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An analysis and investigation of warranty rework and costs

Case Study of a Swedish Contractor

Master's Thesis in the Master´s Programme Design and Construction Project Management

MUNTADAR DAEBES
OGUZHAN YILMAZ

Department of Architecture and Civil Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
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Department of Civil and Environmental Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

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ABSTRACT

The purpose of this thesis work is to identify the warranty work and aftermarket work that the case company faces. In recent years the case company has met an increase in the warranty work. The master thesis has been carried out in a Swedish contractor and is limited with remarks from warranty inspection protocols and data collection for four apartment projects. The study is based on interviews with senior executives in the case company.

The results in this study show that the three most common defects that occur during the first two years are as follows: cracks on walls/ceilings, cabinet and boxes and doors. This three building parts account for 55.5% of the total number of remarks, based on the warranty inspection reports. The study presents appropriate improvement work to avoid the emergence of the warranty work and to facilitate the follow-up of the warranty work.

The main reasons for warranty remarks are based on several different conditions. The causes can be attributed to moisture-related movements, lack of care and maintenance, assembly errors and lack of product selection. The design phase has the major role when it comes to rework. This in turn led to quality errors to occur. Furthermore, the pressure of time in the construction sector has an impact in the result of quality shortcomings. Construction companies are willing to be done in a shorter time than they really need. This naturally leads to stress at the last stage and leading to shortages at the end of the handover of the residence.

A closer relationship between the internal organization and the site manager is needed to solve aftermarket problems in a more efficient way. Most of the experiences learned from previous project are not delivered inside the organization, it rather stands with the specific person. Therefore, it is important for the companies to gather information and experience from previous project and deliver it to the project organization. Companies should have strategies to encourage further training so that individuals get better knowledge of the working methods. In order to prevent defects and mistakes during the production phase, experienced personnel from the production management should be involved in the early design phases.

Key words: warranty work, warranty cost, warranty inspection, rework, quality, quality defects and cost of quality defects

En analys och utredning av garanti arbete och kostnader
En fallstudie vid ett svenskt byggföretag

Examensarbete inom masterprogrammet Organisering och ledning i bygg- och fastighetssektorn

MUNTADAR DAEBES
OGUZHAN YILMAZ
Institutionen för bygg- och miljöteknik
Avdelningen för Construction Management
Chalmers tekniska högskola

SAMMANFATTNING

Syftet med denna avhandling är att identifiera garantisarbetet och eftermarknadsarbetet som fallbolaget står inför. Under senare år har fallföretaget mött en ökning av garantiarbetet. Examensarbetet har utförts i en svensk entreprenör och är begränsad med kommentarer från garantinspektionsprotokoll och datainsamling för fyra lägenhetsprojekt. Studien bygger på intervjuer med ledande befattningshavare i fallföretaget.

Resultaten i denna studie visar att de tre vanligaste defekterna som uppstår under de två första åren är följande: sprickor på väggar / tak, skåp och lådor och dörrar. Dessa defekter står för 55,5% av det totala antalet anmärkningar, baserat på garantinspektionsrapporterna. Undersökningen presenterar lämpligt förbättringsarbete för att undvika garantiarbetet och för att underlätta uppföljningen av garantiarbetet.

De främsta orsakerna till garantianmärkningarna är baserade på flera olika förhållanden. Orsakerna kan hänföras till fuktrelaterade rörelser, brist på vård och underhåll, monteringsfel och brist på produktval. Designfasen har den stora rollen när det gäller att omarbeta. Detta ledde i sin tur till att kvalitetsbrister uppstod. Dessutom har tidspressen inom byggsektorn påverkat resultatet av kvalitetsbrister. Byggföretag är villiga att bli klara på kortare tid än vad de verkligen behöver. Detta leder naturligtvis till stress i sista skedet och leder till brist vid slutet av överlämnandet av bostaden.

En närmare relation mellan den interna organisationen (eftermarknad) och platschefen behövs för att lösa eftermarknadsproblemen på ett mer effektivt sätt. De flesta lärdomar från tidigare projekt levereras inte inom organisationen, det stannar ganska med den enskilda personen. Därför är det viktigt för företagen att samla information och erfarenhet från tidigare projekt och leverera det till projektorganisationen. Företagen bör ha strategier för att uppmuntra vidareutbildning så att individer får bättre kunskaper om arbetsmetoderna. För att förhindra fel och misstag under produktionsfasen förordas erfaren personal från produktionsledningen vara involverad i de tidiga konstruktionsfaserna.

Nyckelord: Garantiarbete, garantikostnad, garantiinspektion, omarbeta, kvalitet, kvalitetsbrister och kostnader för kvalitetsbrister

Contents

Preface

This study has been conducted on a Swedish construction company which is the final part of the author's master's program in Civil Engineering, Design and Construction Project Management at Chalmers University of Technology. The master thesis fulfils a full-time semester studies, which corresponds to 30 education credits.

First and foremost, we would like to thank our supervisor, Christian Koch, professor at Chalmers University of Technology, who gave guidance and feedback during the study's implementation. We would also like to thank our supervisors at the case company that has enriched the study with advice and dedication.

Finally, we would like to thank all participants and colleagues at the case company who have contributed with valuable knowledge and information to conduct this master thesis.

Göteborg June 2017

Muntadar Daebes

Oguzhan Yilmaz

Notations

Aftermarket	Internal organisation, with main focus on aftermarket
CSS	Customer Service System

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1 Introduction

In this part an introduction to the thesis will be presented, which include a background followed by the purpose of the project. Furthermore, research question and established limitation of the project will be presented.

1.1 Background

In recent years, the construction industry in Sweden has grown (Statskontoret, 2009). The sale of single-family homes has become a profitable business for some construction companies. However, the significance lies in the property not being delivered without issues in the first place. The pressured construction times have arisen due to the willingness to hand over the project to the customer as soon as possible, which might not turn out as expected. In some circumstances may the property be considered as incomplete (Boverket, 2007). The short-term thinking proves for future problems to occur. Remedying a problem afterwards often costs significantly more than taking the extra time needed to do well from the beginning. Josephson and Larsson (2001), explains that it can be roughly 1000 times costlier for the construction company to repair the error if the customer already have moved into the dwelling. The construction industry has seen an increase in the number of warranty and rework reports related to the lack of quality in buildings (Statskontoret, 2009). Boverket (2007) measured the cost of warranty and rework report to be just over 1.3 Billion SEK during 2005. Furthermore, the cost of time loss due to estimate error and defects for the main contractor was approx. 18 000SEK per unit. The calculation of repairing errors is not included. While for the customer the value was slightly higher, 20 000SEK (Boverket, 2007). Larsson et al. (2002), Josephson and Hammarlund (1999) meaning that the construction companies are reducing their project profits as the rework costs are allocated to cost between 2-6% of the contract value.

Larsson et al. (2002), has investigated and could categorize the causes of rework in the construction sector. The main causes could be related into the earlier stages in the project phase. Larsson et al (2002) means that if there is lack in early project phases, it will in the future lead to deficiencies in the dwelling. Low and Chong (2006), interact about the design phase of the project to be very important. It has a dominant cause for latent (post) defects which could cost the construction company a high amount of capital to repair. Customers will not be satisfied if the dwelling is not delivered properly from the first stage. There are possibilities to detect errors in the earlier stages, and that the companies can prevent extra costs. The possibilities lie in the commitment of the personnel of the construction company as well as in their education and experience (Josephson, 2013).

The case company has, during the recent years, met high warranty costs in the form of quality shortcomings that arise during the warranty period. The case company has during the final inspections few remarks or no remarks at all. However, the significance lies at, quality shortcomings occurring during the warranty period which causes high warranty costs for the case company. Consequently, the warranty work is followed up by an internal organization (aftermarket) within the case company that has the main responsibility to handling the warranty remarks. Often the case company needs to solve warranty works that may be uncertain and questionable on who is

responsible for the error. In order to keep customers satisfied, the case company precedes the work as a goodwill which, in the long-term leads to very high costs. Therefore, an investigation of the current area is required.

1.2 Purpose

The study aims to examine and study the warranty works as well as investigate possible causes of its origin. The study will also show possible improvement work that can be implemented in order to prevent the emergence of the warranty works.

1.3 Research questions

In order to achieve the purpose of the study, ***four*** questions have been formulated. This to illustrate connections between the conducted literature review and the case study

I. What are the most common issues in the aftermarket?
II. What are the causes of the most common issues?
III. What measures should be applied to prevent warranty costs?
IV. In what time period does the case company have the greatest impact in the warranty costs?

1.4 Limitation

This study is

- limited to a Swedish construction company.
- geographically limited to a specific region.
- limited to four residence projects.
- linked to the two-year warranty inspections and data collection from the case company's own database.

2 Method

In this chapter the methodology of the master thesis will be presented. An explanation of how the thesis work has been carried out will also be presented. The chapter concludes with a summary of the approaches that have been taken during this study.

2.1 Research methods

The approaches used in this study were mixed methods which consist of both quantitative and qualitative methods. The quantitative methods have mainly been used to establish warranty inspection reports and warranty costs for entering the amount of data. While qualitative methods emerged in the study in order to understand and interpret the reality of the situation, mainly in the form of interviews and observations.

The choice of research method depends on how much information and knowledge the researcher has received (Stukát, 2005). Educational studies are divided into different categories which usually appear as quantitative and qualitative research. The most appropriate approach may be to use a combination (method triangulation) of different methods that can complement each other. According to Stukát, (2005) a use of both quantitative and qualitative methods may support the study and generate more valid research results and realistic interpretations. Using of the qualitative research method can give rise to quantifying data which creates the possibility of a collection of generic information (Stukát, 2005).

2.1.1 Quantitative method

Quantitative method is a research strategy that emphasizes quantification of data collection and analysis (Bryman and Nilsson, 2011). The method contains a deductive approach to the relationship between theory and practical research that focuses on the examination of theories. The researcher collects large amounts of information and/or data (Stukát, 2005). Thus, the material is analyzed to detect an assumption that is assumed to be applying generally. According to Stukát (2005), in a quantitative research, the results are interpreted using static methods where the focus is on reaching large and representative selections such as survey research. Stukát (2005), mentions that quantitative studies focuses on empirically quantifiable, objective measurements and observations, such standardized test, structured surveys and controlled experiments. However, quantitative studies have difficulty gaining a depth in the survey because the results are broad and general. In recent years, the qualitative research method has taken more places instead of the quantitative method that used to be the dominant method (Stukát, 2005).

2.1.2 Qualitative method

In contrast, qualitative research can be perceived as a research strategy that usually emphasizes words and not quantification during the collection and analysis of data (Bryman and Nilsson, 2011). The method emphasizes an inductive approach to the relationship between theory and exposition, focusing on the generation of theories.

Qualitative methods focus on interpreting and understanding the results produced by the research, based on empathy and social aspects (Stukát, 2005). The data collection is based mainly on information from observations, interviews or similar behavior. Thus, the researcher has the main task of interviewing, observing and analyzing other people to understand the particular case. Deep interviews, open interviews and unstructured observations are considered important tools that play a key role in the implementation of qualitative studies (Stukát, 2005).

Stukát, (2005) points out that the researcher's previous experience and knowledge is judged to be an asset in a qualitative study. This in turn can create a burden for the person who has performed the interpretation of the result. Reliability is characterized by an uncertainty in this method when the low number of investigators prevents the possibility of generalization (Stukát, 2005).

