Quality Status and Quality Aspects in The Icelandic Construction Industry

by

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Thesis submitted to the School of Science and Engineering
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Abstract

A common discussion is that the construction industry lacks efficiency, quality is poor, budgets are unreliable and prices are excessive. Better management would result in increased efficiency with reduced quality failures while saving tremendous amount of money.

This research aims at identifying and documenting the current status of the construction quality in Iceland. This involves identifying the main problems and point out where the scope lies for improving and by what means it is possible to do so.

To begin with, a literature review was performed in order to analyze the status of quality in construction with regards to quality problems and quality aspects. After having analyzed the data, a questionnaire was designed and sent to construction professionals, both with engineering firms and contractors firms. Finally interviews were conducted with quality professionals in organizations whom staff had participated in the questionnaire.

The research strongly suggests that quality is a problem for the construction industry in Iceland. The research revealed that there is a scope for improving quality and it is possible. This conclusion is both supported with literature research and the research results. The research revealed that quality professionals saw clear improvements in organizational operations after having implemented a quality management system. Furthermore the general employee had a very positive view towards applying and using the system on his work. However the research suggests that there is a gap in the use and implementation of quality management systems and that knowledge needs to be improved. The training and teaching methods on using and implementing quality management systems is in general inadequate, especially amongst the contractors. 47% of participants with the engineering firms were satisfied with the amount of training received while only 30% of participants with the contractor firms were satisfied with the training received on implementing the system. The research revealed that the training and teaching methods amongst engineering firms is in more comprehensive manner than among the contractor firms.

Hopefully, the results will give a clearer picture of the quality status and where improvements are needed. The study supports the importance of improving management quality within the construction industry in order to attain more systematic efficiency in its operation. Public project owners play a key role in increasing implementation of quality managment among construciton parties.

Útdráttur

Sú umræða að byggingariðnaðinn skorti skilvirkni, gæðum sé ábótavant og kostnaðaráætlanir séu óáræðanlegar er ekki ný af nálinni. Betri stjórnun innan byggingariðnaðarins myndi leiða til betri nýtni, færri galla og gæðafrávika auk þess sem umtalsverðir fjármunir myndu sparast.

Þessi rannsókn miðar að því að greina og skrásetja stöðu gæðamála í byggingariðnaði á Íslandi. Helstu gæðavandamál eru greind og leiðir til úrbóta settar fram.

Í upphafi rannsóknarinnar var framkvæmd úttekt á fræðilegum heimildum. Borin voru kennsl á helstu vandamálin sem stafa að iðnaðinum gæðalega séð auk umfjöllunar um gæðaviðhorf og gæðamenningu ásamt því að fjalla um tæki til úrbóta. Í framhaldi af fræðilegu rannsóknarvinnunni var útbúin spurningarlisti. Spurningalistinn var sendur til starfsmanna verkfræðistofa og byggingaverktaka. Eftir úrvinnslu þeirra gagna voru tekin viðtöl við gæðastjóra fjögurra stærstu fyrirtækjana sem voru hluti af úrtaki spurningarlistans.

Niðurstöður rannsóknarinnar benda sterklega til þess að gæði séu ófullnægjandi innan byggingariðanarðins á Íslandi. Rannsóknin sýndi fram á möguleika og getu til gæðaaukningar innan iðnarins. Fyrrgreind atriði eru studd, bæði með fræðilegu umfjöllununni og niðurstöðum spurningarlista og viðtala. Greindar voru skýrar umbætur í stjórnun fyrirtækja eftir innleiðingu gæðakerfis. Starfsmenn fyrirtækjana voru þar að auki mjög jákvæðir í garð notkunnar gæðakerfisins í sinni vinnu. Þrátt fyrir þetta benda niðurstöður til þess að það sé glufa bæði í notkun og innleiðingu gæðakerfa og virðist skorta þekkingu á þessum efnum innan iðnaðarins. Rannsóknin leiddi í ljós að kennsla og þjálfun varðandi notkun gæðakerfa var ófullnægjandi, sér í lagi meðal verktakafyrirtækja. 47% starfsmanna verkfræðistofa voru ánægðir með þá kennslu sem þeir fengu á meðan aðeins 30% starfsmanna verktakafyrirtækja voru ánægðir með kennsluna. Rannsóknin leiddi í ljós að kennsla meðal verkfræðistofa varðandi notkun kerfisins var mun ítarlegri en kennsla meðal verktakafyrirtækja.

Niðurstöðurnar munu vonandi gefa skýrari mynd af stöðunni hérlendis og hvar úrbóta er þörf. Rannsóknin styður það hversu mikilvægt er að auka gæði stjórnunar innan byggingariðnaðarins til að ná fram markvissari reksri. Opinberir verkkaupar og kröfur þeirra spila lykilhlutverk varðandi aukna innleiðingu gæðastjórnunar innan byggingariðnaðarins.

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Secondly, I would like to thank the organizations that were willing to participate in the research, all the respondents who took the time and effort to answer the questionnaire and last but not least, the interviewees for granting me a part of their time.

Thirdly, I would like to thank my friends and family. Without their support, motivation and care, I would never have managed to finish this marathon, which this thesis has been.

Last but not least, I would like to thank Ásgeir Einarsson, for being there for me all the way along my writing journey.

Preface

This thesis is submitted in partial fulfillment of the requirements for a Master's Degree in Civil Engineering with specialization in Construction Management. The thesis is a result of a roughly five months research work at the Department of Civil Engineering at the Reykjavik University. The writing of the thesis has been a journey that has had both uphill and downhill scenarios. In the beginning I experienced some troubles in choosing the research topic. After having browsed roughly through what I had come across my way during my five years at the University, after sending emails to inventive parties, after having browsed through older research done and last but not least, after having gotten lost in my own brainstorm which had been pushing me in various directions, the light bulb finally ignited. It was important to me to carry out a research that really interested me, a research that provided answers to questions that are in need of answers. Through my work, I had witnessed a mild struggle and even light frustration towards the chosen topic and I'm far from excluded from this equation. These thoughts lead me to the starting point, the point where I set of with my research, a starting point established with the following short question: Is quality a problem for the construction industry? A lot has happened since then, but now the journey has reached its endpoint. All the questions that were formulated and asked to begin with have now been allotted with answers.

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Abbreviations

AEC	Architecture, engineering and construction
ASCE	American Society of Civil Engineers
ISO	International Standards Organization
QA	Quality Assurance
QC	Quality Control
QM	Quality Management
QMS	Quality Management System
TQM	Total Quality Management

1 Introduction

This chapter discusses the reasons for choosing this specific topic. Furthermore, the background is reviewed. The research questions and objectives are then presented. The research methodology is reviewed and finally the structure of the thesis is outlined.

1.1 Statement of the problem

The construction industry is one of the oldest industries in the world. It has many traditions and habits. Across the whole these habits and traditions have not changed drastically as time has passed, though they have of course changed up to some level. Still, the basic concepts remain the same. That does not mean the way things are done is perfect, on the contrary, the construction industry and its performance and productivity have been criticized over the years. The habits and traditions have become so ingrained that new methods towards improvement face problems gaining a foothold.

A common discussion within the construction industry is that the quality is poor, budgets are unreliable and the prices are excessive. The industry has been accused of lagging behind other industries when it comes to efficiency. It has been stated that there are great possibilities for improvements within the industry. Failures and errors in the construction industry have many manifestations and their reasons and causes vary. Failures are indeed occurring over all the diverse steps of the construction process. Raising the quality status within the industry, the construction process as a whole would improve, resulting in lower costs, less project time and increased productivity.

According to international studies and researchers it seems as construction parties are increasingly realizing that the quality bar must be raised higher, quality must be improved and defects and rework reduced. The results of doing so would lead to better effectiveness and efficiency within the sector. Moreover, more emphasis must be put on creating value for the customer by meeting his needs and demands. Successfully implemented quality management has been proven to be a useful tool helping to obtain these goals.

Many organizations have been implementing quality management systems and by that, improving project performance (cost, time and quality). One desirable gain from implementing a quality management system is reduction in quality cost. Organizations are not clear on whether or not implementing the system has proven to be cost beneficial since very few of them measure their quality cost. By not measuring quality cost and linking it to non-conformance, knowledge is not being obtained on where the path for improving operations lies.

1.2 Aim and objectives

Few studies in Iceland have focused on the quality and the use of quality management systems (QMS) within the Icelandic construction sector. These studies have mostly been directly focused on the use of QMS in the construction industry with regards to client satisfaction and system benefits. No study has yet been performed on the extent of rectifying quality problems in the Icelandic construction industry.

The aim of this research is to increase knowledge an awareness of quality related matters in the construction industry. The research aims for identifying the main problems the industry is having with quality. In addition, the research aim is to examine where the scope lies for improving and identifying barriers that might be standing in the way of quality improvements.

The research focuses on shedding light on how the construction industry is standing in relation to quality and quality related matters. This involves analyzing the quality status theoretically as well as catching a glimpse at construction parties experience and views on quality related matters and their use of QMS. It is crucial to map the magnitude of quality problems as well as mapping the human aspects. Analyzing how well the two aforementioned items converge is of importance as well. In order to see the big picture, it is helpful to compare Iceland to other countries in relations to construction quality related topics. This should give a better understanding of what needs to be done raise the quality bar.

In order to form the research direction and set the reasearch demarcation, research questions were formed. The research questions marked the strategy choosen for this research. This research is a triangulation of methods. In addition to sending out a questionnaire, interviews were conducted with quality managers in the four largest organizations participating in the questionnaire. The purpose of the interviews was to gain a deeper understanding of questionnaire results. The research questions that will be kept in mind during the research are the following:

1) ***Is quality a problem for the Icelandic construction industry?***
    a. *What are the main problems and to what extent are they occurring?*
    b. *Is it possible to improve the quality?*
    c. *What meaning does the industry put in quality?*

2) ***Do quality management systems increase quality?***

3) ***By what means is the application of quality management systems conducted?***
    a. *What is the employers' experience of working with the quality management system?*
    b. *Are there any gaps in the use of the quality management system?*

1.3 Research methodology

This subchapter describes the methodology used in this research. Firstly, the field of the research is identified. Secondly, the research approach and methods used in this work are discussed. Lastly, the framework of the thesis is presented.

1.3.1 Research classification

Doing research is a process of exploration. Doing research is a way of finding out things the researcher is interested in (Esterberg, 2002). Research is systematical investigation, either on existing knowledge or the discovering of new knowledge. Research can be classified in a range from being pure research to being applied research. Most research fall somewhere between the two extremes (Robson, 2002). This research is a scientific study that seeks to solve practical problems and can therefore be classified as applied research.

A traditional approach to social research is based on a paradigm known as positivism. In positivism, the goal is to discover a set of causal laws, laws that can be used to predict general patterns of human behavior (Esterberg, 2002). This research is positivism by nature. The purpose of the research is descriptive, i.e. the research aims at reflecting an accurate picture of the situation of the Icelandic construction industry in relation to quality. Research approach

The objective of this research is not to prove or disapprove something. Hypothesis testing is therefore of little use. The purpose is to explore how the Icelandic construction industry stands towards quality related matters and what the aspects towards quality are. In order to do so, the construction quality status in Iceland must be looked at with regards to how things stand in other countries and comparison with best practice. After analyzing where the scope lies for improving, methods that have proven useful in the field are looked into. Finally, these methods are looked into in relation to the Icelandic construction practice. A questionnaire was presented to the Icelandic AEC sector, designed to answer the objectives of this research and then followed up by conducting interviews. The results hopefully give a further understanding on the quality status and quality practice in Iceland and whether or not it needs improvement and what steps can be taken towards improvement.

1.3.2 Research methods, techniques and tools

The research methods form the framework for this thesis. The way data are compiled and then analyzed depends on the research method chosen and it is important to choose the appropriate method for the thesis. Traditionally research methods are divided into two categories (Teddlie & Tashakkori, 2008):

> **Quantitative methods:** Techniques associated with the gathering, analysis, interpretation and presentation of numerical information and studying the relationship between them. Conclusions are conducted from scientific measuring techniques.
> **Qualitative methods:** Techniques associated with the gathering, analysis, interpretation and presentation of narrative information**.** This research seeks insights on particular phenomena or thematic analysis. The results or conclusions from such a research rely on the researcher in recognizing patterns.

In this study, a triangulation of methods was used. Quantitative methods were used for collecting facts and sets of facts by gathering data on the topic, both by literature search and with questionnaires. Questionnaires are useful to get an overview of aspects and views from the group they are submitted to. Conclusions are then drawn from these sets of facts. There was much quantitative data that was found on construction quality that the author could base his research on. To frame the research qualitative research was used in the form of interviews. The third chapter presents the research methodology and research design in full detail.

1.4 Thesis limitation

The limitations of this research is that no major quality case study yet has been published that has been performed in Iceland. Therefore results from other countries that the author evaluates can be transferred to the Icelandic construction industry are looked into and analyzed with aspect to the Icelandic industry.

The sample method is also a limitation. The methods used are based on non-probability sampling techniques. The sample is therefore not representive of the entire population and could therefore include sampling bias. Bias refers to a constant difference between the results from the sample and the theoretical results from the entire population. The sample size is also of limitation to the research and could result in bias.

1.5 Thesis outline

The thesis has six chapters:

In the first chapter the background of the research is presented, aims and objectives are described and the research method is presented.

The second chapter presents the theoretical background of the study. Firstly, it discusses quality in general. Secondly, it discusses the special characteristics of the industry and quality barriers within the industry. Thirdly, it discusses quality management systems in relation to their use and implementation. Finally, it discusses quality problems and their costs.

The third chapter goes into full detail on the methodology and methods used in this study. Furthermore, it describes how the questionnaire and interviews were designed and carried out.

Chapter four presents the research findings, both from the questionnaire and the interviews conducted. The results are presented with supportive data such as graphs, tables and text.

Chapter five discusses the research findings with regards to the research questions and previous findings. This chapter also analyzes and discusses the results in a broader context.

Chapter six provides a final conclusion on the research and recommendations for further research.

2 Literature review

This chapter outlines the theoretical background for this research. The main topics are quality in general, construction industry characteristics and quality management. Furthermore, quality barriers will be discussed. This chapter will focus on how quality matters have been developing for the last decades, how they stand today and how they might continue to evolve in terms of identified quality barriers and past history.

2.1 Introduction

As the years are passing, building projects have become larger and more complex. Project owners have therefore increasingly been demanding higher standards for their delivery. Quality and quality assurance are important parts of achieving and demonstrating that these standards are being met. During this age of technology more and more of the work is being executed with the help of computers and computer-based methods, such as finite element models, technology and computer-aided design as well as advance scientific theories continue to emerge. But despite all those useful tools, construction failures continue to occur at an alarming rate (Ortega & Bisgaard, 2000).

Construction failures and defects are constantly occurring. Another term used for describing construction failures and defects is the term ‘quality failures’ or the term ‘non-conformance to quality’. Quality failures and defects are occurring during the lifetime of the project; they have many different manifestations and can be linked to many root causes. One thing that all quality failures have in common is that they lower the project efficiency, add to its cost and reduce the liability, and they affect the construction industry’s overall performance that has been criticized over the years in terms of efficiency.

According to international studies and research, it seems as if construction parties are increasingly realizing that the quality bar must be raised higher; this includes reducing defects and rework. Moreover, more emphasis has to be put on creating value for the customer by meeting his needs and demands, and by that giving him a better quality product. It has been shown that there are great potentials for improving quality in the construction sector. There are available strategic management methods that have proven useful in other industries. These methods have been adjusted and adopted to some level in the construction industry. These methods have in many cases proven useful to the construction industry as well, but they have not gained as much widespread as they have in other industries.

2.2 Quality

Defining quality is of importance. Many definitions can be found for the term. When defining quality within an organization, it is important that all parties know what that definition is and that they understand it. Having a common language for the organization’s employees, regardless of their background, eliminates disputes between parties (Sigurðardóttir, 2008).

Philip Crosby, Edwards Deming and Joseph M. Juran are all well-known quality gurus and pioneers in the field of quality management. The influence from their pioneering work has now spread worldwide. They have their own different definition of quality. Crosby defined quality as conformance to requirement; he also stated that quality must be defined in measurable and clearly stated terms (Crosby, 1996). Deming on the other hand, did not define quality in a single phrase but asserted that the quality of any product or service depended on the customer's definition. Deming furthermore stated that quality was a relative term that was subject to change depending on the customers need (Deming, 1986). Juran defined quality as fitness for use. Juran also stressed the need for meeting the customer needs while eliminating deficiencies (Juran, 2005). It can be seen that while all those quality pioneers had their own distinctive emphases when defining quality, the purpose with their definitions and their pioneer work was all aimed at a joined goal of improving the overall quality.

2.2.1 Quality performance

The concept of performance may take on different meanings depending on the context in which it is used. At the global level, performance represents the results of activities. Traditionally effectiveness has been measured (doing the right things) as well as efficiency (doing them right). Performance has been attributed numerous dimensions, such as quality, productivity, profitability, safety, timeliness, growth, attendance and satisfaction. To add to the complexity of performance the before listed functions can also be interpreted as functions of each other's. In general the framework for the performance in any given context requires (Yasamis, Arditi, & Mohammadi, 2002):

- *A combination of criteria (not a single measurement)*
- *A level of analysis (such as end-users, employees, etc.)*
- *A certain focus (kind of performance desired).*
- *A time frame (short or long range)*
- *A measurement system (quantitative versus qualitative, objective versus subjective)*

Quality performance is result oriented and seeks evidence of quality awareness within the operations and outputs of a contractor. The quality performance is defined over the long-term for the effects to be permanent (Yasamis et al., 2002)

2.2.2 Construction quality

Construction quality can be viewed as one part of a triangle as seen in Figure 2-1. The contractor must attain the cost level as planned; meet the schedule deadlines while achieving the required quality level. There must be a balance amongst those three aspects because they define the project scope. However, quality may be the first of those components to be disregarded in favor of increased cost savings and time reductions (Chini & Valdez, 2003).

