QUALITY ASSURANCE OF CONSTRUCTION WORKS IN HONG KONG

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Abstract of the thesis entitled:

QUALITY ASSURANCE OF CONSTRUCTION WORKS IN HONG KONG

submitted by Kam Chak Wing
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This Ph.D. thesis presents research on the quality assurance system used in the construction industry in Hong Kong and problems encountered in implementing the ISO 9000 standards. The ISO 9000 standards were essentially written with the manufacturing industry in mind. Their application to construction processes has faced many challenges over the past years. The investigation was initially directed at problems regarding the suitability of ISO 9000 standards for construction works. A technical review of each quality element of the ISO 9001 standard indicated that most of these quality clauses are directly relevant to construction processes. Although there are fundamental differences between the manufacturing and construction industries, the basic concept of quality assurance, suitably modified, can be applied to the construction industry.

Research done in the early stages of the development and implementation of the quality assurance system in the construction industry of Singapore carries a valuable lesson for Hong Kong. It has been observed that Hong Kong has already stepped up measures to improve the quality standard of public housing but there is no measurement scheme for private building and civil engineering works as in Singapore. The Performance Assessment Scoring System and Preferential Tendering Eligibility System being used by the Hong Kong Housing Authority may not effectively bar the poorer contractors from obtaining the contracts and modifications to these systems are recommended. There is a lack of an effective scheme to maintain the quality

improvement momentum in both cities and a hybrid incentive scheme is proposed for adoption.

Further, two intensive questionnaire surveys on ISO 9000-certified consultants and contractors were carried out to investigate the quality management issues including the initial motivation for seeking certification, perception of the benefits received and problems in managing for quality. The responses on the adaptability of the ISO 9000 standards to the construction industry appear positive. Ironically, the main reason for certification is to get a "work permit" rather than to look for quality improvement. Although certain improvements have been made as a result of implementing a quality assurance system, the actual achievements, in most areas, are far below the original expectations. The situation has been reviewed for analysis and rectification. With a better understanding of the principle of quality assurance - "get things right first time", the construction sector can keep the balance among the quality, cost and time in the construction projects and reap the maximum benefits from ISO 9000 certification.

Although many consultants and contractors have successfully achieved ISO 9000 certification, it is considered that their quality management systems should have room for continuous improvement. Three quality manuals from consultants and another three from contractors were selected for study. It was found that some quality manuals are prepared simply to satisfy the minimum necessary requirements to assure certification. Some of the other manuals include redundant procedures and activities which clutter the system and are therefore harmful to its implementation. Based on case studies and with hands-on experience on the preparation of a quality management system for the Territory Development Department, two model quality manuals, one for consultants and one for contractors, have been developed to allow for application in the construction industry.

DECLARATION

I hereby declare that the present thesis entitled "Quality Assurance of Construction Works in Hong Kong" has not been, either in whole or in part, previously submitted to this or other institutions in application for admission to a degree, diploma or other qualifications and contains no material previously published or written by other person, except where due reference is made.

Kam Chak Wing

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This thesis is dedicated to my mother and my wife for their endless love and support throughout this research period. I especially wish to express my deepest gratitude to my loving late father who passed away in June 1998. I wish he had lived to see me graduate.

PUBLICATIONS BASED ON THE PRESENT WORK

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

The use of quality standards is not new. For example, evidence is clearly seen in such accomplishments as the construction of the great pyramids and temples in ancient Egypt and the vast underground terracotta army in China. Modern quality standards have been developed steadily since the Second World War for military defence. The development of British Standards (BS) and later International Organization for Standardization (ISO) are motivated by the needs of industry. ISO 9000 is a series of three international standards and supplementary guidelines on quality management and quality assurance. It was first published in 1987 and revised in 1994. These quality standards are now widely accepted throughout the world and have been adopted as the national standard in more than 90 countries (ISO, 1999).

The construction industry has been playing a vital part in Hong Kong's economic growth. Growing consciousness among the clients, consultants and contractors about quality, timely completion and cost factors have added pressures to this industry. With the continuous scrutiny by the public of such as public housing and civil engineering projects, the need for quality assurance is not only necessary but also demanded to ensure that the best quality products and services are offered.

In 1989, the Hong Kong Housing Authority stepped up measures to improve the quality standard of public housing. A real boost was given to the construction industry in 1991 when the Housing Authority requested its building contractors to be certified to ISO 9000 as a condition for tendering its housing projects after March 1993. In March 1994, the Works Bureau promulgated a quality policy to require its major civil engineering consultants and contractors to achieve ISO 9000 certification in 1996. ISO 9000 compliance is rapidly becoming a prerequisite for companies seeking Government construction projects. These gave a big impetus to the acceptance of quality assurance in construction works in Hong Kong.

The ISO 9000 standards were initially developed for the manufacturing industry and its application to construction processes was questionable. The quality assurance processes as described in the standards have not yet been unanimously agreed by the construction sector. Vigorous debates have ensued on how appropriate ISO 9000 is for the construction industry and what benefits are gained from the ISO 9000 certification. In order to learn more about ISO 9000 implementation in the construction industry and to allay the concern of the construction sector, a comprehensive research has been carried out to investigate how the quality assurance system can be effectively applied to the consulting engineering firms and construction companies in Hong Kong.

1.2 Research Methodology

In order to examine how the impacts of quality assurance system are on the construction industry in Hong Kong, a 4-phase investigation, as shown in Figure 1.1, was designed to provide accurate and in-depth understanding of ISO 9000 in relation to construction work. From the results of both the questionnaire surveys and case studies, the motivation for and experience in implementing quality assurance system to ISO 9000 standards by the construction sector have been identified for analysis. The benefits and shortcomings of the ISO 9000 for the construction industry can be determined. The quality policy of construction industry in Singapore has been used as a benchmark when considering how to improve quality performance in Hong Kong.

1.2.1 Literature Review

Review on the relevant books, journals, articles and previous research findings regarding quality assurance management and construction works were carried out to delineate the problems of the implementation of quality assurance system in the

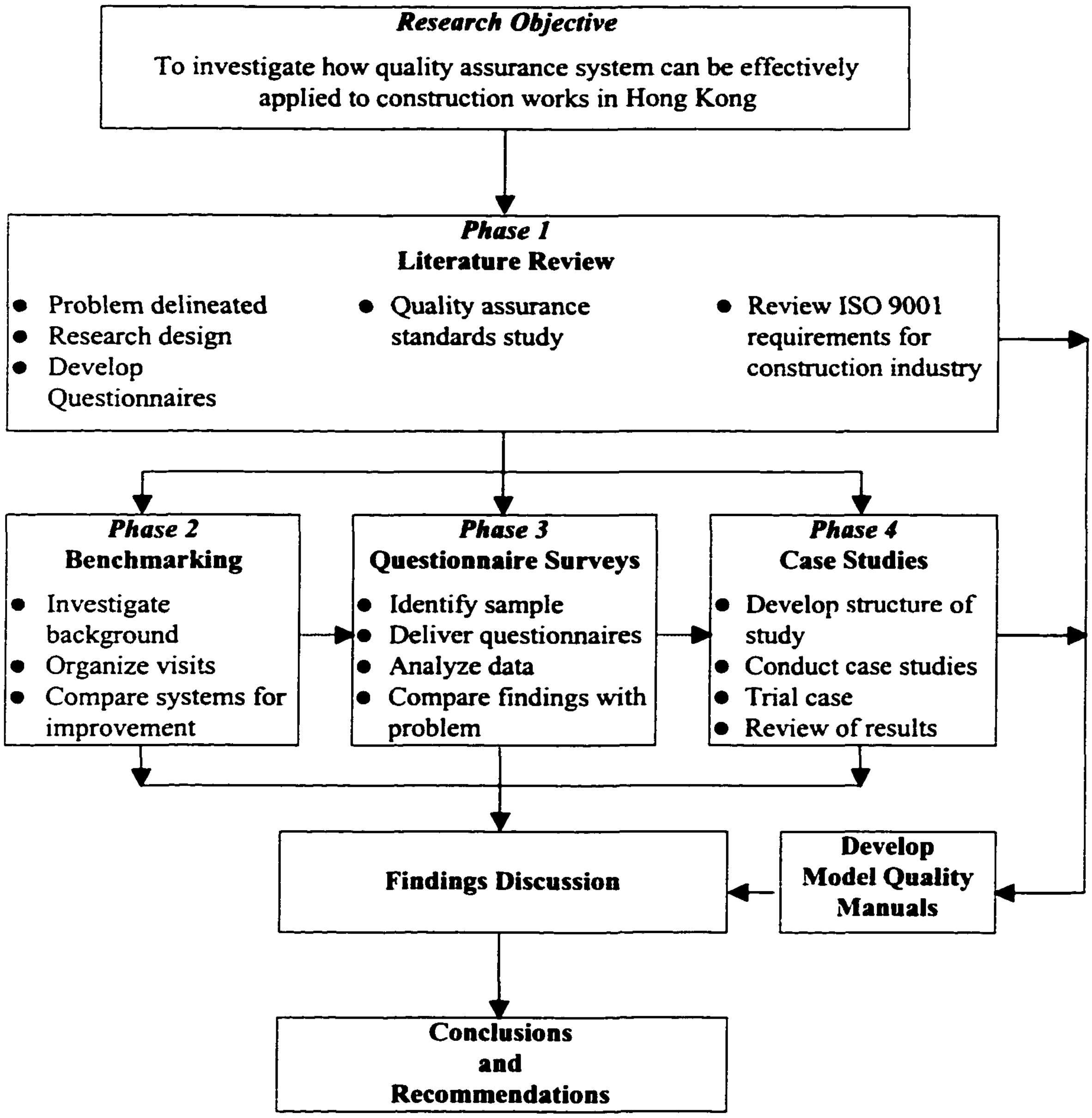


Figure 1.1 : Research Plan

construction industry. At the beginning of study, a literature review on the previous work was conducted in order to set up the direction and target of research domain. During the course of study, relevant work of other scholars and researchers was quoted for discussing and interpreting the findings.

The purpose of the literature review was also to provide a brief introduction of ISO 9000 quality assurance standards and to identify their requirements for the construction industry. Based on the review of other research methods, the questionnaires had been developed to explore the application of ISO 9000 to the consulting engineering firms and construction companies.

1.2.2 Benchmarking

The construction practices in Singapore and Hong Kong are similar. Both cities have taken ISO 9000 standards as the norm for their quality management systems in construction work. In order to collect sufficient information for analysis, the author had visited Singapore thrice during the study period: -

(i) April 1995

- Attended the "ISO 9000 Internal Quality Audit Workshop" organized by the Construction Industry Development Board of Singapore and met the quality assurance managers and auditors at the workshop
- Visited and interviewed the staff of: -
  - Construction Industry Development Board
  - Housing and Development Board
  - Public Works Department
  - Singapore Institute of Standards and Industrial Research

(ii) October 1997

- Attended the "International Conference on Leadership and Total Quality Management in Construction and Building" sponsored by the Institution of Engineers of Singapore and shared the quality management experience with the participants

(iii) February 1998

- Attended the "Second International Conference on Construction Project Management" organized by Nanyang Technology University of Singapore
- Presented a research paper (Kam and Tang, 1998a) in the conference and discussed how the quality assurance system could be effectively applied to construction industry with other speakers and participants

In Hong Kong, the author also visited the Hong Kong Quality Assurance Agency, Housing Department, Industry Department, Civil Engineering Department and Works Bureau to gather information about the quality policy being applied to the construction industry. Through the seminars, site visits and quality audits, he discussed with project directors, engineers, technical staff, quality assurance managers and auditors regarding the benefits and drawbacks of implementing the ISO 9000 standards in construction work. By benchmarking with the quality assurance system in Singapore, some recommendations had been made for Hong Kong.

1.2.3 Questionnaire Surveys

Apart from the literature review, experience in and opinion of the practicability of applying ISO 9000 in the construction industry from the consulting engineers and construction contractors were collected through questionnaire surveys. Jensen (1994) indicated that ISO 9001 standard was not adequate for consulting engineering services. In order to examine Jensen's statement, ten consulting firms were selected for interview in late 1995 (see Section 5.3.1). A questionnaire was designed to examine Jensen's findings and to address the key issues in implementing a quality assurance system to ISO 9001 by consultants. This survey could be considered as a pilot survey of the quality system in the infant stage of quality management development in Hong Kong.

After the pilot survey, two intensive questionnaire surveys were separately conducted on the consulting firms and construction companies. The questionnaires were developed, based on the literature review and survey results, to measure to what extent the respondents agreed or disagreed with the perceived internal and external problems, benefits and expectations in implementing the ISO 9000 quality management system within their own organizations. The questions were also designed to collect the demographic data of the respondents and their experience in preparing, implementing and maintaining the system. The structured questionnaires were posted to 36 ISO 9001-certified civil and structural consulting engineering firms in September 1997 (see Section 5.4) and 100 ISO 9000-certified construction companies in June 1997 (see Section 5.5) for responses.

The data obtained from the surveys were analyzed and evaluated. The survey results were compared with the identified problems and other research results as far as possible. The respondents were asked whether they were completely satisfied with the ISO 9000 standards and guidelines. If the answers indicated that model quality manuals were desirable, it was necessary to develop them for reference.

1.2.4 Case Studies

Case studies were employed in this research. The purpose of the case studies was to get more details from the construction sector in order to identify the requirements and contents of quality manuals for consultants and contractors to the ISO 9000 standards and to recommend a suitable style and format of quality manual for their use.

The quality manuals from three consulting firms (see Chapter 6) and three construction companies (see Chapter 7) had been obtained for study. A comprehensive study on one consulting firm had been carried out from the development of the quality management system to certification stages. The performance of a quality assurance consultant had also been reported under this case study. An overview had been given in each case study and then an overall comparison was made between case study results. If the quality manuals under study were found "room for improvement", the model quality manuals would be proposed.

The author had assisted the Territory Development Department, one of the works departments under the Works Bureau, in setting up a quality management system to ISO 9001 certification. It was a good trial case to verify the research results.

1.2.5 Findings Discussion

Findings obtained from the benchmarking, questionnaire surveys and case studies would be summarized and compared with other research results. The limitations of the research methodology would be highlighted for discussion. The model quality manuals developed for reference would be re-addressed. The overall conclusions and recommendations would then be made.

1.3 Literature Review of Previous Work

Much has been said about quality in construction works. Authoritative studies on how far quality has been achieved in the construction industry are less easy to find. ISO 9000 standards were published in 1987. Since then there has been a huge amount of work published on this subject. More of these publications are viewpoints and commentaries, but some are case studies on the impacts of ISO 9000 at individual and aggregate levels (Buttle, 1997). Many researchers had examined the general problems in the implementation of ISO 9000 in the construction projects. However, not many studies emphasized the suitability of ISO 9000 for the construction industry. Kwok (1997) and Yuen (1999) conducted literature surveys on this subject area and both reported that there was a lack of information and research findings with respect to the study of performance of the ISO 9000 quality system in the construction industry in Hong Kong. Therefore, there is no single chapter dealing with a literature review in this dissertation but the relevant work of other scholars is quoted for discussion in each chapter. Nevertheless, a literature review of previous work has been conducted and is briefly summarized below.

1.3.1 Technical Researches

One of the few published accounts is that undertaken by the Building Research Station in 1960s. It reported the findings of the "National Building Studies Special Report 33 : A qualitative study of some buildings in the London Area". It stressed the effects of materials and techniques in relation to the buildings taking into account the concept of quality (Atkinson, 1987). Until the BS 5750 - "Quality System" was released in 1979 as a generic quality assurance standard for British industries, quality assurance for the construction industry was brought into focus. The Construction Industry Research and Information Association (CIRIA) had been actively engaged in matters relating to quality assurance and published the Report 109 "Quality Assurance in Civil Engineering" in 1985 to provide some facts for the construction industry as an aid to understanding quality assurance (Bransby, 1988). In early 1986, the Institution of Civil Engineers (ICE) began a particular study of the likely impact of quality assurance in the construction industry (Severn, 1988).

McNicholl, *et. al.* (1989) carried out a case study on two quality assurance schemes for the production of precast prestressed spun concrete piles for housing projects in Hong Kong. They reported that the schemes introduced a welcome and high measure of quality assurance for an important element in the building process. An investigation of the early quality schemes being developed to deal with construction design and site work by Hall and Fletcher (1990) had shown the considerable scope that quality assurance gave for improving the quality of buildings. As the ISO 9000 was essentially written with the manufacturing industry in mind, Oliver (1990) had prepared the CIRIA Special Publication 74 for the interpretations of the standard for the construction industry. Furthermore, Barber (1992) had reviewed the subject of contractual relationships and forms of contract in construction against the background of quality management and recommended how best all parties, client/engineer/contractor, could be given the maximum incentive to maintain and enhance the standard of their own work.

Hellard (1993) argued that the quality standards required from the contract had already been specified in the contract documents - the drawings, specifications, schedules, bill of quantities and so on - and the addition of references to ISO 9000 were likely to be more confusing than helpful. Over the past years, a number of case studies were reported on how to implement ISO 9000 in the construction industry (Bradley, 1992; Low and Goh, 1994; Rwelamila, 1995; Tsiotras and Gotzamani, 1996; Singh, 1997). It was observed that contractors had welcomed the use of the principles of quality assurance over the world and there was no significant argument against the suitability of ISO 9000 for them. A further study continues in this direction to elaborate on the application of the quality assurance system to the local contractors (see Section 5.5).

The question of interrelation between quality management and contractual obligations also arose in the consulting engineering service area. In 1990, the Association of Consulting Engineers in Denmark (FRI) initiated a study on quality assurance requirements in consulting engineering firms and found that the ISO 9001 did not address all parameters relevant to the quality of knowledge-based services and some of the parameters in ISO 9001 were not relevant. Oliver (1992) had edited the CIRIA Special Publication 88 to give detailed guidance to quality assurance managers in design offices for the preparation and implementation a quality management system meeting the requirements of the ISO 9001 standard.

Jensen (1994) opined that the fulfilment of ISO 9001 by a consulting engineering firm would not enhance the confidence of the client, as the standard did not reflect an engineering consultancy's structure. Laustsen (1995) indicated that the differences between product-based and knowledge-based endeavours were considerable and the standard was not relevant for consultancy. Based on the survey results of the Status Report on Quality Assurance for Engineering Consultancy Services in Europe, Hohberg (1995) disputed that ISO 9001 was promising for consulting services and the question was no longer whether the standard was applicable to engineering consultancies. Wright, *et. al.* (1999) found that the 2nd edition of ISO 9001 was more relevant to the needs of the service industry including engineering consultants. However, it still had many parts based on manufacturing needs which could only be applied to the engineering consultancy with a very loose translation. The standard still did not address some of the needs of engineering consultant business. However, discussion on this topic continues. The author attempts to give the answer based on the results of this research work.

1.3.2 Surveys on ISO 9000 Implementation

(i) Vloeberghs and Bellens (1996) conducted a survey to all known Belgian ISO 9000 certificate-holders (sample no. = 689 and response rate = 42%). Only 3.55% of responding companies were from construction sector. The main objectives of their survey were to define the company's motivation for implementing ISO 9000, evaluate their experiences with ISO 9000 implementation, and analyze the effects of the ISO 9000 system on their organization. The main findings in this survey were: -

- Most of responding firms cited external motives, such as improvement of quality image and requests from clients, as the most important reasons for implementing ISO 9000.
- Strong senior management commitment, well-structured quality system and strong employees motivation were the most important factors of ISO 9000 implementation.
- ISO 9000 implementation brought the most important internal change to a well-defined system of procedures and external change to a more trust in their relationship with the client.
- Guaranteeing continuity and uniformity was the biggest advantage of the quality manual.
- The biggest disadvantages of the quality manual were its enormous administrative burden and the loss of flexibility when the manual was used.

(ii) Construction Industry Research and Information (CIRIA, 1995) launched a project to collect objective and representative evidence of the practical outcome of applying BS 5750 (identical to ISO 9000) to construction industry in U.K. The research report presenting the findings from a survey of experience of BS 5750 within the construction industry was published in May 1995. In the course of research, a total of 35 organizations, including five consulting firms and five construction companies, were interviewed from across the industry to determine their experience of installing a quality management system to BS 5750.

The objectives of the research programme were to assess the implementation of BS 5750 in the construction industry, against the background of arguments both for and against its use. It wanted to identify, evaluate and draw conclusions from: -

- the benefits obtained by the firms with certification, their customers and the industry
- the time and resources required to install, achieve certification and maintain a quality management system (QMS)
- any drawbacks or disappointments

The key findings of the research were: -

- Most firms covered by this survey decided to install a QMS to BS 5750 and gain certification in order to improve their profile in the industry and increase business, efficiency and management control.
- To achieve certification and implementation of a QMS, it was important that senior management was fully committed and leaded the drive for quality.
- The time taken to install QMS and gain certification varied significantly between firms. The average time taken was 29 months. The major cost items were those associated with employees' time, quality assurance consultants and certification body.
- The benefits gained through the implementation of a QMS had not lived up to original expectations.
- Three principal reasons why the level of benefit enjoyed by firms had not been as expected were: -
    - some firms still did not have a full understanding of BS 5750

- the level of benefits expected from BS 5750 were too high in some cases and some firms directly transformed BS 5750 to their business
- some firms managed their QMS in a "mechanical manner"

(iii) The University Industrial Centre of the University of Hong Kong conducted a questionnaire survey to ISO 9000-certified firms (sample no. = 640 and response rate = 36.7%) in August 1996 with a view to providing answers to the following questions in relation to Hong Kong environment (Lee, 1998): -

- What were the reasons for certification?
- What were the benefits and limitations of ISO 9000?
- Is ISO 9000 certification the end of the quality journey?
- What are the important quality management concepts?

All respondents in the survey fell into one of the three industrial sectors, namely manufacturing, services and construction. According to the returned questionnaires, 92 firms (39% of the respondents) were from construction. The main findings in relation to construction sector were: -

- A high proportion of the construction firms was driven by their clients to become certified. Others considered that they had to be ISO 9000-certified in order to stay in business.
- Construction firms reported to have achieved the benefits of getting better team spirit, improvements in efficiency and reduction of complaints from existing clients.
- One of the biggest limitations of ISO 9000 was that it focused on systematic process management with little emphasis on the use of technology.
- The manufacturing and service firms appeared to be more positive towards continuous improvement of quality management than the construction firms.
- Construction firms considered that safety management, teamwork and leadership were important management concepts in connection with quality management system.

1.3.3 Academic Researches

Through the Library Electronic Database dissertation search, it was found that UMI Company and Expert Information Limited had collected about 60 dissertations in respect of the ISO 9000 standards. However, only three of them were slightly related to the construction. Bray (1994) was aware that the trend toward ISO 9000 certification might soon affect U.S. construction industry. The certification would require significant commitment of time and money for domestic contractors. He assembled the cost models, profiles of ISO 9000-certified contractors and a brief list of resources including books, software and audio and video tapes into a simple computer programme as resource for U.S. construction contractors pursuing ISO 9000 certification. Aniftos (1996) reported how the U.S. construction industry was lagging behind in the ISO 9000 standards development and the potential cost for this limited involvement. His study report contained a concise summary of the processes required to develop and implement international standards and also explained the consequences of not being directly involved in standards development. The findings would assist firms from the U.S. construction industry in determining their desired level of involvement in the ISO 9000 standard activities in order to enhance their competitiveness in the international arena. Al-Atiq's (1997) research provided a summary of an assessment of the ISO 9000 quality systems of fifteen major construction contractors in the Eastern Province of Saudi Arabia. The study revealed that the contractors' quality systems varied in complexity ranging from an informal inspection and test system to a comprehensive system where inspection and testing was only one element among many others. The study disclosed that "Contract review", "Inspection and testing" and "Handling, storage, packaging, preservation and delivery" were the quality clauses of the ISO 9000 standard that the selected contractors most often complied with, while "Management review", "Design control", "Corrective and preventive action", "Internal quality audit" and "Statistical techniques" were the least. It was also found that the majority of the contractors lacked document of the quality system.

In Hong Kong, academic research on ISO 9000 standards commenced in 1992 and about 30 research studies had been done in the universities. Two M.Phil dissertations are related to the clothing industry and software development. The remainders are either at M.B.A. or M.Sc. level in various topics. Only five studies are concerned with the ISO 9000 quality system and construction industry. The theme of this Ph.D. thesis falls within a new research area and the availability of relevant information is quite limited. Nevertheless, some previous research works in Hong Kong are quoted below for reference.

(i) Leung (1993) carried out a research to examine the responses of the building contractors on the introduction of the ISO 9000 certification scheme by the Hong Kong Housing Authority. Based on the survey results, he noted that the principles of quality assurance were not widely understood nor accurately interpreted by the contractors. They often argued that the application of quality assurance in construction industry was intrinsically difficult. Insufficient quality assurance system implementation practice, lack of company-wide support of the quality system and the sole responsibility of developing the quality system by the quality assurance manager were the main reasons that building contractors failed to achieve the ISO 9000 certification at that time.

In order to overcome the ISO 9000 implementation problems, Leung recommended that selected senior staff should be properly trained in the art of audit, that the experience of contractors in implementing the quality system should be shared among the contractors and that model documents should also be prepared and published to cover the elements of ISO 9000 standards.

(ii) Kwok (1997) in his research attempted to provide a critical evaluation on the implementation of ISO 9000 in the building industry in Hong Kong. The objectives of his study were: -

- To identify the importance of acquiring ISO 9000 certification by building contractors

- To identity the advantages and disadvantages of implementation of ISO 9000 by the contractors and the industry
- To conclude the findings and make recommendations for quality system improvements

With the introduction of the ISO 9000 quality system to the building industry in Hong Kong since 1990's, quality awareness of the contractors within the building industry had been improving. Kwok identified that the majority of building companies held a very positive attitude to the ISO 9000 standards. The impetus behind these companies' drives toward ISO 9000 certification generally fell within one or more of four categories: customer demands and expectations, competitive pressures, regulatory environment and internal benefits. The most significant external and internal benefits were the increase of competitive advantage and better documentation respectively. The disadvantages of implementation of ISO 9000 were generation of paperwork and resistance from staff.

He also pointed out that ISO 9000 was not a magic tool. It was procedures and systems oriented. Like any quality management improvement programmes, ISO 9000 was not without drawbacks and limitations. In general, the professionals in the building industry of Hong Kong were rather satisfied with the performance of the ISO 9000 system and paid a high regard to it. If one could understand the flexibility of the standard and was able to develop a simple and effective system with minimal amount of paperwork, the ISO 9000 system would have been proven successful by many organizations as well as contractors within the building industry.

(iii) Tam's (1999) study aimed to evaluate the effectiveness of ISO 9000 system as a tool of quality assurance management in construction industry in Hong Kong. In order to achieve the objective, he conducted interviews with 120 senior management staff in construction companies through third party audit. The observations of audit experience in these companies also formed part of the findings in his study.

The interview results indicated that the Hong Kong construction industry had adopted the ISO 9000 standards as a basis of quality system and the quality concept and culture had been improved. However, many interviewees still had doubts in using of ISO 9000 standards as quality management system for construction companies. A lack of self-motivation and commitment was found not only in site staff but also in top management. The quality concept and culture still needed to be promoted and improved. Although the ISO 9000 quality system had been operated in the construction industry, it still required a lot of improvements. He proposed that the change of Government quality policy in managing the main contractors and subcontractors, the second party audit programme and the Total Quality Management were some of the solutions to the shortcomings of ISO 9000 system.

Through the observations from Tam's audit experience, the following findings could have a certain impact on the current practice of quality system used in the construction system: -

- Many quality assurance consultants were not familiar with the experience in the Hong Kong construction industry and introduced a system that was very basic and not properly established.
- Many contractors wholly relied on the advice of quality assurance consultants and allowed changing their company's practice to fit into the quality standard. The staff often faced great difficulties during implementation of the system.
- The quality training provided to the quality assurance managers was limited. The quality training to staff was often provided at the beginning of system implementation and there was no more training after that.
- The operative staff had a lack of quality concept and felt that the ISO 9000 quality system was inappropriate for use in the construction industry. The site staff were unwilling to commit site matters to paper. Verbal instructions were typical examples in that no follow-up document was made.

- Many quality assurance consultants did not have a commitment to the ISO 9000 quality system and were not ISO 9000-certified. This would lead the clients to doubt that what they were presented with was an effective system.

1.4 Outline of this Research Study

The overall outline of the present study is presented in this section. This dissertation consists of nine Chapters: Chapter 1 provides an introduction including the research methodology and literature review; Chapter 2 is an overview on the development of quality assurance system; Chapter 3 investigates the need for quality assurance in construction works and discusses each of the twenty clauses of ISO 9001 for construction industry; Chapter 4 compares the quality system between Singapore and Hong Kong and suggests some improvements; Chapter 5 summaries and analyses the survey results on the appropriateness of ISO 9000 for the construction sector in Hong Kong; Chapters 6 and 7 present the case studies on the implementation of a quality assurance system for consultants and contractors and establish model quality manuals for reference; Chapter 8 discusses and analyzes the research findings, and finally Chapter 9 concludes the whole dissertation and makes recommendations for further studies. The scope of the thesis includes four main aspects: -

a) Suitability of the ISO 9000 Standards for Construction Works

After a brief review of the development of quality assurance in Chapter 2, Chapter 3 deliberately investigates the suitability of and the need for quality assurance in construction works, discusses each quality element in ISO 9001 and offers interpretive comments to help the construction sector better understand and assess the quality requirements. The findings in this Chapter are then used to support the survey results in Chapter 5 on the assessment of the suitability of ISO 9000 standards for the construction industry.

b) Improvements in the Quality Assurance System in Hong Kong

A comprehensive study of the early stages of development and implementation of quality assurance in the construction industry in Singapore and Hong Kong is reported in Chapter 4. The existing quality systems and the related incentive schemes in these two cities have been examined and compared in order to recommend a new incentive scheme for consideration. Revision to the quality policy and the Performance Assessment Scoring System are also suggested for improving the quality system in Hong Kong.

c) Practicability of Applying ISO 9000 in the Construction Industry

The results of questionnaire surveys to consultants and contractors about their motivation for seeking ISO 9000 certification, experience of installing a quality management system and difficulties encountered during the implementation and maintenance of the system are presented in Chapter 5. The results reveal that many consultants and contractors were forced to become certified and some had not appreciated the benefits arising from certification. Although the construction sector has accepted the ISO 9000 as a norm for their quality system, some possible improvements to the quality management, such as quality costing system and quality training programme, have been proposed for consideration.

d) Installation of Quality Assurance System and Model Quality Manuals

The case studies on the installation of quality assurance systems by the consultants and contractors for certification are presented in Chapters 6 and 7 respectively. The contents, format and the layout of a quality manual and quality procedures are discussed. Based on the survey and case study results, two model quality manuals, one for consultants and one for contractors have been developed to provide trade-specific guidelines. The process of achieving certification by the Territory Development Department has been detailed for adoption by the certification pursuers.

CHAPTER 2

DEVELOPMENT OF QUALITY ASSURANCE

The concept of a quality management system (QMS) is not a new one. It has been used by suppliers in quality control for high technique products since the Second World War. BS 5750 published in 1979 for all businesses was the first British quality assurance (QA) standard. The ISO 9000 series was introduced in 1987 and put QA on an international level. Subsequently, the ISO 9000 standards were technically revised in 1994 to keep abreast of modern management methods. The development of quality assurance during the last three decades is briefly reviewed and discussed in this chapter.

2.1 What is Quality?

The word "Quality" is itself used for several distinct purposes (Sherwood, 1986; Sanson, no date): -

a) "comparative" sense or "degree of excellence" where similar products may be ranked or graded on a relative basis.

b) "quantitative" sense where product is measured technically or statistically to define its quality level.

c) "fitness for purpose" which relates the product to the satisfaction of a given need.

In the context of a quality system, quality is not used to express a degree of excellence in a comparative sense nor to evaluate a quantitative sense in technical measurement. "Quality" is defined in ISO 8402:1994 as the "Totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs". Thus, the "fitness for purpose" definition is used when making decisions about quality (Hoyle, 1994). Quality is a characteristic which is sometimes obvious by its presence, but always conspicuous by its absence. It can only be achieved if it is planned and managed.

A primary concern of an organization must be the quality of its products and services. In order to be successful, ISO 9004-1:1994 recommends that an organization should offer products or services that: -

a) meet a well-defined need, use or purpose.

b) satisfy customers' expectations.

c) comply with applicable standards and specifications.

d) comply with requirements of society.

e) reflect environmental needs.

f) are made available at competitive price.

g) are provided economically.

In order to meet these objectives, an organization must organize itself in such a way that technical, administrative and human factors affecting the quality of its products and services are under control. This can be achieved through the application of a quality assurance system.

2.2 Quality Assurance

"Quality Assurance" is formally defined in ISO 8402 as "All the planned and systematic activities implemented within the quality system and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality". QA, in the form of sound technical and administrative procedures for assuring quality, offers more scope for reducing costs and enhancing competitiveness and profitability than many other management controls (DOT, 1985). It is based on the principle that prevention is better than cure. By using a preventative approach to quality rather than inspection of the final product (quality control), an organization can save the money and time which could be spent on scrapping and reworking.

QA is a systematic way of ensuring that the organized activities happen in the way they are planned. It provides complete control of quality from planning the design, through purchasing of materials and production to services. For this to be successful it obviously requires careful management of all activities at every stage. The ISO 9000 series of standards provides guidelines for quality management and quality assurance. An organization, which installs a QMS to the ISO 9000 standard, can assure the customer that it has the required capabilities for supplying a high-quality product or service.

2.3 Developments in Quality Standards

The concept of quality standards arose as a result of many lessons learned during the Second World War. Early quality standards were published as military specifications for the defence manufacturers. The US Department of Defence introduced its military standard MIL-Q-9858A to its suppliers in 1963. In 1968, the North Atlantic Treaty Organization (NATO) issued the first edition of an Allied Quality Assurance Publication known as AQAP-1 requiring its contractors to operate a quality control system. In response to NATO quality requirements, the British Ministry of Defence published its first Defence Standard DEF STAN 05-08 in 1970 and a more definitive document, DEF STAN 05-21 in 1973.

The introduction of a quality management concept to the defence industry pushed the British Standards Institution (BSI) to take action in providing guidance and information on the subject to a wider industrial audience. The Institution published BS 4891:1972 - "A Guide to Quality Assurance" for organizations developing their quality systems. As the benefits of a quality system became apparent both to customers and to suppliers, the need was recognized for a stronger QA standard which could be used by industry in general. Subsequently, BSI issued BS 5750 - "Quality Systems" in 1979, a quality system standard which evolved from DEF STAN and AQAP military standards. The British government vigorously promoted BS 5750 throughout the private sector and publicized it to increase consumer awareness and acceptance of the standard. Any organization could be certified if it satisfied the certification body that its QMS met the requirements of BS 5750. Its benefits were rapidly appreciated on the international level.

The International Organization for Standardization (ISO), a Geneva-based organization promotes the development of international standards to eliminate barriers to the exchange of goods and services between nations. It is composed of the national standard bodies from 110 countries, many of which have participated in developing the quality system standards. In 1979 the Technical Committee 176 (ISO/TC 176) was formed to harmonize both international activities in quality management and quality assurance standards. The Committee succeeded in publishing the ISO 9000 series of standards in 1987, which was primarily based on BS 5750. The generic ISO 9000 title is commonly used to identify the involvement of an organization with these quality standards. These standards provide a comprehensive set of management concepts and models for external quality assurance requirements for all activities. More than 90 countries around the world have adopted the ISO 9000 standards as their national standards.

2.4 ISO 9000 Series of Standards

The ISO 9000 series provides a framework for manufacturers and suppliers to establish, document and maintain an effective QMS that will demonstrate to their customers that they are committed to quality and can meet their customer's needs. The ISO 9000 series consists of five essential documents numbered ISO 9000 to ISO 9004 which were revised in 1994. Their titles and scope are shown in Table 2.1.

ISO 9000-1 clarifies the principal quality-related concepts and provides guidelines for the selection and use of the ISO 9000 series for internal quality management (ISO 9004-1) or external assurance purposes (ISO 9001, ISO 9002 or ISO 9003).

ISO 9001 is the most comprehensive conformance standard. It is used for external quality assurance to give confidence to the customer. The standard consists of 20 quality elements that must be addressed by an organization that is involved in design, development, production, installation and servicing.

Type	1987 Edition	1994 Edition
Quality management and quality assurance standards (guidelines)	***ISO 9000*** Guidelines for selection and use	***ISO 9000-1*** Guidelines for selection and use
Quality systems (contractual purposes)	***ISO 9001*** Model for quality assurance in design/development, production, installation and servicing ***ISO 9002*** Model for quality assurance in production and installation ***ISO 9003*** Model for quality assurance in final inspection and test	***ISO 9001*** Model for quality assurance in design, development, production, installation and servicing ***ISO 9002*** Model for quality assurance in production, installation and servicing ***ISO 9003*** Model for quality assurance in final inspection and test
Quality management and quality system elements (quality management purposes)	***ISO 9004*** Guidelines	***ISO 9004-1*** Guidelines

Table 2.1 : ISO 9000 Series

ISO 9002 is the most widely implemented quality standard and is applicable to all organizations involved in production, installation and servicing but only where there is no specific design element involved.

ISO 9003 is the least used standard. It is applicable to organizations where conformance to specified requirements is to be confirmed by the supplier, solely at the final inspection and test.

ISO 9004-1 is a descriptive guidance standard to be used by an organization for internal quality management purposes. It describes an extensive list of quality system elements pertinent to all phases and activities in the life cycle of a product to assist an organization to select and apply elements appropriate to its needs.

2.5 Quality Management Guidance Standards

Since the conformance standards are very general and not easily understandable, several of the guidance standards have been developed by ISO/TC 176 to assist in the implementing and understanding of the ISO 9000 series. Some of the guidance standards aid in the selection of the appropriate conformance standard and the others provide insight, support, interpretation and proper guidance to the principal ISO 9000 quality standards. The following guidance standards are available for reference: -

Terminology

ISO 8402	Quality Management and Quality Assurance - Vocabulary

Quality Management and Quality Assurance Standards

ISO 9000-2	Generic Guidelines for the Application of ISO 9001, ISO 9002 and ISO 9003
ISO 9000-3	Guidelines for the Application of ISO 9001:1994 to the Development, Supply, Installation and Maintenance of Computer Software
ISO 9000-4	Guide to Dependability Program Management

Quality Management and Quality System Elements

ISO 9004-2	Guidelines for Services
ISO 9004-3	Guidelines for Processed Materials
ISO 9004-4	Guidelines for Quality Improvement
ISO 10005	Guidelines for Quality Plans
ISO 10006	Guidelines to Quality in Project Management
ISO 10007	Guidelines for Configuration Management
ISO 10011-1	Guidelines for Auditing Quality Systems, Part 1: Auditing
ISO 10011-2	Guidelines for Auditing Quality Systems, Part 2: Qualification Criteria for Quality Systems Auditors
ISO 10011-3	Guidelines for Auditing Quality Systems, Part 3: Management of Audit Programmes

ISO 10012-1	Quality Assurance Requirements for Measuring Equipment, Part 1: Metrological Confirmation System for Measuring Equipment
ISO 10012-2	Quality Assurance Requirements for Measuring Equipment, Part 2: Guidelines for Control of Measurement Processes
ISO 10013	Guidelines for Developing Quality Manual

The guidance standards are useful documents and enable the user to develop a better quality system. The user should initially use the guidance standard, ISO 9000-1 to select the appropriate conformance standard for his organization. He must then study the applicable conformance standard ISO 9001, 9002 or 9003, and ISO 8402. ISO 9004-1 provides quality management guidelines and can be used for reference. ISO 10013 and 10011 are selected when developing a quality system documentation and establishing an internal audit programme respectively. Other guidance standards should be read, when necessary. A simplified clause listing ISO 9001, 9002 and 9003 is shown in Table 2.2. The applicability of the individual clauses of ISO 9001, 9002 and 9003; and the cross-reference with ISO 9000-1, ISO 9000-2 and ISO 9004-1 are also indicated in the table.

2.6 Changes to the ISO 9000 Quality Standards in 1994 Editions

The ISO 9000 series was first published in 1987 with a programme to review and revise once every five years. The revisions had not been completed for publication until July 1994 by ISO/TC 176 owing to the lengthy international negotiations over the comments on and suggestions to the drafts. The new ISO 9000 series comprises ISO 9000-1, which embraces ISO 9001, ISO 9002, ISO 9003 and ISO 9004-1, with minor changes in their serial numbers and titles as shown in Table 2.1. The revised editions of the ISO 9000 series have not brought major changes in the structure of the quality system standards, but the clause numbers have been unified among three contractual models, ISO 9001, 9002 and 9003, for ease of cross-reference.

Quality Requirements				QM	Road	Application
Clause Number and Title in ISO 9001		ISO 9002	ISO 9003	Guide ISO 9004-1	Map ISO 9000-1	Guide ISO 9000-2
4.1√	Management responsibility	√	∅	4	4.1, 4.2, 4.3	4.1
4.2√	Quality system	√	∅	5	4.4, 4.5, 4.8	4.2
4.3√	Contract review	√	√	x	8	4.3
4.4√	Design control	x	x	8		4.4
4.5√	Document and data control	√	√	5.3, 11.5		4.5
4.6√	Purchasing	√	x	9		4.6
4.7√	Control of customer-supplied product	√	√	x		4.7
4.8√	Product identification and traceability	√	∅	11.2	5	4.8
4.9√	Process control	√	x	10, 11	4.6, 4.7	4.9
4.10√	Inspection and testing	√	∅	12		4.10
4.11√	Control of inspection, measuring and test equipment	√	√	13		4.11
4.12√	Inspection and test status	√	√	11.7		4.12
4.13√	Control of nonconforming product	√	∅	14		4.13
4.14√	Corrective and preventive action	√	∅	15		4.14
4.15√	Handling, storage, packaging, preservation and delivery	√	√	10.4, 16.1, 16.2		4.15
4.16√	Control of quality records	√	∅	5.3, 17.2, 17.3		4.16
4.17√	Internal quality audits	√	∅	5.4	4.9	4.17
4.18√	Training	√	∅	18.1	5.4	4.18
4.19√	Servicing	√	x	16.4		4.19
4.20√	Statistical techniques	√	∅	20		4.20
	Quality economics			6		
	Product safety			19		
	Marketing			7		

Key:
√ = Comprehensive requirement
∅ = Less-comprehensive requirement than ISO 9001 and ISO 9002
x = Element not present

Table 2.2 : Cross-reference List of Clause Numbers in Quality Standards

ISO 9000-1 itself is still an advisory document and continually plays the role of a road map for the series. It is designed to help organizations understand how to use the ISO 9000 series. For 1994 this standard has been substantially revised to explain the previous ambiguous clauses, to clarify the principal quality-related concepts, to introduce the complete ISO 9000 and ISO 10011 series and to supplement new requirements for quality management.

The second edition of ISO 9001 is still the most comprehensive part of the standards. It covers the supplier's process including design, development, production, installation and servicing, and contains 20 clauses describing various requirements of the quality system. The "servicing" requirement has been included in the ISO 9002:1994 edition, expanding it to 19 clauses rather than the 18 of the 1987 edition. All these 19 clauses correspond word for word with ISO 9001 except for clause 4.4 - "Design Control", which is not required by ISO 9002. Four quality elements, viz. "contract review", "customer-supplied product control", "corrective action" and "internal quality audits", have been added to ISO 9003, resulting in an increase of the quality system requirements from 12 clauses to 16. These 16 clauses are similar to the other two standards but some are less detailed. The additional requirements have reinforced the guiding principle of quality assurance - "Right First Time" and made the standard more useful and practical.

ISO 9004-1 is still an information document for internal quality management. The new edition uses "document", "evaluation", "verification" and "holdpoint" to replace "define", "review", "inspection" and "checkpoint" respectively in the old standard to enforce stringent procedures for management. Some quality procedures have been re-grouped into other clauses to give a better understanding. The philosophy of continuous improvement is reinforced by an introduction of a new "Quality Improvement" element. It requests the management to ensure that their quality system will facilitate and promote continuous quality improvement. The effectiveness of the quality system is to be measured in financial terms by the means of three recommended methods, viz. quality-cost approach, process-cost approach and quality-loss approach described in the 1994 edition. This new standard emphasizes more on planning and preventive actions. Due consideration has also been given to customers' expectations, environmental needs and safety.

A full comparison of the 1987 and 1994 editions was conducted by Kam and Tang (1995). They summarized that the ISO 9000 series had been technically revised to include the practical experience gained from the past few years and the recent development of quality management methods. Some clauses were reworded to provide more details and guidance on the quality components and clarify the previous ambiguity. The necessity of documented procedures and records in each clause was well defined to ensure a complete documentation procedure.

As an international quality standard, the ISO 9000 series is almost universally accepted. The concept of continuous quality improvement has been applied to the standard itself by regular reviewing and updating. The requirements of meeting customer needs, a servicing process and preventive action in the new edition have put the standard a further step towards the principle of total quality management (TQM). Development and change to the standard do not cease. Some relatively minor changes to the standard were done in 1994. As stated in the ISO 9004-1:1994, a major review of the structure of the ISO 9000 quality system standard series will be carried out in the next five-year revision.

CHAPTER 3

ISO 9000 STANDARDS FOR THE CONSTRUCTION INDUSTRY

There had been much research recently on the incidence and source of failures within construction industry (Duncan *et. al.*, 1990; Burati *et. al.*, 1992a). It was generally agreed that about 50% of cost-related error was found in the design fault, 40% was due to construction management and 10% resulted from defective materials (CIRIA, 1989). Burati *et. al.* (1992b) conducted a study in the USA and suggested that as much as 12.4% of project cost was avoidable. Duncan *et. al.* (1990) recognized that these cost-related errors were primarily due to the following: -

a) inadequate training and management of design engineers in particular in dealing with excessive changes to the detail design and information throughout the construction period of the project,

b) inadequate or incorrect specification in tender documents,

c) poor communication between the contract's principal parties,

d) inadequate definition of responsibility and authority to the staff at the head and site offices,

e) inadequate training and management of the technicians and labourers on site,

f) inadequate verification procedures to ensure that design, construction methods, materials and workmanship meet specified requirements.

With a better control on the design process, site work is more confident. Engineers do not make mistakes deliberately. It was considered that a formal QA system could provide solutions to the problems stated above.

3.1 The Need for Quality Assurance in Construction

Construction is as concerned about quality as other industries, and it concentrates rather more than most industries on confirming "fitness for purpose" over a considerable period of time. In comparison with other products, the life of construction "product" is longer and those who construct these "products" will be held liable for defects for many years after the handover to the client. The application of QA can help to focus attention on the imprecision of predicting the service life of construction works and their overall quality performance.

Assurance inspires the idea of confidence, whereas the legal connotation is of warranty. Mass-produced manufactured goods can have the advantage of prototype testing under simulated or actual service conditions. The manufacturer can take an acceptable financial risk for repairing defective articles within the warranty period, normally 1 to 3 years. However, a construction project team cannot reasonably be expected to give such a warranty to a project for its predicted service life, for example 120 years for Tsing Ma Bridge. Construction works are generally unique or subject to a unique set of circumstances. They cannot be fully verified by subsequent inspection or testing and deficiencies may become apparent only after the structure is in use. Therefore, the client need to be assured that all reasonable actions have been taken in order to be confident that the project will be fit for purpose within a designed period. QA is concerned with systematically providing evidence to the client that all reasonable actions have been taken to achieve the required quality.

3.2 Quality Assurance Standards for Construction

The ideas of quality assurance originated in manufacturing industries and the ISO 9000 quality standards were written essentially with manufacturing industries in mind. As such, it has two significant disadvantages for the construction industry (Oliver, 1990). First, it employs terminology which the construction industry does not use, for example the terms of "supplier" and "servicing". Secondly, and apparently, there is no part of the standard appropriate to consulting firms carrying out the design work only, or design and site supervision only. While it has been possible in construction to take advantage of the QA experience in those industries, there are special features in construction projects and practices which have to be looked at. These features raise considerations and impose constraints which are different from those commonly encountered in manufacturing. For example: -

a) Construction projects commonly contain a significant one-off prototype work.

b) Performance testing is generally not feasible as a basis of acceptance and the feedback from performance in use is slow.

c) It is common to have separate contracts for design and construction and for the designer also to be appointed to supervise the construction work.

d) Decisions to reject defective parts of a construction project need to be taken promptly before succeeding parts are superimposed.

e) It is not feasible to reject the finished work on account of a defect in part of it.

Therefore, it is necessary to look into whether the quality requirements of the ISO 9000 standards are relevant to the construction activities.

3.3 Technical Review of ISO 9001 Requirements for Construction Industry

Hoyle (1994) identified the basic requirement of ISO 9001 that "the organization shall establish, document, implement and maintain a system which will provide confidence to both its own management and the customer that the intended quality of its products and services will be, is being and has been achieved and which will ensure that its products and services supplied conform to customer requirements". He summarized the 20 principal quality requirements of ISO 9001 for implementation. Fox (1993) divided the 20 quality elements of ISO 9001 into three groups, dealing with system management, with system methods, and with system maintenance. Hughes and Williams (1995) classified ISO 9001 quality elements into system operation and compliance operation. These classifications give analytical approach for all sectors in preparing QMS for their organizations.

The construction industry has lagged behind other industries in the implementation of QMS programme. Owing to the misconceptions of the quality assurance of construction works (Power, 1985), ISO 9000 standards have not been fully recognized by the construction sector. Difficulties in interpreting the standards have already frustrated the engineers in quality assurance management. Ashford (1989), Duncan (1990), Oliver (1990), Nee (1996) and Tam (1999) generally described how ISO 9000 quality elements could be implemented in the construction industry. However, an explicit interpretation of the quality standard for construction-related organizations is really necessary. Based on the literature review, discussions with quality auditors from certification body and construction-related organizations, and author's experience, the special requirements of the 20 quality elements in ISO 9001 standard for the manufacturing sector, construction consultants and contractors, from clause 4.1 to 4.20, are technically reviewed and discussed below. The numbering system used in ISO 9001 is also used throughout this dissertation.

