Assessment of the quality improvement in housing construction companies in Santiago, Chile

A time comparison of the impact of
quality management systems on the construction process

P.V. Tiemessen
December 2008

Universiteit Twente
de ondernemende universiteit

Assessment of the quality improvement in housing construction companies in Santiago, Chile

A time comparison of the impact of a
quality management system on the construction process

Author:
P.V. (Pieter) Tiemessen

Supervisors:
Ir. J.E. (Jimmy) Avendano Castillo — University of Twente
Prof. A. (Alfredo) Serpell — Pontificia Universidad Católica de Chile

Institute: Department of Engineering and Construction Management at Universidad Catholica

Period of research: form May 2008 till August 2008

Pontificia Universidad Católica de Chile (Santiago, Chile)

University of Twente (Enschede, The Netherlands)

Foreword

This report is written in order to obtain the degree of Bachelor in Civil Engineering and Management at the University of Twente. The research was carried out at the Department of Engineering and Construction Management at the Pontificia Universidad Católica de Chile.

Here I would like to thank the people that were important to me during the execution of the research. I would like to thank Professor Alfredo Serpell and Ir. Jimmy Avendano Castillo for their supervision and Ir. Tania Romero for her advises. Then I would like to thank all the people of the Oficina Gestion for their great help, especially Andres Rodriguez, Hugo Berroeta and Omar Zegarra. I would also like to thank all the people that participated in the interviews, especially Patricio González. Last but not least thanks to Maarten Cannegieter for the contacts and information.

Enschede, December 10, 2008

Pieter Tiemessen

Management summary

With the implementation of a ISO 9001:2000 certified Quality Management System (QMS) Chilean housing construction companies are trying to improve the quality of the construction process and as a consequence of that the quality of the end product, the building. Implementing a QMS can have great benefits, but might also not perform in the foreseen way. The Chilean construction industry is booming, but is still very labour intensive and highly fragmented. Ir. Tania Romero measured in 2006 the impact of the implementation QMSs in the construction industry, on the performance of the construction processes and on the quality of the houses. Her research forms the basis of the research that will be presented in this report. The goal of this research is to find out if the performance of the construction processes in ISO 9001:2000 certified construction companies improved during the last 2 years. The performance of the construction processes in ISO 9001:2000 certified construction companies is measured and compared to the situation in 2006 (the results of the research of Romero, 2007). To measure the performance of the construction process, the quality of the construction process was defined. The variables that represent the dimensions of the quality of the construction process where defined as: Productivity, Compliance with the programming, Construction costs, Accidents, Caring for the environment, Efficiency of administrative processes and Efficiency in managing resources. In order to measure the performance a questionnaire is constructed which is applied to 11 practitioners in a personal interview. For every dimension several questions where created that needed to be answered in a 7 point Likert scale. Having the possibility to interview practitioners in Chile, gave a good opportunity to get extra information about the Chilean construction industry at the topics of time performance (delays) and cost of quality (rework costs). The obtained data was analysed using the SPSS software version 15.

The main conclusion of the research is that the quality of the construction processes in ISO 9001:2000 certified housing construction companies does not significantly differ from 2 years ago. Since the QMS focuses on continuous improvement, a higher quality could be expected.

An other conclusion of the research is that there is no statistical significant difference found between the perceptions of the groups Headquarters and Construction site. In the research of Romero (2007) there was a statistical significant difference. The fact that the interviewed groups in the organisations think the same about the application the QM principles, is a difference compared to 2 years ago. Top management support and having the same organisational goals are important factors for the success of a QMS (Omar and Low, 1997; Romero, 2007). The research indicates that this factor for the success of a QMS is at place in most housing construction companies.

Several recommendations follow from this research. These recommendations are divided into two types: Academic recommendations and recommendations for the construction industry.

Academic recommendations:

- Obtain more interviews to increase the significance of the research results.
- A research should be carried out which goes into the possibility to measure also the indirect costs of non-conformances.
- It should be investigated how workers that work on a construction site can be trained.
- More research should be carried out in order to find possibilities to improve the construction processes in order to increase productivity in Chilean construction companies.

Recommendations for the construction industry:

- The research indicated that the people who need to operate the QMS need good schooling before they start working with the system. Construction companies need to school these persons.
- Construction companies should give the workers a basic training in the principles of QM. The workers need to understand how the QMS has to be operated.
- The construction companies need to make their planning as realistic as possible.
- Safety at the construction site should be improved.

Table of contents

1 Introduction

In this introduction chapter first the background of the research, the construction industry in Chile, will be discussed. Then a summary of the research of Romero (2007) will be presented, which measured the impact of Quality Management Systems (QMSs) in the construction industry. Romero's research forms the basis of the research that will be presented in this report. It will be explained that the research presented in this report focuses on the construction process. Hereafter the research problem will be defined. Here from follow the research objective and the research question. How the objectives will be achieved and how the questions are being answered is described in the methodology. Here also the limitations and risks are being handled.

In the second chapter the literature regarding the research topic will be discussed. In chapter 3 the research methodology will be explained more extensively. Here is also described how the data will be collected. What follows then is the analysis of the collected data in chapter 4. Here also a comparison between the research results of Romero (2007) and the results of this study is presented. Furthermore the research results on the quantitative variables time performance and cost of quality will be given. During the interviews with the practitioners multiple striking issues regarding the quality improvement in housing construction companies raised, which give a better insight into the research topic. These issues of interest are discussed in Chapter 5. The conclusions and answers to the research questions are presented in Chapter 6. Recommendations for the industry, as well for future research topics are given here.

1.1 Construction industry in Chile

The construction industry Chile forms the main background of this research. It gives the setting in where the research took place and therefore it will be described hereafter. Chile is one of the most stable economies of Latin America. Though the nation derives a majority of its revenues from copper exports, it is now making a concerted transition to other sectors. Populated by about 3,500 contractor-players, the construction industry of Chile is forecast to contribute an estimated 9% to the nation's gross domestic product (GDP) in 2007 (Chile Infrastructure Report Q1 2008, 2007 November).

At the end of 2007, it anticipates that investment in new projects - including housing, industrial projects and public infrastructure - will rise by 7.7% to US$15.6 billion, growing well ahead of GDP growth of around 5.5%. It has seen growth that Jaime Muñoz, vice-president of the Chilean Construction Chamber (CChC), describes as "explosive". In 2007, new industrial projects represented investment in construction worth US$7.0 billion, up from US$5.7 billion in 2005 and US$6.5 billion in 2006, according to the CChC (Dowling 2007). Between 2001 and 2005, investment in construction was led by the development of both public and private infrastructure, which represented 64.1% of total investment in the sector, while housing accounted for the remaining 35.9% (Foreign Investment Committee and the Chilean Chamber of Construction, 2007).

The Chilean economy has been thrown open to liberalisation with an extensive privatisation policy. Infrastructure, especially roadways, has improved substantially since the adoption of concessions to maintain commercially viable roads. Construction demand in the form of housing units is also expected to drive the growth in the industry where more than 500,000 units are planned to be built by 2010.

Proposed free trade agreements (FTAs) with Malaysia, Thailand and Ecuador in 2007-2008 are expected to provide an additional boost to the construction industry. According to BMI, the Chilean construction industry is forecast to be valued at US$16.89 billion by 2012 (Chile Infrastructure Report Q1 2008, 2007 November).

Figure 1: Location of Santiago in Chile

In spite of the bright horizon, the Chilean construction industry is still very labour intensive. Also, building material costs are bound to be affected by any flare-up in global oil prices. Further, the industry is highly fragmented with few local contractors having the ability to handle major infrastructure or housing projects (Chile Infrastructure Report Q1 2008, 2007 November).

1.2 Research Romero (2007)

The research of Romero (2007) forms the basis of the research that will be presented in this report. Therefore the main points of that research will be described hereafter. In the years 2006 and 2007 Tania Romero conducted a study with the title: Critical analysis of the impact of quality management systems in construction. The research was conducted at the department of Engineering and construction management at Pontificia Universidad Católica de Chile under supervision of professor Alfredo Serpell. The goal of the research was to determine the impact of ISO 9001:2000 certification on the performance of housing construction companies. This study was divided in three areas of interest: 1) to measure the current level of application of quality management's principles; 2) to measure the impact on process improvement; and 3) to measure the impact on the quality of houses. The research instrument was a survey that was applied as a personal interview to 118 individuals from 11 Chilean housing construction companies out of a total universe of 34 ISO 9001:2000 certified housing construction companies.

The research that will be presented in this report elaborates on the second point of the research of Romero. It focuses on the impact of ISO 9001:2000 certification on process improvement in housing construction companies. Since the construction industry in Chile is booming the last years and will keep growing in the years to come, the construction process is of a big interest. Improvement of the construction process is an important topic within the construction industry as will be described in the literature review in chapter 2. Since the research of Romero forms an important basis of this research it will firstly be described more extensive, thereafter the research problem will be given.

The universe of Chilean IS0 9001:2000 certified housing construction companies was to be determined by Romero, since an official listing of companies certified under this norm is not available. 34 IS0 9001:2000 certified housing construction companies were identified in Chile, 27 of them where headquartered in the Santiago's Metropolitan Region. Considering the little size of the universe, it was decided to apply a census to construction companies headquartered in the Metropolitan Region. Only 11 of them were willing to participate in the survey, which represented 32% of the universe. The sample in each company consisted of at least one person from each production line's hierarchical level, that is, from the CEO to the foremen. Headquarters' personnel and construction site's personnel from each company were interviewed. Each company was free to choose the construction site from

which the site personnel was interviewed. The company had to choose the most representative construction site of its QMSs application.

To determine the impact of ISO 9001:2000 certification on the process improvement in housing construction companies, the quality of the construction process needed to be measured. Here for first the dimensions of the quality of the construction process were identified. The dimensions were found by analyzing the frequency of appearance of different dimensions in the existing literature. The chosen dimensions were the variables that were being researched. Together they measure the quality of the construction process. The definition of Quality Management (QM) and the variables that measure the quality of the construction process are also being used in the research presented in this report and are described in the literature (chapter 2).

18 Questions where asked in the survey, aimed at determining the degree of improvement in the quality of construction processes in relation to the implementation of a QMS. Some questions asked about improvement since the implementation of the QMS. Other questions asked about the current situation of the construction process. Measuring conducted between January and July 2006.

The main results indicate that the people perceive that quality management's principles were applied in an insufficient way, but in any case, improvements have been observed in the construction processes' quality and in the houses' quality. The results of the research on the construction processes' quality will be discusses more widely hereafter.

