การประเมินผลของการปฏิบัติตามระบบบริหารคุณภาพอิงมาตรฐาน ISO-9000: กรณีศึกษาบริษัทผู้รับเหมาในประเทศไทย

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EVALUATION OF ISO 9000-BASED QUALITY MANAGEMENT PRACTICES: THE CASE OF CONTRACTOR COMPANIES IN THAILAND

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เชอร์เรล ลีน คารปีส: การประเมินผลของการปฏิบัติตามระบบบริหารคุณภาพอิงมาตรฐาน ISO-9000: กรณีศึกษาบริษัทผู้รับเหมาในประเทศไทย (EVALUATION OF ISO 9000-BASED QUALITY MANAGEMENT PRACTICES: THE CASE OF CONTRACTOR COMPANIES IN THAILAND) อ.ที่ปรึกษา: ผศ.ดร. วัชระ เพียรสุภาพ. อ.ที่ปรึกษาร่วม: รศ.ดร. ธนิต ธงทอง, 126 หน้า.

ความต้องการของลูกค้าและความซับซ้อนของโครงการก่อสร้างที่เพิ่มขึ้นทำให้งานก่อสร้างจำเป็นต้องมีระบบบริหารคุณภาพ ซึ่งระบบประกันคุณภาพอิงมาตรฐาน ISO 9000 เป็นกลุ่มมาตรฐานหนึ่งสำหรับการบริหารคุณภาพที่สนับสนุนคุณภาพในกระบวนการทำงาน โดยแนวคิดในการประกันคุณภาพได้ถูกนำมาใช้ในงานโครงการก่อสร้างเพื่อทำให้เกิดความมั่นใจในคุณภาพ อย่างไรก็ตามเครื่องมือที่เหมาะสมสำหรับการประเมินผลของการปฏิบัติตามระบบบประกันคุณภาพอิงมาตรฐาน ISO 9000 ยังมีข้อจำกัด งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาแนวทางในการประเมินการปฏิบัติตามระบบบริหารคุณภาพอิงมาตรฐาน ISO 9000 เพื่อบรรลุวัตถุประสงค์ งานวิจัยได้ออกแบบการศึกษาเป็นสองส่วน โดยขั้นตอนแรกเป็นการพัฒนาเครื่องมือและเกณฑ์ที่ใช้ในการประเมินระดับของการปฏิบัติตามระบบมาตรฐานคุณภาพที่ประกอบด้วยกลุ่มปัจจัย 2 กลุ่ม กล่าวคือ การประเมินระดับของการประยุกต์ใช้หลักการตามคู่มือมาตรฐานคุณภาพอิงมาตรฐาน ISO 9001:2000 และการประเมินระดับของเป้าหมายด้านคุณภาพ การพัฒนาเครื่องมือและเกณฑ์ที่ใช้ประเมินเริ่มจากการรวบรวมบทความ การสัมภาษณ์กับผู้เชี่ยวชาญ 14 ท่านที่เกี่ยวข้องกับงานคุณภาพในบริษัทก่อสร้างไทย โดยผลจากการเก็บข้อมูลสามารถนำมาพัฒนาเครื่องมือที่ประกอบด้วย ปัจจัยที่ใช้ในการประเมินระดับการปฏิบัติตามระบบมาตรฐานคุณภาพจำนวน 33 รายการ ระดับเป้าหมายด้านคุณภาพที่บริษัทต้องการจำนวน 10 รายการ และเกณฑ์ที่ใช้ในการประเมิน ขั้นตอนที่สองของงานวิจัยเป็นทดสอบเครื่องมือในการประเมินผลของการปฏิบัติตามระบบมาตรฐานคุณภาพจากกรณีศึกษาผู้รับเหมาก่อสร้างไทย ซึ่งเครื่องมือดังกล่าวได้ถูกทดสอบโดยผู้รับเหมาจำนวน 23 บริษัทที่ใช้มาตรฐานคุณภาพอิงมาตรฐาน ISO 9000

ผลการศึกษาพบว่าระดับการปฏิบัติตามระบบมาตรฐานคุณภาพของแต่ละบริษัทก่อสร้างมีความแตกต่างกันจากการประเมินด้วยเครื่องมือที่นำเสนอในงานวิจัยนี้ ผลการประเมินข้อกำหนดคุณภาพแสดงถึงความจำเป็นในการปรับปรุงด้านความพึงพอใจของลูกค้า ในขณะที่ผู้ประเมินของบริษัทกล่าวถึงผลดีของการใช้ระบบประกันคุณภาพในด้านการควบคุมติดตามและเป็นเครื่องมือที่ใช้สำหรับวัดผล สำหรับผลการประเมินเป้าหมายด้านคุณภาพของบริษัทพบว่าบริษัทยังมีข้อจำกัดในการบรรลุคุณภาพของงานตามเป้าหมายที่ต้องการ โดยเครื่องมือที่เสนอในงานวิจัยนี้สามารถช่วยให้บริษัทผู้รับเหมาสามารถประเมินการปฏิบัติเพื่อหาข้อจำกัดและสิ่งที่ต้องพัฒนาในองค์กรด้านคุณภาพได้

ภาควิชา.....วิศวกรรมโยธา..... ลายมือชื่อนิสิต.....

สาขาวิชา....วิศวกรรมก่อสร้างและการบริหาร... ลายมือชื่ออาจารย์ที่ปรึกษา .....

ปีการศึกษา .....2550..... ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

##4970725821: MAJOR IN CIVIL ENGINEERING

KEYWORDS: QUALITY MANAGEMENT / ISO 9000 / MEASUREMENT / CONSTRUCTION INDUSTRY

CHERYL LYNE CAPIZ: EVALUATION OF ISO 9000-BASED QUALITY MANAGEMENT PRACTICES: THE CASE OF CONTRACTOR COMPANIES IN THAILAND. THESIS ADVISOR: ASST. PROF. VACHARA PEANSUPAP THESIS CO-ADVISOR: ASSOC. PROF. TANIT TONGTHONG, 126 pp.

The demand on quality management systems (QMSs) is brought by increasing client needs and complexity of construction projects. ISO 9000, a recognized quality management system often used in quality assurance, has been adopted by several construction companies to help ensure work quality. However, a suitable tool for assessing quality management practices, particularly, ISO 9000-based QMSs, in the construction industry is still limited. This research aims to contribute to the continuous search for the best possible way of assessing quality management practices. Towards this objective, this research has been designed into two phases. First is the development of tool and criteria for assessing ISO 9000-based quality management practices. The proposed tool in this research is adopted from the concept of effectiveness in previous studies. Effectiveness of ISO 9000-based QMSs is assessed based on achieving the specified QMS requirements derived from the ISO 9001:2000 standard and quality goals. Two different sets of scales to aid in the evaluation were also developed and are highlighted in this research. The development of tool and criteria is derived from literature review and interview with 14 professionals involved in ISO 9000. From data collection, thirty-three (33) quality principles, ten (10) prescribed company quality goals, and criteria for evaluation were developed. The second phase is the evaluation of quality management practices using the data collected from twenty-three (23) ISO 9000 certified contractors in Thailand.

The result illustrates that there are different levels of practice among contractors using the proposed tool for evaluation. Results show that among the quality principles, contractors need to improve on client satisfaction. Meanwhile, good results were obtained in the control of monitoring and measuring devices. For the quality goals, the respondents need improvement on achieving better quality of work. The proposed tool in this research can help construction companies to identify their constraints and improve areas of their quality management practice.

Department :	Civil Engineering	Student's Signature:	
Field of Study :	Civil Engineering	Advisor's Signature:	Vachara Peansupap
Academic Year:	2007	Co-advisor's Signature:	

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CHAPTER I

INTRODUCTION

1.1. Background of the Study

Construction has certain characteristics that set it apart from other industries. First, the construction industry is unique as compared to the manufacturing industry which is repetitive (Pheng and Omar 1997; Ortega and Bisgaard 2000; Karim et al. 2005; Turk 2006). This uniqueness results from varying management practices and construction methods among countries and within the industry itself (Pheng and Omar 1997). In addition, clients have changing needs. This requires the flexibility of the construction industry to respond to changes in the society, economy and technology (Pheng and Omar 1997). Second, unlike manufacturing, the design for construction is carried out by external firms except for Design and Build companies (Karim et al. 2005). Third, the teams involved in each project are continuously changing. Fourth, supervision of workers becomes difficult because construction sites are dispersed (Pheng and Tan 1996). Last, construction projects are linked with different factors such as local effects, environmental factors, social reactions and the cost and completion period to be planned at the designed stage (Turk 2006). This can also be related to the unpredictable economics of construction (Karim et al. 2005). It is therefore quite difficult to attain an acceptable quality level in construction because of its highly dynamic, complex and competitive nature (Battikha 2003).

To help construction companies achieve the required quality and minimize quality related problems, different quality management practices and techniques are employed. Among the most popular techniques used are ISO 9000 and Total Quality Management (TQM). These techniques help in planning, implementing and controlling quality systems. Several studies point the benefits of quality management in construction. For example, quality-related problems can be eliminated and prevented at early stages with an effective quality management ((Battikha 2002a; Battikha 2002b) cited in (Battikha 2003)). A formal quality management system in place records lower levels of rework for projects ((CIDA 1995) cited (Love and Edwards 2004b)). Quality management can be used to ensure that appropriate controls

are set to monitor the works (Love and Edwards 2004a). Abdul-Rahman (1997) stressed the role of quality management in the successful management of construction projects.

However, several construction companies still fail to realize the importance of quality management in reducing quality related problems. Instead, they focus more on time and cost as majority of clients pay attention to the lowest possible cost of construction rather than quality (TMCIT 2001). If poor quality is not properly addressed and prevented through quality management, a number of repercussions may arise. Among these are productivity loss; client dissatisfaction leading to market share loss and possible profit reduction and safety, service and economic problems (Battikha 2000). Therefore, companies need to be aware of the importance of quality management to avoid some adverse effects to their business.

1.2. Statement of the Problem

Several studies can be linked to the assessment of quality management practices. The approach used in some studies is by measuring the effectiveness of quality assurance (QA) systems. There are, however, some doubts as to the existence of methods for measuring the effectiveness of QA systems in the construction industry. The effectiveness of QA systems is difficult to evaluate and measure despite the introduction of ISO 9000 (Al-Nakeeb et al. 1998). These doubts may be due to the limited requirement of ISO 9000 on business results, performance measurement and indicators (Lee et al. 1999). Lee et al. (1999) described ISO 9000 as a more qualitative standard than a quantitative standard. Thus, there is a need to supplement the inadequacy by developing some form of measurement.

Measurement allows managers to know how close they are to their targets and how to make the right decisions for improving work processes (Al-Nakeeb et al. 1998). This can help establish aspects that are most unsatisfactory and entail greater attention (Ng 2005). Quantification or measurement is also important in identifying the position of a company with respect to its own past performance and can provide direction for improvement (Lee et al. 1999).

There are available methods for measuring the effectiveness of QA systems. Some of them, however, are quite misleading according to Al-Nakeeb et al. (1998). Thus, a suitable tool for measuring the effectiveness of QA systems is still needed (Al-Nakeeb et al. 1998).

The inadequacy of tools for evaluating the effectiveness of QA systems at the construction company level led to the development of this research. This research endeavors to develop ways to improve the previous methods proposed for measuring effectiveness and incorporate them into the tool for assessing quality management practices. Continuous studies must be encouraged to improve current practices and search for the best evaluation tool.

1.3. Research Objectives

The research aims to:

1.3.1. To propose a tool for assessing quality management practices at the construction company level.

1.3.2. To apply the proposed tool for assessing quality management practices and evaluate the case of ISO 9000 certified contractors in Thailand.

1.4. Scope and Limitations

The evaluation of quality management practices is based on the implementation of ISO 9000 standard requirements and achievement of prescribed company quality goals and objectives. Thus, this research focuses on ISO 9000-based quality management systems (QMSs). The case of ISO 9000 certified contractors in Thailand were chosen. The sample included local and foreign companies.

1.5. Research Methodology

The research methodology consisted of three essential stages.

1.5.1. Literature review. The purpose of literature review was to obtain information about ISO 9000, its definition, history, benefits, barriers to implementation, etc. It also sought to acquire information relating to the assessment of quality management practices in the construction industry based on the concept of effectiveness.

1.5.2. Interview with the persons in charge of selected ISO 9000 certified contractors in Thailand. The interview formed the basis for developing the survey questionnaire. The information obtained were verified and incorporated into the tool for assessing quality management practices.

1.5.3. The development and distribution of a survey questionnaire. From this, the proposed tool can be applied and thereafter, assess quality management practices among contractors in Thailand.

1.6. Significance of the Study

The tool proposed in this research can help construction companies in assessing their quality management practices. Without any tool, companies have limited means of determining the suitability, applicability and effectiveness of an ISO 9000-based QMS in their organization. The framework can also help companies determine the extent of their failure in achieving their targets. As a result, they can develop ways to improve their system and achieve better results.

CHAPTER II

LITERATURE REVIEW

2.1 Approaches to Quality Management Systems

Figure 2.1 shows how a company can set up its quality management system. Quality management systems can be ISO 9000-based or non-ISO 9000-based. If a company's quality management system is based on the ISO 9000 standard, then it is said to be ISO 9000-based. Otherwise, it is non-ISO 9000-based. For ISO 9000-based, companies can also choose between formal and informal. A formal quality management system means that a company has obtained an ISO 9000 certificate. On the other hand, informal refers to the use of ISO 9000-based QMS without the certificate. The contractors in this research are implementing ISO 9000-based QMSs and are all ISO 9000 certified.

Some construction companies prefer to use an informal and simple quality management system rather than a formal one like ISO 9000. Ahmed et al. (2005) pointed that the reasons for this are insufficient pull and lack of initiative from clients or government and limited resources as in the case of firms in the United States. According to the same study, these firms have frequent monitoring and inspection as their informal quality management system. A formal quality measurement was unnecessary because of the insignificant overall defect costs and that tight control by site staff is more effective than taking quality measurement (Ahmed et al. 2005).

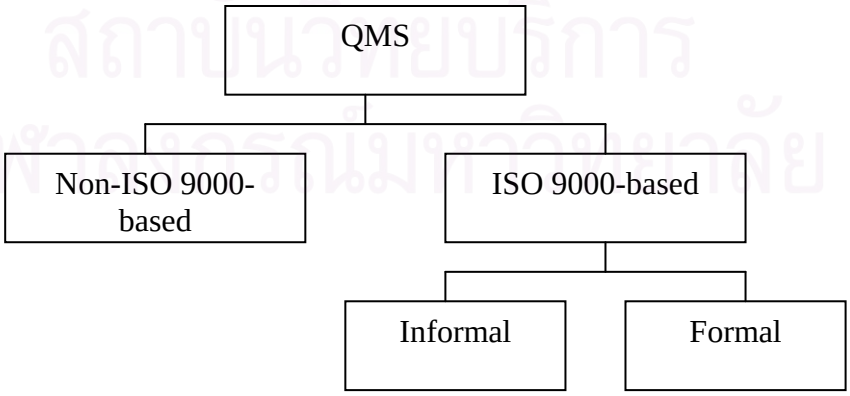

Figure 2.1. Approaches to quality management

2.2 ISO 9000

ISO 9000 is a general term for the family of quality standards used by an organization in developing its quality management system (Nee 1996). ISO 9000 encompasses all that an organization does to enhance customer satisfaction by meeting customer and applicable regulatory requirements to continually improve its performance. Table 2.1 presents the ISO 9000 series of standards for quality management (McCabe 1998).

The idea of the ISO 9000 standards began in 1974 when the British Standard Institution (BSI), introduced the guidelines (BS 5179) for organizations producing their own quality assurance documentation ((Duncan 1990) cited (Hiyassat 2000)). The BSI introduced BS 5750 in 1979 aimed at promoting quality of services and goods. It consisted of three major parts with the first representing the highest level of standard and the third the lowest. In 1987, a number of countries from different parts of the world ratified and thereafter recognized an International Quality System Standard, the ISO 9000 series. This was an equivalent of the BS 5750. The ISO 9000 series was then revised in the mid-1994 to include some new requirements and clarify some points with specific requirements (Moatazed-Keivani et al. 1999; Pheng and Alfelor 2000; Pheng and Fong 2000).

2.3 ISO 9000 and the Construction Industry

ISO 9000 is a recognized quality management system often used in QA (McCabe 1998). Although this standard was initially applied in the manufacturing industry, it has also long been used in construction. Several construction companies in developed countries obtained ISO 9000 certifications but only a few companies are certified in developing countries.

A system that ensures quality is essential as competition is intensified in both local and international levels of the business world caused by globalization (Hiyassat 2000). The use of QA certification (ISO 9000 for example) as a tool for improving corporate management systems should be continuously encouraged in the

construction industry ((Latham 1994) cited in (Öztaş et al. 2007)). However, more evidence is needed to ascertain its help in improving performance and project delivery before requiring it for public sector works ((Latham 1994) cited in (Öztaş et al. 2007)).

Table 2.1. ISO 9000 series of standards for quality management (McCabe 1998)

ISO Reference	Subject
9000 – 1	Guidelines for selection and use of ISO 9000
9000 – 2	Guidelines for application of ISO 9000
9000 – 3	Guidelines for application of ISO 9001 to the development, supply and maintenance of software
9000 – 4	Dependability management
9001	Model for quality assurance in design, development, production, installation and servicing
9002	Model for quality assurance in production, installation and servicing
9003	Model for quality assurance in final inspection and testing
9004 – 1	Guidelines for quality systems elements **9004 GUIDELINES**
9004 – 2	Services
9004 – 3	Processed materials
9004 – 4	Quality improvements
9004 – 5	Quality plans
9004 – 6	Project management
9004 – 7	Configuration management

The suitability of ISO 9000 and formal quality assurance to the construction industry has been a continuing debate (Shammas-Toma et al. 1996). This may be due to its perceived nature. According to Öztaş et al. (2007), there are factors which complicate the transfer of concepts from the manufacturing industry to construction. Among these are the long time required for construction project completion; human relationships are usually formed once and difficulties in quality standards definition, process feedbacks and cost estimates determination. Thus, it is difficult for the industry to meet its needs due to the diversity of its processes and the requirements to produce a different product or service for each project (Turk 2006).

The construction industry generally follows ISO 9001 and ISO 9002. ISO 9001 is for those organizations carrying out design work while ISO 9002 is a more appropriate model if design work is not involved (McCabe 1998).

ISO 9001, specifically the ISO 9001:2000 version, is the reference used in this research. This edition of ISO 9001 constitutes a technical revision of ISO 9001:1994, ISO 9002:1994 and ISO 9003:1994 (ES ISO 9001:2000).

The ES ISO 9001:2000 or simply the ISO 9001 specifies the requirements for a quality management system that can be used for internal application by organizations, for certification or for contractual purposes. It promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management to enhance customer satisfaction. Process approach is the application of a system of processes within an organization, along with the identification and interactions of these processes and their management. Such approach facilitates the ongoing control over the linkage between the individual processes within the system of approaches and over the combination and interaction.

The requirements of the ISO 9001:2000 are shown in Table 2.2. The quality principles discussed in Chapter IV are verified against these requirements.

2.4 Reasons behind ISO 9000 Adoption

ES ISO 9001:200 states that the adoption of a quality management system should be strategically decided by the organization. Its design and implementation is influenced by varying needs such as objectives, products provided, processes employed and the size and structure of the organization. Thus, before deciding on whether to adopt or not a quality management system that is ISO 9000-based, construction companies need to assess their current system and capabilities (E.g. human resources and financial status).

The reasons for adopting ISO 9000 can be interpreted in three ways. First is mandatory. Interest of construction companies to adopt ISO 9000 is brought by mandatory requirements (McCabe 1996; Kam and Tang 1997; Lee 1998; Au and Yu 1999; Ahmed et al. 2005; Palaneeswaran et al. 2006). Some countries like Singapore and Hong Kong have made it mandatory for construction companies to obtain an ISO

9000 certificate before bidding for public projects (Kam and Tang 1997). Certification has also become mandatory for Australian organizations wishing to do business with the government and major private companies (Love and Li 2000). ISO 9000 certification is a qualification for them to operate across national boundaries (Love and Li 2000). In Hong Kong, engineering consultancy firms seek certification because of the government's mandatory requirement (Tang and Kam 1999). A number of construction companies were also driven by their clients to be certified (McCabe 1996; Lee 1998; Palaneeswaran et al. 2006; Turk 2006). The adoption of ISO 9000 to satisfy mandatory requirements can be considered as an external force driven ISO 9000 adoption. Jones et al. (1997) categorized this as non-developmental, as companies were pushed by the demand of important customers or requirement for government bids. Zaramdini (2007) described this as external motive since is it linked with the elements outside the organization (E.g. customers, competitors, government and suppliers).

The second reason for adopting ISO 9000 is voluntary. Construction companies may voluntarily adopt ISO 9000 as part of their improvement process. Companies seek certification as part of a larger improvement strategy: gaining competitive advantage; increasing efficiency and productivity in operations; satisfying top management's corporate directive; competing more effectively for overseas projects; improving the quality of work and reducing costs of operations (Pheng and Yeo 1997). Thus, this reason for adoption can be considered as an internal force driven ISO 9000 adoption, which is synonymous to the developmental category in Jones et al. (1997). For the developmental category, companies were motivated by the internal benefits of the certification process such as improvement in the company's internal processes and business performances. This is similar to the internal motive in Zaramdini (2007). The forces are associated with operational and managerial performances.

The third reason is a combination of both mandatory and voluntary reasons, similar to the mixed category in Jones et al. (1997). Companies adopted the system for improvement and marketing advantage.

Table 2.2. ISO 9001:2000 system requirements (ES ISO 9001:2000)

Sections	Subsections
Section 4. Quality Management Systematic Requirements	4.1 General Requirements 4.2 Documentation requirements
Section 5. Management Responsibility Requirements	5.1 Management commitment 5.2 Customer focus 5.3 Quality policy 5.4 Quality planning 5.5 Responsibility, authority and communication 5.6 Management reviews
Section 6. Resource Management Requirements	6.1 Provision of resources 6.2 Human resources 6.3 Infrastructure 6.4 Work environment
Section 7. Product Realization Requirements	7.1 Planning of product realization planning 7.2 Customer-related processes 7.3 Design and development 7.4 Purchasing 7.5 Production and service provision 7.6 Control of monitoring and measuring devices
Section 8. Measurement, Analysis and Improvement Requirements	8.1 General 8.2 Monitoring and measurement 8.3 Control of nonconforming product 8.4 Analyzing of data 8.5 Improvement

Government involvement is important in promoting construction quality. However, compliance to government laws and client requirements should not only be the reasons for adopting a quality management system. In Lee (1998), the companies which pursued certification because of client's pressure were unreceptive in adopting ISO 9000 and therefore achieved fewer benefits. Interest of construction organizations to be certified is driven by their fear of removal from the tender list of large clients (McCabe 1996). This meant that their basis for implementing the system is not for long-term improvement. Without a motivation for sustainable continuous improvement, most organizations have opted to go through the certification process (Love and Li 2000).

There are also a number of organizations which adopted the right approach for seeking ISO 9000 certification. As an example, the study by Zaramdini (2007) revealed that certified companies in the United Arab Emirates (UAE) focused on the potential internal benefits. Thus, organization should believe in the value of their efforts in maintaining and improving the quality in their works.

2.5 Benefits of ISO 9000 Adoption

Several studies dealt with the analysis of ISO 9000 benefits. These benefits can be classified as internal and external, similar to the reasons behind its adoption. Table 2.3 lists the benefits obtained from different articles.

It can also be inferred from Table 2.3 that benefits of ISO 9000 are those pertaining to increasing competitive advantage, meeting client's expectations and improving the quality of work. In the rapid changing business environment, organizations are motivated to continuously search for new ideas and processes that can help them beat all other companies and competitors (Ehigie and McAndrew 2005). ISO 9000 may help achieve this goal. Construction companies also need to comply with the client's expectations. Some clients tend to prefer an ISO 9000 accredited contractor. The certification shows that the contractor operates under international standards. Above all these, contractors need to realize the use of ISO 9000 in improving the quality of work.

2.6 ISO 9000 Implementation and its Barriers

The process of ISO 9000 implementation needs considerable time of planning, involving a number of tasks. Certain aspects must be ensured before, during and after implementation. If consistently implemented with management philosophies, ISO 9000 can change the organization in a positive way such that continuous improvement can be achieved (Love and Li 2000).

Table 2.3. Summary of ISO 9000 benefits

Benefits	Classification	Reference
1. Enhanced company communication and documentation	Internal	Dissanayaka et al. 2001; Low & Yeo 1997
2. Improved methods of working and quality of work done	Internal	Low & Yeo 1997; Lee et al. 1999; Turk 2006
3. Reduced quality related problems (e.g. reworks, disputes, wastage and defects)	Internal	Palaneeswaran et al. 2006; Dissanayaka et al. 2001; Love & Li 2000; Jones et al. 1997
4. Better competitive edge	External	Low & Yeo 1997
5. Improved client satisfaction	External	Low & Yeo 1997; McCabe 1998
6. Enhanced company reputation and marketability	External	Ofori 2002; Turk 2006, Love & Li 2000; Low & Yeo 1997
7. Increased efficiency and productivity in all areas of operation	Internal	Low & Yeo 1997
8. As part of a larger improvement strategy	Internal	Low & Yeo 1997; Hiyassat 2000; Ofori 2002
9. Encouraged teamwork and increased team spirit	Internal	Lee et al. 1999; Hiyassat 2000; Ofori 2002
10. Increase quality awareness of employees	Internal	Hiyassat 2000; Ofori 2002
11. Better control of subcontractors	Internal	Lee et al. 1999
12. Improved sales, profit and growth	External	Hiyassat 2000; Ofori 2002

Since organizations are considered to be complex entities, it is likely for them to view and solve problems differently ((Meyerson and Martin 1987) cited in (Bresnen and Marshall 2001)). Therefore, it pays to identify and evaluate the implementation process of an organization.

In the study of Naveh et al. (2006), the implementation of ISO 9000 is a learning process. It involves experimentations and sharing of technical and social knowledge about what and how to achieve tasks. The research findings of Serdar and Arditi (2006) revealed that the diffusion of ISO 9000 certification in the Turkish precast concrete industry is primarily driven by internal (i.e. imitative behavior) rather than external (i.e. complying with client requirements, changes in government regulations, demand conditions and consulting firms' suggestions) influence factors.

ISO 9000 implementation can be modeled similarly to the study of Ahire and Ravichandran (2001). Ahire and Ravichandran (2001) theorized total quality

management (TQM) as a four-stage process: adoption, adaptation, acceptance and use. By following these steps, a more systematic way of implementing ISO 9000 is achieved. The model also eliminates employees' confusion. All these stages include the involvement of every individual in the organization in determining the success of the implementation process. Successful implementation leads to continuous adoption of the innovation.

The success, however, of an ISO 9000-based QMS cannot be achieved overnight. It is inevitable to encounter problems along the way, especially during the early stages of implementation. The implementation process as described by Beer et al. (1990) (cited in (Bresnen and Marshall 2001)) has always been problematic, long-drawn out or simply unsuccessful. Organizations are unable to realize the benefits of planned change because the failures in implementation (Naveh et al. 2006). A series of monitoring activities must be conducted regularly in order to identify the barriers which form the basis for developing necessary actions.

For the case of ISO 9000, several barriers are associated with the initial stage. First, there is difficulty in understanding the quality management system (Kam and Tang 1997; Serpell 1999; Ofori et al. 2002). Employees have passive attitude towards maintaining an effective quality management system (Au and Yu 1999). This passive attitude can be attributed to the ostensibly complex ideas of ISO 9000. Second is the difficulty in communication (Serpell 1999; Ofori et al. 2002). Management needs to plan the simplest way of conveying the new system to all staff. To do this, regular training and meeting of staff must be conducted. Third, extra effort is needed in documentation (Serpell 1999; Tang and Kam 1999; Ofori et al. 2002; Turk 2006). Company procedures need clear definitions. Significant amount of time is necessary to update these procedures and replacing the superseded copies is tedious. Last, is the shortage in manpower (Serpell 1999; Ofori et al. 2002). Au and Yu (1999) added the lack of competent quality personnel to carry out the assigned duties. There are also difficulties in coping with new role and responsibilities as well (Pheng and Yeo 1997).

Another setback of ISO 9000 is the high cost of implementation (Serpell 1999; Ofori et al. 2002; Turk 2006). There are costs to cover third party audits (McCabe 1998). Low and Yeo (1997) suggest that ISO 9000 improves quality of work done but

at a cost. This is in contrast to the expectation that good quality work reduces operating costs.

The lack of management and employees' commitment (Serpell 1999; Tang and Kam 1999; Ofori et al. 2002; Palaneeswaran et al. 2006) is another barrier associated with ISO 9000. Before expecting people to commit into following the rules, the management must make it a point to serve by example. Management must educate and train the people as to the importance of having and properly following the procedures in order to benefit from it. Companies must realize and live up to the very purpose of quality management.

The literature cites other barriers to the successful implementation of ISO 9000 in the construction industry. Among these are: nature of the project, work demand and nature of construction (Pheng et al. 1999), lack of emphasis on the organization cultural values, insufficient checking of works on the part of the site staff, poor response in filling out standard forms, lack of participation from consultants and high staff turnover (Pheng and Yeo 1997).

