, labelled competent mindlessness and it is of importance in the context of intuition and decision making.

Blackler’s images can be further illustrated by looking at some more individual authors’ views on organisational knowledge. Some of their notions are overlapping and some are complementary. Sometimes different terms are used to describe similar things. For instance, Hodgkinson and Sparrow (2002) describe how cognitive maps portray the idea that knowledge is represented in a way that makes reality simpler and forms a basis for action. In organisations, groups develop shared representations of reality. Individual and collective knowledge structures thus are seen to work as mental patterns that can be used to give meaning to an “information-rich environment”.

Another example is Walsh and Ungson (1991) who use the term organisational memory to describe how interpretations from the past are embedded in artefacts and systems in organisations. They argue that individuals obtain information through problem-solving and decision-making activities. Even though individuals’ understanding of problems and solutions may differ, consistent understandings in organisations are made possible through the sharing of interpretations. It is the process of sharing that allows interpretations to go beyond the individual according to the authors. The locus of organisational memory is individuals, culture, transformations, structures and ecology.

*Individuals* have their own ability to remember, express experiences and process information according to their own cognitive orientation. *Culture* is described as a learned way to think and feel about problems transmitted to members of the organisation. It carries past experiences and is stored in language, shared frameworks, stories and shared symbols. *Transformations* that turn input to output build on earlier experiences and store knowledge. Such transformations can be the practice of design of work, budgeting and market planning. Furthermore, individual roles are linked to organisational *structure*. This is since people expect certain behaviours of someone who has a particular role. In this way, experiences are stored in the roles that exist within an organisational structure. The physical structure of the workplace, also called workplace *ecology* tells about such things as status hierarchy in the organisation and is thus a carrier of organisational knowledge. Finally, there are also *external archives* that also hold information about an organisation. Such external archives can be former employees.

A further example is March (1991), who argues that organisations learn from individuals in the organisation over time. Knowledge created by individuals is accumulated and stored in the organisation’s rules, norms, procedures and form. Individuals also learn from the organisation, according to March, by being “socialised to organisational beliefs”.

EKestedt et al. (1999) suggest that knowledge is embedded at three levels in an organisation. *Capital-embedded* knowledge refers to knowledge related to technology, tools and machines etc which are used by the organisation. They can be considered to represent knowledge developed over time which has been transmitted to the design of the physical equipment. *System-embedded* knowledge refers to knowledge related to rules, roles, traditions and culture and laws as well as knowledge related to the work organisation. System embedded knowledge includes institutional and organisational embedded knowledge which in many cases are difficult to tell apart. This concerns for instance, the decision to organise in a specific way locally and can refer to a
tradition related to the industry. Finally, individual-embedded knowledge refers to knowledge possessed by individuals and includes thinking, feeling, acting patterns as well as motivation.

The descriptions of organisational knowledge point to that it is not to be considered as static. It has been described as showing patterns of action and collective practices. Action is social, and individual action has to be understood as a result of interaction with other actors in a particular context (Ekstedt et al. 1999). An organisation is such a context, where action can be understood in terms of its embeddedness in the organisation at four levels. At the structural / physical level action is embedded in physical systems and technology. This means that actions can be influenced when production machinery is changed. This can lead to new ways of producing something or to organisational changes. Action is also embedded in rules and traditions at the institutional level. These are set internally as well as externally and include laws and professional traditions. As a result of local solutions, organisational design, task formation, etc action is embedded at the organisational level. This can concern incentive systems to promote a certain behaviour. Finally, action is embedded at the individual level. Individual action is influenced by the organisation, structures and institutions, but it is also influenced by the individual him or herself. Different individuals have different skills and abilities, which influence their way of acting.

Ekstedt et al. 1999 further describe that action is needed to utilise knowledge and knowledge is important for informed action. Grant (1996) suggests that there are specific mechanisms that allow for knowledge in organisations to be applied. He mentions sequencing, routines, and group problem solving and decision making as ways to integrate individuals’ knowledge in organisations. Sequencing refers to organising production activities in chronological order. This is described as allowing for minimising the need for communication at the same time as knowledge can be integrated. Routines can be uncomplicated sequences, but they can also be complex patterns of interactions between individuals, which are not based on rules, directives or verbal communication. Some tasks require personal interaction and intense communication. For these tasks, group problem solving and decision making is a way to integrate knowledge.

These mechanisms for integrating personal knowledge rely on common knowledge to work (Grant 1996). Common knowledge allows for individuals to combine aspects of knowledge which are not common. There are various types of knowledge for various types of knowledge integration. First, a common language allows for verbal communication among individuals. Lack of common knowledge may work as a barrier for integrating knowledge among individuals. A common language includes
the aspect of other forms of symbolic communication as well. For instance, acquaintance with the same software can ease communication between individuals. Sharing specialised knowledge also influences how well knowledge can be integrated among individuals. While the purpose may be to integrate different types of knowledge held by different individuals, they may find it difficult to integrate their respective knowledge unless there is some common base.

Since communication based ways to integrate knowledge involve converting tacit knowledge into explicit knowledge, it often involves knowledge loss according to Grant. Shared understanding is the way to communicate tacit knowledge he claims. Metaphors, analogies and stories are examples of tools for combining individual experiences and understandings. Finally, productive knowledge integration is said to demand that everyone knows about the other individuals’ knowledge repertoire.

Whether tacit knowledge can be made explicit is subject to discussion. Nonaka (1994) claims that making tacit knowledge explicit is part of a process to create new organisational knowledge. Argyris and Schön (1995) take the view that observations of implicit patterns of action embedded in organisational routines, which may be tacit, can be made. Tsoukas (2005) on the other hand claims that tacit knowledge can only be manifested in what we do. It cannot be captured, translated or converted. Tacit and explicit knowledge cannot be separated and studied separately since they are not two ends on a continuum. All explicit knowledge, according to Tsoukas has a foundation in tacit knowledge. However, without distinguishing between tacit and explicit knowledge, we can according to Tsoukas, discuss how we do things and how we relate to our environment. In this way, we can draw attention to things we have not noticed before about how we do things and thus create new insights.

In this thesis, I have chosen to apply the notions of embedded knowledge and action as presented by Ekstedt et al. (1999) to describe the specific organisational context in which the studied change effort takes place. This approach is considered to be suitable since it includes the aspect of an organisation’s ability to change relative to its stock of knowledge expressed as embedded (see section 3.8.2). Since the study concerns two entities which differ, i.e. Peab and SBE, these notions were found useful to distinguish their respective knowledge stocks and thus their ability to achieve desired changes. How the approach was used to identify facilitators and barriers to achieve the desired changes in the studied company is further described under section 3.8.5. Furthermore, tacit and explicit knowledge are not considered separately in this thesis, in line with Tsoukas’ arguments. By studying the change effort taking place in Peab and SBE, attention is drawn to how things are done in this particular organisational context which constitutes both tacit and explicit knowledge.
In this way, it is believed that new insights about facilitators and barriers to achieving certain changes in a particular organisational context can be gained.

### 3.3 Organising to reduce uncertainty in construction

This chapter started by pointing out that construction projects concern combining actors with different skills that are independent outside the specific building contract. Here the notions of embedded knowledge and action as presented by Ekstedt et al. (1999) are applied to support the understanding of differences between firms working together in building projects. Embedded knowledge and action are also used to explain how such different and independent firms manage to cooperate in building projects with ever changing constellations of actors.

Organisational types can be distinguished by what is the dominant type of embedded knowledge and action (Ekstedt et al. 1999). In the context of a building project, there are companies which are dominated by each of the types of embedded knowledge and action mentioned above. Among, for example, the consultants there are companies which are dominated by individual level embedded knowledge and action. For instance, a structural engineering firm or consultancy firm that designs electrical services may have most of their organisational knowledge and action embedded in individual consultants. Even though it can be stored in other ways as well in such companies, it may mean a significant loss if an experienced person leaves the firm.

A supplier of some sub components such as radiators may be highly automated. While knowledge and action resides in individuals and traditions as well, such a firm may rely heavily on knowledge embedded at the capital level, i.e. in robots and other machinery used for production. A building contractor, on the other hand, who takes on coordination of design and conducts construction, may have a large share of its knowledge embedded at the system level. A large part of the contractors’ work, both during design and during construction is about managing actors and tasks. Relations between actors are strongly influenced by standardised contracts and traditions related to the actors’ roles and will be described under section 3.3.1. The contractor relies on such system embedded knowledge and action while managing actors and their tasks.

The character of construction work means that such different actors have to manage networks with complex interfaces (Gann and Salter 2000). Essential for each actor is to be able to combine its own business processes with building project processes together with other actors. Since building projects are meetings between different and independent organisations, there may be diverging interests among them. This can concern preferred ways of acting to meet individual as well as project goals. The way
knowledge is embedded in an organisation can give a hint on how it is likely that the firm prefers to act to achieve profits. For instance, a contractor managing a building project has an interest in keeping production costs for the entire project at a certain level. To do this, the contractor may decide to spend the least possible sum for a certain consultancy service. The consultant on the other hand may be dependent on a certain rate per hour, to make a profit on his/her work. Therefore, the consultancy hours for this particular consultant spent on work for a particular building project may be reduced to meet the contractors target cost. For the building project, this may lead to sub optimisation.

Construction work in projects where independent actors with potentially different interests meet implies uncertainties (Du bois and Gadde 2002; Guidado 1996). While companies in all industries face uncertainties, the combination of a number of uncertainties is claimed to be unique for construction (Groåk 1992). The uncertainties concern individual actors’ work in the particular project as well as their coming projects.

Since work at the construction sites in a particular building project constitutes a large number of tasks, carried out in sequence by several teams, each team’s workplace is defined by the previous team. The sequence of tasks is fixed and there is no complete description of coming activities on the site since unexpected events may occur. The absence of control of the workplace due to task sequence implies an uncertainty which makes construction different to factory based production lines or work groups (Groåk 1992). Teams, materials and work vary between projects and management is not acquainted with local resources and local conditions (Gidado 1996). The large variety in contractual arrangements and the large variety in combinations of participants in turn results in a great variety of building processes. More, the participants in a construction project at any given time during the process may not know what and where the next contract will be, what the contract sum and project duration will be, or what technologies and resources will be required.

Furthermore, the different interests actors may have can also be a source of uncertainty since behaviour to protect their own interests may jeopardise the chance of meeting project goals.

Construction work organisation is formed to allow for actors to deal with such uncertainties (Du bois and Gadde 2002). Construction can be described as a site specific, project-based activity, where focus on individual projects is strong. In individual construction companies, project focus is realised through decentralised decision making and financial control. As was pointed out by PGS core team
members in chapter 1 in this thesis, this is considered as a contributing reason for inefficiency in the organisation. For instance, it prevents sharing experiences between different building projects and therefore mistakes were said to be repeated over and over again.

However, there is also a reason for the focus on individual projects to exist. There cannot be a complete description of forthcoming activities in a building project due to for instance unexpected weather conditions or changed political or economic conditions which may occur during project duration. More, materials, teams and roles vary with time and place, which contributes to uncertainty about contents of working tasks. Therefore, the individual building project team needs to be able to make local adjustments to meet requirements in the individual building project. Decentralised decision making and financial control make local adjustments possible. This relates to organisational/system embedded knowledge and action. Focus on the individual project is thus a response to management being unfamiliar with local resources and local environments where construction projects are carried out. Furthermore, the need for local adjustments is described as being a contributing reason for the construction industry to prefer relying on standardised parts rather than standardised systems, as it is difficult to develop systems suitable for such varying conditions.

Even though there is a focus on individual building projects, which prevents some experiences from being reused between building projects, the work organisation includes strong forces which carry gained experiences from one project to the next. Kadefors (1995) suggests that work organisation and produced buildings vary less between projects than is often emphasised by studies of construction from a project management perspective. A number of conditions which, at least in a Swedish context, contribute to this are identified. These contain knowledge and action embedded at the system/institutional and individual levels, which relate not only to individuals and organisations, but also to the entire industry. They exist to allow for making management of a large number of actors and activities in an uncertain environment easier by contributing to standardisation of actors’ skills, content of work and the interface between actors.

Governmental regulations influence the design of buildings, especially in the case of housing in the sense that building codes state requirements on the buildings and thereby contribute to standardisation. Local planning authorities also contribute to homogenizing since they are involved in all building projects. Furthermore, working practice is influenced by regulations concerning, e.g., safety.
Standard contracts, which are used in almost every project, are labelled *formal standardisation initiated by the industry*. Standard contracts incorporate many standard formulas and determine the distribution of responsibility and power in the building project. Other examples of formal standardisation initiated by the industry are standards for building components, documentation and work principles. In Sweden for instance, the AMA system (General description of materials and work processes) exists. Instead of providing detailed documentation, a reference to the AMA system can be included in building project documents.

This formal arrangement, i.e. when contracts are the basis for the different actors’ relations in a specific building project implies certain characteristics. These include that the contractual documents are very detailed and the contractor checks the suppliers’ work. Communication is often said to be only one-way and there are few feedback loops.

*The tendering system* contributes to standardisation of tasks. Almost all tasks are subject to tendering where competing firms bid on tasks which buyers have specified. Prediction of price is made easier if tasks are standardised, since it allows for earlier experiences and standard price lists to be used. Sub-contractors, consultants, etc, are contracted based on competitive tendering, where lowest (fixed) price often is the most important criterion. This is done to make sure the best possible total production cost is achieved. It also implies that relations between actors are often short term.

*Roles and interest organisations* refer to the various actors in the building industry. Few firms combine several specialities such as heating and ventilation or architecture and engineering. Even when there is a firm with several specialities, such firms are often only contracted for one of them in a specific building project. Furthermore, there are interest organisations which represent all major players in building projects. These organisations are engaged in such activities as lobbying.

*Standardisation of skills and knowledge* plays an important role in construction projects. There is an informal control system which is mentioned in formal contracts as “current standards of workmanship”. The industry collectively forms the view of what is meant by current standards of workmanship and it changes over time. Standardisation of skill and knowledge is also described to be a way to deal with uncertainty in building projects. Even though tasks are supposed to be well specified in contracts, it is not possible to foresee everything, for instance weather or geological conditions. More, the time span between project decision and the completion of the building is often long and therefore changed building requirements and thus late design changes may occur. Due to time pressure, it is often most convenient to allow
for lower levels of the organisation to make decisions regarding these issues. High levels of standardisation make these decisions more predictable.

Standardisation of skills and knowledge also gives rise to prejudices among the actors. There are strong ideas among the various actors about each others’ competences, personal characteristics and what views they are expected to have on different questions (Kadefors 1997). The actors believe that there are strong contradictions among themselves. The ideas are perceived to be strongest concerning the architect’s, the engineer’s and the contractor’s views about each other. This is illustrated by Chapman (1988), who describes these actors’ views on reasons for quality deficiencies in the building process, based on a survey. The architects state that they find the architect’s role being too weak in the building process as the main reason for quality deficiencies. This statement is put among the last by the engineers and contractors. The contractors find that the main reason for quality deficiencies is that contractors are involved in the process at a too late stage. This statement is put among the last by the architects and engineers. The engineers found that one of the most important reasons for quality deficiencies is that they do not get paid to follow through the whole building process.

Learning and routine is also said to contribute to institutionalisation. Even though a project task is brand new, its parts may very well be handled in a way that is familiar to the participants. Participants can, in this way, reuse their experiences from project to project. This way of acting is described by Schön (1991) by describing the design process as a dialogue between the designer and the design context. To make sense of a situation, a designer sees it as something already known for him/her. He/she uses a gained repertoire of examples, images, understandings etc. The designer’s ability to see unfamiliar situations as familiar ones and to act in unknown situations as in known situations is the basis for bringing past experiences to the new case. In a similar way, project participants can see a new project task as a familiar task.

3.4 Embeddedness as a way to interpret behaviour

While system or institutionally embedded knowledge and action function as an expression of how to act in particular situations, they do not determine individual actors’ behaviour, as organisations or individuals, completely. The same goes for other forms of embedded knowledge and action. The notions of embeddedness do not say that that individuals’ acting is completely determined by the physical, organisational and institutional context it takes place in. It should rather be seen as a way to interpret actions in a specific context (Ekstedt et al. 1999). Physical and system context can be used to understand individual members’ behaviour in an organisation, but personal judgements are also made.
Individuals and their organisations differ, and this also affects behaviour. Individuals differ for instance in the social context they have experienced, which affects their way of acting and thinking (Tsoukas 2005). Individuals’ acting is made similar through rules related to their roles in the organisation and through education and informal interaction. In this way, firms try to make individuals’ actions similar, i.e. “normative expectations” are defined. In a specific situation, individuals chose to use the aspects of the normative expectations related to his/her role which are considered relevant as well as aspects related to his/her personal experiences or interests. These are in turn combined by the individual, with aspects related to conditions prevailing in the place where action takes place.

This chapter earlier dealt with how organisational knowledge can be embedded at different levels of the organisation. It has been claimed that system and individually embedded knowledge and action as described above, reduce uncertainties in the context of building projects. How does this occur? Even though there is room for personal judgments, the standardising factors in a construction context contribute to decreasing uncertainty for actors, since they clarify the “rules of the game” for the particular context. These rules of the game were seen as knowledge and action embedded at the institutional and individual levels above. Such rules are created because they are believed to support the achievement of particular goals (Tsoukas and Vladimirou 2005). Organisational tasks are performed by organisational members who have learned to apply rules and traditions according to a shared view. Applying the rules means learning to act in accordance with previous examples, which form the basis for the existence of the rules. It can also be described as a way to keep traditions alive.

In the construction context, this concerns both what is expected of individual actors and how the interfaces between them work. For instance, by using standard contracts, actors face less risk in terms of missing out basic things that are useful to include in a normal contract. Current standards of workmanship make the insecurity about what to expect of different tasks less, even though their content cannot be fully specified. Through the standardising conditions, mentioned above, that exist in construction, the industry tries to make actors, both as organisations and individuals act in similar ways from project to project. This is a way to preserve traditions and it is a way to transfer knowledge from one project to another. However, building projects constitute independent actors. Individuals acting in a building project should therefore be understood based on embedded knowledge and action related to his/her organisation as well as based on conditions related to the specific combination of different actors’ embedded knowledge and action for the building project.
3.5 Organisational competence – actor and project features

Knowledge was described above as important for informed action. How can informed action be understood in the context of business operations? What is it that allows an organisation to perform its business satisfactorily? What is it that allows independent actors in a building project to produce houses, bridges, roads and other things?

To describe this, the expression organisational competence is used here. The concept is related to the resource-based view of the firm (RBV). RBV is often used to examine and explain the sources of a firm’s competitive advantage (Hoopes et al. 2003). It focuses on a firm’s abilities and resources as a source for profitability and competitiveness. It has also been used to examine how firms use and combine resources, how competitive advantage is maintained, what causes heterogeneity across firms as well as how to evaluate the impact of innovation in a firm (Peteraf 1993 and Durand 1997).

Central to the RBV are resources. These can be tangible as well as intangible and include physical, human as well as organisational features, which the firm uses to perform its business (Eisenhardt and Martin 2000). All firms have a unique set up of resources and they also differ in their ability to use them. Writers who apply and elaborate on the RBV point to the distinction between resources and capabilities or competences (see e.g. Grant 1991 and Amit and Schoemaker 1993). It is argued that resources in the form of tangible assets in themselves are not enough to explain competitive advantage. This means for instance that it is not enough to have a superior production plant. To achieve competitive advantage, the firm must also be able to manage it properly (Hamel 1994).

To be able to use its resources, a firm needs to have capabilities as some writers call it, or competencies as other call it. The value of a resource relies on how the particular resource is “embedded and used within a system of resources and activities in an organisation” (Sanchez and Heene 2004). Such a system of resources and activities is the organisational design. Forming the organisational design includes task allocation, distribution of authority and information flows. Controls, in the form of measures of performance, are set up to give managers and employees feedback on their performance. There can also be incentives that encourage a certain behaviour and discourages another. Core processes describe the types of activities the organisation carries out and how it tries to do them.

The distinction between doing and having is illustrated by how resources, capabilities and competences are described. Resources are described as being made up of assets,
capabilities and knowledge (Sanchez and Heene 2004). They can be firm specific, i.e. owned by or closely controlled by the firm. They can also be firm –addressable, i.e. not owned or controlled but available to the firm. Assets are either tangible, e.g. machines and tools or intangible, e.g. ideas and relationships. Capabilities are the organisation’s ‘repeatable pattern of action in the use of assets to create, produce and/or offer products to a market’. Capabilities are action-based and occur when groups and teams are capable of coordinating their skills in performing a process that is essential to the organisation. They are seen as a specific type of intangible asset since they establish how a firm uses its tangible and other intangible assets (Sanchez 2001). Competence is considered as an organisational feature that occurs when the organisation’s team and group capabilities can be co-ordinated in a manner that supports the realisation of the organisation’s goals. To qualify as competence, an activity must thus include coordination of various capabilities and be intended to and have the potential to meet the organisations’ goals.

Some types of competences are argued to be the root of a firm’s competitiveness. These are labelled core competences and are seen as constituting collective learning in the organisation (Prahalad and Hamel 1990). “A competence is a bundle of constituent skills and technologies, rather than a single, discrete skill or technology and a core competence represents the integration of a variety of individual skills” (Hamel 1994). The author therefore suggests that it is uncommon that a whole core competence can exist in a single individual or a small team. To allow for a competence to be considered as core it must, inter alia, be unique and difficult for competitors to imitate. To stay competitive over time the ability to select core competences, building core competences, deploying core competences, and protecting core competences is essential. It is recognised that companies can differ in their abilities to manage competences and this is likely to influence performance.

Hamel (1994) provides examples of three broad types of competences that illustrate what is meant by core competences. These are market-access competences, integrity related competences and functionality related competences. Market access related competences refer to skills that bring the company close to the customer, e.g. sales and marketing, distribution and logistics. Skills that make the company quicker, more flexible or more reliable than other players such as cycle time management and just-in–time management belong to competences that are referred to as integrity related. Functionality related competencies are those that allow the firm to offer products or services with unique features.

Davis and Brady (2000) suggest that for the design and implementation of complex product systems such as telecommunication systems and flight simulators, specific
project capabilities are important. These are necessary for preparation of bids and execution of projects. In a similar way construction companies and projects can have specific organisational competences. These can refer to individual actors’ organisations and it can also refer to building projects in their role as temporary organisations. A contractor can, for example, have the competence to finish building projects on time. This competence resides in the contractor’s own organisational conditions such as the authority to decide about the most suitable consultants, sub contractors and suppliers for each project. A building element supplier can have the competence to produce “tailor made” elements as opposed to standard elements. This competence resides in the element supplier’s own organisational conditions, such as production equipment. To perform their businesses, they are both dependent on organisational competence on the building project level.

In building projects, actors with different organisational competences are combined. Based on contracts, the building project as a temporary organisation coordinates resources which to a great extent are available but not controlled by the project. The ability to co-ordinate a specific combination of resources to fulfil the building projects goals therefore constitutes the building project’s competence. This competence resides in inter alia the decentralised decision making authority, contractual arrangements, the standardised skills and contracts, laws, physical equipment used as well as in the individuals who participate directly or indirectly. Competence occurs when individuals and teams jointly are able to put their knowledge into action in this particular context to meet the goals of the project.

Thus, organisational competence is an ability to perform activities which are aimed at fulfilling the organisation’s goals. The ability is influenced by the organisational design, which is formed to co-ordinate the use of resources. Organisational competence therefore resides in resources themselves as well as the in the organisational design. Organisational competence in this thesis refers to teams of individuals or an entire organisation acting and applying knowledge influenced by the individuals themselves and the physical, system, institutional and structural context where it takes place. Thus, it can be described as teams acting and applying embedded organisational knowledge. The individuals making up the teams have the ability to combine their personal qualities and judgements while pursuing organisational tasks with a specific purpose while fulfilling organisational goals. The teams in turn have the ability to combine their qualities and judgements while pursuing organisational tasks with a specific purpose while fulfilling organisational goals. Organisational competencies can be of different types and exist at various places in the organisation.
Industrialised building was described in terms of organisational competence in chapter 1 of this thesis. In line with the reasoning above, it was pointed out that standards or modern production equipment in themselves are not enough to improve performance in an organisation. The individual actors as well as the building project as a temporary organisation must also be able use them in a way that leads to fulfilment of goals. Thus, a change in one actor’s organisation may or may not lead to enhanced competence on the building project level.

3.6 Peab and SBE - contexts for change

The organisational conditions which form the basis for the studied industrialisation effort in Peab and SBE are described here by focusing on the relevant parts of the organisational design and processes for performing business. By describing the organisational design according to official descriptions and how processes are performed within the organisation according to employees working there, it was found possible to create an understanding of important organisational competences and how they reside in the organisations.

3.6.1 Peab - A work organisation with strong local managers

At the time of the research, Peab operated through five construction divisions and a nation-wide civil engineering division. This constituted the permanent parts of Peab’s organisation. The construction divisions were defined based on their geographical location. Size of the geographical areas and turnover varied significantly between the divisions. The divisions were subdivided into regions and the regions in turn were subdivided into contracts managers groups. Peab had local offices at over a hundred places in Sweden. The number of contracts manager groups was about 150. During the period of the research, organisational changes took place that aimed at, among other things, concentrating the company group’s competence on housing production to certain units. A particular division for housing covering the main market for housing, i.e., the Mideast of Sweden including the Stockholm area was established. Furthermore, the south division concentrated its competence on housing to a particular housing region.

Building projects were managed from start to finish by the contracts managers and their teams at the local level. A contracts manager's group was like an organisation within the larger organisation with its own staff and responsibility for economic results. Even though managers at the regional and divisional levels contributed to the creation of business opportunities, the contracts manger was responsible for making sure that the group got new projects. The groups consisted of white-collar workers, i.e., the contracts manager, project leaders, site managers, supervisors and administrators. Even though all the contracts managers groups included the same
type of staff they were not identical across Peab’s organisation. Some groups had a permanent troupe of white-collar workers, while others had a partly permanent troupe and shared some functions across contracts managers groups belonging to the same region. Purchasers, for example, were connected to the groups, but could in some divisions or regions change groups according to needs among the groups belonging to the same region or division. The contracts managers groups belonging to the same region were supported with common functions such as quantity surveying and accounting. Peab’s craftsmen were employed at the divisional level and allocated to sites according to needs, and thus, they worked with several contracts manager and their site managers.

Peab’s organisation was formed to allow for individual contracts managers and their teams to run projects largely according to their own preferences by applying decentralised decision making. Contracts managers and their site managers were described as having a lot of freedom to run projects in ways that suited them and their teams without too many central guidelines to consider. A very important requirement was to make a profit on every project. In addition to Peab's own staff, a significant amount of external actors such as various consultants (for example architects, structural engineers, service consultants) and different types of subcontractors and suppliers were needed in the production of buildings. When the study was conducted, the local entities with their contracts managers had the right to chose and contract external resources and to chose and purchase most of the necessary materials for a building project. As a result, the different contracts managers groups had developed their own routines and they had also developed special skills in using different construction methods.

In some of Peab’s divisions, the vast majority of the contracts managers groups had developed skills in using cast in situ concrete. The processes for design and construction were adapted to this construction method, and their own staff as well as external resources were skilled in working according to these. In other divisions, contracts managers had developed skills in using semi prefabricated structural building systems. In addition, there were some contracts managers that applied fully prefabricated structural systems in combination with other construction methods.

There were many contracts managers groups that had worked together a long time and thereby had developed their skills in managing building projects, which was said to show in the economic results. A group with individuals that has worked together a long time was described by a contracts manager to be very tight and skilled in conducting building projects according to the routines developed within the group. A newly established group differs in the sense that the individuals need some time to
develop routines and become as tight as the older groups, it was claimed. There was said to be some learning between contracts managers groups. Exchange of information between contracts managers groups was said to take place both on an informal personal basis as well as through formal meetings where contracts managers or site managers meet to discuss experiences. The exchange of information on a personal basis was said to take place for instance when someone phones a college in another group to discuss how to solve a certain problem.

Relationships with external actors needed to conduct building projects such as consultants and suppliers, were said to be short term in many cases. These were described to be co-ordinated through standard contracts. Even though there was an ambition to develop longer relationships with a few, the relations were often short term and external resources were in many cases contracted based on price as the most important criterion. Exceptions to this were mentioned and concerned that individuals in the contracts managers groups developed their own personal contacts with consultants and suppliers. In some regions and even divisions longer-term relations with external resources existed as well.

Interviewees considered that Peab held certain skills that distinguish it from competitors and thus contribute to its competitiveness. These were said to include the organisation’s ability to make quick decisions and act quickly upon them. Another thing mentioned was Peab’s conscious focus on building production that was considered to contribute to the organisation holding good skills in this particular area. Good relations with stakeholders at local markets and good knowledge about local markets were also mentioned.

Thus, important for Peab’s organisational competences related to housing construction is the organisational design, which includes decentralised decision making to meet conditions and requirements of individual projects. This implies that the competences related to housing construction to a large extent are found within the 150 contracts managers’ teams and the skills they have developed. Since there were few central guidelines to follow, their skills were based on different construction methods, such as cast in situ or prefabrication. Their skills were also based on small differences in their relations with other actors such as the time span of the relation.

In addition to its organisational competence and where it resides in the organisation, Peab can also be distinguished as a specific business type according to Giertz (1999). A company that works on a project basis and engages different actors with specific skills to conduct tasks is labelled “publishers” according to his way of categorising different types of companies. Important for these companies to achieve profitability
are real costs in relation to the budget, purchasing costs in relation to purchased amount and project milestones ready in due time. These, together with knowledge and action embeddedness provide insight into Peab’s preferred way of acting to achieve profitability on its projects as will be described below. It also provides insight into some issues regarding combining SBE and Peab in building projects, as will be pointed out under section 3.6.5.