Construction process
The study found that improvements in the quality of the construction processes have not been as huge or as immediate as expected. This is because the company staff is following the directions of a rule (the ISO standard) which they believe it does not suits their needs. The company staff also thinks they can improve the production system without changing the way they see the production system. In essence, their QMS is operating almost perfectly, but in practice it has several flaws. For example, not all staff have the same ultimate goals, which is deducted from the differences in perceptions of quality that each staff member has.

1.3 Research

1.3.1 Research problem

In the past 15 years, housing construction companies have invested a large amount of resources in the development and implementation of ISO 9001-based QMSs. Main motivators (Romero, 2007) for doing this have been: To increment the level of satisfaction of their customers, to improve their construction processes, and to assure the quality of the houses they build. However, most of the construction companies do not have information to evaluate if the investment on QMSs improved their work as they hoped.

One could expect that the implementation of ISO 9001:2000 standards and thereby QMSs (because ISO certification has deep roots in the quality management theories) should allow the achievement of improved processes and thus improved performances over time. The construction industry is however different from other industries. Following Love, Irani and Edwards (2004) the construction industry is criticized for its fragmented nature, lack of coordination and communication between participants, adversarial contractual relationships, lack of a customer-supplier focus, price-based selection, and ineffective use of technology. It could be the case that the actual adoption of ISO standards in construction companies has not or just very little contributed to achieve process improvement over time. Implementing a QMS can have great benefits, but might also not perform in the foreseen way. This is more extensively discussed in the review of the past studies in chapter 2.

To summarize the previous paragraphs, the research goal of Romero (2007) was to determine the impact of the implementation of the ISO standard, and thereby a QMS, on the performance of housing construction companies. This research builds forward on that research and will focus on the construction process. Since the QMS focuses mainly on the construction process, this part of the total construction project is the most interesting to investigate. This is because the construction process is directly affected by the QMS. Construction companies want to improve their construction processes

and thereby also the quality of the houses. By looking into the performance of the construction process the effectiveness of the QMS can be investigated. By focussing on the construction process it gives the possibility to visit projects that are currently being build and talk to people who are currently executing the work.

1.3.2 Research objective

The research problem that was described in the previous paragraph will now be translated into a research objective. The objective of the research is to find out if ISO certification and the thereby the use of a QMS in ISO 9001:2000 certified construction companies contributed to improve the quality of the construction process. In order to set boundaries of the research tighter, the objective will be set more specific: The goal of this research is to find out if the performance of the construction processes in ISO 9001:2000 certified construction companies improved during the last 2 years. The performance of the construction processes in ISO 9001:2000 certified construction companies will be measured and compared to the situation in 2006 (the results of the research of Romero, 2007).

1.3.3 Research question

The research objective now has to be translated into a research question. In order to answer the research question better, two sub questions are defined. Also a third sub question is asked to get a better insight into the situation of the construction industry in Chile.

Research question:

- Did the quality of the construction processes in ISO 9001:2000 certified housing construction companies improved over the last 2 years?
  The quality of the construction process is precisely defined in paragraph 2.4 of the literature chapter.

Sub questions:

- How is the quality of the construction processes in ISO 9001:2000 certified housing construction companies at this point in time?
- Is there a difference in the perception of the quality of the construction processes in ISO 9001:2000 certified housing construction companies, between the different groups Headquarters and Construction site?

- How is the performance of the ISO 9001:2000 certified housing construction companies on time and cost of quality?

1.3.4 Hypothesis

The expected research results are as follows: The ISO 9001:2000 certified construction companies have a construction process of a higher quality then 2 years ago. In Chapter 3 Research methodology, it will be explained how to measure and compare this quality. The ISO standard and thereby the QMS have a strong focus on continues improvement of processes and therefore the quality of the construction process should have increased. From the research of Romero (2007) was concluded that the companies with the certified QMS increased the quality of their construction processes. It can be expected that after a period of 2 years the quality of these processes has improved further. This means that the quality of the construction process at this time is higher then 2 years ago.

1.3.5 Interest

This research gives interesting insight into the situation in the housing construction industry in Chile in two different time frames. One could expect that the adoption and implementation of the ISO standards should allow the achievement of improved processes and thus improved performances over time. The construction industry is however different from other industries. It could also be the case that the actual adoption (or lack of adaption) of ISO standards in construction companies has not contributed to achieve process improvement. Companies invest a lot of money and time in getting the ISO certification and applying the QMS. For the companies it is important to see if the investment in

the system pays off. If the system made it possible to get improvement in the process and product, the investment was worth it.

1.4 Methodology

For the purpose of receiving the Bachelor degree, the researcher needed to execute a research and write a thesis. In order to reach this goal the researcher worked at the Department of Engineering and Construction Management at the Pontificia Universidad Católica de Chile for 3 months. The department wanted the researcher to build forward on the research of Romero. Because of this the basis of the research presented in this report, is the research of Romero. In this paragraph the methodology of the research will be explained. First the study design will be made clear. Then the steps that are taken in the research are briefly described with a methodology flowchart. Also the risks and limitations of the research are given in short.

1.4.1 Before-and-after study design

As described in paragraph 1.3, with this research a comparison will be made between the situation at this point in time and the situation 2 years ago (results research Romero). ISO certified housing construction companies applied a QMS during this time, and because of this the quality of the construction process may have changed. The research can be described as a before-and-after study. According to Kumar (1996) a before-and-after study design is the most appropriate design for measuring the impact or effectiveness of a program. A before-and-after design can be described as two sets of cross-sectional observations on the same population to find out the change in the phenomenon or variables between two points in time. The change is measured by comparing the difference in the phenomenon or variables at the before and after observations.

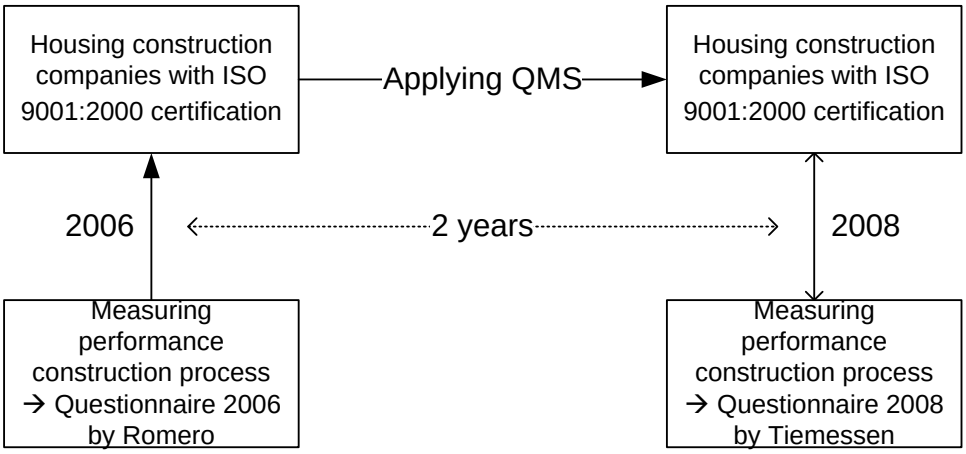

Figure 2: Study design

In this case the population is described as housing construction companies with an ISO 9001:2000 certification. The first observation (the 'before' observation) on the population was done in 2006 by Romero. Romero measured the performance of the construction process in ISO 9001:2000 certified housing construction companies. This was done by interviewing the company staff at the housing construction companies. A questionnaire was used to collect the data.

The second observation (the 'after' observation) on the population is done in 2008 by the researcher. The researcher also measured the performance of the construction process in ISO 9001:2000 certified housing construction companies. Also in this case housing construction company staff was interviewed. Mostly not the same people where interviewed as 2 years earlier, but since the study population is housing construction companies with an ISO 9001:2000 certification, the measurement on the population is still done in the same manner. The data collection instrument was a questionnaire.

The comparison of the results of both observations on the study population is needed in order to answer the research question.

1.4.2 Methodology flowchart

Now the research methodology will be described with the help of the Methodology flowchart (figure 3). The most important steps that where taken in the research are illustrated, whereby is mentioned in which chapter in this report these steps are described more extensively.

The first step in the research was to investigate the theories on QM. The research of Romero formed an important basis for this. Also a literature study was done which addresses past studies and the most important topics for this research, the QMS and the ISO standard.

From these theories, past studies and other literature followed the forming of the research problem. Logically this is followed by setting the research objective and research question. These where all already described earlier in this introduction chapter.

After the research question was described, the variables that measure the quality of the construction process needed to be defined. These variables are bases on the research of Romero and other literature. The definition of these variables can be found in the literature chapter (chapter 2).

The next step in the research is the composition of a data collection instrument, the questionnaire. This is described in chapter 3. The questionnaire in this research is based on the questionnaire that Romero used in her research.

The questionnaire was applied in a personal interview on the same study population as in the research of Romero.

The data that was collected through the interviews and questionnaires then was analysed (chapter 4). The results where compared with the results of the research of 2006 (research of Romero).

From the data analysis and the comparison with the research of Romero follow the conclusions of the research (chapter 6). The research question will be answered here.

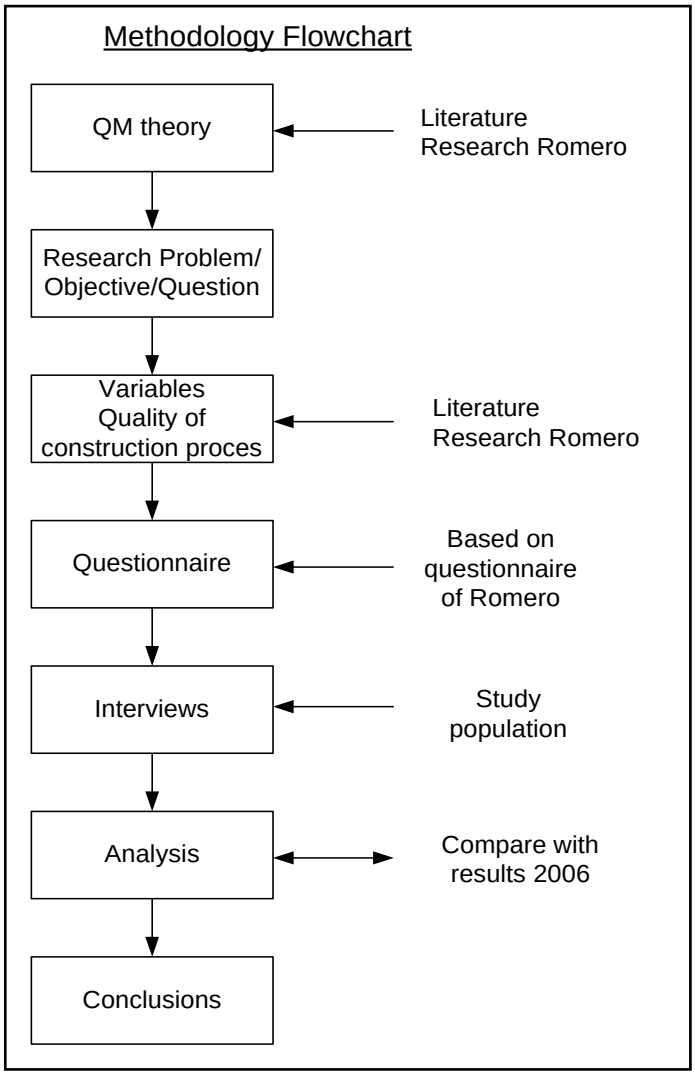

Figure 3: Methodology flowchart

1.4.3 Limitations & risks

This research is, as any research, bounded with some limitations. Also risks that can arise during the execution of the research can be identified. The most important limitations and risks will be briefly described hereafter. A more extensive description and how the researcher coped with these limitations and risks is described in chapter 3 Research Methodology.

