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Construction Quality: the Challenges and Keys to Improvement

A multi-level, explorative study of the Quality Management Practices in a Large Swedish Construction Company

Master's thesis in Design and Construction Project Management

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ABSTRACT

Lacking construction quality and recurring defects leads to significant costs and inconveniences for companies and customers within the Swedish construction industry. While other industries have implemented formal quality management practices with positive results, the construction industry has had a harder time to implement these ideas effectively. The complex nature of the industry is claimed to make it difficult to implement routines that are easily adopted in other ones, also shaping the general traits and behaviours of the people working in the industry. The aim of this study was to make a multi-level exploration of the quality work of a case company; to investigate both the formally provided routines as well as the actual work in order to outline their quality related challenges. It was found that fundamental aspects of quality management practices suggested in literature were lacking or even missing, especially routines that ensure continuous improvements and organizational learning. Quality does not seem to be prioritized on strategic levels, leading to lacking organizational structures and operational routines, placing the heavy weight of ensuring sufficient quality performance on the shoulders of individual managers at project level. The quality reached comes to depend on the interests, experience and knowledge of the managing individuals, their prerequisites and their ability to cope with those and coordinate their teams. The ultimate balance between formal quality procedures and efforts to foster sufficient quality cultures is yet to be found, but efforts aimed to improve both the formal routines and enhance the collective motivation are needed, and some suggestions of improvements are therefore developed for the case company, addressing them both.

Key words:
Construction Quality Management, Construction Industry, Organizational Learning, Knowledge Transfer, Construction Culture, Quality, Continuous Improvements, Motivation, Defect, Error

Byggkvalitet: Utmaningarna och Nycklarna till Förbättring

En explorativ studie på flera nivåer av Kvalitetsarbetet i ett stort, svenskt Byggföretag
Examensarbete inom masterprogrammet Design and Construction Project Management

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SAMMANFATTNING

Bristande kvalitet och återkommande byggfel leder till stora kostnader och problematiska konsekvenser för såväl företag som kunder i den Svenska byggbranschen. Medan andra industrier med framgång har implementerat formell kvalitetsledning verkar byggbranschen ha lyckats mindre bra. Komplexiteten som branschen förknippas med används ofta för att förklara svårigheterna med att implementera rutiner som fungerat bra inom andra industrier och har också kommit att forma de generella beteenden som finns hos de anställda inom byggbranschen. Syftet med denna studie var att studera hur ett stort, svenskt byggföretag arbetar med kvalitet; att genom en explorativ studie på flera nivåer undersöka såväl de formella rutinerna som det faktiskt praktiska arbetet, för att belysa de kvalitetsrelaterade utmaningar som detta företag har att bemöta. Resultaten tyder på att flertalet, enligt litteraturen, fundamentala aspekter brister eller rent av saknas, särskilt vad gäller rutiner som säkerställer ständiga förbättringar och organisatoriskt lärande. Kvalitet verkar inte prioriteras tillräckligt på strategiska nivåer, vilket leder till att organisationsstrukturer och operativa rutiner brister eller saknas, vilket i sin tur medför ett stort ansvar för enskilda ledare på projektnivå att säkerställa god kvalitet. Den uppnådda kvaliteten kommer till stor del att bero på individens egna intressen, erfarenheter och kunskaper, deras förutsättningar och förmåga att hantera dessa, samt samordningen och motivationen inom projekt-teamen. Den ultimata balansen mellan formella kvalitetsrutiner och ansträngningar ämnade att skapa och upprätthålla kvalitetsgynnande kulturer återstår att finna, men att ansträngningar som syftar till att förbättra både de formella rutinerna och den kollektiva motivationen behövs står klart. Några förbättringsförslag utvecklas därför för fallföretaget som berör dem båda.

Nyckelord: *Kvalitetsledning, Byggbranschen, Organisatoriskt Lärande, Projektkultur, Ständiga förbättringar, Bristhantering, Kunskapsutbyten, Byggfel, Brister*

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Sebastian Bartek & Elin Olsson
Gothenburg, May 2021

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1 Introduction

The following chapter will introduce the study, starting with some background information regarding the research topic. The aim of the study is then presented, followed by a description of the delimitations made.

1.1 Background

Quality has been a rising topic through many industries in recent decades as companies are becoming more aware of the benefits of meeting customer requirements and saving operational costs, often by implementing quality management practices (Sullivan, 2011). While many industries have successfully improved their quality work and productivity, the construction industry has been falling behind (Sullivan, 2011; Hoonaker, Carayon & Loushine, 2010). The costs of damages and reworks in the construction industry is a clear indicator on the issue of poor quality practices, as exemplified by Josephson & Hammarlund' study (1996), where the average costs of defects were calculated between 2.3 and 9.4 percent of the project production cost. Other studies found similar estimations, landing between 6.85 and 7.36 percent of the total project production cost (Lopez & Love, 2012). The main reasons for the difficulties of improving the quality in construction are claimed to be the complex and competitive nature of the industry and how the traditional traits of the industry shape the people and practices within it. The consequences for the construction industry's slow improvements in quality practices was recently presented by *Boverket* - the Swedish National Board of Housing, Building and Physical Planning - in their study from 2018 on defects, errors and damages in the Swedish construction industry (Boverket, 2018). While the actual cost for poor quality is hard to establish, the study estimates that around 100 billion SEK a year is wasted due to poor building practices.

Most construction defects are claimed to occur during the production phase due to the complex nature of the industry and construction sites (Boverket, 2018; Boverket, 2007). However, defects occur during the design phase as well (Boverket, 2018), and they may lead to even more dangerous consequences. The longer a defect remains undetected, the bigger the risks for error stacking effects or following failures, and also the bigger the costs to repair the damage according to both Love and Josephson (2004) and Frese and Keith (2015). Boverket (2018) found that lacking knowledge, insufficient knowledge transferring within and between construction projects and parent organizations, as well as human factors like poor work motivation on project sites, are the most probable causes of most defects, which the Swedish Construction Industry's Organization for Research and Development and the industry organization Byggföretagen agreed upon (Byggföretagen, 2020).

The currently most costly defects are related to various forms of water damages, often caused by inadequate climate screens or wetness in construction materials due to poor protection during construction (Boverket, 2018). Water penetration through roofs, flat roofs, courtyard floor structures, terraces and facades, often through minor holes or insufficiently constructed joints, due to significant weather conditions and precipitation are unfortunately very common, often leading to significant costs of investigations and repairment. Door and window mountings are also crucial moments

of the construction and production, often leading to water penetrations through the jointing strips or lacking functions (Boverket, 2018). They are apparently difficult to detect early on, and may be caused by a design error that remains undetected or by a slip or mistake during the production phase. There are however many other kinds of defects that arise during construction projects. Many or most of them are seldom documented as they are corrected at once, being a natural part of the problem-solving work day within a complex industry like construction (Koch & Schultz, 2019). The total costs of all quality defects within Swedish construction may therefore be way more significant than what Boverket (2018) estimated.

Many organizations attempt to work proactively with quality to ensure correct work practices, to avoid the appearance of defects, and therefore develop or adapt and implement a *Quality Management System* (QMS) to achieve target quality. Varying trends have made organizations translate well known *Quality Improvement Programs*, in parts or as whole, to suit their specific needs in their pursuit of better quality (Johnsson, 2016; Bergqvist, Elg & Gremyr, 2020; Bergman & Klefsjö, 2020). The implementation and effects of these programs in the construction industry are questionable however. Literature regarding construction defects suggest that construction organizations seem to have difficulties of learning from past mistakes, which therefore result in the same defects reappearing over and over again (Josephson, Knauseder & Styhre, 2003b; Love & Josephson, 2004). It makes one wonder where the underlying difficulties lay, inferring a need for further investigation. Are the QMS processes adapted lacking or have the systems been insufficiently implemented within the organizations? Or are the practiced work not aligned with the QMS procedures, and if so why?

1.2 Aim of the Study

The aim of this study is to make a comprehensive, in depth exploration of the quality work in a large Swedish construction company, detailing the formal quality management implemented, and how it translates into day-to-day quality practices. This in order to outline what challenges are leading to lacking quality and recurring defects within the case company, but also to provide some suggestions of how to improve their current quality work. Therefore, this study will take a holistic, multi-level approach, from strategic to operational levels, investigating both the formally provided practices, via the company quality management and support system activities, as well as the actual work, including the practical utilization of formalities and the human factors affecting the quality performance. The following research question has been formulated to be answered by the end of this study:

How does the formal Quality Management and the actual work affect the Construction Quality of a large construction company in Sweden, and how could it be improved?

1.3 Delimitations

The management system of the case company is vast, and conscious decisions had to be made in order to limit the analyzed material. The decisions were made in collaboration with the case company representatives, and the results of the analysis, i.e. the mapped figure and additional descriptions, were confirmed to include all the

most vital activities and processes of their QMS. There are, however, more activities related to quality in their management system than those found and presented. But, since these eventual activities were neither found, mentioned nor remembered during the interviews, the management system analysis nor the final workshops, where all findings were presented, these non-mentioned activities are considered non-existent or non-required in the management system.

20 interviewees with various roles and perspectives participated in the study, three of which were employed by support departments working closely with the case region. Their collective thoughts, challenges and ideas were considered to represent the general situation of the case region in this study, but one should keep this in mind while interpreting the content of this report. There may be other views of the various matters discussed that are not presented in this current version.

The study was conducted within the regional department for residential and commercial buildings in Gothenburg of the case company. Therefore, quality management practices utilized in other regions and the quality management system affecting other regions are not considered in this study. Therefore, it cannot be claimed that the study findings or suggestions for improved construction quality are applicable to all regions of the company, nor for any general company within the industry at large. The study findings could however be considered inspirational, for those experiencing similar challenges within their own organization, or encourage further studies of similar character within other companies.

2 Theoretical Framework

This chapter presents the theoretical findings of the thesis, serving as a framework for the further study. It begins with some general information of Quality and common Quality Management to introduce the common theories and practices used. A description of its implementation in the construction industry will follow, including the applied practices, related challenges as well as both hard and soft factors that may affect the quality performance in construction companies.

2.1 The Concept of Quality

What is quality, really? A search for a sufficient definition of the concept resulted in several different ones depending on the various authors. Bergman and Klefsjö (2020) defines the quality of a product or service as its ability to satisfy the needs and expectations of the consumer. The reaching or exceeding of these needs and expectations would be considered good or very good quality. The *International Organization for Standardization* (ISO) presents another version, defining quality as "*the degree to which a set of inherent characteristics of an object fulfills requirements*" in the ISO9000 series (International Organization for Standardization [ISO], 2015). This whilst the Swedish Standards Institute, SIS (2016) also includes the relationship between the expected or intended performance or function and the perceived value of the end user within the phrase "*the ability to satisfy*", as seen below:

"The quality of an organization's products and services is determined by the ability to satisfy customers and the intended and unintended impact on relevant interested parties" (SIS, 2016)

It is difficult to find a singular definition of quality as it is dependent on the organizational objective and determines the way the product or service creation, development or improvement are to be conducted (Gremyr, Bergqvist & Elg, 2020). *Good quality* is also hard to define since it depends on the expectations, both explicit and implicit ones, of the customers and stakeholders involved. Although these definitions vary to some extent they all include some significant characteristics: namely the clients or stakeholders involved as well as the relation of expectations or requirements and the value attained and experienced of the process, product or service. Good quality seems to be achieved if those expectations or requirements are considered reached or exceeded by the customer or other stakeholders. However, the implicit and explicit needs, requirements, expectations and trends develop over time and organizations must continuously work to understand their customers in order to perform to satisfactory results. This fact demands a continuous work of organizations to improve their established processes in order to deliver sufficient value to the stakeholders as their needs are varying (Gremyr, Bergqvist & Elg, 2020).

Consequently, the quality is considered lacking or poor if the requirements and expectations of the customer(s) are not fulfilled to some extent (ISO, 2015). A quality defect relates to a nonconformity, defined by ISO as a "*non-fulfillment of requirements*", which may be caused by material aspects or human errors, unintended or not, as a result of the apparent context. Of course, all organizations, no matter the industry, are confronted with errors (Frese & Keith, 2015). *Errors* are a fundamental

aspect of both individual and organizational learning and development, leading to reflections and following actions needed in order to solve the problematic situation and to prevent its recurrence. Many or most of those errors are easily corrected, but some of them may lead to negative or even devastating consequences. The errors can be categorized due to the nature of their occurrence, where action errors are clearly distinguished from violations, failures or inefficiency issues.

Errors can be either intentional or unintentional, but stem from human actions within the organisation. *Mistakes* are unintended by the persons committing them, while *Violations* or smaller *slips* are intentional, where a conscious choice is made to disregard norms or rules. An organisation needs to be able to cope with both, preventing mistakes from happening and preventing violations, which might stem from too many rules or competing values. These errors should be mitigated to prevent *Failures*, a negative organizational outcome or consequence, which may arise if the error remains undetected. There are also *Inefficiency issues*, which do not result in failure, the intended organizational goal is achieved in an ineffective way. However, no matter the error categorization, they all cause quality concerns and must be dealt with sufficiently in order to minimize the negative consequences and damages, as well as repeated appearance (Frese & Keith, 2015)

Love and Josephson (2004) explain that the manifestation of a defect is the result of a "*Chain of Actions*". This Chain is started by an underlying cause, also called the *Root Cause*, causing one or several human actions which makes the defect manifest, resulting in some kind of a consequence and often a corrective measure. Human actions are the only things that can be erroneous, as previously exemplified by the different types of actions, adding *Inaction* to the list. While accidents and incidents may happen, it is primarily by human actions that these incidents happen, either because of intended or unintended actions. The underlying root cause can lie at any level, like organizational, project or individual level, and can also lay in the combination of various contextual factors.

Because, no matter the nature or kind of underlying root cause, quality defects may lead to a various spectrum of negative consequences. Love, Matthews and Fang (2020) describes how all defects may lead to either severe costs or lack of profit or else, if really unfortunate, to safety or environmental incidents if not detected in time. Latent defects may be stacked upon one another, ultimately leading to accidents or fatalities, contaminations or pollution, reputational damage, significant costs of insurances, as well as extreme costs. Even if corrections are made, the defects, and their need for consequent reworks, always lead to losses in productivity and profit, work delays to some extent, as well as unwanted stress and fatigue among the ones involved (Love et. al, 2020).

Organizational conditions, or team settings in general, may affect and influence both individual and shared or team errors and their consequences. Communication is a key here, which if sufficient can have positive effects on error detection, correction and organizational learning and improvement, but it could just as well trigger individual as well as team errors if insufficient (Frese & Keith, 2015). A weakened organizational error defense, caused by insufficient or clashing cultures, organizational structure or decisions by managers for example, may be figuring a latent error, which in time may

cause further failures if triggered by other actions. Also, teams may be able to help each other to reach a common goal, having an open communication and being able to detect and deal with errors more efficiently, but without proper communication and cooperation the individual errors might not be detected nor corrected (Frese & Keith, 2015). Most organizations tend to focus on error prevention, often with a strong belief that no errors should be allowed at all, and systematized quality management is therefore applied within the organization with the idea to ensure good quality from the start.

2.2 Quality Management

The most common view of Quality Management, according to Gremyr, Bergqvist and Elg (2020), is that it concerns the systemic efforts made with an aim to improve the processes and products for the organizational stakeholders. Organizations provide their practitioners with a set of core principles, tools and procedures, all sequentially connected to ensure that the intended level of quality is reached. To enable customer value by understanding, managing and improving these processes of the organization is therefore what quality management is all about (Gremyr, Bergqvist & Elg, 2020).

ISO defines a process as "*a set of tasks that are completed to work towards an ultimate goal*" (ISO, 2015) and Johnsson (2016) adds that these activities should have clear inputs and outputs, that a process is a series activities that transform the input into output, all intended to add value of some sort. Gremyr, Bergqvist and Elg (2020) also claims that these linked processes, from a quality management perspective, are based upon three fundamental principles, formulated as: customer focus, continuous improvements, and teamwork. An organization-wide focus on the customers and their needs are claimed to be vital in order to achieve their acceptance and satisfaction, a fundamental aspect of organizational survival and profitability. Continuous improvements are needed to attain consistent customer satisfaction, which is best achieved through teamwork or collaboration between all actors throughout the network of supply chains, production and final consumption (Gremyr, Bergqvist & Elg, 2020).

Bergman and Klefsjö (2020) explains how the scope of *Quality Work* and Development has developed over time from the narrow view of solemnly production Quality Control around the times of the second world war to now include more proactive work and activities as well. The wide terms of Quality Work or Quality Development now imply the management of the entire system of organizational processes aimed to continuously improve the end product quality, both before and during as well as after the production. Quality Assurance procedures are performed prior to the production process, proactively providing sufficient conditions for a successful production, whilst Quality Controls take place afterwards in order to ensure that the intended quality has been reached. Quality Management is then distinctively described as the quality related production processes, during the production phase, where constant improvements are aimed for in order to sequentially improve the end product quality. Bergman and Klefsjö (2020) claim that Quality Assurance, Quality Control and Quality Management are all important parts of the organizational Quality Development or Quality Work, seen as separate phases but highly intertwined systems of processes integrated within the organizational work of continuous improvements.

2.2.1 Continuous Improvements

The purpose of continuous improvements is to plan, monitor, evaluate and respond to improve the production system and its processes in order to constantly strive towards better production and results (Johnsson, 2016). It is a core function of quality management and no process should be excluded from it, neither core processes nor supporting ones. Johnsson continues to explain that improvements can be categorized into two variances, the first being Smaller improvements, often optimization changes made by small economic means, often made by the people within the processes that are being improved upon. The second category is the Larger improvements, often referring to new trial implementations in projects or systematic changes in the management system, most commonly driven on by top or higher management. Bergman and Klefsjö (2020) also emphasize this similarly, that continuous improvement does not solemnly infer groundbreaking organizational change but also smaller ones. Some changes might seem to lead to small economic gain or improving effects at start but may prove significant results as they are often easier to implement and adopt throughout the organisation than transformational ones. Scaling originally small, incremental changes may therefore lead to great improvements. Johnsson (2016) describes that in the best of worlds, smaller improvements come from the people involved in the processes, whilst transformational changes must be catalyzed from a change agent who dedicates more time to understand the system as a whole, like a Quality Manager, as a part of a larger strategic plan.

Continuous Improvement is a fundamental part of quality management according to Johnsson (2016), being an underlying aspect of all or most systems of quality management philosophies since customer and stakeholder expectations are ever changing. In order to improve the current processes there has to be an understanding of the current practice as it is in order to see where improvements are needed. Bergman and Klefsjö, 2020) explain that financial indicators, like revenue or profitability, or other key performance indicators regarding leadership or customer satisfaction, which could be measured with surveys or qualitative interviews, are often concurrently documented, evaluated and analyzed. These evaluation and analysis processes are not exempted from continuous improvement efforts either, as improvements should be considered for both value creating processes and internal processes as well. The idea of continuous improvements are closely related to the theory of systematizing the relation and combination of reflections and actions to ensure a never ending cycle of learnings (Johnsson, 2016). The PDSA cycle is a well known model for systematic improvement work, commonly considered another fundamental aspect of quality management (Gremyr, Bergqvist & Elg, 2020).

The four-step iterative method for continuous improvement; the *Plan-Do-Study-Act Cycle* (PDSA), also called The *PDCA-Cycle*, the *Deming cycle* or *The Cycle of Improvements*, is central in any systematic improvement program or quality management theory according to Gremyr, Bergqvist and Elg (2020). The idea is that a consistent application of the method should lead towards better quality and performance of the organisation. See Figure 1.

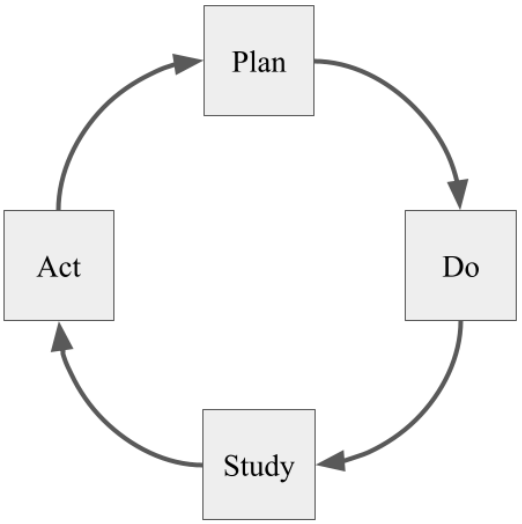

Figure 1. The PDSA Cycle, made by the authors, inspired by ISO9001 (ISO, 2015)

During the first *Planning* phase, objectives are established and plans developed in order for the organisation to achieve them and improve. The plans are put into action during the second *Doing* phase, by the implementation of the activities planned, and the results are then measured during the *Study* phase to be reflected and learned upon. Did the plans work and were the objectives met? Why or why not? Ultimately, during the last stage of the cycle method, the learnings are put into *Action*. Successful ideas and methods are implemented and widely spread throughout the organisation, whilst less working ideas are rejected, forming the initial situation for the next PDSA cycle (Gremyr, Bergqvist & Elg, 2020; Johnsson, 2016).

2.2.2 Quality Improvement Programs

Quality improvement programmes are combinations of different tools or procedures that organizations can adopt to improve their quality management, each programme promoting its own goals, focus areas, tools or processes and leadership philosophy. (Gremyr, Bergqvist & Elg, 2020). Which kind of program an organization adopts typically depends on the organizational structure and their particular needs or objectives as well as fashionable trends. However, all programmes tend to include a number of general characteristics, such as the organization-wide implementation, and that the programme implementation is considered a long term and continuous initiative, aimed to achieve continuous organizational and end product improvement, reduced costs and/or increased customer satisfaction. Again, the principles of continuous improvements in accordance with the PDSA-cycle are seen in many of these programmes, as it lays the foundation of quality improvements. The particular principles and practices exploited are determined by the top management and clearly based on an extensive participation of all organization-wide employees. *Lean*, *Total Quality Management* (TQM) and *Six Sigma* are three commonly adapted programmes, having their own toolboxes and philosophies aimed for Quality Improvement specifically (Gremyr, Bergqvist & Elg, 2020; Bergman & Klefsjö, 2020).

2.2.2.1 Lean

The concept and managerial tool box of Lean was originally developed by the automobile company Toyota in Japan but is now adopted worldwide in a wide variety of industries (Bergman & Klefsjö, 2020). The overall idea of the concept is to avoid all kinds of waste throughout the supply and production chain whilst constantly focusing on value creation for the customer. Overproduction, time waiting, unnecessary transportations, movements or storage, production defects, as well as poorly utilized human resources are all considered examples of waste to be avoided. Every activity or other circumstances that do not create value for current or future clients are considered a potential waste which should be reduced. This while striving for efficient processes or activity flows, also called value flows, identifying bottlenecks to minimize their negative effects, and to decrease product and process variations (Bergman & Klefsjö, 2020).

Bergman and Klefsjö (2020) emphasize that Lean is like a toolbox, containing tools and methods to adapt in order to slim the production process to create maximum value possible and minimize the waste. However, Lean is not enough on its own. If we look closer on the successful case of Toyota where Lean Production was first established, one can see that Lean is only one part of "*The Toyota Production System*" (TPS), which in turn is only a part of "*The Toyota Way*" (Bergman and Klefsjö, 2020). The TPS includes the ideas of: long-term thinking and prioritization, the continuous search for the root cause of issues to foster a learning organization, the value stream based focus on processes to reach successful results, as well as the fundamental principle of a leadership that develops the employees and other stakeholders involved in order to create value for the organization through exceptional individuals and teams. Also, all work procedures, activity connections and communication should be clearly defined and formally conducted, and the work of continuous improvements should be based on scientifically approved methods and constantly measured and monitored by experts. Bergman and Klefsjö (2020) then describes the Toyota Way as the leadership and culture so strongly embedded within the organization, which seem to be a very important key to the indisputable success of Toyota. How the Toyota Way goes beyond a set of tools and methods for efficient production through a leadership that promotes proactive learning instead of reactive problem solving. How this in turn has created a system of employee mentoring, where more experienced employees teach and support the less experienced throughout the organization, which has become a key aspect forming the transparent and learning culture. An organizational culture that promotes transparency, in addition to sufficient methods tools like the ones that Lean provides, focusing on learning for continuous process and end product improvements instead of individual blamings or instant problem solving, seem to be the key to organizational success (Bergman & Klefsjö, 2020).

2.2.2.2 Total Quality Management

TQM is a set of practices shaped by a group of so-called "*quality gurus*", and is built upon the experiences of these gurus (Prajogo & McDermott, 2005; Sullivan 2011). TQM aims to deliver high quality to the end customers by integrating all processes to a high degree, continuously improving each process and thereby the quality as a whole. Total quality management points out that quality is a strategic goal that the organization must strive towards in order to stay competitive, as the cost of poor

quality products is too high (Bhat, 2009). This requires the commitment and empowerment of the entire organization, from management to production, to packaging and inspection. Every employee should be informed and educated on the importance of quality, and be empowered to affect the production to ensure this quality, like giving the power to stop production momentarily to ensure the inspection of a potentially faulty product. This dedication requires everyone within the organization to get involved and work towards the same goal. This is achieved by understanding and focusing on customer needs and expectations and engaging all workers to achieve high motivation, rather than promoting formal routines and structures. Top management should be committed and involved in the organization and engage employees, creating opportunities for learning, education, empowerment and motivation. TQM suggests that processes should be designed with customer satisfaction as the main goal and employees and management should understand the processes. Effective quality management focuses on preventing defects from happening, and understanding where the source of the risks lie, rather than detecting defects through inspections (Bhat, 2009). The philosophy of a Quality Culture plays a very big part in TQM, as values of ensuring quality at all costs as well as employee empowerment is strongly connected to the organizational culture itself.