3.6.2 Peab’s building process - processes formed by work organisation and construction methods

Peab Sverige AB started construction of 3200 new dwellings during 2005 and by the end of the year the company had about 5000 dwellings under construction (Peab årsredovisning 2005). The figures include dwellings built on contract for a client and its housing developments. The largest part of the dwellings the company produces is confined to multifamily buildings. Customers include private, municipal and co-operative clients and final users when the company works as a developer. The largest share of the housing production is focused on rental and tenant ownership dwellings for average income households of any size or age. In smaller markets, it was claimed that the target group includes households with stronger purchasing power as well, since the markets often are too small for focusing on only the average income group.

Peab’s role was described to differ somewhat depending on the type of contract at hand for a specific building project. For projects when Peab works as a developer, the company co-ordinates the actors and their activities from idea to finished building. In cases when Peab is contracted by a client, the responsibility for co-ordination of actors and their work can differ depending on the type of contract. For housing production, working as a developer is a common form. It was said that the trend now is that even though Peab (or other contractors) build on contract for a client, the process is developing towards that of working as a developer. This means that the client and the contractor work closely together from idea to finished building, as opposed to the client contracting the contractor to design and/or build according to already developed specifications. Therefore, the focus here is on describing the process for Peab developing a project from idea to finished building. This process normally takes about four to five years from initial idea until the project is finished. The first year is spent on preparation for the work with the local planning authorities. Then one and a half-years to two years are spent on the detailed work with the planning authorities. Finally, detail design and construction work takes one and a half years to two years.

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5 In Sweden, the total number of started dwellings were 27 600 in 2004 and the number of completed dwellings the same year was 25 283 (SCB). The forecast for number of started dwellings is 33 500 for 2006 and 35 000 for 2007 and 2008, respectively.
The development of an idea for a building project based on a design and build contract where Peab works as a developer was said to emerge as a result of an iterative process where the goal is unclear from the beginning and grows clearer as different ideas are tested and refined. This is in line with how Lawson (1997) describes design work and the design process, i.e., an iterative process involving finding and solving problems until a satisfactory result has emerged. Peab’s roles were to represent the customers (buyers of the apartments), and to co-ordinate the actors and tasks from design to construction. This was described as involving seeing to it that the emerging building corresponds to boundary conditions set by market demand and regulations and is finished in due time.

Already from the outset, the work in the building project was said to be influenced by the goal of making profits in the individual building projects. When an idea for a housing project is developed during the early phase of a project where Peab works as a developer, Peab’s developer and the contracts manager, an architect contracted by Peab and in some cases the manager at the regional level are involved. It was described by two of Peab’s housing developers and two contracts managers that the goal formulation for the project is not always clear at the very beginning. For Peab, an important criterion during this phase is to find a solution which is economically feasible for the company. To find such a solution, various alternatives are presented by the architect by trying out different ideas that could fit the piece of land in question. This is conducted in dialogue with the local planning authority. In some cases, this was considered to be quite a complicated process because of, for example, neighbours or society interest and laws and regulations. As the idea for the project emerges, potential customer requirements are collected through contacts with local housing brokers and by using experience from earlier projects. In some cases, a consultant is hired to conduct a market analysis.

Furthermore, it was perceived that often too little money is spent on the architect in the early phase, which results in the architect having to do a lot of work in very little time. A common view among the interviewees, who are involved in the design phase of the building process in their daily work, was that it is important to steer the architect, otherwise he or she may aim for a too complicated and expensive product that does not correspond to market demand. This view reflects points made by Kadefors (1997) concerning the ideas different actors in the building process have about each others’ competence, personal characteristics and what views they have in various questions. The author points out that the actors believe that there are strong contradictions between the various actors, especially between the contractor, the architect and the structural engineer.
The views expressed above reflect the contractor’s belief that the architect works towards goals that differ from those that the contractor has. This influenced, according to interviewees’ descriptions, how Peab and the architect interact. Normally the detailed land development plan constrains the design of the building in densely built up areas, but interviewees described that Peab also tries to steer the architect to keep to such things as straight angles on the building and also to keep to certain widths of the floor plans. However, site conditions in these areas often make it difficult to stick to these frames and the resulting compromises are believed to make the building more expensive. It was also described to be difficult to trace how different deviations from these frames influence the final production costs, since current methods for cost estimates do not allow for such comparisons.

During the early phase of a project when Peab works as a developer, the relation with the local planning authority was said to be very important. The suggestions prepared by Peab and the architect that Peab collaborates with must be thoroughly prepared since the local planning authorities in some places demand quite detailed descriptions of the project to make a decision about building permits. This was said to force certain decisions about the design of the building to be taken earlier than was desirable. The planning authority’s own architect sometimes has detailed comments on the project as well. Nevertheless, these comments and the dialogue with the local planning authorities were considered as positive in general.

"They (the local planning authority) consider more the long-term perspective of the whole area. So do we, but they never have to consider the economical aspect of the project. And it is clear in some cases that they don’t. It is about balancing, and I guess it is useful, because it leads to a good dialogue." (Peab housing developer)

During the next stage, detail design, a Peab’s project leader or design coordinator manages actors and tasks. Often meetings with the whole design team are held on a regular basis, and in between these, smaller groups meet to deal with detailed questions. The meetings were considered very important for the coordination of the work and for making proper documentation on decisions made to be able to follow up that the work is made in accordance with these. However, this practice was also perceived to include certain drawbacks. Often problems occur which concern decisions not being made in due time and drawings being delayed. Delayed drawings were described to occur as a result of the different actors that represent companies which are independent outside the contract for the specific building project, are engaged in several other projects at the same time. It was also described as being connected to Peab’s own choice to make certain decisions as late as possible.
Working procedures during design and construction were found to be tied to applied construction methods. Construction methods here refer to the features of the structural system, which in Peab’s case often are semi prefabricated floor slabs, steel beams and cast in situ walls or semi prefabricated floor slabs and double walls depending on the preferences in different contracts managers groups. Design and construction of buildings normally go on concurrently especially when in cast situ concrete structural systems are applied. This was said to be rational since construction on site can start as soon as the design has reached a certain level of detail, provided that no later changes are needed. If there is a mistake in a drawing, people at the site can spot it and make a correction before production starts when cast in situ concrete systems are applied as pointed out by a contracts manager and a project leader. A manager at the regional level, two contracts managers and a site manager claimed that many teams across Peab’s organisation are very skilled in using cast in situ systems. Methods for casting in situ walls were said to be very efficient today and do not require very much labour on site.

Peab’s role in the case where the usual methods are applied, is to co-ordinate different actors’ work on site as well as to conduct the actual production and assembly of the structural parts. Routines for site work were described as being closely related to design, production and assembly procedures tied to the particular structural system. This includes work with the structural system itself and design and assembly of such things as services, external walls, partitions and fittings. Cast in situ systems involve conducting construction concurrently with design. To save time, construction starts before design is finished, which is possible when lead-times for prefabrication do not exist. In case a fully prefabricated structural system is applied, certain parts of the design work and assembly may be outsourced to the supplier of the structural system. Thus, the content and procedure of the work is based on skills related to specific construction methods.

The importance of knowledge and action embedded at the capital/physical level, i.e., the construction method, was expressed through experiences from trying other construction methods. The views reflected perceived difficulties to reach an acceptable cost level when applying other construction methods, which were not fully compatible with existing organisational competence. Several interviewees, both PGS and non-PGS members, claimed that earlier experiences from using prefabricated structural systems did not lead to reduced costs. The explanation was claimed to be that most teams were very skilled in producing structural systems according to current methods and the process has become efficient over the years. Furthermore, it was considered easier and less expensive to make corrections that are spotted on
drawings before producing something in situ than correcting a mistake on a prefabricated element when it arrives to the site for assembly. The habit of allowing for late changes was said to apply, even though prefabricated systems were used, which caused problems since drawings need to be ready in time to allow for production in factories to start in due time.

A quantity surveyor said that often when cost estimates are made for projects where a prefabricated structural system is used, the estimate is based on using a cast in situ system, since there are no better ways available to do it. Costs for the structural parts are removed and replaced with the cost estimate from the prefabricated system supplier. There are difficulties in estimating how other costs such as shorter time on the construction site affects the total cost when a prefabricated system is used. Since it is difficult to follow up actual costs, it was perceived difficult for the quantity surveyor to increase his or her skills in estimating costs for such projects.

3.6.3 Peab’s relations

System embedded knowledge and action, related to standardised contracts, actors’ skills and the competitive tendering system had strong influences on relations between Peab and other actors. Peab’s description of the architects’ work provides an illustration of how relations between actors can work. Another example of how interaction between actors was dealt with concerned how their relations are influenced by contractual arrangements that influence the business climate. Different aspects of the will to share information and experiences with others within the same projects and within the organisation were expressed. Within the same project, there may be obstacles to achieving an open climate that encourages sharing experiences and information. An obstacle, which was mentioned several times, is lack of trust among the parties in the building project. Current business climate and contractual arrangements were described to contribute to this. As soon as a mistake occurs in a project, all parties do their best not to be blamed as responsible to avoid economic penalties. Also, within Peab’s own organisation, the relations were influenced by a certain unwillingness to share information. The interviewees found that normally it is easy to contact colleagues within the organisation to ask for advice for example about daily work issues, while sharing information about economic results for a building project can be a very different thing.

Cost estimation was described to be ongoing concurrently with the development of the project idea. Making cost estimates at an early stage that show what the project will cost in the end was said to be difficult by contracts managers, a project leader as well as a quantity surveyor. Current practice to let the project idea emerge as the process goes on, results in the same process for the cost estimate, since a cost
estimate cannot be more detailed than the emerging idea of the building as pointed out by a quantity surveyor. Furthermore, it was described that the cost estimate models in use show the perfect situation where nothing goes wrong during the process. It may well happen, a contracts manager explained, that minor mistakes that are difficult to notice are done during the construction of the structural parts. These may then cause trouble when partitions and finishes are done. Several small mistakes may add up to a sum that in the end is significant.

'You never know the total cost until the project is finished.' (Contracts manager, Peab)

The practice to contract consultants and suppliers was said to be adapted to suit the insecurity about the final project costs. To avoid cost limits being over run, consultants and suppliers often, (although practice differs across the organisation), are contracted based on price as the most important criterion. To make sure that costs are kept within stated limits, decisions on design solutions and purchasing of building materials are made as late as possible so available time is spent on making sure that the best possible price is obtained. It was considered as a smaller total risk to pay a lower price for a service or a good that may or may not result in acceptable quality, compared to paying more for the same service or good and still risking that the quality will be unacceptable and cause increased costs.

It was also considered difficult to get good prices from suppliers that have been hired too many times and thereby started to feel too secure about being chosen. For almost every project, the market is scanned to find the supplier offering the best price for certain items. A purchaser explained that he found central purchasing agreements useful in some cases, but often they were too stiff. To get a really good deal, he explained, a purchaser must be free to scan the market and not be tied to too many central agreements. A good price was perceived possible if there is competition between suppliers. This is one reason for changing consultants and suppliers for almost every new project. An exception to this was described by a contracts manager that explained that in his group, sub-contractors were contracted based on trust instead. Since the team considered itself to have good knowledge about competitive prices, cost limits could be kept even though sub-contractors were contracted based on trust.

As mentioned earlier, this practice also implied certain perceived drawbacks, such as barriers to reuse knowledge from one project and another and barriers to make use of advantages that may come out of developing long-term relations with suppliers. This practice was claimed to be one of the reasons for high administrative costs which could be reduced by developing longer term relations with fewer suppliers and
consultants. However, currently, avoiding the risk of over running target costs by late decisions and many different suppliers is evaluated as a lower risk option than developing long term relations for future cost reductions, at least at the contracts managers group level where responsibility for profits and authority to make decisions on choice of consultants and suppliers lies.

Thus, an important competence was to manage actors and tasks to produce a building that corresponds to requirements set by customers, laws, regulations etc. It relied to a great extent on the organisational design with its decentralised decision making, standardised contracts, skills, etc as well as the construction method applied. The decentralised decision making allowed for individuals and teams on a building project level to co-ordinate actors and tasks. They could choose collaborating actors and suppliers which they found suitable for the specific project. They could also decide at what point in time to make a certain decision. This allowed for the individual building project team to handle uncertainties as well as managing changes during the course of the process. The applied construction method influenced both content and sequence of tasks during the building process. This exemplifies knowledge and action embedded at the system level as well as the capital/physical level. The system embedded knowledge and action refers to Peab as well as other actors in the Swedish construction industry.

3.6.4 SBE - A work organisation under construction

Skandinaviska Byggeelement AB was founded in 2002 and has its origin in the Swerock-group, which is part of the Peab group. SBE was founded when Swerock’s plants for prefabricated concrete elements were put into one organisation. At the time for the study, the company developed, manufactured and sold prefabricated concrete elements for housing and infrastructure and provided support throughout the building process to its customers. Products for housing produced by SBE included semi prefabricated floor slabs, double walls, solid walls and floor slabs. SBE’s customers for housing products, i.e. building systems and building elements, were for example contractors, public clients and municipal housing associations. The company had a subsidiary, S:t Eriks AB, that manufactured concrete products for landscaping. There were five production facilities in the company group. Peab was one of several contractors that bought products from the company group.

During the year of 2003, the organisation was restructured to allow for better coordination of resources across the different production plants. Instead of focusing on the market close to the factories, the sales personnel were located close to the major markets and were supposed to sell products from all production facilities. New personnel were also successively hired to build up an organisation which could
operate the business with a significantly larger production capacity than earlier. In the new plant in Katrineholm, there was a completely new crew. An assembly team was also hired. The team started operating in October 2003.

The company and its subsidiary were organised according to a matrix with two geographically based regions vertically and the functions marketing/sales, accounting, design, production and quality/environment horizontally. Purchasing was made based on central agreements, combined with a significant share of project specific purchases. SBE had its own sales organisation, production facilities and staff as well as support functions. The staff at the regions included, for each of the four market districts, market managers and project leaders. Furthermore, for each production facility there was a production manager, supervisors and operators. In the southern region there was also staff for structural engineering for the purpose of manufacturing the building elements. At each region there were also administrative, accounting and quality staff. In addition to their own staff and facilities, structural engineers were needed to design the elements. The company did not have their own structural engineers, but worked with a newly established network of consultants for this purpose.

Each region included production facilities, which were specialised in different products. The regions were divided into market districts with responsibility for monitoring the market with regard to all products supplied by SBE. The sales and marketing staff were together responsible for providing all production facilities with projects. The northern region, with plants in Uppsala and Bjästa, was focused on fully prefabricated concrete building elements and had recently expanded its organisation with an assembly team. In 2003, the Uppsala factory changed its production from roof elements for a major tunnel project to structural elements for housing. The southern region with plants in Katrineholm and Kalmar, was focused on semi prefabricated products. All plants except the new one in Katrineholm used production techniques that included a significant amount of manual work.

Swerock/SBE had had plans for a facility for automated off site production of concrete building elements since the 1980s, but the plans were not realised until recently when the decision about investing in the factory in Katrineholm was made by the company group top management. Since the 1980s, the development of new factories in Germany, Austria and Belgium had been closely monitored according to SBE’s managing director. The products supplied by the monitored factories were still the same, but the manufacturing technique changed from the use of manual labour to automation of the manufacturing process, he explained. SBE has learned from
experiences made in these factories through personal contacts over the last years. These experiences were used when designing the factory in Katrineholm.

Parallel to the work in the PGS core team, SBE defined the structural systems that were to be produced by their plants. Two main systems were defined, one fully prefabricated and one semi-prefabricated. These were defined according to what was perceived to be needed to fulfil demands of the company’s customers, Peab and others, and according to what the existing plants could produce. Product development together with Peab in the PGS core team was mainly connected to the Uppsala plant during the time of the study. The idea was to use this old factory for production as well as product development and when the time seemed right, start production of newly developed products in the Katrineholm factory. Product development work, not only connected to PGS but in general, took place in the Uppsala plant both as separate projects and in connection with conducted projects. Some results were suitable for SBE’s production system and could be implemented in real building projects.

SBE as a supplier of building elements, served customers that worked in different building projects. Therefore SBE’s organisation was designed to work in building projects through the project leaders. The logistics of the manufacturing work were adapted to the production of elements to individual building projects, even though production for several projects can be ongoing in one factory at the same time. It was said that since the set of elements manufactured to various projects differ, the production logistics must be planned continuously and demands certain experience.

Thus, important competences for SBE were to sell, design and manufacture building elements according to customer requirements. These relied on individuals who were able to interact with other actors in the building process. They also relied on production equipment and individuals’ ability to manage the tools and machines as well as logistics related to production. This is to say that capital/physical and individually embedded knowledge and action were closely related to the individual production facilities and the method and routines applied there, which are described under section 3.6.5. The organisational skills developed in the respective factories were developed mostly independently of each other, but exchange of experiences and information also took place both through informal contacts as well as formal meetings. In some building projects, the different factories cooperated to supply elements to the customer. The new organisation was designed to increase coordination between the factories through the sales and marketing functions.
According to the categorisation of different types of companies suggested by Giertz (1999), SBE can be labelled a manufacturer of bespoke products. Such companies manufacture a small series of products directly to specific customer orders. To achieve profitability e.g. the time in use for machinery, staff’s experience, and value of failed products in relation to purchasing value are of importance. This together with knowledge and action embeddedness provides insights to SBE’s preferred way of acting. It also provides insight into the issue of combining a publisher like Peab with a manufacturer of bespoke products like SBE in a building project.

3.6.5 SBE’s process for supplying structural systems under development

SBE’s role in the building process has traditionally been, and still was at the time for the study in many cases, that of a building element supplier with a project leader who supported customers with suggestions, including cost estimates, for the structural parts of the building. The project leader was also the customer contact with SBE and participated in meetings during the design and construction stages. Customers could, for example, be professional clients such as public and private real estate owners or contractors such as Peab, NCC, JM or Skanska. Elements were supplied according to requirements in individual building projects. General design of the elements was conducted by consultants and structural engineers, while design related to manufacturing existed in-house. Structural engineers were earlier normally contracted by the contractor, but since recently SBE had tried to work with its own network of consultants and take on the task of contracting these in a few projects.

Findings from SBE interviewees’ descriptions about their process for supplying structural building elements point to that Peab’s (or other contractors’) way of working to achieve profits for the individual project, was not fully compatible with SBE’s process to design and manufacture prefabricated structural elements without waste in SBE’s process.

SBE’s task during the design phase of a building project, was said to include SBE’s project leader making a suggestion for a structural system including cost estimates and supporting the customer and the design team with advice. This was described to involve advising designers on prefabricated solutions that are suitable for the specific project at hand and feasible from a manufacturing and assembly point of view. It was also said to include providing the manufacturing team in SBE’s factories with necessary information for planning and conducting production. Thus, the knowledge brought to the building project team by SBE’s project leader was connected to the individual project leader’s knowledge about feasible solutions for the specific case and also the skills from the rest of the SBE staff that the project leader takes advantage
of. Furthermore, the project leader also brings with him/her knowledge embedded at the capital/physical level in SBE’s production plants through advising on solutions that are feasible from a manufacturing and assembly point of view.

As mentioned under the description of Peab’s design process, it was found that ways of working to assure profits on individual projects depend on, among other things, how relations with other actors are dealt with. It was pointed out by several SBE interviewees; two project leaders, four members of the production staff and the assembly manager, that they found that often SBE, as other suppliers of prefabricated structural elements, are involved in the building process at quite a late stage. It is not unusual that the decision to apply a prefabricated structural system is taken when the detail design stage is about to start. To allow for a proper amount of time for design and production of the prefabricated structural system for a specific case, it was pointed out that it would be useful to be involved earlier. However, as pointed out by the SBE project leaders, it is not useful for SBE to be involved earlier in the process as it works now, since the client (e.g. contractor or real estate owner) normally does not take the decision about applying a prefabricated structural system until the time for the detail design stage. Before that decision, SBE cannot influence the design of the structural system anyway. As soon as the decision is taken and SBE’s project leader becomes part of the design team, it was said that efforts are made to influence the design solution in order to make it feasible from a manufacturing and assembly point of view.

As mentioned earlier, Peab staff found it feasible to make certain decisions as late as possible to allow for time to make sure a better option is not missed. This way of acting can be understood based on that purchasing price is important for a publisher to allow for profitability. Its organisational design, which allows it to choose the supplier that best corresponds to its target price/performance criterion also allows it to make that decision at a point in time when it suits Peab. SBE staff on the other hand, found it useful if the decision would be taken earlier to allow for enough time for design and manufacturing in its factories. Thus, Peab’s and SBE’s different requirements for timing of certain decisions implied a difficulty for feasible collaboration on building projects.

Manufacturing of the elements was conducted in SBE’s facilities. Until recently the different sellers/project leaders focused on selling products that were manufactured at the factory where they were based. According to the restructured organisation launched in 2003, sellers/project leaders were supposed to sell products from all SBE’s production facilities. As the elements leave the factory, the element supplier’s role traditionally has been to answer questions about assembly and dealing with
complaints, if any. Assembly of the building elements was normally handled by the contractor in projects where semi prefabricated products are used. In projects where fully prefabricated products are used, SBE since recently could offer assembly.

The process for manufacturing differed between SBE’s production facilities depending on the type of equipment in the factory and the types of products produced. In the Uppsala and Kalmar factories, a lot of the work was done manually according to a specific sequence of tasks, while in the new factory in Katrineholm the work was highly automated. Different parts of the process had been automated or mechanised in the different factories. In the Uppsala factory for instance there was an assembly line along which form work and moulding were conducted manually. In the Kalmar factory, the elements were made manually on formwork tables, while the plotting of drawings was automated. The process in the new factory in Katrineholm was automated to a much higher extent. Form work, plotting of drawings for form work, moulding and surface finishing were automated. Logistics of the production process were planned for each production facility to perform, as rationally as possible, the production of elements for different building projects. It was said that often production for several projects including different sets of elements was ongoing concurrently, which demanded continuous planning and good knowledge of the production facility.

In the longer run, there were ideas about developing SBE’s business to become a structural systems supplier or a subcontractor. This role implies a significantly expanded role and new organisational knowledge compared to currently, including a larger responsibility for structural design and assembly on the site. Depending on the type of contract, being a systems supplier or subcontractor could include taking responsibility for work at the site including such things as transport, cranes, staff and the working environment. Becoming a sub contractor or system supplier with expanded responsibility for design and assembly implies moving competence that by tradition has been with the contractor (such as Peab) to a sub contractor. It was claimed by SBE staff that SBE could not start hiring staff for this purpose until their customers start demanding it instead of using their own labour.

3.6.6 SBE’s dependence on interaction with other actors
An important purpose with building up a new organisation and new routines, was to overcome previously experienced problems with current practice in the building process and become more competitive to contribute to decreased production costs. It was said that the market for semi prefabricated floor slabs was characterised by high competition with several manufacturers offering similar products and using similar production methods. As a result, costs for transport become an important factor to
compete with. At the time of the study it was said to be possible to transport the products approximately 300 km. A longer journey would make the price of a competitor who is located closer to the site more favourable for the customer. Therefore it was considered important to focus on its own profile, for example, by offering a concept for a complete structural system, which was one of the ideas with the PGS concept.

The drawbacks with the current work organisation and practice were said to mainly be related to the co-ordination of various actors and their work during the course of the building process. Examples of this have already been mentioned. These concern the contractor’s and the building element supplier’s preferences about timing of decisions and the practice of conducting cost estimates as well as the available tools for this.

It was generally claimed by the SBE interviewees, PGS core team members and non-core team members, that it is only possible to benefit economically from using a prefabricated building system if the design stage is finished earlier that what is customary today when in situ concrete is used. Today construction starts before the design is finished. Problems occur when this way of working is applied for prefabricated systems as well. Drawings, etc are, due to applied working practice not ready in time and changes are made during the course of the construction stage. The potential economic benefit is then lost since delays occur, and in some cases, the elements even have to be redone. Problems were also perceived to occur because of lack of co-ordination between the design of the prefabricated building elements and the design of the services. Several respondents thought that today there seem to be no systematic approach to the design of the services. SBE receives documents that include mistakes and are delayed.

Over all, co-ordination between the manufacturer of prefabricated elements and other parties during the design stage was perceived to be lacking. Thus, Peab’s skills to make sure desired cost levels are met on the individual project or contracts managers level, (which was found to be important for its competence), is not fully compatible with SBE’s requirements about early decisions and no late changes to be able to perform its competence to design and manufacture building elements according to set goals. Furthermore, problems were said to occur when the contractor could not provide SBE with information because the contractor had promised the customer to decide certain things later and make changes. Perhaps the customer does not want to have a power outlet in a certain place, because he or she wants to put the sofa there. It may well be so that SBE already has manufactured the element and then the change becomes complicated.
'It is very important that the 'system thinking' can be implemented with the construction group, so that they can see the advantages in using an element system thinking, which demands very thorough preparations. It is dependent on thorough preparations. Then you can gain economically from using it.' (Managing director SBE)

To be able to contribute to reduced costs through applying prefabricated structural systems, two project leaders explained that SBE in Uppsala needed a certain production volume, preferably based on a system with a certain amount of non-complicated standard elements combined with more special elements. The production system in the new factory in Katrineholm was said to be more flexible and required a lower degree of standardisation. While Peab staff claimed that a higher degree of standardisation would be feasible to stop inventing the wheel in every new project, it was also emphasised that it was necessary to allow for local solutions. This issue was discussed by the PGS core team, but it was not solved at the time of the study.

3.6.7 SBE's new manufacturing technique and development of a new role

SBE is, as mentioned, a recently founded organisation whose work organisation was being built up at the time of the study. An important feature in SBE’s work organisation was that it constituted a combination of physical production equipment suited for continuous production, while the process from sales to delivery was adapted to serve customers who work in reoccurring projects. SBE was contracted by a contractor or a professional client for a specific building project and supplied products in accordance with specified requirements, even though production equipment was perceived as being used more effectively if large volumes of standard elements could be supplied on a continuous basis. As described above, it was found that perceived problems with the interaction between Peab and SBE occurred as a result of the two having difficulties to combine requirements set by their respective businesses.

At the time of the research, several changes took place within SBE. These were the result of intentional strategic decisions taken by top management to reduce production costs for housing by applying an industrial approach. Production in the new plant in Katrineholm started during the autumn of 2003, and the plant in Uppsala changed its production from roof elements to a major tunnel project to structural elements for housing. New staff was hired for the new plant in Katrineholm and an assembly team, based in Uppsala was also hired. This implied changes in established routines due to new conditions, which differed between the
two production plants. The old factory in Uppsala took on an extended task with design, manufacturing and assembly of a new product and the new factory in Katrineholm started producing familiar products with an ordinary scope to the task.

The restructuring of the organisation aimed at separating sales and manufacturing in the sense that the whole sales organisation became responsible for selling all types of products, not only those supplied by the facility where the seller was based. It was also seen as one step towards its desired future role. This put new requirements on the entire process. Already existing routines and systems for communication and transfer of information could be used to some extent, but it was also necessary to solve problems as they occurred along the way, sometimes in an ad hoc way. This is further described under section 4.2.4.

### 3.7 Facilitators and barriers to change

This section starts by describing barriers to change in general terms based on a literature review of the issue. It continues by describing how a specific organisational context affects a firm’s ability to change. Based on this overview, the approach to identify facilitators and barriers to achieving the specific changes in the specific studied organisational context in this thesis is presented.

#### 3.7.1 Different types of barriers to change

A central issue related to the topic of organisational change is the relation between the organisation and its environment (Pawlowsky 2001). There is a great interest in what firms can and should do to adapt to ever changing conditions in order to achieve and sustain competitive advantage. Over the last half century there has been a change in the view of how companies can cope with changes in their environment. This is exemplified by Grant (2002) who describes shifting focuses. In the 1950s and 1960s, corporate planning was seen as important to forecast market demands, revenues, etc. Industry structures and the firm’s position in relation to competitors were emphasised in the 1970s and 1980s. During the last decades, interest in firms’ internal abilities to build competitive advantages and achieve profitability has increased. Building and enhancing competences and knowledge to meet changing business conditions are seen as essential for competitiveness. There is a great interest in organisational learning in the context of change (Pawlowsky 2001).

The process of change and learning in organisations is, however, not always easy in reality. It requires effort and many times the outcome is not what the initiators had hoped for (Anatal et al. 2001 and Kotter 1998). There is literature on how to manage the change process that claims to provide guidance on how to create an organisation which can build knowledge continuously (see e.g. Senge et al. 1999 and Duck 1993).
Yet many firms fail to achieve the goals set up for their change efforts. Kotter (1998) claims to have watched more than 100 companies of various sizes, aiming to change their way of conducting business to become better at meeting new challenges imposed by their environments. Only a few of the efforts have been successful and a few were total failures. Most of them were said to end up between the middle and lower end of the scale.

Kotter has found eight common mistakes among companies he has watched, which have caused change efforts to fail. These mistakes can be considered as barriers to change and facilitators if the process is managed differently. The first concerns failing to establish sufficient feelings of urgency among people at all levels in the organisation, which is claimed to be a reason for not achieving the goals. Second, a strong and powerful enough guiding team must be established. If this fails, it is claimed that the effort may produce good results for a while, but at some point the forces that preserve the old behaviour will take over.

Third, a reasonable vision about the change effort is essential. Without a vision the change effort may become confusing. Sub projects may be incompatible and strive in the wrong direction. The fourth mistake mentioned is not communicating the vision in the appropriate way. Communication must include words as well as deeds. Fifth, allowing for obstacles to hinder the new vision is another common mistake. This may include individuals who resist changes and sometimes this may concern organisational structures. Sixth, failing to create short-term victories, can lead to too many employees giving up. Seventh, celebrating victory too soon may lead to the old forces that preserve the old behaviour winning. Finally, eighth, failing to include the changes in the corporate culture may lead to new behaviours being abandoned in favour of old ones.