The most important limitations are:

- The time limit of 12 weeks. In this short period of time the entire research and the writing of the thesis has to be finished.
- The language skills of the researcher. In Chile most people speak and write Spanish, while the researcher's knowledge of Spanish is very limited.

- The collection of data. For the gathering of information there has to be worked with opinions of experts and practitioners, not with factual data. This limits the robustness of the research.

The most important risks are possible difficulties in:

- The communication with the supervisors of the researcher.
- The communication with people outside the university.
- Finding people that want to participate in the interviews.

2 Literature

In this chapter the literature that is relevant for the research will be described. First a clear definition of QM will be given. Then the main advantages of the ISO standard and how a QMS should look like according to this standard, will be explained. Hereafter past studies regarding the topic of QMS in the construction industry are discussed. Finally the quality of the construction process will be defined with seven variables that have their origin in the literature.

2.1 Quality Management

In Chile the introduction of quality management systems recently began in the nineties, when seminars on the subject took place. Unlike other countries, which have followed the guidelines of different philosophies and standards, the companies in Chile are almost exclusively dictated to the family of ISO 9000, as adapted Chilean Official Rules since 1994 (Romero, 2007). The current version in force is 2000.

2.2.1 Definition of Quality Management

In the literature multiple definitions are given for the concept of Quality Management. However there is no agreement which definition can be applied to all industries and fully reflects the concept. Nevertheless, there are common themes that are emphasized in one degree or another as continuous improvement, integration of employees and equipment, thinking long term and use of statistical measures (Grandzol and Gershon, 1997, cited by Romero, 2007). The most applicable definition of Quality Management that is found in the literature, that will also be adopted in this research is as follows:

"Quality Management is defined as an integrated approach to achieve and maintain high quality results, with emphasis on maintenance and continuous improvement of processes and prevention of defects at all levels and functions of the organization, to meet or exceed customer expectations." (Flynn, Schroeder and Sakakibara, 1994, cited by Romero, 2007)

It is believed that this definition is the most appropriate for the following reasons (Romero, 2007): 1) "…an integrated approach to achieve and maintain high quality results…": in the construction industry specifically, this must involve all areas of the company in this task (human resources, procurement, etc.), so not only the area responsible for building itself.

2) "…with emphasis on maintenance and continuous improvement of processes…": it is not enough to dominate a perfect construction technique or tool, there must be constant research and innovation to maintain and improve the effectiveness and efficiency of processes, and thus maintain position in the market.

3) "…preventing defects at all levels and functions of the organization, to meet or exceed customer expectations.": is a very important point for any company in any field, especially for the construction industry. The construction industry must meet strict standards. At this moment there is also a huge housing supply, so if companies do not meet the expectations of their clients they can come in serious economic problems. In any case the ultimate goal of a company should be to meet or to exceed customer expectations.

2.2 ISO standard

The main advantages of the ISO standard will be explained hereafter. Then it will be described how a QMS should look like according to the ISO standard.

The ISO 9001:2000 is a standard that puts demands on the quality of an organization and how the organization deals with the quality at stake. After an external audit has been completed, the

organization receives a certificate attesting that they meet the requirements laid down by the standard. The main advantageous of implementing the ISO 9001 standard (Isoqar, 2008) are:

- It shows commitment to quality, customers, and a willingness to work towards improving efficiency.
- It demonstrates the existence of an effective quality management system that satisfies the rigours of an independent, external audit.
- An ISO 9001 certificate enhances company image in the eyes of customers, employees and shareholders alike.
- It also gives a competitive edge to an organisation's marketing.

2.2.1 Quality management system according to ISO 9001:2000

A quality management system based on ISO 9001:2000 provides organizations a framework for continuous improvement and provides confidence that the processes used are capable of generating products of the characteristics identified by the organization. It focuses on the analysis of customer requirements, on the definition of processes that contribute to the development of products acceptable to the customer, and to keep these processes under control through the stages detailed below:

1. Determine the needs and expectations of customers and other stakeholders.

2. Establish objectives for policy and the quality of the organization. The policy and objectives of quality provide a framework for directing the organization, determine the desired results and help to allocate available resources to achieve those results. So the goals of quality must be measurable and consistent with the policy of quality and the commitment to continuous improvement. Achieving them translates into a positive impact on product quality, operational efficiency and financial performance and hence on customer satisfaction.

3. Identify processes and responsibilities involved in achieving the goals of quality. The organizations systematically identify and manage their processes and their interrelationships, i.e. working under an approach based on processes to operate effectively, since normally the result of a process is the input for the next process.

4. Establish methods for measuring the effectiveness and efficiency of each process.

5. Apply these measures to determine the effectiveness and efficiency of each process.

6. Identify ways to prevent nonconformities and eliminate its causes.

7. Establish and implement a process for continuous improvement of the quality management system.

2.3 Past studies

There is are many studies conducted regarding the topic of the implementation of QMSs in companies. e.g. Rao *et al.*, (1997) found that ISO certification positively affects quality management practices and quality results in firms. As most other studies, this study regarded mostly the manufacturing industry. Since the construction industry is different from other industries (Love, Irani and Edwards, 2004) a closer look into the literature that addresses the implementation of QMSs in the construction industry is necessary. Multiple studies where done to investigated the results of QMSs implementation in the construction industry.

Given continuing concerns regarding the achievement of quality in the construction industry (Moatazed-Keivani, 1999), firms in the construction industry are increasingly adopting ISO 9000 as the basis for their quality management systems (Bayes, 1993, 1994; Barrett, 1994; Latham, 1994; Doe, 1995; CIRIA, 1996, 1997, cited by Moatazed-Keivani, 1999). Landin (2000) found that the broad acceptance of the ISO 9001 standard an important step is towards the establishment of systematic quality control within the construction sector.

Several studies found that the implementation of QMSs in the construction industry have affected in better results. A case study in the Singapore construction industry (Pheng, 2001) concludes that the implementation of a ISO 9000 QMS has several advantages: Improvement of the overall quality, a safer and more efficient working environment on the site, higher buildability and higher cost-effectiveness for the project. The ISO 9000 system has inevitably involved some additional costs and paperwork, but the overwhelming finding of the research of Moatazed-Keivani (1999) in the UK construction industry is that it is justifiable by the improvements gained.

In spite of the widespread acceptance of ISO 9000 in the industry some writers have voiced their concerns over the suitability of formal techniques of quality assurance to the construction industry (Seymour and Low, 1990; Pheng, 1993; Shammas-Toma *et al.*, 1996, cited by Moatazed-Keivani, 1999). In this regard it has been argued that the particular characteristics of the construction industry, e.g. fragmentation, separation of design and construction, and relative lack of control over working environment and site conditions, has meant that many aspects of construction work do not lend themselves to quantification and measurement.

Not all previous studies are positive regarding the results of the implementation of QMSs in construction companies. Quazi *et al.*, (2002) found no statistically significant relationship between ISO 9000 registration status and quality management practices and quality results of firms. A large part of the research sample consisted of construction firms.

In Honk Kong, where implementation of the ISO 9000 standard by public housing construction companies was mandatory, only a few contractors could improve their quality performance (Tam *et al.*, 2000).

Summarizing can be said that there are some studies that found no positive results of the implementation of QMSs in the construction industry. Nevertheless, the ISO standard is widespread accepted in almost every industry. Also in the construction industry there are multiple examples of companies that successfully implemented a QMS. It can be that the nature of the construction industry limits the effectiveness of the system, but it can also be that the system is not implemented or operated in a good way.

2.4 Quality construction process

In this paragraph the variables that define and measure the quality of the construction process are described. This definition matches the definitions that Romero used in her research. This will make it possible to compare results of both studies with each other.

The quality of the construction process is defined in this research with seven variables. The better the performance on these variables, the better the entire quality of the construction process will be. The variables of the quality of construction processes were obtained by selecting the most commonly used in research related to quality management and awards for excellence in quality management and then discriminated according to their applicability in this investigation (Romero, 2007). The variables that represent the dimensions of the quality of the construction process are:

- Productivity
- Compliance with the programming
- Construction costs
- Accidents
- Caring for the environment
- Efficiency of administrative processes
- Efficiency in managing resources

These variables are the same variables Romero (2007) used in here research. These variables where not changed in order to make a good comparison possible. Romero extracted the variables from the literature on this topic, but also added two dimensions. It was found that the dimensions “Accidents” and “Caring for the environment” are important dimensions in a QMS and were therefore added to the dimensions that where already extracted form the literature on construction process quality. For every variable a small description will be given:

Productivity: Is defined as the ratio between the work done and the time or resources that were consumed.

Compliance with the program: The amount of work that is completed within the scheduled time.

Construction costs: This considers cost that are associated with the construction and also post-sale costs. This variable has not been used much in the literature, but it is relevant at the time of obtaining the views of persons related to housing construction, because they are interested to know if they are "saving" to maintain a quality management system.

Accidents: This did not appear in the literature, but it regards its relationship with the influence of the implementation of a quality management system it is concluded.

Care of the environment: This did not appear in the literature, but it concluded with the implementation of a quality management system.

Efficiency of administrative processes: The process performance of the support process.

Efficiency in the Resource Management: How all the resources within the construction process are handled. Also includes the number of waste on the quantity of finished products.