Manufacturing Sector	Construction Consultants	Construction Contractors
Clause 4.1 Management Responsibility		
Management at the executive level shall define its quality policy and quality system organization, provide resources, appoint a person with responsibility for the quality system and conduct management review of the quality system to ensure its suitability and effectiveness.	This clause is required for quality system management. Interpretation of this clause is common to all construction-related organizations. Regarding the appointment of Management Representative (MR), there may be two levels of involvement in the consultant and contractor's organizations - corporate and project. The corporate "Quality Manager" will normally report to the chief executive. At project level, the "Project Quality Co-ordinator" will report direct to the Project Manager. A management review of the quality system should be conducted once or twice a year by the management at corporate level but more frequent reviews at project level.	
Clause 4.2 Quality System		
A documented system for ensuring the products and services meet customer quality requirements shall be established. The procedures and instructions contained or	This is another system maintenance requirement common to all construction-related organizations. The structuring of the quality system is dependent on the unique characteristics of each organization. In general, there are three documents: company quality manual, quality procedures and	

referenced in it must be implemented and maintained.	forms (see Chapter 6 for details). A project quality plan is required to set out the specific quality practices, resources and sequence of activities for individual new project. The project quality plan is a dynamic document and is extremely important for a consultant undertaking a new project design or a contractor co-ordinating the construction of a new building.	
Clause 4.3 Contract Review		
Contracts or purchasing orders from customers shall be reviewed before and during the progress of contract in order to ensure that the requirements are adequately defined and that the company has the capability of meeting them.	Contract review where design effort is involved will be more complex. The review process will require client inputs that must be interpreted and documented at the inception stage and continue until the design is finalized. If the consultant is to eventually act as an agent for the client, the construction contract will also require development. The consultant will be "the supplier" of design services to the client and must ensure that "the purchaser's" requirements are adequately defined and understood. As the client's agent is letting out the construction contract, the consultant, now acting as "the purchaser", has a duty to ensure that the tenderer or contractor receives an adequate definition of "the purchaser's" requirements for review.	This requirement is particularly important in construction industry in which the contracts are large and unique. The "contract review" covers activities that contractor normally associates with "quantity surveying", "estimating" and "tendering". The "pre-tender meeting" between client, consultant and contractor is held to resolve any ambiguities and incompleteness in the contract. When an "alternative tender" is proposed by a contractor, the review process will be beyond the quality requirements under this clause and is also covered by clause 4.4.
Clause 4.4 Design Control		
Product and service design shall be planned, organized and controlled by documented procedures so that the design output can be demonstrated to meet specified requirements and defined user needs.	A thorough, sequential process is given under this clause to be followed when designing a new project. The design activities that start with design inputs from the client, which, through feasibility study and design, result in design output. Design review, through organizational and technical	Contractors generally build to designs specified by the clients or by the clients' consultants. This clause is not applicable to construction works. Many contractors, however, also engage in "design and build" work. If design activities are included, they are requested to have explicit procedures for planning and

	interfaces (high risk points where control responsibilities are likely to become confused in design office), determines if the design outputs meet the design inputs. Following design review, design verification is considered to make sure that the functional design meets the design outputs. Next, design validation determines if the design meets the client's needs and, if resulting design changes are required, new design inputs will be implemented. The validation for design is normally performed on the final product which is produced by the contractor. The design performance cannot be entirely controlled by the consultant himself and is possibly affected by the contractor. Therefore, the validation may be done in earlier stages prior to product completion, for example the wind tunnel evaluation for tall building.	controlling the design process for ISO 9001 certification. In order to give more design flexibility to the contractors, the Works Bureau of the Hong Kong Government decides that the requirement for ISO 9000 certification is not applicable to design and build contract (WB, 1998).

Clause 4.5 Document and Data Control

All documents and data relating to the quality system must be reviewed and approved for adequacy by authorized personnel before use. Controls shall be employed which ensure the use of valid documents and data in operation serving the achievement of customer requirements. Changes or modifications to documents and data must go through the same review and approval procedures as the originals.	Document and data control are essential in all construction-related organizations. Because of the nature and complexities of a construction project, current copies of all specifications, drawings and procedures must be available where they are needed. Any revisions or changes to the document must be timely disseminated to all parties concerned to avoid confusion, delay and unnecessary rework. The obsolete issues are removed from use. At least one copy of superseded drawings may need to be retained for contractual purposes. Documents to be controlled by the construction sector will normally include project brief, design statements, calculations, drawings, specifications, conditions of contract, inspection and test plans, works instructions, operation sheets, quality manual, project quality plans, quality system procedures and computer output.

Clause 4.6	***Purchasing***
The supplier must ensure that the purchased products and services, which directly or indirectly affect the quality of final products and services supplied to the customer, conform to the specifications.	Interpretation of this clause is common to consultants and contractors though the nature of the "purchased products" will clearly be different. The purchasing provisions of ISO 9001 pertain to bought-in services, which the construction sector normally refers to as "subletting" or "sub-contracting". The clause requires "the supplier" (the consultant/contractor who, confusingly, is now acting as a purchaser when enters a contract with a subconsultant/subcontractor) to ensure that all purchased services and products meet specified requirements. Clause 4.6.4.2 indicates that when the customer (the client) decides to carry out verification at the subcontractor's facility, such verification cannot be used by the supplier (the consultant/ contractor) as evidence of effective control over the subcontractor. However, the situation is different in construction industry. An example for requiring source inspection at the point of manufacture for construction industry could be structural items that may be erected at the time of delivery on site. Source verification of items being installed or erected when receipt inspection is impractical could avoid costly delays and modifications to accommodate the nonconforming product. This clause requirement should be amended to suit construction work.

Clause 4.7	***Control of Customer-supplied Product***	
The supplier must verify, store, maintain and account for products supplied by the customer for incorporation into the supplier's product.	This clause may not often be relevant to design firm but the principles apply as regards "verification" when a client makes the incorporation of a particular product specification, subconsultants or a requirement of the services to a project. The suitability of customer-supplied product for its purpose must be assured. The product can include as-built drawings, survey data etc.	The clause requires the contractors have control on the customer-supplied product. This pertains directly to materials commonly described as "free issue" and, by extension, to the verification of nominated suppliers and nominated subcontractors. For construction contract, materials from nominated suppliers and services from nominated subcontractors are considered under this clause rather than the more stringent general purchasing clause 4.6. The management of "nominated suppliers and subcontractors" needs careful arrangement on site.

Clause 4.8 Product Identification and Traceability		
Products, processes and services shall be identified by suitable means at all stages. When necessary this identity shall be unique to individual product or batches. Where specified, individual batches or units must be traceable.	The consultant should ensure that all documents, drawings etc. produced in the course of the design are clearly identified and traceable to the particular project. It must be possible to relate each aspect of design work back to an original instruction or decision.	The contractor's materials and works control procedures should provide for identification and traceability of materials and workmanship. A system to ensure full traceability on a construction site can be very costly and time consuming to implement. Therefore, only concrete and steel are required for tracing. Traceability should be done fully in high-risky contracts, for example the concrete nuclear pressure vessel.
Clause 4.9 Process Control		
All manufacturing operations must be carried out under controlled conditions. These controls are taken to include process qualification, documented work and inspection instructions, adequate environment and appropriate monitoring of workmanship. Special processes which cannot be verified by subsequent inspection or testing are subject to special control.	The process in consulting firm is the design, design-related work or construction supervision itself. Many aspects of control of this process will be covered under clause 4.4. There will however be certain administrative activities which will need consideration under this clause, for example the office administration, use of software etc.	Everything that takes place at the construction site is a process and should have a construction method statement and work instruction including quality plan to assure conformance to specifications and requirements. The contractor shall ensure that requirements and procedures for special processes, in particular welding and concreting, are adequately described in the project quality plan.
Clause 4.10 Inspection and Testing		
Inspection and testing shall be considered at all stages in the production process and be carried out to verify that specified product requirements are met. Records should be kept as evidence of the tests performed.	Inspection and test in the context of design services will apply to the checking and approval of calculations, drawings, study reports etc. Holdpoints must be established on drawing preparation before calculations have been checked and approved. In design services, the product is exclusively a document of	The construction project is a complex network of inspections and tests beginning with the boring tests for piles through handing over the project to the ultimate owner. The inspection and test plan must be established to specify the nature of the inspection and test required in each operation or element. Notification points and

	some sort. Cross-reference should be made to clause 4.5 above. The intention of receiving, in-process and final inspection and testing for consulting firm should also be met by its response to requirements of clause 4.4.	holdpoints for inspections and tests are generally used on site. Positive recall procedure must be established for in-situ concrete awaiting the results of 28 days concrete cube tests.
Clause 4.11 Control of Inspection, Measuring and Test Equipment		
Suppliers must provide, control, calibrate and maintain inspection, measuring and test equipment to suitably demonstrate that their products conform to their customer's specified requirements.	The requirements of this clause will be relevant to all survey equipment used for pre-design survey but may have little relevance to ensuring design work itself. For consulting firm, there is normally no particular instrument or equipment that requires testing or calibration under this clause.	This clause has numerous applications to a site of construction work. In addition to the survey equipment, it will apply to concrete batching plant, weighbridge etc. The control of inspection, measuring and test equipment related to the construction site is not as complex as it is in precision manufacturing industries because there are less stringent tolerances allowed in construction.
Clause 4.12 Inspection and Test Status		
Suppliers should establish a system for identifying the inspection status of product during all stages of manufacture. Records must be kept showing who was responsible for releasing conforming product.	The consulting firm is required to show that design input, design output and the design process activities have been properly checked and approved where applicable. The appropriate authority to do so should be identified as required by the inspection and test procedures of clause 4.10.	Construction products require careful inspection and test status to ensure a high level of client satisfaction. The contractor shall establish procedures for tracking inspection and test status and for release of intermediary and final works. Cross-reference should be made to inspection and testing under clause 4.10.
Clause 4.13 Control of Non-Conforming Product		
All non-conforming product should be clearly identified to prevent inadvertent use or mixing with conforming product. A procedure should describe who is authorized to decide the means of disposal for non-conforming material	The entire construction process is ripe with opportunity for non-conforming product from the time of design until final acceptance by the owner. The clause sets out requirements for a further safeguard against an unaccepted product. Design control procedure under clause 4.4 above should be such as to ensure that non-conforming design work is recognized before it is utilized. The authority for review the nonconformances and the decision on disposition must be identified in the construction	

and how subsequent operations are controlled.	process. A quick decision should be made to minimize loss and re-work on site. It is essential that only the client has enpowerment to grant concessions and the contractual implication should be well documented.	
Clause 4.14 Corrective and Preventive Action		
Actions are introduced to prevent the occurrence and recurrence of non-conformities. The effectiveness of corrective and preventive activities should be verified.	Nonconforming design, product and processes are common occurrences in a construction project. There should be general procedures to deal with the rectification of any non-conformances identified during the design and construction phases of the project both in the design and site offices so as to prevent their recurrence. The appropriate authority to implement, verify and review the effectiveness of both corrective and preventive actions should be identified. Actions are documented to prevent future recurrence in the later works or the next construction project.	
Clause 4.15 Handling, Storage, Packaging, Preservation and Delivery		
Measures shall be taken to handle, protect and prevent damage or deterioration to product while under the supplier's control.	Where the product is in the form of design documents, it can be covered by the requirements under clause 4.5. This clause only requires the design office to operate procedures which effectively prevent damage to the design calculations, drawings etc. both whilst on the design office and in transit elsewhere.	This clause has less relevance to the construction industry than to manufacturing industry because its ultimate products tend to be manufactured on the clients' premises. They do not, in general, require handling, storage, packaging and delivery. However, the contractor shall have procedures for protecting the materials and the completed works before handing over.
Clause 4.16 Control of Quality Records		
Records, including records on subcontractors, shall be established, documented and maintained which demonstrate achievement of the customer requirements and the effectiveness of the quality system. They may have to be made available to the customers, if contractually agreed.	This clause is required for system maintenance requirement. Interpretation of this clause is common to all sectors. Quality records related to construction project are evidence of inspection and tests conducted at necessary points during design and construction. Such records should be adequately identified, filed and stored. Retention periods and the storage medium of such records should be established. Microfilming of records and drawings achieves savings in space, but the rules governing admissibility as evidence in legal proceedings need to be observed.	
Clause 4.17 Internal Quality Audits		
Audits shall be planned and	The consultant and contractor are required to set up procedures	

executed to verify that the quality system is effective in ensuring that products and services conform to customer requirements. Audit procedures and results must be documented, and corrective action taken on deficiencies.	for planning and executing the internal quality audits at least once a year with competent and trained staff to determine the effectiveness of the whole company's quality system. They shall also audit the quality plan for each project on a regular basis as appropriate to the size and scope of individual projects. The schedule may need to be agreed with the client if the audits are for different phases of work over the life of a project. The internal quality audit shall cover the subcontractor's activities.	
Clause 4.18 Training		
The training needs of personnel whose work affects quality shall be identified and the necessary training provided. Critical tasks must be undertaken by quality personnel, and records of training kept.	The consulting firm should have a stated policy regarding the technical and professional ability of their staff. Staff should be evaluated at regular intervals following a recorded procedure to identify their strength and any weaknesses. Personnel record detailing qualifications, training and experience should be reviewed before staff are deployed on any new project.	The building trades provide training and apprenticeship programmes for many disciplines that provide the basis for basic construction. Formal education is complemented with long-term practical skill training in order to become proficient. This training in many areas is not available and must be provided by the construction company that employs the personnel performing building trade activities. For temporary labour not normally covered by the contractor's training programme, the contractor shall ensure that appropriate guidance and instruction are given.
Clause 4.19 Servicing		
Where servicing is part of a contract, suppliers must establish procedures for controlling and verifying the quality of services performance.	This clause is not expected to apply directly to consulting firms. The servicing of a completed structure will of course be a consideration of the design output.	After-sales service does not form part of a construction contract unless the contractor will provide ongoing maintenance after commissioning. This clause is relevant to the correction of defective work carried out during the defect liability period. It will not be relevant to pure maintenance contracts. The contractor can simply cover the maintenance process as an element under clause 4.9.

Clause 4.20	***Statistical Techniques***
Measures shall be taken to control the selection and application of statistical techniques used in verifying process capability and acceptable product characteristics.	Since most construction is, by definition, "one off", this clause has little relevance to the construction industry. Although ISO 9001 is not specific in requiring statistical techniques, it implies the benefits of implementing them. Statistical techniques can be applied throughout construction-related work but are seldom used in routine activities. For example, the statistical technique can be applied for the improvement of concrete mix design.

3.4 Summary

Although ISO 9000 has been well established in manufacturing industries, it is observed that the quality standards generally fit the construction industry too. From the above, it is only found that clauses 4.19 and 4.20 are not entirely relevant to the construction-related organizations. Some consultants and contractors unfamiliar with the quality standard have blamed that the construction projects are hindered rather than helped by trying to adapt the language of the manufacturing quality system to the site. However, Duncan, *et. al.* (1990), Lam, *et. al.* (1994) and Nee (1996) affirmed the benefits of ISO 9000 to the construction industry but recommended that the quality system with reference to construction practices should be carefully reviewed.

This chapter has analysed each quality element in ISO 9001 and offers interpretative comments to help construction sector better assess what is required of the standard. In order to facilitate the adoption of quality assurance in building and civil engineering works and to enhance the ease of understanding and application to the construction industry, model quality manuals for consultants and contractors should be developed for reference. One of the objectives of this research is to develop such model quality manuals.

Further to the technical review of the ISO 9001 standard, the application of it in the QA of construction work will be explored in the following chapters. A survey on the satisfaction with ISO 9000 for the construction sector will also be presented.

CHAPTER 4

DEVELOPMENT AND IMPLEMENTATION OF QUALITY ASSURANCE IN CONSTRUCTION WORKS IN SINGAPORE AND HONG KONG

There is a world-wide trend towards more stringent client expectations with regard to the quality of construction work. As the technical specifications may not in themselves guarantee that the quality requirements will be consistently met, the ISO 9000 quality system standards have been developed to complement the technical specifications. Construction has been living with the concept of QA certification for 20 years, since the UK issued BS 5750 - "quality system" in 1979. The adoption of the international standard ISO 9000 in construction started in 1987. Most of the largest construction companies in UK and other European countries have been certified to ISO 9000 standards since the late 1980s.

In Asia, QA in construction has received attention in recent years. The Singapore construction industry boomed in the early 1980s (Lam *et. al*, 1994). At that time, construction was a relatively labour-intensive industry and the shortage of skilled construction workers resulted in poor workmanship in many housing projects. In order to rectify the situation, the Housing and Development Board (HDB) of Singapore started a major quality improvement programme for its projects in the mid 1980s. In 1988, the Construction Industry Development Board (CIDB) of Singapore began to implement a quality development strategy towards ISO 9000 standards for the construction industry. In 1989, the Hong Kong Housing Authority (HKHA) stepped up measures to improve the quality standard of public housing (Bates, 1993). A real boost was given to the construction industry in 1991 that the HKHA requested its building contractors to be certified to ISO 9000 as a condition for tendering its housing contracts after 31 March 1993. In May 1991, the Secretary for Works of Hong Kong Government issued a quality policy statement which committed works departments to achieving quality standards in public works (Byrne, 1993). Another quality policy was issued in March 1994 to require major consultants and contractors for public works to achieve ISO 9000 certification in

1996. These gave a big impetus to the acceptance of QA in construction works in Hong Kong.

The construction practices in Singapore and Hong Kong are similar. Their major construction projects consist of land reclamation, mass transit railway, expressways, public housing, new towns and airport development. All these projects are becoming more complex and the demand for high quality is increasing. Both cities have the ISO 9000 standards as the norm for their quality management systems in construction work. By comparison with the development and implementation of QA in construction work in Singapore, the efficacy of the QA system being applied in Hong Kong can be appraised (Kam and Tang, 1997).

4.1 Quality Development in Singapore's Construction Industry

Following the rapid development of the construction industry in Singapore in the early 1980s, the problems of poor quality caused by the shortage of construction workers and the employment of unskilled labour at that time was acknowledged immediately. The CIDB was set up in 1984 with the main task to oversee, train and develop the construction sector (Ngaw, 1994). In 1989, CIDB set up the Construction Quality Assessment System (CONQUAS) to assess the quality of public building work. One year later, the Premium Scheme was introduced to provide tendering advantage of up to 5 percent or S$5 million (whichever is the lower) in public sector building tenders, to those constructors who consistently achieved good quality work as reflected by high CONQUAS scores. The scheme quickly became an incentive and encouragement to contractors with good track records for quality. Having understood the importance of the quality, the construction industry could be more receptive and ready to consider the ISO 9000 quality management standards. The CIDB and Singapore Institute of Standards and Industry Research (SISIR) ISO 9000 Certification Scheme was launched in June 1991. This third party certification gave added confidence to the client. At the same time, another scheme - Building Quality Assessment Services (BQAS), which was similar to CONQUAS, was offered by CIDB for the assessment of private building projects. CONQUAS and BQAS scores are well recognized by the construction industry as yardsticks for grading the quality of both public and private building projects.

4.1.1 Construction Quality Assessment System (CONQUAS)

CONQUAS was developed with inputs from the major public sector agencies, such as HDB, CIDB, Public Works Department (PWD) and Port of Singapore Authority (PSA), to provide a standardized, quantifiable and systematic assessment system for grading the construction quality of a building (CIDB, 1995a). It sets out the standards and criteria to measure the quality of various parts of building work and awards points to the work according to the given criteria.

CONQUAS covers the broad area of general building work. The assessment consists of three parts: structural (40 percent), architectural (50 percent) and external (10 percent) works. The ratio is derived from the approximate cost of these three major works for a general reinforced concrete building. The assessment system does not include works for piling, heavy foundation, substructural works, mechanical and electrical services as they are usually carried out under separate contracts or subcontracts. Each part is further divided into several items for precise checking. A comprehensive sampling system has been established to cater for different sizes and various types of projects. The assessment results can then adequately represent the performance of the entire building. The assessment should be carried out by the resident engineer, the architect or a professional from an independent party, such as CIDB. CIDB updated the scoring system for the CONQUAS in 1995 to allow for more tests on materials and functional performance (CIDB, 1995b).

The summation of the total quality score for structural works, architectural works and external works will give the total CONQUAS score for a completed building project. Since CONQUAS was introduced to the construction industry in 1989, more than 650 building projects were assessed by the system at 1995. The average yearly CONQUAS scores rose from 65 in 1989 to 71 in 1995 and indicated that quality was being improved by the contractors (CIDB, 1995a).

4.1.2 Building Quality Assessment Services (BQAS)

While CONQUAS was compulsory for public sector building projects, CIDB provided the Building Quality Assessment Services in 1991 to assess the quality of private building projects based on the CONQUAS with service charge. The service is only applied to the superstructure works and includes scoring the structural, architectural and external works. On completion of assessment, CIDB will give the BQAS score for the building project. The BQAS score is also eligible for the Premium Scheme. From January 1993, BQAS was a requirement for all private projects built on lands sold by the HDB and Urban Redevelopment Authority (URA). This is to ensure a continual quality improvement in private sector buildings.

4.1.3 Civil Engineering Construction Quality Assessment System (CE CONQUAS)

With continued quality improvement in building projects after the implementation of CONQUAS in 1989, it was logical to have a quality system to assess the civil engineering work. Based on the principles of CONQUAS, the Civil Engineering Construction Quality Assessment System (CE CONQUAS) was adopted in 1993. The assessment covers the construction work in five main categories viz., road works and car parks, bridges and flyovers, drainage works, sewerage works and marine structures.

Each category of work has been broken down into various components for assessment according to its quality standards and tolerances as stipulated in the CE CONQUAS manual. The method of sampling is in accordance with the characteristics of each work type. For complex projects involving more than one category of civil engineering work, the different relevant CE CONQUAS will be applied to its particular type of work. The weightage assigned to each category of civil engineering work will be directly proportional to its value of work of the entire contract sum.

Every category is scored under its assessment items which are allocated the corresponding points. The final CE CONQUAS score for a project is based on the scores achieved in all assessments throughout the entire construction process. Both CONQUAS and CE CONQUAS scores of projects are eligible for the Premium Scheme for their works categories.

4.1.4 CONQUAS Premium Scheme

Since its introduction in 1989, CONQUAS has been used as the basis to assess the quality of building projects. The assessment system has been recognized as a standard method of measurement for building quality and has become an indicator of construction quality in Singapore. In order to provide an incentive for building contractors to maintain and improve their quality standard, CIDB introduced the CONQUAS Premium Scheme in 1990, which provides a tendering advantage for contractors if their average CONQUAS score is above 65. For every point above this figure the contractors will be given a premium of 0.2 percent up to a maximum of 5 percent or S$5 million, whichever is the lower (CIDB, 1993a). The Premium Scheme was extended to civil engineering projects in May 1993 and was applicable to local contractors and joint ventures with local participation.

A contractor is eligible for a preferential margin if the average CONQUAS score of his three most recently completed projects is over 65. For example, if a contractor gets an average CONQUAS score of 73, his premium (P) will be (73-65)x0.2% = 1.6%. The contractor will be awarded the contract if his tender price does not exceed the lowest tender by 1.6%. The contractor, however, will be paid, based on his original tender price. The amount of premium advantage is also subject to a ceiling cost based on the total value of the three most recent scored projects as shown in Table 4.1.

For example, a contractor achieved a 1.6% premium for three completed school projects with total value (TV) of S$15M. When he tenders for a S$50M building project, he can only enjoy a price advantage of 1.6% x S$20M = S$0.32M (ceiling cost) instead of 1.6% x S$50M = S$0.8M.

Total Value of Three Scored Projects (TV)	Ceiling Cost (S$ Million)
S$ 3 M < TV ≤ $10M	P x S$ 10M
S$10M < TV ≤ $20M	P x S$ 20M
S$20M < TV ≤ $50M	P x S$ 50M
S$50M < TV	P x S$100M

Table 4.1 : Premium Advantage

Although the amount of the premium is only a small portion of the tender price, the incentive has been effective. In December 1994, more than 70 contractors were entitled to tendering premiums in public sector tenders. Obviously, the average CONQUAS scores have risen steadily and the number of contractors on the Premium List has also increased.

CIDB has also been promoting the development of quality management for design and construction works. In 1991, CIDB and SISIR introduced a quality certification system to comply with the ISO 9000 standards. Contractors who are certified to ISO 9000 standards will have a further advantage in the competitive market.

4.1.5 CIDB-SISIR ISO 9000 Certification Scheme

The Singapore Institute of Standards and Industrial Research, which was established in 1973, is the national standards body and a research and development organization. It offers services such as contract design and development, technological consultancy and training, testing and calibration and other technical support to assist companies improve and develop their products and process. SISIR promotes the use of international standards and adopted ISO 9000 quality management standards in its national quality certification schemes in 1988 (SISIR, 1994a).

CIDB-SISIR ISO 9000 Certification Scheme for the construction industry was launched in June 1991 and is jointly administrated by CIDB and SISIR. The scheme is open to companies dealing with construction, consultancy and project management, building, civil engineering and E&M contractors (including subcontractors and specialist contractors) performing construction and maintenance work, manufacturers of concrete and building related products and curtain walling/cladding. The certificate will be awarded to companies which have demonstrated continual operation of the quality systems to the requirements of ISO 9000 standards and the terms and conditions of the certification scheme.

CIDB-SISIR provides certification for Singapore Standard SS ISO 9001 and 9002 which are identical to ISO standards (SISIR, 1994b). Generally, a company will have to go through two stages viz., Application/Pre-Audit Review Stage and Audit Stage, in order to be certified under the scheme. CIDB and SISIR will conduct a joint audit to assess whether the quality system being documented is implemented adequately and accordingly. After awarding the certificate, the system will be subject to routine surveillance twice yearly to ensure that the quality system is properly maintained. The certificate will be renewed every three years after a new auditing. As at October 1995, 71 companies had received certificates and other 68 companies would seek certification before April 1996 (CIDB, 1996a).

4.1.6 ISO 9000 for Contractors and Consultants in Singapore

As announced on 3 June 1994, all G6, G7 and G8 Contractors, with tendering capacity of S$30M, S$50M and above S$50M respectively, and consultants engaged in architectural, engineering and quantity surveying work for public projects valued at S$30M and above would have to be certified to ISO 9000 standards in five years' time (CIDB, 1994). On average, a company takes between 12 months and 24 months to reach certification. Companies newly committed to quality improvement should be able to achieve certification within the deadline. In order to encourage contractors working towards ISO certification, those who have obtained the CIDB-SISIR ISO 9000 certificates can enjoy an additional premium of 0.5 percent or S$0.5M ceiling when they tender for public works. The extra premium, with effect from July 1995, will apply until July 1999 when the new requirements comes into effect.

4.1.7 Training Schemes for ISO 9000 Certification

CIDB considers training as an important step towards the CIDB-SISIR ISO 9000 Certification Scheme and has expanded and strengthened its training programmes since 1992. The training course is to enable the professionals to embark on the setting up of their own QMS for their departments, in terms of documenting and implementing under the ISO 9000 standards and carrying out effective internal quality system audits.

In addition, CIDB has initiated a joint development programme with the Singapore Contractors Association Limited (SCAL) to assist their members in the interpretation of the requirements of ISO 9002. The CIDB-SCAL programme stretches over a period of six months during which the contractor staff study the standard requirements, document their companies' quality management system, implement it and apply for pre-audit and certification.

Subcontractors are the key players in the construction industry and any upgrading in the industry must involve them. SCAL has launched the Singapore List of Trade Subcontractors (SLOTS) scheme to identify and assist trade subcontractors to set up their quality system. The list has become a reliable reference in the selection of subcontractors by the main contractors. The SLOTS registered subcontractors can receive preferential rates for various upgrading courses conducted by CIDB and SCAL (CIDB, 1993b).

On behalf of the Economic Development Board (EDB), CIDB administers the Local Enterprise Technical Assistance Scheme (LETAS) to grant small local enterprises a part of their training cost for certification. Eligible enterprises are also allowed to engage quality consultants for developing their quality management system under an approved short-term assignment with reimbursements of up to 70 percent of the allowable costs.

4.1.8 Singapore's Way to Quality

The construction sector continued to be a major contributor to the strength of the Singapore economy and its growth was expected to be 7.8 percent in 1996. With continued economic growth in Singapore, prospects for the construction industry remained good in 1996, with the value of contracts awarded expected to reach S$14.3 billion (CIDB, 1996b). Although there are so many contracts available, contractors in Singapore feel that competition is still very keen owing to an increase in the total number of local contractors and the entry of more foreign contractors. For the sake of survival, it is important that they should constantly upgrade themselves to provide quality work and value for money to their clients. Those contractors with high CONQUAS scores and a ISO 9000 certificate will enjoy a tendering advantage for public sector projects under the Premium Scheme. This is an important incentive for them to continue to maintain the quality standard that has so far been achieved.

The CIDB, through its quality and productivity promotion programme, has already developed a high quality construction industry in the last decade and it intends to raise Singapore's construction quality standards to those of developed countries and envisages that by 2003, the average CONQUAS score of 78 points will be attained by quality conscious contractors (MITA, 1994).

4.2 Quality Development in Hong Kong's Construction Industry

Similar to Singapore, QA has also been brought to the construction industry in Hong Kong through the public housing quality problem. In 1960s, there was a great demand for public housing to accommodate new immigrants. Much of the public housing built at that time, though in large quantity, had been at the expense of quality, resulting in 26 housing blocks for 70,000 people required to be redeveloped in 1986. The cost in remedial work was enormous and the HKHA completely recognized the QA concept of "getting it right first time".

Understanding the potential benefit of the QA management system, the HKHA encouraged the two major local precast prestressed spun concrete pile manufacturers to develop quality schemes for their products in 1987 (McNicholl, 1989). Under the quality surveillance of the manufacturing of the concrete piles, it was observed that the schemes provided a high measure of quality assurance for an important element in the building process.

In 1990, the HKHA identified the need for a formal set of design and construction procedures for their professionals. The Hong Kong Industry Department (HKID) incidentally was having a quality drive at that time and it encouraged the HKHA to take its need one step further for ISO 9000 certification. It was decided that the Works Division of the HKHA would develop a QMS complying with ISO 9001 by mid 1993.

In line with the quality improvement, the HKHA established its own List of Building Contractors in April 1990, with a requirement that the latter should obtain ISO 9000 certification by 31 March 1993. Furthermore, the HKHA had adopted the Performance Assessment Scoring System and Maintenance Assessment Scoring System to assess the contractors' performance on new works and maintenance works respectively.

4.2.1 Performance Assessment Scoring System (PASS)

In order to measure contractors' performance against the defined standards and to compare individual contractors, the Performance Assessment Scoring System (PASS), which was developed based on Singapore CIDB's quality assessment scheme - CONQUAS, was adopted in February 1990. Since 1991, the performance of the building contractors on new works has been measured monthly under the scheme. In reviewing the system at a later stage, the contractor's organization, his management capability and capacity were also included in the assessment system. The overall performance reports are used to set the preferential tendering opportunity for the contractors. As it is essential to look at the building after its occupation and the performance of the contractor during the maintenance period, the maintenance period assessment has also formed part of the contractor's overall performance in a contract.

4.2.1.1 PASS Manual

PASS has been designed to measure the level of quality for a building and the contractor's performance throughout the whole contract period. The PASS manual provides the guidelines to measure every building component at each construction stage (HKHA, 1994a). A full set of score sheets has been printed to facilitate the assessors to conduct the assessment. The assessment is a quality checking system but it does not replace the technical inspections and tests as required under the contract. The PASS manual was revised in 1995, 1996 and 1997 to make improvements in the system incrementally.

4.2.1.2 PASS Components

PASS has three major parts, namely, Output, Input and Maintenance Period Assessment. The hierarchy is shown in Figure 4.1.

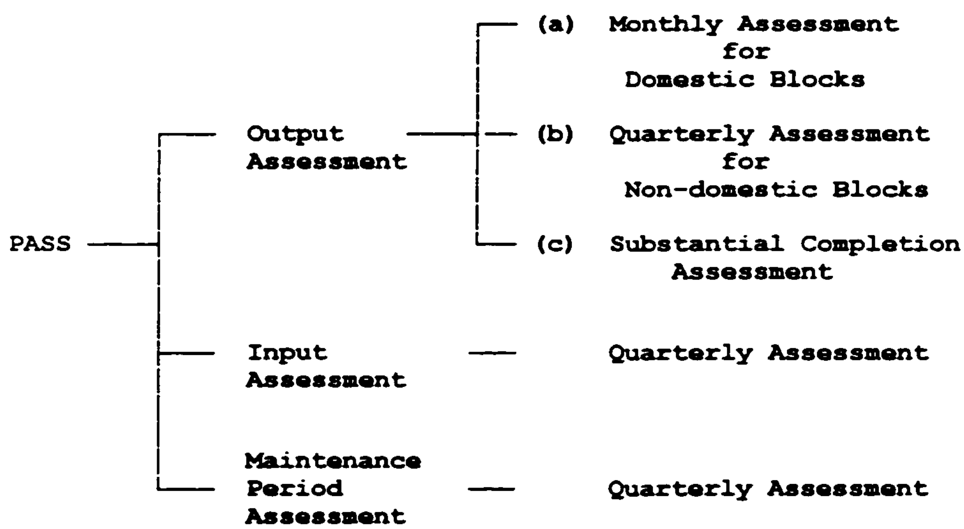


Figure 4.1 : Hierarchy of Performance Assessment Scoring System (PASS)

4.2.1.3 Output Assessment

There are three types of assessments in the Output Assessment to be conducted in a contract. They are: -

a) Monthly assessment for domestic blocks

A monthly assessment for domestic blocks includes structural, architectural and external works (total 80 marks), and other obligations (for example general site safety and care of the finishing works) (20 marks). Each type of work is further broken down into a series of factors for detailed assessment.

b) Quarterly assessment for non-domestic blocks

For building contracts consisting of non-domestic blocks, separate structural and architectural assessments are conducted on a quarterly basis. The details of assessments are similar to the monthly assessment for domestic blocks but the number of sampling locations and factors for checking are slightly different.

c) Substantial completion assessment

At substantial completion of the contract, all building works and relevant items of other obligations are checked by a substantial completion assessment. The assessment is conducted at the month of substantial completion. The sampling locations, the assessment factors and the number of spots are similar to the monthly or quarterly assessment.

4.2.1.4 Input Assessment

The PASS Output Assessment can be used to measure the standard of work done. In order to help the Housing Department Contractors Performance Reviews Committee (New Works) with the assessment of a contractor's performance and to provide constructive feedback to contractors, an Input Assessment has been devised to measure the standard and effectiveness of the contractor's site management and progress directly against defined standards. It also provides a fair means of comparing the performance of individual contractors. The assessment is carried out every 3 months and the contractor will be informed of the assessment results and shortcomings.

4.2.1.5 Maintenance Period Assessment

This is a quarterly assessment of the contractor's performance in management, response and the repair of outstanding works during the contract maintenance period.

4.2.2 Maintenance Assessment Scoring System (MASS)

Apart from the PASS, the HKHA also established the Maintenance Assessment Scoring System (MASS) for their maintenance works covering: re-roofing, re-decoration, asbestos abatement, spalling repair, toilet renovation, re-plumbing, floor re-surfacing and lift maintenance. The progress of works and services to tenants are also factors under assessment.

Similar to PASS, MASS for the assessment of the maintenance works covers workmanship and the quality of the finished work and accounts for 80% of the whole assessment. The contractor obligations for site safety and general site management are allowed at 20%. The system is based on examining workmanship at random sampling locations. The MASS Manual (HKHA, 1992) provides the guidelines and checklists for assessment purposes.

4.2.3 Preferential Tendering Eligibility System

In Hong Kong, there is no premium advantage for the contractors as in Singapore. However, in managing the List of Building Contractors, the HKHA considered that contractors who perform to a higher quality standard should have more tendering opportunities than those who did not achieve the required level (HKHA, 1994b). Based on the PASS Output and Input Assessment scores, the results can determine building contractors' performance and then their tendering opportunities. The preferential tendering eligibility for contractors is defined from a Banded Score League. The PASS Input and Output scores are used for compilation of a 6-Month Composite Score for their building projects. The contractors will then be separated into three groups by the Composite Target Quality Score (CTQS) at the upper 75 percent position and the Composite Lower Score Threshold (CLST) at the lower 25 percent position. After considering the number of contracts to be tendered out for the coming quarter, the HKHA assigns the number of contracts to be tendered by each band of contractors. This arrangement will let the contractors with low composite scores keep their resources in their existing contracts for quality and management improvements. In addition to the Preferential Tendering Eligibility System, all contractors who want to be retained in the list for bidding housing projects should be certified to ISO 9000.

4.2.4 HKQAA ISO 9000 Certification Scheme

The Hong Kong Quality Assurance Agency (HKQAA) was established in 1989 by the Hong Kong Government, as an independent subvented organization, to undertake third party certification under a registration scheme based on the ISO 9000 standards (HKQAA, 1994). Its scope of operation covers companies carrying on business in the manufacturing, construction and service sectors. The certification process normally includes a first stage assessment visit, pre-audit (optional) and certification audit stages. It is a requirement of the HKQAA that companies must have substantially complete records for more than 3 months before a certification audit. After an award of certification, a subsequent surveillance programme is applied to monitor the implementation of the system not less than twice a year. A renewal certification audit will be conducted every three years. The first ISO 9000 certificate was issued in April 1991. Up to mid 1997, HKQAA had issued more than 880 certificates, of which about 350 were awarded to the construction sector.

4.2.5 Hong Kong Laboratory Accreditation Scheme (HOKLAS)

The Hong Kong Laboratory Accreditation Scheme (HOKLAS), being managed by the Hong Kong Industry Department, offers formal recognition to Hong Kong laboratories that performs objective testing falling within the scope of the accreditation scheme and which meets the HOKLAS criteria of competence. Accreditation criteria are in accordance with the ISO/IEC Guide 25:1990(E) which also contains all quality system elements of ISO 9000 related to laboratory operation for calibration and testing activities (HKID, 1995).

4.2.6 Accreditation Service

Apart from HKQAA, about 11 overseas certification bodies have provided certification services for ISO 9000 in Hong Kong. Of these, five certification bodies have been recognised by the Works Bureau. Most of these certification bodies are supervised by the "accreditation bodies" in their own countries. The Hong Kong Government intended to set up a local "accreditation body" to supervise the conduct of certification bodies in the hope that certification services would be more reliable. In the Addendum of the 1996-97 Hong Kong Government Budget, there was a proposal to formulate a Hong Kong Certification Body Accreditation Scheme (HKCAS) to provide a more comprehensive accreditation programme. The Industry Department subsequently established the Hong Kong Accreditation Service (HKAS) in November 1998.

4.2.7 ISO 9000 for Contractors and Consultants in Hong Kong

Following the quality policy statement issued by the Works Bureau in May 1991, a Quality Management Committee was immediately set up to develop the quality management programme for the construction industry. The Secretary for Works announced the quality policy at the "Quality in Public Works" seminar held on 30 March 1994 and issued the formal quality guidelines on 4 March 1996 stating that the major consultants and contractors would be required to obtain ISO 9000 certification by 1996.

Under these requirements, the consultants and the contractors were forced to be certified to the ISO 9000 standards unless they did not want to undertake contracts with the Government. ISO 9000 certificates became a "work permit" to obtain public works contracts.

Most major civil engineering consultants in Hong Kong with overseas parent companies were already certified to ISO 9000 in their overseas operation. However, their regional offices in Hong Kong might not have such certification. The Association of Consulting Engineers (Hong Kong) had accepted in principle that consultants employed by the Government should be certified to the ISO 9000 quality standards.

The contractors had also recognized the need for formal quality management. Building contractors working for the HKHA must have achieved the certification of the company quality system to ISO 9002. All the Airport Core Programme projects were contractually required to have included detailed quality assurance requirements for the construction works (NAPCO, 1992a). The Mass Transit Railway Corporation (MTRC) had internally established and implemented a quality management system and had requested that its design consultants and contractors for the Airport Railway Project also operated a quality management system (Lo & Yeung, 1995). The Hong Kong Construction Association (HKCA, 1992) published the "Guidelines for Quality System Implementation" to give helpful advice for contractors to follow when implementing a quality management system for certification to ISO 9002.

Material suppliers were aware of the importance of quality assurance. The ISO 9000 certification scheme was a proof of their capability to provide expected quality and services, thus strengthening their position in winning contracts.

Owing to the difficulty in administration, the Works Bureau Technical Circular No. 20/98 instructs that the requirements for ISO 9000 certification are not applicable to subconsultants and subcontractors (WB, 1998). It is found that the sub-contracting system has seriously damaged the quality of construction works in Hong Kong (see Chapter 5). The situation will not be improved if the quality policy remains unchanged.

4.2.8 Training Schemes for ISO 9000 Certification

The training related to the ISO 9000 quality system has been offered by the Hong Kong Productivity Council (HKPC), the Construction Industry Training Authority (CITA) and some commercial quality consultancy organizations. The HKPC was established by statute in 1967 to provide consultancy and technical support services to the industry. The Quality and Management Consultancy Division of HKPC is actively involved in quality improvement services and helps local companies to adopt effective quality management practices in accordance with ISO 9000 requirements. It has developed a series of ISO 9000 training modules which aims at helping companies prepare for ISO 9000 certification by stages. The training modules enable participants to have a comprehensive understanding of the ISO 9000 quality system development and implementation with hands-on experience. CITA provides quality assurance training as an integral part of many of their construction courses.

The Government has already established the Industrial Support Fund (ISF) for research projects relating to quality management. In 1996, funding support was so far provided for fourteen projects which are concerned with quality management in the production industry.

Some tertiary institutions in Hong Kong are running post-graduate courses on quality management in manufacturing and production engineering. Quality training seems inadequate in the construction and civil engineering courses. In view of the new quality requirements in the construction industry with effect from 1996, the construction engineering faculty should offer more courses using the concept of ISO 9000 standards and quality management in connection with construction work. The students should build up a quality culture on campus and apply quality management to their business.

4.2.9 Hong Kong's Way to Quality

In the face of the growing demand for high quality products in the international market in the 1990s, Hong Kong manufacturers should upgrade the quality of their products to satisfy buyers' expectations. In March 1990 the Hong Kong Government officially launched a Quality Awareness Campaign to raise interest in the concept of quality. The Industry Department embarked on another quality promotion programme in 1994 to maintain the momentum. "Quality Week" is now an annual quality promotion event with the objective of raising the level of quality awareness among local manufacturers. The event also provides an opportunity for them to update their information on quality.

Obviously, the quality promotion programme has been concentrated in the manufacturing industry but the importance of quality management in the construction industry cannot be ignored. The construction industry contributes about 5% of Hong Kong's Gross Domestic Product based on economic activity (HKG, 1996). In current practice, construction contracts are usually awarded to the lowest bidder despite the growing quality awareness. Such an arrangement has taken away the contractors' incentive to adopt ISO 9000 quality standards. Many small construction companies consider that the initial investment in a quality system is expensive and the cost of going for the ISO 9000 certification is high (Pendrous, 1993; Serjeant, 1994). The need for extra manpower to implement the ISO 9000 quality system in the construction industry is also considerably high (Lee, 1994). These costs will eventually be reflected in the tender price. The contractors implementing the quality management systems may be squeezed out by their rivals who offer a lower tender price which is without the running cost of a quality system (Tam, 1993). This is not a healthy situation. However, this situation should have been better after October 1996 as all major contractors for public works have been certified to the ISO 9000 standard in order to tender for public works. The stipulation by the HKHA and Works Bureau on all their major contractors to be ISO 9000 certified can provide an equal footing enabling fair competition. With the ISO 9000 quality requirement to the consultants and contractors, it can be postulated that the whole construction industry will benefit.

4.3 Summary and Recommendations

Table 4.2 summarizes the implementation of QA Systems in Singapore and Hong Kong: -

Quality Management System	Singapore	Hong Kong
Quality Assessment System :		
Public building	CONQUAS	PASS & MASS (HKHA)
Private building	BQAS	Nil
Civil engineering works	CE CONQUAS	Nil
ISO 9000 Certification Required of:		
Consultants	July 1999	April 1996 (WB)
Contractors	July 1999	March 1993 (HKHA) October 1996 (WB)
Incentive Scheme:	Premium Scheme - Tender Advantage for All Public Works	Preferential Tendering Eligibility System for Public Housing Projects
Financial Assistance Scheme :	LETAS	ISF
Recognized Certification Body :	CIDB-SISIR	HKQAA and Others
ISO Certificates Issued to Construction-Related Companies :	About 130 (as at April 1996)	About 350 (as at mid 1997)

Table 4.2 : Quality Management Systems in Singapore and Hong Kong

4.3.1 Quality Assessment System

CIDB has been singled out to oversee the development of a quality management system for the construction industry in Singapore. The simple assessment systems of CONQUAS, BQAS and CE CONQUAS in completed projects can measure the level of quality achieved by the contractors. The rise of CONQUAS scores in the past years indicated that the building quality had been improved in the construction industry in Singapore (CIDB, 1995a).

Modified from CONQUAS, the PASS/MASS system used in the HKHA has given an intensive monthly assessment to the building works. As the assessment does not take over the routine works inspection, it can be somehow regarded as a second party quality audit to the contractors. Also, after the contractors have obtained ISO 9000 certificates, they should perform internal audits of their works. Under both tight surveillance from the certification bodies and internal auditors, the quality of works should be guaranteed. However, the quality improvement in public housing works is not obvious. The multiple quality inspections on site become a burden both to the contractors and supervisory staff. They spend a lot of time in completing various quality assessment reports and cannot concentrate more on the work itself. The PASS/MASS system should be reviewed and simplified to meet the actual needs.

The PASS score, and so is the CONQUAS score, is only for quality assessment and cannot be used to accept or reject the defective works so detected. If the PASS and CONQUAS systems can form part of contractual requirements, they will strengthen their application to quality improvement in construction works. When this happens, the legal and contractual implications must be carefully considered.

As private building works and public civil engineering works have predominated the construction market in Hong Kong, quality assessment systems similar to BQAS and CE CONQUAS in Singapore ought to be devised to assess and promote their quality achievement. It will give a quality indicator and an added public confidence.

4.3.2 ISO 9000 Certification Requirement

Singapore and Hong Kong take the ISO 9000 standards as the norm for their quality management systems in construction work. Singapore Government required its major consultants and contractors to achieve ISO 9000 certification in five years' time. On the contrary, Hong Kong Government only allowed two to two and half years for the major consultants and contractors to obtain ISO 9000 certification. A majority of the HKHA's building contractors complained that the ISO certification time was too short and only a few contractors met the deadline (Leung, 1993). The new quality policy in Hong Kong pushed the contractors to immediately embark on the certification journey without sufficient time for planning, developing and implementing a QMS. Many of them subsequently encountered problems in certification and maintenance of the quality system.

The Singapore List of Trade Subcontractors (SLOTS) is a scheme set up by the Singapore Contractors Association Limited (SCAL) to identify and assist trade subcontractors. The Singapore Government urged all its subcontractors to register themselves with SLOTS and to participate in quality activities (CIDB, 1993b). In contrast, there is not yet a requirement for subcontractors to have a QMS to ISO 9000 standard in Hong Kong (WB, 1998). Subcontractors are among the key players in the construction industry. Any upgrading in the industry must involve them. The building quality will not be effectively improved if the existing quality policy is not extended to cover the subcontractors in Hong Kong.

4.3.3 Incentive Scheme

The Premium Scheme in Singapore, acting as a carrot, provides an incentive to the contractors to improve their quality standard and achieve the ISO 9000 certification. It gives tendering advantage for the contractors with high quality score in their respective assessment. This incentive scheme encourages the contractors to strive for better quality. Unfortunately, this kind of "carrot" does not exist in Hong Kong.

Although there is no premium scheme in Hong Kong, yet based on the PASS score, a Preferential Tendering Eligibility System, acting as a stick, has been established by HKHA to bar the poorer building contractors and prevent them from tendering. There are still many complaints about the poor quality of public housing flats built by the contractors with high PASS scores. It is also noted that the Preferential Tendering

Eligibility System only considers the PASS records of the previous six months. A contractor can take an advantage by only concentrating his resources in improving the quality of workmanship when he intends to bid for a new contract during the next half year. Therefore, a final PASS score for a completed building, similar to CONQUAS, may be more practical to reflect the overall quality performance and keep the contractor maintaining a high quality standard during the whole construction period. To make the situation more complete, it is proposed that the PASS score should be one of the weighting factors, similar to the safety records, in the tender assessment.

The requirement of the ISO 9000 certificate for the listed consultants and contractors forces them to seek and maintain certification. It may not be a good phenomenon if the consultants and contractors achieve the certification only for the sake of a "work permit" and do not seek to continually improve their quality management systems. Hence, some kind of incentive schemes, such as the Premium Scheme in Singapore, must be developed to encourage the construction industry to continually maintain a good quality management system.

Both Singapore and Hong Kong have similar assessment systems to ensure the quality of construction works and provide their own incentive or penalty schemes for contractors to seek and maintain the ISO 9000 certification. If the two cities can adopt both schemes, Premium Scheme and Preferential Tendering Eligibility System, for their construction industries, the hybrid scheme will give a double encouragement to their contractors.

CHAPTER 5

HOW APPROPRIATE IS ISO 9000 TO THE CONSTRUCTION SECTOR IN HONG KONG

Quality Assurance has generally been accepted by the construction industry since the introduction of ISO 9000 quality standards in 1987. Up to mid 1997, the Hong Kong Quality Assurance Agency had issued over 880 ISO 9000 certifications, of which 350 were awarded to construction-related organizations. More than 150 major consulting engineering firms and construction companies have successfully achieved ISO 9000 certification but the quality assurance processes described in the standards, have not been unanimously agreed by the construction sector. The ISO 9000 was initially developed for the manufacturing sector and its application to construction processes is questionable. Two surveys, one for consultants and another for contractors, were conducted to collect objective and representative evidence of the practicability of applying ISO 9000 in the construction industry. Their motivation for and experience in implementing QMS to ISO 9000 are revealed in the survey results. The benefits and shortcomings of the ISO 9000 for the construction industry and the inter-relationship between quality, cost and time are also explored.

5.1 ISO 9001 for Engineering Consultancies

ISO 9000 was first published in 1987. Since then, a vigorous debate has been raised on how appropriate is ISO 9000 for the construction industry, particularly the consulting engineering services. Jensen (1994) commented that quality requirements in ISO 9001 were not adequate for the knowledge-based services to enhance the confidence of the client. Laustsen (1995) also questioned the suitability of ISO 9001 for engineering consultancy due to its differences with a product-based process. Hohbery (1995), however, observed that many quality assurance consultants and an increasing number of auditors agreed that the ISO 9001 approach, process-based and project-oriented, was promising for consulting services. In May 1995 the Construction

Industry Research and Information Association published the findings of a survey on experiences with ISO 9000 within the construction industry in UK. It was evident that positive benefits had been gained from ISO 9000 QMS in the industry and the quality standard was generally acceptable to the construction sector including consulting engineering firms (CIRIA, 1995).