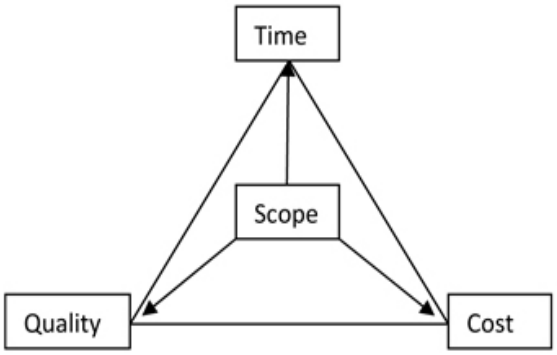

Figure 2-1 Construction triangle

Quality is involved in every stage and every aspect of construction. Construction projects and quality are inseparable parts of each other. Quality in construction cannot exist without a project and a construction project cannot exist without quality**.** The modern construction market requires construction companies to guaranty the quality of their product to their clients. **Error! Reference source not found.**shows various concepts that are considered to influence the quality of the product that can be associated with quality in construction. The figure reflects the product features, processes of production and organization, as well as company business/industry issues (Harris, McCaffer, & Edum-Fotwe, 2006).

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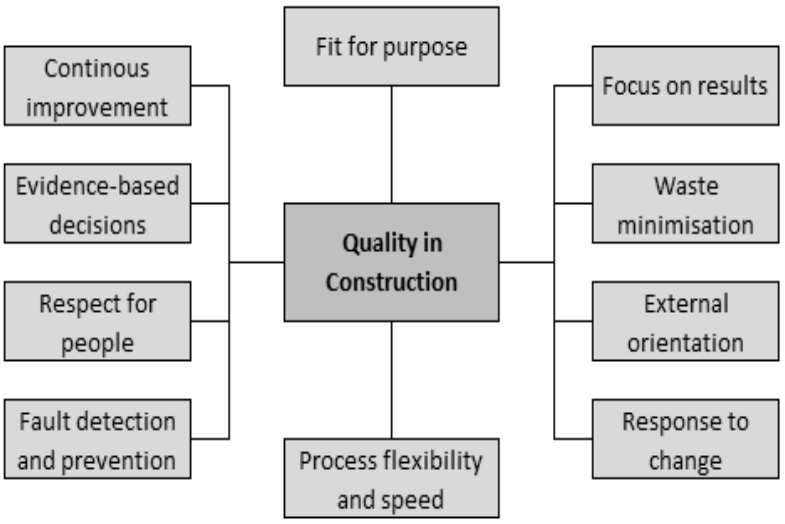

Figure 2-2: The figure shows aspects involved in the concept of construction quality (Harris et al., 2006)

The model in Figure 2-3 gives a comprehensive view of construction quality framework. This model on one hand deals with the service received by the owner and on the other hand, the product received by the end-user. The model furthermore frames the related aspects of the construction project and its aspects to the corporate quality culture in the contracting company. Quality is the red thread that goes through all stages and aspects of the construction process, whether it is at the corporate level or project level. Quality is therefore a concern for all the parties involved in every stage of the construction process.

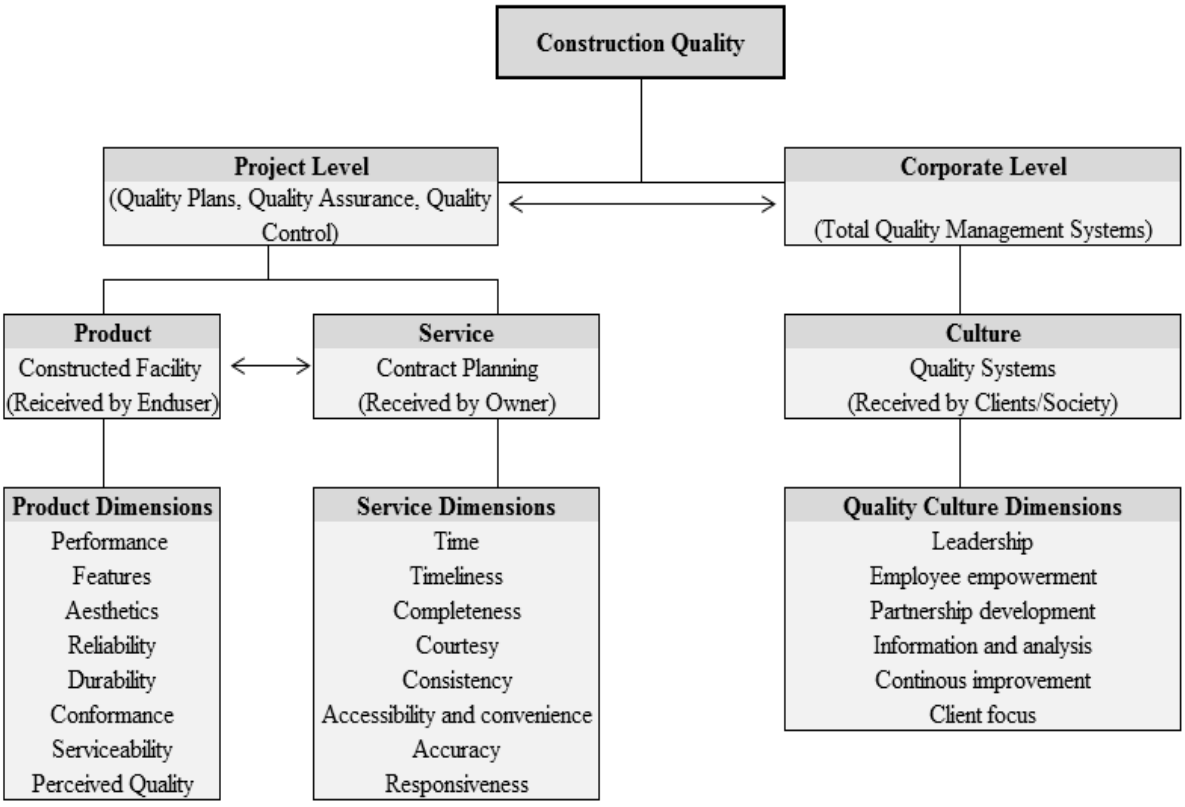

Figure 2-3: The figure shows alternative framework to construction industry (Yasamis et al., 2002)

2.2.3 Measuring construction quality

It can be difficult to define and put a measure on quality in construction. But nevertheless it is necessary. The term 'quality' should not be used as an expression of degree of excellence, as may be implied by a dictionary definition, but how well it is fit for its purpose (Chini & Valdez, 2003). Pheng and Teo (2004) define quality as the total features and characteristics of a product or service that satisfy the personalized need of the customer (Pheng & Teo, 2004). Arditi and Gunaydin (1997) define quality as meeting the legal, aesthetic and functional requirements of a project. The quality requirements may be simple or complex or they may be stated in terms of the end result (Arditi & Gunaydin, 1997). The bottom line is that quality is only obtained if the stated requirements are adequate and the completed project fulfills the requirements. According to an ASCE study, quality can be characterized as follows (Arditi & Gunaydin, 1997 p. 236):

- *Meeting the requirements of the owner as to functional adequacy; completion on time and within budget; lifecycle cost; and operation and maintenance.*
- *Meeting the requirements of the design professionals as to provision of well-defined scope of work; budget to assemble and use a qualified, trained and experienced staff; budget to obtain adequate field information prior to design; provisions for timely decisions by owner and design professionals; and contract to perform necessary work at a fair fee with adequate time allowance.*
- *Meeting the requirements of the constructor as to provision of contract plans, specifications, and other documents prepared in sufficient detail to permit the constructor to prepare priced proposal or competitive bid; timely decision by the owner and design professional on authorization and processing of change orders; fair and timely interpretation of contract requirements from field design and inspection staff; and contract for performance of work on a reasonable schedule which emits a reasonable profit.*
- *Meeting the requirements of regulatory agencies (the public) as to public safety and health; environmental considerations; protection of public property including utilities; and conformance with applicable laws, regulations, codes and policies.*

In a U.S. case study by Hoonakker (2006), the results showed that it was hard to define and put a measure on quality in the construction industry. Contractors had an attitude of: "looks good, feels good" which is a measure that is hard to quantify. Hoonakkers's main results were that it was hard to find a quantifiable outcome measure of quality in construction (Hoonakker, 2006).

Measurements play an important role in identifying and tracking progress against organizational goals and identifying opportunities for improvement. It can prove hard to

manage what cannot be measured. Not being able to put a measure on quality therefore results in a problem of not knowing where things stand. When there is knowledge on what can be improved, appropriate direction of strategy can be formulated. Without the right strategy for improving it is hard to head for the right direction where the proper results can be achieved. The fact that it has proven hard to put a measure on quality in construction could be an indication that organizations do not know where they stand when it comes to quality and quality defects, and therefore do not realize their potential for cost efficient quality improvements.

2.2.4 Quality requirements

Establishing quality requirements for the project begins at the project inception. During the design stage the requirements of the client are identified. Furthermore, the standards of quality are defined. This is done through procedures, drawings and technical specifications. This stage aims at achieving an adequate balance between the owner's requirements with regards to project cost and schedule while achieving desired operating characteristics, materials of construction and giving the design professional adequate time and budget to execute his work (Arditi & Gunaydin, 1997).

The work in the design phase is usually split into several temporary sequences and then delivered to different specialists for its execution. The design professional is obligated to fulfill all necessary legal requirements such as public health and safety in the context of the final completed project. The constructor is responsible for the methods, techniques, sequences, and procedures of construction, as well as safety precautions and programs during the construction process (Arditi & Gunaydin, 1997). Problems arising from this work sequence have been discussed for many years. The main problems are caused by the little iteration between parties involved in the design and construction phase (Alarcón & Mardones, 1998). The problems caused in the design phase, are not discovered or revealed until the construction phase is reached. Those problems can be incomplete designs, change orders, rework, construction delays, etc. Moreover the impacts of change are not fully understood and rarely recognized, in terms of costs and schedule (Alarcón & Mardones, 1998).

To begin with, Icelandic government agencies executed their projects by themselves, either by hiring labor groups or employees. Now almost all of their work is being executed by the hands of independent contractors. The competitive bid began being used in Iceland around 1970, a little later than abroad and is now a frequently used bidding form in construction (Frímannsson, 1997). For government agencies, it is now required by law and in accordance with government procurement policy to seek for competitive bids for all major projects, both for the design and construction phases (Guðlaugsson, 2002). However, there has been a growing concern among parties within the construction industry over the "competitive bidding" arrangement. Each bid aims at being as low as possible, in order to get the work which can results in choosing as low quality as possible since it is sought to push the price down by choosing cheap material, subcontractors and resources to achieve higher margins.

2.3 Construction industry Characteristics

To understand why defects and failures seem to be such integral problems of the construction industry, one must realize its peculiar nature. The construction industry is one of the few industries where there is a separation in the design and manufacturing functions. Exclusion from this is the not so commonly used "design and build" contract, in which the contractor provides both the design and construction for the project. Another distinctive feature of the construction industry is that, unlike most other goods or products produced by other industries, each building project is different or unique to some extent. There are number of factors that differentiate the construction industry from other industries and provide it with their special characteristics. A few of those items are listed below (Douglas & Ransom, 2006 p.11-12):

- *Variable site conditions. No two building plots are identical in terms of topography, access, subsoil, climate/exposure, available services, etc.*
- *Restrains such as planning control and building regulations vary in implementation from region to region, and these change over periods of time.*
- *Most building projects take many months if not more to complete. This time factor makes many sites susceptible to disruption and inclement weather.*
- *The people involved in each building project may change from month to month. No two construction jobs have the same set of designers, advisors, supervisors or operatives. This invariably leads to variations in quality. There is, moreover, a certain lack of continuity in construction jobs often resulting from a change in the workforce composition.*
- *Innovative materials or components or techniques or old materials used in new situations are continually being tried out in building without much knowledge of their long-term performance features.*
- *Much of the work is carried out in the open. Thus, a great deal of the work is not only exposed to the elements but it also carried out in non-factory conditions. This makes it harder to maintain a stable environment to undertake work undisturbed by wind and rain.*
- *Materials and components do not necessarily come from the same sources for all contracts. This tends to lead to greater variations in quality.*
- *Because of the dichotomy between the designer and contractor indicated above, architects do not normally tell builders how to erect buildings. In other works, the client, via the designer, tells the builder what is required – he does not tell the contractor how to go about it, unless special site or contractual considerations are present. This may lead to some changes in the construction during the contract by the builder to suit his programme.*
- *Quality control is not consistent from site to site. For instance, standards of supervision by site agents and clerks of works will depend upon the respective backgrounds of those involved, their attention to detail and the time spent on site, etc.*

- *Feedback between the user or installer and designer is often slow or difficult if not non-existent.*

2.4 Quality management

Many researchers have argued that the root of quality-related problems in the construction industry lies in the management field of the project (Ortega & Bisgaard, 2000). The use of quality management has been recognized as a successful management philosophy in manufacturing and service industry. Many have claimed that it is possible to embrace similar tools in the construction industry to help raise quality and productivity (Pheng & Teo, 2004). Management of construction quality is a specialization that has been growing over the past few decades to embrace aspects of the project and company activities that are often considered to have impact and influence on the quality of the product and which have come to be associated with construction quality (Harris et al., 2006).

Quality management is a process to achieve the best quality for manufactured products or service. This is achieved by defining and implementing fixed work processes right from the start and monitoring them with inspections and statistical quality control techniques (i.e. sampling). Quality management involves continually meeting the defined requirements and expectations of the customer with minimum cost (Harris et al., 2006). Customer satisfaction is the key factor driving companies towards improved quality and competitive marketplace. Customer satisfaction is considered to affect the customers retention which affects profitability and competitiveness (Kärnä, 2009).

Several studies have shown how quality management can be successfully implemented in the construction industry. Pheng and Teo's (2004) research showed how implementation of total quality management was successful in their two case studies. The results were a reduction in quality cost, better employee job satisfaction due to less defects and client complaints, recognition by clients, work carried out correctly right from the start, subcontractors with proper quality management systems and closer relationships with subcontractors and suppliers (Pheng & Teo, 2004). A report on 400 demonstration projects identified clear improvements in project performance, cost, time and quality (Pheng & Teo, 2004). These results were gained by following the introduction of the Rethinking construction recommendations (Egan, 1998). That report formulates proposals for improving performance in the U.K. construction industry. The scope for improving is clear. The report showed that it is possible to achieve better performance and reduce quality failures, but only if the industry is prepared to challenge the poor quality arising from the existing working practices continuous and sustained improvement is achievable (Egan, 1998). Quality management origin can be traced to the production industry around the middle of the twentieth century. It is linked to various pioneers in the field from Japan and the United States. Edwards Deming, Joseph M. Juran and Philip Crosby are well known figures in the quality management history, who have left their mark on development of quality management (Gunnlaugsdóttir, 2010). Today, quality management is applied in most industries.

Quality management practices have evolved dramatically since they first emerged. Initially quality management was primarily involved in the quality monitoring of production, i.e. to separate defective product from the satisfactory products. Later, the concept of quality control evolved which is involved in testing the product. Subsequently, attempts were made to ensure the quality with quality assurance by considering quality cost, reliable technology and eliminating defects. Nowadays, the emphasis is on strategic methods that involve ensuring quality within all elements of the organization. Quality requires commitment of all parties involved (Gunnlaugsdóttir, 2010).

2.4.1 Deming's 14 Points

Deming (b.1900, d. 1993) taught Japanese engineers statistical process control techniques and by that, contributed to the rapid revitalization of the Japanese economy after World War II (Anderson, Rungtusanatham, & Schroeder, 1994). The Japanese made good use of his ideas and were successful in implementing them. Beforehand, the Japanese were known for their cheap and poor production, but after having seen how it was possible to increase quality, but at the same time increasing profit, they became successful on raising the quality level in Japan (Sigurðardóttir, 2008). Deming returned to the U.S. and in 1986 he published a book called "Out of the crisis" where he presented 14 points that he believed would save the U.S. from industrial doom at the hands of the Japanese. These points as follows are the base for today's total quality management. Deming's points are as follows (Deming, 1986):

1. Create constancy of purpose for improvement of product and service.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on the basis of price tag alone. Instead, minimize total cost by working with a single supplier.
5. Improve constantly and forever every process for planning, production, and service.
6. Institute training on the job.
7. Adopt and institute leadership.
8. Drive out fear.
9. Break down barriers between staff areas.
10. Eliminate slogans, exhortations, and targets for the work force.
11. Eliminate numerical quotas for the work force and numerical goals for management.
12. Remove barriers that rob people of pride of workmanship.
13. Institute a vigorous program of education and self-improvement for everyone.
14. Put everybody in the company to work to accomplish the transformation.

2.4.2 Deming's PDCA model

Deming is also known as the author of Plan-Do-Check-Act (PDCA) model (Gunnarsdóttir & Ingason, 2007). The PDCA cycle is an iterative four step management method used in business for controlling and gaining continuous improvement of processes and products. The steps in the PDCA cycle are (Love & Smith, 2003):

Figure 2-4: PDCA model

Plan: Design or revise the business process components to improve results. The project team determines the nature of the problem and then constructs a plan of action to take when the problem occurs and indicates the expected results.

Do: Implement the plan and measure its performance. Implementation procedures a set of results about the expected and unexpected actions taken and the impact these actions have had on project performance (i.e. cost and schedule).

Check: Assess the measurements and report results to decision makers. This stage forms an internal part of the learning cycle as the project team reflects on associated plans and results to determine the effectiveness of the actions taken.

Act: Decide on changes needed to improve the process. This stage closes the loop to demonstrate the decision to continue with or alter the form of process improvement implemented.

The PDCA circle involves planning the process, operating it, inspecting its output, and adjusting it in light of the observation. These four activities are then repeated continuously to monitor and improve the process performance.

2.4.3 Juran's trilogy

Joseph M. Juran (b. 1904, d. 2008) is one of the most important pioneers in the quality management field. He developed the Juran's trilogy, an approach that consisted of three key managerial processes: quality planning, quality control and quality improvement. These functions all play a vital role in evaluation of quality (Gunnarsdóttir & Ingason, 2007).