2.2.2.3 Six Sigma

The concept of Six Sigma was inspired by the holistic view of Quality Management of Lean, and the Japanese way of implementing it, as the improvement program was introduced by Motorola in the 1980s (Bergman and Klefsjö, 2020). The concept is commonly initiated by top management in order to increase profitability by decreasing variations throughout the production process towards the end products. Undesired variations are claimed to be a significant source of unnecessary costs and dissatisfied customers, and the main goal is therefore to eliminate, or at least decrease, these variations which ultimately would result in dramatic organizational and end product improvement (Gremyr, Bergqvist & Elg, 2020; Bergman & Klefsjö, 2020).

The improvement program is based upon an extended version of the PDSA cycle called DMAIC, referring to the phases to Define, Measure, Analyze, Improve and Control, and an idea of a strategic work of parallelly structured improvement initiatives, separate but connected to the ordinary organizational hierarchy (Gremyr, Bergqvist & Elg, 2020; Bergman & Klefsjö, 2020). The parallel structure is organized by various levels of Six Sigma specialists, depending on the level of education within the concept, leadership, and analysis methods. The more experienced support and teach the lower level experts of the parallel structure, and each level has their own responsibilities in order to align the parallel initiatives with the rest of the organisation. The Quality Management theory of Six Sigma is based on an in-depth knowledge of the organisation and its processes, collected through extensive data analyses and statistical performance metrics in addition to qualitative process mapping methods, to systematically ensure that all members of the organization knows what, when and how to deal with quality matters or whom to contact for help if in need (Gremyr, Bergqvist & Elg, 2020).

2.2.3 Quality Management Systems

ISO (2015) defines Management Systems as a set of processes which an organization has decided to follow or conduct in order to meet their certain objectives. The implementation of a Management System is a strategic decision, made by top management, aimed to improve the overall performance of the organization, sometimes within a certain focus area (ISO, 2015). The systems can be aimed at a variety of areas, such as Environmental Management, Health and Safety or Quality, whereas a Quality Management System (QMS) naturally is focused on the area of Quality Management (Gremyr, Bergqvist & Elg, 2020).

The systems are uniquely fitted to suit the organization, and the content can either be adapted and implemented as a package, provided by a reputable party, or programmes like Lean, TQM or Six Sigma, or else be activities developed by the organization themselves (Gremyr, Bergqvist & Elg, 2020). The systems are often combining activities from various programmes with the companies' own procedures, being tailored by and for the organization and their particular business and objectives. The finished QMS can be kept separate or else be combined and integrated with company management systems of other focus areas, with the possibility to apply for certifications of compliance. The idea with the systems is to formalize the working procedures of the organization to ensure as consistent and sufficient performances as possible at all times (Gremyr, Bergqvist & Elg, 2020).

It is common to certify the system in accordance with a reputable third party to ensure that the system covers all the necessary or important activities that ensure good quality of both internal processes and end results (Gremyr, Bergqvist & Elg, 2020; Bergman & Klefsjö, 2020). ISO offers a standard for QMSs named ISO9001, which has become widely implemented in many different organizations, in a variety of industries all over the world.

2.2.3.1 ISO9001

Many large companies choose to certify their QMS according to the standard ISO9001, the latest version of it being introduced in 2015 named *ISO9001:2015 - Quality Management Systems* (Johnsson, 2016) which is utilized by over 1.1 million companies and organizations world wide (Gremyr, Bergqvist & Elg, 2020). An ISO9001-certification is a great benefit for customers, as it provides a guarantee that the company works in a consistent way with quality management and improving their processes.

The quality management model is designed to be applicable for all organizations in all industries, so the guidelines are very flexible and general to allow manufacturing, service and construction industries alike to implement its principles (Johnsson, 2016). The standard provides guidelines on how to set up a QMS, and requirements on what needs to be included in the system to be granted the certification, making it possible to build your management system on the principles of ISO or to create a management system on your own and then certify it if you fulfill all the requirements. Therefore every industry and organization has to decide how to implement ISO9001 themselves and what aspects that are of most importance for them specifically (Johnsson, 2016; Gremyr, Bergqvist & Elg, 2020). There are a number of standard documents within

the ISO9000-family, aimed to guide the implementation in different organizations in various ways. One of those documents is called ISO 10006, which describes how the management system standard of ISO 9001 could be implemented in project based organizations.

As seen in Figure 2, ISO9001 is based on the PDSA-cycle and builds upon it by emphasizing the importance to understand the customer needs, including the planning of how to deliver a product with a quality that matches those needs, then executing that plan, collecting data from the processes and customer satisfaction and finally, adjusting the system to improve quality (Johnsson, 2016).

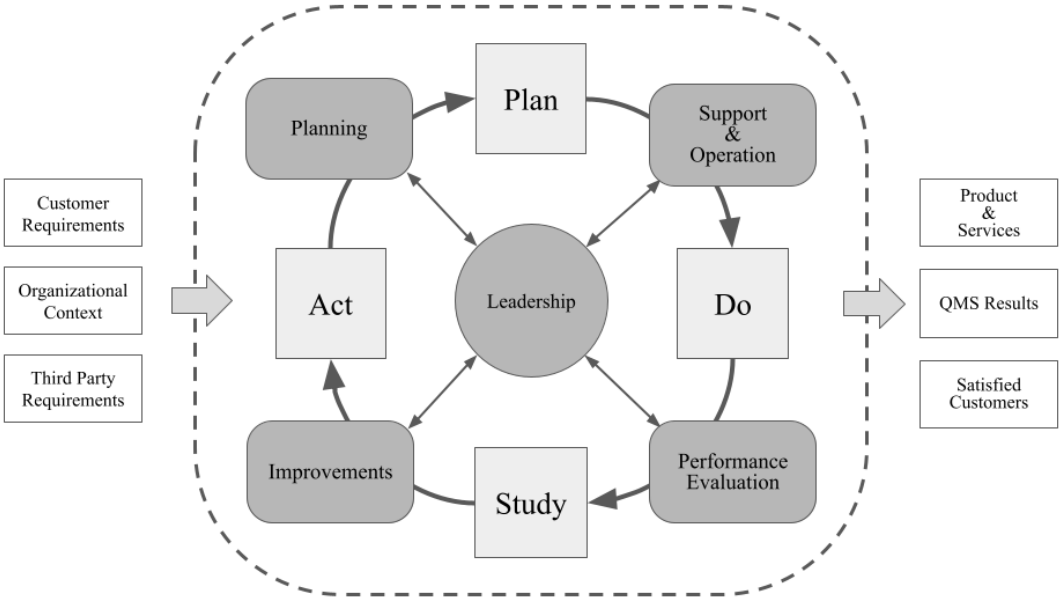

Figure 2. Visualization of the ISO9001 principles, made by the authors inspired by ISO (2015)

There are a set of key features emphasized in ISO9001 and shown in Figure 2, the fist being Leadership, which is strongly tied to taking responsibility for the quality work through the company (ISO, 2015). This includes communicating the importance of quality work, ensuring enough resources are provided to the quality organization and promoting continuous improvements as well as employee engagement. The leadership is also responsible for creating a quality policy for the organization. Planning ensures quality goals are set based on requirements from customers and other parties, as well as design the path to the goal and how to achieve improvements upon the process. This requires consideration on which routines and practice should be utilized, what resources are needed to reach the goal and evaluate if the actions have contributed to reaching the goal. The Support role is focused on implementation, taking on responsibility for the supportive activities like infrastructure, communication, constructing effective teams and managing knowledge within the organization to reach the goal. Operation focuses on the product itself, ensuring it reaches the intended quality and meets the customers requirements, documentation of the product as well as day-to-day business. Within Performance Evaluation, the organization should decide on what indicators to monitor, analyze and evaluate in order to improve the business. Improvements are a continuous work to ensure the organization is

fine-tuning it's processes to better reach it's quality goals based on customer requirements. These features are guidelines on how to implement the PDSA-cycle, and by implementing all these guidelines, an organization is eligible for an ISO9001-certification. One of the critiques of ISO9001 is how general the guidelines are, requiring certain documentation that might not be relevant for some industries and hince not being value-adding to the quality process (Johnsson, 2016).

2.2.4 Project Based Quality Management

Project based organizations have some peculiar conditions to consider when it comes to the organizing of quality management. A project is defined as a "unique process undertaken to achieve an objective" according to ISO, where the Project Management Body of Knowledge Guide (PMBOK Guide), provided by the Project Management Institute (PMI), adds on the aspect that it is a temporary endeavour to reach a certain project result or service. A parent organization may undertake several projects at the same time, each assigned to their own project organization that carries out the project (PMI, 2017; ISO, 2018). So, the parent organization may have several projects going on simultaneously, maybe in various project phases, all temporary organizations that are put together for a limited time. The quality management may therefore be more complex, due to the more complex organizational context, which may enhance the need for structures and good planning even more.

The PMBOK Guide defines what is considered good practices of Project Management, and the practices described are applicable to any industry or organization that aims to achieve their objectives via project based organizations (PMI, 2017). The ISO standard ISO21500 presents a very similar framework for project management as PMBOK but in a much smaller, less detailed version, mostly defining the contents of project management without details of various tools (Gasik, 2013). Therefore, the PMBOK Guide will be used to describe the project based quality management perspective. The theories are built upon the PDSA-cycle and customer satisfaction as a key driver, with a strong belief that it is better to proactively plan for good quality, to prevent defects or errors from occurring, than to find the errors during later stages and inspections (PMI, 2017).

The project management framework is divided into ten different areas of management knowledge, according to the PMBOK Guide (PMI, 2017), one of which is identified as Project Quality Management. The Knowledge Area of Project Quality Management is divided into three groups of processes, namely Plan Quality Management, Perform Quality Assurance and Control Quality. The planning phase aims to identify the quality standards and requirements to be achieved by the project and to describe how to demonstrate the level of result compliance. The next phase aims to ensure that the project follows the documented procedures and requirements of the Quality Management Plan, and to provide confidence that all expectations and requirements will be met by the project deliverables. The third and final phase is aimed to record, monitor and assess the performance and results of the executed quality activities and to recommend process changes for future projects if needed. All process groups are organized to clearly present the inputs, tools and techniques to use and the outputs of each stage to attain satisfactory project results (PMI, 2017). So far, the quality management practises look rather similar in theoretical structure to the ones for non-project based organizations. Even when it comes to the fact that there are more

aspects than Quality that should be considered, and that many aspects are claimed to be very intertwined and affected by one another (PMI, 2017).

However, the most peculiar aspect that distinguishes the projects based organizations from other ones is probably that very thing: the organizational structure, and the relations between the parent organizations and its projects, and the quality management structure, among other knowledge areas, must be organized to cover both the projects and the parent organization as whole (PMI, 2017; ISO, 2018). Top management should provide the projects and all employees with the tools and practices they may need to operate, control and monitor the project process, and also facilitate a sufficient quality culture, where lessons learned are collected and utilized as input for strategic improvement processes (PMI, 2017; ISO, 2018). The standard ISO10006 (ISO, 2018) explains how the responsibilities should be clearly divided and communicated between the different organizations and other involved parties or roles, but it also claims that an active top management commitment and involvement between both the projects and parent organizations is key to attain and maintain a sufficient QMS for both the project and the parent organization. So, from a Quality Management perspective, aiming for continuous organizational improvements, it seems as if the main particularity comes down to the ability to collect and learn from the experiences gained in the projects even as the temporary organizations often are disbanded upon completion (PMI, 2017; ISO, 2018). The parent organization should therefore take the lead here, to ensure that lessons learned in a project are implemented in other or future projects to achieve continuous improvement.

2.3 The Construction Industry

The construction industry is primarily project-oriented, where every project process and final product is unique, with several parties cooperating in one form or another within each project (Sears, 2015). The projects are often led by a general contractor, where various tasks or services are acquired from others in order to deliver a qualitative product. funded by the customer who ordered the project for their purposes. Several companies generally compete to gain the contract, whereas the lowest bid often determines the winner. As the lowest bid is often utilized, the industry is relying on small profit margins, and with a high product diversity, quality is rarely considered a main competitive advantage, as long as requirements are reached, as price will often be a more dominant factor (Sullivan, 2011). This creates considerable pressures of time and money in the projects to stay within budget and schedule, as delays may be devastating coordination-wise and lead to significant fines according to Swedish standard contracts, and thereby affect the profit of the company (Sears, 2015).

Commonly considered traditional or conservative, the construction industry is often described as slow to change and development in comparison to other industries. Several studies describes that the construction industry as lagging behind many other industries over the last decades in many issues such as efficiency, profitability, quality, digitalization among other things, claiming that the organizational learning is lacking and overall development seems to be tough (Josephson, Knauseder & Styhre, 2004; Hoonakker, Carayon & Loushine, 2010). Change and improvement is needed, but why is the industry development slow in comparison to others? Quality issues and building defects are very common within the industry and it seems to be hard to

systematize the learnings of previous experiences, to spread the knowledge throughout the organization, in order to prevent them from happening again elsewhere (Johnsson, 2016). The complex organizational structures of the industry and the uniqueness of each project are often used to explain the general difficulties of improvement within the industry.

2.3.1 Construction Management

The construction industry is primarily made up of construction companies, enterprises and developers, each involved in any number of parallel projects depending on their size and availability of jobs. These projects are connected to the parent organization, but are run by a team of individuals assigned to work within the project (Sears, 2015). Depending on the company and their expertise, the team will be responsible for certain aspects of the project, such as the design, installations, planning, construction, logistics or any combination of these, whilst other aspects are outsourced and conducted by external consultants or subcontractors. Each project is considered a unique product, with different budgets, schedules and designs depending on the customers requirements. To deliver this project, many parties collaborate through different means to achieve the end result, each role hired for their specific purpose. The project team tends to change throughout the entire project life cycle, depending on the phase or tasks and expertise needed, all gathered around the project or specific phase itself to split up and move on to a new one once their job is done (Josephson and Hammarlund, 1996; Johnsson, 2016). A project organization is, in its very nature, temporary which creates an isolation for the parties involved from the parent organization and other projects. The management on project sites and the organizational support from the core organization, aimed to coordinate all processes by providing structure and preferred practices, become important aspects in order to cope with the complexity of each project (Sears, 2015).

Construction companies provide support to their projects through economical means, guidelines, sometimes standardized structures or preferred procedures and other support and knowledge which the projects might need, often via management systems, policies and organizational value proclamations. The strategic decisions are generally made by the parent organizations but the projects themselves are often operated rather independently within the rules and frameworks provided. The project and site managers possess an interesting role of great responsibility here, serving as the main linkage between the upper organizational level and the projects themselves (Johnsson, 2016). There seems to be a lot of individual freedom in each project, allowing the managers to try new ways of working and new routines as long as the pre-set goals and requirements are met, which leads to varying project conductions and results depending on the managing individuals (Josephson, Knauseder & Styhre, 2003a).

Sandberg, Löwstedt and Räisinen (2021) agrees, describing how the role and work of construction site managers are considered to have a hub-like function, connecting the two system layers of the ”outside” organizational layer and the ”inside” project layer. The site managers possess a multifaceted role with both strictly managerial responsibilities, as well as more ”mundane” and leadership related activities needed to motivate and engage the ever changing project team. It is truly a complex role with the responsibility to materialize the systems and objectives of the parent organization

into concrete building practices, and at the same try to ensure a motivated team and pleasant proceedings (Sandberg, Löwstedt & Räisinen; 2021). The level of autonomy and ability to control and manage a project according to one's own preferences is seen as an important and eligible aspect of the role by the managers themselves, and previous attempts or propositions to standardize and "simplify" their work has not been positively received (Löwstedt & Sandberg, 2020). However, the fact that the projects are conducted differently depending on the managerial individuals results in varying quality of the project outcomes (Johnsson, 2016). The rather loose couplings between the projects and the parent company also affects the ability to spread and learn from experiences throughout the organization to the other projects, leading to recurring quality defects.

In order for construction companies to achieve their objectives, structured ways of planning, conducting and controlling their business activities are either adapted or developed. This is important on both individual projects' level and for the parent organization in general, no matter which manager or team is in lead, to ensure good project results as well as company image continuity (PMI, 2017). The fact that the project end product, the project organization, the building process and context all are unique in each and every construction project, requires a flexible mindset and adaptability for the managers that lead the projects onwards. Time schedules and budgets or cost constraints must be kept to no matter the complexity of individual projects, or else all the following tasks and their teams will be affected in addition to financial fines (Sears, 2015). However, small components and management processes of the construction tend to be consistent from job to job, from project to project, and both could and should therefore be considered and developed to ease and improve all project conductions of a company (Sears, 2015).

Finding ways to truly understand and more effectively manage the construction process is key. Construction companies tend to adapt or develop formally provided Management Systems, just like other industries, to achieve their goals and to strive for better, expected and less varying project results. These systems are systematically built up as a series or scheme of procedures, covering activities aimed at certain focus areas such as sustainability, quality or work environment or several areas combined, aimed to ensure that organizational and legally required standards are met if followed by the employees (Sears, 2015).

2.3.2 Quality in the Construction Industry

Hoonaker et al. (2010) conducted a study in order to investigate how companies within construction define the term of Quality, concluding that it seems to be hard to define within the Construction industry as well. They claim that there is a general attitude among contractors that good quality is reached if the result looks good, works well and the preset requirements of the project are reached. Boverket (2018) in their study on defects and errors in the Swedish construction industry decided to not utilize a definition, but rather to leave the definition up to each company involved in the study. They also say that the unclear definition of Quality makes it hard to find a way to measure and compare different outcomes. Many tend to turn to the aspect of Customer Satisfaction, but this kind of measurement is hard to compare between different organizations or even projects due to at least two reasons. First, there are no standardized ways of measuring Customer Satisfaction within the industry, making

them difficult to compare or benchmark to others (Hoonaker et al., 2010). Second, the expectations of various customers, both underlying or known, are highly individual, and therefore the various customers of each project will interpret the Quality of them differently (Gremyr, Bergqvist & Elg, 2020).

However, as Koch and Schultz (2019) express, that even though the term of Quality is hard to define and the causes of less good Quality are complex and varying, it is contrastingly shown in very concrete ways in practise; resulting in recurring, costly defects and sometimes even severe failures on construction sites. They therefore claim that the blurry definition of quality really does not matter, arguing that it is important to investigate the defects to find the underlying causes of them in order to learn and prevent them from happening again.

2.3.3 Quality Management Programs in the Construction Industry

The often criticized poor performance, lacking quality and decreasing productivity during the past decades within the construction industry has led to increased adaptations of structurized management practices throughout the design, production and guarantee period stages (Hoonakker et al., 2010; Sullivan, 2011). Many have tried to adapt various quality management programmes (QMPs), being inspired by their positive results within manufacturing and other industries. However, the construction industry's general structure is quite different compared to other ones, and it has shown to be rather difficult to adapt and implement these programmes in our organizations.

Sullivan (2011) describes how the three well known programmes of TQM, Lean and Six Sigma have been applied to various extent within construction companies, what strengths and weaknesses they each have within construction, as well as the effects they have had in the industry. His study concluded rather bluntly that the progress from these programmes has been reported to be close to non-existent in the construction sector, finding the unique, complex nature of the industry as the primary barrier that makes them hard to implement. The high product diversity and low levels of standardization within the industry seems hard to combine with the exclaimed vagueness of TQM, i.e. the difficulty of defining its very purpose, goals and descriptions of how to reach them. The inability to control the construction production process has made it difficult to adapt Lean principles, and the non-existent methodologies to evaluate performance improvements or defect rates as promoted by Six Sigma, has made contractors question the effectiveness of the three programmes. There does not seem to be a sufficient way to measure the value gained or paid of the programmes versus the quality reached in construction (Hoonakker et. al, 2010; Sullivan, 2011).

2.3.4 Quality Management Systems in the Construction Industry

Instead of applying programs that were initially developed for manufacturing industries in a construction context, which has proved to be frustrating or even impossible in some cases, construction companies now tend to apply some selected tools, methods and practises from them to suit their specific needs in various phases (Johnsson, 2016). Numerous activities and processes, which may be collected from or inspired by ones in well known QMPs, or else developed or found in other ways, all aimed to maintain, ensure or improve quality, are then combined. All together forming

the Quality Management System of the organization, provided by top management to support the projects and ensure consistent performance and quality throughout the organization. Johnsson (2016) explains that Quality Management Systems are common in the construction industry but that they often are merged and intertwined with other focus areas, organized to suit the needs of a certain organization. It is common in the Swedish construction industry to apply for a certification of the QMS, especially among larger companies, to validate the management system structure and the quality content, most commonly towards the international standard ISO9001 (Johnsson, 2016).

ISO9001, as described in Chapter 2.2.3.1, provides guidelines on how to create a QMS and what contents that should be included in it. The standard is presented in very general terms since it is made to be applicable in any organization, no matter their structure or the industry, and it is up to each organization to consider how to implement the guidelines and shape their QMS to serve themselves the best way possible (Johnsson, 2016; Gremyr, Bergqvist & Elg, 2020). It seems to be rather difficult to do within construction though, and there are even organizations that specialize in the matter, to help construction companies implement ISO9001 into their management and structure their ways of doing business (Byggföretagen, n.d.)

A typical QMS in construction companies contains quality goals and policies, descriptions of processes and routines on various levels of detail, required meetings and their different agendas, checklists and other documents that can support the organization and their projects to achieve sufficient quality and continuous improvements (Johnsson, 2016). Altogether in order to create suitable conditions, to support the planning, executing, and controlling activities to ensure good quality. But it should also describe how to deal with deviations and defects, how to fix the errors and make use of the experience to promote development and improvement of both production processes and end results (Johnsson, 2016; Sears, 2015).

Johnsson (2016) also suggests that there should be a balance in the QMS; that the employees should know what their quality work encompasses and how it should be carried out, but still allow some freedom of problem solving and being able to actually follow the routines put in place. A QMS utilized in a large organization, especially in the construction industry where larger companies tend to do a large amount of construction activities, a detailed description of every process will grow cumbersome and impossible to keep updated. On the other hand, if the system is too vague, responsibilities and practices will become hard to pinpoint and miscommunication and errors might become more frequent (Johnsson, 2016).

Previous experiences and interests of the project managers or collective project teams tend to shape the way the project is conducted, where areas of specific focus are chosen whilst other ones are unprioritized as a social construction, leading to various aspects of the project being valued differently (Koch & Schultz, 2019). This is possible due to the commonly rather vague requirements in the management system, making the quality reached depend on the project managers' own interests and experiences, often resulting in that quality is deprioritized in the straining environment caused by budgets and time schedules (Koch & Schultz, 2019) Some say that the common practice of integrating all management aspects into one combined management system indicates a reduced strategic importance from the organizational

point of view as well (Koch & Schultz, 2019; Johnsson, 2016; Hoonakker et. al, 2010). Especially while not stressing and communicating its importance to the same extent as environmental aspects for example (Johnsson, 2016; Sullivan, 2011; Hoonakker et. al, 2010).

2.3.5 Construction Quality Management in Practice

When mistakes happen or defects are identified; when something did not go according to plan, there should be a clear plan for documentation and division of responsibilities as well as routines for restoration or correction of the error. There should also be a plan in place for how to learn from the experience, to ensure that it does not happen again in neither the same nor other projects (Sears, 2015). This applies, of course, through all phases of the project from the early stage until its completion, and preferably also including the customers' experiences after completion and handover. This particular thing, making up the very basis of organizational learning through knowledge and experience transferring, seems to be particularly tough to organize within the construction sector (Johnsson, 2016; Love & Josephson, 2004; Sears, 2015; Hoonakker et. al, 2010; Sullivan, 2011).

While the project organization has guidelines on quality management practices provided by their parent organization, the customer is often involved in additional quality requirements. As the customers expectations are to be met, they have a large say in the quality practices of the project and can add additional activities or requirements (Johnsson, 2016). Adding requirements often raises the cost of the project, and so the tendering plays a major role in getting the right presets to the project. Inspiration and knowledge are preferably collected from similar reference projects from documentations or experienced colleagues (Johnsson, 2016; Sears, 2015). The combined knowledge and expertise of the project team during the following design phase is crucial, as well as their decisions made regarding subcontractor and service procurements as well as materials purchasing. Internal reviews of all project documents, drawings and designs produced are common to ensure that all documents are correct and complete, with additional external audits sometimes, according to the QMS before production (Johnsson, 2016; Sears, 2015).