5.2 Surveys of ISO 9001 Implementation in Engineering Consultancies

The research on ISO 9001 implemented in engineering consultancies was carried out in two stages. During the first stage, a survey, which joined with an undergraduate research project, was conducted to collect objective evidence of the practicability of applying ISO 9001 to consulting engineering services in the infant stage of quality management development in Hong Kong (Tang *et. al.*, 1997). During the second stage, another survey of all ISO 9001-certified consulting engineering firms was conducted. The purposes of the second survey were to examine the consultants' motivation for and experience in implementing a QMS to ISO 9001 (Tang and Kam, 1999). The benefits of the ISO 9001 quality system to consulting engineering firms were also examined.

5.3 The First Stage Survey of Consulting Engineering Firms

The ISO 9000 quality standard series was technically revised in 1994. ISO 9000-1:1994 has explicitly indicated that the ISO 9000 family can apply to organizations providing services. In view of the improvements in the new editions, it can help to re-assess the controversial comments made by Jensen (1994) on the suitability of ISO 9001 in knowledge-based services.

In the course of the first stage research, a total of ten consulting firms were selected to investigate their experience of and feedback from operating a QMS to the ISO 9001 standard. The survey was conducted in two phases between November 1995 and January 1996. The first phase was to evaluate the ISO 9001 shortcomings for consulting engineering process based on Jensen's comments in 1994. The second phase was to investigate the application of ISO 9001 to consulting engineering firms.

5.3.1 Research Method

In mid 1995, only a handful of consulting engineering firms embarked on the ISO 9000 certification scheme. The selection of consulting firms for the study was based on the following background conditions: -

a) According to the Buyer's Guide (HKQAA, 1995), there were in total only four consulting firms ISO 9001-certified.

b) As advised by HKQAA, one consulting firm was recommended to the Certification Board for granting the ISO 9001 certificate a little later. HKQAA also introduced other four consulting firms which were preparing their quality management system for certification.

c) The supervisor of the author introduced another consulting firm which was actively developing its quality system towards ISO 9001 standard.

All these ten civil and structural consulting engineering firms were selected for interviews. These ten consulting firms were divided into two groups : five were ISO 9001-certified, with the other five seeking for certification. Nine of the firms have overseas parent companies, either in Europe or Australia, while one only was locally established. The majority of the firms employed more than 100 engineering and technical staff, with three employing 300 to 600 and one more than 600 staff.

Information was obtained through interviews with the quality management staff in each firm. All interviews were based around two sets of structured questionnaires (Chung, 1996), one for firms that were ISO 9001-certified and another for firms that were pursuing certification. The questionnaires were designed to address the key issues in installing and operating a QMS to ISO 9001. Questions related to the following themes:

a) ISO 9001 shortcomings in the consulting engineering process as discussed by Jensen (1994),

b) effect of implementing a quality management system to ISO 9001,

c) importance of ISO 9001 certification,

d) requirements of sub-consultants in terms of quality management.

As all interviewees were quality assurance managers (QAMs) with ample hands-on experience of QA management, their responses to the questions directly reflected the common practice of quality management in consulting engineering firms. A total of ten completed questionnaires was obtained and the results are analyzed below.

5.3.2 Critical Quality Parameters Required by Consulting Engineering Process

Quoting the results from a study of "Quality Assurance Requirements in Consulting Engineering Companies" (FRI, 1990), Jensen stated that the ISO 9001 did not address all critical quality parameters relevant to the consulting engineering process. Six parameters, which were identified in the above-mentioned study report, and which were not covered by ISO 9001, were listed in the questionnaire for collecting the views from the QAMs. The survey results are shown in Table 5.1.

Critical Quality Parameters of which the ISO 9001 has not Covered	**Number of Firms**		
	Agreed	**Neutral**	**Disagreed**
1. Management of technology and facilities	2	2	6
2. Sub-consultants and co-operations	1	1	8
3. Errors and omissions	2	0	8
4. Feedback	0	0	10
5. Financial management	7	2	1
6. Quality cost	9	1	0

Table 5.1 : Quality Parameters Relevant to Consulting Engineering Process but not covered in ISO 9001

There was a consistent result showing that the ISO 9001 did not cover the quality parameters of financial management and quality cost. These two parameters have, however, been addressed in ISO 9004-1:1994. Most of the respondents disagreed with the suggestions that ISO 9001 had not properly addressed the management of technology and facilities and development of technical knowledge. The requirements of the selection of sub-consultants, and corrective and preventive actions for non-conformities (errors and omissions) have been well defined in the standard. All (ten) respondents confirmed that there were adequate procedures in ISO 9001 for dealing with feedback and complaints activities. It is noted that the study in FRI was conducted between 1988 and 1990 and was based on ISO 9001:1987. Since then many quality standards and supplementary guidelines have been updated and published, for example ISO 9004-2:1991 - Guidelines for Services. These additional references have given QAMs a better concept for understanding and interpreting quality requirements in ISO 9001. The different results from Jensen's and the present survey is most probably due to the recent development and improvement of ISO 9000 quality standards.

5.3.3 Shortcomings of ISO 9001 in the Consulting Engineering Process

Six other quality statements have been proposed (Jensen, 1994) to further explore the shortcomings of ISO 9001 in the consulting engineering process and the results are listed in Table 5.2. Among the findings, it was learned that seven respondents agreed that QA was determined by human performance, but only four of them thought that the selection of right people for the right project was adequately addressed under ISO 9001. Certain decisions and expectations from the client, for example control of costs, were not adequately covered by ISO 9001.

The respondents had neutral views on the process of developing and using knowledge. Seven respondents suggested amending the existing quality standard to suit the QMS for consulting engineering services. Some engineers may wish to have a tailor-made quality standard for consulting engineering services, as similar to concrete mix design charts, for ease of reference. However, it is the author's view that a quality standard tailored to the needs of the consulting engineering process may be impractical. ISO 9001 is a common standard and an international quality language, and it should be valued as such.

Test Statements	Number of Firms		
	Agreed	Neutral	Disagreed
1. Decisions from client are not covered	3	3	4
2. Certain expectations required by client are not covered	5	3	2
3. Process of developing and using knowledge is not covered	4	2	4
4. Selection of right people for the right project is not adequate addressed	4	1	5
5. QA is mainly determined by human performance	7	2	1
6. ISO 9001 clauses should be amended to suit the quality system for consulting engineering services	7	2	1

Table 5.2 : Shortcomings of ISO 9001 in Consulting Engineering Process

5.3.4 Effect of Implementing a QMS to ISO 9001

Despite the queries about the suitability of ISO 9001 for consulting engineering services, many consulting firms were seeking for certification at the infancy stage of quality management development in Hong Kong. The survey investigated the benefits and drawbacks of a QMS according to ISO 9001. In order to illustrate the different views between the certified and non-certified consulting engineering firms, the results are split into two groups and are shown in Table 5.3.

Only four respondents replied that QMS was introduced because of problems with quality arising from poor design. All respondents confirmed that the quality documents were developed from their existing quality systems to meet the requirements of ISO 9001. There was unanimous agreement that installing and maintaining a QMS would incur significant expenditures of time and money. Most respondents, however, believed that implementing QMS would eventually save money by minimizing the amount of waste, corrective work and poor products in the long run. No divergence of opinion between the certified and non-certified firms was noted on these cost-related issues.

Activities	Number of ISO 9001 Certified Firms			Number of Non-Certified Firms		
	Agreed	Neutral	Disagreed	Agreed	Neutral	Disagreed
1. Introduce a QMS because of many problems with quality arising from poor design	4	0	6	4	0	6
2. Prepare QMS documents based on existing works procedures	8	2	0	10	0	0
3. Incur time and money for the QMS	10	0	0	10	0	0
4. Save the overall firm's money	6	2	2	6	2	2
5. Minimize the amount of waste, rework and poor products	10	0	0	8	2	0

Table 5.3 : Effect of Implementing a QMS to ISO 9001

5.3.5 Importance of ISO 9001 Certification

The concern about the importance of certification from certified and non-certified firms is shown in Table 5.4. All respondents expected that their firms would be more competitive as a result of gaining ISO 9001 certification. However, there were divergent opinions in both groups as to whether team spirit and morale had been significantly improved. The certified firms noted improvement, but the non-certified firms had negative views. Probably the negative view of the non-certified firms was due to the paperwork and internal audit conflicts between staff during the establishment of the system. The certified firms had already gained the advantages of implementing the system while the non-certified ones had not yet appreciated them. Significant managerial skills are essential in processes of installing and implementing a QMS. There may also be problems if a consulting engineering firm pursues certification only for the sake of a "work permit" and does not seek to continuously develop their QMS.

Activities	Number of ISO 9001 Certified Firms			Number of Non-Certified Firms		
The engineering consulting firms certified their QMS to ISO 9001 so that:	Agreed	Neutral	Disagreed	Agreed	Neutral	Disagreed
1. they will be qualified to tender Government consultancy agreements	10	0	0	10	0	0
2. they will have a better marketing position in construction industry	8	2	0	10	0	0
3. they will have a better team spirit and morale	6	4	0	4	0	6
4. they will give added confidence to international client and can tender for overseas jobs	10	0	0	10	0	0

Table 5.4 : Importance of ISO 9001 Certification

5.3.6 Quality Requirement for Sub-consultants in Terms of Quality

The quality requirement when appointing sub-consultants is proposed in Table 5.5. Sub-consultants are key players in consultancy services and the quality of the design work is dependent on them. There is no conclusive view from the survey results on selecting sub-consultants based on quality requirements. In fact, the appointment of a sub-consultant is traditionally dependent on experience and the relationship with the main consultant. Even though there is a requirement in ISO 9001 that evaluation of sub-consultants should be included in the quality system, it may not be strictly followed owing to commercial decisions.

Activities	Number of ISO 9001 Certified Firms			Number of Non-Certified Firms		
	Agreed	Neutral	Disagreed	Agreed	Neutral	Disagreed
The sub-consultants are best to be certified to ISO 9001 or have their own QMS	2	6	2	4	2	4

Table 5.5 : Quality Requirement of Sub-consultants

5.3.7 Interview Assessment

Apart from the questionnaire, information regarding the application of ISO 9001 to consulting engineering firms, was also obtained through interviews. They are summarized in Table 5.6.

Questions	Certified Consultants	Non-Certified Consultants
1. Why did your company decide to apply for ISO 9001 certification?	• improve efficiency • save time and money • have same quality language with the client and parent company • fulfil the Government requirement	• comply with Government requirement and get new jobs • assure and improve the quality of design work
2. What benefits did you expect in implementing a QMS to ISO 9001?	• improve communication • improve control of documentation	• improve communication • improve image and competitiveness • improve marketing • cost saving
3. Have your expectations been realized since certification?	• have a better quality awareness through auditing • have a cost saving • improve the quality in design	• not applicable
4. What sort of problems have you encountered in tailoring ISO 9001 requirements to your normal working practices and vice versa?	• difficult to comply with some requirements • difficult to perform the requirement of "validation" from consultancy point of view	• need a great deal of interpretation • require transformation of existing procedures to satisfy the standard • generate more paperwork
5. What is the effect of ISO 9001 on the management practices?	• identify the responsibility for each staff • improve the flow of information with a better management	• require additional resources for installing a QMS • better planning for starting a new project
6. Have you encountered or expected any specific problems in implementing ISO 9001?	• have strong pressure from the top management • staff reluctant to follow the procedures	• need a lot of effort in implementing the procedures as stipulated in the QMS • staff do not like the changes in working practices

7. ISO 9001 specifies that all information be documented in a controlled manner. Do you perceive this requirement to be an integral part of your working practices?	• have been a company standard practice rather than a quality standard	• slow down the output before the system reaching maturity • have been an integral part of company's working practice
8. ISO 9001 requires all non-conformities be formally documented and corrective and preventive actions be implemented. Have you found this to be an effective manner for improving your design work?	• take rectification action more efficiently • aware of client complaints and let the responsible staff involve with the corrective actions in order to prevent the recurrence of the non-conformities	• have a formal and systematic approach in handling non-conformities and complaints, and subsequently corrective and preventive actions
9. ISO 9001 emphasizes training of personnel for any tasks that affect quality. How do you consider this requirement?	• special training is essential • will affect the routine work • effectiveness of training can not be easily assessed in cost terms	• formal procedure for identifying the training needs will ensure high quality of design work • may not apply to small design office
10. Do you find or think ISO 9001 relevant to consulting engineering services?	• is relevant to many consultancy activities • the system is very hard to run • some firms suggested that the publication of an additional ISO standard specifically tailored for consulting engineering services may be considered	• its generic nature allows it to be adopted for consultancy services • ISO 9001 is a tool for developing a QMS for consulting engineering firm

Table 5.6 : Summary of Interviews with Consulting Engineering Firms

With the recent development and improvement in the ISO 9000 quality standards, their application to consultancy services has been accepted by the interviewees. Even though ISO 9001 does not cover all the consulting engineering activities, most of the critical points in the consultancy process are stipulated in the standard except for some aspects of financial management and quality cost. These are covered in the other quality guidelines. Nevertheless, some firms were of the view that a supplementary quality standard tailored to the needs of consulting engineering services should be available. The author's view on this point has already been given in Section 5.3.3.

Since April 1996, all engineering consultants have to be certified to the ISO 9001 standard for all Government consultancy agreements over HK$ 10 million (Ko and Yim, 1997). The suitability of ISO 9001 to consultancy services had been recognized by the authority and the Association of Consulting Engineers (ACE) of Hong Kong had accepted this pre-qualification requirement. Thus, the consultants were forced to seek ISO 9001 certification unless they did not want to undertake jobs from the Government. They endeavored to fit their QMS to the requirements in ISO 9001 and to satisfy the client needs. With more experience in running the QMS, the certified consultants were aware of the shortcomings in ISO 9001 for their businesses. One or two quality requirements for consultancy activities not covered by the standard, for example business development and financial management, had been included in the consultants' quality procedures. These quality elements would give added confidence to the clients on their overall business administration. The survey results show that all firms believed that they had made improvements to their management as a result of implementing a QMS according to ISO 9001 and obtaining certification.

5.4 The Second Stage Survey of Consulting Engineering Firms

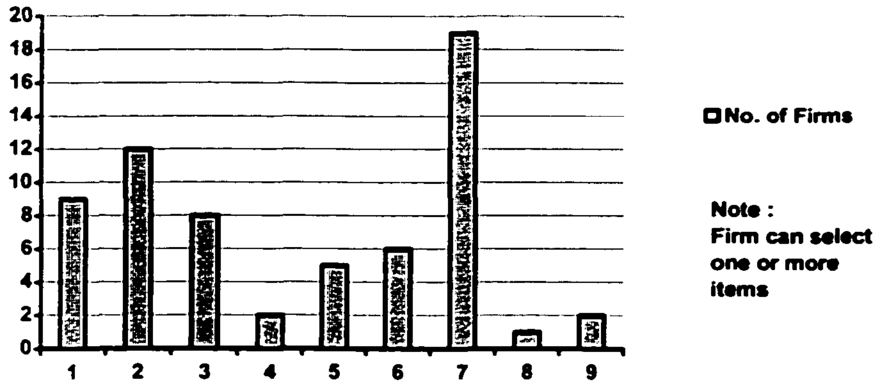
In a quality audit seminar organized by the Works Bureau in November 1997, the convener called for a simple "show of hands" to affirm the perception of benefits received by consulting engineering firms and construction companies from ISO 9000 certification. Surprisingly, only a very low level of support was received from the consultants and contractors present. In mid 1997, 36 civil and structural engineering consulting firms had already achieved ISO 9001 certification in Hong Kong. Apparently, most of the certified firms had not yet experienced meaningful benefits from the QMS.

In order to re-assess the suitability of ISO 9001 for engineering consultancy, an intensive survey was conducted for certified engineering consultants. The purposes of the survey were to examine their initial motivation for seeking ISO 9001 certification, evaluate their experiences and difficulties in establishing a QMS to ISO 9001, and collect views about the maintenance of the QMS. The survey also assessed the perceptions of the consultants of the benefits from implementing QMS and requested comments on the proposed improvement to quality management. The inter-relationship between quality, cost and time were also investigated.

In September 1997, 36 copies of a structured questionnaire (see Appendix A) were sent to QAMs of civil and structural consulting engineering firms that were listed in the Hong Kong Government Consultants' Services Directory and certified by HKQAA. The questionnaire was designed based on literature review (CIRIA, 1995; Chung, 1996; Vloeberghs and Bellens, 1996) and the experience of the author. 19 completed questionnaires were returned, of which 14 were from firms with overseas parent companies and five were local firms. 17 firms (89%) responding to the survey provide design services, 16 firms (84%) undertake an engineering feasibility study and 12 firms (63%) perform site supervision. Three small firms have fewer than 50 employees; six medium firms have between 51 to 200 staff members and the remaining 10 large firms employ more than 200 staff members. The response rate of 53% of all ISO 9000 certified consulting firms in Hong Kong can be considered high and the results can support definitive conclusions.

5.4.1 Motivation for Seeking ISO 9001 Certification

Many reasons and benefits have been suggested in the literature as to why organizations seek ISO 9000 certification (HKQAA, 1994; Shaw, 1995; Buttle, 1997). These reasons have been condensed to nine elements in the survey. QAMs were asked to indicate their initial motivations for seeking ISO 9001 certification. As shown in Figure 5.1, all respondents (100%) cited that Government requirement is the prime reason for seeking certification. The Works Bureau required its major engineering consultants to be certified to ISO 9001 as a condition for retention in its Consultants' Services Directory after March 1996. The mandate from the Government to have ISO 9001 certification is a major driving force and has pushed the consultancy services in Hong Kong to a new level. Nine consultants (47%) acknowledged the advantage of promoting the firm's image in the construction industry. 12 firms (63%) were aware of the benefit of improving the firm's efficiency and management and eight (42%) recognized that the certification would make better internal and external communication. It is noticeable that there is not a high proportion of respondents who consider the quality improvement in their business as the most important motivation for seeking certification.



1. To improve the firm's quality image in the construction industry
2. To improve the firm's efficiency and management
3. To improve the internal and external communication
4. To resolve the quality problem arising from poor design work
5. To reduce liability risks and insurance cost
6. To meet the internal policy requirement from the parent company
7. The mandate from the Government
8. The demands from the private developers
9. As a start for total quality management (TQM)

Figure 5.1 : Motivation of Consultants for Seeking ISO 9001 Certification

Two firms (10%) implemented the QMS to ISO 9001 because of the quality problems arising from poor design work. Five firms (26%) accepted that a certified QMS would reduce liability risks and insurance cost. Such low response rates indicated that the function of the QMS, which could rectify the design process to avoid design fault, had been overlooked. Six firms (31%) reported that certification was due to the internal policy from a parent company and one firm (5%) due to demands from private developers. A lack of understanding of the total quality management (TQM) in the design office was found from the survey results, as only two firms (10%) took the ISO 9001 certification as a stepping stone to TQM. This confirmed Bradley's (1994) statement that most certified companies had not yet taken the crucial steps towards using ISO 9000 as a start to TQM.

Obviously, all responding firms initiated their QMS because it was demanded by the customer, the Hong Kong Government. If this prime factor was not taken into account, only two thirds of respondents (63%) would consider starting QMS for internal quality improvement (see item 2 in Figure 5.1). According to the Buyer's Guides published by HKQAA, there were only 11 ISO 9001-certified engineering consulting firms in March 1996 but the number jumped sharply to 42 in November 1997 to meet the Government requirement. In fact, an ISO certificate has become a "work permit" and no consultant can afford to ignore it (Giles, 1993).

5.4.2 Establishment of Quality Management System

Since the consultants provide knowledge-based services and are familiar with technical standards, only eight (42%) of the 19 firms employed external quality assurance consultants (QACs) to assist in developing the QMS. The QACs were only found generally helpful because they did not familiarize the consulting engineering process. The time taken to achieve certification by 19 firms varied from 9 to 24 months and the average time is 14 months. By comparing the staff number in quality assurance departments of the responding firms, it is found that the period is dependent on the staff efforts but not the size of the firm. It is also noted that the early certified firms took more time than the later ones as the latter tried hard to achieve certification before the deadline set by the Government.

Most consultants have already established their management and design procedures. The QAMs were asked to indicate, as a percentage, the proportion of quality procedures in their QMS how many were directly adopted from their existing documented procedures, how many were amended from the existing procedures to suit ISO 9001 requirements, and how many were entirely new. The results showed that 29% of QMS procedures were revised from the original procedures and 17 % of new quality procedures were developed for the quality system. Nearly a half of quality documents was new to staff. This usually caused problems in the implementation of the QMS. On average, the quality manual has 37 pages and the quality procedures 160 pages. As each set of quality manual and procedures is unique, there is a significant variation in the contents of the firms but again this is not dependent on the size of the firm. These documents were widely distributed to the staff, including the clients and sub-consultants, for implementation or reference.

The respondents were requested to rate how relevant each ISO 9001 quality clause was to their business. They considered that most of the 20 clauses were "considerably relevant" to consultancy services except clauses 4.11 - "Control of Inspection, Measuring and Test Equipment" and 4.15 - "Handling, Storage, Packaging, Preservation and Delivery" which were of very little relevance. Furthermore, clauses 4.19 - "Servicing" and 4.20 - "Statistical Techniques" were classified to be of no relevance to their business. These results generally match the findings in Section 3.3. Some QMSs have included the above procedures for the control of software, delivery of building model, post-contract services and statistical analysis of the causes of nonconformities. Certain relevant aspects, for example financial control, human resource management and computer aided design control, were not mentioned in the ISO 9001 standard. Special quality procedures for these items have been suggested to add to the QMS for guidance.

The ISO 9001 was initially developed with the manufacturing industry in mind but is now applied to the design and site supervision processes. The QAMs were further asked whether they were totally satisfied with ISO 9001 for consultancy services. As depicted in the pie chart in Figure 5.2, 63% agreed that ISO 9001 was an adequate quality system applicable to their business. However, over one third (37%) had reservations as to the suitability for the standard to their services. As the production work (construction) is undertaken by another party (contractor), the design, development and production processes related to ISO 9001 requirements could not be entirely controlled and performed by the consultants. Difficulties in interpreting the standard, for example design validation, have frustrated the staff during establishment and implementation of the QMS. The survey results reflect that although the ISO 9001 is adequately applied to consultancy services, there remains room for improvement.

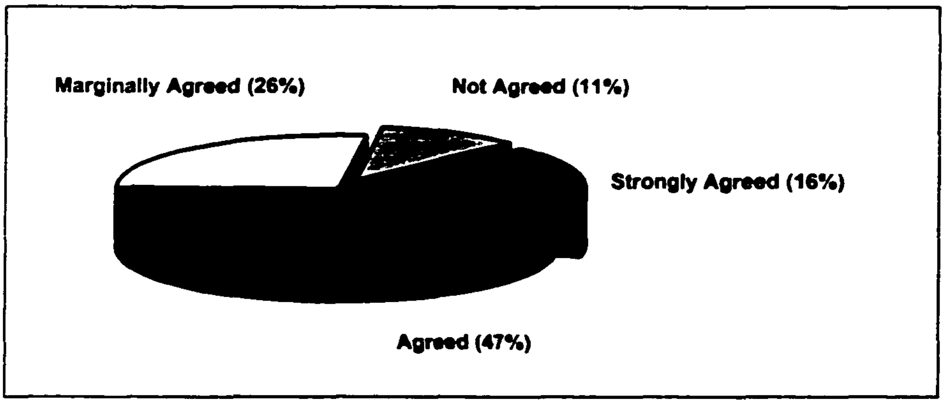
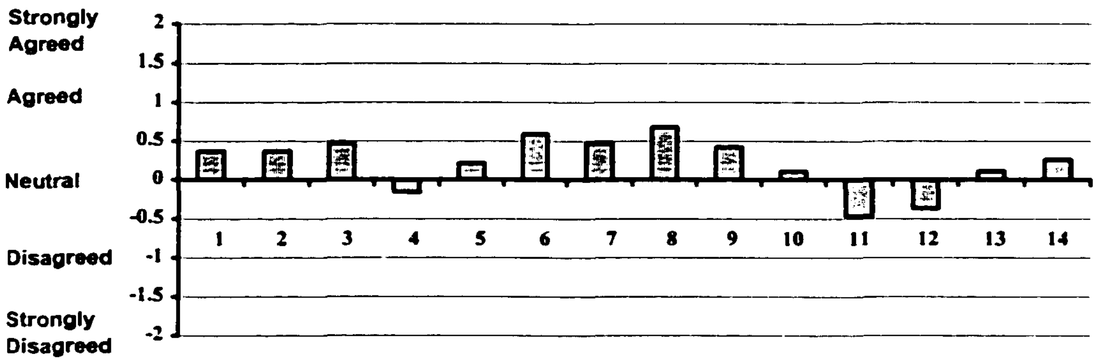


Figure 5.2 : Satisfaction with ISO 9001 for the Consultancy Services

5.4.3 Implementation of a Quality Management System to ISO 9001

Once the QMS has been implemented, many problems follow. Figure 5.3 shows the common difficulties that respondents encountered in implementing the QMS. The respondents were asked to indicate their experience of implementing ISO 9001 within their firms with regard to the 14 items as proposed in the questionnaire. The response to each item is measured on a five-point scaling, under categories of "strongly agreed (2 points)", "agreed (one point)", "neutral (zero point)", "disagreed (minus one point)", and "strongly disagreed (minus two points)". Based on the given scale of +2 to -2 points, the average scores that each respondent gained on each item are then calculated. This method is also applied to the later survey data.

In the aggregate, they found that the most difficult task was to make their staff understand and accept the ISO 9001 quality standard. Engineers always claim that they are trained to look for quality and the QMS cannot help improve their design work. Some impractical ISO 9001 requirements on consultancy services and the excessive documentation procedures bring resistance from the professionals. Some are afraid that design flexibility will be lost when a quality manual is adopted. Yuen (1999) also identified in his survey results that the professionals believed that ISO 9000 had reduced their autonomy. Professionals were trained to produce quality work and sometimes this meant that they were "programmed" and had little autonomy in how to do the work. The author considers that a well-structured QMS can allow for flexibility in the design process and allay the engineer's concerns.



1. Lack of strong senior management involvement
2. Resistance or bad attitude from the staff
3. Engineers are trained to look for quality and are often not convinced that ISO 9001 is the best way to do so
4. Absence of well-structured quality system and procedures
5. Lack of effective communication even under quality procedures requirements
6. Too much documentation control and record
7. Impractical ISO 9001 requirements on consultancy services
8. Not fully understanding the requirements of ISO 9001 by the staff
9. Change in culture
10. Insufficient quality training to staff
11. No co-operation from the client to meet your procedures under project quality plan
12. QMS is not applied to sub-consultants
13. The clients only require the consultants to have ISO 9001 certification but they do not have such quality knowledge
14. Aim at maintaining the ISO 9001 certification as "Work Permit" but not seeking for further quality improvement

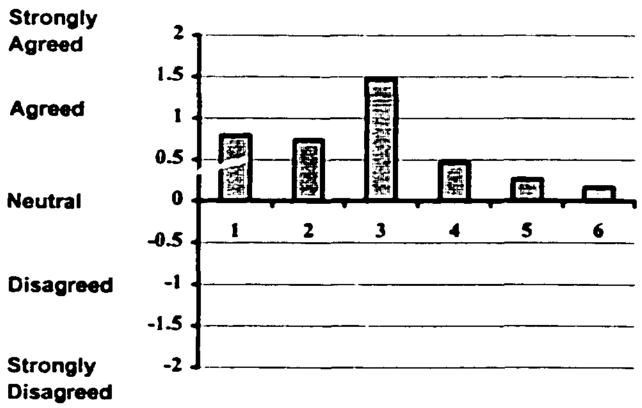
Figure 5.3 : Difficulties Encountered in Implementing a QMS for Consulting Engineering Firms

The change of a quality culture, together with insufficient quality training, has made staff disinclined to place reliance on QMS. Lack of strong support from the management and effective communication in the design team has also induced significant impact on QMS. There is no strong view about the client who just requires the consultant to achieve certification but does not own a similar quality management system. The respondents did not agree to the assumptions in items 4, 11 and 12 of Figure 5.3 as their QMS had been certified and were already distributed and to a certain extent applied to their sub-consultants and clients. Because of the prerequisite from the Government, QAMs were aware of the unhealthy aspects of maintaining the certificate as a "work permit". It is hoped that all consulting firms will continuously improve their QMS. Even though difficulties have been encountered, the survey result shows that there is no insurmountable problem, in implementing QMS according to ISO 9001, to consulting engineering firms.

5.4.4 Maintenance of the Quality Management System by Consultants

Having achieved ISO 9001 certification, many firms only run their business in accordance with the certified QMS so as to reap the maximum benefits from it automatically. Actually, continuous improvement of the QMS is of paramount importance to meet clients' new requirements and expectations. Six items for the maintenance and continuous improvement of QMS were set in the questionnaire for QAMs' assessment.

As illustrated in Figure 5.4, QAMs strongly agreed that retention of quality staff is the best way to maintain the QMS. Since consulting engineering firms provide knowledge-based services, the staff is really the asset of the firm and affects the overall quality performance. A regular review of quality documents and strong motivation for continuous improvement to the system initiated from their quality assurance department were also important factors. A benchmarking exercise may be attempted with ISO 9001-certified consultants sharing experience in implementing the quality system. However, as the project quality plan will form part of the technical proposal in bidding a consultancy agreement, nobody will want to reveal their expertise to their rival firms. QAMs marginally agreed that they could improve the QMS by obtaining quality assurance information and techniques from the Government and certification bodies. However, it is noted that there are very few quality-oriented periodicals published locally.



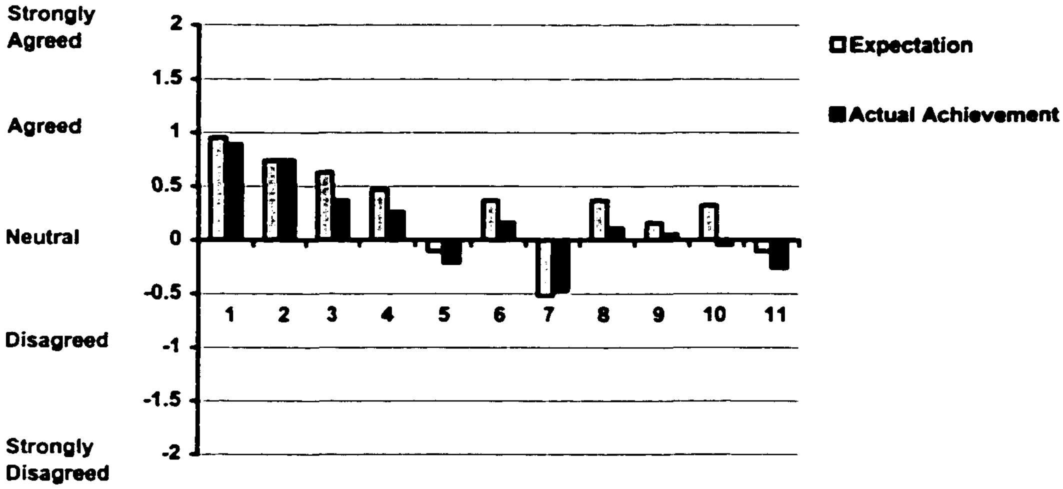
1. Regularly review the quality manual and procedures for improvement
2. Strong motivation from quality assurance department
3. Retain quality staff
4. Benchmarking with other certified companies
5. More QA information and technique provided by the Government and certification bodies
6. Plan to implement TQM system

Figure 5.4 : Factors for Maintenance and Continuous Improvement of QMS in Consulting Engineering Firms

Referring to item 9 in Figure 5.1, it is disappointing that only a very small number of consulting firms planned to implement a TQM for continuous quality improvement at the QMS maintenance stage. Tan and Lu (1995), based on their research results, also felt that there was in general a lack of appreciation of TQM in consulting engineering firms in Taiwan. There is some doubt whether the QAMs were completely satisfied with the ISO 9001 QMS as they only attempted to meet the minimum quality requirement from the Government and did not invest more for upgrading their quality system to TQM. The QAMs agreed that the management review, quality audit, quality training, corrective and preventive actions could help in improving the QMS. The introduction of quality indicators to measure the quality achievement was also a means of assessing the quality achievement through the system.

5.4.5 Benefits from Operating a Quality Management System to ISO 9001

A series of statements concerning the benefits from operating a QMS to ISO 9001 was included in the questionnaire. Since all responding firms were ISO 9001-certified and had experienced some beneficial outcomes, they were asked to compare the benefits they originally expected to achieve and those they actually received as a result of gaining certification. The statements used in the questionnaire and the survey results are shown in Figure 5.5.



1. Enhanced the firm's quality image
2. Increased client satisfaction
3. Won more agreements/contracts
4. Improved administrative system among different functional departments
5. Reduced management attention required for routine matters and supervision
6. Trimmed the onerous procedures to simpler version and improved efficiency and productivity
7. Reduced the amount of paperwork with a better documentation control
8. Improved design process and improved management to the site resident staff
9. Increased certainty of achieving contract requirements and deadlines
10. Achieved saving through a reduction in design failures and reworks
11. Improved personal job satisfaction and morale

Figure 5.5 : Benefits from Operating a QMS to ISO 9001 in Consulting Engineering Firms

As shown in Figure 5.1, a major reason of attaining ISO 9001 certification for many consulting firms is to have better quality image. All respondents concurred that the firm's image had improved as a result of gaining certification and the degree of enhancement was very close to their expectation. Most of the respondents believed that ISO 9001 certification would increase the level of client satisfaction. The survey results explicitly demonstrated that the increase in client satisfaction met the original high expectation. All ISO 9001-certified consultants expected to have advantages in winning more agreements. Unfortunately, they found that although opportunities had increased, the certification could not help in the competition as other consultants were also certified. Apart from the technical and quality requirements, they believed that the fee proposal was still the main factor in winning agreements.

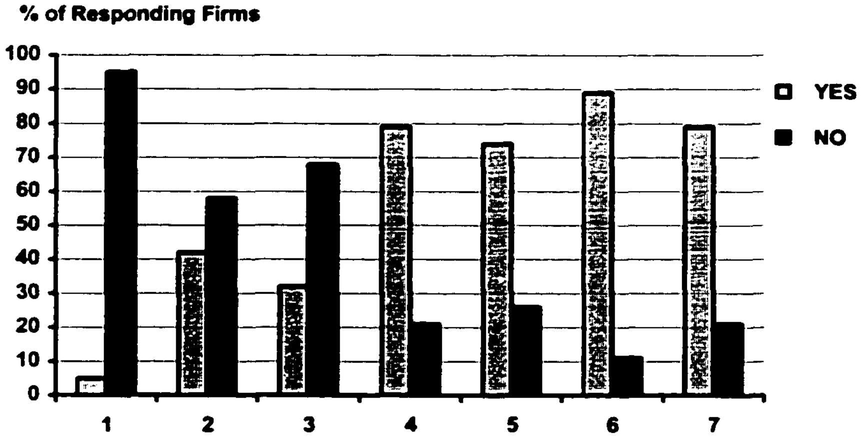
Most consultants expected that their design process and resident site staff management would be better after implementing the QMS. Conversely, they had found no significant improvement in these areas in reality. Once the documented procedures were established, it was anticipated that an improvement in achieving contract requirements and deadlines would be gained. Figure 5.5 shows that both expectation and actual achievement for item 9 were low and respondents considered that the QMS could not help in this regard. Ironically, QAMs reported that there was no positive savings from the reduction in design failures and reworks achieved by the QMS. It is presumed that QAMs had no track record with regard to quality cost.

Respondents had expected that the personal job satisfaction and morale would slightly decrease following the implementation of their QMS but the disadvantage actually experienced by them was twice as bad as expected. Professionals possibly have a stronger resistance to documented procedures, paperwork and quality audit at the early stage of certification. The author considers that once the quality procedures are well streamlined, the professionals will find the quality manual a useful handbook and will not be further troubled by the system.

The overall benefits which the consultants have gained as a result of implementing a QMS to ISO 9001 are not significant. Throughout the survey, respondents indicated that the level of improvement had not lived up to original expectation. Brecka (1994) indicated that companies certified for more than five years would benefit more from lower operating cost, reduced wastage, and improved efficiency and productivity than companies that had just completed the certification. ISO 9001 certification should be viewed as a long-term investment and the benefits of certification would increase with time. It is noted that most responding firms have only achieved certification for one or two years. Perhaps these firms will reap more benefits from the QMS over the next few years.

5.4.6 Further Development of QMS in Consultancy Services

Another series of questions, which focused upon the development of quality-related cost, incentive scheme, training and so on, were put to the QAMs. Figure 5.6 shows the survey results. 13 out of 19 firms disclosed their estimated quality-related costs and the average quality cost was about 5.6% of their annual turnover. The remaining six firms reported that they had no such record. However, only one respondent confirmed that he had apportioned quality-related costs into prevention, appraisal and failure. The accuracy of the estimated quality cost is questionable. Furthermore, only 40% of the firms would agree to operate a standardized quantifying system to determine an accurate quality related cost for the assessment of the effectiveness of QMS. 60% of respondents objected to this proposal because the quantifying system might become a fault finding system and put much pressure on the designers. It is the author's view that with a better understanding of the quality cost, the defects in design process can be promptly identified and rectified, and the staff performance can then be improved. Dale and Lascelles (1995) affirmed that quality costing could be used to monitor the effectiveness of quality improvement initiatives. They also proposed the "eight steps" by which an organization could approach the collection and analysis of quality cost. In a design office, a simple time sheet recording the resource inputs together with the quality problems is sufficient for the analysis. It is recommended that research on the quality cost of construction work should be carried out.



1. Does your firm apportion quality related costs into prevention, appraisal and failure ?
2. Is there a need for a standard quantifying system to determine an accurate quality related cost ?
3. Should a quality assessment system be introduced to quantify the consultant's quality performance in each engineering project ?
4. Should an incentive premium scheme be devised to give tender advantage to the consultants with good quality performance records ?
5. Is a formal training course required in academic institutes ?
6. Is a model QA document covering ISO 9001 requirements required for consultancy services ?
7. Do you accept second party quality audit conducted by your client ?

Figure 5.6 : Future Development of QMS in Consultancy Services

Nearly 70% of respondents did not accept a technical scoring system for measuring their quality performance in each project. They feared that this would make things too complicated. The author argues that with a standard yardstick to measure the quality performance, it will be possible to eliminate any subjectivity and provide a reliable assessment to the client. Such a scoring system can also screen out the poor consultants from the invitation list. In order to maintain quality improvement, it is recommended that an incentive premium scheme should be devised to give advantage to those consultants with good quality track records. 80% supported the proposal while the remaining 20% were more concerned about the difficulty in rating quality achievement. Nevertheless, the incentive premium scheme should be developed to tie in with the quality assessment system, like what is being done for contractors in Singapore (see Section 4.1.4).

To save on-the-job training in quality concepts and practices for graduate engineers, over 70% of respondents preferred the inclusion of quality elements in the syllabus of academic institutions. It will help build up a quality culture in the campus and prepare a sense of quality awareness in their job.

About 90% of QAMs preferred to have a quality standard solely for the consulting engineering services. However, with reference to Figure 5.2, only 11% of respondents did not agree with ISO 9001 as their quality norm. There seems to be an inconsistency between these two survey results. In practice, ISO 9001 is an international quality language that has met construction industry needs. It is the author's view that a more trade-specific approach may lead to a proliferation of supplementary standards that undermine the integrity of ISO 9001 standard, as mentioned in Section 5.3.3. This will also impose additional certification problems. He proposes that some guidance notes should be prepared by the engineering institutions to assist consultants in interpreting the ISO 9001 standard and to enable them to improve the quality management technique.

Apart from the third party audit, nearly 80% of QAMs accepted second party audit of their QMS by their clients. They considered that it would provide the latter with added confidence and better understanding of their knowledge-based services. The remaining 20% considered that continuing assessment audits should be carried out by the certification body only, as the second party audits would put an extra workload on the consultants and violate the spirit of the ISO 9000 third party certification scheme. It must be noted that the essential resources in a consulting engineering firm is the professionals and the consultancy service is intangible. Second party audits are sometimes required to assure the consultant's capability and design process.

5.4.7 The Balance between Quality, Cost and Time within Consultancy Process

The achievement of quality in an engineering project must also be linked with cost and time. To assess the impact of ISO 9001 on a design office, the QAMs were asked the importance of quality in relation to design fee and time. The responses are summarized in Figure 5.7. Three out of 19 firms did not give any ranking as they considered that all these factors were of equal importance. Of the remaining 16 respondents, over 60% cited that quality performance was more important than either design fee or time. Furthermore, time was considered as the second important factor. The design fee was considered not so important in comparison with the technical proposal as its weighting factor, in the assessment, would only occupy 20 to 40 percent of the total marks in the tendering. The consultancy agreement will be awarded to the consultant with excellent technical knowledge of the project and a good quality track record. The consultant with a poor quality performance record will not be shortlisted.

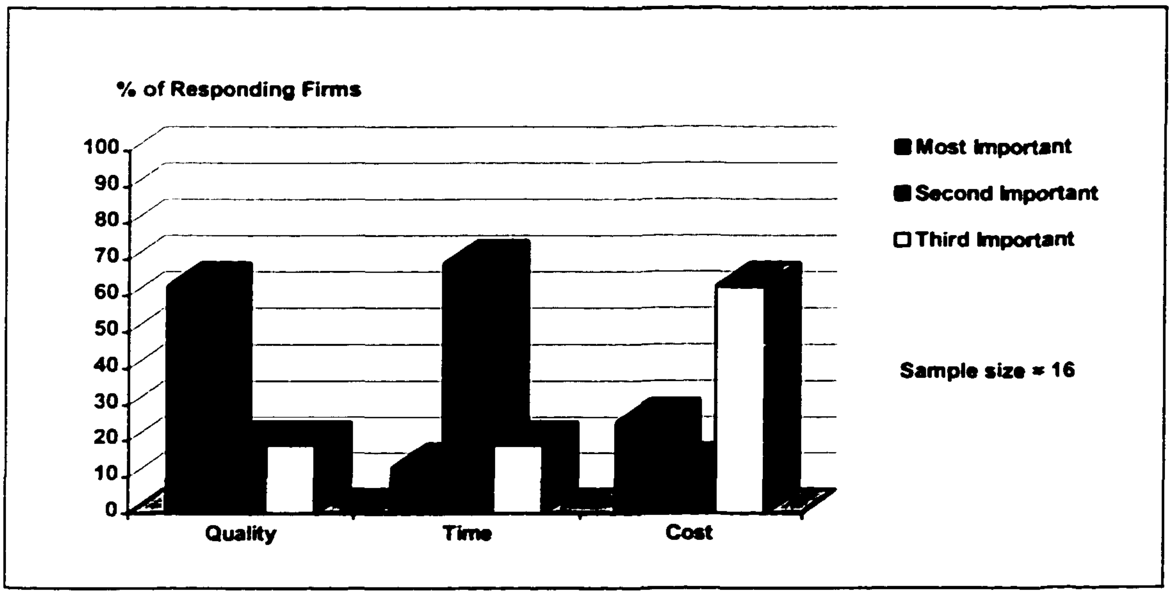


Figure 5.7 : The Importance of Quality, Time and Cost in Consultancy Process

Even though quality is the prime factor in the project, cost and time must be given equal priority. Consultants shall, in a timely way, provide the best design within budget. Quality assurance is a system to help make the product right the first time and at minimum cost. With good planning in the QMS, consultants will appreciate the major benefit of ISO 9001, in the balancing of quality, cost and time.

5.5 ISO 9000 for Building and Civil Engineering Contractors

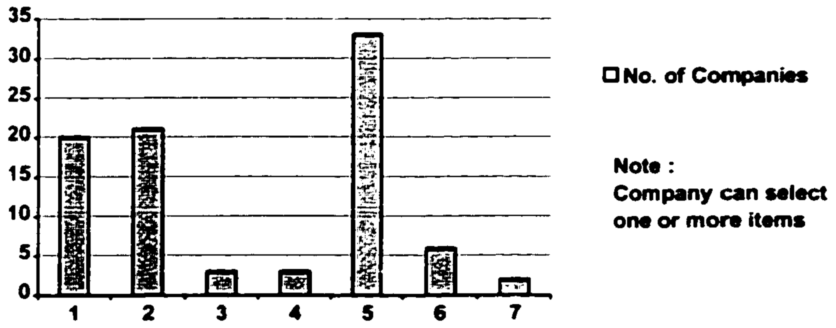
In June 1992, HKQAA issued the first ISO 9002 certificate to a local building contractor (Tam, 1993). Up to mid 1997, HKQAA had issued about 140 ISO 9000 certificates to 100 major building and civil engineering contractors (one company may offer several construction services and obtain more than one certificate). The increasing number of contractors achieving ISO 9000 certification is apparently due to the pressure from clients.

In order to learn more about the ISO 9000 implementation in the construction industry, a survey, similar to the one for consultants, was conducted for certified contractors in Hong Kong (Kam and Tang, 1998b). The purposes of the survey were to find their motivation for implementing a QMS to ISO 9000, evaluate their experience and difficulties in developing and implementing the QMS, and collect representative views on the maintenance of the QMS. The survey also examined the benefits of operating ISO 9000 by contractors and asked about any possible contributed improvement to quality management in the construction industry.

A structured questionnaire (see Appendix B) was sent in June 1997 to QAMs of 100 ISO 9000-certified construction companies that were listed in the Hong Kong Government Works Bureau's Approved Contractors Lists. 35 completed questionnaires have been received and the response rate is 35%. 25 companies (71%) provide building construction services. 23 companies (66%) undertake civil engineering works and eight contractors (23%) are involved in piling works. Eight small construction companies have below 50 employees. 13 medium contractors employ between 51 to 200 staff members and 14 large companies have more than 200 staff members.

5.5.1 Motivation for Having a Quality Management System to ISO 9000

QAMs were asked to indicate their original motivations for having a QMS to ISO 9000. As shown in Figure 5.8, 33 respondents (94%) indicated that Government requirement was the most important reason to seek ISO 9000 certification. The Hong Kong Housing Authority and Works Bureau required their major contractors to be certified to ISO 9000 as a condition for their retention in their approved contractor lists after March 1993 and September 1996 respectively (Tang and Kam, 1997). 20 contractors (57%) were aware of the advantages of improving the company's image and management by ISO 9000 certification.



1. To improve the company's quality image in the construction industry
2. To improve the company's efficiency and management
3. To resolve the problem with poor quality arising from the construction process
4. To reduce the failure cost and liability risks
5. The mandate from the Government
6. The demands from the private developers
7. As a start for total quality management (TQM)

Figure 5.8 : Motivation of Contractors for Having a QMS to ISO 9000

Six companies (17%) pointed out that they pursued certification because of the demands from private developers, mainly the quasi-government organizations such as the Mass Transit Railway Corporation. It was noted that private developers had not yet enforced the quality assurance requirement for private jobs and the quality of those works could not be measured. Only three companies (9%) recognized that the QMS could help in resolving quality problems and reducing the failure costs. Such a low response reflected that insufficient information about quality-related costs in construction sites led to a difficulty in understanding the long-term savings in construction works. There was in general a lack of appreciation of the TQM approach in managing construction projects. Only two companies (6%) considered that the ISO 9000 certification was a good start for TQM.

5.5.2 Development of a Quality Management System to ISO 9000

29 (83%) of 35 companies reported that they had set up a quality management department for the development of the QMS. For most of these companies, two to four staff were necessary to maintain ISO 9000 certification. Obviously, there was a correlation between company size, number of construction sites and the number of employees needed to support and maintain the QMS. 24 companies (69%) responded that they employed quality assurance consultants (QACs) to help them in setting up their quality system. The QACs were quite helpful at the initial stage to provide professional advice in interpreting the ISO 9000 requirements. About one third of these 24 companies considered that the QACs were of little help or even not helpful during the preparation of quality procedures because they did not entirely understand the practices on construction sites. Some complained that the QACs tried to change the construction company's normal procedures to fit the ISO 9000 requirements.

17 contractors (48%) confirmed that they had already achieved ISO 9000 certification for their whole business. The remaining 18 contractors (52%) stated that only the initial major tasks had been certified. Some had plans for additional certification. The length of time for achieving certification by 35 contractors varied

from 9 to 30 months with an average of 13 months. It appeared that the large companies had spent more time, about 18 months, in obtaining certification.

On average, there are 43 pages in the quality manual and 170 pages in the quality procedures for construction companies. Regarding the project quality plan, there are about 28 pages for an individual project. It was found that the thickness of the quality documents is proportional to the size of the company since the larger company provides more types of construction services. It was also noted that about 33% of existing working procedures were modified to meet the ISO 9000 requirements and 15% of new quality procedures were prepared for the QMS. The staff would have problems in compliance with many of the new quality procedures. The quality documents have been fully circulated to the head and site management, but only a few copies have been distributed to the site supervisory staff and subcontractors for reference.

The QAMs were asked whether they were totally satisfied with ISO 9000 for construction activities. As depicted in the pie chart in Figure 5.9, a majority of respondents (74%) agreed that ISO 9000 was an adequate quality system to be applied in their companies. As not all quality clauses were directly related to construction activities, for example clauses 4.19 - "Servicing" and 4.20 - "Statistical techniques", 23% respondents marginally agreed to take ISO 9000 as their quality norm. One QAM

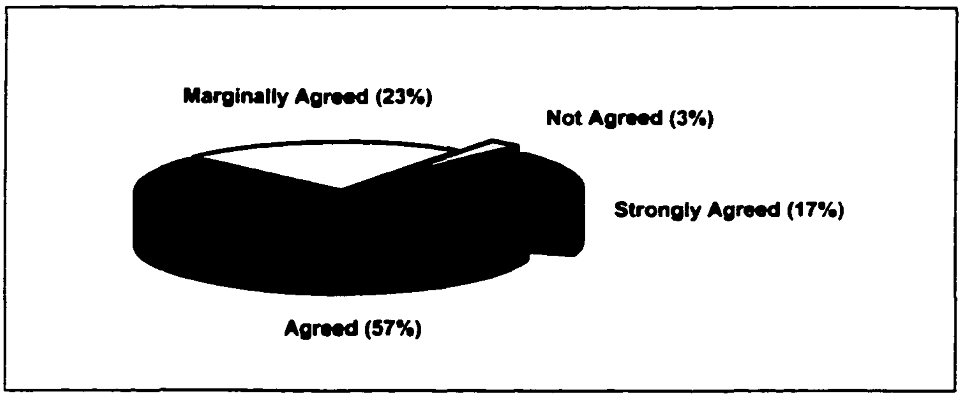
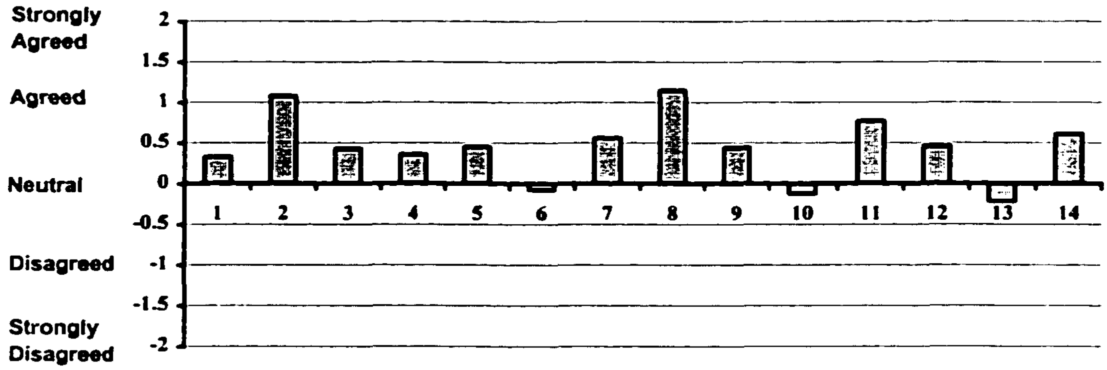


Figure 5.9 : Satisfaction with ISO 9000 for the Construction Industry

(3%) claimed that construction works heavily relied on professional judgment and disagreed that construction processes could be controlled by dogmatic quality requirements.