A qualitative approach is often found in case studies where the researcher is studying a special event and using different tools trying to gain a deeper understanding. In order to create a degree of generalisability, the researcher can then describe his case in relation to similar situations. (Stukát, 2005)

2.1.3 Interviews

Stukát, (2005) explains in his book that the interview refers to one of the most common work tools in scientific research. But at the same time he points out that the choice of method should be determined on the basis of the survey nature, not for personal reasons. He also states that it is the author who decides which approach would be most effective in their study to implement an interview/s. Depending on the amount of leeway given by the interviewer to the respondent; thereby there is a better chance to catch up new and clearer information.
Bryman and Nilsson (2011), notes that the use of a recording is preferred for interviews in order to increase the ability to record the respondents' answers in their entirety. Therefore, the interviewer should notify the respondent of the recording as a support for the proper preparation of the interviews.
Bryman and Nilsson (2011), states that the purpose of a research interview is that the interviewer wants to gather information about the underlying purpose of the interview, also known as the respondent. The purpose of performing an interview is that some information is exchanged between the parties (Bryman and Nilsson, 2011). To enable this, there are several different types of interview and the rules that style the degree of implementation. He presents in his book three types of interviews are often determined by degree of their structuring and standardization.

The structured interview is considered one of the most common types of interviews when it comes to use in quantitative studies like a survey interview (Bryman and Nilsson, 2011). The purpose of a structured interview, the questions should be standardized to reduce variation and ensure a comparable compilation of various interviews.
According to Stukát, (2005) the use of standardized and pre-determined interview questions will help to develop an objective situation between the parties and also clarify the asserted answers. He also mentions that the method has the advantage that the interviews are not need to maintain previous skills in interview techniques and can

also be utilized in an interview with a larger group. On the other hand, there are great demands on the design of the questions and answers and have difficulty getting deep into the study (Stukát, 2005). This method lacks flexibility because it is built on pre-defined questions and the answers that are expected.
Semi-structured interviews means that in advance the main questions should be identified and then start asking follow-up questions to get deep information as possible (Bryman and Nilsson, 2011). According Stukát, (2005) in a semi-structured interview is given the ability of interviewers to take advantage of the specific information that occurs at every interview. Respondents may express themselves freely to develop his personal view on the subject. But he also emphasizes the importance of the interviewer's ability and skills of a research area and the type of information that is required of the interview. While the implementation of this method is time-consuming in the compilation phase of all interviews (Stukát, 2005).
In an unstructured interview, the interviewer uses only one list or general questions as a tool (Bryman and Nilsson, 2011). The method consists of open questions with great independence for the respondent to interpret and develop their ideas. Bryman and Nilsson, (2011) notes that an unstructured interview tends to be like a normal conversation.

2.1.4 Literature study

The authors wanted to obtain and deliver a deeper understanding and more knowledge about the warranty work. Literature research was carried out continuously during the entire implementation of the study in order to enhance the objectivity of the research. The theoretical part included a literature study in the form of books and scientific articles obtained from Chalmers library and Chalmers library database. Literature research was conducted continuously throughout the duration of the study to strengthen the objectivity of research. Initially, the authors decided to explore general literature and previous studies to create a picture of the current state of knowledge. Furthermore, the authors focused more on relevant literature to find articles and other literature in the subject area.

The purpose of a review of existing literature is to find out what knowledge already exists and what has been done before (Bryman and Nilsson, 2011). In order to facilitate the exploration, similar stories or events are used concerning the topic chosen to study. A literature review is not just about reproducing or referring to what has been written but also being able to interpret the statement and having a critical attitude to it. Furthermore, the added knowledge can be used as support for the researcher´s own opinions and arguments (Bryman and Nilsson, 2011) .Stukát (2005) emphasizes the importance of the author's ability to make an appropriate and illustrative selection of literature studies and link it to their own problem.

2.2 Evaluation method

In order to increase the study's reliability, the authors have chosen to use a quantitative approach by interviewing key persons at the case company. Respondents seem to receive good knowledge and experience in the subject studied, which indicates good validity. The authors have also used recordings during the interviews to ensure the development of valid and reliable results. The choice of respondents was

done by the supervisor of the case company, which was considered most suitable for answering the questions of the study.

The collection of previous studies in the field has been utilized and a comparison has been made to increase generalizability. The approaches used in this study were mixed methods consisting of both quantitative and qualitative methods. With the purpose of strengthening both validity and reliability, and having a combination of different methods to provide as wide a picture as possible.

2.2.1 Reliability

According to Stukát, (2011) all studies have shortcomings and it is motivated that the researcher himself shows his awareness than that others discover them. Therefore, it is important that the strengths and weaknesses of the investigation must be discussed in detail. According to Bryman and Nilsson, (2011), the reliability is an important criteria that is often associated with quantitative research to check the reliability and consistency of the study. Stukát, (2005) also believes that reliability can be explained by how well measuring instruments are used during the study.

The reliability of a survey method can be verified by repeating the measurement, called test-retest method (Stukát, 2005). The results of both measurements are expected to agree to find that the reliability is good and vice versa (Bryman and Nilsson, 2011). However, the time interval between both measurements must not be too long, people and their behaviour will change constantly. Another way to check reliability is to allow two people to do the measurement independently (Stukát, 2005).

2.2.2 Validity

According to Stukát (2005), validity means how well an instrument measures what is supposed to be measured. He also notes that even if the study is equipped with a great measuring instrument (high reliability), it is not certain to achieve a high level of validity. This may be due to the fact that wrong things are measured in the research. An evaluation of the measurements´s validity has to be taken into account in order to emphasize the value of the study. Thus, Stukát, (2005) emphasizes that validity is regarded as elusive and more ambiguous concepts, but still fundamental to the value of the survey.

Validity often becomes relevant in quantitative research and assesses whether the conclusions generated from an investigation are linked together or not (Bryman and Nilsson, 2011). The researcher needs to chart that the validity is high enough, where the measure seems to reflect the content of the current term.
According to Bryman and Nilsson, (2011) there are two forms of validity, internal validity and external validity. Internal validity is about how causal relationships appear between two or more variables at the conclusion of the study. Internal validity can be resolved by asking other people if the measure, according to their opinion, seems to capture the term. Furthermore, the researcher could check interpretations with those interviewed or observed, stay in place for a long time, as well as ask colleagues to comment on the results of the study (Bryman and Nilsson, 2011). External validity depends on the extent to which the results of a study can be applied

in other circumstances than the specific case. According to Bryman and Nilsson (2011), a case study has difficulty being generalizable because the researcher chooses a case study to go deep within a particular situation. One way for a case study to be representative is to use multiple cases that concern the same area.

2.3 Implementation of the study

As a starting point, the authors have had access to the case company's internal documents throughout the duration of the study. The collected internal documents consisted mainly of warranty inspection reports, booked warranty costs and the case company's own database, called Customer Service System (CSS). The selection of the four studied projects in this study took place in consultation with the supervisor of the case company. The reason for the selection was based on the project's high warranty costs and the availability of data. The authors also want to note that data collection of internal documents has required a lot of effort and time as the documentation was hard to get.

Interviews were carried out with twelve key persons in the case company. In this study, a semi-structured form was taken by the authors to conduct the interviews. This means that some questions were identified in advance, while others might not be fixed in order to develop a better understanding of the current area. The technique gives an opportunity for the researchers in order to ask follow-up questions, at the same time it has a structure that can be followed. Thereby the authors decided to perform the interviews with a relatively low degree of structuring and standardization. Due to the increasing ability of the respondent to develop their answers and get detailed picture of the problem.
The author began by explaining the purpose of the study for the respondents and what it is supposed to achieve. The author also announced respondent to minimize the risk of loss of data and to accurate representation of the interview could afterwards by using recording supplement completed notes. Furthermore, the authors informed respondents that the collection of materials and data would be anonymous. This means that during the implementation of the study, only the authors had access to the project's name. Then in chapter empirical material, the projects have been presented with reference to a letter and a title abbreviation of the respondents in the extent that it remains confidential.
The selection of respondents as considered appropriate to answer the study's research questions, was done with support of the supervisor from the case company. The respondents obsessed with good professional experience and represented different job roles. The authors have been in contact with staff in production such as project managers, production managers and a project engineer, as well as quality manager and aftermarket staff such as aftermarket manager, a project manager and three service leaders.

2.3.1 Data collection

The collected data mainly consisted of warranty inspection reports as well as documentation and data from the case company for four projects. The authors have chosen to go the route via warranty inspection because the warranty inspections are carried out by an independent surveyor thus he or she has an objective view of the project. The theoretical part is based on a literature study consisted of various books and scientific papers, retrieved from Chalmers library and Chalmers Library database. Furthermore, data has been collected from the case company's own database called Customer Service System (CSS), where the customer can either call or mail to about issues that occur during the responsibility period.
Interviews were also carried out with twelve key persons in the case company. In this study, a semi-structured form was taken by the authors to conduct the interviews. This meant that some questions were predetermined in advance, while others might not be fixed in order to develop a better understanding of the current area. This technique gives an opportunity for the researchers in order to ask follow-up questions, at the same time it has a structure that can be followed.
In this study, the author has chosen an inductive approach, since its main purpose is to clarify the opportunities and obstacles by examining the current situation.

The approaches used in this study were mixed methods which consist of both quantitative and qualitative methods. The quantitative methods have mainly been used to establish warranty inspection reports and warranty costs for entering the amount of data. While qualitative methods emerged in the study in order to understand and interpret the reality of the situation, mainly in the form of interviews and observations.

2.3.2 Case study

This paper is based on a case study where a particular area has been studied by the authors, aftermarket. The study has been conducted on a Swedish construction company. The purpose of the study is to examine the most common errors that occur after the submission of the projects and thus enable a positive development in that area. The case study has begun to gather information from literature studies and the case company's own documentation and database. Data collection has been carried out using various sources, which occurred mainly in the form of warranty inspection protocols, carrying costs and interviews.

A case study contains a detailed and thorough investigation of a single case, where the case may be individuals, organization, or a situation (Bryman and Nilsson, 2011). The researcher tries by concentrating on a particular event, person or phenomenon in order to maintain knowledge and deeper understanding (Stukát, 2005). Bryman and Nilsson, (2011) mentions in their book that the case studies are often associated with qualitative research because those techniques are recommended in order to push forward a detailed examination of the study. But they find that the statement does not match completely, because the case studies often include the use of both approaches.

The author's goal is to initially begin to highlight the case in a proper way to specify the case study as a research design. The difference between case study and other approaches is that the researcher has an interest in finding out and analyzing the case's unique characteristics (Bryman and Nilsson, 2011).

2.4 Review of used methods - A summary

The purpose of the study is to examine the most common errors that occur after the submission of the project. The case study begun by gathering information from literature studies and the case company's own documentation and database. The collected data mainly consisted of warranty inspection reports as well as documentation and data from the case company for four projects. The authors have chosen to go the route via warranty inspection because the warranty inspections are carried out by an independent surveyor thus he or she has an objective view of the project.

The theoretical part is based on a literature study consisted of books and scientific papers, retrieved from Chalmers library and Chalmers Library database. In addition, data has been collected from the case company's own database called Customer Service System (CSS), where the customer can either call or mail to about issues that occur during the responsibility period. In order to increase the study's reliability, the authors have chosen to use a quantitative approach by interviewing key persons at the case company. Interviews were carried out with twelve key persons in the case company. In this study, a semi-structured form was taken by the authors to conduct the interviews. This meant that some questions were predetermined in advance, while others might not be fixed in order to develop a better understanding of the current area. This technique gives an opportunity for the researchers in order to ask follow-up questions. Thus, the approaches used in this study were mixed methods consisting of both quantitative and qualitative methods. With the purpose of strengthening both validity and reliability, and having a combination of different methods to provide as wide picture as possible. The authors also want to note that data collection of internal documents has required a lot of effort and time as the documentation was hard to get.

The division of work has been equally divided between the authors of the thesis, and both have been equally involved in the different parts of the study.

3 Theory

In this part a literature study will be presented. In the first phase the construction contracts and laws will be presented and later on the cost of quality. More on, some recommendations on how to reduce waste in the construction industry. Finally, a previous case study will be presented.