Quality planning is the starting point for creating a process that will be able to meet established goals and do so under operating conditions. The operation planning subject can be anything: an office process for producing documents or an engineering process for designing products (Juran, 2005). Following quality planning, the process is turned over to the operating forces. The operation forces run the process at optimal effectiveness. The operating team monitors the operating process and waste that is occurring and report on the waste. The causes for the waste are then analyzed. Once the cause(s) has been determined and corrective action taken the process improves (Juran, 2005).

2.5 Quality management in Iceland

Around 1990, there was an increased focus on quality management (QM) in Iceland. The quality management association in Iceland was established in 1991 in cooperation with the main stakeholders in the industry (Hansen, 2002). Despite all the publicity, presentations and seminars on the subject that have been held for the last years, quality management has not gained as much foothold as it has in other Nordic countries (Hansen, 2002).

The interest for quality management systems has been increasing in the last years, especially for organizations within the export industry as well as engineering and design firms. The benefits are mostly in terms of market position and image. Many will now agree that investing in a quality management system, whether it is certified or not, is an investment that pays off (Yasamis et al., 2002). Contractors have gradually been increasing their management demands.

In a recent study examining the effect of quality management in the construction industry in Iceland, a significant difference was found to be between owners satisfaction with a project's execution based on whether or not the contractor was working according to a QMS. The findings also showed that the status of QM in the construction industry in Iceland is particularly poor within the smaller construction companies (Ólafsdóttir, 2011).

In January 2011, new laws for structures in Iceland came into effect. The purpose of the new laws is to enhance structural quality while strengthening the consumer protection and making building administration as effective as possible. The new laws define the owner's responsibility more distinctively than the former law. It is clearly stated that the owner holds the final responsibility for the structure, since he is responsible for hiring professionals for each individual aspect of the construction. There is also a demand that the owner is responsible for hiring a design manager, who simultaneously cannot be a designer for the structure. The same applies for the legal construction manager. The construction manager cannot simultaneously also serve as the master craftsman for the structure. This could sound like a normal demand, since it is would be bizarre and unreasonable to expect people to surveillance themselves. Smaller projects, are however, excluded from this provision (Ólafsdóttir, 2011).

The new laws demand that designers, construction managers and master craftsmen have implemented a quality management system according to the 17th article of the law. However, it is also stated that if the aforementioned group has not received certification on their quality management systems by an accredited certification bodies, the Construction Authority should perform an assessment on their quality management systems. The 24th, 28th, and 32nd Articles of the law define minimum requirements that are required in order to fulfill quality management system demands. The 60th article includes different demands to quality management systems based on the type of structure. Under temporary provision in the law, it is furthermore stated, that before 1 January 2015, The Construction Authority and all building representatives should have implemented a quality management system (Ólafsdóttir, 2011).

2.6 Quality management systems

A Quality management system consists of set of processes. These processes ensure the attainment of defined quality standards for the provision of provided services and products by the project or a construction company (Harris et al., 2006). Quality management is considered to be based upon three pillars which are time, cost and needs or expectations. Quality management is all about defining the need of the customer within the given time and cost (Sigurðardóttir, 2008). A Quality management system consists of two main components, the first being the framework for guiding quality related actions by all employees (design of quality system) and the second, means of assessing how well these actions are carried out (delivery of quality system). Companies are increasingly being persuaded to adopt quality management systems in order to meet the globalized marked demands (Yasamis et al., 2002).

2.6.1 ISO 9000 Standards

ISO 9000 is a series of international quality management standards. ISO 9000 is a set of defined standards, rather than a management philosophy. The standards were created to provide uniform quality assurance standards for products and service in a globalization perspective. They have now been adopted by organizations all over the world (Chini & Valdez, 2003).

The ISO standards are designed to help organizations meeting the needs of the customers and other stakeholders. They are published by ISO, the International Organization for Standardizations. The twenty elements required of certified ISO 9000 organization have continuously been identified with manufacturing procedures. Nevertheless, they have been adapted to construction procedures as well and are believed to cover a wide scope of quality related activities of construction-related firms (Chini & Valdez, 2003). Researchers have illustrated the interaction and application of the ISO 9000 requirements to construction activities (Chini & Valdez, 2003).

The main standards of the ISO 9000 series are the following ("Icelandic Standards (IST)," n.d.).

- ISO 9000:2005 is a framework to guide their organizations towards improved performance. It includes basic concepts, principles and definition of terms.
- ISO 9001:2008 Deals with the fundamental requirements for quality management systems that organizations wishing to meet the standard have to fulfill, including the eight management principles:
    - Customer focus
    - Leadership
    - Involvement of people
    - Process approach
    - System approach to management
    - Continual improvement
    - Factual approach to decision making
    - Mutually beneficial supplier relationship

- ISO 9004:2009 Describes practices that can be implemented to make the quality management system more effective and efficient to achieve your business goals and objectives.
- ISO 19011:2002 Provides guidance on the principles of auditing, managing audit programs, conducting quality management system audits and environmental management system audits, as well as guidance on the competence of quality and environmental management system auditors.

ISO does not itself certify organizations. Many countries have formed accreditation bodies that issue certificates of conformity to the ISO standards. The certifications must then be renewed at regular intervals recommended by the certification body.

The main motivator for ISO 9000 certification in construction firms should ideally be the achievement of quality in a company's internal procedures in order to optimize its resources and satisfy their customer requirements. However, many organizations mainly seek for ISO 9000 certification in in order to satisfy specific requirements from the customers. Other organizations are obtaining certification due to increasing government requirements and other firms take advantage of ISO 9000 as an effective marketing tool to improve the company's reputation (Chini & Valdez, 2003).

The use of ISO 9000 in construction has its followers and opponents. The supporters believe that it can be successfully applied to construction and the benefits are substantial. Furthermore, the supporters believe that by standardizing corporate procedure, the operation can improve, resulting in more efficiency and more effective control. ISO 9000 can be used as proof that an optimal level of quality is being obtained through all stages of the quality circle. However, the opponents of ISO 9000 believe that the construction industry has such special characteristics and properties that the standard interface causes problems and the construction procedures cannot be standardized at all. The processes of construction involve such a variety of professionals and tradesmen and the working environments where the processes are carried out are often exposed to aggressive elements. Another argument is that the ISO 9000 has such a generic nature that it often leads to differences in interpretations and implementation of the standard (Chini & Valdez, 2003).

Despite the criticism, ISO 9000 is respected and has gained wide acceptance in the global construction market. In some places in the world, like Australia certification is becoming mandatory for all construction organizations that are working with government agencies and major private companies. Europe is increasingly requiring the use of ISO 9000 for construction companies, with support from the European Union (Chini & Valdez, 2003).

In Iceland, construction firms are increasingly implementing quality management systems. The Icelandic construction industry has however lagged behind other industries in the application of ISO 9000 and in the number of organizations certified for these standards. In 2011 there was a total number of fifty five ISO 9001:2008 certified organizations in Iceland, of which only seven were in the joined group of Construction and metal industry. A total number of twelve organizations were within the software development, consulting and

engineering services (Gunnlaugsdóttir, 2011). Engineering firms have increasingly been seeking international certification since they have been aiming for the global market. Many of the medium and bigger engineering firms in Iceland have become certified while there is only one of the larger contractors in Iceland that has a certification.

2.6.2 The federation of Icelandic Industries certification

The federation of Icelandic industries offers a local quality certification. The certification improves operations of organizations systematically step by step. This certification meets the demands of organizations that are hesitating to establishing ISO 9001 certification but are seeking to improve their operation. The certification process consists of four certification levels or phases, D, C, B and A-certification ("SI - The Federation of Icelandic Industries," n.d.):

The first phase, D-certification requires organizations to meet certain minimum requirements regarding access for reliable operation information. Eleven organizations in Iceland have received D-certification.

After having received D-certification, organizations must demonstrate that they have developed an organizational strategy, margin accounts, filing systems, offer and sales summary, work plans, contracts with suppliers, Health & safety programs. No organizations are C-certified today.

To be able to get B certification requires the organization to demonstrate that it has job descriptions, procedures, comparison of profitability, tender and contract review, surveillance, safety and project meetings. Two organizations are B-certified today.

When reaching the last level, A-certification they are close to satisfying the international quality standard ISO 9000:2008. A-certification requires the organization to form annual strategy policies, planning programs, procedures, manuals and overview of work insurance. One organization has achieved A-certification today.

Even though organizations only decide on achieving D- or C-certification, in many cases they have achieved substantial improvements.

2.6.3 Problems with certification

There are some problems the industry is having with the certification process. One of the big problems is the lack of knowledge on quality management and its use as a management tool. Sigurðardóttir's (2008) research on Icelandic contractors and their use of quality management systems revealed that there was a common misunderstanding on the terms quality management, quality systems and quality assurance. The contractors interviewed seemed to think of a quality system as a type of paper system instead of looking at it as helpful management system. Furthermore, the Contractor's general opinion was that quality

management was too complex. The contractors did not see the financial gain and they did not see the connection to the management of the companies (Sigurðardóttir, 2008).

General research on quality management system implementation in Iceland has also been conducted. The research participants were asked if anything had taken them by surprise in the implementation process. The following is a list of some of the items mentioned (Sigurðardóttir, 2011):

- Hard to get staff to see the positive side
- Implementation and follow-up period was more time consuming than expected
- High bureaucracy
- How the quality system simplified things
- The common sense nature of standards
- Safer staff
- Happier staff
- How the workplace culture could impede good things

From these points it can be seen that the human factor and human habits can be a barrier to implementing new things such as quality management. Implementation of new methods and habits is likely to meet resistance to begin with but in the end people seemed to realize the positive benefits.

The time and cost consuming factors of implementation were also identified as repellent factors to the organizations. A study from 2010, conducted among certified organizations in Iceland, showed that the implementation cost was from 1.5 million to 25 million ISK, or 12.4 million on average. The certification cost is divided in labor costs, purchased work and registration fees (Gunnlaugsdóttir, 2010). A survey of US firms indicates that the major obstacle to using the ISO 9000 standards is the additional cost of modifying work procedures and the additional cost of revising standards (Arditi & Gunaydin, 1997).

A research conducted by Hoonakker (2006) showed that despite all the barriers, the contractors saw obvious benefits of quality improvement. The two most cited benefits were more repeat customers and reduced rework (Hoonakker, 2006). Other studies have found similar results. Research by McIntyre & Kirchenman (2000) identified substantial economic benefits attainable through implementations of TQM techniques (McIntyre & Kirschenman, 2000).

2.6.4 Quality barriers

The primary barrier to quality management system implementation success seems to be the nature of the construction process (Hoonakker, 2006). The projects are large; their locations are different from one project to another. The workforce is often transient and the demand fluctuates, subject to the client's perception of the construction project value (Hoonakker, 2006). There are number of different participants in a single project. Each construction project is a cooperative effort of several participants, each with their own perspectives and interest. The participants have to adapt to a project plan that typically changes several times while

being constructed. During that time the participants try to minimize weather/environment, occupation hazards, schedule delays and building defects (Hoonakker, 2006).

A second barrier to quality implementation is the many parties involved in the process. Traditionally, the construction industry consists of three primary participants; the owner, designers and the contractor. Even though they are sharing a common goal of completing the project, the participants retain their own interest in terms of gain from the project process. The typical project owner would most likely agree on wanting to get his desired project completed while spending as little money as possible. The designers provide a service to the owner and the relationship with the contractors is often unclear. The contractors attempt to provide the product by constructing it using information from the designers as efficiency as possible to maximize profit. Many other parties are also involved, such as sub-contractors and suppliers (Hoonakker, 2006). Each stakeholder wants to achieve his objectives and goals and that can result in conflicts in the project process. All these parties are constantly influencing the process, adjusting and adapting to the project during its execution. This complicates projects and calls for high integration and skills for all the parties involved.

A third barrier to quality implementation is non-standardization. The general contractor wants to ensure quality throughout the project but non-standardization causes him some problems. Products are one-offs and each production process is to some extent different between each product. This can lead to difficulties in quality assurance. Quality is therefore often at risk when there are excessive changes throughout the construction process (Hoonakker, 2006).

The bidding process is an important quality implementation barrier. There is a concern among contractors and researchers over “competitive bidding” by having as low quality as possible and choosing the cheapest material, subcontractors and resources to achieve higher margins. Competitive bidding is usually the standard practice but some owners and general contractors have begun to realize the advantages of using either partnerships or pre-qualification criteria for the awarding of contracts. By having pre-qualification, the risk of poor performing contractors or subcontractors is reduced, both by the client and by the general contractor. With pre-qualification the bidders must meet a minimum requirement of experience, performance, safety or management programs. With partnership, the general contractor only works with a select pool of subcontractors they have a good experience of working with in the past so they can rely on meeting their project needs (Loushine, Hoonakker, Carayon, & Smith, 2006).

2.7 Quality cost

Quality cost is a widely used term. Quality cost is the total cost of all quality related items. Quality cost is the cost of ensuring good quality and rectifying poor quality. Quality cost is just one type of measurement that can provide the management team with information about process failures and activities that need to be redesigned to prevent reoccurrence. By measuring quality costs throughout a project, the information can be used to help transfer lessons learned to the next project.

Crosby (1996) explains that he stopped using the term 'cost of quality' due to a negative reaction from quality professionals. Quality professionals seemed to become defensive about the term since, according to Crosby, they felt that the quality cost was being blamed on them. They therefore resisted registering quality cost and only registered a low number, which worried no one. Instead of the term 'cost of quality', Crosby started using the term 'price of nonconformance' which was better accepted. Every transaction in the company was then accomplished either in a conforming or nonconforming manner. Black or white, nonconforming meant rework or correction in some way. These corrective actions would take money that was not provisioned, money that had to come from somewhere which usually meant a reduced margin. Reduced margin will catch the attention of everyone (Crosby, 1996).

2.7.1 Quality cost breakdown

There are many methods on collecting and classifying quality costs. Costs can be classified as either cost of conformance or non-conformance. Conformance costs include: training, indoctrination, verification, validation, testing, inspection, maintenance and audits. Non-confirming costs include: rework, material waste and warranty repairs. The most widely accepted method of determining construction quality cost is the traditional prevention appraisal failure (PAF) model which classifies quality costs in the following way (Love & Irani, 2003):

Prevention: All amounts spent or invested to prevent or reduce errors or defects, that is, to finance activities aimed at eliminating the causes of defects. Examples of such prevention activities are shown below:

- Quality system development
- Quality program development
- Personnel training
- Specifications/design review

Appraisal: The detection of errors or defects by measuring conformity to the required level of quality. Examples of appraisal activities are listed below:

- Materials inspections/tests (e.g. reinforcement and door hardware)
- Inspection
- Maintenance of testing/measuring equipment

Deviation: A departure from established requirements. Deviations can be categorized to internal and external failures. Internal failures are due to scrapping or reworking defective product or compensation for delays in delivery. External failures occur after the delivery of a product to the customer: costs of repairs, returns, dealing with complaints, and compensation. Examples of deviations are shown below:

- Communications errors
- Defective materials
- Design errors or omissions
- Poor workmanship

- Faulty equipment

All these categories relate to direct cost of preventing and correcting errors of a poor product/service quality and they can be measured and estimated with a high degree of precision, while others can only be estimated. Costs will rise as more time is spent on prevention, but as processes improve, appraisal costs should reduce as inspection is no longer necessary. It will take time for quality improvement expenditures to reduce failure cost. Appraisal and prevention costs are unavoidable costs. Failure costs, on the other hand, can be avoided in most cases since they tend to originate from ineffective management practices (Love & Irani, 2003).

2.7.2 The PAF model

Many organizations have found difficulties in balancing prevention and appraisal costs and failure costs. The PAF model does not provide numerical solutions on how much the organization should invest in a particular activity. Figure 2-5 shows that very high failure costs correspond with low quality and vice versa. Quality levels improved through greater investment in prevention and appraisal methods. Failure cost lowered, but beyond a certain point further investment would only produce modest failure cost reduction. The resultant total quality cost curve will therefore fall to the optimum cost level and then rise when the improvements are gained (Tim & Le, 2007).

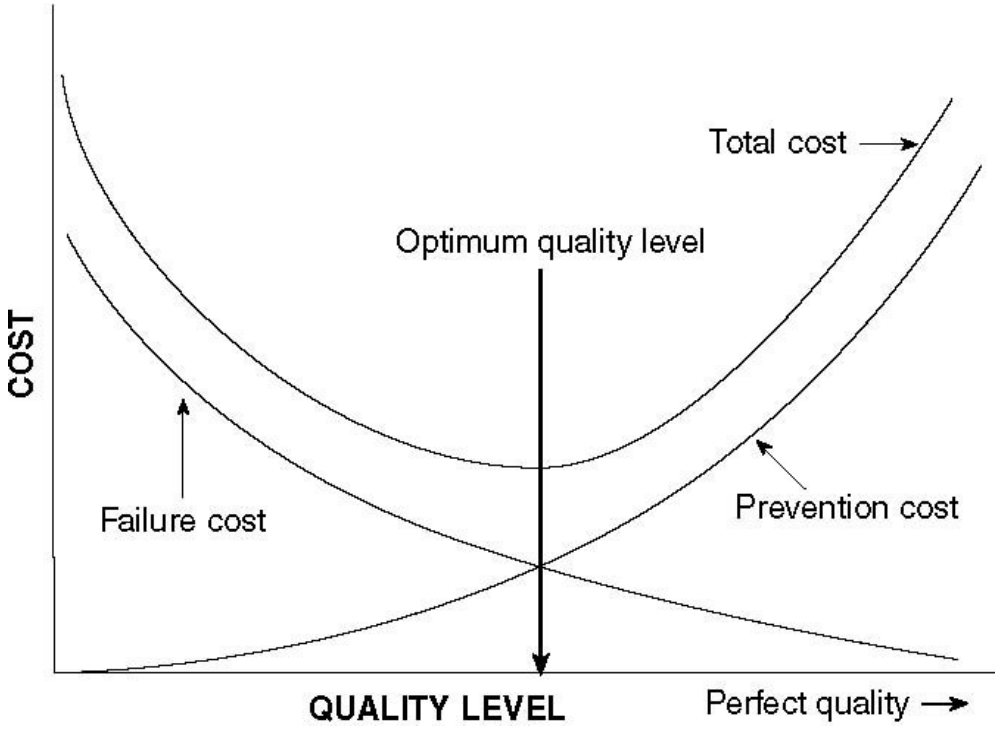

Figure 2-5: The quality cost model (Tim & Le, 2007)

There is awareness of quality cost in the construction industry. In research by Aoieong (2002) on quality cost models, all the contractors he interviewed had obtained ISO 9000 certification. All expressed that they were aware of the concept of quality cost. Even so, the majority believed that it was just a process to measure the cost of nonconformance. This incomplete view of quality costing could be traced to the nature of their jobs, most being quality managers within their company (Aoieong, Tang, & Ahmed, 2002). This shows that the main focus of those interviewed was on the outcome of the lack of quality instead of trying to get to the root of the cause and seeing the quality picture as a whole.