Production managers are then responsible for the planning and execution of the project production; to ensure that all conditions, materials and actors needed are on site and prepared in time. In addition, work preparations for critical production activities, and continuous meetings are carried out to be able to coordinate everything. Self-checks (in Swedish: Egenkontroller), where each construction worker or subcontractor performs inspections of his or her own work constitutes the main controlling factor, in addition to continuous site rounds by production managers where they identify problems they may discover. And the QMS content supports the project employees all throughout the design and production phase with process descriptions whenever they are needed to plan, do and check the project proceeding (Johnsson, 2016; Sears, 2015). Errors and defects will always occur though, no matter how waterproof a QMS may be, but they should not continue to reoccur again and again if dealt with and learned from sufficiently, which they unfortunately keep doing in the construction industry (Johnsson, 2016; Boverket, 2018).

2.3.6 When, How and Why Defects Occur

Boverket (2018) has pointed out that little change has been seen in the industry for several decades, although the defects are scaling with the larger production volume of new construction. The main reasons for defects found in the study are often relating to time constraints and insufficient resources provided by the organization, leading to human mistakes or errors (Boverket, 2018), something that is frequent in the industry (Sullivan, 2011; Hoonakker et. al, 2010). Furthermore, Boverket's study (2018) finds that lacking knowledge, insufficient knowledge transfer and low employee motivation are major contributors to the poor quality in the industry. The lack of knowledge is pointed out to be especially critical for the customers and designers, as knowledge and experience becomes important for budgeting and planning the project. Motivation was highlighted as a problem especially among contractors, as the engagement and will to cooperate is even more crucial in the stressful and complex environment of construction sites.

The study by Boverket (2018) claims that most of the commonly occurring defects appear during the production phase of a project, caused by human slips or mistakes by the building or mounting individual or team, either because of a momentary slip or lacking knowledge, information given, communication or motivation at the critical moment of its occurrence. Some problems also appear during the design phase, where technical details might not have been solved properly, following through the construction design and drawings, in spite of internal and external audits and inspections, to be built on site accordingly. Again, the problems seem to be caused by momentary slips or lacking knowledge or information given or communicated (Boverket, 2018).

When the issue of preventing construction defects was discussed in 2003, the authors Josephson, Knauseder and Styhre (2003a) identified a few solutions from their interviews with Swedish construction companies. Individual characteristics like knowledge, experience, understanding and motivation was the consensus among the experts as major contributors to detecting errors. As the project organization changes over time, it is important to have key knowledge bearers remaining to carry the experiences and communicate them to newcomers in the project. Furthermore, improving activities was suggested, referring to cooperation between the different teams, better planning and work preparations, as well as more careful and structured inspections and self-checks was stated as major contributors. Lastly, being handed better resources in terms of time to follow up on errors, consequences and information on results on activities was stated as a possible solution. The authors emphasize the human contact over ever more encumbrance administration, but the personal meetings between actors and exchange of experiences are very important for a functioning quality work (Josephson, Knauseder & Styhre, 2003a).

2.3.7 Knowledge and Learning

The construction industry, as described by Johnsson (2016) is one of solving problems as they occur, rather than working proactively in a systematic way to mitigate the risk of the defects recurring. He describes that many actors and individuals in the construction industry are highly engaged, motivated and more than ready to accept

new challenges, and often the problem can be fixed before it actually appears, but this culture is highly reliant on those actors and individuals. Engagement becomes the powerhouse of the project, organization and industry. In a large organization, referring to both large projects and companies, Johnsson (2016) argues that this engagement is very important, but it should not be the solemn driver of the quality management. Larger organizations and projects need more systematic work with improvements and quality assurance in order to achieve consistent results.

In order to fight errors, they first need to be detected, before the cause is identified and the defect fixed, whilst continuously also making sure that the organization learns from the experience (Love & Josephson, 2004). This might lead to increased costs in administration initially, but it is fundamental that management make sure that every individual in the organization understands that they need to react, respond and act on every error detected. Love and Josephson (2004) explains that when fixing a defect, either single-loop learning or double-loop learning can take place. Single loop learning is fixing the defect and identifying the cause, but not changing any routines and preserving the current norms in the organization. Double-loop learning includes correcting the defect as well as making organizational changes to prevent the defect from happening again, changing current norms and practices. The second is what one always should strive for.

In general, learning from past experiences, especially when it comes to defects, is not too common in the construction industry (Love & Josephson, 2004; Johnsson, 2016; Josephson, Knauseder & Styhre, 2003b). When defects do occur, the organization focuses primarily on fixing the defects in a timely and cost-efficient way, but then moves on toward the next task without storing experiences from the defect. Josephson, Knauseder and Styhre (2003b) found in their report that learning in construction companies is situational, unprioritized, unsystematic, happening only to serve short-term goals and is mostly focused on solving problems in a given situation. The study also found that evaluation meetings held at the end of a project were the main evaluation method planned for. However, it was also stated that these meetings were often cancelled, held too long after the project was finished, or they were unproductive. Thus, the main routine for evaluation is severely lacking in execution and practicality (Josephson, Knauseder & Styhre, 2003b). The study also found that feedback on the design or the production team's work is rarely made, creating a scenario where an individual worker can make the same mistake over and over again without being aware of the consequences. The few times feedback is given, it is often about the defects themselves, and rarely about the work methods or quality of the management practices. Many of the interviewees in the report stated that “we are the main obstacle for learning”, meaning that they needed to take the time to learn and improve, rather than doing it in the same way as before.

Love and Josephson (2004) explained that there is a chain of actions with an underlying root cause behind every manifested defect. In the construction industry, their study found that these error-chains can be very long and spann across the different stages of the project. Time delays and organizational shifts before an error is detected makes it harder to trace it backwards and identify the root cause that caused the human error. Sometimes, as errors remain undetected and uncorrected they can result in very costly or even dangerous failures (Josephson & Hammarlund, 1996; Love & Josephson, 2004). The longer the error chain, the harder the detection and

costlier failures. It is therefore important to identify the root cause in order to avoid recreating the same circumstances, which would lead to recurring similar defects, and to conduct sufficient corrective measures to prevent further consequences.

Much research has been conducted on the subject of construction defects and their causations, most often finding human errors caused by poor managerial practices as the main problem (Love & Josephson, 2004). The human errors, i.e. slips or mistakes, caused by a main underlying root cause or several stacked, often makes the manifested defect difficult to detect early on and trace it back to its original cause. This since they occur within the routines and processes of the organization that are highly intertwined with others and at the same time disconnected. The nature of the construction industry, where different actors are active in the projects for a limited time for specific phases or assignments makes communication and knowledge transfer harder (Josephson & Hammarlund, 1996; Love & Josephson, 2004).

A lack of sufficient structures or practises in place to identify and discover the faults as they appear is still, unfortunately, a common problem throughout both the design and production phase in the construction industry (Koch & Schultz, 2019; Love & Josephson, 2004). The defects therefore tend to follow the project undetected, sometimes leading to severe damages or failures and great costs later on (Boverket, 2018). The internal reviews of drawings during the design phase (Johnsson, 2016) does not seem to be enough in the way they are currently conducted since errors still remain undetected. During the production phase, where most defects and errors seem to occur (Boverket, 2018; Josephson & Hammarlund, 1999; Love & Josephson, 2004), the main quality control is made up by site management inspection rounds and construction worker self-checks (Sears, 2015; Johnsson, 2016), which does not seem enough either. The knowledge, motivation or both is lacking, and insufficient routines and organizational support make the performance highly dependent on the individuals or teams involved (Love & Josephson, 2004; Johnsson, 2016; Koch & Schultz, 2019).

Koch and Schultz (2019) agree with both Josephson and Hammarlund (1999) and Love and Josephson (2004), that human errors are the main reason for appearing construction defects, adding to the complex social context of the industry. They argue that the phenomena of defects and their causes should be viewed upon through a social lens, studying the actual practice in construction and its social context that affects the behaviours in the industry. Many studies have been conducted where cultural significance, including socially constructed individual and group identifications, within construction on both corporate and project level, in offices and on sites have been analyzed and discussed (Löwstedt & Räisinen, 2014; Bröchner, Josephson & Kadefors, 2002; Josephson & Hammarlund, 1999; Ganta, 2014). Several of the studies express that there are evident connections between the apparent project cultures or common behavior and project quality or corporate performance.

2.3.8 Social Identities

A construction worker is commonly described, by themselves and others, as practically and rationally oriented persons that are excellent problem solvers and proudly independent or autonomous in their work (Bröchner, Josephson & Kadefors, 2002; Johnsson, 2016, Löwstedt & Räisinen, 2014; Koch & Schultz, 2019). It does not matter if you are a carpenter, skilled worker, driving heavy machinery or part of

the site management - they all tend to identify themselves as a ”construction worker” (Löwstedt & Räisinen, 2014); as one actor out of many involved that produce the project collectively having a somewhat familiarly culture (Irani, Beskese & Love, 2002). They also tend to avoid conflicts, having their strong feelings guarded, whilst keeping communications abstinent (Bröchner, Josephson & Kadefors, 2002). One would rather avoid to react or complain on the work of other workers which may lead to undetected defects or errors, according to Love and Josephson (2004).

If conflicts or inconveniences arise there is often a particular sense of an ”us” on the inside, like the production/design team, the company or fellow craftsmen, which one would stand by through most conditions, as well as a”them” on the outside, like external consultants, the other production/design team or top management (Löwstedt and Räisinen, 2014). This creates a situation where the people on the outside are considered the ”bad guys” that question ”our” ways of doing ”our” work or even threaten ”our" independence, not understanding the complexity of the work. Löwstedt and Räisinen (2014) explains this phenomena and its correlation to the collective social identification of construction workers and their common characteristics. Van Knippenberg (2000) describes the phenomenon that a collective group can develop unproductive norms if they stand in conflict with another group, like management. This may happen when the informal connections within the group creates pressures to behave in a certain way, strongly tied to the identity of the group. Unproductivity is undesired from the company point of view, but the group might have developed other values and goals due to conflicts of interests.

Project and site managers are in complex positions here, having the responsibility to mediate in between various camps and the possibility to affect the general behaviours in their respective project and parent organizations (Styhre & Josephson, 2006; Sandberg, Räisinen & Löwstedt, 2016; Löwstedt & Sandberg, 2020; Koch & Schultz, 2019; Sears, 2015; Johnsson, 2016). The couplings are often loose between the projects and parent organization, enhancing the independence of the managing roles and their ability to focus specifically on areas of their own interests (Sandberg, Löwstedt & Räisinen; 2021).

2.3.9 Cultural Constructs

Bröchner, Josephson and Kadefors (2002) explains how the Swedish construction culture is slow to change and has been developed over a long period of time, affected by individual conservatism, slow institutional shifts and a rather continuous national law system. They argue that significant historic periods in Sweden have shaped the way our construction work is conducted. It is described how they have developed our preferences of both craftsmanship, built mostly on tacit knowledge, favoring independence, and military engineering with its strong commanding nature and scientific knowledge grounds (Bröchner, Josephson & Kadefors, 2002). Which one of those traditional traits that dominates tend to depend on the type of project, like housing projects versus heavy infrastructure construction, since their very different characteristics have proven hard to merge or combine. Bröchner, Josephson and Kadefors (2002) found this to be indicated by the QMS introduction in Swedish Construction and their implementations and results so far.

Culture is explained as a set of shared values, that from a quality perspective can promote sharing of knowledge or a guarding of it, affecting the common behaviours as if one would rather ask for help or try to solve the problem yourself (Philipson, 2019). The report concludes that the values of any organization should be well documented and communicated, as it cements the values and helps create a stronger identity within the organization. The development of a project culture should be done in the very early stages to cement the values that should be shared among the participants in the project. To carry this culture to the later stages of the project, there needs to be clear communication about the purpose of the values and culture of the project, to allow the rest of the team to understand why and not only see it as additional requirements. The purpose of the culture and values should be to direct the efforts of every individual and group against a common goal (Philipson, 2019). To proactively promote and enforce these principles, more support and education is needed for the managers and leaders of the construction industry.

Some say that construction companies should strive for further formalization and higher levels of standardization in both processes and products to enhance quality, productivity and performance (Sears, 2015; Hoonakker et. al, 2010). Standardized processes would decrease result variations, drawing from universal principles of industrialized production systems, resulting in increased productivity and quality whilst reducing unnecessary costs and waste. However, the uniqueness of each project and context demands great flexibility and adaptability (Hoonakker et. al, 2010; Löwstedt & Sandberg, 2020). Löwstedt and Sandberg (2020) argues that the focus on standardization often lacks a sufficient consideration of social perspectives; that the workforce is considered rational and instrumental resources. They believe that standardization initiatives must be more aligned with the realities on site, considering the deeply embedded culture and identity of construction workers and their autonomous and independent craft, since a compelling change towards strictly standardized work otherwise may be resisted by both managers and employees (Löwstedt & Sandberg, 2020). So how do we decrease quality variations while coping with the oppositions of more or less formality in our organizational structures?

The industry does not seem able to decide whether they want more formality or not in their Quality management practices. The companies adapt selected activities of their choice from various QMPs, mixing formally natured ones from Six Sigma or ISO 9001 with the less formally approached programmes of Lean and TQM (Sullivan, 2011; Hoonakker et. al, 2010). Interestingly, the construction workers now seem to request more easily understood organizational guidance for more consistency and coherence throughout their organizations and own work, to improve the quality of both processes and end results (Koch & Schultz, 2019; Sullivan, 2011; Hoonakker et. al, 2010), possibly as a result of the continuous opposing cultural needs (Bröchner, Josephson & Kadefors, 2002).

2.3.10 Employee Motivation

Josephson & Hammarlund (1999) explains that an individuals' ability to perform tasks is dependent on three factors: Knowledge, Information and Motivation. Motivation is an individual's desire to contribute to the task's outcome, but also; the expectation that effort will contribute to change and; commitment, the expectation of others to contribute. Ganta (2014) explains in his report on motivation that "Managers

cannot ‘motivate’ employees, but they can create an environment that inspires and supports strong employee motivation”. The managers must construct this environment, taking the specific employees that are working within it into account, as they all have different ambitions, goals and factors that motivates them. Some employees are driven by economic incentives, some by praise and some by personal development.

Ackerman (2015), the founder of the theory and group development tool named ”The House” and nowadays also a well known lecturer on the subject in Sweden, explains that there is a significant difference between a group of employees and a true and pleasantly collaborative working team. He claims that no ”rocket science” is needed to build a productive team, but structure and systematics are needed in order to support the development of efficient teams. He claims that a lack of structure and systematics is a way too common mistake made, and that frequent efforts and support is needed in order to attain and remain a well functioning work team (Ackerman, 2015).

Efficient teams will not appear upon request or by magic, not even if the leader demands it. Ackerman (2015) agrees with Ganta (2014) that the group manager has a key role here, being responsible to continuously provide the team with the right prerequisites and tools, to give their team the ownership of their own development with the help of their guidance and structures. Ganta (2014) claims that the managers should try to get to know their employees, their various identities and needs, and experiment with different techniques to find what might work. There are many techniques, theories and frameworks for understanding and improving motivation, and it lays upon the managers’ responsibility to decide which composition of methods that should be utilized (Ganta, 2014). He says that the key is to make the work of the employees more fulfilling; working consciously to make them all feel more involved in the big picture, of being in control of their task and performance and making them understand the holistics of the work. All aimed to bring more control and involvement of the worker into the company at large. Ganta (2014) also says that to set clear goals and deliverables for the group to reach is another way of improving motivation, and Van Knippenberg (2000) adds that it would be even better to let the workers themselves participate in setting these goals. By including the workers themselves in the goal-setting, it improves group identity and commitment to the goals, as well as improved communication and collaboration within the group.

It is not enough to arrange a one-time-occurrence either, as the team start-up for example, but has to be worked with continuously throughout its existence and work period (Ackerman, 2015). Consciousness is a fundamental part of group development, where the participants involved are actively and consciously deciding, acting and reflecting upon their work together. The group manager or leader have the main responsibility to provide the group with the structures and tools they may need, whilst the group themselves are working with and within them, discussing, reflecting, doing exercises, testing behaviors, taking decisions, and creating their own routines within the frames given - all to both create and maintain a sufficient climate for efficient collaborative work (Ackerman, 2015; Ganta, 2014).

As previously mentioned, a series of lectures and a workshop was conducted during the autumn of 2020 and spring 2021 by Boverket, CMB and IQ Construction

(Swedish: IQ Samhällsbyggnad) as a response to the report by Boverket (2018). The Workshop, Strategidagen 2021 - Ledarskap för minskat slöseri i byggbranschen (English: Strategy Day - Leadership for mitigating waste in the construction sector), invited about 60 people from the Swedish construction industry with experience in a management or leadership position, to discuss topics in small groups with mediators. The results from the discussions were clear, that inclusion, collaboration and clear communication are key factors for a successful project (CMB, personal communication, March 25 2021). As a leader, being humble and handing out praise for a good job was seen as important, as well as reflecting in groups over what went well and what can be improved. To include all parties in problem solving is important, especially with inexperienced or parties who recently joined the project, as they need to be included and listened to. There was also an emphasis on being able to question norms and solutions, reporting defects without worries for consequences, as well as being listened to in those situations. Culture and team spirit was very important to develop proactively, including newcomers and explain the purpose of the group, to create a good quality product in the best way possible. To achieve this, the values and culture of the project needs to be discussed and enforced regularly, notably bringing the topics up on the daily agenda to hand out praise, discuss challenges, welcome new parties etc. The leadership becomes very important here, and more education and support should be given to the managers and leaders of the company.

3 Method

The following chapter will describe how this thesis was carried out and the qualitative method that was utilized. A case study was conducted during the spring of 2021 at the regional department for residential and commercial buildings in Gothenburg of one of the largest construction companies in Sweden. A detailed description of the case company, the research approach, the data collection and all methods used will follow below.

3.1 Case Company Description

The Case Company of this study is one of the largest contractors in the Swedish construction industry that operates all over Sweden as well as internationally. The company is active within a variety of different civil areas such as infrastructure, industrial solutions as well as residential and commercial buildings. They also have their own internal project development organization and support structures for operational efficiency within areas such as environmental and social sustainability, work environment and safety, procurement and business development, as well as technical specialists, all regarded as internal consultants for the regions and projects to appoint. This study is conducted at a regional department in Gothenburg, focused on residential and commercial buildings. The region is subdivided into several districts that are specialized in either commercial buildings or residential buildings, with a number of active projects each, but operates under the same region that is often referred to as "Buildings, Gothenburg"

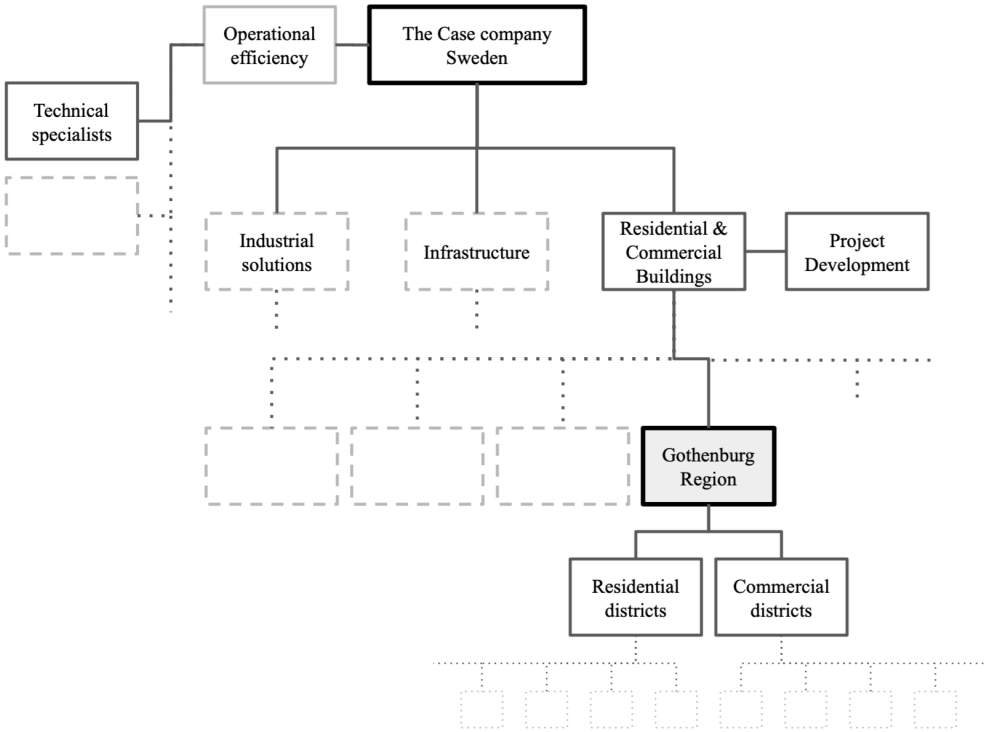

Figure 3. The case company's organizational structure, made by the authors based on information found on the company employee intranet.

The case region consists of 350 employees in total, of which around two thirds are white collar workers, based at the regional headquarters, and the remaining third are blue collar workers, deployed by the various projects. The organization is led by a regional manager, supported by a development manager, a health and security manager, a regional economist, an HR partner, the various district managers, one manager in charge of significantly large projects, and an operative manager, also supported by a group of legal and communications experts, IT support, environmental and social sustainability experts. The operative manager leads a group called operational support, which consists of managers of specified teams within project accounting support, procurement and project planning, digital development leaders, and a combined team for quality and aftermarket errands.

3.1.1 Quality Management at the Case Company

The quality policy states that the company aims to create a better society, taking responsibility for the quality of all company deliverables. They want to reach and exceed the requirements and expectations of all customers and other stakeholders involved or affected while staying true to their organizational values. The company strives to be the first choice of the customers, always keeping the customer and their need their most prioritized focus. They also claim to have high and challenging goals, constantly striving to improve their processes and tools to meet the ever changing needs of society and clients. This is enabled by their high competence and vast collective knowledge, attained by systematic learning from one's own and organizational experiences, being talented engineers and craftsmen that takes pride in good performance and responsibility for both our actions and products.

The Quality management of the case company is mainly based on the processes and practices stated and described in their Management System, which all employees are obliged to follow, aimed to attain successful project and organizational results throughout the company business. There is also an online database, from here on called The Technical Details Platform, containing various functions developed by the company to support the projects. The Management System and The Technical Details Platform are both national systems with specific chapters, subchapters or parts aimed for various regions or types of projects. All regions and districts are also allowed to add on further activities that suit their specific practices or purposes to support their own organization and work. This is allowed to further tailor the management system on the national level to the operations of each region and district.

The quality management within the case region is led by the regional quality manager, who is in charge of the quality and aftermarket team, and thereby part of the operational support group, that deals with all errands discovered by the warranty period of the region's projects. The team's primary focus is the aftermarket errands, and will therefore be referred to as the aftermarket team henceforth, but have been working proactively to some extent with quality for the last couple of years. The equivalent focus area of construction quality on the national company level is led by a national quality manager who is also in charge of the technical specialists department. The national and regional quality managers are not meeting on a regular basis, but the regions work rather closely with representatives from the technical specialists department which makes out the main linkage between the regional and national quality works. The technical specialists department are also the ones in charge of the

Technical details platform, a digital platform of standardized designs solutions, that supports the operative work throughout the company and the case region's projects. The regional aftermarket team, led by the regional quality manager, and the technical specialist department are in other words the most vital teams that drive the quality work within the region.

The aftermarket department consists of a team of service managers and service workers, led by the regional quality manager, and are given the regional districts' projects once they are completed and have passed all inspections as they enter the warranty phase of the project life cycle. The company is, according to Swedish construction legislations, responsible to provide a warranty for all projects for a certain number of years in order to truly ensure that the customers' needs and expectations are met. Some construction defects or functional issues are not discovered until after the customer handover, and all the defects that are discovered later than that are carried out by the aftermarket team. The scope of various tasks is wide, ranging from replacements of scratched kitchen cabinets, corrections of other minor defects that slipped past inspections, or to investigate an apparent water leakage to find and correct its original cause and restore the construction. There is therefore a lot of knowledge in the aftermarket department about these various defects, which are considered particularly important to decrease since they affect the customers and thereby the company reputation, which is why the regional quality manager was sourced from this department.

The regional quality manager explained that various forms of water damages, caused by incorrect production practices, are the most costly quality defects that their department are facing, most often connected to balcony attachments, window and glass door mountings, and prefab facade installations. Unfortunately, they are rather common as well. These are tricky issues that are hard to detect early on, leading to severe consequences as they are discovered too late. The aftermarket team has been learning a lot about the defects that are discovered during their stage, and are now trying to work proactively, to support the earlier projects stages with their knowledge in different ways, in order to mitigate the costs and consequences from these damages. This proactive work seemed to increase as the current regional quality manager was appointed a few years ago, which also led to an organizational change within the region. The aftermarket function was previously part of the operational efficiency organization, on a company level, just like the technical experts department, but a team is now part of the regional operational support instead and appears to be more close to the regional projects. So, the aftermarket team with the regional quality manager in their lead are the main drivers of quality improvement issues within the Gothenburg region, together with the technical specialists department driven by the company.

The technical specialists department works to continuously develop the technical design solutions of the company, operating from their three offices in the cities of Stockholm, Malmö and Gothenburg. They provide technical solutions and support for the entire company, on a national level, providing all projects with a certain share of free support and could also be contacted for further technical services within the projects as internal consultants upon request. Representatives can for example be hired for a project to solve a specific difficult problem or to work in the design team during the project. The department investigates and writes reports on significant

challenges within the organization, such as specific recurrent defects or other areas within the company where new technical solutions are needed, the decisions and delegation of which is made by the national quality manager. The solutions found to the various challenges are collected on the technical details platform, as standard details and methods with various forms of drawings and descriptions, to be utilized by all company employees in need.