3 Research Methodology

In this chapter the research methodology will be described in detail. First is explained how improvement of the construction process will be measured. Then it is illustrated how the measuring instrument, the questionnaire, is constructed. Thereafter is mapped out how the researcher collected the data. Then the sample size will be described. As the last part of this chapter the limitations and risks that are involved with this research are extensively described. Here also will be mentioned how the researcher coped with the limitations and how the foreseen risks are handled.

3.1 Measuring improvement

Measuring improvement is very difficult, because there is no hard data from which improvement can be concluded. As a basis for this research the questionnaire in the research of Romero (2007) will be used. Questions will be updated and there will be questions added to the questionnaire. So partly the same questions that where asked to the persons in the construction companies 2 years ago, will now be asked to the persons in the construction companies at this time. In this research the people who are interviewed now are normally not the same persons as 2 years ago. But the people interviewed in this research have in general the same jobs as the people interviewed 2 years ago. So they come from the same study population. Staff from headquarters as well as from the construction site are interviewed. The answers to the questions in the new questionnaire are going to be analysed and compared to the results of Romero (2007). Higher average results then 2 years ago indicate improvement. For example if people now think that there is les downtime during construction, then that can be seen as improvement. The comparison of the opinions of the different groups (2006 versus 2008) can give a good insight into the differences between the 2 timeframes.

A point of attention is that the same question might be answered a little different, because things can have changed in 2 years time. The general opinion about what they expect from the construction process can be different from 2 years ago. For example the general opinion of what is efficient handling of materials, or what is taking care not to damage the environment, can have changed a little. Maybe in general the people now expect more (or less), so the scales are not perfectly the same. However by asking the same questions or the same sort of questions a good insight can be given in how the construction process is performing at this time, according to the people who work in the companies who operate them.

3.2 Measuring instrument

The measuring instrument used in this research is a survey (questionnaire), which is applied to each person in an interview. The survey was chosen as the collecting data method, because "…it investigates on attitudes, beliefs, prejudices, preferences and opinions", according to Salkind (1999, quoted by Romero, 2007). Specifically, the objective was to obtain the people's perceptions about the use and the effectiveness of the QMS and of course the quality of the construction process. It is preferred to apply the survey as an interview in order to make sure the questions are answered in the right way. Also this gives the opportunity to deepen the research with extra information that is gained during the interview.

The quality of the construction processes is measured with the seven variables that where presented earlier in the literature chapter. The table shows the structure of the measuring instrument. It indicates which questions are aimed at measuring the different variables.

Variables	Question number in questionnaire
Quality of construction processes:	
Productivity	1, 2, 3, 4
Compliance with the programming	5, 6, 7
Construction costs	8, 9
Accidents	10, 11
Caring for the environment	12
Efficiency of administrative processes	13, 14
Efficiency in managing resources	15, 16, 17, 18

Table 1: Structure of measuring instrument

In order to make clear how the measuring instrument is constructed it has to be explained where the questions in the questionnaire ask about. Firstly it has to be made clear that in the years before 2006 several housing construction companies implemented QMS and received an ISO 9001:2000 certification. The housing construction companies did not implemented the QMS all at the same time. For every company the date of implementation is different. The moment of implementation of the QMS will be referred to with T, which is show in the table beneath.

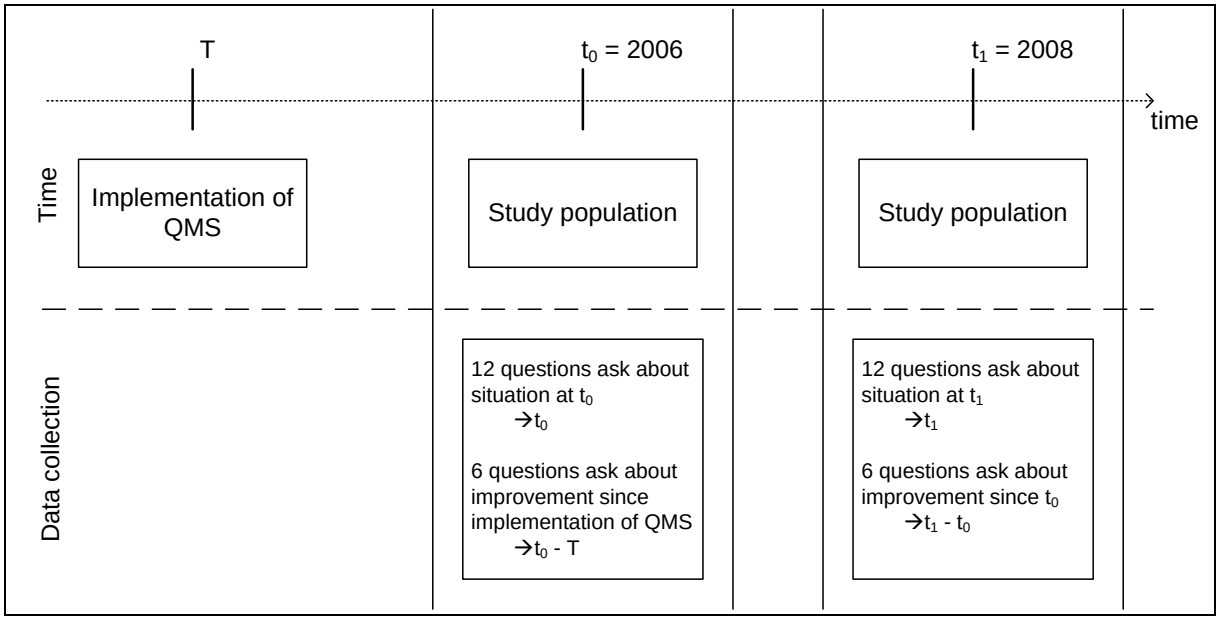

Figure 4: Data collection

The questionnaire in the research of Romero included in total 18 questions or statements that asked about the construction process. These questions refer to the performance of specific areas, the variables, of the construction process. As mentioned, the study of Romero was executed in 2006. This moment is set to be t_0. It was the first observation of the study population, which is described as housing construction companies with an ISO 9001:2000 certification. 12 of the 18 questions ask about the situation at that point in time, t_0. 6 of the 18 questions ask about the improvement of the construction process since the implementation of the QMS, which is described as t_0 – T.

The questionnaire that will be used in this research also consist of 18 questions. This second observation of the construction companies with an ISO 9001:2000 certification is done in 2008. This moment is set to be t_1. 12 of the 18 questions ask about the situation at this point in time. 6 of the 18 questions ask about the improvement of the construction process since 2006, which is described as t_1 – t_0. So, for the research presented in this report these 6 of the 18 questions needed to be changed compared the questionnaire of Romero. They now need to ask about the improvement in the last 2 years, in stead of improvement since the implementation of the QMS.

Questions number 1,2,3,5,8,9 ask about the improvement since 2006. The questions with number 4,6,7,10,11,13,14,15,16,17,18 are the same as in the questionnaire of Romero, and now ask about the situation in 2008. This is also shown in the table to the right.

	Situation in 2008	Improvement since 2006
1		X
2		X
3		X
4	X	
5		X
6	X	
7	X	
8		X
9		X
10	X	
11	X	
12	X	
13	X	
14	X	
15	X	
16	X	
17	X	
18	X	

Table 2: Content questions in questionnaire

Likert scale

The questions need to be answered based on a Likert scale of 7 points. The number 4 is the median of the scale. So if is asked about improvement the last 2 years, there is improvement when the answers score above the median.

Likert scales may be subject to distortion from several causes (Intelligent Measurement, 2008). Respondents may avoid using extreme response categories; agree with statements as presented; or try to portray themselves or their organization in a more favourable light. By adding 2 negative statements to the questionnaire the chance that the respondent agree with the statements presented is lowered. By getting the answers to the questionnaire in an interview, the distortion can be minimized.

The questions and statements in the questionnaire:

1. The productivity has improved considerably the last 2 years.
2. Productivity has steadily improved the last 2 years.
3. The amount of time busy making repairs has decreased sharply the last 2 years.
4. Generally there is no downtime during the execution of construction activity.
5. The number of activities scheduled to be completed in the stipulated time has increased significantly the last 2 years.
6. The tasks assigned to me always can be met within the stipulated period.
7. This company always comply with the work programmes.
8. The last 2 years the costs of no quality have declined considerably.
9. The cost of after-sales repairs have been greatly reduced the last 2 years.
10. I think the quality management system helps reduce the number of accidents occurring at the construction site.
11. I think the quality management system helps reduce the severity of accidents occurred at the construction site.
12. This company takes care not to damage the environment.
13. In this company the administrative processes (support process) always works correct?
14. In this company there is unnecessary bureaucracy in administrative processes.
15. On this project occurs much waste of materials.
16. The human resource management is very efficient in this company.
17. The handling of materials at the storage place is very efficient.
18. The equipment and machinery are in excellent condition to use for work.

Measuring quantitative variables

Having the possibility to interview practitioners in Chile, gives a good opportunity to get some extra information about the Chilean construction industry. All the previous 18 questions only ask about qualitative variables. To extend the research also quantitative variables will have to be examined. The research is then not only be based on the opinions of persons on qualitative questions but also conclude the opinions about quantitative variables. It was considered not possible to find the ”hard” data of the quantitative variables. Here fore the research has to be more focussed on attaining hard numbers. This research then needs to be of a different form, and not only a small interview. Considering the limits of the research, which will be described in the next paragraph, this is not possible.

Following Ir. Romero the housing construction companies might only have insight in the numbers about the time performance (delays) and cost of quality (rework costs). At the time of the research of Romero in 2006, the construction companies where not able to give here quantitative variables, because these companies did not measure it. With the implementation of a QMS more variables are being measured. This makes it more certain that is possible to get this information in this research. It is good to not only obtain numbers about the situation now, but also numbers about the situation 2 years ago (or longer). 4 Questions about the quantitative variables, time performance and cost of quality, will be included in the questionnaire. 2 questions about the time performance and 2 questions about the cost of quality construction costs.

The complete questionnaire in English and Spanish can be found in the appendix.

3.3 Data Collection

The questionnaire needed to be addressed to the people who work at the ISO 9001:2000 certified housing construction companies. The interviews always took place at the workspace of these people. For the execution of the interviews the researcher visited several headquarters of housing construction companies. Also different construction sites where visited in order to interview persons. The visited construction sites where all construction projects of apartment buildings of at least 10 stories high. Some projects where just started, while other projects where almost finished. And of course there where also projects that where halfway finished.

