A STUDY OF THE PROSPECTS OF EVOLUTION FROM QUALITY ASSURANCE TO TOTAL QUALITY MANAGEMENT FOR THE HONG KONG CONSTRUCTION INDUSTRY

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LAU WAI TANG ANDREW

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis entitled “A STUDY OF THE PROSPECTS OF EVOLUTION FROM QUALITY ASSURANCE TO TOTAL QUALITY MANAGEMENT FOR THE HONG KONG CONSTRUCTION INDUSTRY” is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgment has been made in the text.

Andrew Lau_ (Signed)

Lau Wai Tang Andrew (Name of student)

Abstract of this thesis entitled:

A study of the Prospects of Evolution from Quality Assurance to Total Quality Management for the Hong Kong Construction Industry

Prior to the application of Quality Assurance (QA) systems in 1991, the Quality Control (QC) culture dominated the Hong Kong construction industry in quality management of construction works. The government organization - Hong Kong Housing Authority - took the lead in adopting QA system including the implementation of the Performance Assessment Scoring System (PASS) in 1991. In the following 15 years (1991 - 2006), the QA culture continually developed and a majority of construction industry organizations in Hong Kong became fully familiar with the application of QA. However, sub-standard construction and shortcoming in the industry's operation were still reported. The industry stakeholders started looking for other quality management approaches to improve the effectiveness and efficiency of their quality systems. The Total Quality Management (TQM) philosophy was included in these other approaches.

The objective of this thesis is to investigate the impact of the QA system to the Hong Kong construction industry and how TQM could affect the Hong Kong construction organizations to achieve "Excellence" in construction project quality. These objectives are achieved by six questionnaire surveys carried out in two stages, in 2007 / 2008 and 2011 / 2012 respectively.

The results of this investigation indicate that back in 2006, the quality control culture of supervision and inspection had already been transformed to a mature systematic quality assurance culture in the Hong Kong construction industry. Yet

the TQM culture was still far from mature at that time (2006). The analysis of the questionnaires of the second stage survey completed in 2012 (or more exactly January 2013) suggests, however, that the construction industry is becoming more familiar (although not mature) with the application of TQM. The questionnaire respondents also tend to agree that TQM elements of top management leadership, continual improvement and organizational learning are the main focuses for sustaining business in the construction industry.

Such Hong Kong experience should be of interest to organizations in countries that seek to implement improvement frameworks to raise their construction quality culture.

PUBLICATIONS ARISING FROM THE THESIS

1. Lau A. W. T. & Tang S. L. (2007, July). Comparison of Construction Quality Management Systems in Japan, Hong Kong and Singapore. In *Proceedings of the Fourth International Conference on Construction in the 21st Century Proceedings: Accelerating Innovation in Engineering, Management and Technology: CITC-IV* (pp.453-460).
2. Lau, A. W. & Tang, S. L. (2009). A survey on the advancement of QA (quality assurance) to TQM (total quality management) for construction contractors in Hong Kong. *International Journal of Quality & Reliability Management*, *26*(5), 410-425.
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1.1 Construction quality management in Hong Kong

Before 1990, the construction industry in Hong Kong generally adopted "Quality Control (QC)" approach to achieve the quality of construction products. The Hong Kong Government launched a "Quality Awareness Campaign" in 1990 and the campaign brought about a growing demand from clients for "Quality Assurance (QA)" in construction services. The Hong Kong Housing Authority (HKHA) implemented the Performance Assessment Scoring System (PASS) in 1991 and subsequently required its contractors to be certified to the ISO 9000 series quality assurance standards in 1993 (Tang *et al.*, 2003). In 1996, the Hong Kong Works Bureau administrating public construction works required all design consultants and major main contactors (List I, II and Group C) to be certified to the same ISO 9000 standards.

In 1999, HKHA introduced Preferential Tender Award System for building contracts. In 2000, the Hong Kong Works Bureau implemented the Contractors' Performance Index System (CPIS) in order to provide an indication of contractors' performance for reference by the tender board in tender evaluation.

Prompted by a few high profile cases of sub-standard construction and shortcomings in the industry's operations (Tang, 2001), the Hong Kong government commissioned the Construction Industry Review Committee (CIRC) in 2000 to carry out an overall performance review of the construction industry. The CIRC issued a report containing 109 improvement measures, many of which were related to the "Total Quality Management (TQM)" philosophy (CIRC, 2001).

1.2 Statement of the Problem

The Performance Assessment Scoring System (PASS) and the Contractors' Performance Index System (CPIS) formed part of the assessment criteria of the "Preferential Tendering Eligibility Scheme". The public clients had hoped to rely on this scheme in preventing construction organizations of low quality performance to

tender or be awarded public construction contracts. Many publications in the late 1990s, however, argued that this anticipation of hindering the participation of low performance organizations had not been realized. The Construction Industry Review Committee (CIRC) report has also identified the key quality problems including lack of client involvement, short-term attitude to business development, non value-adding subcontractor, fragmentation and adversarial culture, and substandard work.

Some publications in the late 1990s further pointed out the need for the Hong Kong construction industry (contractors, consultants and clients alike) to adopt something more than the quality assurance (QA) approach which had been dominating the industry's quality management since the certification to the ISO 9000 standards became mandatory in early 1990s.

QA is a systematic and static and hard approach as compared to the dynamic people-oriented TQM approach which facilitates a learning environment in construction organizations for continual improvement, the main theme of prevailing quality management systems.

The focus of this thesis is to study the prospects of evolution from quality assurance to total quality management for the Hong Kong construction industry

1.3 Research Dimension

Quality Assurance (QA) embraces all the activities and functions needed to provide adequate confidence in a product or service for satisfying given requirements for quality. It is essentially a preventive approach.

Total Quality Management (TQM) as the management philosophy and company practices that aim to harness the human and material resources of an organization the most effective way to achieve the objectives of the organization. TQM is not merely about implementing management system; it is also about embedding a culture of continual improvement and a focus on both internal and external customer within all participants in an organization

To survive in the competitive construction market, organizations need to evolve effectively under a dynamic environment. In the ISO 9001 year 2000 version, TQM elements including consumer satisfaction, continual improvement, process approach, etc. were introduced into the standard. Certification to this new ISO 9001 standard has been mandatory since 2003 for all government and most public contracts, and the construction organizations in Hong Kong had accordingly been influenced by the TQM philosophy in their management development. The objectives of this thesis are:

a. To collect evidence of how the quality assurance (QA) efforts in the first 15 years (1991 to 2006) had impacted the Hong Kong construction industry in evolving, and to identify the degree of understanding of TQM principles by the participants in the construction industry.

b. To investigate whether the problems in implementing QA can be alleviated by adopting total quality management (TQM) philosophy for the existing cultural environment of the Hong Kong construction industry after 2006 (i.e. from 2007 to now)..

c. To analyze the collected data to highlight how TQM could affect those evolving organizations and its effects on achieving “Excellence” in construction project quality.

d. With the achievement of objectives a, b, and c, it is hoped that an approach to achieve a sustainable construction quality management system could be recommended to the industry.

1.4 Research Methodology

Two questionnaire surveys were carried out in order to collect the data and comments from the construction industry required for this thesis.

Following an extensive literature review of the quality management systems with

particular attention on those having been adopted for the Hong Kong construction industry, a pilot questionnaire survey was conducted. After taking consideration of the comments from the pilot survey, three final questionnaires for the first survey were established and subsequently sent to construction contractors, engineering consultants and client organizations in 2007 and 2008 for their completion and response. The purpose of the questionnaire was to collect data about the Hong Kong construction industry's knowledge in both QA and TQM.

Following the completion of the analysis of data collected in the first survey, a pilot questionnaire for the second survey was established and sent to construction related organizations for comments. After taking consideration of the comments from the pilot survey, three final questionnaires for the second survey were sent to the three groups of construction organization in 2011 and 2012 in a manner similar to the first survey. The purpose of the questionnaire was to establish the level of the TQM familiarization of the Hong Kong construction industry and to collect information on both the short term and long term priorities of the applications of different TQM elements in Hong Kong.

Such Hong Kong experience should be of interest to organizations in countries that seek to implement improvement frameworks to raise their construction quality culture.

1.5 Thesis organization

This thesis is divided into seven chapters. Construction quality management in Hong Kong, statement of the problem, research dimensions and a brief description of research methodology are introduced and discussed in Chapter 1. Literature related to quality management systems with particular focus on the Hong Kong construction industry are reviewed in Chapter 2. Research objectives and the survey methodology that forms the basis of the research method, questionnaire design techniques and data analysis techniques are found in Chapter 3. Results for the first survey and their analysis are presented in Chapter 4 while those for the second survey are presented in Chapter 5. Comments on that the TQM could affect those evolving organizations, its effects on achieving "Excellence" in construction project quality together with

the final conclusion are presented in Chapter 6. The full details of the survey results and their statistical analysis are included Chapter 7 of this thesis.

1.6 Hong Kong Construction Industry Quality Culture Development

Despite the release of first ISO 9000 international standard in 1987 and the initiation of the "Quality Awareness Campaign" in 1990 (Tang *et al.*, 2005), the quality control (QC) culture had been dominating the Hong Kong construction industry until 1991 when the Hong Kong Housing Authority implemented the Performance Assessment Scoring System (PASS). Since then, the pubic clients progressively mandated the certification of ISO 9000 for concrete suppliers, contractors and engineering consultants. The ISO 9000 version released in 2000 contains some TQM elements and the public clients mandated the certification to this revised ISO 9000 version in 2003. In 2001, the government commissioned Construction Industry Review Committee (CIRC) issued an improvement initiation report which contains many TQM initiations and their application. The author's study began in 2006 which is five years after the release of the CIRC improvement initiation report and three years after the mandatory of the ISO 9000:2000 version, both of which contained some TQM elements. In conjunction with a comprehensive literature review, it is expected as from around 2006, there would be a requirement of the Hong Kong construction industry for additional quality management approach, including TQM, to satisfy the continual improvement approach philosophy demanded in both the local and international market.

A time line figure (Figure 1- 1) below shows the Hong Kong Construction Industry Culture Development:

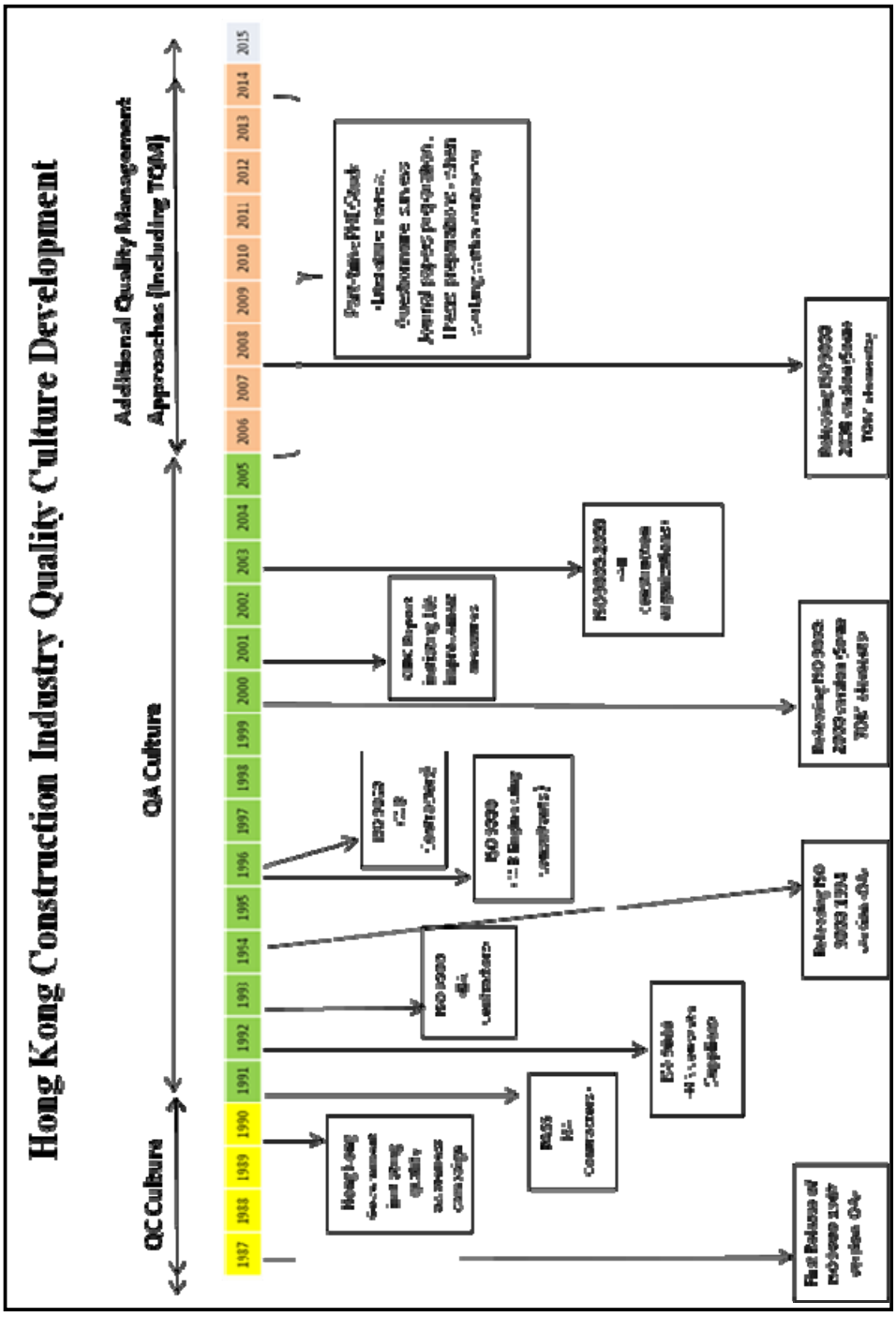

Figure 1-1 Hong Kong Construction Industry Quality Culture Development Time Line

1.7 References

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Chapter 2 - Literature Review

2.1 Quality Concerns in the Construction Industry

The construction industry in many parts of the world have been suffering from problems such as complaints of un-satisfactions from clients and users, disputes amongst stakeholders arising from time overrun and project delays or suspensions due to cost overrun (Al-Sinan, 2004).

The construction sector is generally not a coherent entity, and the causes of its fragmentation are deeply rooted (Rabeneck, 2008). Fragmentation, which takes the form of an individual participant pursuing singular interests on a project, has a substantial hindering effect on the quality of the construction engineering industry, where the pace of improvement is considered to lag behind that of other industries (McCrary *et al*., 2006).

Several national reports have been published within the last fifteen years, highlighting required enhancements in the quality of construction projects and the general performance of the construction industry. For example, the Egan (1998) report in the UK identifies five key drivers of change: a quality-driven agenda, committed leadership, integrated process and teams, a focus on the customer and a commitment to people. In South Africa, the document "White Paper: Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry" (Department of Public Works 1999) proposes reinforcing programs to develop a stable delivery environment, enhance industry performance, enable human-resource development strategies, promote new industry capacity and develop the public sector as the cornerstone of the improvement strategy. The Construction 21 Review Committee (1999) study in Singapore proposes six strategic thrusts: enhancing professionalism, raising skill levels, improving industry practices and techniques, adopting an integrated approach to construction, a collective championing effort for the construction industry and the development of an external wing. The Building for Growth (1999) report in Australia initiated a reform agenda in five key areas: creating a more informed marketplace, maximizing global business opportunities, fostering technological innovations, creating economically and ecologically sustainable

environments and creating a best practice regulatory environment (NatBACC, 1999). These four national report examples demonstrate the concerns of industry stakeholders worldwide over construction quality issues.

2.2 Quality Management Practices and Systems - Quality Control (QC), Quality Assurance (QA) and Total Quality Management (TQM)

The meaning of quality varies under different organizations' perception and definition. In general, quality carries an implication of excellence, high status and deluxe feeling (Tang *et al.*, 2003). BS 4778 (BSI, 1971) defines quality of as the totality of features and characteristics of a product and service that bears on its ability to satisfy the stated or implied needs. The German Standard, DIN, defines quality as all those properties and characteristics of a product or activity that affects its suitability to satisfy given requirements (Tang *et al.*, 2003). Juran and Crosby, the quality gurus, consider quality as conformance to the given requirements (Tang *et al.*, 2003). Juran also believes that quality must meet the test of its fitness for the intended use (Arcaro, 1995) which seems to be in line with the conventional approach in controlling quality in construction.

2.3 Quality Control (QC)

Both the American National Standard Institute (ANSI) and the International Organization of Standardization (ISO) define quality control as the operational technique and activity to control and measure the characteristics of a process, product or system. (Tang *et al.*, 2005).Based on the checking and inspection to ensure compliance with given specifications, quality control has long been used in construction. The essentials of quality control are to detect changes in quality by inspection and testing, and to make necessary adjustments to the production process. It provides useful feedback and enables defective areas to be given early attention or to be corrected. However, there have been numerous cases where ways were found to deceive or bypass the inspection. Since correction of substandard work causes delay, looses and pain to parties concerned, more frequent and stringent testings are often adopted by the industry (Tang *et al.*, 2003).

2.4 Quality Assurance (QA)

Quality assurance embraces all the activities and functions needed to provide adequate confidence in a product or service for satisfying given requirements for quality. It is essentially a preventive function. Quality assurance is based on the principle that prevention is better than cure and it is more economical to get things right in the first place. Everyone should aim at doing things right the first time and every time, thus achieving zero defect in performance. To implement quality assurance, proper and systematic procedures are drawn up and followed by all concerned.

Development of the ISO 9000 series quality standard – The ISO 9000 series, formerly known as BS 5750, quality standard became the most popular formal quality standard for the manufacturing industry more than two decades ago. The concept of this series of quality standard first appeared in UK in Defense Standard (Def Stan) 05-08, NATO Quality Control system Requirement for Industry, published by the UK Ministry of Defense. The Def Stan was subsequently revised in 1973 and several standards, Def Stan 05-21, 05-24 and 05-29 were issued with their corresponding guides for the defense industry (Aoieong, R.T., 2004). In response to the needs for similar standards applicable to manufacturing, the British Standards Institution (BSI, 1971; BSI, 1972) produced two guidance standards: BS 4778 Quality Vocabulary (1971) and BS 4891 A Guide to Quality Assurance (1972). The first version of BS 5750 Quality System was published by BSI in 1979 which became the UK Standard for quality assurance. In 1987, BS 5750 was reissued to correspond with the International Standards Organization (ISO 9000), the international equivalent, and in 1994 it was renamed BS EN ISO 9000. ISO 9000 was first published in 1987, mainly based on the 1979 version of BS 5750. It was initially used mainly within the manufacturing sector. As its popularity grew in the 1990s, its application extended slowly to other industries including construction. In the 1994 version of ISO 9000 series, identical to BS EN ISO 9000 series, three system levels are specified. Level 1, ISO 9001, is intended for ‘Design, development, production, installation and servicing’. Level 2, ISO 9002, is intended for ‘Production, installation and servicing’ while Level 3, ISO 9003, is designed for ‘Final inspection and test’. The 20 clauses in ISO 9001 (ISO, 1994) have been generally

adopted in the construction industry. Tang *et al.*, (2003) provides an illustration of the application of these 20 clauses to construction related activities:

1. Quality system: requirements to set up, document and maintain a quality system;
2. Organization: delineation of responsibility as defined in the quality manual;
3. Review of the system effectiveness: ensuring effectiveness of the quality system and its suitability to other projects;
4. Planning: sequencing and logistics which facilitates the achievement of quality;
5. Works instructions: for activities which affect quality such as batching of concrete;
6. Records: developing and maintaining a system of records for inspection by client and as proof of quality assurance;
7. Corrective action: procedures to deal with dimensional discrepancy;
8. Design control: following a design standard, code of practices or in-house guidelines;
9. Documentation and change control: issuing and recording amended drawings;
10. Control of inspection, measuring and test equipment: checking accuracy of steel bar and concrete testing machines;
11. Control of purchased materials and services: control of material suppliers and nominated subcontractors services;
12. Manufacturing control: control of concreting operation on site;
13. Purchaser supplier material: control of material and component supplied by clients
14. Complete item inspection and test: inspection and water test of completed pipelines;
15. Sampling procedure: procedures for sampling of concrete for tests
16. Control of non-conforming materials: rejecting substandard bored pile or assigning a lower working load;
17. Indication of inspection status: identifying the inspected and approved formwork and reinforcement ready for concreting;

18. Protection and preservation of production quality; covering the concrete surface for curing purpose;
19. Training and statistical technique: identifying all training requirement for activities and functions which can affect quality;
20. Statistical techniques: using of simple charts and diagrams to highlight problems, analysis them and propose various solutions.

2.5 Differences between QC and QA

While quality control is taken as a system of activities intended to provide a quality product, quality assurance is a planned system to ensure that the quality control program is actually effective. Quality control comprises those quality assurance actions related to the actual physical characteristics of the product, the hardware or the activity. Quality assurance includes and is broader than quality control. It is concerned with all the activities from initial conception through detailed design, manufacture, assembly etc., until the finished product is put into use.

The Effectiveness in Implementing QA System – ISO 9000 series quality management system is regarded the most popularly adopted international QA system (Lam et at, 1994). It emphases documentation control which covers daily management, production and administrative activities. The success of developing and implementing a certified quality system relies on commitment and encouragement of top management, and the support and participation of staff.

A survey (Poon and Xu, 1997) indicated that majority (80.3%) of large construction firms in Hong Kong have been certified to ISO 9000, while only 5.3% and 31.4% of small and medium size firms have their quality systems been accredited. The low percentage of small to medium contractors with certified QA systems was due to the client's low priority on quality and the difficulty to adjust the management style by the local family business. Another study (Tam, 1996) on the effectiveness of the QA system in the construction industry concluded that there was not enough strong evidence to justify the benefits claimed previously of the QA schemes. Contractors considered the certification exercise as a means of eligibility for tendering and their commitment was not genuine.

Ahmed *et al*. (1998) identified that benefits of ISO 900 certification such as ‘improved profitability, effectiveness and efficiency’ and ‘reduced cost of correcting errors’ were not significant and below the original expectations. A similar survey by Tang and Kam (1999) for ISO 9000 certified engineering consultant in Hong Kong also showed that the government requirements was the prime reason for seeking certification. The actual achievement and benefits of the ISO certification were again insignificant. Surveys (Lee, 1997; Kam and Tang, 1998) further indicated that the majority of construction of firms was under pressure from clients, and the firms were passive in adopting ISO 9000. All these studies showed that the QA systems implemented in the Hong Kong construction industry were client driven at the time of late 1990’s and the quality culture in the industry was yet to be established in order to reap the true benefits intended by the quality standards.

2.6 Total Quality Management (TQM)

In 1980s and 1990s, a "quality revolution" was established to match the globalization of the marketplace and increased competition. As a result, Total Quality Management (TQM) became one of the dominating management approaches in the 1990s. The successful implementation of TQM in the manufacturing sector within both Japan and the United States inspired other industry sectors in all developed countries to adopt the approach. Since then, many private and public organizations started the application of TQM, in association with other quality management systems.

BS 7850 (BSI, 1992) defines TQM as the management philosophy and company practices that aim to harness the human and material resources of an organization the most effective way to achieve the objectives of the organization.

The American Society for Quality (ASQ) defines TQM as a management approach to long-term success through customer satisfaction. With TQM efforts, all members of an organization participate in improving processes, products, services, and the culture in which they work.

(http://asq.org/learn-about-quality/total-quality-management/overview/overview.html)

According to Nathan (1997), TQM is a holistic management philosophy that seeks continually to maximize customer satisfaction, and continually to identify and eliminate non-value-adding activities for organizations. Another definition of TQM, which is used by the Department of Defense in USA, is a philosophy and a set of guiding principles that represent the foundation of a continually improving organization (Tingey, 1997). .

(Logothetis, 1992, Oakland, 2000) describes TQM as a culture advocating a total commitment to customer satisfaction, through continual improvement and innovation in all aspects of the business. The customer, in the TQM culture, does not mean only the final recipient of the organization's end product or services. The "customer" is also every individual or department stakeholder within the organization

The above definitions and descriptions indicate that TQM is not merely about implementing dynamic management system; it is also about embedding a culture of continual improvement and customer focus within an organization. It is the application of quantitative methods and human resources to improve the material and services supplied to an organization, all the processes within the organization, and the degree to an organization, all the processes within the organization, and the degree to which the needs of the customer are met, now and the future. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach focused on continual improvement. It is a management-led process to obtain the involvement of all employees, in the continual improvement of the performance of all activities, as part of the normal business to meet the needs and satisfaction of both the internal and external customers. The principle benefit of commencing a TQM programme is to obtain and improve the future health of the business.