5.5.3 Implementation of a Quality Management System to ISO 9000

Figure 5.10 shows the common difficulties that the respondents encountered in implementing a QMS to ISO 9000 for construction companies. Most of them agreed



1. Lack of strong senior management involvement
2. Resistance or bad attitude from the staff
3. Poor internal/external communication
4. Not fully understanding requirements of ISO 9000
5. Impractical ISO 9000 requirements on site work
6. Absence of well-structured quality system and procedures
7. Too much documentation control and records
8. Change in culture
9. Insufficient quality training of staff
10. Quality documents are written in English and not easy to follow by site staff and workers
11. Site staff are used to work under supervision rather than to a procedural manual
12. QMS is not applied to sub-contracting system
13. The company's QMS does not match another QMS being operated by the Resident Engineer appointed by the client
14. Aim at maintaining the ISO 9000 certification as a "Work Permit" but not seeking for further quality improvement

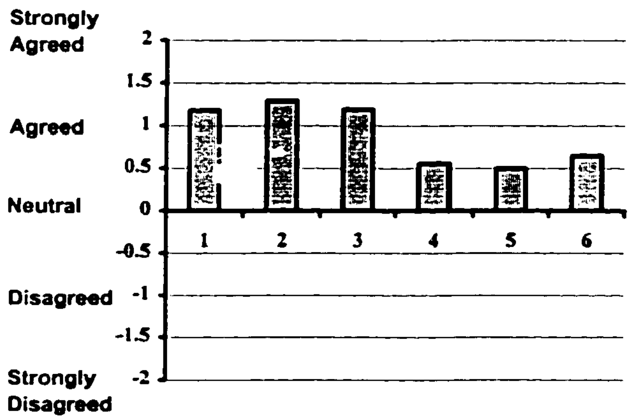
Figure 5.10 : Difficulties Encountered in Implementing a QMS for Construction Companies

that the change in culture required for following the QMS brought resistance from the staff and affected the performance on site. Site staff are used to working under supervision rather than to quality procedures. The required quality documentation control and records have generated an extra workload for them. Since all responding companies were ISO 9000-certified, they had already met and overcome the problems in receiving management commitment, understanding the ISO 9000 requirements, providing quality training to staff, and managing subcontractors at the QMS development stage. They did not agree with the assumptions in items 6, 10 and 13 of Figure 5.10. Remarkably, more QAMs noted the unhealthy trend in maintaining the certification as a "work permit" and sought continuous improvement in their QMS.

5.5.4 Maintenance of the Quality Management System by Contractors

After a QMS has been certified to ISO 9000, many companies follow only the documented procedures to run their quality system without considering the maintenance of it. Maintaining a QMS is critical to continuously satisfy a client needs while protecting the company's interests. Low and Omar (1997) conducted a survey to study the maintenance method adopted by ISO 9000-certified construction companies in Singapore. They agreed that a measure of quality improvement could be indicated by how well the QMS was maintained and confirmed that continuous monitoring and improvements to the QMS would increase quality standards and productivity. Six items for the maintenance and continuous improvement of the QMS were proposed to the QAMs for agreement in the questionnaire.

As shown in Figure 5.11, the QAMs concurred that strong motivation for continuous improvement to the system should be initiated from their quality assurance department. A regular review of quality documents and retention of quality staff were also important factors. As there were only a few quality periodicals published in Hong Kong, the respondents marginally agreed that they could improve the QMS with assistance from the Government and certification bodies. They considered that benchmarking with other ISO 9000-certified contractors might share the experience in implementing the quality system, but nobody would like to display trade secrets to their rivals. However, a considerable number of contractors planned for practising TQM for continuous quality improvement at the QMS maintenance stage.



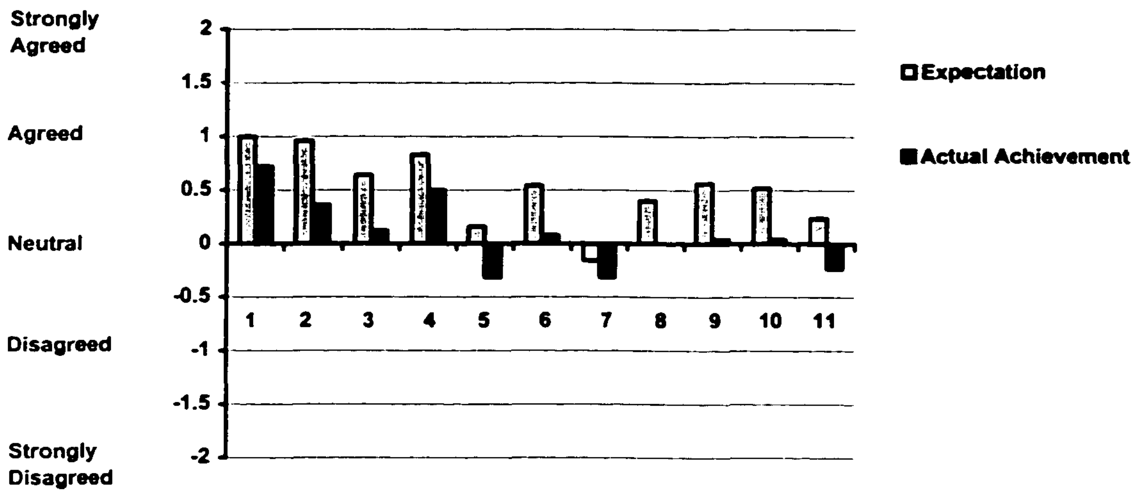
1. Regularly review the quality manual and procedures for improvement
2. Strong motivation from quality assurance department
3. Retain quality staff
4. Benchmarking with other certified companies
5. More QA information and techniques provided by the Government and certification bodies
6. Plan to implement TQM system

Figure 5.11 : Factors for Maintenance and Continuous Improvement of QMS in Construction Companies

5.5.5 Benefits from Operating a Quality Management System to ISO 9000

A series of statements concerning the benefits from operating a QMS to ISO 9000 was included in the questionnaire. QAMs were asked to compare the benefits they originally expected to achieve during the establishment of QMS and those they actually received after gaining certification to ISO 9000. The statements used in the questionnaire and the average responses are listed in Figure 5.12.

As shown in Figure 5.8, a major reason for attaining ISO 9000 certification for many construction companies is to increase their profile in the construction industry. All respondents agreed that the company's image had improved as a result of gaining certification and the degree of enhancement was close to their expectation. Most of the respondents at first believed that the ISO 9000 should greatly increase the overall level of client satisfaction. However, the survey results indicated that the increase in client satisfaction was significantly below expectation. In order to have a better idea, it is recommended that the clients, for example Government works departments, should be interviewed to collect their views on the quality performance of these ISO 9000-certified contractors. To assess the views of the clients on what benefits they had received as a result of their suppliers gaining certification to ISO 9000 may be the next valuable piece of investigation work. All companies expected that the certification would give a competitive edge in bidding contracts. In fact, they found that opportunities almost remained the same, as most contractors were also certified. They believed that a low tender price was still the main factor in winning contracts.



1. Enhanced the company's quality image
2. Increased client satisfaction
3. Won more contracts
4. Improved administrative system between site and head office
5. Reduced management attention for routine matters and site supervision
6. Trimmed the onerous procedures to improve efficiency
7. Reduced the amount of paperwork with a better documentation control
8. Improved construction process and site safety
9. Increased certainty of achieving contract requirements and deadlines
10. Achieved saving through a reduction in failures and reworks
11. Improved personal job satisfaction and morale

Figure 5.12 : Benefits from Operating a QMS to ISO 9000 in Construction Companies

Improvements in the administrative system between head and site offices were experienced by the contractors. Although the benefits were slightly below expectation, the documented procedures had really improved the company's internal communication. With a low expectation that ISO 9000 would reduce management attention for routine matters and site supervision, the respondents also gave a negative view in this regard. The reason perhaps is that the internal audits and system reviews had already demanded much time and attention from the management. The documented procedures could not reduce the level of supervision on workers on an ever changing construction site. There was a relatively high expectation that the trimming of the onerous procedures would improve the efficiency of management but the contractors perceived the actual benefit gained from this was lower than expected. Moreover, the contractors clearly understood that there would be an increase in the amount of paperwork in the ISO 9000 quality system, for document control. Their experience showed that the additional paperwork was even far beyond their anticipation as more inspection request forms required completion.

Most contractors expected their construction processes and site safety to be better after implementing the QMS. In view of the neutral responses, they had found no impact in these areas. Once the documented procedures were in place, the contractors had anticipated an improvement in achieving contract requirements and deadlines. The chart showed that the respondents were aware of the achievement but the level of improvement was negligible. Similar result appeared for item 10 of Figure 5.12 as no significant savings through the reduction in construction failure and rework costs by the QMS were achieved. The author believes that there should be savings but the contractors just did not know the actual amount of savings and therefore gave a neutral response.

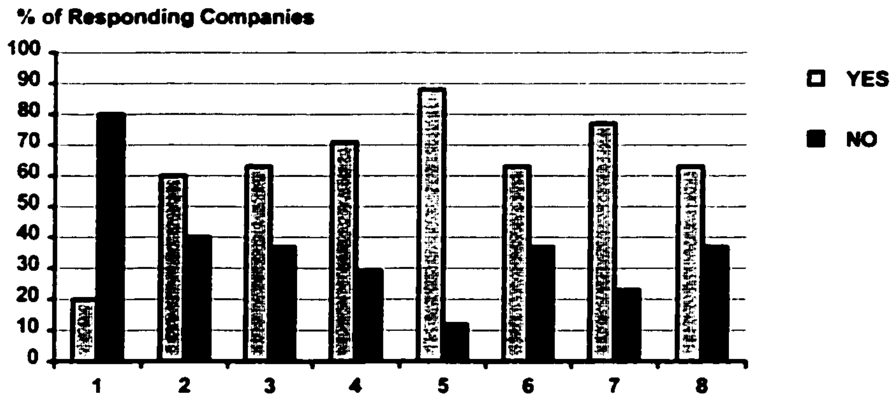
Respondents had expected that personal job satisfaction and morale to slightly increase following the implementation of their QMS but the benefits perceived by them were opposite to the expectations. The staff resisted the paperwork and quality audit at the early stage of implementation. Wong (1997) carried out a case study about the impact of ISO 9000 on employee job satisfaction in an IT company. The result of study gave an insight that the implementation of ISO 9000 improved job satisfaction. The author anticipates that once the quality procedures are well established on site, staff will enjoy the work more and make fewer complaints.

The overall benefits which contractors have gained as a result of implementing a QMS to ISO 9000 are small. Throughout the survey, respondents indicated that the level of improvement was far below their original expectation. Some contractors seemed to think naively that simply by writing ISO 9000 into their processes the quality of the product they achieved would be dramatically improved. Tam (1996) conducted survey on the actual benefits experienced by ISO 9000-certified contractors and concluded that they were not achieved as expected in most of site activities. The situation has not been improved in the past years. Many contractors failed to reap great benefits. Their attitude in implementing the QMS was wrong as it resulted mainly from the pressure from clients seeking ISO 9000 certification. Unless the QMS is adequately planned and maintained, the real benefits of an effective system cannot be realized. Lee (1998) shared this view in his research work on ISO 9000-certified firms in Hong Kong.

5.5.6 Further Development of Quality Assurance in the Construction Industry

Figure 5.13 shows the survey results of another set of questions focused upon the development of the quality-related cost, incentive quality scheme and training. 24 out of the 35 companies disclosed that their estimated quality-related costs were between the range of 0.3% to 5% of their annual turnover and that the average quality cost was about 2.2%. The remaining 11 respondents stated that they had no such data or that the cost was negligible. However, 80% respondents stated that they did not apportion quality-related costs into prevention, appraisal and failure. Without the tracking system in place to quantitatively measure these costs in association with implementation of ISO 9000, the accuracy of the quality cost data is in doubt. Therefore, 60% companies supported having a standardized quantifying system to determine an accurate quality-related cost for the assessment of the effectiveness of

QMS. 40% objected to this proposal as it would put much the pressure on site staff and staff in accounts and quality departments who already worked under a tight construction programme. Hence, a simple aide-memoire for collecting the required information should be designed for general use. Low and Yeo (1998) agreed to the proposal and recommended a quality costs quantifying system for site operations.



1. Does your company apportion quality-related costs into prevention, appraisal and failure ?
2. Is there a need for a standard quantifying system to determine an accurate quality- related cost ?
3. Should a construction quality assessment system be introduced to quantify the civil engineering project ?
4. Should an incentive premium scheme be devised to give tender advantage to the contractors with good quality performance records ?
5. Should all major building trade workers be properly trained and certified to improve their quality awareness in construction work ?
6. Is a formal training course required in academic institutes ?
7. Is a model QA document covering ISO 9000 requirements required for construction industry ?
8. Do you accept second party quality audit conducted by your client ?

Figure 5.13 : Future Development of Quality Assurance in the Construction Industry

The Hong Kong Housing Authority has already used its Performance Assessment Scoring System (PASS) to assess the building contractor's quality performance. However, there is no such assessment scheme applied to civil engineering work. More than 60% accepted the introduction of a system or yardstick to measure the quality performance of civil engineering contractors. Since most contractors are ISO 9000-certified, the certificate holders are now on an equal footing and have no advantage when bidding for contracts. In order to maintain the momentum in quality improvement, it is suggested that an incentive premium scheme be devised to give tender advantage to those contractors with good quality track records. Over 70% supported the proposal while others were concerned about the difficulty in rating quality achievement. Therefore, an incentive premium scheme, for example the Premium Scheme in Singapore which is tied in with the Construction Quality Assessment System (CONQUAS), should be developed to tie in with the quality performance assessment system.

The workers are the key players in a construction project. If all building trade workers are properly trained and certified, the quality of construction work can be improved. Nearly 90% agreed to such a proposal but the remainder had reservations on the high costs in employing certified workers on site. The Works Bureau (1999) has required its contractors to employ more qualified tradesmen in 15 building and civil engineering trades. The requirement is to ensure that works are carried out effectively and competently by the contractors and to improve the quality of the construction works. To maintain an effective QMS, the construction companies should employ quality assurance managers and staff. 60% of respondents preferred the inclusion of quality elements in the syllabus of academic institutes. 40% argued that engineering courses, already, forced the students to look for quality and the quality assurance training should not be unnecessarily duplicated. As the ISO 9000 is still a new subject in the construction industry, the author opines that the quality awareness course for students will reduce practical training on site.

ISO 9000 was written primarily on a manufacturing and product assurance basis. This had made interpretation of the standard difficult for construction processes, as each construction project is unique. In the last decade, much effort has been spent in making a sensible and meaningful interpretation of ISO 9000 for the construction industry

(Duncan *et. al.*, 1990; Oliver, 1990; Lam *et. al.*, 1994; Nee, 1996). Nevertheless, nearly 80% of QAMs still preferred an industry-specific quality standard for construction. However, with reference to Figure 5.9, only 3% of the respondents did not agree that ISO 9000 could be applied to the construction industry. It could perhaps be worthwhile to consider publishing additional guidance notes for the construction industry in order to assist contractors in interpreting the ISO 9000 standard and to enable them to improve the management techniques which they can apply to their QMS. The author does not agree to the publication of an industry-specific quality standard for construction. ISO 9000 is good enough for such a purpose. The reasons have been given in Sections 5.3.3 and 5.4.6.

Even though the continuing assessment audits were being conducted by the certification bodies to the ISO 9000-certified contractors, over 60% of the contractors accepted a second party audit of their QMS, by their clients. Those who objected opined that surveillance audits were performed periodically by third party assessors and therefore their clients needed not to conduct quality audits. Multiple second party audits would be costly to contractors. The author finds that, in some cases, second party audits are required in specific areas, for example site safety planning, where the contractor's QMS is beyond the requirements of ISO 9000.

5.5.7 The Balance between Quality, Cost and Time in Construction Contract

It is of no use achieving the required quality standard at the expense of delay in completing the contract or in presenting an incompetitive cost. The QAMs were asked the importance of quality in relation to construction cost and time. The responses are summarized in Figure 5.14. Four out of 35 companies did not give a ranking to these three factors because they considered that all were of the same importance. Of the remaining 31 respondents, over 70% cited construction cost as being more important than either construction time or quality. Furthermore, time was considered as the second important factor. Only about 10% of QAMs took quality as the prime factor. Despite the good quality track record, a contract will normally be awarded to the contractor with the lowest tender price. The liquidated damages for delay in completion of a contract is costly too. In order to save construction cost and time, contractors usually rush to complete their work at the expense of quality.

This is understandable since most site management highlights the cost and time and leave the responsibility of quality to others. It is a contention that quality must be given equal priority with cost and time within construction project. In fact, quality assurance is a systematic prevention system to help make a product right the first time and at minimum cost. ISO 9000 can help retrieve the balance between the concerns for quality, cost and time. The survey results indicate that many contractors have not yet appreciated the major benefit of ISO 9000 in the improvement of not only the quality but also the cost and time.

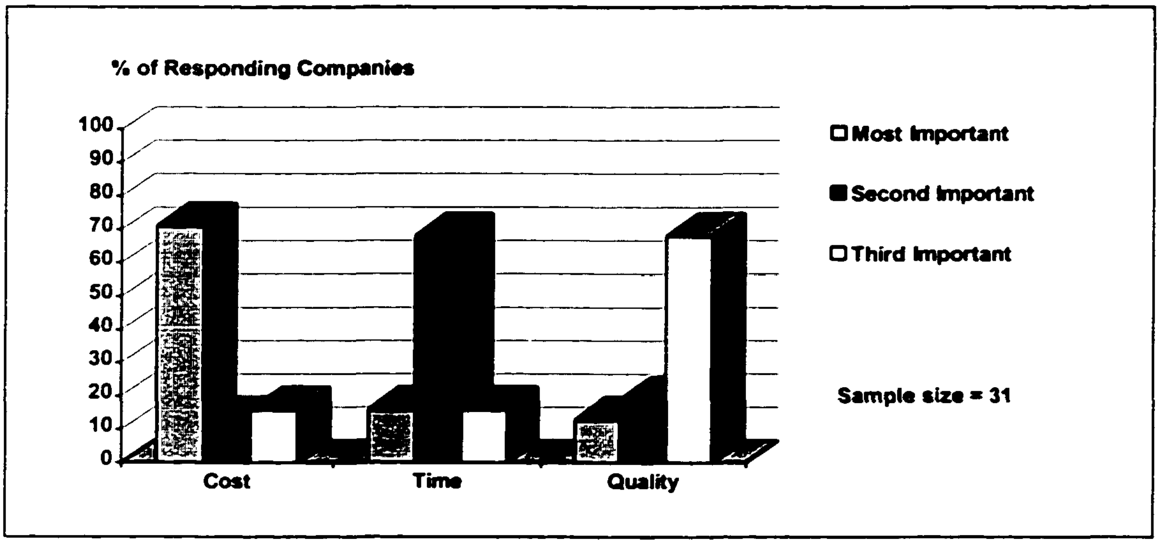


Figure 5.14 : The Importance of Cost, Time and Quality in a Construction Contract

5.6 Conclusions

Over 150 major consultants and building and civil engineering contractors have already achieved ISO 9000 certification in Hong Kong. In carrying out the survey work for this study, first hand knowledge of the experience of 19 consulting engineering firms and 35 construction companies has been gained. The experience relates to their motivation for seeking ISO 9000 certification and their practices in installing and maintaining a QMS to ISO 9000, together with the difficulties encountered during the implementation.

Though some quality elements are not applied to the construction activities, the results of the surveys demonstrate that the construction sector generally accepted the ISO 9000 as a norm for their QMS. A quality standard tailored to the construction industry is not supported. Some guidance notes should be prepared to assist construction sector to improve the quality management technique.

The main reason for construction sector seeking certification was the mandatory requirement from the Government. The "work permit" syndrome has pushed the consultants and contractors to "jump on the bandwagon" without thorough quality planning for their business. The change to quality culture and the new QMS have brought resistance from the staff. The adverse responses at the quality audit seminar (see the 1st paragraph in Section 5.4) are understandable since the consultants and contractors have faced many problems during the implementation and maintenance of their QMS. As there is no special assistance from the Government or the certification bodies, there is a great demand for the model QA documents to help the construction sector improve the efficiency of the QMS (see item 6 in Figure 5.6 and item 7 in Figure 5.13).

Consultants and contractors found that they had made certain improvements to both their services and works and the management of the business as a result of implementing a QMS to ISO 9000 but the actual achievements were below their original expectations, especially for the construction companies. The latter possibly had unreasonable expectations of what ISO 9000 and certification could deliver. A similar survey result was found that the level of improvement, in most of construction activities, had not lived up to expectation in the UK construction industry (CIRIA, 1995). Brecka (1994) indicated that companies certified for over 5 years would reap greater benefits from the QMS. It is expected that the responding companies will gain more benefits from their certification as time goes by.

The quality assurance and the triangular relationship between quality, cost and time are not fully understood or accurately interpreted within the construction industry. While the consultants consider quality as the sole prime factor for the projects, the contractors take the construction cost as the most important item at the expense of quality. Many quality-related costs were excess production costs arising from the inability to "get things right first time" (Dale and Plunkett, 1991). The "get it right first time" concept could save time and money for both the contractors and clients (Chapham, 1991). With a better understanding of the principle of quality assurance, the construction sector can maintain the balance among these three elements in construction projects.

Kumar and Brittain (1995) indicated that quality costing programme not only reduced production costs but also could assist to improve the reliability of quality. Low and Yeo (1998) have already recommended a quality costs quantifying system for the building industry in Singapore, but the quality-related cost has not formally been assessed in Hong Kong. It is proposed that a simple structured system recording the resource input for repairing the nonconformities should be devised to help identify the quality problems in design and construction work. Hence, the remedial and preventive actions can be planned for quality improvement.

Proper quality training of the management and professionals is required to improve the manner on managing QMS. The requirements of the building trade workers to keep the quality of construction work to a satisfactory standard could be realized through training and certification by an authority, such as Construction Industry Training Authority. The syllabuses of civil engineering undergraduate courses should consist of quality elements to enable the graduate engineers to be equipped with relevant quality knowledge when carrying out their duties in the construction industry.

To keep the quality improvement momentum in the construction industry and to encourage construction sector to continually seek quality improvement, apart from the ISO 9000 certification, incentive schemes similar to CONQUAS Premium Scheme in Singapore, must be developed in Hong Kong. In order to effectively implement such an incentive scheme, a quality performance assessment system must simultaneously be devised to provide a fair assessment for both building and civil engineering projects.

Although the effectiveness of a QMS can be assessed by the certification body, the respondents welcomed the second party auditing as this will give added confidence to the client. It is recommended that further research work is conducted as to how the clients ascertain what benefits they have received as a result of their suppliers, the consultants and contractors, gaining certification to ISO 9000.

ISO 9000 standard is the foundation of TQM and the best approach is to use ISO 9000 as an entry key to total quality (Tsiotras and Gotzamani, 1996; Salim and Kashef, 1997). It is hoped that the trend in construction quality will move in such a direction in the next decade.

CHAPTER 6

ISO 9001 QUALITY ASSURANCE SYSTEM FOR THE CONSULTANTS

As noted in Chapter 5, the construction sector did not hold positive views about the benefits of the ISO 9000 quality standard. Taylor (1994) obtained similar results and observed that there was a large gap in the sector between an awareness of ISO 9000 and an understanding of its purpose. Even though the major consultants and contractors have successfully achieved ISO 9000 certification in Hong Kong, the application of quality assurance principles to the construction activities is still not well established. They still have doubt how the quality standard can really help improve quality performance.

ISO 9001 is a model for the management of a quality management system in consultancy services. To support the QA concept, the standard requires the preparation of a quality manual for implementation. The quality manual is the top level document in the QMS consisting of developed and approved quality policy and objectives addressing each quality element as contained in ISO 9001. It also provides the basis for assessment and certification audits. The QMS should be unique to each consultant and reflect the style and operation of the firm. However, commonality lies on the fact that the basic requirements of ISO 9001 must be satisfied in a quality manual which should have working procedures in common. Lee (1992) and Rothery (1995) had already prepared model documentation for manufacturers. If a generic quality manual suitable for most engineering consulting firms is produced, it may help to bridge the gap and bring more acceptances to the standard from the construction sector.

To be able to prepare a model quality manual, the current QA practice in consulting firms must first be known. A full case study was conducted between the last quarter of 1995 and mid 1996 to investigate how a consultant established a QMS for ISO 9001 certification. Two other quality manuals from ISO 9001-certified consultants were also selected for evaluation. Moreover, the quality approach to achieve certification by the Territory Development Department (TDD) of the Hong Kong Government was explored. The aim of the case studies was to identify the requirements and content of a quality manual for consultancy services to ISO 9001 standard and to recommend a suitable style and format for a model quality manual which would facilitate ease of use. As ISO 9000 was initially developed for the manufacturing industry, a quality manual for a production company was first examined to explore the different QA approaches between production and consultancy service processes.

6.1 The Structure of a Quality Management System

A QMS, for ISO 9000 certification, is a documented system which generally consists of a quality manual, quality procedures, forms and a project quality plan. The quality manual is the top level policy document and the quality procedures and forms are the enactment of the policy. The project quality plan will call up the quality procedures for a particular project.

6.1.1 **Quality Manual** (for management level use)

A quality manual is a document containing the essence of a company's quality system and gives a clear overall view of the quality management being practised by the company. It informs the staff, and often the customers, of the company's policy and objectives for quality. Broadly, it states what is done to assure quality. ISO 10013 - "Guidelines for Developing Quality Manual" provides guidelines for the development, preparation and control of quality manuals.

6.1.2 **Quality Procedures** (for supervisory level use)

Quality procedures are the documents, which are pertinent to quality, and which describe the company's activities when conducting business. It instructs the staff in broad terms how the policies and objectives expressed in the quality manual are to be followed and achieved. For example, the production of a concrete mix requires a quality procedure. In fact it is the method statement with reference to relevant specification documents.

There are considerable benefits if a standard format can be used for the control of procedures. Consideration should be given to use a "ten-point system" which utilizes the following items: -

a) Purpose
b) Scope
c) Responsibility
d) Definition
e) Flow chart
f) Procedure content
g) Supporting documents (external documents)
h) Reference (internal documents)
i) Records
j) Appendices (work instructions or forms)

6.1.3 **Forms** (for supervisory and working levels use)

The form serves to demonstrate and record that the product or service provided has been developed and produced in accordance with the specified quality procedures and requirements. It also proves that the QMS is operating effectively. A good designed form should be user-friendly and written in a language at a level to suit the user.

6.1.4 **Project Quality Plan** (for project team use)

A project quality plan is a document derived from the QMS, and which sets out the specific quality practices, resources and activities relevant to a particular project. Normally, it comprises the company's quality manual, the relevant quality procedures and other new quality procedures specific to the project. The inspection and test plan often forms a part of the quality plan. Similar to the quality procedures, the following items are recommended for inclusion in a project quality plan: -

a) Scope and introduction
b) Distribution list
c) Definition
d) Document status and control
e) Organization for quality
f) Related documents
g) Manufacturing flow chart that shows the sequence of inspection and test relative to production schedule
h) Description of inspection and testing, including details of the methods and equipment to be used
i) Schedule of equipment showing details of quality activities
j) Control of subcontractors
k) Identification of safety factors
l) Reliability activities
m) Packaging and storage limitations
n) Acceptance criteria

6.2 Quality Manual for a Manufacturing Company

A quality manual for a fiber optic components production company in UK was examined to determine how the ISO 9001 standard was used in the manufacturing industry. The company designed and manufactured fiber optic components and accessories used with laser printers. It had operated a QMS to ISO 9001. The structure of the quality manual simply duplicated the structure of the ISO 9001 standard. It adopted the ISO 9001 paragraph numbering system to address all the quality elements. A brief introduction about the company and manual is given in chapter 1 of that quality manual. The company quality policy including vision and mission statements is stated in chapter 2. An organization chart is shown in chapter 3 to highlight the inter-relationship between the departments in the company. Chapter 4 identifies the quality system and staff responsibilities for the 20 elements in ISO 9001. Chapter 5 is a flow chart to summarize the product development, design, production, inspection, package, delivery and maintenance activities.

6.2.1 Quality Elements

The company's quality system has been detailed in chapter 4 of that quality manual. The system provided a means of identifying activities within the company and identifying how these matched the requirements of customers. The system documented the flow through the company, from planning and initial negotiation about the customer requirements to the production and delivery of the finished product to the customer. The manual also emphasized the role of the top management and the responsibility of each department and each position. The system had been developed following the 20 clauses in ISO 9001 one by one. The necessary quality procedures had been immediately mentioned under the quality elements. Since the ISO 9001 standard had been mainly designed for the manufacturing industry, the company was easily aware of all quality requirements and could directly transfer them to its production line.

Some quality elements, for example clause 4.20 - "Statistical techniques", were difficult to be applied in the consultancy services but were very effective and functional in the manufacturing processes. The manual highlighted that the company's quality philosophy applied a "right first time" approach to product quality by means of statistical process control to determine the fitness of processes for manufacture. As every construction project is unique, the prototype test in the factory could not appropriately be used in the design office.

6.2.2 Overview

Technically, the 20 quality elements in ISO 9001 embraced all activities of a manufacturing company: marketing, contract acceptance, product design, production, inspection, package, delivery, services and administration. Following the step-by-step guide in the standard, the manufacturing company could develop and implement an effective QMS in a factory. Contrary to the manufacturers, the consultants could not simply adapt ISO 9001 to their business. They had not only to be familiar with the quality elements but also to understand the purpose behind each. How this purpose could be interpreted in terms of the consultancy services and documented in the quality manual for implementation and assessment was very important.

6.3 Case Study - KTC Consulting Engineers Limited

To keep abreast of the quality demand from the clients and the requirements of ISO 9000 certification of consultants from the Government, KTC Consulting Engineering Ltd. (an alias is used to keep the firm in confidentiality) intended to seek ISO 9001 certification in September 1996. KTC is a locally established civil and structural consulting engineering firm with about 30 professional and technical staff. Their clients come both from the private and public sectors. The scope of certification covered the "Provision of civil and structural consulting services to customers' requirement". The firm had appointed a quality assurance consultant (QAC) to assist in preparing, implementing and seeking certification. The task commenced in October 1995. A regular weekly management meeting with QAC was arranged to discuss and review the documentation work. The author attended the meetings until the achievement of certification.

6.3.1 Quality Management System

The Technical Director of KTC was appointed as the management representative (MR) to oversee the development of the QMS. All professional staff in the firm had been assigned duties for the preparation of procedural documents. The firm had identified 18 quality system procedures (QSPs) which were required to back up the quality manual. The QSPs for clause 4.5 - "Document and data control" were drafted first in order to create a filing system for the controlled documents. Other QSPs were prepared for the major activities within the scope of certification. The quality manual would be compiled later to include all QSPs for reference.

6.3.2 Quality Procedures Writing

As advised by the QAC, the engineers initially constructed the flow charts for the technical activities and then fine tuned the procedures with their senior engineer. Once the flow charts were agreed, they documented the procedures in an agreed six-section format (Stebbing, 1986) which comprised "objective and scope", "responsibility", "definitions", "procedure", "records and forms" and "references". The draft procedures were released to all involved staff for their review. The comments received from the staff were then considered at the management meeting to determine which were applicable and which were required to be incorporated into the document. The amended procedures were then checked by the responsible staff and approved by the Managing Director prior to issue for use.

Regarding some quality management procedures, for example project quality planning and design control, the staff did not understand the QA concept and encountered difficulties in drafting the procedures to meet the ISO 9001 requirements. The QAC gave some procedure examples to facilitate the documentation work. However, the staff felt that the examples were from construction companies and could not adequately provide relevant information for their business. It was also noted that the QAC could not accurately interpret the requirements of ISO 9001 for the consultancy services, for example design verification and design validation, because of lack of civil engineering knowledge. During the preparation of the project quality plan, useful comments could not be offered on the normal practice in the design office. It was observed that the sole contribution of the QAC was to provide basic quality guidelines in the establishment of QMS and training, but that all the essential works had to be done by the in-house staff.

6.3.3 Quality Manual

A simple structure was designed for the KTC's quality manual, essentially duplicating the structure of the ISO 9001 standard. It was a slim document of just 40 pages. The contents, revision list and glossary were printed as a preface to provide the background information. The manual was then compiled in six main sections: -

a) Quality policy
b) Company background
c) Organization, responsibility and authority
d) Quality system sections
e) List of quality system procedures
f) Control of quality manual

Each page had a title block containing the company name, section title, page number, issue number, revision number and effective date for identification. Such layout was easily updated without affecting other pages.

The quality policy in section 1 stated the company should aim at economical, practical and innovative solutions and complete the project on time with profit. It required all staff to support this goal. Sections 2 and 3 described the activities of the company and set out its management structure. It also defined the responsibilities for the principal managerial and professional posts and established the duties of the MR.

The company's quality system contained 20 sub-sections that collated the 20 elements in the ISO 9001 and were outlined in section 4. Minor modifications to the element items for the sub-section titles had been made to give a better understanding of the company's activities. Each sub-section consisted of three paragraphs - "Scope and responsibilities", "Summary of procedure" and "Supporting procedure". The action required by the staff was clearly defined under each sub-section to avoid confusion. The system for meeting the quality requirements was prepared with due consideration of the company's resources, practices and capabilities. To keep the system simple, the detailed procedures were not included within the manual but documented in the QSPs for reference.

The list of the 18 QSPs was placed under section 5, making cross-references to ISO 9001 clauses. No QSPs were designed for the clauses 4.11 and 4.12. It was observed by the author that the contents in these two clauses did not sufficiently clarify the control of inspection, measuring and test equipment and the inspection and test status in the design office. Even though clause 4.11 might not directly relate to the consultancy service, the need of a QSP for clause 4.12 should be considered.

A quality manual was issued under controlled and uncontrolled conditions. The revision and distribution procedures were presented in section 6. The distribution list was established on the "need to know" rather than "want to know" basis to keep the controlled copies to a minimum. It could reduce the maintenance work for the controlled documents. The QSPs were only made available at point of use, for example drawing office.

6.3.4 Certification Audit

The documentation work of the QMS was completed in June 1996. Selected staff were sent for internal quality auditor training. Fine tunings of the QSPs were continued to eliminate the ambiguities found during the implementation stage. All staff had kept quality records as required for the certification audit in September 1996.

The certification body spent 3 man-days to assess the quality system. 13 minor nonconformities (NCs) in total were found and 5 observations were made. These NCs were identified in the following areas: -

ISO 9001:1994 Clause		No. of NCs
4.1	Management Responsibility	2
4.4	Design Control	2
4.5	Document and Data Control	1
4.6	Purchasing	2
4.9	Process Control	2
4.16	Control Quality Records	1
4.17	Internal Quality Audits	2
4.20	Statistical Techniques	1

The occurrences of NCs and observations were mainly due to the omission of required quality records and oversights on documented procedures for particular activities by the staff. In view of the minor nature of NCs, the MR had immediately prepared and forwarded the corrective action plan to the certification body detailing the proposed correction actions and a programme for implementation. KTC received the ISO 9001 certificate in October 1996.

6.3.5 Overview

KTC is a small consulting engineering firm and its services are mainly in building works. The extent of working procedures for the activities could be well defined and the quality manual was kept simple. The directors had shown strong commitment to and involvement in the quality system. A quality culture was rapidly built up in the firm. The staff prepared the procedures and kept the quality records in accordance with the agreed schedule. The QMS was accepted by all staff as the system had been established by them. It only spent 12 months achieving certification.

The MR opined that the acquisition of ISO 9001 certification was only to meet the Government's new quality requirement. Even though the QMS had improved the document control system in the firm, he had not yet appreciated other significant benefits from the certification. The certification cost, including QAC's fees, was expensive in comparison with the turnover of the company. A small company could not afford the time and money for an extensive quality training programme. The service from the QAC in achieving certification was not very helpful as he had no engineering background. The staff had spent much time drafting the procedures and manual. The MR suggested that a model quality manual for consultancy services could help the consultants build up the QMS independently.

6.4 Case Study - Quality Manual for HAC Limited

HAC Ltd. (alias also) is an overseas multi-disciplinary consulting engineering firm and employs over 300 staff in Hong Kong. It has wide experience on civil and structural engineering projects and specialized in tunnelling and underground structures, transportation and traffic engineering, urban and rural development, water and sewage treatment. As its major client was the public sector, the firm had to be certified to ISO 9001 to comply with the mandatory requirement of bidding for Government projects. It had set up a quality assurance department to establish the QMS by the in-house staff. The firm spent about 24 months and achieved certification by the end of 1995.

6.4.1 Quality Manual

Similar to the KTC Consulting Engineering Ltd., HAC also prepared its quality manual in the style of the ISO 9001 standard. The quality manual simply comprised six sections. The first section was an amendment record sheet listing the changes in the manual. The second section highlighted the distribution and revision procedures for the controlled copies. The next three sections gave the company's scope of services, authorization of staff and quality policy statement. The last section was the 20 sub-sections which explained the company's quality system to ISO 9001. Job descriptions and organization charts were placed in the appendices. Unlike the KTC's manual, HAC linked all sections together without a page break for each section. Any amendment to a single section would have the numbering on the following pages to be adjusted and therefore would need to reissue the whole set.

The firm's quality system was developed following the sequence of the 20 quality clauses in ISO 9001 and gave short instructions to staff on how to perform the duties and to fulfil the quality standard. As a design firm, comprehensive quality procedures for design control and process control had been provided. A disclaimer for clause 4.19 - "Servicing" was made because the firm considered that servicing did not form part of its scope of operations due to the nature of the products supplied to clients. The firm also claimed that its processes used in providing services to its clients never involved the use of statistical techniques, clause 4.20, as part of the services. These arguments were accepted by the certification body and exemption for the clauses granted. However, it is the author's view that the statistical techniques and analysis are often useful for continuous improvement to the QMS.

There was no detailed working procedure incorporated in the manual. Once further instruction was required, a special quality procedure was designed and referred to. There were 34 QSPs in total prepared to back up the quality manual. All procedures contained seven sections namely: "Purpose", "Scope", "Reference", "Definitions", "Responsibilities", "Procedures" and "Records". One of the procedures for the "Project Quality Plan" was designed to record the necessary information for the particular project.

6.4.2 Overview and Observation

HAC Ltd. had prepared a very simple quality manual with only 17 pages but the staff had to refer to 34 QSPs for operation. Although the guidelines to QSPs had been formulated to help them find the procedures relevant to their works, the staff had to read all procedures because all procedures were inter-related. If some instructions in the quality manual could have been further extended, direct information could have been obtained from the manual and the number of QSPs reduced.

The content of the quality manual and procedures were adequate to meet the quality standard. However, it was found that the design output did not satisfy the client's need in a road project. HAC Ltd. was the author's consultant responsible for the design of a road tunnel. The designer proposed to use diaphragm walls with central barrette piles to minimize the excavation work and to support the tunnel slabs. Apart from the designed dead and live loads, he included 50kN surcharges imposed from the adjacent buildings to the tunnel walls. He adopted a simply supported beam method for the structural analysis. The design met the basic requirements in the client project brief and was verified by his senior engineer with a signature in accordance with the quality procedures.

In order to protect the client's interest, a technical inspection of the design work was carried out by the author, who considered that the tunnel box could be designed as a twin-cell structure. Such structural analysis could reduce the bending moment at the mid span and subsequently the thickness of the slabs. The cut off level of barrette piles should be below the bottom slab in order to have a continuous flat slab to eliminate the seepage problem in the construction joints. The surcharges could be reduced as the adjacent areas were highway reserves, for example a wide footpath with utilities, and the diaphragm walls could effectively retain the nominal loading. The author's comments were endorsed by the Highways Department and the consultant took the advice and revised the design accordingly.

Regarding the consulting engineering work, it was a knowledge-based service and wholly dependent on the firm's capability and staff's professional skill. Obviously, HAC had followed the documented quality procedures to prepare and check the detailed design for the tunnel box. Even though all required quality procedures had properly been performed, an incompetent design team could consistently produce a low level of design work. It might marginally reach the design criteria but never meet the client's expectation. The consultants, therefore, should frequently review whether sufficient resources (ISO 9001 Cl. 4.1.2.2) and proper training to the staff (ISO 9001 Cl. 4.18) had been provided for in the design activity. If the client relied solely on the consultant's quality system and only looked into the quality records, he might not receive a cost-effective and sophisticated design. A second party audit, combining the technical inspection with quality system checking, could be the best approach for ensuring the quality of output from a design office.

6.5 Case Study - Quality Manual for CMT Limited

CMT Ltd. (alias) is a world-class multi-disciplinary engineering consultancy. It is a wholly independent international company, based in the UK, with more than 450 staff in Hong Kong. The firm recognized the benefits of implementing a quality system, not only as a means to give clients the confidence that the work was being carried out in a controlled manner, but also as a mechanism to enable staff to improve the management of their activities. The company spent about 18 months and achieved ISO 9001 certification in early 1996.

The scope of certification covered the "Provision of consultancy engineering, design, project management, contract administration and construction supervision services for structural, civil and building projects". As the scope had not explicitly included the study service, the firm was not shortlisted for an engineering feasibility study project by a client. In fact, the firm had already provided such service. If the scope did not fully describe the company's services, it would be detrimental to the business. CMT Ltd. immediately requested the certification body to re-assess its QMS for the extension of the scope.

6.5.1 Quality Manual

CMT's quality system included three levels of documentation. These comprised quality manual, procedures manual and practice manuals. The quality manual identified how the requirements of ISO 9001 had been interpreted by the firm for implementation within a multi-disciplinary consulting engineering practice. The manual also provided details of the structure of the quality system and identified staff responsibilities relating to the management of commissions, implementation and operation of the quality system. The procedures manual consisted of a series of procedures which provided information as to how activities were managed. Procedures identified what had to be undertaken, who was responsible for carrying it out and generating the records. A number of other manuals had been produced for providing guidance and good practice for the staff to follow. These practice manuals would not be subject to quality system audits.

The presentation of CMT's quality manual was radically different when compared with the above two studied manuals. The manual was designed on a process basis. The first five sections highlighted the establishment of the firm, the quality policy statement, the structure of quality system, the organization chart and the responsibilities of key personnel. The next four sections described the major activity processes to be performed within the firm and are as follows: -

a) Company management including sub-sections for dealing with management review and staff training,

b) Project control (technical) including sub-sections for contract review, design control, process control, procurement of sub-contracts and site supervision,

c) Project control (administration) including sub-sections for document control, computer application, control of external suppliers, maintenance of inspection, measuring & test equipment, records control, storage and issue of documents, servicing and statistical techniques,

d) Quality system administration including sub-sections for the handling of feedback, control of defective work, quality auditing and preventing reoccurring nonconformances.

The operational processes under the quality system were detailed in these four sections and collated to the quality elements when required. The staff could get the appropriate instructions to perform their duties but might not be aware of the fundamental quality requirements from the ISO 9001 standard. It was noted that no direct introduction or reference to the procedures manual or practice manuals had been mentioned in the contents of these four sections. A table making cross-reference of the quality manual and procedures manual against the requirements of ISO 9001 was provided at the appendix to help staff find suitable procedures for their duties and to assist the auditor to check the compliance with the standard. The table showed that there were 11 paragraphs in the quality manual and 12 procedures manual relevant to ISO 9001 clause 4.9 - "Process Control" and 2 paragraphs in the quality manual and 8 procedures manual for clause 4.5 - "Document and Data Control". It was observed that inter-related quality activities had not been grouped into a single section for action. The dispersal of the quality requirements in the quality system could cause difficulty during implementation and auditing. CMT also claimed that clause 4.19 - "Servicing" and clause 4.20 - "Statistical Techniques" were not applicable to their normal services. Where these activities were required, they would be controlled through the preparation and implementation of the project quality plan.

32 procedures manual had been prepared for the QMS. Each procedure consisted simply of five sections entitled "Scope", "Reference", "Procedures", "Records" and "Attachments". The responsibilities of the staff were identified in the procedures section. 65 forms were designed to facilitate the checking and recording of that quality performance. The procedure for the preparation of a project quality plan had 20 pages and provided a tight control on the particular project.

6.5.2 Overview

The CMT' quality manual was process-oriented. It became a simple working manual to give an overall picture to the staff on how to perform their duties. However, the content of the sections did not contain sufficient quality information or reference to ISO 9001. The staff had to seek supplementary procedural guidelines through the specially designed table. The layout of the manual and the number of procedures might completely exhaust the staff's understanding of the whole QMS.

The certification body accepts any type of quality manual provided that it fully describes the organization's activities and complied with ISO 9001 requirements.

However, it is the author's view that if a quality manual was designed in line with the ISO 9001 standard's structure, it would enable the readers to become more familiar with the standard and could allow direct comparison between their QMS and the stated quality requirements for improvement. CMT's quality manual did not follow this criterion. In addition to the structure of the quality documents, the scope of certification was also an important subject in the QMS and should be clearly defined in the quality manual.

6.6 Acquisition of ISO 9001 Certification by Territory Development Department

As mentioned before, the Secretary for Works launched a Quality Policy in March 1994 which required all major consultants and contractors to be certified to ISO 9000 standards by 1996. The Territory Development Department (TDD) of the Hong Kong Government, being the major works department responsible for consultancy management and project administration, had to install its QMS to keep pace with the quality development in the construction industry (Cheung and Kam, 1997). The author, working in the TDD, was requested by the department to be a Quality Manager to establish a QMS to ISO 9001 certification for the department. The quality development programme commenced in August 1997 and the department acquired certification in December 1998.

6.6.1 Selection of ISO 9000 Standard

The main role of the TDD is to provide lands and balanced development for new towns and urban areas. It is a works department employing consultants for the design and supervision of the construction of civil engineering projects. Its staff was mainly involved in project and consultancy administration and did not carry out detailed design work for any engineering project. Superficially, the TDD's functional capacity was likely to fall within the ISO 9002 as no design work was involved. However, the TDD prepared specifications and documents for an engineering consultancy brief and made decisions and comments on the design output submitted by the consultants. It was considered that the adoption of ISO 9001 for the department was more appropriate. A preliminary consultation with the certification body reinforced the concept. The installation of QMS to ISO 9001 would have the same quality standard as the consultants and contractors. Considering the TDD's organization and operations, the department planned to achieve ISO 9001 certification within 18 months. The scope of certification covered the major activity of "Project management services for civil engineering and associated works".

6.6.2 Coverage of Certification

Most of the works departments in the Works Bureau started on the development of their QMS from office or division level (Ng, 1997). The TDD had five regional development offices of which functional activities were basically similar. The development of a QMS in each office depended on the judgment of the Project Manager as the head of the office. He made decisions on the quality procedures for the activities directly prepared by his staff. The certified quality system could then be referenced by other development offices when developing their QMS for certification. However, it would be difficult to unify the operations at a later stage when each office already had its own quality manual and as a consequence, would take much longer to achieve a global ISO 9000 certification for the department. Therefore, the department adopted another approach to gain the certification for the department at one go.

With well planned co-ordination between headquarters and development offices, all staff shared the heavy workload generated from the documentation of the QMS in the TDD. The discussion of quality procedures at office level provided agreed working procedures for departmental operations. The working groups for preparation of quality procedures united staff from regional offices and improved the communication and morale in the department. Though the certification for the whole department would require instant input from all staff in the TDD, it was considered that such an arrangement would be beneficial in terms of staff resources and programming.

6.6.3 QMS Development Programme

The QMS development programmes were implemented in three stages: -

Stage 1 - System Review

Before embarking on the installation of a QMS, an examination of the department's current operations and system was necessary in order to conduct an evaluation against the requirements of the ISO 9001 standard. The purpose of the system review was to enable the department to make an assessment of the time frame and resources required for putting the QMS in place.

Stage 2 - Development, Implementation and Training

After reviewing existing practices and identifying the critical aspects of activities, the quality management team documented and developed them in a clear and precise format to facilitate a subsequent review and audit. Approval of the implementation of the documented procedures was then given by the steering committee. Sufficient time and resources for quality training, education and awareness were provided at this stage.

Stage 3 - Internal Audit and Certification Assessment

A series of comprehensive internal audits to the whole QMS was conducted prior to the certification audit. Documentation review and corrective actions were completed before certification assessment.

6.6.4 Achievement of ISO 9001 Certification

The process of developing, implementing and obtaining ISO 9001 certification for the TDD is shown in Figure 6.1.