At one construction site the researcher was invited by the project manager to look around at the construction site for a few days. The researcher had the chance to walk with the quality manager for 3 days. The quality manager showed and explained how the QMS was executed at the construction site. This gave the researcher a good overview of how a QMS can be implemented in a construction project. Hereafter some pictures are shown of the visited construction sites.

Figure 5: Construction site in Santiago, 23 stories finished

Figure 6: Office of Quality Manager

Figure 7: Construction workers, working on the next floor

Figure 8: Construction workers, poring concrete

3.3.1 Research sample

Now the research sample will be described. First the planned research sample will be described. Because the real research sample differences a little from the planned research sample, it will be described thereafter.

Planned research sample

There is no official list of ISO 9001:2000 certified housing construction companies in Chile. At the time of the research in 2006 it was believed that there were 34 9001:2000 certified housing construction companies, of which 27 had their headquarters in the metropolitan area of Santiago. Decided was to conduct a census to builders with headquarters in Santiago. Replies were received from 11 of them.

In order to get the information to answer the research question, people in several construction companies have to be interviewed. According to Professor Serpell there are at this point in time around 50 IS0 9001:2000 certified housing construction companies. Only a relatively low number of companies can be interviewed, because of the time constraint of the researcher. Because of this, it was planned that the companies that were going to be interviewed are selected out of the 11 companies who participated in the survey that was performed by Tania Romero in 2006. If not enough companies are willing to participate in the research, other ISO 9001:2000 certified housing construction companies in Chile will be approached. The goal was to talk to 6 different companies. When possible, companies with a different size will be selected: 2 large sized companies, 2 medium sized companies and 2 small sized companies. From every company 2 people will be interviewed. One person from the headquarters and one person from the construction site (project manager). The choice of which project to visit depends on the willingness of the company and the accessibility to the project. Because of limited time and resources only offices and projects in the city of Santiago can be visited. This is not a problem since de fast majority of all ISO certified housing construction companies are situated and working in Santiago. By working in this way there can be made a good comparison between the situation in the two different timeframes, despite the relatively low number of contacted companies.

Real sample size

In total staff at 5 ISO certified housing construction companies where interviewed from 27 June 2008 till 18 July 2008. Of these companies, 3 where also included in the research of 2006 and 2 other companies were interviewed. The 5 companies that were interviewed are:

- TECSA
- Constructora Bravo e Izquierdo
- Empresa Constructora ISA
- Desarrollos Constructivos AXIS S.A.
- Constructora Fe Frande

Within the 5 companies 11 persons were interviewed. These were persons either working at the headquarters or at a construction site. At the headquarters the persons job description was Operations Manager or a Quality Manager. At the construction site the persons had as job description Project Manager or Site Manager.

Characterizing the sample

The sample is divided into the 2 different workspaces of the respondents in order to verify whether there are differences in the perception of the performance of QMS between the different groups. This is shown in the table below.

Workspace	Number	Percentage
Headquarters	5	45%
Construction site	6	55%

Table 3: Workplace of the respondents

3.4 Limitations & risks

The limitations and the risks that are involved with the research where already shortly described in the introduction chapter, but will now be described more extensively. Here also will be mentioned how the researcher coped with the limitations and how the foreseen risks are handled.

3.4.1 Limitations

This research is bounded by some limitations. The three most important limitations identified and are concerning time, language and working with opinions. These limitations will be explained hereafter. After mentioning the limitation it is described how this was managed during the research.

Time

The research is limited by the time that is available for conducting the research and writing the thesis. This thesis is written in order to obtain the degree of Bachelor. For the entire research and the writing of the thesis only 12 weeks are available. This has the consequence that the research has to be very well marked out. Also the research can not be very thoroughly be performed. Because of the limited time it is not possible to do things over or change important things along the way of the research.

Because of the time limitation the research was constructed in such a way that it could be finished in the stipulated time period. During the execution of the research some parts of research were delayed. Decided was then to focus mainly on obtaining the data, since that is the basis of the research. The time for writing the report was then extended.

Language

An other limitation of the research are the language problems. The research is conducted in Santiago, Chile where the spoken language is Spanish. Some people speak English to some extend, but this is not always the case. The researcher's knowledge of Spanish is very limited. This can cause difficulties with arranging things and gathering information.

The limitation caused by language problems was narrowed down by translating the questionnaire in Spanish. If people did not speak English, the researcher could make use of this instrument. For arranging interviews the secretary of the department was glad to help the researcher with making appointments. Because the researcher learned Spanish to some extend a simple conversation and interview in Spanish were not a problem.

An other difficulty is that the thesis is being written in English and also the communication with the supervisor in The Netherlands is in English. The researcher knows the English language quite well, but communicating in English is still more difficult that communicating in his mother language, which is Dutch.

This limitation was just something the researcher needed to cope with. Writing and communicating was done as good as possible. It took more time to write the report in good English.

Information

The final limitation that will be discussed here is of a more substantive nature. For the gathering of information there will be mostly worked with opinions of experts and practitioners, not with factual data. This limits the robustness of the research.

By making a good questionnaire with multiple questions per variable it was tried to get the data as reliable as possible. Also some questions that ask about quantitative variables are being asked. The fact that the research data is still dependent on the opinions the interviewed persons is a limitation that has to be accepted.

3.4.2 Risks

Before the start of the research it is important to indentify possible risks that can appear during the performance of the research. It is essential to know what the possible risks are, so that they can be minimized or avoided. Three risks where identified at the start of the research: Communication with supervisors, language problems and finding people for interviews. They are described and also the way how they are managed.

Communication with supervisors
One risk could be difficulties in the communication with the supervisors of the researcher. Communication with my supervisor in The Netherlands is via email. This way of communication is less effective then face to face communication. By having periodic contact about the progress of the research, good communication was still possible.

The supervisor of the researcher in Chile is professor Serpell. He is the head of the department and did not have full attention for my research at all times. A solution to this problem was that I also received supervision from an other person within the department. If I had questions about the research I could always go to this person.

Communication outside university
The second risk is difficulties in communication with people outside the university. With the execution of the research interviews with local people had to be taken. These people sometimes spoke very little English. I myself only spoke a little Spanish. There was a high risk that false or incomplete communication would occur. To capture this problem a data collection instrument (questionnaire) was constructed. The questions were available in English as well as in Spanish, so that every party can understand them.

Participants in interviews
It was difficult to find construction companies and people who can and wanted to receive the researcher for an interview. Not every company is easy to contact and will agree with an interview. Also in general the professionals in the construction industry are very busy. By using the contacts of the department this risk was minimized. Also if the researcher spoke to someone in a company it was asked if it was possible to get access to a construction project. This way of working increased the number of interviews.

4 Data analysis

The answers to the questions, collected trough the questionnaire in the interviews need to be analysed. In order to compare results of this research with the research of Romero in 2006 the answers need to be statistically analysed. For this the statistical program SPSS version 15 will be used. In order to get answers that have statistical reliability more interviews should be taken. The 11 interviews taken are not enough to get statistical reliability. However the results give an indication of the situation of the total universe of ISO 9001:2000 certified housing construction companies. The complete results of the statistical analyses can be found in the appendix. In this chapter the results of the data analysis will be presented and discussed.

4.1 Statistical analysis

The answers to the 18 questions need to be statistical analysed in order to draw conclusions. 6 Questions (questions 1,2,3,5,8,9) out of the total of 18, ask directly about improvement over the last 2 years. The values of the answers on these questions can not directly be compared with the same questions in the questionnaire of 2006. Therefore these are not concluded in this first statistical analysis. The answers to these questions will be discussed and will be put side by side with the results of the questionnaire of 2006 in paragraph 4.1.5 Improvement last 2 years.

Before the data can be analysed, the answers to 2 questions (14 and 15) need to be reversed. Because a score of "1" to this questions means that this part is doing very well, the answers need to be reversed. In the table below the reversed results of these questions are shown.

The total of 18 questions where divided over 7 dimensions. As mentioned 6 of these questions are not included in this statistical analysis because they will to be analysed in a different way. In order to make a good comparison between the results of the research in 2006 and that of 2008 the comparison will be made on certain variables and per dimension. In the table presented hereafter the questions that are expelled from this statistical analysis are marked in grey.

	2006 question number	**2008 question number**	**2006 results Mean**	**2008 results Mean**
Productivity	44	1	5,6	5,0
	45	2	5,8	5,5
	46	3	5,7	5,1
	47	4	4,5	4,2
Compliance with the programming	48	5	5,4	5,7
	49	6	5,4	4,8
	50	7	5,2	5,3
Construction costs	51	8	5,6	4,9
	52	9	5,7	4,3
Accidents	53	10	6,0	5,5
	54	11	5,4	5,2
Caring for the environment	55	12	6,5	6,0
Efficiency of administrative processes	56	13	5,7	5,4
	57	14	3,8*	5,0*
Efficiency in managing resources	58	15	4,3*	5,5*
	59	16	5,7	4,9
	60	17	5,7	5,0
	61	18	5,8	5,5

*Results of inverse questions

Table 4: Research results 2006 and 2008

The comparison between the research of 2008 with the results of 2006 can only be done on the results that are marked in white. Every dimension will be compared with the results of 2 years ago. Only on the dimension “Construction costs” there is no direct comparison possible. The comparison by dimension will be done as described in the table below.

Dimension	Comparison
Productivity:	Question 4
Compliance with the programming:	Question 5 and Question 6
Construction costs:	No comparison
Accidents:	Comparison of total score of this dimension.
Caring for the environment:	Comparison of total score of this dimension.
Efficiency of administrative processes:	Comparison of total score of this dimension.
Efficiency in managing resources:	Comparison of total score of this dimension.

Table 5: Comparison by dimension

4.1.1 Reliability Analysis

In order to find out the reliability of the measuring instrument a reliability analysis will be carried out. Reliability analysis allows knowing whether the measuring instrument is really measuring (or not) what it is supposed to measure. The reliability is measured with the Alpha of Cronbach coefficient (α) and the Item-Total Correlation (ITC). The Alpha of Cronbach coefficient measures the intern consistency. The Item-Total Correlation allows to quantify the item’s contribution to the measuring instrument’s internal consistency (Lévy and Varela, 2003). Nunnally (1978, quoted by Tania, 2006) advises as an orientation but not in a decisive way, to use scales with values of α between 0,75 and 0,9, and Lévy and Varela (2003) consider that an item is not consistent if its ITC is too low. According to Lévy and Varela (2003) generally this is less than 0,35. For statistical calculations the statistical program SPSS was used.