2.7 Differences between QA and TQM

The European Construction Institute (1993) identified the following major differences between QA and TQM:

Quality Assurance	Total Quality Management
Provides procedures for doing things right	Provides for doing the right things right
Makes improvements by eliminating recurring problems	Makes improvement by cultural change based on measurement of performance and elimination of root causes and constraints
A part of the quality improvement process	A process for continual improvement
Relies on regular monitoring and audits to identify and correct non-conformance	Involves getting ideas and suggestions for improvements from everyone
Provides procedures for all activities	Focuses on a full understanding of the various business processes by day to day involvement of all concerned
Use regular management reviews the procedures and working practices to lead improvement	Stresses the importance that products and services delivered to the internal and external customers will meet requirements whether specified or not
Static conformance approach	Dynamic people approach

The earlier versions of the ISO 9001, versions 1987 and 1994, mainly focus on QA approach. In the ISO 9001 year 2000 version, TQM elements including consumer satisfaction, continual improvement, process approach, etc. were introduced into the standard. The latest Year 2008 version contains similar TQM elements**.** There are indications the widely adopted ISO 9001 quality management international standard is now taking a semi-TQM approach.

2.8 TQM and the Construction Industry

The construction industry shares certain characteristics with the manufacturing industry, as both focus on product delivery. However, the construction industry can also be seen as a ‘project based’ industry. Each construction project is unique in its physical site constraints, project stakeholders, design changes and site logistics. The following characteristics are nevertheless common to most

construction projects (Ashford, 1989; Hadavi and Krizek, 1994; Low and Peh, 1996; Kanji & Wong, 1998; Tam *et al*., 2000; Brockmann & Birkholz, 2006 and McCrary *et al*., 2006):

- Most projects contain risky uncertainties in terms of ground and weather conditions.
- Basic processes are repeated from job to job, but the specifics of application always vary due to project constraints and site environments.
- Parties to projects have differing traditions and often opposing interests, leading to resources being spent on defending the parties' positions.
- Short-term employment for migrant workers, which discourages company loyalty.
- Multi-interfaces complicate the communication efficiency and tracing system.
- Costs and time are generally more precisely defined than quality in construction contracts. The latter gives more room for contractors to manipulate, leading to the risk of giving unnecessarily high priority to costs and time at the expense of quality.
- Little integration between designers and construction contractors, resulting in low buildability designs.
- Changes, both in design and in construction, are excessive and frequent.
- Changes cause delays, claims and confrontations, which undermine the quality of the project.
- Almost every job is a prototype

These characteristics have substantial effects on the quality of the construction industry, which is considered to be lagging behind other industries (McCrary *et al.*, 2006)

The importance of TQM was raised in a study (Burati *et al*., 1992) on the construction industry in the USA. It was suggested that any company which does not implement TQM in his firm will not be competitive in the construction market within the next five to ten years.

The principle for adopting TQM is to stay in business. There is a need to continually improve everything we do and TQM provides the vehicle for:

a. Improving the bottom line: Reducing rework and removing unnecessary procedures.
b. Delighting the client: Improving efficiency of the contractor and giving results both the client and the contractor would benefit.
c. Involving the entire workforce: The workforce will fell more involved, realizing their opinion counts and be able to contribute ideas to make the project a success.

2.9 Difficulties of TQM Implementation in the Construction Industry

Al-Sinan (2004) expressed that the construction industry have been facing when challenges when applying the TQM approach in his quality management system. Leaders of the industry believed that those obstacles identified by Strange and Vaughan (1993), Low and Peh (1996), Haupt and Whiteman (2004), Love *et al*. (2004), Tang *et al*. (2005), Koh and Low (2008) and Martinez-Costa *et al*. (2009) have been hindering the successfully application of TQM in the construction section and these obstacles related to the following construction inherent constrains:

- The unique nature of the construction projects making the generalized solution not applicable.
- The limited company loyalty as a result of short-term and migrant employment restricting investment in training at job level.
- The highly competitive market preventing margins for money on quality and management training for employees.
- The highly demanding construction program restricting time for seminars, retreats and symposia.
- TQM does not align with the culture of the employees in terms of behavior and value;

- Long term benefits would not emerge until 10 year after implementation, short term benefits only restricted to reduced re-work, increased and improved client satisfaction;
- Low education level of field workers.

It has been that industry's major concern that the conventional practice of evaluating planning, engineering and construction tender bid with the heaviest emphasis on price but limited consideration for past experience, current workload and reputation for quality does not give tendering party any incentive to adopt TQM principles (Yiwei and Eng, 2000).

2.10 TQM elements applicable to the Construction Industry

Koh and Low (2010) carried out a detailed review of TQM elements discussed in nine prevailing articles and one national standard and established the following eight construction specific TQM elements:

	TQM Element	**Specific application to construction related activities**
a.	Top management leadership	Commitment and leadership of the top management involving the acceptance of quality evaluation and responsibility by head of departments, the institution of comprehensive planning and communication, the emphasis of the importance of quality in relation to cost and schedule of construction (Culp *et al*., 1993;Saraph *et al*., 1989)
b.	Customer management	Management focusing on the production of goods or services that fulfill top management leadership l the customer's needs of the technical specification and service satisfaction (Chase, 1993; Chiles and Choi, 2000). Satisfaction initiatives peculiar to construction include impressing the end users in post-design or post-construction phase, and the provision of specific services or solution to the client's project (Koh and Low, 2010)
c.	People management	Management focusing on the collaboration between manager and his sub-ordinates, and between customers and their suppliers. This collaboration process forms the basis of cross-functional quality improvement teams. Employees in the construction related processes are encouraged and empowered to

		inspect and rectify any quality problems with the provision of supporting framework (Black and Porter, 1996; Chase and Federle, 1992)
d.	Supplier management	Management of the co-operation between a firm and its service/material suppliers. This interdependence is crucial in construction for subcontracting, including outsourcing of technical services, Quality of the facility and services by the principal stakeholder are directly related the quality of resources and works provided by various parties (designers, suppliers, and subcontractors). Supplier management requires the establishment of partnerships involving selection of suppliers on the basis of quality instead of solely on price (Pyzdek, 1990; Stuart and Mueller, 1994; Weston and Gibson, 1993).
e.	Quality information management	Management for the systematic collection of data during the whole design and construction process. The data collected are then used for considering decisions, process control and learning materials (Flynn *et. al.* 1994).
f.	Process management	Management of all horizontal and interlinked process during construction. It involves the attachment of quality of measures to the construction processes and continual monitoring and improvement of those processes (Claver *et al*., 2002)
g	Organizational learning	The learning process ensuring mistakes are not repeated and lessons learnt are applied to the existing processes (the process task knowledge). It also ensures the foundational knowledge on organizational system (the profound knowledge) simulates continual improvement (Anderson *et al*., 1994). The two major themes in organization learning are double- loop learning and learning dimensions (Burati and Oswald, 1993; Imai, 1996; Kululanga *et al.,* 2002; Stange and Vaughan, 1993).
h.	Continual improvement	The constant examination of both technical and administrative processes for better performance of the management of the construction business. The enhanced performance allows an organization continually meeting the increased expectations of the customers (Dean and Bowen, 1994).Continual improvement involves a technical system that identifies the key improvement processes for process and cost control, company performance and overall benching marking by the construction market (Burati *et al*., 1992b; Fisher and Pollock, 1995; Lema and Price, 1995; Oswald and Burati, 1992).

2.11 General situation of quality management in the Construction Industry in the Asian Region

Infrastructure construction has always been attached to economic development and the management of quality problems associated with construction is expected to evolve continually. This section of literature review describes the recent construction quality systems in Japan, Singapore, Mainland China, Taiwan and Hong Kong. All these Asian regions already developed high standard of construction management. In general, the level of application of quality management principles in developing countries is relatively lower than in developed countries, where clients continually demand enhancement in the overall value of their investment in construction projects.

After the Second World War, quality management has been well received by all industries in Japan. The Quality Control concept had caught the attention of the Japanese construction industry since the 1970s. To Japanese contractors, quality is a means to increase sales and profit. By applying the quality management tools, many Japanese contractors are practicing total quality management. In order to compete internationally, many contractors also commenced their ISO 9000 certification programmes in mid 1990s.

In Singapore, the Construction Quality Assessment System (CONQUAS) was set up in 1989 to assess the quality of construction work. In 1995, the Singapore government announced the ISO 9000 certificates requirement for contractors and consultants. In response to the Construction 21 1999 recommendation, the Building Design Appraisal System was set up by the authority in 2001 to assess the quality of buildability in design.

Mainland China started adopting TQM in the construction industry back in the 1980s (Zeng *et al*., 2003). The Provisional Construction Supervision Ordinance in 1988 introduced the requirement for construction supervision (CS), which specifies particular supervision of the total quality elements of planning, progress, costs and quality of state-owned construction projects (Li, 2004). Yusuf *et al.* (2007) suggested that the key success factors for TQM application by

organizations in China are top management leadership, alignment with company's business objectives, customer satisfaction and communication and internal needs. Zeng *et al.* (2002, 2003) expressed similar key success factors in their construction quality specific papers.

Taiwan, which is considered to be more influenced by the US in terms of technology and management practices, has also practiced TQM in its construction industry since the late 1990s (Shieh & Wu, 2002). TQM application is considered an effective tool for maximizing the alignment and integration of key customer satisfaction achievement factors. In this regard, it has been suggested that leadership ability and supplier management are the two most important elements (Chen & Chen, 2007; Kuo & Kuo, 2010)

The awareness on construction quality in Hong Kong also emerged in late 1980s. The Performance Assessment Scoring System (PASS) was set up in 1990 for measuring building contractor performance. In 1993, the authorities commenced ISO 9000 registration requirements for contractors and consultants. To address shortcomings persisted in the construction industry operations, a construction industry review committee was commissioned by the HKSAR Chief Executive in 2000. A review report named "Construct for Excellence" was issued by the committee, setting out the strategic directions for competitiveness enhancement through continual improvement. The concept of total quality has been cultivated by the report and the construction industry in Hong Kong has shown increased familiarization towards TQM (Tang and Chen, 2013).

The following gives an account of the development of quality management in Japan, Singapore and Hong Kong which are countries / regions where the construction industry is relatively more developed in Asia.

2.12 Quality management in the construction industry in Japan

1. Total Quality Management in Japanese Contractors

In early 1970s, there was a strong complaint from the owners and the public alike that construction quality in Japan was abysmal (Adbul-Aziz, 2002). Most contractors followed the lead of their manufacturing counterpart and began incorporating Total Quality Management (TQM) philosophies into their organizational culture.

Nearly all Japanese contractors are adopting TQM as their company quality policy (Xiao and Proverbs, 2002; Levy, 1993). They build up long-term relationships with customers and subcontractors. They invest in their own future by providing well-designed, on-the-job training both for their own and for their subcontractors' staff (Bennett, 1993; Levy, 1993). The concept of Kaizen (continual improvement), customer satisfaction and company wide responsibility are the major principles for establishing the system (Bennett, 1993).

Most contractors in Japan have incorporated design teams in their corporations whose quality systems usually contain an upstream section for design and a downstream section for conformance. The main features of total Quality Management in construction in Japan are summarized as follows:

2. Design and planning

Design of works is complete in every detail before construction begins. The detail design is based on standardized details which are familiar to the subcontractors. The overall effect is that buildability, based on well practiced methods and skills, is thoroughly considered at the design stage (Bennett, 1993; Maeda and Maeda, 1997). Construction works are planned in exceptional detail on every project, with remarkable consistency. The starting point of the consistency is that construction projects are completed exactly on time by main contractors with no exceptions (Levy, 1993; Bennett, 1993; Paulson and Aki, 1980).

3. Work routine

Commitment to quality by the contractors results in meticulous attention to detail. Once work commences, all tasks including material purchasing, payments, labour engagement and design work are carried out on site. Every activity undergoes the same plan, check, double-check and record regime. Moreover, almost every level of site management is by consensus, with plans and policies being agreed by all the parties including client, designers, engineers, supervisors and subcontractors (Paulson and Aki, 1980; Levy, 1990). The project managers are expected to prepare reports on matters as diverse as the weather, labour, machinery and raw materials. All such meticulous documentation is connected to TQM's requirements for decisions to be based on data and facts.

4. Cost Control

In Japan, contracts are normally awarded on a lump sump basis (Hasegawa, 1988). Cost control has to be as tight as it can be. For a typical design and build contract, cost control starts at preliminary planning and continues all the way through to final delivery. The contractors operate on the general assumption that if the quality and time criteria are fulfilled, costs will then look after themselves (Bennett *et al.*, 1987) Adjustment to contract sums due to variations is issued through gentlemen negotiations based on reasonableness and relative bargaining strengths (Abdul-Aziz, 2002).

5. Time control

In Japan, because of client expectation, meeting delivery deadlines becomes almost sacrosanct (Levy, 1990). Hence a lot of effort is spent on programming using bar charts and network technique for various time-frames ranging from total, monthly, and ten-day breakdown (Hasegawa, 1988). Detailed time control is achieved through consistent daily meetings with subcontractors who in turn hold their tool-box meetings with the workers (Abdul-Aziz, 2002). Later in the day, the site management team conducts its own internal meeting to discuss

whatever short term progress issues may have arisen. It is a common practice in Japanese projects that sufficient slack is built into the short-term schedules to ensure that all the key project dates are met (Bennett *et al.*, 1987).

6. Kaizen (continual improvement)

The Japanese contractors consider that the most important factor in steadily improving the remarkable consistency in performance is Kaizen, the continual incremental improvements (Bennett, 1993). Kaizen matters may be raised at daily meetings as an integral part of the normal work. Improvement ideas are taken seriously by the site management. The best ideas each year are selected to go forward to branch and then to the company presentation meetings. These presentations and publication are intended to emphasize the importance of looking for improvements by both staff and subcontractors.

7. Adoption of international quality management standards

It is considered by the Japanese construction industry that its quality management system needs to have a global as well as a corporate focus (Hirao, 1997). The Ministry of Land, Infrastructure and Transport (MLIT) started some pilot projects in 2000 in which ISO 9000 certification was included into the competitive bidding pre-qualification criteria. In 2001, MLIT expanded the trial for ISO 9000 series requirement to 155 construction projects and 21 service projects (RICE, 2002).

Many of the Japanese international main contractors take the lead in acquiring the international quality management standard to maintain their eligibility for tendering contracts internationally. These contractors started getting the ISO 9000 certification back in 1995. In 2003, it was reported that 12,950 companies had registered with the Japan Accreditation Board (JAB) for ISO 9000 certification in the construction sector (RICE, 2003).

Lau and Tang (2007) presented a comparison of the quality management in construction in Japan against those in Singapore and Hong Kong, which is summarized in Figure 2-1:

	Japan	Singapore	Hong Kong
Awareness of quality problems	Late 1960s	Late 1970s	Early 1980s
Initiation on solving problems	Contractors	Government (BCA)	Government (HKHA, Works Branch)
Quality management in construction industry	Integrated into overall company and project management	Mandated by clients	Mandated by clients
Quality culture in construction industry	Supported by nation-wide education principles	Led by government and major clients	Led by the government and major cIients
Quality Performance Benchmarking	Implementation of TQM (as early as 1967) Obtain Deming Prize and Japan Quality Control Medal Award Increasing business opportunity	CONQUAS (introduced by BCA in 1989) Provide premium tendering advantages	High scores in PASS (launched by HKHA in 1991) Obtain maximum tendering opportunities
ISO 9000 certification	Started in 1995 Widely adopted by international main contractors	Started in 1999 Required by BCA	Started in 1993 Required by HKHA and Works Branch

Figure 2-1 – Comparison of Quality Management in Japan, Singapore and Hong Kong

2.13 Quality management in the Construction Industry in Singapore

1. Development of Quality Systems in the Construction Industry

Quality in the Singapore construction industry first began to gain attention in the late 1970s (Low, 1993). The Construction Industry Development Board (CIDB) was formed in 1984 with a main task to oversee, train and develope the

construction sector (Kam and Tang, 1997). In 1999, it then merged with another government department to form the Building and Construction Authority (BCA) which now administers both the development and regulatory functions pertaining to the construction industry. CIDB set up the construction quality assessment system (CONQUAS) for public building construction in 1989 (Kam and Tang, 1997).

Quality in consultancy services is also managed by BCA. In conjunction with the launching of the central panel system in 2004, the Quality – Fee selection method was implemented for procuring consultancy services in architectural, civil, structural, M & E, quantity surveying and project management. The quality to fee weighing varies from 60/40 to 80/20 depending on the nature of the services to be procured (Quality–Fee Method, 2004). The Buildability Design Appraisal System (BDAS) was also implemented in January 2001 to enhance buildability, productivity and quality in the industry (BCA, 2005).

To further recognize the importance of construction quality, BCA imposed mandatory quality management system standard requirement in July 1999, when ISO 9000 certificate became a prerequisite for contractors and for consultancy firms undertaking public sector projects with values above S$10 million and $30 million respectively (BCA ISO 9000 Certification Scheme, 1991).

2. Quality Assurance Certification Scheme

The requirements for ISO 9000 certification for contractors and consulting firms who undertake government projects took effect from 1 July 1999. These requirements apply to:

a. Contractors with a registration grade of A1, A2, B1 and B2 (with tendering limits unlimited, S$ 65 million, S$30 million and S$10 million respectively) in BCA's Contractors Registry undertaking general building, civil engineering and piling works.
b. Consulting firms engaged in architectural, engineering and quantity surveying services who undertake public construction projects valued at more than S$30 million.

3. Construction Quality Assessment System (CONQUAS)

CONQUAS was initially implemented in 1989 for public building construction. The scoring is done on the works that are inspected for the first time. The objective of this practice is to encourage "*doing things right the first time*" (CONQUAS 21, 1998). After refinements and with modifications, it was then extended to cover also private building and civil engineering construction. The fifth edition of this assessment scheme was launched as CONQUAS 21 by the Building and Construction Authority (BCA) in 1998, together with the Bonus Scheme for Construction Quality (BSCQ) (Chiang *et al*., 2004).

4. Public construction tender quality bonus and discount

In attachment to the CONQUAS quality scheme, the Singapore government has set up a bonus and discount mechanism for tendering of public works. In 1990, one year after the launching of the CONQUAS scheme, the associated premium scheme was also introduced to provide tendering advantages of up to 5% or S$5 million who consistently achieve good-quality work as reflected by high CONQUAS scores (Kam and Tang, 1997). Upon the launching of CONQUAS 21, the maximum tendering advantages reduces to 3% or S$2 million. A maximum disadvantage loading of S$2 million will however be imposed on contractors having scores below the average CONQUAS score (CONQUAS 21, 1998).

5. Buildability Design Appraisal System - Buildability score

The legislation of buildable design took effect from January 2001, after which the Code of Practice on Buildable Design then applied to building work developments. Minimum Buildability Scores are required to be met prior to development approval. In 2005, the minimum Buildability Score for new building varies from 57 for residential (landed) of GFA less than 5000 m^2 and to 77 for industrial of GFA more than 25,000 m^2 (BCA, 2005).

2.14 Quality management in the Construction Industry in Hong Kong

1. Development of Quality Systems in Construction Industry

In the early 1980s, the Hong Kong Housing Authority (HKHA) decided to knock down and re-developed 26 public housing blocks which had been built during 1963 to 1975 and were having serious structural problems. Seventy thousand people were required to be re-accommodated in the re-development scheme (Kam and Tang, 1997; Chin and Choi 2003). Other quality related expensive maintenance problems associated with thousands of public residential buildings, including water leakages in cast-in pipe, water leakages in external wall, de-bonded tiles, spalling of concrete, and honeycombing also surfaced during 1980s and 1990s (Chiang *et al*., 2004). The continual increase in maintenance costs for the huge public and private establishment pressed the Hong Kong construction industry and particularly the Hong Kong Housing Authority to promote quality assurance and management for its perceived potential saving in maintenance in the long run. (Chiang *et al*., 2004; Kam and Tang, 1997).

In March 1990, the Hong Kong Government launched a "quality awareness campaign" and the Hong Kong Housing Authority (HKHA) took the initiative by striving for an improvement in the quality in the construction of all public housing works (Kam and Tang, 1997; Tang *et al*, 2005). The key events in the Hong Kong Government's drive for quality in construction are summarized as follows:

a. In 1991, HKHA implemented the Performance Assessment Scoring Scheme (PASS) and the Maintenance Assessment Scoring Scheme (MASS).
b. In 1993, HKHA required all building contractors to achieve registration under ISO 9000 series quality assurance standards.
c. In 1996, Works Bureau administrating public construction works required all design consultants and major main contactors (List I, II and Group C) to be certified to ISO 9000 series quality assurance standards.

d. In 1999, HKHA introduced Preferential Tender Award System for building contractors.

e. As from 1 November 1999, the Works Bureau only accepts ISO 9000 series certificates issued under the rules of the Hong Kong Certification Body Accreditation Scheme. A comprehensive quality assurance accreditation system for the public sector construction was then established.

f. Following the emergence of a number of defective piling problems in the public housing construction, the HKHA embarked on a "Building Quality Reform Plan" containing 50 improvement initiatives in eleven core items for the enhancement of the building quality and the restoration of the public confidence (HKSAR – Audit Commission, 2001)

g. In 2001, the Construction Industry Review Committee (CIRC) issued the Report "Construct for Excellence", which recommended 109 improvement measures including timely actions in fostering a quality culture.

2. Performance Assessment Scoring System

In parallel with the ISO 9000 certification requirement, the Hong Kong Housing Authority also implemented a series of Performance Assessment Scoring System (PASS) and Maintenance Assessment Scoring Scheme (MASS) to measure contractors' performance against defined standards. The system was first introduced by the HKHA in 1990, aimed at building (Building PASS) and maintenance contractors (Building Works MASS) to ensure effective monitoring. It has been refined over the years and extended to building services sub-contractors (Building Services PASS and Building Services MASS) in 1997 and to piling contractors (Piling PASS) in 2005. A separate set of quality indicator for laboratories after the name Laboratory Assessment Scoring System (LASS) was also introduced by HKHA in 1997.

A comprehensive range of output items covering structural and building elements is assessed under the system. Structural elements include reinforcement bars, formwork, finished concrete and construction quality. Building elements cover floor, internal and external wall finishes, ceiling, windows, plumbing and drainage, precast components, waterproofing, shop front and cladding.

With regards to input, an assessment on the management covering organization, resources, co-ordination and document, programming and progress achievement, safety and health management and environmental management is conducted.

An overview of the PASS assessment (Tang *et al*, 2005) is illustrated in Figure 2-2.

Assessment	**Wt.**	**Frequency and Assessment Team**
Output Assessment		
Structural Works Assessment	70%	Monthly assessment – two months in a quarter by IT and the remaining month by PT
Architectural Works (Interim) Assessment)		
Architectural Works (Final) Assessment		Once by IT after Substantial Completion Certificate is issued
Input Assessment		
Management Input Assessment	10%	Quarterly Assessment by PT
Safety Assessment	8%	
Programme and Progress Assessment	2%	
Other obligation Assessment	10%	
Maintenance Period Assessment	-	Quarterly Assessment by PT
Wt. – Relative weighting; IT – Independent Team of Assessors; PT – Project Team Members		

Figure 2-2: PASS Assessment Overview

3. Quality performance considerations in tendering for public works

In managing the building contractor list, HKHA has taken the view that contractors who perform better in quality standard should be given more tendering opportunities than those less performing contractors. The preferential eligibility is defined from a banded score league. The PASS and MASS scores of the contractors are compiled to a six-month composite score for their projects. The contractors are then separated into three groups by the composite target quality score (CTQS) at the upper 75% position and the composite lower score threshold (CLST) at the lower 25% position. In each coming quarter, HKHA assigns the number of contract tenders to each band of contractors. This arrangement is intended to allow ample opportunities to those contractors with low composite to keep their resources in their existing contracts for quality and management improvements. (Kam and Tang, 1997)

Similarly, the Hong Kong Works Branch also implemented the Contractors' Performance Index System in 2000 to provide a ready indication of contractors' performance standard for reference by the project office and relevant tender board in tender valuation. A quarterly measured weighted average of the performance scores in the immediate past three years is taken as the contractor's current performance rating. The two weighting factors used in the score calculations are original contract sum and time lapse between the date of score assessment and the date of the individual project performance report. The highest contract sum category and the most recent project report receive the heaviest weighting.

A typical example of project report on Contractor's Performance is shown in Figure 2-3.