There are technical and non-technical (behavioral) elements of quality management (Pheng 1998). Effective quality management systems in the building industry can be achieved if non-technical factors such as organizational politics, leadership styles, socio-political conflicts, change environment, etc. are properly handled (Pheng and May 1997). These factors may also be held true for the case of ISO 9000-based QMSs.

In addition, Low and Alfelor (2000) identified cultural differences in values and attitudes to be affecting the successful implementation of quality management in an organization. The same study revealed that conflicts arise because of differences in building codes and environmental standards, nationalities, corporate cultures, professions and the value systems of the project participants, units of measurements, types of tools and equipment and construction techniques, management styles and ethical beliefs, religious leanings or colonial influences. The two case studies suggest that effectiveness depends on the successful handling of the non-technical attributes and management of the cross-cultural influences. Moreover, quality managers must understand and accept these cultural differences if they are to facilitate an approach

which values and benefits from the diversity. At the same time, they could formulate appropriate operational plans to achieve quality in construction.

2.7 Previous Proposed Methods for Evaluating Quality Management Practices

In this research, the development of the tool to assess quality management practices is linked with the measurement of effectiveness in previous studies. Methods for measuring the effectiveness of QA systems are discussed in this section.

There are some methods recognized by companies for measuring the effectiveness of QA systems. One of these methods is quality auditing. Quality audits have gained prominence over the years as tools for evaluating the effectiveness quality assurance efforts and compliance with standards like ISO 9000 (Karapetrovic and Willborn 2000). Through quality audits, compliance of quality assurance procedures with applicable standards and guidelines as well as effective and suitable implementation to achieve quality objectives can be attained (Karapetrovic and Willborn 2000). According to Karapetrovic and Willborn (2000), there are some concerns on the consistency of auditors and audits results, overall quality of audits (internal and external) and their ability to achieve improvement. Moreover, although quality audits may uncover deficiencies and propose the required corrective action but they remain audits on the planned and systematic actions and do not in reality measure the impact of a QA system on the organization (Al-Nakeeb et al. 1998).

Another method used by companies is through client satisfaction surveys. Customer focus (client focus for this research) is the most important principle in all systems (Piskar 2007). These surveys may be excellent indicators of client's satisfaction but some clients are inexperienced and may have great expectations on a contractor's QA system (Al-Nakeeb et al. 1998).

In addition to quality audits and client satisfaction surveys, quality costing serves as a way to assess quality. Quality costing permits the quantification of cost in failure events and demonstrates the importance of prevention (Abdul-Rahman 1997). Whilst quality costing can indicate financial quality trends, it tends to be more project-oriented and may not assess the effectiveness of QA system overall

(Al-Nakeeb et al. 1998). Other factors may affect the increase or decrease in a company's profit, for instance.

In Al- Nakeeb et al. (1998), there seemed to be no available evidence of measuring the effectiveness of the quality system of UK construction companies. These companies had held BS 5750/ISO 9000 certificates for more than a year. They were deluded by the definition of effectiveness. Effectiveness according to the BS 5750 refers to meeting and complying with specified requirements of the BS Standards and not to the specified requirements and prescribed quality objectives of the company. They also thought that third party certificates and positive audit results imply effective quality management systems. Thus, in his research, e*ffectiveness* of the system was defined as meeting the company's specified requirements and prescribed quality objectives (Al-Nakeeb et al. 1998).

There were hypothetical methods proposed by some researchers for measuring the effectiveness of quality management systems in the construction industry. These methods aimed to solve the misconceptions concerning the recognized methods discussed earlier. This research highlights, in particular, the studies of Al- Nakeeb et al. (1998) and Öztaş et al. (2007).

Al-Nakeeb et al. (1998) proposed a hypothetical comprehensive matrix which can indicate the quality trend over a period of time. The matrix incorporated measurable quality characteristics or attributes obtained by balancing the views of both customers and the individuals within the contractor's organization. Weights, as percentage, are assigned to these quality characteristics based on their importance rank. These are then measured and the results are translated to a common scale of 0-10. The quality score is calculated by multiplying the weight by resulting common scale scores. The sum of the quality score for each quality characteristics gives the final quality score. This final quality score is compared with other scores during a time period. Although the proposed matrix can indicate quality trend, Al-Nakeeb et al. (1998) explained that it fails to reflect the effectiveness of QA systems themselves. This is due to the presence of other organizational and external factors which may influence quality trends. Adding to this is the unique nature of the construction industry.

Another matrix model for measuring the effectiveness of QMSs was developed by Öztaş et al. (2007) based on Al-Nakeeb et al. (1998). It is a comprehensive system combining many quality characteristics such as appearance, utility, cost, reported performance, reliability and serviceability. Two matrix models were developed: the Matrix of Principles and the Matrix of Goals. The Matrix of Principles describes the result of whether or not the firm is effective in achieving specified QMS requirements. The Matrix of Goals, on the other hand, gives the result of whether or not the firm is effective in achieving company's prescribes quality objectives. The model may be superior to other measures because it is expressed in numbers, which gives a clear indication of the effectiveness of QMS. Turkish firms that have or have not received QMS certification were used to evaluate the matrices. Results showed that Turkish construction firms are successful in achieving prescribed quality objectives but failed in meeting specified requirements of QMS. This means that end results are more important than the tool used to achieve them.

Since the results of the studies described above are in matrix form, a quantitative way of measuring the effectiveness of QA systems is obtained. Although such matrix may not completely or correctly measure effectiveness, it can supplement the views and opinions of individuals in evaluating QA systems.

2.8 Research Gaps

One of the objectives of this research is to propose a tool for assessing quality management practices at the construction company level. Towards this objective, some recommendations on how to improve previous proposed methods, which utilized the concept of effectiveness, were identified and are presented next.

First, different sets of quality components (quality principles and quality goals) for the measurement matrices were gathered, this time by interviewing ISO 9000 certified contractors in Thailand, in particular. In this way, the quality components incorporated into the proposed tool can essentially represent the understanding among construction companies. This also allows for the identification of similar concepts on quality management applied to the construction industry. These principles and goals were consolidated and verified against the ISO 9001:2000

standard for completeness. The concept of Öztaş et al. (2007) to measure effectiveness based on the ISO 9000 standard requirements and prescribed company quality goals and objectives was adopted in developing the tool for assessing quality management practices in this research.

Second, two sets of scales were developed by referring and modifying some concepts regarding the description of each point in the scale from literature. Both scales are five-point scales. In Öztaş et al. (2007) and Al-Nakeeb et al. (1998), a "weight" is assigned to each of the quality characteristics. This concept is also applied in this research but with some modifications. The term "weight" assigned to a quality attribute was modified to "level of implementation" for the quality principles and "level of achievement" for quality goals. The determination of the weight is based on the two scales being proposed in this research. The description of each point in the scales facilitates a more objective way of assessment. In addition, the use of a five-point scale can adequately capture the current state of QMS implementation at the company level, as compared to a two-point scale ('yes' or 'no'), for example. Companies may describe their quality management practices to some extent or level.

Third, the importance rate assigned to each of the quality attributes was limited to only five points. In Öztaş et al. (2007), the importance rate scale changes according to the total number of quality characteristics. Problems may arise when the number quality characteristics increases. It may also be difficult to assign a single importance rate for each quality characteristic. Thus, in this research, a five-point importance rate is proposed.

Last, the interview in the methodology is supplemented with a survey questionnaire. In this way, the proposed tool can be applied using the results of the survey questionnaire. Consequently, the state of quality management practices among contractors in Thailand can be determined. This allows for the identification of areas for improvement.

2.9 Research Framework

Figure 2.2 illustrates the framework of this research. It starts by establishing a company's system requirements, goals and objectives. These describe the expectations of the company in adopting an ISO 9000-based QMS. The specified QMS requirements refer to the processes in the organization which were derived from the ISO 9001:2000 standard. These may include procedures or activities necessary for the execution of works. The prescribed company quality goals and objectives include the targets and expectations of the organization in adopting an ISO 9000-based QMS. A company decides the expected level of implementing the specified QMS requirements and the expected level of achieving the prescribed company quality goals and objectives. As soon as these requirements and objectives are established along with all the necessary preparations, the organization may proceed with the implementation process. After a certain period of time, a company needs to determine whether or not it has achieved its expectations with the new system. It carefully assesses the level it has actually achieved and compares it with the expectations. In this manner, a company can determine the extent of its success or failure in achieving its requirements and objectives. Appropriate actions can be developed to address the areas for improvement.

The available tools or methods for assessing quality management practices are unfortunately few and may have some limitations, hence the need for this research. This research aims to propose a tool for assessing quality management practices, particularly, ISO 9000-based QMSs. It then applied the proposed tool using the results of the survey questionnaire.

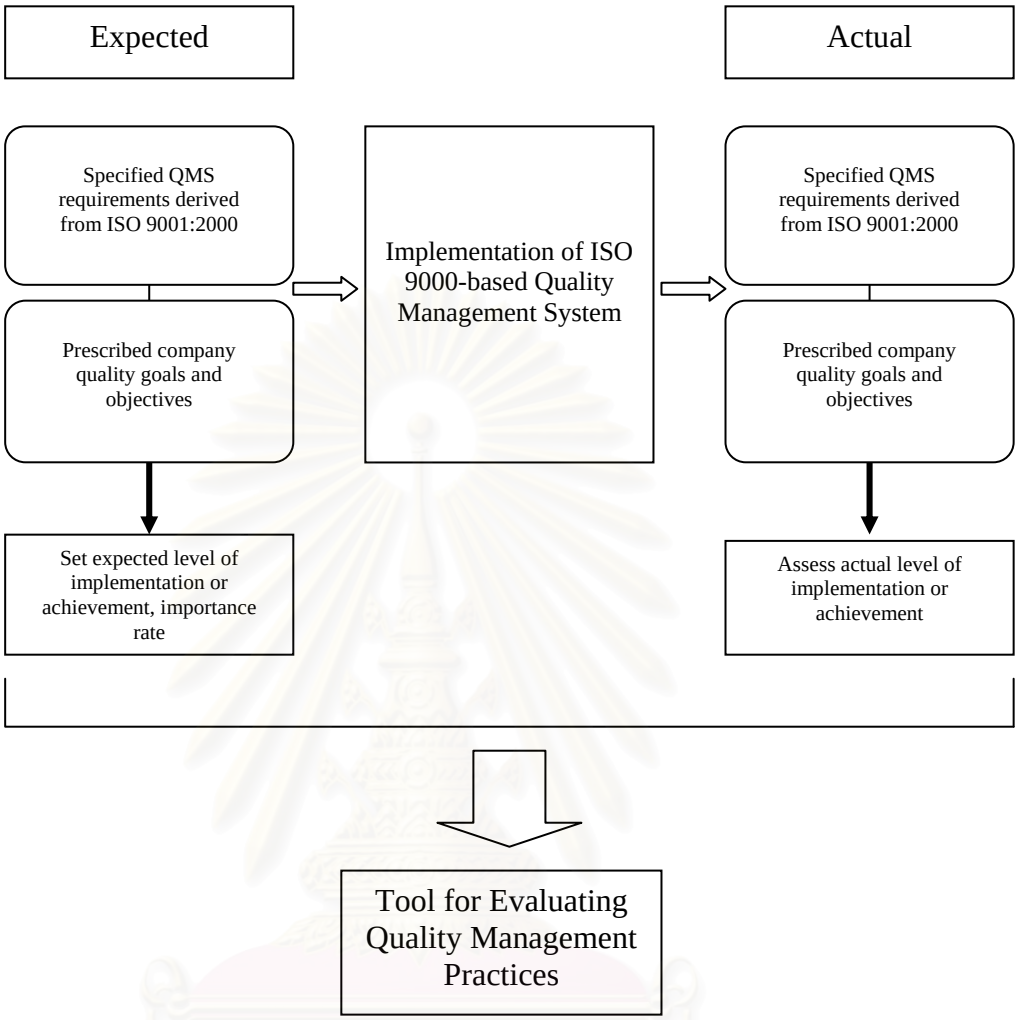

Figure 2.2. Research Framework

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Approach

The research methodology (Figure 3.1) was based on a quantitative approach. A quantitative research is based on testing a theory, measured with numbers and analyzed by statistical techniques (Creswell 1994).

A case study was selected for this research. A case study can provide analytical rather than pure statistical generalizations and can capture the complexity and dynamism of organization settings in projects (Love and Edwards 2004a). It is more appropriate for understanding complex organizational problems in which quantitative methods are not appropriate (Prajogo and Sohal 2004). This research investigated the case of ISO 9000 certified contractors in Thailand. It aimed to assess their quality management practices using the proposed tool in this research. As mentioned, the proposed tool is based on the concept of effectiveness. Thus, before accomplishing this, the current methods for measuring effectiveness used by these contractors were to be determined and examined first. Their motivations; specified QMS requirements derived from the ISO 9001:2000 standard; prescribed company quality goals and objectives and the actual benefits of ISO 9000-based QMSs were some of the information to be explored during the interview.

3.2 Research Methodology

This research was designed into two phases (Figure 3.1). The first phase was about the development of the tool to assess quality management practices. The second phase, on the other hand, is the evaluation of quality management practices among ISO 9000 certified contractors in Thailand. Using the proposed tool in this research, the stages of QMS implementation of these contractors were identified. Their perceptions on quality management were also analyzed. In addition, the areas

for improvement in their QMSs were evaluated. The steps in completing these two phases are discussed in the succeeding sections.

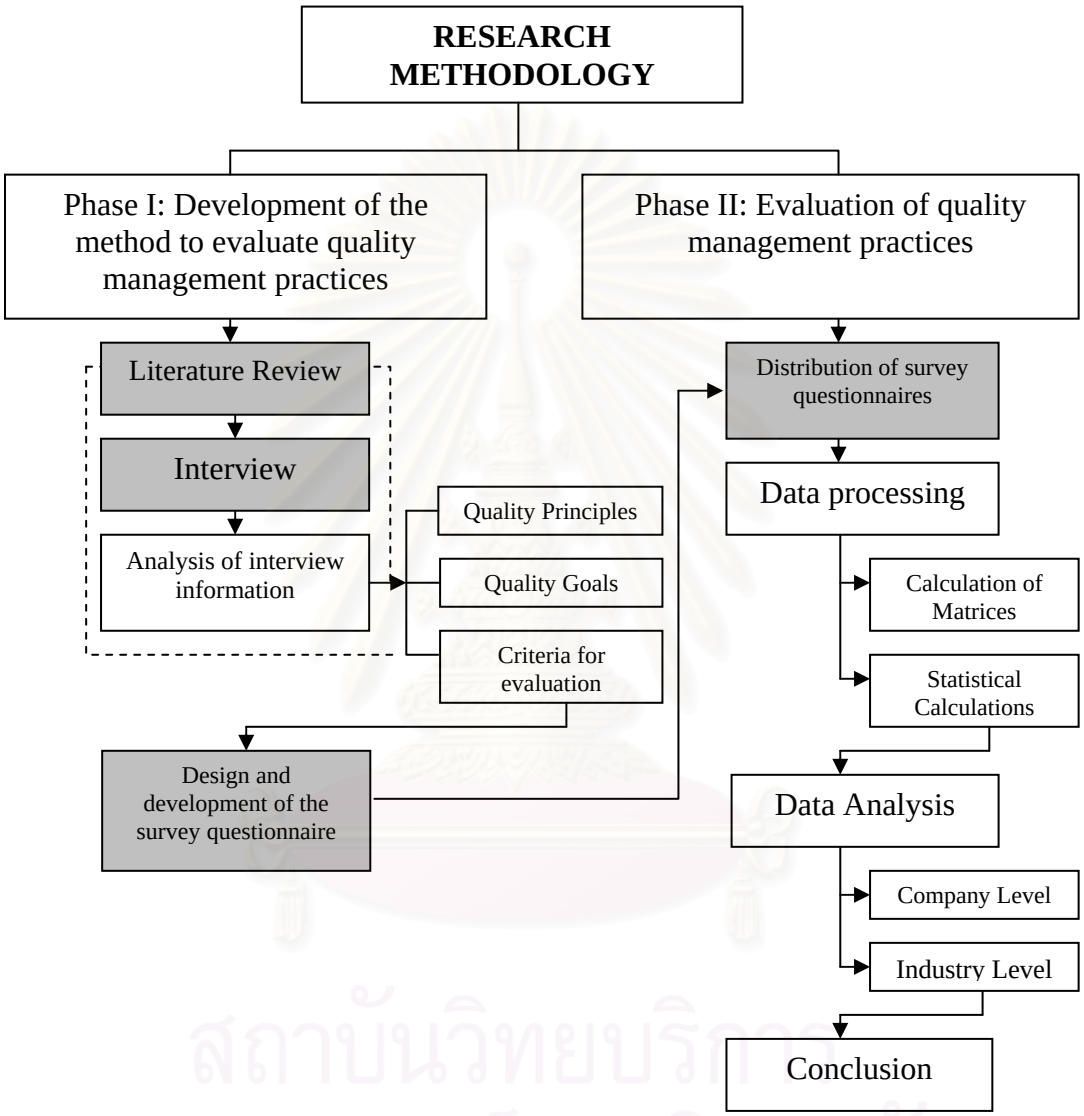

Figure 3.1. Research methodology

3.2.1 Phase I: Development of the Tool to Assess Quality Management Practices

3.2.1.1 Information obtained from Literature Review

Some basic ISO 9000 information, such as its definition, history, reasons behind adoption, benefits, barriers, etc., were gathered from literature. In this way, readers will be able to understand some concepts first and eventually know how studies on ISO 9000 have evolved over the years of its application to the construction industry. As this research adopted the concept of effectiveness in developing the tool to assess quality management practices, common methods, as well as hypothetical methods developed by other researchers to measure the effectiveness of QA systems, were also explored. This was fundamental in identifying the factors or gaps leading to the research problem. A review of literature also allowed for the development of the scales incorporated into the proposed tool in this research. Another purpose of the literature review was to develop the questions for the interview, the second essential step for data collection.

3.2.1.2 Information obtained from Interview

Companies were approached by phone, email or in person. Interview schedules were then arranged with the responsible professionals of ISO 9000 certified construction companies in Thailand. The preparation of questions from literature helped in keeping up the flow of conversation during the interview. This also allowed the interviewer to maintain composure when asking the questions. Interviewees were allowed to explain as thorough as they can. They were interrupted in cases where a particular comment was deemed to be expounded. Follow-up questions were asked when necessary. The interview covered a variety of topics. These include the views of contractors in Thailand on quality management; ISO 9000 certification; current methods for measuring the effectiveness of their ISO 9000-based QMSs; quality principles and prescribed quality goals and objectives.

By analyzing the results from literature and interview, necessary information for the proposed tool to assess quality management practices were obtained. Included here are the quality principles, quality goals and the criteria for evaluation.

3.2.1.3 Design and Development of the Survey Questionnaire

A survey questionnaire was designed based on the information obtained from literature and interviews. Several ideas were contributed by the interviewed individuals from the thirteen (13) contractors in Thailand. These individuals included managers and officers in charge of divisions in the organization, such as quality assurance, engineering, construction and administration.

The survey questionnaire was reviewed and corrected by the researcher's advisors. Valuable comments on how to improve the survey questionnaire were also contributed by other individuals. A copy of the survey questionnaire can be found in Appendix A.

The survey questionnaire consists of four parts. First is about the respondent, his or her work experience and number of years in the company. Second is about some company information. Third is related to the measurement of the effectiveness of ISO 9000-based QMSs. The required data for assessing quality management practices among these construction companies were primarily furnished in the third part of the survey questionnaire. The last part is about the implementation of ISO 9000 among construction companies in Thailand. Questions about their motivations for ISO 9000 adoption; actual benefits achieved; problems, barriers and disadvantages encountered and satisfaction on their ISO 9000-based QMS were included.

3.2.2 Phase II: Evaluation of Quality Management Practices

3.2.2.1 Distribution of Survey Questionnaires

Survey questionnaires were sent and filled in by the persons in charge of ISO 9000 certified construction companies in Thailand, which included quality managers, engineering managers, construction managers, project managers and administration personnel. Initially, companies were obtained from the list of the Thai Industrial Standards Institute (TISI). Thailand, through the TISI, under the Ministry of Industry, promotes the standardization of work for the purpose of consumer protection, safety, environmental protection, energy saving as well as industrial development of the country to be competitive in the world market. The standardization aims to promote correct understanding and awareness in standardization among the public. ISO 9000 certification is one the standards encouraged by the Thai government. A total of one hundred twenty (120) companies in the construction sector are listed in TISI as of February 2008 (TISI 2008). The list includes general contractors; subcontractors for electrical, mechanical and finishing works, etc. and project management companies (TISI 2008). Additional ISO 9000 certified contractors were searched in the internet. Survey questionnaires were sent through fax, email or in person. Constant follow-up was essential in order to ensure collection of all distributed survey questionnaires.

The objective of the survey questionnaire is to apply the proposed tool for assessing quality management practices using the case of ISO 9000 certified construction companies in Thailand. Out of the 120 companies listed in the TISI, only thirty-four (34) companies were initially assumed as contractors. Additional of seven (7) companies were found in the internet. Thus, the total is forty-one (41). However, survey questionnaires were only sent to thirty-six (36) of these companies because contact information of the remaining companies was unavailable. Out of the 36 sent questionnaires, twenty-eight (28) were returned, representing a response rate of 77.8 percent. Upon return, it was found that only twenty-three (23) are contractors. Thus, the final sample size is 23.

3.2.2.2 Data Processing

Data processing in this research comprised two parts. First was the evaluation of the matrices. Second was the statistical calculation of the results in the matrices.

3.2.2.2.1 Evaluation of the Matrices

The proposed tool for assessing quality management practices includes the formation of two matrices. These matrices were based on the studies of Al-Nakeeb et al. (1998) and Öztaş et al. (2007). These two matrices are the Matrix of Principles and the Matrix of Goals. The Matrix of Principles describes the effectiveness of a company in satisfying and implementing the QMS requirements derived from the ISO 9001:2000 standard. The Matrix of Goals describes the effectiveness in achieving the prescribed company quality goals and objectives in implementing an ISO 9000-based QMS. The components and formation of the matrices are discussed in Chapter IV.

3.2.2.2.2 Statistical Calculations

Descriptive statistics of the survey questionnaire results were calculated. In order to conclude whether there is a significant difference between the expected and actual final quality scores of the matrices, statistical tests were performed.

The Student's t-test was used for this research. There are two versions of the t-test, the dependent samples t-test and independent samples t-test. The t-test for independent samples is one of the several inferential statistical tests employed for hypothesis testing involving samples in which each is comprised of different subjects (Sheskin 2004). On the other hand, if the analysis involves the test for the difference of two means before and after the application of a new method, a dependent or paired sample t-test is utilized (Dovich 1992). The dependent means test can also be used when the within group variation, which normally contributes to measurement errors, can be easily identified and excluded from the analysis (StatSoft 2008).

Independent sample t-tests were conducted to determine if there is a significant difference among the responses of construction companies involved in this research. This is due to the characteristics of the sample size, which consists of different types of companies (Thai and Foreign) with varying size (small, medium and large). Thus, before proceeding with the dependent sample t-test, it is important to know first if the companies can be considered as one group.

The dependent sample t-test was also utilized in this research. The application of ISO 9000-based QMSs in construction is considered as the method from which the difference between before and after conditions can be assessed. Respondents were asked to indicate the expected and actual levels of their implementation in the quality principles and achievement in the quality goals. The differences between the expected and actual results can be caused by the differences in the respondents and performances of these respondents before and after the implementation of ISO 9000-based QMSs. The expected responses can be interpreted as the 'before" condition while the actual can be regarded as "after" condition. By comparing the actual with the expected, ISO 9000-based QMSs can be assessed. Since the significant difference between the expected and actual final quality scores of the same samples, construction companies in this case, is sought, paired samples t-test is the more appropriate test to use for this case.

The Student's t-test is a statistical test based on the assumption of normality. The Central Limit Theorem (CLT) states that if the sample size, n, is sufficiently large ($n \geq 30$), the theoretical sampling distribution of the mean will be normally distributed (Bernstein and Bernstein 1999). There is no absolute rule regarding the sample size needed for the CLT to hold. This is why other references state that sample sizes as small as twenty-five (25) or twenty (20) are sufficiently large (Bernstein and Bernstein 1999).

The Student's t-distribution is used when the population standard deviation is unknown and the sample is small, i.e., $n \leq 30$ (Kothari 2005). The t-test is uniformly most powerful under the assumption of normality, i.e., the distribution of t becomes normal and the sample standard deviation converges to the population standard deviation (Tiku and Akkaya 2004). Thus, it is said that the t-test is robust against the departures from the assumption of normality, especially when the sample sizes are

large (Gress 1987; Tiku and Akkaya 2004). A total of 23 samples were collected in this research. Thus, the t-test can be applied and that CLT holds, also considering the robustness property of t-test and that a sample of 20 can be sufficiently large.

In this research, respondents were asked to indicate the expected and actual outcomes of their ISO 9000-based QMSs.

The t-statistic for the paired samples t-test is given by (Dovich 1992):

$$t = \frac{\bar{d}}{\left(\frac{s}{\sqrt{n}}\right)} \qquad (1)$$

Where :

d = average difference of the paired samples

s = standard deviation of the differences

n = number of pairs

df = degrees of freedom, df = n-1 (2)

The hypotheses for the dependent sample t-test in this research were tested and followed the steps below.

a. The null (H_o) and alternative (H_1) hypotheses are given by:

H_o: $d = 0$

H_1: $d > 0$

Where: μ_1 = “expected level” mean of each of the quality principles and quality goals

μ_2 = “actual level” mean of the quality principles and quality goals

$d = \mu_2 - \mu_1$

In this research, we wish to determine if there is a significant difference between the expected and actual level means. Since, we also want know whether the actual level mean is greater than the expected level mean, a one-tailed t-test was conducted. We also hypothesized that the application of ISO 9000-based QMS can help meet or exceed the expectations at the start.

b. The significance level, α, is equal to 0.05.

c. The critical t-statistic, t_c, is the value of t at (n-1) degrees of freedom and 95% confidence interval.

d. The decision rules are:

Reject H_o	if $t > t_c$
Fail to reject H_o	otherwise

With the critical region shown in Figure 3.2.

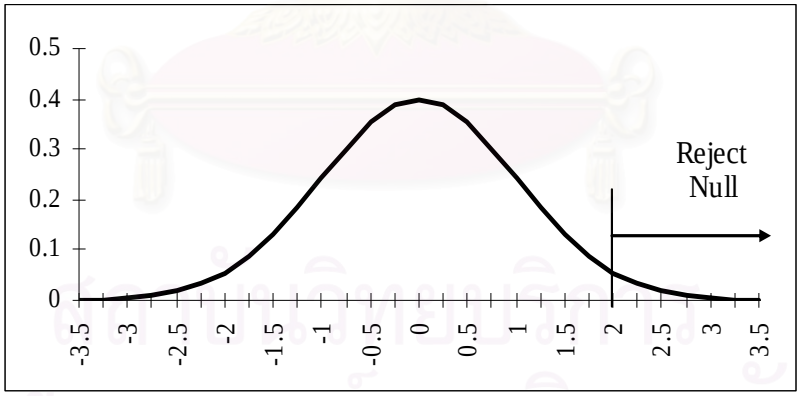

Figure 3.2. Critical region for one-tail test

3.2.2.2.3 Data Analysis

Data analysis was performed at the construction company level and industry level. Analysis at the construction company level was done by considering the resulting matrices, the Matrix of Principles and the Matrix of Goals. The stages of quality management practices among construction companies in Thailand were also determined. At the industry level, areas for improvement in the quality principles and prescribed company goals and objectives were identified through statistical methods, as discussed in Section 3.2.2.2.2. In addition, perceptions of contractors on quality management were also described.

3.3 Summary

This chapter describes the methodology of the research. As a summary, the research methodology was based on a quantitative approach, considering the case of construction companies in Thailand and utilizing some statistical techniques. The research methodology comprised two phases, with three essential steps: literature review, interview with the persons in charge of ISO 9000-certified construction companies and the development and distribution of a survey questionnaire. Reviewing the literature was not only vital in the preparation of the questions for the interview but also to the design and development of the survey questionnaire. Valuable information were contributed by the interviewees coming from different divisions such as quality assurance, construction, engineering and administration. The quality principles and quality goals are two of the most important information obtained.

Data analysis was performed at the company and construction industry levels. Processing of survey questionnaire data was done through the evaluation of matrices. These are the Matrix of Principles, which describes effectiveness in satisfying and implementing the QMS requirements derived from the ISO 9001:2000 standard, and the Matrix of Goals, which depicts the effectiveness in achieving the prescribed company quality goals and objectives. These matrices were incorporated into the proposed tool to assess quality management practices.

Analysis at the construction industry level was done by statistical techniques, the Student's t-test in particular. Independent sample t-test was conducted to determine the significant difference among the companies, differing in size and type. Paired sample t-test was performed to compare the 'expected' and 'actual' conditions of the same subjects.

The list of ISO 9000 certified construction companies were obtained from the TISI and the internet. A total of twenty-three (23) contractors were surveyed.

CHAPTER IV

DEVELOPMENT OF THE TOOL TO EVALUATE QUALITY MANAGEMENT PRACTICES

4.1 Concept for Assessing Quality Management Practices

The concept for assessing quality management practices in this research involves the identification of the company's specific requirements and prescribed quality goals and objectives. This idea was adopted from the definition of effectiveness in previous studies on quality management systems. If a company has not defined what its quality management system is set to achieve, then it will be difficult to measure its impact to the company (Al-Nakeeb et al. 1998; Öztaş et al. 2007).