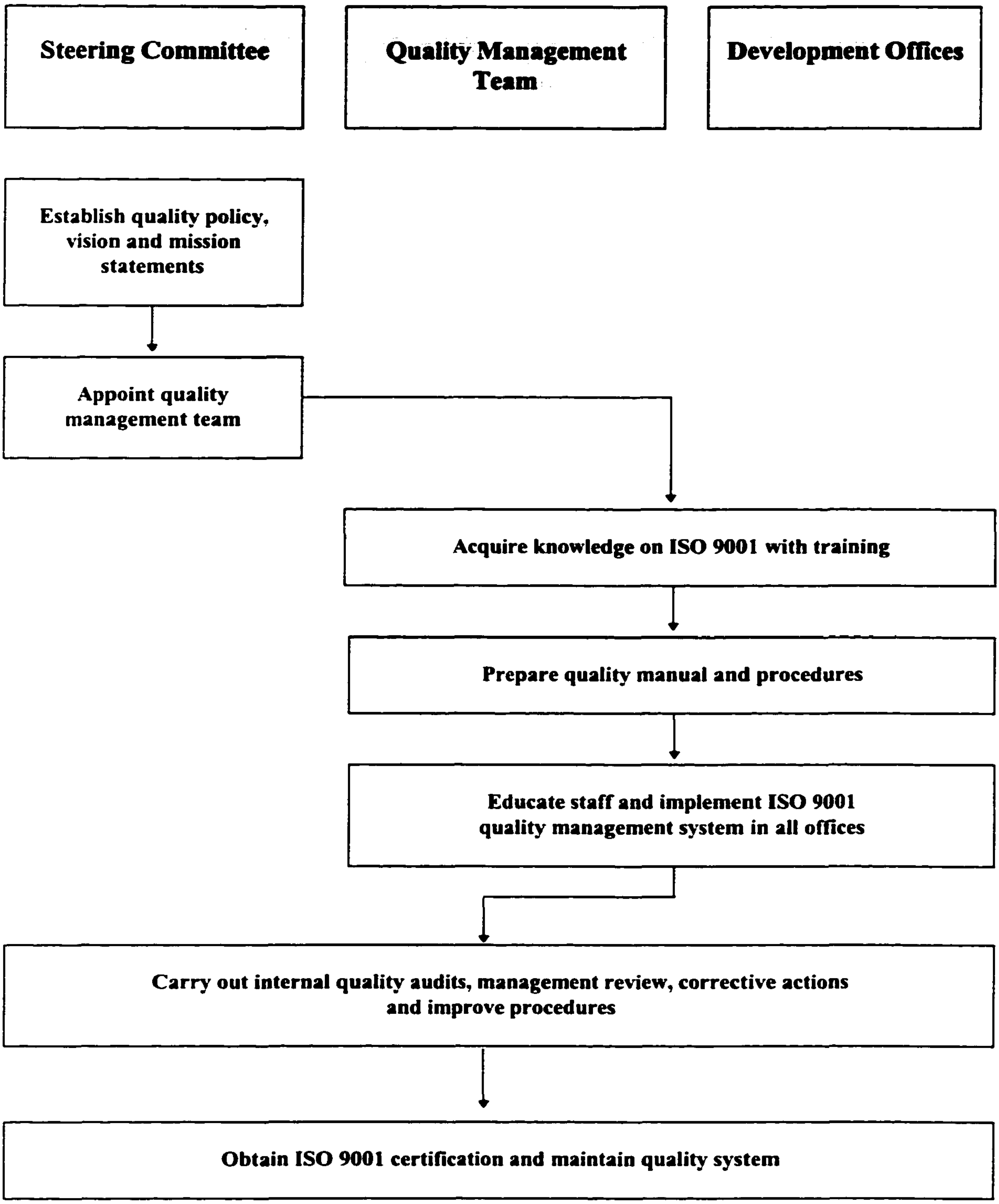


Figure 6.1 : Procedure for QMS Development in Territory Development Department

Seven steps had been implemented for achieving certification: -

Step 1 - Affirmation of Management Commitment

The establishment of the QMS could succeed only with the initiative and commitment of top management. The management's commitment had a positive effect and served as a strong motivation to the staff in implementing the system. With support from the top management, the QMS was installed effectively. The Director and Project Managers had affirmed their support of the system before the programme started.

Step 2 - Formation of Steering Committee and Quality Management Team

A steering committee had been formed to provide direction, co-ordination and supervision of the strategies employed in putting the QMS into place. An Assistant Director was appointed as Management Representative to oversee the documentation work and the implementation of the system. The initial study and ground work needed to be done by a quality management team. Team members were nominated from each development office.

Step 3 - Familiarization of ISO 9001 Requirements

The TDD engaged quality assurance consultants to assist in developing and implementing the quality system. The selection of consultants was based on their quality management experience with works departments and training techniques. The consultants were required to assemble the quality system, plan the implementation strategy and carry out the mock audit for the department. The rest of the effective implementation, review, maintenance and system improvement had to be done by the quality management team and our staff. To avoid any divergence and to keep the consultancy on the right track, the consultants were closely monitored.

Key staff had been trained in an understanding of the ISO 9001 standard, documenting the quality system to meet the quality requirements, and conducting internal audits. A clear understanding of the ISO 9001 requirements and interpreting them to the operations of the TDD were essential as these staff were responsible for drafting the manual and procedures.

Step 4 - Preparation of Quality Manual and Procedures

Officers responsible for the operations were assigned for drafting the relevant parts of the quality manual and procedures with assistance from the quality assurance consultants because: -

a) the operations personnel were most familiar with the procedures and they would know the most effective ways of executing the operation,

b) staff would view the system as part of their efforts.

Initially, a set of activity flow charts was drawn to identify the operations that actually required comprehensive procedures to be written. The steering committee had to decide on the best or most effective way for the department to adopt. To avoid excessive paperwork, the existing Government procedures and instructions were not directly copied in the manual but were referenced to their sources by a simple "pointing system". For example, the required procedures for selection of consultants shall follow an external document Works Bureau Technical Circular (WBTC) No. 16/95. In the TDD's quality procedure, it simply mentions about the basic requirements from the department and then points to WBTC No. 16/95 for details.

The author prepared the quality manual and some quality system procedures. Having studied other quality manuals, he designed the format and layout of the manual in line with the ISO 9001 structure. 19 quality procedures had been identified to cover all major activities for certification. These procedures were presented in a "ten-point system" to provide more clarity. All documents were produced in hard and soft copies to meet staff requirements. The quality manual was checked and accepted in its entirety by the certification body, HKQAA, at the first assessment visit.

Step 5 - Education and Implementation

The method of delivering the new QMS to the entire staff was carefully planned as this would have a significant influence on its acceptance. Adequate education and awareness promotion can reduce the learning curve for following the system. Training courses including quality awareness, procedure writing, internal audit and QMS implementation had been conducted to let the staff learn the quality management technique. Quality news had been published in the department's newsletters to keep staff informed of the QMS development programme. Implementation of the QMS was completely done across the board. This application was to ensure that all the procedures in the headquarters and all development offices were tested at the same time.

Step 6 - Internal Audit, Feedback and Review

Internal audits were conducted after a three-month trial run of the QMS. This was good training for the quality management team and also provided a forum for officers on the ground to respond to the procedures that were drafted. The steering committee carried out the management review following the internal audits. Corrective actions were taken to improve the system.

Step 7 - ISO 9001 Certification

The acquisition of the ISO 9001 certification was both a major target of and an achievement for the department. The best possible result in the certification audit was obtained. Neither "nonconformity" nor "observation" was found. It was proved that the quality system was accepted by the staff and easily followed. The quality records demonstrated the full compliance of the new QMS to ISO 9001. The lead auditor commended the strong commitment from the top management in securing the certification result and the QMS had brought an innovative idea in the continuous improvement area.

6.6.5 Overview

Even though the TDD itself is a Government department, the ISO 9001 certification award would demonstrate to its clients and public that a quality system was being implemented. Internally, it could improve the operation efficiency as agreed quality procedures were in place. It could also enhance the morale of the staff as formal recognition of their QMS had been obtained. Externally, the department could maintain a certified QMS and keep abreast of consultants and contractors in the quality management development.

As a Quality Manager, the author found that the planned "seven-step" approach to achieve certification was effective in gaining the co-operation of both the top management and the staff. There were additional quality requirements to be followed by the staff but the designed QMS documents were user-friendly and were not a burden to them. This arrangement led the TDD to spend only 16 months to obtain certification in December 1998, two months ahead of schedule.

6.7 Quality Assurance System for the Consultants

The basic requirements of a quality assurance system are that the organization: -

a) prepares a documented quality system which covers all aspects of its quality procedures and instructions,

b) puts the quality system into practice,

c) maintains the quality system by both monitoring its application and improving it by frequent constructive audits and reviews.

A good QMS could help organization streamline the working procedures and improve its overall performance. The quality manual should be a useful directory to which the staff can refer to. If a well structured quality manual and procedures are available, the staff can easily become familiar with the ISO 9001 standard and meet the quality and operational requirements in all aspects.

6.7.1 Quality Manual and Procedures for the Consultants

From the above case studies, it was found that although the ISO 9000 series was written for all industries, its contents and structure favoured the manufacturing industry. It was evident that the fiber optic components production company could completely transfer its production process to fit all quality requirements of ISO 9001. As consulting engineering services were knowledge-based and project-oriented, the development of quality system for the consulting firms could not strictly follow the quality standard. The difficulty, experienced by the consulting firms under study, was in part due to the fact that the ISO 9001 was not easily interpreted in terms of and directly applied to the consultancy services.

Any style of quality manual could be accepted by the certification body, subject to all appropriate quality elements being adequately addressed for assessment. The ISO 10013 standard allowed flexibility for the organization to prepare a quality manual to suit its particular operation. The time spent for achieving ISO 9001 certification by the above three consulting firms in the case studies varied from 12 months to 24 months. By comparing the contents of their quality manuals, it was observed that the time required for achieving certification was proportional to the number of quality procedures and services provided. KTC and HAC's quality manuals, which simply duplicated the structure of the ISO 9001, were effectively maintained and user-friendly. On the contrary, CMT's quality manual designed on a process basis could not group the quality requirements under a particular section and brought the difficulties in implementation and auditing.

Although the ISO 9001 did dictate that the organization should have procedures for a variety of processes, not one sentence in it specified how anyone should implement a particular clause nor did it state how many procedures need to be written (Lamprecht, 1996). It had already been found that some quality procedures were essential, some less so, some could no doubt be dispensed with altogether in a quality system (Ashford, 1989). KTC had written 18 quality system procedures for its quality management system. HAC and CMT had prepared more than 30 quality procedures to back up their quality manuals. The extensive procedures list encountered the argument that excessive paperwork introduced as part of a quality system added unnecessary burdens to the engineers. Clearly there was a need for control. Through the above case studies, it was observed that if the contents of some sections in the quality manual could be revised and slightly expanded, a number of quality procedures could be omitted and replaced by simple instructions. Therefore, a balance design between the quality manual and procedures should be provided.

6.7.2 Quality Documents, Procedures and Records as Required by ISO 9001

In general, processes which affect quality shall be carried out under documented procedures. Having reviewed the above consulting firms' and TDD's quality manuals, this section proposes which essential quality documents, procedures and records should be contained in a QMS for consulting firms, as required by ISO 9001. The author recommends that the quality system in order to meet the operational needs should include all or part of the documentation as outlined in Table 6.1 below. The table is developed originally by the author. The omission of these quality documents will adversely affect quality performance in a design office.

It is found that the project quality plan is an important document for new construction projects. Therefore, a special quality procedure for the preparation of project quality plan should be incorporated into the QMS for proper control. The project quality plan is used as the document, procedure and record to fulfil the quality requirements under the QMS in order to cut the redundant documentation. Though some firms have already established their own QMS, the proposed documentation can help the ISO 9001-certified firms review their systems for necessary improvement and control. It also provides an overview to the non-certified companies about the amount of paperwork needed.

Table 6.1 : Quality Documents, Procedures and Records as Required by ISO 9001

ISO 9001 Clause No.	Documents	Quality System Procedures (QSP)	Records
4.1.1	*Quality policy* 1. Quality Policy Statement		
4.1.2.1	*Responsibility and authority* 1. Organization Chart 2. Duties List		
4.1.3		1. QSP 1.1 Management Review 2. QSP 1.2 Management Review Meeting Agenda	*Management review* 1. Management Review Meeting Minutes
4.2.1	*Quality system* Quality Manual		
4.2.2		*Quality system procedures* 1. QSP 2.1 Preparation of Quality Procedure	
4.2.3		*Quality planning* 1. QSP 2.2 Project Quality Plan	
4.3.1		*Contract review* 1. QSP 3.1 Contract Review 2. QSP 2.2 Project Quality Plan	
4.3.4			*Contract review* 1. Contract Review Checklist 2. Contract Review Record

4.4.1		*Design control* QSP 4.1 Design Control	
4.4.2	*Design and development plan* 1. Project Quality Plan		
4.4.4	*Design input* 1. Project Quality Plan		1. Design Input Checklist
	Design output 1. Project Quality Plan		1. Design Output Checklist
4.4.6	*Design review plan* 1. Project Quality Plan		*Design review* 1. Design Review Schedule 2. Design Review Report 3. Design Review Actions
4.4.7			*Design verification* 1. Design Review Schedule 2. Design Review Report 3. Design Review Actions
4.4.8			*Design validation* 1. Design Review Schedule 2. Design Review Report 3. Design Review Actions
4.4.9	*Design changes* 1. Quality Manual	1. QSP 4.2 Design Change Control 2. QSP 2.2 Project Quality Plan	1. Design Change Report
4.5.1		*Document and data control* 1. QSP 5.1 Internal Document Control 2. QSP 5.2 External Document Control	1. Quality Manual and Procedures Master List 2. Document Distribution List 3. Document Transmittal Record 4. Quality Forms Master List

4.5.2	*Master list of documents* 1. Quality Manual		1. Quality Manual and Procedures Master List 2. Quality Forms Master List
4.6.1		*Purchasing* 1. QSP 6.1 Procurement of Sub-consultant Services	
4.6.2			*Approved sub-contractor list* 1. Approved Sub-consultant List 2. Sub-consultant Performance Report
4.6.3	*Purchasing data* 1. Quality Manual	 1. QSP 6.1 Procurement of Sub-consultant Services 2. QSP 2.2 Project Quality Plan	
4.7		*Customer-supplied product* 1. QSP 7.1 Control of Customer-supplied Information 2. QSP 2.2 Project Quality Plan	*Unsuitable customer-supplied product* 1. Client-supplied Drawings List 2. Client-supplied Documents List 3. Project Quality Plan
4.8		*Product identification and traceability* 1. QSP 5.1 Internal Document Control	*Identification of individual product* 1. Document Distribution List 2. Document Transmittal Record
4.9		*Process control* 1. QSP 9.1 Feasibility Study 2. QSP 9.2 Conceptual Design 3. QSP 9.3 Preparation of Tender Documents 4. QSP 9.4 Issue of Tender Documents	*Qualified processes, equipment and personnel* 1. Project Quality Plan

		5. QSP 9.5 Evaluation of Tenders 6. QSP 9.6 Contract Administration 7. QSP 9.7 Site Control and Supervision 8. QSP 2.2 Project Quality Plan 9. QSP 4.1 Design Control 10. QSP 6.1 Procurement of Sub-consultant Services	
4.10.1		*Inspection and testing activities* 1. QSP 10.1 Inspection, Measuring and Testing Equipment 2. QSP 10.2 Computer Application 3. QSP 4.1 Design Control 4. QSP 5.2 External Document Control 5. QSP 6.1 Procurement of Sub-consultant Services 6. QSP 9.5 Evaluation of Tenders	*Inspection and test* 1. Project Quality Plan 2. Record of Inspection, Measuring and Test Equipment 3. Record of Approved Computer Data
4.10.2.1		*Verification of conformance* 1. QSP 10.1 Inspection, Measuring and Testing Equipment	
4.10.2.2			*Evidence of conformance* 1. Project Quality Plan
4.10.2.3		*Positive recall* 1. QSP 2.2 Project Quality Plan	*Product released prior to verification* 1. Project Quality Plan
4.10.3		*In-process inspection and testing* 1. QSP 2.2 Project Quality Plan	
4.10.4		*Final inspection and testing* 1. QSP 2.2 Project Quality Plan	

4.10.5			*Inspection and test* 1. Quality Test Record
4.11.1		*Control of Inspection, measuring and test equipment* 1. QSP 10.1 Inspection, Measuring and Testing Equipment	*Test software checks* 1. Record of Inspection, Measuring and Test Equipment 2. Record of Approved Computer Data
4.11.2	*Basis for calibration process* 1. Quality Manual *Validity of previous results when test equipment found out of calibration* 1. Quality Manual	1. QSP 10.1 Inspection, Measuring and Testing Equipment 1. QSP 10.1 Inspection, Measuring and Testing Equipment	*Calibration for equipment* 1. Equipment Register 2. Calibration / Maintenance Record 3. Calibration Report
4.12		*Inspection and test status* 1. Quality Manual 2. QSP 2.2 Project Quality Plan	
4.13.1		*Control of nonconforming product* 1. QSP 13.1 Non-Conforming Product Control	
4.13.2		*Review of nonconforming product* 1. QSP 13.1 Non-Conforming Product Control *Re-inspection of repaired product* 1. QSP 13.1 Non-Conforming Product Control	*Condition of repaired nonconforming product* 1. Non-Conforming Record 2. Corrective Action Report 3. Register of Corrective Action Reports

4.14.1		*Corrective and preventive action* 1. QSP 14.1 Preventive and Corrective Action	*Changes in quality procedures* 1. Corrective Action Report
4.14.2			*Results of nonconforming investigation* 1. Corrective Action Report
4.15.1		*Handling, storage, packaging, preservation and delivery of product* 1. QSP 15.1 Records and Archive 2. QSP 5.1 Internal Document Control 3. QSP 5.2 External Document Control 4. QSP 16.1 Control of Quality Records	
4.16		*Control of quality records* 1. QSP 16.1 Control of Quality Records 2. QSP 15.1 Records and Archive	*Quality records including sub-contractors* 1. Archives Instruction Form 2. Archived Documentation Register 3. Archives Box List 4. Archives Reclaim Form 5. Archives Disposal Form 6. Quality Records Retention Period List 7. Microfilm Drawing
4.17		*Internal quality audits* 1. QSP 17.1 Internal Quality Audits	*Audit results* 1. Internal Audit Schedule 2. Internal Audit Notification 3. Internal Audit Checklist 4. Internal Audit Timetable 5. Non-Conformance Report 6. Corrective Action Request 7. Observation Report 8. Audit Opening Meeting 9. Audit Closing Meeting 10. Internal Audit Report

			11. Internal Audit Report Log 12. Corrective Action Request Log *Follow-up audit activities* 1. Completed Non-Conformance Reports
4.18		*Training* 1. QSP 18.1 Training	*Training* 1. Staff Training Record 2. Personnel Record 3. Training Plan 4. Training Application Form
4.19		*Servicing* 1. QSP 19.1 Post - Project Servicing	1. Maintenance Schedule 2. Handing Over Records
4.20.2		*Statistical techniques* 1. QSP 20.1 Statistical Techniques	1. Statistical Methods

The above table has used the concept of the quality system documentation hierarchy to define, structure and cross-reference all levels of documentation. It is a useful checklist of quality system procedures and corresponding records required for most consulting firms. The proposed quality system procedures in the table under Clauses 4.1, 4.2, 4.11, 4.12, 4.14, 4.16, 4.17 and 4.18, such as QSP 1.1 - "Management Review" and QSP 17.1 - "Internal Quality Audits", are required for the management and maintenance of a QMS. The other proposed quality system procedures under the remaining 12 ISO 9001 clauses, such as QSP 6.1 - "Procurement of Sub-consultant Services" and QSP 9.1 - "Feasibility Study", are the essential operational procedures for consulting services. The decision as to which quality system procedures and records should be documented must be based on the company quality policy's objectives. The management and quality assurance manager should determine and include all necessary documents in their QMS.

6.7.3 Second Party Audit to Quality Assurance System

Pendrous (1993) pointed out that ISO 9000 certification only guaranteed consistency of quality: if you put rubbish in the QMS, you still got rubbish out - guaranteed. The author had such experience with HAC. The design team of HAC followed its ISO 9001-certified QMS and consistently produced low level of design work which could not meet the client's expectation (see Section 6.4.2). In order to resolve the problem, the author proposed to conduct a second party audit for ensuring the quality of output from a design office. Through the research, Tam (1999) also supported the second party audit to be conducted by the client. He believed that the operation of such checking could enable the client to take effective action to timely rectify any nonconformities. A similar practice had successfully been implemented by MTRC for railway projects. The second party audit gave added value to the Corporation in project management (MTRC, 1999). From the questionnaire survey result, this proposal was generally accepted by the consultants (see item 7 in Figure 5.6).

6.7.4 Model Quality Manual for Consultants

Experience and research had indicated that in producing a QMS organizations tended to encounter two major problems: not appreciating the volume of work required to prepare the system and balancing the need for both a knowledge of QA and an understanding of the functioning of the organization (Hughes and Williams, 1995). The use of quality assurance consultants (QAC) in most cases would provide the organization with the basic philosophy of a QA system but they often lacked technical knowledge of the tasks that such a quality system should address.

KTC had employed QAC for setting up its QMS. The management representative (MR) of KTC concluded that the QAC was not very helpful in preparing the quality manual as the latter had no engineering background. Some engineers also complained that the QACs tried to change their normal operational procedures to fit the ISO 9000 requirements (see section 5.5.2). HAC and CMT had developed the QMS by their quality assurance managers but the format and style of their quality manuals were not satisfactory. As most of documentation work were done by in-house staff, the MR suggested producing a model quality manual to help the consultants build up the QMS independently. This proposal had received strong support from other consulting firms (see item 6 in Figure 5.6). Leung (1993) identified the need of model quality documents for the construction industry. Lee (1992) and Rothery (1995) had already successfully produced model documentations for manufacturers to assist them in preparing quality manual for ISO 9000 certification. Model quality systems had been continuously designed by the researchers for other industries (Brooks, 1994; Johnson, 1997). The development of model quality manuals for the construction industry was considered necessary.

Although the ISO 9001 was designed fundamentally for manufacturing industry, yet it can apply to consultancy services if it is suitably structured. From the case studies, it was found that the quality manuals under study still had room for improvement. Through the above case studies and with hands-on experience in consultancy management and writing the manual for the TDD, the author prepared a model quality manual for the consulting engineering services (see Appendix C). The firm, Polytec Consulting Engineering Limited, described in the model, is an imaginary one. Its scope of certification, which covered the general consulting engineering services, was for the "Provision of study, investigation, design, tendering and site supervision for civil, structural and associated engineering consultancy services". The manual with recommended quality procedures provided a balance design to meet both the design office processes and quality standard requirements. The adopted layout and format could be considered to meet the document control and maintenance purpose. Although most of the consultants had claimed exemption from clauses 4.19 and 4.20 of ISO 9001, these quality elements were still included in the model for consideration when necessary.

Most of the consulting engineering firms had already established and implemented their certified QMS. The model manual was intended to provide an opportunity for them to review their system for improvement, if applicable. It was also noted that the ISO 9000 certification requirement would be extended by the Government to cover all medium consulting firms and contractors in the near future. The model document could help these organizations to have a short cut to find out the best way in setting up a more effective and reliable quality system.

CHAPTER 7

ISO 9000 QUALITY ASSURANCE SYSTEM FOR THE CONTRACTORS

In the previous chapter, QMSs of consulting engineering firms were discussed. In this chapter, that of construction companies will be looked into. Nee (1996) pointed out that the construction industry was lagging behind in the realization that client satisfaction was the secret to success. The contractors were still wrestling with the concept of "the lowest bidder gets the job". As the client continued to push for a higher quality, individual construction companies would be forced to become more efficient, quality-focused and cost-competitive if they expected to be considered as acceptable bidders on a construction project.

From 1992, the Hong Kong Government initiated a quality assurance requirement for all Airport Core Programme (ACP) projects. The Government wished to have more confidence in the quality performance of these important items. All ACP contractors had to set up a QMS to meet the contractual requirement. Three quality plans developed for ACP projects by contractors were studied to investigate how they could meet the quality requirement.

Following the success in the ACP projects, the Government continued its quality journey throughout the construction industry and requested all its major contractors to seek ISO 9000 certification. Starting from October 1996, ISO 9000 certificate had been a prerequisite for bidding for Government Group C contracts. Most of construction companies had established their own quality system and prepared the quality manual for certification. Hellard (1993) considered that the quality standards required from the contract had already been specified in the contract documents and the addition of references to ISO 9000 was likely to be more confusing than helpful. In view of the findings in Chapter 5, his comments might not be true. Three quality manuals from contractors were collected for further elaboration. As these quality manuals were confidential documents, the company's names were not disclosed and replaced by aliases. This chapter has tried to explore how the contractors prepare their quality systems for ISO 9000 certification and at the same time satisfy their company policy. As the responding contractors in Chapter 5 were eager for a relevant ISO 9002 standard quality manual for their trade, a model quality manual was prepared for their reference.

7.1 Quality Assurance in Airport Core Programme Projects

The Hong Kong Government established the policy that all Airport Core Programme projects should have a quality assurance system in relation to the management, design, construction and installation of the works. Following the policy statement, a contractual requirement to provide a quality plan was laid down in the Clause 45 of the General Conditions of Contract for ACP Civil Engineering Works (NAPCO, 1992a).

As required under the ACP Procedures (NAPCO, 1992b), the tenderers must submit as part of the tender an outline quality plan illustrating their intention of compliance with the requirements of the QA system. The outline quality plan should contain sufficient information to demonstrate clearly the proposed method of achieving the tenderer's quality objectives with regard to the requirements of the contract. It would form the basis for the development of detailed quality plans for the contract.

A study of the ACP project quality plans was carried out in 1994. The objective of the study was to find how these quality plans could meet the QA requirements during the infant quality development stage in Hong Kong.

7.1.1 Quality Plans for ACP Projects

Three ACP project quality plans prepared for the harbour reclamation, the reprovisioning of a typhoon shelter and the suspension bridge contracts have been studied. These quality plans were prepared by the contractors in accordance with the ACP Procedure 311 - "Quality Assurance" for submission to the Engineer for approval. The quality plans generally consisted of QA policy statements, management quality plans, design quality plans, and construction and installation plans for all major activities in the contract. A manufacturing quality plan was required when the non-standard proprietary equipment and materials were used for the contract.

7.1.2 Management Quality Plan

The management quality plan defined the structure for the development and implementation of a quality system for construction management. It included those management procedures relevant to the site activities. The required procedures were: -

a) Organization and Responsibility
b) Correspondence
c) Oral Communications
d) Records
e) Change Control
f) Subcontract Services
g) Quality Audit
h) Quality Plan Review and Revision
i) Inspection, Measuring and Test Equipment
j) Archives
k) Training

Additional procedures could be added in the quality plan to meet particular requirements in the contract.

7.1.3 Design Quality Plan

The design quality plan outlined the process for the design work. The proposed design procedures were similar to but not as detailed in the Clause 4.4 - "Design Control" of ISO 9001. The design performance, design methodology, design control and design review were the major activities for documentation. A checking engineer was appointed as an independent checker for the design of temporary work. The design quality plan could ensure the adequacy of the design works on site.

7.1.4 Construction and Installation Quality Plan

This quality plan highlighted the factors required for the preparation of construction and installation works. As a contractor, the methods of construction and installation were essential for the completion of a contract. The quality plan covered the quality requirements on material, workmanship, method statement, inspection and testing, handling of non-conformance, corrective action and auditing. A good construction and installation quality plan would be a very useful tool for construction works.

7.1.5 Comments

In order to meet the new airport opening schedule, the "right first time" approach was essential for all ACP projects. A tight control on the design, construction, materials and programming was necessary. Under the ACP General Conditions of Contract, contractors should meet the Government's quality requirements that the works should be constructed in accordance with the specified QA procedures. They had submitted the above quality plans to the Engineer for approval and auditing. The success in the QA system would be eventually determined by the contractor's contributions and the Government's commitment. Since these three projects were undertaken by overseas contractors with ample quality management experiences, all quality plans were basically developed from their ISO 9001 quality system. These quality plans, incorporating the local practices, could provide sufficient quality guidelines to the staff for implementation. The technical staff were instructed by the project managers of these contracts and could easily follow the documented procedures and achieve the defined quality standards in all aspects. However, problems were often encountered due to the fact that the quality procedures could not be directly applied to their labourers and subcontractors. Furthermore, the approval and comments on the quality plans by the Engineer were arbitrary due to inadequate training provided for their quality auditors.

In comparison with the ISO 9000 quality standards, the ACP Project Procedures only consisted of some (not all) quality clauses in ISO 9001 since it had been devised for the site management only. If the contractors were ISO 9000-certified, the Government would be more confident that the contractors would achieve a high quality standard in these important projects.

The HK$ 155.3 billion Airport Core Programme comprising ten inter-related infrastructure projects had been acclaimed for its completion with high quality, on schedule and within budget. In view of the success in ACP projects, the Government extended its quality management requirements to ISO 9000 certification for its major contractors from 1996. Three case studies on how the contractors prepared their quality manual for ISO 9000 certification are detailed below.

7.2 Quality Manual for GAB (Singapore) Pte. Ltd.

GAB (Singapore) Pte. Ltd., which is an international contractor, had participated in the construction of major building, civil engineering and infrastructure works throughout the world including Hong Kong and Singapore. The quality manual of GAB (Singapore) Pte. Ltd. was chosen for the study of the QA practice of the contractors in Singapore.

GAB's quality manual was planned to meet the Singapore's national standard SS ISO 9001:1994 (identical to ISO 9001:1994). The scope of certification covered "The design and construction of building and civil engineering projects and associated infrastructures". The Company achieved SS ISO 9001:1994 certification in 1996. The quality procedures were developed to provide the customer with the assurance that the quality of the product would meet the contractual requirements.

7.2.1 Quality Assurance Manual

The Company's manual was divided into six sections. The first section highlighted the control and maintenance of the manual. The second section described the Company profile. The third section gave the Company quality policy. The management responsibility (Cl. 4.1 of ISO 9001) occupied section 4 and quality system (Cl. 4.2) was detailed in section 5. The remaining 18 clauses were grouped as system procedures under section 6. Apart from these 20 standard clauses, it was noted that a special clause for "subcontracting" was supplemented under Cl. 4.6 - "Purchasing".

Section 1 - Quality Assurance Manual Control

This section introduced the Company's aim at providing quality assurance to its clients and complying with the scope of the SS ISO 9001 certification. It also defined the responsibilities of Quality Assurance Manager and Managing Director for preparing, reviewing and approving the quality assurance manual. The copy holders of this manual were required to keep the manual updated. A revision record sheet was also included for identification.

Section 2 - Company Profile

The establishment of the Company has been depicted in this section. It describes the general organization and the construction activities offered by the Company.

Section 3 - Quality Policy

The triad relationship among quality, time and cost was the foundation of GAB's culture and commitment to its clients. GAB requested all staff from the top down to share in the responsibility for the proper quality of its products and services. The Company's quality management system was established from SS ISO 9001 but would be continuously improved towards total quality management (TQM). The objectives of the quality management system were to ensure that the products and services provided by GAB complied with the specified contractual requirements. All staff were required to understand and henceforth diligently implement this policy.

Section 4 - Management Responsibility (Cl. 4.1)

In this section, the organisation charts for the Company and typical project site office clearly identified the inter-relationship between each post and department. A detailed duty list described the responsibilities and authority for 26 important posts. A supplementary note in the list pointed out that responsibilities of the project staff might vary depending on the organisational structure of the project and the amendments to responsibilities of the project staff would be defined in the project quality plan. It could reduce the number of amendments in the quality manual.

Regarding the resources, a proper approval procedure for the allocation of manpower, material and equipment was prepared.

The QA Manager was appointed as the Company's Management Representative to implement and maintain the quality assurance system. He reported directly to the Managing Director for the implementation of the QA policy. The arrangement for conducting the annual management review are laid down in this section.

Section 5 - Quality System (Cl. 4.2)

The quality system was maintained in the following documents: -

Company System: -

a) Quality Assurance Manual
b) Company System Procedures
c) Information Data Documents
d) Company Operational Document

Project System: -

a) Project Quality Plan
b) Project System Procedures
c) Subcontractor Quality Plan
d) Site Method Statements
e) Project Design Plan
f) Servicing and Maintenance Plan

Staff received the whole or part of these documents according to the document issue list for the duration of his employment in the Company. A hierarchy of quality system documentation and a cross-reference of SS ISO 9001 requirements to the contents of the quality assurance manual and 21 company system procedures were also tabulated in this section for quick reference.

Section 6 - System Procedures (Cl. 4.3 to Cl. 4.20)

The company system procedures were prepared in line with SS ISO 9001 requirements and summarized below: -

Cl. 4.3 - Contract Review

The contract reviews were required in three stages: -

a) Pre-contract review
b) After signing contract review
c) Contract stage review

All records of reviews were required to be kept in a contract review file. Whenever amendments to the contract were made, the Project Manager should transfer the information to the concerned staff and departments.

Cl. 4.4 - Design Control

A project design plan was prepared for design control of each project. The design management and co-ordination role included appointment of designers, provision of design briefs, design review, assignment of design verification and validation, and co-ordination between designers, clients and subcontractors. Design control procedures should ensure that all required design validation, demonstrations and tests were carried out by the assigned engineer in accordance with the specified requirements. Formal design reviews with designers and other concerned parties should be conducted at the defined stages. Verification should consist of checking drawings and calculations, and comparing with the design outputs with documented records. On site design changes should be documented and approved by the authorised persons. The changes should be incorporated into the later revisions or as-built drawings.

Cl. 4.5 - Document and Data Control

Documents requiring control for a contractor were: -

a) drawings
b) specifications
c) inspection instructions
d) test procedures
e) work instructions
f) quality system documents
g) all incoming and outgoing documents recorded in master register books
h) documents being circulated under controlled procedure
i) documents being filed with company document filing index system

All necessary and appropriate quality related documents should be available at their recorded locations. Any changes to the quality related documents were made in writing and recorded with agreement from the department which gave original approval. Provision should be made for the removal or identification of obsolete document from issue and use. The dates of issue of the documents and amendments were recorded. A register was kept to identify the current revision of relevant documents. Quality records were filed in the quality verification file system.

Cl. 4.6 - Purchasing

The selected suppliers (subcontractors or material suppliers) should have capability in compliance with the specified quality requirements and programme. Purchasing procedure should ensure proper evaluation and review on: -

a) suppliers' quality system;

b) suppliers' past performance; and

c) supplier's facilities to assure quality.

A list of approved suppliers were maintained, regularly reviewed and updated. The purchasing order should incorporate contract specifications and conditions which defined all relevant technical data, appropriate inspection, documentation, identification and quality requirements. Suppliers were informed that client should be afforded the right to verify the material at source but the client's verification should not be used as evidence of effective control of quality by them.

GAB recognized that different types of materials or products required a varying degree of quality assurance requirements and therefore materials and products were classified into three QA categories for inspection which then were defined in each project quality plan.

A new procedure was prepared for "subcontracting" work. Subcontractors, external designers and services supply companies were selected by evaluation of their ability to meet the specified requirements including quality requirements. A list of approved subcontractors was maintained and on-going performance was assessed. The level of quality assurance requirements imposed on subcontractors was dependent on the work scope, complexity and degree of confidence. A four QA category classification with requirements was defined in the appropriate project quality plan.

Cl. 4.7 - Client Supplied Items or Services

All client supplied items or services, which were used for the permanent works, should meet Company's procedures and requirements. These items were inspected and verified upon receipt and stored in accordance with the specified requirements. Any error in quality or quantity, or any damage or nonconformity in products should be recorded and reported to the client. Verification by the Company should not absolve the client's responsibility to provide acceptable items or services.

Cl. 4.8 - Product Identification and Traceability

A systematic numbering system was used to identify and distinguish between different contracts. Each phase of works was identified both on "Request to Inspection Form" or "Test Record" and on a sketch of phasing work maintained in the quality verification file. Traceability records were maintained on each batch of materials used on site.

Cl. 4.9 - Process Control

The project quality plan, project design plan, inspection and test plan, and method statements were the documented work procedures for controlling all construction activities with regards to achievement of quality as defined by the specified requirements. Work procedures defined the matter of meeting the specific requirements and set hold points and witness points at inspection or tests in order to provide a means of control on the construction process. Records of inspection and tests through all phases of construction were maintained as quality records. Subcontractors were also required to observe documented work procedures, method statements and work instructions either issued by the Company or produced by them.

Cl. 4.10 - Inspection and Testing

All materials were subject to receiving inspection and testing. A formal inspection and testing of the works under construction were performed in accordance with documented procedures as laid down in the Inspection and Test Plan in the project quality plan. A final inspection of completed work with quality documentation to ensure all inspections and tests were completed satisfactorily.

An inspection of works was performed by personnel who were authorised by the Project Manager to release conforming materials and works. Acceptance criteria for inspection or testing were defined on the Inspection and Test Plan. Clients were informed of work activities which they might wish to inspect. Subcontractors were required to implement their own inspection and test system via subcontract documents.

Cl. 4.11 - Inspection, Measuring and Test Equipment

Procedures were designed to control, calibrate, and maintain the inspection, measuring and test equipment which were used to demonstrate the conformance of materials and the works to the specified requirements. The surveyor on the contract was responsible for the management of all survey equipment. All site standards were traceable to national and international standards. All measuring equipment affecting quality should be marked with its identification number and calibration status. This equipment was regularly checked and calibration records were maintained. Equipment found to be out of calibration should be immediately removed from service. Tracing procedures must be established to ensure that traceability was possible in the event of equipment being found out of calibration.

Cl. 4.12 - Inspection and Test Status

The "Request to Inspection Form" and "Quality Verification File System" indicated the inspection and test status of materials and works. These records identified the inspected and uninspected materials and works, and distinguished between conforming and nonconforming materials and works. Items or works which did not meet the requirements were segregated from construction flow. Items requiring further inspection or testing after delivery on site were identified as being "on hold". Subcontractors were informed of their obligation to implement and manage their own Quality Verification File System. Marked-up drawings or charts were also used to indicate clearly the status of inspection.

Cl. 4.13 - Control of Nonconforming Product

The QA Manager opened a nonconformance (NC) report upon the detection of materials, products or works non-complying with the specified requirements. The method of disposition would be prepared by the department in-charge of the works or liaised with subcontractor or supplier. Unless the repair method had been previously agreed, the client's decision should be sought on the work requiring repair or use-as. NCs were analysed for corrective and preventive action. Corrective Action Requests (CAR) were filed and could not be closed until the NCs had been satisfactorily resolved.

In order to minimise delays in the construction programme, construction works might proceed subject to the details of the as-built being recorded on the site design amendment sheet.

Cl. 4.14 - Corrective and Preventive Action

The cause of the NCs should be investigated by an analysis of all relevant processes, work operations, concessions and quality records. Corrective and preventive actions to deal with problems should be identified to the extent commensurate with the risks and consequences. CARs were issued by QA Manager for NCs as a follow-up to quality audit, inspection and test.

Preventive action should be instructed through a preventive action request (PAR).

The QA Manager should record any changes to the documented procedures resulting from corrective or preventive action and submit to the Management Review Meeting for discussion. Complaints by the client were managed in accordance with a documented procedure for customer complaints.

Cl. 4.15 - Handling, Storing, Packaging, Preservation and Delivery

Procedures for handling, storage, package and delivery of materials were defined in the relevant project quality plan. Methods should be designed to ensure that completed works were protected, as far as practicably possible, in a planned, systematic, controlled and agreed manner. Subcontractors were informed of their obligation of protection of the works and materials via the subcontract QA requirements. The condition of materials in stock was assessed to detect deterioration at appropriate intervals. Methods for authorised receipt and despatch from such areas should be defined in the project quality plan.

Cl. 4.16 - Quality Records

Quality records consisted of: -

a) inspection records
b) test data
c) calibration data
d) survey records
e) certification of compliance origin
f) supply technical specifications
g) nonconformance reports
h) corrective action requests
i) audit reports
j) management review records
k) contract review records
l) design review records
m) training records

Quality records were classified as either permanent or non-permanent type. All quality records were filed. The scope and retention period of quality records were agreed in writing with the client for each project and were defined in the project quality plan. Pertinent quality records from the subcontractor also formed part of the quality records. Other documents, for example general correspondence, were required to be retained in accordance with the client's requirement or Government ordinance as contract records but were not classified as quality records.

Cl. 4.17 - Internal Quality Audit

Internal audits were conducted by the QA Manager and qualified internal auditors to ensure continuous adherence to the Company's quality system. All persons carrying out the audits were required to be independent of the activity being audited. The QA Manager arranged the audits in accordance with a project audit schedule and audit findings were recorded on standard forms. NCs were recorded on CAR with verification follow-up performed by the auditor. The effectiveness of the corrective action must be determined. Preventive action might be issued as an observation where it was considered that the system had potential weaknesses which might result in a NC. Project audits incorporated auditing the subcontractors and also the suppliers. The audit reports should be reviewed by Management Review Committee.

Cl. 4.18 - Training

Staff employed in the supervision and execution of construction work were required to be adequately qualified and experienced in the duties they performed. Where necessary, additional training should be provided to staff for special tasks. The training needs were determined by the Managing Director and QA Manager and detailed on a Training Planning Matrix. Specialised training needs were usually identified through the annual employee performance appraisal. All training session records and staff training logs were maintained. Subcontractors were informed of their obligations to ensure that they provided adequate and suitable training for their staff and workers engaged on the project.

Cl. 4.19 - Servicing and Maintenance

Under contractual requirements, the Company should establish and maintain procedures for performing and verifying that servicing or maintenance met the specific requirements. The servicing or maintenance plan was designed specially for each project which set out servicing and maintenance requirements, pre-handover, handover and post handover activities. NCs were recorded on the defect lists and copied to the QA Manager for evaluation and preventive planning for future projects. Servicing and maintenance procedures might include plans for protecting works prior to handing over, operator training, issue of operation and maintenance manuals.

Cl. 4.20 - Statistical Techniques

The Project Manager should identify the procedures for establishing, controlling and verifying process capability and product characteristics. Statistical sampling methods were used to check the acceptability of materials delivered to the site, for example ready mixed concrete. Statistical techniques were also developed on the results concerning corrective and preventive action.

7.2.2 Comments

As a district branch of an international construction company, the quality manual had been developed from the parent company's manual with due consideration to the local practice. Except an additional procedure for "Subcontracting", the quality manual and system procedures were prepared following the format of SS ISO 9001 (or ISO 9001). Such a layout was easily cross-referenced to the quality management standard for auditing. Some minor changes to the clause titles provided better ideas about the Company's practice.

Although GAB was a large construction company, it still relied on its subcontractors to undertake part of the construction work. It was aware that the subcontractor's performance would directly affect the quality of the final work. In the quality manual, there were requirements in 11 procedures which required the subcontractors to set up their own quality management system. The special "Subcontracting" procedure under Cl. 4.6 - "Purchasing" fully reflected the Company's concern about subcontractors' quality performance. It was found that the direct control of the subcontractors' quality management system by the main contractor might not be practical or effective. All subcontractors, therefore, were encouraged to seek ISO 9000 certification in Singapore. A series of training schemes were offered by the Singapore Government (see Section 4.1.7).

To achieve effectiveness in contractual management, clear procedures were given on the employment of subcontractors and inspection and test of materials. These procedures provided direct guidelines to the staff for action and eliminated any possible misunderstanding. It was noted that the construction specifications could not give instruction on how to deal with some problems on site but the quality procedures could provide a directive. For example, to avoid delay in the construction programme, the system procedures allowed the work to proceed when the design details were omitted or not yet resolved, subject to the construction records being properly kept on site (see Cl. 4.13 on page 7-13). Following the requirements under "Quality Records" system procedure, all project documents were kept properly and easily retrieved. The Company learned from experience that such an archive system required by ISO 9000 helped in re-collecting information for contractual claims and arbitration. Soo (1999) concurred that the proactive teleological approach to dealing with construction disputes could integrate with and make effective use of ISO 9000 documentation and record systems. The archive systems were in operation in most large-scaled construction projects, thereby elevating the functions of ISO 9000 as a tool to another spectrum in project management.

7.3 Quality Manual for KCT Construction Co. Ltd.

The KCT Construction Co. Ltd. is locally established and listed on the Stock Exchange of Hong Kong Limited. It is an "Approved List 1 Public Works" contractor for site formation, roads and drainage works. KCT bid for public civil engineering contracts and its quality performance records would have an effect on winning a contract. Therefore, the Company spent nine months in establishing its quality system and achieved ISO 9002 certification in early 1996.

7.3.1 Quality Assurance Manual

KCT's quality manual defined and documented the Company's quality system for providing the "Construction of Civil Works to Customers' Requirements" and to demonstrate that their quality system complied with the ISO 9002. No design service was provided.

The Company's manual consisted of four sections: -

a) Section 1 - Summary of amendments

b) Section 2 - Scope of the quality manual

c) Section 3 - Definitions

d) Section 4 - Procedures for the 19 quality requirements

The controlled copies of quality manual were distributed with a cover page marked "Controlled Document" in red. The manual was backed up by 19 system procedures and consistent with the 19 quality clauses in ISO 9002.

Section 1 - Summary of Amendments

Four headings viz. revision number, effective date, sections number and details of amendment had been designed to highlight the changes in the manual. The details of the amendments were precise and met the requirements under Clause 4.5 of ISO 9002.

Section 2 - Scope of Quality Manual

This section generally described the scope of quality manual and its associated system procedures, project quality plan, documents, forms and records applied to all aspects of the project undertaken by the Company.

Section 3 - Definitions

Definitions for special terms used in the quality manual and procedures were given in this section. It could unify the terminology for general use.

Section 4 - Quality System Elements

The Company prepared the quality procedures to meet the 19 quality requirements in ISO 9002: -

Section 4.1 - Management Responsibility

KCT described its Company quality policy statement under this section and committed to meeting customers' requirements for the construction of civil works. The QMS was to ensure the effectiveness and conformity to ISO 9002 standard. The Company policy was approved by the Managing Director. All staff were to ensure that the company quality policy was understood, implemented and maintained.

The interrelationship of all personnel was shown on the organization chart. The Managing Director and General Manager led six departments, viz.: -

a) Quality Assurance Department
b) Purchasing Department
c) Quantity Survey Department
d) Estimating and Planning Department
e) Project Department

f) Administration Department

The departmental functions, responsibility and authority of heads were also defined in this section.

The QA Manager was designated as Management Representative by the Company with authority and responsibility for ensuring that the requirements of the quality system were implemented and maintained. The QA Officer was designated as Deputy MR and would act in place of in the absence of the official MR. Management review meetings were planned to be held at six-monthly intervals.

Section 4.2 - Quality System

The Company operated a QMS including the following documents: -

a) Company Quality Manual
b) Company System Procedures
c) Project Quality Plan
d) Contract Documents

The QMS should assure that all completed works conformed to the requirements of the contract. Project quality plan should be established to meet the specified requirements for a project. The cross-reference between clauses of ISO 9002, quality manual, system procedures and project quality plan had been identified.

Section 4.3 - Contract Review

The Estimating & Planning Manager was required to review tender documents and ensure that: -

a) client's requirements were adequately defined;
b) differences between the tender and contract documents were resolved;
c) the Company had the capacity to meet the contract requirements.

Contract amendments should be directed to relevant project managers for consideration and action. Records of contract amendments should be maintained.

Section 4.4 - Design Control

As the Company had sought ISO 9002 certification, the scope of work of the Company did not include the quality system requirements for design control. When design works were required under contract, a sub-contract designer would be appointed by the Company for such a task.

Section 4.5 - Document and Data Control

The controlled documents under quality management system included: -

a) quality manual
b) project quality plan
c) system procedures
d) project work procedures
e) inspection and testing plan
f) method statement
g) filing list
h) contract documents
i) specification and standards
j) related forms

Controlled documents should be approved by authorized personnel and were available at all essential locations. A master list was established to identify the current revision of document and data in order to preclude the use of obsolete documents. Obsolete documents should be promptly removed from all points of use or identified and kept by the Office Administrator. Changes to documents were reviewed and approved by the same functions that performed the original review. The nature of the change was identified in the document or the appropriate attachments.

Section 4.6 - Purchasing

All purchasing and sub-contracting activities by the Company should conform to the specified quality requirements. Selections of subcontractors and suppliers were based on their capability to meet contract requirements. Quality records of approved subcontractors and suppliers should be maintained for reviewing their performance in the next selection exercise.

Purchasing documents should contain sufficient information to identify the product or service ordered. All purchasing documents were reviewed and approved for adequacy of specified requirement prior to release. Verification arrangement and method of work release should be specified in the purchasing document. The client could afford the right to verify the subcontracted product or work at the Company or subcontractor's premises.

Section 4.7 - Control of Client-Supplied Product

The client's supplied materials were verified, inspected, identified and recorded. Any loss, damage or unsuitable for use would be recorded and reported to the client.

Section 4.8 - Product Identification and Traceability

The works performed and product were identified and traceable. Project works were identified by a project number. An index number was assigned for internal reference, works location, project drawings and corresponding inspection and test records.

Section 4.9 - Process Control

Works were identified, planned and documented in the relevant project quality plan, in accordance with the contract requirements, so as to ensure that the process was under control and specified requirements were met. All works performed by subcontractors were also controlled according to the associated procedures in the project quality plan. The relevant resource and equipment were properly specified and maintained to ensure continuing process capability.

Section 4.10 - Inspection and Testing

A procedure for inspection and testing activities was established to ensure that the contract requirements for the works were met. Materials used in the works were subject to receiving inspection and verification of documentation.

Incoming materials would be identified and recorded when released for urgent use. In-process inspection and testing for the works were defined in "Inspection and Test Plan" to ensure that quality inspections were identified so as to indicate the level of inspection to be carried out.

Final inspections and tests were carried out by authorized personnel to ensure that all inspections and tests had been carried out in accordance with the contract requirements. Records of inspection and tests were maintained in order to show the evidence that the works had passed inspection and test criteria.

Section 4.11 - Control of Inspection, Measuring and Test Equipment

This procedure was to ensure that inspection, measuring and test equipment (IMTE) was controlled, calibrated and maintained. Calibration results were traceable to national or international standards. If no such standards existed, documentation was necessary to show the basis or procedures used for calibration in the project quality plan.

A register of the IMTE should be maintained and recorded by the designated staff. Each item was physically identified by means of a unique reference number. Calibration record should contain: -

a) calibration frequency
b) master calibration equipment used
c) calibration environmental conditions
d) acceptance criteria
e) calibration steps

The calibration data should be recorded and filed. Adhesive labels should be affixed to the body of IMTE showing the date of calibration and the staff who performed the test. The next date of calibration should be also indicated.

Any defective IMTE should be returned to the custodian for repair and re-calibration. Damaged tapes should be immediately scrapped. Any work carried out using the defective IMTE should be rechecked using a calibrated IMTE and a report confirming the status of the work should be submitted to Project Manager for his review. All IMTE should be protected and stored in accordance with the manufacturer's recommendations.

4.12 - Inspection and Test Status

The inspection and test status of product and work should indicate either conformance or nonconformance in relation to inspection and test performed. Nonconforming materials would be immediately removed and segregated.

Section 4.13 - Control of Nonconforming Product

A nonconforming product should be identified, segregated and recorded on the nonconformance report. Nonconformance report could be raised by any staff in the Company and submitted to responsible manager for correction. Responsible manager should complete the report by filling in the cause of nonconformity, corrective action and agreed completion date. A corrective action report should be raised by the responsible manager for implementation of the corrective and preventive action. Disposition of nonconformance could be: -

a) reworked to meet the specified requirements,

b) scrapped,

c) re-graded,

d) accepted with concession subject to client's approval.