Aspect of Performance	**Achieved Grading**			**Maximum Score**	**Contractor's Score**
	VG	**S**	**P**		
1. Workmanship		X		15	9
2. Progress		X		15	9
3. Site Safety		X		25	15
4. Environmental pollution control		X		15	9
5. Organization		X		10	6
6. General Obligations		X		5	3
7. Industry awareness		X		5	3
8. Resources		X		10	6
9. Design		NA		10	6
10. Attendance to emergency		X		10	6
Overall performance		X		Not relevant	
	Grading Score Factor: VG - very good = 1.0 S – Satisfactory = 0.6 P – Poor = 0				
	Note : A 'poor" in anyone of aspects 1,2,3,4 will be a mandatory "Poor" in the "Overall performance" and the report will be rated as "Adverse"				

Figure 2-3: Example of Project Performance Score Sheet

Quality performance assessment by the government bodies is also extended to architectural and engineering consultancy firms for public works projects. As reported in the Provisional Construction Industry Co-ordination Board (PCICB) 2005 report, the works branch has been assessing quality aspects of the consultants in the marking schemes used for establishing the branch performance index system. Such index system has been used as a criterion for selection of consultants since September 2003. Likewise, the assessment on the quality aspects of consulting firms in public housing projects has also been included in the consultancy selection process since 1998 through a price and quality competition mechanism in which the technical submission including quality aspects carries a weighting of 60% of the total tender score for straight forward project to a maximum weighting of 80% for complex project. The flow chart below summarizes the prevailing quality managements and bench marking systems for construction in Singapore and Hong Kong (Tang and Chen, 2013).

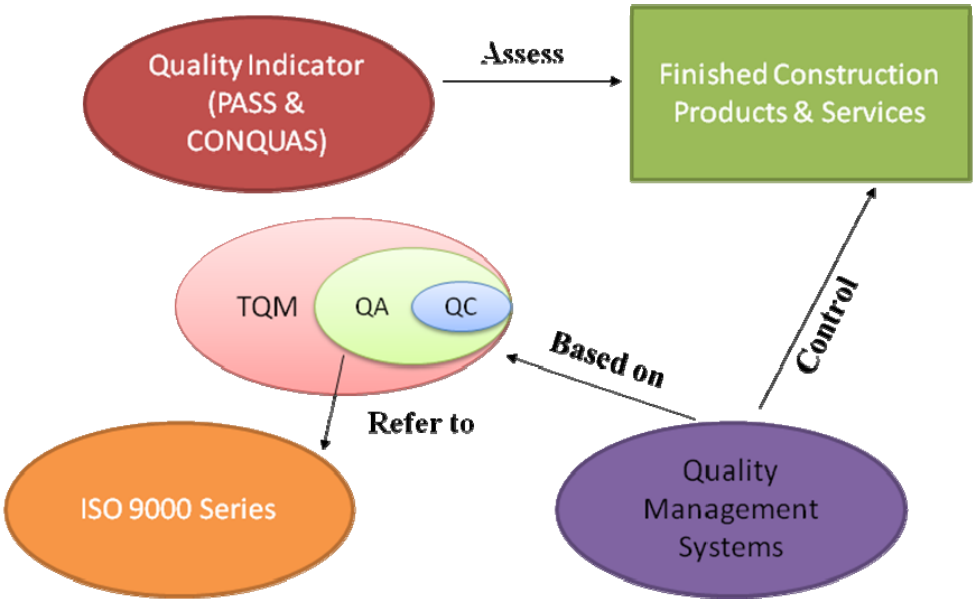

Figure 2-4 – Typical Construction Activity Quality Management and Bench Marking System (Tang *et al.*, 2005) and (Tang and Chen, 2013)

4. The HKHA Housing Quality Reform **(**HKSAR Audit Commission, 2001)

Following a few incidents on defective piling works and other areas of housing development, the reputation of the Housing Authority has been adversely affected. In April 2000, the Housing Authority issued a two-phased implementation plan, containing 50 improvements initiates covering eleven different areas. These eleven areas addressed aspects of customer satisfaction, site supervision, procurement practices, partnering culture, quality assurance enhancement, professionalism uplifting, and improvement of productivity.

5. Construction Industry Review Committee Report 2001 **(**Tang, 2001**)**

The PASS benching marking system was implemented in 1991 while the ISO QA system had been implemented since 1993. In 1999/2000, the HKHA however uncovered short pile scandals in 3 to 4 different sites. In combination with other non-compliant construction incidents and shortcomings in the industry's operations, these piling quality issues shattered confidence in public and private housing performance and quality. To address the public concern about the need for reforming the industry, the Construction Industry Review Committee (CIRC) was commissioned by the HK SAR Chief Executive in April 2000 to carry out an overall performance review on construction industry. The Committee set up three Sub-committees comprising largely of representatives of banks, government, and the construction industry for the review. After nine months of intensive and wide-ranging consultation with industry stakeholders, the CIRC issued the "Construct for Excellence" report in January 2001. This report revealed the following the nine key quality problems in the industry:

I. Lack of client involvement
II. Short-term attitude to business development
III. Extensive use of traditional and labour-intensive construction methods
IV. Non value-adding multi-layered subcontracting
V. An inadequately trained workforce
VI. Tendency to award contracts to the lowest bidders
VII. Fragmentation and adversarial culture within the industry
VIII. Substandard works and lax supervision
IX. Highly aggressive construction program resulting from high land costs

A package of 109 improvement measures was proposed in the report to uplift the all-round performance of the construction industry. The improvement measures to be implemented under proposed time frames, ranging from immediately to within 5 years, and cover following seven main themes in relation to the construction quality in Hong Kong:

1. Fostering a quality culture – comprising seven sub-items covering aspects of "a knowledgeable & involved client", "importance of planning & design stages", "realistic project programming", "clear accountability", "subcontracting", "site supervision & quality assurance" and "raising the quality standard of renovation contractors & decorators";
2. Achieving value in construction procurement;
3. Nurturing a professional workforce;
4. An efficient, innovative and productive industry – comprising nine sub-items covering aspects of "process re-engineering", "wider use of standardization in component design & processes", "wider use of prefabrication", "wider application of information technology in project implementation", "investment in construction related research & development", "facilitating regulators", "more reliable records of underground utilities", "lowering the cost of ready-mixed concrete" and "export potential of the construction industry";
5. A safer workplace and an environmentally responsible industry;
6. Institutional framework for implementing the change program; and
7. Review of implementation progress of the change program.

The importance of strong leadership from the project clients and the need for a culture of continual improvement by the industry participants were also highlighted throughout the report. The approach of total quality product and total system control appeared in numerous sections of the report. The report also introduced the concept of prime contracting in which the prime contractor brings together all parties in the supply chain to meet the clients' requirements effectively. This report ultimately set the long term goal that a contractors is capable of working with the relevant parties for the total delivery of a

construction project, fit for purpose and in-line with the whole-life costs concept. It appears evident that the approaches, concepts and expectations brought up in the report are in line with the basis of the TQM philosophy.

2.15 TQM Elements reflected in CIRC report

With the awareness that the CIRC report contained the basic TQM concepts, the author of this thesis observes that the seven main themes of the improvement measures generally match the following construction specific TQM elements established by Koh and Low (2010):

a. Top management leadership – In relation to construction organizations' management activities, this element is reflected strongly in many of the CIRC improvement themes. Under the theme of "Fostering a quality culture", the report suggests all sectors' top management to lead their associated disciplines in securing an integrated input that facilitate efficient project planning, development and implementation, as an important driving force for a quality culture. The voluntary registration scheme for renovation contractors and decorators suggested in the report will also require substantial involvement of the contractors' top management. Under the theme of "An efficient, innovative and productive industry", the report recommends all industry sectors to work together to promote competition in the local ready-mix concrete industry. It encourages leader of the industry stakeholders to consider wider use of on-site concrete and prefabrication. Under the theme of "A Safer Workplace and Environmental Responsive Industry", the report suggests all sectors' top management to take lead in establishing a safety culture based on a preventive approach. The report further suggests construction organizations' management to promote sustainable construction by minimizing construction wastes and promoting environmentally friendly construction methods. Under the theme of "Institutional Framework for Implementing the Change Program", the improvement recommendations require all sectors' management to liaise closely with the improvement program co-ordinating body for all matters relating to needs and improvements.

b. Customer management – This TQM element is reflected in many of the CIRC improvement themes. Under the theme “Achieving value in construction procurement”, all organizations should adopt a procurement arrangement that allows their supply chains to maximize their ability of adding value to the project. Under the theme “An efficient, innovative and productive industry”, the report indentifies that with the combined expertise of accounting, financing and legal services, the Hong Kong construction industry could provide a comprehensive service package to foreign clients in the region through direct contracting or in associations with those local construction companies. It also suggests construction organizations to communicate, co-ordinate and invest in researches relating to construction material and construction methods that meet the local and regional needs.

c. People management – The association of people management with construction organizations’ activities are specifically discussed in the CIRC improvement theme “Nurturing a professional workforce”. Skill training for professionals, construction technician, construction supervisions and construction worker is emphasized. The responsible attitude towards work is highlighted. Broader adoption of direct labour in replacement of daily wage labour is recommended.

d. Supplier management - This element is reflected in two the CIRC improvement themes. The improvement measures recommended in the theme of “Fostering a quality culture” request subcontractors, suppliers and other projects team members to be accountable for their clearly defined roles and responsibilities and to perform to the best of their abilities in full alignment with the stakeholders’ long term objectives. These improvement measures also refer the organizations to nurture stable partnership with good standing subcontractors and suppliers through feedback and review in the pre-contract and post-contract stages. Under the theme “An efficient, innovative and productive industry”, the report further recommends the

ready-mix concrete suppliers to establish an agreed code of practice and to set up long term government off-loading and land use policies.

e. Quality information management - This element is reflected in at least three of the CIRC improvement themes. Under the theme of “Fostering a quality culture”, the report suggests the establishment of a voluntary registration scheme for small scale contractors (sub-contractors). The data base requires an efficient information management system readily accessible by the industry stakeholders. In the theme for “An efficient, innovative and productive industry”, the industry is recommended to develop a common data infrastructure that allows seamless electronic communication. The industry is also encouraged to develop software applications that would improve both local design capability and project logistic management. Under the theme “Review of implementation progress of the change program”, it is expected that all quality related information data is processed efficiently and adjustments to continual improvement program are communicated effectively to the stakeholders.

f. Process management – Process management is crucial to contractors as they deal with projects that are usually unique in terms of site environment, associated risks and the sequence of construction. In the theme “Fostering a quality culture”, process management is reflected in the detailed planning requirements for design, resources, procurement, co-ordination and programming. In the theme “An efficient, innovative and productive industry”, process management is highlighted in the integrated approach to project implementation. Process management is also emphasized in the standardization of component design and the prefabrication process of these components. The element is further reflected in the recommendation for streamlining regulatory approval for construction activities including that for excavation in the public land, which is usually a major element in the construction program for those design and build contracts. Under the theme “A safer workplace and an environmentally responsible industry”, process improvement though an integrated approach to project implementation is again recommended to enhance the overall effectiveness

of site supervision. Such enhancement will also raise the standard of site safety and mitigate the project related environmental impact.

g. Organizational learning (Internal error detection & correction and strategy for acquiring & applying up to-date external knowledge) – This TQM element is specifically reflected in the theme "Nurturing a professional workforce". The CIRC report requests the construction organizations to equip the site supervisors with academic knowledge and practical experience, in order to build up a pool of competent and committed mid-stream site personnel on whom effective project management can reply. Many of the current of site supervisors worked their way up from a tradesman background do not possess adequate formal knowledge will require in-house or external systematic training to cope with the demand of their jobs. For frontline workers, the report suggests a competence-based qualification framework to motivate the workers to acquire higher qualifications and new construction technique.

h. Continual improvement – The spirit of reviews and improvements spreads throughout the CIRC report. In association with construction organizations' management activities, continual improvement is highly reflected in the themes "Fostering a quality culture", "An effective, innovative and productive industry" and "Review of implementation progress of the change program". The report suggests the industry to put further emphasis on site supervision to uphold the quality of public housing. It also suggests the adoption of independent technical auditing for all public works, to identify areas for further improvements. With respect to construction related research development, the report recommends the industry to take account of both the immediate needs as well as the direction of the long-term development towards excellence. The report further points out that the pace of improvement for the Hong Kong construction industry is generally set by the surrounding competitive forces and global market. It suggests the industry to appoint a statutory body to co-ordinate the improvement scheme and to devise incentive schemes to encourage continual improvement to excellence.

The TQM elements corresponding to the CIRC main themes and their sub-items are summarized as below in Figure 2-5:

CIRC Report Main Theme	**Theme sub-items**	**Corresponding TQM element(s)**
(1) Foster a quality culture	I. A knowledgeable and involved client	Top management leadership (a)
	II. Importance of the planning and design stages	Process management (f)
	III. Realistic project programming	Process management (f)
	IV. Clear accountability	Supplier management (d)
	V. Subcontracting	Supplier management (d)
	VI. Site supervision and quality assurance	Continual improvement and Quality information management (h & e)
	VII. Raising the quality standard of renovation contractors and decorators	Top Management leadership (a)
(2) Achieving Value in Construction Procurement		Customer management (b)
(3) Nurturing a professional workforce		People Management and Organizational learning (c & g)
(4) An Efficient, Innovative and Productive Industry	I. Process re-engineering to achieve better integration	Process management (f)
	II. Wider use of standardization in component design and processes	Process management (f)
	III. Wider use of prefabrication	Process management (f)
	IV. Wider application of information technology (IT) in project implementation	Quality information management (e)
	V. Investment in construction-related R&D	Continual improvement and Customer management (h & b)
	VI. Facilitating regulators	Process management (f)
	VII. More reliable records of underground utilities	Process management (f)
	VIII. Lowering the cost of ready-mixed concrete	Supplier management and Top management leadership (d & a)
	IX. Export potential of the construction industry	Customer management and top management leadership (b & a)
(5) A Safer Workplace and an Environmental Responsible Industry		Top management leadership and Process management (a & f)
(6) Institutional Framework for Implementing the Change		Top management

Program	leadership (a)
(7) Review of Implementation Progress of the Change Program	Quality information management and Continual improvement (e & h)

Figure 2-5– CIRC recommendations compared against TQM elements

It is also observed that these main themes are also reflected in the core values, mission statements or company policies of many active Hong Kong based construction contractors and construction engineering organizations.

The implementation of the 109 improvement measures is monitored by a progress monitoring organization known as the Construction Industry Council (CIC). It reported that 84 of the 109 items had been fulfilled (The Standard Supplement 11 March 2011, Page 19) and all remaining items were in good progress. Whilst the progress of implementation appeared to be satisfactory, the author of this thesis was not aware of any report published by CIC on the progressive achievements of the intended improvements.

In parallel with the implementation with the CIRC recommendations, the Works Bureau also required all contractors to be certified to ISO 9001:2000 as from December 2003. ISO 9001:2000 is considered an improvement to its earlier version in 1994 in areas of customer satisfaction, resource management, management responsibility, continual improvement and process approach (Thermo Fisher Scientific, 2002). The processes based quality management model emphasizes the identification of critical processes such that they are adequately planned, monitored and controlled (Aoieong *et al*., 2002; Tang *et al*., 2005). The top management has also to provide evidence of his commitment to measureable improvements on the business processes and customer satisfaction (Graham, 2002). The latest version of ISO 9001 was released in 2008. Although there are few differences from the 2000 version, the 2008 version largely explains and clarifies the ambiguities and imperfections contained in the 2000 version. The big change took place in the 2000 version, which took a big step forward in quality management and embraced some (but not all) of the TQM

elements that were absent from the 1994 version. The 1994 version (and also the 1987 version) was mainly intended for QA, rather than TQM.

As explained above, there are similarities between the CIRC recommendations and the TQM elements. In addition, all public clients and most private clients have enforced their contractors to comply with the requirements in the 2000 (or 2008) version of ISO 9001, which is more inclined toward the philosophy of TQM compared to the earlier ISO 9000 series standards (Martinez-Costa *et al.*, 2009; Ho, 2001). The influence of TQM on the Hong Kong construction industry has been increasing and many Hong Kong contractors have started to adopt TQM principles for business improvements (Wong, 1999).

2.16 Indications from the literature review

Both ISO 9000 certification and the objective quality performance measurement yardstick PASS have been mandated for more than 10 years. The general level of quality in building construction however has not significantly improved (Tam *et al.*, 2000). Ahmed *et al.* (1999) reported that QA systems were not considered by contractors as effective in assuring quality. Kumaraswamy and Dissanayaka (2000) suggested the integration of ISO 9000 initiatives into the more rewarding TQM journey. The biggest housing client HKHA and the SAR government initiated large scale quality reforms in 2000 and 2001 respectively. There is apparently enough driving force in the society to quest for total quality construction. There is a signal that a research is due to capture the mindset of the stakeholder for starting a culture driven total quality management program. The task of my research study is to acquire the necessary background knowledge for the research and embark on the research in an attempt to overview the quality management evolvement and to make recommendations for further advancement of quality management in the construction industry.

In the thesis, reports on the following seven surveys will also be presented, four of which have been published and one submitted for publication:

1. Lau A. W. T. & Tang S. L. (2007, July). Comparison of Construction Quality Management Systems in Japan, Hong Kong and Singapore. In *Proceedings of the Fourth International Conference on Construction in the 21st Century Proceedings: Accelerating Innovation in Engineering, Management and Technology: CITC-IV* (pp.453-460)

2. Lau, A. W., & Tang, S. L. (2009). A survey on the advancement of QA (quality assurance) to TQM (total quality management) for construction contractors in Hong Kong. *International Journal of Quality & Reliability Management*, *26*(5), 410-425.

3. Tang, S. L., & Lau, A. W. (2009). An investigation on the change from QA culture to TQM culture for engineering consultants in Hong Kong. *HKIE Transactions*, *16*(1), 38-44.

4. A survey on the advancement of QA (quality assurance) to TQM (total quality management) for client organizations in Hong Kong. --- Survey report is not published.

5. Lau, A. W.T.; Tang, S. L. & Li, Y.S. (2015). The level of TQM application by construction contractors in Hong Kong. *International Journal of Quality & Reliability Management*, *32*(8), 830-862.

6. Lau, A. W.T.; Li, Y.S.; Tang, S. L. & Chau, K.W. (2015). TQM application by engineering consultants in Hong Kong.--- submitted for publication.

7. The level of TQM application by client organizations in Hong Kong --- survey report is not published.

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Chapter 3 – Objective and Methodology

3.1 Background

Kam and Tang (1997) pointed out the vision of Hong Kong quality proponents has been that "Under tight surveillance from both the certification bodies and internal auditors, the quality of works can be guaranteed; the preferential tendering eligibility system can effectively bar the poor [on quality performance] contractors and prevent them from obtaining contracts with a low tender price". Many publications, e.g., Tam (1996), Tang and Kam (I997), Kam and Tang (1998), Tang *et al*. (1998), Ahmed *et al.* (1998), Tang and Kam (I999), and many others, however pointed out that this vision did not relate to reality and demonstrated the need for the Hong Kong construction industry (contractors, consultants and clients alike) to adopt something more than the existing quality assurance (QA) approach.

Stacey (2003a and 2003b) argues that human organizations are pools of interactions that continually evolve. In this context, it is pertinent to study how the quality management efforts have impacted our industry and how they evolve. Is the current quality assurance (QA) system adopted by the industry inadequate for our quality management purposes? Is total quality management (TQM) a better approach which will better suit our needs? Is there a need of evolution from QA to TQM in the Hong Kong construction industry?

3.2 Objectives

The thesis has the following four objectives:

a. To collect evidence of how the quality assurance (QA) efforts in the first 15 years (1991 to 2006) had impacted the quality management in the Hong Kong construction industry in evolving. Year 2006 was also five years after the release of the Construction Industry Review Committee report which contains many TQM elements and three years after the mandating of the ISO 9001: 2000 version which also contains some TQM elements. It is anticipated that the degree of understanding of TQM principles by participants in the construction industry could be detectable after such period of TQM philosophy cultivation. The evidence collected is presented in the questionnaire survey described in Chapters 4 of this thesis.

b. To investigate whether the problems in implementing QA can be alleviated by adopting total quality management (TQM) philosophy for the existing cultural environment of the Hong Kong construction industry after 2006 (i.e. from 2007 to now). The investigation and data collection are presented in Chapters 5 of this thesis.

c. To analyze the collected data to highlight how TQM could affect those evolving organizations and its effects on achieving “Excellence” in construction project quality. The analysis and the prospects of evolving from QA to TQM are presented in Chapters 4, 5 and 6 of this thesis.

d. With the achievement of objectives a, b, and c, it is hoped that an approach to achieve a sustainable construction quality management system could be recommended to the industry.

3.3 Methodology

The methodology can be presented diagrammatically in Figure 3-1 as follows:

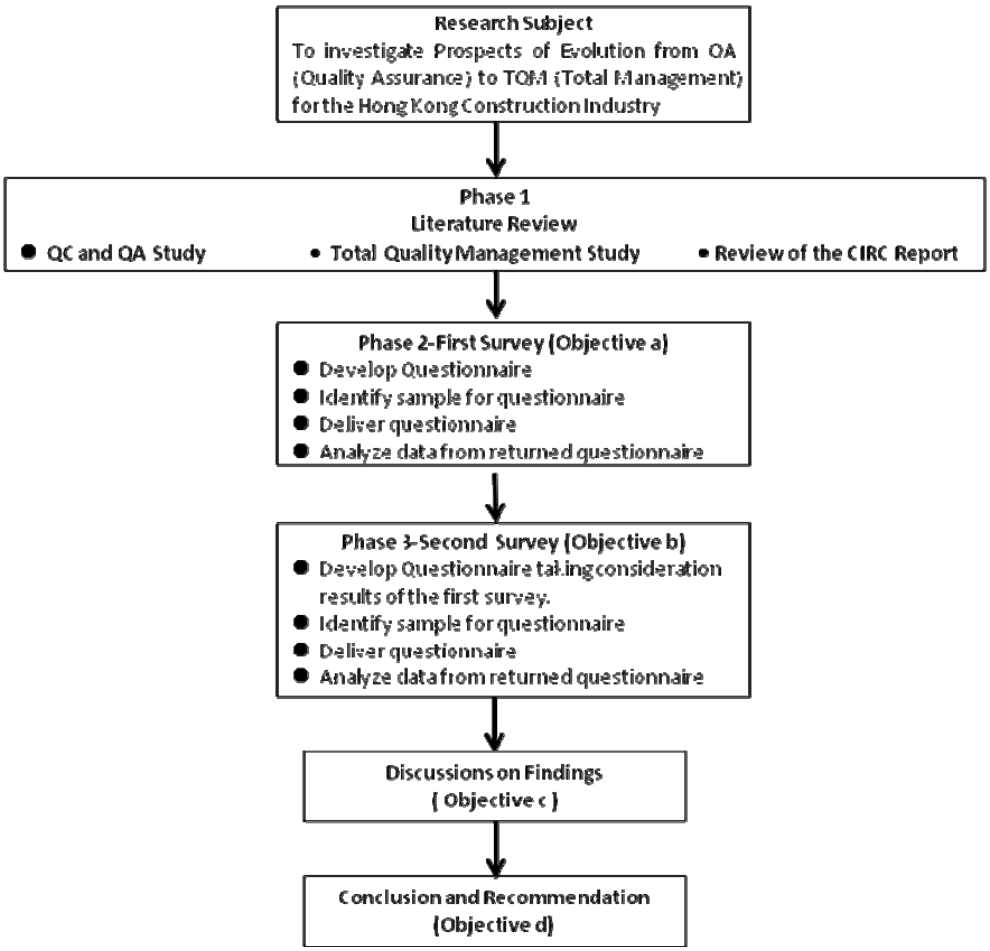

Figure 3-1 Methodology Flow Chart

3.3.1 Literature Review

A review of the relevant books, journals, articles and previous research findings regarding quality assurance / management in construction works were carried out to delineate the problems of the implementation of quality management systems in the construction industry. At the beginning of the study, a literature review on previous works was conducted in order to

set up the direction and target for the research domain. During the course of study, relevant works of other scholars and researchers were quoted for discussing and interpreting their findings.

The purpose of the literature review was also to provide an introduction of Quality Assurance (QA), ISO 9000 quality assurance standards and Total Quality Management (TQM) so as to identify their requirements for the construction industry. Based on literature review and the author's experience in construction, questionnaires were developed for finding out the effectiveness of QA and TQM applications by construction contractors, engineering consultants and client organizations in Hong Kong.

The literature review also extended to include the study of the Construction Industry Review Committee (CIRC) Report issued in January 2001 in Hong Kong in the later part of the research study. The report was prepared and compiled by researchers, practitioners, and government officials and it marked the change and determination of the Hong Kong SAR Government in striving for excellence of the Hong Kong construction industry. The report identified seven main themes of improvement measures comprising 109 items, most of which reflect the principles of TQM. It was therefore expected that the implementation of these improvement measures would enhance the construction industry participants' understanding and appreciation of TQM. Based on survey analyses, this thesis further identifies the short team and long term issues of the Hong Kong construction industry.