3.1 Construction processes and laws

The Swedish Competition Authority (Konkurrensverket, 2014, p.10), describes the construction industry to be a project-based industry and this due to that, "*the development of the industry largely depends in efficiency and innovation of individual projects*". The construction companies take lesson learned from each individual project to improve efficiency (Konkurrensverket, 2014).

At the beginning of a new project, an investigation and research work is often carried out (figure 3.1) (Nordstrand,2008). Projects outcomes and economic aspects must meet the company's expectations to investigate the project. If the results is as the company's expectations, technical building regulations will be studied. The projects pre-design will be carried out together with building legislations and a contract will be signed between partners. During the production, the main contractor is responsibility delivering the project to the extend and on time to the customer. At the final stage when the construction is completed and handed over to the customer the warranty period of a 10-years liability begins (Nordstrand, 2008, Byggandets, 2009). (More about inspection procedures in appendix A)

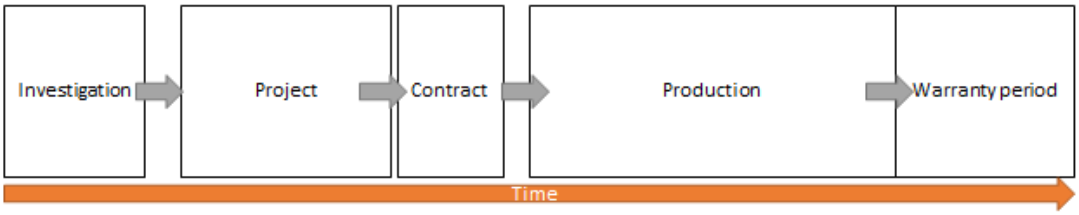

Figure 3.1 - Illustration of the construction process

In the construction industry, there are some general contract forms. The most common of construction forms are design-build (DB) and design-bid-build (DBB) contracts. Under DB (AB04) contract the entire process will be carried out by contracting organization, both design and execution. DBB (ABT06) contracting can be summarized as performance contracting where the client has the responsibility of the design-phase. There are some differences between these contract forms, however, it is worth noting that the DBB-contracts are used in more design-related projects such as buildings, while DB can be used in more standardized projects (for eg. warehouses) (Konkurrensverket, 2014, Potts and Ankrah, 2013).

The contracts can be procured with different types of procedures. But the selection of procurement route can be challenging. Some procurements procedures are open call for tenders, direct negotiation with the contractor or by request to selected contractors. Building contracts that are procured by the state, municipality or alike will be under the Swedish Public Procurement Act (2007:1091). The contractual applicable to the involved parties is governed by the General Conditions, AB. The provisions are designed by clients and construction companies through the association Construction

Contracts Committee, BKK. The reimbursement can be either cost-based or price-based (Konkurrensverket, 2014).
According to ABK09 (Byggandets, 2009) the constructor is responsible, even if the finished project has been approved by the client. It is important to know what the parties had agreed between each other. If problems arise after construction, which is often time consuming and expensive, it is important to know what has been reached between the parties. There are good examples and several clauses written in the ABK09 (Byggandets, 2009) that describes the constructor's responsibility and how to act in a professional manner. Furthermore, the ABK09 describes the responsibility the vendor has to mark hidden defects if these are known. Therefore, it is also the buyer's obligation to carry out a through investigation during the inspection to detect "hidden defects", otherwise the buyer cannot turn against the vendor (Svensk and Byggandets, 2004, Konkurrensverket, 2014, Lavers, 1999).

3.2 Rework in construction

In the following section, the causes and costs of rework in construction will be described.

3.2.1 Cost of rework

Building structures are suffering from various defects and deficiencies in both production and maintenance phase which later leads to rework costs.
Management of faults and defects arising during production is equivalent to a cost of about 2-6% of the production. A construction building during the production phase accounts for a defective charge of 6% of the manufacturing cost. Defects introduced during the maintenance phase correspond to about 3-5% of the production cost. According to Josephson and Hammarlund (1999), the reasons behind the production defects occur mainly in production, but also related to the design phase. A previous study done by Josephson (1990) showed that production accounts for 54% of errors costs, 34% are attributed to construction management and 20% of the workforce. Unlike the causes that occurs during the maintenance phase that the design is mainly responsible (Josephson and Hammarlund, 1999).

Rework costs include direct and indirect costs that add up to the so-called total rework costs (TRC) (Love and Edwards, 2004). Boverket, (2007) explains in its report that the direct costs cover the cost to remedy defects that occur because of work and materials. While the indirect cost of errors and defects after the housing has been in use refers to loss of time for accommodation to customers and construction companies, which accounted for SEK 1.3 billion in Sweden 2005. According to Boverket, (2007) the total indirect cost of construction companies and clients corresponded to 820 million SEK during the first occupation year (Boverket, 2007).

3.2.2 Causes of rework

In literature studies there are various definitions for rework. Depending on the scope and context of the definition of rework may subsequently result in costs and actions looks different in these studies. The common definition of rework written by Love and Li, ”as the unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time" (Love, 2002, p.138). Errors and omissions can naturally occur at different phases of a project's life cycle. Thus construction companies need to develop effective measures to improve process management and minimize any possible defect costs (Josephson and Hammarlund, 1999). Defects occur during the design and construction phase as a result of different reasons (Love et al., 2016). On the other side, Robinson Fayek explains rework as the “total direct cost of re-doing work in the field regardless of initiating cause”. He noted that product defects due to manufacturing and changes ordered by the client or the design team are not considered as rework (Love, 2016, p.1).

The seven building projects that were studied by Josephson and Hammarlund (1999), closely 3000 defects have been detected. This could be estimated to 2-6% of the cost of production.
Boverket (2007), National Housing Board, had in their report investigated six property development projects that were sold by construction companies directly to private residential customers. Based on assumptions and calculation the cost of indirect rework for year 2005 in Sweden would be 1,3 billion SEK.
Larsson et al. (2002) further investigated and could categorize the causes of rework in six different sections (as shown in figure 3.2).

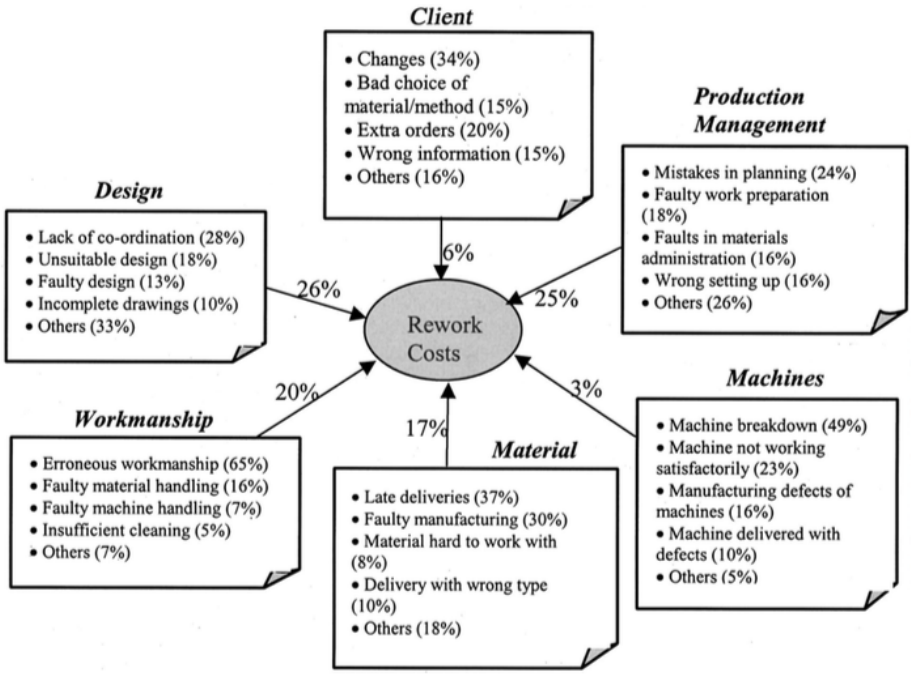

Figure 3.2 – Causes of rework (Larsson et al., 2002)

- Client (6%),
- Design (26%),
- Production management (25%),
- Material (17%),
- Machines (3%)
- Workmanship (20%).

The most significance was design-related causes, such as insufficient design and lack of insight of designers. Chong and Low (2006) argues that design are one of the dominant causes for latent (post) defects in construction projects and thus need to be improved to avoid rework. The cost of total 645 reworks due to design were estimated to about 2MSEK (Larsson et al., 2002). Secondly, production management was identified, such as poor planning which could lead to inappropriate installations. According to Love and Edwards (2004) the site management team and suppliers must have an adequate planning to avoid inaccuracy. Production management resulted for

805 rework causes that were calculated to cost closely to 2MSEK. The third most significant cause for rework was workmanship related such as carelessness, and could be estimated to cost over 1MSEK. Boverket (2007), in its report stated that the lack of communication and leadership may be one of the main reasons that skilled labour make mistakes, and also lack of motivation.

3.3 Quality

Quality concept has had many definitions over the few past decades. Crosby, (1979) defines the concept based on a producer's view that "conformance of requirements" which focuses on meeting the customer's demands (Bergman and Klefsjö, 2010). This points to get everyone to do what they have agreed to do, and to do it right from the start. The concept of quality covers different parts of wholes and has different definitions for different customers. Therefore, the customer can perceive a product is inadequate, although it has met all the requirements that were set in the description documents.

There are two general aspects of quality concepts - a measurable side and a more subjective side (Bergman & Klefsjö, 2010). The objective side is aimed at fulfilling the customer's requirements without taking into account future perceived needs. But in the end it is the customer experiences that evaluate the product from their own subjective point of view that will be crucial to its success (Bergman & Klefsjö, 2010).

Another definition given by Bergman & Klefsjö (2010), which focuses on the customer perspective that says "the quality of a product is its ability to satisfy and preferably exceed, the needs and expectations of the customer ". They argue that it is not enough to meet customer expectations without endeavouring to surpass those, in order to simultaneously maintain their customer base and attract new customers. That represents a challenge for a company that wants to work forward to exceed their customer's needs and expectations. The definition also stresses us as customers not only assess the individual product but to create an overall picture of the company's experience that delivers and sells the product.

Josephson (2013) explains in his book that many customers do not have the ability to express their demands and needs. This usually leads to dissatisfaction of the customer when the final product is delivered which cannot imagine the customer's expectations. Sörqvist (2001) mentions that there are different kinds of customer requirements as outlined customer needs.
Awareness by the customer for certain needs, others needs are considered too obvious and further some are unaware until they experienced. It means that it is difficult for a company to ascertain customer needs, until you have defined who the customer. Bergman & Klefsjö (2010) pointed that a company should develop its quality work by creating value for the organization and systematic

- Find out the organization's customers
- Find out their expectations and needs
- Be sure to fulfil, and preferably exceed, these needs and expectations

3.3.1 Quality defects

In a report written by Boverket, (2007) it remain issues in buildings, even though they have been approved and put into service for the customers. The inspector assesses the building's condition to write down the errors and shortcomings that exist and must be addressed by the considered responsible either before client access or after moving. According to Boverket, (2007) this leads to the small as large issues in form of time loses and additional non-calculated costs for both the buyer and the construction company. Small defects can be detected by the customer after moving in. According to Boverket, (2007) such defects can be remedied more quickly if the current employees are in place. Therefore, describes Boverket, (2007) the customers who moved in earlier stages of the project are more satisfied than those who move in later. Although it is difficult to define who is responsible for the faults and shortcomings, but someone will have to pay for these non-calculated costs. Either way, there is often the potential for companies to constantly improve and develop their organizational processes in the early stages to reduce the errors and shortcomings that arise. Josephson (2013) says that companies should invest in prevention and control, which in turn results in reduced defect costs, known as cost of quality defects.