The description of the nonconformance that was accepted by the client should be recorded clearly on the non-conformance report. Nonconformance reports should be reviewed in the Management Review Meeting and relevant project management meeting.

Section 4.14 - Corrective and Prevention Action

Nonconformance was a deficiency in characteristic, documentation or procedure which did not conform to the specified requirements raised from client's complaint, internal quality audit, second party audit, certification audit and non-conformance report.

Corrective action should be taken by the responsible manager to rectify non-conformity. Corrective action report should be raised for the implementation of the corrective and preventive action. QA Manager should verify the corrective and preventive action and record the completion date. A new corrective action request should be issued to any unsatisfactory case.

A responsible manager should formulate preventive action with analyzing the cause and effect of the problems, generating potential solutions, evaluating and selecting action. QA Manager should verify Client's complaints, quality audit reports to evaluate the effectiveness of the corrective and preventive action. CAR should only be closed by

QA Manager upon satisfactory completion of the correction action. Summary of CARs should be reviewed at the Management Review Meeting.

Section 4.15 - Handling, Storage, Packaging, Preservation and Delivery

KCT should provide method to handle and prevent damage or deterioration of materials. Materials used in the works were handled by suitable equipment or plants as directed by the site staff. The storage location of the material should be suitable for receipt and logged. The methods for packaging, preservation and delivery should be defined in project quality plan.

Section 4.16 - Control of Quality Records

The Company had established identification, collection, indexing, filing, storage, maintenance and disposition of quality records. Office Administrator and project QA Manager should maintain a company/project filing list of quality record in order to demonstrate the achievement of the required quality and the quality system.

All quality records should be legible and identifiable, stored and maintained in a ready retrievable way and in a manner likely to prevent from deterioration. All types of records should be assigned a retention period. Where contractually agreed, quality records should be made available for evaluation by the client for an agreed period.

Section 4.17 - Internal Quality Audit

A comprehensive system of planned and documented internal quality audits would be made to verify whether quality activities in compliance with planned procedures, and to determine the effectiveness of the quality system within the Company. Internal audits should be carried out in a quarterly basis with a schedule to take into account the type, status and importance of the activity to be audited. Audits were conducted by trained personnel who were not directly responsible for the functions being audited.

Section 4.18 - Training

A training procedure should be established to show how training was implemented for those personnel performing activities affecting quality. Training records were maintained for all permanent staff. Personnel were assessed and qualified on the basis of education, training and experience as required for their tasks and responsibilities. Training should be provided to staff as and when necessary.

Section 4.19 - Servicing

When servicing was specified in the contract, the Project Manager should establish and maintain a project work procedure for performing and verifying that servicing met the specified requirements in project quality plan.

Section 4.20 - Statistical Techniques

The Project Manager should establish procedures for identifying adequate statistical techniques required for verifying the acceptability of process capability and works or product characteristics.

7.3.2 Comments

As the certification scope of the Company covered the "Construction of Civil Works to Customers' Requirements", the quality manual and quality procedures were designed solely to meet ISO 9002 excluding the design element. The Company quality manual was simple and briefly explained how the quality performance within the Company could meet the ISO 9002 quality requirements. The 19 quality procedures were prepared to directly correspond to each quality element.

It was noted that the Company's procedures provided only the basic information just sufficient to meet the ISO 9002 quality requirements. More flexibility for the management and professionals to determine the necessary management procedures on site could then be allowed. On the contrary, more decisions from the management would need to be sought from the staff as insufficient guidelines were available from the quality system.

The quality manual required the management review to be held at half-yearly intervals and the internal audits to be conducted on a quarterly basis. In view of the short contract period, most of the construction companies generally agreed to conduct quality audits at three-month intervals in order to ensure quality performance in individual construction activities. Such arrangements could provide more information to the management for timely review and improvement of performance.

The Cl. 4.4 - "Design Control" stated that a subcontract designer should be appointed by the Company for contract requirements. However, no further information, even under quality procedure "Purchasing", was given. For a construction project, all temporary works on site were required to be designed by a qualified engineer and checked by an independent engineer. A procedure in the project quality plan for appointing design and checking engineers should be necessary to ensure the quality performance of the design work.

As stated in Cl. 4.9 - "Process Control" (and in some other sections also), all works control were required to be documented in the project quality plan for meeting the specific requirements. It was suggested that the project quality plan should include the following elements for this subject: -

a) identification and acquisition of controls, processes and equipment,
b) compatibility of the construction process, installation, inspection and test procedures,
c) inspection and testing techniques,
d) identification of measurement requirement,

e) identification of verification at appropriate stages in the works,

f) classification of standards of acceptability for requirements.

As indicated in Cl. 4.11 - "Control of Inspection, Measuring and Test Equipment", the damaged tapes should be immediately scrapped. The measuring tape always brought a control problem in quality audit. It was costly to calibrate and repair a tape on site. This instruction could eliminate the calibration problem.

The quality system also emphasised a control on subcontractors by the main contractor. However, there was no requirement to encourage subcontractors and suppliers to have their own quality system. If a certified quality system had to be established by the subcontractor, a tight control over subcontractor by the main contractor would be removed and the staff in the Company could then concentrate their efforts on internal improvement. Leung (1993) had recommended all specialist subcontractors to obtain the ISO 9000 certification within a reasonable period.

Even though there were quality procedures for ISO 9002 Cl. 19 and 20, no particular method had been proposed to handle the quality-related matter until the needs were found in the course of a project. These clauses should be regularly reviewed at the Management Review meeting.

7.4 Quality Manual for OB Joint Venture

The OB Joint Venture (OBJV) was formed by a large local civil engineering contractor and an overseas building contractor to undertake a Government highway contract. The contract involved the design and construction of an expressway in the New Territories, Hong Kong.

Since this non-ACP project commenced in mid 1994, there was no established requirement from the Government that the contractor should have ISO 9000 certification. In order to ensure project quality, the Highways Department (HyD) of the Hong Kong

Government required the OBJV to establish a quality assurance system under the employer's requirements in the contract document. As both contractors were already certified to ISO 9002 quality system and this contract was subject to the external quality audit, the OBJV had already installed a project quality system to meet the ISO 9001 requirements (detailed design was required under this contract) and the Conditions of Contract for this project.

The aim of the quality system was to ensure that all staff, subcontractors and suppliers understood the importance of quality in their activities. The quality assurance manual was to provide guidance and directives to the site management for completion of the contract in the most efficient and cost effective manner.

7.4.1 Quality Assurance Manual

The purpose of the quality assurance manual is to demonstrate the procedures by which the OBJV should manage, perform and verify the works to satisfy the contractual requirements.

The manual had the following sections and appendices: -

a) Sections 1 and 2 detailed the quality policy, management responsibility and the structure of the quality system.

b) Sections 3 to 20 outlined the required procedures and responsibilities to meet the requirements of ISO 9001 and the Conditions of Contract for this contract.

c) Appendices 1 and 2 contained the staff organisation chart and job description.

d) Description of the works was given in Appendix 3.

The controlled copies of the quality assurance manual were printed on green paper and was only issued to those persons on the distribution list held by the Quality Assurance

Manager. Any secondary copies made were printed on white paper and could be used for information only.

Section 1 - Management Responsibility and Organisation

The quality policy of the OBJV emphasised the importance of quality in the contract. The services and products must satisfy the employer's supervising engineer and staff's requirements. Since the site staff had been seconded from two companies, the policy was therefore signed by both directors. Such arrangements would not alienate the staff working for the Joint Venture. A Chinese version of the policy was also printed to ensure that all levels of staff were aware of the requirements.

Each company had the staff with the special technical knowledge and experience required by the contract. The organization in the site office was important and would affect the performance. A master staff organisation chart for the six major divisions in the OBJV site office is shown in the Appendix 1 of the quality manual. A set of supplementary organisation charts was also attached to specify the staff arrangement in each division. The charts showed the post, staff name and inter-relationship to enable the right person to be contacted rapidly.

The job descriptions for all 54 posts are detailed in the Appendix 2 including not only the duties for each post but also the persons responsible to. By referring to the organisation chart and duties list, staff could be aware of their responsibilities and authority, and could carry out their duties more efficiently and satisfactorily.

Adequate resources should be provided to carry out the contract works by the Project Manager of the OBJV. The required resources should be identified in the Management and Contract Review Procedures, Work Procedures, Method Statements and Inspection and Testing Documents. The competency of personnel should be determined by the OBJV prior to their assignment to the contract.

The QA Manager was responsible to the Project Manager for the resolution of all matters pertaining to quality and ensured the integrity of the quality management system.

The OBJV should conduct management review of the quality system by holding meetings chaired by the Project Manager, at intervals not exceeding four months, to ensure the continuing suitability and effectiveness of the system. A high frequency of management review meeting was definitely required for a short life civil engineering contract.

Section 2 - Quality System

The quality system was developed in accordance with the parent company quality manuals. This project quality manual could be considered as a project quality plan for this specified contract. Additional quality assurance procedures were incorporated to meet contract requirements. An action column was placed in the quality manual to easily identify the responsible staff.

The manual was subject to regular audits and management reviews to re-affirm its adequacy and conformity to the specified requirements. Any variation or amendment to the contract should be reviewed to ensure the alternations required in the work procedures and inspection and test schedules.

Section 3 - Contract Review

Contract reviews were performed to ensure that all the client's and supervising engineer's requirements were adequately defined and documented, and that adequate resources were available to meet requirements. Reviews should be held at the beginning, during and at the end of the contract. They should include a review of any subcontractors, suppliers and costs as necessary.

Section 4 - Design Control

The design of permanent works was carried out by an appointed consulting engineering firm and was controlled by consultant's own design quality procedure. Checking was carried out by another independent checking engineer. This section also covered the design of temporary works on site.

The OBJV should, in conjunction with the designer, review the permanent works design to ensure the design was constructable and economical. Regular meetings should be held between the designer, the client and OBJV for exchanging the information regarding design issues. Design and check certificates should be recorded and controlled.

Section 5 - Document Control

Procedures were established to control the receipt, production and issue of all documents with regard to: -

a) correspondence and documents received and despatched;
b) instruction and queries received from the supervising engineer;
c) all construction information, for example drawings, specifications and instructions received or issued by OBJV;
d) all engineering technical queries and site initiated design changes raised by OBJV and its subcontractors;
e) other quality related documentation.

Procedures were established for the control of incoming and outgoing mail, technical queries and site initiated design changes, incoming drawings and temporary works drawings. Registers of each set of controlled documents were prepared and kept. All sketches produced on site should be given a reference number and approved by the construction engineer prior to use. Where appropriate, notes of telephone conversations should be made, circulated as necessary and then filed.

Section 6 - Purchasing

The Construction and Commercial Mangers should initially be responsible for requisitioning the major materials and should involve in discussion with prospective suppliers. The defined purchasing procedures should be followed when ordering materials and appointing sub-contractors.

Routine inspection and witnessing of tests might be undertaken on a supplier's premises. Inspection and testing of any subcontractor's works should be in accordance with the subcontractors documented procedures and in no case should the inspection and test requirements be less than those specified in the OBJV's procedure or the contract specification.

Section 7 - Employer Supplied Materials

Precast kerbs, paving blocks and other materials would be supplied by the clients as stated in the contract documents. A programme with a delivery schedule detailing quality required, location and proposed delivery date should be furnished to the client. A site engineer should produce a non-conformance report for deliveries which contained damaged items and notify the Construction Manager.

Section 8 - Material Identification and Traceability

All staff should ensure that materials, which were handled and installed prior to the completion of testing, could be traced back to source or to their position in the works when required. For example, traceability of concrete pouring was based on the delivery ticket numbers and site location. Fill material should be identified by truck tickets with source location and destination.

Section 9 - Preparation of Work Procedures

This section set out the manner in which the OBJV intended to control its construction works prepared by itself and the subcontractor. The procedures should be prepared by the site staff in consultation with other staff directly concerned with the execution of the work. If a work procedure included hold points, these should be reflected in the inspection and test schedule. Work procedure was of a general nature but the method statement should be specified to a particular activity. Once the procedure was approved, controlled copies should be issued to the staff on the distribution list and forwarded to supervising engineer for record purposes.

Section 10 - Inspection, Sampling and Testing of the Works

All products and services should be inspected and tested as follows: -

a) upon receipt of materials on site and prior to delivery;
b) during the course of construction;
c) as required under technical specification;
d) at completion of the works.

Inspection and test checklists should be incorporated into the relevant works procedures. The checklists should be signed when the item has passed inspection. Requests for inspection forms should be timely submitted to the supervising engineer and all records retained. After completion of work, the QA Manager should check that all records have been collated and should sign on the Inspection and Test schedule to indicate its completion.

Section 11 - Inspection, Survey and Test Equipment

Instruments used for setting out must be checked regularly by the project surveyor to ensure accuracy. A register of all current calibration certificates was kept up-to-date. Instruments and equipment for inspection and testing supplied by an external party requires certification proving that such item of equipment has been calibrated by a competent person or a company within a stated and acceptable time. An instruction or equipment calibration check sheet should be used to record the history of the instrument when it is transferred to another site.

Section 12 - Inspection and Test Status

Inspection and testing must be carried out in accordance with the contract requirements. The inspection and test status of an incoming product should be the responsibility of the manufacturers, subcontractors and suppliers; and any audits carried out by the OBJV on them should be checked on this aspect. It was a condition of contract between the OBJV and its suppliers that items delivered to the site must have conformed to the specification as declared on the purchase order. If there was any doubt that the product delivered fell below the required standard, it must have been recorded on the material received note and forwarded to the Commercial Manager for action. The signed off check sheets should be collated with any associated defect lists and submitted to QA Manager.

Section 13 - Control of Nonconforming Works and Materials

Nonconformance reports should be raised for any of the following: -

a) materials received which did not meet the specification;

b) poor workmanship;

c) setting out errors;

d) damage to completed works;

e) defective works by sub-contractors or suppliers.

The nonconformance of a product must be clearly identified to prevent from: -

a) unauthorized use;

b) mixing with conforming materials;

c) further work being carried out, in case of poor workmanship.

The defeats could be dealt with: -

a) reworking or repairing to meet contract requirements;

b) submitting a concession application to the supervising engineer to either kept or used the defective work or material;

c) rejected and replaced.

Action taken must be recorded on the NCR. QA Manager should keep a register and the copies of all NCRs raised. The QA Manager should take follow-up action to ensure all corrective actions were carried out as required. An application for a concession should be in the form of a letter to the supervising engineer with any back-up or design information.

Section 14 - Preventive Action and Corrective Action

Where a customer complaint was not covered by the above procedure - "Control of Nonconforming Work and Material", the complaints should be treated as incoming correspondence and dealt with by the appropriate department head. When a customer complaint or non-conformity was found during an inspection of the work, they should be recorded on a NCR.

The QA Manager should investigate the cause of a nonconformance and the result should be recorded on the NCR form. The NCR should be closed when all remedial actions had been taken. Project Manager and QA Manager should be notified of all instances of NCs or defects. They should ensure that all other staff who might be involved in similar work, which would rise to NC elsewhere, were informed.

The QA Manager should analyze the NCRs to prevent a recurrence. Any preventive action taken should also be recorded on the NCR form. Preventive action could include revising the procedures to prevent recurrence or carrying out more frequent internal audits in the section of works where the NC often occurred.

Section 15 - Material Storage and Protection of the Works

This ISO 9001 clause requirement was confined to handling, protection and storage for civil engineering works. Delivery and packaging of the works was not applicable to this contract. Method statements should be given for the handling of dangerous or large item, when appropriate. Generally materials should be stored adjacent to the area in which they were to be used. Materials with a limited shelf life should be used before the expiry. The responsibility for the protection of the works should be defined in the work procedures. In the case of subcontractors, the protection of their item should also be considered before the award of a subcontract.

Section 16 - Quality Records

It was required to maintain procedures for collecting, indexing, filing and storage of quality records for OBJV and its subcontractors. Quality documentation included: -

a) work procedures
b) method statements
c) inspection and test schedules
d) inspection sheets
e) certificates
f) working drawings
g) as-built drawings and records

Quality records should be maintained by the Record Coordinator during the contract period. Documents should be deposited in safe archives store which prevented deterioration of the records. Records should be stored for a period of ten years from the end of the maintenance period. Access to the records should only be through the Project Manager or QA Manager.

Section 17 - Internal Quality Audits

Internal audits were applied to the OBJV and its subcontractors and suppliers. Internal audits should be conducted at regular four-monthly intervals as contractually required by the Clients. Audits should be carried out by an audit team appointed by QA Manager and should cover selected sections of the Quality Assurance Manual. Ad hoc audits would be required by: -

a) when significant changes were made in functional areas;

b) the quality of an item was in jeopardy due to deviation;

c) the effectiveness of Quality Assurance Manual was in doubt.

The verification of any corrective actions should be the responsibility of the QA Manager. He should check the proposed solutions to the corrective action requests. Audit reports should be submitted to the audited management with copy to Project Manager. When the corrective action taken was verified by the lead auditor, the relevant corrective action form should be signed off. A new corrective action request should be escalated to a higher level of management if the proposed corrective action had not been taken.

Section 18 - Training

All personnel employed on the project should have or receive adequate training relevant to their level of employment and the tasks they would perform. Quality assurance training should be an on-going process. Records of on-site training should be kept by the QA and safety departments.

Section 19 - Maintenance

Maintenance in the context of this contract should cover the obligations of the OBJV and its subcontractors during the maintenance period of the contract. When defects raised owing to any act or omission on the part of the OBJV or its subcontractor during the maintenance period, a remedial programme should be agreed with the client. The OBJV should notify the client of the nominated person, who could be contacted during the maintenance period after the OBJV had vacated the site. The OBJV should ensure that each subcontractor had provided the Company with a contact person to deal with defects during the maintenance period.

Section 20 - Statistical Techniques

An analysis of the results from testing concrete cubes should be made. When appropriate other statistical techniques should be used and documented in the relevant work procedure.

7.4.2 Comments

Since the two contractors were ISO 9002-certified companies, they had prepared a new quality assurance manual for this contract to meet ISO 9001 requirements and incorporating their designer's quality procedures. As the key staff were seconded from two companies, the site organization chart and duties list could help in identifying the responsibility of and authority for each post. It also showed the demarcation of the management area of two companies in the joint venture.

Some clause titles in the quality manual were revised to clarify the site activities. The contents of each clause in the quality manual had been extended to provide detailed information as far as possible in order to give direct instruction to the site staff. Therefore, only a few operational procedures were required to supplement the quality assurance system. With an action column placed in the manual, the staff could immediately find out what duties required to be performed by them. The controlled copies were printed on green paper. The duplicated copies on white paper could easily be distinguished as uncontrolled copies.

Because of the short contract life, the management review and internal audit was conducted at four-monthly intervals. As the staff change rate on construction sites is normally high, a close monitoring of staff performance was necessary. A series of contract review meetings was proposed for a tight control of the contractual matters. It was to ensure that the requirements of the contract were fully understood and could be fulfilled. As the work was designed by the contractor, the manual included procedures for design control. It was noted that such procedures were directly adopted from the appointed designer and the suitability of the design process for the OBJV's quality system should be reviewed by the Project Manager.

Part of the works were undertaken by subcontractors. Requirements were set in several clauses either to encourage the subcontractors to establish their own quality procedures or to follow the OBJV's quality system. Internal audits were required to cover the subcontractors.

The statutory retention period for the contractual documents was 12 years starting from the contract completion date. The period (10 years) stated in the quality manual must be agreed with the client.

The requirements for delivery and packaging in ISO 9000 were not relevant to civil engineering projects. Disclaimers were generally applied to these items. Section 19 - "Maintenance" explained the liability of the contractor for defects. A good communication channel among the client, contractor and subcontractor for the follow-up maintenance works must be established.

7.5 Quality Assurance System for the Contractors

The application of a quality plan in ACP projects instigated quality assurance management on the construction sites. The requirement of quality plans had ensured the overall performance in these important construction projects at the infant quality development stage in Hong Kong. The second-party auditing of the quality plans by the

Engineer maximized the benefits as it was specifically project-related. However, the coverage of the quality plans was narrow by comparison with the ISO 9000 international quality standard.

To maintain the quality momentum of the construction work, a quality assurance system certified to ISO 9000 was inevitably required. The aim in having the system assessed by a third-party agency was to enable clients to know that the system existed and was used to ensure the satisfaction of the product against both technical specification and quality requirements. Hellard (1993) had the view that ISO 9000 was an excellent document when the audit was specifically concerned with the manufacturing and multi-repetitive service industries, but it was not well related to the needs of the construction industry and its clients. However, through the above case studies, it was proved that the contractors could follow the generic terms in the quality standard and establish their own quality system for success in certification. However, it was observed that the standard and the contents of the quality manuals varied in companies.

7.5.1 ISO 9000 Standards for the Contractors: ISO 9001 or ISO 9002?

GAB and OBJV had prepared their QMS to the ISO 9001 standard because they undertook design work. KCT claimed that it solely provided services for the construction of civil works to customers' requirements and therefore its QMS should meet the ISO 9002 requirements. In general, all construction companies should carry out the design work on site, for example the design of excavation work, formwork, sheetpile wall etc. It was arguable that all construction companies should have documented procedure for design control and their QMS should comply with the ISO 9001 standard.

The definition of "product" in ISO 9001:1994 is "the result of activities or processes". It can be explained that Cl. 4.4 - Design Control will only apply to the design work for permanent or final products but not cover the temporary work. The temporary design can be a part of production and installation processes and will be controlled under Cl. 4.9 - Process Control. Therefore, ISO 9002 standard is suitable for the contractors who only provide construction services. The argument has been accepted by the certification bodies and Works Bureau. The temporary design work is usually a part of construction method statement. KCT had documented procedure for the checking and approval of temporary design calculation under the relevant clause of Process Control.

7.5.2 Frequency of Management Review for Construction Companies

The quality standard requires that the management shall review the quality system at defined intervals sufficient to ensure its continuing suitability and effectiveness to meet quality requirements. GAB conducted management review annually. KCT carried out review at six-monthly intervals. OBJV held the review meetings at intervals not exceeding four months. In view of the short life of civil engineering contract and most of construction activities are unique, a high frequency of management review meeting is definitely required on site. For the construction companies, the management review shall be conducted at two levels: corporate level and project level (see Clause 4.1 in Section 3.3). It is recommended that the management review of the quality system should be conducted once or twice a year by the top management in the head office. Management review meeting at project level in the site office can be held at four-monthly intervals by the project manager for timely review and improvement of the quality system.

7.5.3 Quality Management of the Subcontractors

Tam (1999) found that the characteristics of subcontractors in the Hong Kong construction industry were poor, of no professional competence and of no guarantee of quality. He suggested that the Government should establish legislation to achieve some quality measures, such as subcontractors having ISO 9000 certificates as a prerequisite for work with the Government contracts. Based on the survey result, Lee (1998) had a different finding that not many contractors (17 out of 92 responding construction companies) demanded the subcontractors to be certified to ISO 9000 in Hong Kong. In fact, many companies would ask the subcontractors to obtain certification only when their clients so demanded, for example the subcontractor for piling work. In order to satisfy the requirements of ISO 9000, particularly Cl. 4.6 of ISO 9001 and ISO 9002, many certified contractors implemented new evaluation schemes to select subcontractors on the basis of their ability to meet subcontract requirements including the quality system and any specific quality assurance requirements. The selection would base on the subcontractors' technical capability, tendering price, quality records and relationship with the main contractor. The level of quality assurance requirements imposed on the subcontractors are dependent on the work scope, complexity and degree of confidence.

GAB, the construction company in Singapore, was deeply concerned about the subcontractors' quality performance and encouraged the subcontractors to establish QMS to improve their overall performance. The company recognized that subcontractors with different type of QMS required a varying degree of inspection and supervision, and prepared a specific quality procedure to monitor the subcontracting work under Cl. 4.6. The procedure defined a four quality assurance category classification with the supervision requirements as follows: -

S1 - for large subcontractors with an ISO 9000-certified quality system

S2 - for subcontractors who are implementing part of quality system

S3 - for subcontractors who have limited quality system

S4 - for subcontractors who have no quality system

Subcontractors were allocated one of the four QA classifications and corresponding degrees of company's control was defined in the project quality plan. Furthermore, GAB had conducted internal quality audits to the subcontractor's activities for enhancing the effectiveness of the quality assurance system.

OBJV required that inspection and testing of any subcontractor's works should be in accordance with the subcontractor's certified documented procedures. Otherwise, the inspection and testing should be undertaken in accordance with the relevant OBJV procedures or contract specification. There was no relaxation for the subcontractor who implemented a part of quality system. KCT simply imposed the control on the subcontractors directly under clauses 4.6 and 4.10 of ISO 9002 and there was no special inspection or supervision arrangement for the subcontracting works. In general, when if the subcontractors could be classified by their established quality assurance system and quality performance record, an appropriate level of supervision (S1, S2, S3 or S4) would be imposed to them. It would not only provide confidence to the main contractor but also save inspection effort from the supervisory staff.

KCT and OBJV had only established quality procedures for in-house staff training. It seemed necessary for the main contractors to provide more training and assistance for the subcontractors in order to upgrade their quality consciousness (Lee, 1998). GAB was aware of the importance of training for direct and indirect workers on site. Apart from the general requirements of the ISO 9001 standard, GAB also provided training to its subcontractors on the appropriate elements of the company's quality system. Its subcontractors were informed of their obligations to ensure that they provided adequate and suitable training for their staff and workers engaged on the project, particularly for those performing quality related functions or verifications. Such arrangement had make the training requirement of ISO 9001 more suitable for the construction industry.

7.5.4 Model Quality Manual for Contractors

The majority of construction companies were under client pressure when seeking ISO 9000 certification (see item 5 in Figure 5.8; Lee, 1998). From the above case studies, it was found that the contents of a quality manual were mainly dependent on the contractor's quality objective. If the contractor, like KCT, only wanted a "work permit", his quality manual would be as simple as possible and just meet the certification purpose. When a contractor, like GAB, took the certification as a vehicle for quality improvement, his quality system would highlight the company's practices together with well planned procedures for implementation. A construction project was not a prototype, each has a unique production process. A quality manual or quality plan should be tailored to the requirements of the company or the specific project. Nevertheless, the nature of construction work is consistent. A model quality manual could help the contractors precisely to understand the requirements of ISO 9000 and collating their systems for benchmarking.

A model quality manual has been prepared (see Appendix D) for a hypothetical company, Qualitec Construction Company Limited, to seek ISO 9002 certification for its major services of "Construction of building, civil works and infrastructures to the customer's requirements". The manual was compiled in line with the ISO 9002 standard incorporating the current practices of building and civil engineering contractors. The manual detailed each required activity under the 19 quality clauses in ISO 9002. The necessary quality procedures and forms were recommended for operational need. The contractors should develop these procedures and forms with due consideration to their technical capability and staff resources. Even though some quality clauses, for example statistical techniques, might not directly apply to the construction sector, the relevant quality procedures have also been included for reference.

Since the survey results in Chapter 5 indicate that guidelines are needed for contractors to better understand and interpret the ISO 9000 requirements applicable to construction, the author hopes that this model quality manual will be able to serve such a purpose.

CHAPTER 8

RESEARCH FINDINGS AND DISCUSSION

ISO 9000 is a series of generic international standards developed for quality assurance and quality management. It is not a product specification or product standard, but a management system standard that outlines the minimum requirements for an organization to establish a QMS and helps ensure that it provides a consistent quality product or service. Because of the nature of its development from the original defence standards (see Section 2.3), ISO 9000 was written primarily from a manufacturing and product assurance viewpoint. This has made interpretation more difficult for service industry including construction.

This research project has attempted to review and evaluate the current application of ISO 9000 quality standard to construction industry in Hong Kong and has investigated the critical factors and difficulties encountered in the management of the quality assurance system in order to enable the construction sector to achieve, maintain and improve quality. The research findings from the literature review, questionnaire surveys and case studies together with the author's experience acquired from the process of this research are discussed in this chapter.

8.1 ISO 9000 Standards for Construction Industry

ISO 9000 standards are completely generic and can be applied to almost any situation where a quality system is needed. Indeed, because the standards meet all types of products and services, ISO 9000 leaves much room for interpretation. Oliver (1990) had prepared a set of interpretations to ISO 9001 for the construction industry. Those proposed interpretations were very general and they would require further "tailoring" to suit individual sectors of the construction industry. Grice (1992) pointed out that much adverse reports about the suitability of ISO 9000 in the construction industry was due to poor initial advice, improper interpretation of the requirements of the standard in respect of a company's activities and lack of sustained effort. Power (1985) identified that quality assurance had become a somewhat misconstrued and misunderstood discipline to construction work and the ISO 9000 standard was then not fully recognized by the construction sector. The misconceptions had already hindered the implementation of quality assurance system in the construction industry.

ISO 9001 has been technically reviewed in this research. In the review, consideration has been given to each quality requirement of the ISO 9001 standard and how it can be applied to the construction consultants and contractors. It is important to understand that the requirements of the standard are descriptive and not prescriptive. The consultants and contractors have the flexibility to address the required subject clause in the manner that is most appropriate to them. It is found that ISO 9001 Clauses 4.1, 4.2, 4.11, 4.12, 4.14, 4.16, 4.17 and 4.18 give the requirements how to manage and maintain a quality system. These clauses are generally applicable to all types of business and are of no particular requirement for the construction industry. The remaining 12 clauses are concerned with the operational methods in a quality system. Special interpretations to these clauses shall be elaborated in order to provide a better understanding of them for the construction sector. For example, the requirement of Clause 4.3 - "Contract Review" is much more complicated for the construction industry. The consultant will enter an agreement with his client for a design work and later invite tenders from contractors. Similarly, the contractor will sign a contract with the client and then sub-let his work to subcontractors. The consultant and contractor often have double status, the "purchaser" and the "supplier". Their quality procedures for contract review should be prepared for both roles. The Clause 4.15 - "Handling, Storage, Packaging, Preservation and Delivery" is mostly concerned with the packaging of a product after completion. In fact, it is more relevant to manufacturing industry than to construction industry because the packaging requirement cannot be applied to a completed huge structure. However, the consultants shall have procedures to protect the design documents and the contractors shall operate procedures for protecting the completed works before handing over to the client. Since most of construction projects are unique, the construction sector does not make use of statistical sampling techniques to monitor progress and problems. Therefore, the Clause 4.20 - "Statistical Techniques" is not relevant to the construction industry.

From Section 3.3 of this thesis, it is found that most of the quality clauses in ISO 9001 are relevant to construction work except Clauses 4.19 - "Servicing" and 4.20 - "Statistical Techniques". In addition, Clause 4.15 - "Handling, Storage, Packaging, Preservation and Delivery" has little relevance to both consultants and contractors. Furthermore, Clause 4.11 - "Control of Inspection, Measuring and Test Equipment" is seldom applied to the consultancy service. These findings generally agreed with the survey results and case studies. Although ISO 9000 series are generic quality standards which appear coherent with manufacturing kind of industry, they are quite relevant to construction industry also. A majority of respondents in the surveys affirmed that ISO 9000 was an adequate quality system to be applied in the construction work. They also agreed that correct interpretations of the ISO 9000 standards could make the implementation of quality assurance system in construction industry as smooth as in any other industry.

8.2 Quality Systems in Singapore and Hong Kong

As most standards and codes of practices are originally adopted from the British system, the construction practices in Singapore and Hong Kong are quite similar to each other. Both cities take the ISO 9000 standards as the norm for QMS in the construction industry. By benchmarking with Singapore, the quality system in Hong Kong can be improved.

8.2.1 Quality Assessment Systems

Through literature review and visits to Singapore, the author observed that the Singapore Government had already prepared a long term quality improvement programme for the construction industry. As the Government agency directly responsible for the construction sector, the Construction Industry Development Board

(CIDB) was enacted with the aim of elevating the quality level of the industry. CIDB has implemented a "Construction Quality Assessment System (CONQUAS)" to measure the workmanship of contractors for public building projects. The main objective of CONQUAS is "first-time-inspection" (Ngaw, 1994); essentially it means that the quality assessment is done prior to any rectification work to defects. The idea is to encourage the contractors to do things right first time. It is a big step towards the quality assurance management. CONQUAS was extended to formulate Building Quality Assessment Services (BQAS) and Civil Engineering Construction Assessment System (CE CONQUAS) for the private sector building and civil engineering projects respectively. The CIDB, through its quality promotion programme, has already achieved a high quality level in the construction industry in Singapore.

Developed from CONQUAS, the Performance Assessment Scoring System (PASS) and Maintenance Assessment Scoring System (MASS) used in the Hong Kong Housing Authority (HKHA) have given intensive monthly inspections to the public housing and maintenance work. There is no quality assessment system for private building and civil engineering work in Hong Kong. As the PASS/MASS does not take over the routine works inspection, the multiple quality inspections on site become a burden both to contractors and supervisory staff. There is a degree of resentment from the supervisory staff because they often look at PASS/MASS as additional paperwork. Unfortunately, the quality improvement through the PASS in public housing work is not obvious in Hong Kong. The repeated shoddy construction works in public housing have already received strong complaints from the public. These scoring systems should be critically reviewed to tie in with the whole process of public housing production and meet the actual needs.

The CONQUAS and PASS are the assessment systems for grading the level of building quality and cannot be used to accept or reject the defective works so detected. If these systems can form part of contractual requirements, they can strengthen their application to the construction work. It can reduce the multiple inspections on site and the quality level of building work can also be assessed.

8.2.2 ISO 9000 Certification

To make the quality system more complete, the Singapore Government required its major consultants and contractors to achieve ISO 9000 certification in five year's time. Such requirement had brought the QMS in construction industry to an international level. The Government was aware of the great contribution from the subcontractors to the industry. A series of programme had been designed for the subcontractors for upgrading their quality awareness (CIDB, 1993b).

In contrast, Hong Kong Government only allowed two to two and half years for the major consultants and contractors to obtain ISO 9000 certification. The certification period was considerably short (Leung, 1993). The requirement had pushed the consultants and contractors to "jump on the bandwagon" without thorough quality planning for their business. They had faced many problems during the implementation and maintenance of their QMSs. The ISO 9000 certification requirement will be extended to cover the medium size contractors soon. Small companies are not practising quality assurance as good as the large ones (Allen and Oakland, 1988). Therefore, sufficient time should be given to the medium size construction companies for establishing well-structured quality systems. The construction sector has understood that the subcontractors could significantly affect the quality performance in the construction industry. Ironically, the Hong Kong Government has not required or encouraged the subcontractors to establish a quality system to ISO 9000 standard (WB, 1998). If the existing quality policy remains unchanged, the quality level in construction industry in Hong Kong will not be raised.

8.2.3 Incentive Scheme

CIDB noted that some contractors were grudging in adopting CONQUAS and only did the minimum to meet the requirements (Ngaw, 1994). The Board has devised a CONQUAS Premium Scheme to provide incentive for the contractors to strive for better quality. The scheme is a classic stick-and-carrot approach. Only the contractors who have consistently attained high CONQUAS scores and achieved ISO 9000 certification will have premium advantage in tender exercises.

Based on the PASS scores, HKHA has created a Preferential Tendering Eligibility System to bar the poorer building contractors from tendering the housing contracts. Since the Preferential Tendering Eligibility System only considers the PASS records of the previous six months, a contractor can simply make an effort to rectify his poor situation when he intends to bid a new contract in the next half year. Therefore, a PASS score for a longer time frame, such as the assessment of a completed building project in the CONQUAS, should be more practical to reflect the overall performance of a contractor. There is no premium scheme in Hong Kong. It is, therefore, recommended that the PASS score should be one of the weighting factors in the tender assessment in order to give preference to those contractors with higher quality scores.

In order to keep the quality momentum, incentive schemes must be introduced. A proposed hybrid incentive scheme combining the Premium Scheme and Preferential Tendering Eligibility System can be considered. This modified scheme will give a double encouragement to the contractors. Furthermore, a "pay for quality scheme" (Ahmed *et. al.*, 2000), similar to the "pay for safety scheme" being managed by the Works Bureau of Hong Kong Government (WB, 1996), for the ISO 9000-certified contractors should be explored.

8.3 Implementation of ISO 9000 in the Construction Industry

ISO 9000 quality standard was developed in a manufacturing environment, and gradually it was realized that the concepts and disciplines formulated for that environment could be applied with equal advantage to the other industry (Fox, 1993). However, the construction sector did not hold positive views about the benefits of the standard (Tam, 1999). Hellard (1993) perceived that the additional quality requirements from the ISO 9000 to a construction contract would be more confusing than helpful. Jensen (1994) and Laustsen (1995) also questioned the suitability of ISO 9001 for consulting engineering service. Two surveys, one for consultants (sample number = 36 and response rate = 53%) and another for contractors (sample number = 100 and response rate = 35%), were conducted to collect objective and representative evidence of the practicability of applying ISO 9000 in the construction industry in Hong Kong. The key findings are discussed below.

8.3.1 Motivation for Seeking ISO 9000 Certification

Based on the literature review, there are some typical driving forces for companies to embark on ISO 9000 certification. The responding consultants and contractors in the surveys cited the mandate from the Government to have ISO 9000 certification as the most important reason for seeking certification because only the ISO 9000-certified companies could bid the Government job. The quality improvement to the companies' efficiency and management was of second importance. These findings are in agreement with those published by other researchers including CIRIA (1995), Vloeberghs and Bellens (1996), Kwok (1997) and Lee (1998). It is observed that the quality-oriented culture in the construction industry has not completely been built up.

8.3.2 Satisfaction of ISO 9000 for the Construction Industry

The contractors often argued that the application of ISO 9000 in construction industry was intrinsically difficult (Leung, 1993). Yuen (1999) concluded his research findings that the ISO 9000 quality system that worked with the manufacturing industry might not work with the construction industry. Tam (1999) also found that the senior management still had doubts in using ISO 9000 for their construction companies. Owing to the misconceptions to and improper interpretation of the quality standard, ISO 9000 has not yet won full support from the construction sector in Hong Kong. Nevertheless, from the survey results of this research, a majority of respondents considered that most of the 20 quality clauses were considerably relevant to their business. They also agreed that ISO 9000 was an adequate QMS related to the construction industry but improvements to the system were still required. The findings different from other researchers may be due to the different approaches in the questionnaire surveys. The author had firstly requested the respondents to rate how relevant each ISO 9001 quality clause was to their business and then asked whether they were satisfied with ISO 9000 standard. As the respondents had thoroughly examined each clause, their answers were more reliable.

However, it is noted that a number of respondents wished to have a tailor-made quality standard for the construction industry. However, it is the author's view that a quality standard tailored to the needs of the construction process may be impractical. ISO 9000 is a common standard and an international quality language, and it should be valued as such. It is perhaps worthwhile to have additional guidance notes to assist the construction sector to better interpret the ISO 9000 standard.

8.3.3 Difficulties in the Implementation and Maintenance of a Quality System

Common difficulties in implementing the quality system and methods for maintenance and continuous improvement of it had been proposed in the questionnaires for the consultants' and contractors' assessment. The respondents indicated that the change of quality culture together with insufficient quality management knowledge had made professional and technical staff disinclined to place reliance on the QMS. Some impractical ISO 9000 requirements and excessive paperwork had brought resistance from the staff. They were afraid that design flexibility would be lost when a quality manual was used. The responding results were in general consistent with the findings from CIRIA (1995), Vloeberghs and Bellens (1996) and Kwok (1997). The author considers that a well-planned QMS and a well-structured quality manual can allow for flexibility in the construction process and alley the construction sector's concerns.

Regarding the continuous improvement of QMS, Leung (1993) had suggested that the experience in implementing the quality system should be shared among the contractors and model documents should also be prepared. The respondents agreed that benchmarking with other ISO 9000-certified companies could improve the quality management technique, but nobody would like to reveal their expertise to their rivals as the quality plan would form part of tender submission for assessment. The author supports Leung's proposal that model quality documents should be prepared to assist construction sector improving its quality system. The model document is in fact one of the products of this research.

8.3.4 Benefits from Operating a Quality System

Respondents were generally of the opinion that operating a QMS and gaining ISO 9000 certification had led to a significant improvement in companies' quality image and client satisfaction. The consultants reported that they had met their high original expectations in both issues, but the contractors perceived that benefits gained were lower than expected. In order to have a better idea, it is recommended that the clients' views on the quality performance of these ISO 9000-certified companies should be collected for analysis. All responding companies expected that the certification would give a competitive edge in bidding contracts. Unfortunately, they found that opportunities almost remained the same, as most companies were also certified. All responding companies also anticipated a reduction in the level of errors. Doubtfully, the respondents indicated that there was no positive savings from the reduction in failures and reworks through the implementation of their QMS. Since ISO 9000 certification is a relatively recent phenomenon in Hong Kong, no formal studies have yet been conducted to accurately measure and report the cost savings.

The overall benefits which the responding companies have gained as a result of implementing a QMS to ISO 9000 are small. Throughout the survey, respondents indicated that the level of improvement, in most areas, was far below their original expectations. CIRIA (1995) and Tam (1996) had identified the same problems in the construction industry. The situation has not yet been improved in the past years. Many consultants and contractors failed to reap great benefits because their attitude in operating the QMS was wrong. They operated QMS mainly from the pressure from clients (see Section 8.3.1). Unless the QMS is adequately planned and maintained, the real benefits of an effective quality system cannot be realized. Lee (1998) had made the similar recommendation in his research work on ISO 9000-certified companies (all industries) in Hong Kong. Brecka (1994) indicated that companies certified for over 5 years would reap greater benefits. It is expected that the responding companies will gain more benefits from their QMS as time goes by.

8.3.5 Further Development of Quality Management System

Based on the survey results, the average quality-related costs are 5.6% and 2.2% of the annual turnover for the consulting firms and construction companies respectively. As most responding companies reported that they had no breakdown of the quality-related costs, the accuracy of the estimated quality cost was questionable. Kumar and Brittain (1995) indicated that an effective quality costing programme could reduce production costs and assist to improve the reliability of quality. Low and Yeo (1998) had already introduced a quality costs quantifying system for the building industry in Singapore. A similar cost assessment system for the construction industry should be developed in Hong Kong. It is considered that a simple aide-memoire recording the resource inputs together with the quality problems is sufficient for the analysis.

Although the effectiveness of a QMS can be assessed by the certification body, over half of responding companies accepted second party audit of their QMS by their clients. The objectors argued that the second party audits would put an extra workload on the companies and violate the third party spirit of the ISO 9000 certification scheme. The author has found that the second party audit is a very useful quality management tool which will provide the client with added confidence and better understanding of their suppliers' services. In order to ensure that a supplier operated an effective QMS, CIRIA (1995) recommended to carry out a second party audit. Tam (1999), who was an ISO 9000 certification auditor, also supported the proposal for using second party audit to enhance the quality management.

Engineers always claim that they are formally trained to look for quality and the quality assurance training will not be unnecessarily duplicated. It is noted that a lot of quality problems have often happened in design offices and on construction sites. Tam (1999) found that quality training provided to the quality assurance managers was limited. Knowledge is one of the major keys to success. As the ISO 9000 is still a new subject in the construction industry, the author prefers that the quality concepts and management techniques should be included in the syllabus of academic institutions. It will help graduate engineers build up a quality culture in the campus and prepare a sense of quality awareness for their job.

8.3.6 Quality, Cost and Time in the Construction Project

The achievement of quality in construction industry must also be linked with cost and time. The survey results reveal that many consultants and contractors have not yet appreciated the major benefit of ISO 9000 in the improvement of not only the quality but also the cost and time. The consultants always consider quality as the prime factor for the projects and spend a lot of time in considering other alternative design options. The contractors often take the construction cost as the most important item at the expense of quality. Chapham (1991) explained that the quality assurance system could put things right the first time and save time and money for both the supplier and client. With a better understanding of the principle of quality assurance - "get things right first time", the construction sector can properly maintain the balance among the quality, cost and time in construction projects.

8.4 Quality Management System for the Consultants and Contractors

ISO 9001 and ISO 9002 are the models for the management of quality systems for consultants and contractors respectively. To support the quality assurance concepts and its application, the standards require the preparation of a quality manual for implementation and audit. The quality manual is the top level document in the QMS which consists of the organization's quality policy and objectives and addresses each quality requirements of the standards. Eight quality manuals, one from production company, three from consultants, three from contractors and one from Government works department, have been collected for study.

Technically, the 20 quality elements in ISO 9001 embraced all activities of a manufacturing company. From the case studies, it was evident that following the step-by-step guide in the ISO 9001 standard, the fiber optic components production company had successfully transferred its production process to fit all quality requirements of ISO 9001. On the contrary, the consulting engineering services were knowledge-based and project-oriented. The quality system for the consulting firms could not straight follow the quality standard. The difficulty, experienced by the consulting firms under study, was in part due to the fact that the ISO 9001 was not easily interpreted in the real terms of and directly applied to the consultancy services. The construction companies under study had also faced the same problems but the situation is better as the construction process is closer to production process. Nevertheless, the quality elements in ISO 9001 have been technically reviewed in Section 3.3. It has offered interpretative comments to help construction sector understand what is exactly required by the standard.

8.4.1 Quality Manual

The quality manual is the organization's interpretation of the ISO 9000 standards. The case studies confirmed that all case companies could follow the generic terms in the quality standards to assemble their quality manuals for certification. However, it has been observed that the format and the contents of these manuals leave much room for improvement. KTC, HAC, GAB, KCT and OBJVs' quality manuals, which simply duplicated the structure of the ISO 9000 standards, are effectively maintained and user-friendly. In contrast, CMT's took a different approach and constructed its quality manual on a process basis with a matrix which related the ISO 9001 clauses to various sections within its management practices. Although ISO 10013 provided flexibility for the organization to prepare a quality manual to suit its particular operation, the author found that CMT's quality system had brought the difficulties in implementation and auditing. Lamprecht (1996) highly recommended the quality manual structure following the standard because it was easier to audit, and most auditors would appreciate the format.

Quality procedures are the documents which describe the organization's activities. Ashford (1989) cautioned that some quality procedures were essential, some less so, some could no doubt be dispensed with altogether in a quality system. Through the case studies, it was noted that some consultants had prepared too many procedures to back up their quality manuals. Such excessive paperwork had added unnecessary burdens to their staff. The author considered that if the contents of some sections in the quality manual were slightly expanded, a number of redundant procedures could be deleted. Therefore, a balance design between quality manual and quality procedures should be maintained. Table 6.1 has listed the essential quality procedures for consulting firms. They can select suitable procedures which are specific to their services. Based on the research findings, the author had planned a "seven steps" approach for the development of a QMS for the Territory Development Department (TDD) to seek ISO 9001 certification (see Figure 6.1). This arrangement allowed the Department to spend only 16 months to achieve certification and obtain the possible best audit result - "neither nonconformity nor observation was found in the certification audit". The author's quality management experience can be shared with other researchers.

8.4.2 Model Quality Manuals

Somebody stated that it was common for quality assurance consultants (QACs) to write the quality manual for an organization. Hughes and Williams (1995) agreed that the use of QACs in most cases would provide the organization with the basic philosophy of a QA system but they often lacked technical knowledge of the tasks that such a quality manual should address. The survey results of this research indicated that the QACs were only found generally helpful in developing the QMS because they were not familiar with the construction work. Tam (1999) through his audit experience confirmed that many QACs in Hong Kong were lacked of detailed knowledge of the local construction practice and only produced a quality system that was inflexible. Eventually, an inflexible QMS would not give real benefits and would generally fail in the longer term.

Owing to the difficulty in interpreting and implementing the ISO 9000 standards, the construction sector has strongly demanded model quality documents to enable them to improve their quality system (see item 6 in Figure 5.6 and item 7 in Figure 5.13). Leung (1993) also indicated the needs for the model documents. One case company under study also suggested establishing a model quality manual to help its staff build up the QMS independently. Lee (1992) and Rothery (1995) had already produced model quality manuals for the manufacturers. Because of the unwillingness of consultants and contractors in benchmarking the quality systems with other rivals in the construction industry, the development of model quality manuals for consultants' and contractors' reference is considered necessary. The model quality manuals could help the construction sector precisely understanding the requirements of ISO 9000 and collating their systems for advancement.

Based on the case studies, the working experience in construction management and the hands-on experience in preparing the quality manual for the TDD, the author has prepared two model quality manuals, one for engineering consulting firms (ISO 9001) and another for construction companies (ISO 9002). These model manuals including recommended quality procedures give a balance design to meet both construction process and quality standard requirements. The presented structure and format could successfully meet the document control and maintenance purposes. Most of the consulting firms and construction companies in Hong Kong have already implemented their certified QMS. These model manuals are intended to provide opportunities for them to compare with their own systems for continuous improvement. For the companies who wish to gain certification to ISO 9000, these model documents could give them a clear picture on how to set up a more effective and reliable quality system.

8.5 Limitations of the Study

The limitations of the study are summarized as follows: -

(i) The scope of this research is to investigate how a quality assurance system can be effectively applied to construction works in Hong Kong. The research is a new area of study in Hong Kong. Very little prior knowledge is available on the topic and similar studies are less easy to find for comparison. That the lack of relevant existing information about the subject makes it difficult to develop a sound theoretical base for study. Nevertheless, the author has attempted to contrast his findings with the limited prior research findings published in the literature for verification. This study will contribute to build up the literature in the field of quality management in the construction industry in Hong Kong and will provide some guidance and encouragement to other researchers who may want to pursue the same track.

(ii) The research domain is on the engineering consultants and the building and civil engineering contractors in the construction industry. The other sectors of the industry, such as the architectural consultants, quantity surveying consultants, building services consultants and contractors, are deeply involved in the construction work in different manners. The research findings cannot represent all the other sectors in the construction industry. Future work should broaden the research base to include a wider range of sectors for investigation. Moreover, the research is solely for capturing the quality experience of consultants and contractors from the supply side of the industry. Views of "clients" on the ISO 9000 certification have not been included for assessment.

(iii) The questionnaire surveys mainly cover the major consulting firms and construction companies in the Works Bureau's approved lists. There are quite a lot of medium and small consultants and contractors in Hong Kong and their attitudes towards quality issues may have a significant effect on the construction industry. The Hong Kong Government will tighten up the quality management in these consultants and contractors soon. Their responses to the ISO 9000 requirements should be studied.

(iv) Each survey questionnaire is completed by a quality assurance manager whose own personal knowledge and experience may be biased. The generalized or incorporated opinions representing the entire surveyed organization may not be obtained. CIRIA (1995) had interviewed three individuals in each case company, covering senior management/quality representative, middle manager and technician, to collect a full picture about the effects expected by the company from implementing a QMS to ISO 9000 and achieving certification. To provide an internal cross-check, further research should consider interviewing up to three individuals including those "managing" and those "being managed" in each company.