Kotter’s eight common mistakes are not the only reasons for change and learning efforts failing. Antal et al. (2001) presents a literature overview that provides insight into how barriers to organisational learning are described. They find that barriers to learning in organisations reported can be divided into three main categories. These are interrupted learning processes; psychological and cultural barriers, and barriers related to organisational structures and leadership. Interrupted learning processes can occur for several reasons. Four types of interruptions described by March and Olsen in their work “The uncertainty of the past: organisational learning under ambiguity” from 1975 are pointed out. First, role constrained learning can occur if an individual is constrained by his/her role from acting on learning. Second, audience learning may occur if some individuals change their behaviour, but cannot convince others to change organisational behaviour. Third, superstitious learning may occur in case
members draw the wrong conclusions about how organisational actions influence the environment. Fourth, when changes in the environment are difficult to distinguish, learning under ambiguity may occur.

Another form of interrupted learning processes described is situational learning, which refers to that learning which occurs in a specific situation but is not stored for re-use. This may occur, for instance, in a crisis situation. Fragmental learning can occur when one unit in an organisation learns, but the whole organisation does not. Furthermore, Hedberg used the concept of organisational unlearning in his work “How organisations learn to unlearn” from 1981. This refers to how the ability to change certain skilled behaviours, i.e. to unlearn, is important in order to develop new ones. If established mental models cannot be changed, new ideas cannot be developed.

The psychological and cultural types of barriers to organisational learning are the next category mentioned by Antal et al. This category includes defensive routines as a barrier to organisational learning. This refers to individuals developing routines to protect themselves from threatening situations. Such routines can be maintained by organisational culture. Anxiety is also mentioned as a potential barrier to learning. For instance, in organisations where the predominant management style and system have punished employees who have moved away from organisational norms, it is likely to be difficult to convince employees that learning is safe.

This category also includes the role of success and failure for organisational learning. There are different views presented in the literature on how this works. For instance, success can become a barrier to learning when members of an organisation expect the success to continue and reject signals about changes in the environment as irrelevant or outside their control. Crisis may be a trigger for change. Furthermore, success may hinder learning when prevailing competences are exploited while omitting developing new ones. This may cause the organisation to get trapped in a situation where new ideas are constantly rejected before enough experience has been gained to make use of them. In this way, the organisation keeps on searching and failing. Active inertia can be a barrier to learning. This refers to when companies that have been successful over a long time start to experience failures, and they are inclined to engage in “flurries of activities”. These activities tend to make the problems worse, since they are not based on an understanding of the fit between new market conditions and current assumptions on which strategy processes and practices are based. This way of acting takes place when managers believe that not doing anything is the worst thing to do.
The notion that perceptions are important for the occurrence of barriers to organisational learning is mentioned. The ability to learn is pointed out to be not only a question of numbers of successes and failures, but also how these are perceived, interpreted and remembered. Perceptions that become shared and embedded in the organisational culture can work as a way to make sense of information, but they can also restrict understanding to that which makes sense according to shared perceptions. In this way, it may hinder learning. Furthermore, subcultures with different goals and languages may exist in the same organisation. This may hinder learning in cases when these subgroups cannot understand each other. In a similar way, learning between organisations may be hindered for the same reason.

The last category of barriers described by Antal et al. is related to organisational structures and leadership. One such structural barrier is related to departmental structures. Learning can focus on problems relevant for one department and fail to incorporate other parts of the organisation. Antal et al. find that the least clear notions of barriers to organisational learning refer to those related to leadership. Leaders’ behaviours and attitudes are described as influencing the emergence of barriers to learning. For instance, leaders that limit the possibility for others to participate may hinder learning. So may the attitude among leaders that “knowing is a greater virtue than learning”.

This study does not deal with barriers and facilitators to organisational change and learning in general. The study is focused on specific ideas for change, labelled industrialisation of house building. It is confined to an effort to pursue such changes in the Peab group. The studied change effort was initiated intentionally and the specific ideas for change were expected to contribute to specific goals which were set as production cost reduction by 30% and lead time reduction by 40%. The change effort was initiated as a response to external demands for lower production costs and better quality products. The effort was also initiated as a response to an internal desire to increase productivity and competitiveness. How can facilitators and barriers to making organisational changes for the purpose of industrialising house building in a construction company be identified?

So far, the thesis has dealt with potential facilitators and barriers to achieving the desired changes in the target organisation by relating the ideas for change to embedded knowledge and action (see section 3.7). It was argued that the intended changes were likely to affect embedded knowledge and action in many ways and require changes to existing organisational competences. It was pointed out that some of the desired changes lie outside the control of the individual building projects and,
in some cases, even outside the control of the individual firm as a result of action and knowledge embeddedness.

In addition to how knowledge and action is embedded in a particular organisation, its corresponding knowledge creation processes needs to be considered to understand its ability to change (Ekstedt et al. 1999). This is dealt with under section 3.8.2. To identify specific facilitators and barriers related to specific changes, as is the case for this study, the change process itself was seen as a feasible unit of analysis. Section 3.8.5 presents the approach taken to identify the actual facilitators and barriers that emerged during the process of pursuing the change effort studied.

3.7.2 Existing knowledge and action and knowledge creation

To change, firms can acquire new knowledge in many ways. Huber (1991) presents a literature review and points out that there is a large volume of literature on knowledge creation. He describes knowledge creation based on a literature review as five processes. The first described process is **congenital learning**, which refers to when organisations are born, they cannot be considered as clean sheets. Rather, they consist of the knowledge inherited from their original members and any additional knowledge acquired before they start up.

When the organisation has started its business, it is said to acquire knowledge through **direct experience**, which is the second process. This type of learning can be intentional as well as unintentional. Intentional experimental learning is described as being of different types. One example is organisational experiments which refer to analysis and feedback on cause-effect relationships between actions and results. Another example is organisational self-appraisal where member participation is essential for learning.

The third type of process described by Huber is **vicarious learning** or acquiring second hand experience. This concerns how firms search for information about what competitors do and how they do it. **Grafting** is the fourth type of process, and it refers to acquiring knowledge from new members who are holders of knowledge that was not available within the organisation earlier. Mergers and acquisitions are examples of large scale grafting. The fifth process described is **searching and noticing**. This refers to firms that scan their environments to find out about changes.

Some authors point to how the ability to acquire and apply new knowledge can be a specific competence or capability. For instance, Chandler (1990) takes the view that the ability to change relates to specific capabilities. He argues that multinational industrial firms appeared during the period of the 1880s to 1940; as a result of that they developed specific skills to exploit the potentials of economies of scale and
scope. The key was that these firms developed functional and strategic capabilities which were the internal dynamic for continuing growth. In other words, firms developed abilities to change.

Tecce et al. (1997) argue that existing resources together with capabilities influence the ability to change. They use the concept of dynamic capabilities to describe specific firms’ ability to change. The name dynamic capabilities refer to the aptitude to accomplish new forms of competitive advantage. Dynamic refers to the ability to adapt to ever changing business conditions and capabilities referring to the key role of strategic management in developing skills, resources and functional competences to fit new conditions. A firm’s ability to make short-term modifications in current routines and development of new routines can be limited by path dependencies created by current organisational processes and assets. Therefore, past choices with influence on prevailing competences affect future choices, which imply that a firm tends to follow a certain path of development.

Winter (2003) claims that firms also change without dynamic capabilities. In some cases firms change through what Winter calls ad hoc problem solving. This type of change may occur as responses to events that to some extent were unpredicted.

The meaning of the concept of dynamic capabilities has been discussed by, for example, Eisenhardt and Martin (2000), who argue that dynamic capabilities are distinctive processes such as product development, strategic decision making and alliancing. They contribute to competitiveness through their ability to change and modify resources into useful strategies. It is suggested that they can be conceptualised as tools which manoeuvre resource configurations. The authors argue that development of dynamic capabilities is based on learning mechanisms. Long-term competitive advantage is said to rely on resource configurations that managers create, rather than on dynamic capabilities themselves.

Firms apply different ways at different times for acquiring new knowledge, but they also develop their own routines for learning (Helleloid and Simonin 1994). From experience, organisations establish ways for feasible knowledge acquisition, processing, storage and use. The routines, or established ways for creating new knowledge, are influenced by how knowledge and action is embedded in the organisation (Ekstedt et al. 1999). For capital embedded knowledge, there are familiar ways to create change. The knowledge stock can be improved by, for example, upgrading of production equipment. Spreading and maintaining capital-embedded knowledge can be done by standardising manufacturing processes and maintenance of such knowledge can be achieved through marginal continuous changes. There are
also known forms for generating and phasing out individual-embedded knowledge such as reducing and increasing the work force. This does not necessarily lead to change, since recruitment of new staff often includes choosing people who are trained and educated to fit in to the prevailing system.

For system-embedded knowledge, it is pointed out that there are few established ways for change and changes do not take place naturally. The preserving forces for such knowledge are strong due to that the knowledge is defined by conditions that are beyond the control of the individual firm. Education and training systems, industry-specific knowledge, forms of work organisation, standardisation, principles, etc are affected by trade associations and national or international laws and regulations. Thus, a change process is more difficult to keep going for this type of embedded knowledge than for the others.

System/institutional embedded knowledge and action were pointed out as important for carrying knowledge from one project to another in the context of the Swedish construction industry (see section 3.3). However, such embedded knowledge and action can also be a barrier to change. It does not allow for any great changes in individual building projects and the possibility for an individual company to introduce new working procedures is also limited, since behaviours related to the system/institutional embedded knowledge and action is to a great extent outside the control of the individual firm. Furthermore, if one actor changes a working procedure it may well affect other actors as well.

In other words, the control over the level which embeds action and knowledge in actors who conduct building projects together belongs to different categories. From the description earlier in this chapter, five categories can be distinguished;

- society; including e.g. authorities
- the entire construction industry including various actors and stakeholders involved in construction
- individual organisations
- construction projects
- individual employees

This implies that pursuing changes that in turn require changes in embedded knowledge and action at a level that lie outside the control of the organisation, project, individual, etc that pursue it, may imply difficulties. It has already been mentioned that laws and regulation form part of system of embedded knowledge and action in construction companies. The power to institute laws relates to authorities.
Laws represent institutionally embedded knowledge and action in organisations, which they cannot control and therefore have to adhere to, unless some special circumstance prevails.

Even though the standardised tendering system supports and simplifies work, it also contributes to making firms similar, which results in a contractor not learning more from one supplier than another (Dubois and Gadde 2002). Moreover, government regulations which play an important role for the design of the buildings are outside the control of the individual firm, which makes design changes more difficult. Finally, the tendering system promotes standard offers, which does not encourage innovation.

There are also different areas of control within a company, which relates to distribution of authority in the organisation. Managers of a company can have the power of deciding which type of machinery should be used to produce a certain product that the company supplies. Machinery represents capital/physical embedded knowledge and action in a company, and an individual employee may not have the power to decide to use some other type of machinery for this specific purpose. In a construction project actors may want to include certain agreements in the contract. Certain agreements may be handled at the project level, if they concern issues that are within the area of control of those involved in the project. If the representatives of actors participating in a building project wish to establish a long-term relation, this may be an issue that is beyond their control. Such a change may have to be dealt with on the proper level within each of these organisations, and not only on project level.

3.7.3 Relying on combination of actors’ competences

There is a difference in established knowledge processes in permanent and temporary organisations (Ekstedt et al. 1999). Permanent organisations tend to have well developed ways to create, store, use and phase out knowledge. They build up functional entities with the task to utilise, develop and diffuse knowledge. In temporary organisations, there are fewer incentives to set up particular entities to develop knowledge. It is difficult to take care of knowledge that has fulfilled its purpose when the task of the temporary organisation is completed. Instead people with certain knowledge and certain resources are combined to produce a specific product or service.

Construction projects are temporary organisations that combine different actors’ skills to conduct projects and almost every new project has a new combination of actors. Actors with specific skills may be combined to handle a specific issue or task in a project. This leads to increased knowledge for the involved individuals, but a
central issue is how this knowledge can be re-used in future projects with different actors. Authors have made efforts to increase understanding about how learning takes place in construction. One example is Sthyre et al. (2004) who find that organisational learning in construction projects depends on personal contacts, communities of practice and learning by doing. Furthermore, to allow for learning and innovation to take place, Dubois and Gadde (2002) argue that longer term relations with other actors are needed. Dorée and Holmen (2004) find, based on a case study of a contractor developing a new technology, that the design-construct contract and the involvement of the same people as in earlier projects made the technological advance possible.

Peab provided an example of the issue related to storing gained experiences in a way that allows others to make use of it. There was no obvious way to spread a change across 150 contracts managers’ groups and their 500 site managers. They were to a great extent autonomous units within the larger organisation, and they were free to decide how to conduct their work. They relied mainly on creating new knowledge by combining actors with specific skills in individual projects. Furthermore, re-using gained experiences from one project to another across Peab’s organisation implied difficulties as well. Peab staff expressed frustration over not being able to re-use experiences across the organisation. A general view among PGS core team members as well as non-PGS core team members was that finished projects were not followed up properly with the result that there was a lack of reliable information to make future cost estimates and a lack of easily available gained experiences to avoid making the same mistake that someone else already made. Cost estimates were seldom followed up in detail. The total cost for the project was followed up, but the accounting system did not allow for an easy comparison between cost estimates and actual cost at the end of the project. A quantity surveyor described that he seldom found out if the cost estimate was correct or not, unless there was a complete failure. It was claimed there is no general system within the company to follow up projects in the same way.

'We follow up projects, but we don’t have a system to follow up different projects in the same way, so the truth becomes ‘political’ also when we work internally. If you want to prove that something particular is true, then it becomes the truth.' (Housing developer, Peab)

'Perhaps if something goes very well, you would talk about it. But if something goes wrong, you don’t say anything.' (Expert in environmental issues, production support, Peab)

After the final project meeting, facts about the project should be posted on the Peab intranet to allow for experiences to be spread across the organisation. However, for
one reason or another, the project facts did not always reach the intranet. One example of a project where inspections were made during the course of the project was mentioned by a PGS core team member working for production support. Normally the workers are not aware of their own mistakes since they move on to the next project when they are finished, while a service carpenter takes care of the mistakes. The inspections during the project made them aware of their failures. It was claimed by a contracts manager that it is not the will to follow up that is lacking, it is the time to do it that is lacking.

3.7.4 When is change achieved?

How do we know that change actually has been achieved? There are different descriptions concerning when organisational learning has occurred or when change has been achieved in organisations. Under section 3.2, where organisational knowledge and action were described, the process of socialisation and developing shared representations of reality were mentioned. Many approaches to organisational learning found in literature deal with the issue of transferring learning at the individual level to the organisational level (Pawlowsky 2001). Nonaka (1994) provides an example of a description of how organisational knowledge is created and how it becomes organisational. He describes the knowledge creation process as a conversion between tacit and explicit knowledge. On the individual level four modes of knowledge creation are suggested. First, socialisation refers to the process of creating tacit knowledge through sharing experiences between individuals. Second, the process which refers to individuals sharing explicit knowledge is labelled combination. Third, externalisation refers to a process where tacit knowledge is converted into explicit knowledge. Finally the fourth process refers to conversion of explicit knowledge into tacit knowledge. Nonaka argues that all four processes are necessary for creating organisational knowledge.

To allow for organisational knowledge to be created the four processes must be triggered to occur in a cycle pattern. These triggers include creating a team or another context where socialisation can take place. Externalisation is triggered by creating a dialogue, which allows individuals to express their views and experiences. Through a learning by doing approach internalisation can be triggered. Combination can then be triggered by coordinating team members with other parts of the organisation in the search for more information. Overall, Nonaka describes the knowledge creation process as iterative, incorporating trial and error while ideas take a more tangible form.

Turner and Crawford (1994) describe this in terms of competence development. They argue that firms hold personal as well as corporate competences. Personal
competences are those embedded in individuals while corporate competences are a combination of features, skills and knowledge embedded in systems and processes. Structures, technology and people carry these. Personal competences do not stay in the organisation if the holder leaves, while corporate competences last over time independently of individuals. For organisational competence development to take place, knowledge must be spread in the organisation and be embedded in its structures or processes according to Turner and Crawford. Organisational competence development can occur as a result of an intentional effort but also as a by-product from conducting current business. In both cases, it is pointed out that it has to be embedded at some level of the organisation before organisational competence can be developed systematically.

Different types of change efforts may result in different types of organisational learning. Many authors have developed typologies for learning types which illustrate different scopes of change efforts. For instance, refinement is one such type of change, which aims at improving existing processes (Hedberg and Wolff 2001). In this case the organisation learns to become better at what it already does. There are numerous models available for supporting refinement such as Total Quality Management (TQM). Another type is single-loop learning, which refers to implementing changes within the same frame of reference. This means for instance that new market segments are exploited with the same products. Furthermore, learning can also be seen as discovery. This means that learning resides in the organisational culture, and only when assumptions, beliefs, and success formulae are made explicit, can they be questioned and are open to experimentation. The corresponding learning type in this case is labelled double-loop learning.

In a similar way, different types of changes are expressed in terms of organisational competence. Sanchez (2001) distinguishes between competence building, competence maintenance and competence leveraging. Competence building is a process where the firm achieves new assets and capabilities and develops new abilities to co-ordinate these in ways that support fulfilment of firm goals. Maintenance refers to the process in dynamic environments, when keeping existing competences requires successive updating of resources and capabilities. Leveraging means applying existing competence to exploit new or current market opportunities without changes in assets or capabilities.

Even though the different learning types or the different types of competence development seem straightforward, they may not be easy to distinguish in practice. Argyris and Schön (1995) point to the difficulty to distinguish whether double loop learning has taken place or not. Double loop learning refers to changes in values of
theory in use (implicit patterns of action based on norms and strategies). It is pointed out that all changes in theory in use do not qualify as learning. Consider the example of a firm which faces decreased demand for its products. Such a situation may lead to patterns of action in the firm which weaken its norms in terms of members losing enthusiasm and becoming careless in their work. Furthermore, it may be difficult to determine for instance whether changes in theory in use really have been embedded in the organisational memory.

Further, learning does not always lead to visible changes in behaviour (Huber 1991). The author quotes Friedlander’s work on patterns of individual and organisational learning from 1983, which suggests that learning may result in new insights that do not prescribe changes in behaviour. The essence of the learning in such a case is the conscious awareness of differences implied by various alternatives. Thus, the choice of a certain alternative of behaviour, which may be current behaviour, can be deliberately made based on a better understanding than previously.

3.7.5 Pinpointing facilitators and barriers

This section has pointed out some potential facilitators and barriers to achieving changes in general. Facilitators and barriers in this study were examined by looking into the actual change process ongoing in the Peab group. I have chosen to focus the study on the system level, i.e., the team and organisational levels. Thus, identified facilitators and barriers refer to teams and entire organisations.

The approach taken to identify system level facilitators and barriers is processual. This means that the study concerns a specific context, a process taking place in this context and the outcome of the process (Pettigrew 1997). It deals with how the three interrelate and form each other. The context has been described in this chapter at two levels. The first level concerns organisation in construction in general and the second level concerns Peab’s and SBE’s particular organisational contexts. The study of the change process includes a sequence of events taking place over a two years period. Furthermore, events taking place before and after are briefly described to frame the course of events taking place during the time of the study.

How did I “measure” facilitators and barriers? The study covers two years of an ongoing process aiming at extensive changes, which was planned to continue several years after the finish of the study. Therefore it was considered important to capture steps taken on the way towards the overall cost and lead time reduction goals to identify facilitators and barriers to industrialising house building. As was pointed out earlier, industrialised building is in this thesis seen as an organisational competence. It concerns teams’ and entire organisations’ ability to act and apply knowledge
influenced by the individuals themselves and the physical, system, institutional and structural context, while fulfilling organisational goals. Changes that affect embedded knowledge and action therefore influence this ability. New organisational competence or enhancement of existing organisational competence may therefore be required as a result of a change that affects embedded knowledge and action.

To identify facilitators and barriers, the course of events concerning efforts to make specific changes were described. The course of events concerned the process of pursuing the specific changes which were conducted as part of the overall effort to industrialise house building in the studied company. The specific changes’ influence on embedded knowledge and action was in focus for the description of the course of events. It was investigated whether new or enhanced organisational competence could be achieved as a result of the specific changes made. Thus, if the specific change contributed to fulfilment of organisational goals such as cost targets, milestones ready in time, reduction of mistakes, it was considered that organisational competence could be achieved. Facilitators were seen as that which started and kept the process of building new or enhancing existing organisational competence going. Barriers were thus seen as that which prevented the process of building or enhancing organisational competence from starting or which interrupted it.

However, building and enhancing competence does not necessarily mean that the organisation has taken a step towards the overall goal of the industrialisation effort. In a similar way, failing to build or enhance competence does not necessarily mean that the overall goal will not be met. Nevertheless, achieving organisational competence as a result of a change in embedded knowledge and action does say something about the ability to meet the overall goals in the long run by making this particular change. It can be used as a basis for discussing the feasibility of a certain approach to change.

As pointed out above, it is not always easy to know whether change has taken place or not. For the part of the case study, which is presented in chapter 4, this means that changes and non-changes in embedded knowledge and action dealt with are those that could be observed or were mentioned by interviewees. In addition to these there may be others that were not detected at the time.

### 3.8 Industrialisation ideas and the context for change

Against what has been presented about how work is organised in construction and the reason for this, this section provides a discussion about how ideas for industrialisation, which PGS expressed and that are also are relevant in other
construction companies, may influence traditional ways of organising and working. The essence of some of these industrialisation ideas can be summarised as:

◊ Increased use of prefabricated sub systems (e.g. structural systems, bathroom modules) in housing production
◊ increased use of product standards
◊ longer-term relations among actors
◊ changed division of responsibility of tasks (in the PGS case this concerned a desire to increase Peab’s control over the design stage and increased responsibility for design and assembly of the structural system for SBE)

What does it mean for the need for new organisational competences in a construction company? What do these ideas for industrialisation mean for combining different independent actors in a building project?

All of these ideas for change will affect individual construction companies differently depending on their prevailing organisational competence and how it is embedded in the organisation. The ideas can also be interpreted and applied differently in different organisations, which influences how they affect current ways of working. For instance, increasing the use of prefabricated parts does most likely affect different organisations differently, depending on the extent to which prefabricated parts are used already. One organisation may be competent in constructing by using cast in situ techniques, while another is skilled in applying prefabricated systems. The same goes for increased use of standardised products. One construction company may already have central purchasing agreements which contribute to standardisation by limiting choices to specific suppliers and their products. Another construction company may rely mainly on purchasing being done on the individual project level. Nevertheless, below, some examples of possible implications on a construction company applying the ideas are given.

Consider the example of a building project team, deciding to use a prefabricated structural system in a specific building project. Let us say that the contractor’s team, who manage the process from idea to finished product, is unused to this type of structural system. Normally the team applies the cast in situ technique. To point out some of the differences between applying these two types of systems in the building process, Koskela (2000) provides a useful example. First, there are more production and assembly locations since prefabrication includes production in factory and assembly on site, while cast in situ implies constructing the structural system on site. This in turn requires different coordination of actors both during design and
construction. Design work differs since the two systems are different technologies, and it has to be finished at an earlier stage of the process than for the cast in situ system to allow for factory production to start in due time.

Changing timing of activities during the design stage appears as a straightforward change, which can be handled at the construction project level, but a closer look reveals that it also involves embedded knowledge and action, which is outside the control of the individual project. For example from the point of view of the contractor, changing the timing for the design phase may involve more than just finishing design work earlier than usual. In Peab’s case, as was pointed out earlier in this chapter, timing of decisions was adapted to make sure that best possible prices for each item were obtained and in that way reduce uncertainty about total project costs. Timing of decisions was also seen as a way to handle unexpected events of other kinds. This way of acting resides in, inter alia, the decentralised organisational design, standardised skills of actors, and the tendering system. Creating an alternative way to handle unexpected events and uncertainties about project costs, therefore involves making changes to a way of acting that relies on system embedded knowledge and action, which also relates Peab’s entire organisation and to other actors.

Furthermore, it takes a longer time to discover dimensional errors in drawings when prefabricated systems are applied, since they may not be discovered until the finished building element arrives at the site, while such errors may be discovered and corrected before production on site when cast in situ is applied. This makes requirements on dimensional accuracy higher since it is not possible to make adjustments by compensating through making adjustments to an adjacent prefabricated building element. Such adjustments are possible when applying a cast in situ system.

In a similar way as above, it may seem a straightforward task to improve dimensional accuracy to avoid adjustments on site. It may well be so to a certain extent. However, as pointed out earlier, construction work involves decentralised decision making to allow for local adjustments on site, due to uncertainties faced. This means that the organisation is designed to make local adjustments when necessary. By moving production to an off-site factory and asking for production there to take care of unexpected events that may occur at other locations and during other phases of the building project, requires changes that are outside the control of the individual project. It requires developing skills to manage uncertainties in other ways than in accordance with prevailing knowledge and action which reside in, among other
things, organisational design and professional roles. This is outside the control of the individual project.

Dubois and Gadde (2002) point out that standardisation of components is more common in construction than standardisation of systems, due to the varying requirements between building projects. It is difficult to create entire systems that can respond to all possible differences that various building projects may have. In the PGS case, the ideas concerned a building system with certain standards, which were not yet specified. The ideas for standardisation concerned type houses which could be adapted in shape and external appearance according to local requirements. The system should be used across Peab’s organisation. To make sure that chosen standards are applied, the idea was to develop a database for feasible design solutions and take increased control over the design stage of the building process. Well-known design solutions, supplied by fewer selected suppliers were believed to reduce uncertainty about production costs.

These ideas imply great changes to organisations such as Peab. The competence to manage a building project from idea to finished house resides to a great extent in local contracts managers' teams who in turn rely on the current organisational design to conduct their work. Decentralised decision making which allows them to conduct the work according to what they find most suitable for the individual project is an important part of this. These teams have also developed skills in applying different construction methods which also are an important part of their competence.

Product standards to be used across Peab’s organisation imply changes in current decentralised decision-making structure. The design data base would include removing part of the decentralised decision making from the individual projects to some other level, perhaps a central one. Thus, new competence would be needed for developing as well as continuously updating such a database, since current design knowledge to a large extent constitutes external resources. Finding new ways to deal with the need for flexibility to handle unique requirements and uncertainties related to unique projects are also likely to be needed.

Longer-term relations with other actors were also seen as desirable, both for development of the new building system and for improvements of performance in the building process in general. There was awareness that in-house skills in design were not enough to develop the building system. Therefore, the design of the building system including the standards was perceived to be done best by closer collaboration with selected suppliers. Lorentzoni and Lipparini (1999) suggest that the ability to interact and share knowledge with other organisations is a distinctive
organisational competence, which can, for example, be developed over time through continual work to position themselves in their networks to best benefit from technical competence and development in industry. Currently, collaboration between actors in the building process is usually short term, which was also described by interviewees. Therefore, the skill to interact and share knowledge with other actors most likely is an organisational competence that needs to be developed to achieve the desired change. This involves (obviously) other actors and is therefore not entirely within Peab’s or SBE’s control. It may also include changing the views actors have about each other.

Changed division of responsibility in work also implies a need for developing new competence. In the PGS case, this was mentioned as a need to increase responsibility for design and assembly of the prefabricated system for the manufacturer. This was intended to be done by transforming SBE to a building system supplier. As described by the interviewees, this implies great changes for SBE. New skills regarding interacting with other organisations, as mentioned above are most likely a part of this, and a number of skills related to the extended tasks of designing and assembling the structural system. Changing the interface to other actors is not in SBE’s control entirely, since interfaces need to fit together with others.

In chapter 1, it was pointed out that Japanese housing producers sometimes are referred to as good examples of companies that have managed to adopt a similar approach to production as applied in the manufacturing industry. How did they manage to get there? The aim is not provide a full answer to this question here, but a comparison between the origin of these firms and such companies as Peab provides some insight into this. The Japanese housing producers, such as Sekisui and Toyota, have their origin in large industrial companies, which have developed their production system over a long time and they also have resources to conduct research and development. Housing production within these organisations thus came out of a decision to develop a new product to exploit a new market segment. The organisations were able to rely on familiar production principles, while developing plants, processes, etc for housing.

In other words, they did not change existing organisational structures and processes. Instead they built new organisational competence by using knowledge gained from their original businesses. This is different to changing existing ways of working and organising, as is the case for construction companies aiming at adopting the ideas for change discussed above.
Thus, for a construction company with a decentralised organisational design these ideas for industrialisation may imply significant changes. Chapter 4 treats how this was dealt with in the Peab group’s effort to industrialise house building.

3.9 Summary

This chapter has described the context for change in construction in general and in Peab and SBE in particular.

Construction is a project-based business that combines the skills of different and independent actors to conduct tasks. Actors’ relations are based on contracts in individual building projects. Since the constellation of actors often differs from one project to another, relations are short term. To make management and collaboration between many independent actors in individual building projects easier and less uncertain, organisational design allows individual projects to make most decisions by themselves. Furthermore, industry specific standards such as contracts, tendering systems, actors’ roles and laws have been developed.

Organisational knowledge is a way to distinguish organisations. The notions of embedded knowledge and action are applied in this thesis to distinguish different organisations and their ability to change. These notions, together with the concept of organisational competence are also applied to identify facilitators and barriers in the studied case. Knowledge and action can be embedded at three levels of an organisation. First, individually embedded knowledge and action refer to that individuals’ knowledge and their way of acting is influenced by thoughts, feelings, skills and abilities. Second, capital embedded knowledge and action refers to knowledge and practices developed over time that have been transmitted to the design of physical equipment such as machinery and tools. Third, system embedded knowledge and action refers to routines, culture, design of the work organisation, laws, education systems, etc.

Individuals’ behaviour in a specific context described by capital and system level embedded knowledge and action, cannot be determined by this context. It can only be interpreted, since there is room for personal judgements. Organisational competence is seen as teams’ and entire organisations’ ability to act and apply embedded knowledge, while fulfilling organisational goals.