BIM360-Field has been recently introduced in the case region's daily work in the projects. BIM360 Field is a digital tool, so far used for documenting and reporting defects, as well as integrating work documents in day-to-day activities. The case region has utilized this software in a few projects so far, but will most probably become widely implemented in future projects.

3.2 The Research Approach

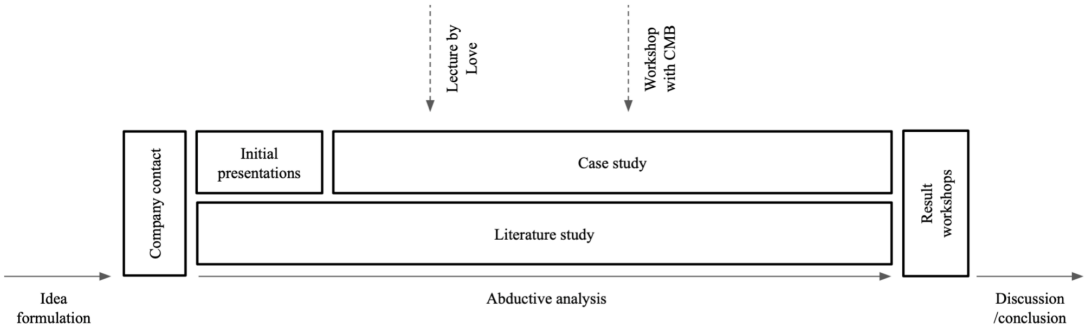

Figure 4. An overview of the methodology of the study.

A qualitative research strategy was adopted in order to suit the complex and explorative nature of the research topic. Backman (2016), Silverman (2014) and Bryman and Bell (2015) all describes how a qualitative study is based on words, how it is the best strategy to use in order to analyze a social context, where interviews and reviewings of materials or documents are common, in comparison to quantitative studies that rather are based on scientific experiments or numerical measures. The research questions are seldom decided from the beginning in a qualitative study, since the research is allowed to change and develop as further information is collected and knowledge gained (Backman, 2016; Bryman & Bell, 2015), which was the case in this thesis as well.

Two initial presentations regarding the company, their quality work and current challenges were held, giving the authors of this study a good starting point for the further study. A literature study was begun simultaneously, to begin the form of a theoretical framework, covering the concepts of quality, quality management and quality management systems, as well as common managerial practices within the construction industry and the various challenges that are claimed to impede the work towards better quality. In addition, both authors attended a workshop by CMB, where the managerial aspect of quality and employee motivation was discussed by various industry representatives in Sweden in order to broaden their knowledge and understanding of the research topic. The authors also attended a lecture, regarding the causes of rework in the construction industry held by professor Love from Australia, who's works have been frequently referenced in this study.

An interview study and a mapping of the company's QMS, based on a review of the company management and support systems along with various documents, which are not solemnly focused on quality, were conducted simultaneously with the literature study. An abductive research approach was thereby used, meaning that the literature and case studies were conducted in parallel, in an iterative way, to form the theoretical framework and empirical results simultaneously (Bryman & Bell, 2015; Dubois & Gadde, 2002). This allowed the authors to gain a deeper understanding of the theory and empirical data, and to develop the interview questions and theoretical searching along the way as more data and knowledge was collected. The iterations between the empirical and theoretical works continued throughout the entire study, which is common in abductive studies (Bryman & Bell, 2015; Dubois & Gadde, 2002).

A continuous analysis was made of the alignment between the case company QMS and the actual work conducted within the system, based on the interviews and QMS mapping with the theoretical framework at hands, aiming to find the underlying causes of the roccuring quality defects. Suggestions for company improvements were then formed out of the final analysis, which were thoroughly discussed and further developed during a workshop (Workshop 1) with the regional quality manager and the development manager. After that, two additional workshops (Workshop 2 and Workshop 3) were arranged where all the previously interviewed employees were invited to discuss the suggestions once again, to ultimately result in a final trice-fold iterated list of suggestions.

It is important to consider the validity and reliability of qualitative studies since the rather flowing research boundaries may open up for various personal interpretations or misunderstandings (Bryman & Bell, 2015; Silverman, 2014). Therefore, leading questions were avoided during the interviews in order to decrease the risks of biases, and the various forms of data collections also allowed the authors to triangulate the findings, to let the different methods confirm or strengthen each other. The final workshops held with the regional quality and development managers and the previous interviewees were aimed to validate the study findings via loopings, to confirm that their expressed experiences were interpreted correctly, to also ensure that the possible solutions suggested were considered reasonable.

3.3 Data Collection

Three different methods were utilized iteratively to collect the data for this qualitative study. A semi-structured interview study was conducted in addition to a literature review, to form a theoretical framework, as well as a review of the company management and support systems, aimed to map all project activities in relation to Quality Management.

3.3.1 Interview Study

The interviewees were selected together with the regional quality manager and development manager with the aim to collect as many perspectives of the topic as possible. The interviews were conducted with representatives of several projects of the case company to provide a broader perspective of the practices implemented. As

the construction industry is primarily project-oriented, and each project has a different management team, different workers and practices, it is reasonable to assume that the implementation of the QMS will differ between projects at least to some degree. It resulted in a total of 20 interviewees, covering the following different roles within the region:

- Regional Quality Manager
- Development Manager
- HR Partner
- Project Managers
- Design Managers
- Project Developer
- Service Manager
- Service Worker
- Site Managers
- Site Supervisors
- Construction worker representatives
- Safety and Health Manager
- Technical Specialist

The interviews were scheduled for approximately one hour each and followed a semi-structured form, which means that questions were prepared beforehand but spontaneous follow-up questions were asked as well. This allowed a more curious approach, letting the interviewees own the discussions of their experiences whilst the authors mostly guided the topics and follow-up questions to remain within the scope of the study. This flexible interview structure is commonly used for qualitative studies like this one to achieve rich yet rather comparable data to be collected (Bryman & Bell, 2015; Dubois & Gadde, 2002). As the literature study was conducted in parallel to the interviews, due to the abductive approach, the later interviews tended to bring more in depth discussions as the authors gained more knowledge of the topics, and more detailed questions regarding work motivation, defect management and organizational learning were asked later on for example. Equally, the literature search was extended and formed as the new topics were brought up by the interviewees, such as when practical issues of recurring defects were discussed which led the authors to study the difficulties of organizational learning more deeply.

All interviewees were informed beforehand that they would remain anonymous throughout the study and report in order to collect trustworthy data and avoid any following inconveniences for them. The prepared questions were tailored for the various roles of the interviewees, but they generally consisted of three parts. An initial phase where the interviewee explained his or her background and current position in order to get to know one another. The second phase regarded the interviewee's general view of quality, quality management, their experiences with the company's support and management systems, and how he or she currently worked to ensure good quality in their role. And the third and final part were more acute, focusing on their specific quality challenges and personal reflections of how the quality of both their own work and the company could be improved.

Both the separate interviews and the interview study as whole were conducted until a sense of saturation was found; when the interviewees mostly confirmed each other's

statements instead of adding new topics and all subjects discussed at that time, within the thesis topic, had been searched for in literature. All interviews were recorded and transcribed in summaries, to later on be analyzed in comparison to each other. 10 significant and commonly appearing themes or challenges were found, some because they were frequently mentioned by several interviewees, while others were influenced by findings in literature and confirmed by the interviewees. As these themes and challenges had been identified, another round of transcription analysis began to collect all expressions made regarding the different topics, to then be described comprehensively in order to cover the various perspectives. Both authors agreed upon the interview interpretations made, and the interviewees found the general findings correct and well interpreted during the final result workshops where they were able to express their opinions regarding the study.

The original plan was to visit some projects and conduct the interviews on site, but the current restrictions due to the Covid-19 pandemic forced a change of interview settings. Only one interview was conducted face to face, whilst the remaining 19 were conducted via online meeting platforms. Unfortunately, this change made it tough to reach out to the construction worker force, due to technical difficulties, and their share of representation in this study is therefore lower than what was first intended. On the other hand, the online meeting platform allowed the interviews to be video recorded, which made the following transcriptions and interpretations of the interviewee sayings easier, including what was said in between the lines and visible in their facial expressions, which may have led to a more accurate data collection (Bryman & Bell, 2015; Silverman, 2014).

3.3.2 Quality Management System Mapping

An explorative study of the case company management system and supportive databases were made to outline all activities that relate to their quality management, as the systems and databases consist of integrated management focus areas, in order to map the Quality Management System. The content of these were way too vast to explore to their entirety and describe all the content in detail, and a decision was therefore made to focus on the chapters aimed for residential and commercial building projects, and thereby did not explore the other chapters, even though they might include activities that are used by or connected to the case company region. For example, neither of the subchapters aimed specifically for the project development nor the technical experts departments were studied, even though representatives of these departments were involved in the interview study. These interviewees were involved due to their active role in the daily operations of the case region's projects, and the operations within the case company region of residential and commercial buildings were the solemn focus of this study. It was a conscious choice, decided together with the company representatives and the thesis examiner.

The study was conducted exploratively, where the authors "clicked" themselves back and forth in systematic ways, stopping to take notes and reflect upon the content regularly, highlighting significant activities and connecting them to each other, in order to map the content of relevance to Quality Management. Some information was read only to support and enhance the authors' understandings of the various activity correlations, and other activities were described in summaries or more down to detail, to express and explain the various content of the system and databases. The mapping

resulted in a visualization of important quality related activities and their relations conducted in the company projects, supplemented with descriptions of additional quality related initiatives in the region, and was all reviewed and confirmed by the company representatives as complete descriptions of their current quality work.

3.3.3 Literature Study

Apart from a few physical books lended at the Chalmers Library, the main theoretical data was collected via the well known electronic searchengines of Google Scholar, Chalmers Library and Scopus. The abductive study approach, as described earlier, allowed the literature study to continue along the entire study, searching for further niched knowledge as new topics arised. The key words used therefore differed, starting with a more general search regarding Quality Theory, Quality Management and Quality Management Systems, Project based Quality Management and Construction Quality Management. As more knowledge was gained, and new topics arized, further searching was made about Construction Defects, Error Management, Learning in the Construction industry, as well as Work motivation and Performance.

The main general Quality theory was based on books by well known authors that are listed as course literature in several courses at Chalmers. A few other books were referred to for the more general study chapters of Construction Quality Management, which seemed to be up to date and yet frequently referenced to in other articles. The articles used for more specific or nuanced parts of the theoretical framework were chosen due to their well known authors and many recitations, and their years since published were considered as well. Some articles referred to are rather old, but the topics discussed in those have not been subject to any significant development since then and were therefore considered relevant still.

3.3.4 Workshops

Three workshops were held after the interview study was concluded. The first workshop involved a presentation of the empirical findings from the management system analysis and interviews to the development manager and regional quality manager of the case company, as well a discussion and brainstorming session regarding possible improvements that could be implemented in the region. The following two workshops were held for the former interviewees, where the combined results from the interview findings, the QMS analysis and the results from the previous workshop were first presented. The presentations allowed for continuous questions and reflections or eventual critique from all participants, and the suggested solutions of the study were edited in response to the feedback given.

4 Empirical Results

The following chapter presents all empirical results of the study, starting with the findings made investigating the formal management procedures of the company. Hence, the management system was explored to map the QMS, and the Technical details platform as well as additional quality related activities of the region are described. The interview results will then follow, and the chapter is concluded with the workshop results, including the improvement suggestions developed for the case company.

4.1 Management System Analysis

The construction company has an extensive Management System aimed to describe how work should be conducted within their organization, including descriptions of all organizationally required activities and processes throughout their vast scope of business. The system is certified according to various standards such as ISO14001, for environmental management systems, as well as ISO90001, for Quality Management Systems, among others. As implied, it combines several Management Focus Areas, being organized for the practice of construction work, but all required activities and processes concerning quality, regarding planning, controlling, correcting and learning procedures, should be described in the system. The management system is provided to all employees via an online platform, which was changed just about a year ago, and the content can be filtered depending on various working roles. All employees of the company are obliged to follow this management system and they also receive online training in the system in the beginning of their employment.

The first one sees when opening the Management System page on the online platform is a quick overview of various chapters that correspond to different departments of the company. There are separate chapters for leadership (aimed to describe the business management processes of the company for managers and various leader groups, development managers, controllers or HR partners, etc,), building constructions (including subchapters for building projects, construction service, housing project development as well as commercial building development), heavy construction, industrial solutions (divided into rock materials, asphalt (manufacturing and paving), concrete, infraservice and rental solutions) and finally the "supportive" chapter (including subchapters for work environment, health and safety, purchasing, economy, customer markets, the personnel handbook, Technical Support Department and IT). The system is vast, and the amount of information is enormous in an attempt to cover the entirety of the company business.

The first page one reaches while entering the subchapter for Building Projects, within which the content of most direct importance for the case company department of our study is situated, is another overview page, organized as a matrix. On the vertical axis are the following themes displayed: About building projects, Organization and management, Economy and income, Planning, Risks and opportunities, Purchasing, Requirements management (quality, environmental and work environment requirements), and lastly Technical solutions and production methods. The horizontal axis displays the different phases of construction projects, dividing the matrix into columns named Tendering, Project preparation, Design, Production preparation,

Production, Final stages and Guarantee period. Within each cell are then a varying number of subchapters corresponding to the respective theme and project phase.

Each subchapter then includes some kind of description of its content and purpose, activity explanations and related documents that could or should be of use for the particular purpose. The subchapters and activities vary in quality and nature drastically, some of them describing more generally how something could or should be conducted, like the subchapter "Partnering in production" whilst others, such as "Start meeting production" is more explicitly described in detail, how and when it should be conducted, who is responsible for the activity, and the topics to discuss during the meeting are attached as a template document with a detailed agenda. Each subchapter is organized a bit differently, not standardized through a template, due to the different nature, purpose of the activity/process or level of detail needed. However, there is most often a descriptive text on the left side of the screen, explaining the activity, its purpose and how it is supposed to be conducted. If there are other informational guides, documents, or corresponding templates relating to the activity they are listed on the right hand side, along with name and contact information to the person responsible for the subchapter's page or activity as such.

There is a filter function available in order to locate the themes, project phase, activity descriptions and processes of the user's interest. One can also filter the content by work roles and certain areas of interest, finding activities relating to areas such as Work environment, Purchasing, Quality, Logistics, Environment or Partnering. There is also a Search engine function if one would like to search for documents or activities relating to specific terms or words instead.

When one filters the Building Projects page for Quality related activities and processes the matrix changes and the number of rows and columns. Now, all one can see are the vertical themes of Requirements management, and Technical solutions and production methods, along with the subchapters relating to the various project phases in their corresponding cells. It is observed that several activities reappear in more than one cell, under more than one project phase. For example, the activity of "Organizing and planning the Quality Management" appears in three different phases (Project preparations, Design and Production preparation), indicating that the activity either is conducted during one of those phases or continuously cross-phases. That is unclear to us. However, following the same activity by clicking the various links under the different phases leads to the same following page. It seems to be the same with all activities that are mentioned several times; following links with the same names, even if they are mentioned at multiple places, they all lead to the same elaborating page, where further details are presented on the subject.

A general overview of the Quality Management of a whole construction project in its entirety was found as an attached document in the descriptive subchapter called "organize and plan the quality management", created in 2016. However, it is very simplified, describing rather vaguely what quality related activities that should be done and very approximately when, during which project phase, it should be done. There is no other model where one can follow the sequence of quality relating activities from the early stages of conditional assessments and planning, through the managerial and controlling activities until the project ending and described loopes of feedback.

There is however a relatively detailed description of the Quality Management during the production phase, described in a 12 page document, where the purpose and conduction of all different activities aimed to plan, organize, manage and control the production quality is explained in text and a descriptive figure. It is stated in the document that information regarding the design phase is to be found elsewhere, apparently in the section "Design phase - Quality", but it is unclear if this refers to another document or subchapter in the Management System. Either way, we did not find it. However, combining hints found in the descriptive document for the production phase, the simplified illustration of quality management mentioned earlier, and our exploration of the Management system and the various activities described in it, resulted in our own descriptive model of all quality related activities found, spanning across the entirety of a construction project, in the subchapter of Building Projects. See Figure (5).

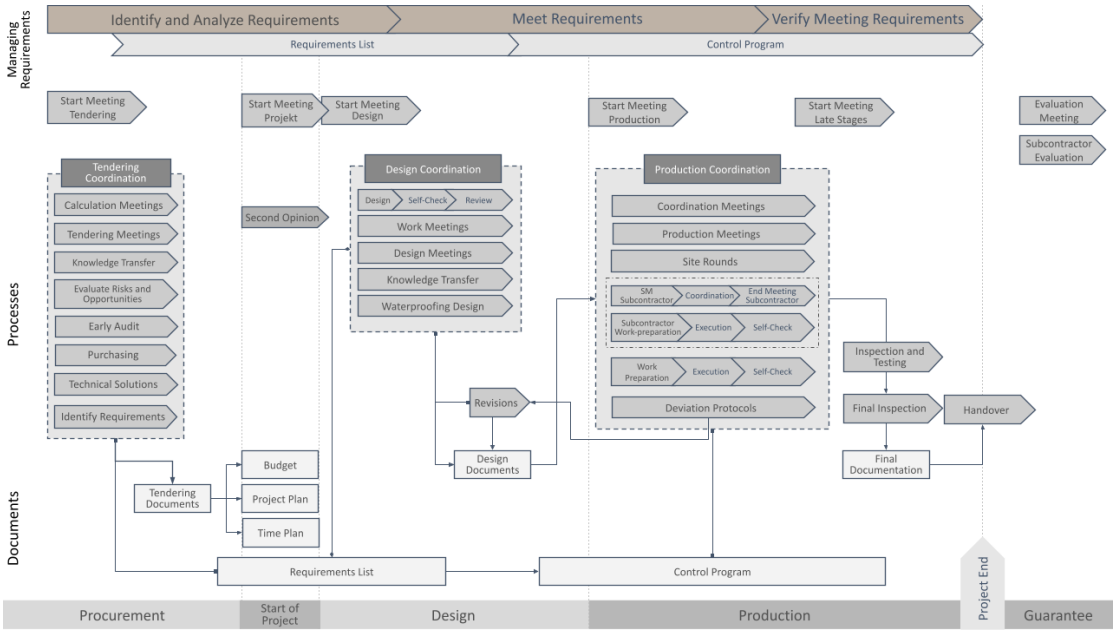

Figure 5. Quality Management System of the Case Company, made by the authors. A larger version is available in Appendix.

Each activity is described in rather general terms in the system in order to be adaptable for all different project types of the organization, detailed to the point to include a short explanation of the purpose and aim of the activity, the person(s) responsible for its execution, sometimes presenting some optional ways of conducting it, in addition to some attached documents/links in relation to the subject or activity. Each project, department or region is supposed to tailor the system content (i.e. activities) according to their own needs and preferences, being allowed to add on further procedures if they want in order to find their best way of operation, as long as the system is not breached. Projects are therefore being managed differently depending on the project, its context and the ones in charge of or involved in the management as they tend to interpret and adapt the system content in different ways.

Something that became clear during the exploration of the management system is the lack of cohesion and standardization. While some activities have clear process

descriptions and process overviews, indicating a sequence of events, some important activities are simply described out of context. Sometimes it is stated in the description of the process what comes next or what should come before it, but in many cases the connections remain unknown unless one finds another process that explains their connection. There are no clear descriptions of the process connections, leading to lacking overviews that makes it difficult for newcomers, like the authors of this study, or perhaps newly employed, to understand the system.

The system content is way to vast to present and describe in detail within the time and scope of this thesis, but a limited selection of all activities was made to describe the general strategic position of Quality, given by its prioritization in different activities, and the way it is planned for, controlled and ensured by other ones and how the processes connect to one another. A description of the components included in Figure 5 will now follow.

4.1.1 Start Meetings

The start meetings are a routine kick-off for every stage of the projects. These meetings are often longer and the involved parties meet for half a day or so in order to identify frameworks and responsibilities for each participating individual. They are located at the upper region of processes in Figure 5.

The Start Meeting Tendering sets up the goals and methods to use while delivering an offer to the customer. This template is rather advanced, covering many different project aspects to regard during the meeting, such as environmental and social sustainability aspects or other particular project requirements. It is also required that previous experience that could be of relevance for the project is collected, though not how this should be done, and no bullet point touch on the topic of quality.

The Start Meeting Project is aimed for the general planning of the project, dividing responsibilities and deciding the methods of working. Quality routines should be discussed in this meeting, but no support in options or quality goals are given besides a written comment of encouragement to utilize the digital tool of BIM360-Field to report defects. The Start meeting uses the Tender documents to start the production of the Control Plan, Time Plan and Project Plan. At this stage a Second opinion activity is mandatory, where the regional support staff add their experiences to the project, as well as other company projects with similar profiles, budget etc are used as reference.

Start Meeting Design has no template agenda to be followed at the moment, but it seems as if there have been templates available for the startmeeting of each design phase. Maybe these templates are kept locally and not on the management system platform? A describing text is available however, presenting key areas that should be discussed and organized during the meeting, one of those is Quality, but no further goals or suggestions of subtopics to discuss are made here.

Start Meeting Production has a template agenda composed of 18 bullet points with topics to discuss. Quality is mentioned, however, the areas of Quality, Environment and Work Environment are bunched together into one bullet point, without encouraging any specific discussion or decisions via subheadings. This combined

bullet point shows up as number 13, whilst safety is placed as the first bullet point, which is considered a clear sign of the lesser prioritization that quality is given.

Start Meeting Late Stages should be scheduled a few months before the Inspections and Testing as well as Final Inspections begins and outlines the routines and schedule for the projects' last stage. The agenda template is only a few bullet-points long, where Quality, Environment and Working Environment are bunched together into one bullet point, again, to be discussed during the later part of the meeting. No further descriptions of what to discuss in relation to the topics are provided either.

4.1.2 Tender Coordination

The Tender Coordination is led by the Tender Manager and the goal is to deliver an offer to the customer which will result in a contract being signed and the project will be carried out by the case company. As described in Figure 5, the Tender process is the first step of the project. To do this, the tendering team has to identify risks and opportunities as well as requirements from the organization and outside parties like governmental or customer requirements. Requirements are documented in the Requirements List which is later on utilized by the design team. To coordinate this work, both Calculation meetings and Tender meetings are held continuously as early designs, Technical Solutions, methods, material choices and costs are calculated. At this stage an Early Audit is conducted by the regional support staff as well, to add their knowledge and experience to the project. This knowledge and experience is based on their personal memories since there is no formal gathering or database of previous experiences to store or collect knowledge or experience, apart from the company's standardized details/procedures on the technical details platform.

4.1.3 Design Coordination

The design coordination, found in the design stage of the project (See Figure 5) is a process to deliver Design Documents for the Production team and is led by the Design Manager and Installations Manager. The coordinating activities are Work Meetings, Design Meetings and Reviews where different parties like architects, designers, ventilation and technical experts meet and discuss responsibilities and deliverables. The Design Meetings focus on the customer's requirements and needs as well as other requirements from the organization or other parties. The meetings are also carried out to create a common vision and maintain a good team spirit. At the end of the design stage, before the last design meeting, the Design Manager is responsible to collect and spread experiences through the region. It is not clear how or if this is done however, and there are no formal ways to collect, store and review previous experiences. The spreading of experiences that do happen is made on an informal basis via personal networks or contacts.

Highlighted in the management system is the Waterproofing Design, which is aimed to prevent water damages, added as a special target area due to the significant costs these issues inflict on the company. This is overseen by the Design Manager, but has extra steps and processes tied to it, ensuring the final design will prevent water from penetrating the building. It is unclear though how or if this specific focus will lead to improvements later on.

The main activity is the iterated design process itself. It is carried out by responsible designers who look over requirements in the Requirements List, create the Design, perform Self-Checks on their work made, and submit their partial designs to the main collected design. The design is Reviewed continuously at specific times where different designs are put together into the main design for the purpose of creating the final design documents. The Plans are conducted in different stages, such as early, technical, final et cetera, and in between each of those is a review period scheduled. It is important that the right people are involved in each reviewing process, as different parties can contribute different sets of knowledge.

Revisions are made where deviations in the production or design are added to the design documents. These may come from the customer or from non-critical deviations in the production which will be compensated for in other ways. These deviations are always added to the design documents to ensure that the Final Documentation is complete and correct prior to the project Handover.

4.1.4 Production Coordination

The production team is led by the Site Manager and the Productions's mission is to transform materials and the design documents delivered by the Design team into a finished building. This work is coordinated through *Production Meetings*, seen in the Production Stage of Figure 5, which includes weekly meetings, daily morning meetings, monthly meetings, weekly safety meetings and others. In general, all participants are given the opportunity to describe what they have been working on since the last meeting, what they are planning to do until the next meeting and if they see any obstacles to do so, and then there is an opening for the other participants to ask questions. Then, the topic of safety is focused on specifically, where observations and eventual current or upcoming risks are discussed, as well as overall information regarding the site coordination and logistics. No 'quality meetings' are conducted according to the management system. No particular quality focus is mentioned either. All meetings held are supposed to be documented and experiences collected with the intent to add those to the Evaluation Meeting at the end of the project. This is seldom done however, and we have not been able to find these collected notes anywhere. *Coordination Meetings* are held with subcontractors. To oversee the construction project and site, *Site Rounds* are held both daily and when necessary. These are intended to catch defects or mistakes as well as getting an overview and discussion on different challenges of the project.