In line with the idea of effectiveness, the proposed tool incorporates two main components, namely, the quality principles and quality goals. In this research, quality principles and quality goals are collectively called "quality attributes". These quality attributes were obtained from both literature and interview.

The proposed tool for assessing quality management practices includes the formation of two matrices, based on Öztaş et al. (2007). These two matrices are the Matrix of Principles and the Matrix of Goals. The Matrix of Principles describes the effectiveness of a company in satisfying and implementing the QMS requirements derived from the ISO 9001:2000 standard. The Matrix of Goals describes the effectiveness in achieving the prescribed company quality goals and objectives in implementing an ISO 9000-based QMS.

The resulting quality principles and quality goals which are essential in the formation of matrices are presented in the succeeding sections. The criteria for evaluation, calculations and interpretation of scores for the matrices are also highlighted in this chapter.

4.2 Quality Principles

As mentioned, the e*ffectiveness* of the system is defined as meeting the company's specified requirements and goals. The requirements are those instituted by every company and define how an activity is to be executed, as in a procedure. All procedures need to comply and corresponded to the requirements of the ISO 9000 standard.

Several quality management procedures were obtained from the interview with thirteen (13) contractors. The *quality principles* in this research were derived from such procedures and the ISO 9001:2000 standard. The final list of quality principles incorporated into the survey questionnaire was mainly derived from interviews. Table 4.1 shows which quality principle has been set-up by the interviewed contractors. However, after reviewing the ISO 9001:2000 standard, additional quality principles are required. Among these are the establishment and maintenance of a QMS (QP1), establishment and commitment to quality policy and objectives (QP6), definition of responsibility and authority (QP8) and provision of resources to set-up and maintain the QMS (QP11). The list of quality principles were again examined and summarized in such a way as to reflect and represent the common understanding among construction companies. A total of thirty-three (33) quality principles were finalized. In addition, these were verified against the ISO 9001:2000 standard for correctness, suitability and conciseness (refer to Appendix B).

Table 4.1. Quality management procedures obtained from the interview

Code	Quality Principles	Contractors												
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
QP1	Establishment and maintenance of a QMS													
QP2	Document and data control	■	■	■	■	■	■	■	■	■	■	■	■	■
QP3	Control of quality record		■	■	■	■	■	■	■	■	■			■
QP4	Management commitment on QMS								■					
QP5	Client satisfaction on quality		■	■					■		■	■		
QP6	Establishment and commitment to quality policy and objectives													
QP7	QMS planning												■	
QP8	Definition of responsibility and authority													
QP9	Communication				■	■								
QP10	Management review		■	■	■	■	■	■	■	■	■	■		■
QP11	Provision of resources to set-up and maintain the QMS													
QP12	Recruitment and personnel development	■	■	■		■				■	■	■	■	■
QP13	Training		■	■	■	■	■	■	■		■	■	■	■
QP14	Provision of quality infrastructure									■				
QP15	Provision of quality environment	■	■	■								■		■
QP16	Construction planning	■	■		■	■		■	■	■	■		■	■
QP17	Control of client-related processes		■	■		■	■			■	■			■
QP18	Design development	■	■	■		■	■	■				■	■	■
QP19	Design control (change, review, verification and validation)	■	■	■	■	■	■	■			■	■	■	
QP20	Contract review	■	■		■	■	■	■	■		■	■		
QP21	Purchasing process		■	■	■	■		■		■	■	■	■	■
QP22	Supplier and subcontractor control	■		■	■	■							■	■
QP23	Inspection and testing		■		■	■	■	■		■		■	■	■
QP24	Identification and traceability of construction processes and materials				■		■			■	■			■
QP25	Material handling, storage and delivery processes		■		■	■		■		■	■		■	■

Table 4.1. Quality management procedures obtained from the interview (continued)

Code	Quality Principles	Contractors												
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
QP26	Control of monitoring and measuring devices		■	■	■	■			■	■	■		■	
QP27	Rectification of defects						■							
QP28	Control of client complaints			■			■						■	
QP29	Internal audit	■	■	■	■		■	■	■	■	■	■	■	■
QP30	Control of non-conformances		■	■	■	■				■	■		■	■
QP31	Data analysis relating to client satisfaction, conformity to product requirements, characteristics and trends of processes and products, and suppliers				■	■			■		■		■	
QP32	Corrective and preventive actions		■	■	■	■		■		■	■	■	■	■
QP33	Continuous improvement process			■	■	■			■				■	

4.3 Quality Goals

During the interview, contractors were asked about their quality goals. These quality goals describe the expectations of the company in adopting an ISO 9000-based QMS. A total of ten (10) quality goals were finalized based on interview results and reference to previous studies. Table 4.2 presents the prescribed company quality goals of each contractor interviewed. There were also suggestions on how to evaluate these goals. Some of which coincide with those found in literature as presented in Table 4.3.

Table 4.2. Quality goals obtained from interview

Code	Quality Goals	Contractors												
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
QG1	To organize, improve and control construction activities			▪	▪				▪	▪	▪		▪	
QG2	To ensure on time or earlier delivery of construction projects and services *(reduced no. of days delayed in completing the project, on time handover to client).*	▪	▪	▪	▪	▪	▪		▪		▪	▪		▪
QG3	To maintain a safe working environment *(reduced no. of minor and serious accidents).*	▪	▪	▪				▪		▪	▪	▪		▪
QG4	To enhance organization's quality image, gaining competitive advantage and having a better marketing tool *(increased no. of projects won in competitive bidding).*			▪					▪					
QG5	To achieve better quality of work *(reduced no. and degree of non-conformances).*	▪			▪	▪	▪	▪				▪	▪	
QG6	To satisfy clients *(reduced no. of client complaints, increased no. of quality awards given by government and non-government organizations).*	▪	▪	▪	▪	▪	▪	▪	▪	▪			▪	
QG7	To reduce the number of quality related defects *(reduced no. of defects, repair and reworks).*	▪		▪		▪								▪
QG8	To develop staff capabilities *(no. of internal and external trainings provided to staff).*	▪		▪	▪	▪		▪		▪			▪	▪
QG9	To continuously develop the quality management system of the company							▪	▪	▪	▪			
QG10	To save cost *(reduced discrepancy between the estimated bill of quantities and actual volume of materials used, reduced amount of material wastage).*		▪		▪					▪		▪		▪

Table 4.3. Company quality goals and objectives obtained from interview with corresponding bases for evaluation

Quality Goals (QG)	Basis for evaluation
1. To organize, improve and control construction activities	
2. To ensure on time or earlier delivery of construction projects and services	• reduced no. of days delayed in completing the project* • on time handover to client
3. To maintain a safe working environment	• reduced no. of minor and serious accidents
4. To enhance organization's quality image, gaining competitive advantage and having a better marketing tool	• increased no. of projects won in competitive bidding*
5. To achieve better quality of work	• reduced no. and degree of non-conformances*
6. To satisfy clients	• reduced no. of client complaints * • increased no. of quality awards given by government and non-government organizations*
7. To reduce the number of quality related defects	• reduced no. of defects, repair and reworks*
8. To develop staff capabilities	• no. of internal and external trainings provided to staff
9. To continuously develop the quality management system of the company	
10. To save cost	• reduced discrepancy between the estimated bill of quantities and actual volume of materials used • reduced amount of material wastage

Note that the above bases for evaluation, specifically those with (*), were adopted from the previous studies (Pheng and Yeo 1997; McCabe 1998; Hiyassat 2000; Dissanayaka et al. 2001; Ofori et al. 2002; Xiao and Proverbs 2003; Ng 2005; Palaneeswaran et al. 2006; Öztaş et al. 2007)

4.4 Criteria for Evaluation

The quality attributes needed in the formation of matrices were already identified based on literature and interviews with construction companies (refer to Sections 4.2. and 4.3. The next step is defining the criteria for evaluating these quality attributes. The criteria are essential in calculating the scores for the Matrix of Principles and the Matrix of Goals.

A 'weight', in percentage, is assigned to each of the quality attributes. In this research, the term 'level' has been used instead. The level of implementation for the

quality principles using the scale in Table 4.4, developed based on Boyce & Kinnaman (2007) and Lin & Mills (2001). For example, if the company expects commitment to improvement beyond minimum regulatory and company requirements and thorough enhancement in Training, assign a level of three (3) with an equivalent level score of 0.6. Notice that this is just equal to three divided by five. On the other hand, assign the level in achieving the quality goals using a different scale shown in Table 4.5. Some recommendations to ensure objectivity in assigning a level in the quality goals are presented in Table 4.3.

After assigning the levels, the importance of each quality attribute is decided. A scale from 1 to 5 is being proposed in this research (see Table 4.6). This scale may be more practical to use than ranking, especially when several quality attributes are considered. Moreover, one quality attribute may be as important as the rest. Thus, if a company perceives *Training* to be important, an importance rate of three is assigned.

Table 4.4 Scale for Quality Principles adopted from (Lin and Mills 2001; Boyce and Kinnaman 2007)

Level	Score	Description
1	0.2	• Awareness of the need and in the process of understanding the ISO 9000-based Quality Principles • Early stages of improvement orientation and some trends of improvement in the ISO 9000-based Quality Principles
2	0.4	• Adequate understanding ISO 9000-based Quality Principles • Improvement in most ISO 9000-based Quality Principles based on facts
3	0.6	• Committed to improvement in ISO 9000-based Quality Principles beyond minimum regulatory and company requirements • ISO 9000-based Quality Principles are thoroughly enhanced
4	0.8	• High level of continuous improvement in ISO 9000-based Quality Principles • ISO 9000-based Quality Principles are fully set-up for all primary areas • Benchmarking with other companies
5	1.0	• Sustained excellence in ISO 9000-based Quality Principles over several years • Sustaining best practice in ISO 9000-based Quality Principles

Table 4.5 Scale for company quality goals and objectives

Level	Score	Description
1- Very Low (0-20) %	0.2	• Very low level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
2- Low (21-40) %	0.4	• Low level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
3- Average (41-60) %	0.6	• Average level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
4- High (61-80) %	0.8	• High level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
5- Very High (81-100) %	1.0	• Very high level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.

Table 4.6. Importance Rate

①	②	③	④	⑤
Least important	Somewhat important	Important	Very important	Most important

4.5 Calculations and Interpretation of Results

The evaluation of quality management practices is dependent on the scores obtained from the matrices. The expected and actual levels of implementation for the specified QMS requirements are identified. Similarly, the expected and actual levels achieved in the quality goals are also determined. These levels are essential in calculating the expected and actual quality scores for each quality attribute.

The expected quality score (EQS) is equal to the product of the expected level score (ELS) and importance (I) given to that quality attribute. Multiplying the level score with the importance was derived from the studies of Al-Nakeeb et al. (1998) and Öztaş et al. (2007).

$$EQS_i = ELS_i \times I_i \quad (3)$$

Similarly, the actual quality score (AQS) is given by:

$$AQS_i = ALS_i \times I_i \quad (4)$$

Where:

ALS - actual level score

i = (1, 2, 3, ….n) th quality attribute (quality principles and quality goals)

Consequently, the expected and actual final quality scores are calculated by:

$$EFQS = \sum_{i=1}^{n} EQS_i \quad (5)$$

$$AFQS = \sum_{i=1}^{n} AQS_i \quad (6)$$

The final quality score is given by:

$$FQS = AFQS - EFQS \quad (7)$$

The basic evaluation of quality management practices, specifically ISO 9000-based QMSs, is based on the following conditions:

If:

$EFQS \leq AFQS$	Ok
Otherwise	Needs improvement

Aside from the conditions shown above, the expected and actual final quality scores of a company can be plotted in a graph as shown in Figure 4.1. There are four levels for interpreting the position of the company. Level I indicates low expected and low actual final quality scores. Level II indicates low expected and high actual final

quality scores. Level III indicates high expected and low actual final quality scores. Level IV indicates high expected and high actual final quality scores. Figure 4.1 also shows the possible options for a company. Table 4.7 presents these options.

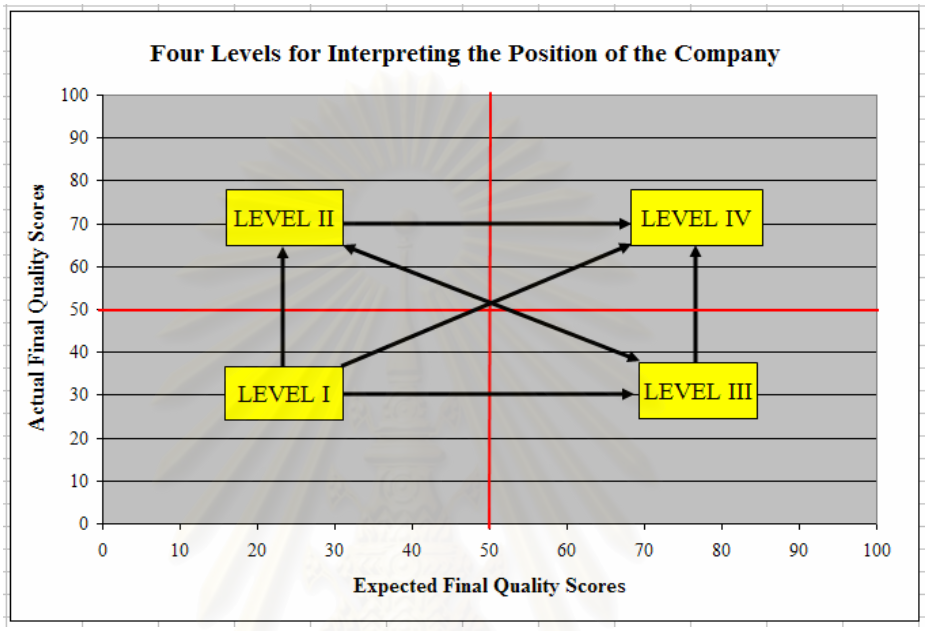

Figure 4.1. Four levels for interpreting the position of the company

Table 4.7. Possible options for a company

Level	Option(s)
Level I	① Level I → Level II → Level III → Level IV ② Level I → Level II → Level IV ③ Level I → Level III → Level IV ④ Level I → Level IV
Level II	① Level II → Level III → Level IV ② Level II → Level IV
Level III	① Level III → Level II → Level IV ② Level III → Level IV
Level IV	Maintain good practice

The four levels described can be further subdivided into six cases as shown in Figure 4.2. Figure 4.2 also shows the actual final quality scores versus the expected final quality scores, which can be used as reference for interpreting the scores for quality principles and quality goals.

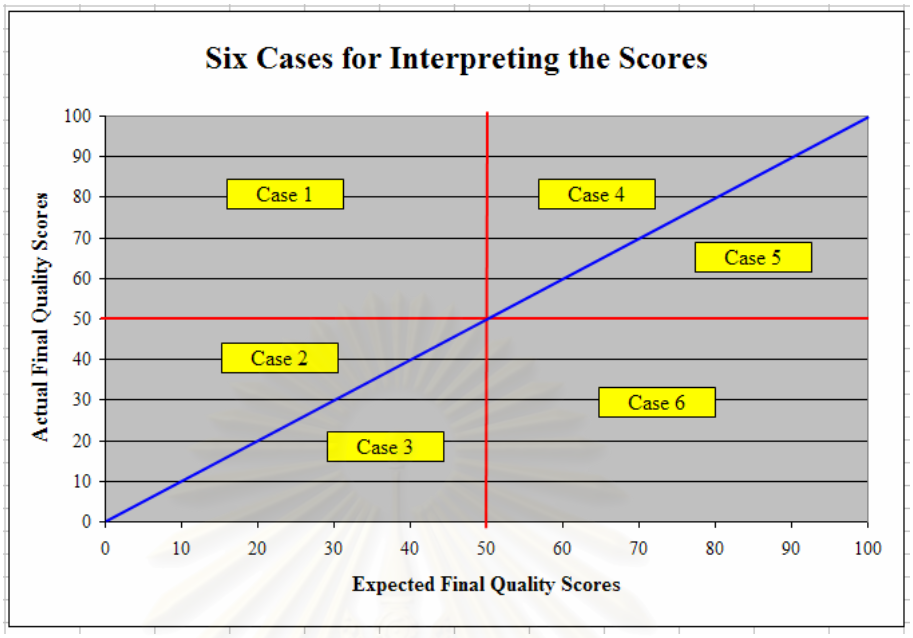

Figure 4.2. Six cases for interpreting the scores

The scores are converted to percentages in order to easily assess the status of a particular company with respect to the maximum possible scores attainable. The figure is divided into six (6) regions, with both average actual and expected final quality scores at fifty (50). The diagonal represents equality between the actual and expected final quality scores. Any point along this diagonal is an indication that a particular company met its expectations. Scores falling above the diagonal means that a particular company exceeded its expectations. Conversely, scores falling below the diagonal means that improvement on certain areas is needed.

The 6 regions were translated into six cases. The corresponding descriptions of these cases are presented in Table 4.8. Cases 3, 5 and 6 fall below the diagonal, which means that the actual final quality scores are less than the expected. If the scores fall anywhere in these cases, then that particular company needs to improve on certain areas. Companies should prepare corrective performance plans for the unsatisfactory areas and regularly monitor them. Improvement activities for the unsatisfactory areas can also be scheduled. On the other hand, cases 1, 2 and 4 fall above the diagonal, which indicate good position. However, for cases 1 and 2, companies may opt to increase their targets and consequently improve more on their implementation. For Case 3, despite low expectations, expectations are still not met. Thus, improvement in

quality attributes is needed to meet and exceed expectations. Thereafter, targets can be increased for continuous improvement.

Table 4.8. Six cases for interpreting the expected and actual final quality scores

Cases	Description
Case 1	High actual, Low expected, Actual > Expected
Case 2	Low actual, Low expected, Actual > Expected
Case 3	Low actual, Low expected, Actual < Expected
Case 4	High actual, High expected, Actual > Expected
Case 5	High actual, High expected, Actual < Expected
Case 6	Low actual, High expected, Actual < Expected

In addition to the Figure 4.2, results can also be interpreted by quadrant analysis Figure 4.3 . A quadrant analysis (TCRP Report 47 1999) is performed in order to provide basic understanding of the importance rates given by contractors to each of the quality principles. The concept of quadrant analysis in TCRP Report 47 was translated to align with this research. For example, the “strengths” are those falling above the median in importance and also above the median in final quality score. Similarly, the “weaknesses” or “opportunity” are those quality principles above the median in importance but below the median in final quality score. Quality principles below the median in importance but above the median in final quality scores are considered “maintenance of effort” quadrant. Lastly, the “non-critical” are those rated below the median in importance on which the final quality score also falls below the mean.

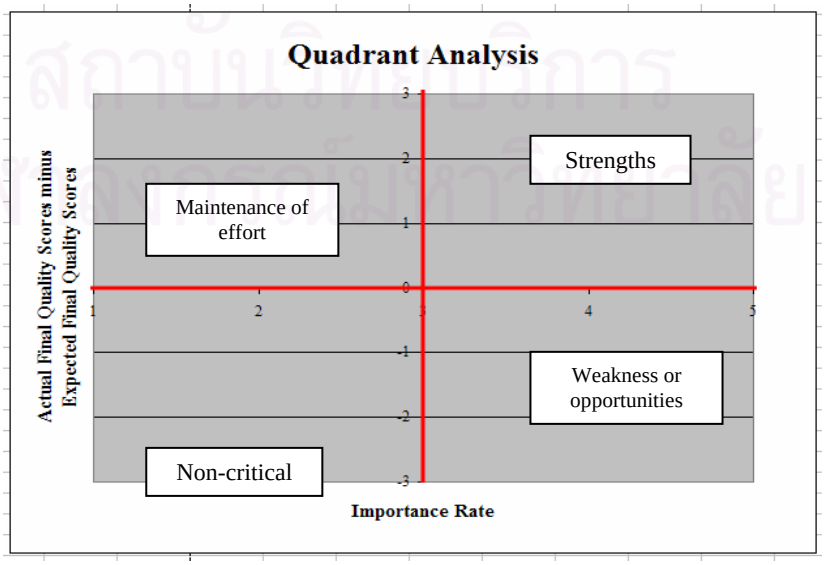

Figure 4.3. Quadrant Analysis

4.6 Summary

This chapter illustrates the development of the tool for assessing quality management practices. The concept of assessment was derived from the definition of effectiveness in previous studies. Towards this end, quality attributes (quality principles and quality goals) were determined from literature and interviews. A total of thirty-three (33) and ten (10) quality principles and quality goals were confirmed, respectively.

The proposed tool incorporates two matrices, the Matrix of Principles and Matrix of Goals, adopted from the research of Öztaş et al. (2007). The evaluation of these matrices involves the use of two scales presented in Table 4.4 and Table 4.5. These scales facilitate the assignment of level score for each quality attribute. Importance rates for the quality attributes are decided by referring to Table 4.6.

Calculation of expected and actual final quality scores are presented in Section 4.5. This is accompanied by the interpretation schemes in the form of graphs shown in Figure 4.1 and Figure 4.2. The graphs can help determine the stage of quality management practice of a company. At the same time, possible options for a company (Table 4.7) falling under a certain level are also described. Six cases which can aid in interpreting the scores are presented. In addition, a quadrant analysis (Figure 4.3) to interpret the results was also introduced. Thus, a company may have the basis for deciding the necessary actions. It may opt to increase its targets for continuous improvement or formulate the most appropriate strategy to meet or exceed its expectation in the future.

CHAPTER V

EVALUATION OF QUALITY MANAGEMENT PRACTICES

The evaluation of quality management practices, involving ISO 9000-based QMSs, is divided into two main parts. The first part aims to explore the perceptions and experiences of contractors in Thailand on quality management implementation, particularly ISO 9000-based QMSs. In addition, their levels of quality management practices were identified. These levels were determined through the evaluation of the matrices discussed in Chapter IV. The second part aims to explore the areas for improvement at the construction industry level based on the expected and actual final quality scores in the quality principles and quality goals.

5.1 Perceptions and Experiences of Contractors in Thailand on Quality Management Implementation

The perceptions and experiences of contractors in Thailand on quality management implementation were identified by integrating the information obtained from interviews and survey questionnaire.

5.1.1 Characteristics of the Interviewed Contractors

A total of thirteen (13) contractors agreed for the interview. These contractors are engaged in both design and construction works and have completed several building construction projects in Thailand. All of which are ISO 9000 certified and have adopted the ISO 9001:2000 version in particular.

Fourteen (14) individuals were interviewed. This figure comprises eight (8) quality assurance personnel, three (3) engineering managers, two (2) construction managers and one (1) from administration.

The interview covered a variety of topics. These included the perceived importance of quality management by the interviewed contractors in Thailand; their ISO 9000 adoption and methods for measuring the effectiveness of ISO 9000-based QMSs; quality principles and prescribed quality goals and objectives.

In order to maintain confidentiality of the information provided and protect the interests of the interviewed contractors, they are referred to in this research as C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12 and C13.

5.1.2 Characteristics of the Surveyed Companies

Survey questionnaires were distributed to ISO 9000 certified construction companies in Thailand. The objective of the survey questionnaire is to get the necessary data for applying the proposed tool in this research.

Out of the thirty-six (36) sent questionnaires, twenty-eight (28) were returned. Out of this 28, twenty-three (23) are contractors, representing a response rate of 74.2 percent. Note that this figure also includes the interviewed contractors. A total of twenty-nine (29) individuals answered the questionnaire. Additional respondents from three companies participated in the survey. Their replies were, however, excluded from the subsequent analysis as these may over or under represent their respective cases. Taking the average of their answers also contradicts to the very essence of the scales proposed in this research. Moreover, it may be incorrect or biased to translate, for example, the average values, so that they can correspond to the given scales.

The decision as to which survey response to choose was made by considering those individuals who directly work under the quality assurance division. Quality managers were preferred as they usually coordinate the certification process and believed to have more experience and training in quality management (Zaramdini 2007).

Table 5.1 shows the descriptive statistics of the respondents and construction companies' information. Notice that most of the respondents are engaged in quality assurance. This may have been due to the perception that quality assurance managers are the persons directly involved to issues concerning ISO 9000. Thus, the request to answer the survey questionnaire was passed to them when these companies were contacted. There were also some individuals from other divisions, like top management, engineering, project management and administration, who participated in the survey.

Table 5.1. Companies and respondents' information

Description	Total Number
A. Respondent's work experience	
Quality assurance	19
Project management	3
Engineering	3
Others	3
B. Company Size	
Small (< 100) employees	4
Medium (100 - 500) employees	14
Large (500 - 2000) employees	10
C. Nature of Business	
Contractor	23
Real estate	2
Project and construction management/engineering consultancy	3
D. Company Type	
Thai	18
Thai-Foreign	10
E. Years of ISO 9000 Certification	
≤ 1 year	2
1 < years ≤ 5	13
> 5 years	13

Most of the responding companies are Thai companies. The remaining is a merge between Thai and a foreign group. Fourteen (14) of the companies are medium in size. The numbers of small and large companies are four (4) and ten (10), respectively. Note that company sizes were classified according to the total number of employees. As the number of employees increases, the size of the company becomes larger. This may imply that a large company has the capabilities and resources to support and handle a greater number of people. Furthermore, an increase in the number of projects awarded to a company may require additional staff. Additional projects may suggest more chances for gaining profit, hence, the increase in reputation or category for the company. In addition, there was no classification by size found in government construction agencies. Classifying according to profit, registered capital and some other assets was difficult to accomplish, as some of these information are unavailable.

Thirteen of the twenty-eight companies have implemented ISO 9000 for over six years already. Two companies recently obtained ISO 9000. One of which has been using the system in the organization before obtaining the certificate.

Data from the survey questionnaires were analyzed using the Statistical Package for Social Sciences (SPSS) Version 11.5.

Contractors who participated in the interview also took part in the survey questionnaire. Respondents in the survey questionnaire are referred to in this research as C14 through C28, to continue with the numbering from the interviewed contractors. Note that in the succeeding data presentations, companies C17, C18, C23, C25 and C27 are not included, as they fall on different business category.

5.1.3 Classification of Quality Management Efforts among the Interviewed Contractors

The first part of the interview dealt with the perceptions on quality management in the construction industry in general. Different opinions were observed from the contractors interviewed and are discussed next.

The contractors in this research believe in the importance of quality management to their business. This is manifested by the efforts they placed on quality. These efforts can be classified as contractor-driven and client-driven.

The contractor-driven refers to the efforts instigated by the contractors themselves. This means that quality management improvement efforts are part of company management's plan. Despite the need to invest manpower and financial resources on quality management, some contractors still go through the certification process. The contractors in this case study believe that quality management assists in controlling and preventing defects, reworks and repair works. Contractor C9 in particular, emphasized the importance of quality management in ensuring the delivery of quality products and services for the satisfaction of clients. In addition, Contractor C7 stressed that by showing commitment and priority to quality, long term business relationship can be sustained.

The client-driven refers to those which were primarily influenced by client requirements. A quality management system that is ISO 9000 certified, for example, is required by clients these days according to Contractor C2. Contractor C3 thinks that clients somehow need assurance that a contractor is operating under an internationally accepted standard. This allows clients to be more confident on the quality of work. Contractor C10 accentuated that most of the tenders requiring ISO 9000 were awarded to them because other contractors were not able to meet this requirement.

Although other contractors in Thailand may have similar views on the importance of quality management, they can not easily set up ISO 9000-based QMSs in their respective organizations. Moreover, they can not readily get a certificate. According to Contractor C3, some contractors, especially the smaller ones lack the needed resources, such as manpower and financial capabilities. Human resources are essential in setting up and implementing the system. There is also the cost associated with the certifying body and implementation expenses. Contractor C10 added the considerable amount of time spent in studying the standard itself.

5.1.4 ISO 9000 Adoption

The second part of the interview dealt with the adoption of ISO 9000. Among the topics discussed were their motivations, previous methods used to ensure work quality, expectations on ISO 9000, its benefits and barriers during implementation.

5.1.4.1 Motivations of Contractors in Thailand for Adopting ISO 9000

During the interview, contractors were asked about their motivations in adopting ISO 9000 to their organizations. Four motivations, namely, mandatory requirement by the government, client requirement, encouragement from main company and management's own initiative, were derived. These motivations were included in the survey questionnaire. Interview and survey questionnaire results were combined and are shown in Table 5.2. Details are presented in Appendix C. From the results given in Table 5.2, it can be seen that most of the contractors involved in this research are motivated by both client requirements and management's own initiative.

Nowadays, most clients require contractors to be ISO 9000 certified before they can tender, especially for large public projects. To them, this is a guarantee that a contractor is operating under an internationally accepted standard, thus allowing them to be more confident on the services provided. However, the proper motivation is to enhance quality management and work quality. Companies need to realize that by proper orientation and outlook towards ISO 9000, benefits can be achieved, which by far are more important than merely satisfying client's requirement. Contractor C11 for instance said that applying the system is its main concern and not the certificate or recognition.

Table 5.2. Motivations of the contractors for adopting ISO 9000

Motivations	No. of Contractors
Mandatory requirement by government	1
Client requirement	17
Encouragement from main company	2
Management's own initiative	17

5.1.4.2 Previous Methods to Ensure Work Quality and Expectations on ISO 9000 of the Interviewed Contractors

During the interview, contractors in this research were asked about the previous methods they used to ensure work quality. Two of the methods are highlighted in this section. The first is the use of existing set of procedures based on their main company in responding to quality assurance and control. In order to ensure correct execution of tasks, employees often refer to these procedures. The quality procedures under their quality management systems were non-ISO 9000 based or ISO 9000-based but informal. The second method was stressed by Contractor C3. Contractor C3 further explained that the quality of work may be dependent on the engineer. An engineer, through his own judgment and use of checklists can informally ensure the quality of work.