To improve the performance of construction organizations and reduce costs, many have stressed the need to measure quality costs. Very few construction companies and consulting firms have in place assessment systems for their quality costs. In addition, available quality tools and techniques for improving performance are rarely used (Love & Li, 2000). If an organization is not measuring quality cost, it is difficult to prove that the quality systems they have in place are cost-effective. Although the direct cost of quality can be quantified with some accuracy (salaries, documentation cost, audits, etc.) it is hard to put a measure on the corresponding benefits (Love & Li, 2000)

2.7.3 Quality cost approaches

Quality cost in the construction industry is relatively high compared to the total project cost. Literature review shows that only a few papers have been written on how quality costs can be determined. Some of the models limited their focus on measuring failure cost and only a few of them pinpointed the causes of the problems, either by describing them in words or by using codes. Prevention and appraisal costs are important because they could be a significant part of total quality costs. Aoieong (2002) lists up the desirable main features a good quality tracking system as follows (Aoieong et al., 2002 p.182-183):

- *The quality tracking system should be able to capture all components of quality costs. With one or more components missing, the effect of varying one component on the others cannot be visualized. Within each component of quality costs, standardization of category is necessary, so that the meaningful data can be compared between projects. On the other hand, the categorization should be flexible enough to ensure that the system can be modified when necessary to suit different types of projects.*
- *The use of a coding system in tracking quality costs is essential. As suggested by former researchers in this field, the coding system should be compatible with the local quality assessment systems, if any.*
- *The ease of use of the quality cost tracing system is essential. The system must be straightforward, because the people who would be collecting cost data are the personnel on site. Any extra workload created from the system must be kept to a minimum. Due to the highly competitive environment in the construction industry, it is impractical*

to implement any extra system that would result in much extra workload to site staff.

- *The practicality of the quality cost tracking system is essential. The main barrier to trying out the system is the long construction time involved.*

Aoieong research (2002) identified barriers to implementing a quality cost tracking system to be lack of resources and added extra cost to the company due to extra personnel. Adding to that, most companies considered quality cost data to be confidential and were reluctant to release any data. The top management must be convinced that collecting quality costs is truly beneficial to the company (Aoieong et al., 2002).

By having a PAF cost model or other type of quality cost model in place it is possible to capture the cost of quality for construction projects. The data gained from these models could then be analyzed and used as a guide to improvement. The typical basic results gained from such a model could the following outcomes (Aoieong et al., 2002):

- The average quality costs of building projects expressed as a percentage of the total project cost.
- The distribution of quality cost according to the PAF categories.
- The distribution of quality costs according to the origins (parties involved) in the project.
- The analysis of the interrelationship of prevention, appraisal and deviation costs.

The Construction Industry Development Board in Singapore stated that contractors spent 5-10% on average of the project cost in doing things wrong to begin with and rectifying them. They concluded that an effective quality management information system would cost about 0.1-0.5% of the total construction cost but would produce a saving of at least 3% of the total project cost (Love & Irani, 2003). This clearly underlines the importance of knowing how to prevent recurrence which not only benefits the contractor, but also the client and end-users.

2.7.4 Defects and deviations

It is no wonder that, over the years, many building professionals have studied and showed interest in the nature and consequences of defects and failures. Firstly, research has shown the cost of repairs and corrective maintenance to be very high each year. Secondly, the presence and spread of faults, particularly within housing, causes needless annoyance and distress to the occupants and contradicts the quality term of 'meeting customers' needs and expectations'. Thirdly, the industry's reputation is being undermined by stream of incompetent, embarrassing and sometimes dangerous series of failures, and is reflected in the number of litigation cases against building professionals and contractors (Douglas & Ransom, 2006).

Most building defects are avoidable. In general they occur, not due to lack of basic knowledge, but due to non-application or misapplication of it (Douglas & Ransom, 2006). Such knowledge seems to become mislaid from time to time. Professionals that have made

particular study of building defects and those with long memories are often struck by the re-emergence of problems which have been well researched and documented. A call goes out for more research, but in truth all that is needed is a functional system for the retrieval of information, a better procedure for its dissemination (Douglas & Ransom, 2006)

Defect or deviation cost is responsible for the largest part of quality cost and it can reach up to 60-90% of the total quality cost (Þráinsdóttir, 2010). Deviation cost is related to defects in a product or a service. However, this cost is the easiest one to reduce. As previously mentioned, this cost is divided to internal and external failure cost. Internal failure is due to errors during the construction phase, including design and other preparation. External failure costs are discovered after the work has been delivered to the buyer. Failures can cause a chain reaction that can lead to cost and time overruns.

Quality defects and deviations are a costly unwanted part of all construction activities. The major problems in construction that have been identified to cause costly errors are (Tim & Le, 2007):

- Inadequate training and management of designers. Poor design quality reflects in high number of variation orders and claims due to frequent changes in the detailed information throughout the project's construction process.
- Inadequate or incorrect specifications in the tender.
- Inadequate definition of responsibilities with management groups, both in the office and on site.
- Poor communication among involved parties. This can lead to confusion and costly delays.
- Inadequate training and management of the construction labor force on site.
- Inadequate verification procedures and policies to ensure that design, materials and workmanship meet the specific requirements.

In their book, Understanding Building failures, Douglas and Ransom (2006) assert that current training in design tends to concentrate on what to do rather than on what not to do. They also point out that a similar situation exist in training in constructional techniques, where the craftsman is instructed on best practice in undertaking his operations but to a lesser extent on the dangers of deviation from an accepted technique. Understanding of the likelihood of defects through inadequate design or construction is taught implicitly rather than explicitly in most built environment degree courses (Douglas & Ransom, 2006).

2.7.5 The cost of mistakes

To be able to perform rational defect prevention, knowledge about defects causes and associated costs, is necessary. A number of studies of defects occurring in the production and maintenance phases of construction have been conducted. However, there are only a few studies relating to the briefing and design phases (Josephson & Hammarlund, 1999). In a case study of three construction projects, the cost of quality rectification problems was found to range from 3.4 per cent to 6.2 percent of the project value. Other research has put the cost of rework as high as 12 per cent (Karim, Marosszeky, & Davis, 2006).

When several defect origin studies were summarized as a percentage of the total defect cost, the breakdown range was as follows (Josephson & Hammarlund, 1999):

- Client 5-15%
- Design 15-30%
- Production 35-55%
- Material 5-20%
- Other 0-15%

A defect study of seven building projects was performed in the period 1994-1996 in cooperation between the Department of Building Economics and Construction Management at Chalmers University of Technology and a group of construction companies in Sweden. In that study the main focus was on the causes of defects, including underlying causes. The defects ranged from 3.1% of the production cost to 9.4% (Josephson & Hammarlund, 1999).

The results showed that, on average, 32% of the defect cost originated in the early phases, i.e. in relation to the client and the design. 45% of the defect cost originated on the site (site management, workers and subcontractors). 20% of the defect cost originated in materials or machines, this breakdown can be better seen in Figure 2-6 (Josephson & Hammarlund, 1999). By knowing the origin of the mistake cost within the organization, effective preventive measures can be undertaken.

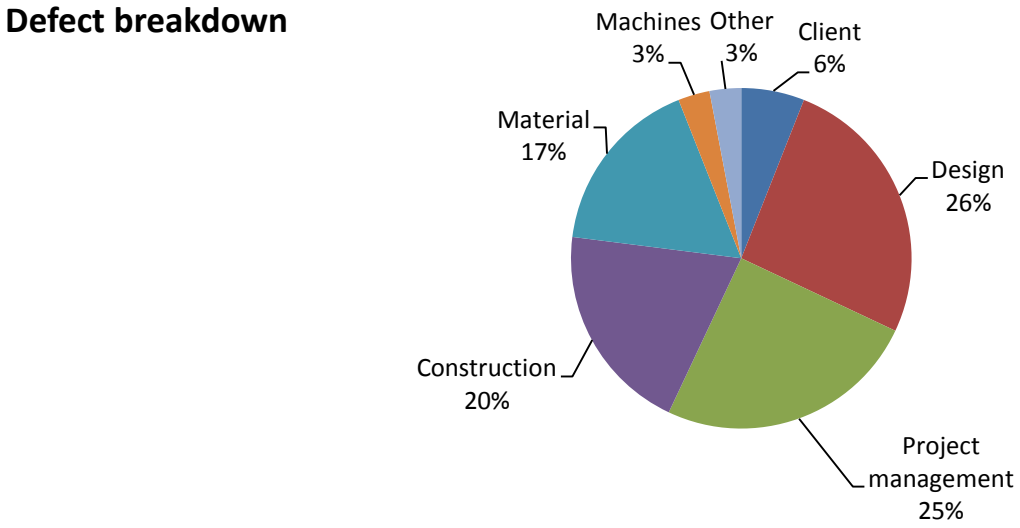

Figure 2-6: Defect breakdown

To follow up on the data analysis in the seven building projects, 92 key employees were interviewed. They linked the mistakes to short project execution time and pressure on contractors. Other identified factors were competition and underbidding. The contractors and designers therefore had to spend less time executing their work, which led to worse work practices which had an impact on the rest of the work (Þráinsdóttir, 2010).

3 Empirical Study

This research is a triangulation of research methods. Triangulation is a term used to explain the combination of different methods in dealing with particular subject matter. This research approach is chosen in a single study to gain a broader and more complete understanding of the phenomenon. This means checking the results of qualitative method with those of a quantitative method or vice versa (Robson, 2002)

The fundamental principle of triangulation is to use complimentary methods to enhance interpretability. This research is primarily based on quantitative study where the interpretation of statistical analysis is enhanced by a qualitative narrative account. Conversely, a qualitative account may be the major outcome of the study, but it can be enhanced by supportive quantitative evidence used to buttress and clarify the results.

This chapter describes the research study and the methods used. A quantitative questionnaire was prepared and qualitative interviews were used. The chapter is divided in two main subchapters, the first of which discusses the quantitative part of the research, and the second discusses the qualitative part of the research.

3.1 Quantitative research

3.1.1 Questionnaire design

A survey is an appropriate tool for this research since it is a system for collecting information to describe, compare and predict attitudes, opinions, values, knowledge and behaviors. Designs for survey studies can be categorized as experimental or descriptive (Fink, 2002). The questionnaire used in this research is descriptive. The descriptive design produces information on groups and phenomena that exist.

The survey gives information collected from a group of participants in a standardized form. An appropriate sample of people is formed and respondents are asked to give their answers in a standardized form. However, there is always a limitation in survey case studies, since people evaluations and opinions vary. But it is expected that the questionnaire as a whole will give a good indication and information regarding the subject and could therefore provide meaningful results on the subject.

The questionnaire design was a result of information that had been collected during the literature research and its goal was to shed further light on the research topic and the research questions asked. This involves getting answers to how well the data collected by literature research complies with data collected using the questionnaire and the learning that can be drawn.

Respondents were chosen from engineering firms and contractors that had been selected for the research. The questionnaire was divided to four sectors:

1. Respondents backgrounds
2. Quality systems
3. Quality aspects
4. Company characteristics.

In the questionnaire respondents were asked to give their answers against a five-point Likert scale which is good for measuring either positive or negative responses to a statement. This questionnaire was used to provide a deeper understanding of quality in general, quality status and quality systems.

The organizations were divided to three size groups: small (1-30 employees); medium (31-99 employees); and large (with more than 100 employees). In the large organizations it was considered appropriate to send the survey to around 10% of the employees; whereas in the medium organizations; the ratio was raised to 20% to capture the variety and for the small organizations, 50% of the employees were targeted.

3.1.2 Sample of respondents

The sample was based on convenience sampling. This involves the sample being drawn from that part of population which is selected because it is easily available and convenient. This approach to sampling was considered the most appropriate for this research. The advantages for this type of sample are the following:

- Convenience sampling is very easy to carry out with few rules governing how the sample should be collected.
- The relative cost and time required to carry out the sample is less in comparison to probability sampling.
- This sampling method is appropriate to achieve the research goals since it is focused on a few individual organizations within a certain sector and comparing them.

The disadvantages for this type of sampling is that convenience sampling often suffers from a number of biases so it is unlikely to be representative of the population and undermines the research ability to make generalizations from the sample to the population studied.

With the convenience sample, in most cases the respondents were handpicked from accessible employee list. When choosing a sample for each organization, it was sought to obtain a certain breadth that could reflect the whole organization. The sample included CEOs and general employees and they came from different departments of the organizations with a breadth of education that was considered to reflect the organization as a whole. Only employees linked directly to construction were chosen. Support department staff was obviously not appropriate as respondents. In a few cases, with the medium and small organizations, the list of appropriate recipients was provided by the organizations themselves.

The sample size was rather small compared to the population, since the aim was not to apply the results to the whole population of the construction industry, but to indicate how things stand in the sector.

3.1.3 Execution

The questionnaire was presented to respondents through the medium of Google Documents (docs.google.com) where one feature is to create questionnaires that then collect information for online spreadsheets. Four individuals read and answered the pilot version to check the timing, review phrasing of questions and answers, instructions and spelling as well as giving general feedback on what could be improved or if any errors popped up. It took them 5-10 minutes to answer the questionnaire; which was mentioned in the email sent to participants, see Appendix A. The questionnaire was open for answers between the 26 March and 12 April. During this period, one reminder was sent out.

3.1.4 Data analysis

The questions were presented to the respondents based on the literature review presented in chapter 2. In most of the questions, respondents were asked to give their responses against a five-point Likert scale. The typical form of this scale is to ask participants to specify their level of agreement or disagreement with a statement. Another version used in the research was a Likert scale going from poor to excellent. The Likert scale has proven to be very useful in measuring whether people have a positive or negative attitude towards an object or a statement, and is therefore suitable for this research. The rest of the questions were questions about participants' background and their definitions of quality terms. In those questions, the respondents were asked to check boxes and/or write alternative answers.

The survey was conducted through Google Documents in which all the results were collected on a spreadsheet and showed statistical data on the responses. The data were analyzed further using Excel and its statistical functions such as pivot tables. Graphs, tables and figures were also created in Excel. The sample size is small, but despite that it is a reasonable indicator of how matters stand. The results of the questionnaire are presented in Chapter 4 and are then discussed further in Chapter 5.

3.2 Qualitative research

3.2.1 Interviews design

Interviews were carried out to gain a deeper understanding of the subject. There are several types of interviews, including structured, semi-structured and unstructured. For this research, semi-structured interviews were chosen. Semi-structured interviews are less rigid than structured interviews. In semi-structured interviews, the goal is to explore a topic more openly and to allow interviewees to express the opinions and ideas in their own words. In semi-structured interviews, the researcher needs to listen carefully to the participant's responses and to follow his or her lead (Esterberg, 2002). The author has predetermined questions in mind, but is able to modify the order based upon the interviewer's perception of what seems

most appropriate. Phrasing of questions can be changed, explanations given and for some interviewees, when applicable, some questions can either be omitted or added to the interview (Robson, 2002).

The questions were based upon the literature research and the questionnaire results. The main questions or topics that were kept in mind in the interview were the following:

- Time since current quality management system was implemented
- The reasons for implementation
- Benefits of quality management system
- Disadvantages of quality management system
- Training and education on the quality system
- Level of satisfaction among employees with the quality management system.
- Collection of quality cost
- Status of quality in the construction industry

3.2.2 Sample of respondents

The interviewees were selected with a purposive sampling, where the researcher chooses the sample based on who they think is appropriate for the study. This is the case since the goal was to contact people that held certain positions in the organizations. The people interviewed were all quality managers within the four large organizations that had been a part of the quantitative research.

3.2.3 Execution

Those interviewed were firstly contacted by email to arrange an appointment. The interviews were then conducted via phone. The interviews were recorded in order to ensure that no information got lost; the highlights were then subscripted. The main topics were kept in mind as guidance for the interview while allowing questions that originated extending from these questions to occur. The interviews were conducted between 25 April and 30 April.

3.2.4 Data analysis

In qualitative research, data analysis is a process of making meaning. It is a creative process, not a mechanical one (Denzin, 1989; Esterberg, 2002). Generally, analyzing qualitative data involves several stages. These stages apply to this research and were followed during the data analysis. Firstly, one must find some way to physically manage or organize the data in the research. Then one must be immersed in the data and become familiar with what has been gathered and in what context it is in relation to the data retrieved from the quantitative research. After getting to know the data, the researcher generated themes or categories or identify patterns in the data. Finally, a way of presenting the analysis to others was found (Esterberg, 2002). The results of the interviews are presented in Chapter 4 and then discussed further in the Chapter 5.

4 Survey findings

This chapter presents the research results. The chapter is divided to two main subchapters. The first subchapter presents the results from the questionnaire and the second subchapter presents the results from the interviews.

4.1 Questionnaire result

This chapter presents the result of the questionnaire on construction quality and quality aspects in Iceland. Firstly, the characteristics and background of the respondents will be described and, secondly, descriptive statistics will be introduced. Most of the later questions required the respondents to give their answers on a five-point summated rating (or Likert) scale. The summated rating approach is very widely used.