(v) Due to limited resource and time restriction, the model quality manuals have solely been tested by the author through the preparation of the quality manual for the TDD. The auditors from the HKQAA appreciated very much the format and contents of the quality manual. However, these model manuals should be subject to more tests for validation.

CHAPTER 9

CONCLUSIONS AND FUTURE RESEARCH

9.1 Conclusions and Contributions of Present Work

The main objectives of this Ph.D. study have been to investigate how a quality assurance system can be effectively applied to construction works in Hong Kong. In this dissertation, four main contributions have been made: -

a) the recognition of the suitability of ISO 9000 standards for construction works;

b) the suggested improvements to Hong Kong's quality assurance system by benchmarking with Singapore's practices;

c) an exploration of the practicability of applying ISO 9000 in the construction industry using questionnaire surveys;

d) the provision of a fundamental understanding about the installation and implementation of a quality assurance system by consultants and contractors using case studies and the development of model quality manuals in the light of ISO 9000 requirements.

9.1.1 Suitability of the ISO 9000 Standards for Construction Works

The ISO 9000 was initially developed with the manufacturing industry in mind but is now mandatory to the construction industry. To affirm the suitability of ISO 9000 standards for the construction works, the 20 quality clauses in ISO 9001 have been fully examined. It is concluded that most of the clauses are indeed relevant to both consulting engineering firms and construction companies apart from Clauses 4.19 - "Servicing" and 4.20 - "Statistical Techniques". In addition, Clause 4.15 - "Handling, Storage, Packaging, Preservation and Delivery" has little relevance to both of them. Furthermore, Clauses 4.11 - "Control of Inspection, Measuring and Test Equipment" has no relevance to the consultancy service. Although there are differences between construction and manufacturing, these are not expected to hinder the applicability of ISO 9000 standards to the former. Based on the questionnaire survey results, most consultants and contractors agree that ISO 9000 standards are suitable for their business but correct interpretations of the standards are needed.

9.1.2 Improvements in the Quality Assurance System in Hong Kong

The construction practices in Singapore and Hong Kong are similar. Both cities have adopted the ISO 9000 standards as the norm for their quality management systems. Singapore began using quality assurance in the construction industry in the mid 1980s. The Construction Industry Development Board was set up to oversee the development of a quality system for construction works. The designed assessment systems of CONQUAS, BQAS and CE CONQUAS, for the public and private buildings and civil engineering projects respectively, can efficiently measure the level of quality achieved by the contractors. The Premium Scheme provides incentive to the contractors and consultants to continuously improve their quality standard and achieve the ISO 9000 certification. With proper quality training, including the subcontractors, quality awareness has quickly spread over the construction industry in Singapore and the achievement is obvious.

In Hong Kong, only the PASS system is being used by the HKHA to assess its contractors' quality performance in building contracts. It is observed that its Preferential Tendering Eligibility System in connection with the 6-month PASS scores may not effectively bar the poorer contractors from obtaining contracts. It is recommended that an average PASS score for a completed building contract, similar to the CONQUAS, should be more practical and reflect the overall quality performance. Moreover, the PASS and CONQUAS do not take over the routine works inspection and have imposed heavy workload to contractors and supervisory staff. If these assessment systems can formally be a part of the contractual requirements, it can reduce the multiple inspections on site and improve the efficiency. As the private building works and public civil engineering projects have predominated in the construction market, quality assessment systems, like BQAS and CE CONQUAS in Singapore, ought to be devised to measure and promote quality achievement in Hong Kong.

In order to maintain the quality improvement momentum, incentive schemes must be further developed to be put into operation after the majority of consultants and contractors have achieved ISO 9000 certification. A proposed hybrid scheme, combining the Premium Scheme and Preferential Tendering Eligibility System, can give double encouragement to the construction sector in the continuous pursuit of high quality achievement.

9.1.3 Practicability of Applying ISO 9000 in the Construction Industry

Two intensive questionnaire surveys, one for consultants and another for contractors, were conducted to collect objective and representative evidence of the practicability of applying ISO 9000 in the construction industry. The high response rates can support the following definitive conclusions: -

a) The primary reason for ISO 9000 certification from consultants and contractors is to get a "work permit". Quality improvement is only a secondary reason.

b) The majority of respondents agreed that ISO 9000 was an adequate quality system for the construction industry but also opined that a trade-specific quality standard might be a good alternative. It is the author's view that ISO 9000 is an international common language in quality and a more trade-specific approach could undermine the integrity of the ISO 9000 standard. It is worthwhile to have additional guidance notes to assist the construction sector to better interpret the ISO 9000 standard. The two model manuals (see Section 9.1.4) were written for such a purpose.

c) The main difficulties in implementing and maintaining a QMS are the change of quality culture, insufficient quality management knowledge and excessive paperwork. The benchmarking with other ISO 9000-

certified companies for quality improvement is not workable in the construction industry in Hong Kong.

d) Consultants and contractors perceived that they had made certain improvements to key areas as a result of implementing a quality management system to ISO 9000 but the actual achievements were below their original expectations. It is noted that their expectations might have been too high in some cases. Brecka (1994) indicated that companies certified for over 5 years would reap greater benefits from the quality management system. Since most of respondents only obtained their ISO 9000 certification for one or two years at the time of the surveys, it is expected that the responding companies will gain more benefits from their certification as time goes by.

e) Quality related costs data of construction projects were either not available or confusing if available. As an effective costing system can reduce the production costs and improve the reliability of quality. A standardized aide-memoir for the analysis of quality related costs and quality problems should be designed in order to provide convincing evidence for the cost savings due to the introduction of a quality assurance system.

f) The construction sector generally welcomed the second party auditing as it could provide added confidence for their clients. It can also assure the quality of the end product through the client's hands-on management control.

g) Quality management knowledge is one of the major keys to success and its influence will be profound. The syllabuses of civil engineering undergraduate courses should contain quality assurance elements. This would satisfactorily reduce the learning curve about quality systems for the young engineers.

h) The quality assurance and the triangular relationship between quality, cost and time were not fully understood or accurately interpreted within the construction industry. While the consultants solely considered quality as the prime factor for the projects, the contractors often took the construction cost as the most important item possibly at the expense of quality. In fact, quality assurance is a systematic preventative approach to make a product right the first time and at minimum cost. With a better understanding of the principle of quality assurance - "get things right first time", the construction sector should be able to maintain the balance among the three major factors.

9.1.4 Installation of Quality Assurance System and Model Quality Manuals

Although the majority of consultants and contractors in Hong Kong have successfully achieved ISO 9000 certification, a good application of a quality assurance system to construction activities has not been completely realized. The problem perhaps comes from the difficult interpretation of the ISO 9000 quality elements in real terms of consultancy services and construction work on site. If some guidance notes, such as model quality manuals, were in place, the construction sector could more easily and fully understand the ISO 9000 standards and meet the quality requirements in all aspects.

From the case studies, it is noted that the case organizations can follow the generic terms in the quality standards in order to assemble the quality manuals and procedures for success in ISO 9000 certification. However, it has also been observed that the contents of the quality manuals still have room for a continuing improvement component. It has been found that the format of the manual which simply duplicates the structure of ISO 9001 is the best arrangement. The page layout with section header can keep the manual ease of updating. The quality manual is not simply a case of documenting procedures. It should start with a total re-examination of the current practices and processes within an organization and take the opportunity for improvement. The redundant procedures, which have no bearing on the quality of the product or service, should not be included in the quality system. Table 6.1 has listed the essential quality documents for the consulting firms for reference. A balanced design between quality manual and quality procedures must be obtained in order to simplify the paperwork.

There has never been a better time for an organization to embark on seeking ISO 9000 certification. Indeed the "seven steps" approach taken by the Territory Development Department for achieving ISO 9000 certification can be adopted by other organizations aiming for certification.

To meet the strong desire from the construction sector, two model quality manuals, one for consultants (ISO 9001) and one for contractors (ISO 9002), have been developed for reference. The normal practices in the construction industry and the quality assurance principle have been taken into account during the preparation of the manuals. The essential quality procedures are proposed for consideration. To the extent that each organization is unique, it follows that every organization's quality manual should be an original document. Nevertheless, these model manuals are intended to give helpful advice for the ISO 9000-certified organizations to review and maintain their system for continuous improvement and for the new comers to have a better understanding on how to set up an effective quality assurance system.

Quality does not happen by chance - it has to be managed. ISO 9000 standards are the foundation of Total Quality Management. It is hoped that the trend in construction quality will move in such a direction in the next decade.

9.2 Recommendation for Future Research

The benefits of implementing a quality management system to ISO 9000 standards have already been mentioned in the literature and are now being expected by the certified consultants and contractors. As ISO 9000 is applicable to contractual situations, the view of clients should be examined to ascertain the benefits accruing from employing ISO 9000-certified suppliers. It is recommended that the clients, such as Government works departments and Mass Transit Railway Corporation, be interviewed to collect opinions on the quality performance of ISO 9000-certified organizations and, in particular whether the third party certification is a successful tool in providing client reassurance.

Quality assurance is based on the principle that prevention is better than cure. It is more economical in time and money to have work executed correctly at the first attempt. However, there is no definitive analysis of the relationship between the quality cost and the application of a quality assurance system in the construction industry. It is recommended that research into the cost of introducing and operating the quality assurance system and the cost saved through its introduction be conducted. The result of such research may suggest to the construction sector that "quality is free".

ISO 9000 standards require the purchase of products and services from the subcontractors to be under proper control. In Hong Kong, a multi-layered subcontracting system is a detriment to quality in construction works. From the survey results and case studies, it has been clear that the main contractors have difficulty in enforcing a quality assurance system upon subcontractors. Since the subcontractors are the key players in the construction works, it is recommended that a plan be investigated and developed to assist the subcontractors in upgrading their quality consciousness. As the Government is now actively considering extending the ISO 9000 certification requirement to cover medium size contractors, such investigation will help the subcontractors to gradually build a full quality system for certification and eventually push the construction services to new levels of quality.

By February 1999, more than 100 consultants and 280 contractors on the Works Bureau's approved lists had obtained ISO 9000 certification. At present the certified consultants and contractors have no tangible advantage in bidding for contracts. Thus in order to keep the construction sector striving for quality improvement, some incentive schemes should be devised. Under the Works Bureau's pay for safety scheme (WB, 1996), the contractors receive payments after implementing certain safety measures. Apart from the previously proposed hybrid scheme, it is recommended that a similar pay for quality scheme (Ahmed *et. al.*, 2000) should be explored in an effort to keep the construction sector continuously improving their quality management system.

It is understood that the ISO 9000:2000 edition will be published in the second half of the Year 2000 (Ng, 1999). Its committee drafts have been circulated for discussion and comment. The new edition will bring to light new concepts of quality management principles and strategic techniques. It is recommended that a study, similar to the research work done by Kam and Tang (1995), be conducted to identify the changes detailed in the new edition in order to assist the certified companies to modify their existing system for certification renewal.

Appendix A

Questionnaire for Consultants

Ref. No : ______

Company Name : ______

Type of Consultancy Services : Feasibility Study ☐ Design ☐ Supervision ☐ ☐ Others (please specify) ______

Number of Employees:

Less than	25	☐
	25 - 50	☐
	51 - 100	☐
	101 - 200	☐
	201 - 400	☐
More than	400	☐

A. Motivation for Introducing a Quality Management System (QMS) to ISO 9000 Standards

1. Your Company's original motives to implement a QMS to ISO 9000 standards are (please enter a tick ☑ in one or more selected items) :

a. to improve the company's quality image in the construction industry ☐
b. to improve the company's efficiency and management ☐
c. to improve the internal and external communication ☐
d. to resolve the quality problem arising from poor design work ☐
e. to reduce liability risks and insurance cost ☐
f. to meet the internal policy requirement from the parent company ☐
g. the demand from the Government (e.g. Works Bureau, Housing Authority) ☐
h. the demand from the private developers ☐
i. as a start for total quality management (TQM) ☐
j. others (please specify) : ______ ☐

B. Development of Quality Management System

1. Setting up a QMS in the Company :

a. Did your Company set up a Quality Assurance Department for the development of the QMS ? Yes ☐ No ☐

b. If yes to (a), how many new posts have been created in the Quality Assurance Department ?
One ☐ Two ☐ Three ☐ Four ☐ Five or more ☐

c. Did your Company employ quality consultants to assist in developing the QMS ? Yes ☐ No ☐

d. If yes to (c), do you consider that the quality consultants are :
Very helpful ☐ Helpful ☐ Little helpful ☐ Not helpful ☐
Reason : ______

e. The Quality Manual and Procedures cover : (i) all business activities ☐
(ii) only major activities ☐

Reason for (ii) : ____________________

f. Length of time to achieve ISO 9000 certification :
Below 9 months ☐ 12 months ☐ 18 months ☐ 24 months ☐
30 months ☐ More than 30 months ☐

g. Please fill the figures in the brackets to indicate the approximate number of pages in each quality document (if any of the document is not used please leave it blank) :
(i) Quality Manual [ ] pages
(ii) Full set of Quality Procedures [ ] pages
(iii) Project Quality Plan [ ] pages

h. Comparison of quality documents before and after certification - percentages of **u**namended, **a**mended and **n**ew procedures are **(U+A+N = 100%)** :

Procedures	10	20	30	40	50	60	70	80	90	100 %
Unamended:										
Amended:										
New:										

i. Your Quality Manual and/or Procedures have been distributed to :
Company Management ☐ Engineers ☐ Technical staff ☐
Resident site staff ☐ Clients ☐ Sub-consultants ☐

2. Is ISO 9001 Standard relevant to Consultancy Services ?

Please rate how relevant of each ISO 9001 quality sub-section to your business :

4. High Degree of Relevance
3. Considerable Relevance
2. Average Relevance
1. Very Little Relevance
0. No Relevance

	ISO 9001 Quality Management Clauses	0	1	2	3	4
4.1	Management Responsibility					
4.2	Quality System					
4.3	Contract Review					
4.4	Design Control					
4.5	Document and Data Control					
4.6	Purchasing					
4.7	Control of Client Supplied Product					
4.8	Identification and Traceability					
4.9	Process Control					
4.10	Inspection and Testing					
4.11	Control of Inspection, Measuring and Test Equipment					
4.12	Inspection and Test Status					
4.13	Control of Non-conforming Product					
4.14	Corrective and Preventive Action					

ISO 9001 Quality Management Clauses	0	1	2	3	4
4.15 Handling, Storage, Packaging, Preservation and Delivery					
4.16 Control of Quality Records					
4.17 Internal Quality Audits					
4.18 Training					
4.19 Servicing					
4.20 Statistical Techniques					
Other Quality Management Parameters Proposed for Consultancy Services, if any					
(i) Financial Control					
(ii) Human Resource Management					
(iii) Computer Aided Design Control					
(iv) Others (please specify) :					

3. Design validation is normally performed on the final product. How do you interpret the requirement for the engineering design work under sub-section 4.4.8 - Design validation ?

____

____

4. How do you verify the purchased computer programmes before using them for design works ?

____

____

5. Do you have any testing equipment or other instruments under calibration control ?

____

____

6. Is sub-section 4.19 - Servicing applied to your activities ? Yes ☐ No ☐
Reason :

____

____

7. Which of your activities require sub-section 4.20 - Statistical techniques for control ?

____

____

8. Which ISO 9001 sub-sections are difficult to implement in consultancy services ?

____

____

9. The ISO 9000 is initially developed with the manufacturing industry in mind but is now applied to the design and site supervision processes. On the whole, do you agree that ISO 9000 standard is relevant to consultancy services ?

Strongly agree ☐ Agree ☐ Slightly agree ☐ Not agree ☐

Reason : ______________________________

____

C. Implementation of Quality Management System

1. Difficulties Encountered in Effectively Implementing the QMS in the Company

By your experience, please indicate whether you agree or disagree the following statements :

-2. Strongly Disagree
-1. Disagree
0. Neutral
1. Agree
2. Strongly Agree

	Difficulties often Encountered	2	1	0	-1	-2
a.	Lack of strong senior management involvement					
b.	Resistance or bad attitude from the staff					
c.	Engineers are trained to look for quality and are often not convinced that ISO 9000 is the best way to do so					
d.	Absence of well-structured quality system and procedures					
e.	Lack of effective communication even under quality procedures requirements					
f.	Too much documentation control and records					
g.	Impractical ISO requirements on consultancy services, e.g. calibration, servicing etc.					
h.	Not fully understanding the requirements of ISO 9000 standard by the staff					
i.	Change in culture					
j.	Insufficient quality training to staff					
k.	No co-operation from the client to meet your procedures under project quality plan					
l.	QMS is not applied to sub-consultants who will eventually affect the quality of final product					
m.	The clients only require the consultants to have ISO 9000 certification but they do not have such quality knowledge					
n.	Aim at maintaining the ISO 9000 certification as "Work Permit" but not seeking for further quality improvement					
o.	Others (please specify) :					

2. Improvement to the Installed Quality Management System

By your experience, please indicate whether you agree or disagree the following statements :

-2. Strongly Disagree
-1. Disagree
0. Neutral
1. Agree
2. Strongly Agree

	QMS can be Improved by/through	2	1	0	-1	-2
a.	Internal quality audit					
b.	External quality audit					
c.	Management review meeting					
d.	Effectively complete corrective and preventive actions					
e.	With reference to modern quality management technique					
f.	Quality training					
g.	Introduction of quality indicators (measurement of quality achievement, e.g. design period, accuracy of estimates etc.)					
h.	Others (please specify) :					

D. Maintenance of Quality Management System

1. Continuous Improvement to Quality Management System

By your experience, please indicate whether you agree or disagree the following statements :

-2. Strongly Disagree
-1. Disagree
0. Neutral
1. Agree
2. Strongly Agree

	QMS can be Continuously Improved by/through	2	1	0	-1	-2
a.	Regularly review the quality manual and procedures for improvement					
b.	Strong motivation from Quality Assurance Department					
c.	Retain quality staff					
d.	Benchmarking with other certified companies					
e.	More QA information and technique provided by the Government and certification bodies					
f.	Plan to implement Total Quality Management (TQM) system					
g.	Others (please specify) :					

E. Benefits and Drawbacks from Operating QMS

1. Expectations and Actual Achievement of Gaining a Certification to ISO 9000

By your experience, please indicate the benefits of which the company had originally expected to achieve and the actual achievements at this juncture :

-2. Strongly Disagree
-1. Disagree
0. Neutral
1. Agree
2. Strongly Agree

Expected Benefit √ *Actual Benefit* √

	Benefits of Gaining a Certification to ISO 9000	2	1	0	-1	-2
a.	Enhanced the Company's quality image *(Expected)*					
	(Actual)					
b.	Trimmed the onerous procedures to simpler versions and improved efficiency and productivity					
c.	Increased client satisfaction					
d.	Won more agreements / contracts					
e.	Improved administrative system among different functional departments					
f.	Reduced management attention required for routine matters and supervision					
g.	Reduced the amount of paperwork with a better documentation control					
h.	Improved design process and improved management to the resident site staff					
i.	Increased certainty of achieving contract requirements and deadlines					
j.	Achieved savings through a reduction in design failures and rework					
k.	Improved personal job satisfaction and morale					
l.	Others (please specify) :					

F. Professional Opinion on the Application of QMS to Consultancy Services

1. What is the total costs of all quality related activities as a percentage of your Company's turnover ? ☐ %

2. Does your Company divide quality related costs into prevention, appraisal and failure ? Yes ☐ No ☐

3. Is there a need for a standard quantifying system to determine an accurate quality related cost for assessment of the effectiveness of QMS? Yes ☐ No ☐

4. Do you accept second party quality audit conducted by your client ? Yes ☐ No ☐
Reason : ______________________

5. There is only a half-year consultants' performance assessment conducted by Government and it may not fully reflect the quality performance of the consultant. A quality performance assessment system on each project should be introduced to the Government engineering projects to quantify the quality achievement by the individual consultants. Yes ☐ No ☐

6. An incentive premium scheme should be devised to give tender advantage to the consultants with good quality performance records. For example, if a consultant submits a fee proposal of \$50M and his past quality record assessed by an independent authority allows him to have a tender advantage of 5% , then his consultant's fee will be treated as \$47.5M for competition but the actual payment to him under agreement is still \$50M. Yes ☐ No ☐

7. Quality Assurance is still a new subject in the design office. A formal training course to the engineering students in academic institutes is necessary. Yes ☐ No ☐

8. A model (i.e. standard) QA document covering ISO 9000 requirements for consultancy services is desirable. Yes ☐ No ☐

9. Please give priority (1, 2 & 3) to the following items in connection with your business :
Cost ☐ Quality ☐ Time ☐

10. Please give priority (1, 2, & 3) to the following items for the selection of sub-consultant :
Past quality performance ☐ Tender price ☐ Relationship ☐

11. Suggestion for further improvement to quality assurance in consultancy services :

____

____

Position of Respondent : ______________________

Appendix B

Questionnaire for Contractors

Ref. No : ______________________________

Company Name : ______________________________

Type of Contractor : Building ☐ Civil Engineering ☐ Piling ☐
☐ Others (please specify) ______________________________

Number of Employees:

Less than	25	☐
	26 - 50	☐
	51 - 100	☐
	101 - 200	☐
	201 - 400	☐
More than	400	☐

A. Motivation for Introduction a Quality Management System (QMS) to ISO 9000 Standards

1. Your Company's original motives to implement a QMS to ISO 9000 standards are (please enter a tick [√] in *one or more* selected items) :

a. to improve the company's quality image in the construction industry ☐
b. to improve the company's efficiency and management ☐
c. to resolve the problem with poor quality arising from the construction process and product ☐
d. to reduce the failure cost and liability risks ☐
e. the request from the Government (Housing Department and Works Branch) ☐
f. the demands from the private developers ☐
g. as a start for total quality management (TQM) ☐
h. others (please specify) : ______________________________ ☐

B. Development of Quality Management System

1. Setting up a QMS in the Company :

a. Did your Company set up a Quality Assurance Department for the development of the QMS ? Yes ☐ No ☐

b. If yes to (a), how many new posts have been created in the Quality Assurance Department ?
One ☐ Two ☐ Three ☐ Four ☐ Five or more ☐

c. Did your Company employ quality consultants to assist in developing the QMS ? Yes ☐ No ☐

d. If yes to (c), do you consider that the quality consultants are :
Very helpful ☐ Helpful ☐ Little helpful ☐ Not helpful ☐
Reason : ______________________________

e. The Quality Manual and Procedures cover : (i) all business activities ☐
(ii) only major activities ☐

Reason for (ii) : ______________________________

f. Length of time to achieve ISO 9000 certification :
Below 9 months ☐ 12 months ☐ 18 months ☐ 24 months ☐
30 months ☐ More than 30 months ☐

g. Please fill the figures in the brackets to indicate the approximate number of pages in each quality document (if any of the document is not used please leave it blank) :
(i) Quality Manual [ ] pages
(ii) Quality Procedures [ ] pages
(iii) Project Quality Plan [ ] pages

h. Comparison of quality documents before and after certification - percentages of unamended, amended and new procedures are :

Procedures	10	20	30	40	50	60	70	80	90	100 %
Unamended:										
Amended:										
New:										

i. Your Quality Manual and/or Procedures have been distributed to :
Headquarters Management ☐ Engineer ☐ Site Management ☐
Site foreman/Worker ☐ Client ☐ Sub-contractors ☐

2. Is ISO 9001 Standard relevant to Construction Industry ?

Please rate how relevant of each ISO 9001 quality sub-section to your business :

4 High Degree of Relevance
3 Certain Extent Relevance
2 Average Relevance
1 Very Little Relevance
0 No Relevance

	ISO 9001 Quality Management Clauses	0	1	2	3	4
4.1	Management Responsibility					
4.2	Quality System					
4.3	Contract Review					
4.4	Design Control					
4.5	Document and Data Control					
4.6	Purchasing					
4.7	Control of Client Supplied Product					
4.8	Identification and Traceability					
4.9	Process Control					
4.10	Inspection and Testing					
4.11	Control of Inspection, Measuring and Test Equipment					
4.12	Inspection and Test Status					
4.13	Control of Non-conforming Product					

4.14	Corrective and Preventive Action					
4.15	Handling, Storage, Packaging, Preservation and Delivery					
4.16	Control of Quality Records					
4.17	Internal Quality Audits					
4.18	Training					
4.19	Servicing					
4.20	Statistical Techniques					
Proposed Other Quality Management Sub-sections for Construction Industry, if any						
(i)	Financial Control					
(ii)	Site Safety					
(iii)	Environmental Control					
(iv)	Others (please specify) :					

3. **On the whole, do you agree that ISO 9000 standard is relevant to construction Industry**

Strongly agree ☐ Agree ☐ Slightly agree ☐ Not agree ☐

Reason : ____

C. Implementation of Quality Management System

1. **Difficulties Encountered in Effectively Implementing the QMS in the Company**

With your experience, please indicate to which you agree or disagree the following statements :

Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree

	Difficulties often Encountered	2	1	0	-1	-2
a.	Lack of strong senior management involvement					
b.	Resistance or bad attitude from the staff					
c.	Poor internal / external communication					
d.	Not fully understanding requirements of ISO 9000 standard					
e.	Impractical ISO requirements on site work, e.g. calibrations					
f.	Absence of well-structured quality system and procedures					
g.	Too much documentation control and record					
h.	Change in culture					
i.	Insufficient quality training to staff					
j.	Quality documentation is written in English and not easy to follow by site staff and workers					
k.	Site staff are used to work supervision rather than procedural manual					
l.	QMS is not applied to sub-contracting system					
m.	The company's QMS does not match another QMS being operated by the Resident Engineer appointed by the client					

n.	Aim at maintaining the ISO 9000 certification as "Work Permit" but not seeking for further quality improvement					
o.	Others (please specify) :					

2. Improvement to the Installed Quality Management System

With your experience, please indicate to which you agree or disagree the following statements :

Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree

	QMS can be Improved by/through	2	1	0	-1	-2
a.	Internal quality audit					
b.	External quality audit					
c.	Management review meeting					
d.	Effectively complete corrective and preventive actions					
e.	Quality training					
f.	Introduction of quality indicators (measurement of quality achievement, e.g. time, safety, workmanship etc.)					
g.	Others (please specify) :					

D. Maintenance of Quality Management System

1. Continuous Improvement to Quality Management System

With your experience, please indicate to which you agree or disagree the following statements :

Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree

	QMS can be Continuously Improved by/through	2	1	0	-1	-2
a.	Regularly review the quality manual and procedures for improvement					
b.	Strong motivation from Quality Assurance Department					
c.	Retain quality staff					
d.	Benchmarking with other certified companies					
e.	More QA information and technique provided by the Government and certification bodies					
f.	Plan to implement TQM system					
g.	Others (please specify) :					

E. Benefits and Drawbacks from Operating QMS

1. **Expectations and Actual Achievement of Gaining a Certification to ISO 9000**

With your experience, please indicate the benefits of which the company had originally expected to achieve and the actual achievements at this juncture :

Expected Benefit ☐ *Actual Benefit* ☐

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

	Benefits of Gaining a Certification to ISO 9000	**2**	**1**	**0**	**-1**	**-2**
a.	Enhanced the Company's quality image					
b.	Trimmed the onerous procedures to simpler versions and improved efficiency and productivity					
c.	Increased client satisfaction					
d.	Won more contracts					
e.	Improved administrative system between site and head offices					
f.	Reduced management attention required for routine matters and site supervision					
g.	Reduced the amount of paperwork with a better documentation control					
h.	Improved construction process and site safety					
i.	Increased certainty of achieving contract requirements and deadlines					
j.	Achieved savings through a reduction in failures and reworks					
k.	Improved personal job satisfaction and morale					
l.	Others (please specify) :					

F. Professional Opinion on the Application of QMS to Construction Industry

1. What is the total costs of all quality related activities as a percentage of your Company's turnover ? ☐ %

2. Does your Company apportion quality related costs into prevention, appraisal and failure ? Yes ☐ No ☐

3. Is there a need for a standard quantifying system to determine an accurate quality related cost for assessment of the effectiveness of QMS? Yes ☐ No ☐

4. Do you accept second party quality audit conducted by your client ? Yes ☐ No ☐
Reason : ______________________________

5. Similarly to the Performance Assessment Scoring System (PASS) implemented for public housing projects in Hong Kong, a construction quality assessment system should also be introduced to the Government civil engineering contracts to quantify the quality achievement by the individual construction company. Yes ☐ No ☐

6. An incentive premium scheme should be devised to give tender advantage to the contractors with good quality performance records. For example, if a contractor submits a tender of $100M and his past quality record assessed by an independent authority allows him to have a tender advantage of 5% , then his tender price will be treated as $95M for competition but the actual payment to him under contract is still $100M. Yes ☐ No ☐

7. All major building trade workers should be properly trained and certified to improve their quality awareness in construction work. Yes ☐ No ☐

8. Quality assurance staff in construction industry is limited. A formal training course in academic institutes is necessary. Yes ☐ No ☐

9. A model (i.e. standard) QA document covering ISO 9000 requirements for construction industry is desirable. Yes ☐ No ☐

10. Please set priority (1, 2 & 3) to the following items in connection with your business :
Cost ☐ Quality ☐ Time ☐

11. Please set priority (1, 2, & 3) to the following items for the selection of sub-contractor :
Past quality performance ☐ Tender price ☐ Relationship ☐

12. Suggestion for further Improvement to Quality Assurance in Construction Industry :
____
____

Position of Respondent : ______________________________

Appendix C

Model Quality Manual
for
Consultants

POLYTEC CONSULTING ENGINEERS LIMITED

ISO 9001 : 1994
Quality Manual

(Issue One)

This manual describes the Polytec Consulting Engineers Limited's quality management system and is a mandatory requirement of the system. Its issue is controlled if the copy number is marked in red.

This manual does not form part of any agreement and is not intended to imply any representation or warranty. The Company reserves the right to amend its procedures from time to time in order to comply with individual agreement requirements.

Controlled Copy Number :

Verification			
Description	Post	Signature	Date
Prepared by	Quality Manager		
Reviewed by	Quality Assurance Director		
Approved by	Managing Director		

Revision History

Rev. No.	Effective Date	Section/ Page	Revision Details	Prepared by	Reviewed by	Approved by
0	1.05.97	All	New Issue			

Contents

Introduction

This Quality Manual outlines the policy of Polytec Consulting Engineers Limited (the Company) relating to its Quality Management System (QMS).

The Company's QMS is designed to and operates within the requirements of ISO 9001 : 1994.

Purpose

The purpose of this Quality Manual is to document the Company's policies which have been established and implemented to assure the quality of products and services.

The policies are implemented by documents identified in Section 4.0 of the Quality Manual and other Procedures.

This Quality Manual applies to all activities in the Company.

Authority

This manual is issued on the authority of the Managing Director, Quality Assurance Director and Quality Manager.

Issue of the Manual

The master copy of the Quality Manual is held by the Quality Manager. He is also responsible for the issue of amendments to the Quality Manual and withdrawal of obsolete information.

Controlled copies of the Quality Manual will be numbered in red and registered.

Uncontrolled copies of the Quality Manual may be distributed to organizations or Clients at the discretion of Quality Manager. These will be current at the date of issue only and will not be subject to amendment action.

Amendments

Controlled manual and procedures will be updated and revised as required. The issue of amendments requires formal action by the Quality Manager.

Review

The Quality Manual will be reviewed annually. However, the Company reserves the right to change the contents of this Quality Manual without notice.

Copyright

The copyright of this Quality Manual is owned by Polytec Consulting Engineers Limited. No part of this Quality Manual may be reproduced in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of the Company.

1.0 Quality Policy

QUALITY POLICY
OF
POLYTEC CONSULTING ENGINEERS LIMITED

Mission Statement

Polytec Consulting Engineers Limited is the leading civil and structural consulting engineering company in Hong Kong.

Vision Statement

Unsurpassed reputation for quality and consulting engineering services.

Policy Statement

Polytec Consulting Engineers Limited provides comprehensive consulting engineering services to all sectors in the construction industry in Hong Kong. It is the Company's policy to fulfil the agreed requirements of our Clients. The services provided are founded on technical excellence and reliability.

In pursuit of our mission, we operate a quality system complying with the requirements of ISO 9001 : 1994. Our aim is to ensure that our business is managed in the most effective way to meet our Clients' needs and to continually strive to improve our quality, reliability and services. All staff are responsible for working to achieve these objectives.

Managing Director

Date

2.1 Description of Company

Polytec Consulting Engineers Limited was established in Hong Kong in 1993. The Directors of the company have wide experience in civil and structural engineering projects and specialize in reclamation, marine work, geotechnical engineering, highway structures and project management.

The services provided include feasibility studies, conceptual design, detailed design, contract documentation, supervision of construction and project management.

The office is located at:

8th Floor, Polytec House, Causeway Bay, Hong Kong

2.2 Scope of Certification

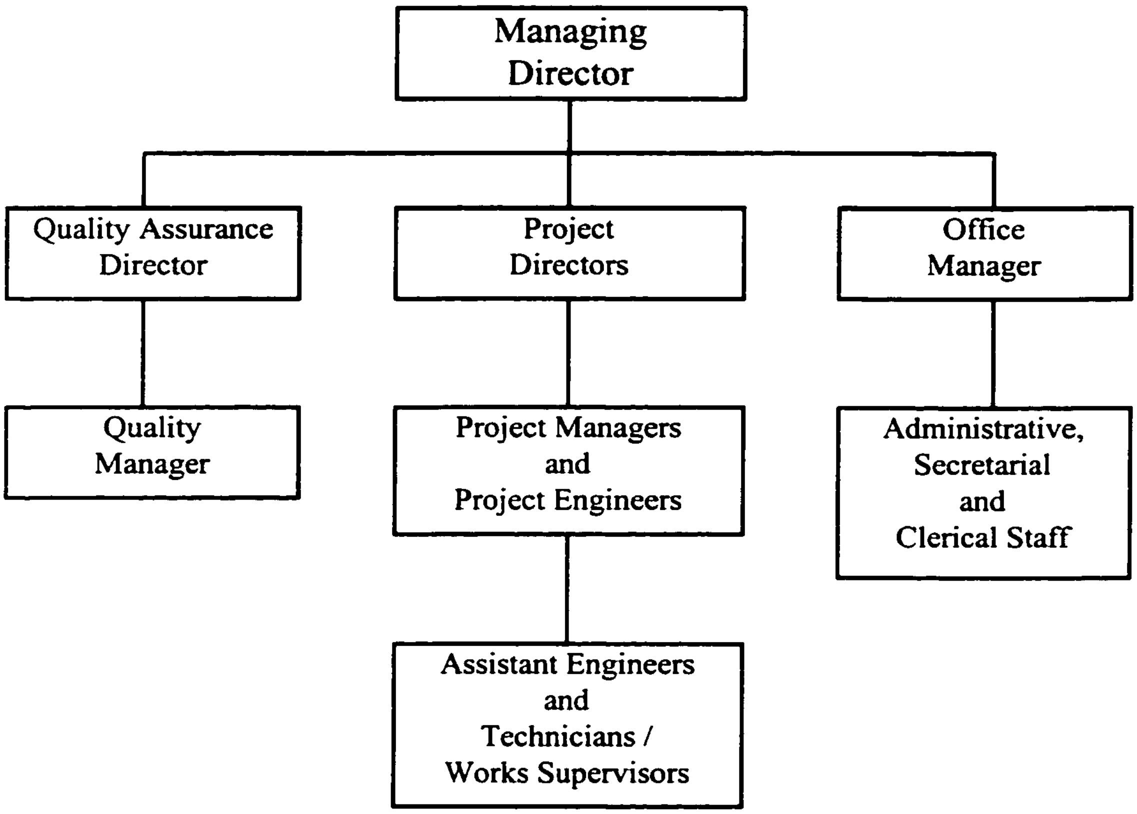
The scope of this quality management system and its certification to ISO 9001:1994 relates to the: -

Provision of study, investigation, design, tendering and site supervision for civil, structural and associated engineering consultancy services

provided by the Polytec Consulting Engineers Limited.

3.0 Organization

Organization Chart



Typical Organization Chart

3.1 Responsibilities

A. Managing Director

The Managing Director is appointed by the Board of Directors of the Polytec Consulting Engineers Limited. He is responsible for the overall control of commission, including the quality system. His specific duties consist of: -

- assigning responsibility for new projects to Project Director
- ensuring that adequate resources are available to comply with the Company's Quality Policy
- approving the quality system and conducting the management review

B. Project Director

The Project Director is appointed by the Managing Director and is responsible for the successful completion of the project in the most cost-effective way. His specific duties consist of: -

- appointing the project team staff
- ensuring that adequate staff resources allocated to the project and they are experienced on the assignment
- negotiate fees and programme with the Client
- ensuring that the quality system is applied to projects

C. Project Manager

The Project Manager is appointed by the Project Director and is responsible for individual projects including the preparation of Project Quality Plan. His specific duties consist of: -

- day-to-day management of the project in technical and financial aspects
- agreeing the scope of work and any changes with the Client
- ensuring that the activities are complied with the quality system

D. Project Engineer

The Project Engineer is responsible for the tasks assigned by the Project Manager including engineering studies, design work, co-ordination, inspection, collection of data in accordance with the Project Quality Plan.

E. Assistant Engineer

The Assistant Engineer is responsible for assisting the Project Engineer to perform his technical work such as design calculations, checking and preparing the contract documents and specifications.

F. Technician/Works Supervisor

The technician/works supervisor is responsible for assisting the Project Engineer and Assistant Engineer to prepare contract drawings, measurements or undertake site supervision.

G. Office Manager

The Office Manager, with assistance from the administrative, secretariat and clerical staff, is responsible for handling of personnel and training records, document registration, filing and other office administrative and secretarial works.

H. Quality Assurance Director

The Quality Assurance Director is authorized by the Board of Directors and responsible for the implementation and operation of quality system within the Company.

I. Quality Manager

The Quality Manager is responsible for drafting the Quality Manual and Procedures, assisting the Quality Assurance Director to implement and operate the quality system, carrying our internal audits and arranging the management review meeting.

4.0 Quality System Requirements

The quality system of Polytec Consulting Engineers Limited contains 20 clauses corresponding to the 20 elements in the ISO 9001:1994. They are: -

Section	Quality System Sections	Corresponding ISO 9001 Clause
4.1	Management Responsibility	4.1
4.2	Quality System	4.2
4.3	Contract Review	4.3
4.4	Design Control	4.4
4.5	Document and Data Control	4.5
4.6	Purchasing	4.6
4.7	Control of Client Supplied Product	4.7
4.8	Identification and Traceability	4.8
4.9	Process Control	4.9
4.10	Inspection and Testing	4.10
4.11	Control of Inspection, Measuring and Test Equipment	4.11
4.12	Inspection and Test Status	4.12
4.13	Control of Non-conforming Product	4.13
4.14	Corrective and Preventive Action	4.14
4.15	Handling, Storage, Package, Preservation and Delivery	4.15
4.16	Control of Quality Records	4.16
4.17	Internal Quality Audits	4.17
4.18	Training	4.18
4.19	Servicing	4.19
4.20	Statistical Techniques	4.20

4.1 Management Responsibility

This section defines the Company commitment to quality.

4.1.1 Quality policy

The Company's quality policy is stated in Section 1 of this Quality Manual. The Company is committed to achieve this policy through the implementation and maintenance of a Quality Management System.

4.1.2 Organization, responsibility and authority

The organization chart, responsibility and authority of personnel are defined in Section 3 of the Quality Manual. Unless otherwise specified in the document, the staff structure is used as the model and modification may be made to suit the particular circumstances.

4.1.3 Verification resources and personnel

Resource requirements are identified in Quality System Procedures (QSP) for verifying conformance to specified requirements by the appropriate levels of review checking, monitoring and internal quality audit. Adequate resources are provided according to the resource requirements. The Quality Manager shall ensure that personnel engaged in verification activities are trained.

4.1.4 Management representative

The Quality Assurance Director is the appointed Management Representative (MR) and is responsible for ensuring that the Quality Management System is effectively implemented, operated and maintained. He is also required to report the performance of the Quality Management System to the management. Quality Manager is designated as Deputy MR.

4.1.5 Management review

The established Quality Management System is reviewed at least once a year by the Management Review Committee. The review will be chaired by the Managing Director and attended by the whole management team. The results of management review are recorded and the Quality Manager is responsible for ensuring that the necessary actions agreed from the review are carried out effectively and verified on completion.

4.1.6 Supporting procedures and forms

QSP 101	Management Review
QSP 102	Agenda of Management Review
QF 101	Management Review Meeting Minutes

4.2 Quality System

This section defines the quality system operated by the Company to ensure that all services conform to specified requirements.

4.2.1 Summary of procedure

The quality system is structured in three levels: -

Quality manual (Level 1)

The quality manual contains the quality policy of the Company, the responsibility and authority of key personnel.

Quality procedures (Level 2)

The quality procedures are to define and control of activities affecting the quality of services.

Work instructions (Level 3)

The work instructions are produced to supplement quality procedures and detail the methods, control, verification and records on the performance of specific activities.

Project quality plans

The project quality plans are project specific documents prepared to define and control fundamental aspects of special projects. They set out the strategy to achieve the desired quality in the project and serve as a summary.

4.2.5 Supporting procedures and forms

QSP 201 Preparation of Quality Procedures
QSP 202 Project Quality Plan
All other current Company Procedures and Works Instructions

4.3 Contract Review

This section defines the way in which Client's requirements will be established and reviewed.

4.3.1 General

The Company has established documented procedures for contract review to be performed by the Project Director.

4.3.2 Review procedures

A contract review is carried out for all commissions. The client project brief shall be reviewed to ensure that the requirements are adequately defined and documented, to identify any differences to those proposed are resolved and to determine the Company's ability to meet the contractual requirements.

Contract review is carried out throughout the various stages of a project, including invitation of tenders for construction contracts on behalf of the Clients, and is controlled by procedures. Amendments to the Client's requirements are reviewed, recorded and communicated to all affected functions in a timely manner.

4.3.3 Supporting procedures and forms

QSP 301	Contract Review
QSP 202	Project Quality Plan
QF 301	Contract Review Checklist
QF 302	Contract Review Records

4.4 Design Control

This section defines the way in which design and services will be controlled in order to satisfy the Client's requirements and thereby achieve the Company's mission.

4.4.1 General

The Company maintains procedures and documentation in order to control the design activities and to ensure that the design output meets all specified requirements.

4.4.2 Design and development planning

Planning is carried out during the contract review. The Project Manager is responsible for preparing the project quality plan. The project quality plan shall be developed to identify the responsibility for the design and development activities together with the establishment of the staff resources and overall programme for each project. Plan is updated in the course of the design, development and construction of the project.

4.4.3 Organizational and technical interfaces

The Project Manager is responsible for identifying organizational and technical interfaces between different groups, as well as documenting, transmitting and periodically reviewing the necessary information for the realization of the project quality plan.

4.4.4 Design input

The design inputs are identified as Client's requirements in the brief, statutory and regulatory requirements and implied requirements on safety and economy. These are reviewed by the Project Manager before incorporation into the project quality plan and may be updated from time to time as necessary. Incomplete, ambiguous or conflicting requirements shall be resolved prior to commencing the design.

4.4.5 Design output

Design output are reports, drawings, calculations, bills of quantities, specifications, tender documents and associated documents. These are controlled and required to meet all design input, the statutory requirements, the Client's specified acceptance criteria and requirements laid down in the project quality plan. The reviews shall be carried out and documented before release.

4.4.6 Design review

During the course of the project, design reviews are carried out at frequencies determined by the Project Manager and incorporated in the project quality plan. Representatives from all relevant functions are invited to ensure a comprehensive review. Records of reviews shall be maintained.

4.4.7 Design verification

To ensure that results of designs continue to meet design input requirements, the Project Director shall appoint another Project Manager to carry out design verification, which may take the form of comparison with previous designs or the preparation of alternative calculations. The design verification measures shall be recorded.

4.4.8 Design validation

Design validation is carried out by the Project Manager normally at the final output stage but may be necessary in earlier stages prior to product completion. These shall be performed to ensure that the structure conforms to the defined requirements.

4.4.9 Design changes

All design changes and modifications are to be identified and documented. They are reviewed by the Project Engineer and subsequently approved by the Project Manager.

4.4.10 Supporting procedures and forms

QSP 401	Design Control
QSP 402	Design Review Plan
QSP 403	Design Change Control
QSP 202	Project Quality Plan
QF 401	Design Input Checklist
QF 402	Design Output Checklist
QF 403	Design Review Schedule
QF 404	Design Review Report
QF 405	Design Review Actions Plan
QF 406	Design Change Report

4.5 Document and Data Control

This section defines the way in which all documentation forming part of the quality management system will be controlled.

4.5.1 General

The quality system procedures have been established and maintained to control all documents and data, including those of external origin such as standards and client drawings, that relate to and are required for an effective operation of a quality management system.

4.5.2 Document and data approval and issue

Documents and data relating to the quality of services are subject to control in respect of their review, approval, issue and disposal as appropriate. The issue of all such documentation shall be authorized by the Quality Assurance Director and be controlled and recorded by the Quality Manager. The Quality Manager shall also maintain a register listing all quality manual and procedures relating to the quality system. It is the responsibility of all personnel to check and ensure that the documents and data being used are the correct issue.

4.5.3 Document and data change

Changes and revisions of controlled documents and data are reviewed and approved by the personnel who has given the original approval. The nature of any change shall be indicated in the document or attachment where it is considered practicable. Distribution lists are used to ensure that controlled copy holders are updated with new documents and data issues.

4.5.4 Supporting procedures and forms

QSP 501	Internal Document and Data Control
QSP 502	External Document and Data Control
QSP 503	Incoming / Outgoing Correspondence Control
QF 501	Master List of Controlled Documents
QF 502	Controlled Document Distribution List
QF 503	Document Transmittal Record
QF 504	Master List of Quality Forms

4.6 Purchasing

This section defines the controls on the purchase of materials and services used in the design process.

4.6.1 General

The Project Director is responsible for the purchase of materials and services for his project in accordance with the documented procedures.

4.6.2 Evaluation of sub-consultants and suppliers

The Company selects sub-consultants and suppliers on the basis of their professional abilities to meet specified requirements including quality performance. The assessment is based on the project requirement, the quality system, ability, past performance and price. The evaluation is carried out by the responsible personnel identified in the procedure. Records of acceptable sub-consultants and suppliers are kept by the Quality Manager and are reviewed and approved by the Quality Assurance Director bi-annually.

4.6.3 Purchasing data

The purchasing data for sub-consultancy is interpreted as the brief which forms part of the agreement with the sub-consultants or suppliers. The Project Manager prepares the purchasing document which is reviewed and approved by the Project Director to ensure that purchasing data are adequate and accurate.

4.6.4 Verification of purchased product

The Client's source verification requirements will be identified at the contract review stage. When specified in the contract, the Client has the right to verify at source or at the supplier's plant that purchased products or services conforms to specified requirements. Such verification by the Client cannot be used by the Company as evidence of effective control of quality by the suppliers.

4.6.5 Supporting procedures and forms

QSP 601	Procurement of Sub-consultant/Supplier Services
QSP 602	Assessment of Sub-consultant/Supplier Procedure
QF 601	Approved Sub-consultants/Suppliers List
QF 602	Sub-consultant's/Supplier's Performance Record

4.7 Control of Client-supplied Product

This section defines the way in which client-supplied product shall be controlled.

4.7.1 Summary of procedure

The client-supplied products, which include specifications, survey records, data, drawings etc., are subject to control and to be outlined in the project quality plan.

All the supplied products shall be properly stored and maintained. Where the product is found to be unsuitable, or where the product is lost or damaged, this shall be recorded and immediately reported to the Client by the Project Manager for further action. Verification by the Company does not absolve the Client's responsibility to provide acceptable product.

4.7.2 Supporting procedures and forms

QSP 701	Control of Client-supplied Product
QSP 202	Project Quality Plan
QF 701	Client-supplied Documents List
QF 702	Client-supplied Drawings List

4.8 Product Identification and Traceability

This section defines how product identification and traceability will be maintained.

4.8.1 Summary of procedure

The Company has established procedures for identifying the applicable drawings, specifications, reports and other documents produced and issued during all stages of the project. Each project is allocated a unique identification number and project documentation is traceable using the project reference.

The engineering works on site shall be recorded by means of as-built drawings, photographs or other feasible methods to be defined by the Project Manager. He is also responsible for establishing and maintaining relevant quality records for the identification and traceability of product.

4.8.2 Supporting procedures and forms

QSP 501	Internal Document and Data Control
QSP 502	External Document and Data Control
QF 502	Document Distribution List
QF 503	Document Transmittal Record

4.9 Process Control

This section defines the way in which design and supervision processes shall be controlled.

4.9.1 Summary of procedure

All processes that affect the quality of services are identified and detailed in the quality procedures. Process control is achieved by means of those procedures which describe the responsibilities and manner in which they are performed by the personnel. A project quality plan is also prepared to suit the special requirements in each project.

The procedures of the production processes at various design and construction stages are: -

a. Project bidding stage

QSP 901	Technical and Fees Submission
QSP 301	Contract Review

b. Design stage

QSP 902	Feasibility Study
QSP 903	Conceptual Design
QSP 904	Site Investigation
QSP 202	Project Quality Plan
QSP 401	Design Control
QSP 601	Procurement of Sub-consultant/Supplier Services

c. Tender stage

QSP 905	Preparation of Tender Documents
QSP 906	Issue of Tender Document
QSP 907	Evaluation of Tenders
QSP 908	Signing of Contract

d. Construction stage

QSP 909	Site Supervision and Control
QSP 910	Employment of Resident Site Staff
QSP 911	Completion, Handover and Maintenance of Contract

e. Office Administration

QSP 1001	Computer Application

4.9.2 Special processes

In the case of any process the result of which cannot be fully verified by subsequent inspection and product testing, control, monitoring and verification procedures during the course of design and construction stages are heavily relied on to ensure quality. The Project Manager is responsible for the development of these procedures with approval from the Project Director.

4.9.3 Supporting procedures and forms

QSP 901	Technical and Fees Submission
QSP 902	Feasibility Study
QSP 903	Conceptual Design
QSP 904	Site Investigation
QSP 905	Preparation of Tender Documents
QSP 906	Issue of Tender Document
QSP 907	Evaluation of Tenders
QSP 908	Signing of Contract
QSP 909	Site Supervision and Control
QSP 910	Employment of Resident Site Staff
QSP 911	Completion, Handover and Maintenance of Contract
QSP 1001	Computer Application

4.10 Inspection and Testing

This section defines the conduct of inspection and testing activities to verify conformance with specified requirements in various project stages.

4.10.1 General

The Company has established and maintained documented procedures for inspection and testing activities to verify the design and construction works.