Some of contractors using a non-ISO 9000-based or informal ISO 9000-based QMS realized the inadequacy in their respective QMSs. Thus, they decided to extend their efforts to adopting ISO 9000 and getting the certificate itself.

The next question asked on the interviewees was about their expectations on the ISO 9000 standard at the time they decided to adopt it in their respective organizations. They all believe that ISO 9000 is a good standard for improving quality management systems. The ISO 9001:2000 version in particular, has a provision for continual improvement and monitoring of objectives and targets. It also serves as a preparation towards Total Quality Management as explained by Contractor C1. A few expressed their doubts on the application of such standard to their company and to the construction industry. Contractor C8 in particular explained that this may be due to the unpredictable nature of the construction industry. According to him, the continuous changing of teams involved and project location hinder in its application.

With regard to the contractors' future plans for quality management, all are certain about maintaining their ISO 9000 certificates. They see it as becoming more important and useful in sustaining their long term business engagements and upholding commitment to quality. Some of them, particularly Contractors C3 and C4, plan to extend their efforts to Total Quality Management. The others think that their ISO 9000-based QMSs are more than enough for their organizations.

5.1.4.3 ISO 9000 Benefits as Perceived by Contractors in Thailand

Contractors also named the benefits they have achieved by implementing an ISO 9000-based QMS in their organizations. The benefits as perceived by the contractors in the interview are given in Table 5.3.

Table 5.3. Benefits of ISO 9000-based QMS given during the interview

Benefits of ISO 9000-based QMS	Contractors												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
1. Systematic management and communication	■				■		■			■			
2. Systematic and standardized procedures for checking work			■	■	■	■			■			■	
3. Traceability of documents				■						■	■		
4. Helped in tendering process											■		
5. Organized and clear definition of staff responsibility			■										
6. Improved productivity						■		■					■
7. Reduced number of non-conformances													
8. Earlier or on time execution of works	■					■							
9. Better quality of work	■			■	■				■				■
10. Staff is in order.		■											■
11. Company recognition, enhanced company image			■	■		■				■			
12. Won more projects										■		■	■
13. Gained more profit		■				■							■
14. Reduced number of defects	■					■		■	■	■			■
15. Reduced number of non-conformances	■							■					
16. Saved money because of the reduction in reworks													
17. Enhanced client satisfaction						■		■	■		■	■	
18. Reduced client complaints								■		■			■
19. Better quality awareness among staff							■						
20. Saved money because of the reduction in defect costs											■		

Some contractors expressed their views on the above benefits during the interview. Contractors C3, C4, C5 and C6, for instance, stated that by having an ISO 9000-based QMS, things are more organized. There are check sheets, method statement, work instructions to better control, monitor and inspect the works. With specific procedures to follow, more efficiency in the work is achieved according to Contractor C5. The tendering process and document control are two of the major areas improved in terms of efficiency. Contractor C11 stressed the help of the system in its tendering process. Along with Contractor C11, Contractors C4 and C10 also believe that their document control system became better. Document can be easily traced when needed.

The clear definition of staff responsibility was pointed out by Contractor C3. At times, work becomes chaotic because an employee tends to overlap duties with another. Thus, a clear description of each person's duties and responsibilities can avoid confusion.

Contrary to Contractor C1 and C6, Contractor C3 thinks that work, particularly, that of the procurement process and subcontractor selection, becomes slower. According to the interviewee, *"The procedure becomes a hassle"*. In addition, because of too much technicality in the work, staff sometimes overlook a few procedures, especially the paperwork. Staff perceive the paperwork as troublesome, thus, it usually comes later.

Contractors C3, C5, C7 and C8 commented on the relationship between profit and ISO 9000-based QMSs. According to them, increase in profit can not be directly attributed to the implementation of ISO 9000-based QMSs. Although quality defects and claims are generally reduced, the increase in profit can not be readily inferred. Contractor C7 said that other factors such as operation costs, economic, social and political issues may influence the increase in profit. Another important aspect to consider about profit is the amount of material wastage, as identified by Contractor C3.

Views on the increase in productivity were also expressed by Contractors C7 and C9. Contractor C7 thinks that the increase in productivity is not much. Productivity depends primarily on the labor skills. Improved quality does not imply an increase in productivity. Higher productivity may not actually be related to the

adoption of ISO 9000-based QMS as mentioned by Contractor C7. The interviewee instead exemplified that productivity affects the number of delays for each project.

In this research, all contractors believe that achieving the mentioned benefits can not solely be attributed to an ISO 9000-based QMS. An ISO 9000-based QMS must be accompanied by top management support and employees' cooperation.

These benefits mentioned during the interview can be summarized into six categories. These six benefits were included in the survey questionnaire. Table 5.4 shows the results from both interview and survey questionnaire. Refer to Appendix D for the details. Systematic, standardized and improved work procedures is evidently the benefit mostly perceived by the contractors. This may imply that the contractors in involved in this research recognize the use of ISO 9000-based QMS in the systematic execution of work. Thus, the prevention of mistakes can be ensured. A reduction in quality related problems may also be a consequence of standardized procedures. Ten (10) contractors, observed the benefit of ISO 9000-based on client satisfaction. Fifteen (15) contractors, on the other hand, agreed on the enhanced company image and improved marketing strategy brought by ISO 9000-based QMSs. For these companies, ISO 9000 helped in advertising the company. Only a few believe in saving money as a result of the reduction in defect costs. The reason for this, as mentioned by some contractors in the interview, is that other factors may affect cost. Among such factors are economical, social and political factors. Better quality awareness among staff is yet to be achieved. Companies need to conduct training to improve awareness on ISO 9000-based QMS among employees.

Table 5.4. Summary of ISO 9000-based QMSs benefits from interview and survey questionnaires

ISO 9000 Benefits	No. of Contractors
1. Systematic, standardized and improved work procedures	22
2. Enhanced company image and improved marketing strategy	15
3. Reduced quality related problems	8
4. Enhanced client satisfaction	10
5. Better quality awareness among staff	5
6. Saved money because of the reduction in defect costs	4

5.1.4.4 Drawbacks of ISO-based QMSs and Barriers during Implementation as Perceived by Contractors in Thailand

Along with the benefits described in Section 5.1.4.3, contractors were also asked to elaborate on the drawbacks of ISO 9000-based QMSs during the interview (Table 5.5.).

Table 5.5. Drawbacks of ISO 9000-based QMS given during the interview

Drawbacks of ISO 9000-based QMSs	Contractors												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
1. Difficulty in understanding the system	■							■	■			■	
2. Too much detail in work procedures, thus creating hassles and slowing down some processes.	■		■										■
3. Too much paperwork			■		■	■	■			■			■
4. Difficulty in writing procedures that will meet the requirements of the standard										■			
5. Difficulty in educating the staff	■	■		■		■	■	■	■	■	■	■	
6. Lack of management commitment	■	■	■	■	■	■	■	■	■	■	■	■	■
7. Additional cost						■							

The first drawback given in Table 5.5 is the difficulty in understanding an ISO 9000-based QMS as emphasized by Contractors C1, C8 and C9. The complexity of the ISO 9000 standard makes it more tedious to write the procedures which will comply with its requirements.

The procedure for a particular work may be too detailed as well. Employees sometimes skip a few steps. Those missed steps, according to Contractor C1, may be the most critical and sometimes the root causes of a much bigger problem. The technicality in the work is also sometimes perceived as a hassle and troublesome according to Contractor C3. One consequence is that the procedures sometimes slow down the process. As the process may get in the way of executing the work at the

earliest possible time, some staff overlook the procedures. Another consequence is the additional paperwork described by Contractor C3. Some, according to Contractors C3 and C6, fail to make the necessary records. They will then forge the records when preparing for the audit. Contractor C10, on the other hand, stressed the importance of the additional documentation. These documents may prove to be useful later on.

Two of the main perceived drawbacks of ISO 9000 were identified. The first is the difficulty in educating the staff. There is also lack of cooperation and regard for quality management by employees. Quality awareness and understanding are very essential and at the same time difficult to inculcate into the minds of employees. Thus, appropriate quality orientation and training need to be conducted. Second is the lack of top management support and commitment. The top management plays a more vital role. Commitment to quality must be demonstrated first by top management before expecting the lower levels to follow.

The drawbacks given in the interview were confirmed by referring from literature and can be summarized into six groups. Note that the fourth drawback in Table 5.5 is combined with the first drawback. These drawbacks were then included in the survey questionnaire. The summary of drawbacks from the 23 contractors in this research is shown in Table 5.6. Clearly, the lack of management commitment and imperfections on the part of employees are the greatest drawbacks perceived by the contractors involved in this research. This means that in order to implement an ISO 9000-based QMSs, both management and employees must ensure commitment to the system. The increase in paperwork seemed to be experienced by some contractors. For some contractors, too much technicality or detail in work procedures is one disadvantage. Looking into the details sometimes consume a lot of time, thus, slowing down the process. Noticeably, only four (4) complained about the extra cost incurred. Thus, for most of the contractors, the cost associated with ISO 9000-based QMS is not a big issue to them. The rest may have already understood or expected the additional costs associated with ISO 9000-based QMSs. Moreover, they may believe that the additional cost may have subsequent savings on defects cost in the future.

Table 5.6. Summary of ISO 9000-based QMSs drawbacks from interview and survey questionnaires

Drawbacks of ISO 9000-based QMSs	No. of Contractors
1. Difficulty in understanding and communicating the system	8
2. Increased effort in documentation	12
3. Too much detail in work procedures	5
4. Lack of competent personnel to carry out quality management duties and additional time needed in management and training	16
5. Additional cost	4
6. Lack of management commitment	16

5.1.4.5 Methods Employed by the Contractors in Assessing their Quality Management Practices

This research involves the development of a tool to assess quality management practices, i.e., ISO 9000-based QMSs, in particular, based on the concept of effectiveness. To do this, contractors were first asked about how they measure the effectiveness of their ISO 9000-based QMSs. Table 5.7 shows the methods cited by the contractors as forms for evaluating effectiveness. From Table 5.7, internal quality audits, client satisfaction surveys, key performance indicators (KPIs) and management reviews seem to be the common methods for measuring effectiveness. The contractors however revealed some views about these methods as described next.

All contractors first cited internal quality audits as means for evaluating the effectiveness of ISO 9000-based QMSs. Some contractors said that the number of non-conformances and corrective actions were mainly the bases for evaluating effectiveness by internal audits. These values are then compared with the past audit results.

Some positive and negative views on internal quality audits were revealed by contractors in this research. According to Contractor C3, audits are not only good at identifying problems and areas requiring greater attention. Audits are also beneficial to the person being audited in that he or she can improve performance.

Criticisms on audits were also exposed. First, the process of doing audits is too systematic and customary as described by Contractor C9. Staff begin to do things right because they know that an audit is coming. Second, it is based on a sampling method, thus representing only an estimate according to Contractor C7. Third, there

are cases of biased findings which may have radiated from the inadequate training of auditors or simply varying personalities as described by Contractors C6 and C8. They also emphasized that if the system is well-understood by the parties involved, there should be no room for disorder.

Client satisfaction surveys are exercised in some of the contractors interviewed. Some of them have a client satisfaction feedback form which they distribute to all clients. Since other clients do not prefer forms of this kind, some contractors carry out surveys through interviews, such in the case of Contractors C6 and C8.

Like internal quality audits, client satisfaction surveys have associated advantages and flaws. Similar to audits, these surveys can help identify areas for improvement. Contractors C1 and C4 explained that it is difficult to assess effectiveness based on these surveys alone. One reason for this is that different clients have different satisfaction levels, standards and expectations on the quality of work. With this, results may prove to be unreliable. It is also sometimes not easy to get enough feedback from clients. Since some information can only be obtained from their perspective, contractors may be deprived of the information which might have helped them in one way or another.

An important point about client satisfaction survey was expressed by Contractor C11. He said that improving or modifying a particular work in response to satisfying clients may be unreasonable. Some clients demand a better quality of work that does not correspond to the amount they are willing to pay. This creates loss on the contractors' side. Thus, for Contractor C11, it will opt to accept low client satisfaction ratings rather than losing money at that particular instant.

Key performance indicators were also considered to be tools for measuring effectiveness by Contractors C4 and C6. Targets for the key processes are first established. Performance indicators related to these processes are regularly monitored and evaluated after a period of time. The resulting values and then compared with the targets. Target values are adjusted depending on the results.

Table 5.7. Methods for assessing ISO 9000-based quality management practices from interview

Methods for Assessment	Contractors												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
1. Internal quality audits	■	■	■	■	■	■	■	■	■	■	■	■	■
2. Client satisfaction surveys/Feedbacks	■	■	■	■	■	■	■	■	■	■	■	■	■
3. Key Performance Indicators (KPIs)				■		■						■	
4. Management reviews			■			■	■	■	■	■		■	■
5. Quality control checklists	■												
6. Project review		■											
7. System review			■										
8. Client and engineer inspection					■								
9. Collection of quantitative data from all divisions in the company						■							
10. Comparisons between targets and actual outcomes								■			■		
11. Feedbacks from employees								■					
12. Certification of Quality Achievement awarded by clients									■				
13. Statistical Methods										■			

Management reviews are conducted in all of the contractors interviewed. Issues from internal quality audits are raised during these meetings. The management committee formulates and decides the best solution to deal with the issues. However, management reviews can not actually evaluate effectiveness. These aim to review the existing system in order to be more effective.

Integrating the methods given during the interviews with the results of the survey questionnaire, the common methods for assessing ISO 9000-based QMSs were obtained (refer to Table 5.8). Conducting internal quality audits is the common method employed by the contractors followed by client satisfaction questionnaire. Since quality audits are required by the ISO 9001:2000 standard, contractors may readily perceive and accept them as methods for assessing their quality management practices. Client satisfaction surveys were clearly considered as determinants for assessing quality management practices. If contractors are able to satisfy their clients with their work, then their quality management practice may be working well. Although management reviews may not directly be considered as methods for assessing quality management practices, nine (9) contractors consider them as such. A few contractors monitor KPIs, objectives and targets in order to assess their practice.

Table 5.8. Common methods employed for assessing ISO 9000-based QMSs among contractors in Thailand

Drawbacks of ISO 9000-based QMSs	No. of Contractors
1. Internal quality audits	16
2. Client satisfaction surveys	14
3. KPIs	5
4. Management reviews	9
5. Monitoring of objectives and targets	5

5.2 Assessment of ISO 9000-based Quality Management Practices at Company Level

The assessment of ISO 9000-based quality management practices among contractors in Thailand was based on the concept of effectiveness. Thus, evaluation based on achieving the specified QMS requirements derived from the ISO 9001:2000 standard and prescribed company quality goals and objectives. Different companies have different requirements and expectations on the implementation of a quality assurance system. Thus, the effectiveness or impact of the system to the company depends on the predefined purpose.

As mentioned in Chapter IV, the proposed tool incorporates two matrices, adopted from the studies of Al-Nakeeb et al. (1998) and Öztaş et al. (2007). Evaluation of these two matrices, the Matrix of Principles and the Matrix of Goals, are presented in Sections 5.2.1 and 5.2.2., respectively.

5.2.1 Matrix of Principles

The Matrix of Principles describes the effectiveness in satisfying the QMS requirements based the ISO 9001:2000 standard. Thirty-three (33) quality attributes for the Matrix of Principles, referred to in this research as “quality principles”, were obtained from interviews. These quality principles were carefully reviewed and verified against the ISO 9001:2000 standard. Completeness, correctness and clarity in the terms used were ensured to reflect the common understanding among construction companies.

Respondents were asked to indicate their expected level of implementation in the quality principles at the start of their ISO 9000 adoption. The scale for quality principles in Table 4.4 was provided as their guide. Similarly, they were also asked to specify their actual level of implementation since the adoption of ISO 9000. There were some unanswered quality principles. Respondents concerned were then contacted to clarify as to whether they failed to notice that particular quality principle or it was not applicable to their organization. Due to some circumstances beyond the control of the researcher, some respondents did not have the time to reply. Thus, the unanswered items were interpreted and reported as not applicable and left blank for the analysis. SPSS (Version 11.5) excludes these in the calculation.

The equations given in Section 4.5 were evaluated to determine the final quality scores of each contractor for the quality principles. Recall that the assessment of ISO 9000-based quality management practices through the following conditions:

If:

$EFQS \leq AFQS$	Ok
Otherwise	Needs improvement

Appendices F, G and H show the raw data on quality principles from the survey questionnaires. Calculated AFQS and EFQS are shown in Appendix I. The gaps in each quality principle are presented in Appendix L. Considering all quality principles, only three companies, specifically companies C6, C20 and C22, are satisfactory with respect to their respective expectations. The values of AFQS in excess of EFQS are 20.8, 16.8 and 0.2, respectively. Clearly, company C6 obtained the highest score among the three. The rest of the companies failed to meet or exceed their expectations in some of the quality principles. Such companies may have been satisfactory in one or more of the quality principles. At the same time, the quality scores in some quality principles may have had corresponding higher negative scores in the other quality principles. For example, Company C2 is satisfactory in implementing all quality principles except for QP22, the supplier and subcontractor control (refer to Appendix L). This simply means that the final quality score only depicts the position of the company with respect to the overall quality management system, i.e., considering all the quality principles. Therefore, a negative value of final quality score suggests that a company needs to look into the individual areas of its quality management system.

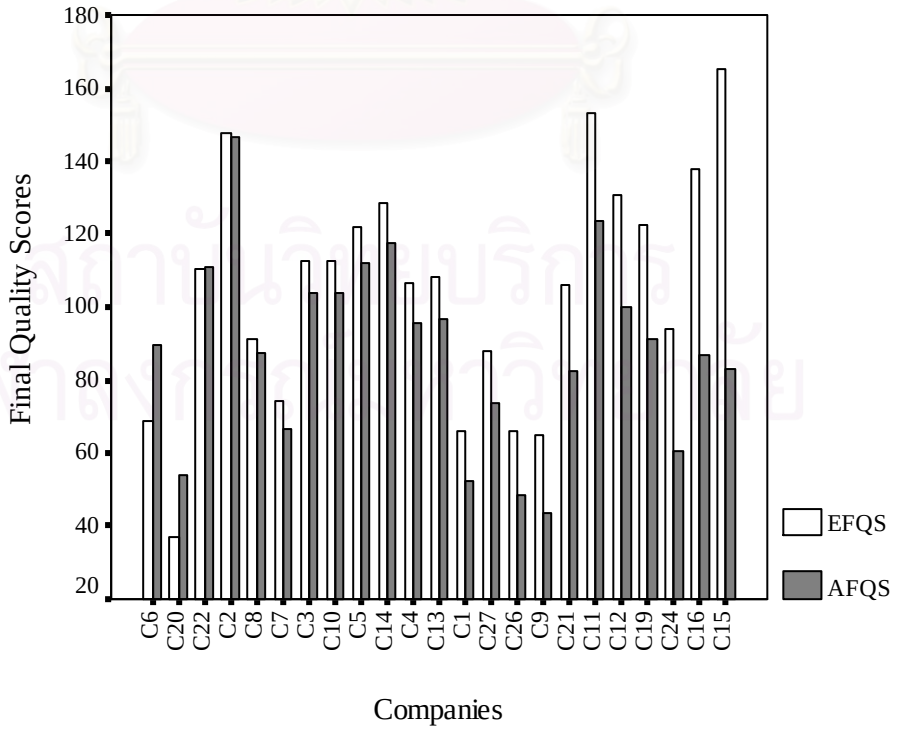

Figure 5.1. Individual company's EFQS versus AFQS for the Matrix of Principles

Figure 5.1 shows the difference between the EFQS and AFQS for each company. Notice the big gap between the EFQS and AFQS for Company C15. This suggests that Company C15 needs to look deeply into each of the quality principles and determine which areas it needs to examine. Management needs to think of solutions to remedy this disparity. Other companies, like C2 and C8, nearly achieved their expectations, as depicted by the small gap between their EFQS and AFQS. Thus, these companies can meet or exceed their expectation by developing and executing some improvement plans and maintaining good practice.

On the average, it appears that respondents are generally unsatisfactory in client satisfaction on quality (QP5) (see Appendix L and Figure 5.2). QP5 obtained an average of -0.86, which is the most negative value among the thirty-three quality principles. This means that the expected final quality score, EFQS, was not met and that it exceeds the actual final quality score, AFQS. Along with QP5, poor results were obtained in the establishment and commitment to quality policy and objective (QP6), data analysis (QP31) and the recruitment and personnel development (QP12).

On the other hand, notice that the least negative value is on QP20, contract review (-0.16) followed by design control (QP19), with an average of -0.21. Although these are negative values, they can signify that companies nearly achieved their expectations on these quality principles. However, it may be misleading to immediately conclude that companies performed well in QP20 and QP19, relative to the other quality principles. The reason for this is that some companies did not answer these items in the survey questionnaire. Thus, in the computation, the missing values were excluded, reducing the sample size. Hence, results do not represent the 23 contractors. Therefore, contractors actually, to some extent, were satisfactory on QP26, control of monitoring and measuring devices, with a value of -0.22.

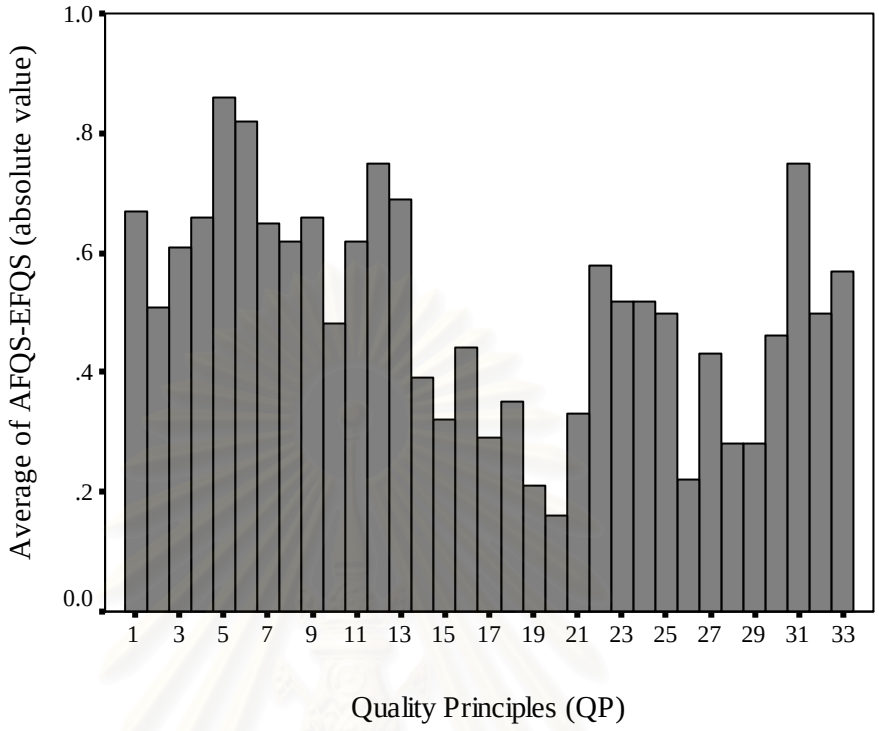

Figure 5.2. Quality principles against the average of AFQS-EFQS (absolute value)

Figure 5.2 shows the average of the difference between the AFQS and EFQS, i.e, |AFQS-EFQS|. Aside from QP5, respondents need improvement in the establishment and commitment to quality policy and objective (QP6), data analysis (QP31) and the recruitment and personnel development (QP12). Meanwhile, the companies are not too far from meeting their expectations in the control of client complaints (QP28), internal audit (QP29) and control of client-related processes (QP17).

Based on the results in Appendix L, the respondents are mostly unsatisfactory in the Management Responsibility requirement of the ISO 9001:2000 standard. Next to this is on the Product Realization requirement followed by the Measurement, Analysis and Improvement requirements. Clearly, management commitment is vital in effectively implementing an ISO 9000-based QMS.

5.2.2 Matrix of Goals

As mentioned, the Matrix of Goals describes the effectiveness in achieving the prescribed company quality goals and objectives in implementing an ISO 9000-based QMS. The ten (10) quality attributes, called “quality goals” obtained from the interviews were used to evaluate the Matrix of Goals. Bases for evaluating these quality goals were provided to permit similar manner by which the respondents can assess each of them (see Table 4.3). Similar equations presented in Section 4.5 were evaluated for the Matrix of Goals. Respondents were asked to indicate their expected and actual level of achievement in the quality goals (Appendix J). The scale for quality goals in

Table 4.5 was provided as their guide. There were no missing data for this case.

From the calculated results in Appendix K, out of the 23 contractors, only three (3) companies (C8, C20, C22) are satisfactory relative to their respective expectations, considering all the quality goals. Among these companies, C8 obtained the highest positive final quality score equal to 5.8. This means that overall, C8 exceeded its expectations. Companies C20 and C22 both obtained zero scores, which depict equality between their expectations and actual final quality scores on quality goals. Note that companies C20 and C22, which are satisfactory in the quality principles, also performed well with the quality goals.

In Figure 5.3, Company C15, once more obtained the lowest score in terms of quality goals. Company C6, the best in quality principles, is unsatisfactory in terms of the quality goals.

Among the 10 quality goals, achieving better quality of work (QG5), i.e., reducing the number and degree of non-conformances, resulted to the greatest negative value equal to -0.94 (refer to Appendix M). On the other hand, enhancing organization’s quality image, gaining competitive advantage and having a better marketing tool (QG4), turned out to have the value closer to zero (-0.49). This means that, generally, the respondents practically achieved their expectations on this quality goal. QG2 or ensuring on time or earlier delivery of construction projects and services is next in terms of the lowest negative value, equal to 0.51.

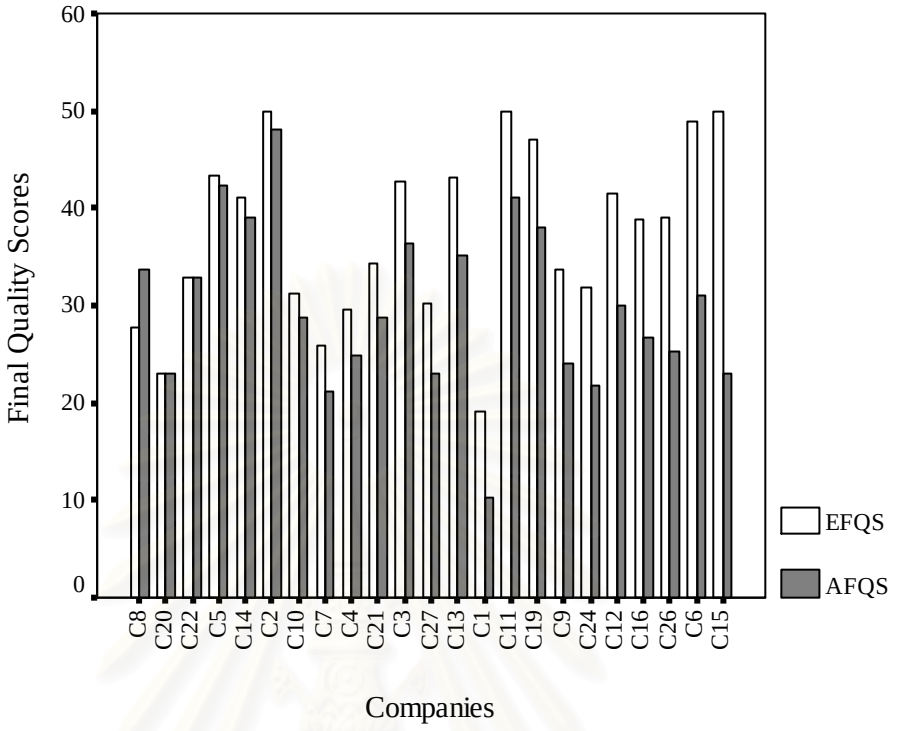

Figure 5.3. Individual company's EFQS versus AFQS for the Matrix of Goals

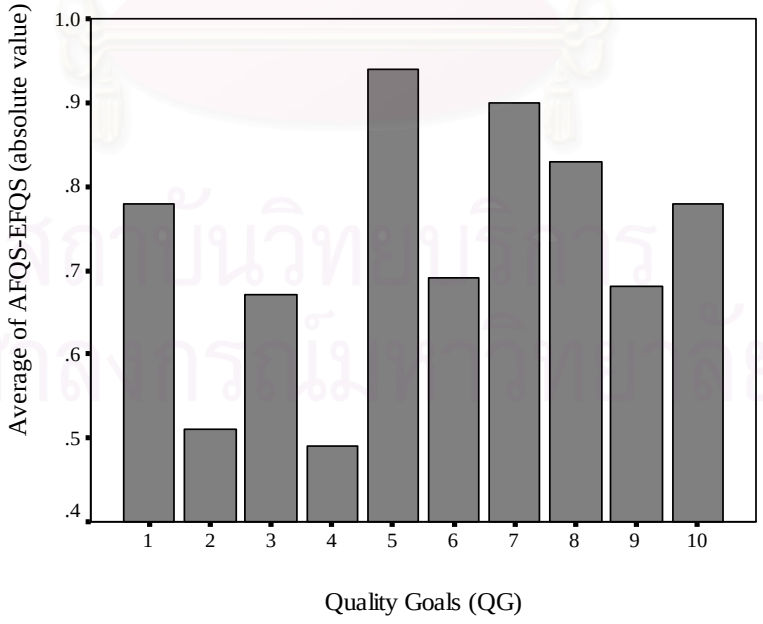

Figure 5.4. Quality goals against the average of AFQS-EFQS (absolute value)

Figure 5.4 shows the average of the difference between the AFQS and EFQS, i.e, |AFQS-EFQS|, for the quality goals. Notice that the values for QP1 and QP10 have the same values, while QP3, QP6 and QP9 are comparable to each other.