3.3.2 First Survey

In 2006/2007, the author gathered from literature review that the construction participants should have acquired good knowledge about QA (basically ISO

9001:1997) and the state of application is considerably mature. Such level of application was also generally agreed by those construction industry practitioners interviewed by the author in a pilot survey scheme in 2007. The purpose of the First Survey was to verify the level of QA knowledge of the industry participants and the state of QA application by these participants. Another purpose was to gauge the participants' awareness and understanding of TQM and to see if the TQM knowledge and application has yet to be further cultivated. Three set of survey questionnaire were sent to construction contractors, engineering consultants and client organizations respectively in late 2007. The consultants group included organizations practicing architectural design, E & M design, structural design and civil engineering design.

3.3.2.1 - Questionnaire for Construction Contractors

A pilot set of questionnaire was sent to three construction contractor practitioners to test its effectiveness and ease of understanding. Based on the comments received from the three practitioners, a full scaled three-part questionnaire was then developed. Part 0, Part 1 and Part 2 of the questionnaire are designed to gather information on the organization being surveyed, the knowledge and application of the QA (basically ISO 9001:1997) requirements of the organization, and the knowledge of TQM of organization respectively. For Part 1 and Part 2, Likert (Hayes, 1998) scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statement proposed in the questionnaire. The questionnaire was then sent to 100 Group C contractors in the Hong Kong Works Bureau's published list of contractors in mid-December 2007 (this list had coincidently exactly one hundred contractors). The last completed questionnaire

was received in mid February 2008. The questionnaire is shown in Appendices 4A-A and 4A-B of this thesis. The survey results are presented in Chapter 4A of this thesis.

3.3.2.2 - Questionnaire for Engineering Consultants

After a review of the pilot set of questionnaire by three engineering consultant practitioners, a three part full scale questionnaire was developed. Part 0, Part 1 and Part 2 of the questionnaire are designed to gather information on the organization being surveyed, the knowledge and application of the QA (basically ISO 9001:1997) requirements of the organization, and the knowledge of TQM of organization respectively. For Part 1 and Part 2, Likert scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statement proposed in the questionnaire. The questionnaire was sent in late December 2007 to all (75) engineering consultants who were approved by the Hong Kong Architectural Services Department for tendering structural and architectural design packages. Replies to the questionnaire were received from late January to late February 2008. The questionnaire is shown in Appendices 4B-A and 4B-B of this thesis. The survey results are presented in Chapter 4B of this thesis.

3.3.2.3 – Questionnaire for Client Organizations

After a review of the pilot set of questionnaire by the three client organization practitioners on the effectiveness and ease of understanding, a three part full scale questionnaire was developed. Part 0, Part 1 and Part 2 of the questionnaire are designed to gather information on the organization being surveyed, the knowledge and application of the QA (basically ISO 9001:1997) requirements of

the organization, and the knowledge of TQM of organization respectively. For Part 1 and Part 2, Likert scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statement proposed in the questionnaire. The questionnaire was sent in late December 2007 to 60 client organizations, covering both the private and public sectors. As there was no well established clients list in Hong Kong, a non-probability sampling approach was used for this special case. The approach is called convenience sampling (Sekaran, 2003; Sekaran and Bougie, 2009). In this convenience sampling, the 60 target respondents were selected based on their convenient accessibility and proximity to the author. Practitioners who had been working in construction client organizations at technical or managerial level were invited to complete the survey. They were reasonably be expected to have had expert knowledge by virtue of having gone through the experience and process themselves and might have perhaps be able to provide good data or information to the author. Most of the respondents of this survey were friends and acquaintances of the author and they worked in local construction related companies and had the relevant professional experience. Out of these 60, 21 questionnaires had been completed and retuned. The last completed questionnaire was received in late February 2008. The questionnaire is shown in Appendices to Chapter 4 Part C of this thesis. The survey results are presented in Part C of Chapter 4 of this thesis.

3.3.3 Second Survey Series

Following the establishment of level of knowledge and application of QA, and the preliminary understanding of TQM awareness by the construction industry from the first survey, the author designed a second questionnaire survey for the purpose of investigating whether the problems in implementing QA can be

alleviated by adopting total quality management (TQM) philosophy for the existing Hong Kong quality culture in construction.

3.3.3.1- Questionnaire for Construction Contractors

A pilot set of questionnaire was sent to five construction contractor practitioners to test its effectiveness and the ease of understanding, and to establish the relevance of the TQM elements identified in my literature review to each of the questions. Based on the comments received from the five practitioners, a full scaled four part questionnaire was developed. Part 1 of the questionnaire was to gather the business information of the organization being surveyed. Part 2, Part 3 and Part 4 were designed respectively to obtain the level of familiarization with TQM of the organization, to establish the short term action for improving construction quality, and to establish the long term action for achieving excellence in construction quality. For the Part 2, Part 3 and Part 4 questionnaire, Likert scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statements proposed in the questionnaire. The questionnaire was then sent to all the 107 Group C contractors in the Hong Kong Works Bureau's published list of contractors in May 2011. This was the same group of contractor as compared to that of the first survey, which had a slight change in quantity as compared to that in the first survey in year 2007. The last completed questionnaire was received in August 2011. Totally 40 completed questionnaire were returned which was the same quantity as compared to first survey in 2007. The questionnaire is shown in Appendices to Chapter 5 Part A of this thesis. The Likert scale survey results are statistically analyzed by the Statistical Package for Social Science (SPSS) to obtain Pearson Correlations of

significance at 0.05 level or below (2-tailed). The survey results are presented in Part A of Chapter 5 of this thesis.

3.3.3.2- Questionnaire for Engineering Consultants

A pilot set of questionnaire was sent to five engineering consultants to test its effectiveness and the ease of understanding, and to establish the relevance of the TQM elements identified in my literature review to each of the questions. Based on the comments received from the five practitioners, a full scaled four part questionnaire was developed. Part 1 of the questionnaire was to gather the business information of the organization being surveyed. Part 2, Part 3 and Part 4 of were designed respectively to obtain the level of familiarization with TQM of the organization, to establish the short term action for improving construction quality, and to establish the long term action for achieving excellence in construction quality. For the Part 2, Part 3 and Part 4 questionnaire, Likert scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statements proposed in the questionnaire. The questionnaire was then sent in May 2011 to all (74) engineering consultants which were either approved by the Hong Kong Architectural Services Department for tendering structural and architectural design packages or members of the Association of Consulting Engineers of Hong Kong. The last completed questionnaire was received in August 2011. The questionnaire is shown in Appendices to Chapter 5 Part B of this thesis.

The Likert scale survey results are statistically analyzed by the Statistical Package for Social Science (SPSS) to obtain Pearson Correlation index. The survey results are presented in Part B of Chapter 5 of this thesis.

3.3.3.3- Questionnaire for Client Organizations

A pilot set of questionnaire was sent to three client organizations to test its effectiveness and the ease of understanding, and to establish the relevance of the TQM elements identified in my literature review to each of the questions. Based on the comments received from the two practitioners, a full scaled four part questionnaire was developed. Part 1 of the questionnaire was to gather the business information of the organization being surveyed. Part 2, Part 3 and Part 4 were designed respectively to obtain the level of familiarization with TQM of the organization, to establish the short term action for improving construction quality, and to establish the long term action for achieving excellent in construction quality. For the Part 2, Part 3 and Part 4 questionnaire, Likert scale 1 – 5 is adopted to capture the level of agreement of the respondent to the statements proposed in the questionnaire. The questionnaire was then sent in May 2011 to 60 professionals working in client organizations, which covered both the public and private sectors. Convenience sampling was adopted in this questionnaire survey. Practitioners who had been working in construction client organizations at managerial or technical level were invited to complete the survey. They were reasonably be expected to have had expert knowledge by virtue of having gone through the experience and process themselves (Sekaran, 2003). Out of these 60, 20 questionnaires had been completed and retuned. The last completed questionnaire was received in January 2012. The questionnaire is shown in Appendices Chapter 5 Part C of this thesis.

The Likert scale survey results are statistically analyzed by the Statistical Package for Social Science (SPSS) to obtain Pearson Correlation index. The survey results are presented in Part C of Chapter 5 of this thesis.

3.4 Findings and Analysis

Findings and their related analysis are presented in each of the survey chapters. Supplementary statistical analysis is included to support interpretation of data. Chats, diagrams and tables are adopted to present the data, findings and analysis results.

3.5 Conclusions and recommendations

The conclusion chapter will discuss how TQM could affect those evolving organizations and its effects on achieving “Excellence” in construction project. Limitations of the research study and recommendations for future study will also be discussed in the Chapter 6 – Conclusions and recommendations.

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Chapter 4 – Part A

First Survey - A Survey on the Advancement of QA (Quality Assurance) to TQM (Total Quality Management)

Part A – Report on survey for Construction Contractors in Hong Kong

4A.1 Introduction

Quality on construction projects and project success can be regarded as the fulfillment of expectations of those participants involved (Ahmed *et al.,* 2005). Quality management is a crucial element of the successful management of construction projects (Abdul-Rahman, 1997). Quality management systems provide the framework in which the participants' expectation can be achieved. Quality and quality systems are topics which have received increasing international attention (Chan, 2007; Yates and Anifors, 1997). Diverse management factors including support of senior management, appropriate leadership style, cultivation of employee's enthusiasm and participation, open communication and feedback must be managed properly to achieve a good quality management system in construction (Ahmed *et al.*, 2005). Broadly speaking, there are two kinds of quality management systems, quality assurance (QA) and total quality management (TQM). Usually, QA is implemented before TQM; the former usually serves as a stepping stone for an organization to embark on the latter (Tang *et al*., 2005). The purpose of this thesis section is to report an investigation on the advancement of QA to TQM for construction contractors in Hong Kong.

4A.2 Literature review

Quality Assurance (QA)

Quality Assurance (QA) embraces all the activities and functions needed to provide

adequate confidence in a product or service for satisfying given requirements for quality (Chan and Fan, 1999). It is essentially a preventive function. Quality assurance is based on the principle that prevention is better than cure and it is more economical to get things right in the first place (Tang *et al.*, 2005). Everyone should aim at doing things right the first time and every time, thus achieving zero defect in performance (Low and Teo, 2004). To implement quality assurance, proper and systematic procedures are drawn up and followed by all concerned. The ISO 9000 series of the International Organization for Standardization is a quality standard for quality assurance purposes (ISO, 1994).

The latest published version of the ISO 9000 family standard was issued in 2000. This version is of a more generic process-based structure. Lau (2001) identified notable changes in the elements of "customer satisfaction" and "continual improvement". It also assembles a limited amount of Total Quality Management elements (Tang *et al*., 2005), but is still mainly a quality assurance model standard. It is anticipated the next version of the ISO 9000 standard (4th edition) will be released in late 2008. This edition is supposed to include only minor clarifications to the existing document. Enhancement of clarity and compatibility with the ISO 14000:2004 standard is also expected (Dawson, 2008).

Total Quality Management (TQM)

BS 7850 (BSI, 1992) defines TQM as the management philosophy and company practices that aim to harness the human and material resources of an organization in the most effective way to achieve the objectives of the organization. Another definition of TQM, which is used by the Department of Defense in USA, is a philosophy and a set of guiding principles that represent the foundation of a continually improving organization (Tingey, 1997). TQM is a management-led process to obtain the involvement of all employees, in the continual improvement of the performance of all activities, as part of the normal business to meet the needs and satisfaction of both the internal and external

customers (Tang e*t al.*, 2003).

TQM philosophy extends beyond management systems related to production processes. It embraces principles, processes, practices and procedures necessary for providing customer satisfaction and achieving improvement in productivity and business performance (Love *et al*., 2004). Reasons for initiating TQM as suggested by Low and Peh (1996), Love *et al*. (2004) and Low and Teo (2004) include:

- Time and cost overrun has engendered an adversarial relationship between the client and the contractor.
- Building projects have gone larger and more complex; clients are also increasingly demanding higher standards for their delivery.
- The ever increasing challenging and onerous environmental and safety requirements have also exacerbated the need to change the management culture towards TQM.
- Parties to projects have differing traditions and often opposing interests – resources are spent on defending the parties positions, which are better spent on achieving customers' satisfactions.

Quality management in the Hong Kong construction industry in the past fifteen years

In Hong Kong, the Performance Assessment Scoring System (PASS), a construction product bench marking system (Hong Kong Housing Authority, 2002), has been implemented since 1991 while the ISO 9000 QA system has been implemented since 1993. Both ISO 9000 certification and the objective quality performance measurement yardstick PASS have been mandated for more than fifteen years in the construction industry in Hong Kong. Dissanayaka *et al*. (2001) commented that there had been a maturing of attitudes towards ISO 9000 within the construction industry, but the general level of quality in construction has however not significantly improved (Tam *et al.*, 2000). Ahmed *et al.*

(1999) reported that QA systems were not considered by contractors as effective in assuring quality. Kumaraswamy and Dissanayaka (2000) suggested the integration of ISO 9000 initiatives into the more rewarding TQM journey. The biggest housing client Hong Kong Housing Authority and the Hong Kong government initiated large scale quality reforms in 2000 and 2001 respectively, the main objective of which is to achieve total quality construction. There is apparently enough driving force in the society to quest for total quality excellence in the construction sector. It appears obvious that a survey is due to capture the mindset of the stakeholders in the Hong Kong construction industry prior to starting a culture driven total quality management programme.

4A.3 Methodology

Further to the literature review, a questionnaire survey was designed for a full scale survey. The questions on QA were developed primarily from the clauses in ISO 9001 (1994) while those on TQM were developed from the management principles in BS7850 (1992). Construction related elements including management organization, construction planning, design quality control, process and product correction actions, quality management tool training and statistical techniques were integrated into the questions with reference made to techniques and experience expressed in "Quality Improvement Techniques in Construction [Steven (1998)], "Modern Construction Project Management [Tang *et al*. (2003)]", "Construction Quality Management [Tang *et al*. (2005)]" and the 25 years of working experience of the author.

In advance of the full scale survey, a pilot set of questionnaire was sent to three practitioners in November 2007 to test the effectiveness and ease of understanding of the survey questions. The final set of the questionnaire consisted of three parts. Part 0 was

intended for gathering the organization information of the company in which the respondent was working. Part 1 focused on the ISO 9000 requirements while Part 2 was set based on TQM principles in the context of construction. Parts 1 and 2 of the questionnaire are shown in the Appendices of this thesis. This questionnaire was then sent to professionals working in contractors in December 2007. Replies to these questionnaires were received during January and February 2008.

The survey attempted to acquire how familiar was the industry with the ISO 9000 quality management applications. In the same survey, an enquiry was also made on how are the TQM principles and techniques are perceived. In the next two sections, discussions on the findings will be presented, and further approaches on how can quality management in the Hong Kong construction industry advance will be suggested.

4A.4 Summary of findings

Return rates and background of respondents

In return of 100 enquiries, 40 completed questionnaires were received, which represent a return rate of 40%. The size of the organizations in which the respondents were working varied from 50 staff to more than 500 staff. Amongst the organizations, more than half (61.1%) were larger than 500 employees in size.

	Building Construction	Civil Construction	Mixed Construction	Large size – more than 500 staff	Medium to small size – staff of 500 or less
Proportion. of organizations	7 (19.4%)	6 (16.7%)	23 (63.9%)	22 (61.1%)	14 (38.9%)

Figure 4A-1a– Business background of organizations to which respondents are attached

	Project / Department Manager	Section Manager	Senior Engineers	Quality Managers
Proportion. of respondents	12 (30%)	12 (30%)	12 (30%)	4 (10%)

Figure 4A-1b – Background of individual responsibility of respondents

The 40 respondents were working for 36 different contractors. The type of construction work executed by the contractors in which the respondents were working were building works, civil works and a mixture of building and civil works. When all respondents' organizations are considered as a whole, 19.4% emphasize in building construction, 16.7% focus on civil construction and the remaining 63.9% execute both building and civil works. Figure 4A-1a shows the details of the basic business background of the surveyed organizations. Job responsibilities of the respondents ranged from senior engineer to project managers, which are summarized in Figure 4A-1b.

ISO 9000 certification

A great majority, more than 97%, of the respondents' organizations were ISO 9001 certified organizations. Of the 36 respondents' organizations, only one medium size fit-out contractor had not been maintaining the ISO 9000 quality management system certificates. The popularity of ISO 9000 quality system in the industry is clearly portrayed.

Respondent averaged score

The average of the scores assigned by the respondents against each questionnaire item is defined as the respondent averaged score of an item, with the score scale based on a 5-point Likert System (Hayes, 1998). This means that if a respondent agrees to a great extent to a question (see Appendices), s/he will get 5 scores, and if s/he does not agree at all, s/he will get 1 score. The respondent averaged score for a question is the sum of the

scores of the 40 respondents for that specific question divided by 40. The respondent averaged scores for the twenty five ISO 9000 items are shown in Figure 4A-2 and those for the twenty TQM items are shown in Figure 4A-3. The item identifications of the highest three and lowest three of the averaged scores are labeled on these figures.

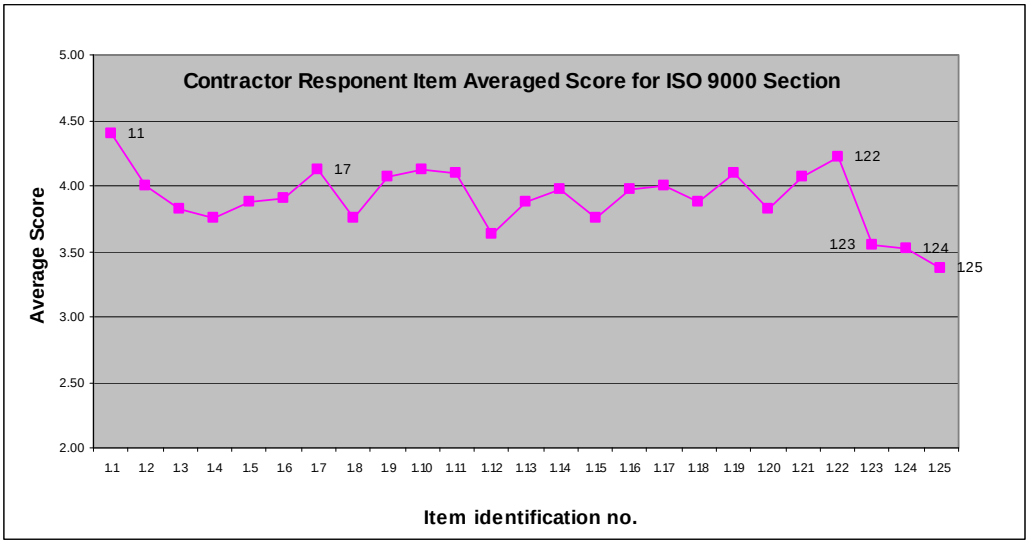

Figure 4A-2 Respondent Averaged Score for ISO 9000 Section Items

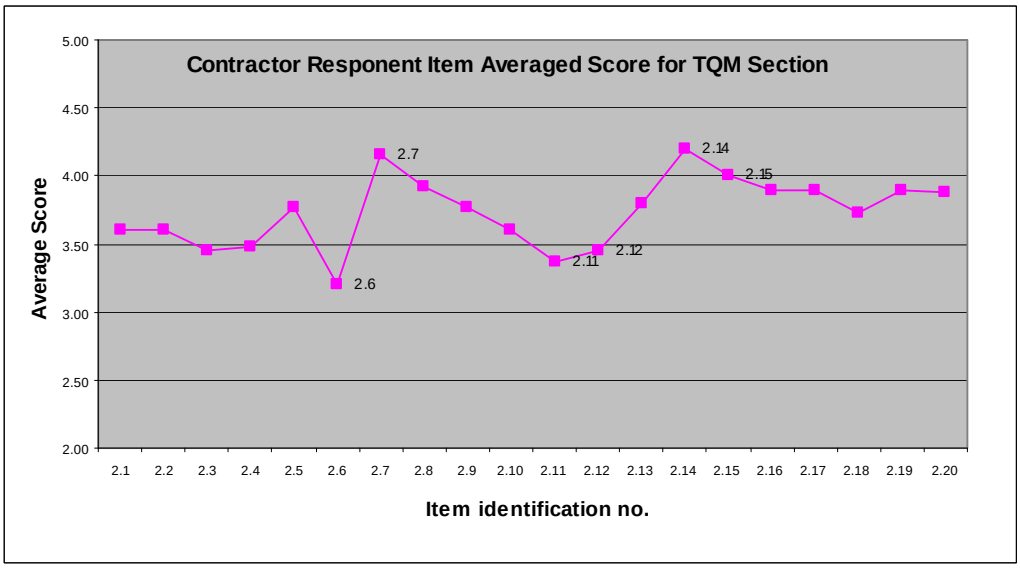

Figure 4A-3 Respondent Averaged Score for TQM Section Items

Respondent Averaged Score Range Item Distribution

The respondent averaged scores for both the ISO 9000 questionnaire items and the TQM questionnaire items are allocated to one of the five range groups which are of scoring 4.5 and above, scoring 4.0 to 4.5, scoring 3.5 to 4.0, scoring 3.0 to 3.5 and scoring less than 3.0 in a descending order. Figure 4A-4 shows the score range distribution of the items. A comparison between the ISO section item score range and the TQM section item score range reveals that more ISO 9000 than TQM items score more than 4.0, while more TQM than ISO 9000 items score less than 3.5. This reflects that respondents are more familiar with the ISO9000 quality assurance systems than the TQM systems.

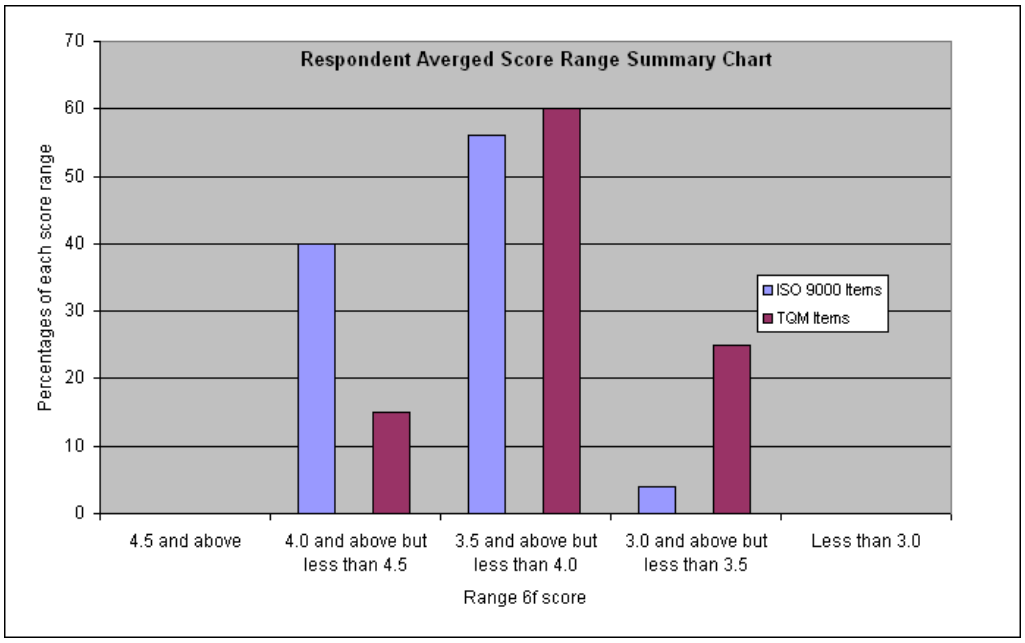

Figure 4A-4 – Respondent Averaged Scored Ranges Percentage Summary Chart

Average score of individual respondents against sets of questionnaire items

The average of the scores calculated from all questionnaire items in the ISO 9000 section assigned by a respondent is defined as the ISO 9000 item averaged score of the respondent. Similarly the average of the scores calculated from all TQM items by a respondent is defined as the TQM item averaged score of that particular respondent. The difference between his ISO item average score and his TQM item average score is also calculated. Such results of the 40 respondents are given in Figure 4A-5 and also graphically in Figure 4A-6.