There are three strategies to reduce errors and consequences (Josephson, 2013):

1. Eliminate causes of faults
2. Detect faults as early as possible
3. Learn from common faults

3.3.2 Cost of quality defects

There is a certain curiosity among people and especially organizations to know how much errors will cost to repair. But according to Josephson (2013), this has been the basis for the development of preventive improvement programs to avoid these costs. However, quality costs can be divided into three categories when first introduced in 1950s; error preventing costs, control costs, and costs for non- conformance (Josephson, 2013). Furthermore, the costs for non- conformance divided into internal and external costs. Sörqvist, (1998) describes the internal costs for non- conformance for deviations that occurred before the delivery to the external customer, such as rework, scrap, delays, etc. Even the external costs for non- conformance are defined as lack of quality that occurs after delivery of products or services to the customer, for example, complaints, warranty work, badwill, etc (figure 3.3.1).
Josephson, (2013) explains that the external costs resulting in costlier and more serious measures than the internal costs. He argues that the errors founded after the customer access will cost more to fix than those detected during production. It will also create a dissatisfaction of the customer who probably had expected to move to a flawless apartment or house.

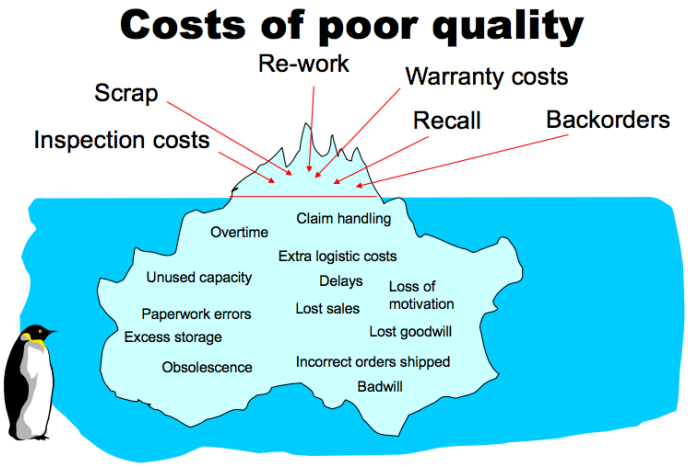

Figure 3.3.1 - Cost of poor quality (Santos, 2016)

Increasingly began the concept of poor quality costs to be used, then it was realized that there is a lack of quality that costs money and cover costs for error preventing (Josephson, 2013). Sörqvist, (2001) defined the concept as follows: "the total losses caused by the products and processes of a company are not perfect". Josephson and Lindstrom, (2011) explains this definition in their study that the companies should also take into account the effect of poor quality, which leads to loss of customers and probably miss to tie up new customers. Today, the concept of quality has a wider point of view which is considered as a more customer focused perspective (Josephson and Lindström, 2010). This means that the perception of the quality concept includes all who are involved and who may be affected by the products or services that provided by companies.

Josephson, (2013) mentions in his book that poor quality costs are extensive and generally estimated at 10-40 percent of the company's turnover. Furthermore, he points out that the costs for failure consists of two types; visible and hidden failure costs. The difference that the visible costs and their consequences can obtain and register with the current knowledge and methods of measurement. In a construction project the visible costs for non- conformance are estimated at 2-10 per cent of the project cost. It is therefore necessary to develop and streamline company´s processes to be able to visualize all the more hidden failure costs. This creates opportunities to improve and develop knowledge and measurement methods, which results in reduced costs of poor quality (Josephson, 2013).

According to Josephson & Lindström, (2010) there are three main groups of poor quality costs:

- Group 1: direct costs for the action of faults, including compensation for damages and guarantees
- Group 2: indirect costs due to the rescheduling of the project / production for other projects that are affected or delayed
- Group 3: indirect costs for loss of goodwill or revenue of similar reason

Josephson and Larsson (2001) concluded in their study that faults are usually detected too often at the project's final phase. Josephson estimated the cost to correct an error increases by a factor of ten for each stage. Thereby, an early client costs for non-conformance 1 to fix immediately, 10 to repair during design, 100 to repair during

production and 1000 to repair during operation and maintenance phase (figure 3.3.2). As a result, the cost to fix errors is increasing with time and its highest when errors are discovered by the consumer. It is therefore in all activities of interest to reduce the cost of poor quality by systematically identifying and preventing them (Campanella, 1999).

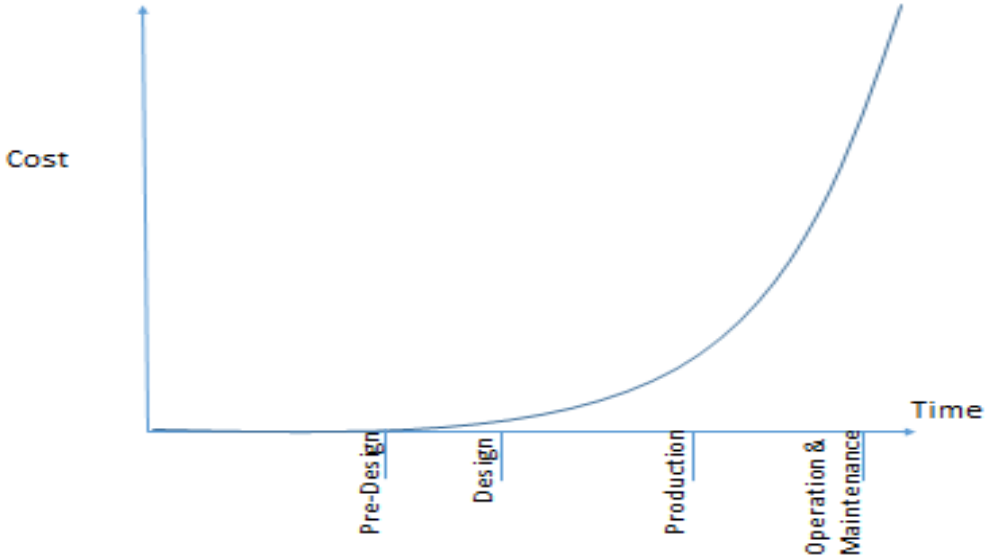

Figure 3.3.2: time-cost table

Josephson, (2013) says in his book about the interaction between observers and other personnel involved had the task of assessing the possibilities for detecting errors in the earlier stages. Thus they managed to catch up between 60-90 percent of the actual number of errors. They noted that 35% of the errors could have been easily detected earlier, and another 36 percent had perhaps could have been detected earlier. Other faults were judged to be very difficult to detect before. In the same book mentions Josephson, 2013 an inaccurate execution for a window opening in a building construction which was 1.5 meters wide. They managed to complete the window opening and mounted down the facade scaffold before the error was discovered. This made the correction became more difficult to perform and thus increase the cost to correct the error. The example proves how difficult and costly to rectify a fault detected in the later stage.
Quality costs focusing on finding the basic causes of errors and omissions that may occur.

3.3.3 Causes of poor quality cost

Josephson, (2013) complains that the construction projects and construction processes are so complex that the causes of errors cannot be eliminated altogether. It is therefore more cost effective to reduce the consequences of error than eliminating the causes. However, Campanella, (1999) maintains in his book with the objectives of a quality cost system is that the causes are always prevention.

Suggestions on what is required to detect errors in the earlier stages (Josephson, 2013):

- Develop individual properties
- Improve single activities

- Create work instructions and procedures and
- Provide adequate conditions

3.3.4 Quality work and profitability

Campanella, (1999) describes that every time an issue is identified with help of quality cost process, it is an opportunity to increase profits. Quality improvement and quality cost reduction describes techniques for using quality cost data in programs to improve quality, reduce cost and thereby improve profits. Improvement work starts by first identifying areas of current problems causing additional rework cost. Quality improvement work includes techniques and methods used to reduce quality costs and improve profits. Campanella (1999) points out that we should apply a quality focus in the organization to avoid extra warranty rework. According to Bergman & Klefsjö, (2010) means quality work not to raise costs, but rather to establish a high quality at lower cost. Bergman & Klefsjö believes the increased profitability at a lower cost is achieved by taking advantage of all available knowledge and experience in the company.

Furthermore, Söreqvist, (1998) describes the quality of work contributes to increased profitability as customer satisfaction is obtained and streamlining the work process in the companies. This requires providing products or services that meet customer requirements and expectations. With customer satisfaction covered both internally and externally. By internal meant increased motivation and fellowship of employees. However externally include customers who are willing to once again make future purchases and evaluates the company's products or services.

An improved quality can affect profitability positively in terms of revenues, expenses and assets of the business. The main causes of increased operating costs and reduced profitability are complaints, changes and the number of revision operations. According Sörqvist (2001) lack of quality costs is considerable. Several studies show that cost of poor quality can reach to 10-30% of the company's turnover. Costs for improving quality is considered to be low and seen as an effort to reduce the cost of poor quality. Therefore, describes Sörqvist (2001) that quality improvement is a very positive way to improve the financial results.

Bergman & Klefsjö, (2010) warns that the follow-up costs of poor quality will not solve quality problems. The quality cost process presents no specific measure rather shows where to start looking problems in an organization. In addition, the time is long between the detection of a problem and its registration in the system that monitors the bad quality. This makes it difficult to track what's wrong, and even the ability to identify action that will lead to cost reduction (Bergman & Klefsjö, 2010).

3.3.5 Focus on customer

Today it is a major challenge for most construction companies to meet customer needs, as well as to reduce costs as a result of quality defects. According to Sörqvist, (2001) the meaning of developing a measuring system for quality costs is to meet customer needs and expectations. Since these measurements can be used as a result to reduce costs by improving the efficiency of the organization's processes. First of all the causes should be identified and then find the best actions for them. Anyway, it is very difficult to determine customer needs because there are certain needs that customers have not experienced yet (Bergman & Klefsjö, 2010). Sörqvist, (2001) also points out that customers may misunderstand the product or using it incorrectly, which in turn lead to the increasing of quality costs. Other factors that can determine the customer's assessment of the quality can be, the company's promises, the importance of the product for the customer and other products offered in the market. Another example of the quality problems, Sörqvist mentions that the stakeholders of a company in the form of owners focus more on increasing the profits of their investments.

According to Campanella, (1999) the company's economy can be measured by having satisfied customers who are willing to make repurchases in the future. While Josephson (2013) also emphasizes the importance of companies to verify the client's needs throughout the project life cycle.

While Bergman & Klefsjö, (2010) mention in their study that there is an important perspective in the quality improvement work is to focus on customers. They believe in the end it is the customer who appreciates how well the quality has completed its requests. The quality of a product is largely determined by customer needs and competition on the market that can offer better performance, price and functionality. Bergman & Klefsjö, (2010) presents in his study an example of how Toyota worked ahead to find out what their new customers' needs are. A new model car (X) was about to be launched by Toyota on the American market. Toyota organized for some engineers to stay with American families to achieve a better understanding about American customer´s needs. Bergman & Klefsjö, (2010) also highlights the internal customer needs such employee must also be met in order to do a good job.

3.4 Reducing waste

Josephson and Saukkoriipi (2009) describe in their report thirty-one recommendations on how to increase profitability by reducing waste. These recommendations have been gathered from the results in a questionnaire survey were over 500 professionals had answered. These recommendations are then divided into five groups:

- Leadership and management
- Standardize products and processes
- Successive improvements
- Structure the process
- Development of the organization

Leadership and management processes are of great importance for business development. The leadership needs to monitor, manage and control the organization for a long-term philosophy (Josephson, 2013). The individuals need to be motivated and feel that they are involved in the process. According to Ling (2003) leadership is essential for managing technological innovation, but firms must also have relevant capabilities. Ling (2003) also implies that if companies create a reward system, it may promote innovation success. As Ling (2003), Josephson (2013) mentions that a reward system will benefit the company's profitability in the long term. With a no-blame culture in companies the staff could experiment with new ideas which will lead to innovation (Ling, 2003).