The main work of the Production team can be described by the following steps: *Work Preparations, Executions* and *Self-Checks*. Before every Work step, like installing windows, painting or other tasks, a work preparation is conducted by the Site Supervisor. These are intended to plan the execution, analyze potential risk, identify requirements and explain how the work should be carried out. To describe what should be checked and controlled, as well as inspected, the Site Manager utilizes the *Control Program*, detailing all aspects of the design that should be checked. The Execution activity is rather straightforward, following the Work Preparation, followed up by a Self Check. The Self Check is a very important step in the process, as it is aimed to make sure that all requirements identified are taken into account during the execution and that the method used is correct. The Self Checks are conducted on an individual level, where the person installing a window for example is

checking/reflecting upon their own work. These are commonly made according to pre-prepared templates, provided via the management system, which are very generally described in order for each site manager to tailor them for the specific needs of their projects.

This main process of work is the same for subcontractors, but the Work Preparations are conducted by the subcontractors themselves, by their team leader, and delivered to the Site Supervisor to be double-checked. The collaboration with a subcontractor is always initiated with a Start Meeting Subcontractor and ended with an End Meeting Subcontractor. These meetings are aimed to discuss the intended methods, specified requirements and to evaluate the efforts made of the subcontractor.

Lastly, the *Deviation Protocols* are a set of processes and routines to make sure deviations from the design documents are checked and documented. These can arise from a change in requirements or a mistake that is later compensated to the customer, but they should always be documented, leading to a revision of the design documents.

4.1.5 Final Steps of the Project

The *Inspections* and *Testing* are conducted by the production team and should ensure that the building has met all requirements detailed by the client, company and third parties. This can include testing of acoustics, water resistance, thermal functions, visual/aesthetic details, functionality etc. The F*inal Inspection* is carried out by a third party and should give the final green light for the project to be handed over to the customer and end users. With this handover the *Final Documentation* including design documents, maintenance routines etc should be done.

A few months after the project ends, the *Evaluation Meeting* is supposed to take place. The aim of this meeting is to ensure knowledge transfer from the project to the rest of the organization. When searching for examples of what these meetings result in, several problems became apparent. Firstly, several interactions over email with project managers and the operational manager confirmed that these meetings are rarely called upon by the Project Manager and the notes from the meetings are not accessible. The meeting notes are only shared within the project team and to the district manager. The project could be submitted to become a Reference Project, but these are used on a very shallow level, like budget, outcome and if the project has an interesting profile. What is lacking both in the template and in the criterias for a Reference Project is the Quality aspect.

The *Subcontractor Evaluation* is a meeting where subcontractors can be discussed and evaluated. Experiences of subcontractors are documented in a digital subcontractor platform, where individuals can rate subcontractors, which can be used by the manager of the next project when deciding which subcontractor to hire.

4.2 Regional Activities

The case region of this study described some additional quality related activities of theirs, including recurring regional gatherings, district gatherings, role specific cross-project meetings, a mixed group with a specific Quality focus, additional

start-up meetings in the beginning of the design and production phases focused on quality, as well as short and informational quality specific newsletters, all of those with some specific focus on Quality improvement by spreading awareness and information and providing various forums for experience exchanging.

4.2.1 Regional and District Gatherings

On both the district and regional level, the company conducts quarterly organized meetings for all employees where various important and current topics are discussed and highlighted. These are platforms to distribute new experiences and to share ideas within the district or region. The Quality Manager is occasionally invited to discuss the work of the aftermarket team and report on defects and how these could be solved. It is mainly the most costly issues that are presented here due to the limited time.

4.2.2 Role-specific Forums

The role-specific forums are designed for discussion and knowledge transfer between individuals with the same responsibilities within various projects in the region. There are role-specific forums for site managers, project managers, site supervisors and others. These are popular for exchange of experiences and knowledge in an informal way. There are no similar forums for construction workers.

4.2.3 The Quality Reference Group

The reference group, led by the regional quality manager and composed by employees of various roles with a specific interest in quality, reviews the designs in the Technical Details Platform. The reference group is often requested to provide feedback on new standardised details in order to add more perspectives to the usability of the detail. The group often discusses and works on solutions on common defects and operational changes that can be implemented in projects, like standardizing work preparations.

4.2.4 Quality Newsletters

The regional quality manager sends out a newsletter on common defects and solutions found in projects on a regular basis, commonly one every other month. The idea is to highlight critical issues or good examples, presented in a quick and easily accessible way on a printed A4 page. It aims to reach all employees within the region, distributed via the districts' managers, and should be of relevance for everyone no matter their specific roles.

4.2.5 Start Meeting Quality

The regional quality manager hosts a start meeting with the focus on quality. These are conducted in each project, once at the start of the design phase and one at the start of the production phase. Common defects and possible solutions are discussed here, based on the experiences from the aftermarket team. Further coordination can be made here, discussing whether or how the aftermarket team can be involved in the project. Without further coordination it is a one time occasion at the beginning of the respective phase.

4.2.6 Project Culture Workshop

The operative manager of the region conducts culture and value oriented workshops at the beginning of each project with the project participants that are involved at that present stage. The intention is to bring the company and project goals and visions down on a project and personal level. For instance, the case company values are discussed and defined in collaboration with the participants, discussing how it can be upheld and implemented in the project. The main goal is to create a strong, inclusive and productive project culture. There are no follow-up occasions planned or held during the rest of the project proceeding at present.

4.4.7 Technical revisions

Each region is given eight free technical revisions per year where the technical support department review the technical solutions and detailed plans of four different projects and provide their feedback and input, as well as evaluating the implementation of the standardised detail solutions in the project. The regional operative manager is in charge of the decisions here regarding which project that should be reviewed and how.

4.3 The Technical Details Platform

An online database is available for all employees, developed by the technical specialists department and various managers collectively, where technical building details and preferred building methods are collected. The idea is that this Technical Details Platform shall describe the concrete ways of how the company builds and produces the projects, whilst the Management system describes how the projects and organization are to be managed. The Technical Details Platform is divided into three parts: one for Buildings, one for Roads and Pavement or Heavy Construction, and a third one for Industrial Solutions. The first of those, focused on Buildings, is the one of relevance and therefore described in this thesis.

This database is aimed to describe how the company designs, constructs and produces their buildings and should complement the Management System. It is not supposed to replace any of the routines or processes mentioned in the Management System, and is structured of three separate, but kind of intertwined, parts: tested and established technical solutions, a list of risky or prohibited techniques or materials, and a Swedish housing platform based on best practice.

The part about technical solutions includes descriptions and detailed figures to describe standardized construction segments. These are developed over a long period of time by technical experts, based upon previous experiences and data, to ensure that the segment built meets all requirements and that intended quality is reached. There are some descriptions for every part category of a building, from foundations or floors, to interior or exterior walls and various bearing structures or ceilings. The information searched for can be found either in a structured list, with related documents attached for each part, or by a 3D model of a building. They both contain the same information, just structured differently. There are also guides and standardized production methods listed and explained via short video clips, for quite

many and continuously increasing, building parts that are supposed to support the work preparation activities in the projects.

Building techniques or materials that have led to tedious experiences, such as significant uncertainties or great guarantee costs, for the company are collected in the lists of warning or prohibited building techniques or materials, managed by the national quality manager. The prohibited ones are not allowed to be used within the projects at all, but the risky ones may be accepted if certain precautions are ensured. Each aspect is thoroughly described and listed with a responsible person to contact if needed.

Within this system is also the Housing Platform is developed by and for the Swedish inhouse project development departments and the production, with support from technical experts, and is based on the best practice of the company. It includes the previously mentioned preferred building methods and materials, as well as largely finished building concepts. The building concepts have been developed over time to ease the work of project developers, to save costs as well as time. There are also pre-packaged, thoroughly developed so-called green solutions - environmentally friendly concepts and technical parts that makes the selling and production of them easier. A sparring group, consisting of experienced employees, is available for bookings to support the regional housing projects in their early stages, working with the given materials on the platform with standardized techniques and methods as well as their own collected experiences. They aim to help the regions to create profitable and cost effective projects of sufficient quality, resulting in high customer satisfaction, by analyzing all project documents produced at the given time.

4.4 Interview Findings

4.4.1 General Impressions

Many interviewees found the subject of quality as a complex matter, being considered an inseparable performance factor among many others, affected by all choices made and actions taken daily along the projects' proceedings. It was said to be interwoven into material choices and closely related to scheduling and budget considerations for example, often also clashing with other requirements, factors or wishes. Tough choices have to be made sometimes, for example when sustainable material are chosen before a low-maintenance, high-quality material that would have lasted longer, due to company prioritizations, or in regards to finding the balance of delivering a high-enough quality without overdoing it, and thereby blowing the budget or loosing possible profit. These dilemmas were frequently mentioned, mirroring the frustrating difficulties to improve the overall quality. Because, quality is described as a complex matter, affected by and affecting other factors of the projects respectively.

Many interviewees wanted to point out that the company is generally good at what they are doing and that all their colleagues are competent and proficient at solving problems as they arise. The company was also praised when it came to team spirit and motivation as well as the open communication in the region, most interviewees added that they themselves were blessed that they worked on a site with such competent and engaged colleagues. One interviewee explained in amazement that, in spite of all the challenges of the complex construction process, it often turns out as good as it does (13), thanks to his engaged colleagues.

However, many also described how the quality is highly dependent on having sufficient prerequisites to work with, being able to make the right choices and to prioritize good work. This includes the right budget, schedule, resources and "*the right people*". Experience within the team was emphasized as key in order to plan ahead, make the right decisions and solve problems as they appear. Because, as many interviewees explained, they are very focused on planning and to correct issues as they appear and are identified, but as long as the customers or inspector do not find any issues, the quality is seldom discussed. As one interviewee (12) explained:

"Quality is not an issue, unless something is not working"

All interviewees were well informed that the defects connected to water damages infers significant costs within the region. Many described how faulty climate screens, designed to keep water and moisture out, caused by lacking designs or incorrect production practices, allow water to get into the building (3,4,8,5,9). Balcony attachments, window, door and prefab element mountings, insufficient sealants, flat roofs or garage draining functions were exemplified as especially critical and difficult in interviews. The more frequent defects were explained to be minor ones though, often aesthetic defects that are relatively simple to detect and fix. These are often corrected right away, without further documentation or consequences. All of these interviewee explanations are very similar to the information given by the Regional Quality Manager. The extreme weather conditions of the Swedish west coast, the unique projects and contextual settings, time pressures and competing values, hard technical challenges and lacking knowledge were all said to be reasons for the many defects within these areas.

However, several unknown recurring defects that were not presented on the Regional Quality Managers list of common costly defects. While some did not seem to be frequently appearing nor very costly, others demonstrated a pattern of returning regularly and thereby resulting in significant costs for the projects or company at large. A site manager explained an example of this: a situation where steel doors were installed without problem, but once they were in place it was realized that the locking mechanism collided with the concrete wall, making it impossible to open the doors completely. When the site supervisor contacted his manager, the manager responded that this problem was frequently occurring, and that they needed to remove an area of the concrete wall so that the locking mechanism could fit. The interviewees found this both frustrating and typical for the industry, exclaiming in amazement:

"So this has happened several times before? Sawing in concrete is not very cheap. How can this really happen? How is it possible?"

"It is a strange industry, the same problems happen again and again, and it's really baffling. It's definitely an area in need of improvement".

4.4.2 Detecting Defects Early on

In an ideal world, no defects should be found by the end customer, since this may affect the company reputation negatively. When it does happen, it is very expensive to

correct the defects once residences have moved in, one interviewee explains (6), adding when asked about the consequences of defects that:

"I get nightmares when I think about it. It's always expensive, very inconvenient for the customers and a lot of work for us [the case company] to coordinate the corrective activity".

Fixing defects in a moved-in home requires both compensation to the customer as well as the costs of fixing the problem itself. While the financial costs of fixing defects in homes are large, the major loss for the company is the loss of trust of the customers, which can spread among residents and on to other potential customers. It is therefore important to identify all defects early on during the project, so the defects are not left behind for the guarantee period.

The main activities aimed to control the project work and discover eventual defects are employee self-checks, site management, inspection and rounds during production; self-checks and audits during the design phase; and otherwise spontaneous observance by colleagues throughout the project. The general view is that each individual on site plays a big role in reporting to the site supervisor or site manager directly if any defects or errors were observed. Some of these site managers and site supervisors highlighted the importance of clear communication and to clarify their expectations on this issue. It is very important to have an open and positive approach when confronted with these reports, to ensure that no individuals are to be blamed or ashamed of their work, to stress that we are only humans and mistakes will happen but that we need to be noticed so that the defects can be corrected. It was generally viewed as important to make clear to the workers that defects should be reported when found, since this could not be taken for granted, and that the reporting made was positively reinforced and praised. According to the several interviewees, it is all about ensuring that the right knowledge about the defects is present within the project and that the people involved are given sufficient information on what to expect and look for. Among many interviewees, it was also highlighted that motivation of a team or individual is crucial, as it affects the level of which they are willing to perform, observe and support the work of colleagues.

Rounds are also important routines to discover defects and are conducted by site supervisors who look through the project for defects, allowing the supervisor and workers to discuss eventual challenges and possible solutions as they pass by. Two challenges were identified here: first, in order to actually see and detect defects it is crucial that the rounding supervisor understands the work and knows what to look for. It is not possible to control every single detail constructed so a deliberate choice of what to look at must be made. The same challenge is apparent during the design phase audits as well. Construction worker representatives described that the supervisors are getting younger and younger, thereby possessing less experience, and that they therefore often lack the wide knowledge and understanding they would need. However, as long as these individuals are open with this, and turn to their more experienced colleagues for help, this would not be a significant problem. Unfortunately though, it seems as if some new supervisors are too proud or afraid of asking questions, believing that they can solve problems by themselves, which may lead to overlooked defects, according to the interviewees. This leads us to the second challenge: that some would prefer not to cause unnecessary conflicts or disputes, and

therefore choose not to report a defect that has been observed. A site supervisor explained that it can sometimes be difficult to point out the errors of another worker, as the worker's pride can be an obstacle for receiving feedback on work performed.

The importance of self-checks were apparent in the interviews, and there was a strong consensus that they should be more integrated in the work routines of all employees. The self-checks are the most important control mechanism that ensures that a task has been performed in the correct way, and so they play a vital role in quality control according to our interviewees. A well performed self-check should be enough to ensure good quality, but unfortunately, they are sometimes hastily made and not filled out properly, therefore not serving its purpose. Examples were given where self-checks had been skipped, not read through, filled out at a different time or performed by another worker in the group. How could another person know what someone else has done in detail? There were also examples that described how self-checks could be conducted weeks after the task had been completed, after several reminders from supervisors. Although not all self-checks are lacking, most interviewees with experience from the production had several examples of encounters with neglected or misused self-checks.

A project manager told a story about a worker who installed a heating pipe, doing as he would usually install piping and skipping over the instructions and filling in the self-check boxes afterwards. It was later found that both the instructions and self-check document clearly stated that the pipe was supposed to be installed with another feature, an unusual one that did not fit with the ordinary routines of the worker, but still clearly stated in the documents. The defect was found afterwards, once the concrete floors had been cast above, and the client had to be economically compensated since a correction of the defect would have been too expensive and inconvenient. In the situation, all information was given, but the routine of the worker did not include reading the instructions and double-checking his work through the self-check, resulting in damages. The same project manager (4) gave another example, that a sealant had been placed incorrectly, not according to instructions, allowing water to come in behind the outer facade but preventing it from coming out, resulting in water damages inside the building. The water damage was found very quickly, as soon as the signs were visible indoors by the customers, but it took years before the cause of the problem, the sealant, was found and could be corrected by the aftermarket team.

The construction site can be perceived as chaotic, partly because of the many actors that come and go along the project's proceedings, and partly as some design solutions are not completed by the designers, and thus have to be figured out by the workers on site whilst dealing with their normal everyday logistics. The workers are used to making quick decisions and solving problems, to utilize their individual and collective experience to solve the current problems at hand. However, this could lead to defects remaining unnoticed, as the solutions chosen often are unique and seldom confirmed by higher instances or technical experts. Since the feedback given on previous efforts are lacking to non-existent and other collections of relevant knowledge or experience before the problem solving initiation, one tends to tackle each situation as a new one without regarding previous mistakes or defect manifestations during similar tasks. These issues or challenges will be further in the following subchapters, but they do affect the ability to discover defects early as well. It will be difficult, or even

impossible, to improve the early error detection if we do not learn from previous mistakes or incidents and learn where to look more closely.

As previously mentioned, there are many actors involved on site, some remaining in the project for a longer duration and some performing a single task to leave the project forever afterwards. Those who remain for a longer time are easier to integrate into the team spirit, which makes it easier to talk openly about their work and potential errors or defects they made. It is more difficult to "double-check" those who are not familiar, mainly single-task subcontractors. A lot of trust is placed in the subcontractor's capabilities to perform their task, as the site management team, for one, does not know how the task is supposed to look or function, and second, does not know if the subcontractors are in need of support or guidance in their task.

Several interviewees who had experience with the recent implementation of BIM360 Field explained that it is a big step in the right direction to simplify the process of documenting defects as well as for communication and coordination within the project. Although no clear consensus has been reached on the quality benefits of the system, it is viewed as a useful tool, easily available and easy to document one's work with photos and integrate the self-checks into the system itself. One question was raised regarding the amount of data that is collected during a project and how the company could make better use of it in the long run. Neither the site managers or supervisors nor the regional quality manager has the time needed to structure this data of sprawling knowledge and experience, which currently is left and forgotten as the project is closed.

4.4.3 Systematic Learning from Previous Defects

The fact that errors and defects, small and large, tend to reappear over and over again in the company's projects, according to the interviews, indicates that the learning from previous experiences are lacking. It seems as if the company has been focusing a lot on preventive planning, to avoid the appearance of defects, but it will be difficult to improve those preventive planning activities if lessons are not learned from previous mistakes. The case seems to be similar both within specific projects and on a larger scale throughout the organization.

The process of correcting defects generally looks the same in every project at the case company, as explained by site managers, site supervisors and project managers. When a defect is reported there are two major tasks performed: First, the financial responsibility is decided, often investigating who made the error and therefore should pick up the bill for solving it. The process of finding out who is responsible can be tedious and costly, as working time is spent on administration and 'investigation'. Secondly, it is decided how the defect should be corrected and controlled so that it is corrected accordingly. One site manager explained that they try to cooperate and solve the problem together in his projects, and then decide who is responsible for the costs afterwards in order to avoid time delays. Other projects focus on finding the responsible actor first and to request that they correct the problem as soon as possible. In some very rare cases, where the defect had caused a very high cost, the issues led to contracts being reconsidered or important deadlines were at stake, the problem would be carried to the central organization. This happens rarely. It is up to the project team to decide how to fix their defects and where to seek help if needed, where most

managers and supervisors tend to speak to trusted colleagues in other projects with similar responsibilities. In some cases, the aftermarket team or regional quality manager is contacted for guidance, but it does not seem to happen often.

However, it seems as the common practice after that the defect is corrected and the financial responsibilities are decided upon is to close the errand, without any further reflection or documentation. The consensus among the interviewees is that the construction industry, including themselves, focus on finding the simplest solutions to the defects as they appear and then move on. Some interviewees expressed that they had not thought about this lack of reflection and loss of knowledge before, but that they could see the apparent issue with it. There are no current routines in place within the company for this yet, but it seemed as if the interviewees would want more structure here. They explained that at that critical moment, when precious time has to be allocated to reworking or fixing defects, it is difficult to come up with any own ideas or initiatives of how to avoid future reappearance of the defect. And there is no easy way to find information of previous experiences of common day-to-day challenges at the moment, apart from the technical details platform - but there are mostly issues that are considered more "significant" described there.

One interviewee said that it would be way too costly and time consuming to investigate the cause of appearing defects whilst still having to deal with everything else that goes on in the project. This would have to be done by someone else. As of now, the individuals involved in fixing a defect can however learn from the experience and broaden their own individual knowledge. Hopefully, this particular knowledge has not been forgotten in time for a similar task within their next project. In most cases, no formal documentation or reporting is conducted in the central organization, meaning that the defect, solution and experience gained therefore remain within the projects and those individuals involved. It does not seem to be a sufficient path though, as the defects do not seem to decrease, even with the introduction of BIM360-field to some projects.

It was also said (5) that in general, defects are not documented at all if they can be solved directly. and it would be great to have a database of all previously documented defects and how they were solved. Defects are rarely documented even within the project itself either, and with the stated lack of reflection, this may lead to the project doing the same mistakes over and over again. A site manager explained that:

"*It's often first after you've made the same mistake twice or thrice that you figure out you should have done something about it in the beginning to avoid its recurrence*".

One such recurring issue are window installments, which lead to water leaking through the window. This specific error has been in special focus by the aftermarket group for the past year, as the defects associated have been rampant. They are yet to find the best practice, according to the regional quality manager, but their service workers have been visiting the projects lately before the beginning of the window mountings in order to share their experiences and instruct the construction workers. It has been very appreciated, it remains to be seen if the effort has led to positive quality results. A site manager (16) explained:

"*It's always something going wrong when installing windows and doors. Always!*".

4.4.4 Communication and Knowledge Transfer between Project Stages

A wider, holistic understanding of the project and various roles can be attained by sharing experiences and knowledge and working more closely between the different phases of the project. It was clear that knowledge transfer and communication between the different stages of the project was important, especially between the design team and the production team. Design representatives would like to involve the production personnel earlier, to ensure constructibility and achieve more practical knowledge, and the production personnel expressed that they would like to be involved earlier too. Although some routines are established in the management system to ensure early involvement of the production team to share their perspective and experiences, these routines could be improved.

When interviewing representatives of the two different phases it became clear that they possess very different competencies, perspectives and methodologies to solve problems. Several interviewees working expressed that it is very important to receive production knowledge in the early stages of the project, like the procurement and design stage. It was said that there is a lot of uncertainty in the early stages, but it is also there that changes may have the largest impact on the project down the line. Almost universally, the interviewees highlighted the importance of the right presets when starting a project, like budgeting, scheduling, planning and designing, which are set in the procurement phase. Here, in order to make the right decisions, it is crucial that the right knowledge becomes more available, and so more knowledge transfer needs to happen from the production to the procurement as well as design.

The general view was that the design team and the production team needed more integration, with the production team providing input from an early stage of the project and the design team working closely with the production to smooth the transfer of plans and documentation. The designers at the company are generally becoming more theory-oriented, which creates a disconnect from the production team and the construction site. Hence the design team needs more support from the production team to make sure that the design solutions are efficient to construct and fulfill their purpose. A project manager shared this view, that the gap between the practical production workers and the ever-more theory-oriented designers, the “whole picture” is lost, meaning that the individuals' understanding for other stages of the project and the purpose of some designs is lost. As the two stages are so different, there needs to be an understanding of how the other one works in order to understand the whole picture.

A design manager adds that it is impractical to see designing and production as two separate parts as they should overlap more to get this whole picture and work priorities clear. The design manager’s perspective is shared by many interviewees who highlight the importance of including representatives from the production and the aftermarket team, working closely with the customers and end users to truly understand and plan the project from start to finish. A service manager explains that these perspectives are crucial early on, and can help to define important parameters

and potential risks and challenges. If these issues can be solved early on it can help create the right presets like budgeting and timeframes. Several interviewees agreed, if these perspectives are not included early on, changes to design and priorities become more costly as the project progresses. The service manager explained when she was asked about the state of knowledge transfer that:

"I believe that it is becoming more clear that it is important to push up experiences into the earlier stages of new projects, and that if we find a solid structure for this, it [the projects] will improve. That we really work with collecting experiences from the late stages to make it right from the beginning of new projects."

A Project Manager explained that many details are hard to solve in the design phase and it is not uncommon that these details, complex and important as they are, get shuffled along the design-phase and eventually show up unsolved in the production. This is due to both lacking knowledge of the solutions, the complexity of the challenge itself and it's not always clear that the problem was that important in the first place. The project manager (4) explains:

"the responsibility for solving a detail ends up on the shoulders of a carpenter who must solve what could not be solved in the entire design-phase"

The carpenter is asked to solve the problem to the best of the person's abilities, but it might not be enough and the consequences might not be clear to the contractor in question. There does not seem to be any collaborations in those matters either. Most interviewees shared the view that not all details can be designed perfectly, and standardization can only be used to some extent. That there needs to be a balance in the amount of design documentation, like plans, details and instructions, handed over to the production team and the amount of solutions that needs to come from the production team themselves. This makes it even more important with feedback and clear communication between the design team, production and aftermarket (12). It is important to identify risks and defects and welcome questions about the design and instructions if they are unclear.