Where the mean was above 3 it was interpreted as a positive response towards the statement or the question. When the mean was between 2.5 and 3 it was interpreted as a neutral response. When the responses mean was below 2.5 it was interpreted as a negative response.

When working with descriptive statistics, such as the Likert scale, mean and standard deviations tend to be invalid parameters. This is the case since the scale is ordinal and can therefore not be fitted properly to a distribution curve. The standard deviation can despite being used as a measure of consistency. A rough guide for a five-point Likert scale response distributions with standard deviation below 1 could be called consistent (Sclove, 2001). More appropriate tools for analyzing data from ordinal scales are nonparametric procedures, based on the rank, median or range, are appropriate for analyzing these data, as are distribution free methods such as tabulations and frequencies (Allen & Seaman, 2007).

The survey was presented to respondents in in English and Icelandic. The questionnaire is presented in full context in Appendix B. The questionnaire was sent to employees in twelve organizations that operate within the AEC sector. Eight of the organizations were engineering firms and four of them contractor firms. The organizations were defined in size categories: small (1-30 employees); medium (31-99 employees) and large (over 100 employees). Of the eight engineering firms, there were two large, three medium-sized and three small organizations. Of the four contractor firms participating, there were two large and two medium-sized organizations.

Answers from each organization were collected separately in order to compare them internally to each other. Each organization was allotted a distinctive abbreviation that consisted of three letters. The first letter stands for the type of organization, "C" for Contractor firms and "E" for engineering firms. The second letter reflects the organization size: 'S' for small, 'M' for medium and 'L' for large. The third letter is a number identifying the organizations further. The abbreviations listed in Table 4-1 will be used from now on to distinguish between organizations

Table 4-1: Abbreviations for participating firms

ID		Engineering firm	Contractor firm
Small		ES1	
		ES2	
		ES3	
Medium		EM1	
		EM2	CM1
		EM3	CM2
Large		EL1	CL1
		EL2	CL2

The questionnaire was sent to a sample of 143 people. 14% of the sample consisted of females and 86% were males. Of the sample, 105 (74%) were employed with engineering firms and 37 (26%) with contractor firms. The response rate was 38% amongst the engineering firm's employees and 62% amongst the contractor firm's employees. A total of 62 people answered the questionnaire, providing a response rate of 43%. It was not mandatory to answer all the questions. Most of the questions were answered by all the respondents; the lowest response rate to a single question was 57 responses.

The questionnaire can be divided into four parts depending on the nature of the questions. The first part concerns the respondents' background, the second part covers existence or non-existence of a quality system within the organization, whilst the third part addresses quality aspects and opinions about quality in general. The fourth and last part addresses participants' aspects with company characteristics.

4.1.1 Respondents background

Respondents were asked about their background. These questions included participants' gender, age, length of work experience in the construction industry, educational background as well as asking about their field of work. Figure 4-1shows participants age distribution and Figure 4-2 shows the length of their work experience within the construction industry.

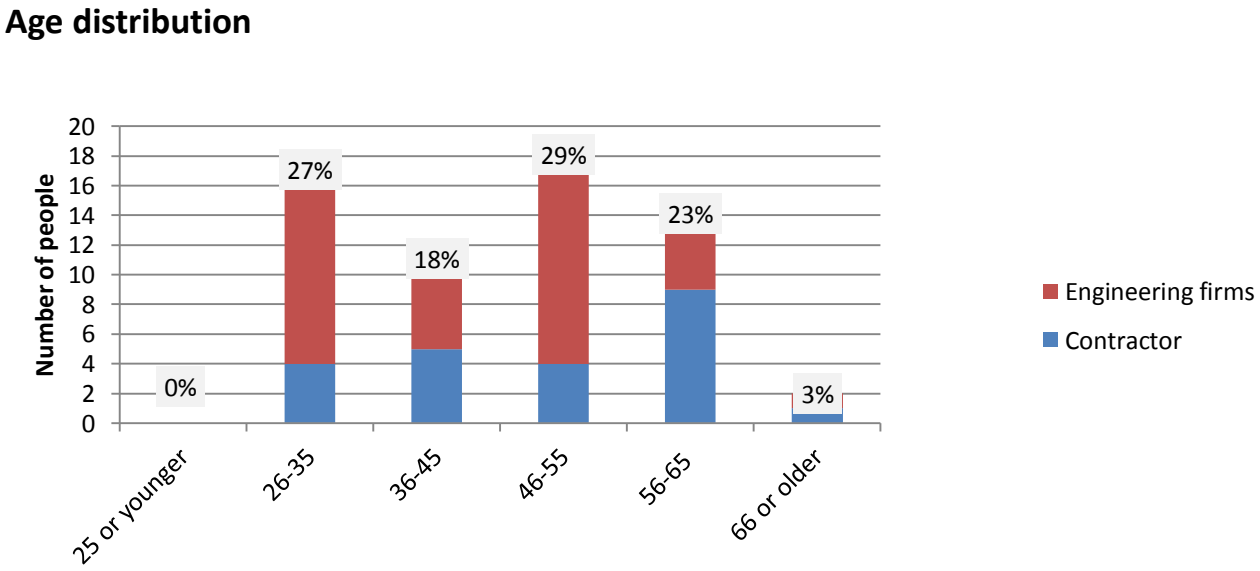

Figure 4-1: Age distribution of respondents

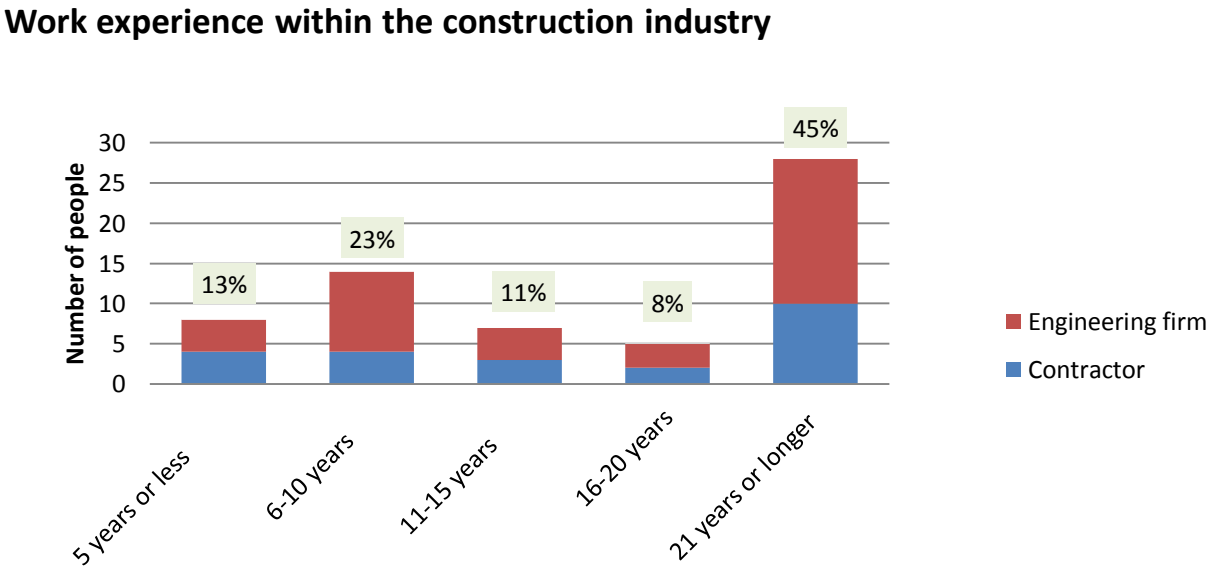

Figure 4-2: Length of work experience within the construction industry

Participants were asked about their educational background, by indicating their highest educational level. Engineers with a master‘s degree were those who mainly submitted the survey at 42% with those who had a bachelor’s degree in engineering at 29%, see

Figure 4-3.

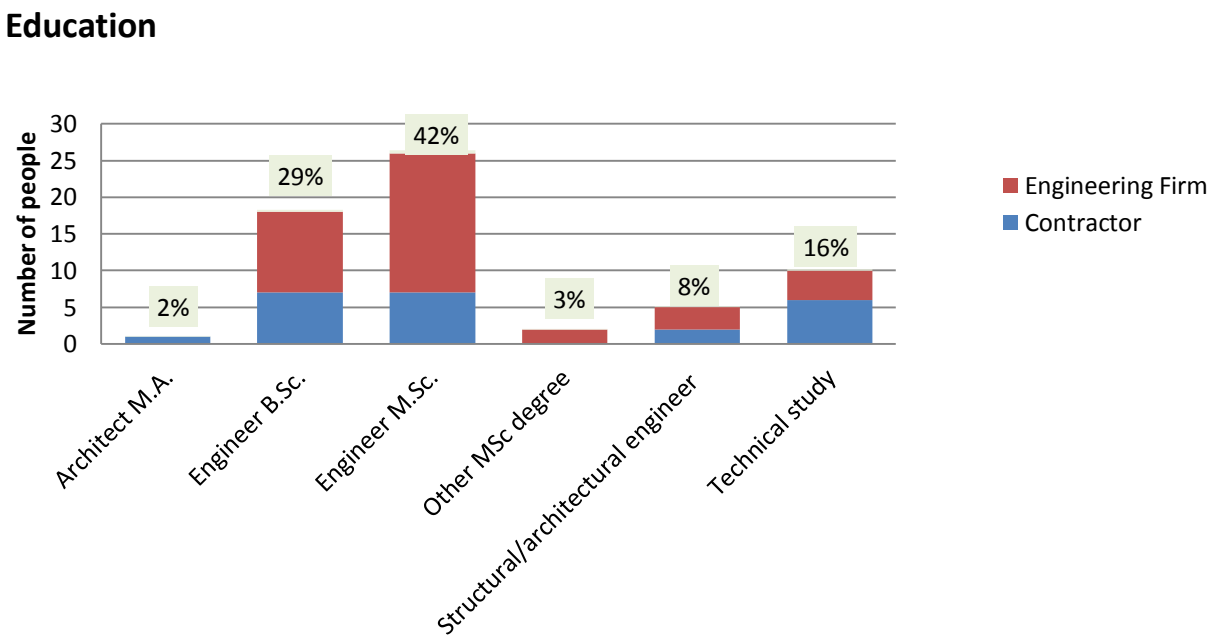

Figure 4-3: Respondents’ educational background.

Participants were also asked about their field of work. The distribution can be seen in Figure 4-4. Most of the respondents were project directors or supervisors (24%), next were those involved in project management (19%) and, last, the largest group fell into the general group of owners, CEOs and heads of department (19%).

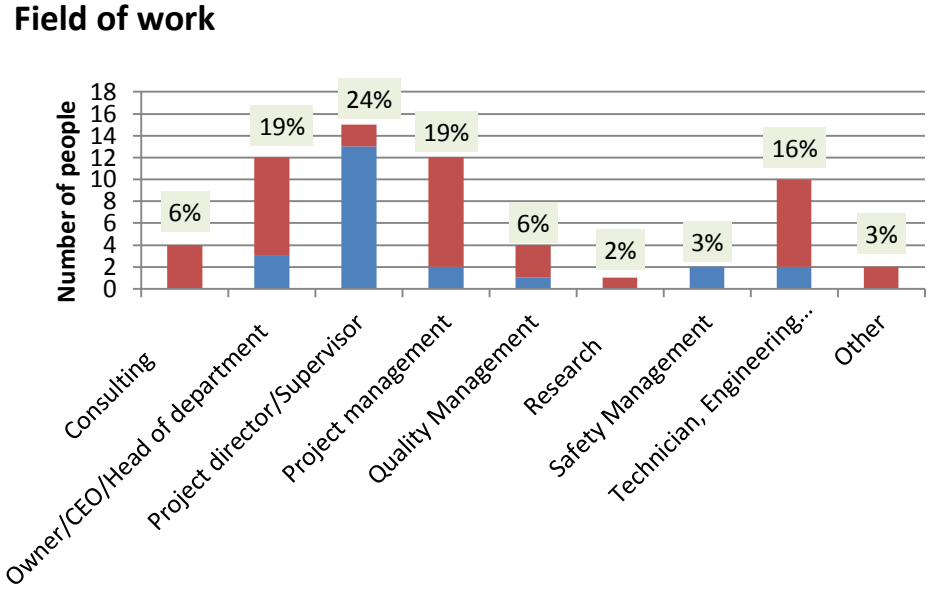

Figure 4-4: Respondents’ field of work

4.1.2 Quality management system

This part of the research aims to identify respondents' views towards the quality management system. In this part, respondents were asked whether or not there was a quality management system within their organization. If they replied there was, they were sent to a new page containing questions regarding the quality management system, if they replied there was not, they were sent to a different page containing questions regarding the absence of the system. The participants who answered 'I don't know' skipped both of the above mentioned pages.

The participants were asked what type of system was in place in their organization, a certified ISO system or other. Almost all of the respondents knew what type of system was in place in their organization, but there was some confusion amongst contractor CL1 and engineering firm EL2 employers. The contractor CL1 has a quality system within the organization, but 30% of the respondents responded that the quality management system was an ISO 9000 certified quality system. It was the other way around with the engineering firm EL2, where two thirds knew rightfully that the organization is following a certified ISO 9000 quality system but one third thought they were following a quality system within the organization.

Participants were asked how much training they had received from their employer to learn to implement the quality system in their work. They were asked to answer on a scale from 1 (No training) to 5 (Comprehensive Training). The average rating was 3.4 (with a standard deviation of 1.05), which can be interpreted as an overall positive response to the question (>3). However, as seen on Figure 4-5, the results show that a total of 22% of participants were negative towards the amount of training they had received on implementing the quality management system, 32% were neutral and 46% were positive towards the amount of training they had received. This means that more than half of the participants answered this question either on a negative or a neutral scale. This could indicate that the organizations that were part of this research are not putting enough emphasis on teaching their staff to use the system.

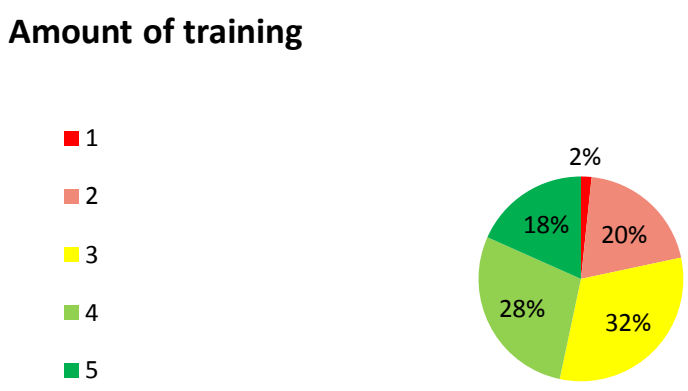

Figure 4-5: Participants views on the amount of training received on implementing the QMS

When comparing the training received by contractors and engineering firms as seen in Figure 4-6 and Figure 4-7, it can be seen that the most common answer amongst contractor employers was a rating of 3, while the most common amongst engineering firms' employers was 4. This could indicate that QMS education is in better shape within the engineering firms than within the contractor firms.

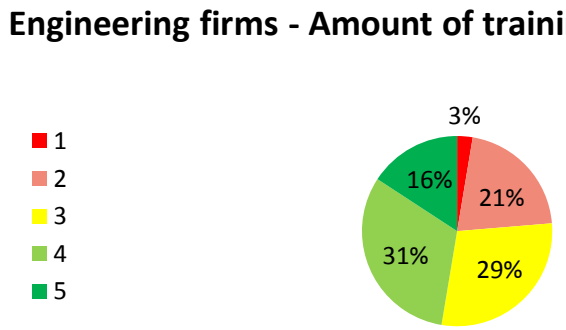

Figure 4-6: Engineering firms employers view on the amount of training received on implementing the QMS

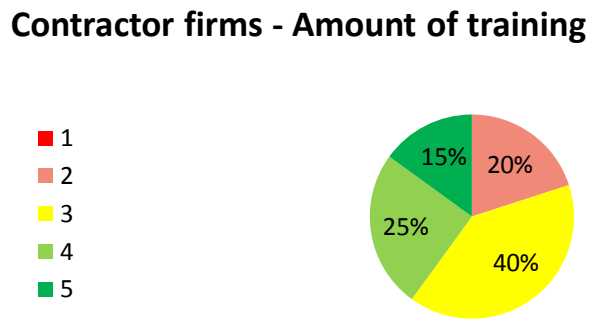

Figure 4-7: Contractor firms employers views on the amount of training received on implementing the QMS.

Participants were asked to what extent they would agree to the statement that the top management was committed to following the quality management system. The average rating was 3.94 (with a standard deviation of 0.80). As can be seen in Figure 4-8, a total of 70% of participants were positive towards the statement, 27% were neutral and 3% disagreed with the statement. As seen in Figure 4-9 and Figure 4-10, there are indications that the top management in the engineering firms holds higher degrees than in the contractor firms. 76% are positive towards the statement in the engineering firms, compared with 59% in the contractor firms. Despite that, the overall response can be interpreted as positive.

Figure 4-8: Participants' views on the degree of top management commitment towards the QMS

Figure 4-9: Contractor firms top management commitment towards the QMS

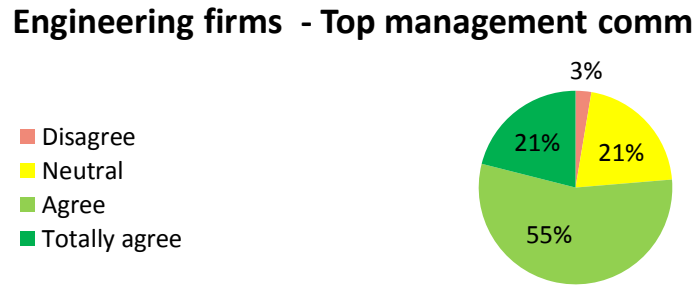

Figure 4-10: Engineering firms top management commitment towards the QMS

Participants were asked about the extent to which they would agree to the statement that the quality system was useful for their work. The average rating was 4.23 (with a standard deviation of 0.61). As seen in Figure 4-11, all the participants were either positive or neutral towards the statement.