Another important aspect is the structure of communication channel. Each and every member in a team must be able to exchange information in order to have a successful project communication. Xie et al (2010) state that the major stage of the project communication is that the team members understand the goal, objectives, outcomes and benefit of the project. The project team needs to understand the customer expectations, that increases the customer value and into what extent (Josephson and Saukkoriipi, 2009). Furthermore, Josephson and Saukkoriipi (2009) mentions that there is insufficiency to be able to see the whole picture of the project. Companies rarely analyse and conduct the total costs of processes. IT-tools such as BIM (Building information modelling) can give a better understanding of the finished product as well as costs (Koch and Jonsson 2015, Josephson, 2013, Josephson and Saukkoriipi, 2009, Josephson and Saukkoriipi, 2005).

By standardization of products and processes, the company can increase the profitability (Josephson, 2013, Josephson and Saukkoriipi, 2009). A development of effortless technical solutions can be an impulse for a more effective process. Such technical solutions could be description of installation of a glass facade or windows which may give a more standardized operation. The development of such technical solution shall minimize variations and the work can be carried out in shorter time (Josephson, 2013). Furthermore, this processes needs to be measured for successive improvements (Josephson, 2013, Koch and Jonsson, 2015). A standard sets the barrier of learning and for continuous improvements, "without standards there can be no learning" (Liker and Meier, 2006, p.288).

As mentioned earlier, costs caused by quality defects has great impact on the company's profit. Josephson (2013), Josephson and Saukkoriipi (2009), Koch and Jonsson (2015) and Oakland et al. (2006) states that companies should seek long-term

relationships with suppliers and subcontractors as they make most of the "actual" work. The work carried out during the production by the subcontractors can be estimated to 80 percent. Thus, the selection of suppliers has great influence on the project's execution as well as for the company's profitability (Oakland et al 2006). The focus for construction companies should be to seeking for long-term relationships with suppliers and have an extend cooperation in order to achieve good quality in every stage (Josephson and Saukkoriipi, 2009). The construction companies need to actively support suppliers in their development to achieve good quality (Josephson, 2013).

In the development of the own organization Josephson (2013) mentions that most of the experiences learned from previous project are not delivered inside the organization, it rather stands with the specific person. The time pressure is one of the reasons that the site manager has no opportunity to look back to the previous project to learn from mistakes. Therefore, it is important for the companies to gather information and experience from previous project and deliver it to the project organization. Companies should have strategies to encourage further training so that individuals get better knowledge of the working methods (Josephson, 2013, Statskontoret, 2009, Josephson and Saukkoriipi, 2009) (Koch and Jonsson, 2015).

3.4.1 Kano model

The Kano model, is a theory based model on product development to meet customer needs where the customer's total experience of quality is met as shown in the figure 3.4.1 below. Bergman & Klefsjö, (2010) states in their book about the customer's different needs and expectations. The Kano model presents three groups to meet customer satisfaction; *Basic needs, Expected needs and Excitement needs*. The reason why we as customers buy or use a specific product is to an existing need. Some of these needs are not obvious for us as customers, or we do not think about it.

The *basic needs* are the requirements that are considered obvious to the customer, they are apparently not mentioned. Bergman & Klefsjö, (2010) mean a company is required to fulfil the customer's basic needs without these being mentioned, also called unspoken needs. However, customers wouldn't be satisfied by only with basic needs, there are other requests that has to be clarified. Therefore, it is important for an organization to find out what the customer wants to achieve, understand the needs and challenges for the customer.

The customers are aware of their *expected needs* and consider them very important to be fulfilled, also called spoken needs. Bergman & Klefsjö, (2010) states that in this stage a company should do much better than their competitors in order to recruit new customers as if these are not met, it will lead not only to dissatisfaction for the customer, but also creates mistrust. At same time a company has to carry out discussions with the customer to identify their *expected needs* and strive to achieve these. Bergman & Klefsjö, (2010) mentions that it is important for a company that wants to be successful on the market to reach both the customer's basic and expected needs and once these are met, it will increase the value for the customer and add a significant competitive advantage for the company. However, that might not be enough, and as a result the customer may be looking for alternative product, or an organization to meet their future satisfaction. Therefore, companies should identify

and meet some *excitement needs* as well, the "innovative" need. In order to create an attractive product for the customers with a specific feature would be needed to develop the customer´s unconscious needs and have a detailed knowledge of customer's habits and preferences.

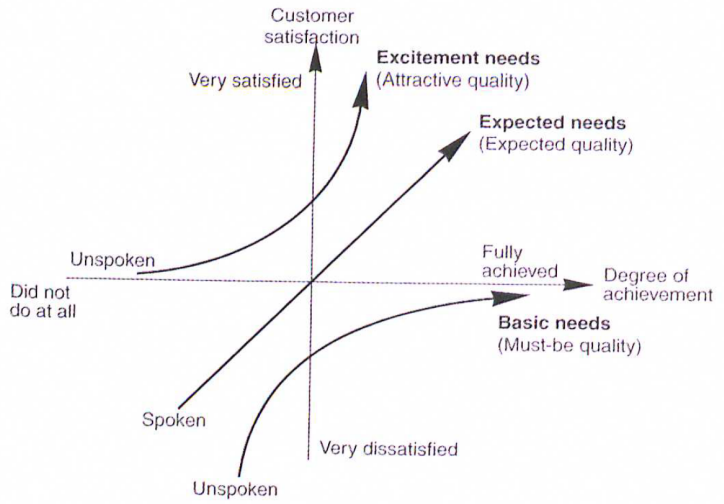

Figure 3.4.1 - The Kano model (Bergman & Klefsjö, 2010)

3.4.2 PDCA-cycle

The PDCA-cycle (Plan-Do-Check-Act) that was introduced by Deming is one of the most successful tools in TQM (Total Quality Management). Each letter has an impact into the process and need to be fully followed to have effects. There are trends where some takes shortcuts or skips some of the steps and later gets disappointed when it doesn´t lead to any solutions (Liker and Meier, 2006).

Plan, is the first stage of the cycle. The main purpose is to identify the issue that occurs (Johnson, 2002). After the identification of the issues comes the next stage, *Do*. In this stage the solutions to the issues will be implemented. Thus, in the upcoming stage one can, *check*, if the solution from the Do-step is the answer to the identified problems. If not, then one needs to go back to the beginning and start all over again. This process can be challenging, however, when one has reached to a solution the final step can be implemented, *Act* (Johnson, 2012). The final stage can further be solution for future challenges and implemented as standardization (figure 3.4.2).

Josephson and Saukkoriipi (2009) state in his report that standardization of processes and product has benefits for the company. He discusses how a Swedish construction company that built all the McDonald's restaurants in Sweden could make huge savings. The products as well as the processes were relatively standardized and the construction company could save 25-30% of the costs. The construction time could be shortened from 16 weeks to only eight weeks. In one case could it be done in only four weeks!

Furthermore, Josephson and Saukkoriipi (2009) discuss Deming's PDCA-cycle to with reflection on Hofstede's study on the cultures of different countries. In the Japanese culture it is easier to take on risk and uncertainty-reducing programs but it cannot just be "mimicked" to the Swedish culture as an improvement program. Anyhow, the standardization of products and processes can be implemented if not as smooth as in the Japanese culture.

The competitive market and the demands of fast deliveries, creates a challenge for the companies. In order to be competitive and deliver value for the requirements from the

customers, the quality management shouldn't be ignored. When a customer buys a product/service it is always important to deliver promptly. Lack of quality will not just have a negative impact for the company that delivers but also for the customer or the next-value adder (Lai and Cheng, 2009).

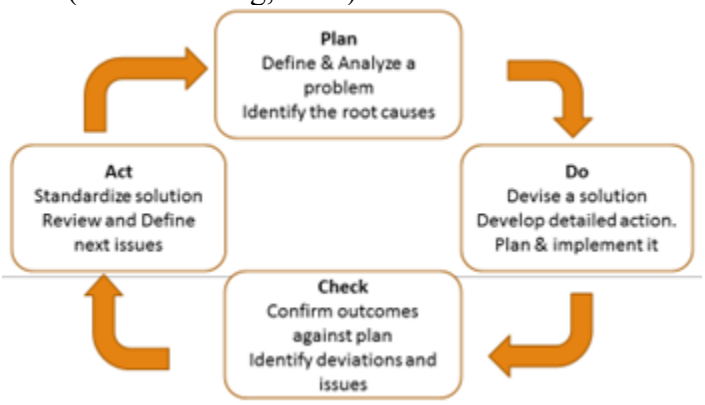

Figure 3.4.2: An illustration of the PDCA-cycle

3.4.3 Cause / effect diagram (Ishikawa Diagram)

The causes and reasons behind the problem needs to be determined before it can be eliminated (Sörqvist, 2001). The famous Japanese scientist Kaoru Ishikawa (1915-1989), had developed a cause-and-effect diagram (shown in figure 3.4.3), also known as the Ishikawa diagram or fishbone-diagram. The Ishikawa diagram is well known and is considered to be one of the basic tools of quality control (Matzler and Hinterhuber, 1998). The purpose of the diagram is to identify causes and their effects to problem that occurs. The diagram looks like a fish, as mentioned earlier, and the "head" of the fish represents the main problem while the "fish bones" represents the factors causing the problem. In the order of continuous improvement, it is obvious to keep learning from previous mistakes (Bergman and Klefsjö, 2010, Sörqvist, 2001).

The identification of causes to the problem can be discussed in team sections and interviews with involved individuals. Team members can use post-it notes and brainstorming to focus more on the major causes to the problem and thus reaching a common solution (Bergman and Klefsjö, 2010, Sörqvist, 2001, Matzler and Hinterhuber, 1998).

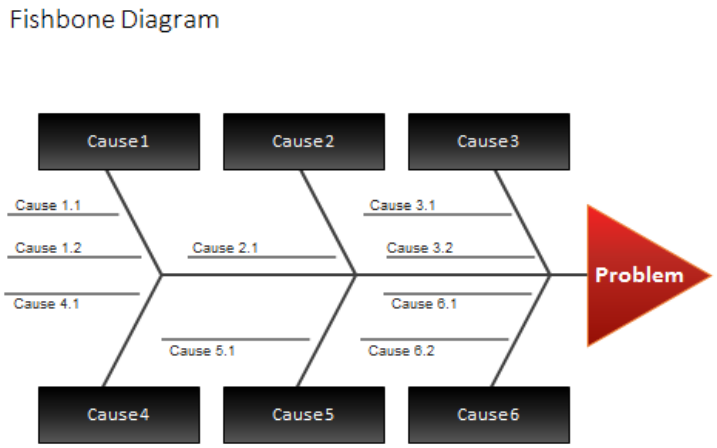

Figure 3.4.3 - An illustration of the Ishikawa diagram

3.5 Summary of the theory framework

The theoretical framework presents how previous construction projects have suffered from quality defects. Problems that arise after construction is often time consuming and expensive. Quality is to meet the customer's conformance of requirements. Larsson et al (2002) has categorized the causes for rework in construction projects where it was shown (3.2) that the design phase had the major impact. To reduce errors, it is of recommendation to spend more time during the design phase. Josephson and Larsson (2001) concluded in their study that errors are usually detected too often at the project's final phase. Josephson (2013) estimated the cost to correcting an error increases by a factor of ten for each stage. Thereby, an early client costs for non- conformance 1 to fix immediately, 10 to repair during design, 100 to repair during production and 1000 to repair during operation and maintenance phase (figure 3.3.2). Thus, it is important for the construction company to measure and detect quality defects early as possible. The literature review indicates that, it is also challenging for construction companies to systematically monitor quality defects and capture lessons learned. Construction companies need to have sections where reflections and training from previous projects can be learned. It is important to deliver lesson learned from previous project into the organization to prevent future errors.

4 Empirical material

In this part of the thesis, the empirical material and analyses will be presented. Warranty inspection notes will be presented for four apartment projects.