Peab as a contractor can be described as company that works on a project basis and engages different actors with specific skills to conduct tasks. Peab’s organisational competences concerning housing construction were found to reside in its organisational design, which includes decentralised decision making to meet the
conditions and requirements of individual projects. Important carriers of competences related to house building were also the building systems used, i.e. capital embedded knowledge and action. Furthermore, standard contracts, tendering systems, etc were of importance for its competence to manage actors and their skills in individual building projects. These are examples of system embedded knowledge and action. The system embedded knowledge and action is not entirely in the control of Peab, and can therefore be difficult to change. A great deal of the PGS ideas for industrialisation would affect the system embedded knowledge and action.

SBE as a manufacturer of prefabricated structural elements, was described as a manufacturer of bespoke products. Such companies manufacture small series of products directly to specific customer orders. SBE served customers that worked in different building projects. Therefore SBE’s organisation was designed to work in building projects through the project leaders. The competences to sell, design and manufacture building elements according to customer requirements relied on production equipment and individuals’ ability to manage the tools and machines as well as logistics related to production. This is to say that capital and individually embedded knowledge and action were of importance. SBE was in the control of changing its physical equipment, but changes which influenced its interface with other actors, such as changing its role in the building process, was not entirely within SBE’s control. This type of change was part of PGS’ ideas for industrialisation.

Combining Peab and SBE in a building project, implied difficulties due to how these different types of organisations prefer to work to achieve profitability. Timing of certain decisions was pointed out to be of importance. SBE preferred that decisions that concerned the structural system were made in due time to allow for enough time for production in the factory. SBE also preferred that few changes were made after a certain point in the process. Peab’s established way of working during design and construction, was to concurrently design product and production systems. While this allowed for flexibility for Peab, it meant increased uncertainty for SBE due to late decisions and changes.

The chapter has also described the approach to identify facilitators and barriers to industrialising house in this study. The approach taken was described as processual. This included that the course of events regarding efforts to make specific changes as part of the overall effort to industrialise house building in the Peab group are described. Focus is on the specific changes’ influence on embedded knowledge and action. Based on the changes made, it is examined whether organisational competence could be achieved. Facilitators are seen as those which started and kept the process of building new or enhanced existing organisational competence. Barriers
were thus seen as those which prevented the process of building or enhancing organisational competence or interrupted it.
4 Change efforts in Peab and SBE

This chapter describes a course of events which is part of the Peab group’s effort to industrialise house building. It describes the efforts made by the PGS core team to conduct its task and to develop a common building system and it describes change efforts made in two particular building projects and two of SBE’s production plants. Facilitators and barriers to making organisational changes for the purpose of industrialising are pointed out.

4.1 The PGS project

PGS’ first project manager returned to Peab after two years employment outside the construction sector. To assist him in his role as project manager, two external consultants, specialising in lean growth were contracted. During the autumn of 2002, the project manager together with representatives from top management appointed a PGS core team for co-ordinating the industrialisation effort. The result was a multi skilled team of seventeen people representing the Peab group in house key functions regarding prefabrication, design, purchasing and construction from all geographical divisions. This mix of professional competences from different geographical units across Peab was considered necessary by the project manager to allow for the project to be accepted across the organisation. The group included contracts managers, site managers, project leaders, purchasers and operations support personnel from Peab. SBE was represented by the technical manager and managing director. A complete list of the first PGS members is presented in chapter 2.

The PGS core team was not supposed to work alone behind closed doors. The project manager described that the idea was that the PGS core team would establish contacts and involve different parts of Peab’s and SBE’s organisations as the work progressed and it became necessary to link them to the project. Such cooperation would include exchange of ideas and also testing them in daily work. Furthermore, the PGS core team would get feedback from its steering group, which consisted of managers and others from across Peab who were interested in the development of a common system concept.

Work in the PGS project was not a full time task for all core team members. The project manager was hired as a full time project manager, but most of the team members spent 25% of their time on the PGS project. Two members spent 50% and 100% respectively on the project. The original group of core team members and the project leader changed during the two years study of the PGS project. Some core team members left the project, because they or their managers did not consider that it was possible to spend time on other things than their normal daily work. Others
joined the project, since they found the PGS ideas feasible and wished to contribute
to the work. The organisation of the project team also changed to make better use of
available resources. After about six months work, some of the original core team
members became a reference group with the task of providing the core team with
feedback. About 1.5 years after the launch of the PGS project, the project manager
was appointed manager for production support in Peab. He and the newly appointed
project manager worked parallel until the autumn of 2004, as the new one was
finishing the work at his previous position. The new project manager was internally
recruited and had worked as a site manager. He was appointed as full time project
manager for PGS.

Starting in December 2002, the project team met once a month and spent one
evening and a full day together for the work. In between the full group meetings, sub
groups met and telephone meetings were held. The majority of the PGS core team
members could allocate just enough time to attend the meetings, and sometimes a
few hours in between meetings. The PGS work was divided into three phases, with
declared working themes and results that were presented by the end of the phases.
Figure 3 on page 107 provides a chronological map over the PGS process with
events, working themes and main results highlighted. These are described in further
detail in the following sections.

Thus, the management decision to allocate resources and launch the PGS project was
a facilitator that triggered the change process to start. The availability of motivated
individuals was another facilitator which made it possible to start a knowledge
creation process within the PGS core team.
Phase 1

- Decision to conduct work in three sub-groups according to three themes:
  - design,
  - market related issues,
  - waste (non-value adding work) in the building process.
- Appointment of pilot projects. Start of data collection.
- First meeting with top management.

Phase 2

- Change of group organisation. Appointment of reference members.
- Decision about new themes for the work in new sub-groups:
  - purchasing and logistics
  - work organisation
  - structural design.
- Emergence of different tracks in the work.
- Meeting with top management and Peab representatives.

Phase 3

... ongoing at the end of the study.
- Decision about new themes for the work in new sub-groups:
  - continue to develop solutions for logistics and select suitable suppliers.
  - let suggestion for new work organisation rest and continue with waste analyses in pilot projects.
  - continue development of the structural system and work with analyses of pilot projects.
- Closer collaboration with suitable units in the rest of the organisation.
- New PGS project manager in June 2004.
4.1.1 Emerging working themes and scope

Phase 1

The first meeting with the PGS core team took place in December 2002. The team gathered in Peab’s office which at that time was located in Solllentuna, north of Stockholm. Some of the team members knew each other before the start of the PGS project, but they had never worked together on a development project before. For me, all the faces were familiar, since I had met all of them through my first round of interviews earlier during the autumn. During the breaks, I had opportunities to chat to team members to find out what their impression of the first meeting was. A contracts manager said that he found this initiative very important, but he was also very curious to see how the team could conduct its task. A manager at the regional level pointed out that he was still not sure about what the task exactly involved and said that he aimed at bringing up the question for discussion.

The meeting set the basis for the PGS core team work until August 2003 and it also set the pattern for how the meetings would be formed during the entire time for my study. Working in a renewal project was new to most of the core team members. Even though development projects had taken place before in the organisation, there were no established routines for such work that the newly established core team could take advantage of. To make up their own routines for the work, the project manager received help from the external consultants, who were contracted to support him and the core team in the work. The consultants influenced the form for the monthly meetings as well as its content, and they brought with them tools for Peab and SBE to apply, for improving performance in Peab’s and SBE’s organisations.

Monthly meetings were always conducted in a seminar style, where the project manager and the consultants took turns in chairing the meeting. Each meeting had an agenda, which included presentations and discussions of work done since the last meeting, presentations and discussions of things relevant to the project going on inside as well outside the organisation, and time for project work. In between the meetings, the project manager and the consultants were involved in the work done by the core team members, both as supporters and for doing various activities.

The question about the PGS core team’s task was brought up during the first meeting. The project manager stated that the task the PGS core team was assigned by top management was to develop a building system. However, the exact scope of the building system was not predefined. This opened up for core team members to express different views about this issue, such as whether services should be included or not. It was agreed that this should be part of their task to decide. The question whether the PGS work should be based on SBE’s products or not was also brought
up. The project manager argued that PGS should be free to choose the solution that seemed most suitable, without limitations. Others disagreed and said that top management intended the PGS project to work with SBE’s products.

Despite disagreements about preconditions for the work, the team started. An important activity during the first meeting was a brain-storm session that served as a basis for deciding on working themes for the coming six months. The outcome of this brain-storm session also influenced working themes at later phases of the PGS project. It served as a way to capture the members’ views on issues they found necessary to deal with, and were labelled “ideas for industrialisation”. The project manager and the consultants then used these as a basis for suggesting three themes for three subgroups to work with.

The nature of the problem which the PGS core team worked with and its way of working to create new knowledge, as will be described below, was in line with how Lawson (1997) describes the nature of design problems and design work. He claims that design problems cannot be comprehensively stated. It is not possible to be sure that all aspects of the problem are known, since several parts of the problem are not likely to appear until an effort to solve them has been made. It is not unlikely that many aspects of the design problem never emerge. The process often starts with a primary generator, which refers to some ideas about the solution to the design problem at hand. Central ideas are then used to structure the proposed solution and considerations around. Furthermore, design concerns the future since it is about planning a change from the current situation to a future situation (Lundequist 1995).

The PGS task to develop a building system can be understood as a design problem as Lawson describes. At the time when the work started, there were many things about the future building system that were not known, and could not be known. More knowledge about it could only be gained by starting to develop it. In the PGS case, there were different views about the primary generator, i.e. whether the team was to base their work on SBE’s products or not. This made the start of the work “open”, since there was nothing to structure the ideas which the core team members had around. Instead the ideas, which were documented during the brain storming session, were used as a basis for starting the work.

Design problems are generated by many individuals, groups and factors such as clients, designers themselves, laws and regulations, all with varying degrees of involvement or influence on the decision process (Lawson 1997). Different designers perceive design problems differently and have different ideas of how to solve them. The understanding of the problems and the information needed to solve them
depends to some extent on designers’ ideas about how to solve them. Professional background and knowledge may play an important role for the understanding of the design problem.

The aim in composing the PGS core team the way in which it was done was to allow benefiting from a variety of views and experiences existing in the organisation. The core team members in several cases, emphasised that their views of the PGS project and its task reflected their personal experiences gained through a carrier in the construction sector and/or elsewhere as well as their own knowledge about how things are done in the own organisation and how they thought performance should be improved. Altogether, this resulted in many aspects which were considered as important for the PGS project. This became clear as the core team started its work and brainstormed about issues to deal with as part of the project work. These issues included product features, how to improve processes as well as collaboration with other actors in the building process. It was not considered possible to rank the importance of perceived problems or relevance of solutions as they were presented when the work started. Instead it was considered important to point out as many aspects as possible in the beginning. Prioritising took place during the course of the process as the knowledge of the problem increased, and was incorporated in the working themes.

Three working themes were defined by the project manager and the consultants, based on the outcome of the brainstorming session:

- To allow for meeting market requirements in the future product, the first theme focused on market related questions.

- The need to improve performance during the design phase of the building process, which was perceived as a great issue by several members, called for a second theme focused on this issue.

- Finally, the third theme was suggested by the external consultants and reflected their view of how to improve performance. This theme focused on waste, i.e. anything that does not add customer value to allow for reducing production costs throughout the building process. The concept of waste was collected from the production philosophy called lean production with an origin in the Japanese car manufacturing industry. Waste was suggested to be measured and analysed as a way to define how lead times in production could be reduced.
Furthermore, already during the first meeting, the consultants introduced Porter’s value chain. The consultants suggested the value chain as an analysis tool for production costs. It was described to be useful to learn more about such issues as the trade-off between standardisation and flexibility in product design and the trade-off between off-site and on-site fabrication. The adapted Porter value chain was one of the models which was used to represent the cost aspect of a building system.

The project manager and the consultants divided the PGS core team into three groups that were assigned to work with each of the themes. The group members working with each of the themes were appointed according to how they perceived individuals’ expertise, experiences, and interests could contribute with valuable input to the different themes.

The starting point used by the three sub-groups when they worked according to the themes, was their own experiences and facts collected from other parts of the organisation. This was used to dig deeper and identify perceived core problems to be dealt with. By collecting views and facts from colleagues and external sources such as literature and combining them with their own views and experiences, the groups developed a better understanding of issues related to their respective themes. The form for the work was discussions during meetings and doing “homework” in between meetings.

Lawson further says that creating knowledge in the context of design is an iteration between problem setting and problem solving. This occurs as a result of the nature of design problems. It involves finding as well as solving problems, and problems and solutions are seen to emerge together. This is described as problem setting and problem solving, where means and ends are defined iteratively through testing ideas and alternative solutions by using models. Based on the outcome of tests and analyses, new problems can be formulated and thus new alternative solutions can be tested and so the process continues.

Work done by the PGS core team according to the themes was an iterative problem-setting and problem-solving process, as will be described below. By adding

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6 Porter’s value chain is a tool for examining activities a firm carries out and how they interact in order to analyse the sources of competitive advantage (Porter 2004). The value chain is made up of value activities and margin. The value activities are carried out by the firm while creating products. Margin is the difference between total cost for conducting the activities and the total value. The way in which the activities are performed and their economics reveal if the firm has low or high costs compared to its competitors. The way in which the activities are performed also sets the firm’s role in meeting different customer needs, i.e. differentiation.
knowledge to what was already known, new questions emerged and steered the search for more information. In this way, the team gained new knowledge about the issues related to the working themes. The iterative problem setting and problem solving was facilitated by that the team had a common language and that members had a common knowledge base to start from. This common knowledge base included knowledge related to construction work in general and the specifics of Peab’s and SBE’s organisations. The team also had the ability to combine individuals’ skills which facilitated knowledge creation.

During phase 1, the work did not involve suggesting physical solutions for the future building system or concrete solutions for the corresponding production and assembly process. The nature of the suggested solutions to emerging problems was instead more information or facts that could be added to what was already known. In this way, the teams created a better understanding of issues related to the respective themes. Team members’ own experiences and beliefs about the reasons for shortcomings in current ways of working as well as information in literature played an important role as input to the analysis work during the entire phase 1. The results were presented in written reports, Powerpoint presentations and a cost analysis model, based on Porter’s value chain.

During the course of the work, experiences and facts were discussed, both in the subgroups and in the whole group, which revealed new aspects of the issues related to the working themes. For example, the sub-group dealing with waste found it difficult to discuss in the beginning, since the individuals had different perspectives depending on their position in daily work. The difference between perspectives presented by core team members representing Peab and SBE was perceived to be most evident. SBE core team members found that a main reason for waste was lack of coordination among actors during the design phases, while Peab core team members mentioned mistakes in prefabricated building elements as important. By using various simple supporting tools such as drawings, the process was said to be useful for creating a common understanding of the issue. Over time, the sub-group members said that they were able to communicate among themselves about waste much better. Interviews with colleges outside the PGS core team and literature reviews also contributed to increased understanding of the issue.

The sub-group that initially worked with market related questions started focusing on adapting Porter’s value chain to allow for analysing production costs for housing production. Developing this tool involved creating a common understanding of the various parts making up the total production costs for a building project. For a start, there were vivid discussions among all the core team members since everyone had a
different view of how to distribute such items as materials and labour costs among different parts of the building and different phases of the process. An entire afternoon during one of the monthly meetings was spent discussing how to categorise construction costs. Some of the core team members got very engaged in the discussion, while others found it frustrating that this issue would fill a full afternoon. After many rounds of discussion, taking place over a few months concurrently with the work of developing the tool, the core team could agree on the design of the tool. Practical factors such as availability of input data as well as the discussions contributed to the agreement.

The core team did not only gain better understanding about the problem they worked with, they also gained a better understanding about their own working conditions. This included that available resources were found to set limits to what the PGS core team could address. Early during the process, the team perceived that the initial broad scope of the PGS work and the time available for conducting it were not compatible. All along the process, the team members found it difficult to make time available for the PGS work between meetings, which affected the pace of the work progression. This became evident, for example, when there were not enough resources available for collecting relevant information from an ongoing building project.

The problem setting and problem solving process included that the PGS core team needed to interact with Peab’s and SBE’s organisations. Early during the process, this mainly concerned getting information on various things, such as market data and data on building costs. While discovering what information the team needed, it also became evident that there was no clear counterpart in the organisation that could provide the core team with the information it needed to progress in its work. The organisation was able to deny the core team access to information and building projects, which formed the problem solving and problem setting process. This is further described under section 4.1.4.

The work also contributed to an understanding of their task as big and complex, in particular in relation to available resources. The work with searching for more information and gaining a better understanding of certain issues was at times found to be frustrating by the team members. During the first phase, many of the PGS team members felt that they could not grasp the problem they dealt with properly. They described the task as huge and complex. Therefore it was perceived as difficult to see whether their work was leading to the target or not. Difficulties to interact with Peab’s organisation also caused frustration, since it made it difficult to continue work as planned.
During breaks I chatted with core team members about this frustration. Some of them told me that they thought the work was progressing too slowly. They found the analyses lengthy and wished to produce concrete results instead. A site manager told me that he thought that they should have started with drawings of an existing building system from the start as a basis for developing an improved system. Others said that they thought it necessary to go through this to create a common understanding of where to head with the project.

Themes, tasks and meeting structure were questioned frequently during and between meetings. There were moments of frustration and even despair at times, even though the team members expressed that they considered the work far too important to give up. Many said that they found the scope of the work too broad and that focus was fuzzy. All along, there was an open dialogue about the confusion and insecurity about the work and its value and progress. Project management tried to pick up the team members’ views on this and made efforts to improve the situation by focusing the themes and reorganising the team. Through discussions with top management, the project manager and some of the team members tried to establish a PGS-market group, which could work as a PGS client and contribute to focus the work and provide the core team with information. As a result of this work, such a group was established by the end of phase 2, in March 2004.

The emerging result from the first phase was described by the core team as an analysis of the current situation pointing in the direction of continued work. The main results included an analysis of current shortcomings in the design process, an analysis of main reasons for waste throughout the process and an adapted model of Porter's value chain to be used as an analysis tool. In addition to the value chain model, work was represented in written reports and drawings of building systems. The experiences from the first phase of the PGS work also concerned the PGS core team’s conditions for conducting its work.

At the end of phase 1, a first meeting with top management and the whole PGS core team was held. The purpose of the meeting was to present results up to date and discuss the continuation of the work. It was a two days meeting, held in a conference centre located in a nice environment on the country side, a few kilometres from the new factory in Katrineholm. I watched the somewhat nervous rehearsing of the presentations during the first day. The second day started with a visit to the factory in Katrineholm. Both the PGS core team and top management went there together to see the factory, which was about to start production at that time. During the afternoon, the PGS core team presented its results and suggestions for continuation of the PGS work. Top management agreed on many of the points for improvement
presented by the team, and pointed to areas for action especially concerning marketing and the improvement of the design process. Top managers also trusted the group to continue with the work, but emphasised that tangible results were necessary. One of the top managers stressed that since organisation change is a heavy process, tangible results is a must for the process to progress. Others agreed and a demand for a complete affordable house concept was expressed.

Quick results were another point that top management stressed. Tangible results must be presented very soon according to another top manager, otherwise it may be difficult to win market shares and in the longer run this will endanger jobs. During the dinner in the evening, yet another top manager tried to reduce the originally planned time for the project in order to see results sooner. The PGS project manager was determined not to accept this and no agreements on this were made.

**Phase 2**

Core team members’ frustration over the scope of the PGS work and top management’s feedback made the project manager and the team focus hard on finding ways to reach the organisation. Based on what had been done during phase one and a determination to get closer to the target organisation, three new working themes were defined. Their own experiences from the first part of the task and feedback from management pointed to that work had to be more specific and produce tangible results in order to make sure that the target is met. As during the previous time, the project manager and the external consultants suggested the working themes. Based on more knowledge than the previous time, the themes were defined to deal with:

- the structural design of the system to be developed;
- purchasing and logistics and
- work organisation.

A number of sub themes to be dealt with under each of the main themes were also suggested. These aspects had turned out to be important according to the conducted analyses, discussions and brainstorming sessions during phase 1. Examples of sub themes were the trade off between prefabrication and site production, and standards. Parallel to these themes, studies on waste and the development of the value chain as an analysis tool were decided to be followed up by a few individuals who were able to allocate a larger share of their time to the project.

Furthermore, the sub groups were reorganised. Some of the original members became associates in a reference group, and their role was to give the PGS core team feedback on a regular basis.
Work according to the new themes was conducted in a similar way as before, but
with some more input from external contacts. These included learning how to
measure waste through a short course at one of the Swedish technical universities,
Chalmers. Furthermore, another external consultant with long practical experience
from the construction industry was contracted to advise and support the team. As
previously, new knowledge was added to existing knowledge. Work under the new
themes was perceived by the team members to be more tangible, even though there
were some thoughts on the approach and scope of the work. Some found that the
work was still aiming for too much in relation to available resources. Others found
that it would be useful if the group could produce tangible results that could be of use
for daily work. A housing developer said on several occasions that he thought that it
would be good if PGS could produce some small tangible results that the members of
the organisation could make use of in their daily work right away. In this way, they
would be able to better understand what PGS was aiming for. He thought that these
tangible results could be produced as outcomes of the work on the way to the target.

In a similar way as during phase 1, the core team used already gained knowledge as a
basis for searching for more. The different groups also worked to define interfaces
between their respective tasks. During the course of the process, the common
understanding of the problem evolved and the discussions got more focused, even
though many PGS core team members still perceived that the project was aiming for
too much. Based on gained knowledge about the design of the structural system itself
as well as the PGS core team’s available resources, it was clearly expressed during
phase 2, that the scope of the PGS work was the structural parts and the roof, even
though there was a demand for a complete house in Peab’s organisation. As the
scope of the work became clearer, the interfaces with other parts of the organisation
become evident, both regarding needed input and also for reception of the results.

Already during phase 1, it became clear that there was no obvious customer for the
PGS work, i.e. no entity or person in the organisation who could set requirements
and take care of and make use of the results. There was a demand for a complete
concept for affordable housing in Peab's organisation as expressed by management,
but the PGS core team, defined the scope of its work to include only the structural
parts and the roof, based on knowledge they had gained. Therefore a counterpart
who could define the rest of the concept and take care of marketing of the concept
was perceived to be needed. The lack of such a counterpart was brought to
discussion with top management on several occasions, and just before the end of
phase 2, a group was appointed to take on the task.
A few of the PGS core team members, who were able to spend a significant part of their time on the development work, continued the work with the value chain and waste studies. To be able to conduct production cost analyses and waste studies, interaction with Peab’s and SBE’s organisations was necessary. A few of the core team members spent most of their PGS time on work making cost and waste analyses on a few ongoing building projects. Through this work it became evident to the PGS core team that it had limited opportunities to influence what kind of analyses and new ways of working could be introduced to contracts managers and their teams. The team also learned that it had to accept that contracts managers were not always willing to share information about their projects with others. These issues and how they affected the PGS work is further described under 4.1.4.

The outcome of the work in phase 2 was still considered by the team to have the character of analysis work. The team members claimed, as they did before the PGS work started, that good examples where the PGS ideas are proved to work were needed to persuade others in the organisation to follow. However, to be able to produce these good examples, the group mentioned on several occasions that there was a great need for identifying contracts managers who were willing to work with the PGS team so that the core team’s ideas could be tried out in real projects. The issue of getting access to the rest of the organisation did not only concern access to building projects, but also to the central units working with purchasing and personnel which two of the sub-groups worked with. The team perceived that it needed a closer relation to other parts of the organisation to be able to pursue its work. Working themes for phase 3 were formulated based on this, together with knowledge on the design problem and available resources.

The results achieved by the sub group dealing with logistics and purchasing included suggestions on strategies and areas for further investigation on these issues. Since this was the area of expertise of some sub group members, their experiences and knowledge about how logistics and purchasing works today combined with their ideas on possible improvements influenced their search for alternative strategies.

The second theme concerned the work organisation. The sub group decided to deal mainly with the work organisation at the construction site. This area of interest emerged as a result of group members' increased knowledge about the shortcomings of the current work organisation concerning ability to learn from one project to another and also as a result of studies on waste on the construction site. The group produced a suggestion for a new work organisation by the end of phase 2.
Finally, the third theme concerned the structural system itself. Some of the SBE representatives had begun to think that the PGS work was more a Peab project than a common project, since the focus was not on including SBE’s current products in the work initially. For this reason and since some PGS members thought that SBE’s products were predefined, a market scanning was conducted. This scanning meant that SBE’s current systems were evaluated against other systems in the market. In this way, it was believed that the best possible system could be selected as a basis for future development. The outcome of the evaluation pointed to refinement of a traditional fully prefabricated concrete system supplied by SBE for the near future. This made the work on developing a building system more tangible for the core team. It also became a way to get access to real building projects, as will be described under section 4.1.5. The choice of refining SBE's fully prefabricated system (described under section 4.1.3) mirrored the views of several of Peab’s PGS members, and also some of SBE's representatives in the PGS core team. The development and choice of a common system is described in more detail under section 4.1.3.

By the end of phase 2, a second meeting with part of top management and middle managers was held. This time the meeting was held in Peab’s office in Sollentuna during an afternoon. At this meeting it was announced by top management and the PGS project manager that the PGS project should be organised differently to reach the organisation more efficiently. The PGS project manager had, all along the process, communicated with top management and emphasised the need for more pilot projects and contacts with various functions in the organisation in order to allow for development, based on the experiences made by the PGS core team. The new organisation of the PGS core team which one of the top managers presented, was partly a response to this wish. The new organisation of the PGS project included the current project manager being replaced with a full time resource and two part time assistants. Furthermore, it was suggested that closer collaboration with a group of contracts managers should be established and the PGS subgroups should establish close collaboration with certain departments within the organisation. The new organisation was planned to be launched after the summer of 2004.

Phase 3
As during the previous phases, the working themes were suggested by the project manager and the external consultants. Again they used gained experiences as a base for formulating the themes. This time it was decided to appoint counterparts in the Peab group organisation, to allow for reaching the organisation better.

-The first theme formulated concerned logistics and purchasing including defining suitable suppliers to develop longer-term relations with. Counterparts in the Peab
group organisation, the IT and purchasing departments, were appointed to work with the sub-group.

-The second theme concerned work organisation, routines and roles. Counterparts to the group dealing with this theme were defined as contracts managers, site managers the central personnel division and the union.

-Finally, the third theme concerned the building system itself. The PGS sub-group defined Peab’s production support division and an external engineering design firm as counterparts in this work.

Based on feedback from top management and others in the organisation as well as the PGS core team members’ own views, the priority of the themes was set as 1: the building system, 2: purchasing and logistics and 3: work organisation.

During phase 3, a new person representing the personnel division joined the core team to create the desired connection between this division and the PGS project. Furthermore, an architect contracted as a consultant joined the group to contribute with his competence.

In June 2004, the PGS project passed an important milestone, i.e. change of project managers. The first project manager was some months earlier appointed production support manager and was therefore no longer able to spend full time on the PGS project. At first there was some insecurity about what this meant for the survival of the PGS project among the core team members. Soon however, a new full time project manager to manage the PGS project to the end in 2007 was appointed. The new project manager was recruited internally and had a long experience from the construction industry, both with Peab and other companies, as a craftsman and recently as a site manager with Peab. Additionally he had a university degree in business administration and used to teach contract law to civil engineering students at one of the Swedish technical universities. During the summer and half way through the autumn, the old and the new project managers worked together.

The study covers seven months of the phase-3 work, i.e., the period from April 2004 to October 2004 and work in this phase was still ongoing as the study ended. Work during this period involved more analytical work for all three themes. The sub groups continued as previously with their work. Some efforts were made to connect with the appointed counter parts, but during the time of the study there was no specific progress reported concerning this work, except for some collaboration with the newly established market group, which was a PGS counter part. Already during phase 2, this
counterpart to the PGS core team was appointed. The PGS core team was able to ask top management and the rest of the organisation to put together a so-called market group. The market group included representatives from each of Peab’s divisions. They had the task to each present a building project, which they perceived successful, and to which the PGS structural system could be applied through some further development work.

A lot of effort was spent on analysing suggested type houses or concept houses supplied by the newly established market group. It was found that these included some parts that could be considered for the PGS concept, but it was also considered that the PGS team should develop a system without being limited by the suggested concept houses. Connected to this work, the architect worked on developing the PGS manual which was to include feasible design solutions.

The PGS work during phase 3 was considered by the core team members to be correctly prioritised, but it was still considered difficult to find time to do the PGS work. The team wished for some members who could spend 100% of their time on the project to allow for work to progress. It was also considered desirable to see to it that the project would be tightly connected to decision makers in the organisation. The current position was considered to be too far from decision making and therefore, as in phase 1 and 2, a lot of effort had to be spent on making the organisation accept PGS and its work before any work could be done at all. By the last month of the study, the core team came up with the idea of trying to establish what they called full-scale laboratories. In this way, they would not have to ask some contracts manager about trying out their ideas in a real building project. This would allow the PGS core team to decide which of their ideas to test. The idea was still under discussion as this study ended.

Here, in October 2004, the study of the PGS project ends. An epilogue describes shortly the status of the PGS project in April 2006. The rest of this chapter deals with some parts of the process, which have been mentioned above, in more detail.

4.1.2 Competing interests
As the PGS core team started its work there were different interpretations among the group members regarding the extent to which they were constrained by the products produced by SBE. Some thought the PGS work would imply developing a system based on SBE’s current products, while others, among those the project manager, thought it necessary to search beyond the solutions supplied by SBE currently, to develop something new that could be supplied by SBE in the future. Thus, the starting point for the work in the PGS core team included different interpretations,
which were subject for discussions at several occasions during the course of the work. This disagreement became a contributing reason for the process to almost diverge onto two different tracks. It worked as a barrier to develop the common system concept in terms of causing confusion about the work and frustration.