Figure 4-11: Participants' views on usefulness of the QMS

Participants were asked to what extent they would agree to the statement that the quality management system was easy to use in their work. The average rating was 3.69 (with a standard deviation of 0.73). As seen in Figure 4-12, a total of 65% were positive towards the statement, 28% were neutral and 7% were negative.

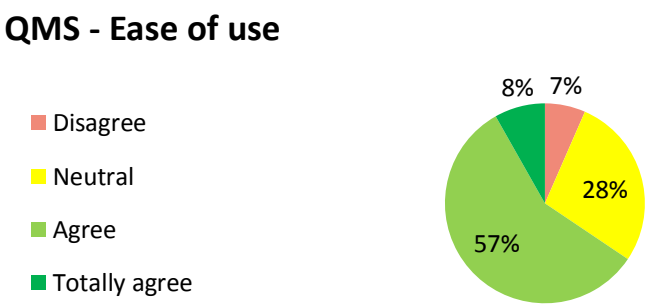

Figure 4-12: Participants' views of how easy it is to use the QMS

It seems that the participants are, overall, positive towards the amount of training received, system usefulness, system ease of use and top management commitment towards following the system although there are some negative responses. Pearson's correlation coefficient was calculated between the amount of training and the other before mentioned factors. There was a positive correlation in all cases. The correlation was 0.28 between training and usefulness. Between training and ease of use, the correlation was 0.34 and between training and top management commitment the correlation was 0.35. Though is not possible to generalize from such a small sample, as in this case, the positive correlation, could be an indication of (a) that the amount of training personnel are receiving on implementation influences their experience of using the quality management system and (b) the amount of training provided could possible reflect top management commitment to the system.

4.1.3 Quality in general

This part aims to identify aspects to quality in general. Respondents were asked to grade a list of eleven factors on how well they indicated good quality performance. The factors that were identified as being most important were (1) repeat business from the client with an average rating of 4.1; the factors that came next were (2) management commitment to quality, (3) skilled work force, (4) certified quality program and (5) customer satisfaction. The lowest rated factors were (11) quality awards, (10) the length of warranty and (9) amount of rework due to errors. The ratings can be seen in Table 4-2. From these results, it can be interpreted that participants have a positive view towards almost all of the factors, except for quality awards.

Table 4-2: Quality indicators ranking

Rank	Quality indicator	Rating	Std. dev.
1	Repeat business from the client	4.1	0.94
2	Management commitment to quality	3.9	0.87
3	Skilled work force	3.8	0.91
4	Certified quality programs such as the ISO9000 series	3.8	0.99
6	Customer satisfaction	3.8	0.94
5	Regular inspections	3.7	0.91
7	Training and education	3.7	0.89
8	Use of Standards	3.6	0.89
9	The amount of rework due to errors	3.3	1.22
10	The length of warranty	3.1	0.97
11	Quality awards	2.8	0.97

Figure 4-13 shows how rating between contractor firms and engineering firms varies for each of the factors. In most of the cases there was coherence in their rating, but the contractor firms' employers were, in most cases, rating the factors a little bit higher than the engineering firms' employers.

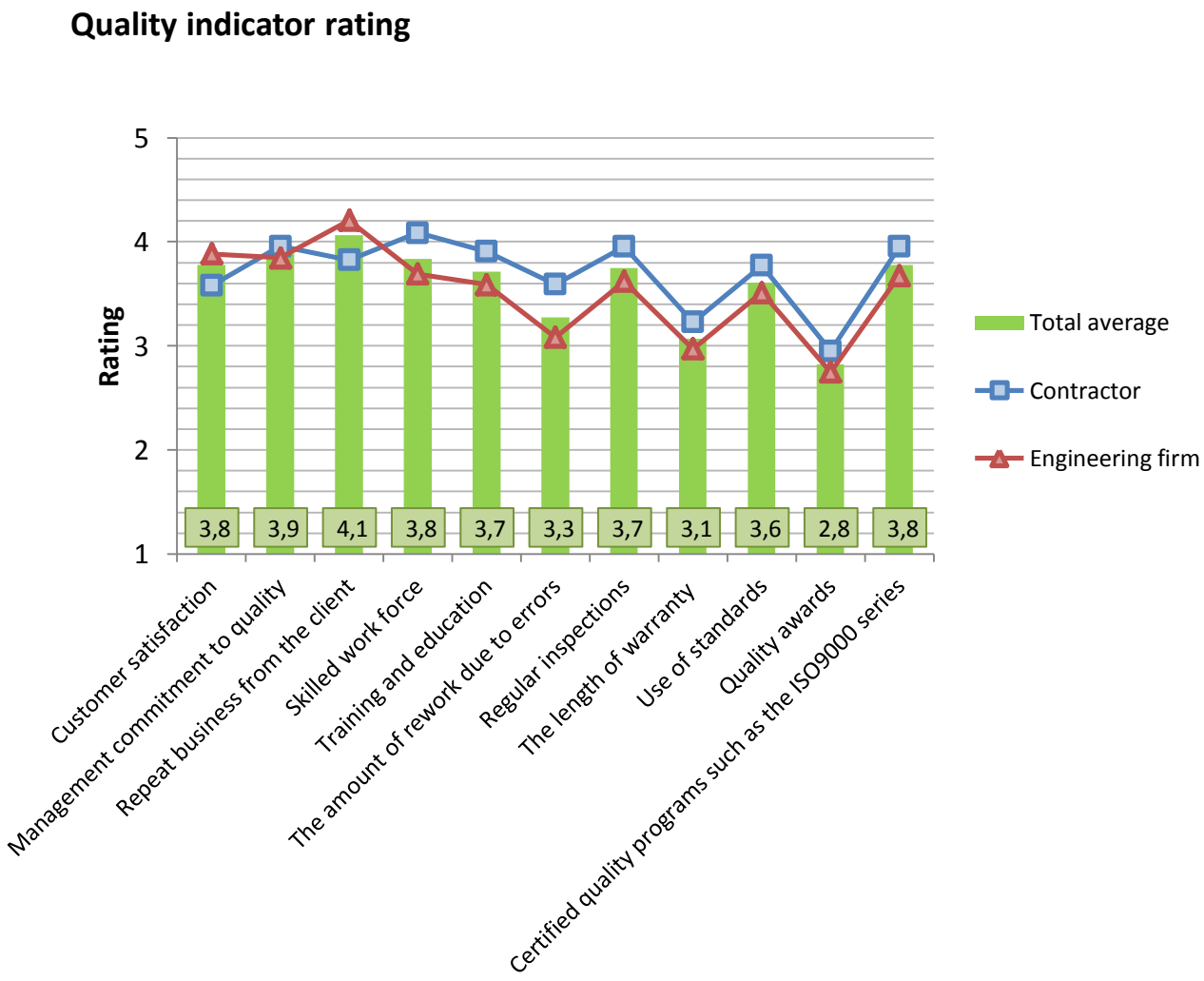

Figure 4-13: Quality indicator rating

Participants were asked to define quality. They were given some options, but they could also type in their own definition. All of the respondents checked a given option. As seen in Figure 4-14, a majority (66%) of respondents said that quality could be defined as meeting all the customers' expectations or demands for the finished product. 24% defined quality as being able to guarantee that the finished product will not fail or have problems. 6% of respondents said that quality could be defined as „looks good, works good, or proud to put the company's name on the finished product. 4% said either that quality was non-applicable to their work or they did not use a definition of quality.

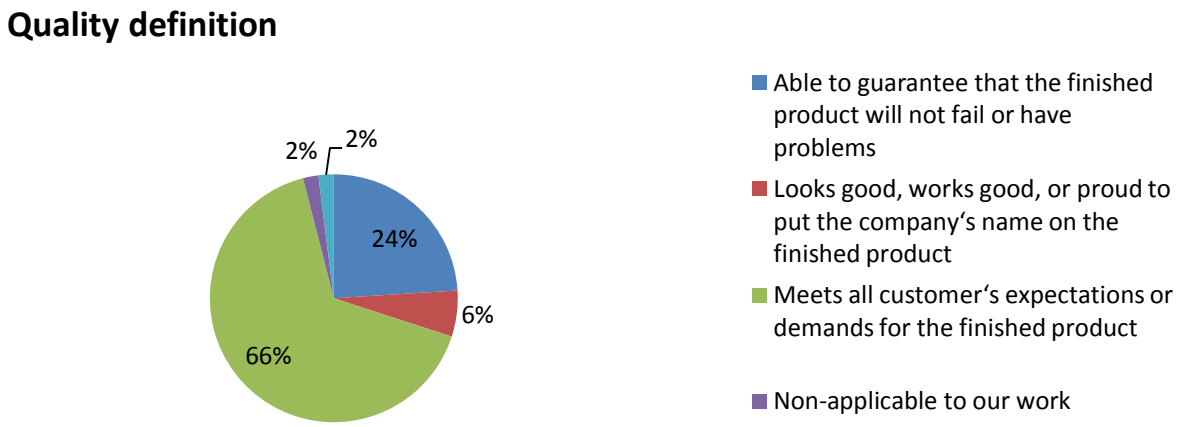

Figure 4-14: Participants' definition of quality

In the next question, respondents were asked whether or quality cost was being collected at their work place. As seen in

Figure 4-15, 30% said 'yes' to this questions, 70% either did not know whether or not the quality cost was being collected or answered that this was not the case.

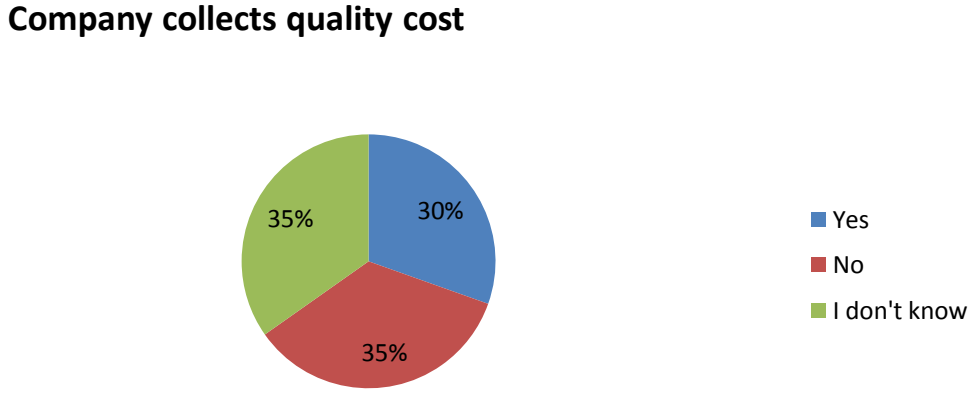

Figure 4-15: Quality cost collection

Participants were asked about their perception of what was involved in the term "Quality cost." Several options were given and they were able to select as many as they felt applied to the term as well as writing in their own explanation. All respondents answered this question. Figure 4-16 shows how the respondents answered to the question. The majority of respondents (69%) said quality cost involved prevention cost, almost half of them (45%) said that appraisal cost was a part of the term, then came cost of quality assurance (37%), cost of repairing defects (29%) and cost of repairing defects after handover (26%). Only a small number of respondents (13%) indicated that they did not know what was involved in the term quality cost.

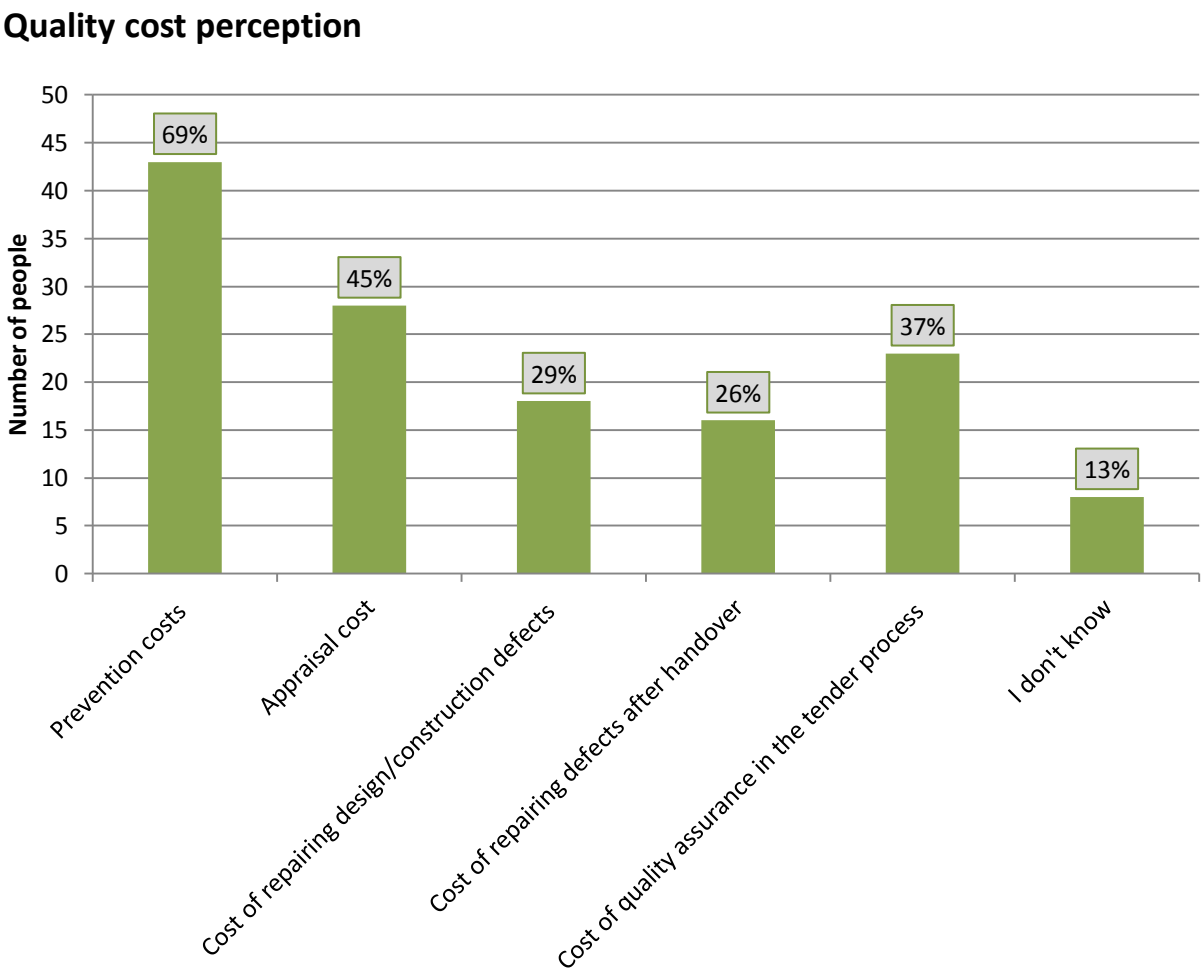

Figure 4-16: Participants' perception of quality cost.

Participants were asked to rate the status of quality and safety within the construction industry in Iceland. The scale was from 1 (Very bad – Serious Problems) to 5 (Very good – No problems). As shown in Table 4-3, the contractors' employees rated the safety status at 3.74 on average and the quality status a little lower at 3.48. Both the ratings can be interpreted as positive outcomes. The engineering firm's employees rated the safety status at 3.21 and the quality status at 2.97, the later can be interpreted as a neutral response. The results show that the contractor's employees rated both quality and safety higher than those working in the engineering firms.

Table 4-3: Quality and safety status rating

		Safety status		Quality status	
Group	**N**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Contractor	23	3.74	0.74	3.48	0.50
Engineering firm	39	3.21	0.85	2.97	1.00
All participants	62	3.40	0.85	3.16	0.88

4.1.4 Company characteristics

This part aims to identify the importance of various aspects regarding the company characteristics and its effect on construction quality within the organization. Participants were asked to rank the importance of various aspects for improving quality. The participants were asked to give a grade from 1 (less important) to 5 (most important). The highest ranked aspects were (1) employee involvement, (2) management commitment and (3) clearly defined quality goals and objectives. The bottom ranked aspects were (24) increased use of strategic methods, e.g. Lean, (23) increased use of special software e.g. BIM, (22) criteria used in pre-qualification in bidding process and (21) regular meetings. All mean ratings were above three so they can be interpreted as positive aspects towards improving quality. The complete list is presented in Table 4-4.

Table 4-4: Quality improving factors

Rank	Factor	N	Mean	Std.dev.
1	Employee Involvement	61	4.6	0.55
2	Management commitment	60	4.6	0.58
3	Clearly defined quality goals and objectives	60	4.5	0.67
4	Skilled workforce	61	4.4	0.64
5	Communication between managers and employees	61	4.4	0.66
6	Training and education	61	4.4	0.66
7	Well-defined roles and responsibilities	60	4.4	0.58
8	Systems for collecting and tracking data for ensuring quality objectives are reached	61	4.3	0.75
9	Clearly defined goals relating to quality work performance	60	4.3	0.65
10	Means and methods for ensuring continuous improvement	61	4.2	0.63
11	Incentives for good quality performance	60	4.2	0.77
12	Training and education	61	4.2	0.76
13	Review /analysis used to improve performance	60	4.2	0.70
14	Regular inspections and audits	60	4.2	0.77
15	Written program or policy	59	4.1	0.77
16	Clearly defined guidelines for customer satisfaction	61	4.0	0.76
17	A review/analysis process for identifying errors in the system	61	3.9	0.95
18	Certified program	58	3.8	0.92
19	Subcontractors involvement	61	3.8	0.85
20	Organizational culture	60	3.8	0.72
21	Regular meetings	58	3.7	0.94
22	Criteria used in pre-qualification in bidding process	60	3.5	0.94
23	Increased use of special software e.g. BIM	59	3.4	1.02
24	Increased use of stragetic methods e.g. Lean	57	3.3	1.03

4.2 Interviews result

The interviews were conducted to shed more light on the information gathered by the questionnaire, especially in regard to the four largest organizations. The interviews results are presented and placed in the context of the questionnaire results.