4.1 Warranty cost

According to respondents, the main warranty costs are external costs that arise after the handover of the residence to the customer. Also, mentioned in the 3.3.2 *Cost of quality defects* section, the cost to fix a defect or a problem increases dramatically by time. Thus, improvements to minimize the warranty costs must be considered as an important task for the company. The warranty costs have also negative impact for the customers as they may feel it stressful. Furthermore, it has an impact on the company's results as well as on the company's brand.

The greatest warranty costs incurred according to respondents typically when the rainwater penetrates or enters into the structures. For example, leaky roofs and facades, and poor connection to the windows and balconies result in major cost implications. Rainwater in turn, causes moisture damages. This type of injury often leads to consequential damages where extensive measures are necessary. Furthermore, it is common that great efforts need to be undertaken to identify where and why the problem occurred. High warranty costs can also occur when the contractor has functional responsibilities which later are not met.

The authors have studied and analysed documentations from the company accounts. Warranty inspection notes and documentation from the company's database for four projects have been studied. The database documentation is from the customer service center, (CSS) where complaints and question are asked from the customers regarding their dwellings. The reason that the authors chose these four projects are based on the high warranty costs that the company faces.

4.2 Inspection notes

In the following section the warranty inspection notes from four apartment projects will be presented, as well as remarks from the case company´s database (CSS).

4.2.1 Warranty inspection notes

The case study covers four projects. The total numbers of warranty remarks from warranty inspection protocols are more than 2000 remarks (table 4.1). The quantitative part of the data collection consists of warranty inspection of these projects. The projects are geographically limited to a region of the case company. The case company consist of many departments and thus the warranty costs are hard to list. When the project is completed and handed over to the customer, the project account will be closed. The results and profits from the project will later be divided between participants as bonuses. The internal organisation then takes over the total responsibility as the projects has been closed. Furthermore, a warranty account is then created where costs during the liability period will be registered. As the documentation of warranty work have recently been improved with more details it is

hard for the authors to identify previous warranty costs. Therefore, the costs of warranty work are held as a lump sum rather than specific cost of a task. However, the warranty costs will not be presented in this thesis due to confidentiality reasons.

Categorization of warranty remarks have been made, this due to limit the very large presence of unique observations and give a clearer view. For example, remarks on doors with comments such as "door hang" or "door slow" are categorized in the main category "Doors", (see appendix B). A category can thus determine as a summary of remarks. Furthermore, in order to decrease the amount of categories, and have an even better view of the most errors that occur, the authors chose to leave unique remarks into the category "Others".

As mentioned earlier, the case company has a customer service system (CSS) where the company can gather complaint from the customer and thus have statistic on. But the database can be misleading for the authors as some complaint are hard to identify and in some cases contain several comments. Thus, the authors chose to look at the warranty inspection notes from each project during the second year of the residence.

Projects	Warranty Inspection notes	Customer-service-system (CSS)
Project A	593	635
Project B	562	482
Project C	307	355
Project D	933	820
Sum	2395	2292

Table 4.1 - Extracts from the author's work table

4.3 Analysed building parts

The defects with highest remark frequency will be analysed below.

4.3.1 Cracks on the walls and ceilings

The most common remark are cracks on the wall-/ceilings and responds for 36% of the remarks. There are several reasons and factors why this error occurs. The respondents explain that the apartments and houses are "moving" during the first two years. The respondent explained it as following: "*Building materials swells during hot summer while shrinking a bit in the winter as it is cooler.*" When this annual cycle is repeated a few times arise almost inevitably cracks. These cracks are generally straight and usually sit in corners, angles and joints. If the material that are used consist of wood elements the cracks can be a recurring problem since the seasonal moisture conditions vary. Although, the wall and ceilings made of concrete elements can also suffer of such an error, as it still depends on the moisture-induced movements (figure 4.1.1).
Furthermore, the pressure of time in the construction sector has an impact in the result of cracks on the walls-/ceilings. Construction companies are willing to be done in a shorter time than they really need. This naturally leads to stress at the last stage and leading to shortages at the end of the handover of the residence.
Operations such as painting and plastering in some cases are then carried out at an earlier stage. If the building hasn't had the time to "sit" before the painting work, there is a risk that the cracks in angles occur and the colour burst.
Despite, if the dehydration is carefully controlled so that the applicable requirements are met, small movements can still occur. The movements do not have to be huge or serious, cracks still can occur in the angles. Thus, to fulfil the requirements for dehydrations does not mean cracks will not occur.
Curtain walls are now common, and these walls are mainly built of steel or wood elements, or combinations of these materials are also possible. When they meet a strong wind load, these walls are going to move much, up to five millimetres in the middle of the wall. Thus, this may also be a reason that cracks occur in angles.

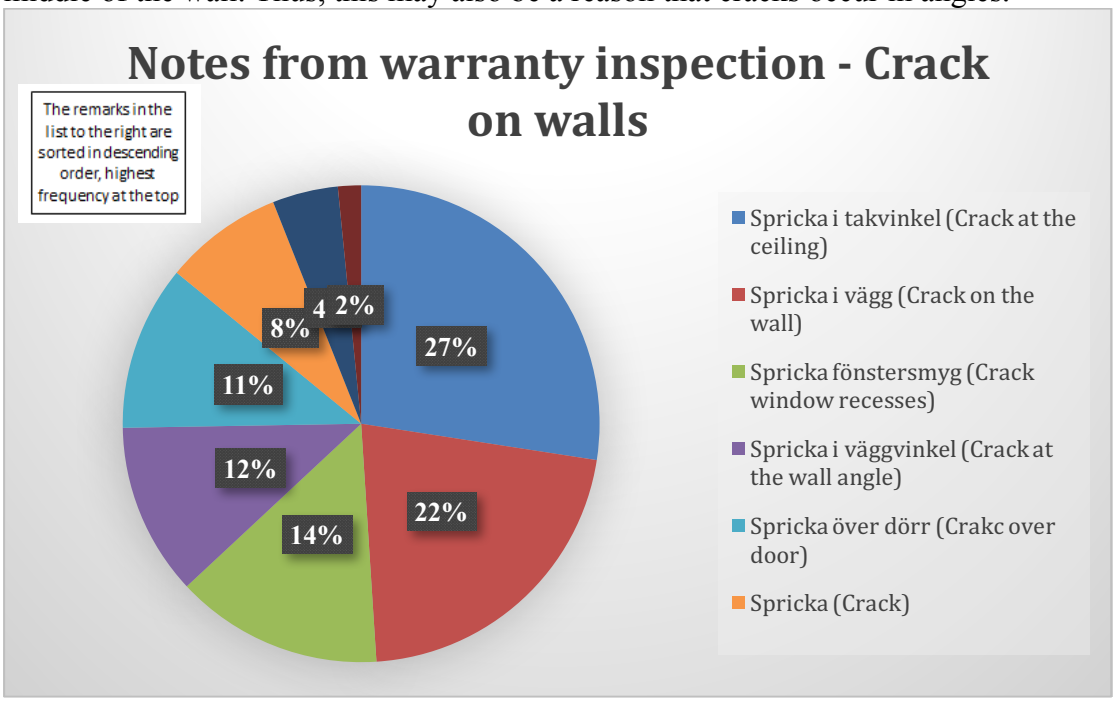

Figure 4.1.1: Notes from warranty inspection on Crack on walls-/ceilings.

4.3.2 Cabinets and boxes

Cabinets and boxes do together respond (10,4%) to the second most remarked issues in the warranty inspection notes (figure 4.1.2). According to respondents the issues with cabinets and boxes is mainly about care and maintenance, but also the choice of right material has an implication. The most common remark as shown in the figure (4.1.2) is “defect cabinet fronts” in the warranty inspection notes.

In major circumstances the suppliers do replace the products and execute the work by themselves. But not to all of them. Other suppliers do not execute the job but sends new products. This in order turns out to cost the company serious amount of capital instead. However, the company can go further with the case but to keep the customer satisfied they need to act quickly and takes it as “goodwill”.
Furthermore, respondents explained the reason behind that the supplier did not want to execute the work were based on that the actual work wasn't done according to their instructions from the beginning. And, it is difficult for the company to prove this claim.

Respondents furthermore explain that suppliers wanted to meet the higher demands on material in terms of environmental requirements. Which lead to that the first new series of products could not tolerate as much water as previous product. Thus, water and moisture damage occurred in this product and thus they all needed to be replaced. However, these products were replaced by the supplier and it didn't affect the main contractor financially but their prestige.

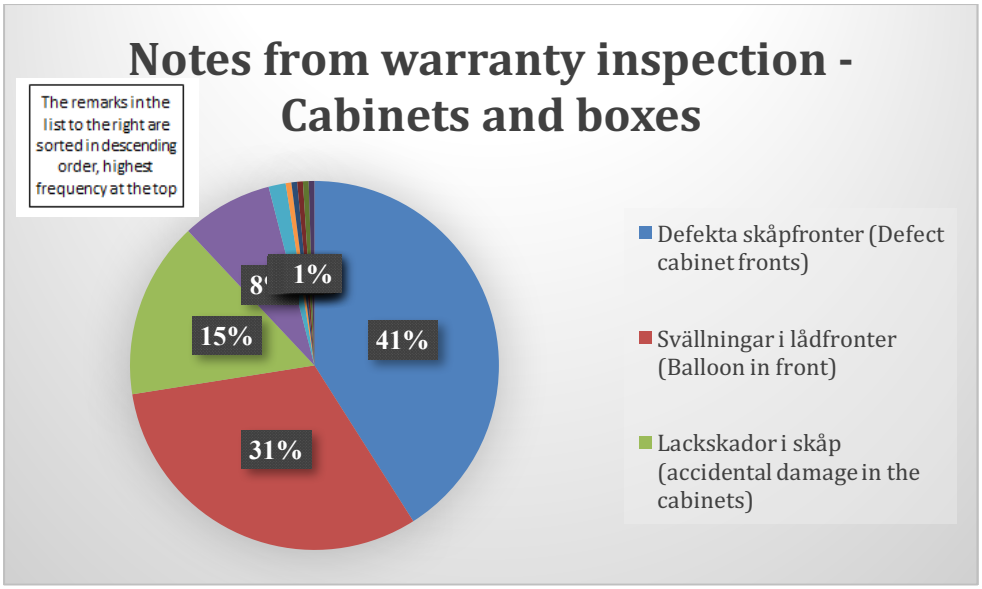

Figure 4.1.2: Notes from warranty inspection on Cabinets and boxes.

4.3.3 Doors

The third most common remark is on the building part, door. The reason can refer to a number of factors. According to respondents, the evolution of the door design has led to increasingly heavier materials. The door need to meet to a variety of requirements for e.g. to fire performance, sound, vibration and escape. Doors are today consisting of generally more technical details; they are wider and contain a higher proportion of glass which overall contributes to a high overall weight. This leads to higher torque on the hinge and greater stress on the frame and attachment.
These components are not always designed for this load. In terms of exterior doors, the number of hinges declined from previously three to two pieces today, while the overall weight increased. The reason behind declined pieces of hinges must be due to cost savings, according to the respondents.

The most remarked comment on door is, “doors hangs” (figure 4.1.3). The doors are those materials that the customers use in everyday life and according to respondent customers are rarely willing to take care of them. The reason is very simple, as the respondents’ states, the customer whom had invested in the new apartment want to just live there without worrying about anything. But, as mentioned, some building parts needs service already during the first two years of the residence but the customer doesn't find it to be necessary. It is then of recommendations to have a service during the first two years with the customer to prevent remarks during the warranty inspection (more recommendations in chapter 5.-discussion).