Even though Peab and SBE belong to the same company group, there was a perception among the core team members, already before the start of the PGS work, that the two had different expectations related to the project and many had views about the new factory in Katrineholm and its products. Several interviewees from Peab pointed out that since the products to be produced in the new factory in Katrineholm, floor slabs, solid slabs and double walls, are not novel and can be bought from other suppliers it is important to take a holistic view in the PGS work and not only concentrate on those specific elements. Furthermore, the thought of a building system suitable for rational production was not new to Peab and there had been earlier attempts to develop such a system. Perceptions about different interests and earlier experiences were expressed as:

'...we see how they perhaps are more for manufacturing certain parts, while we wished a complete structural system for example. Maybe a complete house in the end.' (Contracts Manager, Peab)

'Of course, that was not anything revolutionary for our in situ concrete product and I can buy floor slabs around here if I want to. So that is nothing novel. I think it is very important to see that there is no need for a factory that supplies floor slabs, but one that has the overall view of the structural system.' (Manager at the regional level, Peab)

'If the factory cannot meet the demands of the “construction” side, “the construction side” will not buy. That’s how it is. I think it’s necessary to develop a system that is as complete as possible.' (Design coordinator, Peab)

'I think it is important that you don’t set your mind on a certain solution since there are several different types of building elements. One type is good in one case, in the next case another type is good, and in the third case perhaps you should cast something in situ. So it’s about finding the optimal solution without blindly focusing on selling floor slabs and certain types of squares; instead you must make sure it is used in the right way, since there are different interest. Skandinaviska Byggeelement wants to sell building elements. We must focus on the final product and not on selling this or that.' (Purchaser, Peab)

The respondents from SBE expressed awareness of Peab being aware of the products from the Katrineholm factory to be too limited since they wished for a supplier of a complete structural system. However, they all mentioned the holistic view of the
structural system as important and considered the approach of the PGS project and the future final outcome to be the same for Peab and SBE.

'The factory in Katrineholm is focused on certain products, but the project as a whole has a different approach. That's why this project is so interesting for Peab, that we now take a holistic common view in the company group and make use of the best possibilities.' (Technical Manager, SBE)

'People from the construction side think that what we can produce seems very limited. The factory in Katrineholm is designed for rational production of floor slabs, double walls and solid walls. (...) It is going to be difficult to have a complete structural system at once. We must develop a structural system within the company group that we know is effective and that people can use correctly. And then we have the partitions. They want to include as much as possible in the structural system, but partitions will come gradually. When we have learnt how to do the structural parts we can perhaps start adding other parts. The holistic view of what this will be in the end is the same, but we know that we can't provide everything at once. It is a development process of several years to develop a structural system that is as complete as possible.' (Managing Director, SBE)

'We will develop a common concept within the Peab group.' (Technical manager, SBE)

Peab and SBE usually cooperate in building projects on a single project basis rather than long-term basis even though they are different business units in the same company group. Even though they have a formal connection outside the contracts of particular building projects in terms of belonging to the same company group, they are different business units with responsibility for their respective profits. Neither their belonging to the same company group or the contracts applied in most building projects automatically allowed them to share profits from applying products produced by SBE in common building projects at that point in time. Therefore it seemed to Peab that there was more of an upside for SBE than for themselves in the PGS effort. Some of the interviewees even expressed an anxiety that Peab would be forced to apply products it would not approve of.

4.1.3 Diverging or converging concepts?

Some members thought that it was pretty clear that management meant for PGS to focus on SBE’s current products, while others, among them the project manager, thought that the PGS work should focus on something new that may well be found outside the organisation. He argued that while systems supplied by SBE currently are useful for allowing for volume production today, the concept to be developed by the PGS core team may be found outside the Peab group. In the longer run, SBE may be able to supply such a system.
These different views resulted in a period of the process during phase 1 and 2, when it seemed as if the project would diverge onto two tracks. One was the analysis oriented PGS track which aimed at not necessarily including SBE’s products. This track was considered by some SBE core team member representatives to be mainly Peab oriented. The other track was practically oriented and concerned SBE and Peab working together in real building projects, where SBE and Peab together could learn from experiences. This track was connected to PGS through the waste and cost studies.

Already during phase 1, parallel to the work in the PGS core team, SBE developed two structural systems which could be supplied by its factories. This pace of development was considered necessary since SBE’s factories were ready for production. Products had to be defined and supplied to the market to keep the plants busy in order to make money, even though the PGS work did not focus on SBE’s products specifically at this point. It was not possible for SBE to wait for PGS to make up its mind, as one of the SBE core team representatives pointed out. The same individuals that were involved in SBE’s own product development work were also involved in the PGS work, so some ideas could be transferred. The two systems defined at that time were:

◊ A fully prefabricated structural system constituting massive concrete elements. Services could be included if desired. This system could be supplied by SBE's factory in Uppsala alone or together with the factory in Katrineholm which could manufacture solid inner walls.

◊ A semi prefabricated structural system constituting floor slabs and double walls. This one could be manufactured by the Katrineholm factory alone or together with the factory in Uppsala and the factory in Kalmar.

These systems were presented to the PGS core team as suggested inputs to the work during phase 1. The nature of the work in the PGS core team and the disagreement about how to deal with SBE’s current products in the PGS work at that point resulted in the core team not directly addressing further development of the two systems presented during phase 1. The nature of the work implied that it was not focused on a specific building system at that point, rather it was focused on analysing the current situation to create a better understanding of the requirements of a future system. As mentioned earlier in this chapter, this worked as a barrier initially for the PGS core team to develop the common system concept since it caused confusion about the team's task. This issue was subject for discussions several times in the group.
Since SBE needed to keep their factories going in order to earn money, the two systems were put into business as soon as the factories in Uppsala and Katrineholm were ready to produce them. They were sold to Peab for multi family housing projects at different locations in Sweden and also for a hospital project during the first one and a half years of the PGS project. While the work in the PGS core team did not directly address development of these systems initially, individual PGS members from Peab and SBE played an important part in making some of these common projects available for the core team to study.

To become more concrete in the search for a future building system and come to an agreement about what system to opt for and develop further in the PGS core team, an evaluation exercise was conducted during phase 2. This was an attempt to overcome the barrier implied by the different views and confusion regarding the type of system to go for. Different structural systems available on the market were evaluated against a set of criteria defined by the whole PGS core team, to decide on the one that would suit the PGS purposes best. This implied that the two systems supplied by SBE were evaluated against those of competitors, in order to allow for selecting the most feasible system as the future PGS-system. This exercise caused further confusion among some of the PGS members regarding whether SBE and its products were predetermined or not. Some of the PGS core team members representing SBE thought that the project had developed into a Peab-oriented development project, rather than a common interest effort. Others found it a useful exercise to show management that the PGS core team was not there to confirm management's decisions about producing certain products in the new factory.

By the end of phase 2, the sub-group that worked with the evaluation presented their results. The system that got the best score in the evaluation among a number of systems available on the market was SBE's massive wall and floor slab system. This system was to be further refined during the third phase of the project. Thus, by the end of phase 2, i.e. spring of 2004, the PGS core team had come to an agreement on the type of building system considered suitable for achieving desired cost reductions. This solution included meeting perceived top management expectations to a certain extent, since it involved SBE’s current products, but also what the core team thought would be a feasible solution.

This outcome mirrored the view of some of the PGS members who found semi-prefabricated products inefficient and it also promoted the concept that the Uppsala factory could supply, rather than the one supplied by the factory in Katrineholm. Despite earlier discussions, the outcome did not seem to give any great surprises to the group, since many thought that SBE and its products were the predetermined
choice, even though some group members had hoped for something more radical for the future. PGS was thus not able to change the organisation’s path of development.

4.1.4 Difficulties to interact with the target organisation

Discussions and actions that were observed at PGS meetings showed that the PGS core team perceived that it was dependent on input from the organisation for the progress of its work and that it also had a limited ability to reach the target organisation to exchange information and to establish collaboration. Thus, the ongoing PGS work revealed barriers to interact with Peab and SBE. As part of the work to collect information about the current situation for analysis purposes during phase 1 as well as 2, it was desirable to get access to various kinds of information from the rest of the organisation. This proved worthwhile doing but also implied some difficulties which concerned getting access to certain kinds of information, both for practical and attitudinal reasons.

The difficulties to interact with Peab’s and SBE’s organisations became evident as the PGS core team needed to collect information for its work with cost and waste analyses. It became obvious that there were no established ways to make contact and begin collaboration with different parts of Peab’s and SBE’s organisations. The PGS core team members therefore had to establish such contacts through their own personal contacts as well as making contact with people they did not know to ask for information and establish a basis for collaboration. The team contacted contracts managers who were in charge of projects, which were considered interesting to analyse. However, the team learned that it had to accept contracts managers denying them information and/or access to building projects, since the organisational structure in terms of decision authority entitled them to do so. Furthermore, there was no habit within the organisation to share certain kinds of information with others, which made information gathering even more difficult.

Both the information that the team actually got access to, and the information that was not accessible contributed to the core team’s knowledge about the PGS design problem. For example, the group dealing with waste in the building process during phase 1, found that their initial approach to analyse waste in the current process, which was based on their own estimates and interviews with site managers and team leaders led to approximate figures which were not reliable enough to serve as a basis for action. To gain more knowledge, the team realised that resources had to be spent on learning methods for this purpose. The team also learned that access to building projects was needed.
Another example concerned cost analysis work using the analysis tool, adapted based on Porter’s value chain. Two reference projects were selected to develop and try out the tool. However, it proved difficult to get access to all necessary information due to how the accounting system was designed as well as due to what kind of information contracts managers were willing to share. The team learned that they had to find ways to get legal access to projects to be able to collect desired information.

The information that was difficult to get hold of included data on costs for finished projects on the format and level of detail that was desired. It was also difficult to get access to ongoing projects for the purpose of studying non-value-adding activities (waste) on the construction site. Practical reasons for these obstacles included the format and level of detail of the information available from the accounting system on costs, while attitudinal reasons included contracts managers’ and site managers’ reluctance to give away information as well as the trade union’s unwillingness to allow studies of the craftsmen’s work. The trade union was reluctant to allow such studies but accepted after a few rounds of discussions, while SBE accepted studies of the work of their assembly team.

This opened up discussions within the PGS core team on ways of thinking in the construction industry in general and in their own organisation when it comes to sharing information with others and routines for following up projects. The unwillingness to share information was explained by a fear of showing failures and a prevailing mentality that everyone has to learn from their own mistakes. It was concluded that for the continuation of the PGS work it was important to get around these issues and get access to necessary data. However, it was considered important that this was done in a sensible way in order not to risk getting into a locked position where the PGS project would be denied any further information.

It was also perceived difficult to spread information about the PGS work to the rest of the organisation as pointed out during several PGS meetings. Despite written information on the intranet, in the internal paper, etc as well as information meetings and personal chats, the PGS ideas did not seem to be fully understood by the organisation and did not involve people in dialogues with the group. All along the PGS process, the project manager worked to spread information about PGS in the organisation to make people interested and reduce fear for a change that may lead to lost jobs. Another purpose with meeting people at the construction sites was said to be to capture any valuable ideas they may have as input to the work. The PGS members also had information material and were encouraged to spread information about the project. Despite their efforts to communicate the message, the PGS core team perceived that it was difficult to reach out with the information. Even though
meetings and internal papers were used along with personal contacts, it was perceived that the general understanding in the organisation about PGS was that PGS and the new factory in Katrineholm were the same thing. Therefore, it was perceived that there was no way they were going to make all 10,000 Peab group employees enthusiastic about the PGS work. If they could manage to reach just a few, a lot would be won.

Furthermore, as the work had progressed, discussions during the PGS meetings showed that it became obvious to the PGS core team that there was no obvious receiver of its work in the organisation, which made spreading of results difficult. Instead the work produced within the project had many different receivers in various places in the organisation. It was found difficult to get the relevant receivers to take over and further develop some of the results in their daily work. One example concerned the suggestion for new work organisations produced by one PGS sub group by the end of phase 2, which was handed over to the personnel function. The personnel staff accepted the documents, but there were no clear idea of how they should deal with it. The PGS sub group therefore had to continue to “translate” its suggestion to relevant individuals to establish a dialogue on the issue. However, a core team member pointed out that the staff at the personnel department was polite, but it seemed as if they were not really interested.

Some parts of the work, dealt with by the PGS core team during phase 1, were considered appropriate to conduct as their own projects through Peab’s production support division. This concerned, for example, work with developing methods and standard solutions for Peab’s design process since related work was ongoing there. These ideas were possible to transfer to the target organisation since the project manager had become manager of Peab’s production support division.

Reason for the difficulties in exchanging information with the target organisation in this case were found to be that this was an unusual way to create new knowledge in the organisation. According to PGS core team members as well as non-core team members, when new ways of working are developed or new methods are tried out it usually occurs within the context of a building project. It was explained by PGS core team members as well as non-core team members that in the daily work, people deal first with all the urgent things that need to be taken care of and if by chance there was time left, perhaps they would look into improved ways of working suggested by others. However, if it is not obvious that something can help to improve work immediately, it is unlikely that people will spend time on learning more about it or further develop it. A reason is that some people in the organisation kept a distance from the PGS project and seemed reluctant to get involved in a dialogue with the
core team, was mentioned by a team leader, who was a member of the PGS core team. He pointed out that among some there is a fear of what this project may do to their jobs. Therefore, they preferred to stay away.

As described earlier, the knowledge created by the PGS core team was presented in written reports and spoken information, which needed to be processed or translated to actions to be used and stored in the organisation. In line with the notions of Helleloid and Simonin (1994), the new knowledge presented by the PGS project, was in a format that the organisation was not used to receive and transform into action or further develop. Neither did it occur in the context of a building project or as a response to a perceived urgent need to change ways of working, which was the established way to create new knowledge. Instead it was various suggestions which affected daily work, initiated outside the specific contracts manager or project context. The suggestions also affected sharing of information, which normally was only shared within the contracts manager’s group. The format as well as the implications of the PGS core team’s results was new to the organisation, which made it reluctant to make use of it and provide access to daily work.

Thus, the PGS project as a way to create change was in itself a change, since it was a new way to create change. There were no established ways for collaboration between such a project team and the rest of the organisation. Neither were there any conditions that triggered (i.e. no facilitator) a process which would allow the organisation to learn to create change in this way. No particular efforts at appropriate management levels were done to change the situation. Therefore, it was difficult to use knowledge created in the PGS project to create change in the target organisation. The PGS project became more or less isolated instead.

One effort though was made, which could be seen as a potential facilitator to create change based on the PGS work. For the purpose of providing the PGS core team with feedback on work and also to be a contact with Peab’s organisation in particular, a reference group was appointed. This group also existed beside the line organisation, as the PGS core team. It consisted of people representing Peab’s different divisions and dealt with questions related to such issues as housing policy and housing markets. However, during the two years of the study, findings from observations, interviews and informal chats showed that there was very little contact between the PGS core team and its reference group.

4.1.5 Finding ways to interact with the rest of the organisation
From the very start of the PGS project, the project manager asked the organisation to point out projects which could be interesting for the PGS core team to study and
learn from in their work with developing the common system concept. Peab had produced local concepts which were considered by these local units to be cost effective solutions that were worth developing further. The project manager’s thought was to involve Peab’s organisation in the PGS work and thereby benefit from some of the ideas behind these concepts. However, as mentioned earlier, the first efforts to study such projects proved to involve difficulties getting access to desired information for cost analysis purposes, both for practical and attitudinal reasons. The PGS core team learned from this experience and was determined to find a solution, but at the same time the team perceived that it had to make sure it acted in a way that did not put it in a position where it would be denied further access to new projects.

A solution appeared by the later part of phase 1, when SBE was ready to supply its two different structural systems for multi family housing to Peab as described under 4.1.3. The development of these systems was indirectly related to the PGS work since SBE’s representatives in the PGS core team were also involved in SBE’s internal development work. They were, in this way, able to incorporate the PGS core team’s views in their work. The systems reached the target, in this case Peab, through established ways, i.e. SBE’s project leaders selling to Peab’s contracts managers. These building project teams involved a few PGS core team members from SBE as well as Peab, which was the reason for PGS to get access to the projects at all.

Three projects, one in the Stockholm area and two in Skåne in the south of Sweden, were selected for conducting waste and cost analysis. These projects were appointed pilot projects and were made part of the PGS core team work. The PGS core team focused on preparing monitoring activities to collect necessary information to use as input for developing the specific future PGS concept, i.e. a further system developed based on SBE’s existing fully prefabricated system. The focus for the analyses that the PGS core team could conduct was connected to the methods and tools dealt with in the work during phase 1 and 2, i.e. waste-analyses and cost analyses according to the adapted version of Porter’s value chain. Furthermore, the external consultants introduced the Visible Planning (VP) method, developed by Toyota, to be used during the design stage. Experiences from using VP were documented by the PGS core team, as part of its work.

PGS thus found a way to interact with Peab’s and SBE’s organisations as a result of prevailing conditions. In a similar way as Mintzberg (2000) described that strategies can emerge as result of prevailing conditions without being planned, PGS found ways to interact with the organisation which were the result of prevailing conditions rather than plans. These conditions included the personal connections between the PGS
core team and the appointed pilot project teams, which were perceived to contribute to the opportunity to get access to the projects. Furthermore, these specific contracts managers had a positive attitude towards trying out something new and learning from it to be able to improve performance in the future. The contracts managers also shared the PGS core team’s view of how construction should be changed to become effective. Thus, personal contacts and shared interests and beliefs in PGS’s ideas for industrialisation facilitated change creation in a building project, as a result of knowledge created in the PGS project. However, the PGS core team had to adapt its ideas for change according to what the receiving organisation allowed. It also had to adapt its way of working to how the receiving organisation was used to conduct change.

Once PGS got access to the building project, change was created according to the established way. Individuals with different skills solved problems at hand together. It concerned establishing forms for collaboration, since there was no established ways to make use of collaboration and the situation was new to most involved individuals. The core team members also had to spend time on informing about the purpose of collecting information to establish trust between the PGS project and the people who were subject to its study. Time also had to be spent on teaching some people in the building project teams to use the analysis tools, such as the value chain.

Even though, it was perceived to be great progress to get access to these projects, the team learned from this experience that it was not able to influence what should be tried out in the building projects or how this should be done. Prevailing business conditions set the frames for what the contracts managers and their teams found feasible to change. PGS was only able to ask for permission to do things, and the contracts manager and his team were entitled to say yes or no, according to what they found feasible. For instance, PGS’s suggestion about a new way of organising work on site was not accepted.

The experiences made by the PGS core team concerning its opportunities to interact with other parts of the organisation, made the team question its own work organisation and position in the organisation. The PGS core team learned that it had to strengthen its position in terms of being able to interact with the rest of the organisation. It did so through the appointed pilot projects and through appointing counterparts in the organisation. However, experiences made through these connections as they worked out during phase 1 and 2, made the team realise that it still was too limited in its ability to influence daily work. At the beginning of phase 3, this issue was brought up for discussion again. It was perceived by the team that the project was positioned too far from where decisions were made, which limited the
project’s opportunities to interact with day to day business. Furthermore, the team’s ability to interact with day to day business was also considered limited by available resources. The experiences made the team come up with the idea of working with full-scale laboratories.

4.2 **Experiences from applying a fully prefabricated structural system**

4.2.1 A Peab perspective – a contracts manager’s group applying a new construction method

One of the building projects where Peab and SBE cooperated and that was appointed as a PGS pilot project was *Folkparken*, located in the Stockholm area. In this project, SBE’s fully prefabricated system was applied. The particular contracts manager group that managed this project had limited experience in building with fully prefabricated structural systems, but decided to try it in the housing project Folkparken in Haninge south of Stockholm. For a start, the decision about applying this system was made for the first 82 apartments of approximately 400 apartments to be built by Peab in the same area.

From the beginning, when the architect was developing the idea for all 400 apartments for the detailed land development plan, he explained that he had developed the conceptual design with a cast in situ structural system in mind since there were no discussions about going for a fully prefabricated system at that time. Later during the process, by the time the detail design phase was about to start, the decision about applying a fully prefabricated structural system had been taken by Peab’s contracts manager group. The decision was within the authority of the contracts manager to make, which thus was a facilitator. This decision influenced the design of the house as well as the detail design process, and action was taken to adapt to the new conditions.

As in many sites in metropolitan areas, the architect and the housing developer explained, this one provided challenges from a noise perspective since it was located adjacent to a railway. Furthermore, there was a water source on the site, which also provided challenges for developing a feasible housing project. From Peab’s point of view, the project was considered a typical example of the type of complicated conditions that have to be dealt with when developing housing in metropolitan areas. It was therefore desirable to create a solution for a house with certain parts that could be re-used in future projects and that also allowed for cost effective production. The contracts manager together with the project coordinator from his team and the housing developer therefore made changes to the idea that the architect already had
developed for the detailed land development plan, in order to come up with some reusable solutions that in their view would allow for feasible production costs. This took place about the time when the detailed land development plan gained legal force, and the project was to be handed over from Peab’s developer to the contracts manager and his group for detail design and construction.

Cost estimates for this project were said by the quantity surveyor to have been made according to current practice, based on a cast in situ solution where the costs for the structural parts were replaced with SBE’s estimate for a prefabricated structural system. As expected, the contracts manager and the quantity surveyor explained, it turned out to be more expensive than the usual option, which for this contracts manager’s group would be semi prefabricated floor slabs and cast in situ walls. Even though the cost estimates made did not show that the fully prefabricated structural system allowed for reduced production costs, the contracts manager and his team decided to go for it. In this case, there were two more facilitators in addition to control, as mentioned earlier, that facilitated the decision. First, there was a belief in the contracts manager group that through increased use of prefabricated systems, cost could be reduced in the long run. Second, since cost estimates showed that this alternative was more expensive than the usual option, an economic incentive in the form of a subsidy was received from the company group’s central budget to encourage the contracts manager and his team to go for a fully prefabricated system.

It was found that in many ways this project was conducted according to how projects normally are conducted in this and other contracts manager’s groups. In other words, the findings point to that embedded knowledge and action influenced how the new construction method with its new technology was applied. Even though the studied project team expressed an awareness that certain things should be done differently when applying a fully prefabricated structural system compared to applying a cast in situ system, they did not change their way of acting more than to a certain extent.

4.2.2 Peab’s deliberate non changes
Timing of the decision, i.e. when the detail design was about to start, to go for a fully prefabricated structural system instead of cast in situ was deliberate and so were the consequences. The housing developer, contracts manager as well as the project leader recognised that the decision to apply a fully prefabricated structural system in this case was taken at a late stage, and pointed out that the result would have been better if the decision had been taken earlier. Making the decision already during the conceptual design stage would have allowed for avoiding time shortages and changes in the design, they pointed out. The architect agreed by pointing out that his
approach to the conceptual design would have been different if he had known about the fully prefabricated system from the start.

Even though the late decision was pointed out as a barrier to fully benefit from the prefabricated structural system, some common reasons for making the decision later than what was generally considered feasible were pointed out. The project’s housing developer claimed that Peab’s staff working during the conceptual design stage generally had too limited knowledge about designing using a prefabricated structural system to be able to state this in the instructions to the architect. As a result, it is common that conceptual design drawings are made with a cast in situ system in mind, which was what happened in this case. To start developing a project idea with a cast in situ system in mind, and then at the time for the detail design stage change to a prefabricated structural system, was not unique for the Folkparken project and another reason for this was mentioned. Other contracts managers described that this occurs every now and then and it was said that it can happen because at a later stage something such as production costs or time shortage, indicates that a prefabricated system would be a more feasible solution for the particular case at hand.

Thus, there was a reason for the decision to be taken at a late stage. Deciding about the timing of certain decisions, sometimes by making them as late as possible, was described by Peab staff to be a way to handle uncertainties related to project costs and other unexpected events. This way of acting in individual building projects was possible since Peab has a decentralised decision structure. It is up to contracts managers and their site managers and teams to decide about such things as construction methods, which sub contractors and suppliers to use. They are also free to decide about the timing of such decisions. The change from a cast in situ system, to a prefabricated system was in itself a way to handle uncertainty about future costs. An earlier decision about applying the fully prefabricated system could thus have involved an increased risk in terms of being unable to compensate for later unexpected events. It could have prevented the normal way of handling uncertainties from functioning. Changing such ways of acting was outside the control of the individual building project, since there was no other way to handle uncertainties available.

4.2.3 Peab’s deliberate changes within its own area of authority

During the conceptual design stage, the project idea was developed by the architect based on the idea of applying a cast in situ system. The changes in the design of the house due to changing the type of structural system, which were not considered to be too radical in this particular case, affected, for example, shafts and floor plans and the architect had to make some efforts to make a working solution. Tendering
documents for service sub contractors had been made based on the cast in situ structural system initially, but the decision about applying the fully prefabricated structural system was made just in time for procurement of service subcontractors to be made based on a prefabricated system instead, as described by Peab’s project leader.

Work during the detail design stage had to be adapted to better suit the fully prefabricated structural system, the contracts manager and the project leader explained. Since Peab’s project team had limited experience in using a fully prefabricated structural system, the team had to create new working procedures to meet the new requirements. It was said by the project leader and the contracts manager that general knowledge on how to manage detail design using a prefabricated structural system and support from SBE’s project leader, who participated as a team member was used for this purpose. They said that they solved problems that occurred by using the skills of the individual team members and sometimes other colleagues were consulted, as in other projects. Thus, a common knowledge base was of importance for solving issues related to working with the new technology. Furthermore, all participants shared the same language, which also facilitated this.

Since prefabrication and cast in situ represent two different technologies, a different approach to coordination of design of the structural system and services had to be taken. Since SBE had taken on the task of coordinating design of the structural system, which was normally Peab’s task, the structural design consultants were SBE’s choice and SBE’s project leader coordinated contact with them and the rest of Peab’s design team. This is further described under 4.2.5. One important requirement, which was well known among the project team members, was that drawings had to be ready earlier than when cast in situ systems are applied, to allow for production of the building elements in the factory to start in due time. It was pointed out that a failure to do this would mean delays in assembly and in the end, a postponed finish date for the project. In this case it was decided to go for a structural system where services were included in the structural elements. It was therefore also necessary to finish design of services earlier than what is customary today when in situ concrete is used, in order to allow for manufacturing of the elements to start in time in the factory. Peab’s project team therefore adapted the time schedule for the detail design stage.

Another example concerned the working practice for the service designers, which Peab had to manage. When cast in situ is applied, the service designers were said to draw their solutions on other designers’ drawings and state all measures with figures printed on the drawings, without perfect match with the drawing’s scale. When the
prefabricated structural system was applied in this project, the service designers had to draw their solution in the proper scale to allow for the drawings to be correctly interpreted by the factory’s computer system. To deal with issues that differed from what most of the team members were used to and to allow for finishing in time, more meetings than normal were held and SBE’s project leader played an important role in contributing with knowledge on how to design the prefabricated structural system, Peab’s contracts manager described. Peab’s contracts manager, Peab’s project leader and SBE’s project leader claimed to have spent more time than normal on the detail design stage and that a lot of work had to be done in a very short time. Everyone on the design team was aware of the very tight time schedule and the service consultants were said to have worked hard to finish in time.

The differences from how an ordinary project is conducted during design were described by the team members to include the timing of activities and the number of meetings. Furthermore, the content of the design work also differed since the fully prefabricated system with services is a different technology to what the contracts manager’s group normally dealt with. For this case this meant coordinating design of various items such as structural parts and services in ways that are different to how it is done when cast in situ is applied.

Thus, a change at the physical/capital level, i.e., the structural system, was triggered by SBE’s desire to sell its products and one of Peab’s contracts manager team’s motivation to benefit from perceived advantages with this type of structural systems. The change at the physical/capital level in turn triggered changes to be made related to knowledge and action at the individual and system levels. The contracts manager was authorised to decide about all of the changes made concerning timing, number of meetings and management of coordination of work among the actors which Peab had contracted. None of these changes affected knowledge and action outside the control of the team. The changes were done according to the established way, i.e. by combining people with different skills to handle the specific issues related to the individual project. Their common knowledge base and common language contributed to facilitating combination of their individual skills. The contracts manager and his team decided by themselves that these particular changes were feasible to do in order to be able to manage the new technology.

While the team knew that some more changes would have been feasible to make, it was outside its control to conduct them. This concerned making the decision about the structural system at an earlier stage than what was done in this case. Timing of decisions and choice of methods, suppliers etc is the individual contracts manager team’s way of performing its skills and handling uncertainties. Changing from the
team’s normal option for structural system to a fully prefabricated one, was made because it was perceived to imply potential benefits in terms of reusable solutions and lower production costs in the long run. The long term advantages were perceived to exceed the short term disadvantages caused by the late timing of the decision. The timing of the decision was in accordance with the team’s established way of working which includes that decisions and changes can be made at a late stage if it is considered necessary. Changing such way of acting most likely requires changes that are outside the control of the individual building project. Such changes did not occur in this particular case. To allow for the team to concentrate on developing skills in using a new type of structural system and benefit from it, conditions that trigger this are needed. Such conditions may include for instance decreased demands on profits during a learning period or incentives to develop relationships with other actors and must be initiated by management levels above the contracts manager.

The changes made were therefore temporary adaptations of working procedures, aimed at making the new technology manageable given embedded knowledge and action. The change process was interrupted before organisational competence could be achieved since it was not possible to make necessary changes to allow for benefiting from the new type of structural system. Changes were mainly stored in the organisation in the individuals, who gained experiences from the project.

4.2.4 A SBE perspective - Extended task and new products in an existing production plant

The fully prefabricated structural system applied in the Folkparken project was produced by SBE’s plant in Uppsala. As described earlier, SBE developed two systems, which could be supplied by their factories, parallel to the PGS work. One of these was a fully prefabricated system, which could be supplied by the Uppsala plant alone or in collaboration with the new plant in Katrineholm. As soon as the Uppsala plant was ready for production, SBE made efforts to sell its fully prefabricated system and one of the first customers was the contracts managers group working with the Folkparken project. Furthermore, as a step towards becoming a structural system supplier instead of a building elements supplier, SBE decided to take on the task of coordinating the design of the structural system which traditionally is done by the contractor, for instance Peab. The choice to do this was made based on a belief that this would increase SBE’s competitiveness. The decision was facilitated by the fact that it was within the control of the factory management. There was also a will to create a place for product development, which did not exist in the organisation earlier.
This project was a challenge for the Uppsala factory during its first year as a structural system supplier. The fully prefabricated system that SBE had developed was described to imply an extension of its normal task in terms of making the surface of the elements ready for finishing and including services in the elements combined with the extended task of assembly. The entire package offered by SBE in this project included structural design of wall and floor elements, and manufacturing and assembly of the elements. External resources, i.e. consultants contracted by SBE, conducted the design of the elements. This was, as described above, a transfer of responsibility from Peab in this case, to SBE. Stairs and staircases were included in the package, but purchased from a special supplier. This package was described by a project leader to represent one of the systems SBE wished to supply. This system was the one selected by the PGS core team for further development into the common system concept.