The Alpha of Cronbach coefficient (α) of the measuring instrument is 0,795. This value of α is a good value since it is between 0,75 and 0,9. The value of α can be higher when certain questions are eliminated from the analysis. Considering the low number of questions (12) in this questionnaire and the low number of replies (11), no questions will be eliminated. Eliminating questions will not help to increase the significance of the answers. It will only make the amount of available data less.

The Item-Total Correlation (ITC) of question 17 is a little below 0,35 (0,32) and the ITC of questions 10 and 11 is even very low (-0,24 and -0,17). This says that the results on these questions are not consistent with the results on the other questions. This means that these questions do not ask about to the same content as the other questions. The other questions all have an ITC that is higher then 0,35. Question 17 asks about the efficiency of the handling of materials at the storage place. Questions 10 and 11 ask about accidents on the construction site. It is likely to say that these questions about accidents do not measure the performance of the construction process. Maybe not all the respondents think the occurrence of accidents has something to do with the QMS, but it does. Continuous improvement is of high importance in a QMS so also the dimension of accidents has to be measured in order to see how the construction process is performing. Also for the same reasons as mentioned earlier after the analyses of the Alpha of Cronbach coefficient, no questions will be eliminated.

4.1.2 Factorial Analysis

A Factorial analysis will be carried out in order to calculate one score for each dimension. This in order to make the comparison of the results more easy. The factorial analysis is a mathematical procedure that attempts to reduce the dimensions of a set of variables, by obtaining a new set of variables which has a smaller size but is capable to explain the common variability found in a group of individuals on which the original variables were observed (Lévy and Varela, 2003). This can be denoted in the following formula:

$C = \alpha 1V1 + \alpha 2V2 + \alpha 3V3 + \ldots + \alpha nVn,$ where

C = new variable
α= a factor
V = variable.

In this case the different questions can be seen as the variables. There are multiple questions for every dimension. This dimension can be seen as het new variable. For the following dimensions one score per dimension has to be calculated: Accidents, Caring for the environment, Efficiency of administrative processes, Efficiency in managing resources. The first 3 of these dimensions consist of 2 or 1 questions. The last mentioned dimension consists of 4 questions. In order to calculate one score per dimension the average of 2 scores can be calculated. Obviously when a dimension only consist of 1 question, the score to this question also is the score for the dimension. To calculate one score for a dimensions consisting out of 4 questions a factorial analysis needs to be carried out. For statistical calculations the statistical program SPSS was used.

First the number of factors is calculated. The procedure is visualised in the table 5 hereafter. In this case 2 factors explain in total 77,5 percent of the total variance. Now the number of factors is known, a component matrix can be composed (Table 4).

	Component	
	1	2
EffResours15	,779	-,307
EffResours16	,667	-,632
EffResours17	,593	,710
EffResours18	,777	,308

Table 6: Component Matrix

For every question the highest score for 1 of the 2 components needs no be chosen. The total of these scores has to be set to 100%. With the factors that are calculated, one score for the dimension “Efficiency in managing resources” can be given. The calculation is summarized in table beneath. The score for Efficiency in managing resources calculated is 5,24. This score will be used in the means analysis that will be discussed next.

	2008 question number	**Factor score**	**Factor score %**	**2008 results**	**Score**
Efficiency in managing resources	15	0,78	0,27	5,5	1,45
	16	0,67	0,23	4,9	1,12
	17	0,71	0,24	5,0	1,21
	18	0,78	0,26	5,5	1,47
		2,93	1,00		**5,24**

Table 7: Factorial analysis

4.1.3 Means analysis

The information that was gathered can now be analysed. In order to do that some statistical parameters (Average, minimum, maximum and standard deviation) are calculated and are presented in the table below.

Dimension	Average	Minimum	Maximum	Standard Deviation
ProductivityQ4	4,2	1,0	6,0	1,99
CompProgQ6	4,8	2,0	6,0	1,17
CompProgQ7	5,3	2,0	7,0	1,42
AccidentsTOTAL	5,3	3,0	7,0	1,38
EnvironmentTOTAL	6,0	4,0	7,0	1,26
EffAdminTOTAL	5,2	3,0	6,5	1,19
EffResoursTOTAL	5,2	3,0	6,5	0,91

Table 8: Statistical information

A few things come to notice when you look at the results. All the average scores are above 4 (from 4,2 tot 6,0), so that means that on all the dimensions the score is above the median of the 7 point Likert scale (which is 4). This means that the company staff think is in general positive when is asked about the quality of the construction process. Then there is the high score (average 6,0) for “Caring for the environment”. This means that the interviewed persons believe that their company takes very good care not to damage the environment. The lowest score is for productivity with an average score of 4,2. Also remarkable is the high spread. The minimum score is 1 and the highest score is 6 and the standard deviation is 1,99. This shows that there are big differences between the different companies when looking at productivity.

The overall average score on the question is a little bit above 5. This means that the interviewed persons agree with the statements and think that the construction process is performing pretty good. The score of 5 on a scale of 7 also means that the quality of the construction process is far from excellent yet. There still is a lot of improvement possible.

4.1.4 Workspace

Now differences in the perception of the performance of QMS between the different groups Headquarters and Construction site will be investigated. It is interesting to examine differences between groups, because a QMS aims to continuously improvement and it can be expected that all the implied people must have the same vision of the current situation of the company. Also it is expected that they have the same vision of the goals of the company. By analyzing the averages of the different groups it can be detected if there is agreement between them regarding the topics covered.

The objective of this analysis is to examine the differences between different groups for the averages of each dimension of the quality of construction processes, and to verify that these differences are statistically significant. The parameters that are used to analysed the differences are the statistical parameter F and the Statistical Significance (Sig.). The parameter F follows the Snedecor Law and it is defined as the quotient between two quadratic means, between the studied variable’s mean and the error’s quadratic mean. The Statistical Significance (Sig.) corresponds to the area of Snedecor F-distributions placed to the right of the F value (critical value that delimits the hypotheses’ reject area) which is the reject area (Lévy and Varela, 2003).

Dimension	Headquarters Average	Construction Site Average	F	Sig.
ProductivityQ4	4,20	4,17	0,057	0,946
CompProgQ6	4,80	4,83	3,000	0,250
CompProgQ7	5,40	5,17	0,200	0,833
AccidentsTOTAL	5,40	5,25	3,533	0,368
EnvironmentTOTAL	5,60	6,33	0,600	0,625
EffAdminTOTAL	5,20	5,17	2,520	0,284
EffResoursTOTAL	5,22	5,27	1,606	0,223

Table 9: Statistical information workspace

The differences between the answers of the 2 groups to the 12 questions is not statistically significant. Biggest difference in average is with caring for environment (0,73). The personnel at the construction site have the opinion that the company takes very good care not to damage the environment, personnel at the headquarters think this is only good.

4.1.5 Improvement last 2 years

In the 2008 questionnaire the questions 1,2,3,5,8,9 ask directly about improvement over the last 2 years. In the 2006 questionnaire these questions ask about the improvement since the implementation of the QMS. The average value of the answers to these questions can not be compared directly with each other. For example a lower value in the questionnaire of 2008 does not directly mean that the situation did not improve. It only indicates that their might be less improvement in the last 2 years compared to improvement (measured in 2006) since the implementation of the QMS. The results of the answers to the questions are shown in the table below.

	2008 question number	**Improvement since QMS (2006)**	**Improvement last 2 years (2008)**
Productivity	1	5,6	5,0
	2	5,8	5,5
	3	5,7	5,1
Compliance with the programming	5	5,4	5,7
Construction costs	8	5,6	4,9
	9	5,7	4,3

Table 10: Improvement last 2 years

Since the questions are answered in a 7 point Likert scale an average of more then 4 would mean improvement. There is improvement, but the improvement is lower in the last 2 years, then in the time since the implementations of the QMS to 2006. These results can be analysed in many different ways, but it can not be concluded that the rate of improvement is slowing down or increasing. What can be said is that most interviewed persons motioned that the quality of the construction process improved a lot the last 5 to 10 years, and only improved a little over the last 2 years.

4.1.6 Comparison results 2008 to results 2006

In order to compare the results of the research of 2008 with the results of the research 2 years earlier the mean, minimum and maximum scores will be compared to each other.

In the research of 2006 some questions were deleted after the reliability analysis. To compare the results of questionnaire of 2008 with the same questions of the questionnaire of 2006, the comparison will be made with all the questions included in both questionnaires. In order to make a good comparison a score for the dimension “Efficiency in managing resources” in the research of 2006 needs to be calculated. Therefore a factorial analysis is carried out, in the same way as when the score for the dimensions for the 2008 research were calculated.

The means of the answers to the questions and dimension are presented in the next table. Also the difference between the 2008 research and the 2006 research are shown. Since the difference is [2008]-[2006], a positive score means a higher score in the latest research.

Dimension	2008 mean	2006 mean	2008-2006 mean
ProductivityQ4	4,18	4,52	-0,34
CompProgQ6	4,82	5,40	-0,58
CompProgQ7	5,27	5,22	0,05
AccidentsTOTAL	5,32	5,67	-0,35
EnvironmentTOTAL	6,00	6,50	-0,50
EffAdminTOTAL	5,18	4,75	0,43
EffResoursTOTAL	5,24	5,39	-0,14

Table 11: Research results 2008 versus 2006

The number of replies in 2008 is too little to make a statistical comparison for each question. It is not possible to say if the differences between the means on the questions and dimensions are significantly different. Of course some remarks can me made. What comes to notice is that 5 of the 7 questions/dimensions score lower then 2 years ago. Only “This company always comply with the work programmes”” and “Efficiency of administrative processes” seam to have improved over the last 2 years.

No statistical difference

It is possible to compare all the means of the 2006 research with al the means of the 2008 research and see if there is a statistically significant difference between them. For this purpose the statistically procedure of a Paired Samples T test will be carried out. The Paired Samples T Test compares the means of two variables. It computes the difference between the two time frames for each question, and tests to see if the average difference is significantly different from zero (Archambault, 2000). If the significance value is less than .05, there is a significant difference. If the significance value is greater than. 05, there is no significant difference. From the statistical calculation follows that the significance value is 0,172. This means that there is no statistical significant difference between the results of 2006 and those of 2008. Here has to noticed that because of the low number of persons interviewed (11) a relatively big difference is needed to make the difference statistically significant.

4.2 Quantitative variables

The answers to the 4 questions about quantitative variables will be discussed hereafter. The answers to these questions are hard data in some cases, but sometimes also thoughts and opinions of the interview persons. In the table below the analyses (mean, lowest, highest value) are presented.