When the design is handed over to the construction worker, there are few detailed instructions, the project manager explains. "*There are no IKEA-like instructions with steps A to C, that is not how it looks on the construction sites*". When there are instructions on critical solutions, often the instructions are not very user-friendly and include too much 'unnecessary' information, leading the construction worker to simply dismiss the instructions, one project manager explains (8). According to a service worker (3), it was explained that if something looks wrong in the instructions from the design team it is not always possible to speak up, as some experience that their feedback is not listened to, making it much easier to follow the instructions, knowing the result will be of poor quality. As one interviewee, a former construction worker and foreman explained:

"It is not easy to change something that someone has decided, then it is much easier to give feedback before the decision is made"

So why do we not just "ensure" early involvement of production representatives in the tendering and design phases? Well, there are some coordinative issues that one must

overcome. The first is that it is rarely clear who the intended site managers and hired subcontractors will be, and therefore it is difficult to invite them to early involvement. Paradoxically, a design manager explained that knowing who to invite is crucial to get everything right for the production team, adding:

"It would really help us in the design team to have the contractor's input and also strengthen the engagement and commitment of the subcontractor, as they get the opportunity to affect and be part of the design"

Adding to this difficulty, the production personnel are often involved in the late stages of their projects as their new upcoming projects are being designed, and it can therefore be difficult to find sufficient time for meetings and provide design input in a new project. They may therefore need support, to know what they are able to and should contribute with and how.

A design manager described a workshop they had a while ago, where design representatives were asked to write a list of things that they would like the production representatives to help them with, who also were asked to write a list - but of what they would like to be able to affect at an earlier stage. Interestingly, the lists were nearly identical. These lists may, if merged and further worked with, become sufficient support for the production personnel as they are invited or visit the design meeting. However, there is yet another challenge - of how to decide when and how and by whom someone should be invited or invite oneself?

Cross-phase involvements are encouraged by the management system but seem to be rather vaguely expressed. The interviewees explains that the amount of involvement in a project is highly dependent on the design and site managers responsible for it and their personal interests or previous experiences. Some interviewees discussed that early involvement could be improved by stating, i.e. regulating, where experiences and involvement should come from together with whom, or what roles, that should participate could help to streamline the process and ensure that more people are included. Maybe it would only have to be required for a while? Because as one interviewee explained, it would probably become much easier for employees to actively seek contact and help from various stages once they have gotten to know each other, and knows the person at the other end of the line. There is a lot of knowledge available in the company that is not utilized enough at the moment, and there is truly something to work further with.

4.4.5 Knowledge and Experiences do not Leave the Projects

Many defects that appear during the projects are dealt with directly and do not reach neither the clients nor the aftermarket group, which is great! However, it seems as if these defects are not reflected upon, as previously discussed, and the experience and knowledge gained from them therefore never leaves the individuals or project team involved. They are not documented, processed and stored anywhere to be accessed by others to learn from. This is unfortunate, since it may lead to unnecessary repetitions of defects within the company. We should not have to tackle each problem or critical situation as if it was the first time it was done within the company, because there is probably some other colleague that has encountered a similar situation before, as several interviewees expressed.

A site manager explained that, in general, the knowledge gained within a project rarely leaves their teams or individuals, saying that *"everyone is sitting in their own room and inventing their own wheels"*. Many said that a vast array of genius, good solutions are created in each project, but that they rarely leave the project. It is only in specifically significant cases, often when the costs of the defect are too high, that the errand is discussed on a regional level or during cross-project meetings with a possibility of reaching other projects. This view was shared among the majority of the interviewees, that good solutions are found, but the generated experiences don't transfer efficiently to the rest of the organization. The primary way of the knowledge generated in a project to leave the project is through informal personal networks, like if a site manager contacts a close colleague in a different project to ask for advice.

The formal forums that promote exchange of knowledge were highlighted as an important aspect of knowledge transfer between projects. These include the district forums, regional forums, cross-project role specific forums or other site visits. These forums allow members of different projects to discuss quality issues, defects and solutions, but the forums are also platforms to talk about other issues like work environment, safety incidents, time schedules or logistics solutions etc.. So, there is an opportunity for the knowledge generated within projects to transfer to other projects, but it is highly dependent on what other topics that are discussed within the forum and the amount of time given to the topic of quality.

Another challenge, or problem really, is that these meetings are held around four times each every year (unless a pandemic comes in between), and the timing of which topics that are discussed and the various projects' states may affect their ability to be effective according to the interviewees. If the others' projects are in completely different stages it might be irrelevant for them to discuss the issues that I am facing now, as one interviewee expressed. This situation affects the others' ability to receive relevant information as well, which will be discussed in the next subchapter.

The only other channel where knowledge could formally leave the projects is the project end meetings, intended to evaluate and collect experiences from the project so that the individuals in the project can carry the whole project's experiences to other projects. However, most interviewees explained that they had never attended such a meeting, or if they had, it had been a long time ago. It seems as if the meetings are seldom conducted at all, even if they are required according to the management system. Several interviewees said that it is difficult to coordinate the relevant participants for a meeting once the project has ended and many have moved on for new tasks. One site manager (9) explained that the end meetings, if they even happen at all, are lacking and can vary greatly in quality "*The meetings have to be concrete and productive!*" the interviewee said. It seems to be unclear what to discuss, which makes the meeting less effective, and the notes taken are seldom stored centrally or distributed beyond the meeting participants at all. The eventual reflections made therefore tend to remain with these particular individuals to be stored informally, which may lead to loss of knowledge - or at least no strengthening of the collective organizational knowledge.

When a site supervisor was asked if it is possible to share knowledge from the project to the organisation anywhere he explained that he believed that it could be done (10),

but added that he himself had not done it. This is clearly a challenge within the organisation, that knowledge or feedback have no formal and direct channel from the projects to the central organization, where experiences can be collected, structured and later accessible to other projects. This work is happening to some degree in the aftermarket group, where the more severe and often costly defects are found and fixed to later be shared through the regional quality manager via site visits or through the forums discussed. The aftermarket deals with the late stages of all regional projects and draws experiences from the defects they encounter and their following solutions. They also have some idea of which the most common issues they deal with are, and have collected them in lists centrally in their group, which later on are discussed during the various regional forums. There are no equivalent collections of the defects or challenges appearing in the design or production stages, as their experiences are not stored and centralized, but rather informally distributed among each other. Several of the interviewed individuals from many sides of the project life cycle explained that knowledge transfer is very important, and that experiences must be collected after the project so that the company can learn from their work.

4.4.6 Knowledge and Experiences are not Provided to the Projects

There is generally a lot of knowledge in a large company such as the case company. One challenge to overcome however is to deliver and direct the right kind of knowledge, in the right way and at the right time to the projects, otherwise there is a risk that crucial information is lost, resulting in defects reappearing again and again. From interviews with individuals from the early, mid and late stages of the project lifecycle, it became clear that it is difficult to deliver relevant experiences to the projects at the right time.

The formal channels available to direct or be given knowledge to project representatives are: the regional and district gatherings, the cross-project role specific groups, and the quality start meetings held by the aftermarket group at the beginning of the design and production phases respectively. As mentioned earlier, the timing of which topics that are discussed is of essence, and the various projects' states may affect their ability to be effective. The various initiatives are well appreciated by the interviewees and the topics are often interesting, but the information does not always have the intended effect. Some interviewees explained that it is hard to discuss concrete solutions in the forums, and as most forums are held quarterly, the information about particular defects, like window installations, does not always match well in time with the stages of the attendees' projects. And it will not be relevant to discuss frequent defects during kitchen installations during the start meetings for example, two years before it is time for it in the project, and the knowledge is therefore often forgotten or lost.

In order for employees to search for help or support as they need it at other times, they first have to actually know that they are approaching a critical activity and that they are in need of any help at all. How are we supposed to catch these situations and reach out with organizational help and support without someone or a group with a general project overview?

The interviewees explained that there is no one at the regional or district level that has an overview of the projects' various stages and probable challenges that are to come.

Some suggested a full-time employee or group that could be involved in several projects and collect experiences and then transfer these to the projects. This person could be gathering information and knowledge from both the design and production and ensure that the knowledge is transferred between projects and the organization, to the right employees at sufficient times. The aftermarket group, which is the main distributor of quality knowledge at the moment, is focusing on the defects that they face and deal with during the guarantee period, and it is mainly these issues that are discussed during the district and regional gatherings and quality start meetings in the projects. Other issues are not documented and reflected upon to be stored centrally, so this experience is only transferred in informal ways. Several people pointed out that many topics, like sustainability and health and safety have coordinated teams, while quality has a single person stuck between two separate responsibilities.

The projects and their involved employees can of course collect relevant knowledge from other places as well in addition to these mentioned informational channels. Depending on their needs, they are always able to contact either technical specialists within the company (internal consultants) or else external consultants. They can also find a lot of knowledge stored within the technical details platform available to all employees. However, this requires two fundamental prerequisites: First, that the individual or team involved remember that these sources exist, and secondly, that they want or choose to utilize them. It is more common that the employees contact experienced or close colleagues to ask for advice, according to the interviewees, but then we risk missing the source that possesses the most relevant or best knowledge. Both the regional quality manager and a technical specialist explained that they are available for anyone with questions during their interviews, but that they are very seldom called upon to help or for support. It has however seemed very appreciated the few times when the regional quality manager has been contacted and the experiences from the service team had been utilized within a production team.

A site supervisor explained that construction workers and site management seldom receive feedback on their previous work. The only feedback they get are mostly rumors, from informal personal connections, bringing rather vague explanations like "there is a leakage in your old project" but not knowing or sharing the cause of it. This makes it hard for the employees to learn from their mistakes - it must be difficult to learn from your mistakes if you don't know you are making them. In order to learn we must fail sometimes, but one must also ensure to reflect upon the mistake and the cause behind it, as an interviewee said. The site supervisor (15) adds:

"a solution may appear to be great, until several years later when it is finally discovered that it was not great at all… The times when solutions are bad were often a result from believing you were doing the right thing, but really you were not. I've been working as a site supervisor for 3-4 years and I have not yet received any feedback that I've made any mistakes, so I guess I haven't"

Knowledge transferring seems to be tough within the case company and the routines for it are apparently lacking within all project stages according to the interviewees. When asked about the routines of knowledge transfer, a Service manager (6) explained that routines are lacking, as there is a lot of knowledge regarding specific defects among service workers which is not utilized. These individuals have a lot of experience and knowledge about common defects and design issues, which they have

been told about from the customers, making their knowledge valuable for the entire organization. However, the service manager explained that, in the best scenario, these experiences are currently collected in excel spreadsheets outside the formal platforms of the case company. This understanding of why one should document things and how it will be utilized later on, seems to be lacking within all project stages. She explains:

"*The routines are lacking. I am worried that not everyone documents when they are supposed to when it comes to defects. Here we can definitely improve! It can be made more clear how the routines are supposed to work, what should be documented and how, as well as when and where it will be used for later*"

When discussing the potential idea of a database of common defects and their various solutions, many interviewees were positive to the idea. One site manager explained that he would like a list of common defects that are frequent or costly at different stages of the construction, like prefabricated element mountings or balcony installments for examples (9). These problems are often solved in the project as they appear, but it would save a lot of time to not have to resolve the same problems again and again, and instead utilizing experiences from other projects. In order to create such a dataset, standardized procedures for documentation and storage are needed so that it becomes easier to report and sort defects, the interviewees explain. BIM360 Field has made the documentation quick and easy for the employees, but two individuals can report the same issue in two different ways, using various abbreviations etc., so it is currently very difficult to sort and process the collected data.. He concludes that:

"large financial sums can be saved if you can manage to avoid even the small problems"

A technical specialist (12) explained that if the company started today, they would definitely maintain a database with defects and experiences. It seems as if they consider it a way to time consuming and complex task to develop one now though, even though they all expressed positive feelings of having one easily accessible. A project manager was very positive about a database of defects (10), stating "*A lot of money could be saved on such a database, if used correctly*". One site manager explained though (13), that even though he could see the possible gains from a database of common defects he thought that it would be difficult to make it work in practice, as different people prefer different solutions to problems which could cause conflicts with standardized solutions. However, all interviewees agreed that since the defects are not always manifesting or identified during the production, feedback from the end result as well as previous experiences from other projects would be considered helpful. In general, it was considered important to be able to know what defects to look out for and how they might manifest themselves.

A few interviewees explained that the local quality manager and the experiences from the guarantee-stages should be regularly invited to the production site to promote exchange of experiences and knowledge. This was suggested to be done in connection to certain tasks, so that the potential difficulties and common mistakes could be discussed before the work started. He himself expressed that he would like to do so too, but that it is difficult or even impossible to find enough time to visit all the

projects. He is just one person, and he is also responsible for all regional guarantee errands that arise and cannot manage all the proactive work that he would like to do.

4.4.7 Lacking both Specific and General Knowledge in Projects

A common theme that was repeatedly discussed during the interviews was the perceived lack of knowledge, both specific expertise and other more holistic or general kinds, at critical moments throughout the projects. Several interviewees brought up the subject and elaborated on their thoughts regarding possible causes and the various effects of the matter. It seems to be an issue spanning across the entire project life cycles, being caused by several intertwined contextual aspects and structural issues.

All interviewees agreed that water damages, caused by defects in the exterior building shells for example, are too common in the company, leading to severe costs of repairings and unhappy customers. Several interviewees express that we seem to lack sufficient knowledge of technical building physics in order to design and construct details that keep the water out. Project Managers described that their organizations have too few specialists who actually understand building technology well and know how moisture and water affects the building quality for the end user. Since the knowledge seems to be lacking in the design as well as the production phase, the problems may appear early and remain undetected. The defect may appear due to a fault or mistake in the design documents, because of lacking knowledge, which the production then follows without acknowledging the malfunction. If the production team had the knowledge and carefully went through the documents, also demanding a certain level of individual motivation of course, one might identify the fault before it got too far.

The job for the production team is not only dependent on the instructions handed to them, but there has to be some level of general experience and knowledge (10). Even if the instructions say something, there has to be some knowledge of what actually will work in practice, so that a conversation can be held about doing it differently, one interviewee explains. The defect could also appear due to a slip or mistake during the production, due to lack of knowledge, even though the design documents were correct, or else due to lacking documents handed over to the production.

The lastly described alternative seems to be more common than one might think. Several interviewees express that the design documents seldom are fully complete and that the things that are most commonly left out for the production personnel to solve are the most complex details, which apparently seem too difficult to design/imagine at the office. Instead, the quality of the detail depends on the knowledge of the production team or the responsible site manager or supervisors. One interviewee explained that moisture and water damages is a big issue that the company is focusing on right now (9), among some other critical areas, but it is difficult to solve, needing expert knowledge and more data of best practices.

The site manager or team in charge has a task of great responsibility, being the one(s) to plan, coordinate and control the entirety of the design or production process. On top of all that they also need to solve complex technical issues that were not solved during the previous phase, plan for sufficient construction or mounting methods and also

control the functional as well as aesthetic quality. Their knowledge and collective experience becomes crucial for the project quality performance. Experience and knowledge is required to assess the quality of a product, and with poor feedback from the different stages of the project, it can be difficult to learn the functionality, and thereby the true quality of a product. As one site manager (16) explained:

"*Experience is required to work with quality. If a person does not know how a product is supposed to look and function they are not capable of assessing its quality. This goes not only to visual indicators, but also functionality and all other aspects of quality*".

Team composition is important, as exemplified in an interview, an experienced design manager might help cover the gaps of knowledge of a less experienced team member, but if too many inexperienced individuals get too much responsibility it can be harder to ensure good quality. The knowledge and experience is simply missing in such a team, which might not be a problem as long as it is clear where to look for help, support and guidance. As of now, the employees do not seem to turn to neither externally hired controllers, nor the technical support division, available for all employees of the company to contact at any time, nor to the team or manager responsible for the regional aftermarket with their great experience, for some reason. Instead they try to solve the problems themselves, which several interviewees express is a natural and interesting part of their everyday work.

In addition to the lack of specific technical knowledge across the projects there also seem to be a visible trend of lacking and decreasing project overviews, as expressed by several interviewees. Project Managers (4, 8) explained that individuals within all stages of construction projects have a huge challenge to understand the "whole picture" of the design or construction process, project phase or the project's end purpose. One expressed that "*it is hard to see the consequences of one's decisions while not understanding the whole picture*" (4). This lack of overview creates a poor understanding of the purpose of the building in question, and not understanding the importance or purpose of the tasks required to complete the building.

This trend seems to be noticed in all project phases and some interviewees expressed that it seems to be a general trend within the industry as well. To hire external consultants for specific design tasks is increasingly common and the same thing is happening in the productions, where various subcontractors are procured to conduct specified tasks. Fewer parts of the projects are conducted by company employees, leading to less learning. One interviewee, a former construction worker, explained that in his opinion, the company is outsourcing too much of their work to subcontractors, which creates a loss of knowledge for the company. As the company stops doing certain tasks, they lose their ability to check the work of the subcontractor hired to do the task, as well as losing the ability to learn from the task. He explains:

"I would say that it has gone so far that we don't know how to build houses anymore. We have so few tasks so we can no longer learn from each other. We're on a dangerous path. We're in the hands of others nowadays, more or less"

Some interviewees said that the organizational knowledge of how to build our buildings is decreasing. This trend of more specified teams or individual employees

makes it even more important that the management possess the vital overview picture and are able to coordinate and communicate the following steps to everyone involved.

A number of alternatives of how to cope with the decreasing understanding of the whole process or project was mentioned by the interviewees. Some suggested that there should be frequent meetings where the consequences and purpose of certain activities should be discussed so that every individual gets a sense of responsibility for their part (3). Others (5) said that the purchasing team members have been attending work preparation meetings on sites in order to attain a greater understanding of the procured materials, which could help the purchasers to understand the challenges faced in the production. More cross-functional integrations like this would be great, but the limited time available does not allow this to a greater extent. It is also said that visual tools and management techniques are used to help create this overview, helping each designer to understand their part and the whole picture (5) which should become common practice.

Several interviewees came to the conclusion that company support from a national level is needed to help find an organizational solution to improve the overview knowledge on project level (11). Especially since, as several interviewees point out, there is a generational shift on its way in the industry, as well as in the company, where experienced individuals retire, and the next generation is almost 20 years younger, leading to a huge gap in knowledge without effective systems in place to be stored within the organization (4,7,8). The projects need help to see the big picture, on both project, cross-projects and organizational levels, to spread their knowledge and help using the management systems. A former construction worker expressed that:

"We have people within the company who've been working for 40 years and seen everything. If they can sit down and look at the plans, they will be able to find the problems. This can also help to engage people and motivate".

Maybe this could be a way to support the younger, less experienced managers and simultaneously ensure that the vast knowledge and experience of the elder employees are utilized efficiently within the organization?

A site supervisor suggested that the company assign a regional quality representative, which could support the projects hands-on, both on site and at the office, to act as a bridge for knowledge transfer between the project parties, the central level and the different projects. Others (5) say that the organization should focus on communication and leadership rather than growing the management system, emphasizing soft parameters that lead to concrete actions. As an example, a manager explains that a picture of the end product needs to be built in the heads of the design team and they need to be able to express this to the production. There needs to be a common view and a common language.

"With too many checklists, we risk losing the ability to think and learn for ourselves"

4.4.8 Quality is seemingly not prioritized

This may sound as a bold statement, quality and building physics are of course important topics for a construction company such as the one considered in this case

study. It has however become clear during the interviews that quality seems to be deprioritized in comparison to other aspects of the projects and company business, which is perceived on both the upper organizational level as well as on project levels.

Several interviewees expressed that ecological and social sustainability matters have been the main topics of organizational focus and work during recent decades and that quality topics have been rested in the shadows of them (4, 8). Also, strategic initiatives regarding safety and work environment have led to organizational changes as well as improving health statistics. There is a regional team of staff focusing solemnly on health and security issues, working closely with district managers and the projects to secure sufficient routines and stress their importance. The interviewees wonder when the same efforts will be made towards quality improvements? It has however also been mentioned that an appreciated organizational shift was made within the case region around two years ago, where the aftermarket department was moved to the level of operational support, closer to the projects, and the proactive approach towards improved quality within the group has led to an increased focus within the region since then.

Quality is a value one never would strive to neglect, but it is difficult to ensure good quality while competing values of time and money are constraining. One site manager explained that if the budget runs low, one has to prioritize what to cut (11). It is important to not deliver *too good* quality, claiming that it would be too expensive and reduce the profits made, that it is a constant challenge to balance the delivery quality towards goals and requirements. The project and site managers and supervisors in charge of the projects possess key roles here, where their interests and attitudes affect the way their project is managed and conducted, being ultimately in charge of the quality performance. (11) One interviewee explained that if the interests of the managers are to promote quality, there is rarely an issue, displaying how much power those individuals hold. This view is shared among all site managers interviewed (7, 11). Their motivation towards good quality is crucial for good results according to the interviewees as they are the ones that could make or break the employees' opportunities to do a good job.(12)

All employees are of course responsible for the quality of their own work, to deliver in accordance to given requirements and expectations, but if the management is stressing the other key aspects more, or does not invest their time to listen proposals for process or products improvement or sharing feedback on previous accomplishments, it will be tough to reach all the way. So, the management plays a significant role here, but there seem to be more ways to increase the focus on quality within both the company at large and the case region.

Several interviewees also acknowledge the lower prioritization of quality within the regional organization and the structure of operational activities. There are clearer structures in place for handling safety and work environment issues, where also appointed persons are close at hand to discuss the respective topics with, according to some interviewees. The regional quality manager, who also leads the aftermarket group, is actually just a phone call away, but it has not yet become a routine to utilize that contact.

The topic of quality is discussed late on meeting agendas, as part of a combined topic considering quality, environment and work environment issue , whilst other aspects like safety, budget, schedules and contextual aspects around the project are discussed much earlier. No further clarification or examples of what needs or should be discussed during that dot is provided. Some say that this would be a great opportunity to discuss previous experiences, lessons learned and upcoming risks to get better quality in future projects. Further examples are found while considering the purchasing of building materials, where monetary costs and the ecological sustainability of the material is perceived to be given higher priority than quality, according to a site manager. One even wonders if anyone has examined the alternative material from a long-term perspective, believing that it would be better both economically and ecologically to invest in more qualitative materials in many cases.

There seems to be an underlying wish for more structure and continuity (11) in the quality work and communication, on both project and central levels, among all the interviewees. Frustration regarding repeatedly appearing defects are expressed, and the site manager and supervisors as well as construction worker representatives explain that there are no structures in place to ensure that defects and their causes are reflected upon. It is said that smaller defects are routinely documented at the time of their discovery, the person or team responsible for the damage or mistake are identified and told to fix or repair the problem, and the case is then closed once the repair is done and the economic responsibilities are cleared. The knowledge of the experience remains informal with the involved individuals and precautions are seldom made to avoid similar situations from happening again. A site manager, project manager and the Quality manager expressed that we should discuss quality and reflect upon previous defects more, preferably continuously, to work more proactively and learn from all mistakes.

Initiatives within the region like the rather new quality specific start-up meetings in the beginning of the design and production stages, the cross-project role specific forums for experience exchange among specific roles, and informational newsletter on the topic are all expressed to be appreciated. Site managers expressed that various forums and mediums are needed in order to reach out to all employees. Communication and information is very important (6,11), but also a great challenge. When and how the information is given is crucial, as information on certain defects and risks or their recurrence should be brought up when the relevant job is close in time. Talking about kitchen installations during the production start meeting would do no or little good (11). A continuous and close contact throughout the project was stated to be a strong factor for the quality of the project, as it allows more immediate actions when problems appear. There is a vision and effort to create a team spirit from the beginning to the end of the project as well as an understanding of the whole picture where even the smallest screw contributes to the satisfaction of the end user. As many people enter and leave the project, the team spirit is very important.

4.4.9 Motivation, culture and quality performance

The project team composition with their interests and attitudes was found as a key factor to a successful project, as many of the interviewees highlighted this issue (5,7,8). It was said that the complex nature of construction projects require a flexible leadership that provides structure and coherence whilst still being open minded

towards employee suggestions and quick changes (8). In the design phase, one interviewee explained that a more agile leadership is required to utilize the vast knowledge in the digital systems at the company, which is really the main issue according to one of the project managers. There is a lot of information and help to find, but the manager must be willing and interested to put down the effort for it. Out in the production, site managers and supervisors explain that both agile and flow-based leadership aspects are required to communicate, coordinate and ensure good quality. It is expressed again and again how the quality performance really depends on the individuals involved, their attitudes and interests, and how well put together the teams are. One site manager explained that good quality is achieved when everyone does a little bit extra and keeps the next person in mind.

It is important to have a solid team who complement each other's strengths well (9). From the interviews (3,4,5,7,8,10,11, 13) it is clear that the individual plays a big role in the construction industry and in the quality work of the project. The composition of knowledge, experience, skill and interests was explained as a major factor of success in projects. Many interviewees point out the difference in working with engaged individuals, trying their best and maintaining a strong pride in their work, versus unmotivated individuals, who lack the care and ambition to make a good day's work. One interviewee explained that it is very different working with an engaged colleague versus an unmotivated one, both on a social level but also for the project. The mentality of "*someone else will do it*" creates situations where defects are not reported and errors are made, leading to higher costs and work for the production team (17). In addition, the leadership style of the project managers, site managers and site supervisors are very individual and priorities are set based on the manager's own interests. One site supervisor explained that he aims to involve the workers when solving problems, stimulating problem solving, whilst some supervisors point and explain what needs to be done, leaving little room for creativity. Many interviewees mentioned the importance of this involvement, that being part of solving the problem creates engagement for the task at hand, which is important on all levels.