Since the task was extended and the elements included more than usually, the design stage was described by the project leader to be more complex and time consuming. This implied, he explained, that more information than usual had to be transferred between SBE, Peab and external design consultants as well as within SBE, i.e. between the project leader, the production supervisors in the factory and the design team. The project leader claimed that much more time had to be spent on designing the system in this project than usual, since there were no established routines for such an extended task to rely on. For example there were no established ways to ask for or for collecting, and storing design information and documents for services from the design consultants. This was taken care of in the way that seemed most suitable each time information was transferred. Sometimes it was sent by fax, sometimes by email and other times over the phone. Experiences from this project pointed to areas to be developed by setting some requirements on routines and systems that needed to be developed for this purpose, the project leader pointed out.

The project leader and production supervisor pointed out that extra effort was made to make communication between the project leader, manufacturing team and the assembly team within SBE work in this project since the project was more complicated than normal and there were higher demands on dimensional accuracy and surface finishing than normal. Communication was perceived to work better than normal, but mistakes in the transfer of information occurred in the interfaces between the functions within SBE as well as between SBE and the different actors in the project, and caused delays in manufacturing and assembly. The project implied that a new team of designers, manufacturing staff and assembly staff started working together and since members were not acquainted with each other, systems for communication and transfer of information had to be established.
For the manufacturing team in the factory in Uppsala, the changed focus for production from roof elements for a tunnel to structural housing elements did not have any major implications for their working techniques as explained by a production supervisor and two team leaders. While the layout in the factory had been changed to fit the new products, the actual methods and techniques for producing concrete elements were described to be very much the same. The differences mainly concerned the details that were included in the elements. A greater difference was experienced in planning production for different projects to make logistics in the factory work. Planning of projects with a large amount of standard elements of a similar size was relatively easy and could be done for one floor plan at the time as drawings arrived. More complicated projects with a larger amount of different elements were said to make the necessity of co-ordination of information within and across organisations become very obvious.

The start of the manufacturing phase of the project was described by the project leader, a production supervisor and two team leaders to be quite chaotic in the factory. It was said that the manufacturing team had prepared equipment according to information they had received, but due to misunderstandings, the preparations were made based on the wrong information. This resulted in the fact that the moulds they had prepared were not the ones that should be used from the start. Re-preparing took a few days and thus a delay was unavoidable. After some time and a number of meetings, the team had enough information to grasp the overall task and start concentrating on planning the production and conducting the work. However, some drawings were delayed due to a delay with one of the structural design engineers contracted by SBE at a later stage of the project, which caused further delays for the manufacturing and also had consequences for the assembly on site. Since some drawings were late, the order of the manufacturing of the elements caused problems in the assembly order on site.

In the Folkparken project, planning of logistics in the factory was said to be very complicated since there were many different types of elements, some including services which made the work more complex. Due to the large number of different elements, the production supervisor and two team leaders explained that the rotating line in the factory could not be used properly and other solutions had to be found. More space than usual had to be used in the factory to make all the different elements. Different solutions were tried out to make logistics in the plant work. The team claimed to have learned during the course of the project by their own mistakes how to distribute time and space between complicated and less complicated elements.
in the factory to make logistics work better in the end than in the beginning of the project.

Speed of production of the elements was said to increase significantly during the course of the project. In the beginning, a team leader described how his team made common efforts to interpret the drawings for the complicated elements. As work progressed, the staff members increased their skills in interpreting drawings and learned the complicated solutions by heart, which contributed to reduction of production time. The tough demands on dimensional accuracy and surface finishes were achieved by the team. Before the start of the project, there had been certain doubts about this among the manufacturing team, and reaching the goal made their self esteem improve. Equipment for surface finishing was invested in, and can be re-used for coming projects. Furthermore, some technical solutions from this project were identified to be developed further and be part of the standard that was being developed gradually. This concerned, for example, solutions for connectors between elements.

In SBE’s Uppsala factory, the changes concerned manufacturing new products and managing an extended task including design and assembly, while keeping old production equipment. It turned out that the design of the structural system to be manufactured and the production system in the factory were not fully compatible since the production equipment required a larger amount of repetition in element design. It was said that this implied that it was not possible to take advantage of the production equipment’s ability to produce structural elements efficiently. Thus, the knowledge and action embedded at the capital/physical level was not compatible with the requirements set by this particular project and its product. No renewal at this level was made in this case. Embedded capital/physical knowledge and action therefore influenced the scope of changes that were possible to pursue by the staff in the factory. It was not within the factory staff’s control to renew production equipment. However, the skills of the staff allowed for a temporary solution to manage the manufacturing for this particular project.

The extended task of taking on design and assembly required organisational competence to co-ordinate actors and tasks, which SBE in the Uppsala factory did not have at that time. Therefore, the project leader and his team made ad hoc solutions to manage the task in this project. They were not able to build the required organisational competence with available resources at the time. Thus, the change process was interrupted before organisational competence could be created.
Figure 4. The building project Folkparken. Massive inner wall concrete element, manufactured by SBE’s factory located in Uppsala. Source: The PGS project.

Figure 5. Assembly of a massive concrete floor slab in the building project Folkparken. The element is manufactured by SBE’s factory located in Uppsala. Source: The PGS project.
4.2.5 Interface between Peab and SBE

Applying the fully prefabricated structural system and the decision to extend SBE’s task, resulted in some changes in the division of work between Peab and SBE. For Peab this implied that responsibility for co-ordination of part of the design work and assembly work was transferred to SBE. For SBE the task was extended with these items. It was explained that this transfer of work was possible because the tradition of keeping design and assembly with the contractor is not as strong for this type of system as for cast in situ systems or even semi prefabricated systems. Findings suggest that even though changes in the division of work were achieved, Peab’s and SBE’s relation were also influenced by traditions that reside in how relations with other actors are dealt with to achieve their goals.

In the Folkparken project, Peab contracted the main structural engineer who designed foundations, external walls and roofs, while structural engineers contracted by SBE designed the structural system and its elements. This division of work was described by SBE’s project leader and Peab’s design team leader to include some double work since designing the foundations requires information on the structural system. In the longer run, as the system is elaborated, SBE’s project leader pointed out that his organisations would like to take a larger responsibility for structural design of foundations and maybe roofs in housing projects. In this project it was perceived to be an advantage to be able to discuss solutions among the structural engineers, since the project involved many new ideas for SBE staff as well as Peab staff.

Assembly on site was conducted by SBE’s team. This was said to be possible to do since the fully prefabricated system implied that work which traditionally is conducted by the contractor, is easier to let go of since the technology is not the one that constitutes the core of this particular contractor’s skill. Even though a general perception among the Peab team members was that the construction site in the future will be more of an assembly place and that assembly of prefabricated elements should be done by specialists, this implied a great difference from what they were used to. Some expressed that this way of working implies a risk. Outsourcing of production and assembly of the structural system requires that the resources are there according to plans, the contracts manager explained. He pointed out that it felt a bit strange to hand over drawings to an assembly team that only see the drawings and then start to assemble, while he felt that there were others that were better acquainted with what was actually going on.

The Peab team agreed that due to how the process for this project had developed with a late decision about the type of structural system, the outcome had to be a
compromise between many requirements such as those implied by site conditions, rational production and aesthetics. One such issue concerned the level of repetition of building elements which, despite their efforts, did not reach a satisfactory level. As a result of the shape of the building, it turned out to be impossible to re-use the same type of building element several times. Instead, a great number of different elements had to be drawn and manufactured. This, in combination with how communication between the design team and the factory worked, turned out to have consequences for prefabrication in terms of delays and mistakes, as described above. Thus, it also had consequences for the assembly work at the construction site, where delays also occurred as a consequence.

Due to the fact that the manufacturing of the building elements was delayed, assembly on the construction site also was delayed. Furthermore, when the elements arrived to the site, there were problems with fitting service connections between floor and wall elements. Assembly work was furthermore delayed because the assembly team had to spend time on correcting these mistakes manually while assembling the elements. This caused frustration within the Peab project team. I met the site manager on a day when the construction site was quiet, because the delivery of elements was delayed. He was frustrated and told me that this was not how it was supposed to be on the site at this stage of the project.

The contracts manager as well as the site manager explained that these types of delays and mistakes are not unusual when prefabricated systems are applied. They were frustrated about being unable to control the situation in the way they were used to. The contracts manager thought that assembly should be done by specialists as in this project where SBE’s assembly team took care of assembly of the structural system. However, he explained, to benefit from using a prefabricated system, all drawings need to be correct from the beginning and resources have to be available just in time. He found that this situation shows that there is a long way to go before that will work. Applying cast in situ was explained to be more effective since people are skilled in using this method and the number of people needed on site is small and comparable to the number needed to assemble a fully prefabricated system. Furthermore, the problem with mistakes in drawings was described as less serious since it was possible to make corrections on site before casting walls and floors.

Due to the delays, there was a period in the project when the assembly work progressed much slower than planned, while waiting for the elements to arrive from the factory. This was described by the contracts manager as causing losses due to that staff had to wait and do nothing. The site manager also expressed frustration since he was not able to influence the course of events as he was used to. Due to delays in
assembly he explained that time plans had to be redone to plan for evening work using a larger number of people to allow for meeting the deadline for the project. Furthermore, while waiting for the elements to arrive, he had to call different suppliers to ask for later delivery of, e.g. windows to avoid having to store items on the construction site where space and right conditions for this purpose did not exist.

The contracts manager explained that the team had expected that things could go wrong during this project, since so many new things were tried out. Therefore a special paragraph in the contract had been included. It aimed at increasing openness among the actors by regulating functional requirements and economic responsibilities related to failures to meet these. It was described by all interviewed Peab and SBE project team members that increased openness between Peab and Skandinaviska Bygglement was achieved. However, despite increased openness and the specific paragraph, it was said by Peab’s contracts manager, SBE’s technical manager and SBE’s assembly manager that different interests based on own profits also created a business climate that made it difficult to sort out problems that occurred during the course of the project.

Mistakes in the transfer of information occurred which caused mistakes in the building elements, delays and annoyance in the project as described above. Some mistakes were said to be corrected during the course of the work, but there were others that could not be repaired immediately. According to prevailing business climate, influenced by contractual arrangements, all parties do their best not to being blamed for a mistake in order to avoid economic penalties as pointed out by Peab’s contracts manager. A purchaser described the behaviour when disagreements occur, and suggested that the internal (between actors belonging to the same organisation) arguments are often the toughest. Arguments occurred in this project and unwillingness based on business conditions became evident, which contributed to difficulties to find out the reason and take actions for correction.

One example which was described concerned a disagreement between Peab and SBE about the contents of an agreement made during a meeting in the Folkparken project. The agreement concerned actions to be taken in case of a failure to meet stated functional requirements. It turned out that this particular requirement was not met, which led to an argument between SBE and Peab that was difficult to solve. The reason was described to be that accepting responsibility would mean paying, which resulted in a deadlocked position.

Thus, the specific contractual arrangements to achieve openness helped to some extent, but system embedded knowledge and action which related to actors
standardised roles and current standards of workmanship was stronger. By claiming that work had been done according to what was expected, nobody wanted to admit mistakes. In this way, discussions got stuck on some occasions. Even though team members wanted to achieve an open climate to contribute to achieving project goals, they were still independent actors and had to protect their own economic interests. Since the team was not in control of changing system embedded knowledge in this case, the change process was interrupted and organisational competence could not be achieved.

Project members said that they learned a lot from this project and provided that the same team would work together again, they believed that they would be able to improve performance.

### 4.3 Experiences from applying a semi prefabricated structural system

#### 4.3.1 A Peab perspective – a contracts manager’s group applying a familiar construction method and a new approach to detail design

The second contracts manager group that conducted building projects appointed as a PGS pilot project, used the semi prefabricated system which was supplied jointly by the Katrineholm and Kalmar factories in two projects. The projects were both located in the south of Sweden, one in Svedala and the other in Brunnskög. The Svedala project consisted of 125 apartments and the project in Brunnskög consisted of 177 apartments.

Applying such a semi-prefabricated system was not new to this contracts manager group. It was said by the contracts manager that this type of system was commonly used among all contracts managers in the south division of Peab since a few years back. Therefore, in the Svedala and Brunnskög projects, the decision about the structural system was taken at an early stage since it was a natural choice. The contracts manager and his team had used semi prefabricated structural systems supplied by SBE’s factory in Kalmar before, but this was the first time they were supplied by the Katrineholm factory. The reason for applying a semi prefabricated structural system was said to be that it made work on the construction site easier and faster than cast in situ concrete structural systems. SBE worked only as a supplier of the structural system in these projects and did not take on structural design or assembly as in the Folkparken project. The project leader from SBE was said to participate in the design stage of the projects and supported them with knowledge on feasible solutions for the double walls in particular.
This particular contracts manager group was at the time in an expansion phase with many new employees and a turnover that had increased by 300% in a year. As everywhere else in the organisation, the design phase of the building process was considered problematic and the contracts manager perceived a need to change the situation to be able to cope better with the growing organisation. Through the PGS project manager he was introduced to the external consultants working with the PGS core team, and they suggested trying visible planning (VP) for the detail design phase, a method developed by Toyota. It was decided to try out the method in the Brunnshög project. Thus, visible planning is not a direct outcome of the PGS work, rather an effect of the external contacts the project brought to the organisation.

The team that worked together during the detail design stage in the Svedala and Brunnshög projects was the same. In the Svedala project, which took place before the Brunnshög project, the design phase was conducted in a traditional manner, according to practice described under section 3.6.2. A lot of problems with delays were described by the contracts manager to occur due to that drawings were seldom ready in due time. The contracts manager and the design co-ordinator said that as in many other projects, the team members did not progress with the work they were supposed to between meetings which affected the other members’ work and the situation got worse during the course of the project. They further described that the project design team members knew each other and were well aware of the problems they had faced while working together. The contracts manager described that when he announced that they were going to try visible planning in the Brunnshög project and that this would imply meetings two times a week, the design consultants were not very happy.

Despite the complaints, the design work started and visible planning was introduced with support from the external consultants. As work progressed, the Peab project members said that the group had found a suitable mode of working with one hour meetings two times a week. The difference to how the design phase was handled normally was said to concern that the contents of the work and the person responsible were made visible by using simple tools, post-it notes and a white board. Furthermore, the work was said to be conducted more intensely than usual during a shorter period of time. To encourage a positive attitude, the team had a snack together at each meeting. Since the team met so often, drawings were mainly exchanged in paper form at the meetings instead of being sent by email. The outcome of the design phase was described by the Peab team members to be that the same team that had had great problems in the Svedal project, finished the design work according to plan in the Brunnshög project. Furthermore, they claimed to have spent
less time than normal on the design work in this project. The team members claimed that they had only started to learn to apply VP, and by applying it again in the same team, would allow working procedures to be further refined.

Applying VP was facilitated by the contracts manager getting to know about the VP method and that it was within his control to make the decision to use it. VP was applied in the Brunnskög project by combining individuals’ skills to solve problems related to the change. This was in line with familiar ways to create change in Peab. Individual team members’ common knowledge base combined with the external consultant’s specific knowledge on VP facilitated the adoption of the mentioned to the team’s specific needs. Furthermore, to benefit from the advantages with the VP method, changes in the working procedure, which were possible to do, based on decisions made at the project level, were enough. Changes related to knowledge and action at the system level did not involve such things as applying new forms of contracts, or changing traditional roles for the purpose of implementing VP. Thus, the formal relation between the actors was not changed. It was rather routines and informal relations on a personal level that was changed. By making each person’s tasks and content of work together with time plans visible, it was much more difficult to be delayed since the consequences became very obvious. In this way, the usual delays could be avoided.

As a result of making work and its content visible, timing of decisions was affected. However, there were no signs that VP hindered the established way of handling flexibility and uncertainty as a result of this. This may depend on that key decisions such as choice of structural system and design team members had been made at an early stage, since this was the normal procedure in this contracts manager’s group. It also depends on the fact that VP could be used to co-ordinate actors’ work and decisions in a way that suited the team’s requirements on ways of working, rather than forcing the team to adapt to requirements set by the method itself.

Initial barriers implied by the negative attitude among project members, were overcome as the process progressed and good results emerged. The VP-method can be considered as compatible with embedded knowledge and action and served as a basis for enhancing organisational competence at the individual project level. However, to be re-used and further enhanced, the same team probably needs to work together again since experiences could mainly be stored in involved individuals.

Assembly at the construction site was delayed in both projects due to delays in the Katrineholm factory, which occurred as a result of the plant being in the process of building up its organisation and working procedures. This is further described below.
The delays caused frustration and annoyance in the Peab project team, and efforts were made both from Peab and SBE staff to discuss the problems. Peab staff from the involved contracts managers group got involved in work with improving processes in the new factory.

Figure 6. Assembly of external double wall in the building project in Brunnsbög. Source: The PGS project.

4.3.2 A SBE perspective - Starting up the new plant

A new factory was established based on a top management decision, since top management in the Peab group believed that it would contribute to competitiveness and generate profits. The Svedala and Brunnsbög projects were among the first to be supplied with products from the new factory in Katrineholm. The decision to invest in a new factory in turn made it possible to start a change process where knowledge existing within SBE and Peab could be combined with external knowledge to design and construct the new factory. The new production plant was designed to produce the same products as the SBE’s older factories, but with other, more modern, methods. Even though production equipment and the factory’s internal organisation were all new, the establishment of the new factory in itself did not require any
changes to the existing parts of the organisation. The factory was a renewal of the
capital/physical level embedded knowledge and action and it was designed to fit into
the existing structure. The establishment of the factory did not imply a new role for
SBE in building projects. There were still project leaders who sold the products and
functioned as customer contacts during the process. Thus, the interface to SBE’s
customers such as Peab was unchanged. In other words, the new factory was
designed to fit into existing structures. A lot of knowledge related to the products and
their use could be used as earlier, for instance in contact with customers.

Despite existing knowledge, there were many parts that had to be built up in order
for the new plant to work. It was, for instance, suggested by the production
supervisor that the new staff had to learn how to use the production equipment and it
was also necessary to build up routines for how to handle the process from making
the offer to the customer to delivery.

During the first months of operation, SBE staff claimed that it became evident that
communication between the different functions of the organisation in the plant did
not work satisfactorily. It was said by the production supervisor that problems
occurred as there was no system for distributing information from project leaders on
sales on the level of detailed need for production to be planned properly. The factory
had produced the semi prefabricated structural system for two housing projects in
Skåne, Brunnshög and Svedala and for one hospital project. In addition some smaller
deliveries of floor slabs had also been made. These projects did not include any
complicated elements, but delays in production and delivery occurred due to the
deficiencies in internal communication. In the new factory there were no established
routines to rely on and efforts were made to build up routines to manage the process
from order to delivery. The scope of the task was not extended compared to SBE’s
traditional role as a building element supplier, and the products were familiar to the
old parts of the organisation but the equipment and staff at the plant was new. Each
function in the plant such as design for manufacturing and production worked from
the start on building up their skills to apply its equipment and manage interfaces with
other internal functions as well as interfaces with other organisations in SBE’s supply
chain.

The production department in Katrineholm worked on building up its skills in
operating the production lines through rotation of the staff between the different
stations and tasks. Small issues that could be solved by the production department
internally were dealt with as they occurred, but the production manager emphasised
the need for a holistic effort to make the whole organisation work to allow for
significant progress. Extra resources, allocated to support the organisation in building
up routines and communication skills started working during the spring of 2004. Peab staff from the contracts managers group involved in the Svedala and Brunnshög projects supported this work. As this is being written in spring 2004, work to build up the missing links has been going on for some time, and improvements were reported from SBE representatives in the PGS core team.

Thus, based on new technical equipment and new staff, new organisational competence to manage a process from sales via manufacturing to deliver was being built up. No changes outside the control of SBE and its factory staff were required to do this.

![Figure 7. Work station in SBE's factory in Katrineholm. A robot places magnets on the mould table. Formwork will then be placed on the magnets. Source: The PGS project.](image)

4.3.3 Interface between Peab and SBE

In the Svedala and Brunnshög projects, there were no changes in responsibility of work between Peab and SBE and therefore both organisations could act according to current practice, as applicable in their respective organisations. However, there were certain parts of the work that both parties wished to transfer responsibility for, but due to the embedded action and knowledge which can be referred to the semi prefabricated structural system, this proved to include barriers.
In accordance with current practice in the application of this type of semi prefabricated structural system in this case, Peab contracted the structural engineers who conducted the design of the structural system while SBE took care of structural engineering work connected to manufacturing of the elements in the factory. This division of work also mirrors a tradition with its origin in the application of in situ concrete structural systems, SBE’s business manager explained. Semi prefabricated systems as those used in the two projects have by tradition only moved the manufacturing of the semi prefabricated elements which are a kind of mould to factories, while design and assembly has stayed with the contractor as in the case for cast in situ systems.

Both Peab and SBE preferred it if SBE through its own or contracted engineers, as pointed out by Peab’s contracts manager and PGS core team members, could take responsibility for the structural design instead of Peab. That would allow for SBE to develop longer term relationships with the structural engineers, they perceived.

Transferring the responsibility for assembly of semi prefabricated structural systems was considered more complicated. SBE’s business manager and Peab’s contracts manager thought that given current business conditions there are no incentives to make the transfer of assembly of semi prefabricated systems. While it was seen as a feasible and possible future development, SBE could not start offering it today since that would imply competing with its customers, the business manager explained. Peab on the other hand was not prepared to give up the assembly given current business conditions since this was considered to be the most profitable part of the work conducted on site, Peab’s contracts manager pointed out. Furthermore, such a transfer would include moving resources from the contractor to the structural system supplier. Otherwise the situation would be a lot like now when Peab sometimes rejects prefabricated structural systems because its own staff needs to be kept busy, as pointed out by a purchaser. However, at the time for the study, SBE’s organisation was still that of an element supplier’s rather than that of a system supplier involving competence for a process from design to assembly of structural systems.

Renewal of capital/physical embedded knowledge and action did not automatically make SBE a structural system supplier, as suggested in one of the PGS ideas. Both Peab and SBE staff were well aware of this, and they were also aware of some issues related to this transformation, which were described above. Embedded knowledge and action related to the products produced by SBE in the new factory and their corresponding established procedures for design and assembly, implied a certain division of work between Peab and SBE. At the time of this study, the new plant and related knowledge and action were designed to be compatible with established
procedures for design and assembly, which also corresponded to the knowledge and action in SBE’s organisation as a whole.

### 4.4 Summary

The *PGS core team* started working with the aim to develop a building system that could contribute to the reduction of production costs by 30% and reduce lead times by 40%. This system was imagined to be prefabricated and include Peab specific standards. Standards were intended to be developed through longer term relations with fewer key suppliers as opposed to prevailing ways of working. Furthermore, it was imagined that it would be feasible to transfer responsibility for design and assembly of the structural system from the contractor (in this case Peab) to a structural system supplier (in this case SBE). However, as the change process was started, the imagined content of the change was turned into something else. The identified facilitators and barriers point to how this occurred.

The management decision to establish the PGS core team and allocate resources for its work facilitated a knowledge creation process to start within the team. Resources, motivated PGS core team members and the team’s ability to combine and integrate individuals’ knowledge kept the process going. A common language and a shared knowledge base facilitated integration of individuals’ knowledge. Barriers were revealed when the PGS core team tried to interact with the target organisation. Usually changes were initiated on a project basis as a response to a specific need in the particular project. PGS instead approached contracts managers with requests for information and suggestions about how to improve work. Distribution of authority allowed local contracts managers to deny the PGS core team information and access to daily work. Thus, the project itself was an unfamiliar way to create change in the target organisation. Since there were no facilitators that allowed a process to start which could “teach” Peab and PGS to create knowledge together, the change process was interrupted. Therefore, it was not possible to create new organisational competence this way.

Instead, the PGS core team identified facilitators to interact with the target organisation. These consisted of personal contacts which allowed for access to a few building projects. However, the PGS core team was not able to interfere with the work more than to a limited extent. Collection of data for analyses in collaboration with the building project team was allowed. To do this, the PGS core team had to adhere to the established way of creating change, i.e. combining individuals’ skills. This was the way the PGS team introduced the new methods and tools for costs and waste analysis to the building project teams.
The outcome of the PGS-process by the end of this study was that the PGS project was only able to analyse and suggest, instead of contributing to the changes it aimed for when the process started.

In the building project Folkparken the decision to apply a fully prefabricated system in this specific contracts manager’s team was facilitated by economic incentives and motivation. In a similar way, the decision to take on an extended task and manufacture a new product was facilitated by a belief that this approach would contribute to SBE’s competitiveness. The change of division of work between Peab and SBE was facilitated by that the tradition to keep a certain division of work was not so strong for this type of building system.

The decision to start the change processes were in the control of the contracts manager and his team and staff in SBE’s Uppsala factory, but it was not within their control to target all levels of embedded knowledge and action that were necessary to be able to benefit from the fully prefabricated system and achieve organisational competence. Therefore change processes were started and kept going since the teams had the ability to combine different individual’s knowledge to handle the changes. The change processes were interrupted since the team were not able to make all necessary changes to achieve organisational competence. Instead, the teams made temporary changes for this particular project at the individual, system and physical levels to be able to manage the new technology and new working procedures. Even though the teams had knowledge about further changes that would have been useful to do, they were not able to change embedded actions. They were not able to create conditions to allow for developing skills in using this type of structural system and fully benefit from it. Such conditions may include e.g. decreased profit requirements during a learning period and incentives to create new types of relations with other actors. Neither were they able to change knowledge and action that influenced their business relation. Finally, SBE’s project leader and his team were not able to build new organisational competence to handle the extended task on this first project. It was for instance beyond the team’s control to renew the production equipment. Thus, since the team was not in control to make all necessary changes, the process was interrupted and organisational competence could not be achieved.

The change made during the design stage in the building project Brunnsbåg was facilitated by a decision of the contracts manager. In a similar way, the establishment of the new factory was facilitated by a top management decision. These decisions combined with motivated individuals started a change processes which led to new and enhanced organisational competence. The processes kept going since there was access to necessary internal as well as external knowledge. The teams working with these
changes were able to combine their knowledge. Individuals’ common knowledge base contributed to facilitating the process. Necessary changes were in the control of the units which pursued them. Therefore, the teams were able to start and pursue the change processes and in this way start the process of building new and enhancing existing organisational competence.
5 Conclusions

This thesis has looked into the issue of industrialising house building, which is a label many construction companies put on their current efforts to change in order to improve quality and productivity in housing production. The specific research question was stated as:

*What are the facilitators and barriers to make organisational changes for the purpose of industrialising house building in a construction company?*

The individual construction company perspective was taken and efforts to industrialise building were seen as efforts to pursue organisational change. Facilitators and barriers to making organisational changes for the purpose of industrialising house building were studied through the Peab group change effort during two years. The entities within the Peab group that are included in the study are Peab Sverige (contractor) and Skandinaviska Byggeelement (structural concrete element supplier). This chapter summarises findings from the study and draws it to a conclusion.

5.1 Summary of findings

5.1.1 Prevailing ideas for industrialisation – a revolution for a construction company

Construction can be characterised as a project based business, where skills of independent actors are combined in individual building projects. Relations between actors are often short term. Actors therefore have to manage complex networks with complex interfaces, which can differ between projects. Firms’ technical specialisation related to other firms, affects how skills can be used and thus how the firms can perform. To manage uncertainty which occurs when many new actors meet in a project to conduct numerous tasks, standardisation has developed. This standardisation concerns actors’ roles and skills, contracts, regulations and tendering systems. Furthermore, the decision making structure in construction companies is often decentralised which allows for individual project teams to make decisions to be able to handle requirements on flexibility and to handle uncertainties.

While the work organisation has its reasons to be designed the way it is, it also has its drawbacks. For instance, there is little feedback between phases and actors in the process. Since relations often are short term, and actors vary between projects it is difficult to re-use knowledge gained in a previous project. Such and other drawbacks are seen as the reason for quality deficiencies and low productivity in housing
production. To overcome the drawbacks, many construction companies make efforts to change by using the manufacturing industry as a source of inspiration. Such approaches are often labelled efforts to industrialise. Currently, common ideas for industrialisation concern product standardisation, increased degrees of prefabrication and longer-term relations with other actors in the building process. The Peab group is one of many construction companies that deal with such changes.

As in many other construction companies, Peab has a decentralised decision-making structure, which implies that most decisions relating to individual projects can be taken by contracts managers and their site managers, i.e. managers directly responsible for the individual building project. Such a decision structure exists to allow for flexibility to handle specific requirements for individual building projects and for allowing for dealing with unexpected events. The ability to make decisions and act quickly was described as one of Peab’s advantages. SBE, who manufactures concrete elements for the structural parts of a house, has a different work organisation. It had, at the time of the study, several factories, which collaborated but specialised in different products. A new factory was being established at the time of the start of this study. Since SBE’s customers were found in the construction industry, the company produced for different construction projects. The equipment in the factories was said to be better suited for continuous production. Therefore, certain standards and certain production volumes were considered important for SBE’s business.

Difficulties in combining these two types of companies in a building project were pointed out. SBE’s products and production system require that decisions concerning the structural system are made in due time to allow for enough time for production in the factory. Changes are difficult to handle after a certain point during the process. Peab designs product and production system concurrently through an iterative process where changes occur. Peab’s preferred way of working means increased uncertainty for SBE due to late decisions and changes. SBE’s preferred way of working means decreased flexibility for Peab.