The four quality mangers who were interviewed worked for the four largest organizations, i.e. large contractors, CL1, CL2 and large engineering firms, EL1 and EL2. All of the quality managers were working with their organization when the organizations' current quality management system was implemented. All had a certified ISO9001 quality management system, except for CL1, but they operated a quality management system that was based on the ISO system. The four organizations had been operating their current quality management system for 3-5 years.

4.2.1 Motives for QMS implementation

It is obvious based from these interviews that most of the organizations based their decision on implementing the current quality management system on the grounds of market demand i.e. demands from project owners.

- CL1 quality manager said that the rationale for implementing the system was that there had been certain expectations that project owners would soon require contractors to have an ISO certification. Therefore, they wanted to be prepared for the certification process. Asked about the reasons for not going all the way in terms of a formal ISO 9001 certification, the interviewee said that it would reduce their competitiveness since they would be running a more expensive system than competitors.
- CL2 quality manager said that they had extensive operations in many locations so that the rationale for implementation was to achieve uniformity in the management of projects while increasing operational efficiency. He also said that demands from foreign clients and contractors played a role in the decision on implementing the system.
- EL1 quality manager said their main reasons for implementing the ISO 9001 were due to demands from project owners.
- EL2 quality manager said that the motives were mainly due to increased quality awareness and demands from project owners.

4.2.2 Benefits from QMS implementation

All the interviewees agreed, without a doubt, that the implementation of their quality system has had substantial advantages.

- CL1 quality manager mentioned the information flow and personnel's access to information as well as information regarding personnel's experience and licenses.
- CL2 quality manager said that the ISO certification opened their doors to foreign markets and projects. In the last four years, due to the economic crisis, the

organization has undergone major changes, one of which is staff reductions. The quality management system proved useful in preserving knowledge that would else have been lost through staff cuts.

- EL1 quality manager said that it had proven to be very valuable to the organization to have the traceability as well as to have all their processes listed.
- EL2 quality manager said that work practices are more coordinated which is very helpful to them because they have operations at multiple offices. This strengthens the organization as a whole.

4.2.3 Teaching

The questionnaire results reveal differences in the amount of training personnel received in each of the four large organizations. The interviews revealed differences in the organizations' methods on teaching their personnel to use the quality management system. Indeed, when comparing the two large contractor organizations, it was clear that there was a difference in their teaching methods.

CL1 does not systematically educate employees in regard to the quality management system. The quality manager hands out an operational manual that holds necessary information for the employee. This is, though, limited to management personnel. Personnel are also supposed to be educated on site by the site manager. The CL1 quality manager however believes that guidance on site could be improved.

CL2 quality manager says that during the system certification process and after certification, personnel were systematically educated, but due to constant staff cuts, system education and training has been declining and was dropped in recent years. But now, training frequency and amount of training is beginning to increase again.

There seems to be different training emphasis between the two organizations. When looking at the questionnaire results, 33% of CL1 employers were positive towards the amount of training received, as seen in Figure 4-17 while 60% of CL2 personnel were positive towards the amount of training received, as seen in Figure 4-18.

Both of the engineering firms EL1 and EL2 said that they educate their people in various ways in the use of the quality management system and its implementation. Newcomers are educated and, in addition, shorter training and sessions with meetings (for enlightenment) are conducted. Despite these initiatives, only 40% of EL1 personnel are positive towards the amount of training they received as can be seen in Figure 4-19; while 50% are positive with EL2, as can be seen in Figure 4-20.

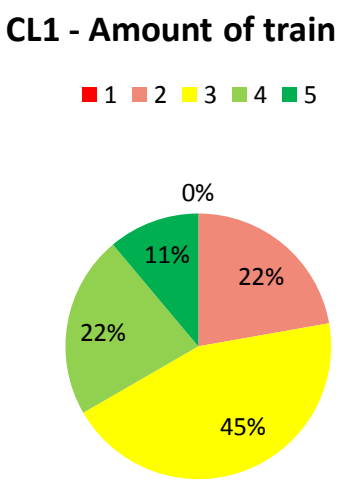

Figure4-17: CL1 Training

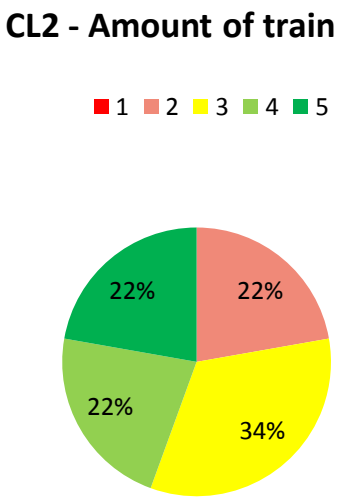

Figure 4-18: CL2 Training

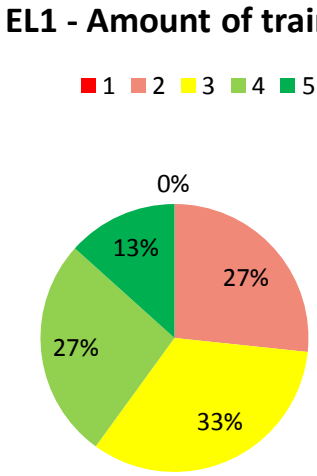

Figure 4-19: EL1 training

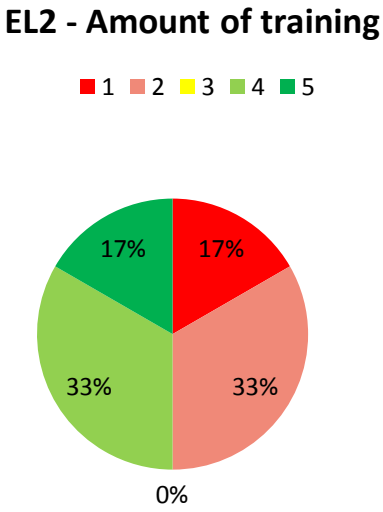

Figure 4-20 EL2 training

4.2.4 Quality cost tracking

The interviewees were asked to what extent their organization collected quality cost. The following responses were received.

- CL1 quality manager states that they collect quality cost partially. The cost for the department is always available. The cost that is not available is the cost behind quality managers at each work site and the cost of quality control. The costs of mistakes, both direct and indirect are registered to a very limited extent. Their system assumes this is done systematically.
- CL2 does not collect the quality cost properly. ISO 9001 assumes this cost is collected systematically. Despite this is not being done, they have all the appropriate tools and registration processes to record available costs.
- EL1 quality manager said that they register all quality cost. They register the time that goes in operating the system and they register the inner quality cost as well as registering the time that goes into correcting mistakes.
- EL2 quality manager said the cost of operating the quality management system and the quality department was available, but people were not preoccupied with it since it is an integral part of running the organization. The interview however said that the company has failed to keep adequate track of the cost of rework due to mistakes because people are reluctant to register it or let anyone know it exists.

Three of the quality managers identified the human factor for being a large part of the lack of quality cost tracking i.e. people seem to be reluctant to register cost deriving from mistakes.

- In the questionnaire, participants were asked whether or not their organization collected quality costs. The most common answer given was “I don’t know.” The results for each organization seem to indicate that the majority of the general employee does not know whether or not the quality cost is being collected.
- Based on the interviews, there are improvements needed within the contractor firms in relation to collecting quality cost, especially if they seek to comply with their quality system demands. Based on the questionnaire results for the engineering firms, assumptions can be can be drawn that the quality cost is not being collected in full extent since employers are not aware of the quality cost tracking as can be seen in Figure 4-17.

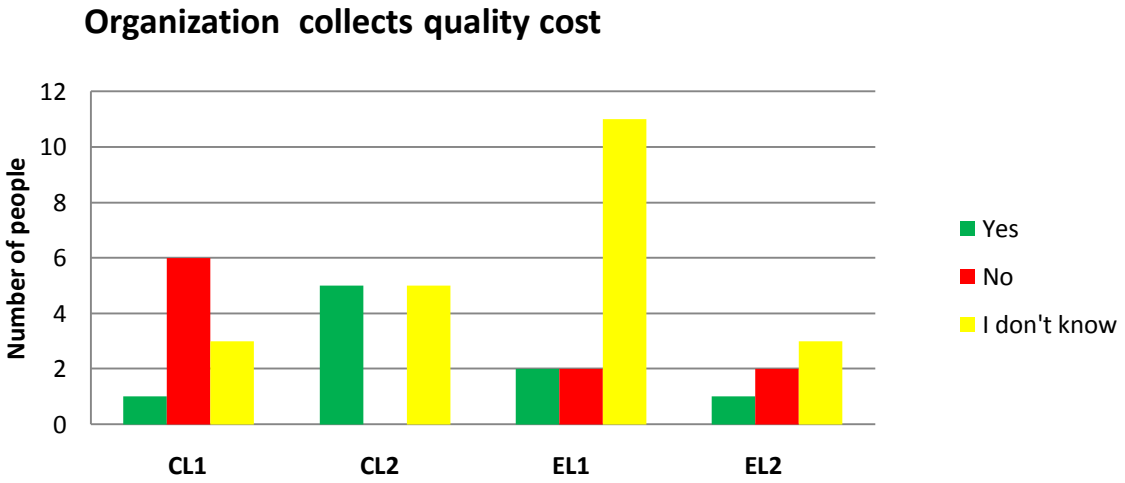

Figure 4-17: Employers knowledge of quality cost tracking

4.2.5 QMS inhibitory factors

The quality managers did not see any disadvantages or inhibiting factors that had complied with implementing the quality management system. CL2 said that on the contrary, the quality management system had made it possible to them to leap forward and make changes because they had written processes for all their work. This fact has made the organization better equipped to see and grab available opportunities. All the quality managers identified the human factor as a barrier to successful use of their system:

- All the quality managers said that there would always be some people that were opposed to the system because they wanted to carry their work in their heads and felt that the system is getting in the way of doing so.
- EL1 quality manager said that to begin with, there were difficulties in enabling the personnel to participate. That situation has changed for the better as people begin to realize the value of the system.
- CL1 quality manager even said that some personnel, especially those who recently started working with the organization, are dissatisfied that the system does not go far enough in defining work processes. All the quality managers also mentioned that there were always individuals who thought that the system was making them do excessive and unnecessary paperwork. The CL1 quality manager added that experienced workers who had been within the industry for a long time were more likely to be a part of this group.
- EL2 quality manager said that some individuals did not find the quality management system completely applicable to their work, although added that it makes it possible for the organization as a whole to march in step, which results in a better and stronger organization

4.2.6 Quality status

All the interviewees were asked their personal opinion regarding quality status overall in the Icelandic construction industry. All the quality managers agreed that it could be improved.

- They agreed that the industry as a whole has not reached as far as they would have hoped for in the use of quality management and quality management systems.
- All the quality managers identified project owners as key players in increasing the use of quality management systems since they set the rules of the game.
- CL1 quality manager said that he had the impression that the project owners were not fully realizing the utility value of quality management systems.
- EL1 quality manager said he had the impression that the Icelandic construction industry could be further ahead in implementing and getting quality management systems certified, especially the contracting firms.
- EL2 quality manager expressed concerns that there could be setbacks in quality related matters within the industry, as a consequence of the economic crises. Although the large engineering and architecture firms had received certifications before the crash, the contracting business had not come as far. Many contracting companies have gone bankrupt or are struggling. Therefore, there is not much room for thought about quality system implementation.
- EL2 shared his impressions about how some of the contractors who have implemented systems have not tailor-made the system to their organization‘s requirements and, therefore, it is not as effective as it could be. These parties can say they have a system in place, but it really is not fully supporting their business or reality.

5 Discussion of results

This chapter discusses the results of the research. The chapter presents the major findings of the research and formulates the answers to the research questions presented in the first chapter. The research results are furthermore presented in relation to earlier findings. The research implications are formulated and suggestions for further research are then presented. The purpose of this research was to explore the quality status in relation to aspects of quality within the Icelandic construction industry.

5.1 Study findings

The study suggests that quality is a problem for the construction industry in Iceland. Quality could be improved. The study furthermore suggests that there is a gap in the use and knowledge of quality management and quality management systems.

5.1.1 Is quality a problem for the Icelandic construction industry?

The research revealed that there is scope for improving quality. The research participants found quality to be inadequate. The research revealed that contractors' employees rated the quality status in a positive manner, slightly above the neutral zone, while participants from engineering firms rated the quality status in the neutral zone. The research indicates that all the quality professionals interviewed found that quality was lagging and could be improved.

Former studies presented in the literature research support the research results. There has been increasing emphasis amongst construction professionals on the necessary of quality improvement. On the one hand, the construction industry has been lagging behind other industries when it comes to efficiency. On the other hand, projects are getting bigger and more complex that has led owners to increasingly demanding higher standards for their delivery.

a. What are the main problems and to what extent are they occurring?

The problems that are responsible for the largest part of the defect cost occur in the design phase and in the construction phase. Their reasons both lie in the field of project management and construction execution. Several research found the total cost of quality rectification problems to range from 3.4% to as high as 12% of the project's value. No research has yet been conducted on quality failures within the industry in Iceland. Despite that, there are no indications that quality failures are occurring at a lower level than in those research.

b. Is it possible to improve the quality?

This research indicated that the construction parties see quality to be inadequate. Therefore, there must be a scope for improvement. The research revealed that quality professionals saw clear improvements in their organizational operations after having implemented new work methods based on quality management. Their experience replicates the findings of other

research presented in the literature research, where there were clear improvements in project performance (cost, time and quality) after having challenged existing working practices.

Some researchers have pointed out similarities between quality and safety. The research revealed that participants rated the overall safety status higher than the quality status. It is the author's impression that a change for the better has been ongoing with regards to safety culture over recent years. One factor that could have influenced these changes is the high demands that have been made in specific workplaces and projects, such as at the aluminum plants in Iceland. The increased knowledge and improved safety culture that people have adopted there seems to be slowly transferring to the external environment and on to other projects. The point about making this connection is that there seems to be a domino effect in how the safety culture has been evolving for the better. Things do not change overnight. If more emphasis were to be put on raising quality, the quality culture would slowly begin change for the better. Project owners play the key role in this relationship, by setting higher demands; the rules of the game would then change.

5.1.2 What meaning does the industry put in quality?

The participants ranked repeat business from the client and management commitment to quality as the top quality indicators. What is interesting is to look at what the participants put on the bottom of the list. The lowest is quality awards, which in itself is not abnormal since there are no quality awards granted in Iceland that the author knows of. But the second and third lowest ranked items are the length of warranty and the amount of rework due to errors. Usually warranty is a direct reflection of the trust the maker of a product has in his products and their durability. Construction warranty is not common practice in Iceland which could explain the low rank. However, the low rank of amount of quality failures could indicate that the effects of quality failures are being underestimated.

Most participants defined quality as meeting all the customer expectations or demands for the finished product. The second largest group defined quality as able to guarantee that the finished product will not fail or have problems. This differs from a study made by Hoonakker (2006), where he found that contractors had an attitude of "looks good, feels good" which is a measure that is hard to quantify. It is, however, possible that the sample method is causing this difference since there were no small contractors who were included in the sample of this research.

The research revealed that the general employee was quite uncertain as to the term of quality cost. Most participants correctly linked quality cost with prevention cost and appraisal cost but only a few saw the cost of deviation being a part of the term. Participants also tended to link the cost of quality to quality assurance. Quality assurance only insurances the project owner should the Contractor/Engineering firm not achieve project completion. Quality assurance has therefore nothing to do with the overall quality of the work and is not part of the quality cost. Previous researchers have asserted that there is a common misunderstanding on quality related terms, such as quality management, quality systems and quality assurance (Sigurðardóttir, 2008). This supports the theory that knowledge of these matters needs to be improved.

5.1.3 Do quality management systems increase quality?

The research results indicate that there were substantial organizational advantages that resulted from implementing a quality management system. All quality managers identified clear improvements in the organization's operations after system implementation, particularly with regards to information flow and preserving knowledge. The overall quality of the organization working methods improved with the quality management system implementation while making all its operations more coordinated and in step. These findings are in coherence and supported by previous findings. Love and Irani (2003) concluded that an effective quality management system would not only be cost effective, but would result in substantial savings due to increased information flow resulting in reduced costly quality rectification problems.

5.1.4 By what means is the application of quality management systems conducted?

The use of quality management systems is becoming more common in the construction industry, though it is not as widespread as in other industries. More and more engineering firms are becoming certified, especially the larger ones. However, there are indications that contractors are lagging behind. Only one of the larger contractors has a certified quality management system. One reason identified for this being the case is that project owners have not been setting unconditional demands on contractors for a certified system.

There are indications that this scenario could be changing with the new building laws. In those laws, more responsibility is put on the owner for hiring capable professionals for each aspect of the construction project. The new laws furthermore demand that designers, construction managers and master craftsmen are required to have an implemented quality management system. The deadline given for meeting those new demands is 1 January 2015. However if the parties have not received certification by an accredited certification bodies by that time, the system can be assessed by the Construction Authority. The author believes that this exclusion will truly reduce the effects that else could have been obtained by having certification as an unconditional demand.

a. What is the employers' experience of working with quality management system?

The research revealed that there seems to be a gap in the training the employees are receiving from their employer in implementing the quality management system. There was a higher satisfaction in the training received with the employers of the engineering firms; whereas, 47% were positive towards the amount of training received, 29% were neutral and 24% were negative. There was a little lower satisfaction among contractors, where 30% were positive towards the amount of training received, 40% were neutral and 20% were negative. In the research, nearly half of all participants were satisfied with their training. Explanations for this difference between types of firms can be explained with different training methods. The training amongst the engineering firms was in more comprehensive manner than with the contractor firms where a training gap was identified. This being said, the overall training process and training methods on implementing the system could be improved.