Score Difference = ISO score – TQM Score	-0.8	-0.7	-0.6	-0.5	-.04	--0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
# of respondent	1	0	0	0	0	2	3	1	7	6	3	7	4	2	0	0	2	1	1

Figure 4A-5 Difference between the ISO 9000 item averaged score and the TQM item averaged score

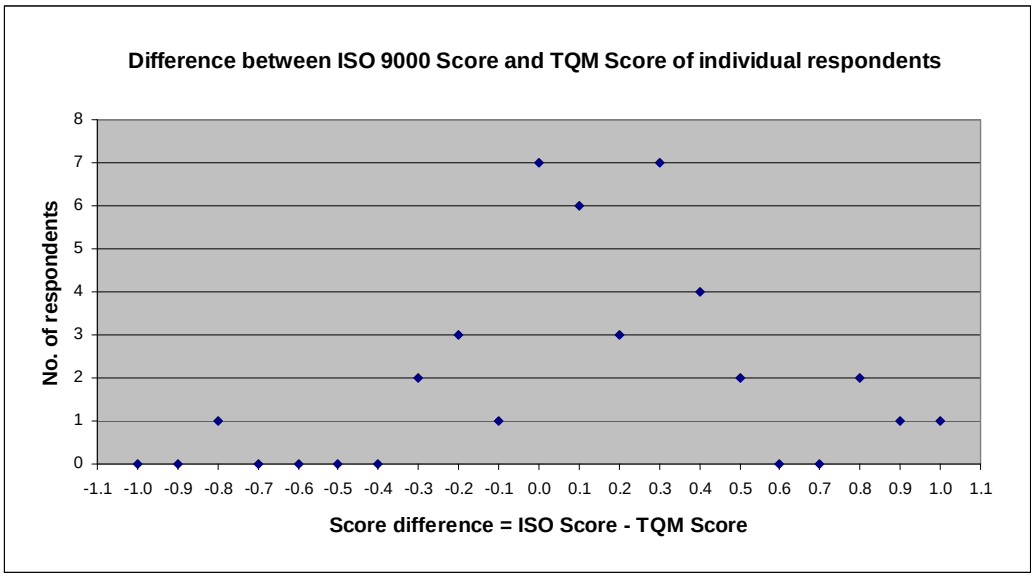

Figure 4A-6 Arithmetic Difference between ISO 9000 item respondent averaged score and TQM item respondent averaged score of respondents

Figure 4A-6 shows a cluster (26 respondents) of the score difference value (ISO 9000 score – TQM score) on the right hand side of the neutral zero, but with only a minority group (7 respondents) on the left hand side of the neutral zero. It therefore indicates that the individual respondents' ISO 9000 item average is generally higher than their TQM item average. This indication suggests that most of the respondents are more readily to practice ISO 9000 principles than the TQM principles.

Three lowest score items and three highest score items

Descriptions of the three lowest score items and three highest score items, as shown in Figures 4A-2 and 4A-3, are summarized as follows:

In the ISO 9000 section –

The lowest three averaged score items are:

a. Item 1.25 (averaged score 3.375) - Scheduled survey for assessment of client's satisfaction.

b. Item 1.24 (averaged score 3.525) - Identification and application of

statistical technique required for verifying process capability and product characteristics for repeating items

c. Item 1.23 (averaged score 3.550) - Identification and provision of required training for staff who are involved in activities directly affecting quality.

The highest three averaged score items are:

a. Item 1.1 (averaged score 4.400) - The company's objectives for quality and its commitment to quality.

b. Item 1.22 (average score 4.225) - Periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system.

c. Item 1.7 (averaged score 4.125) - Comprehensive review of the tender document prior to technical and commercial submissions.

In the TQM section –

The lowest three averaged score items are:

a. Item 2.6 (averaged score 3.200) - Employees are introduced the principles and tools for total quality management at project commencement, in addition to contract specifications.

b. Item 2.11 (averaged score 3.375) - Conducting value engineering workshops with the Client at project commencement in order to highlight potential cost or time saving proposals.

c. Item 2.12 (averaged score 3.450) - Policies for regularly reviewing the Client's project priorities

The highest three averaged scored items are:

a. Item 2.14 (averaged score 4.200) - Responding quickly to the Client's enquiries and complaints.

b. Item 2.7 (averaged score 4.150) - Practicing continual review on construction safety and work place environment with a view for improvement.

c. Item 2.15 (averaged score 4.000) - Offering reasonable explanations and solutions to legitimate complaints.

The above will be further discussed in the next section.

4A.5 Discussion on findings

Quality awareness in the construction industry

The return rate of 40% with 100 sent enquiries is considered as promising. This promising return rate also provides an indication that contractors are fully informed of the quality management principle and practices. The organizations for which the respondents are working include both large companies of employee size more than 500 and smaller companies of employee size less than 500. It appears obvious that quality awareness has also reached medium to small size construction organizations.

Quality adherence to ISO 9000 standards

The extremely high percentage of 97% in ISO 9000 certification by the surveyed contractor organizations indicates the high adherence to the ISO 9000 quality standard and a substantial maturity in quality assurance applications. The cluster of ISO 9000 section items at score ranges of 4.0 to 4.5 and 3.5 to 4.0 in Figure 4A-4 further illustrates this high adherence characteristic.

Application Relationship between ISO 9000 and TQM

Figure 4A-6 generally shows positive differences when the ISO 9000 section scores are compared to the TQM section score for every respondent. The indication is that a

practitioner usually applies ISO 9000 more effectively than applying the TQM principles.

Lowest three respondent averaged score items under the ISO 9000 section

- The score for assessment surveys of client's satisfaction is the lowest. Obtaining direct assessments on contractor's quality systems from clients is not popular in Hong Kong. The Hong Kong Housing Authority's PASS system and the Hong Kong Works Branch/Bureau Contractor's Performance Index reports are the only common client's assessments received by the contractors and consultants. These assessment reports are however formatted to favour qualification and tender assessments rather than to provide information for quality improvement.
- The score for statistical techniques for verifying process and product capabilities is low possibly due to the non-repeating nature of construction works. Some statistics have however been used for concrete design and steel reinforcement testing. For E & M equipment used in construction, statistics are used to control products in factories which are usually considered as the manufacturing industrial undertakings.
- That training for quality has been graded low is not unexpected as the perception that cost and time is the top priority still prevails in the industry.

Highest three respondent averaged score items under the ISO 9000 section

- The score for organizations' quality commitment and objective is 4.40 which is the highest score amongst all. This result is not unexpected as commitment and clear objectives are the prime requirements of the ISO 9000 standards. Such quality assurance requirements has well penetrated into the construction industry and recognized by great majority of the respondents.
- The second highest score item is the periodic internal quality auditing. Regular

internal auditing is also a distinctive requirement in the ISO 9000 standards. This requirement is included generally in a contractor's company quality procedures. Any observations and non-conformances identified in the audits are documented for rectifications and improvement.

- The thirdly ranked highest score item is one related to documentation. Tender document review prior to technical and commercial submissions is well practiced as this review procedure is crucial to the bidding success and subsequently the project success of any organization. This serves as the starting point of long journey of a construction contracts. Any deficiencies and mistakes at this initial stage could generate long contentious issues.

Lowest three respondent averaged score items under the TQM section

- The knowledge of TQM tool is not sufficiently introduced to construction professionals probably due to its development in construction is quite resent. Another explanation can also be that many well established organizations have applied the TQM principles but the TQM label has not been attached to their management policies.
- Value engineering sessions raised by the contractor is not common in Hong Kong, particularly for those construct only contracts, possibly due to the contractual positions taken by the parties.
- Contractors do not often initiate optimization discussion with clients or their representatives in order to prevent contractual debates especially when benefits of the optimization are not achieved as anticipated.

Highest three respondent averaged score items under the TQM section

- The highest score item is quickly responding to client's enquiries and complaints.

Enquiries and complaints are two of the basic tools in project management applied by clients and customers. Inappropriate and belated replies to these items could directly affect the performance assessment of the contractors by clients. The high score of the item implies that contractors are placing high level of priority on addressing enquiries and complaints based on both contract management and quality management considerations.

- The second highest score item relates to review on construction safety. Safety has been regarded as the most important criterion by the Hong Kong government. A series of ordinances and regulations is in place to control construction safety. Government and public corporation contracts also emphasize the importance of safety through the imposition of conditions and specifications under the contract.
- The thirdly ranked item is addressing satisfactorily and resolving complaints. It is a step further to achieve customers' satisfaction by practically streamlining differences in opinions and interpretations of requirements.

Overall indication of advancement from QA to TQM

A further analysis on the range of the respondent averaged scores is attempted. Items scoring below the 3.5 Likert Scale are grouped as Low Score Items and those scoring 4 and above are grouped as High Score Items. The comparison results are shown in Figure 4A-7. From the figure, it is observed that the ratio of low score items to high score items for the ISO 9000 section is 2/10(20%), while the same ratio for the TQM section is 5/3 (166.7%). The ratio for the TQM section is 8.3 times of that for the ISO 9000 section.

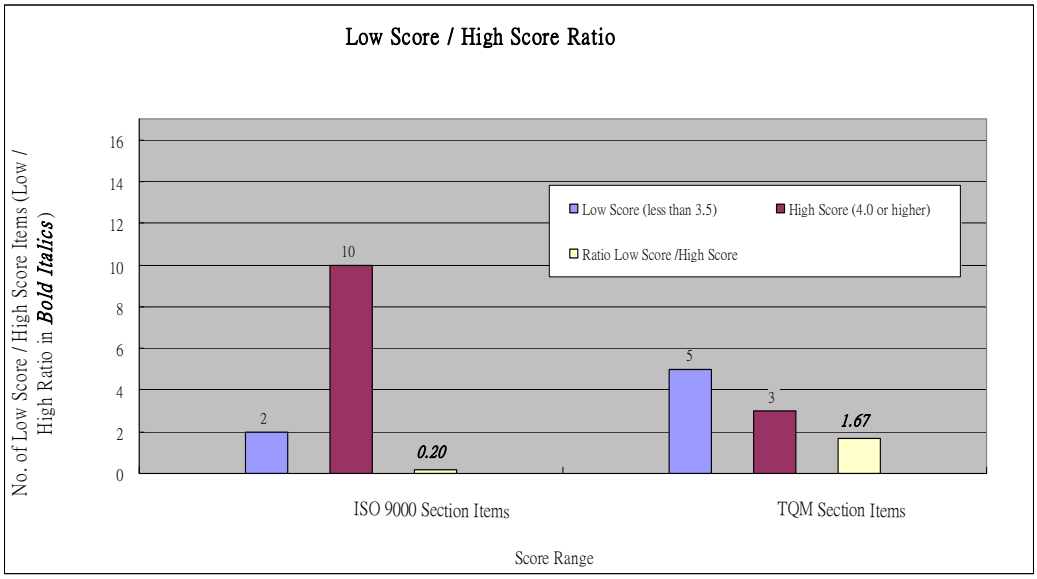

Figure 4A-7 – Comparison of Low and High Respondent Averaged Scores

The small ratio of low score items to high score items for the ISO 9000 section suggests that the companies in which the respondents were working are reasonably mature in the application of ISO 9000 system. On the contrary, the much higher ratio of low score items to high score items for the TQM section seems to imply that although these companies have acquired the basic principles of TQM, the application of these principles by different contractors is however inconsistent.

4A.6 Conclusions

Research literature tends to classify QA as a systematic and static approach while TQM as a dynamic people approach. There is a trend to think that QA and TQM are complementing each other. ISO 9000 has been applied as a QA model and practiced world wide across all manufacturing and service industries including construction which is

different from others in its uniqueness and interfacing characteristics. The Hong Kong construction industry has been actively practicing the ISO 9000 model for more than fifteen years, but the improvements in project quality are less than the industry's anticipation. Public clients have taken the lead to drive for total quality excellence at the beginning of the millennium.

The results of the questionnaire survey on the current application status generally indicated full knowledge of the QA principles and considerable knowledge of the TQM principles. A detailed analysis of the scores assigned by the respondents however indicated that contractor organizations were fully familiar with the QA application but were less familiar with the TQM principles.

In the questionnaire survey, the three QA requirements that were comparatively less adopted by contractors were identified to be clients' satisfaction survey, application of statistical tools and provision of training. On the other hand, the three mostly applied QA requirements were found to be an organization's commitment to quality, independent auditing and review of tender documents prior to submission. In the TQM section, the items assigned with the lowest three scores by contractors were the introduction of the TQM principles and tools, the adoption of the value engineering approach at project commencement and the regular review of clients' project priorities. The top three scores in the TQM section were found to be responding to clients' complaints, resolving these complaints and continual review of construction safety and work environment. The score range of these items reflects the construction quality culture in Hong Kong. The culture is in turn influenced by the society's commercial mind set, the government's regulations and requirements, and the own culture of the contractors' organizations.

Improved quality cannot be achieved in isolation; it requires the commitment of every one of the industry's participants to achieving excellence. Similar studies on the QA and TQM applications by other construction industry stakeholders such as clients and design consultants are warranted.

Under the prevailing competitive business environment and the demanding quality excellence expected by customers, the issue of the way forward for quality management is pressing. A comparison of the prevailing quality system in Hong Kong with those more successful systems practiced in the Asian region and in the international construction sector could be conducted. An attempt to explore the root causes in the current restrictive quality culture and behavior of the participants in the Hong Kong context is also recommended. Such a study could also be expanded to include the consideration of frequent component fabrication in mainland China.

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Chapter 4 - Part B

First Survey - A Survey on the Advancement of QA (Quality Assurance) to TQM (Total Quality Management)

Part B – Report on survey for Engineering Consultants in Hong Kong

4B. 1 Introduction

Quality Management

The Industrial Revolution began in late eighteenth century, brought about new production methods. This changed the lifestyles of people; craftsmen's shops began to rapidly change into commercial establishments. Division of work and mass production made planning the job of the management and production the job of the labour. In order to control quality of production which had previously been self-disciplined by craftsmen, a separate role of quality inspectors was created. This primitive quality detecting process further evolved in the past two centuries into various means of quality control procedures and strategies, which are collectively known as quality management (McCabe, 1998).

Quality management is the process that any sensible organization will carry out in order to consistently satisfy its customers' expectation. It comprises all activities of the overall management function that determine the quality policy, objectives and responsibilities, and their implementation by means of quality planning, quality control, quality assurance, and quality improvement within the quality system (BSI, 1995). The four general approaches towards quality management are inspection quality control, statistical quality control, quality assurance and total quality management (McCabe, 1998). Inspection quality control and statistical quality control are basically classified as detective systems which were widely

applied by the manufacturing industry in early to mid 1900s. They were developed during the two World Wars when manufacturing was becoming more complex and production was becoming massive. Quality assurance and total quality management techniques emerged in 1960s when the post war economies demanded both quantity and quality products, and clients and manufacturers started to realize that quality could not be left as a retrospective task. These two later techniques, which are currently adopted by many types of industry sectors including construction, aim at preventing the occurrence of flaws and at satisfying the customers. Managing design quality is considered critical as design products define quality standards for construction. (Gransberg & Molennar, 2004).

Quality Assurance (QA) and ISO 9000 series Standards

Quality assurance (QA) is defined as all the planned and systematic activities implemented in the quality system, and demonstrated as needed, to provide confidence that a product or service will fulfill requirements for quality (Tang *et al.*, 2005). It is essentially a preventive function which provides warnings ahead of both internal and external problems.

The ISO 9000 series of the International Organization for Standardization is a quality standard for quality assurance purposes (ISO, 1994). The series has been adopted by most public and private organizations as the basic quality assurance system. The latest published version of the series was issued in 2000. It has incorporated additional improvement requirements such as “customer satisfaction” and “continual improvement”. It is anticipated the next version of the ISO 9000 standard (4th edition) will be released in late 2008. The manufacturing and service sectors however do not anticipate material changes in the new version to the adopted concept in the current edition but only enhancement of clarity to the details (Dawson, 2008).

Total Quality Management (TQM)

Total Quality Management (TQM) is defined as the management philosophy and company practices that aim to harness the human and material resources of an organization in the most effective way to achieve the objectives of the organization (BSI, 1992). It extends beyond management systems related to production processes by involving all employees and by eliminating non-value-adding activities, as part of the normal business to meet the needs and satisfaction of both the internal and external customers. Construction stakeholders are becoming more aware of the success achieved in other industry sectors through the implementation of TQM (Low and Teo, 2004).

Quality management in the Hong Kong construction industry in the past fifteen years

In 1990, the Hong Kong Government launched a "Quality Awareness Campaign" and introduced the concept of Quality Management to Hong Kong. The campaign brought about a growing demand from clients for quality assurance elements in the products and services provided to them (Ahmed *et. al*, 1998). In 1993, the Hong Kong Housing Authority made a policy requiring its contractors to be certified under the ISO 9000 standards. Other public clients then followed the housing authority in mandating the ISO 9000 standard requirements on design services and construction contracts. Dissanayaka *et al*. (2001) commented that there had been a maturing of attitudes towards ISO 9000. Tam *et al.* (2000) however argued that the general level of quality in construction has not significantly improved. Further reforms in construction quality were initiated by the Hong Kong Housing Authority and the Hong Kong Government in 2000 and 2001 respectively, to quest for total quality and excellence (HKHA, 2001; Tang, 2001).

It appears that the successful implementation of quality system in the construction

industry is still being questioned and there has been a lack of reported research of the progressive achievements of the systems after quality reforms having been initiated in 2000 and 2001. Design deficiency has been considered as a major cause of construction quality problems (Low and Peh, 1996). The objective of this thesis section is to investigate the level of maturity in the application of both QA and TQM principles by engineering consultants who have been playing a prime role in designing construction. The investigation was carried out through a questionnaire survey and the results of the survey are discussed in this thesis chapter.

4B.2 Methodology

Further to a general literature review, a questionnaire was designed for the survey. The questions on the QA section were developed primarily from the clauses in ISO 9000 (1994) while those on the TQM section were developed from the management principles BS7850 (1992). Construction engineering elements were integrated into the questions with reference to techniques and experience described in "Quality Improvement Technique in Construction" written by MaCabe (1998). The application of these quality standards examined in "Construction Quality Management" written by Tang *et al*. (2005) has also been considered in developing these questions. In advance of the full scale survey, a pilot set of questionnaire was sent to three practitioners in November 2007 to test the effectiveness and ease of understanding of the survey questions. The final set of the questionnaire consisted of three parts. Part 0 was intended for gathering the organization information of the company in which the respondent was working. Part 1 focused on the ISO 9000 requirements while Part 2 was set based on TQM principles in the context of

construction. Parts 1 and 2 of the questionnaire are shown in the Appendices of this thesis section. This questionnaire was then sent December 2007 to professionals working in engineering consultants who were approved by the Architectural Services Department (ASD) for tendering structural and architectural services packages. In addition, questionnaires were also sent to professional working in the member consultants of the Association of Consulting Engineers of Hong Kong, who were not on the ASD approved consultant list. Replies to these questionnaires were received during January and February 2008.

The survey attempted to acquire how familiar the industry was with the ISO 9000 quality management applications. Under the same survey, an enquiry was also made on what level of TQM principles and techniques were applied by the professionals. In the next two sections, discussions on the survey results will be presented, and how quality management of the engineering consultants in Hong Kong can advance will also be suggested.

4B.3 Summary of findings

Return rates and background of respondents

In return of 75 enquiries, 30 completed questionnaires were received, which represent a return rate of 40%. The size of the organizations in which the respondents were working varied from 50 staff to more than 500 staff. Amongst the organizations, more than half (64.3%) were larger than 500 employees in size.

	Building Construction	Civil Construction	Mixed Construction	Large size – more than 500 staff	Medium to small size – staff of 500 or less
Proportion. of organizations	50.0%	16.7%	33.3%	64.3%	35.7%

Figure 4B-1a – Business background of organizations to which respondents are attached

	Director	Design / Technical Manager	Project Manager	Senior Engineers	Quality Managers
Proportion. of respondents	6.7%	23.3%	46.7%	13.3%	10.0%

Figure 4B-1b – Background of individual responsibility of respondents

The 30 respondents were working for 28 different engineering consultants. The type of construction work executed by the consultants in which the respondents were working were building works, civil works and a mixture of building and civil works. When all respondents' organizations are considered as a whole, 50.0% emphasize in building construction, 16.7% focus on civil construction and the remaining 33.3% execute both building and civil works. Figure 4B-1a shows the details of the basic business background of the surveyed organizations. Job responsibilities of the respondents ranged from senior engineers to directors, which are summarized in Figure 4B-1b

ISO 9000 certification

Of the 28 respondents' organizations, all were ISO 9001 certified. The popularity of ISO 9000 quality system in engineering consultants is clearly indicated.

Respondent averaged score

The average of the scores assigned by the respondents against each questionnaire item is defined as the respondent averaged score of an item, with the score scale based on a 5-point Likert System (Hayes, 1998). This means that if a respondent agrees to a great extent to a question (see Appendices), she / he will get score scale 5, and if she / he

does not agree at all, she / he will get score scale of 1. The respondent averaged score for a question is the sum of the scores of the 30 respondents for that specific question divided by 30. The respondent averaged scores for the ISO 9000 items (Part 1 of the questionnaire) are shown in Figure 4B-2 and those for the TQM items (Part 2 of the questionnaire) are shown in Figure 4B-3. The item identifications of the highest three and lowest three of the averaged scores are labeled on these figures.

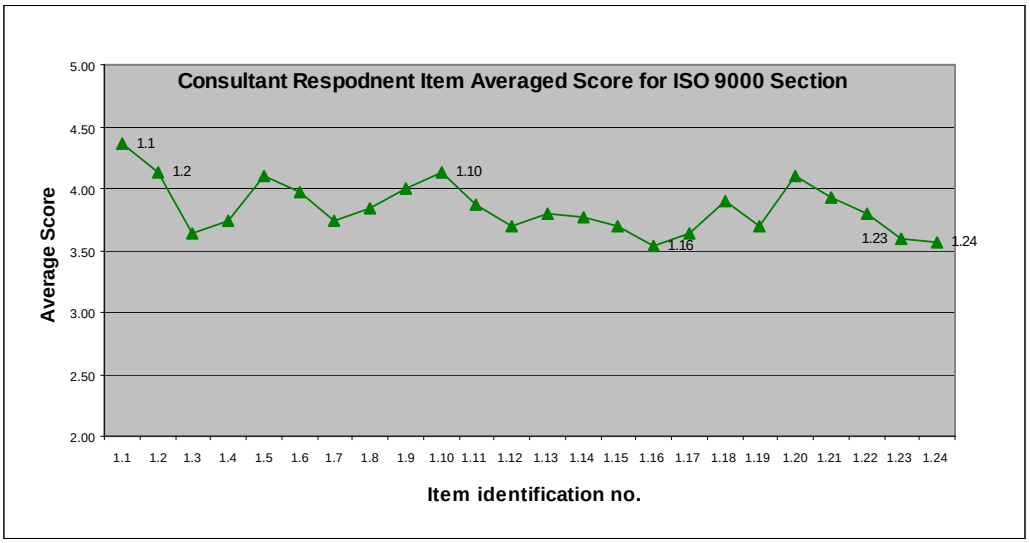

Figure 4B-2 Respondent Averaged Score for ISO 9000 Section Items

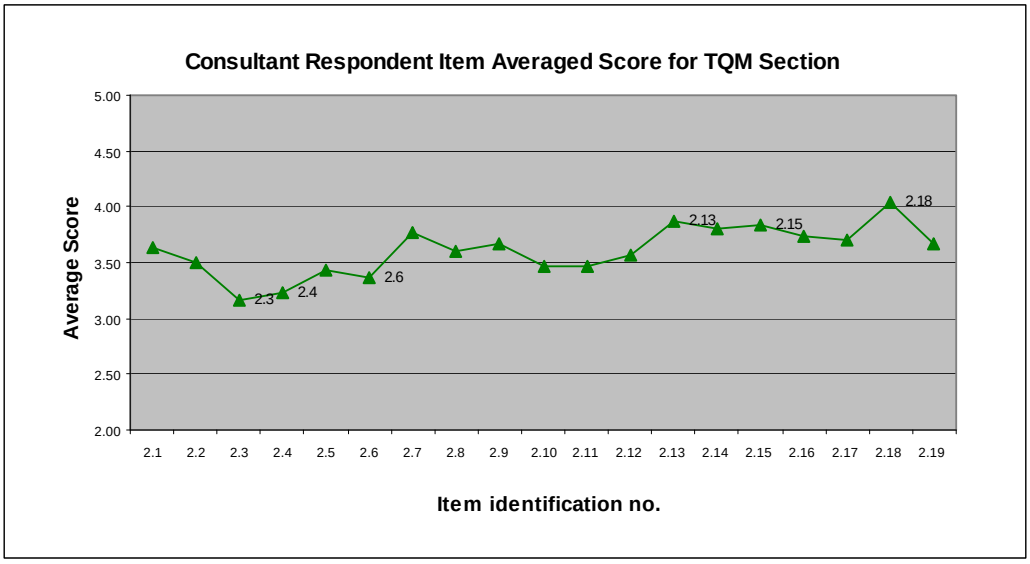

Figure 4B-3 Respondent Averaged Score for TQM Section Items

Three lowest score items and three highest score items

Descriptions of the three lowest score items and three highest score items, as shown in Figures 4B-2 and 4B-3, are summarized as follows:

The lowest three averaged score items		
Averaged Score	Item No.	Item Description
3.53	1.16	Control measures for ensuring design software and hardware are capable of performing the intended functions.
3.57	1.24	Scheduled survey for assessment of client's satisfaction.
3.60	1.23	Procedures for reviewing time and costs of processes with a view for improvement.
The highest three averaged score items		
Averaged Score	Item No.	Item Description

4.37	1.1	The company's objectives for quality and its commitment to quality.
4.13	1.2	Defined responsibility of personnel who manage, perform and verify work that affect quality.
4.13	1.10	Review of drawings and specifications prior to authorization for dispatch.