When asked the importance of motivation, leadership and culture for improving quality, the majority of the interviewees explained that it was very important. "*Short answer, it plays a major role*" one site supervisor explained, adding that as a site supervisor you have to lead by example and promote participation and reporting issues when they appear. A site manager explained that he tries to clearly communicate that he wants to know about all defects and challenges that appear on site (9). He adds that he always tries to promote an open culture with clear communication and the importance of reporting both safety and defect/quality incidents or risks. This is done through positive feedback, to always be supportive and positive when someone comes forward with an issue or problem. The company promotes soft values and team spirit, the interviewee explains, as well as education with a heavy focus on values and healthy workplaces (9). It is difficult to include subcontractors, however, as they sometimes enter the project for a short period of time and leave once their work is completed. A site supervisor concluded:

"*If you suggest solutions but feel that you're not listened to in any way, then the motivation is fading rather quickly*"

Several interviewees expressed that the processes and routines in place to plan for, execute, control and ensure good quality throughout the project are rather non-explicitly designed or expressed, allowing individuals to interpret and implement them differently, and the effect and result of them therefore varies. A design manager describes how:

"It is stated in the management system what should be checked, reviewed and done, but that is not the solution for good quality. It is in the employees' engagement to actually understand what is to be delivered and know their stuff, and that we have the right people with us in every stage of the project. Quality work is not a set of checklists in a system, but how we approach the problems and how we solve the problems." (5)

Examples of varying motivations and approaches from both the design and production phases are mentioned, as well as from both managerial and employee point of views are described in the interviews. It is said that project managers should collect inspiration and learnings from previous projects and experiences in the early stages and invite actors of relevance, preferably production personnel as well as important subcontractor representatives, for design meetings. Where, how (or if) the information/experience are collected and which actors that are involved early tends to depend on the project manager's personal interests, experiences and own networks, and the quality performance of the project therefore depends on his or her motivation, commitment and previous experiences towards it.

A project manager (4) explains that, historically, there is a lot of pride in the carpenter profession, but in the last couple of years a new generation of less motivated individuals have emerged in the industry, one of the project managers explain (4). The project manager theorizes that more people choose to become a contractor as a last resort, and thereby are not very well motivated by the work, but rather the payment alone, leading to a minimum effort.

One interviewee explained that the case company's own employees are much easier to get to know and understand their strengths and weaknesses, making it easier to support or guide them when needed (13). This is much harder with subcontractors, as you most often do not get to know them and therefore do not know what to expect from their work. This creates a situation where the site manager or supervisors cannot guide them, but rather just check if they did a good job when they are done, which may be tough and affect the motivation negatively.

The quality ensured by the main controlling activity on site, made up of individual self-controls of their own work, is also dependent on the motivation of the involved and conducting employee or subcontractor. The interviewees explain that it is rather common to not perform the control in direct adjacent to the work completion, but that people tend to save the control and documentation activity for later due to stress, uncomfortable weather conditions or lack of motivation for example, which may lead to lacking controls and defects remaining undetected. Mistakes or slips are always going to happen, no matter the level of detailed instructions or thoroughly developed controlling system, and we need to ensure that a good supporting culture of motivation, trust, openness and kindness is in place so that we can help each other on site when it happens. Site rounds are conducted by the managers, but a site supervisor

explained that it can be difficult to find the defects unless you know what you are looking for, making it more important that everyone reports defects when they see them. Team spirit and openness is therefore at least as important as good structures within the project and company to reach good quality.

One interviewee (7) expressed that the team composition should take both individuals' knowledge and experience as well as their interests and strengths into account. A team should be well balanced, where knowledge, interests, strengths and experience of the individuals weigh up the lack of others, as well as personal skills complementing each other. The primary solution, according to the interviewees (4,7,8) is to let people gather experience through practice, allowing a greater responsibility, but with supportive guidance. A design manager (5) explains that, in general, the motivation of construction workers is perceived to be lower than among employees with higher education, like architects, designers and engineers. She theorizes that this might be tied to the fact that they rarely affect the design, which emphasizes the need to communicate and integrate different experiences. Listening to the construction workers and acknowledging their input could help with moth motivation and quality. The construction worker representatives gave a similar picture during the interviews, that it is troublesome and frustrating when their experience and suggestions are not sufficiently considered. Once again, we are back to the importance of a motivated, open-minded, supportive management that can lead with structure, supported by the company, and ensure a motivated project work force.

It is not an easy task of course, to find the right balance between strict, supportive structures and remain human, much needed flexibility. Some managers expressed that it is extra hard to maintain a good project culture if the project experiences many challenges and setbacks along the way. However, barriers between different professions need to be mitigated and make it easier to talk about the issues. It is important that everyone can speak their mind and add their knowledge. One of the interviewees repeatedly stated that he was happy and empowered by the fact that he was included in this study, that he was listened to and taken seriously. He explains that it is not very motivating or engaging for anyone if one’s feedback and knowledge is wasted when people would not listen.

The project culture plays a huge role in quality and the leader has to lead by example according to the interviewees (10). A culture of openness is needed, where defects and mistakes are not hidden nor considered a fault to blame the individual for, but where one rather stresses the importance of being honest about the appearances of defects so that they can be processed and corrected at the earliest possible time, before the final inspection and customer handover (2, 4, 7). Start-workshops are considered a great tool to get to know each other and doing activities promotes team spirit and communication between parties from the start. If you develop a strong, supportive and open culture early on it is then more easy to include stakeholders entering the project later. One interviewee (3) suggested that there should be meetings every month or so where everyone involved at the current stage, of various roles, could get together in the same room to discuss experienced difficulties and future risks or opportunities. Openness is very important, as well as trust, the trust in each other and a belief that everyone takes responsibility for their own expertise and work as well as their current shortcomings.

4.4.10 Support Systems and Tools are not used to their full Potential

The centrally provided support systems, i.e. the management system and the technical details platform, in place are generally considered a very good support throughout the daily work according to the interviewees. The knowledge stored is vast, their information covering the entirety of the company business scope, describing many aspects into small details. One interviewee (7) explained that the management system of the company feels very solid, including a large amount of materials that are useful, providing especially good support for new colleagues to learn the company's ways of working. However, all the interviewees agreed that the supportive systems and tools provided are good to have - but all of them also said that they themselves do not use them on a regular basis. One might wonder why?

All interviewees agreed that the very big amount of information, located on various places or online platforms, makes it hard to navigate and it takes time to find the things you are searching for. Experienced employees seldom feel a need to check in the systems, as they have their own routines in place, only searching for information if they feel uncertain or are in need of a specific document - i.e. not on a daily basis. There is a general belief that the design phase employees are working more with the systems than production personnel. The technical details system is sometimes looked into by site managers or supervisors in order to prepare their work breakdown meetings, but the management system seems to be used primarily when certain documents are needed.

There are many checklists, suggested meeting agendas and guides in the system, but one interviewee explains that her team uses their own-made checklists or flow charts for their day-to-day activities. This since it is considered hard to get an overview of the comprehensive content, and to ensure that everything is made in a "correct" or sufficient order. The process orders seem to be hard to find in general, and the complex layout, the vast amount of content, many of which is irrelevant for individual employees, and lacking search and sorting functions, affecting the user friendliness negatively, are repeatedly mentioned subjects. A site supervisor described that:

"*Maybe you're supposed to visit the online systems and follow the processes down to the smallest details, but you generally don't. We are generally good at handling documentation and templates, but if everything is supposed to be filled out correctly and be used, you have to hire a few extra people to do the job. It is simply too much to handle.*"

Again and again it was said that there should be a balance in the work on site, as too much "forced" or standardized ways of work or required documentation can be overwhelming and slow down the actual value adding work. An interviewee (7) explains that the management system should not be bigger, it is big enough - or even too big really. The company is apparently very good at adding to the management system, but not as skilled at removing unnecessary or outdated information. The management system is said to "*feel a bit like the old testament*", as one site manager explained, adding that he would prefer an interface with more interactive functions. The vital parameters of the system should get more focus, where the holistic views are comprehensive; where process and event sequences are visible and project deadlines or milestones with respectively required deliverables are made clear. It was suggested

that this project process sequence could make out the foundation of a new, better structure and layout of the management system - this since the holistic view should be sufficiently integrated, not separately added to the system. One interviewee (12) explained that the employees need organizational support to do a good job, adding that:

"It is not enough to have a good system if nobody knows about or uses it"

As of now, there is a lot of good content in the systems that might not be utilized to their full potential, according to the interviewees, partly because of lacking overviews, but also because of lacking central communication toward the projects regarding their contents' existence, purpose, ways of use and importance. One part of the technical details system includes a database of preferred building techniques, aimed to be used by both design and production employees to ease their work and ensure good quality. A technical expert (12) explained how they develop these standardized design details and production methods in order to make it easier to build correctly and without defects. This effort is loop-structured, where a design is made, communicated to the organization and feedback from the organization is used to improve the design. If a specific design detail is reported to attract many defects, it is reviewed and a suggested cause of action is delivered to the national quality manager. However, none of the interviewees have shared any feedback regarding the technical details available apart from the few involved in a specific quality focused group. Each building component type also has an assigned technical specialist who could be contacted if there are any questions regarding a detail or if help is needed to customize something for their specific needs.

They are seldom contacted through, for some reason. A site manager described that it is more common to contact the architect or design engineer instead. It is also mentioned that the standardized design details are seldom utilized if the design team is externally hired. The technical specialist describes communication between the company, the support functions and the projects as a problem, and she wonders how to communicate to the project organizations of the system content, how to use them, who to contact and when, and how to leave feedback on the designed details. This seems to be a general opinion regarding all the centrally provided contents according to the interviewees. Standardization, according to one site manager (13) has both benefits and drawbacks. On the other hand, it can help support decisions and ensure that the work is conducted correctly, but it can also restrict creativity and the ability to find qualitative solutions to problems.

Several of the interviewees appeared questionable towards a database of standardized details, often referring to the fact that Sweden is a rather long country with various weather conditions and traditional ways of building. They say that a lot of time and money are spent on developing details that are supposed to be used throughout the company, which is considered an ideal way to effectivize the work that does not work in practice. Also, several interviewees express that even though the collection of details is rather big, and ever growing, there is seldom a standardized detail or method developed that suits their unique and current needs. The technical expert adds that if a project design deviates from the standardized designs, it is very important that the design team takes on a greater responsibility for the quality of the end product,

adding:

"We can solve the problem for you, but if you choose to design something else, the responsibility must lie on you within your project"

The increased use of digital tools are believed to be a powerful tool to improve the quality of process, project and company levels. Several interviewees believed that a further implementation of Bim 360 Field could have a lot of potential, making the documentation activities very easy and efficient, enabling a way to store data on incidents and defects, and also presenting a great way to coordinate and direct communication to various actors involved, also at suitable times. The 3D model makes the program easy to use and understand for everyone. At present, it is mostly utilized to coordinate and collect various errands on site, storing information connected to specific site locations on the digital drawings, and the errands are closed as the issue is solved. This is considered easy by both construction workers and managers, especially for the younger generation, and very practical by the site managers and supervisors. There seem to be more potential in these kinds of digital tools to utilize though.

One interviewee described how it feels odd that there are no real statistics available, or at least not communicated to them, regarding quality defects or incidents. It is said that this mirrors the very typical "construction ways" of dealing with problems, considering the one problem at their hands at the moment, solving the issue to move on to the next one directly thereafter, without further reflections apart from the individually stored experience. It is also said however, that there is no time for that kind of reflection either. The documentation of an issue, i.e. to create an errand in Bim 360 Field, is easy to do but there is no one available who has time to analyze or sort the data collected to gain any decent statistics out of it. What if the management-system was implemented in a visual way too, maybe with instructions on a storyboard level, working it down to a detailed level in a pedagogical way, as one interviewee suggested?

4.4.11 Quality Work is Conducted on a Project Level

Several interviewees explained that the site manager is the one with utter responsibility to ensure the project quality, delegating most of the work to the supervisors, unless the project is particularly large or complex so that a local quality manager is assigned to support the site managers in their work. The quality reached will therefore depend on the interests and experiences of this particular individual or team in charge on site. The results reached depend on the interests and engagement of the other workers, consultants or subcontractors involved as well, of course, the attitudes of which could be influenced by the site leadership. The fact that the project quality performance currently depends so much on the interests, attitudes and experience of the individuals involved leads to varying project results according to the interviewees. It should be in the interest of the company to at least ensure a sufficient minimum level through centralized support and control.

Yet, the interviewees describe that the projects are managed very differently depending on the interests and drives of the leaders responsible without much say from the company, apart from the management system provided which seem to allow

a lot of variance which sometimes leads to less positive quality results, more struggles along the way or more defects appearing. One site manager explained that historically, there used to be an experienced contractor in charge with great knowledge of the whole building spectrum that oversaw the entire project process. This holistic knowledge and experience is very rare among the leaders, as well as on site in general today. Trends of rather young or inexperienced management teams and a more divided construction process, where expert roles are hired to conduct certain processes or deliver specific building components, seem to make things even more complicated. There are few leaders today who possess this versatile knowledge that also has the time and other resources available to prioritize quality.

Until some time during the 90's, the Swedish construction industry legislative PBL (in Swedish: Plan- och Bygglagen) required all companies to allow third-party inspectors on site to ensure the project and construction quality. This requirement was removed as the construction worker and subcontractor self-checks were considered to be enough, something that the interviewees were questionable towards. They all agreed that the quality ensured by these self-checks are highly reliant on the motivation and knowledge of the responsible individual filling in their checklist. The regional quality manager explained that the site managers responsible are able to hire external consultants to support with extra quality controls or to seek advice from the internal technical specialists or aftermarket team as well. This is not done to any extent however, for some reason? Should it not be in the interest of the company to ensure that all projects are given the support they need?

Currently, there is a regional aftermarket team responsible for all errands arising after the final handover, when the projects are finished for the clients during the guarantee period. They were previously organized as a support functions department, but since an organizational shift around two years ago they are now considered an integrated part of the operational unit of the region. Many interviewees expressed that this change was very appreciated, making the aftermarket easier to contact as they feel closer to the project operation. The team is led by the regional quality manager, who is thus responsible for both the aftermarket group as well as the overall quality work in the region.

The regional quality manager himself expressed that there are lots to do and that it is hard to cover it all on his own. He said that it is impossible to keep an overall track of all the projects of the region, to know their current states and what obstacles they are to face within a nearby future. There is no one responsible in the region at the moment who has an overall view of all projects with the ability to collect information of disturbances and proactively inform each project as they approach critical stages based on previous experiences or data. It is up to each project and their respective employees to call for support as they need it, which of course presupposes that the persons involved actually are aware of their lacking knowledge or difficulties of an approaching event and are in need of help or advice.

The projects seem to need help and support from a central organizational level, where someone, or a team of staff, have the overall view of all the regional projects with the ability to collect, process and deliver experience and knowledge from and to various projects at suitable times. A team or individual that can ensure that good examples of solutions, both incremental and extensive ones, and information of common defects or

obstacles and their causes, and how to avoid them, collected from all project stages and not just the aftermarket's guarantee period, all reach the different projects. Both structure and support is needed if we are to avoid the reappearing defects, and one interviewee concluded that:

"It is much more fun to work proactively with quality than to be forced to react once things arise"

There are no collected statistics regarding the quality defects that appear or mistakes made on sites or in projects overall in the projects, and what they are caused by, at least not any that the interviewees knew of. The regional aftermarket team has a list of the most frequent and costly defects that they currently work with, like water damages caused by leaks in roofs or exterior walls or incorrectly mounted windows or glass doors to mention a few, which they have been specifically focused on lately. Still, their respective or total costs are hard to keep track of due to lacking statistical information, and, as several interviewees point out, there are many other, often smaller, types of defects that reoccurs on site on a daily or regular basis that are not documented and dealt with, apart from a corrective activity and a decision of economic responsibilities. "*It feels like we are reinventing the wheel over and over again*" as one interviewee said, describing how it sometimes feels frustrating when a similar problem reoccurs for the third time at the same project but how he also never had or took the time to actually prevent it from happening again.

One would think, and several interviewees agreed, that the company could take a lot of learnings and practical ideas from their previous organizational works regarding health and safety into their quality aspects as well. The company has put down a lot of strategic work and managed to build a great focus on health and safety throughout the organization, on both central and project levels - and rightly so! Nobody should get injured or risk their health at work. The company has been working hard strategically and formed a regional Health and Safety division, working closely with the district managers, having staff assigned for a set of specific projects each, being available for questions or advice from all employees, whilst still remaining the general overview over the regional health and safety work, statistics and progress. This has increased the routine control and daily reporting activities of incidents and risks on site, where the documentation is handled centrally on regional level where all experience is collected, so that sufficient corrective actions and preventive measures could be initiated throughout the regional span.

It would be interesting to see statistics over common mistakes, slips and defects along with their respective causes and total costs of materials, time spent and workload. A regionally centralized team could contribute with this, which would give the company a more clear picture of the reality and the practical problems they have to solve. It is common and simple practice for the employees to document quality incidents or defects, especially with digital tools at their hands, like Bim 360 Field, but they do not have enough time or resources to process the data collected within the projects. They currently use their documentation momentarily as a means to coordinate the employees involved and ensure that the fault or defect is corrected. The errand is closed thereafter, and the potential knowledge gained from the experience is not formally stored or spread to others, especially not outside the project borders, but only

stored and spread informally within the individual or team involved and easily forgotten.

The central forums (i.e. the regional and district gatherings and cross-project role specific meetings, each held around four times each year (during non-pandemic years or while other particular circumstances are not intervening)) aimed for experience exchanging are generally positively considered by the interviewees, but they do not seem to be enough. Quality and recurring defects are not the only topics to discuss at those meetings of course, according to the interviewees, and only the most critical things are therefore brought up. The same thing goes for the quality focused project startup meetings, held at the beginning of the project with the actors involved at the time, and the startup meetings of each project phase, where quality aspects may be discussed, but there is no time to discuss "smaller" issues and possible incremental changes at those meetings. Several interviewees ask for continuous follow-ups, to ensure that the things discussed at earlier meetings are dealt with properly and not forgotten, and to have time to discuss the smaller, often more easily dealt with, issues as well. It was also found that the project end meetings, that are required by the company according to the management system, are lacking - if they are even held. It was said that they are hard to coordinate, as the actors involved most often have split up and moved on to other projects, making the logistics tough, and that the topics discussed, conclusions drawn and learnings learned never goes beyond the meeting participants. The organization does not seem to stress the importance of these meetings, and there is no formal place assigned to store the information collected in for other interested employees to find either. Experiences should be collected and stored centrally, to get a more holistic view of the problem, so that the knowledge and information can be distributed and utilized in other projects of the organization as well.

4.5 Workshop Findings

The feedback received by the workshop participants were overwhelmingly positive regarding the presentation of all the study's empirical findings. All participating previous interviewees of each workshop agreed on the problems highlighted in the study and confirmed the challenges ahead were interpreted and presented correctly.

Based on the theoretical framework and analyses of the data collected, some suggested improvements were presented and discussed, resulting in a series of thoroughly kneaded solutions, both small and large, for the case region in which the divergent opinions of the various participants were all taken into account. They do not solve all the issues and challenges found, but could serve as a good start for further development later on. Many of them relate to already existing activities, trying to improve them, in order to avoid adding on new procedures and meeting into the already crammed schedules of the employees.

4.5.1 Collect and Manage Data on Defects

Currently, the only management of data regarding errors and quality defects within the case company is made by the aftermarket team. This leads to several problems. First, a lot of experiences from the projects goes lost as they never reach the aftermarket team. Second, as we "do not know" about all the occurring defects, or at least do not

document and store the data of them formally and therefore risk them to fall out of memory or to not reach the other employees, makes it impossible to keep track of what defects that occur and what costs they are associated with. This should be considered an important starting-point for the case company, to collect and manage this data. From the workshops, it was made clear that the digital tool of BIM360 Field is proficient to use to collect this data, but a set of guidelines on how to document the defects in the system needs to be established to ease the following process of sorting and distributing the data, which also need to be done.

This data on defects could then be listed in the form of "top 10 common defects to avoid ", one for each work step, to make the critical information of what to avoid easily accessible for the employees involved. It was suggested that these lists should be reviewed and discussed during the work preparations, where the site supervisor or project manager can use the information to anticipate and respond to the previous defects and try to avoid them.
The conditions needed for this to become a common routine is that:

1. *BIM360 is utilized in every project,*
2. *that a standard of reporting defects in BIM360 is made,*
3. *An individual or group is appointed to manage the incoming data and format it to be accessible to the organisation and other projects*

4.5.2 Decide and Integrate a Regional Quality Goal and Vision

To have a clear goal to communicate and work towards is important in order to direct the team's efforts in the same direction. As of now, this is seldom discussed in relation to quality within the projects. This suggested improvement of a clear quality goal is aimed to provoke curiosity and engagement among the project teams and all employees, by discussing the goal at regular and sufficient times and together deciding upon how to reach it. Preferably during work preparations for critical elements of the project, as well as during start meetings and monthly meetings, as well as during the regional culture workshop held in the beginning of each project. The project culture, values and team spirit is discussed during these workshops and common guidelines are created by the participants. This is very well appreciated by the participants, as they collectively contribute and establish the framework of the project culture. In this workshop both the *Regional Quality Goal* and *Regional Quality Vision* should be included and discussed. This can stimulate discussion and suggestions for how to reach the goal and uphold the vision.

The goal and vision could complement the previously proposed new routine of collecting and utilizing data on defects, and thereby addressing the quality issues on two fronts: both with routines and with the culture around defects. A suggested goal for the region could be as following:

"Before every Project Work Step, all individuals involved should know about, and prepare to face, the common risks and frequently observed defects associated with that step"

The Regional Quality Vision suggested is aimed to promote an improved learning and to spark discussions on how procedures could be changed for the better, constantly

trying to learn from mistakes and communicating the experiences of them to the organization. The suggested vision for the region is as following:

"Whenever mistakes are made, we are honest and open to report and correct them, always learning and teaching others how to prevent them in the future"

4.5.3 Expanding the Start Meeting Quality

The quality specific start meetings are currently aimed to deliver the experiences of the aftermarket team back to the early stages of design and production phases. The meetings were found to be very appreciated by the interviewees, but it could be improved. It was suggested during the workshops that critical work tasks of the project should be identified and discussed during the meeting from a quality perspective. Common defects and errors associated with each work task should be discussed, as well as reviewing the experience and knowledge of the person in charge of each work task. What kind of help would they need for each step? In response to the identification of critical work tasks, common defects and the level of experiences of each responsible person, the meeting should decide on quality routines for the project. Then, it could be decided when extra help or support is needed, when the aftermarket team or consultants should be contacted, so that one ensures to achieve the needed knowledge at the right time to effectivize the knowledge shared. Furthermore, this is a situation where the previously suggested new Regional Quality Goal and Vision could be discussed to promote discussions about the quality routines. Lastly, since it has been made clear that the final Evaluation Meeting of the projects is lacking, both in terms of topics discussed in relation to defects and quality, as well as being hard to find time for and therefore seldom are conducted at all, it is suggested that the date of the evaluation meeting is booked during the first Start Meeting Quality held in the project.
The following steps are suggested to be added to the agenda of Start Meeting Quality:

1. *Identify Critical Work Tasks*
2. *Discuss the Regional Quality Goal and Vision, and how it could be integrated into the project*
3. *Discuss common defects associated with the different tasks*
4. *Discuss the apparent experience and knowledge among the responsible personnel for the work tasks*
5. *Decide on sufficient Quality Routines for each critical work task*
6. *Set a date the Evaluation Meeting*

4.5.4 Expanding the Quality Discussion in Meetings

Returning to the issue that quality is rarely discussed in nuance or detail, either during regular meetings or at other times, as described in both the company QMS analysis and during the interviews. Quality is seldom discussed, at least not specifically during weekly meetings, and it was found insufficient to bunch up quality together with other factors under one combined bullet point at start meeting agendas. One needs to promote reflection in order to improve the quality of construction processes and results. It was therefore suggested to include more specific quality and common defects related bullet points on the template meeting agendas, similar to the ones below:

1. *Identify Critical Work Tasks in the nearby future*
2. *What are the risks and defects associated with the current work task and how do we prepare for them?*
3. *Do we have enough knowledge and experience among the involved personnel to conduct the task correctly?*
4. *Do we need to contact the aftermarket team or consultants?*
5. *What have we learned since the last meeting?*
6. *How do we collect, spread and make use of that eventual new knowledge?*

4.5.5 Applicable Quality Routines

As meetings are suggested to be made more structured, from the quality perspective, and to increase the communication regarding quality and defects, this suggestion deals with the further *Quality Routines* that could be decided upon for critical work tasks during the start meetings.

As a first suggestion, mentioned by the regional quality manager during a workshop, is that a "*10%-check*" could be made during critical work tasks. The idea is that after a work preparation has been made and the work has started accordingly, the work is stopped as 10% is completed to inspect the reached results closely before resuming. This could ensure that the work preparations, the actual work and the various checks are done correctly, according to plan, and thereby avoid costly redoings and frustration among the workers. This could also promote learning when defects are found and dealt with collaboratively. It creates a situation where potential defects can be found and shared within the projects and not carrying out the whole task incorrectly.