5.2.3 Comparison between the Expected and Actual Final Quality Scores

Comparisons between the expected and actual final quality scores, converted to percentage, for the Matrix of Principles and Matrix of Goals are represented in graphs, shown in Figure 5.5 and Figure 5.6. The maximum possible scores for the quality principles and quality goals are one hundred sixty-five (165) and fifty (50), respectively. Figure 4.2 in Section 4.5 is a graph which can be used to interpret the expected and actual final quality scores for the quality principles and quality goals.

From Figure 5.5, only Companies C6, C20 and C22 obtained satisfactory results for the quality principles as their scores fall below the diagonal. This means that they met or exceeded their expectations on the quality principles. It can also be seen from Figure 5.5 that most contractors fall above the diagonal. At the same time, majority are in Region 5, i.e., they have high expected and high actual final quality scores. Company C20, though satisfactory with respect to its final quality scores, may still increase its targets, thus, aiming for continuous improvement. Company C20 falls in Region 2, where it has low expectations and low actual results. Company C6 has low expectations and achieved high results. Like Company C20, it can improve by increasing its targets.

Considering Figure 4.1, it can be seen from Figure 5.5 that most of the contractors fall in Level IV, which means that they have already high expectations on the quality principles and have achieved high actual results.

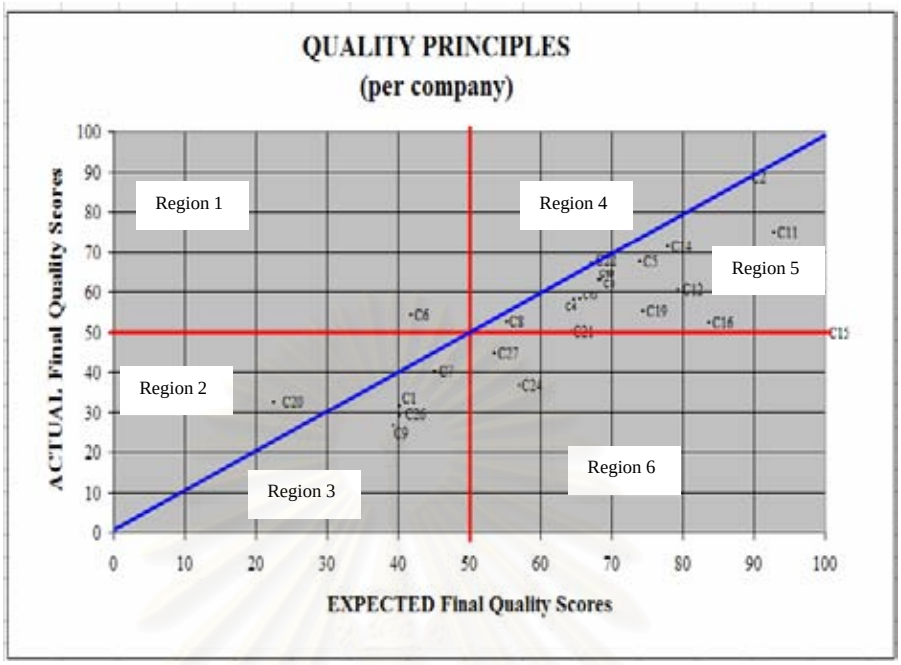

Figure 5.5. Companies as compared to the average values of EFQS and AFQS at fifty (50) for the Quality Principles

Figure 5.6 shows the EFQS versus AFQS for the quality goals. Similarly, Figure 4.2 can be used to interpret the scores. Most contractors fall in Region 5. Their expectations are already high and have achieved high actual results. However, these companies still need to improve their performance as they are above the diagonal. Only Companies C8, C20 and C22 obtained satisfactory results with the quality goals. Company C20 may opt to increase its targets for continuous improvement.

Considering Figure 4.1, it can be seen from Figure 5.6 that most of the contractors also fall in Level IV with respect to the quality goals. This means that they have already high expectations on the quality goals and have achieved high actual results following the implementation of ISO 9000 in their organizations.

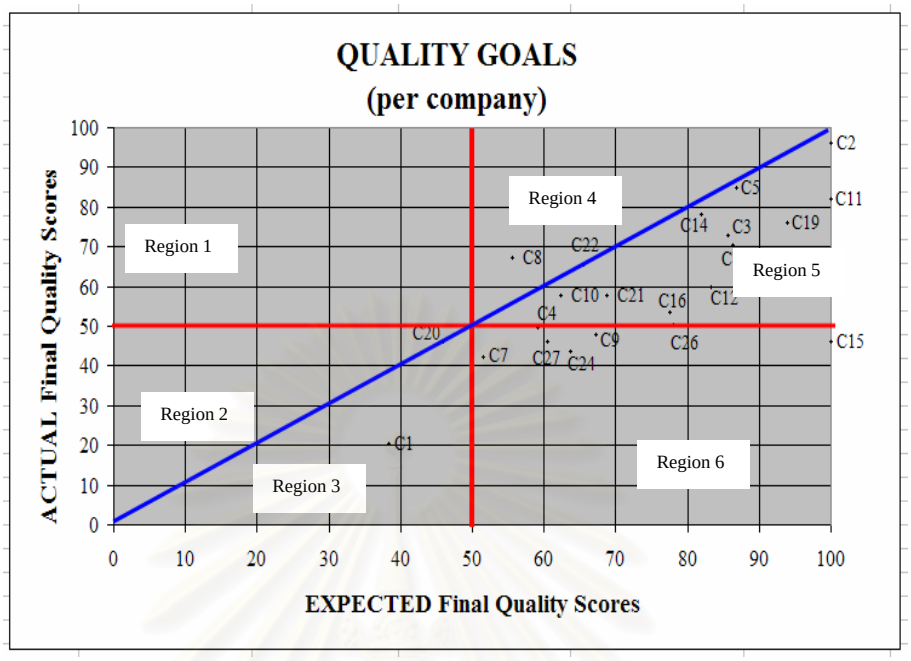

Figure 5.6. Companies as compared to the average values of EFQS and AFQS at fifty (50) for the Quality Goals

5.3 Identification of Areas for Improvement (Analysis at Industry Level)

5.3.1 Independent Sample t-tests

Data analysis at the construction industry level was performed for this research to assess the implementation of ISO 9000-based QMSs with regard to quality principles and quality goals. This includes the identification of the areas for improvement in the quality principles and quality goals.

As the sample in this research is diversified, i.e., contractors are of different types and sizes, independent sample t-tests are performed to determine if there are significant differences among the answers of the respondents. If there are no significant differences, then contractors can be considered altogether.

Table 5.9 and Table 5.10 show the results of independent sample t-tests for the company type and size, respectively. A significance level of 0.05 was chosen. For the company type, the null (H_o) and alternative hypotheses (H_1) are given by:

H_o: Thai = Thai-Foreign

H_1: Thai ≠ Thai-Foreign

In Table 5.10, since all p-values are greater than 0.05, we failed to reject the null hypothesis. This means that the evidence is insufficient to show that there is difference between the Thai and Thai-Foreign contractors. Thus, we can consider them as one group.

Table 5.9. Independent sample t-test results for company type (Quality Principles)

	p-value	Remark
EXPECTED Thai vs. Thai-Foreign	0.486856	Failed to Reject Ho
ACTUAL Thai vs. Thai-Foreign	0.888096	Failed to Reject Ho

Similarly, for the company size, the following are the hypotheses:

H_o: Small = Medium H_1: Small ≠ Medium

Medium = Large Medium ≠Large

Small = Large Small ≠ Large

In Table 5.10, since all p-values are greater than 0.05, we failed to reject the null hypotheses for the company size. This means that the evidence is insufficient to show that there is difference among contractors' sizes. Thus, we can consider them as one group.

Table 5.10. Independent sample t-test results for company size (Quality Principles)

EXPECTED	p-value	Remark
Small vs. Medium	0.164664	Failed to Reject
Medium vs. Large	0.414249	Failed to Reject
Small vs. Large	0.362564	Failed to Reject
ACTUAL		
Small vs. Medium	0.337683	Failed to Reject
Medium vs. Large	0.658726	Failed to Reject
Small vs. Large	0.527858	Failed to Reject

Table 5.11 and Table 5.12 show the results of the independent sample t-tests for the quality goals. Since the p-values are all greater 0.05, we failed to reject the null hypotheses. Thus, we can consider them as one group.

Table 5.11. Independent sample t-test results for company type (Quality Goals)

	p-value	Remark
EXPECTED Thai vs. Thai-Foreign	0.993819	Failed to Reject
ACTUAL Thai vs. Thai-Foreign	0.396762	Failed to Reject

The results of the independent sample t-tests in this research may or may not change if a larger sample size is considered. In this research, the total sample size is only 23, which is quite small.

Table 5.12. Independent sample t-test results for company size (Quality Goals)

EXPECTED	p-value	Remark
Small vs. Medium	0.264327	Failed to Reject
Medium vs. Large	0.350027	Failed to Reject
Small vs. Large	0.507391	Failed to Reject
ACTUAL		
Small vs. Medium	0.320663	Failed to Reject
Medium vs. Large	0.541836	Failed to Reject
Small vs. Large	0.476119	Failed to Reject

5.3.2 Quality Principles

On the average, the respondents have the greatest expectation on inspection and testing (QP23), client satisfaction (QP5) and the establishment and commitment to quality policy and objectives (QP6) (see Figure 5.7). They expected the least in QP19 or design control. However, since there were some missing data for this quality principle, this may not in reality be the case. Thus, QP15 (provision or quality environment) and QP26 (control of monitoring and measuring devices) are the ones with least expected levels.

Figure 5.8 is a graph of the quality principles with their corresponding mean importance rate. The respondents gave the highest importance rate on client satisfaction (QP5), equivalent to 4.695. This is consistent with their expected level of implementation on this quality principle. QP15 or provision or quality environment has the lowest expectation and perceived to be the least important among the 33 quality principles.

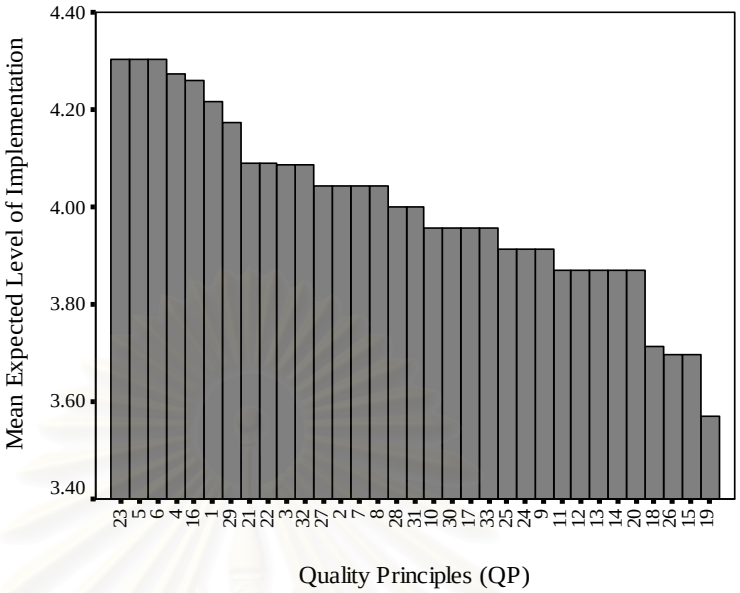

Figure 5.7. Mean expected level of implementation for the quality principles

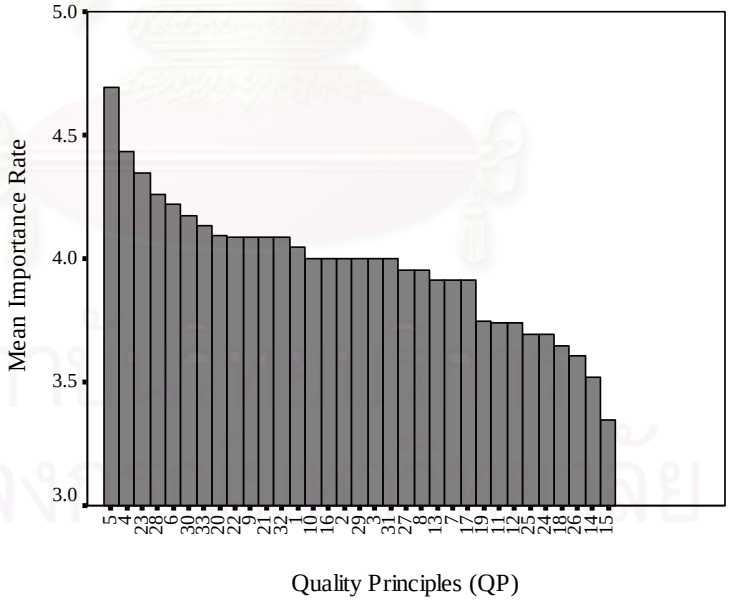

Figure 5.8. Mean importance rate for the quality principles

A quadrant analysis, discussed in Section 4.5, was also performed to interpret the results. Figure 5.9, in order to provide basic understanding of the importance rates given by contractors to each of the quality principles. From Figure 5.9, all quality principles happen to fall in the “weakness or opportunity” quadrant. This means that the respondents considered these quality attributes as more important but from which they obtained very low final quality scores. Although this quadrant analysis does not present the impact of quality principles to the overall final quality scores, it nevertheless gives a general overview of the relationship between quality principles and the final quality scores obtained by companies.

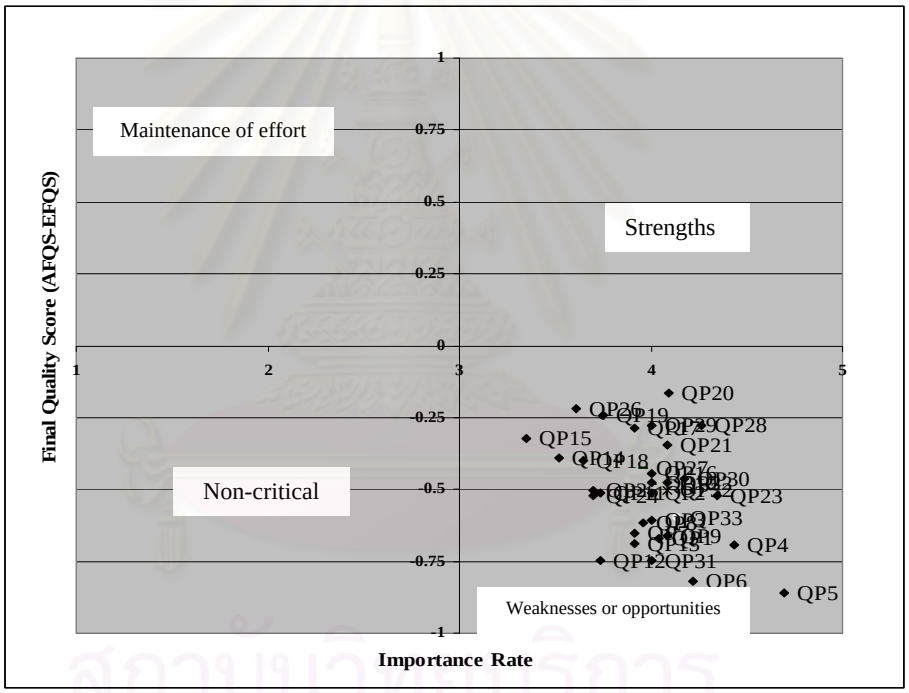

Figure 5.9. Quadrant analysis of Final Quality Scores versus Importance Rate for each quality principle

QP5 is perceived to be the most important but respondents are most unsatisfactory in this quality principle. Therefore, this should be prioritized by management.

Paired sample t-test was performed to assess the implementation of ISO 9000-based QMSs with respect to the quality principles. This test is the more appropriate hypothesis testing method to use since the significant difference between the expected

and actual final quality scores of the same samples, the contractors in this case, is sought. The following are the null (H_o) and alternative (H_1) hypotheses set.

H_o : $d = 0$

H_1 : $d > 0$

Where: $d = \mu_2 - \mu_1$

The confidence level was chosen to be 95 percent, thus, $\alpha = 0.05$. The results of the t-test for the quality principles and quality goals are described in Table 5.15 and Table 5.16, respectively.

Quality principles are listed in decreasing order by their significance (Table 5.15). For quality principles, QP20, QP26, QP19, QP28, QP21 and QP29, the corresponding *p*-values are greater than 0.05. Therefore, we failed to reject the null hypothesis, H_o. The actual final quality scores for QP20, QP26, QP19, QP28, QP21 and QP29, are considerably higher than the expected final quality scores. Overall, contractors are satisfactory in these quality principles.

On the other hand, contractors need to improve in terms of client satisfaction on the quality of their work (QP5), similar to the findings in Section 5.2.1. We rejected the null hypothesis, H_o because the t-statistic for QP5 falls within the rejection region ($5.355 > t_c$). Along with QP5, improvement is needed on QP6 and QP11. There is failure in meeting or exceeding the expectations on most of the quality principles.

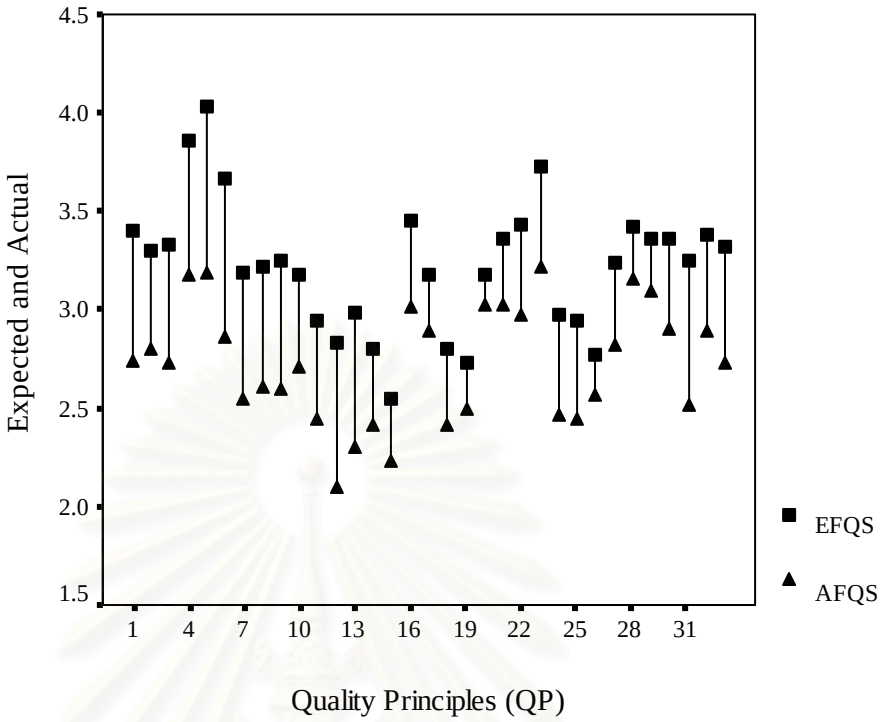

Figure 5.10. Deviation of AFQS from EFQS for Quality Principles

Figure 5.10 shows the deviation of the mean actual final quality score from the mean expected final quality score for each quality principle. The smaller gaps represent those quality principles which are nearly achieved in terms of expectations. The larger gaps, on the other hand, need further attention. In both ways, improvement is needed.

5.3.3 Quality Goals

Similar to the quality principles, the mean expected level of achievement in the quality goals are presented in Figure 5.11. Respondents expected the most in QP6 or satisfying the client. This coincides with their expectation in the quality principles relating to client satisfaction. On the other hand, developing staff capabilities (QP8) turned out to have the least expectation. Figure 5.12 shows the mean importance of the quality goals. QP6 and QP8 are the most and least important quality goals, respectively.

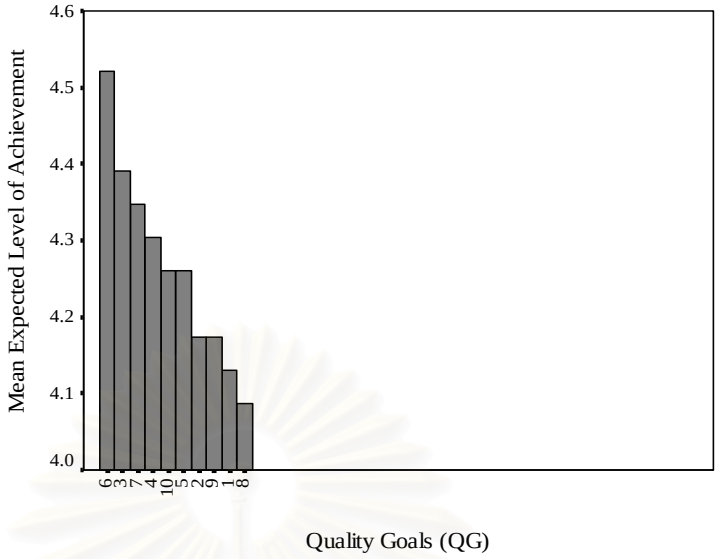

Figure 5.11. Mean expected level of achievement for the quality goals

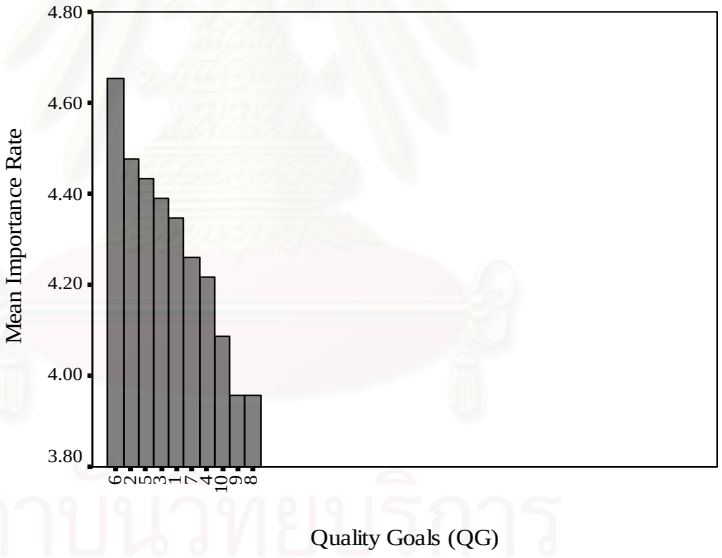

Figure 5.12. Mean importance rate for the quality goals

A quadrant analysis was also performed for the quality goals as illustrated in Figure 5.13. All quality goals fall in the “weakness or opportunity” quadrant, which denotes more importance given but resulted to poor effectiveness. QP6 is perceived to be the most important. However, respondents obtained the least final quality score in QP5.

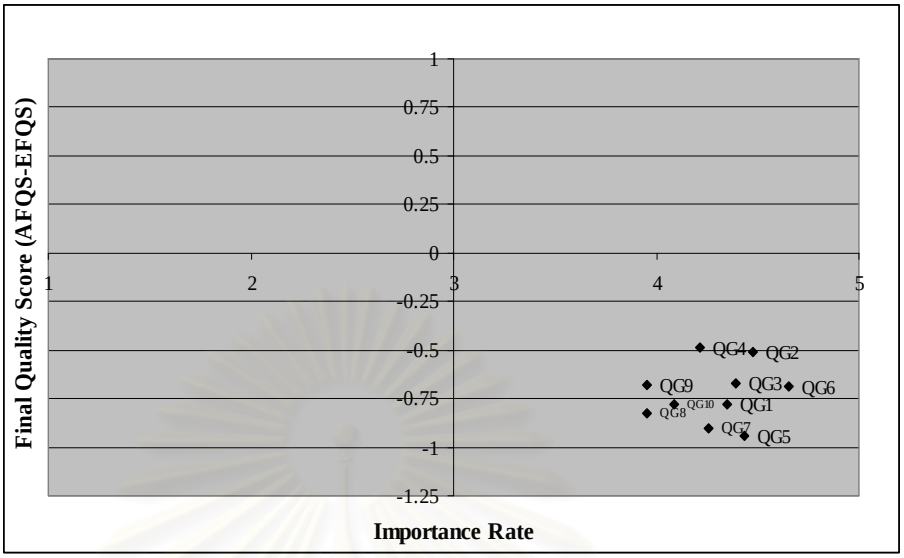

Figure 5.13. Quadrant analysis of Final Quality Scores versus Importance Rate for each quality goal

The paired sample t-test results for the quality goals are shown in Table 5.16. The significant difference between the expected and actual final quality scores is evident in all of the quality goals. Overall, contractors are most unsatisfactory in achieving better quality of work (QG5). Next to this are QG7 and QG10, with t-statistic values of 5.087 and 4.97, respectively. Again, these values fall within the rejection region. Although, there is also ineffectiveness in QG2, this quality goal resulted to the lowest t-statistic value equal to 2.646.

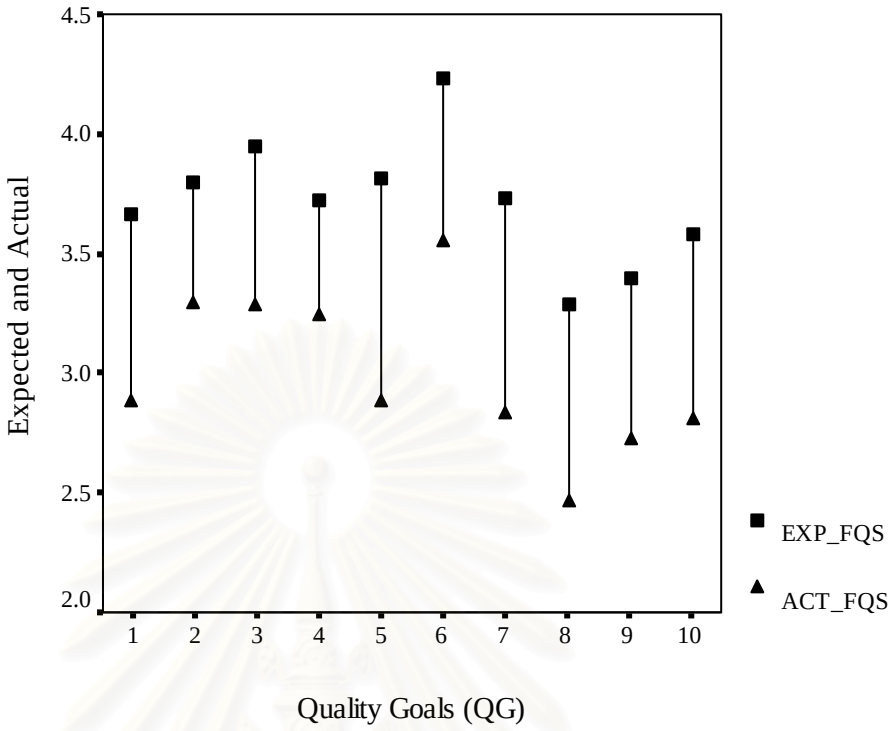

Figure 5.14. Deviation of AFQS from EFQS for Quality Goals

Figure 5.14 shows the deviation of the mean actual final quality score from the mean expected final quality score for each quality goal.

5.3.4 Analysis of Quality Principles and Quality Goals Considering Average Values

Survey questionnaire data were also analyzed considering the calculated average values. These average values include the importance rate, expected final quality scores and actual final quality scores.

Final quality scores were calculated considering the average of the importance rate on the quality attributes as indicated by the contractors. Table 5.13 and Table 5.14 show the final quality scores for the quality principles and quality goals, respectively. Referring to these tables, it can be seen that C6 and C20 maintained their satisfactory scores when the average importance rate of each quality score was considered. The calculated final quality score for C22 became negative. For the quality goals, C8, C20 and C22 retained their satisfactory scores. Note the increase in

the overall final quality scores for the quality principles. Conversely, there is a decrease in final quality scores for the quality goals. The final quality scores for some companies were lowered while the others obtained higher scores. This may be attributed to the low or high importance given to a particular quality attribute relative to the average importance. In other words, companies have different perceptions on the importance of each quality attribute. Thus, the importance given to quality attributes needs careful review.

The expected and actual final quality scores, also converted to percentage, for the Matrix of Principles and Matrix of Goals were compared graphically, by referring to the interpretation in Section 4.5. This time, the average values for the expected and actual final quality scores were considered. The maximum possible average importance rates for the quality principles and quality goals are 4.70 and 4.65, respectively. The corresponding maximum possible final quality scores are 155.00 and 46.52, for the quality principles and quality goals, respectively.

In Figure 5.15, the sample average values of EFQS and AFQS for the quality principles are 67.25 and 56.16, respectively. The figure shows the position of each company with respect to the average scores calculated by considering the sample in this research. It can be seen from Figure 5.15 that the scores for most companies fall above the average scores and are in Region 5. These companies have high expectations and have achieved high actual results. They however, fell short in meeting and achieving their expectations. Only companies C6 and C20 fall in Region 2, i.e., having low expected and low actual final quality scores. They are also below the average scores. They nevertheless exceeded their expectations. For their cases, they may opt to increase their targets for continuous improvement.