Figure 4B-4a - ISO 9000 section Lowest Three and Highest Three Score Items

The lowest three averaged score items		
Averaged Score	Item No.	Item Description
3.17	2.3	Practices to encourage process quality improvement discussions at subconsultants / contractors project meetings.
3.23	2.4	Policies to encourage process optimization discussions during early design management planning based on best design tools and appropriate resources.
3.37	2.6	Employees are introduced to the principles and tools for total quality management at project commencement, in addition to contract specifications.
The highest three averaged score items		
Averaged Score	Item No.	Item Description
4.03	2.18	Most (more than 90%) of the design work are achieving the specified intents and purposes without re-work.

3.87	2.13	Responding quickly to the Client's enquiries and complaints.
3.83	2.15	Establishing courteous attitude and efficient communication with the Client.

Figure 4B-4b – TQM section Lowest Three and Highest Three Score Items

Respondent Averaged Score Range Item Distribution

The respondent averaged scores for both the ISO 9000 questionnaire items and the TQM questionnaire items are allocated to one of the five range groups which are of scoring 4.5 and above, scoring 4.0 to 4.5, scoring 3.5 to 4.0, scoring 3.0 to 3.5 and scoring less than 3.0 in a descending order. Figure 4B-5 shows the score range distribution of the items. A comparison between the ISO section item score range and the TQM section item score range reveals that more ISO 9000 than TQM items score more than 4.0, while more TQM than ISO 9000 items score less than 3.5. This reflects that respondents are more familiar with the ISO9000 quality assurance systems than the TQM systems.

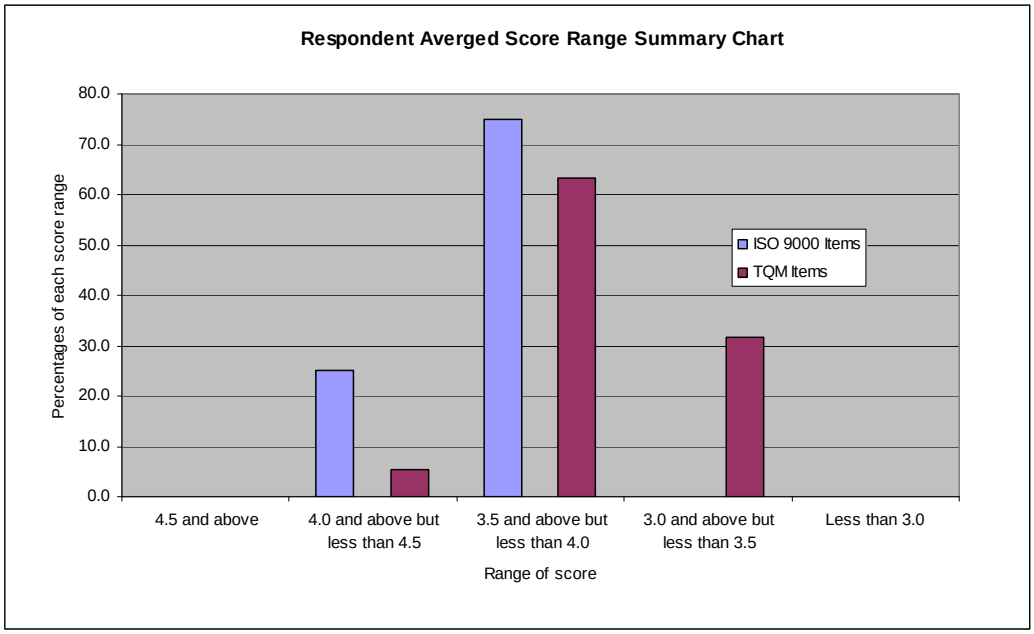

Figure 4B-5 – Respondent Averaged Scored Ranges Percentage Summary Chart

Average score of individual respondents against sets of questionnaire items

The average of the scores calculated from all questionnaire items in the ISO 9000 section assigned by a respondent is defined as the ISO 9000 item averaged score of the respondent. Similarly the average of the scores calculated from all TQM items by a respondent is defined as the TQM item averaged score of that particular respondent. The difference between his ISO item average score and his TQM item average score is calculated and results are shown in Figure 4B-6.

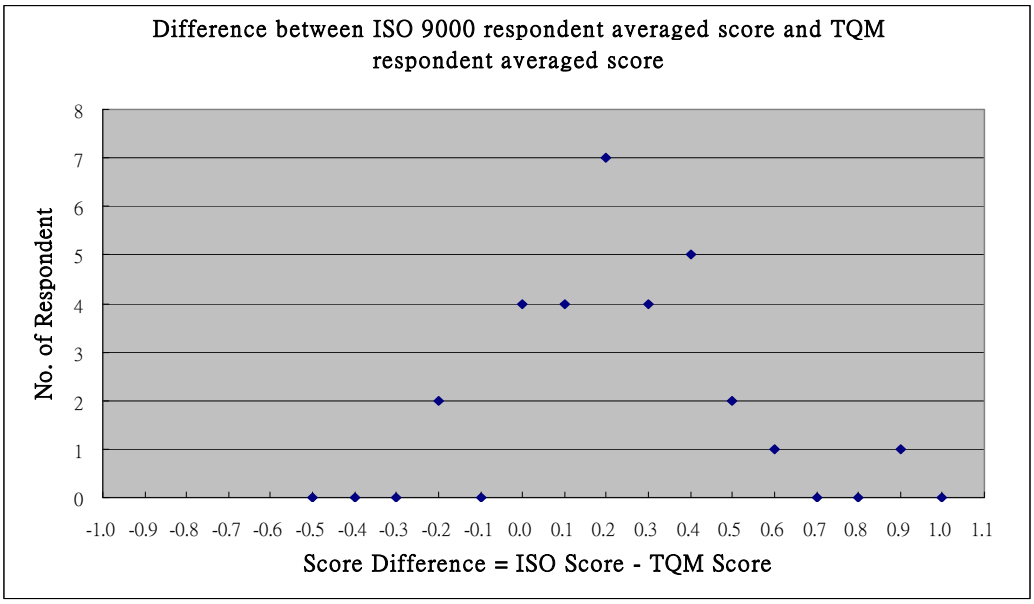

Figure 4B-6 Arithmetic Difference between ISO 9000 item respondent averaged score and TQM item respondent averaged score of respondents

Figure 4B-6 shows a cluster (24 respondents) of the score difference value (ISO 9000 score – TQM score) on the right hand side of the neutral zero, but with only a minority group (2 respondents) on the left hand side of the neutral zero. It therefore indicates that the individual respondents' ISO 9000 item average is generally higher than their TQM item average. This indication suggests that most of the respondents are more readily to practice ISO 9000 principles than the TQM principles.

The above will be further discussed in the next section.

4B.4 Discussion on findings

Quality awareness in the construction engineering consultancies

The return rate of 40% with 75 sent enquiries is considered as promising. This promising return rate also provides an indication that engineering consultants participated in the survey are fully informed of the quality management principle and practices. The organizations for which the respondents are working include both

large companies of employee size more than 500 and smaller companies of employee size less than 500. It is indicated that quality awareness has also reached medium to small size engineering organizations.

Quality adherence to ISO 9000 standards

ISO 9000 certification by all the surveyed engineering organizations indicates the high adherence to the ISO 9000 quality standard and a substantial maturity in quality assurance applications. The cluster of ISO 9000 section items at score ranges of 4.0 to 3.5 in the 5-point Likert System in Figure 4B-5 further illustrates this high adherence characteristic.

Application Relationship between ISO 9000 and TQM

Figure 4B-6 generally shows positive differences, when the ISO 9000 section scores are compared to the TQM section scores for every respondent. The indication is that a practitioner usually applies ISO 9000 principles more effectively than TQM principles.

Lowest three respondent averaged score items under the ISO 9000 section

- Score for software and hardware quality control measures to ensure performance of the intended functions is the lowest. One possible reason is that these patent and expensive design tools are highly specialized and verification control prior to utilization is only feasible by comparison with another specialized system which is equally expensive. Another possible explanation is that most common software and hardware packages have already been approved by the public clients. Suppliers and manufacturers of these design tools are believed to have exercised careful

control on the performance accuracy to maintain their approval status.

- Score for assessment surveys of client's satisfaction is the second lowest. Obtaining direct assessments on consultants' quality systems from clients, especially public clients, through surveys is not popular in Hong Kong. The culture of the construction industry still confines criticisms on others' performance within an organization internally. Releasing adverse comments to outside parties is rare and unusual. Assessment results can however be indirectly obtained from reports issued by clients. As reported in the Provisional Construction Industry Co-ordination Board (PCICB) 2005 report, the Works Branch has been assessing quality aspects of the consultants in the marking schemes used for establishing the branch performance index system. Likewise, the assessment on the quality aspects of consulting firms in public housing projects has also been included in the consultancy selection process since 1998 (Hong Kong Housing Authority, 2001).
- Low scores for established procedures in process review for minimizing time and costs for engineering consultancy works are likely due to the codified nature of designed works, that is, design works usually follow standard design codes. Majority of the time and cost optimization discussions should have taken place during the design briefing and conceptual design stage. Processes downstream of the conceptual design stage will basically be of mathematical and drafting nature. Scope of improvements for these downstream activities inclines more towards areas of clarity of design and ease of buildability. Some engineers also claim that they are trained to look for quality and quality management systems cannot help improve their design process (Tang and Kam, 1999).

Highest three respondent averaged score items under the ISO 9000 section

- The score for organizations' quality commitment and objective is 4.37 which is the highest score amongst all. This result is not unexpected as commitment and clear objectives are the prime requirements of the ISO 9000 standards. Such quality assurance requirements have well penetrated into the construction industry and recognized by a great majority of the respondents.
- The second highest score item is the clearly defined responsibility of personnel who are involved in quality management activities. As required by ISO 9000 standard, clear descriptions of quality management responsibility are to be included in a company's quality procedures. Both the first and second highest scored items further justify the close adherence to the ISO 9000 standard by the engineering consultants.
- The thirdly ranked highest score item is one related to documentation. Review of design deliverables prior to dispatch is well practiced as this review procedure is crucial to the company reputation and subsequently the project success of any organization. Any deficiencies and mistakes at this initial stage could easily generate contentious issues amongst the parties including the client, the contractor and the design consultants.

Lowest three respondent averaged score items under the TQM section

- Practices to encourage process quality improvement discussions with subcontractors and contractors are given the lowest score. The culture of confrontation amongst the construction parties has been considered as an impeding factor to process quality improvement in construction (Shammas-toma, 1996). Consultants do not often initiate improvement discussions with external parties (contractors and subcontractors) in order to avoid debates when benefits could not be achieved due to reasons beyond anticipations.

- Policies to encourage internal process optimization discussions receive the 2nd lowest score. Apart from the codified nature of most engineering design works as previously given in the ISO 9000 low score item section, one other possible cause of limited policies in optimizing design process is the lack of experienced front line design engineers. Optimization requires both insight and innovative initiatives about the elements of the work being designed. The competitive market in the current engineering consultancy business does not always support the employment of experience front line staff who possess the comprehensive design knowledge and thus the confidence to apply innovative ideas. Policies on process optimization might not be fully understood by young staff and are therefore not always followed.
- Introduction of principles and tools of TQM to employees also receives low score. The knowledge of TQM is not sufficiently introduced to the Hong Kong engineering professionals probably due to the fact that its development in the industry is quite recent. Another possible explanation is some well established organizations have applied the spirit of TQM principles but the TQM label has not been attached to their management policies.

Highest three respondent averaged score items under the TQM section

- The item of more than 90% of the design work achieving the specified intents without re-work is ranked highest by its score. Most design works are required to be reviewed by senior staff before they are dispatched for tender or for construction. Independent peer reviews are also required by some clients for critical design packages. These quality requirements could have led designers to reserve some spare capacities in their design to ensure that the design intent is achieved.

- The 2nd highest score item is quickly responding to client's enquiries and complaints. Enquiries and complaints are two of the basic tools in project management applied by clients and customers. Inappropriate and belated replies to these items could directly affect the performance assessment of engineering consultants by clients. The high score of the item implies that consultants are placing high level of priority on addressing enquiries and complaints based on both contract management and quality management considerations.
- The 3rd highest score item relates to the consultants' courteous attitude and communication with clients. High score for this item could be expected as both attitude and communication are crucial elements for maintaining good relationships with clients. Business development is founded on good relationships between parties. It is not difficult to understand that consultants could not underestimate the importance of such relationships.

Overall indication of advancement from QA to TQM

A further analysis on the range of the respondent averaged scores is attempted. Items scoring below the 3.5 Likert Scale are grouped as Low Score Items and those scoring 4 and above are grouped as High Score Items. The comparison results are shown in Figure 4B-7. From the figure, it is observed that the ratio of low score items to high score items for the ISO 9000 section is 0/6(0%), while the same ratio for the TQM section is 6/1 (600%). The ratio for the TQM section is far greater than that for the ISO 9000 section.

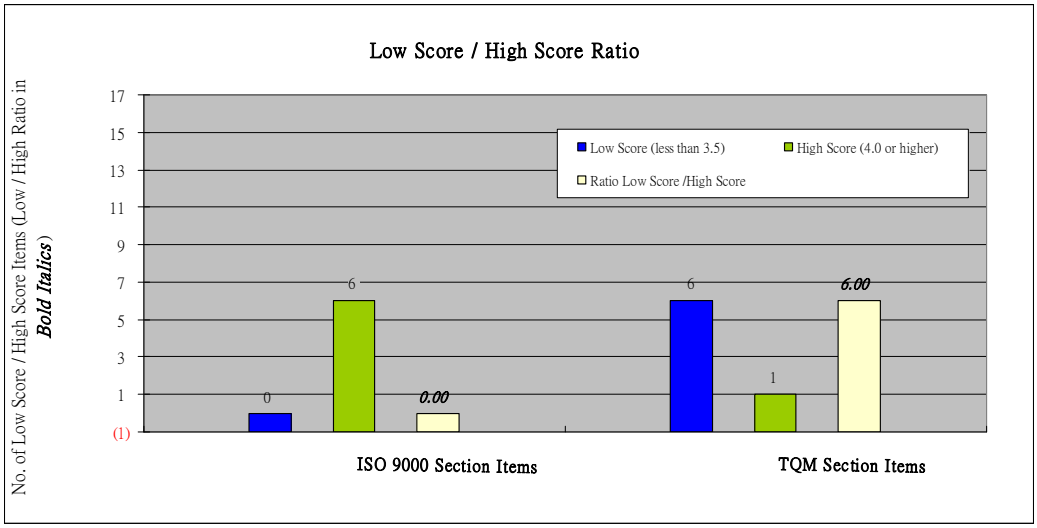

Figure 4B-7 – Comparison of Low and High Respondent Averaged Scores

The zero ratio of low score items to high score items for the ISO 9000 section suggests that the companies in which the respondents were working are highly mature in the application of ISO 9000 system. The excessively high ratio of low score items to high score items for the TQM section however implies that although these companies have acquired the basic principles of TQM, the application of these principles by different consultants is however inconsistent.

4B.5 Conclusions

Quality assurance (QA) emphasizes systematic making good of non-conformances in both processes and products. It is considered as a hard approach with specific rules and systems, as compared to Total Quality Management (TQM) which recognizes that people are the key resource in the various aspects of continual improvement (McCabe, 1998). Engineering consultants providing construction services in Hong Kong have been applying the ISO 9000 QA models for more than 15 years but the results are not satisfactory. Ahmed *et.al* (1998) argued that QA system appeared to be impotent in assuring quality in construction. Tang (2001) identified in his construction reform

quality report that design weaknesses such as poor buildability, insufficient interface engineering planning, lack of communication with the resident project management team and little construction risk assessment were part of the industry's problems.

As indicated by the promising score scales in the overall survey results, the general awareness of the engineering consultants on quality is high. Good score scales are particularly obvious in the organizations' commitment to quality, clear responsibility of staff for the quality management activities, prompt response to enquiries and complaints and achieving design objectives without re-work. The results as summarized in Figures 4B-5, 4B-6 and 4B-7 however convey the message that the engineering consultancy organizations are more familiar with the ISO 9000 QA standard than with the TQM principles and their applications.

Weaker score scales in the systematic control of the IT tools, the customer satisfaction survey and process optimization and improvement discussions reflect generally a low appreciation of the TQM principles of process improvements and customers' satisfaction.

It appears evident that the unsatisfactory progress in quality improvement achievement in the engineering consultants is related to the lack of TQM principles appreciation by the consultants and other stakeholders in the construction industry. Present practices have concentrated on improving the internal management of the company by utilizing the QA procedures. Focus and energy have been diverted from process improvement to routine activities such as recording of non-conformances and other documentation activities.

To further demonstrate that quality improvement in the consultancy sector in Hong Kong would remain stagnant unless the TQM approach is initiated by the sector, a study to explore the root causes in the current reactive quality culture is recommended. A comparison of the adopted quality management approach with other successful

advanced management systems in other Asian cultures would also provide a basis for a framework for our quality advancement.

4B.6 References

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Chapter 4 – Part C

First Survey - A Survey on the Advancement of QA (Quality Assurance) to TQM (Total Quality Management)

Part C – Report on survey for Construction Clients in Hong Kong

4C.1 Background Study

Quality Assurance (QA)

Quality Assurance (QA) embraces all the activities and functions needed to provide adequate confidence in a product or service for satisfying given requirements for quality (Chan and Fan, 1999). It is essentially a preventive function which provides warnings ahead of both internal and external problems (Arditi, & Gunaydin, 1997). Quality assurance is based on the principle that prevention is better than cure and it is more economical to get things right in the first place (Tang *et al.*, 2005). Everyone should aim at doing things right the first time and every time, thus achieving zero defect in performance (Low and Teo, 2004). To implement quality assurance, proper and systematic procedures are drawn up and followed by all concerned. The ISO 9000 series of the International Organization for Standardization is a quality standard for quality assurance purposes (ISO, 1994).

The latest published version of the ISO 9000 family standard was issued in 2000. This version is of a more generic process-based structure. Lau (2001) identified notable

changes in the elements of “customer satisfaction” and “continual improvement”. It also assembles a limited amount of Total Quality Management elements (Tang *et al*., 2005), but is still mainly a quality assurance model standard. It is anticipated the next version of the ISO 9000 standard (4th edition) will be released in late 2008. This edition is supposed to include only minor clarifications to the existing document. Enhancement of clarity and compatibility with the ISO 14000:2004 standard is also expected (Dawson, 2008).

Total Quality Management (TQM)

BS 7850 (BSI, 1992) defines TQM as the management philosophy and company practices that aim to harness the human and material resources of an organization in the most effective way to achieve the objectives of the organization. Another definition of TQM, which is used by the Department of Defense in USA, is a philosophy and a set of guiding principles that represent the foundation of a continually improving organization (Tingey, 1997). TQM is a management-led continual improvement process involving all employees, by eliminating non-value-adding activities, as part of the normal business to meet the needs and satisfaction of both the internal and external customers (Williams 1997, Tang e*t al.*, 2003).

TQM philosophy extends beyond management systems related to production processes. It embraces principles, processes, practices and procedures necessary for

providing customer satisfaction and achieving improvement in productivity and business performance (Love *et al*., 2004). Reasons for initiating TQM as suggested by Low and Peh (1996), Love *et al*. (2004) and Low and Teo (2004) include:

- Time and cost overrun has engendered an adversarial relationship between clients, design consultants and contractors.
- Building projects have gone larger and more complex; clients are also increasingly demanding higher standards for their delivery.
- The ever increasing challenging and onerous environmental and safety requirements have also exacerbated the need to change the management culture towards TQM.
- Parties to projects have differing traditions and often opposing interests – resources are spent on defending the parties positions, which are better spent on achieving customers' satisfactions.

Quality management in the Hong Kong construction industry in the past fifteen years

In Hong Kong, the ISO 9000 QA system has been implemented in the construction industry since 1993. Dissanayaka *et al*. (2001) commented that there had been a maturing of attitudes towards ISO 9000 within the construction industry, but the general level of quality in construction has however not significantly improved (Tam *et al.*,

2000). In 1996, the Hong Kong Works Bureau required all engineering, architectural and associated consultants to be certified to ISO 9000 (Aoieong and Tang, 2004). Tang and Kam (1999) expressed that benefits anticipated from ISO 9000 certification were not experienced by most of the construction participants. Kumaraswamy and Dissanayaka (2000) suggested the integration of ISO 9000 initiatives into the more rewarding TQM journey. The biggest housing client Hong Kong Housing Authority and the Hong Kong government initiated large scale quality reforms in 2000 and 2001 respectively, the main objective of which is to achieve total quality construction. There is apparently enough driving force in the society to quest for total quality excellence in the construction sector. It appears obvious that a survey is due to capture the mindset of the construction industry in Hong Kong prior to starting a culture driven total quality management programme.

4C.2 Methodology

Further to a literature review, a questionnaire survey was designed for a full scale survey. In advance of the full scale survey, a pilot set of questionnaire was sent to two practitioners working in public clients and one working in a private client in November 2007 to test the effectiveness and ease of understanding of the survey questions. The final set of the questionnaire consisted of three parts. Part 0 was intended for gathering the organization information of the company in which the respondent was working. Part

1 focused on the ISO 9000 requirements while Part 2 was set based on TQM principles in the context of construction. Parts 1 and 2 of the questionnaire are shown in the Appendices of this thesis chapter. This questionnaire was then sent to professionals working in construction clients in December 2007. Replies to these questionnaires were received during January and February 2008.

The survey attempted to acquire how familiar was the industry with the ISO 9000 quality management applications. Under the same survey, an enquiry was also made on how are the TQM principles and techniques are perceived. In the next two sections, discussions on the survey results will be presented, and further approaches on how can quality management in the Hong Kong construction industry advance will also be suggested.

4C.3 Summary of findings

Return rates and background of respondents

In return of 60 enquiries sent to practitioners working in public and private client organizations, 21 completed questionnaires were received, which represent a return rate of 35%. The size of the organizations in which the respondents were working varied from 100 staff to more than 500 staff. Amongst the organizations, more than half (66.7%) were larger than 200 employees in size.

	Building Construction	Civil Construction	Mixed Construction	Large size – more than 200 staff	Medium to small size – staff of 200 or less
Proportion. of organizations	52.4%	23.8%	23.8%	66.7%	33.3%

Figure 4C-1a – Business background of organizations to which respondents are attached

	Project / Department Manager	Project Engineer	Project Co-ordinator	Site Representative
Proportion. of respondents	61.9%	23.8%	9.5%	4.8%

Figure 4C-1b – Background of individual responsibility of respondents

The 21 respondents were working for 20 different client organizations. The type of construction work executed by these client organizations in which the respondents were working were building works, civil works and a mixture of building and civil works. When all respondents' organizations are considered as a whole, 52.4% emphasize in building construction, 23.8% focus on civil construction and the remaining 23.8% execute both building and civil works. Figure 4C-1a shows the details of the basic business background of the surveyed organizations. Job responsibilities of the respondents ranged from site representatives to project managers, which are summarized in Figure 4C-1b.

ISO 9000 certification

Of the 21 respondents' organizations, all except one were ISO 9001 certified. The popularity of ISO 9000 quality system in construction clients is clearly indicated.

Respondent averaged score

The average of the scores assigned by the respondents against each questionnaire item is defined as the respondent averaged score of an item, with the score scale based on a 5-point Likert System (Hayes, 1998). The respondent averaged scores for the ISO 9000 items are shown in Figure 4C-2 and those for the TQM items are shown in Figure 4C-3. The item identifications of the highest three and lowest three of the averaged scores are labeled on these figures.