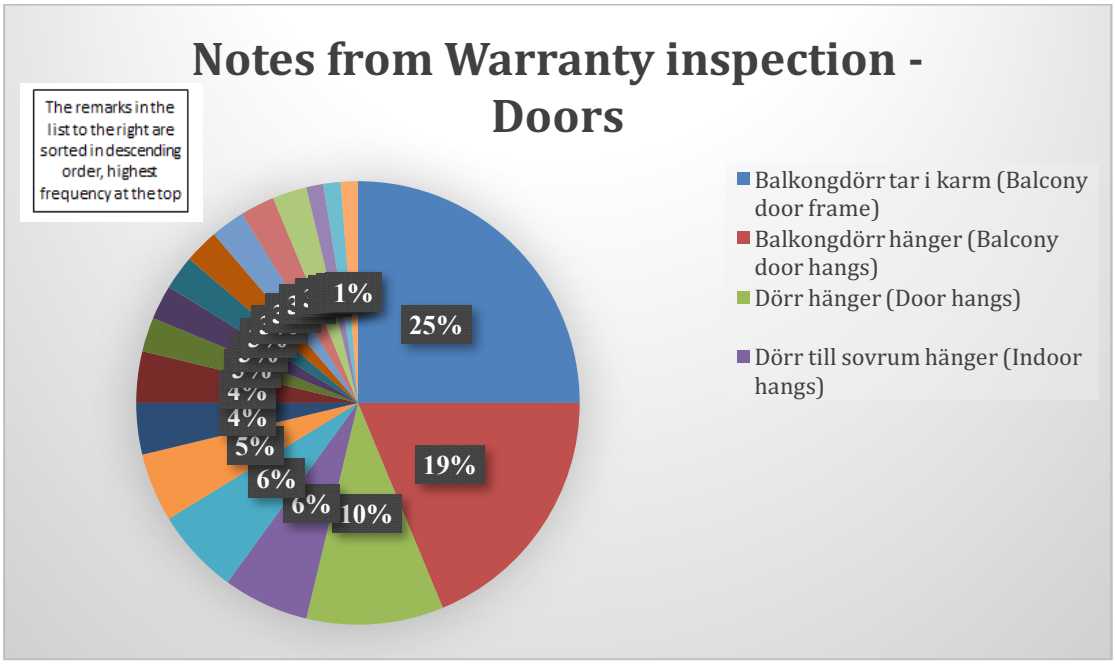

Figure 4.1.3: Notes from warranty inspection on doors.

4.4 Summary of Analysed parts

The authors have chosen to compile all studied projects to highlight the types of errors and defects that are most common. The summary is a result of the warranty inspection protocols from all studied projects. The figure 4.2 shows the existing top 10 errors from both warranty inspection protocols and CSS.

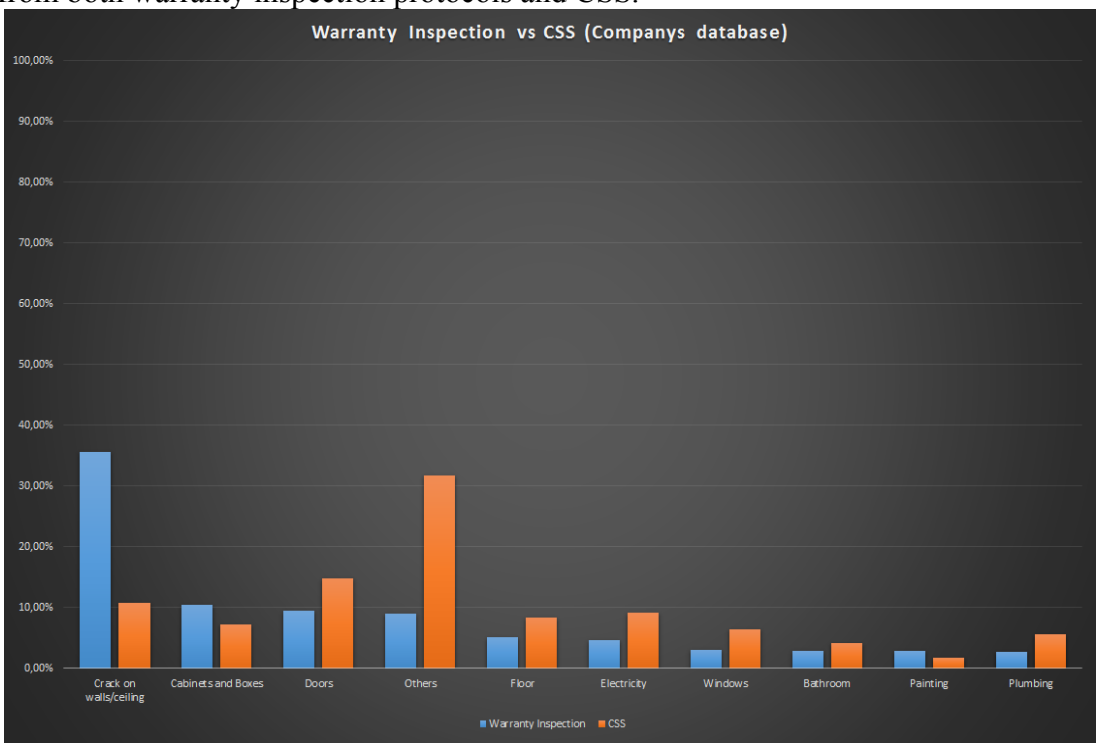

Figure 4.2: Summary of remarks from all four projects

The most remarked building component is cracks on walls-/ceilings and it responds for 35,6% of the total number of remarks. The main cause can be attributed to moisture-related movements. When this annual cycle is repeated a few times arise almost inevitably cracks. The second most remarked is cabinets and boxes, which responds for 10,4%. The care and maintenance from the customer has extensive role, but at the same time, it is important with the right choice of materials.
The third most remarked component is doors and it responds for 9,5%. According to the respondents it is the evolution of the door design has led to increasingly heavier materials. Doors today consisting of generally more technical details; they are wider and contain a higher proportion of glass which overall contributes to a high overall weight. The evolution of the doors can be linked with the Kano-model (3.4.1). The customers like to get more sunlight in their apartment. The higher proportion of glass on the balcony doors are then a considerable solution to customers' demand.

These three components account for 55,5% of the total number of remarks. However, it is the moisture that is the most serious part in the remark list. Such failures can cost the company huge amount of capital and have a pessimistic impact on the construction company's brand. It is meaningful to detect errors in the very early stages to prevent such mistakes (Larsson et al, 2002). Larsson et al (2002) categorizes the design and production management to being the most important stage to consider and thus eliminate mistakes (ch3.2.2). Furthermore, Josephson & Larsson (2001) has

analysed on what it takes to detect errors earlier, and it turned out that the main commitment, knowledge and experience is the key. The PDCA-cycle (3.4.2) along with the Ishikawa-diagram (3.4.3) is such valuable tools to take into consideration. It is of best practise to identify issues and further develop solution to the problems.

5 Discussion

In this chapter, the authors will evaluate the study and considers problems encountered during the work. Some recommendation will be put forward and finally, there are proposals for future studies.

5.1 Reflections

The purpose of the study was to identify quality deficiency costs based on warranty work. However, during the phase of the work it was proved that to tie a certain cost to a specific warranty label were very difficult. One certain remark could take much more time to fix while other could be fixed in a shorter time and thus cost a small sum to fix.

As a result, the authors chose to identify the top three building parts that had the most remarks during the warranty inspection by examining the warranty inspection protocols. Whether if these components are the largest cost drivers or the most time consuming, are not investigated in this study. Thus, implementation of proposed measures for each building parts does not necessarily mean that efforts are being applied to the largest cost drivers. The purpose that the authors chose the top three is to limit the countless causes and solutions to the issues. However, as mentioned the proposed measures are such small examples.

The study has been limited to the remarks from the warranty inspections. This due that the database (CSS), has some limitations and weaknesses. The reported issues often lack in descriptions. In many circumstances the reported issues may include several errors or no errors at all. In addition, they may be postponed to the warranty inspection, this due to that the reported issues do not prevent operations of the subject. With these difficulties, the authors choose to analyse the warranty inspection protocols as they are more appropriate.
According to respondents, certain errors and shortcomings were remedied during the production phase for customers who moved in at the early stages of the project. These costs were counted on the total project cost, instead of being registered in the warranty cost. In order to have a clearer overview of warranty works it is obvious to include all works that are done after the final inspection, as it should be counted in the warranty work. Unfortunately, the authors could not identify what work has been carried out during this period and thus it is not included in the study.

The quantitative part of the study is based on warranty inspection notes from four projects. The reason that the authors chose the four projects were based mainly of access to the warranty inspection protocols and the aftermarket costs that the company faces. In some points the authors found it difficult to collect protocols. To collect protocols, it preliminary depends on what kind of access one have in the case company´s database. However, there are also the risks that it may be hard to find documents for an uninspired person. Other possible reasons for the problem of collecting protocols are that the employee, have retired, changed to another job or had lack of time to share the protocols. However, it is important to point out that such documentations need to be shared in an easier way. Recently, the case company have started to use a more digitalized software system that makes sharing smoother.

Furthermore, as mentioned in the study, it is doubtful whether some remarks should be noted. Some of the remarks might have been drawn to the final inspection, and some may have been caused by the occupiers.
The case company chooses to remedy doubtful warranty remarks as form of goodwill. But there is a risk that, if the contractor remedy remarks based on customers' complaints, the remaining customer would ask for the same action. This in turn led to very highly costs in term of goodwill. If the goodwill remarks had been remarked in separate protocols, not in the warranty inspection note, the case company could have the chance to identify the financial resources for goodwill.

The authors have also noted that some of the warranty inspection notes may be attributable to the subcontractors. These remarks usually do not affect the main contractor costly except that some administration work is still necessary. However, it is still the main contractor that will be concerned, because they have the main responsibility and it is the contractor's brand that reflects to the customer. Which remarks should be attributed to the subcontractors have not been distinguished by the authors, mainly because it is not noted in the warranty inspection protocols. In addition, in order to identify comments related to the subcontractors, it is necessary to know what work contractors have been awarded for subcontracting for each project, which the authors have not been able to take into account.

5.2 Recommendations

The warranty inspection report represents the issues that occur during the consumption of the residence by the owner or the customer. There are several reasons why these errors occur. The authors have had interviews with some key persons from the case company in order to investigate some potential improvements.

5.2.1 Organisational level

During the implementation of the project, according to the respondents, members of the organization should discuss issues and make decisions on solutions in team. The individually developed solutions are not preferable. Because the most appropriate solution may be not used and instead other less good solutions are used. In addition, it is important to work with risks and probability assessments for possible future deficiencies.
The economic aspects can be discussed on alternative solutions. For example, the cost of a preventive action can be set in relation to a possible cost of action for a future error. Working in this level may carrying out a quality-successful work and the most cost-effective solutions can then be used. It is meaningful for the project participants to understand the scope and goals in all stages of the project in order to eliminate and detect errors and mistakes. Thus, in order to prevent quality issues that results in warranty work, it is essential to have quality questions on the agenda throughout the project. Creating a working environment where everyone works together and feel comfortable in their roles provides good conditions for reducing errors and eventual warranty works can be eliminated.

The site manager has had a greater role in the warranty work in the past, but today there is an internal organization (after market), that has all the responsibility for warranty works. It enables the site manager to concentrate more in on-going and

upcoming new projects. However, according to respondent is has also its consequences. While the internal organisation undertakes the process when the project is completed, it is a challenge for them to identify which part is responsible for the occurring errors and this in terms may lead to less satisfied customer if the customer has to wait. However, it is often that the case company solves the issue in a shorter time, as goodwill, but it then in the end turns out to be expensive and costly for the company.
The respondents, recommends a closer relationship between the internal organisation and site managers to solve issues in a more effective ways and exchange experience and knowledge.
Today, subcontractors have a more partnering role in all projects. It is important that the main contractor set higher demands on subcontractors. One step in this work is to request the quality plan from the subcontractor. The purpose of the quality plan is that the subcontractor should describe the work they intend to perform and what quality risks it entails.