Figure 5.16, on the other hand, presents the position of companies on quality goals. The sample average values of EFQS and AFQS for the quality goals are 78.52 and 63.70, respectively, which are quite higher than those of the quality principles. It can be inferred here that even though the implementation of quality principles resulted to lower average scores, companies managed to achieve higher scores on the quality goals. From the figure, the scores for most companies are concentrated at the average values. This means that with respect to every other company, the status of these companies are comparable. Among the companies only company C20 fall in Region

2, where it may choose to increase its targets. Along with C20, companies C8 and C22 obtained satisfactory results as they are above the diagonal. The rest need to improve in order to achieve better results on quality goals.

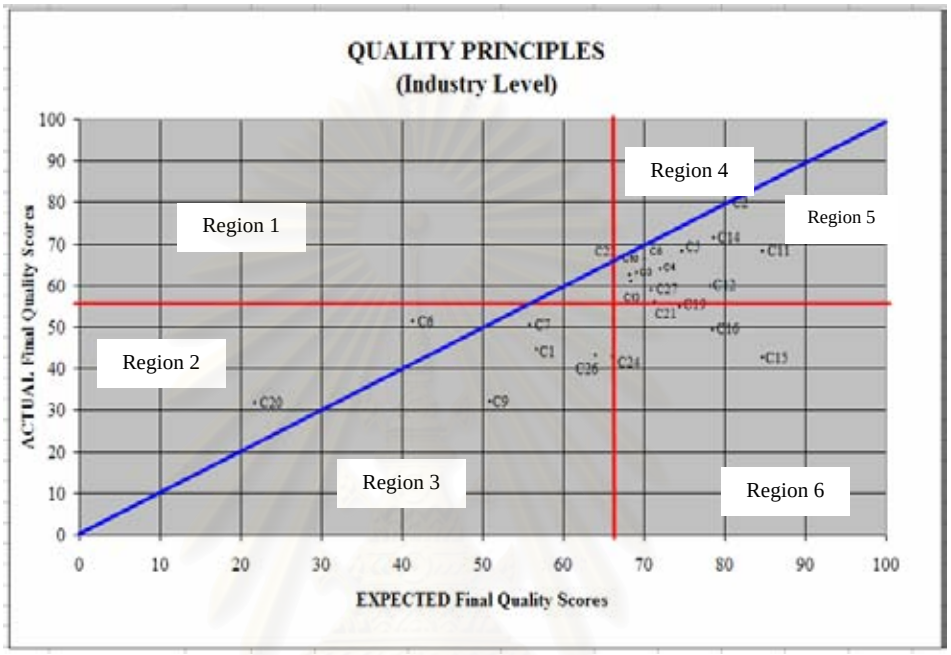

Figure 5.15. Companies as compared to the sample average values of EFQS and AFQS for the Quality Principles

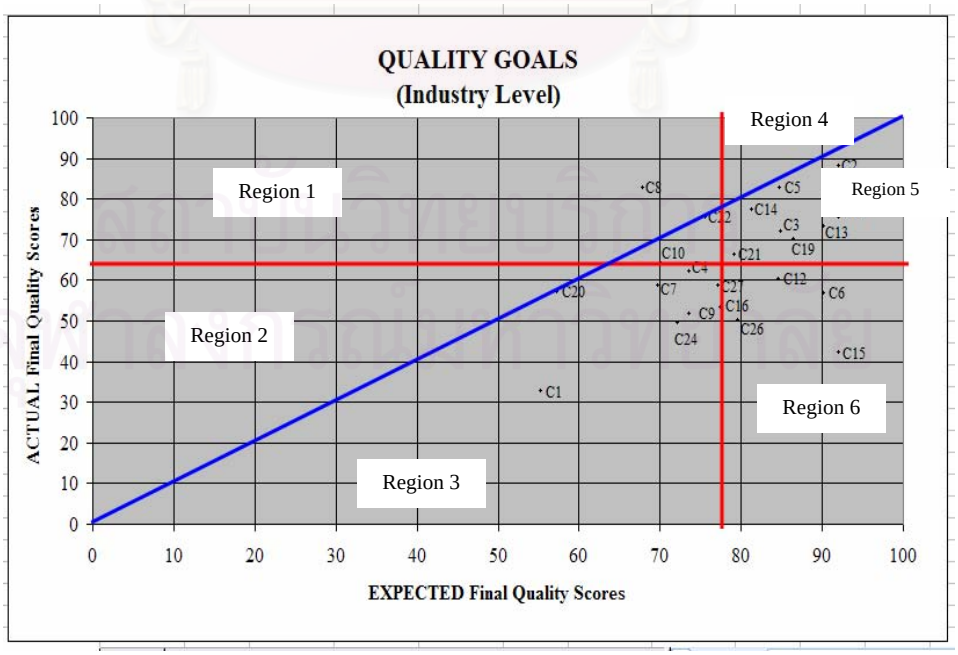

Figure 5.16. Companies as compared to the sample average values of EFQS and AFQS for the Quality Goals

Table 5.13. Matrix of Principles considering the average importance of each quality principle

COMPANY	QUALITY PRINCIPLES																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C6	-0.8087	-0.8	-0.8	-0.88696	-1.87826	-1.68696	-0.78261	-0.7913	-0.81739	0.8	-2.24348	1.495652	1.565217	0.704348	0.669565	1.6	0.782609
C20	0.808696	0.8	0.8	0	0	0	0	0	0	0	0	0	0.782609	0	0.669565	0	0
C22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	-0.8087	0	0	-0.88696	0	-0.84348	-0.78261	-0.7913	-0.81739	-0.8	0	-0.74783	0	0	0	0	0
C7	0	0	-0.8	0	-1.87826	-0.84348	-0.78261	-1.58261	0.817391	0.8	-0.74783	-2.24348	-0.78261	0.704348	0	0	0
C10	-0.8087	-0.8	-0.8	0	-0.93913	0	-0.78261	0	0	0	0	-0.74783	-0.78261	0	-0.66957	0	0
C3	0	-0.8	-0.8	0	0	-0.84348	0	0	0	-0.8	-0.74783	-0.74783	-0.78261	-1.4087	-1.33913	0	0
C5	-0.8087	-0.8	0	0	-0.93913	0	0	0	0	0.8	-0.74783	-0.74783	-0.78261	0	0	-0.8	0
C14	0	0	0	-0.88696	0	-0.84348	0	0	-0.81739	-0.8	0	-0.74783	-0.78261	0	0	0	0
C13	-0.8087	-0.8	0	0	0	0	-0.78261	-0.7913	-0.81739	0	-0.74783	-0.74783	-0.78261	0	0	0	0
C4	0	-0.8	0	0	-0.93913	-0.84348	-0.78261	-0.7913	0	-0.8	0	-0.74783	-0.78261	0	0.669565	-0.8	0
C27	0	0	-0.8	-1.77391	-0.93913	-0.84348	0	-0.7913	-0.81739	-0.8	-0.74783	-0.74783	-1.56522	-0.70435	-0.66957	-0.8	-0.78261
C1	-2.42609	-0.8	-0.8	0	-0.93913	0	0	0	-0.81739	0	0	0	-1.56522	0	0	0	0
C21	-0.8087	-0.8	-0.8	-1.77391	-1.87826	-1.68696	-0.78261	-0.7913	0	-1.6	0	-0.74783	-0.78261	0	-0.66957	-0.8	0
C11	-0.8087	0	-0.8	0	-0.93913	-0.84348	-0.78261	0	-0.81739	0	-0.74783	-1.49565	-0.78261	-0.70435	-0.66957	-0.8	-0.78261
C12	-0.8087	0	-0.8	-0.88696	-0.93913	-0.84348	-0.78261	-0.7913	-0.81739	-0.8	-0.74783	-0.74783	-0.78261	-0.70435	-1.33913	-0.8	0
C9	-0.8087	0	0	-0.88696	0	-0.84348	-0.78261	-0.7913	-1.63478	-0.8	-0.74783	-1.49565	-1.56522	-0.70435	-0.66957	-0.8	0
C19	-1.61739	-0.8	-1.6	-2.66087	-0.93913	-1.68696	-1.56522	-0.7913	-0.81739	-0.8	-1.49565	-0.74783	-1.56522	-0.70435	0	0	0
C26	0	0	-0.8	0	-1.87826	-0.84348	0	-1.58261	-0.81739	-1.6	-0.74783	-1.49565	0	-0.70435	0	-1.6	-1.56522
C24	-1.61739	-1.6	-0.8	-1.77391	-1.87826	-1.68696	-0.78261	-1.58261	-0.81739	-0.8	-0.74783	-1.49565	-0.78261	-0.70435	-0.66957	-1.6	-1.56522
C16	-0.8087	-1.6	-1.6	-1.77391	-0.93913	-1.68696	-1.56522	-0.7913	-2.45217	-1.6	-1.49565	-1.49565	-1.56522	-2.11304	-1.33913	-1.6	-0.78261
C15	-2.42609	-2.4	-2.4	-1.77391	-1.87826	-1.68696	-2.34783	-2.37391	-1.63478	-1.6	-1.49565	-2.24348	-2.34783	-1.4087	-1.33913	-1.6	-1.56522
SUM	**-15.3652**	**-12**	**-13.6**	**-15.9652**	**-19.7217**	**-18.5565**	**-14.087**	**-15.0348**	**-13.8957**	**-11.2**	**-14.2087**	**-18.6957**	**-16.4348**	**-8.45217**	**-7.36522**	**-10.4**	**-6.26087**
AVERAGE	**-1.28043**	**-1**	**-1.13333**	**-1.33043**	**-1.64348**	**-1.54638**	**-1.17391**	**-1.2529**	**-1.15797**	**-0.93333**	**-1.18406**	**-1.55797**	**-1.36957**	**-0.70435**	**-0.61377**	**-0.86667**	**-0.52174**

Table 5.13. Matrix of Principles considering the average importance of each quality principle (continued)

COMPANY	QUALITY PRINCIPLES																SUM
	QP18	QP19	QP20	QP21	QP22	QP23	QP24	QP25	QP26	QP27	QP28	QP29	QP30	QP31	QP32	QP33	
C6	1.46	1.5	1.636364	1.634783	-1.63478	1.73913	0.73913	0.73913	1.443478	1.582609	1.704348	0.8	1.669565	1.6	1.634783	1.654545	16.02482
C20	0.73	0.75	0.818182	0.817391	0.817391	0.869565	0.73913	0.73913	0.721739	0.791304	0.852174	0.8	0	0.8	0.817391	0.827273	15.75154
C22	0	0	0	0	0	0	0	0	0.721739	0	0	0	0.834783	0	-0.81739	-0.82727	-0.08814
C2	0	0	0	0	-0.81739	0	0	0	0	0	0	0	0	0	0	0	-0.81739
C8	-0.73	0	0	0	0	0	0	-0.73913	0	0	0	0	0.834783	0.8	0.817391	0	-5.49522
C7	0.73	0.75	0	0	-0.81739	0	0	-0.73913	0	0	0	0	0	0	0	-0.82727	-8.24292
C10	-0.73	0	0	-0.81739	0	0	0	0	-0.72174	0	0	0	0	0	0	0	-8.59957
C3	0	0	-0.81818	0.817391	0	0	0.73913	0	-0.72174	0	0	0.8	0	-0.8	0	-0.82727	-9.08024
C5	0	0	0	0	0	-0.86957	-0.73913	0	0	0	0	0	-0.83478	-0.8	-0.81739	-0.82727	-9.71423
C14	0	0	0	0	-0.81739	-0.86957	-0.73913	-0.73913	0	0	0	0	-0.83478	-1.6	0	0	-10.4783
C13	0	0	0	0	0	0	-0.73913	0	-0.72174	0	0	0	-0.83478	-0.8	-0.81739	-0.82727	-11.0186
C4	-1.46	-0.75	0.818182	0	-0.81739	-0.86957	-0.73913	0	0.721739	-0.7913	0	0.8	-0.83478	0	-0.81739	-0.82727	-12.1843
C27	-0.73	-0.75	-0.81818	-0.81739	0	0	0	-0.73913	-0.72174	-0.7913	0	0	0	0	0	0	-18.1504
C1	0	0	0	0	0	-0.86957	-0.73913	-0.73913	0	-1.58261	-0.85217	-1.6	-1.66957	-1.6	-0.81739	-0.82727	-18.6447
C21	0	0	0	-0.81739	-0.81739	-0.86957	-0.73913	-0.73913	-0.72174	-0.7913	0	-0.8	-0.83478	-0.8	-0.81739	-0.82727	-23.4968
C11	-0.73	-0.75	-0.81818	-0.81739	0	-0.86957	-1.47826	-1.47826	-0.72174	-0.7913	-0.85217	-0.8	-0.83478	-1.6	-0.81739	-0.82727	-25.1602
C12	-0.73	-0.75	-0.81818	-0.81739	-0.81739	-0.86957	-1.47826	-0.73913	-0.72174	-0.7913	-0.85217	-0.8	-0.83478	-1.6	-1.63478	-1.65455	-28.5006
C9	-2.19	-2.25	0	-0.81739	-1.63478	0	-1.47826	-0.73913	0	-0.7913	-0.85217	-0.8	-0.83478	-1.6	-0.81739	-1.65455	-28.9902
C19	0	0	0	-0.81739	-0.81739	-1.73913	0	-0.73913	0	-0.7913	-0.85217	-1.6	-1.66957	-0.8	-0.81739	-1.65455	-30.0893
C26	-2.19	-2.25	-2.45455	0	0	-1.73913	-0.73913	0	-0.72174	-1.58261	0	-0.8	-1.66957	-1.6	-1.63478	-0.82727	-31.8436
C24	-1.46	-1.5	-0.81818	-0.81739	-0.81739	-0.86957	-0.73913	-0.73913	-0.72174	-0.7913	-1.70435	-0.8	0	-1.6	-0.81739	-0.82727	-35.9272
C16	-1.46	-0.75	-1.63636	-2.45217	-1.63478	-1.73913	-0.73913	-1.47826	0	-1.58261	0	-1.6	-0.83478	-2.4	-0.81739	-0.82727	-45.1606
C15	-1.46	-1.5	-1.63636	-2.45217	-2.45217	-2.6087	-2.21739	-2.21739	-2.16522	-1.58261	-2.55652	-1.6	-1.66957	-2.4	-2.45217	-1.65455	-65.1466
SUM	**-10.95**	**-8.25**	**-6.54545**	**-8.17391**	**-13.0783**	**-12.1739**	**-11.087**	**-11.087**	**-5.05217**	**-10.287**	**-5.96522**	**-8**	**-10.8522**	**-16.8**	**-11.4435**	**-14.0636**	**-395.053**
AVERAGE	**-0.9125**	**-0.6875**	**-0.54545**	**-0.68116**	**-1.08986**	**-1.01449**	**-0.92391**	**-0.92391**	**-0.42101**	**-0.85725**	**-0.4971**	**-0.66667**	**-0.90435**	**-1.4**	**-0.95362**	**-1.17197**	

Table 5.14. Matrix of Goals considering the average importance of each quality goal

COMPANY	QUALITY GOALS										SUM
	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10	
C8	0.869565	1.791304	0	0.843478	0.886957	1.86087	0	0	0.791304	0	7.043478
C20	0	0	0	0	0	0	0	0	0	0	0
C22	0	0	0	0	0	0	0	0	0	0	0
C5	0	0	0	-0.84348	0	0	0	0	0	0	-0.84348
C2	0	0	-0.87826	0	0	0	-0.85217	0	0	0	-1.73043
C14	-0.86957	0	0	0	-0.88696	0	0	0	0	0	-1.75652
C10	-0.86957	0	-0.87826	0	-0.88696	0	0	0.791304	0	-0.81739	-2.66087
C7	0	0	0	-0.84348	0	-0.93043	-0.85217	-1.58261	-0.7913	0	-5
C4	-0.86957	-0.89565	0	0.843478	-0.88696	-0.93043	-0.85217	-0.7913	0	-0.81739	-5.2
C21	0	0	0	0	-0.88696	-0.93043	-0.85217	-1.58261	-0.7913	-0.81739	-5.86087
C3	-0.86957	-0.89565	0	0	0	-0.93043	-0.85217	-0.7913	-0.7913	-0.81739	-5.94783
C19	-1.73913	0	0	0	-1.77391	0	-0.85217	-0.7913	-1.58261	-0.81739	-7.55652
C11	-0.86957	-0.89565	-0.87826	-0.84348	-0.88696	0	0	-0.7913	-0.7913	-1.63478	-7.5913
C13	0	-0.89565	-0.87826	-0.84348	-0.88696	-0.93043	-0.85217	-0.7913	-0.7913	-0.81739	-7.68696
C27	-0.86957	-0.89565	-0.87826	-0.84348	-0.88696	-0.93043	-0.85217	-0.7913	-0.7913	-0.81739	-8.55652
C9	-0.86957	-0.89565	0	-0.84348	-0.88696	-0.93043	-1.70435	-1.58261	-1.58261	-0.81739	-10.113
C1	-0.86957	-0.89565	0	0	-1.77391	-1.86087	-1.70435	-0.7913	-0.7913	-1.63478	-10.3217
C24	-0.86957	-0.89565	-0.87826	-0.84348	-1.77391	-1.86087	-1.70435	-0.7913	0	-0.81739	-10.4348
C16	-0.86957	-0.89565	-1.75652	-0.84348	-1.77391	-0.93043	-0.85217	-1.58261	-0.7913	-0.81739	-11.113
C12	-1.73913	-0.89565	-0.87826	-0.84348	-1.77391	-1.86087	-0.85217	-0.7913	-0.7913	-0.81739	-11.2435
C26	-1.73913	0	-3.51304	-0.84348	-1.77391	0	-2.55652	-1.58261	-0.7913	-0.81739	-13.6174
C6	-0.86957	-1.7913	-0.87826	-1.68696	-1.77391	-1.86087	-1.70435	-1.58261	-1.58261	-1.63478	-15.3652
C15	-2.6087	-2.68696	-2.63478	-1.68696	-1.77391	-1.86087	-2.55652	-2.37391	-2.37391	-2.45217	-23.0087
SUM	**-16.5217**	**-11.6435**	**-14.9304**	**-10.1217**	**-20.4**	**-14.887**	**-20.4522**	**-18.2**	**-14.2435**	**-17.1652**	**-158.565**
AVERAGE	**-0.71834**	**-0.50624**	**-0.64915**	**-0.44008**	**-0.88696**	**-0.64726**	**-0.88922**	**-0.7913**	**-0.61928**	**-0.74631**	

5.4 Important Issues Relating to the Proposed Tool for Assessing ISO 9000-based Quality Management Practices

The proposed tool for assessing the ISO 9000-based quality management practices is in the form of two matrices, the Matrix of Principles and the Matrix of Goals. Essential quality attributes are incorporated into these matrices. The components are labeled as quality principles and quality goals, respectively. A total of 33 quality principles resulted from consolidating the information obtained from literature and interviews. These quality principles were reviewed and verified against the ISO 9001:2000 standard. On the other hand, 10 quality goals were obtained with corresponding bases for evaluation.

Table 4.5). The values from these scales are important in calculating the final quality score. Both scales are five-point scale, in which each point is defined. In each of the quality principles and quality goals, respondents were asked to choose among the 5- point in the scale. Table 5.17 shows the frequencies for each point in the scale for the quality principles (expected levels). It can be seen from the table that at least 4 points in the scale were selected for each of the quality principles. On the other hand, for the expected levels in the quality goals (Table 5.18), a minimum of three points in the scale were chosen. However, 4 points in the scales were recognized by the respondents for the actual levels (Table 5.19). The 5-point scale is more appropriate in order to account for those respondents who are hesitant or neutral in regard to a quality attribute. Without a midpoint, respondents tend to choose the extreme points, creating skewed data. Evident from the answers, respondents recognized the differences among the points in the scales. For instance, they perceive the distinction between the scale of 4 and 5 in Table 4.4.

In addition to the scales that were developed, the importance rate given to each quality attribute is essential in evaluating the matrices. In this research, an importance rate of 1 to 5 is proposed. This makes it easier to assess the quality attributes, as opposed to ranking. The ranking process becomes difficult when the number of quality attributes increases. In addition, one quality attribute may be perceived as equally important as another.

5.5 Summary

This chapter presents the evaluation of quality management practices, particularly the application of ISO 9000-based QMSs, on contractors in Thailand. Results from the interviews and survey questionnaires were integrated to evaluate these contractors. Evaluation is divided into two parts. The first part consists of the perception of contractors on ISO 9000-based QMSs. This includes their motivations and expectations on ISO 9000, its benefits, barriers, etc. In addition, analysis of the survey questionnaire at the construction company level was conducted through the Matrix of Principles and the Matrix of Goals.

For the Matrix of Principles at the construction company level, only three companies obtained satisfactory results in implementing the quality principles, overall. These companies are C6, C20 and C22. Three companies also achieved satisfactory results in achieving the quality goals, namely, C8, C20 and C22. Company C6 was short in achieving satisfactory results on quality goals. Although company C8 needs improvement on quality principles, it achieved favorable results with the quality goals. C20 and C22 both obtained good results in the quality principles and quality goals. However, they may choose to increase their targets for continuous improvement. The effectiveness of some companies in the quality principles but not in the quality goals may be attributed to some other factors beyond the control of the organization. In addition, the definition of each quality principle in the company may not be comprehensive enough. Thus, revising of current quality management procedures is recommended to suit some changes and improvement. On the other hand, some companies need to improve on the quality principles but performed well in the quality goals. This may mean that these companies are only after the final results and may not be really concerned about the manner by which they achieved it.

Among the quality principles, contractors obtained satisfactory results in QP26 or the control of monitoring and measuring device. They generally need to improve on client satisfaction.

With regard to the quality goals, all contractors failed in meeting or exceeding them. In particular, they need some improvement in achieving better quality of work, i.e., reducing the number and the degree or non-conformances.

From the quadrant analysis, all quality principles and quality goals fall on the "weakness or opportunity" quadrant. The plots demonstrate the general overview of the relationship between the importance of quality attributes and the effectiveness of the companies in them.

The respondents seemed to have recognized the differences among the points in the scales for the quality principles and quality goals given in Table 4.4 and Table 4.5. In each of the quality attributes, at least 4 points were selected. The 5-point scale is appropriate to use as it accounts for a neutral or midpoint perception. The importance rate given to each of the quality attributes is also essential in the evaluation. A 5-point importance rate facilitates an easier way for evaluating the quality principles and quality goals.

Table 5.15. Paired sample t-test of quality principles

Pair No.	Pair	Paired Differences		t	df	t-critical (one-tail)	p-value	Decision
		Mean	Std. Deviation					
Pair 20	E20 - A20	0.163636364	0.854425708	0.898290597	21	1.721	0.189607508	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 26	E26 - A26	0.217391304	0.908371257	1.147737847	22	1.717	0.131702489	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 19	E19 - A19	0.24	0.864748214	1.241185135	19	1.729	0.114821816	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 28	E28 - A28	0.27826087	0.958671677	1.392022193	22	1.717	0.088914687	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 21	E21 - A21	0.345454545	1.047776454	1.546441932	21	1.721	0.06846803	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 29	E29 - A29	0.27826087	0.824045741	1.619439533	22	1.717	0.05980017	Failed to Reject Ho. Therefore, AFQS>EFQS
Pair 18	E18 - A18	0.4	0.975489081	1.833802568	19	1.729	0.041198188	Reject Ho
Pair 17	E17 - A17	0.286956522	0.662848089	2.076184809	22	1.714	0.024883266	Reject Ho
Pair 15	E15 - A15	0.32173913	0.689503459	2.237851956	22	1.714	0.017839569	Reject Ho
Pair 27	E27 - A27	0.426086957	0.851318438	2.400325385	22	1.717	0.012639186	Reject Ho
Pair 30	E30 - A30	0.460869565	0.919357053	2.404128822	22	1.717	0.012536202	Reject Ho
Pair 23	E23 - A23	0.52173913	1.037022189	2.412844196	22	1.717	0.012303142	Reject Ho
Pair 14	E14 - A14	0.391304348	0.724827907	2.589069363	22	1.714	0.008372917	Reject Ho
Pair 32	E32 - A32	0.504347826	0.920216507	2.628476218	22	1.717	0.00767224	Reject Ho
Pair 16	E16 - A16	0.443478261	0.757883468	2.806298213	22	1.714	0.005143665	Reject Ho
Pair 24	E24 - A24	0.52173913	0.881608304	2.838191244	22	1.717	0.00478347	Reject Ho
Pair 10	E10 - A10	0.47826087	0.806201262	2.845019803	22	1.717	0.004709535	Reject Ho
Pair 22	E22 - A22	0.542857143	0.820104523	3.033374258	20	1.725	0.003281583	Reject Ho
Pair 25	E25 - A25	0.504347826	0.799703502	3.02457998	22	1.717	0.003114533	Reject Ho
Pair 33	E33 - A33	0.6	0.913392421	3.081095696	21	1.721	0.002832122	Reject Ho
Pair 31	E31 - A31	0.747826087	1.131720157	3.169023631	22	1.717	0.002222265	Reject Ho

Table 5.15. Paired sample t-test of quality principles (continued)

Pair No.	Pair	Paired Differences		t	df	t-critical (one-tail)	p-value	Decision
		Mean	Std. Deviation					
Pair 2	E2 - A2	0.513043478	0.764736644	3.217408379	22	1.717	0.001982969	Reject Ho
Pair 13	E13 - A13	0.686956522	0.986870328	3.338359306	22	1.714	0.001489011	Reject Ho
Pair 3	E3 - A3	0.608695652	0.782718482	3.729567994	22	1.717	0.000581872	Reject Ho
Pair 4	E4 - A4	0.690909091	0.83432841	3.884143041	21	1.721	0.000428366	Reject Ho
Pair 9	E9 - A9	0.660869565	0.816722458	3.880656229	22	1.717	0.000403259	Reject Ho
Pair 12	E12 - A12	0.747826087	0.918927025	3.90286478	22	1.717	0.000382054	Reject Ho
Pair 1	E1 - A1	0.669565217	0.814881354	3.940600631	22	1.717	0.000348527	Reject Ho
Pair 8	E8 - A8	0.617391304	0.710730849	4.165999947	22	1.717	0.000201128	Reject Ho
Pair 7	E7 - A7	0.652173913	0.748859475	4.176639695	22	1.717	0.000195969	Reject Ho
Pair 11	E11 - A11	0.563636364	0.574493943	4.601769813	21	1.721	7.71192E-05	Reject Ho
Pair 6	E6 - A6	0.817391304	0.735868179	5.32713752	22	1.717	1.1974E-05	Reject Ho
Pair 5	E5 - A5	0.860869565	0.770913938	5.355442667	22	1.717	1.11887E-05	Reject Ho

Table 5.16. Paired sample t-test of quality goals

Pair No.	Pair	Paired Difference		t	df	t-critical (one-tailed)	p-value	Decision
		Mean	Std. Deviation					
Pair 2	E2 - A2	0.513043478	0.929958136	2.64578586	22	1.717	0.007382226	Reject Ho
Pair 4	E4 - A4	0.486956522	0.713062759	3.275113457	22	1.717	0.00173014	Reject Ho
Pair 3	E3 - A3	0.669565217	0.943125742	3.404765486	22	1.717	0.001271116	Reject Ho
Pair 6	E6 - A6	0.686956522	0.854562274	3.855222543	22	1.717	0.000428979	Reject Ho
Pair 9	E9 - A9	0.67826087	0.824045741	3.947383861	22	1.717	0.000342818	Reject Ho
Pair 1	E1 - A1	0.782608696	0.848341791	4.424230296	22	1.717	0.000107018	Reject Ho
Pair 8	E8 - A8	0.826086957	0.855579225	4.630516674	22	1.717	6.46755E-05	Reject Ho
Pair 10	E10 - A10	0.782608696	0.755375989	4.96873015	22	1.717	2.84149E-05	Reject Ho
Pair 7	E7 - A7	0.904347826	0.852524732	5.08735952	22	1.717	2.1325E-05	Reject Ho
Pair 5	E5 - A5	0.939130435	0.836518288	5.384115816	22	1.717	1.04464E-05	Reject Ho

Table 5.17. Frequency distribution of the 5-point scale for the quality principles (expected levels only)

Point in the Scale	QUALITY PRINCIPLES																			
	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15	QP16	QP17	QP18	QP19	QP20
1	1	1	1	0	0	0	1	0	0	2	1	2	2	0	1	0	0	1	1	1
2	0	0	0	1	1	1	0	1	1	0	0	0	0	1	0	2	1	2	2	3
3	3	5	6	2	2	1	3	3	6	4	6	2	3	6	8	3	5	5	4	1
4	8	8	5	9	9	11	12	13	10	8	10	14	12	11	10	5	11	7	12	11
5	11	9	11	10	11	10	7	6	6	9	6	5	6	5	4	13	6	6	2	7
SUM	23	23	23	22	23	23	23	23	23	23	23	23	23	23	23	23	23	21	21	23

Table 5.17. Frequency distribution of the 5-point scale for the quality principles (expected levels only) (continued)

Point in the Scale														SUM
	QP21	QP22	QP23	QP24	QP25	QP26	QP27	QP28	QP29	QP30	QP31	QP32	QP33	
1	1	1	1	1	1	1	1	1	0	2	1	1	1	28
2	2	1	1	1	1	3	1	1	1	0	1	1	1	31
3	2	3	1	4	3	3	2	2	5	4	3	2	3	115
4	6	7	7	10	12	11	11	12	6	8	10	10	11	317
5	11	10	13	7	6	5	8	7	11	9	8	9	7	261
SUM	22	22	23	23	23	23	23	23	23	23	23	23	23	752

Table 5.18. Frequency distribution of the 5-point scale for the quality goals (expected levels)

Point in the Scale	QUALITY GOALS										SUM
	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10	
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	3	4	3	4	3	2	2	4	5	4	34
4	14	11	8	8	11	7	11	13	9	9	101
5	6	8	12	11	9	14	10	6	9	10	95
SUM	23	23	23	23	23	23	23	23	23	23	230

Table 5.19. Frequency distribution of the 5-point scale for the quality goals (actual levels)

Point in the Scale	QUALITY GOALS										SUM
	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10	
1	0	0	1	0	1	1	1	0	0	1	5
2	4	2	1	0	3	0	4	8	4	1	27
3	9	9	8	10	10	8	8	7	8	11	88
4	9	8	8	8	7	7	7	6	9	9	78
5	1	4	5	5	2	7	3	2	2	1	32
SUM	23	23	23	23	23	23	23	23	23	23	230

CHAPTER VI

CONCLUSION

The high demand for quality is brought by the increasing complexity of construction projects. Construction companies need to choose and set up the most appropriate quality management system that can address this demand. ISO 9000 is the widely used system in quality management. This standard has gained popularity not only in developed countries but also in developing ones. However, a suitable method for assessing ISO 9000-based quality management practices in the construction industry is still limited. This research, therefore, aims to propose a tool which can add to the continuous search for the most suitable method. It also applies the tool using the survey questionnaire data of contractors in Thailand.