Variable	mean	lowest	highest
Time delay	9,1%	0,0%	20,0%
Time delay last project	8,3%	0,0%	20,0%
Cost of non-conformances %	1,5%	0,1%	6,5%
Cost overrun last project	5,5%	0,0%	35,0%

Table 12: quantitative variables

A general comment to all the results on these questions is that the people in general always think that they are doing better then that they actually do. The percentages presented should therefore not be accepted without asking questions.

Time delay

Time delay = (real project time – original planned project time) / original planned project time.

The average time delay of construction projects in the interviewed companies is 9,1%. This is on average 1 month delay on a construction time of 11 months. The company that says it has 0% time delay, has currently all there projects on time. The company that says it has 20% time delay, has this time delay on average of all there projects. It is remarkable that there are such big differences between the different construction companies.

According to professor Serpell, who has a lot of experience in the construction industry in Chile, clients are very strict on time performance. Construction companies get big claims if they project is delayed. He suspects that the results on this question are close to the real situation.

Professor Serpell also commented that it happens a lot that the client changes its wishes or that there are changes in the construction. These changes in design delay the project, but the client then gives the construction company extra time to finish the project. Delay because of changes in design is probably not taken in to account when looked at the percentage of time delay.

Time delay last project

Time delay last project = (real project time – original planned project time) / original planned project time.

The average of time delay in of the last construction project of the interviewed companies is 8,3%. 2 interviewed persons had no delay in their last project. The biggest time delay was 20%. Also here this big differences is remarkable.

Cost of non-conformances %

Cost of non-conformances percentage = Costs of non-conformances / total construction budget

The average cost of non-conformances is 1,5% of the total construction budget. 3 interviewed persons declared that the cost of non-conformances where 0,1%. 2 of these persons told that these were only the measured non-conformances. The highest percentage of costs of non-conformances was 6,5%.

With the presentation of these number is should be mentioned that most companies only measure the direct cost of a non-conformance. Indirect costs for time, people and after sales repairs are not taken into account. The real percentage of the cost of non-conformances will be a lot higher that what the persons answered to this question.

Cost overrun last project

Cost overrun last project = (Construction costs of last project – planned budget of last project) / planned budget of last project

The average cost overrun on the last project the interviewed person worked on was 5,5%. 3 of the interviewed persons had no cost overrun. One of these persons even was in a project that performed 7% under the budget. The project with the largest cost overrun was 35%.

Professor Serpell commented on this number by mentioning that this percentage of 5.5% cost overrun is very low. He thinks the real percentage lies a lot higher.

5 Discussion of issues of interest

Besides the answers to the questions in the questionnaire, some interesting things raised during the interviews that provided more and better insight into the research topic and also provided some extra information about the construction industry in Chile. These comments will be discussed hereafter. The comments will not only be mentioned, but will also be interpreted with regard of the research results. Also the added value of the comment to the research will be mentioned.

Time delay

An statement that several interviewed people gave is that on average a construction project of 10 month is delayed with 1 month. This is in line with the results on the question on time delay where the average delay was 9,1%. The thing that was most disturbing for the author was that all practitioners accepted this number. They know that when a project is planned to finish in 10 month, it always has 1 month of delay. One Quality Manager mentioned that the construction costs exceed the planned amount with 35% every project. This was mostly because of bad planning. Because the project can not be finished in time, a lot of extra costs have to be made for hiring workers that will work in evening hours and in weekends. The big question here is why the original planning is not changed, if everybody knows the project can not be finished in the stipulated time. More research into this topic can give insight into this. With respect to this one Site Manager said that the company accepts a building time of 12 month, but know they need on average 15 month. This seems a very weird situation.

One company mentioned that time delays in their projects mostly occurred because of changing client wishes (changes in design). This is something that can not be planned and they accept it. As mentioned earlier it is the client who changes the design and is responsible for the extra construction time, so this is not a problem for the construction company. The constructor gets extra time to finish the building.

Non-conformances

Different Quality Managers indicated that the non-conformances that are currently being measured by the QMS are only a certain part of the total number of non-conformances. One Quality Manager thinks 60% is being measured, while an other things it is only 40%. What can be concluded is that not all the non-conformances are being detected by the system. This can mean that the QMS is not being operated very well, but this can also mean that a high volume of non-conformances are difficult to detect. Since measurement is an important part of the QMS more investigation on this topic is needed.

A lot of the interviewed persons are positive about the QMS. So according to a Site Manager the cost of no quality have declined a lot since the introduction of the QMS.

A Quality Manager and also a Terrain Manager mentioned that the focus on quality is a good marketing instrument. But it can also save money directly and indirectly. The number of Non-conformances can be made less, but also the after sales work. Following Chilean legislation the construction company is responsible for the following things after finishing the building: 5 years on finishing, 7 years on piping and 10 years on construction. When the construction is being done right the first time, al lot of money can be saved on after sales repairs.

Evaluation system

A Quality Manager indicated that the QMS is also a good evaluation system, not also during the time of the project, but also afterwards. After the project ending there is normally no time for a good evaluation. Since the QMS records a lot of data, this system can also be used to evaluate the project in a better way.

Principles of QM

A Operations Manager said that the QMS does not have anything to do with the number of accidents. Since continual improvement is a very important part of the QMS this judgement is wrong. It shows that the Operations Manager does not understand the principles of QM and does not know how the QMS works. An other important thing in a QMS is that every person in the company knows the principles of the system. This example shows that it still happens that the staff at the company do not know enough about the system and the ideas of QM. What also is disturbing is the fact that the

system might not have full commitment of the Operations Manager. Top management support is essential for a good functioning QMS (Omar and Low, 1997; Romero, 2007).

Untrained workers
A big problem in the Chilean construction industry is the fact that almost all the workers are untrained. A terrain manager mentioned that because of this it is very difficult to exercise all the principles of QM. All the employees should be involved in the QMS and should know the principles of QM. Because of the fact that the workers are not trained, it is difficult to get them involved. Only to the level of foremen involvement is as at a sufficient level. That makes it difficult to implement any sort of management system. Concluded can be that is desirable that the workers should be given more education.

Several Quality Managers indicated that the current culture at the workspace of the workers is to not look at safety to much. The workers find it too much work to look at safety. This is something that will not change by itself. Clear statements and control by the foreman are needed. This is sometimes still lacking.

Productivity
A Site Manager mentioned that in Chile you constantly need to supervise the workers, because otherwise they do not work. So if you want workers to built a wall, you need to have someone standing next to them to make sure that the workers keep working. Of course this has very negative influence on the productivity.

Almost all the interviewed persons told that the working days in Chile were as follows: People on the construction site work from 8:30h till 20:00h every weekday and sometimes also on Saturdays. If a worker has to work such long hours it is very logical that his productivity per hour is very low.

One Quality Manager even said that the planned working day for a construction worker is from 8:30 till 18:00h, But that till 12:00h the construction workers are not really doing anything. To make up for this they have to work 3 hours more end of the day, so work till 21:00h. Still the work that is planned can not be finished in time. Therefore extra workers have to be hired when they see the project is delaying. Sometimes even 75% more.

Construction budget
One of the interviewed Terrain Managers assured that normally the housing construction projects always stay at the construction budget. He says it is difficult to have a lot of errors in the construction process, since al the housing construction projects are more or less the same. If this is true, then it is remarkable that on average the construction budget still gets exceeded with on average 5,5%. Another thing that can be drawn from this pronouncement is that the construction process in housing construction projects is very suitable for QMS. Since a lot of the same processes are occurring every construction process, these process can be described, executed and controlled very precise. This will have a positive influence on the construction time, costs and quality.

Operating the QMS
A Site Manager indicated that the quality of the people who work with the QMS now is higher compared to 2 years ago. They now know better how to do their work. When the system was just implemented there was a lot of uncertainty about it, also with the people that were operating and controlling the system. So more experience with the system helped these people to use the system in a better way. What can be learned from this is that the people who need to operate the system need good schooling into how the system needs to be operated.

6 Conclusions and recommendations

In this research it is investigated if the quality of the construction processes in ISO 9001:2000 certified housing construction companies improved over the last 2 years. To make the comparison between the 2 timeframes possible a questionnaire was designed for obtaining the right data in order to make the comparison. The questionnaire was applied to 11 practitioners in a personal interview. The collected data was analysed and compared to the results of the research of Romero (2007). The main conclusion that can be drawn from this will now be presented.

To answer the research question, the quality of the construction processes in ISO 9001:2000 certified housing construction companies does not significantly differ from 2 years ago. However 5 of the 7 compared dimensions of the quality of the construction process score lower then 2 years ago. Improvement since the implementation of a QMS was proved by the research of Romero (2007). Since the QMS focuses on continuous improvement, a higher quality could be expected. But the hypothesis that the quality of the construction process in ISO 9001:2000 certified construction companies improved can not be accepted on basis of the results of this research.

An explanation for this result can be that Romero (2007) visited mainly construction projects that were the most representative construction site of its QMS's application in the company. In this research in 2008 construction projects where visited on a more randomly choice. This research indicates that the quality of the construction process in the construction projects at this time is not higher then the most representative construction site in 2006.

An other explanation can be at the time of the implementation of the system the people saw that the system was working. Certain things actually got better. Now after some time they expect more from the system.

In this research no statistical significant difference was found between the perceptions of the groups Headquarters and Construction site. In the research of Romero (2007) there was a statistical significant difference. This finding might indicate that nowadays the entire organisation has in general the same opinion about the application of the principles of QM. The different layers in the construction company think more or less the same about the current situation and the improvement over the last 2 years. Given that the different groups in the organisation think the same of the application the QM principles, this is a difference compared to 2 years ago. Top management support and having the same organizational goals are important factors for the success of a QMS (Omar and Low, 1997; Romero, 2007). The research indicates that this factor for the success of a QMS is at place in most housing construction companies.

Several recommendations follow from this research. These recommendations are divided into two types: Academic recommendations and recommendations for the construction industry. The academic recommendations go into possibilities for future research. The recommendations for the industry can be implemented by the construction companies.

Academic recommendations:

- Obtain more interviews to increase the significance of the research results.
  More interviews with other practitioners in different companies are needed to get statistical significant certainty of the research results.

- A research should be carried out which goes into the possibility to measure also the indirect costs of non-conformances.
  If companies exactly know what the cost of a non-conformance is, then possible improvements can be researched with better accuracy. With better measurement also improvements can be made more visible.

- It should be investigated how workers that work on a construction site can be trained.
  At this point in time most workers on a construction site did not receive any training. The fact that the workers are unschooled gives big problems with the implementation of any QMS. Concluded can be that is desirable that the workers should be given more education.