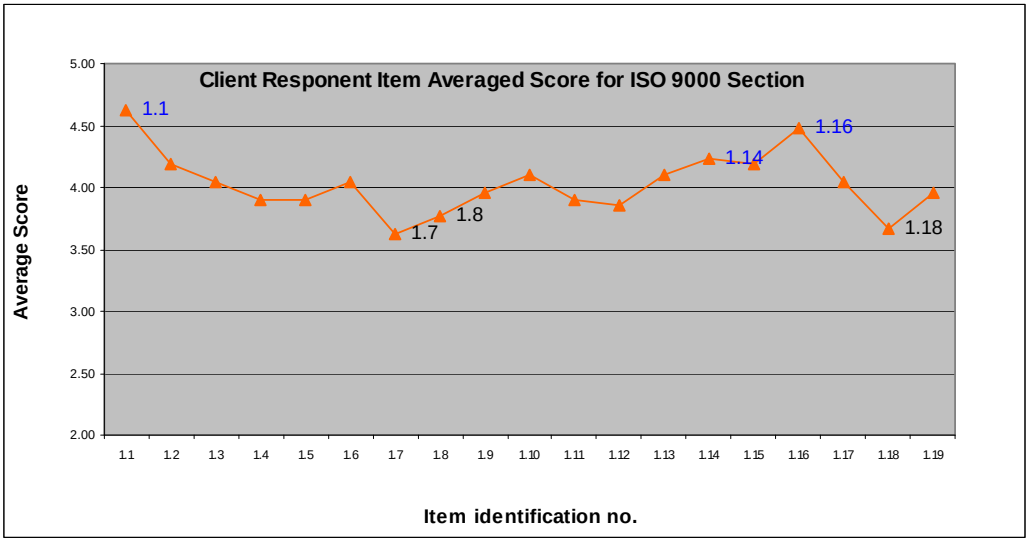

Figure 4C-2 Respondent Averaged Score for ISO 9000 Section Items

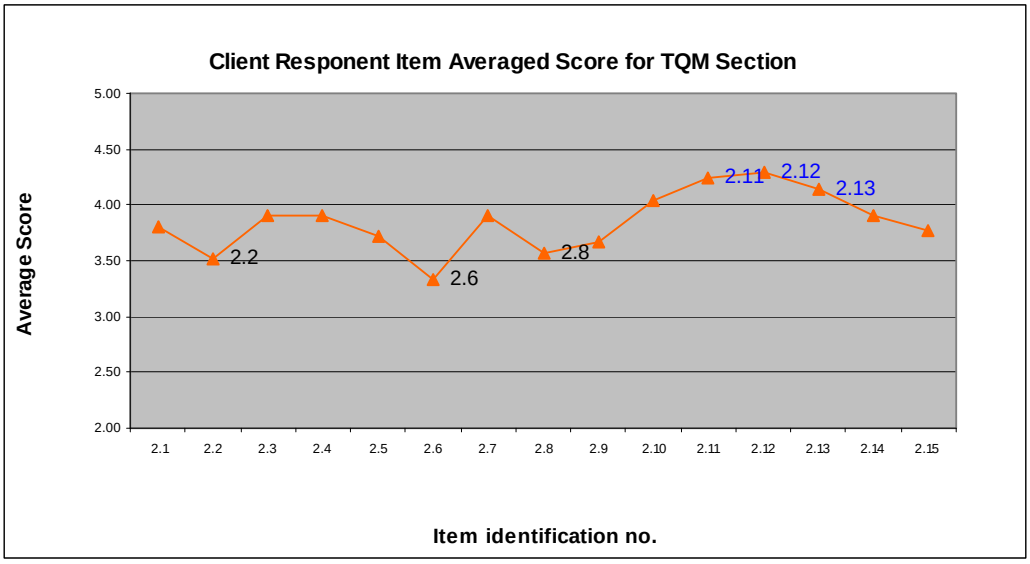

Figure 4C-3 Respondent Averaged Score for TQM Section Items

Three lowest score items and three highest score items

Descriptions of the three lowest score items and three highest score items, as shown in Figures 4C-2 and 4C-3, are summarized as follows:

In the ISO 9000 section (Part 1 of the questionnaire) –

The lowest three averaged score items are:

a. Item 1.7 (averaged score 3.62) – Procedures to efficiently record variations in projects requirements and to correctly transfer variation information to the functions concerned.

b. Item 1.18 (averaged score 3.67) - Procedures for reviewing time and costs (e,g. value engineering) of projects with a view for improvement.

c. Item 1.8 (averaged score 3.76) – Review of project requirements and

performance specifications prior to authorization for instruction dispatch.

The highest three averaged score items are:

a. Item 1.1 (averaged score 4.62) - The company's objectives for quality and its commitment to quality.

b. Item1.16 (average score 4.48) – Periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system.

c. Item 1.14 (averaged score 4.24) – Documented procedure for handling and storing project requirements and performance specifications.

In the TQM section (Part 2 of the questionnaire) –

The lowest three averaged score items are:

a. Item 2.6 (averaged score 3.33) - Employees are introduced at project commencement the principles and tools for total quality management focusing on the specific processes of the project.

b. Item 2.2 (averaged score 3.52) – Practices to encourage project quality improvement discussions at internal project meetings.

c. Item 2.8 (averaged score 3.57) - Practicing continual review on project costs with a view for improvement while maintaining the

latest project requirements.

The highest three averaged scored items are:

a. Item 2.12 (averaged score 4.29) - Offering reasonable explanations and solutions to legitimate complaints.

b. Item 2.11 (averaged score 4.24) - Responding quickly to enquiries and complaints raised by project related parties.

c. Item 2.13 (averaged score 4.14) - Establishing courteous attitude and efficient communication with the project related parties.

Respondent Averaged Score Range Item Distribution

The respondent averaged scores for both the ISO 9000 questionnaire items and the TQM questionnaire items are allocated to one of the five range groups which are of scoring 4.5 and above, scoring 4.0 to 4.5, scoring 3.5 to 4.0, scoring 3.0 to 3.5 and scoring less than 3.0 in a descending order. Figure 4C-4 shows the score range distribution of the items. A comparison between the ISO section item score range and the TQM section item score range reveals that more ISO 9000 than TQM items by percentage score more than 4.0, while more TQM than ISO 9000 items score less than 3.5. This reflects that respondents are more familiar with the ISO9000 quality assurance systems than the TQM systems.

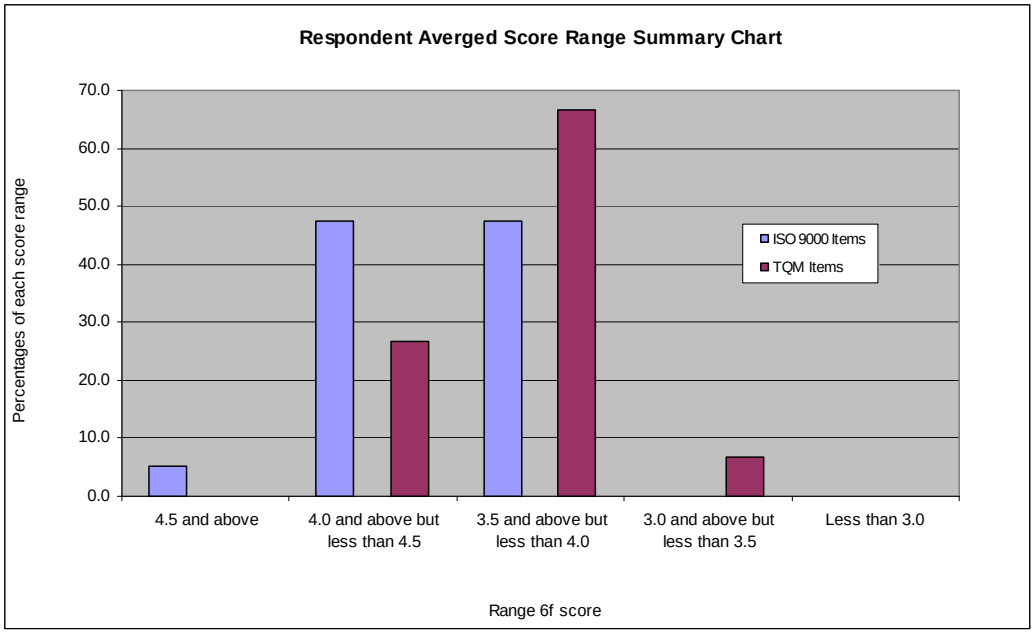

Figure 4C-4 – Respondent Averaged Scored Ranges Percentage Summary Chart

Average score of individual respondents against sets of questionnaire items

The average of the scores calculated from all questionnaire items in the ISO 9000 section assigned by a respondent is defined as the ISO 9000 item averaged score of the respondent. Similarly the average of the scores calculated from all TQM items by a respondent is defined as the TQM item averaged score of that particular respondent. The difference between his ISO item average score and his TQM item average score is calculated and results are tabulated in Figure 4C-5 and also graphically in Figure 4C-6.

Score Difference = ISO score – TQM Score	-0.5	-0.4	-0.3	-0.2	-.01	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
# of respondent	0	0	1	0	0	4	8	2	1	1	3	1	0	0	0	0

Figure 4C-5 Difference between the ISO 9000 item averaged score and the TQM item averaged score

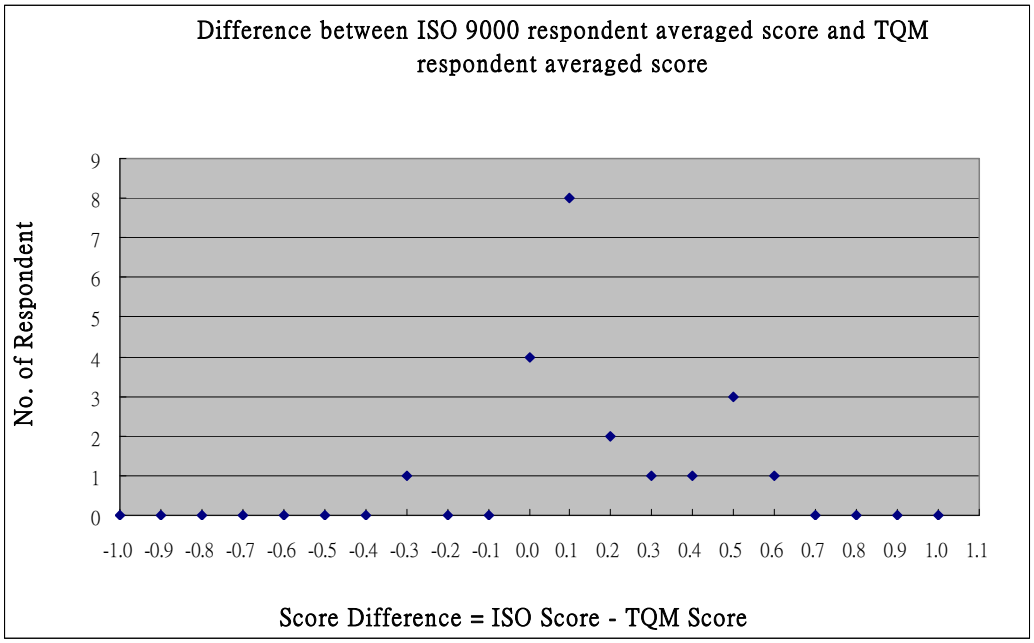

Figure 4C-6 Arithmetic Difference between ISO 9000 item respondent averaged score and TQM item respondent averaged score of respondents

Figure 4C-6 shows obviously a cluster (16 respondents) of the score difference value (ISO 9000 score – TQM score) on the right hand side of the neutral zero, but with only 1 respondent on the left hand side of the neutral zero. It therefore indicates that the individual respondents' ISO 9000 item average is generally higher than their TQM item average. This indication suggests that most of the respondents are more readily to practice ISO 9000 principles than the TQM principles.

The above will be further discussed in the next section.

4C. 4 Discussion on findings

Quality awareness in the client organizations

The return rate of 21% with 60 sent enquiries is considered as promising. This promising return rate also provides an indication that construction clients are fully informed of the quality management principle and practices. The organizations for which the respondents are working include both large companies of employee size more than 200 and smaller companies of employee size less than 200. It is indicated that quality awareness has also reached medium to small size construction clients.

Quality adherence to ISO 9000 standards

The extremely high percentage of 95.3% in ISO 9000 certification by the surveyed client organizations indicates the high adherence to the ISO 9000 quality standard and a substantial maturity in quality assurance applications. The cluster of ISO 9000 section items at score ranges of 4.0 to 4.5 and 3.5 to 4.0 in the 5-point Likert System in Figure 4C-4 further illustrates this high adherence characteristic.

Application Relationship between ISO 9000 and TQM

Figure 4C-6 generally shows positive differences, when the ISO 9000 section scores are compared to the TQM section scores for every respondent. The indication is that a practitioner usually applies ISO 9000 principles more effectively than TQM principles.

Lowest three respondent averaged score items under the ISO 9000

section

- Score for procedures to efficiently record variations in projects requirements and to transfer these variations to affected functional parties is the lowest. One possible reason is that the client organizations usually rely on the project management consultants to administer these variations and changes. The client organizations are thus expecting the management consultants to record and materialize the variation details through instructions to designers and contractors.
- Score for procedures in reviewing time and costs (e.g. value engineering) of projects with a view for improvement is the second lowest. The comparatively low score for the item is quite unexpected. Time and costs are the two of most common deciding factors for construction development projects. For the public clients, procedures in conducting monitoring reviews, but not necessary improvement reviews, on these two project success indicators are usually specified in the contract documents. The procedures for improving time and cost in public projects are lacking could probably be due to the lack of initiatives from the project monitoring staff of the client organization, who usually focuses on target achievement rather than moving the targets for greater achievements.
- Low scores for review of project requirements and performance specifications

prior to authorization for instruction dispatch could be considered as a result of the lack of attendance on change management. Instructions should not be issued to subordinates unless the reasons for instruction are justified. Again there is always a possibility that the clients' staff are relying on the management consultants to justify the reasoning on instructions. One further possible reason for the client organization taking a more relaxed attitude on issuing instruction is belief on protections provided in the contract against the flexibility of changing project requirements by the project developers and the project clients.

Highest three respondent averaged score items under the ISO 9000 section

- The score for organizations' quality commitment and objective is 4.62 which is the highest score amongst all. This result is not unexpected as commitment and clear objectives are the prime requirements of the ISO 9000 standards. Such quality assurance requirements has well penetrated into the construction industry and recognized by great majority of the respondents.
- The second highest score item is the periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system. Regular internal auditing is also a distinctive requirement in the ISO 9000 standards. This requirement is included generally in an organization's quality procedures.

Any observations and non-conformances identified in the audits are documented for rectifications and improvement.

- The thirdly ranked item is the documented procedure for handling and storing project requirements and performance specifications. The proper handling of project correspondence is not only a quality assurance requirement for client organizations but also an important contract administration procedure. The most update project requirements and specifications are documents that should be make readily available to project staff at any time. The procedure of handling these documents should therefore be circulated to all project staff for proper execution to enable efficient project management.

Lowest three respondent averaged score items under the TQM section

- The item requiring that employees are introduced at project commencement the principles and tools for total quality management focusing on the specific processes of the project is given the lowest score. The knowledge of TQM is not sufficiently introduced to the client organizations in Hong Kong probably due to its development in the construction industry is quite recent. Another possible explanation is some well established organizations have applied the TQM principles but the TQM label has not been attached to their management policies.

- Practices to project quality improvement discussions at internal project meetings receive the 2nd lowest score. The low score scenario indicates that the culture of continuous improvement in client organizations is weak. The project management staff appears to be playing a reactive role rather than a proactive role in continuous improvement. The client staff usually would only act on improvement proposals raised by contractors or consultants. Such defending attitude could have been caused by fear of contractual implications by the client party who would raise an improvement proposal which eventually fails.
- Practicing continual review on project costs with a view for improvement while maintaining the latest project requirements also receives low score. Continual review leading to continual quality improvement is one of the fundamental principles of TQM. With the low score for the item for TQM introduction to employees, it is not unreasonable to assume that continual review and improvement is not the prevailing practices in the client organizations. Instead, periodic review with respect to predetermined requirements in accordance with the ISO 9000 guidelines is the wide spread culture in these organizations.

Highest three respondent averaged score items under the TQM section

- The item for offering reasonable explanations and solutions to legitimate

complaints is ranked highest by its score. Pubic clients who are accountable to the public are very keen to address complaints, particularly those that are lodged by political parties and the professional groups. The public clients would generally make their best effort to clarify the issue and make suggestions to prevent recurrence of complaints. Similarly, private clients are also accountable to their customers. The growing knowledge of rights of customers and responsibilities of clients in the society warrants effective procedures in any private client to quickly provide solutions to issues upon which complaints are raised.

- The 2nd highest score item is quickly responding to enquiries and complaints raised by project related parties. Enquiries and complaints are two of the basic communication tools in commercial activities nowadays. Inappropriate and belated replies to the complaints and enquiries could directly affect the performance assessment of client organization by stakeholders including customers. The high score of the item implies that client organizations are placing high level of priority on addressing enquiries and complaints based on both project management and quality management considerations.
- The 3rd highest score item relates to the client organizations' courteous attitude and communication with project related parties. High score for this item could

be expected as both attitude and communication are crucial elements for maintaining good relationships with the project stakeholders. Business development is found on good relationships between parties. It is easy to understand that client organizations would not underestimate the importance of such relationships.

Overall indication of advancement from QA to TQM

A further analysis on the range of the respondent averaged scores is attempted. Items scoring below the 3.5 Likert Scale are grouped as Low Score Items and those scoring 4 and above are grouped as High Score Items. The comparison results are shown in Figure 4C-7. From the figure, it is observed that the ratio of low score items to high score items for the ISO 9000 section is 0/10(0%), while the same ratio for the TQM section is 1/4 (25%). The ratio for the TQM section is far greater than that for the ISO 9000 section.

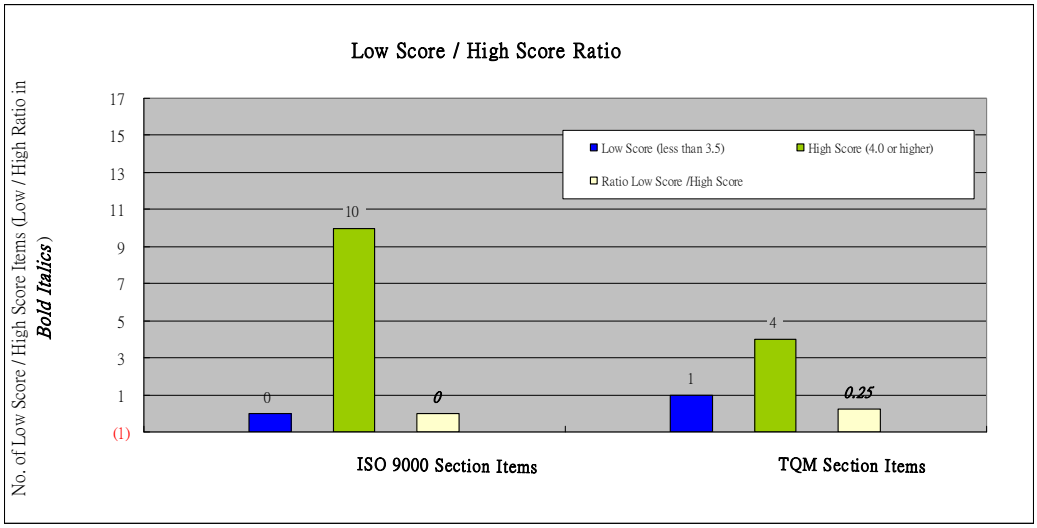

Figure 4C-7 – Comparison of Low and High Respondent Averaged Scores

The zero ratio of low score items to high score items for the ISO 9000 section suggests that the companies in which the respondents were working are highly mature in the application of ISO 9000 system. On contrary, the high ratio of low score items to high score items for the TQM section seems to imply that although these companies have acquired the basic principles of TQM, the application of these principles by different client organizations is however inconsistent

4C. 5 Conclusions

Research literature tends to classify QA as a systematic and static approach while TQM as a dynamic people approach. There is a trend to think that QA and TQM are complementing each other. ISO 9000 has been practiced as a QA model world wide and across all manufacturing and service industries including construction, despite that it is

distinguished from others by its project uniqueness and multi-interfacing characteristics. The Hong Kong client organizations have been actively practicing the ISO 9000 model for more than fifteen years, but the improvements in project quality are less than the industry's anticipation. Public clients who have great concerns on project quality took the lead to drive for total quality excellence at the beginning of the millennium.

The results of the questionnaire survey on the current application status apparently indicate that client organizations have acquired substantial knowledge of the QA principles and also considerable knowledge of the TQM principles. A detailed analysis of the scores assigned by the respondents however indicates that client organizations are more familiar with the QA application than with the TQM principles.

In the questionnaire survey, the three QA requirements that were least practiced by client organizations were variation procedures, review procedures for time and cost minimization and review of project requirements and specifications prior to authorization. On the other hand, the three mostly applied QA requirements were found to be organizations' commitment to quality, internal auditing and documented procedure for handling project specification. In the TQM section, the items assigned with the lowest three scores were introduction of the TQM principles and tools, practices to encourage internal discussions on quality improvement and practicing continuous review

on minimizing project without undermining project requirements. The top three scores in the TQM section were identified to be the explanation and solution to legitimate complaints, responding quickly to clients' enquiries and complaints and the courteous attitude towards and communications with clients. The score range of these items reflects the quality culture of project planning and construction Hong Kong, which in turn has been influenced by the society's commercial mind set, the government's regulations and requirements, and the own culture of the client organizations.

Under the prevailing competitive business environment and the demanding quality excellence expected by customers, the issue of the way forward for quality management is pressing. An attempt to explore the basic causes in the current reactive quality culture and behavior of the participants in the Hong Kong context is therefore recommended. Such a study could also be expanded to include the management of frequent outsourcing of the construction related activities, including design services, procurement documentation, precasting and fabrication of structural element, to China or other countries in Asia.

4C. 6 References

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Chapter 5 - Part A

Second Survey - TQM application by construction related organizations in Hong Kong

Part A – Report on survey for Construction Contractors in Hong Kong

5A.1 Introduction and literature review

The construction industry shares certain characteristics with the manufacturing industry, as both focus on product delivery. However, the construction industry can also be seen as a 'project based' industry. Each construction project is unique in its physical site constraints, project stakeholders, design changes and site logistics. The following characteristics are nevertheless common to most construction projects (Brockmann & Birkholz, 2006; McCrary *et al.*, 2006; Tam *et al*., 2000; Kanji & Wong, 1998; Low and Peh, 1996):

- Most projects contain risky uncertainties in terms of ground and weather conditions.
- Basic processes are repeated from job to job, but the specifics of application always vary due to project constraints and site environments.
- Parties to projects have differing traditions and often opposing interests, leading to resources being spent on defending the parties' positions.
- Short-term employment for migrant workers, which discourages company loyalty.
- Multi-interfaces complicate the communication efficiency and tracing system.
- Costs and time are generally more precisely defined than quality in

construction contracts. The latter gives more room for contractors to manipulate, leading to the risk of giving unnecessarily high priority to costs and time at the expense of quality.

- Little integration between designers and construction contractors, resulting in low buildability designs.
- Changes, both in design and in construction, are excessive and frequent.
- Changes cause delays, claims and confrontations, which undermine the quality of the project.

These characteristics have a substantial effect on the quality standards of the construction industry, which is considered to be lagging behind other industries (McCrary *et al.,* 2006). However, several national reports have been published within the last fifteen years, highlighting enhancements in the quality of construction projects and the general performance of the construction industry. For example, the Egan (1998) report in the UK identified five key drivers of change: a quality-driven agenda, committed leadership, integrated process and teams, a focus on the customer and a commitment to people. The Construction 21 Review Committee (1999) study in Singapore proposed six strategic thrusts: enhancing professionalism, raising skill levels, improving industry practices and techniques, adopting an integrated approach to construction, a collective championing effort for the construction industry and the development of an external wing. The Building for Growth – 1999 (NatBACC,1999) report in Australia initiated a reform agenda in five key areas: creating a more informed marketplace, maximising global business opportunities, fostering technological innovations, creating economically and ecologically sustainable environments and

creating a best practice regulatory environment. These three national report examples demonstrate the concerns of industry stakeholders worldwide over construction quality issues.

During the 1990s, the Hong Kong Housing Authority (HKHA) and the Works Bureau of the Hong Kong government drove for quality and performance improvements in the construction industry by implementing the Performance Assessment Scoring Scheme (PASS), ISO 9000 certification and the Performance Index System (PIS) for both contractors and engineering consultants. Since their introduction, both the PASS and the PIS have provided a quantitative indication of a contractor's performance on quality, which can be used for referencing by the project office and relevant tender board during the tender evaluation.

The need for further reform in the industry was prompted by a reported increase in the shortcomings of the industry's operations and in the quality of its products in the late 1990s. In 2000, the Government of the Hong Kong SAR commissioned the Construction Industry Review Committee (CIRC) to review the quality and performance of the entire construction industry and a report was issued in 2001 (CIRC, 2001). The report identified necessary improvements in the areas of product quality, efficiency, productivity, site safety, environmental sustainability and customer satisfaction.