6.1 Proposed Tool for Assessing Quality Management Practices

This research aims to develop a tool for assessing quality management practices, specifically ISO 9000-based QMSs, in the construction industry based on the concept to of effectiveness in previous studies. As effectiveness of a system is defined as meeting the company's specified requirement and prescribed quality objectives, it is suitable to align the proposed tool with this definition of effectiveness. Thus, the proposed tool is in the form of two matrices, the Matrix of Principles and the Matrix of Goals. The Matrix of Principles describes effectiveness in satisfying the QMS requirements derived from the ISO 9001:2000 standard while the Matrix of Goal describes the effectiveness in achieving the prescribed company quality goals and objectives.

The formation of the matrices has been discussed in Chapter IV. The matrices incorporated different quality attributes, namely, the "quality principles" for the Matrix of Principles and "quality goals" for the Matrix of Goals. A total of thirty-three (33) quality principles were obtained from literature and interview. These quality principles were primarily contributed by the persons in charge of interviewed companies, thus, more or less reflecting the common understanding

among construction companies. In addition, these were verified against the ISO 9001:2000 standard for completeness, clarity and correctness. For the quality goals, a total of ten (10) were gathered (see Table 4.3). A number of suggestions as to how these quality goals can be assessed were also suggested by the interviewees. Some correspond to those obtained from literature.

The two scales in Table 4.4 and Table 4.5 were developed to aid in calculating the matrices. The scales were adopted from previous studies and were modified. Each point of the proposed 5-point scales is defined to distinguish differences. The choice of a 5-point scale proved to be appropriate as survey questionnaire results showed a fair distribution of each point. This may imply that respondents recognized the distinction among the points in the scales.

In addition to the scales, the importance rate given to each quality attribute is essential in assessing the ISO 9000-based quality management practices. In this research, an importance rate from 1 to 5 was selected, with 1 being the least important and 5 the most important. Similar to the scales, there is variation among the answers provided by the respondents. This 5-point importance rate may be more convenient to use rather than the ranking system. The ranking system may be difficult to execute especially as the number of quality attributes increases. Moreover, one quality attribute may be equally important as another.

The concept of assessing implementation is based on comparing the expectations at the beginning and actual results obtained by a company. The equations for calculating the expected and final quality scores were discussed in Chapter IV. Scores for the quality principles and quality goals can be interpreted by means of the graphs shown in Figure 4.1 and Figure 4.2. These graphs show the actual final quality scores versus the expected final quality scores. Figure 4.1 presents the four levels for interpreting the position of a company. Table 4.7 specifies the possible options for a company in deciding as what strategy to use. For the graph in Figure 4.2, the scores are converted to percentages in order to easily assess the status of a particular company with respect to the maximum possible scores attainable. Figure 4.2 is divided into six (6) regions, with both average actual and expected final quality scores at fifty (50). The diagonal represents equality between the actual and expected final

quality scores. Any point along this diagonal is an indication that a particular company met its expectations. Scores falling above the diagonal indicate that expectations are exceeded. Conversely, scores falling below the diagonal means that a particular company needs to improve on the quality attributes. The 6 regions were translated into six cases. The corresponding descriptions of these cases are presented in Table 4.8. Cases 3, 5 and 6 fall below the diagonal, which means that the actual final quality scores are lower than the expected. If the scores fall anywhere in these cases, then that particular company needs to review its system and improve performance. Companies should prepare corrective performance plans for the unsatisfactory areas and regularly monitor them. Improvement activities for the unsatisfactory areas can also be scheduled. However, for cases 2 and 3, companies may opt to increase their targets and consequently improve more on their implementation. On the other hand, cases 1, 2 and 4 fall above the diagonal, which means that a company is in good position.

As a summary, the highlights for the proposed tool are as follows:

6.1.1 The two matrices, the Matrix of Principles and Matrix of Goals, adopted from previous studies. These matrices incorporate quality principles and quality goals obtained from literature and interviews with ISO 9000 certified contractors.

6.1.2 The two 5-point scales adopted from literature and modified. Table 4.4 shows the scale to use when assessing the level for implementing the quality principles. Table 4.5, on the other hand, is the scale to use for evaluating the level of achievement in the quality goals.

6.1.3 The 5-point importance rate, which may be more appropriate to use, especially when considering a large number of quality attributes, in which one can be equally importance as the others.

6.1.4 Interpretation of actual and expected final quality scores through the graphs in represented in Figure 4.1 and Figure 4.2. Table 4.7 and Table 4.8 provide the details in understanding the concepts of the graphs. Companies may refer to these when interpreting their scores. A quadrant analysis may also be performed as shown in Figure 4.3. As a result, appropriate improvement solutions can be devised.

6.2 ISO 9000 Implementation of Contractors in Thailand

Results of the interview show that most of the companies have a client-driven perception on quality management. This means that their main motivation for adopting ISO 9000 to their organizations is to meet client requirements. They nevertheless, believe that ISO 9000 is a good standard for improving quality management systems. However, when combined with the results of the survey questionnaire, it turned out the most contractors are both driven by client requirements and aim to improve quality management systems and work quality.

The greatest benefit of ISO 9000-based QMSs as perceived by the interviewed contractors in this case study are those relating to systematic, standardized and improved work procedures. The standardized procedures can help companies to be organized in the execution of its works. On the other hand, the main drawbacks perceived was on educating and training the staff about the ISO 9000-based QMSs and management commitment. There maybe some resistance to change from some employees. Thus, it was difficult to make them cooperate. This finding is similar to the results of previous research.

The common methods for measuring the effectiveness of ISO 900-based QMS known to contractors in Thailand are internal quality audits, client satisfaction, KPIs management reviews and monitoring of objectives and targets. There were some criticisms, especially on internal audits. First, the process of doing audits is too systematic and customary. Second, it is based on a sampling method. Third, there are cases of biased findings which may have radiated from the inadequate training of auditors or simply varying personalities. But it was emphasized that if the system is well-understood by the parties involved, there should be no room for disorder. Some companies found it difficult to get enough feedback from the client satisfaction surveys. Thus, it is an inadequate method for evaluation. Moreover, clients have differing views with regard to quality.

6.3 Application of the Proposed Tool for Assessing Quality Management Practices to Contractors in Thailand

Results of the survey questionnaire indicated that only three (3) of the twenty-three (23) contractors in Thailand generally obtained satisfactory results in implementing the quality principles. Three (3) companies are also satisfactory in achieving the quality goals. Two of these companies both achieved good results on quality principles and quality goals. It can be inferred here that by correctly implementing the quality principles, companies will be able to perform better on quality goals. But this may not be true at all times. In this research, one company was satisfactory in the quality principles and failed in the quality goals. Another company performed well in the quality goals but failed in the quality principles. This means that others factors may have influenced the results. Thus, the achievement of quality goals may not be solely attributed to the implementation of quality principles. Companies may be more interested with the final results rather than the manner by which they achieved them, as stated by Öztaş et al. (2007). Quality management procedures need to be regularly reviewed to suit some changes in the work processes of the company and to make room for improvement.

Among the quality principles, improvement is needed in client satisfaction on quality among the contractors in Thailand. On the other hand, companies achieved satisfactory results in the control of monitoring and measuring devices. For the quality goals, companies need to improve on achieving better quality of work. This suggests that the reason why clients are not satisfied is that of poor quality work. Therefore, in order to ensure client satisfaction, companies must first ensure good quality.

Companies gave a high expectation level on QP5, client satisfaction. This coincides with the high expectation and importance given to the goal of satisfying clients. Thus, client satisfaction is perceived to be a main determinant in assessing the implementation of ISO 9000-based QMSs. Construction companies realize the importance of satisfying their clients.

Among the requirements of the ISO 9001:2000 standard, results showed that contractors in general are need to improve in terms of the management responsibility requirement. Thus, management plays a vital role in the effective implementation of

ISO 9000-based QMSs. Top management need to impart total commitment to the implementation of the system in order for the staff to follow. In other words, the initiative should come from the top management. Furthermore, proper orientation on the system allows for the cooperation and participation of every individual in the organization.

6.4 Contribution of Research and Recommendations

Results of this research can contribute to the world of quality management in the construction industry. The contribution is a tool for assessing ISO 9000-based quality management practices at both organization and construction industry levels. The tool incorporates two matrices, the Matrix of Principles and the Matrix of Goals, adopted from previous studies, which can describe the effectiveness of the system. Two scales to assess the level of implementation in the quality principles and the level of achievement in the quality goals are also presented. These scales were adopted from literature and were modified for easy understanding. The scales can help companies in realistically assessing the implementation of quality principles and achieving quality goals. The two-point scale, for example, can only present the level of QMS adoption and benefits at the industrial level.

The proposed tool for assessing quality management practices, particularly, ISO 9000-based QMS, can help companies to identify the extent of failure in implementing the system in their organization. Appropriate steps can be devised to solve or improved the current practice. For example, if the company achieved satisfactory results in implementing the quality principles or achieving the prescribed company quality goals, then, it should maintain this good practice to consistently accomplish performance expectations. It may also opt to increase its targets or expectations for continuous improvement. If on the other hand, the company fails to meet or exceed its expectations, then it should prepare corrective performance plans for the unsatisfactory areas and regularly monitor them. Improvement activities for the unsatisfactory areas can also be scheduled.

The results of this research may not fully represent the actual Thai construction industry situation. In particular, contractors in general may not be truly

satisfactory with the quality attributes. At the same time, they may need improvement in one or two of the quality attributes. The reason for this is the small sample size of the respondents. Thus, this research may be extended by considering a larger sample size. The cases of other companies such as consulting firms, subcontractors and project management, are also worth investigating, so that the whole construction industry of can overall be represented.

Although the quality attributes used in this research reflect the common understand among construction companies, they can still be developed. Additionally, in order to account for the different importance perceptions on each quality attribute management need to ask for the cooperation and participation, not only from the officers of each department but also from other staff, who are directly involved.

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APPENDICES

Appendix A. Survey Questionnaire

Instructions: Please answer the following items about your ISO 9000-based quality management system (QMS). All information obtained will be kept confidential.

Date: _____

A. PERSONAL INFORMATION

Respondent's Name: _____
Position: _____
No. of years in the company: _____
Work Experience: _____

B. COMPANY INFORMATION

Company name: _____
Nature of business: _____
Company size: ☐ Large ☐ Medium ☐ Small
Membership in any association: _____

No. of previous projects: _____ No. of current projects: _____
Total no. of employees: _____ Company Type: ☐ Thai
Annual revenue (in US$): _____ ☐ Foreign
Type of ISO 9000 certification: _____
Years of certification: _____
Name of ISO 9000 certifying body: _____
Cost of ISO 9000 certification: _____

C. MEASURING THE EFFECTIVENESS OF ISO 9000-BASED QMS

1. Do you have any methods for measuring the effectiveness of your ISO 9000-based QMS? Please describe below.

2. Please indicate your ***EXPECTED*** and ***ACTUAL*** levels of implementation in the following "quality principles". These quality principles were obtained from the interviews with different construction companies and verified against the ISO 9001:2000 Standard.
   Notes: ***EXPECTED*** – at the start of ISO 9000 adoption
   ACTUAL **–** from the start to present
   Refer to Table 1 for the scale to be followed.

Table 1. Level of Implementing Quality Principles

Level	Description
1	• Awareness of the need and in the process of understanding the ISO 9000-based quality principles • Early stages of improvement orientation and some trends of improvement in the ISO 9000-based quality principles
2	• Adequate understanding of ISO 9000-based quality principles • Improvement in most ISO 9000-based quality principles based on facts
3	• Committed to improvement in ISO 9000-based quality principles beyond minimum regulatory and company requirements • ISO 9000-based quality principles are thoroughly enhanced
4	• High level of continuous improvement in ISO 9000-based quality principles • ISO 9000-based quality principles are fully set up for all primary areas • Benchmarking with other companies
5	• Sustained excellence in ISO 9000-based quality principles over several years • Sustaining best practice in ISO 9000-based quality principles

QUALITY PRINCIPLES	EXPECTED LEVEL IMPLEMENTATION					ACTUAL LEVEL OF IMPLEMENTATION				
1. Establishment and maintenance of a QMS	①	②	③	④	⑤	①	②	③	④	⑤
2. Document and data control	①	②	③	④	⑤	①	②	③	④	⑤
3. Control of quality record	①	②	③	④	⑤	①	②	③	④	⑤
4. Management commitment on QMS	①	②	③	④	⑤	①	②	③	④	⑤
5. Customer satisfaction on quality	①	②	③	④	⑤	①	②	③	④	⑤
6. Establishment and commitment to quality policy and objectives	①	②	③	④	⑤	①	②	③	④	⑤
7. QMS planning	①	②	③	④	⑤	①	②	③	④	⑤
8. Definition of responsibility and authority	①	②	③	④	⑤	①	②	③	④	⑤
9. Communication	①	②	③	④	⑤	①	②	③	④	⑤
10. Management review	①	②	③	④	⑤	①	②	③	④	⑤
11. Provision of resources to set-up and maintain the QMS	①	②	③	④	⑤	①	②	③	④	⑤
12. Recruitment and personnel development	①	②	③	④	⑤	①	②	③	④	⑤
13. Training	①	②	③	④	⑤	①	②	③	④	⑤
14. Provision of quality infrastructure	①	②	③	④	⑤	①	②	③	④	⑤
15. Provision of quality environment	①	②	③	④	⑤	①	②	③	④	⑤
16. Construction planning	①	②	③	④	⑤	①	②	③	④	⑤
17. Control of customer-related processes	①	②	③	④	⑤	①	②	③	④	⑤
18. Design development	①	②	③	④	⑤	①	②	③	④	⑤
19. Design control (change, review, verification and validation)	①	②	③	④	⑤	①	②	③	④	⑤
20. Contract review	①	②	③	④	⑤	①	②	③	④	⑤
21. Purchasing process	①	②	③	④	⑤	①	②	③	④	⑤
22. Supplier and subcontractor control	①	②	③	④	⑤	①	②	③	④	⑤
23. Inspection and testing	①	②	③	④	⑤	①	②	③	④	⑤
24. Identification and traceability of construction processes and materials	①	②	③	④	⑤	①	②	③	④	⑤
25. Material handling, storage and delivery processes	①	②	③	④	⑤	①	②	③	④	⑤
26. Control of monitoring and measuring devices	①	②	③	④	⑤	①	②	③	④	⑤
27. Rectification of defects	①	②	③	④	⑤	①	②	③	④	⑤
28. Control of client complaints	①	②	③	④	⑤	①	②	③	④	⑤
29. Internal audit	①	②	③	④	⑤	①	②	③	④	⑤
30. Control of non-conformances	①	②	③	④	⑤	①	②	③	④	⑤
31. Data analysis relating to customer satisfaction, conformity to product requirements, characteristics and trends of processes and products, and suppliers	①	②	③	④	⑤	①	②	③	④	⑤
32. Corrective and preventive actions	①	②	③	④	⑤	①	②	③	④	⑤

33. Continuous improvement process	①	②	③	④	⑤	①	②	③	④	⑤

3. Please indicate the degree of importance of following quality principles.

QUALITY PRINCIPLES	IMPORTANCE RATE				
	Least Important	Somewhat Important	Important	Very Important	Most Important
1. Establishment and maintenance of a QMS	①	②	③	④	⑤
2. Document and data control	①	②	③	④	⑤
3. Control of quality record	①	②	③	④	⑤
4. Management commitment on QMS	①	②	③	④	⑤
5. Customer satisfaction on quality	①	②	③	④	⑤
6. Establishment and commitment to quality policy and objectives	①	②	③	④	⑤
7. QMS planning	①	②	③	④	⑤
8. Definition of responsibility and authority	①	②	③	④	⑤
9. Communication	①	②	③	④	⑤
10. Management review	①	②	③	④	⑤
11. Provision of resources to set-up and maintain the QMS	①	②	③	④	⑤
12. Recruitment and personnel development	①	②	③	④	⑤
13. Training	①	②	③	④	⑤
14. Provision of quality infrastructure	①	②	③	④	⑤
15. Provision of quality environment	①	②	③	④	⑤
16. Construction planning	①	②	③	④	⑤
17. Control of customer-related processes	①	②	③	④	⑤
18. Design development	①	②	③	④	⑤
19. Design control (change, review, verification and validation)	①	②	③	④	⑤
20. Contract review	①	②	③	④	⑤
21. Purchasing process	①	②	③	④	⑤
22. Supplier and subcontractor control	①	②	③	④	⑤
23. Inspection and testing	①	②	③	④	⑤
24. Identification and traceability of construction processes and materials	①	②	③	④	⑤
25. Material handling, storage and delivery processes	①	②	③	④	⑤
26. Control of monitoring and measuring devices	①	②	③	④	⑤
27. Rectification of defects	①	②	③	④	⑤
28. Control of client complaints	①	②	③	④	⑤
29. Internal audit	①	②	③	④	⑤
30. Control of non-conformances	①	②	③	④	⑤

31. Data analysis relating to customer satisfaction, conformity to product requirements, characteristics and trends of processes and products, and suppliers	①	②	③	④	⑤
32. Corrective and preventive actions	①	②	③	④	⑤
33. Continuous improvement process	①	②	③	④	⑤

4. Please indicate your ***EXPECTED*** and ***ACTUAL*** levels of improvement in achieving the following "company quality goals and objectives" in adopting an ISO 9000-based QMS.
   Notes: ***EXPECTED*** – at the start of ISO 9000 adoption
   ACTUAL **–** from the start to present
   Refer to Table 2 for the scale to be followed.

Table 2. Level of Achieving the Company Quality Goals and Objectives	
Level	Description
1- Very Low (0-20) %	• Very low level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
2- Low (21-40) %	• Low level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
3- Average (41-60) %	• Average level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
4- High (61-80) %	• High level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.
5- Very High (81-100) %	• Very high level of improvement on company quality goals and objectives from implementing ISO 9000-based QMS.

COMPANY QUALITY GOALS AND OBJECTIVES	**EXPECTED LEVEL OF ACHIEVEMENT**					**ACTUAL LEVEL OF ACHIEVEMENT**				
1. To organize, improve and control construction activities	①	②	③	④	⑤	①	②	③	④	⑤
2. To ensure on time or earlier delivery of construction projects and services (*reduced no. of days delayed in completing the project, on time handover to client*).	①	②	③	④	⑤	①	②	③	④	⑤
3. To maintain a safe working environment (*reduced no. of minor and serious accidents*).	①	②	③	④	⑤	①	②	③	④	⑤
4. To enhance organization's quality image, gaining competitive advantage and having a better marketing tool (*increased no. of projects won in competitive bidding*).	①	②	③	④	⑤	①	②	③	④	⑤
5. To achieve better quality of work (*reduced no. and degree of non-conformances*).	①	②	③	④	⑤	①	②	③	④	⑤
6. To satisfy customers (*reduced no. of customer complaints, increased no. of quality awards given by government and non-government organizations*).	①	②	③	④	⑤	①	②	③	④	⑤
7. To reduce the number of quality related defects (*reduced no. of defects, repair and reworks*).	①	②	③	④	⑤	①	②	③	④	⑤

8. To develop staff capabilities (*no. of internal and external trainings provided to staff*).	①	②	③	④	⑤	①	②	③	④	⑤
9. To continuously develop the quality management system of the company	①	②	③	④	⑤	①	②	③	④	⑤
10. To save cost (*reduced discrepancy between the estimated bill of quantities and actual volume of materials used, reduced amount of material wastage*).	①	②	③	④	⑤	①	②	③	④	⑤

5. Please indicate the degree of importance of the following company quality goals and objectives.

COMPANY QUALITY GOALS AND OBJECTIVES	**IMPORTANCE RATE**				
	Least Important	Somewhat Important	Important	Very Important	Most Important
1. To organize, improve and control construction activities	①	②	③	④	⑤
2. To ensure on time or earlier delivery of construction projects and services (*reduced no. of days delayed in completing the project, on time handover to client*).	①	②	③	④	⑤
3. To maintain a safe working environment (*reduced no. of minor and serious accidents*).	①	②	③	④	⑤
4. To enhance organization's quality image, gaining competitive advantage and having a better marketing tool (*increased no. of projects won in competitive bidding*).	①	②	③	④	⑤
5. To achieve better quality of work (*reduced no. and degree of non-conformances*).	①	②	③	④	⑤
6. To satisfy customers (*reduced no. of customer complaints, increased no. of quality awards given by government and non-government organizations*).	①	②	③	④	⑤
7. To reduce the number of quality related defects (*reduced no. of defects, repair and reworks*).	①	②	③	④	⑤
8. To develop staff capabilities (*no. of internal and external trainings provided to staff*).	①	②	③	④	⑤
9. To continuously develop the quality management system of the company	①	②	③	④	⑤
10. To save cost (*reduced discrepancy between the estimated bill of quantities and actual volume of materials used, reduced amount of material wastage*).	①	②	③	④	⑤

6. Which of the following can greatly improve the effectiveness of ISO 9000-based quality management systems among construction companies? (*You may check (✓) more than one.)*

- ☐ Good leadership
- ☐ Quality management induction, trainings, seminars and promotional programs
- ☐ Time and financial investments
- ☐ Incentive schemes
- ☐ Well-written and updated procedures
- ☐ Adequate number and competency of staff to implement the system
- ☐ Regular monitoring of work
- ☐ Suggestion schemes from staff
- ☐ Supplier, subcontractor, consultant and client cooperation
- ☐ Staff cooperation
- ☐ Continuous review of the system
- ☐ Others, *please specify:* _____

D. ISO 9000 Implementation

1. What is/are the main factor(s) influencing your adoption of ISO 9000? (*You may check (✓) more than one.)*

- ☐ Mandatory requirement by government
- ☐ Client requirement
- ☐ Encouragement from main company
- ☐ Management's own initiative
- ☐ Others, *please specify:* _____

_____

2. What actual benefits did you achieve from adopting ISO 9000 in your organization? *(You may check (✓) more than one.)*

- ☐ Systematic and standardized work procedures
- ☐ Enhanced company image and improved marketing strategy
- ☐ Reduced quality related problems (defects, reworks, repair works, nonconformances)
- ☐ Enhanced customer satisfaction
- ☐ Better quality awareness for management and staff
- ☐ Saved costs
- ☐ Others, *please specify:* _____

_____

3. What problems/barriers/disadvantages did you encounter during the implementation of ISO 9000 in your organization? (*You may check (✓) more than one.)*

- ☐ Difficulty in understanding and communicating the system
- ☐ Increased effort in documentation
- ☐ Too much detail in work procedures
- ☐ Lack of competent personnel to carry out quality management duties
- ☐ Additional cost
- ☐ Additional time needed in management and training
- ☐ Lack of management commitment
- ☐ Others, *please specify:* _____

_____

4. Are you satisfied with your ISO 9000-based quality management system? Why or why not?

☐ Yes

☐ No

Reason: _____

_____

5. What are your comments on this survey questionnaire?

_____

_____

Thank you!

Appendix B. Quality Principles obtained from interviews and verified against the ISO 9001:2000 standard

Quality Principles	ISO 9001:2000 Standard Requirements																								
	Section 4: Quality Management Systematic Requirements		Section 5: Management Responsibility Requirements						Section 6: Resource Management Requirements				Section 7: Product Realization Requirements						Section 8: Measurement, Analysis and Improvement Requirements						
	General Requirements	Documentation requirements	Customer focus	Quality policy	Quality planning	Responsibility, authority and communication	Management reviews	Provision of resources	Human resources	Infrastructure	Work environment	Planning of product realization planning	Customer-related processes	Design and development	Purchasing	Production and service provision	Control of monitoring and measuring devices	General	Monitoring and measurement	Control of nonconforming product	Analyzing of data	Improvement			
	4.1	4.2	5.1	5.2	5.3	5.4	5.5	5.6	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	7.5	7.6	8.1	8.2	8.3	8.4	8.5		
1. Establishment and maintenance of a QMS	■	■					■																		
2. Document and data control	■	■					■										■						■		
3. Control of quality record		■																							
4. Management commitment on QMS		■	■	■	■	■	■	■	■																
5. Client satisfaction on quality		■		■			■																		
6. Establishment and commitment to quality policy and objectives		■			■	■	■																		
7. QMS planning		■				■	■																		
8. Definition of responsibility and authority		■					■																		
9. Communication		■					■																		
10. Management review	■	■	■	■	■	■	■	■	■	■	■	■													
11. Provision of resources to set-up and maintain the QMS	■	■					■		■																
12. Recruitment and personnel development	■	■					■		■	■															
13. Training		■					■		■	■								■							

Appendix B. Quality Principles obtained from interviews and verified against the ISO 9001:2000 standard (continued)

Quality Principles	ISO 9001:2000 Standard Requirements																								
	Section 4: Quality Management Systematic Requirements		Section 5: Management Responsibility Requirements						Section 6: Resource Management Requirements				Section 7: Product Realization Requirements							Section 8: Measurement, Analysis and Improvement Requirements				
	General Requirements	Documentation requirements	Management commitment	Customer focus	Quality policy	Quality planning	Responsibility, authority and communication	Management reviews	Provision of resources	Human resources	Infrastructure	Work environment	Planning of product realization planning	Customer-related processes	Design and development	Purchasing	Production and service provision	Control of monitoring and measuring devices	General	Monitoring and measurement	Control of nonconforming product	Analyzing of data	Improvement		
	4.1	4.2	5.1	5.2	5.3	5.4	5.5	5.6	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	7.5	7.6	8.1	8.2	8.3	8.4	8.5		
14. Provision of quality infrastructure	■	■					■		■		■														
15. Provision of quality environment	■	■					■		■			■													
16. Construction planning		■					■		■		■		■				■								
17. Control of client-related processes		■					■							■											
18. Design development		■					■								■										
19. Design control (change, review, verification and validation)		■					■								■										
20. Contract review		■		■			■							■	■										
21. Purchasing process		■		■			■									■									
22. Supplier and subcontractor control		■					■									■						■			
23. Inspection and testing		■					■										■		■	■					
24. Identification and traceability of construction processes and materials		■					■										■								
25. Material handling, storage and delivery processes		■					■										■								

Appendix B. Quality Principles obtained from interviews and verified against the ISO 9001:2000 Standard (continued)

	ISO 9001:2000 Standard Requirements																							
	Section 4: Quality Management Systematic Requirements		Section 5: Management Responsibility Requirements						Section 6: Resource Management Requirements				Section 7: Product Realization Requirements						Section 8: Measurement, Analysis and Improvement Requirements					
	General Requirements	Documentation requirements	Management commitment	Customer focus	Quality policy	Quality planning	Responsibility, authority and communication	Management reviews	Provision of resources	Human resources	Infrastructure	Work environment	Planning of product realization planning	Customer-related processes	Design and development	Purchasing	Production and service provision	Control of monitoring and measuring devices	General	Monitoring and measurement	Control of nonconforming product	Analyzing of data	Improvement	
Quality Principles	4.1	4.2	5.1	5.2	5.3	5.4	5.5	5.6	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	7.5	7.6	8.1	8.2	8.3	8.4	8.5	
26. Control of monitoring and measuring devices																								
27. Rectification of defects																								
28. Control of client complaints																								
29. Internal audit																								
30. Control of non-conformances																								
31. Data analysis relating to client satisfaction, conformity to product requirements, characteristics and trends of processes and products, and suppliers																								
32. Corrective and preventive actions																								
33. Continuous improvement process																								

Appendix C. Motivations for adopting ISO 9000

Motivations	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C19	C20	C21	C22	C24	C26	C27	**Total**
Mandatory requirement by government																		✓						**1**
Client requirement		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓		✓		✓	✓	**17**
Encouragement from main company	✓																				✓			**2**
Management's own initiative					✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**17**