In addition to SBE’s new factory, a project, PGS, was launched to create a common structural system for multi-family housing to be used across Peab’s organisation. The PGS ideas for such a system included that it would be based on certain Peab standards. It should also contribute to increased use of prefabricated products. Standard components should be bought from a selection of suppliers, with whom long-term relations should be developed. To make sure Peab standards would be used and developed, it was imagined that Peab should take increased control over design.
The ideas can be understood as a desire to create and manage a building system that can carry experiences that various actors, not only Peab and SBE, in the building process contribute to today. By transforming useful experiences that various actors bring, to standard solutions in the product, it was believed that vulnerability to repetitive mistakes would be reduced. Overall, the PGS ideas for change would imply changing Peab’s established way of dealing with uncertainty and the need to be flexible in individual building projects, since they would affect the decentralised organisational design, in particular the decision making.

This may at first glance seem as an organisationally conditioned issue, which top management is entitled to change any time. To some extent this can probably be done, but taking it beyond a certain point will require significant changes to ways of working. In Peab’s case, decentralised decision making was said to contribute to its strengths. It was said to make it possible to make decisions and act quickly upon them. It was also found that current practices in Peab’s building process relied on the possibility of making certain decisions concerning design, purchasing and construction methods. To change such ways of working, changes in distribution of authority (obviously) as well as incentive systems are likely to be needed. Embedded knowledge and action related to design and construction which now can be found on the local level in the different contracts manager groups and with external actors would probably also be affected. Peab and SBE most likely need to make sure such skills are housed at some other level of the organisation and also that new ways to collaborate with other actors are developed. Such skills must also find their way to individual building projects to make business work.

To implement and spread the common system concept which would carry the renewal ideas as well as enhance new knowledge gained from applying it, good examples in individual building projects were seen as the way forward. If only all the perceived benefits could be shown in a few building projects, people across the organisation would take an interest in trying it out themselves. Even though good examples can be a trigger of a self spreading mechanism, it probably takes a long time before all of Peab’s contracts managers and their site managers are on board.

Thus, the PGS ideas’ realisation seems to include significant changes to Peab’s and SBE’s organisations. The ideas would not only affect Peab and SBE. They would affect system embedded knowledge related to actors’ roles and skill and contractual arrangements between them. These are not entirely within Peab’s and SBE’s control to change. Furthermore, the task of developing standards that are the remedy to shortcomings of the current work organisation and the replacement of specific skills
held by the organisation, its staff and collaborators seems to be quite an extensive task. How did PGS manage its extensive task?

5.1.2 PGS - stuck in established ways of creating changes

The PGS core team started off as almost beginners, with some exceptions, in pursuing renewal work outside a particular building project. Work started with a broad scope and in the very beginning it had the character of a brainstorm. As time passed, the work got more and more focused and the ways of working, both within the team and the interaction with others outside the team developed. During the course of the work, the PGS core team had gained much experience and new knowledge about the building system itself which was in focus for their effort as well as the conditions for pursuing work which the team faced. Despite this, two years after the launch of the PGS project, the core team found itself relatively isolated from Peab’s and SBE’s organisations. The team had not been able to pursue its work and develop its ideas in the way and to the extent it had hoped. What were the facilitators and barriers that contributed to this?

Facilitators that allowed for knowledge to be created in the PGS core team was a decision by top management to allocate resources for the project. This triggered a knowledge creation process to start within the core team. Knowledge was created through an iterative process where problems were formulated and solved through finding more information and testing potential solutions. The team members’ common knowledge base and common language contributed as a facilitator for this process. Various information and facts were collected from colleagues, from literature and other sources. Discussions among team members on newly gained facts as well as discussions about their earlier experiences took place. Results in the form of more facts or practical experiences were added to what was known already. In this way, the body of knowledge about the future building system and the team’s working conditions grew gradually within the core team. Based on emerging knowledge, the scope of the working themes was narrowed and the ways of pursuing the work were changed.

However, during the two years, which this study covers, the PGS project was only able to contribute to changes in Peab’s or SBE’s organisations to a very limited extent. The project’s attempts to approach the organisation were not fully compatible with established ways of introducing new ways of working. Often when changes are made within Peab and SBE, they are initiated and conducted on a project basis. In this case changes were suggested by someone outside the project, i.e., the PGS core team. PGS asked contracts managers and their teams to change their cost surveying methods and they also wanted to make waste analyses. Therefore, already the first
moves the team made to interact with Peab’s and SBE’s organisations revealed barriers which limited their ability to influence daily work in the way they wanted. This concerned that the core team was denied access to some projects.

No specific efforts were made in Peab’s or SBE’s organisations to support the PGS-work, such as establishing formal counterparts or providing the core team with certain authorities. Thus, the PGS project as a way to create change was new to the organisation. There were no conditions at the time that facilitated a process that could start a change process that could enable the organisation to change through PGS. Therefore, PGS faced established conditions for creating changes with all Peab’s 150 contracts managers and their 500 site managers and SBE’s production plants as potential collaborators and receivers of the results. These were entitled to say no to collaboration with PGS.

This was illustrated through attempts to collect information from various places in Peab’s organisation. The team found that it could not get access to the information it wished, e.g. production costs. Since the distribution of authority allowed individual contract managers to deny sharing information of a certain kind with others and since there was no habit of doing it either, the PGS core team had to accept no for an answer from some contracts managers that were asked. Thus, for the PGS core team, the distribution of authority and information sharing habits in the organisation implied a barrier. No efforts were made on appropriate management levels to change the situation. This barrier contributed to knowledge about PGS’s working conditions, and the team found other solutions instead.

Through the increased knowledge the team had gained in its working situation, facilitators were identified. Through core team members themselves and their personal contacts, the team got access to some building projects, where some of the ideas, which were in line with the PGS ideas, were tested. These projects involved Peab as contractor and SBE as structural system supplier and some of the PGS core team members were also members of the building project teams. In these projects, the PGS core team was allowed to make analyses on costs and waste during the construction stage. At first, the trade union and some building project members were suspicious to this, but through informing and discussing, the PGS core team was granted access. Furthermore, this way of initiating changes was also unusual. Normally such things as new ways of working or new technologies are initiated by project members as a result of a specific need or condition in the particular project. To be able to conduct the analysis, the team adapted its way of creating change to how it is normally done in building projects.
Waste and cost analyses were done in collaboration between the PGS core team members and building project members. To be able to conduct the desired analyses, the PGS core team had to adapt its work to established ways of creating new knowledge in Peab’s and SBE’s organisations. The PGS core team members first had to learn how to conduct such surveys themselves, and then teach their collaborators in the individual building projects. The PGS core team members and the building project team members developed a new common knowledge base, based on their original common knowledge base. This worked as a facilitator to apply the new analysis methods. As in other building projects, knowledge gained from the result mainly reached those involved in the building project, and PGS core team members. Spreading and re-using gained experiences is subject to the same issue as in other cases. Involved individuals need to be able to make use of them in coming projects.

The barriers the PGS core team faced created conflicts and frustration in the core team. Some of the members had expected work to progress faster and that the team would produce suggestions for technical solutions for a building system, rather than doing a lot of analysis work. Some found it hard to see if the work they were doing really was going to lead to the goal. Furthermore, as a lot of time and effort had to be spent on overcoming barriers, the team felt that their resources were not sufficient to do the work which they thought they were there to do. This influenced working themes and ways of working in the PGS project. All along, the project manager together with the team had discussed with top and middle managers about counterparts in Peab’s and SBE’s organisations who could receive and further develop PGS results. However, except for an attempt to establish a market group, nothing happened during the two years of the study. There was no establishment of collaboration with the purchasing department which would have been important for development of product standards and longer term relations with key suppliers. Furthermore, even though some people in the organisation found the PGS ideas interesting, they had difficulties to see how they could make use of them in their daily work.

There were also discussions, which delayed work, about the extent to which PGS was supposed to make use of the products SBE could produce at the time for developing the building system. Some of the core team members wanted PGS to work with a system that SBE could produce in the future, rather than the products they supplied today, while others found it evident that current products should constitute the base for the PGS work. Discussions within the core team and feedback from management resulted in what can be described a compromise from some of the PGS core team members’ point of view. The chosen system could be produced by SBE in its old factory together with the new, but it did not favour the products produced by the
new factory. Those products were considered as traditional and not new and innovative by some of the PGS core team members.

Thus, even though some people, among them the project manager, aimed beyond the Peab group’s current product supply, they were not able to persuade others that it was the right thing to do. They were not able to influence Peab’s or SBE’s path of development with their ideas. Instead, the PGS core team had to stay within existing borders set by already made choices. Already made investments, such as the new factory, were considered to be more important to involve in the development work, rather than going for something that may or may not be produced in-house in the future.

The result was that the PGS project became more or less isolated. It was only possible to nicely ask some of the numerous potential collaborators in Peab’s and SBE’s organisations about access to daily work. These were fully entitled to say no, which the PGS core team had to accept. Despite these barriers, new knowledge was created in the PGS core team, but spreading it and re-using it in the target organisation faced the same issues as new knowledge created in any other project in Peab or SBE. It was to a great extent dependent on that the individuals who held this new knowledge were able to re-use it in daily work. There were no facilitators that allowed the organisation to start learning to change through the PGS project. A small exception to this was that the PGS core team-identified facilitators, i.e. personal contacts to allow for access to make analysis work. By the end of this study, there were ongoing discussions about what were labelled full-scale laboratories by the PGS core team. In these projects the team wanted to influence organisation and working procedures directly.

Thus, PGS’s attempts to create changes were stopped by the target organisation’s established ways to create changes and its already chosen development path. Even though some barriers were overcome, it was not possible for the project team to influence work more than by observing and suggesting. The team actually had less influence over change creation in Peab and SBE than an ordinary building project team has. Neither were those among the core team members who wanted to develop something that could not be produced in-house today able to influence the target organisation’s chosen path.

5.1.3 Building project team lacking control over desired changes

Even though the PGS project was not able to directly influence changes in daily work, there were efforts at change going on in the organisation. One of these took place in the housing project Folkparken, located south of Stockholm. In this project a
fully prefabricated structural system, including services was tried out. The project involved Peab as a contractor and SBE with its old factory in Uppsala as structural system supplier. For Peab’s contracts manager group, working with such a structural system was new. For SBE this project implied producing a new product with existing production equipment and an extended task in terms of design and assembly.

The change was not directly initiated by the PGS project but occurred when SBE’s factory in Uppsala was ready for production of structural elements for housing after conversion from production of tunnel roof elements. The technical manager and his staff wanted to make an effort to develop into a system supplier, as opposed to their current role as element supplier, by extending the task with increased responsibility for design of the structural system and assembly on site. A customer was found in a Peab contracts manager’s group who wanted to develop reusable solutions for multi family housing projects in metropolitan areas.

A fully prefabricated system was seen as an interesting solution for the contracts manager and his team. This motivation combined with an economic incentive facilitated the contracts manager’s decision to apply the fully prefabricated system. One person in the contracts manager’s group, the project developer, as well as the technical manager from SBE were also members of the PGS core team. While the project and Peab’s choice of SBE as a supplier occurred as in ordinary projects, the choice to go for these particular changes was encouraged by the PGS core team members.

It was found that changes to adapt ways of working to the new product and new task were done, but the team also deliberately chose not to make some changes in their ways of working, even though it was claimed that certain changes would have made the outcome better. Team members’ different skills were combined to make what was perceived as necessary changes to solve various issues that came up during the process. The changes that were made in ways of working to handle the new product, were found to rely on team members’ professional knowledge about what was feasible to do and what they were entitled to change.

This was done by making changes to the normal way of working. An increased number of meetings were held, compared to normal, where individual skills were combined to solve issues such as designing services to fit into the prefabricated elements. This is different from designing services for a cast in situ structural system. SBE’s project leader took a more active part than normally as well to contribute with his skills. In this way, the design process could be finished earlier than normal, to allow for manufacturing in the factory to start in due time. These particular changes
were done because team members found them necessary for handling the new product in the process. The team used individual members’ skills as a basis to adapt their way of working and solve new types of problems so that they were able to design the building with the new type of structural system.

Thus, a decision to make a change at the physical level triggered a change process where the team made changes that were related to knowledge and action embedded at the individual and system levels. The changes were initiated at the individual project level, which is a familiar method in Peab and SBE. To handle the changes in the process, individual team members’ skills were combined, which is also a familiar way to deal with new and/or tricky issues at the building project level. Changing from a cast in situ structural system to a fully prefabricated one was possible since such a decision was within the area of authority of the individual contracts manager and his team. So was the decision to adapt content, timing of work and meeting frequency during the design stage to fit together the process and the new structural system.

The team pointed out that a change which was considered important for the result of the project was skipped. The reason for this was said to be that Peab was lacking sufficient knowledge of in-house work to make the change. This deliberate non-change concerned that the decision to go for a fully prefabricated structural system was deliberately taken at a stage which was considered to be too late to have enough time to make for a good result. Team members believed that the outcome of the project would have been better if they had made the decision about the structural system at an earlier stage of the process. They claimed that it would have allowed for a less stressful design stage, less re-working of original drawings and a solution which would have been better suited for prefabrication.

It was found that there was another reason for the change to be omitted as well. Late decision making of this kind is part of the established way to perform existing skills and to handle uncertainties in construction and it relates to embedded knowledge and action, which concerns e.g. organisational design, actors roles in the building process as well as their relation. Making uncertainties manageable is an important reason for construction work to be organised the way it is. Standardisation of skills, contracts, roles, tendering systems, etc is a way to handle uncertainties related to combining a large number of actors to conduct numerous tasks to design and construct a house. To allow for the individual project to deal with uncertainties related to the situation in the individual building project, decision making in construction companies is often decentralised. In Peab, contracts managers and their site managers and teams are authorised to decide about such things as construction methods, which sub contractors and suppliers use, and thus also the timing of such decisions. They also
have financial control over their projects. The central guideline to adhere to is to make a profit on each project.

An earlier decision about a prefabricated structural system would most likely have allowed for more time during the design stage, less re-working and perhaps also a better solution, but it would not have eliminated the risk of something unexpected occurring later, e.g. on site, which could have increased costs. As described by Peab staff, timing of certain decisions is seen as a possible way to compensate for such unexpected cost increases by allowing for choosing suppliers who can offer the best possible price. Late decisions about applying a prefabricated structural system instead of a cast in situ system (and other things as well) were described to occur once in a while in projects for reasons that had to do with handling unexpected events. Changing such ways of acting can be difficult since it is related to embedded knowledge and action, which is outside the individual building project’s control. Thus, the team had the knowledge about how they should act, but were not in control of influencing its actions which were induced by factors outside its control.

Even though there are obvious reasons for deciding about types of structural system at a point in time which allows for sufficient time for following activities, it may also imply a risk since it limits opportunities to compensate for future unexpected events. An early choice in this case would have prevented the established way of handling uncertainty from working in the way people in the organisation are used to, and there was no obvious alternative way available. During the time of the study, the Folkparken project received economic incentives to go ahead with this structural system, but it was not enough to make the team change its behaviour in terms of this particular decision. There were no other signs at the time that management would make other changes which could have contributed to such a change in this case or in future projects. For the team to start developing skills in using this new type of structural system and benefit from it, conditions that trigger such a process are needed. Less focus profitability and incentives to develop new types of relations are examples of such conditions.

In SBE’s production plant, the changes concerned adapting the existing production system to a new product and an extended task. Knowledge about how to deal with the changes was increased during the course of the process as the staff dealt with problems they faced. However, by mistake it was discovered too late that the new product was not fully compatible with existing production equipment. Furthermore, there were not yet any routines to handle such things as transfer of a larger amount of information which occurred as a result of the extended task. Ad hoc solutions had to be made. Staff in the factory made temporary changes in factory lay-out to handle
production for this particular project and they made ad hoc solutions for dealing with
the increased amount of information that had to be stored and transferred. While the
skill of the staff allowed for making temporary solutions, the advantages of the
factory production system were lost. The assembly line could not be used and instead
the elements were made more or less by hand.

The changes made were the result of adaptations of the production system to a new
product and to an extended task. As in the case with the building project design team,
the changes were facilitated by that they were in the control of the staff at the
production plant. The way of conducting the change was familiar in the sense that the
staff was used to making adaptations for specific projects, but this was beyond the
norm. Individual skills were combined, as in normal cases, to solve problems that
occurred during the process. Team members’ common knowledge base and language
contributed to facilitating knowledge integration while solving problems. In this case
temporary changes were made at the physical level, i.e., the factory production
equipment, even though it was not a fully satisfactory solution as it meant losing the
advantages with the production system. It was considered the best solution given
what the staff was authorised to do. Their acting was limited by what could be done
with the physical equipment and their individual skills. The staff made changes which
were within their control, but it was not enough to create organisational competence.
For instance, it would have been beyond their control to buy new equipment for the
factory.

In the interface between Peab and SBE, changes in the division of work were made.
This concerned the fact that coordination of part of the design work and assembly of
the structural parts on site were transferred from Peab to SBE. To manage the new
situation in this project, Peab and SBE strived to achieve increased openness to what
is customary in similar projects. Project members perceived that this was achieved,
even though some disagreements occurred during the course of the project. This
effort was supported by a special paragraph in the contract. However, despite the
effort to increase openness, the relation was influenced by the normal business
climate in such projects, which implied a barrier. This concerned an unwillingness to
be open about reasons for mistakes, since it could result in being blamed and getting
an economic penalty. Such a way of acting is part of the established way of watching
one’s own interest in a building project with other actors who are independent
outside the building project contract, and all have their individual interests and want
to make a profit. Since it is impossible to foresee everything that may occur during
the course of a building project and make statements about it in the contract,
unexpected errors are a source of uncertainty. It was said by Peab and SBE staff that
if possible, actors protect themselves from getting penalties by not being open
towards each other when errors occur. They talked about this business climate as lack of trust among actors.

As a result of the change at the physical level, i.e., the building system, changes were also made at the individual and system levels. As with the previous changes, they were facilitated by that they were within the control of the team. Again, conducting the change on a project level was the familiar way of doing it. The change in division of work between SBE and Peab was also facilitated by traditions tied to prefabricated structural systems. The tradition to keep design and assembly with the contractor is not as strong for this type of system as for cast in situ or even semi prefabricated structural systems. However, changing the division of work also implied an increased exposure to uncertainties for Peab, since the site manager and his team were not able to correct errors that occurred during assembly on site as usually. Since the structural system was manufactured off-site, and assembled by SBE’s team, they were only able to stand by and watch instead of interfering directly as they were used to. It also implied a greater risk for SBE, since they never produced such a product before and the task was extended.

The strive to increase openness between actors in this project was a way to compensate for the increased risk in terms of making staff willing to discuss mistakes and the reasons for them occurring. In this way, the team thought it would be able to improve performance during the course of the work. Team members said they knew many unexpected problems would occur since so many new things were tried out, and they took precautions they knew could help, i.e. using the contract as a tool. It worked to some extent, but the system level embedded knowledge and action which has influence on actors relations was not changed by this. Standardised roles and the current standards of workmanship, which are also part of formal contracts, were stronger than the contractual change and team members’ intentions about openness.

By claiming that work had been done in accordance with what was expected, the discussions about causes of errors got stuck on some occasions. Nobody wanted to admit mistakes that could have contributed to problems that occurred. Despite understanding and a will to contribute to the common goal of this project by being open, actors were, after all, independent and therefore had to see to their own interests. Taking action which was within the control of the individual building project team, was not enough to change system embedded knowledge and action which worked in the opposite direction. Thus, even though the team had knowledge about the need for a different way of acting, it was beyond its control to change the level of embeddedness that influenced prevailing behaviour.
The Folkparken project showed that it is possible for a building project team to decide to use a new technology, without being able to pursue the changes in the work organisation which are necessary to fully benefit from it. Changes within the area of the control of the team were made. These were temporary changes at the individual, system, and physical level for the purpose of this particular project. The particular changes were made since they were considered necessary for the project’s competence to conduct the building project. However, the result was not fully satisfactory. The change process was interrupted since the team was not able to make all necessary changes to build organisational competence. The gained experiences could be stored in the involved individuals, and as in other building projects spreading depends on the individuals’ chance to re-use it.

Individual team members claimed that they learned a lot from this project about what to do next time to improve performance. They believed that more tries would lead to better results gradually. This may well be the case to a certain extent. They may well be able to improve performance by improving ways of working further, but as in the first effort they will only be able to do what is possible and feasible within their own area of control, unless some change beyond their control occurs. Such changes could include for instance incentives to start a learning process to develop skills in using this type of structural system by reducing demands on profitability during a learning period and creating incentives to develop relationships with other actors. During the time of the study, there were no signs of changes that could change the situation.

5.1.4 Building and enhancing organisational competence locally

There were also change efforts taking place, which led to new and enhanced organisational competence in both Peab and SBE. This occurred in one of Peab’s contracts manager’s groups which operated in Skåne in the south of Sweden and also in SBE’s new production plant in Katrineholm. This contracts manager’s group was among the first to apply the products produced by the new factory, but using the type of structural system supplied by the new factory was not new to the group.

In one of Peab’s contracts manager’s groups, a new method for structuring co-ordination of different actors’ work during the detail design stage in the housing project Brunnshög was tried out. As in other places of Peab’s organisation, the design process was perceived as problematic. Through the PGS core team and the external consultants working with PGS, the contracts manager and his team were introduced to the visible planning (VP) method. The contracts manager wanted to try the method in a design team, consisting of contracted consultants and Peab’s own staff that had worked together in housing projects earlier. The team members knew each other and they had experienced problems with delays and mistakes in earlier projects.
With support from the external consultant, working procedures based on VP principles were elaborated. Individuals’ skills were combined to solve problems. The building project team’s common knowledge base was combined with the external consultant’s knowledge. Common language contributed to facilitating this. It was said that changes based on the VP method implied that contents of a work task and the person responsible for it was made visible using a white board and post-it notes. Work was conducted more intensely during a shorter period of time than normal. The result turned out to be satisfactory. Design was finished in time, and total time spent during the design stage was reduced, compared to normal.

Thus, to improve a problematic situation, changes were made in working procedures which related to knowledge and action embedded at the individual and systems levels. In a similar way as in the Folkparken project, the changes were facilitated by that they were within the control of the individual building project team. In accordance with the established way to create changes, they were initiated at the individual project level. By combining team members’ individual skills, including an external consultant, the VP method could be adapted to the building team’s specific needs. Barriers faced during the process concerned that individual members first were sceptical about the change. The new working procedure interfered in their daily planning and therefore affected work outside this particular project as well. Despite their complaints, the contracts manager stayed with the decision to try VP in the Brunnsfög project. As work progressed and advantages emerged, the attitude changed and team members became positive instead.

A difference with the Folkparken project concerned that it was possible to benefit from the advantages with the VP method for the particular purpose in this building project by only making changes which were within the control of the building project team. There were no deliberate non-changes due to conditions, which were outside the team’s control as in Folkparken. Neither did the changes affect such things as the established way to deal with uncertainties, as also happened in Folkparken. Control over necessary changes and the ability to overcome barriers led to the building team being able to enhance its organisational competence concerning coordination of various designers and their work during the design stage.

However, as for the changes made in the Folkparken project, newly gained knowledge can mainly be stored in individuals and to re-use and spread it, these individuals are needed. To enhance knowledge gained from this project, the same team needs to apply the method in new projects.
For SBE, the investment and establishment of a new factory implied a great change, which was initiated before the start of this research and realised during the course of it. The investment was done since management believed that it would lead to increased profits. The factory was designed using knowledge existing within SBE’s and Peab’s organisations, combined with knowledge held by colleagues in other companies who already had such factories as well as contracted external consultants. Making the factory work, involved not only the staff working at the new factory, but also staff from other parts of SBE as well as Peab and external consultants. It was decided to produce products which SBE already produced in one of their old factories and which were familiar to Peab and others in the construction industry, i.e. semi prefabricated structural elements. No changes were made which would make SBE’s role in the building process any different, even though some of the SBE and Peab staff thought it would be desirable.

Thus, even though the factory implied a significant change at SBE’s physical level, the development of the new production plant was influenced by knowledge and action embedded in Peab’s and SBE’s organisations as well as other parts of the construction industry. The products were the same as earlier and no changes were made to SBE’s role. The changes concerned only the way of producing the products.

The changes were responses to external conditions, such as housing demand, which made Peab top management decide to invest in a new factory and execute the decision. This in turn facilitated SBE’s staff to make use of internal as well as external knowledge to design and construct the factory. The new factory was designed to fit into SBE’s embedded knowledge and action in terms of allowing for the organisation around it to be more or less intact. It was fitted into the existing production system by making the interfaces to the rest of the organisation similar to those of the previous production plants. As earlier, a project leader or sales person would sell the products, contribute during design of the building and function as the customers’ contact with SBE.

The factory internal organisation and its equipment were new to the organisation though, which led to start up problems. This concerned, for instance, difficulties with internal communication. Mistakes and delays occurred due to that there were no established ways to transfer information from sales to design and production. Such problems were dealt with by using internal staff as well as staff from Peab and external consultants to build up new routines. New knowledge could be stored in routines for using the production equipment. It could be re-used as routines were repeated. In this way, step-by-step, the performance improved. At the time for the
study it was perceived that there still was a lot to learn before it was really possible to benefit from its potential advantages.

As with VP, changes made related to making the new factory work were in the control of SBE’s organisation. Gradually, factory management and the staff were able to create routines and improve performance without having to make deliberate non-changes due to conditions beyond their control. While their performance affected others in the building process, such as Peab as a contractor when errors in elements or delays occurred, the internal changes made did not interfere with established ways of working in the building process. Since no changes were made to the interface between SBE and other actors in the building process, it was possible to build new organisational competence within the organisation without being dependent on conditions beyond SBE’s own control.

Application of a semi prefabricated structural system did not imply any changes related to the interface between Peab and SBE. Even though the factory was new, the products were familiar to both Peab and SBE and the two kept their normal division of work in the Brunnshög project. This was said to be connected to the traditional division of work between the contractor and the building element supplier, which had its origin in the custom for applying cast in situ structural systems, i.e., the contractor handles design and assembly on site. For semi prefabricated systems only the manufacturing of the semi prefabricated parts has moved to the factories. Even though transfer of responsibility for design and assembly of the structural system were seen as a potential way forward, it was not considered feasible given prevailing business conditions. Assembly on site was said to be one of the more profitable parts of the process for the contractor. Changing division of work was considered a desirable future change, but it was not considered necessary for the chance to benefit from the products produced by the new factory. There were no incentives currently to make efforts to change embedded knowledge and action related to the division of work between Peab and SBE. The factory in itself was not a facilitator for such change.

5.2 Concluding discussion
Based on the findings, which were summarised above, identified facilitators and barriers are discussed here. As the facilitators and barriers were identified in the context in which they occurred, they must also be interpreted in this context to allow for understanding of how they worked. This study has shown how organisational context, content of change and the change process interrelated and formed the outcome of the industrialisation effort during the time of the study. In this case, ideas about achieving fundamental change in a company were constrained and turned into
a few local attempts. Identified facilitators and barriers shed light on how this occurred.

The studied industrialisation effort did not start spontaneously. It was triggered by facilitators. Some facilitators were created deliberately to start a change process, while others emerged as a result of efforts to overcome emerging barriers during the course of the process. Barriers were revealed during the course of the process, as a result of the content of the change and/or how the change process was conducted. The purpose of the change was in some of the studied cases transformed and in others fulfilled as a result of the process and the context in which it took place.

A condition that was found to influence whether the desired effect of the change could be achieved or not, was control over embedded knowledge and action that influenced a certain prevailing behaviour. Control was found to affect the opportunity to make all changes necessary to be able to achieve desired effects with the change. Existence of control worked as a facilitator and lack of control worked as a barrier. The area of control related to the individuals and teams handling the specific changes. Being in control influenced their ability to incorporate the change into their work and build organisational competence, as in the case where VP was introduced. Lack of control made them make the best possible temporary adaption of ways of working to be able to handle the change, as in the Folkparken project where a new type of structural system was introduced. This finding is also likely to be applicable to companies, similar to Peab and SBE aiming for similar changes.

The PGS project was meant to create a new building system that would contribute to reduction of production costs by 30%. Facilitators that triggered the process within the PGS core team to start were top management decision about allocating resources and availability of motivated people. This allowed for a knowledge creation process to start within the PGS core team. Ability to integrate individuals’ knowledge, a common knowledge base and common language kept the process within the team going. A barrier that delayed the process initially was individual team members’ different interests in different types of building systems. Since there was no initial agreement on which type of system to go for, focus for the work was perceived unclear during the first part of the PGS work. This barrier was overcome when the team during the course of the process came to an agreement, based on an evaluation of different systems.

Barriers related to the PGS project’s interaction with Peab’s and SBE’s organisations were revealed as the project made efforts to initiate collaboration. The PGS way of working implied sharing information in a way that the organisation was unused to
and reluctant to. It also implied a way to create change that was unfamiliar to the organisation. The existing organisational structure with its distribution of authority allowed for individual contracts managers to deny the PGS project access to daily work. No efforts on the appropriate management levels were done to establish collaboration between PGS and the target organisation. As a result the PGS project became relatively isolated. To overcome these barriers, PGS had to adhere to establish ways of creating change and to limit its change work to what the contracts managers and their teams found feasible to do.

Instead of leading change towards the development of a building system which could contribute to reduced production costs by 30%, the project could only observe and analyse daily work. With other words, the organisational context in terms of embedded knowledge and action formed how the change process could be conducted, which in turn transformed the content of the intended change. The change process did not influence the organisational context in the intended way. Instead the organisational context formed the change process and its content, which led to that intended changes could not be achieved.

Top management claimed that PGS was a highly prioritised project. Despite spending resources in terms of money and time on the project, the established organisational conditions were able to shut the project out of daily work. The PGS project therefore became more of a symbol for strong action towards industrialised house building than a leader or catalyst for change during the time of the study. Such symbols may be of publicity value, but there is also a risk that members of the organisation lose confidence in change efforts.