A second suggestion would be to offer so-called "*Quality Rounds*", where the aftermarket team visits the construction site and joins the production team on a daily round. This is an opportunity for knowledge transfer, learning and highlighting the importance of quality. This was also suggested by the regional quality manager himself, to be scheduled for critical milestones, and could work as a follow-up session of what was decided or discussed during the Start Meeting Quality.

Project Site Visits, either to or from other regional projects, before or after critical work tasks could also be scheduled during the Start Meeting Quality. Once again depending on the needs of the project and connected to the common defects within the company, to avoid reappearance. In the workshops, It was made clear in the workshops that site visits and personal meetings between different teams are very important as it creates opportunities for knowledge transfer. This is important between projects, between teams as well as between departments. Site visits could therefore be more frequent and be scheduled during the Start Meeting Quality to match the site visits with challenging work steps.

Additional meetings to exchange experiences midway through production or design, or at the later stages before final checks could also be arranged, so that important knowledge and experience gained throughout the project does not get lost. The meeting should be on site, if in production, and open to all workers involved where challenges and experiences can be discussed openly. For this meeting, both the

aftermarket team and the designers can be invited to receive feedback and exchange ideas. While many interviewees explained that they preferred open forums of discussion, this specific suggestion was criticised for being too broad and not building on previous routines, being afraid that this only would become "yet another meeting without value". However, opportunities for open discussions of experiences are rare between the different stages, and the final Evaluation Meeting is, as we know, lacking in function and defects are hard to evaluate after such a long time.

The opportunity for all these "extra" quality routines does already exist, but is seldom utilized in the projects because of lacking routines, tight schedules or forgetfulness. It is believed that these opportunities must be explicitly presented to the projects, and to make a routine of considering the project's needs and challenges in terms of quality and to decide upon proficient measures beforehand. The more that is considered and solved at previous times the less the complexity during critical, stressful moments.

4.5.6 Improve and Implement Work Preparations Throughout the Projects

Work preparations are commonly conducted prior to critical work tasks during the production phase. However, as discussed in the interviews and the workshops, it seems as if every work preparation meeting is prepared for as if it was the very first time the task were to be made, or else at best based on the responsible's own experiences, risking to miss important knowledge that has been gained within the organization. It was therefore suggested during the workshops that the work preparations should be standardized to a greater extent. The intention is to raise the quality of the work preparations and avoid having to start from scratch each time.

First, one must try to ensure that all knowledge of relevance that exists within the organization is considered. Therefore it was suggested to provide a checklist to go through prior to the work preparation meeting preparations by the one responsible for them, including the following bullet points:

1. *Contact two colleagues who have done this procedure previously*
2. *Identify common defects associated with the procedure*
3. *Decide if external help/support is needed*
4. *Include and Discuss critical aspects of the procedure with the people who will carry out the procedure*

Informal channels are widely used among employees when help is needed where they rather talk to a close colleague than call the aftermarket team or consultants for support. This structure could clarify that one should contact other people in addition to searching for knowledge through other media, while also making it a requirement to identify common defects related to the task.

Standardized work preparations could be integrated into digital platforms like BIM360 Field, currently used for other purposes, allowing more user utility and accessibility. Another benefit would be the ease of integrating the self-checks, as they can more easily be defined and involved in the work via the work preparations. This has been tried at one of the projects, and the work is driven by a site manager who standardizes the work preparations for the project, making it easier for the site

supervisors to do their job. These work preparations should also be reviewed afterwards, to reflect upon the alignment of the intended and actual work made, which could be used to improve the standard. The regional quality group was suggested to be responsible for reviewing the work preparations standards and integrated self-checks.

One workshop participant suggested that production work preparations should preferably be made in the design stage, when a particular aspect of the plans is created. The argument was that if the site supervisor creates a work preparation in close contact with the designers, it could improve the collaboration between the various actors and effectivize the work task. The design choices could then become more easily implemented into the procedure.

Furthermore, it was also suggested during the workshops to adopt a similar structure for work preparations during the design phase, prior to the various design stages, to try to ensure that all relevant knowledge within the company is considered prior to critical tasks and milestones. To discuss upcoming risks and previous defects before the same mistakes are made again could improve the employee motivation, due to more collaboration and less frustration, and improve the overall quality by avoiding previous mistakes.

4.5.7 Hire One or Several Quality Representatives

It was found clear during the study that the general overview of all regional projects in terms of quality is lacking, and several interviewees believed that it would strengthen the quality work if a single person or group had an overview of all projects and the challenges and progress of each project. This task would currently fall on the regional quality manager, but as he himself explained, he is unable to keep an overview of every project in the region due to the extensive task and his already crammed schedule. Currently, the regional quality manager is available for employee support at any time upon request, in theory, but is also occupied with two missions: leading the quality work of the region as well as leading the aftermarket team. He simply cannot do this by himself, and his team has a lot to do with their warranty errands as it is.

An additional Quality Representative, or Team, within the region could maintain an overview of all projects, conduct more regular site visits and support the project managers more directly in quality issues. This person or team could create a more personal interaction in quality related issues and act as a bridge between projects as well as in between the designers and production team. This function/role could also be responsible to collect, structure, store and distribute data and knowledge of common defects as well as solutions and feedback to individuals, teams and projects within the region, to not put this great task upon the shoulders of the already strained project managers. Similar structures and roles are already in place in the region within the area of health and security, where very positive results have been seen. It seemed as if a strategic move was needed in order to support the making of sufficient routines on the operational level in that case. Of course, this would imply a rather significant financial move in order to hire new employees for the task, but it would probably be a good way to go. The overall view from the outside is important, because people do not always know when they are in need of help or support, and they do not seek either, so a function that catches the projects before they enter critical stages is needed.

4.5.8 Improve the Design Audits

Some defects appear already during the design phase and remain undetected throughout the project. It was discussed during the workshops how one tends to cut the times scheduled for audits when scheduled are straining and that production related knowledge sometimes is lacking during the design phase. Therefore, it is suggested that a two week requirement is decided, which should not be allowed to be cut. The workshop participants agreed, even though someone would rather see an hourly time target for the audits since she believed that people tend to be less efficient when they have more time to do their task.

Production representatives should also always be invited to the audits of early designs of the project. It was highlighted in one of the workshops that the production personnel should be included in the earliest stages of the audits rather than in the later ones, when they still are able to affect and improve the plans, as their experiences otherwise would arrive too late. It was therefore suggested to include the production team in the audits of early system framework documents.

However, it was also made clear during the study that it is hard to coordinate this early involvement of production personnel since they are active elsewhere at the time. One suggestion is therefore to appoint a Production Representative, that could work as a support with production experience for the design employees. Preferably, this individual should be recruited from within the organization and have relevant experiences from quality work as well as the different stages of a project life cycle. A good candidate would be a site supervisor or site manager, who could see this as a further step within their career. It is important however that their production experience is “fresh”, so that they understand the current challenges within production today. It was then discussed that this could be a short-term mission, held by individuals for a few months whilst in between projects before handing over the responsibility to another person, creating rotation of responsibilities, which could help with both knowledge transfer and learning. This suggestion was questioned during the workshops however, considered a big financial move, and some of the interviewees had a hard time seeing the point of the mission. At the same time, it was discussed that the regional quality manager might not be enough to catalyze the quality work within the region, and more support could be needed.

4.5.9 Ensure Site Manager involvement in early Design stages

Connected to the previous suggestion, this also aims to involve the production personnel with their experience in the design phase, where they could affect and improve the project's buildability and quality based on their practical experience. This is a huge challenge that was discussed during the workshop due to the coordinative difficulties. The intended Site Manager is often unavailable in the early, crucial stages of the design phase, as the person is often in the late stages of their previous project, and therefore have a hard time to participate in the designing of the next project. Preferably the intended Site Manager should participate, as their decisions are crucial for the workflow of the design and production of the project. As the site manager has a lot of influence over the production, their individual preferences must be accessible to the design team, so that collaboration can improve later on. If another person fills

the role in the design phase, their choices can contradict the wishes of the site manager, creating delays and difficulties. It is therefore suggested, even though it is tough to coordinate, that this early involvement is required in all projects by the company. Since it is not required at the moment, people tend to skip this opportunity due to its difficulties. If it were required, then the design manager might feel more okay to spend or schedule the extra time and efforts needed for it.

5 Discussion

Poor Quality has been an issue in the construction industry for a long time with recurring defects being the obvious symptom. Yet, our results show that Quality is sparsely discussed unless the outcomes are significantly positive or negative (while the negative ones are quickly forgotten as soon as corrective measures have been made). It seems as if Quality has been less prioritized, on strategic as well as operational levels, in comparison to other project performance aspects, such as budgets, time schedules, sustainability issues or working health and safety. The same tendencies seem to permeate the industry in general, as quality management systems are increasingly integrated with other focus areas whilst the topic is not communicated and stressed as much as the other ones, and thereby losing its strategic priority.

The literature suggests that construction work is subjected to a variety of inherent complexity, which is constantly used to explain the slow change and lack of learning. This complexity was also confirmed by the results of this study. However, this only strengthens the argument that strategic change is needed, that the lack of systematic error management, organized learning and communicated focus are fundamental issues within the company and industry at large, which seem to be causing the lacking quality and recurring defects. The complex coordination and managerial context of construction projects creates obvious challenges, yes, but this highlights the evident need for more structure and organized routines to face these issues.

The results show that a lot of effort is put into preventive measures, to achieve good quality through efficient planning and coordination throughout the company's project productions to avoid mistakes and defects. There is a heavy emphasis on planning and controlling quality work, but there is a lack of activities aimed for evaluation and reflection. The company Management System is certified by ISO9001, and should therefore contain all required aspects of a good QMS, including the fundamental principles of continuous improvements through the underlying PDSA-cycles (Gremyr, Bergqvist & Elg, 2020). However, it is one thing to have principles sorted out in theory and provided to all employees, but they will not make much difference unless the principles are sufficiently translated into practice. The problem seems to be two-fold, because as the management system itself is lacking, the employees also seem resistant to utilizing it.

The general view according to the results was that the content of the management system and technical support systems provided by the company is solid and vast, but that the interviewees themselves seldom use them actively. The great amount of information was said to make the systems difficult to navigate and that it would take too much time and effort to ensure that all everyday work was conducted accordingly. It feels as if the intention of a management system goes lost if it is not utilized efficiently? The company should therefore review the system and its content, to streamline the system and improve the accessibility of information.

The results of this study show that the case company employees want more organizational structure and consistency, but not too much, expressing that the systems are too extensive as they are already, not wanting to risk losing the independent nature of their work. Both the literature and the study results indicate that

there is a paradoxical clash of ideas here, which also contributes to the challenge of implementing quality management practices: On one side; the strive for independence as proud construction craftsmen, and on the other side; the recognized the need for consistency, support and organizational order in line with military engineering traditions (Bröchner, Josephson & Kadefors, 2002). The military engineering style of organizational order and proud craftsmen identities are hard to balance, where the self-reinforcing idea of freedom as independence, connected to the common construction identity, as described by Löwstedt and Räisinen (2014) may lead to resistance towards change that is interpreted as further restrictions. If new routines are to be used continuously to ensure consistent project procedures and performance, the company needs to emphasize the importance of these routines, making the use of them part of the employees' daily routines, with the aim to ease their workload by reviewing the systems' user-friendliness and content. The challenge of implementing quality management practices is therefore to address both issues, to proactively develop both the formal and practical or cultural aspects of the quality work.

Few quality related activities were identified during the QMS analysis that aimed for *studies* or reflection and the following *action* based on the previous reflections, correlating to the last two stages of the PDSA-cycle. The lack of reflections and the following changes or improvements of processes, leading to improved results, was confirmed by the interview results as well, justifying the lack of relating activities utilized in the daily work. The literature found this as a common issue within the construction industry, that quality defects are seldom reflected upon once the economic responsibility is decided and the corrective action has been made (Koch & Schultz, 2019; Love & Josephson, 2004). The only information that tends to leave the projects formally, to contribute towards organizational learning, are regarding the most severe or costly quality issues that have been found, too late, by the end customer. Lots of knowledge goes lost without proper structures for storage and organizational distribution. How are we to improve our preventive work if previous experiences and knowledge gained are not collected and processed sufficiently? And why are only the most critical quality issues considered and dealt with? As the literature explains, smaller incremental changes may be easier to implement throughout the organization, which may lead to considerable improvement due to scaling (Johnsson, 2016; Bergman & Klefsjö, 2020). This is what most of the suggestions developed during the workshops aim to improve, building on routines and processes already familiar to the organization.

As found in the interview results, construction workers are commonly portrayed as fantastic problem solvers, which notably corresponds to the social identifications mentioned in literature (Löwstedt & Räisinen, 2014). But, one should not have to start from a clean sheet with each challenge which seems to be the general case in the company, since similar situations often have occurred and been dealt with before - if not by the individuals or team involved, so by someone else within the organization. The case company needs to find systematic ways to collect, process, store and deliver the project experiences throughout the organization, to ensure continuous improvement of both processes and results, to improve the preventive quality work. Some solutions have been suggested in this study to address the immediate issues of poor learning and knowledge transfer, promoting continuous reflections, while other goals should be developed long term beyond the scope of this study.

Continuous improvements are essential in any Quality management theory due to the ever changing standards, needs and expectations of customers (Gremyr, Bergqvist & Elg, 2020; Bergman & Klefsjö, 2020). The programmes of Lean production, Six Sigma and TQM, while implemented in full, have all brought proficient Quality results in other industries by providing consistency through routines, clear organizational structures and common understandings and goals throughout the organizations. According to the literature, it has been difficult to translate and implement the programmes to their entirety within the project based construction industry, which might be why it is more common to adapt singular or few activities from various programmes and construct one's own QMS (Johnsson, 2016; Sullivan, 2011). However, it seems as if this has led to sprawling QMSs where goals, responsibilities and deliveries are rather unclear. The construction quality performance is thereby placed upon the shoulders of project level managing individuals, making the results reached dependent on their personal interests and experiences.

At the moment, the structured ways to collect, store and spread knowledge of previous project experiences in the company seem to be lacking. The project end-meetings are seldom conducted and the produced experiences are not distributed beyond the meeting participants. There are no statistics of common defects, apart from the aftermarket team's list of the common defects they encounter, and there is no central department with a general overview of the project quality status. In addition, quality and defects are seldom discussed during regular production meetings, and the entire concept seems to be clearly less prioritized, on both strategic and operational levels, in comparison to other topics. Solutions to some of these problems have been suggested in this study, but further changes in both formal practices as well as project and company quality cultures are needed. Quality and defects should be more frequently addressed and prioritized to truly result in proactive quality management.

The regional organization for working health and safety within the case company has been developed over the past decade, now having a general manager and some focused employees responsible for a few projects each. The general manager possesses the regional overview of the health and safety status and current issues, collecting data of risks and incidents from the projects to have them directed to national or top levels if needed or other relevant projects within the region via their representatives, to decrease the risks of their recurrence. They keep statistics, tracking the progress of various areas, and are easily accessible to answer questions or discuss their subjects to help and support all the company employees. The study results show that a similar organizational structure for Quality work would be preferred, with the aim to centralize the Quality Management, tasked to collect, store and deliver knowledge from and to the projects at sufficient times. The project managers possess strained roles, having to ensure that the budget, time schedules and quality are all coordinated and dealt with sufficiently. This whilst also having to decide upon *how* to organize all procedures and ensure continuous improvements on their own, since the routines provided are lacking, and the constant restraining budgets and schedules forces the managers to deprioritize quality in many ways.

The study results imply that Quality routines to ensure recurring active discussions regarding common defects should be provided by the company to ease the workload of the project managers and ensure consistent results throughout the organization. The

meeting agendas should be reviewed, to ensure continuous discussions, plannings and feedback on previous efforts made in regards to quality. Lacking communication between various roles leads to lacking understanding of others' work and needs. Furthermore, few abilities to contribute to new solutions and little to no feedback regarding previous work performances, all affect the employee motivation negatively. Motivation is a fundamental aspect of individual and team performance, because without the will to make an effort it will not matter how much information, knowledge or experience one is given or possess (Josephson, Hammarlund, 1999).

That the work motivation of the individuals involved in the projects affect the Quality performance was mentioned by the interviewees as well. Team building and team compositions are vital aspects, where the managers should facilitate the team with sufficient systematics to ensure an active and conscious group development (Ackerman, 2015). Continuous and regular occasions for reflection and discussions are fundamental in order to maintain sufficient and productive work groups. Enhanced work motivation may, from a Quality perspective, result in higher general attentiveness and wider, more holistic construction knowledge, which may lead to earlier detections of mistakes and defects in the projects.

The study results show that structure and systematic improvements are needed to enhance the organizational knowledge base and transfer, to decrease the recurring defects within the case company and industry in general. It seems as if Quality needs to be more prioritized on central levels in order to shape structures and develop routines to support the project and production managers in their work. An increased focus and efficient structures that encourage learning and collaboration may also affect the employees' motivation positively, but further efforts might be needed to enhance our project teams and improve the overall performance. Structures may ease the operative work, by providing efficient information flows and the ability to strengthen and utilize both individual and organizational knowledge, but the importance of employee motivation should not be underestimated. One must be *willing* and *committed* in order to identify defects caused by either oneself or others as they occur, to enhance the overall construction Quality of the Case Company and in the industry in general.

6 Conclusion and Practical Recommendations

The aim of this study was to make a comprehensive, multi-level exploration of the Quality work in a case company, investigating both the formally provided routines as well as the actual quality work. This in order to outline the challenges leading to lacking quality and recurring defects within the company. Not prioritizing quality on a strategic level is a fundamental reason for this, which has led to gaps in the organizational structures and operative routines. Heavy responsibility of quality is placed on the shoulders of individual managers on project levels, and the quality reached comes to depend on the interests, experience and knowledge of the managing individuals, their prerequisites and their ability to cope with them, as well as the coordination of the collective knowledge and motivation of their teams. Having strained roles with many responsibilities and crammed schedules already, they do not have the time nor the resources needed in their projects to improve the organizational quality work, to create better routines, nor to strengthen the collective knowledge through learning and sharing of experiences. The company must ensure that systematic tools, structures and support is provided to the projects, for them to utilize, in order to ensure sufficient results and continuous improvements within the organization.

The quality management should preferably become more centralized, with one or several quality representatives: staff supporting the projects and responsible for the regional quality work. The current regional quality manager is split between the aftermarket team with all its associated warranty errands, and working with quality on a regional level, and therefore cannot keep track of the status of all the regional projects. A function with the general overview is needed, which also could commence the mission to collect, process, store and deliver data of quality and defect related experiences to and from the projects, which is a fundamental step for learning and preventing defects. As a reference, the case company's organization for health and safety were brought up by interviewees, as their larger staff and clearer structures provide good support for improvements within these topics. Having responsible individuals with an overview, who also visit the projects regularly, also helps to create a personal connection with employees, making it easier to ask quality-related questions and proactively inform the projects about routines and risks.

The study results imply that information about defects is hard to communicate, and one of the major issues is the difficulty to deliver and attain sufficient information at the right time. The small regional quality organization is unable to keep an overview of all projects and their status. In addition, the projects do not always know what defects to look out for, and so their lack of knowledge regarding common defects hinders them from asking for help or support. Lacking knowledge and information among the employees, combined with the trends of more narrow scopes of tasks for each specified role and project stage, seems to have led to poorer understanding of their project as a whole. Many employees have some gaps of understanding just how their actions and work affect the project results and the colleagues' work around them. These challenges make the individual and the project team motivation and engagement very important, as it can drive the will to learn and fill gaps of knowledge.

The general motivation comes to serve as a safetynet when routines and structures are lacking, and may lead to extraordinary results in the case where the prerequisites are better! An open, honest and including project culture with clear goals that encourages learning and knowledge transfer is vital for the success of quality work. The managerial practices should therefore be reviewed to ensure that these key roles are given the tools needed to provide the project teams with sufficient support and facilitate their group development.

The project managers should be provided with the routines and structures they may need from the company, and the current management and support systems are not enough in this case. The vast amount of knowledge and information collected in them does not matter if they are not utilized sufficiently in practice. The management and support systems should be reviewed, to increase their user accessibility and applicability, so that all the knowledge and experience that exists within the company can be collected and utilized sufficiently. Because, it was truly made clear during the study that there is a vast amount of knowledge and expertise within a large and well-established construction company such as this. One must find sufficient routines and structures, in combination with strong motivation and commitments, to be able to utilize it all in full, in order to continuously improve all processes and results. Only then can we overcome the majority of the recurring quality defects and challenges that we are now facing.

To conclude, as the research question was asked: *how does the formal Quality Management and the actual work affect the Construction Quality of a large construction company in Sweden, and how could it be improved*? It has been made clear that the formal and informal quality procedures are mutually dependent and need to be aligned within the organization. Routines for discovering, documenting and learning from defects are needed, as well as for communication of the known defects throughout the organization. Individual interests and engagement cannot drive the quality work alone. It has also been shown that individual engagement and motivation is required to follow the formally provided routines and structures. Some suggestions of how to improve the current quality work at the case company has been presented (see Chapter 4.5), addressing both the formal structures and routines, as well as efforts to improve the informal, softer and more human factors that are equally important, to promote learning and in turn achieve better quality within the case company.

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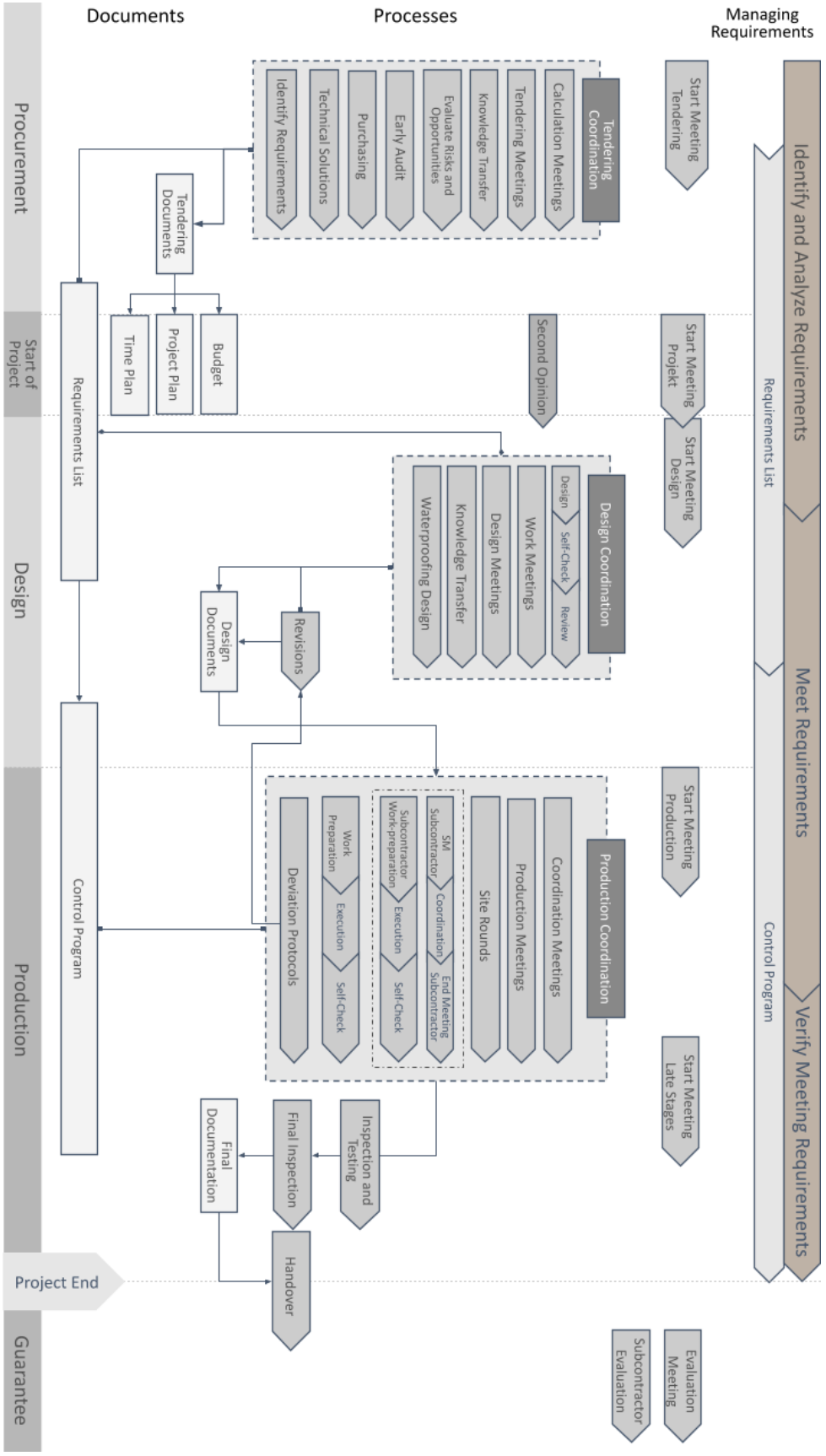
Appendix

Quality Management System Mapping



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