5.2.2 Project level

The size of the quality defect is strongly affected by the time. The highest cost arises when it is of an external character, that is, when the lack is discovered after the handover to the customer. As mentioned in the theory part, earlier detections thus, with high probability, means lower costs.
Already in the design stage, including the choice of material, construction technology and installations, it is meaningful to work with risk assessment in terms of quality. Inadequate design increases the risk that future warranty work will be necessary.

The respondents agree that the defects and mistakes should be discovering in the design phase, not during the production. In order to reduce such risks, experienced personnel from production management should be part of the design team. An experienced site manager can thus assist with his/her expertise and practical experience with alternative solution to issues. However, the alternative solution may be more costly but based on time gain in the production phase it should be preferable. The involvement of production staff can as well have a positive impact later on during production, as the staffs are significantly more involved in the project and feel more pleasant. According to the respondents, the involvement of production staff in the design phase usually leads to minor revision of drawings during production, increasing the likelihood that purchases are correct, the profitability of the project will be maintained and the quality of defects will be reduced.
The use of IT technologies with such tools as BIM and visualizations software's it will give better understanding, knowledge and clearer picture of the project. The case company do use IT technologies in relative high potential but it still need to be improved. However, this is not investigated in this thesis.

5.2.3 Training and reflection

Knowledge- and experience retrieval has in lately been developed in positive direction according to respondents.

The district managers along with the project manager are those whom get feedback from the internal organisation on prevent projects. On the other hand, the site management does not receive any kind of feedback or learned lessons to a great extent such as the top management, which creates the risk that the same mistakes will be repeated. Work-preparations are valuable tools for preventing issues and thus avoid fails. It is however, essential to have clear and effortless work-preparations. For example. It is of utmost essential to review assembly instruction for window installations, different window suppliers may have different instructions, thus explain the consequences that may occur if the instructions are not followed. If a window suffers from faults and defects in the future, it will cost the company a great amount of capital, depending on the failure, as the contractor will be responsible by not following the instructions.

One of the cornerstones in quality management is to let everybody be committed and thus create conditions for participation. The internal organisation that focuses only on finished projects needs to expand their role. Respondents meaning that, in many circumstances they are facing invoices from the internal organisation but with minor comments. This in turn makes it difficult for the project managers to understand and clarify what have been fixed. It takes certain of time to understand what has been accomplished.

The purpose of the collection of information and experience by the internal organisation should be to actively give information by communicating. That in turn will be the sense for successfulness to decrease aftermarket cost in long term. By actively using, and communicating the valuable information from aftermarket employees will create additional satisfaction at work and at the same time decrease issues.

5.3 Proposals for future studies

Some suggestions for future studies that the authors noted during the implementation of this study are presented below.

- Research on how knowledge and experience feedback to professional employees can be developed
- Study the benefits of using BIM (building information modelling) software's during warranty work as well as during the production

6 Conclusion

In this chapter, conclusions based on the empirical and analytical study achieved by the authors will be presented. The chapter begins with a feedback to the study's purpose and questions.

6.1 Comments to the research questions

The purpose of this study was to investigate the aftermarket costs. The research questions are answered with support from results and analysis from the study.

What are the most common issues in the aftermarket?

The authors, with support of respondents, could cut down the great amount of unique warranty inspection remarks in 14 components. The three building parts could be accounted for 55.5% of the total numbers of remarks. Based on warranty inspection protocols the highest remarked part has the following:

- Cracks on walls/ceilings, 35.6%
- Cabinets & Boxes, 10,4%
- Doors, 9,5%

These three components have thus the highest remark rate in the warranty inspection protocols. However, the authors have not investigated whether these building components account for the largest cost.

What are the causes of these most common issues?

The authors have determined the most likely reasons for these three common issues based on the qualitative data collection and analysis.

The main causes of cracking at the ceiling/walls angles are based on movements. According to the respondents, the apartments and houses are "moving" during the first two years. During the summer-period the materials starts expand and the opposite appears during the winter, were the materials shrink. When this annual cycle is repeated a few times arise almost inevitably cracks. The moisture-related movement occur naturally in connections, often in the case of when two materials meet, for e.g. ceiling and walls.

Cabinets and boxes do together respond to the second most remarked issues in the warranty inspection notes. According to respondents the issues with cabinets and boxes is mainly about care and maintenance, but also the choice of right material has an implication. The most common remark are “paint drop”, “bubbles” and “moisture” in the warranty inspection notes.

The authors state that the reason to the remarks on doors is based in the assembly as well as in the product. According to respondents, the evolution of the door design has led to increasingly heavier materials. The door need to meet to a variety of requirements for e.g. to fire performance, sound, vibration and escape. Doors are

today consisting of generally more technical details; they are wider and contain a higher proportion of glass which overall contributes to a high overall weight. This leads to higher torque on the hinge and greater stress on the frame and attachment. These components are not always designed for this load.

What measures should be applied to prevent warranty costs?

The authors have stated that, in order to prevent warranty work and quality issues, improvement work can be done in all stages of the construction process.

An open environment where employees can discuss issues and strive for common solution will benefit the project result. Employees can feel more involved in the project and thus have more influence.
The production staff should be involved in the early planning stages as they have more knowledge and experience with issues that occur during the production. This increases the likelihood that any future issues will be discovered early and thus easily preventable. In addition, with regard to the design, higher requirements must be made for the construction documentations that are provided. If it is difficult to design a drawing, it tends that the planner refrain from drawing, and it increasing the likelihood that quality defects and warranty work arises. Entrepreneurs must therefore strive to obtain complete documents without any question mark. Reducing the financial resources in the design stage should be construed as compromising at the wrong end. Furthermore, it should be avoided that the production starts in the early stages of planning. Designing parallel with production is not preferred because changes in the documents will lead to mistakes.

The relationship with subcontractors should be developed, as it is the subcontractors who make most of the work. Subcontractors are used in the project and higher demands should be pursued in terms of quality from the main contractor

Some warranty inspection comments are hesitant remarks that should not be remarked (according to the respondents). The contractor's representatives should question and discuss the surveyor's decision during the inspection. An experienced and active representative from the contractor's side can have a key role on the remarks that the inspector hesitates on. In other cases, the warranty work may affect the contractor because of the operating and maintenance instruction has not been used by the customer. The reason that the customers doesn't use the instructions for the operating and maintenance, are the complexity of the instructions. A more user-friendly maintenance instruction guide could increase the understanding and inspire the customer to follow it. Such user-friendly tools could be a development of a website or mobile- application. The web-based applications, with easy description and videos can in turn lead to lesser contractors being affected by the warranty work.

In what time period does the case company have the greatest impact in the warranty costs?

According to respondents, the projects suffer from warranty work during the first two years after commissioning of the residence. The total number of warranty notes from the warranty protocol for four projects, are more than 2000 comments (2,395 exact). Almost the same number the authors could determine from the case company´s

database (CSS). As a result, this can entail high costs for the case company in terms of allocated time and resources. This has been the basis for the choice of expiring the study's investigation from the warranty inspection protocol and the case company´s database.
According to an analysis by Boverket, (2007) shows that the vast majority of inspection notes relate to simpler shortcomings, "Last-minute-faults" encountered in the final stages of the contract. Thus, these deficiencies can be detected early by customers, which cause a lot of error remarks to be recorded on case company database (CSS). It is also possible that these errors remain in the warranty view and risk being costly to correct.
According to respondents, the problem may be due to the fact that the customer has high expectations of obtaining a flawless house. Customer are then dissatisfied when the product does not conform to their requirements and wishes. Another reason is that errors and shortcomings arise during the final phase of the project, which results in average quality becoming the target. Due to the time pressure faced the workforce, this will lead to many inspection remarks occurring before the customer's access.

Under special circumstances, the authors have found that more costly errors could occur at a later stage of the project life. For example, water and moisture could penetrate into the construction during the responsibility period and lead to critical consequences that entail huge costs for the case company. Given the fact that water and moisture damage contribute to high costs, this may be misleading as to what period in reality the projects are most dangerous. Therefore, it can be concluded that the first two first years are certainly not the most costly, but the authors can draw attention to the fact that this time is covered by many of the warranty work for the case company.

Other conclusions and some recommendations

- More time in the design phase and thus minimize errors
- Time planning, it is important to have a time at the end of project before handing over to the customer and not stressing in “last-minute”.

Recommendations

- The case company's database can be improved in order to find documentations easily accessed, such as; final inspections, warranty inspections, etc.
    - However, this has not been investigated in this study

7 Appendix

7.1 Appendix A

Inspection procedures

Construction-work defects can occur in several ways and it can be difficult to determine which party is responsible for the problem. However, there are directives and regulations, coercive powers (self-checks), which must be followed and besides these, there are functions which are set by the client (BKK,2009, Planning and Building act 2010:900). Inspections within the construction industry are surrounded by rules presented in AB04 and ABT06. There are several types of inspection where the final inspection has the major impact for the contractor as the contractor gets free from the contracts i.e. the contract will be passed on from the contractor to the client (Byggandets, 2009). Some general inspections are presented in the appendix 1 to have a deeper understanding, but the final inspection will be presented next.

Final warranty inspection

According to ABT 06, ch.4§7, the liability period for construction starts as the final inspection is approved and runs for ten years. An approved final inspection means that the warranty period has started. The purpose with the warranty inspection is to review of defects and errors that have appeared during the liability period (Nordstrand, 2008). The contractor´s work performance warranty period is for five years and two years for materials and goods, unless anything otherwise has been provided in the contracted documents. The client has also duty to report defects that has occurred before the warranty period as to avoid further damages (ABT 06 Ch5§5). However, the contractor has the main responsibility for the defects that appear during the warranty period. In ABT 06 Ch. 5 §5 are some comments, that states the contractor has an obligation to remedy defects that appear during the warranty period. However, the contractor cannot be held responsible if the deviation is attributable to the client such as design fault, or poor maintenance. (ABT 06 Ch.5§6).

Pre-inspection

The main purpose to execute pre-inspection is that some parts of the construction will be unavailable at a later time and must therefore be checked in advance. Example of building parts that can be difficult to access or problematic to fix can be installations. (Nordstrand, 2008; ABT06)

Final inspection

The final inspection is crucial and it is also a confirmation on how the contract has been carried out and that the potential warranty time after the contracts will start to apply. During the final inspection of the building the quantity surveyor will either approve the contract or disapprove. (Nordstrand, 2008)

Arbitration inspection

The client may call for an arbitration inspection if errors occur shortly after the final inspection. This due to that the client doesn’t need to wait until the final warranty inspection. (Nordstrand,2008)

Post-inspection

The purpose of the post-inspection is to check if noted defects from the previous inspection have been remedied. The contractor can also call for post-inspection but if the client is negligence, the faults can be considered as remedied. (ABT06; Nordström 2008)

Extra inspection
Extra inspection can be implemented if one party for any reason are dissatisfied with the survey report. (Nordstrand, 2008)

7.2 Appendix B

Warranty Inspection notes Components
Joint release (materials)
Bathrooms
Balconies
Electrically
Water damage, moisture
Plumbing
Windows
Cabinets and boxes
Painting
Other
Door
List
Floor
Crack on wall/ceilings

7.3 Appendix C

Interview.

The interview starts with a presentation of the authors to this study, then an explanation of the background and purpose of this study and what has been achieved so far. It is clarified for the respondent that the interview will be anonymous and the qualitative data will be used as analysis and results in the study.
The interviews were semi-structured, which means some questions were prepared before the meeting. The semi-structured interview gave the interviewer the opportunity to ask follow-up questions.

Some of the questions that were asked:

- Name, position and background of the respondents
- What are the most common issues in the aftermarket?
- What is causing those issues?
- What is the most costly issue in the aftermarket?
- What are your recommendations to avoid further issues in the future?

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