4.10.2 Receiving inspection and testing

All incoming products and documents received from the Client, sub-consultant and contractor are subject to check and inspection before further processing by the Project Engineer. Only properly accepted and identified products and documents are released for use. Recorded evidence of conformance shall be kept.

When incoming products and documents are needed and released for urgent use, they are positively identified and traceable so as to facilitate recall in the event of non-conformance with specified requirements.

4.10.3 In-process inspection and testing

The extent of an in-process inspection and testing varies depending on the nature of projects. The Project Manager or his authorized representative is responsible for the in-process inspection and testing of the product according to the documented procedures and project quality plan. The product must be held and not used or further processed until the required inspections and tests have been completed.

In the case of site inspections, the checking and recording of site activities are included to ensure that they comply with the contract specifications and drawings.

4.10.4 Final inspection and testing

All products will be subject to a final inspection and test to ascertain conformance to specified requirements. The design verification provides the checking mechanism to ensure that the design work complies with the requirements before issue. The QSP 911 procedure is to ensure that the construction work conforms with the requirements prior to handing over to the Client. The Project Director is responsible for the final inspection of product in accordance with documented procedures and project quality plan. The Quality Assurance Director is also responsible for ensuring that all documented procedures are maintained.

4.10.5 Inspection and test records

The Company establishes and maintains records which provide evidence that the product has been inspected and/or tested. The records of receiving, in-process and final inspection and checking are contained either on the documents themselves or on associated documents. These records shall show clearly which product has passed or failed the inspections and/or tests according to defined acceptable criteria. The procedures for control of non-conforming products shall apply when the products fail to pass any inspection and/or test.

4.10.6 Supporting procedures and forms

QSP 1001	Computer Application
QSP 1101	Equipment Inspection, Measuring and Testing Procedure
QSP 202	Project Quality Plan
QSP 401	Design Control
QSP 502	External Document and Data Control
QSP 601	Procurement of Sub-consultant/Supplier Services
QSP 907	Evaluation of Tenders
QSP 911	Completion, Handover and Maintenance of Contract
QF 1001	Record of Approved Computer Data
QF 1101	Equipment of Inspection, Measuring and Testing Record

4.11 Control of Inspection, Measuring and Test Equipment

This section defines the control of inspection, measuring and test equipment used by the Company.

4.11.1 General

The Company maintains procedures to control, calibrate and maintain inspection, measuring and test equipment used to demonstrate the product conformity with the specified requirements.

4.11.2 Control procedure

The equipment is regularly calibrated against certified equipment having a known valid nationally recognized standard. A calibration schedule chart is maintained by the Quality Manager. When equipment is found to be outside calibration, it is immediately removed and brought to the Quality Manager for corrective action.

All calibrated equipment is handled and stored in a manner necessary to prevent the loss of accuracy. Unauthorized adjustment is prohibited.

4.11.3 Supporting procedures and forms

QSP 1101	Equipment Inspection, Measuring and Testing Procedure
QF 1101	Equipment of Inspection, Measuring and Testing Record
QF 1102	Equipment Calibration Schedule

4.12 Inspection and Test Status

This section defines the way in which inspection and test status will be defined.

4.12.1 Summary of procedure

The verification of inspection and test status for design input and output documents is identified in the document by the approved signature. The site inspection is identified in the inspection forms with the authorized signature.

All design documents and drawings are stamped to indicate the purpose of the issue and the use. Records are maintained to identify the inspection authority responsible for the release of the finished product.

4.12.2 Supporting procedures and forms

QSP 202	Project Quality Plan
QSP 501	Internal Document and Data Control
QSP 502	External Document and Data Control

4.13 Control of Nonconforming Product

This section defines the manner of controlling a design product that does not conform to specified requirements.

4.13.1 General

The Company maintains procedures to ensure that the design product or service provided which does not conform to specified requirements is prevented from unintended use. The control in these procedures includes identification, documentation, evaluation, segregation, disposition of nonconforming product and notification to the users concerned.

4.13.2 Review and disposition of nonconforming product

The Quality Assurance Director or Quality Manager is responsible for reviewing nonconforming product in collaboration with the Project Director or Project Manager in accordance with documented procedures.

In cases where acceptance with or without repair by concession from the Client, a written record with supportive information shall be submitted to the Client and action duly taken on receipt of his confirmation. Records of the description of nonconformity and its disposition shall be maintained.

4.13.3 Supporting procedures and forms

QSP 1301	Control of Non-conforming Product Procedure
QF 1301	Non-conforming Product Record

4.14 Corrective and Preventive Action

This section defines how corrective and preventive action is identified, implemented and reviewed for effectiveness.

4.14.1 General

The Quality Manager shall initiate corrective action request when quality records indicate that defects occurred. Product, process or quality system non-conformances detected will be analyzed to determine their magnitude and cause. Action to prevent any further occurrence will be assigned. Any change to the documented procedures resulting from corrective and preventive action shall be recorded.

4.14.2 Corrective action

Corrective action procedures have been maintained for the following: -

- effective handling of Client complaints and non-conforming reports
- analyzing non-conforming data to determine their extent and causes
- introducing the improvements and corrections as required
- monitoring of the effectiveness of the corrective action taken

4.14.3 Preventive action

Preventive action procedures have been established for the following: -

- analyzing the processes, work operations, concessions, quality records, service reports and Client complaints to identify and rule out possible reasons for the non-conforming activities
- determining preventive measures to deal with problems with risk encountered
- introducing and monitoring the preventive action as required
- ensuring that information on actions taken is submitted for management review

4.14.4 Supporting procedures and forms

QSP 1401 Corrective and Preventive Action

4.15 Handling, Storage, Packaging, Preservation & Delivery

This section defines the controls employed within the Company for handling, storage, packaging, preservation and delivery of product or services.

4.15.1 General

The Company maintains procedures for handling, storage, packaging, preservation and delivery of its product or services. The product or service produced is regarded as the consulting engineering services and the output is drawings, reports, documents and supervision services. This section is not applicable to the construction work as a product.

4.15.2 Handling

A product in the form of drawings, reports and documents is properly handled against damage or deterioration.

4.15.3 Storage

Suitable facilities and equipment for storage are employed to ensure design output is not damaged and lost. The condition of the product in stock is assessed at intervals.

4.15.4 Packaging

Documents are suitably packed and marked for protection.

4.15.5 Preservation

Project documents shall be preserved and segregated in accordance with the project quality plan.

4.15.6 Delivery

The delivery of documents shall be followed the documented procedures to ensure that delivery is achieved without loss or damage. Record of delivery shall be maintained.

4.15.7 Supporting procedures and forms

QSP 1501	Records and Archives of Product
QSP 501	Internal Document and Data Control
QSP 502	External Document and Data Control

4.16 Control of Quality Records

This section defines the maintenance of quality records.

4.16.1 Summary of procedure

All essential quality related activities within the Company will be the subject of records to fully demonstrate the achievement of specified requirements and the effective operation of the quality management system. Records will be suitably stored and maintained to ensure their safe keeping and subsequent retrieval. The Project Manager shall ensure that the quality records are controlled in accordance with individual project quality plans.

The Quality Manager shall maintain all records. The retention periods and the authority for the disposal of records will be defined. Access to quality related records will be made available to Client's representative as required.

4.16.2 Supporting procedures and forms

QSP 1601	Quality Records Control Procedure
QF 1601	Archives Instruction Form
QF 1602	Archives Documentation Register
QF 1603	Archives Box List
QF 1604	Archives Reclaim Form
QF 1605	Archives Disposal Form
QF 1606	Quality Records Retention Period List
QF 1607	Microfilm Drawing List

4.17 Internal Quality Audits

This section defines the conduct of internal quality system audits.

4.17.1 Summary of procedure

The Quality Assurance Director will ensure that all aspects of the quality system are objectively audited. Audits will be carried out systematically and on a regular predetermined frequency as arranged by the Quality Manager.

Audits will be conducted by trained personnel, independent of those having direct responsibility for the activity being audited. Results will be recorded and reviewed by management to ascertain that the quality system is effective in achieving the Company's objectives.

Corrective and preventive action will be assigned to deal with any non-conformances identified. Follow-up audit activities shall verify and record the effectiveness of the corrective action taken.

4.17.2 Supporting procedures and forms

QSP 1701	Internal Quality Audit
QSP 101	Management Review
QF 1701	Internal Audit Schedule
QF 1702	Internal Audit Notification
QF 1703	Internal Audit Checklist
QF 1704	Internal Audit Timetable
QF 1705	Non-conformance Report
QF 1706	Corrective Action Request
QF 1707	Observation Report
QF 1708	Audit Opening Meeting
QF 1709	Audit Closing Meeting
QF 1710	Internal Audit Report
QF 1711	Internal Audit Report Log
QF 1712	Corrective Action Request Log
QF 1713	Completed Non-conformance Reports

4.18 Training

This section defines the arrangements made within the Company to ensure that all personnel are suitably trained for the tasks that they are required to undertake.

4.18.1 Summary of procedure

All tasks within the Company which are adversely affected by the lack of acquired knowledge and skill shall be identified. The subject of a job specification which reflects the extent and evidence of knowledge and skill required shall be established. The Project Director shall ensure that personnel has been trained to perform the assigned task.

The training needs of each person is identified and recorded at the commencement of employment and at all annual reviews held by the Project Director. Continuing professional development training will also be provided to all engineers. Training records are maintained by the Office Manager.

4.18.2 Supporting procedures and forms

QSP 1801	Training
QF 1801	Staff Training Record
QF 1802	Personnel Record
QF 1803	Training Plan
QF 1804	Training Application Form

4.19 Servicing

This section defines the procedure on post-project servicing.

4.19.1 Summary of procedure

The requirements to carry out an on-going servicing or maintenance role for work produced by the Company is not usually specified. When post-project servicing activities are required, this will be addressed through the project quality plan or construction contract, as appropriate.

The Project Manager shall carry out final inspection for completed project. If the works are not completed satisfactorily, he shall instruct the contractor to make good all defects and outstanding items before issuing the completion certificate.

4.19.2 Supporting procedures and forms

QSP 1901	Post-project Servicing Procedure
QF 1901	Maintenance Schedule
QF 1902	Handing Over Records

4.20 Statistical Techniques

This section defines the use of statistical techniques within the Company.

4.20.1 Identification of need

The Company's processes used in providing services to the Client seldom involve the use of a statistical technique. The Quality Assurance Director may select the appropriate statistical techniques for the verification activities and the analysis of quality problems where significant nonconformities are found.

4.20.2 Procedures

In the event that a special process requires a statistical technique, the Project Manager shall establish procedures detailing the application of the technique for that process.

4.20.3 Supporting procedures and forms

QSP 2001	Statistical Techniques
QSP 2002	Statistical Control of Special Process

5.0 List of Quality System Procedures

QSP No.	Quality System Procedure	ISO 9001
101	Management Review	4.1
102	Agenda of Management Review	4.1
201	Preparation of Quality Procedures	4.2
202	Project Quality Plan	4.2
301	Contract Review	4.3
401	Design Control	4.4
402	Design Review Plan	4.4
403	Design Change Control	4.4
501	Internal Document and Data Control	4.5
502	External Document and Data Control	4.5
503	Incoming / Outgoing Correspondence Control	4.5
601	Procurement of Sub-consultant/Supplier Services	4.6
602	Assessment of Sub-consultant/Supplier Procedure	4.6
701	Control of Client-supplied Product	4.7
901	Technical and Fees Submission	4.9
902	Feasibility Study	4.9
903	Conceptual Design	4.9
904	Site Investigation	4.9
905	Preparation of Tender Documents	4.9
906	Issue of Tender Document	4.9
907	Evaluation of Tenders	4.9
908	Signing of Contract	4.9
909	Site Supervision and Control	4.9
910	Employment of Resident Site Staff	4.9
911	Completion, Handover and Maintenance of Contract	4.9
1001	Computer Application	4.10
1101	Equipment Inspection, Measuring and Testing Procedure	4.11
1301	Control of Non-conforming Product Procedure	4.13
1401	Corrective and Preventive Action	4.14
1501	Records and Archives of Product	4.15
1601	Quality Records Control Procedure	4.16
1701	Internal Quality Audit	4.17
1801	Training	4.18
1901	Post-project Servicing Procedure	4.19
2001	Statistical Technique	4.20
2002	Statistical Control of Special Process	4.20

Appendix D

Model Quality Manual for Contractors

QUALITEC CONSTRUCTION COMPANY LIMITED

ISO 9002 : 1994
Quality Manual

(Issue One)

This manual describes the Qualitec Construction Company Limited's quality management system. Its issue is controlled if the copy number is marked in red.

This manual does not form part of any contract and is not intended to imply any representation or warranty. The Company reserves the right to amend its procedures from time to time in order to comply with individual contract requirements.

Controlled Copy Number :

Verification			
Description	Post	Signature	Date
Prepared by	Quality Manager		
Reviewed by	General Manager		
Approved by	Managing Director		

Summary of Amendments

Rev. No.	Effective Date	Section/ Page	Revision Details	Prepared by	Reviewed by	Approved by
0	02.03.98	All	Initial Release			
A	01.08.98	(i)	Revision A added			
		(ii)	Revision No. on 4.9 updated			
		4.9	Supporting document QSP 903 added			
		5.0	Supporting document QSP 903 added			

Contents

Introduction

This Quality Manual (the Manual) outlines the policy of Qualitec Construction Company Limited (the Company) relating to its Quality Management System (QMS). The system is applicable to all aspects of the civil engineering projects undertaken by the Company.

The Manual defines the Company's approach to fulfilling the 19 quality system clauses of ISO 9002 : 1994. Users of the Manual should refer to the complete quality system documents including quality system procedures, project quality plans as well as statutory requirements and the relevant International Standards.

Authority

The Quality Manager is responsible for the preparation, maintenance, issue and control of this Manual.

The General Manager is responsible for reviewing the Manual prior to the approval by the Managing Director.

The Managing Director is responsible for the approval of the Manual.

The Quality Management Committee, chaired by the General Manager, is responsible to review, decide and approve the quality-related matters.

Issue Statue

The issue status of this Manual is indicated on the front sheet and on the header of every sheet in the Manual. It is also controlled by the revision number on each chapter to enable the changes to any chapter while retaining the unaffected portion in the Manual.

The Manual is re-issued bearing a new manual issue number whenever the chapters need to be changed substantially.

Distribution of the Manual

Controlled copies will each bear a unique copy number and will be marked in red on the front page of the Manual. Distribution is controlled by the Quality Manager in accordance with the approved distribution list.

Uncontrolled copies of the Manual may be distributed outside the Company with the approval by Quality Manager. They will be clearly marked "Uncontrolled Copy".

Amendments to the Manual

The Quality Manager will prepare a draft of proposed change for review by the General Manager. When the change is agreed, the Quality Manager alters the chapter revision number and produces a master copy for approval by the Managing Director.

The master copy of the Quality Manual is kept by the Quality Manager. He is also responsible for the issue of amendments to the Manual and withdrawal of obsolete documents.

Periodic Review

Management reviews are periodically conducted in accordance with an approved programme to ensure that the Manual prescribes the approved quality system correctly.

1.0 Quality Policy

The quality policy, as stated below, forms the key to the quality management system. This policy is promulgated to all employees, suppliers and subcontractors. Copies are displayed at the Head Office and Site Offices.

QUALITEC CONSTRUCTION COMPANY LIMITED

QUALITY POLICY

The Company's mission is to consistently provide a quality and reliable construction service to its Clients.

To achieve this objective, the Company has instituted a quality management system to ISO 9002 : 1994 which will: -

- **ensure that the requirements of Clients are satisfied**
- **maintain the safety, skills, co-operation and morale of the work-force**
- **ensure the generation of sufficient profit to provide adequate return on capital employed**

Quality shall be the responsibility of all employees. Everyone has to ensure that this Company Quality Policy is understood, implemented and maintained.

Managing Director
2 March 98

2.1 Description of Company

Qualitec Construction Company Limited was established in 1980 and is a civil engineering construction company with a staff of almost 300 including over 30 professionally qualified engineers. With over 18 years experience, the Company has a long and extensive track record in all forms of civil engineering projects and is one of the leading local contractors.

The Company is an Approved List 1 for Public Works Group C contractor in Road and Drainage, Site Formation and Portworks. The Company has successfully completed numerous projects for the construction of highways, bridges, seawalls, sewage treatment plants and harbour reclamation over the years with individual contract values over HK$ 500 million.

Following the Territorial Development Strategy planned by the Government, demand for both civil and marine construction will remain high in the next decade. The Company is soundly positioned to play a significant role in site formation and infrastructure development.

The address of our office is stated below:

18th Floor, Qualitec Building, Central, Hong Kong

2.2 Scope of Certification

The scope of this quality management system and its certification to ISO 9002:1994 relates to the: -

Construction of building, civil works and infrastructures to the customer's requirements

provided by the Qualitec Construction Company Limited.

3.0 Organization

The organization chart of the Company is shown in Figure A. The Company mainly consists of six functional departments responsible for the execution and operations of all civil engineering projects.

A typical site organization chart of a project team is shown in Figure B. The Project Manager is the leader in each construction project.

Figure A : Company Organization Chart

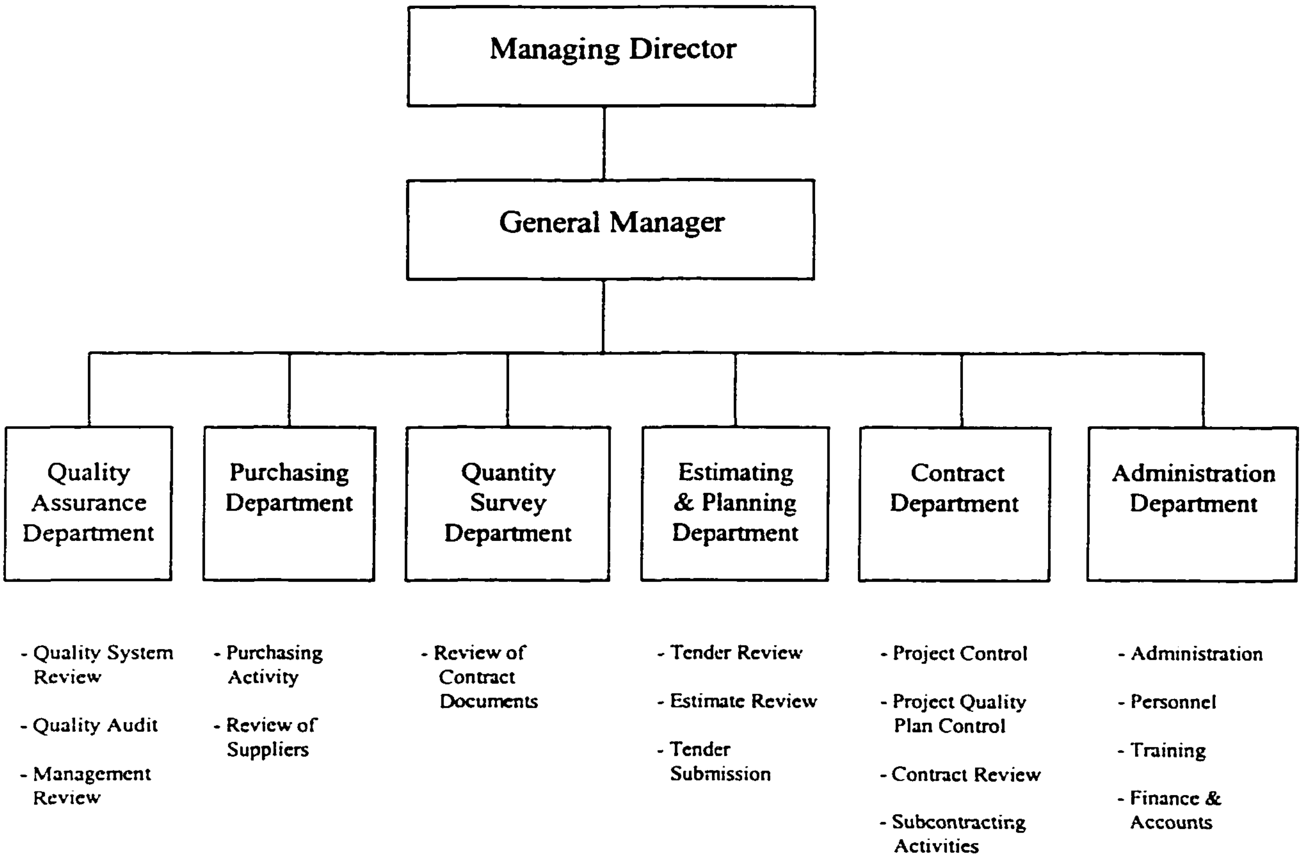
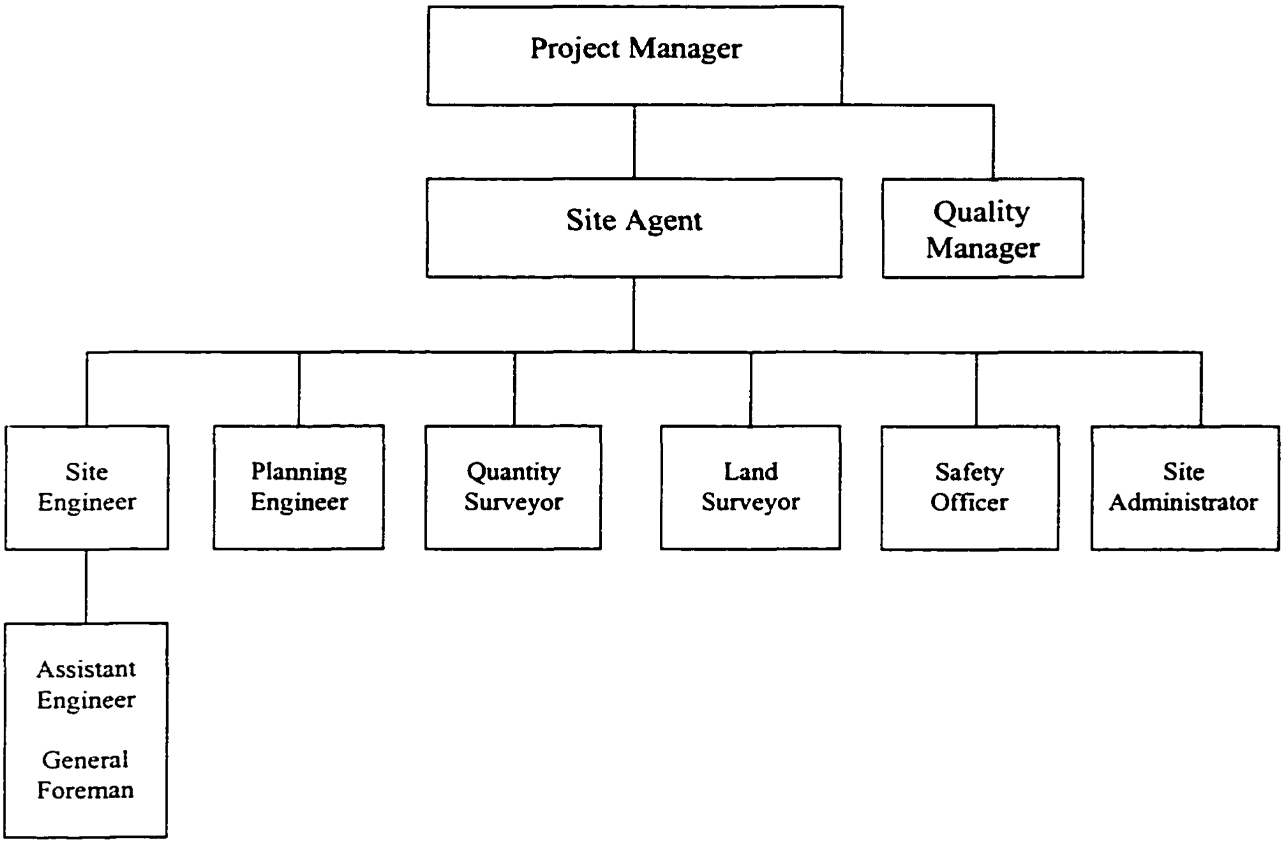


Figure B : Typical Site Organization Chart



3.1 Responsibilities

A. Managing Director

The Managing Director is responsible for planning the Company's strategy for operations and defining the Company quality assurance policy and objectives.

B. General Manager

The General Manager is responsible for the overall management of the operation and quality system of the Company. He assigns a project team staff for a contract.

C. Quality Manager

The Quality Manager is responsible for drafting the Quality Manual and Procedures, assisting the Project Manager to implement and operate the quality management system, carrying out internal audits and arranging the management review meeting.

D. Purchasing Officer

The Purchasing Officer is responsible for purchasing activities of the Company. He will review the performance of suppliers and maintains a list of approved suppliers.

E. Quantity Surveyor

The Quantity Surveyor implements measurement of finalized working drawings and agrees to instruct changes or variations. He prepares Bills of Quantities for subcontracting and financial forecast.

F. Estimating and Planning Manager

The Estimating and Planning Manager is responsible for tendering activities. He will conduct estimate review, tender review and tender submission.

G. Project Manager

The Project Manager is responsible for planning, organizing and controlling the execution of the project in accordance with contract requirements and Company's quality system.

H. Administration Officer

The Administration Officer provides administration services to Company including document control. He is also responsible for staff training, financial control and accounting procedures.

I. Site Agent

The Site agent assists the Project Manager to achieve timely completion of project within budget. He will ensure a safe working environment and quality assurance records.

J. Site Engineer

The Site Engineer provides engineering support to the Project Manager to ensure that temporary works design, standard of workmanship and usage of materials adhere to the contract requirements.

K. Planning Engineer

The Planning Engineer assists the Project Manager in planning the construction programme and monitoring the progress.

L. Land Surveyor

The Land Surveyor is responsible for preparing survey data calculations, setting out, maintaining survey records and checking of survey equipment.

M. Safety Officer

The Safety Officer provides safety advice, audit, planning and training in order to prevent accidents on site and to minimize the potential hazards on health and safety matters.

N. Assistant Engineer

The Assistant Engineer is responsible for assisting the Site Engineer to perform his technical works such as design calculations and preparation of temporary works drawings.

O. Foreman

The Foreman is responsible for monitoring the work standards against contractual requirements by closely supervising the performance and workmanship of direct labour and subcontractors.

4.0 Quality System Requirements

The Quality Manual of Qualitec Construction Company Limited contains 19 sections corresponding to the 19 clauses in the ISO 9002 : 1994. They are :

Section	Quality System Sections	Corresponding ISO 9002 Clause
4.1	Management Responsibility	4.1
4.2	Quality System	4.2
4.3	Contract Review	4.3
4.4*	Design Control	4.4
4.5	Document and Data Control	4.5
4.6	Purchasing and Subcontracting	4.6
4.7	Control of Client Supplied Product	4.7
4.8	Product Identification and Traceability	4.8
4.9	Process Control	4.9
4.10	Inspection and Testing	4.10
4.11	Control of Inspection, Measuring and Test Equipment	4.11
4.12	Inspection and Test Status	4.12
4.13	Control of Nonconforming Product	4.13
4.14	Corrective and Preventive Action	4.14
4.15	Handling, Storage, Package, Preservation and Delivery	4.15
4.16	Control of Quality Records	4.16
4.17	Internal Quality Audits	4.17
4.18	Training	4.18
4.19	Servicing	4.19
4.20	Statistical Techniques	4.20

* The Company's Quality Management System does not include design control. This section is included to align the clause numbering with ISO 9002

4.1 Management Responsibility

This section defines the Company's quality policy and to ensure this policy is understood, implemented and maintained at all levels in the Company.

4.1.1 Quality policy

The quality objectives and commitment of the Company is defined by the Managing Director in the Quality Policy. The Quality Policy is enclosed in Section 1.

4.1.2 Organization, responsibility and authority

Organization charts and essential position descriptions are established and maintained to define the structure of the Company and the authorization and responsibilities of employees respectively. The Company and site office organization charts are shown in Section 3.

4.1.3 Resources

The General Manager and Project Manager shall provide adequate resources including the assignment of trained personnel for quality management, performance of works, inspection and verification activities and auditing of Company's quality system. The resources requirements shall be identified in accordance with the requirements of Company Quality Manual, Project Quality Plan, contract requirements etc.

4.1.4 Management representative

The General Manager is designated as Management Representative (MR) by the Company with authority and responsibility for ensuring that the requirements of the quality management system are implemented and maintained.

Quality Manager is designated as Deputy MR, who will act as Acting MR in the absence of MR.

4.1.5 Management review

The management review of the quality system is held at the corporate and project levels in accordance with the approved management review and audit programme, normally twice a year at least. Reviews are performed on evidence as records in the following significant quality reports :

- previous management review reports
- nonconformity reports
- corrective and preventive action reports
- internal and external quality management system audit reports
- supplier and subcontractor performance reports
- customer complaint reports

The Management shall examine quality activities to ensure that :

- the quality system is suitable and effective
- the quality policy and objectives are achieved
- deviations from the required level of performance are rectified
- corrective and preventive actions implemented are effective

Each review is recorded by Quality Manager. Any actions formulated at these reviews will be implemented by the appropriate personnel.

4.1.6 Supporting documents

QSP 101	Management Review
QF 101	Management Review Meeting Minutes

4.2 Quality System

This section demonstrates the Company through its quality management system to manage, perform and verify the works conforming to specified requirements under contracts.

4.2.1 Quality system documents

The quality system is structured in the following three levels in accordance with the requirements of ISO 9002 : 1994 :

- Quality Manual (QM)
- Quality System Procedures (QSP)
- Works Instruction (WI), Project Quality Plans (PQP) and Quality Record Forms (QF)

4.2.2 Quality planning

A Project Quality Plan shall be established for each particular contract to ensure that the quality management system is followed by our projects.

The Quality Manager has overall responsibility for the control and maintenance of the quality management system documents.

4.2.3 Supporting documents

QSP 201 Quality System Procedure Format
QSP 202 Project Quality Plan
All other current Company Procedures and Works Instructions

4.3 Contract Review

This section is to ensure that the Company and Client's requirements are adequately defined and documented in the contract, and that the Company has capability and capacity to meet these requirements.

4.3.1 Tender review

At tender stage, the tender review is performed in order to ensure adequacy of the Tender Documents and to assess the specified requirements so that potential risks can be identified and determined. The review includes construction method, cost estimate, programme, resources and materials requirements over the contract period. The result of review is recorded in a Tender Assessment Report with approval from the Tender Committee which consists of specialists from Estimating & Planning, Purchasing and Contract Departments. After approval by the Tender Committee, the Tender is submitted to the Client.

4.3.2 Award of contract

Before a contract is signed, the Estimating and Planning Manager shall check carefully the proposed Contract Documents against the submitted Tender Documents to ensure that there are no changes or anomalies between these documents. Should there be any significant differences, the General Manager should be informed and required to resolve problem prior to signing of the Contract.

4.3.3 Contract review

During the course of the Contract, the Client's instruction are reviewed by the Project Manager for adequacy of information and to ensure that the Company has an obligation to carry out the instructions. Whenever amendments or variations to a Contract are made, the Project Manager transfers the information to the concerned departments for follow-up action.

4.3.4 Contract review at completion

At the end of the Contract, a review of the performance during the Contract shall be undertaken. This will include a review of any suppliers and subcontractors.

4.3.5 Supporting documents

QSP 301	Tender Review
QSP 302	Contract Review
QF 301	Tender Review Checklist
QF 302	Tender Assessment Report Form
QF 303	Contract Review Checklist
QF 304	Contract Review Record

4.4 Design Control

The scope of work of the Company does not include a quality management system requirement for design control. When necessary, a sub-contract design engineer or company shall be appointed by the Company for particular contract requirements (see Section 4.6.1).

This section is included to align the clause numbering with ISO 9002.

4.5 Document and Data Control

This section is to ensure that documents and data are reviewed and approved prior to issue and that the pertinent issues of appropriate documents and data are made available for the due performance of quality activities.

4.5.1 General

The Company establishes and maintains procedures to control all documents and data that relate to this requirement of ISO 9002. Controlled documents include a Quality Manual as well as its associated procedures and work instruction, Project Quality Plan, Inspection and Test Plan, contract documents, specification and standards.

4.5.2 Document and data approval and issue

Controlled documents and data are subject to control in respect of their review, approval, issue and disposal as appropriate. The Quality Manager is responsible for the control and maintain of the Quality Manual. The General Manager and Managing Director are responsible for reviewing and approving the Manual respectively. The Project Manager is responsible for controlling the Project Quality Plan and contract documents.

A master list is established to identify the current revision of documents and data in order to preclude the use of obsolete documents. Obsolete documents shall be promptly removed. Any obsolete documents retained for legal and knowledge preservation shall be clearly identified to prevent inadvertent use.

4.5.3 Document and data change

Amendment sheets are used to identify changes in documents, which are reviewed and approved by the persons that performed the original review and approval. Distribution lists are used to ensure that controlled copy holders are updated with new document and data when they are issued.

4.5.4 Supporting documents

QSP 501	Internal Document and Data Control
QSP 502	External Document and Data Control
QSP 503	Incoming / Outgoing Correspondence Control
QF 501	Master List of Controlled Documents
QF 502	Controlled Document Distribution List
QF 503	Document Transmittal Record
QF 504	Master List of Quality Forms

4.6 Purchasing and Subcontracting

This section describes the procedures and controls for the requisitioning and ordering of all permanent materials and subcontracts.

4.6.1 General

The Purchasing Officer is responsible for the purchase of major materials and the Project Manager is responsible for the subcontract activities. The General Manager is responsible for approving suppliers and subcontractors (including design engineer or company) for inclusion in the supplier register and the subcontractor register.

4.6.2 An assessment of suppliers and subcontractors

Potential suppliers and subcontractors are assessed by the Purchasing Officer and Project Manager on their ability to meet the Company's requirements. This is proceeded through the satisfactory assessment of their capability and performance before and after the registration in the approved registers. When selecting tenderers, these registers are referred to so that only approved suppliers and subcontractors are used. The registers are regularly reviewed and updated with feedback provided from the Purchasing Officer and Project Manager.

4.6.3 Purchasing data

Purchasing documents are reviewed for adequacy and compliance with the specified requirements by the Purchasing Officer and Project Manager and approved by General Manager prior to release.

When verification of purchased product is required at the supplier's premises, the verification arrangement and the method of product release are specified in the purchasing documents.

4.6.4 Verification of a purchased product

Verification of purchased product either at the supplier's plant or on site by the Client is permitted where such activities form part of the contract requirements. Such verification by the Client should not absolve the Company from performing inspection and testing in accordance with the applicable procedures prior to the final acceptance of the product. Procedures for source verification of items by the Company should be detailed in the Project Quality Plan.

4.6.5 Supporting documents

QSP 601	Purchasing
QSP 602	Supplier Registering
QSP 603	Subcontracting
QSP 604	Subcontractor Registering
QF 601	Supplier's Performance Appraisal Report
QF 602	Subcontractor's Performance Appraisal Report

4.7 Control of Client-supplied Product

This section to ensure that all client-supplied items or services, which to be incorporated into or used for the permanent works, meet the specified requirements.

4.7.1 Summary of procedure

Project Manager is responsible for controlling client-supplied products, including nominated suppliers and subcontractors, on site. Product supplied by the Client are inspected, stored and controlled. Nonconforming products are properly identified and segregated. Where any losses, damages or other problems relating to the product are discovered, the details will be recorded and the Client will be immediately notified.

4.7.2 Supporting documents

QSP 701	Control of Client-supplied Product
QF 701	Client-supplied Materials Checklist

4.8 Product Identification and Traceability

This section defines the procedure and method used for materials and product identification and traceability of the product and their location on site.

4.8.1 Summary of procedure

Project works are identified by contract number and contract drawings. Each phase of works is identified by inspection and test records.

Materials, such as concrete and steel, are identified by the original packing, delivery documents, tags, colour code or other suitable means if necessary.

Traceability records are maintained of each delivery or batch of materials used, and their location on site.

Where specified or deemed necessary, Project Quality Plan should define the method of material, product or sample identified.

4.8.2 Supporting document

QSP 801 Product Identification and Traceability

4.9 Process Control

This section defines the procedure to plan, monitor and control construction processes which directly affect quality.

4.9.1 Summary of procedure

After contract award, the Project Manager should prepare a Project Quality Plan to define the organization and process control system for the project and make sure that adequate resources are available at the time of construction. The control system shall include but not limited to the following construction processes: -

- Construction Programme
- Construction Method Statement
- Inspection and Test Plan
- Process Monitoring
- Control of Subcontractors

Suitable maintenance of equipment should also be provided in order to ensure continuing process capability.

At the completion of each stage of works, verification by the relevant staff are performed to ensure that the required level of quality is achieved. Any nonconformities found are rectified before proceeding to the next stage.

4.9.2 Special processes

When the result of any processes cannot be fully verified by subsequent inspection or testing, appropriate controls or instructions shall be introduced by the Project Manager.

4.9.3 Supporting documents

QSP 202	Project Quality Plan
QSP 901	Process Control
QSP 902	In-process Inspection
QSP 903	Final Inspection and Testing

4.10 Inspection and Testing

This section defines the procedure and responsibility for inspection and testing activities.

4.10.1 General

The Company performs inspection and testing activities on materials and works to verify that the specified contract requirements are met. The Project Manager is responsible overall for performing and record keeping of these activities. He is supported by suitably quality and experienced site staff.

4.10.2 Incoming inspection and testing

Incoming materials are inspected by trained staff on receipt against applicable instructions or specifications to ensure compliance with specified requirements mentioned in the contract and Project Quality Plan.

When incoming material is released for installation prior to verification, it shall be positively identified and recorded to enable immediate recall and replacement in the event of nonconformity to specified requirements. Nonconforming goods are identified, segregated and disposed of, when necessary.

4.10.3 In-process inspection and testing

Construction works are inspected at defined stages against the applicable instructions or checklists before proceeding to the next stage. The standard and workmanship of construction works are defined in the contract document. A Request for Inspection Form will be sent to the Client inviting inspection of works. The issuance of the Request for Inspection Form will signify that the prior inspection by site staff has been done satisfactorily.

When nonconforming works are detected during inspection with the Client, they are properly identified and rectified. Re-inspection to the rectified works is requested.

4.10.4 Final inspection and testing

A final inspection is performed on finished works prior to the handover to the Client. The final inspection activities include a review of all previous verification records and a final checking of the finished works by using applicable instruction or checklists.

4.10.5 Inspection and test records

Records of inspection and testing are retained as evidence of product conformity. They also document the inspection authority responsible for determining acceptance.

4.10.6 Supporting documents

QSP 202	Project Quality Plan
QSP 902	In-process Inspection
QSP 903	Final Inspection and Testing
QSP 1001	Control of Purchased Materials
QSP 1002	Control of Subcontractor Services
QSP 1003	Replacement of Nonconforming Materials
QSP 1101	Equipment Inspection, Measuring and Testing Procedure
QF 1001	Request for Inspection Form
QF 1102	Equipment Inspection, Measuring and Testing Record

4.11 Control of Inspection, Measuring and Test Equipment

This section defines the control of the inspection, measuring and test equipment (IMTE) used by the Company.

4.11.1 General

Inspection, measuring and test equipment used to demonstrate the conformity of materials, components, completed works or structures to the requirements are calibrated, controlled and maintained. The Project Manager is responsible for ensuring that such activities are properly carried out.

4.11.2 Control procedure

IMTE used to determine acceptance is calibrated prior to release for use, and is regularly re-calibrated.

IMTE are either calibrated by an approved external organization in accordance with recognized international standards or by in-house calibrated equipment in a controlled environment in accordance with the Company's calibration instructions.

A calibration label is attached to each item of equipment which passes the test of calibration. The label carries a unique identification to enable correlation with the appropriate records and the next calibration due date.

Damaged or suspected equipment is identified, segregated and not used until checked satisfactorily. When IMTE is found to be out of calibration to an extent that the quality of the final product may be affected, the suspected works are identified and re-checked.

Records are maintained for all IMTE until their disposal.

4.11.3 Supporting documents

QSP 1101	Equipment Inspection, Measuring and Testing Procedure
QF 1101	Equipment Inspection, Measuring and Testing Register
QF 1102	Equipment Inspection, Measuring and Testing Record

4.12 Inspection and Test Status

This section defines the inspection and test status of the product and works, either conformance or non-conformance, shall be identified clearly at all stages of work.

4.12.1 Summary of procedure

Verification on incoming materials, staged construction processes, calibration and finished works are performed in accordance with applicable procedures or the Project Quality Plan. The inspection and test status with regard to the verification of works performed is normally identified by means of labels, stamps, paints, markings, tags or other suitable means. Inspection and testing records are maintained to identify the inspection authority responsible for the release of the finished product.

4.12.2 Supporting documents

QSP 202	Project Quality Plan
QSP 902	In-process Inspection
QSP 903	Final Inspection and Testing
QSP 1001	Control of Purchased Materials
QSP 1002	Control of Subcontractor Services
QSP 1101	Equipment Inspection, Measuring and Testing Procedure

4.13 Control of Nonconforming Product

This section defines how the nonconforming product is prevented from use.

4.13.1 General

The Company requires that nonconforming materials and works are properly identified and controlled to prevent their unintended use or installation.

The Project Manager is responsible for ensuring that site staff are appointed for the identification, documentation, evaluation, segregation, rectification of nonconformities in materials and works.

4.13.2 Review and disposition of nonconforming product

Nonconformities discovered during incoming inspections, in-process inspections and final inspections are identified, documented, segregated where practical and reviewed in accordance with documented procedures. The Project Manager should make decisions which may include the rework of the nonconformities in order to meet the specified requirements, acceptance by concession, regarded as alternative applications or scrapping.

An application for a concession shall be in the form of a letter to the Client complete with any back-up design information. The description of the nonconformity that has been accepted and of repairs, shall be recorded to denote the actual situation. Nonconforming materials and works are re-inspected in accordance with applicable procedures after rectification.

When a nonconformity is significant, a Nonconformity Report is initiated by the relevant party for remedial action decided by the Quality Management Committee.

4.13.3 Supporting documents

QSP 902	In-process Inspection
QSP 903	Final Inspection and Testing
QSP 1001	Control of Purchased Materials
QSP 1002	Control of Subcontractor Services
QSP 1003	Replacement of Nonconforming Materials
QSP 1301	Control of Significant Non-conforming Material and Products
QF 1705	Non-conformance Report

4.14 Corrective and Preventive Action

This section defines the corrective and preventive action to be taken against non-conformance.

4.14.1 General

The Project Manager and Department Heads are responsible for reporting significant nonconformities and implementing corrective and preventive action decided by the Quality Management Committee. The Quality Manger shall keep a register of the Non-conformance Report (NCR) raised and monitor the satisfactory implementation of the agreed corrective and preventive actions.

4.14.2 Corrective action

When a significant product or process or quality system nonconformity occurs, or a significant Client complaint is received, a Nonconformity Report is initiated. The Quality Management Committee should investigate the cause and maintain the appropriate corrective actions as follows :

- effective handling of Client complaints and nonconformity reports
- analyzing non-conforming data to determine their extent and causes
- introducing the improvements and corrections as required
- monitoring of the effectiveness of the corrective action taken

A Corrective Action Request (CAR) is issued as a follow-up to audit and surveillance.

4.14.3 Preventive action

The Quality Management Committee should also establish the following preventive action procedures to eliminate the potential causes arising from the operations :

- analyzing the processes, work operations, concessions, quality records, service reports and Client complaints to identify and rule out possible reasons for the non-conforming activities
- determining preventive measures to deal with problems with risk encountered
- introducing and monitoring the preventive action as required
- ensuring that information on actions taken is submitted for management review

A Preventive Action Request (PAR) is also issued to instruct the staff to take preventive action.

Changes required to the quality system are implemented in accordance with applicable procedures.

4.14.4 Supporting documents

QSP 101	Management Review
QSP 1401	Corrective and Preventive Action
QF 1401	Corrective Action Request (CAR)
QF 1402	Preventive Action Request (PAR)
QF 1705	Non-conformance Report (NCR)

4.15 Handling, Storage, Packaging, Preservation & Delivery

This section defines the controls on handling, storage, packaging, preservation and delivery of materials and works.

4.15.1 General

The Company implements controls on handling, storage, packaging, preservation and delivery of materials and works to reduce the risk of damage or deterioration. The Project Manager is responsible for ensuring that this policy is implemented in construction site.

4.15.2 Handling

Site staff are instructed in the care they must take when handling materials and finished works to prevent damage or deterioration. When necessary, work instructions are prepared in the Project Quality Plan.

4.15.3 Storage and Preservation

Appropriate methods for preventing damage and deterioration of stored materials and completed works are defined in the work instruction. The condition of materials in storage is assessed regularly.

4.15.4 Packaging and Delivery

Finished works are protected in accordance with contract requirements or trade practices to prevent them from damage after inspection and testing.

4.15.5 Supporting procedures

QSP 202	Project Quality Plan
QSP 902	In-process Inspection
QSP 903	Final Inspection and Testing
QSP 1001	Control of Purchased Materials
QSP 1002	Control of Subcontractor Services
QSP 1501	Handling, Storage, Packaging, Preservation and Delivery

4.16 Control of Quality Records

This section defines the procedures for collecting, indexing, filing and storage of quality records.

4.16.1 Summary of procedure

The Company maintains quality records that demonstrate conformance to specified requirement and the effective operation of the quality system. These records must be legible and identifiable as to the materials, works or activities involved. All quality records are accessible to authorized personnel and are properly filed, stored and controlled to prevent loss, damage or deterioration. The retention period of quality records shall be defined.

The Project Manager is responsible for collecting relevant quality records and keeping a good filing system so that quality records can be retrieved easily.

The Quality Manager shall control and dispose of all quality records. Access to quality records will be made available to the Client's representative as required.

4.16.2 Supporting procedures

QSP 1601	Control of Quality Records
QF 1601	Archives Instruction Form
QF 1602	Archives Documentation Register
QF 1603	Archives Box List
QF 1604	Archives Reclaim Form
QF 1605	Archives Disposal Form
QF 1606	Quality Records Retention Period List
QF 1607	Microfilm Drawing List

4.17 Internal Quality Audits

This section defines the internal quality audits and follow-up actions.

4.17.1 Summary of procedure

The Company performs periodic internal quality audits on the quality system to ensure that it is complied with and is effective. The Quality Manager has overall responsibility for implementing this policy.

Internal quality audits are performed in accordance with approved audit programmes normally in four-month intervals and by trained personnel independent of the activities being audited. The appointed internal auditors, using audit checklists as an aide memoir, systematically follow through the quality activities. Nonconformities found are detailed in the quality audit reports. The internal quality audit shall cover the subcontractor's quality activities, when necessary.

The responsible Department Head of the audited area formulates and implements timely corrective and/or preventive actions. An audit follow-up is performed by the Quality Manager to determine the adequacy and effectiveness of the agreed actions taken. Audit results are summarized and discussed in Management Review meetings.

4.17.2 Supporting procedures

QSP 101	Management Review
QSP 1701	Internal Quality Audits
QF 1701	Internal Audit Schedule
QF 1702	Internal Audit Notification
QF 1703	Internal Audit Checklist
QF 1704	Internal Audit Timetable
QF 1705	Non-conformance Report
QF 1706	Corrective Action Request
QF 1707	Observation Report
QF 1708	Audit Opening Meeting
QF 1709	Audit Closing Meeting
QF 1710	Internal Audit Report
QF 1711	Internal Audit Report Log
QF 1712	Corrective Action Request Log
QF 1713	Completed Non-conformance Reports

4.18 Training

This section defines the arrangement for providing sufficient training for staff.

4.18.1 Summary of procedure

The Company employs individuals with appropriate training and experience for the tasks they are responsible to perform. The Department Heads and Project Manager shall ensure that their subordinates have the required skill, qualification or experience. Together with the Quality Manager, they shall identify the training needs of their subordinates at suitable time and provide the training required to ensure that their subordinates have the skills and knowledge to perform their assigned tasks.

For the temporary staff, the Project Manager shall ensure that appropriate guidance and instruction are given to them prior to commencing the work on site.

Training records are properly maintained by the Administration Officer.

4.18.2 Supporting documents

QSP 1801	Training
QF 1801	Staff Training Record
QF 1802	Personnel Record
QF 1803	Training Plan
QF 1804	Training Application Form
QF 1805	Attendance Record

4.19 Servicing

This section defines the procedure on servicing and maintenance during the defect liability period.

4.19.1 Summary of procedure

When servicing and maintenance is required during the defect liability period under the contract, the Project Manager shall establish and maintain procedures in the Project Quality Plan for performing and verifying that servicing or maintenance meets the specific requirements.

The Project Manger shall notify the Client of the nominated person who can be contacted during the defect liability period. He shall also keep a subcontractor contact list for dealing with the defects.

4.19.2 Supporting procedure

QSP 1901	Servicing
QF 1901	Maintenance Schedule
QF 1902	Handing Over Records

4.20 Statistical Techniques

This section defines the use of statistical techniques within the Company.

4.20.1 Identification of need

The Company establishes and maintains procedures to implement and control the application of statistical techniques in the assessment of product quality, process capability and in the analysis of quality problems where significant nonconformities are found.

4.20.2 Procedures

Sampling methods in accordance with established practice, standards or as agreed with the Client are used to determine the acceptance of materials and works. In the event that a special process requires statistical technique, the Quality Management Committee shall determine appropriate technique in that process.

4.20.3 Supporting procedure

QSP 2001	Statistical Techniques
QSP 2002	Statistical Control of Special Process

5.0 List of Quality System Procedures

QSP No.	Quality System Procedure	ISO 9002
101	Management Review	4.1
201	Quality System Procedure Format	4.2
202	Project Quality Plan	4.2
301	Tender Review	4.3
302	Contract Review	4.3
501	Internal Document and Data Control	4.5
502	External Document and Data Control	4.5
503	Incoming / Outgoing Correspondence Control	4.5
601	Purchasing	4.6
602	Supplier Registering	4.6
603	Subcontracting	4.6
604	Subcontractor Registering	4.6
701	Control of Client-supplied Product	4.7
801	Product Identification and Traceability	4.8
901	Process Control	4.9
902	In-process Inspection	4.9
903	Final Inspection and Testing	4.9
1001	Control of Purchased Materials	4.10
1002	Control of Subcontractor Services	4.10
1003	Replacement of Nonconforming Materials	4.10
1101	Equipment Inspection, Measuring and Testing Procedure	4.11
1301	Control of Significant Non-conforming Material and Products	4.13
1401	Corrective and Preventive Action	4.14
1501	Handling, Storing, Packaging, Preservation and Delivery	4.15
1601	Control of Quality Records	4.16
1701	Internal Quality Audits	4.17
1801	Training	4.18
1901	Servicing	4.19
2001	Statistical Techniques	4.20
2002	Statistical Control of Special Process	4.20

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