Appendix D. Benefits of ISO 9000 according to contractors in Thailand

Benefits of ISO 9000	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C19	C20	C21	C22	C24	C26	C27	**Total**
Systematic and standardized work procedures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		**22**
Enhanced company image and improved marketing strategy		✓	✓	✓	✓					✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	**15**
Reduced quality related problems (defects, reworks, repair works, nonconformances)	✓					✓		✓	✓	✓			✓		✓	✓								**8**
Enhanced client satisfaction						✓		✓	✓	✓	✓	✓	✓		✓			✓	✓					**10**
Better quality awareness for management and staff	✓															✓		✓	✓				✓	**5**
Saved costs											✓					✓				✓			✓	**4**

Appendix E. Drawbacks of ISO 9000 according to contractors in Thailand

Drawbacks of ISO 9000-based QMSs	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C19	C20	C21	C22	C24	C26	C27	**Total**
Difficulty in understanding and communicating the system	✓							✓	✓			✓		✓					✓				✓	**8**
Increased effort in documentation			✓		✓	✓	✓			✓			✓	✓	✓	✓	✓				✓	✓		**12**
Too much detail in work procedures	✓		✓							✓			✓	✓			✓							**6**
Lack of competent personnel to carry out quality management duties and additional time needed in management and training	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓		✓		**16**
Additional cost						✓									✓					✓			✓	**4**
Lack of management commitment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			✓				✓	**16**

Appendix F. Raw data on quality principles from survey questionnaires (Expected)

Company	EXPECTED LEVEL OF IMPLEMENTATION ON QUALITY PRINCIPLES																																
	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15	QP16	QP17	QP18	QP19	QP20	QP21	QP22	QP23	QP24	QP25	QP26	QP27	QP28	QP29	QP30	QP31	QP32	QP33
C1	5	3	3	4	3	4	4	3	3	3	3	3	4	3	3	3	3	2	2	2	2	3	4	4	4	2	4	4	4	4	4	4	4
C2	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	4	5	4	5	4	4
C3	4	4	4	3	5	4	4	3	3	3	4	4	4	4	4	5	4	3	3	4	4	5	5	4	4	4	5	5	4	5	4	5	4
C4	4	5	5	5	4	4	5	4	4	4	4	5	5	4	3	5	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
C5	4	5	5	4	5	4	4	5	4	4	5	4	4	4	4	5	4	3	3	4	5	5	5	5	4	4	4	4	5	5	5	5	5
C6	3	3	3	4	4	4	3	4	3	1	3	1	1	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2	3	1	2	2	2
C7	3	3	3	4	5	4	3	4	3	3	3	4	3	3	3	3	3	3	3	4	4	4	4	3	3	2	3	3	3	3	3	3	3
C8	4	3	3	4	5	5	4	4	4	4	3	4	4	3	4	5	5	4	4	5	5	5	5	4	4	4	5	5	3	3	4	4	4
C9	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C10	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
C11	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C12	5	5	5	5	5	5	4	4	5	5	4	5	4	5	4	5	4	4	4	4	5	5	5	5	4	4	4	4	5	5	5	5	5
C13	5	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
C14	4	4	4	4	4	5	4	4	5	5	5	5	5	4	4	5	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C16	5	5	5	5	4	4	5	4	5	5	5	4	4	5	5	5	4	5	4	5	5	5	5	4	5	4	5	4	5	5	5	4	4
C19	5	5	5	5	5	5	4	5	4	5	3	4	4	4	3	5	5	4	4	2	5	5	5	3	4	3	4	5	5	5	4	5	5
C20	1	1	1	2	2	2	1	2	2	1	1	1	1	2	1	2	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
C21	5	5	5	5	5	5	5	4	4	5	4	4	4	4	4	5	4			4	4	4	5	5	4	5	4	4	5	4	5	4	4
C22	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4			5	5	4	4	4	5	4	4	4	5	4	4	5	5
C24	5	4	3	5	5	5	4	4	3	4	4	4	3	3	3	5	5	5	4	4	3	3	4	3	3	3	4	5	3	3	4	4	4
C26	5	4	4		4	4	5	5	4	4	4	4	4	4	3	4	3	4	4	4			5	4	4	4	5	4	5	5	3	5	4
C27	4	4	5	5	4	5	4	4	4	5	4	4	5	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	3

Appendix G. Raw data on quality principles from survey questionnaires (Actual)

Company	ACTUAL LEVEL OF IMPLEMENTATION ON QUALITY PRINCIPLES																																
	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15	QP16	QP17	QP18	QP19	QP20	QP21	QP22	QP23	QP24	QP25	QP26	QP27	QP28	QP29	QP30	QP31	QP32	QP33
C1	2	2	2	4	2	4	4	3	2	3	3	3	2	3	3	3	3	2	2	2	2	3	3	3	3	2	2	3	2	2	2	3	3
C2	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	4	5	5	4	5	5	4	5	5	5	5	5	4	5	4	5	4	4
C3	4	3	3	3	5	3	4	3	3	2	3	3	3	2	2	5	4	3	3	3	5	5	5	5	4	3	5	5	5	5	3	5	3
C4	4	4	5	5	3	3	4	3	4	3	4	4	4	4	4	4	4	3	3	5	4	3	4	3	4	5	3	4	5	3	4	3	3
C5	3	4	5	4	4	4	4	5	4	5	4	3	3	4	4	4	4	3	3	4	5	5	4	4	4	4	4	4	5	4	4	4	4
C6	2	2	2	3	2	2	2	3	2	2		3	3	4	4	4	4	4	4	4	4		4	3	3	4	4	4	4	3	4	4	4
C7	3	3	2	4	3	3	2	2	4	4	2	1	2	4	3	3	3	4	4	4	4	3	4	3	2	2	3	3	3	3	3	3	2
C8	3	3	3	3	5	4	3	3	3	3	3	3	4	3	4	5	5	3	4	5	5	5	5	4	3	4	5	5	3	4	5	5	4
C9	2	3	3	2	3	2	2	2	1	2	2	1	1	2	2	2	3			3	2	1	3	1	2	3	2	2	2	2	1	2	1
C10	3	3	4	4	3	4	3	4	4	4	4	3	3	4	3	4	4	3	4	4	3	4	4	4	4	3	4	4	4	4	4	4	4
C11	4	5	4	5	4	4	4	5	4	5	4	3	4	4	4	4	4	4	4	4	4	5	4	3	3	4	4	4	4	4	3	4	4
C12	4	5	4	4	4	4	3	3	4	4	3	4	3	4	2	4	4	3	3	3	4	4	4	3	3	3	3	3	4	4	3	3	3
C13	4	3	4	4	4	4	3	3	3	4	4	3	3	4	4	4	4	3	4	4	4	4	4	3	4	3	4	4	4	3	3	3	3
C14	4	4	4	3	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	5	5	4	4	4	4	5	5	5	5	4	3	5	5
C15	2	2	2	3	3	3	2	2	3	3	3	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	3	2	3	3	2	2	3
C16	4	3	3	3	3	2	3	3	2	3	3	2	2	2	3	3	3	3	3	3	2	3	3	3	3	4	3	4	3	4	2	3	3
C19	3	4	3	2	4	3	2	4	3	4	1	3	2	3	3	5	5	4	4	2	4	4	3	3	3	3	3	4	3	3	3	4	3
C20	2	2	2	2	2	2	1	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	1	2	2	2
C21	4	4	4	3	3	3	4	3	4	3	4	3	3	4	3	4	4			4	3	3	4	4	3	4	3	4	4	3	4	3	3
C22	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4			5	5	4	4	4	5	5	4	4	5	5	4	4	4
C24	3	2	2	3	3	3	3	2	2	3	3	2	2	2	2	3	3	3	2	3	2	2	3	2	2	2	3	3	2	3	2	3	3
C26	5	4	3		2	3	5	3	3	2	3	2	4	3	3	2	1	1	1	1			3	3	4	3	3	4	4	3	1	3	3
C27	4	4	4	3	3	4	4	3	3	4	3	3	3	3	3	4	3	3	3	3	4	4	4	4	3	3	3	4	4	4	4	4	3

Appendix H. Raw data on quality principles from survey questionnaires (Importance Rate)

Company	IMPORTANCE RATE GIVEN ON EACH QUALITY PRINCIPLE																																
	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15	QP16	QP17	QP18	QP19	QP20	QP21	QP22	QP23	QP24	QP25	QP26	QP27	QP28	QP29	QP30	QP31	QP32	QP33
C1	3	3	3	5	5	4	4	4	3	3	3	4	3	2	2	2	2	2	3	3	3	2	2	2	2	2	4	4	2	4	3	3	2
C2	4	5	5	5	5	5	5	5	5	5	3	4	5	5	5	4	5	4	4	4	4	5	5	5	5	5	5	4	5	5	5	5	4
C3	3	4	4	4	5	4	4	4	4	4	4	4	4	3	3	5	5	3	3	4	5	5	5	4	4	3	5	5	4	5	4	5	4
C4	5	5	4	5	4	4	4	3	3	4	4	3	3	3	3	4	3	4	4	5	3	4	4	3	3	4	3	4	5	4	4	4	3
C5	4	4	4	4	4	4	4	5	4	4	4	4	3	4	4	4	4	3	3	4	5	5	4	4	4	4	4	4	5	5	5	5	5
C6	5	3	5	5	5	5	4	3	3	5	3	5	5	3	3	4	4	5	5	5	5	5	5	4	3	5	5	5	5	5	4	4	5
C7	3	2	3	5	5	4	3	4	3	3	4	3	4	3	3	3	4	3	3	4	4	3	4	3	3	2	3	3	3	3	3	4	4
C8	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	4	3	3	3	4	4	4	4	3	3	3	4	4	3	3	3	4	4
C9	4	5	5	3	5	3	3	3	5	3	3	4	4	2	2	4	3			3	3	3	5	3	4	3	4	3	3	3	4	3	3
C10	5	4	4	5	4	5	4	5	4	4	4	4	4	4	3	4	4	4	5	5	4	4	4	4	4	4	4	4	5	5	4	4	5
C11	5	5	5	5	5	5	4	4	5	5	5	4	4	4	4	5	5	5	5	5	4	5	5	5	4	4	4	5	4	5	4	5	5
C12	4	5	4	4	5	5	5	4	5	4	4	4	5	4	3	4	4	4	4		5	5	5	4	4	5	4	5	4	5	5	4	5
C13	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	3	5	4	3	4	4	4	5	4	4	4	4
C14	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4
C15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C16	3	4	5	5	5	4	5	5	5	5	4	4	5	4	4	4	4	5	5	4	4	4	5	4	4	5	5	4	5	5	5	5	5
C19	4	4	4	4	5	4	4	5	5	4	3	4	4	4	3	5	5	4	4	4	4	5	5	3	4	3	4	5	3	5	4	5	5
C20	4	4	3	5	5	4	4	5	5	5	4	5	5	4	4	5	4	4	4	5	5	5	5	3	4	3	3	5	5	4	5	4	4
C21	4	3	3	5	4	5	4	3	3	5	4	3	3	3	3	4	3			3	4	4	4	4	4	4	4	4	4	4	5	4	4
C22	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4			5	4	4	4	4	4	4	4	4	4	5	4	4	4
C24	4	3	3	4	5	5	4	3	3	3	4	3	3	3	2	4	5	4	4	5	3	3	4	3	3	2	4	5	3	3	3	3	4
C26	3	4	3	3	5	2	2	3	4	2	3	1	3	3	3	2	2	1	1	1	4	3	4	4	4	2	2	5	3	2	2	3	
C27	4	3	3	3	4	3	3	3	4	4	3	3	3	3	3	4	4	2	2	3	4	4	3	3	3	3	3	3	3	3	3	3	3

Appendix I. Actual and expected final quality scores for the Matrix of Principles

Contractor	AFQS	EFQS	Gaps (AFQS-EFQS)	Remark
C6	89.6	68.8	20.8	ok
C20	53.8	37	16.8	ok
C22	110.8	110.6	0.2	ok
C2	146.4	147.4	-1	Needs improvement
C8	87.2	91.2	-4	Needs improvement
C7	66.4	74.4	-8	Needs improvement
C3	104	112.4	-8.4	Needs improvement
C10	104	112.8	-8.8	Needs improvement
C5	111.8	122	-10.2	Needs improvement
C4	95.8	106.6	-10.8	Needs improvement
C14	117.6	128.4	-10.8	Needs improvement
C13	96.6	108	-11.4	Needs improvement
C1	52.2	66.2	-14	Needs improvement
C27	73.6	88.2	-14.6	Needs improvement
C26	48.4	66.2	-17.8	Needs improvement
C25	118.2	136.2	-18	Needs improvement
C9	43.8	64.8	-21	Needs improvement
C21	82.6	106	-23.4	Needs improvement
C11	123.8	153	-29.2	Needs improvement
C12	100.2	130.8	-30.6	Needs improvement
C19	91.4	122.6	-31.2	Needs improvement
C24	60.8	94	-33.2	Needs improvement
C16	86.6	138	-51.4	Needs improvement
C15	83	165	-82	Needs improvement

Appendix J. Raw data on quality goals from survey questionnaire

Company	EXPECTED LEVEL OF ACHIEVEMENT ON QUALITY GOALS										ACTUAL LEVEL OF ACHIEVEMENT ON QUALITY GOALS										IMPORTANCE RATE GIVEN ON EACH QUALITY GOAL									
	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10
C1	3	3	3	3	3	3	3	3	3	3	2	2	3	3	1	1	1	2	2	1	3	2	2	2	5	5	5	3	3	2
C2	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
C3	5	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	3	3	3	4	5	5	5	5	4	5	4	4	4	5
C4	4	4	4	4	4	4	4	4	4	4	3	3	4	5	3	3	3	3	4	3	4	5	4	3	4	5	3	3	3	3
C5	4	4	5	5	5	5	5	4	5	4	4	4	5	4	5	5	5	4	5	4	5	5	5	5	5	5	5	4	4	4
C6	4	5	5	5	5	5	5	5	5	5	3	3	4	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5	5
C7	4	3	3	4	4	4	4	4	5	3	4	3	3	3	4	3	3	2	4	3	4	2	2	3	4	5	4	4	3	2
C8	3	3	5	3	3	3	5	5	3	4	4	5	5	4	4	5	5	5	4	4	3	5	5	4	3	3	4	3	3	4
C9	4	4	4	4	4	4	4	4	4	4	3	3	4	3	3	3	2	2	2	3	5	5	5	3	5	4	4	4	3	4
C10	4	4	4	3	4	4	4	3	4	4	3	4	3	3	3	4	4	4	4	3	4	4	3	4	4	5	4	4	4	5
C11	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5	5	4	4	3	5	5	5	5	5	5	5	5	5	5
C12	5	4	4	5	5	5	4	4	5	5	3	3	3	4	3	3	3	3	4	4	5	5	4	5	4	4	4	4	5	5
C13	4	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	5	4	4	5	5
C14	5	5	5	5	5	4	4	4	4	3	4	5	5	5	4	4	4	4	4	3	5	5	5	5	5	5	4	4	4	4
C15	5	5	5	5	5	5	5	5	5	5	2	2	2	3	3	3	2	2	2	2	5	5	5	5	5	5	5	5	5	5
C16	4	4	5	4	4	5	4	4	4	4	3	3	3	3	2	4	3	2	3	3	4	5	5	4	5	5	5	4	5	4
C19	4	4	5	5	5	5	5	4	5	5	2	4	5	5	3	5	4	3	3	4	5	5	5	5	5	5	5	5	5	5
C20	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	5	5	3	4	4	4	3	3	3
C21	4	4	4	4	4	5	5	4	4	5	4	4	4	4	3	4	4	2	3	4	4	4	4	4	4	4	4	4	4	4
C22	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4
C24	4	4	4	4	4	5	4	3	3	4	3	3	3	3	2	3	2	2	3	3	4	4	5	5	4	5	4	3	3	3
C26	4	5	5	4	4	5	5	4	3	4	2	5	1	3	2	5	2	2	2	3	5	5	4	5	5	5	4	4	3	5
C27	4	4	4	5	4	4	4	4	4	5	3	3	3	4	3	3	3	3	3	4	4	4	4	4	4	4	3	3	3	3

Appendix K. Actual and expected final quality scores for the Matrix of Goals

Contractor	AFQS	EFQS	Gaps (AFQS-EFQS)	Remark
C8	33.6	27.8	5.8	ok
C20	23	23	0	ok
C22	32.8	32.8	0	ok
C5	42.4	43.4	-1	Needs improvement
C14	39	41	-2	Needs improvement
C2	48	50	-2	Needs improvement
C10	28.8	31.2	-2.4	Needs improvement
C7	21.2	25.8	-4.6	Needs improvement
C4	24.8	29.6	-4.8	Needs improvement
C21	28.8	34.4	-5.6	Needs improvement
C3	36.4	42.8	-6.4	Needs improvement
C27	23	30.2	-7.2	Needs improvement
C13	35.2	43.2	-8	Needs improvement
C1	10.2	19.2	-9	Needs improvement
C11	41	50	-9	Needs improvement
C19	38	47	-9	Needs improvement
C9	24	33.6	-9.6	Needs improvement
C24	21.8	31.8	-10	Needs improvement
C12	30	41.6	-11.6	Needs improvement
C16	26.8	38.8	-12	Needs improvement
C26	25.2	39	-13.8	Needs improvement
C6	31	49	-18	Needs improvement
C15	23	50	-27	Needs improvement
				Needs improvement

Appendix L. Gaps for each quality principle at the construction company level

COMPANY	QUALITY PRINCIPLES																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C6	-1	-0.6	-1	-1	-2	-2	-0.8	-0.6	-0.6	1	-1.8	2	2	0.6	0.6	1.6	0.8	2	2	2
C20	0.8	0.8	0.6	0	0	0	0	0	0	0	0	0	1	0	0.8	0	0	0.8	0.8	1
C22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	-0.6	0	0	-0.6	0	-0.6	-0.6	-0.6	-0.6	-0.6	0	-0.6	0	0	0	0	0	-0.6	0	0
C7	0	0	-0.6	0	-2	-0.8	-0.6	-1.6	0.6	0.6	-0.8	-1.8	-0.8	0.6	0	0	0	0.6	0.6	0
C3	0	-0.8	-0.8	0	0	-0.8	0	0	0	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	0	0	0	0	-0.8
C10	-1	-0.8	-0.8	0	-0.8	0	-0.8	0	0	0	0	-0.8	-0.8	0	-0.6	0	0	-0.8	0	0
C5	-0.8	-0.8	0	0	-0.8	0	0	0	0	0.8	-0.8	-0.8	-0.6	0	0	-0.8	0	0	0	0
C14	0	0	0	-1	0	-1	0	0	-0.8	-0.8	0	-0.8	-0.8	0	0	0	0	0	0	0
C4	0	-1	0	0	-0.8	-0.8	-0.8	-0.6	0	-0.8	0	-0.6	-0.6	0	0.6	-0.8	0	-1.6	-0.8	1
C13	-0.8	-0.8	0	0	0	0	-0.8	-0.8	-1	0	-0.8	-0.8	-0.8	0	0	0	0	0	0	0
C1	-1.8	-0.6	-0.6	0	-1	0	0	0	-0.6	0	0	0	-1.2	0	0	0	0	0	0	0
C27	0	0	-0.6	-1.2	-0.8	-0.6	0	-0.6	-0.8	-0.8	-0.6	-0.6	-1.2	-0.6	-0.6	-0.8	-0.8	-0.4	-0.4	-0.6
C26	0	0	-0.6	0	-2	-0.4	0	-1.2	-0.8	-0.8	-0.6	-0.4	0	-0.6	0	-0.8	-0.8	-0.6	-0.6	-0.6
C9	-0.8	0	0	-0.6	0	-0.6	-0.6	-0.6	-2	-0.6	-0.6	-1.6	-1.6	-0.4	-0.4	-0.8	0	0	0	0
C21	-0.8	-0.6	-0.6	-2	-1.6	-2	-0.8	-0.6	0	-2	0	-0.6	-0.6	0	-0.6	-0.8	0	0	0	0
C11	-1	0	-1	0	-1	-1	-0.8	0	-1	0	-1	-1.6	-0.8	-0.8	-0.8	-1	-1	-1	-1	-1
C12	-0.8	0	-0.8	-0.8	-1	-1	-1	-0.8	-1	-0.8	-0.8	-0.8	-1	-0.8	-1.2	-0.8	0	-0.8	-0.8	0
C19	-1.6	-0.8	-1.6	-2.4	-1	-1.6	-1.6	-1	-1	-0.8	-1.2	-0.8	-1.6	-0.8	0	0	0	0	0	0
C24	-1.6	-1.2	-0.6	-1.6	-2	-2	-0.8	-1.2	-0.6	-0.6	-0.8	-1.2	-0.6	-0.6	-0.4	-1.6	-2	-1.6	-1.6	-1
C16	-0.6	-1.6	-2	-2	-1	-1.6	-2	-1	-3	-2	-1.6	-1.6	-2	-2.4	-1.6	-1.6	-0.8	-2	-1	-1.6
C15	-3	-3	-3	-2	-2	-2	-3	-3	-2	-2	-2	-3	-3	-2	-2	-2	-2	-2	-2	-2
SUM	**-15.4**	**-11.8**	**-14**	**-15.2**	**-19.8**	**-18.8**	**-15**	**-14.2**	**-15.2**	**-11**	**-14.2**	**-17.2**	**-15.8**	**-9**	**-7.4**	**-10.2**	**-6.6**	**-8**	**-4.8**	**-3.6**
AVERAGE	**-0.67**	**-0.51**	**-0.61**	**-0.66**	**-0.86**	**-0.82**	**-0.65**	**-0.62**	**-0.66**	**-0.48**	**-0.62**	**-0.75**	**-0.69**	**-0.39**	**-0.32**	**-0.44**	**-0.29**	**-0.35**	**-0.21**	**-0.16**

Appendix L. Gaps for each quality principle at the construction company level (continued)

COMPANY	QUALITY PRINCIPLES													Σ(AFQS-EFQS)	Remark
	21	22	23	24	25	26	27	28	29	30	31	32	33		
C6	2	-2	2	0.8	0.6	2	2	2	1	2	1.6	1.6	2	20.8	Ok
C20	1	1	1	0.6	0.8	0.6	0.6	1	1	0	1	0.8	0.8	16.8	Ok
C22	0	0	0	0	0	0.8	0	0	0	1	0	-0.8	-0.8	0.2	Ok
C2	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1	Needs improvement
C8	0	0	0	0	-0.6	0	0	0	0	0.6	0.6	0.8	0	-4	Needs improvement
C7	0	-0.6	0	0	-0.6	0	0	0	0	0	0	0	-0.8	-8	Needs improvement
C3	1	0	0	0.8	0	-0.6	0	0	0.8	0	-0.8	0	-0.8	-8.4	Needs improvement
C10	-0.8	0	0	0	0	-0.8	0	0	0	0	0	0	0	-8.8	Needs improvement
C5	0	0	-0.8	-0.8	0	0	0	0	0	-1	-1	-1	-1	-10.2	Needs improvement
C14	0	-0.8	-0.8	-0.8	-0.8	0	0	0	0	-0.8	-1.6	0	0	-10.8	Needs improvement
C4	0	-0.8	-0.8	-0.6	0	0.8	-0.6	0	1	-0.8	0	-0.8	-0.6	-10.8	Needs improvement
C13	0	0	0	-0.8	0	-0.8	0	0	0	-0.8	-0.8	-0.8	-0.8	-11.4	Needs improvement
C1	0	0	-0.4	-0.4	-0.4	0	-1.6	-0.8	-0.8	-1.6	-1.2	-0.6	-0.4	-14	Needs improvement
C27	-0.8	0	0	0	-0.6	-0.6	-0.6	0	0	0	0	0	0	-14.6	Needs improvement
C26	0	0	-1.6	-0.8	0	-0.4	-0.8	0	-0.6	-0.8	-0.8	-1.2	0	-17.8	Needs improvement
C9	-0.6	-1.2	0	-1.2	-0.8	0	-0.8	-0.6	-0.6	-0.6	-1.6	-0.6	-1.2	-21	Needs improvement
C21	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	0	-0.8	-0.8	-1	-0.8	-0.8	-23.4	Needs improvement
C11	-0.8	0	-1	-2	-1.6	-0.8	-0.8	-1	-0.8	-1	-1.6	-1	-1	-29.2	Needs improvement
C12	-1	-1	-1	-1.6	-0.8	-1	-0.8	-1	-0.8	-1	-2	-1.6	-2	-30.6	Needs improvement
C19	-0.8	-1	-2	0	-0.8	0	-0.8	-1	-1.2	-2	-0.8	-1	-2	-31.2	Needs improvement
C24	-0.6	-0.6	-0.8	-0.6	-0.6	-0.4	-0.8	-2	-0.6	0	-1.2	-0.6	-0.8	-33.2	Needs improvement
C16	-2.4	-1.6	-2	-0.8	-1.6	0	-2	0	-2	-1	-3	-1	-1	-51.4	Needs improvement
C15	-3	-3	-3	-3	-3	-3	-2	-3	-2	-2	-3	-3	-2	-82	Needs improvement
SUM	**-7.6**	**-13.4**	**-12**	**-12**	**-11.6**	**-5**	**-9.8**	**-6.4**	**-6.4**	**-10.6**	**-17.2**	**-11.6**	**-13.2**	**-384**	
AVERAGE	**-0.33**	**-0.58**	**-0.52**	**-0.52**	**-0.5**	**-0.22**	**-0.43**	**-0.28**	**-0.28**	**-0.46**	**-0.75**	**-0.5**	**-0.57**		

Appendix M. Gaps for each quality goal at the construction company level

COMPANY	QUALITY GOALS										**Σ(AFQS-EFQS)**	**Remark**
	QG1	QG2	QG3	QG4	QG5	QG6	QG7	QG8	QG9	QG10		
C8	0.6	2	0	0.8	0.6	1.2	0	0	0.6	0	5.8	Ok
C20	0	0	0	0	0	0	0	0	0	0	0	Ok
C22	0	0	0	0	0	0	0	0	0	0	0	Ok
C5	0	0	0	-1	0	0	0	0	0	0	-1	Needs improvement
C14	-1	0	0	0	-1	0	0	0	0	0	-2	Needs improvement
C2	0	0	-1	0	0	0	-1	0	0	0	-2	Needs improvement
C10	-0.8	0	-0.6	0	-0.8	0	0	0.8	0	-1	-2.4	Needs improvement
C7	0	0	0	-0.6	0	-1	-0.8	-1.6	-0.6	0	-4.6	Needs improvement
C4	-0.8	-1	0	0.6	-0.8	-1	-0.6	-0.6	0	-0.6	-4.8	Needs improvement
C21	0	0	0	0	-0.8	-0.8	-0.8	-1.6	-0.8	-0.8	-5.6	Needs improvement
C3	-1	-1	0	0	0	-1	-0.8	-0.8	-0.8	-1	-6.4	Needs improvement
C27	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.6	-0.6	-0.6	-0.6	-7.2	Needs improvement
C13	0	-0.8	-1	-0.8	-0.8	-1	-0.8	-0.8	-1	-1	-8	Needs improvement
C1	-0.6	-0.4	0	0	-2	-2	-2	-0.6	-0.6	-0.8	-9	Needs improvement
C11	-1	-1	-1	-1	-1	0	0	-1	-1	-2	-9	Needs improvement
C19	-2	0	0	0	-2	0	-1	-1	-2	-1	-9	Needs improvement
C9	-1	-1	0	-0.6	-1	-0.8	-1.6	-1.6	-1.2	-0.8	-9.6	Needs improvement
C24	-0.8	-0.8	-1	-1	-1.6	-2	-1.6	-0.6	0	-0.6	-10	Needs improvement
C12	-2	-1	-0.8	-1	-1.6	-1.6	-0.8	-0.8	-1	-1	-11.6	Needs improvement
C16	-0.8	-1	-2	-0.8	-2	-1	-1	-1.6	-1	-0.8	-12	Needs improvement
C26	-2	0	-3.2	-1	-2	0	-2.4	-1.6	-0.6	-1	-13.8	Needs improvement
C6	-1	-2	-1	-2	-2	-2	-2	-2	-2	-2	-18	Needs improvement
C15	-3	-3	-3	-2	-2	-2	-3	-3	-3	-3	-27	Needs improvement
SUM	**-18**	**-11.8**	**-15.4**	**-11.2**	**-21.6**	**-15.8**	**-20.8**	**-19**	**-15.6**	**-18**	**-167.2**	
AVERAGE	**-0.78**	**-0.51**	**-0.67**	**-0.49**	**-0.94**	**-0.69**	**-0.9**	**-0.83**	**-0.68**	**-0.78**		

BIOGRAPHY

Cheryl Lyne E. Capiz was born on 01 October 1981 in Pampanga, a province located in the Central Luzon region of the Philippines. She finished her bachelor's degree in Civil Engineering at the University of the Philippines – Diliman. Her undergraduate research dealt with Transportation Engineering, specifically on the noise levels generated by tricycles. Much of her experiences after graduation were dedicated to transportation engineering related activities. She worked for Leighton Contractors (Philippines), Incorporated, where she served as a technical support under the Quality, Environment, Safety and Health Department. With the encouragement from her undergraduate Advisor, Dr. Karl N. Vergel, she applied for a Master's Degree in Civil Engineering under ASEAN University Network / Southeast Asia Engineering Education Development Network (AUN/SEED-Net) Scholarship. Because of the exposure she gained on construction, she chose the Construction Engineering and Management field. Her work experience in quality assurance has stimulated her to do a research on ISO 9000.