There was a difference in participants' views on top management commitment towards the quality management system. With the engineering firms, 76% either agreed or strongly agreed

with the statement that top management was committed to following the quality management system. With the contractor firms, 59% either agreed or strongly agreed with the same statement. This could indicate that, in general, there is a stronger top management commitment towards quality management systems with the engineering firms than the contractor firms.

The research revealed that there was a very positive view on the usefulness of the quality management system and its ease of use. The overall experience and satisfaction of working with the quality management system has been positive, both for the employer and the organization.

There were few inhibiting factors or disadvantages associated with implementing the system. The red thread in this context is that it seems to be hard, especially to begin with for people to adapt to change, especially if they do not see the gains of doing so and feel like the changes bring them unnecessary or excessive work..

b. Are there any gaps in the use of quality management systems?

The results indicate that there is a gap in the collection of quality cost. A majority of the quality managers interviewed said that quality cost is not being collected up to the level that complies with the requirements of their quality management system. Only one of the quality managers interviewed said that quality cost was being collected to the full extent, but despite that, the majority of employers participating in the survey were uncertain of that fact. This could partly be explained by the confusion the participants were having with the term "quality cost." These findings are supported by previous findings that were presented in the literature research showing that few organizations in the construction industry collect the cost of non-conformance.

The research revealed that there were some individuals who were reluctant to work according to the quality management system since they either felt it was not applicable to their work or made them do excessive unnecessary work. These results are somewhat compatible to Sigurðardóttir's (2011) research where she concluded that it had proven hard to get personnel to see the positive side of the quality management system in the implementation process (Sigurðardóttir, 2011).

5.2 Study further research

Future research should be conducted on the extent of quality failures and non-conformance in Icelandic building projects, both during the design phase and during execution. A study should also be conducted on the whether or not implementing a quality managment system proves to be cost effective for construction organizations. Both these studies would be worthy research topics for researchers and of value to the construction industry.

6 Conclusion

The purpose of this research was to explore construction quality, quality aspects and the problems the industry is having with quality. The research revealed that construction parties find quality to be inadequate. The research identified problems the industry is having with quality and quality failures. A gap was identified in terms of knowledge of quality management and the application of quality management systems.

The research discussed the use of quality management systems in terms of effectiveness and utility to organizations within the industry. Construction organizations identified clear improvements in the organization operation and effectiveness after implementation. Furthermore, personnel working with the system were seen to have a positive attitude towards it and its application. However, the research indicated that employers training on implementing quality management systems could be improved. Merely half of participants were satisfied with the training received on implementing the system. Furthermore the study suggests that there is a gap in the use and implementation of quality management and quality management systems and that knowledge about these matters is inadequate.

There were indications that the effects of quality failures were being underestimated. Very few construction organizations seemed to show interest and put effort into collecting quality cost and, from that, gaining knowledge on the extent of quality failures. Furthermore, the 'general employee' was confused with what was involved in the term quality cost and whether or not it was being collected in their organization. Most of participants in the research correctly connected the term with prevention cost, half of them connected it to appraisal cost, but less than one-third realized that deviation cost was a part of the term. Furthermore, many participants connected the term with quality assurance. This supports the theory that knowledge on quality related matters needs to be improved.

The main problem that the construction industry is having with quality and improvements of quality is that the quality culture seems to be underdeveloped. The peculiar characteristics of the construction industry seem to make it harder than in some other industries to adapt to changes. If more emphasis would be put on raising quality, increasing quality demands and increasing the use of quality management systems, the knowledge on these matters would improve and the quality culture and quality status would slowly begin change for the better. There were indications that project owners did not fully realize the value and benefits of dealing with parties with certified quality management systems. Project owners were identified as key players in increasing the use of quality management systems within the industry, since they set the rules of the game.

Every journey starts with a small step. Existing working practices must be challenged. The path for improving lies in strategic management which is involved in measuring the status, measuring progress made, and following the continual improvement philosophy. When organizations know where they stand and what can be improved, they can formulate an appropriate strategy towards progress and get where they want to be.

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Appendix A: Letter of participation

HÁSKÓLINN Í REYKJAVÍK
REYKJAVIK UNIVERSITY

28.mars 2012

Kæri viðtakandi,

Sandra Dís Dagbjartsdóttir heiti ég og er nemandi í meistaranámi í byggingarverkfræði (sérh. framkvæmdastjórnun) við tækni- og verkfræðideild Háskólans í Reykjavík. Meðfylgjandi er rannsókn sem er hluti af meistaraverkefni mínu. Tilgangur rannsóknarinnar er að skoða stöðu gæðamála, viðhorf til gæða og notkun gæðakerfa og hverju má úr bæta. Rannsóknin einblínir á byggingariðnað á Íslandi.
Niðurstöður rannsóknarinnar verða kynntar í júní.
Rannsóknin er nafnlaus og því er hvorki hægt að rekja hana til einstakra fyrirtækja né einstaklinga við úrvinnslu gagna.

Áætlað er að það taki á bilinu 5-10 mínútur að svara rannsókninni.
Vinsamlegast smellið hér til þess að opna rannsóknina.

Rannsóknin er opin til 10 apríl

Með von um jákvæð viðbrögð.

Kveðja,
Sandra Dís Dagbjartsdóttir
Netfang: sandrad07@ru.is
Sími: 866-0324

Dear recipient,

My name is Sandra Dís Dagbjartsdóttir and I am a student in Construction Management at the Univeristy of Reykjavík.
The following research is a part of my master thesis. The research aims to explore the quality status ,views towards quality and the use of quality management systems in the construction industry in Iceland. It is estimated to take around 5-10 minutes to complete the research and responses cannot be traced back to individual organizations nor induviduals.

The research will be open until the 10th of april

Please click here to participate.

With the hope of possitive reaction

Best Regards,
Sandra Dís Dagbjartsdóttir
Email: sandrad07@ru.is
Phone: 866-0324

Appendix B: Questionnaire design

Background questions

Gender
Kyn

- Male (karl)
- Female (kona)

How old are you? (Aldur)
Aldur

- 25 or younger (25 eða yngri)
- 26-35 (26-35)
- 36-45 (36-45)
- 46-55 (46-55)
- 56-65 (56-65)
- 66 or older (66 eða eldri)

How long have you been working in the construction industry?
Hversu lengi hefurðu starfað í byggingariðnaði?

- 5 years or less (5 ár eða skemur)
- 6-10 years (6-10 ár)
- 11-15 years (11-15 ár)
- 16-20 (20 ár eða lengur)
- 21 years or longer (21 ár eða lengur)

Where do you work?
Hvar vinnurðu?

- Engineering firm (Hjá verkfræðistofu)
- Contractor (Hjá verktaka)

How many people are currently employed with your company? *
Hvað starfa margir hjá fyrirtækinu?

- 1-30
- 31-99
- 100+

What is your educational background? Please mark your highest education level.
Hvaða menntun hefurðu? Vinsamlegast merktu við hæsta menntunarstig.

- Engineer M.Sc. (Verkfræðingur M.Sc.)
- Architect M.Sc. (Arkitekt M.Sc.)
- Engineer B.Sc. (Verk- eða tæknifræðingur B.Sc.)
- Structural/architectural engineer (Byggingarfræðingur)
- Technical study (e.g. carpenter, technical drawing) (Iðnmenntun)
- Final exam at a secondary school/grammar school (Stúdentspróf)
- Primary school (Grunnskólapróf)
- B.Sc. degree other than listed above (B.Sc. gráða önnur en talin upp hér að ofan)
- M.Sc. degree other than listed above (M.Sc. gráða önnur en talin up hér að ofan)
- Other:

What is your field of work?
Hvert er starfsvið þitt?

- Owner/CEO/Head of department (Eigandi/Framkvæmdar-/deildar-/sviðsstjóri)
- Project director/Supervisor (Verkefnastjóri/yfirmaður með mannaforráð)
- Foreman (Verkstjóri)
- Surveyor (Mælingamaður)
- Safety Management (Öryggismál)
- Quality Management (Gæðamál)
- Technician, Engineering background (Tæknimaður með verkfræðilegan bakgrunn)
- Project management (Verkefnastjórnun eða eftirlit)
- Consulting (Ráðgjöf)
- Research (Rannsóknir)
- Other:

Is there currently a quality management system in place in your company? *
Er gæðakerfi starfrækt innan fyrirtækisins?

- Yes (Já)
- No (Nei)
- I don't know (Veit ekki)

Questions about the quality management system in your organization

Spurningar um gæðakerfi sem notað er í fyrirtækinu

What type of system does your company follow?
Hvaða tegund gæðakerfis er unnið eftir?

- ◯ Quality system within the organization (Gæðakerfi innan fyrirtækisins)
- ◯ Certified ISO 9000 Quality System (Vottað ISO9000 gæðakerfi)
- ◯ Certified SI (Samtök iðnaðarins) quality system (Gæðakerfi vottað af samtökum iðnaðarins)
- ◯ I don't know. (Veit ekki)

On a scale from 1-5 how much training have you received from your employer to learn to implement the quality system on your work?
Á skalanum 1-5, hversu mikla þjálfun hefurðu hlotið frá vinnuveitanda þínum til þess að læra að nota gæðakerfið?

	1	2	3	4	5	
No training (Engin þjálfun)	◯	◯	◯	◯	◯	Comperhensive training (Yfirgripsmikil þjálfun)

How much would you agree that the quality system is useful to your work?
Hversu sammála ert þú því að kerfið gagnist þér í þinni vinnu?

- ◯ Totally disagree (Mjög ósammála)
- ◯ Disagree (Ósammála)
- ◯ Neutral (Hlutlaus)
- ◯ Agree (Sammála)
- ◯ Totally agree (Mjög sammála)

How much would you agree that the quality system is easy to use in your work?
Hversu sammála ert þú því að auðvelt sé að nota gæðakerfið í þinni vinnu?

- ◯ Totally disagree (Mjög ósammála)
- ◯ Disagree (Ósammála)
- ◯ Neutral (Hlutlaus)
- ◯ Agree (Sammála)
- ◯ Totally agree (Mjög sammála)

How much would you agree that the top management is committed to following the quality system?
Hversu sammála ert þú því að yfirmenn leggi mikla áherslu á að gæðakerfinu sé fylgt?

- ◯ Totally disagree (Mjög ósammála)
- ◯ Disagree (Ósammála)
- ◯ Neutral (Hlutlaus)
- ◯ Agree (Sammála)
- ◯ Totally agree (Mjög sammála)

Quality system not in place

Ekki gæðakerfi í fyrirtækinu

Do you know why there isn't a system in place, check as many items as apply?

Veistu hvers vegna fyrirtækið starfar ekki eftir gæðakerfi, hakaðu við eins mörg atriði og eiga við?

- [ ] We don't see the benefits (Við sjáum ekki ávinninginn)
- [ ] Too expensive (Of dýrt)
- [ ] We dont belive that the system is useful to us (Við teljum okkur ekki hafa not fyrir það)
- [ ] We don't have the time to implement it (Höfum ekki tímann í að innleiða það)
- [ ] We are currently in the implementing process (Við erum að vinna að innleiðingu)
- [ ] I don't know (Veit ekki)
- [ ] Other:

Questions about quality in general
Almennar spurningar um gæði

Please rank the following items from 1-5 based on how well they indicate good quality performance.
Gefðu eftirfarandi hlutum einkunn frá 1-5 eftir því hversu góður mælikvarði þeir eru á góða gæðaframistöðu.

	1 Less good indicator (Verri mælikvarði)	2	3	4	5 Good indicator (Góður mælikvarði)
Customer satisfaction(Ánægja viðskiptavina)	○	○	○	○	○
Management commitment to quality(Áhersla yfirmanna á gæði)	○	○	○	○	○
Repeat business from the client(Viðskiptavinur kemur aftur)	○	○	○	○	○
Skilled work force(Hæfir starfskraftar)	○	○	○	○	○
Training and education(Þjálfun og fræðsla)	○	○	○	○	○
The amount of rework due to errors(Magn tvíverknaðar v/ mistaka)	○	○	○	○	○
Regular inspections(Reglulegar skoðanir)	○	○	○	○	○
The length of warranty (in years) the companies can give on their work(Lengd gefinnar ábyrgðar)	○	○	○	○	○
General construction standards(Notkun staðlaðra staðla)	○	○	○	○	○
Quality awards(Gæðaverðlaun)	○	○	○	○	○
Certified quality programs such as the ISO9000 series(Vottað gæðakerfi t.d. ISO9000)	○	○	○	○	○

What do you consider to be the most accurate definition of quality in construction?
Hvað telurðu vera réttustu skilgreininguna á gæðum í byggingariðnaði

- ○ We don't use a definition for quality (Við notum ekki skilgreiningu fyrir gæði
- ○ Non-applicable to our work (Á ekki við þá tegund vinnu sem við vinnum)
- ○ Looks good, works good, or proud to put the company's name on the finished product (Lítur vel út, virkar vel, erum stoltir að setja nafn okkar á lokaafurðina)
- ○ Meets all customer's expectations or demands for the finished product (Uppfyllir allar kröfur og væntingar viðskiptavinars um lokaafurðina)
- ○ Meets design or code requirements, minimal call-backs or rework needed (Uppfyllir allar kröfur, hverfandi líkur á mistökum)
- ○ Able to guarantee that the finished product will not fail or have problems (Að geta ábyrgst að lokaafurðin muni vera fullnægjandi, án vandamála og bilana)
- ○ Other: _____

Does your company collect quality cost from project to project?
Heldur fyrirtækið sem þú vinnur hjá utan um gæðakostnað verkefna?

- ○ Yes (Já)
- ○ No (Nei)
- ○ I don't know (Veit ekki)

What is your definition of quality cost? Mark as many items as apply
Hvernig myndir þú skilgreina gæðakostnað? Merktu við eins mörg atriði og við á

- ☐ Prevention costs (Forvarnarkostnaður)
- ☐ Appraisal costs (Kostnaður vegna úttekta)
- ☐ Cost of repairing design/construction defects (Kostnaður vegna galla í hönnun/framkvæmdum)
- ☐ Cost of repairing defects after handover (Kostnaður vegna galla eftir afhendingu)
- ☐ Cost of quality assurance in the tender process (Kostnaður vegna gæðatryggingar í útboðsferli)
- ☐ I don't know
- ☐ Other: _____

What do you consider to be the status of safety in the construction industry
Gefðu stöðu öryggismála einkunn frá 1-5, þar sem 5 er besta einkunn og 1 versta.

	1	2	3	4	5	
Very bad - Serious problems	○	○	○	○	○	Very good - no problems

What do you consider to be the status of quality in the construction industry
Gefðu stöðu gæðamála einkunn frá 1-5, þar sem 5 er besta einkunn og 1 versta.

	1	2	3	4	5	
Very bad - Serious problems	○	○	○	○	○	Very good - no problems

Company Characteristics

On the scale 1-5, how important do you find the following company characteristics for quality work performance?
Á skalanum 1-5, hversu mikilvægir finnast þér eftirfarandi eiginleikar fyrirtækis fyrir gæðaframistöðu þess, þar sem 5 er mikilvægast og 1 minna mikilvægt?

	1. Less important	2	3 Medium	4	5.Very important
Training and education (Þjálfun og menntun)	○	○	○	○	○
Clearly defined guidelines for customer satisfaction (Vel skilgreindar viðmiðunarreglur fyrir ánægju viðskiptavinar)	○	○	○	○	○
Means and methods for ensuring continuous improvement (Aðferðir til að tryggja stöðugar umbætur)	○	○	○	○	○
Clearly defined goals relating to quality work performance (Vel skilgreind markmið gæðaframistöðu)	○	○	○	○	○
Systems for collecting and tracking data for ensuring quality objectives are reached (Kerfi til að safna og rekja gögn til að tryggja að gæðamarkmiðum sé náð)	○	○	○	○	○
A review/analysis process for identifying errors in the system (Greiningarvinna til að finna bresti í kerfi)	○	○	○	○	○

Improving quality

Að bæta gæði

Please rank the importance of the following aspects for improving quality on a scale from 1-5 where 1 is most important and 5 less important.
Vinsamlegast leggðu mat á mikilvægi eftirfarandi þátta til að ná fram auknum gæðum með því að gefa þeim einkunn á skalanum 1-5, þar sem 5 er mikilvægast og 1 minna mikilvægt.

	1 Less important	2	3 Medium	4	5 Very important
Employee Involvement (Þátttaka starfsmanna)	○	○	○	○	○
Management commitment (Áhersla stjórnenda)	○	○	○	○	○
Skilled workforce (Hæfir starfsmenn)	○	○	○	○	○
Communication between managers and employees (Samskipti yfir- og undirmanna)	○	○	○	○	○
Training and education (Þjálfun og menntun)	○	○	○	○	○
Subcontractors involvement (Þátttaka undirverktaka)	○	○	○	○	○
Organizational culture (Fyrirtækjamenning)	○	○	○	○	○
Well-defined roles and responsibilities (Vel skilgreind hlutverk og skyldur)	○	○	○	○	○
Clearly defined quality goals and objectives (Vel skilgreind gæðamarkmið)	○	○	○	○	○
Review /analysis used to improve performance (endurskoðun/greining til að bæta framistöðu(	○	○	○	○	○
Regular inspections and audits (reglulegar skoðanir og úttektir)	○	○	○	○	○
Incentives for good quality performance (Hvetja til góðrar gæðaframistöðu)	○	○	○	○	○
Regular meetings (Reglulegir fundir)	○	○	○	○	○
Criteria used in pre-qualification in bidding process (Kröfur sem eru gerðar í forvali útboðsferlis)	○	○	○	○	○
Written program or policy (Gæðastefna eða áætlun)	○	○	○	○	○
Certified program (Vottað gæðakerfi)	○	○	○	○	○
Increased use of special software e.g. BIM (Aukin notkun sértækra forrita t.d. Bim)	○	○	○	○	○
Increased use of stragetic methods e.g. Lean (Aukin notkun stefnumarkandi aðferða t.d. Lean)	○	○	○	○	○

If there is anything you would like to express regarding this research or its topic?
Viltu koma einhverju á framfæri að lokum varðandi spurningalistann eða efni hans?