In the building project Folkparken, a building system which was aimed at forming the basis for reusable solutions was introduced. The change was triggered by SBE’s need to sell its products, and a contracts manager team’s desire to create a structural system with solutions that could be reused in future projects. An economic subsidy and the authority to make the decision to go for this particular structural system in SBE’s factory in Uppsala and in Peab’s contracts manager group facilitated the process. The process kept going through the team’s ability to combine individuals’ skills, a common knowledge base and a common language.

However, there was a barrier that prevented the team from making necessary changes to be able to fully benefit from the prefabricated system. This concerned that it was not within the teams control to create required conditions, such as decreased requirements on profitability, to allow for a learning process to take place, where a new building process could be properly developed. Therefore, instead of making the
first move towards developing a system with reusable parts, temporary adaptations of normal ways of working were made to be able to handle the new technology. Thus, embedded knowledge and action i.e. the organisational context limited how the change process could be conducted. Instead of altering the embedded knowledge and action, the change process had to be adapted to its conditions. This altered the intended content of the change.

In the building project Brunnshög, Visible Planning, VP, was introduced to improve performance during the detail design stage. The change was facilitated by a contact between the contracts manager and the external consultants working with the PGS core team. It was also within the contracts manager’s authority to make the decision to introduce VP. The team’s ability to combine individuals’ common knowledge base with the external consultant’s expertise on VP as well as their common language kept the process going. A negative attitude towards the new method was a barrier that was overcome by insisting on giving the method a try. Once good results emerged, the attitude was changed. In this case, it was within the team’s control to make necessary changes to allow for benefiting from VP. No changes that were outside its control were required. Here, embedded knowledge and action also formed the change process but it did not transform the intended content of the change. The change process was able to influence embedded knowledge and action to fulfil the intention with the change.

The investment in SBE’s new factory in Katrineholm was a response to a market demand for decreased production costs for housing and desire to rationalise housing production within the company. Top management’s decision to go ahead with the investment facilitated a process where Peab group staff could make use of internal skills as well as external skills to design and construct the new plant. The process was facilitated by top management’s authority to decide about the investment and the staff’s ability to combine and access necessary individuals’ skills to design and construct the plant. The new factory and its work organisation were designed to produce the same products and have the same role in building projects as previous plants and their organisations. This facilitated the internal work with building up new organisational competence in the factory, since there was no dependence on conditions beyond SBE’s control, such as changes in other actors’ organisations.

Here the content of the change and the change process were compatible with embedded knowledge and action. The new factory and its work organisation was fitted into the prevailing pattern in terms of producing familiar products and not changing SBE’s role in the building process. In other words, the content of the change and the change process were formed to fit the organisational context in which
they took place. Even though there was work left to do by the end of this study, SBE was in this way in control of making necessary changes to benefit from the new plant. However, fitting the change into the prevailing pattern in the way it was done here did not automatically solve the problem with high production costs caused by how the building element supplier and the contractor collaborate. This is further discussed under 5.2.1.

While the local efforts led to that daily work changed significantly for some people and that people gained new experiences and insights, the effect on the overall target organisation was rather small, at least as seen from visible changes in ways of acting over a two years period. The new factory in Katrineholm implied significant changes for SBE-staff, but for Peab as a whole its impact was limited. Efforts made by the PGS core team and efforts made in individual building projects led to new insights for the people involved. For storing and spreading gained experiences, good as well as bad ones, the chance for individuals to re-use them in coming projects is important.

Is the outcome of Peab’s industrialisation effort during the two years of the study to be considered as industrialisation according to what is meant by this term in this thesis? Industrial house building here is seen as a development state which can be considered as state of the art and the organisational competence to make use of this state of the art equipment, knowledge etc, to fulfil the organisation’s goals.

It is to be considered industrialisation in local independent units of the organisations, when in this case VP and the new factory can be used to contribute to fulfilment of the goals for these units. For these local industrialisation efforts to be considered as part of industrialised house building, they also need to contribute to fulfilment of goals at building project level in collaboration with other actors. Visible planning as applied in the Brunnshög project, qualified for this. SBE’s new factory contributed partly to this in the Brunnshög project by supplying elements of higher quality, such as improved surfaces, than those from the old factory. Its modern production system also has the potential to contribute to reduced production costs for building elements. However, it is not obvious yet how this state of the art factory can be used in combination with organisations, such as Peab, with different needs, and contribute to the fulfilment of project goals.

What can be learned from this? To achieve a desired change that does not happen by itself, facilitators are needed. Findings point to the importance of competence to create and to managing facilitators to start and keep a change process going. Facilitators that trigger change processes to start, affect where change occurs. Is it
enough to trigger the process to start or will further facilitators be needed to keep the process going? Will the change spread automatically or will further facilitators be needed to spread it? If a specific result from the change effort is expected, attention has to be paid to these questions. Thus, creating facilitators to achieve desired change is a challenge which requires competence. It may well be more than a one off task in the beginning of a change effort. It can be continuous strategic work that involves continuously creating and maintaining facilitators to overcome emerging barriers during the course of the process.

The competence to create and manage facilitators includes being familiar with the specific conditions for change implied by the organisational context in which it occurs. It also includes knowledge about who is in control of creating appropriate facilitators for a specific type of change. The studied case concerns project based organisations with decentralised decision making structure and their features that influence management of facilitators for change. As shown by the findings, it may be possible to decide about applying a new technology in a building project, but to allow for benefiting from it, facilitators which the building project cannot create may be required.

The area of control is an important key to understanding why people behave in a certain way while pursuing changes. It may seem as if they are ignoring to adhere to changes, while they in fact are acting in the most feasible way given the organisational conditions they face and are able to influence. An example of this is the Folkparken building team who deliberately omitted to change the timing of a key decision. This project showed that even if it is within the control of an organisational unit to decide about making a change, it may not be within its control to make all necessary changes to benefit from it. Area of control is also important to consider when an individual, a team such as PGS, etc is given the task to conduct or lead a change effort. If the changes they are asked to manage are outside their control, their efforts, ambitious as they may be, are not likely to lead to desired results.

In practice, while pursuing changes, it may be difficult to distinguish barriers which require changes outside one’s own control from those that can be overcome with increased experience. Therefore, it is probably necessary to reach a deadlock or step on mines once in a while in search for a suitable way forward. Experiences from such efforts may be valuable for creating suitable conditions for future efforts. It may also contribute to increased knowledge about why things are done the way they are in an organisation. Furthermore, conditions may change and things that were beyond one’s control yesterday may be within it tomorrow and vice versa.
Management of facilitators is also important for spreading, storing and reusing changes. If for instance, a facilitator is created to conduct a specific change in a building project, this does not automatically mean that a sustainable change has occurred. To store, spread and re-use gained experiences from such a project, conditions need to be created since they do not exist naturally in such organisations. This is in line with literature and it was found to be valid for changes made in Peab. Other similar construction companies with similar organisational contexts are likely to face similar problems.

In cases where there are conditions that trigger a change effort to start in a central unit or in a specific change project as PGS, in a decentralised construction company, there may not be conditions that trigger spreading it to local units. Depending on the purpose of the change, different conditions for spreading it may be needed. The PGS project and its situation during the time of the study exemplified this. There were facilitators to create knowledge within the core team, but there were no facilitators to allow the PGS project to contribute to creating change in the target organisation. Facilitators which for instance had allowed for integrated knowledge creation with counterparts in the organisation might have helped to avoid isolation. This was what the PGS core team desired, but was not achieved during the time of the study. No efforts on the appropriate management level were made to change the situation.

Facilitators for change that adhere to one actor of a building project may trigger a change process in this specific actor’s organisation. To be able to benefit from this change in a building project, with other actors, further conditions for change that relate to several actors may be needed. SBE’s new and modern factory in Katrineholm is an example of this. While it has the potential to rationalise production of prefabricated building elements, it does not necessarily contribute to improvements on a project level. Many of the problems which are experienced when a contractor like Peab and a supplier like SBE collaborate depend on difficulties to combine their preferred ways of working. The new factory in itself does not solve these problems as will be further discussed under 5.2.1.

Conditions for change in SBE and similar companies are similar to those in Peab in the sense that changes that do not happen spontaneously need to be triggered to get started. Creating facilitators for change in one production plant does not mean that the change spreads automatically to other plants. If spreading is desirable, facilitators need to be created for this purpose. For instance, the changes made in SBE’s factory in Uppsala were not spread automatically to other factories. For storing and re-using made changes, the conditions differ between companies like SBE and companies like Peab. In an organisation such as SBE, where knowledge and action is embedded in
physical equipment to a larger extent than in Peab, changes can be made by altering factory machinery. Such changes may thus be stored in the physical equipment to a greater extent in SBE than in Peab. This in turn allows for re-use.

To summarise, when desired changes cannot happen by themselves, facilitators must be created. These need to be managed in a way that allows for overcoming emerging barriers, if any. Management of facilitators requires knowledge about the specific organisation’s ability to change. Sometimes barriers may not be possible to overcome such as when it is outside the control of an individual organisation to change something, such as a law or industry practices. In such cases, the way forward may be to refine the content of the change and find new facilitators to keep the process going. Since many of the studied ideas for industrialisation were found to be beyond the control of the individual construction company, it is worth considering how such ideas can be refined to allow for contributing to improvements. This concerns for instance the desire to develop longer relationships with other actors.

The case study showed that organisational competence could be achieved as a result of some changes, while in the case of others the change process was interrupted by barriers and organisational competence could not be achieved. Based on what was achieved in terms of changes and identified facilitators and barriers related to these during the time of the study, some issues for achieving improvements with the studied changes emerge.

5.2.1 Combining actors of different types

The study has pointed to some issues related to combining a contractor like Peab and a building element supplier like SBE in a building project. Their respective preferred ways of acting to achieve profitability do not seem to be fully compatible. Peab, the publisher, works on a project basis and combines various actors to conduct the project task. System embedded knowledge and action plays an important role for management of several independent actors to conduct projects which includes tasks that cannot be fully specified in advance. SBE on the other hand, the manufacturer of bespoke products, produces small series of products on direct order from its customers. Production takes place in its permanent organisation where capital/physical embedded knowledge and action are important.

Peab’s way of working includes concurrent emergence of product design and production process. SBE’s production process is predetermined and product specification is required in due time to allow for production in the factory to start on time. Furthermore, Peab sometimes needs to make changes to product design and production process during the course of the project due to customer requirements or
unexpected events. SBE prefers continuous production and as few changes as possible to allow for efficient production.

At the beginning of the study, before the studied industrialisation efforts were made, Peab and SBE pointed to problems related to their way of working. These were believed to be overcome by a standardised prefabricated building system concept and an expanded role for SBE. Furthermore, longer-term relations with other actors were also seen as part of the solution. During the course of the study, some attempts to do this were made. These pointed to issues related to combining companies of Peab’ and SBE’s types.

Peab and SBE both considered coordination of actors and their work, in particular during the design phase, to be a problem that had to be dealt with in order to improve performance. SBE staff pointed to the necessity of solving this issue to be able to make economic profits at all from using prefabricated structural elements. Timing of decisions and changes during the course of the building process were considered as necessary to deal with to be able to benefit from prefabricated structural systems in the building process. In the building projects Folkparken and Brunnhög this was dealt with.

In the building project Folkparken, a fully prefabricated structural system was tried out for the first time. The team finished the detail design stage earlier than what they would have done normally, to allow for production of the building elements to start in due time in the factory. Since the technology was new to most of the team members they had to spend more time than normal on the design stage. However, the actual decision to use this particular building system was taken at a stage which was considered too late to be feasible for the product and the process. This occurred since Peab’s project team stayed with its normal way of performing its work and dealing with uncertainties concerning production costs. They did so since there were no conditions that triggered a changed timing of the decision and no obvious other way to deal with uncertainties.

By applying the fully prefabricated structural system, the building project Folkparken aimed at starting the creation a building system with certain standards. The team wanted to build in experiences into the system to allow for re-using and improving them successfully. In this way, it was believed that the building process could be more predictable and that the wheel did not have to be reinvented in every new project.

However, it was found that in this project, established ways to handle uncertainties on the construction site were changed at the same time as predictability in the process
decreased. This in turn led to increased uncertainty, e.g. increased costs due to unexpected mistakes. This became obvious during assembly on the construction site. The team on the site was not able to correct mistakes that had occurred during design, as would have been possible, at least to some extent, with a cast in situ system. Alternative ways to deal with such uncertainties, that traditionally are taken care of on the site seemed to be lacking. Furthermore, the team was not able to take action when deliveries of building elements were delayed. Similar problems occurred in the building project Brunnshög, when building elements included mistakes and were delayed.

Even though these two projects were exceptional since they were first tries for the structural system supplier, it was claimed by Peab staff that mistakes and delays often occur in these types of projects, also with other suppliers. SBE pointed out that such delays and mistakes occur due to the lack of coordination of actors and their work during design. Thus, it seems as if the use of prefabricated structural systems in these types of building processes and organisational contexts may cause similar problems as they are meant to solve. Predictability decreases for both parties, instead of increasing. For the contractor, it decreases since it is no longer possible to handle unexpected events and mistakes according to established ways. For the system supplier it decreases since late decisions and changes can occur at any time during the process.

This is not to say that prefabricated products cannot be used in building processes such as those performed in the organisational context provided by Peab and SBE. Prefabricated products are useful and they are applied successfully in the building process already. The question rather concerns the degree of prefabrication that is feasible in such a process and context. As long as only standardised prefabricated components are used, the supplier will be less affected by late decisions and changes that are part of the contractor’s concurrent product design and production process development. In a similar way, the contractor has to adapt its timing of decisions and changes to requirements set by the supplier less in such a case. As soon as the design of the prefabricated product is affected by the contractor’s concurrent design of product and production system, the supplier of the prefabricated product is exposed to uncertainties implied by late decisions and changes. In a similar way, the contractor is exposed to uncertainties related to being forced to make decisions at a certain point in time, restrictions of changes and inability to handle unexpected events and mistakes on the construction site. Finding the “right” degree of prefabrication in such a case is a challenge for industrialised building where prefabrication is an ingredient.
In the building project Brunnshög, VP was tried out to improve coordination of actors and their work during the detail design stage. This project was different to the Folkparken project since the project team members who took part in the detail design stage knew each other and had done similar projects together before. Furthermore, this project applied a structural system that was used normally within this contracts manager’s group. Therefore, the decision about applying this particular structural system was taken at an early stage of the building process. VP turned out to work well in this context and it contributed to improved performance of timing and coordination of work during the design stage.

Is VP the remedy that can solve the issues related to coordinating actors and their work during the design of buildings? Would it have helped in the building project Folkparken? During the detail design stage, VP might have contributed to better coordination of actors and their work and in this way saved time and made the process less stressful. However, VP would probably not have made the contracts manager and his team decide about applying this particular system earlier. This decision was taken in accordance with established ways of acting to handle uncertainties. It concerned action and knowledge embedded at the system level, for instance in organisational design and decision making structure, industry standard contracts and tendering systems. Changing such system level embedded action is beyond the control of the building project team. VP cannot contribute to such changes either.

Thus, VP worked well in a context where necessary changes could be made to allow for benefiting from it. However, it cannot solve all potentially problematic issues in the relation between such companies as Peab and SBE. It can contribute to improvements during the detail design stage, at least in a project context as that of the Brunnshög building project. However, the method does not change the way Peab and SBE need to act to become profitable. A contractor still needs to be able to handle unexpected events that may occur at any time during the process, sometimes probably by making late decisions and late changes. The supplier of prefabricated building elements still needs to start manufacturing at a certain point during the process to allow for assembly on site to start in due time. The example of the late decision in the building project Folkparken illustrated this. Neither does a new factory alone, such as SBE’s in Katrineholm solve this issue, even though its production system is more flexible than those of the older factories in terms of time to change production from one type of element to another. Late decisions and late changes will still be problematic to handle.
Specific Peab product standards to be used across the organisation were desirable to develop according to PGS. The effort in the building project Folkparken aimed at pointing out standard solutions to be re-used in coming projects. However, during the time of the study, the work with this had only just begun and there were not yet any results to be seen from this. Nevertheless, product standardisation was argued to be a way to reduce the risk for mistakes in design as well as assembly. Standards are also favourable for SBE since it would allow for larger volumes of standard parts. Can standards help combining such different types of companies for the purpose of building houses?

It may help to a certain extent, since it would support re-use of experience across projects and increase predictability where standards are used. This would be beneficial to both Peab and SBE in their collaboration. But it is a long way to go for a contractor with numerous contracts managers and site managers to create and spread product standards. More, can a too high degree of standardisation have the opposite effect, i.e. increased uncertainty since it reduces the flexibility for taking care of unexpected events in the individual building project? The need for individual solutions in building projects has been pointed out as the reason for standardisation of components rather than systems has emerged in construction. Too extensive standardisation was also mentioned as one of the reasons for mass housing not meeting requirements in individual building projects during the 1960s. The PGS core team said they were aware of this and aimed for a solution that would be flexible enough. During the two years of the study, this issue was discussed, but not solved.

For a company like Peab, developing standards also includes developing organisational competence to create and manage such standards. Today the organisational competence to design housing mainly resides in the individual project teams and their cooperation with other actors. Creating product standards therefore probably also includes developing such competence on some other coordinating level in the company. A great challenge related to this would concern not losing one of Peab’s strengths, which was said to be the ability to make decisions and act quickly on them in individual building projects.

5.2.2 Market related issues
Changing the division of work between the structural element supplier and the contractor along with longer term relations were seen as ways to benefit from the use of prefabricated structural systems with certain standards while overcoming the problems related to coordination of actors and their work and lacking re-use of experiences between projects. This would include that SBE developed into a system supplier instead of an element supplier, as was its original role. Being a system
supplier would include taking on a larger responsibility for design and also assembly on site, in addition to manufacturing. This would include transferring skills which are now housed by the contractor, to the building system supplier.

Such a change may contribute to improvements, since it could make storing and re-use of experiences easier as pointed out by SBE and Peab. The system supplier would be able to store gained knowledge in its products and physical equipment as well as in individuals. This can be re-used more often than would have been the case for the contractor, who maybe seldom uses such products.

These ideas for change point to a striving to make the building process more like a permanent flow process. It is interesting to note that there is a trend in industry in general towards increased use of temporary organisational solutions (Ekstedt 2002). Hierarchical organisations are changed and project organised activities are combined with permanent organisations. There is an increasing number of people working in project based organisations, organised in a similar way as construction companies. Furthermore, experienced project leaders from the construction industry are often recruited to manage projects in other sectors. One explanation of this trend is said to be new consumer patterns. Customers wish to influence design of products which in turn are becoming more advanced and complex. To meet such requirements different skills are combined in projects. Such a project team can constitute staff from the R&D department, subcontractors, consultants and customers.

Construction is already a project-based business for exactly the same reason. Even though it has drawbacks, current ways of organising and working are adapted to allow for combining actors with the specific skills needed for a specific project. Allowing for product design and production process to develop concurrently, often in collaboration with the customer allows for customer requirements to be met during the course of the process, which often takes place over several years. Will such changes as the PGS ideas lead to improvements? Will construction companies and their projects be able to meet customers’ requirements and varying site conditions by making such changes?

Moving work from the construction site for manufacturing of entire building systems in factories may make sequencing of work better. It can also improve working conditions for the workers. However, moving work from the sites to factories and increasing the responsibility of the work for the supplier of the prefabricated system does not change the external conditions faced by the building project. Different customer requirements still have to be met and site conditions can vary significantly and in many ways between different places. Can the building system supplier handle

flexibility and uncertainty in individual building projects through an approach which is more like factory based flow production? Can its products and production systems replace the combination of different actors’ skills? Or will the varying requirements between projects force the system supplier to start working at a more project-based level? In that case, do these ideas just imply moving current problems from one actor and one place to another actor and another place?

Another market related issue concerns the possibility of achieving volume production for the manufacturers of prefabricated housing systems. Is the Swedish housing market big enough for several producers of company specific prefabricated housing systems? To reduce production costs and for the producing companies to be profitable certain volumes are required. The number of completed dwellings on an annual basis in Sweden is currently about 35,000. Of these about 22,000 are confined to multifamily housing. How many of these are suitable for these types of prefabricated systems? More, where are the projects located that may be suitable? Does a long distance from the factory make it too expensive due to costs for transports?

Since more than one Swedish construction company has established a factory for prefabricated housing systems, and the Swedish housing market is quite small, competition is likely to be hard. Do these companies count on creating a larger domestic market by offering a product that costs less? Or are they counting on the international market for export?

5.2.3 Relation between the permanent and the temporary organisation
While there are obvious reasons for construction companies to continue their search for improved housing production methods, what way to choose is not so obvious. Based on what has been found in this thesis, the relation between the permanent and the temporary organisation in a construction company emerges as a central issue for efforts aiming at improving performance. On the one hand, the current way of working and organising implies drawbacks such as difficulties to co-ordinate actors and their work and also for re-using experiences from one project to another. On the other hand, the temporary organisation is flexible and allows for combining actors with specific skills for a specific project. The ideas for industrialisation which were seen as ways to overcome the drawbacks by the staff in the studied company have been questioned here. It has been pointed out that it is not entirely within the individual construction company’s control to pursue them. Furthermore, they risk causing similar problems as those they are aimed at solving, since they may reduce flexibility.
Generally, a permanent organisation is better at storing and allowing for re-use of experiences, while a temporary organisation is better at adapting to specific and temporary conditions. In Peab, the permanent organisation provides support and some coordination between the temporary projects. In the temporary projects, the core business is conducted. The temporary projects combine actors to conduct individual building projects. It is difficult for such a permanent organisation to store knowledge in a way that allows for the projects to re-use it in a feasible way. Since almost every project constitutes a new constellation of actors, it is easier for these actors to rely on the system embedded knowledge and action which has developed over time, even though it includes drawbacks. The system embedded knowledge and action which stores gained experiences and makes collaboration of independent actors easier, is not entirely in the control of the individual actors. It refers to the Swedish construction industry, and is therefore difficult to change for an individual actor.

An effort was made to increase the responsibility for design and assembly of the structural system for SBE, the supplier in the studied case. In SBE, the permanent organisation houses its production plants, while the temporary consists of individuals taking part in building projects. While this allows for easier storing and re-using of knowledge, it does not necessarily lead to improved performance in the building process if knowledge is stored in the permanent parts of such a company, as was discussed above.

This points to that an important challenge for industrialised house building for a construction company is to search for ways to provide continuity to the temporary organisation without violating its need to be flexible. It concerns the roles of the permanent and temporary organisations. How can these roles be developed to improve performance without losing the strengths of current roles and current ways of organising and working? Providing continuity does not necessarily have to be product standardisation or central guidelines imposed on the temporary organisation by the permanent organisation. Perhaps knowledge can be embedded in the permanent organisation by developing its competences in supporting temporary projects, rather than aiming for storing knowledge in it that is now held by independent project actors. Perhaps a permanent organisation that provides temporary coordination between projects and support to temporary projects on request is a better way to go?

5.3 Discussion on applied method

This study contains a description of a case in company, which is based on stories told by different people and events that I have experienced myself. This means that
highlighted events and quotations are my interpretation of what was central for the process I have studied. In chapter 2 I have described how this was handled during the research process. My ambition has been to present a “fair” picture of what happened and why during the time I followed Peab’s industrialisation effort. This was made through providing detailed descriptions of highlighted parts of the process based on different sources of data collected over a two year period, and by letting those involved in the process see my descriptions. I have also tried to distinguish between my reconstructions of what others have told me and my own statements. In this way, I hope that a reader can agree or disagree with my results and conclusions.

As described in chapter 2, I collected part of my data through observations. I observed meetings and visited factories and construction sites. During these observations, I also talked to people to find out about their views of the activities going on. Even though my role as a researcher did not involve making efforts to interfere in the process I was studying, I did socialise with people during these observations. Fangen (2005) argues that such a way of acting is necessary for a researcher to be able to collect reliable data. Not socialising with the people who are being observed, may cause an awkward situation where they become stressed by the quiet spectator. This may affect the studied activities in a negative way according to the author. While I did not make deliberate efforts to influence the process I was studying, it is difficult to say how my presence affected individual people’s thoughts. While my presence may have influenced some individuals’ thoughts, I did not notice that my presence affected the course of events during the time of my study.

The scope of a study like this is also worth discussing. Within Peab, there were also other efforts going on, which also aimed at certain changes. For instance, the purchasing department continuously worked to improve purchasing agreements and procedures. At the divisional and regional levels, there were efforts ongoing that aimed at improving re-use of experiences from project to project. Why did I choose to study the things I did and would my results have looked different if other things would have been included? I chose to limit my study to events and efforts which were associated with the PGS project. This was considered as a natural limitation, and it was also practical. I could get access to data since I attended meetings and met many of the involved individuals. It was also easier to get access to building projects since PGS already had access and the projects were in this way already being studied. Furthermore, the resources for my project were limited and this was also a reason for making limitations in the scope. The results and conclusions I have presented based on the things I studied are valid to the context in which they took place. Results from studies of other efforts to make changes in Peab are other contexts, and my results and conclusions are open to comparisons with such studies.
As a result of how I choose to limit my study, I collected data from people who more or less believed in the PGS industrialisation ideas. Through the people I talked to I found out about some sceptical views on these types of ideas and change efforts. Would the findings from study have been different if I had expanded the data collection to those who chose not to participate in the PGS project because they did not believe in it? The presented views of how to improve performance in Peab’s and SBE’s would most likely have been different. However, it would most likely not have changed the identified facilitators and barriers. The sceptical people’s views are included in these already, by their ways of isolating the PGS project. By denying access to building projects and by staying away and not showing interest their scepticism is captured.

When studying an ongoing process, the chosen end point is worth consideration. In one way or another, most studies has to end. I choose to finish data collection for this study during the autumn of 2004, when the PGS project changed project managers. The change did not mean that I was not welcome to continue studying the project, but it seemed a natural ending point of the phase of the change effort that I had been studying. There were also practical reasons for choosing this particular end, as is in many others cases (Lincoln and Guba 1985). In my case it concerned availability of resources for my project and also that I was about to start my maternity leave.

The end point of a study of an ongoing process naturally opens up questions about what happened afterwards. Would my results have looked different if I had continued to study Peab’s change effort? If yes, can my presented results and conclusions be trusted? There cannot be a definite answer to the question whether my results would have looked different, since it depends on many things, such as what extra time span we are talking about. It also depends on circumstances in a world that is not static. The results and conclusions I have presented here are valid for the context in which they were found. I have aimed for a detailed enough description of the case which allows for comparison with other contexts. Results of a study of Peab’s change effort and the PGS project during a different period of time is another context. My results and conclusions are thus open for such comparisons.

5.4 Recommendations for future research

This thesis has dealt with the issue of industrialising, or making specific changes in an individual construction company. However, it is obvious that to make changes in ways of working or organising involves more than a single company business in the context of construction. Independent actors work together in temporary projects and
they rely to a great extent on commonly developed practices, or system embedded knowledge and action, to collaborate. Changes that one actor wishes to pursue may well depend on other actors’ will to make corresponding changes. Furthermore, some changes may even rely on further changes that are outside the control of the actors and instead rely on changes in education systems or taxation systems. Therefore, an interesting topic for future research would be the ability to make organisational changes in construction networks or on an industry level.

This thesis has also pointed out the issue of the role of the permanent and the temporary part of a construction company and a building element supplier. It has proven difficult for the permanent part of a construction company to store knowledge for re-use between projects. Instead, the skills of individual actors together with industry practices play an important role for carrying knowledge between projects. A building element supplier on the other hand can store knowledge in products and production equipment for re-use. However, it is not obvious that embedding knowledge in the permanent parts of a building element supplier’s organisation or a product is the remedy to problems experienced in housing production (see section 5.2.1). Future research should therefore investigate the role of the permanent organisations within different actors’ organisation in relation to the role of the temporary project organisation on a network level.
In April 2006, I met with the PGS project manager to find out what had happened to the project since I finished my data collection. Last time we met was in December 2004, just before my maternity leave. At that time he was still one of the core team members. During the spring 2005, he accepted the job as project manager when the previous project manager was offered another job.

He told me that by the end of 2004, Peab top management decided to close the Uppsala factory. Since the building system, which the PGS-core team had chosen for further development was to be developed in collaboration with the Uppsala factory, this caused problems. For some months the PGS project's future was insecure. A turning point came when he and the project manager (his predecessor) started to discuss the possibility to make a restart. Inspired by the literature, they came up with the idea to use an existing building system as a base and develop it further by using a modularisation approach. They contacted a Swedish consultancy firm, specialising in modularisation, who agreed to support their work.

Work together with the consultants started during the autumn of 2005. A new core team, with a few of the old members and some new ones was created. The core team consisted of Peab and SBE staff and collaborating architects who were assigned to design houses with the system under development. Furthermore, based on earlier experiences when PGS did not have any clear counterpart or receiver of its work, a reference group was established. This group consists of top managers and meetings were held on a regular basis.

The project manager told me that he and his colleagues had learned from previous experiences that it was necessary to have a unit within the organisation that can manage and further develop the modular system, which the PGS core team was developing. Therefore, a decision about creating such unit had been taken and there were plans to employ staff. Another difference from the earlier way of working, the project manager described, was that the work now deliberately was kept within the project team. The team was strict about what information should be spread to the organisation at what time.

At the time for my meeting with the project manager, there were plans for realisation of the new building system which included a full scale test of prototype modules in a location adjacent to SBE's factory in Katrineholm. Following these tests, the system or parts of it, were going to be used in a real building project. One specific contracts
manager group was appointed as pilot team. A close collaboration between PGS and this contracts manager and his team was being established.

In August 2006, when I spoke to the PGS project manager, work was going according to plan. PGS was an established organisational unit and staff was being employed. A test lab for full scale tests of the developed building system had been set up. Pilot projects were parts of the developed building system were going to be tested were also under way.
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