- More research should be carried out in order to find possibilities to improve the construction processes in order to increase productivity in Chilean construction companies.
  Even with the implementation of a QMS some years ago, the productivity in the visited companies did not improve over the last 2 years.

Recommendations for the construction industry:

- The research indicated that the people who need to operate the QMS need good schooling before they start working with the system. Construction companies need to school these persons.

- Construction companies should give the workers a basic training in the principles of QM. The workers need to understand how the QMS has to be operated.

- The construction companies need to make their planning as realistic as possible. From this research is depicted that the knowledge to make a good planning is available in the companies, but that the planning is still not accurate.

- Safety at the construction site should be improved. Clear statements and control by the foreman are needed. This is sometimes still lacking.

7 Literature

Archambault , S. (2000), Paired samples T test. Psychology Department, Wellesley College, Retrieved July 28, 2008, from http://www.wellesley.edu/Psychology/Psych205/pairttest.html

Chile Infrastructure Report Q1 2008 (2007, November). Retrieved April 20, 2000, from http://www.reportbuyer.com/countries/south_america/chile/chile_infrastructure_report_q1_2008_1.html

Dowling, J. (2007, November). Consolidation in Chile's Construction Industry [Electronic version]. bUSsiness CHILE. Retrieved May 16, 2008, from http://www.businesschile.cl/portada.php?w=old&id=540&lan=en

Foreign Investment Committee and the Chilean Chamber of Construction (2007). Chile's Construction Industry, Internationally Competitive. Santiago de Chile.

ISO 9001:2000 Quality Management Systems Background, Omnex, Retrieved 2 June, 2008, from http://www.omnex.com/standards/iso_9001_2000/iso_9001_2000.html

Isoqar. The international standard for quality management, Retrieved 2 June 2008, from http://www.isoqar.com/iso9001/qualintro.htm

Kumar, R. (1996) Research Methodology, A step-by-step guide for beginners, Sage Publications, London.

Landin, A. (2000). ISO 9001 within the Swedish construction sector. Construction Management and Economics, Sweden.

LÉVY MANGIN, J.-P., VARELA MALLOU, J. (2003) Análisis Multivariable para las Ciencias Sociales, Prentice Hall, Pearson Educación S.A.

Likert scale & surveys, Intelligent Measurement , Retrieved 17 July, 2008, from http://intelligentmeasurement.wordpress.com/2007/11/20/likert-scale-surveys-best-practices/

Moatazed-Keivani, R., Ghanbari-Parsa, A.R., Kagaya, S. (1999). ISO 9000 standards: perceptions and experiences in the UK construction industry. Construction Management and Economics. UK.

Omar, H.F., Low, S.P. (1997).The effective maintenance of quality management systems in the construction industry. International Journal of Quality & Reliability Management. Singapore.

Pheng, L.S., Abeyegoonasekera, B. (2001). Integrating buildability in ISO 9000 quality management systems: case study of a condominium project. Building and Environment. Singapore.

Quazi, H.A., Hong, C.W., Meng, C.T. (2002). Impact of ISO 9000 certification on quality management practices: A comparative study. Total Quality Management. Signapore.

Rao, S.S., Ragu-Nathan, T.S., Solis, L.E. (1997) Does ISO have an effect on quality management practices? An international empirical study. Total Quality Management. USA.

Romero, T, (2007), Análisis crítico del impacto de los sistemas de gestión de la calidad en la construcción. Santiago de Chile.

Subba Rao, S., Ragu-Nathan, T.S., and Solis, E. (1997). Does ISO 9000 have an effect on quality management practices? An international empirical study. Total Quality Management. USA.

Tam, C.M., Den, Z.M., Zeng, S.X., Ho, C.S. (2000). Quest for continuous quality improvement for public housing construction in Hong Kong. Construction Management and Economics. Hong Kong.

A Appendix

A.1 Statistical analyses

Reliability Analysis
From SPSS:

Reliability Statistics

Cronbach's Alpha	N of Items
,795	12

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Productivity04	58,0000	71,800	,433	,786
CompProg06	57,3636	71,855	,866	,746
CompProg07	56,9091	67,691	,884	,735
Accidents10	56,7273	95,018	-,236	,843
Accidents11	57,0000	93,000	-,169	,838
Environment12	56,1818	73,364	,711	,757
EffAdmin13	56,8182	74,564	,637	,763
EffAdmin14	57,1818	77,564	,381	,787
EffResours15	56,7273	69,618	,662	,756
EffResours16	57,2727	73,218	,608	,764
EffResours17	57,1818	82,764	,321	,791
EffResours18	56,6364	77,655	,719	,766

Factorial Analysis
From SPSS:

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,008	50,190	50,190	2,008	50,190	50,190
2	1,092	27,291	77,481	1,092	27,291	77,481
3	,563	14,078	91,560			
4	,338	8,440	100,000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
EffResours15	,779	-,307
EffResours16	,667	-,632
EffResours17	,593	,710
EffResours18	,777	,308

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Compare results 2006 vs. 2008
From SPSS:

Component Matrix[a]

	Component	
	1	2
VAR00001	,637	-,231
VAR00002	,175	,958
VAR00003	-,744	,170
VAR00004	,786	,136

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Compare results 2006 vs. 2008
From SPSS:

Paired Samples Test

	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 VAR00001 - VAR00002	,2057	,3508	,1326	-,1187	,5301	1,552	6	,172

A.2 Questionnaire for interviews in English

INTERVIEW CARACTERISTICS	
Interviewer:	Pieter Tiemessen
Interviewed person:	……
Company:	……
Job description:	……
Workspace:	☐ Headquarters ☐ Construction site
Education level:	☐ Professional ☐ Technician

The aim of this questionnaire is to collect information from various companies and different levels of hierarchy, who where operating a quality management system 2 years ago and still do at this time. This research is an extension to the research of Tania Romero in 2006. The goal is to get an impression about the performance of the construction processes in ISO certified construction companies in 2 timeframes.

Most of the questions are designed so that they can respond in the format of a Likert scale, where the scoring valued from 1 to 7, where:
1 is strongly disagree / very bad,
4 is undecided / sufficient and,
7 is strongly agree / excellent.

Quality of the construction processes in housing construction companies

QUESTIONS	ANSWERS							
	1	2	3	4	5	6	7	Don't know
1. The productivity has improved considerably the last 2 years.								
2. Productivity has steadily improved the last 2 years.								
3. The amount of time busy making repairs has decreased sharply the last 2 years.								
4. Generally there is no downtime during the execution of construction activity.								
5. The number of activities scheduled to be completed in the stipulated time has increased significantly the last 2 years.								
6. The tasks assigned to me always can be met within the stipulated period.								
7. This company always comply with the work programmes.								
8. The last 2 years the costs of no quality have declined considerably.								
9. The cost of after-sales repairs have been greatly reduced the last 2 years.								
10. I think the quality management system helps reduce the number of accidents occurring at the construction site.								
11. I think the quality management system helps reduce the severity of accidents occurred at the construction site.								
12. This company takes care not to damage the environment.								
13. In this company the administrative processes (support process) always works correct?								
14. In this company there is unnecessary bureaucracy in administrative processes.								
15. On this project occurs much waste of materials.								
16. The human resource management is very efficient in this company.								
17. The handling of materials at the storage place is very efficient.								
18. The equipment and machinery are in excellent condition to use for work.								

QUESTIONS
19. A) How is the time performance of the construction processes? What is the percentage of time delayed compared to the original planning?
B) Can you estimate the percentage of time delay with respect to the project time of the last projects you work on?
20. A) What are the costs of non-conformances compared to total budget? (non-conformance information)
B) Can you estimate the percentage of cost overrun with respect to the total project costs on the last projects you worked on?

A.3 Cuestionario en Español

El objetivo de este cuestionario es recoger información de diversas empresas y los distintos niveles de jerarquía, que cuando la explotación de un sistema de gestión de calidad 2 años atrás y todavía lo hacen en este momento. Esta investigación es una extensión para la investigación de Tania Romero en 2006. La meta es obtener una impresión sobre el desempeño de la construcción en los procesos de certificación ISO empresas de construcción en 2 plazos.

La mayoría de las preguntas están redactadas de modo que puedan responder en el formato de una escala Likert, donde la puntuación por valor de 1 a 7, cuando:
1 es totalmente en desacuerdo / muy malo,
4 de indecisos es / suficiente y,
7 está muy de acuerdo / excelente.

Calidad de los procesos de construcción de viviendas

PREGUNTA	NOTA							
	1	2	3	4	5	6	7	No sé
1. La productividad ha mejorado considerablemente los últimos 2 años.								
2. La productividad ha mejorado constantemente los últimos 2 años.								
3. La cantidad de tiempo ocupado en hacer reparaciones ha disminuido mucho los últimos 2 años.								
4. Generalmente no existen tiempos muertos durante la ejecución de las actividades de construcción								
5. La cantidad de actividades programadas que se completan en el tiempo estipulado ha aumentado significativamente los últimos 2 años.								
6. Las tareas que se me asignan siempre se pueden cumplir en el plazo estipulado								
7. En esta Empresa siempre cumplimos con los programas de trabajo								
8. Los últimos 2 años han disminuido los costos de no calidad considerablemente								
9. Los últimos 2 años han disminuido de manera importante los costos de las reparaciones post-venta								
10. Pienso que el sistema de gestión de la calidad ayuda a disminuir la cantidad de accidentes que se producen en Obra								
11. Pienso que el sistema de gestión de la calidad ayuda a disminuir la gravedad de los accidentes producidos en Obra								
12. Esta Empresa se preocupa de no dañar el medioambiente								
13. En esta Empresa los procesos administrativos de obra siempre funcionan correctamente								
14. En esta Empresa existe burocracia innecesaria en los procesos administrativos								
15. En esta obra se produce mucho desperdicio de materiales								
16. El manejo del recurso humano es muy eficiente en esta Empresa								
17. El manejo de los materiales en la bodega es muy adecuado								
18. Los equipos y maquinarias se encuentran en excelentes condiciones de uso para el trabajo								

PREGUNTAS
19. A) ¿Cuál es el porcentaje de tiempo que demora en comparación con la planificación original?
B) ¿Se puede estimar el porcentaje de tiempo de retraso con respecto al tiempo do proyecto de los últimos proyectos en que usted trabaja?
20. A) ¿Cuáles son los costos de no-conformidades "en comparación con el presupuesto total?
B) ¿Se puede estimar el porcentaje de rebasamiento de gastos en relación con el coste total del proyecto en los últimos proyectos en que usted trabajó?