The report put forward a bold vision of the industry delivering better value to the customer through continual improvements (McInnis 2001). The CIRC recommended 109 improvement measures and the Works Bureau, which is the main arm of the government for managing public construction projects, was assigned to take the lead in

implementing these proposed improvement measures. The report categorised the measures into seven main themes (CIRC, 2001):

1. Fostering a quality culture (comprising seven sub-items);
2. Achieving value in construction procurement;
3. Nurturing a professional workforce;
4. An efficient, innovative and productive industry (comprising nine sub-items);
5. A safer workplace and an environmentally responsible industry;
6. An institutional framework for implementing the change programme; and
7. A review of the implementation progress of the change programme.

The importance of strong leadership from project clients and the need for a culture of continual improvement by industry participants were also highlighted throughout the report. The use of 'total quality product' and 'total system control' approaches appeared in numerous sections of the report. The report also introduced the concept of prime contracting, in which the prime contractor brings together all parties in the supply chain to meet the client's requirements effectively. This report ultimately set the long-term goal that a contractor must be capable of and responsible for the total delivery of a construction project, fit for purpose and in-line with the whole-life costs concept. It seems evident that the approaches, concepts and expectations brought up in the report are in line with the total quality management (TQM) philosophy.

Quality management is a crucial element of the successful management of construction projects. According to Tang *et al*. (2005), two important types of quality management systems are currently used, quality assurance (QA) and TQM. QA is based on the principle that prevention is better than cure and it is more economical to get things right

in the first place. Everyone should aim at doing things right the first time and every time, thus hoping to achieve zero defects in performance. TQM is defined as the management philosophy and company practices that aim to harness the human and material resources of an organisation in the most effective way to achieve the objectives of the organisation (BSI, 1992). TQM is a management-led process that involves all employees in the continual improvement of the performance of all activities, to meet the needs and satisfaction of both the internal and external customers (Tang *et al*., 2003). TQM is a higher level of quality management system than QA. The practice of QA usually serves as a stepping-stone for the ultimate implementation of TQM.

As the CIRC report contained the basic TQM concepts, we observed that the seven main themes of the improvement measures generally match the eight TQM elements (a to h) that are specifically suited to construction contractors (Koh and Low, 2010), as follows:

a. Top management leadership – In relation to contractors' management activities, this element is strongly reflected in many of the CIRC improvement themes. Under the first theme of 'Fostering a quality culture', the report suggests that all sectors' top management lead their associated disciplines in securing an integrated input to facilitate efficient project planning, development and implementation, as an important driving force for a quality culture. Under the fourth theme of 'An efficient, innovative and productive industry', the report encourages leaders of the industry stakeholders to consider wider use of on-site concrete and prefabrication. Under the fifth theme of 'A Safer Workplace and Environmental Responsible Industry', the report suggests that all sectors' top management take the lead in establishing a safety culture based on a preventive

approach. The report further suggests that contractors' management promote sustainable construction by minimising construction waste and promoting environmentally friendly construction methods. Under the sixth theme of 'Institutional Framework for Implementing the Change Programme', the improvement recommendations require all sectors' management to liaise closely with the improvement programme coordinating body on all matters relating to needs and improvements.

b. Customer management – This TQM element is reflected in several of the CIRC improvement themes. Under the second theme, 'Achieving value in construction procurement', all contractors should adopt a procurement arrangement that allows their subcontractors and suppliers to maximise their ability to add value to the project. Under the fourth theme, 'An efficient, innovative and productive industry', the report identifies that with the combined expertise of accounting, financing and legal services, the Hong Kong construction industry could provide a comprehensive service package to foreign clients in the region through direct contracting or in association with those local construction companies. It also suggests that contractors should communicate, co-ordinate and invest in research projects related to construction materials and methods that meet the local and regional needs.

c. People management – The association of people management with contractors' activities are specifically discussed in the third CIRC improvement theme, 'Nurturing a professional workforce'. Skills training for professionals, construction technicians, construction supervisions and construction workers is

emphasised. A responsible attitude towards work is highlighted. Broader adoption of direct labour in replacement of daily wage labour is recommended.

d. Supplier management – This element is reflected in two of the CIRC improvement themes in relation to contractors' management activities. The improvement measures recommended in the first theme of 'Fostering a quality culture' requests subcontractors, suppliers and other projects team members to be accountable for their clearly defined roles and responsibilities and to perform to the best of their abilities in full alignment with the stakeholders' long-term objectives. This improvement measure also encourages contractors to nurture stable partnerships with good subcontractors through feedback and review in the pre-contract and post-contract stages. Under the fourth theme, 'An efficient, innovative and productive industry', the report further recommends that ready-mix concrete suppliers should establish an agreed code of practice and set up long-term government off-loading and land-use policies.

e. Quality information management - This element is reflected in at least three of the CIRC improvement themes. Under the first theme of 'Fostering a quality culture', the report suggests the establishment of a voluntary registration scheme for small-scale contractors (sub-contractors). The database requires an efficient information management system that is readily accessible by industry stakeholders. In the fourth theme, 'An efficient, innovative and productive industry', the industry is recommended to develop a common data infrastructure that allows seamless electronic communication. The industry is also encouraged to develop software applications to improve both local design capability and project logistic management. Under the seventh theme, 'Review of

implementation progress of the change programme', all quality-related information data should be processed efficiently and adjustments to the continual improvement programme should be communicated effectively to the stakeholders.

f. Process management – Process management is crucial to contractors as they deal with projects that are usually unique in terms of the site environment, associated risks and the sequence of construction. In the first theme, 'Fostering a quality culture', process management is reflected in the detailed planning requirements for design, resources, procurement, co-ordination and programming. In the fourth theme, 'An efficient, innovative and productive industry', process management is highlighted in the integrated approach to project implementation. Process management is also emphasised in the standardisation of component design and the prefabrication process of these components. This element is further reflected in the recommendation for the streamlining of regulatory approval for construction activities, including approval for excavation on public land, which is usually a major element in the construction programmes of design and build contracts. Under the fifth theme, 'A safer workplace and an environmentally responsible industry', process improvement though an integrated approach to project implementation is again recommended to enhance the overall effectiveness of site supervision. Such enhancement will also raise site safety standards and mitigate the project-related environmental impact.

g. Organisational learning (Internal error detection and correction and strategy for acquiring and applying up-to-date external knowledge) – In association with contractors' activities, this TQM element is specifically reflected in the third

theme, ‘Nurturing a professional workforce’. The CIRC report requests that construction organisations equip their site supervisors with academic knowledge and practical experience to build up a pool of competent and committed mid-stream site personnel on whom effective project management can rely. Many of the current site supervisors, who worked their way up from a tradesman background, do not possess adequate formal knowledge and require in-house or external systematic training to cope with the demands of their jobs. For frontline workers, the report suggests a competence-based qualification framework to motivate them to acquire higher qualifications and new construction techniques.

h. Continual improvement – The spirit of review and improvement is spread throughout the CIRC report. In association with contractors’ management activities, continual improvement is strongly reflected in the first theme, ‘Fostering a quality culture’, the fourth theme, ‘An effective, innovative and productive industry’ and the seventh theme, ‘Review of implementation progress of the change program’. The report suggests that the industry should put further emphasis on site supervision to uphold the quality of public housing. It also suggests the adoption of independent technical auditing for all public works, to identify areas for further improvement. With respect to construction-related research development, the report recommends that the industry take account of the immediate needs and also the direction of the long-term development towards excellence. The report further points out that the pace of improvement for the Hong Kong construction industry is generally set by the surrounding competitive forces and the global market. It suggests that the industry should appoint a

statutory body to co-ordinate the improvement scheme and to devise incentive schemes to encourage continual improvement to excellence.

The implementation of the 109 improvement measures is monitored by a progress monitoring organisation known as the Construction Industry Council (CIC). The CIC reported that 84 of the 109 items had been fulfilled (The Standard Supplement, 11 March 2011, Page 19) and all remaining items were in good progress. While the progress of implementation appeared to be satisfactory, the author of this paper is not aware of any report published by the CIC on the progressive achievements of the intended improvements.

In parallel with the implementation of the CIRC recommendations, the Works Bureau also required all contractors to be certified to the 2000 version of ISO 9001 as of December 2003. This version of ISO 9001 is considered to be an improvement on the earlier 1994 version (and the 1987 version) in the areas of customer satisfaction, resource management, management responsibility, continual improvement and process approach (Thermo Fisher Scientific, 2002). The process-based quality management model emphasises the identification of critical processes such that they are adequately planned, monitored and controlled (Aoieong *et al.*, 2002; Tang *et al.*, 2004). The 2000 version also requires top management to provide evidence of measurable improvements in their business processes and levels of customer satisfaction (Graham, 2002). The latest version of ISO 9001 was released in 2008. Although there are few differences from the 2000 version, the 2008 version largely explains and clarifies the ambiguities and imperfections contained in the 2000 version. The big change took place in the 2000

version, which took a big step forward in quality management and embraced some (but not all) of the TQM elements that were absent from the 1994 version. The 1994 version (and also the 1987 version) was mainly intended for QA, rather than TQM.

As explained above, there are similarities between the CIRC recommendations and the TQM elements. In addition, all public clients and most private clients have enforced their contractors to comply with the requirements in the 2000 (or 2008) version of ISO 9001, which is more inclined toward the philosophy of TQM compared to the earlier ISO 9000 series standards (Martinez-Costa *et al*., 2009; Ho, 2000). The influence of TQM on the Hong Kong construction industry has been increasing and many Hong Kong contractors have started to adopt TQM principles for business improvements (Wong, 1999).

However, a review of the level of application of TQM principles in the construction industries of other countries indicates that levels vary. The Japanese construction industry introduced TQM in the 1970s, while the US and European construction industries began to develop interest in TQM in the late 1980s (Xiao & Proverbs 2001; Al-Sinan, 2004). In general, the level of application is relatively lower in developing than in developed countries, where clients continually demand enhancement in the overall value of their investments in construction projects. As in Hong Kong society generally, the development of quality systems in Hong Kong's construction industry has been strongly influenced by Chinese culture (Anthony *et al.,* 2002). Asian countries with a predominantly Chinese culture have started to adopt TQM for their construction projects under the global quest for quality, although the level of development varies with each country's specific statutory requirements and national policies. The following

paragraphs briefly describe the application of TQM in the construction industry in mainland China, Taiwan and Singapore in recent years.

Mainland China started adopting TQM in the construction industry back in the 1980s (Zeng *et al*., 2003). The Provisional Construction Supervision Ordinance in 1988 introduced the requirement for construction supervision (CS), which specifies particular supervision of the total quality elements of planning, progress, costs and quality of state-owned construction projects (Li, *et al*.,2004). Yusuf *et al*. (2007) suggested that the key success factors for TQM application by organisations in China are top management leadership, alignment with company's business objectives, customer satisfaction and communication and internal needs. Zeng *et al.* (2002, 2003) expressed similar key success factors in their construction quality specific papers.

Taiwan, which is considered to be more influenced by the US in terms of technology and management practices, has also practiced TQM in its construction industry since the late 1990s (Shieh & Wu, 2002). TQM application is considered an effective tool for maximising the alignment and integration of key customer satisfaction achievement factors. In this regard, it has been suggested that leadership ability and supplier management are the two most important elements (Chen & Chen, 2007; Kuo & Kuo, 2010).

Singapore developed a specific system, the Construction Quality Assessment System (CONQUAS), in 1989 to address its own quality problems (Low *et al.,* 1996). In the early 1990s, the Singaporean government made it mandatory for the larger construction and consultancy firms to achieve ISO 9000 certification by 1999 (Low and Hennie,

1997). The government issued the Construction 21 Review Committee's study report in 1999, in an attempt to raise the quality and competitiveness of the country's construction industry (Dulaimi *et al*., 2004). In this quality-demanding environment, many contractors adopted the application of TQM principles and Koh and Low (2010) reported a moderately high level of TQM application, particularly in areas of process management, customer management and top management leadership.

The review above provides a detailed summary of TQM and quality management in the construction industries in Hong Kong and some other countries. The main purpose of this paper is to investigate, through a comprehensive questionnaire, the level/progress of the application of TQM principles in the construction industry in Hong Kong, which should also reflect the achievements in terms of the improvements anticipated in the CIRC report. The survey and analysis of the results are described in the following sections. The major TQM elements that contractors need to focus on to achieve both short- and long-term sustainable businesses are also identified.

5A.2 Methodology

Further to the literature review, a survey questionnaire was designed for a full-scale survey. The questions were developed primarily from the management principles in BS7850 (BSI, 1992). Construction elements were integrated into the questions with reference made to the techniques and experiences documented in 'Construction Quality Management' (Tang *et al*., 2005).

In advance of the full-scale survey, a pilot set of questionnaires was sent to five practitioners in November 2010 to test the relevance of the questionnaire to the

application of TQM principles and elements in the construction industry, and the effectiveness and ease of understanding of the survey questions. This pilot study was also used to establish the relevance of the TQM elements identified in my literature review to each of the questions for a priority assessment based on the survey results. The questionnaire was then modified accordingly. The final questionnaire consisted of four parts. Part 1 collected the necessary information on the companies in which the respondents were working and the nature of the respondents' jobs. Part 2 (see Appendix 5A - A) focused on the respondents' familiarity with the elements of TQM. Part 3 (see Appendix 5A - B) was based on construction quality management principles while Part 4 (see Appendix 5A - C) was intended to obtain the respondents' views on whether the adoption of TQM principles was appropriate for achieving quality enhancement in the context of construction. The questionnaire was sent in May 2011 to professionals working in each of the 107 Group C contractors listed in the Development Bureau's contractor list, who were eligible to tender for government construction contracts of any value exceeding HK$75 million (US$1 = HK$7.8). Replies to the questionnaires were received during July and August 2011.

The data collected from the final survey were analysed using the Statistical Package for the Social Sciences (SPSS). Pearson's correlation analyses were conducted on the survey questions with respect to the scores given by the respondents. The correlations referred to in the analysis are items with significance at the 0.05 level or below (2-tailed). The relative level of TQM application for each part of the questionnaire was also analysed based on the average score for each question in that part.

5A.3. *Summary of key questionnaire survey results for Part 1 – Return rates and background of respondents*

Of 107 enquiries sent, 40 completed questionnaires were received, representing a return rate of 37.4%. The size of the organisations in which the respondents were working varied from 50 staff to more than 500 staff. More than half (55%) of the organisations had more than 500 employees.

	Building Construction	Civil Construction	Mixed Construction	Large size – more than 500 staff	Medium to small size – staff of 500 or less
Proportion. of organizations	7 (17.5%)	10 (25.0%)	23 (57.5%)	22 (55.0%)	18 (45.0%)

Figure 5A-1 – Business background of organizations to which respondents are attached

	Director	Project / Department Manager	Section Manager / Site Agent	Site Engineer	Foreman
Proportion. of respondents	0.8%	22.5%	40.0%	17.5%	12.5%

Figure 5A-2 – Background of individual responsibility of respondents

The 40 respondents worked for different contractors. These contractors were involved in building construction (17.5%), civil construction (25%) and a mixture of building and civil construction (57.5%). Figure 5A-1 shows the details of the basic business backgrounds of the surveyed organisations. The job responsibilities of the respondents ranged from senior engineers to project managers, as summarised in Figure 5A-2.

5A.4 *Summary of key questionnaire survey results for Part 2 – How familiar with TQM are Hong Kong construction contractors? (Full details of the survey results are included in Appendix 5A -A)*

The key results are presented in Figure 5A-3.

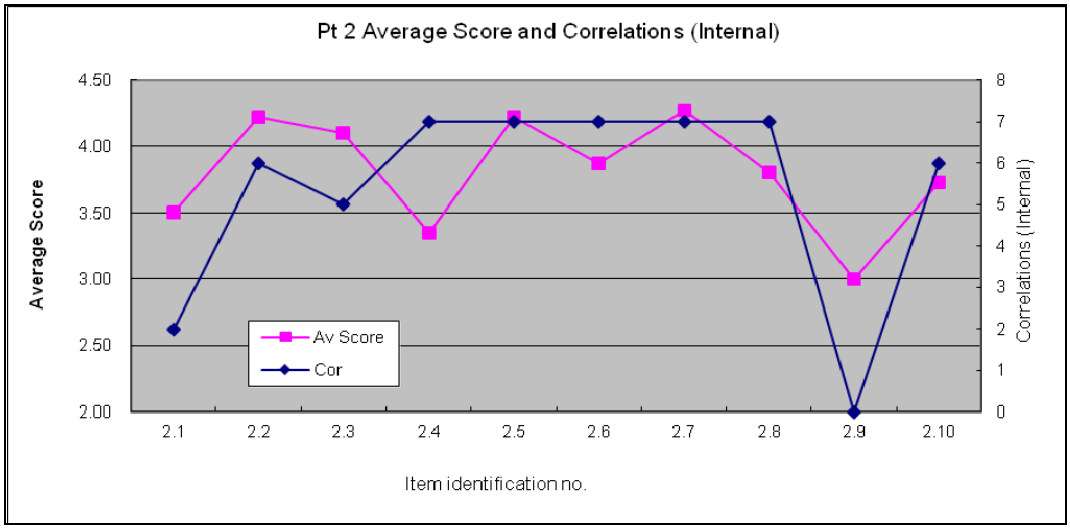

Figure 5A-3 – Questionnaire Part 2 Key Results (the maximum possible score is 5)

Observations on the results for Part 2

1. The key results for Part 2 are shown in Figure 5A-3. The highest scoring items are Item 2.7 – 'TQM tools', Item 2.2 – 'process control' and Item 2.5 – 'internal customer concept'. The lowest scoring items are Item 2.9 – 'TQM training' and Item 2.4 – 'quality control tools'. The implications of these scores are discussed in the following section.
2. With reference to the Pearson correlation results shown in Appendix 5A - A1, the high scores for Item 2.7 – 'TQM tools for improvements', Item 2.2 – 'process quality' and Item 2.5 – 'internal customer concept' are highly correlated with other TQM elements in the familiarisation survey. A high correlation coefficient for an item in a group implies that other items in the group may develop interactively if changes occur in that particular item. The correlation gives an indication that the familiarisation enhancement in any one of these three items may induce enhancement in the other items in that group.
3. The correlations between the respondents' scores shown in Figure 5A-3 also

indicate that low scores for Item 2.1 – ‘quality of management’ and Item 2.9 – ‘management training’, have little or no correlation with the other TQM elements in the familiarisation survey. The low correlation values for these two items imply that these items may develop independently if changes occur in other items in the group. The correlation gives an indication that the familiarisation enhancement for these two items may require specific input independent of the other items.

5A.5 *Discussion of the results for Part 2*

The respondents appear to be fully aware of the concept of internal customers in a supply chain. They generally agree that the adoption of TQM tools would enhance the overall quality management of the industry by means of continual improvement. The average score of 3.85 against a maximum of 5 indicates that the general level of application of TQM principles by most construction contractors is moderately high. It is apparent, however, that process quality still prevails over management quality for most contractors. The results indicate weak application of the specific TQM tools by contractors, despite most contractors agreeing that the TQM tools themselves are suitable for improving quality management. The provision of long-term management training is also weak, reflecting that management training for staff is still a low priority for many contractors.

The results show high or moderate correlations between most of the items in this part of the questionnaire, with the exception of the items concerning management quality and management training. The relatively low correlation values for these two items indicate

that they may develop independently if changes occur in other items in the group. It is also possible that the familiarisation enhancement for these two items may require specific input, independent of the other items.

The relevant TQM element(s) for each question (out of the eight possible elements, a to h) have been discussed in the with the five contractor practitioners in the pilot questionnaire study and a matrix table is established (Appendix 5A - D). Each of the TQM elements was assigned a sub-score, calculated as the ratio of the actual score for the question to the maximum possible score (i.e. 5). The sub-scores for every relevant TQM element in Part 2 of the questionnaire were summed to establish the relative level of application for that particular TQM element. As an example, the TQM element "continual improvement" is associated with Items 2.3, 2.4, 2.7 and 2.8 of Part 2, and the respondents' average scores for these items are 4.100, 3.350, 4.275 and 3.800 respectively. The respective maximum score ratios for Items 2.4, 2.5, 2.7 and 2.8 then become 0.82 (4.1/5), 0.67 (3.35/5), 0.855 (4.275/5) and 0.76 (3.8/5), respectively, and the sub-score for the continual improvement element becomes 0.7763 (the sum of 0.82 + 0.67 + 0.855 + 0.76 divided by 4). A high sub-score indicates that respondents had a high level of familiarity with a TQM element. This mapping process reveals that the contractors were most familiar with the element 'Process management'. Such a result is not unexpected as the new ISO 9001 requirements focus on the process approach. The second and third elements most familiar to the contractors were 'Top management & leadership' and 'Continual improvement', respectively, which are also the two other main focuses of the new ISO 9001 standard.

5A. 6 ***Summary of key results for Part 3 - What actions need to be taken to improve quality in the Hong Kong construction industry?*** *(Full details of the survey results are included in Appendix 5A -B)*

The key results are presented in Figure 5A-4.

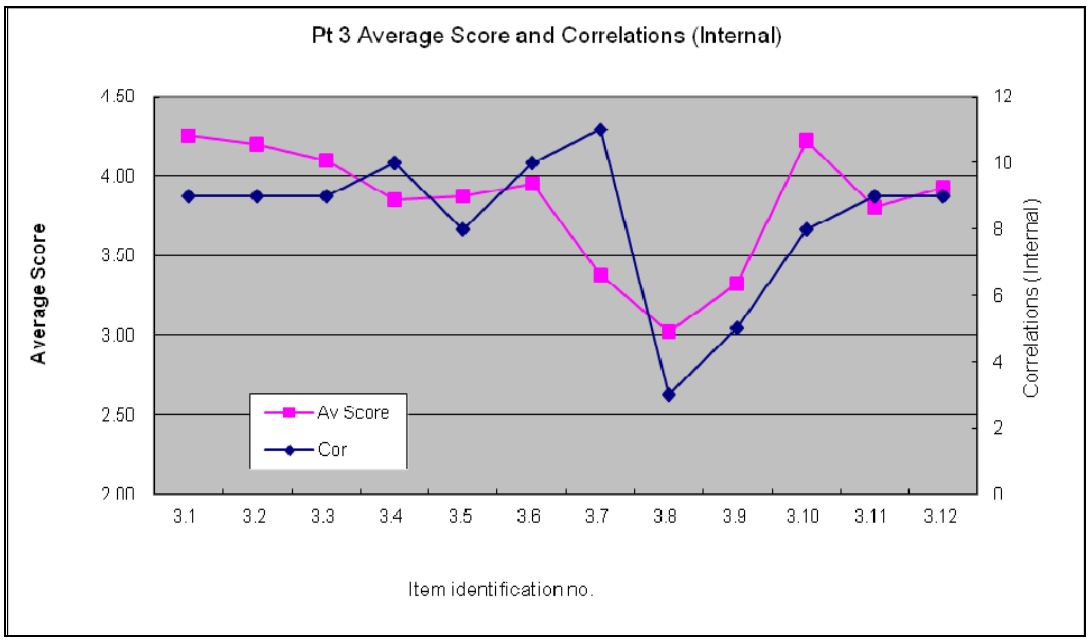

Figure 5A-4 – Questionnaire Part 3 Key Results (the maximum possible score is 5)

Observations on the results for Part 3

1. The key results for Part 3 are shown in Figure 5A-4. The highest scoring items are Item 3.1 – 'frequent fire fighting scenario', Item 3.10 – 'defects and mistakes arising from ambitious cost and time targets', and Item 3.2 – 'low familiarisation with the company core values'. The score for Item 3.8 – 'mistakes due to misinterpretation of given information' is obviously low. The implications of these scores are discussed in the next section.
2. With reference to the Pearson correlation analysis results for Part 3 which is similar to Appendix 5A - A1 for Part 2, the respondents' score patterns indicate that high scores for Item 3.1. – 'fire fighting frequency', Item 3.10 – 'mistakes

caused by taking risks consciously' and Item 3.2 – 'not remembering the company core values' are strongly correlated with the great majority of the TQM elements in Part 3 (actions needed) of the survey.

3. The results also show that the low-scoring Item 3.8 – 'mistakes caused by misinterpretation of information' has a low correlation with the other TQM elements.

5A. 7 *Discussion on the results for Part 3*

The survey results show that fire-fighting scenarios still frequently occur, despite process control being emphasised in the commonly adopted ISO 9001 quality management standard. Top management leadership and process management are the suggested TQM elements for reducing fire-fighting scenarios. Subcontractors often consciously accept high risks in costs and construction time due to extreme competition. The effects of such unhealthy practices could possibly be reduced by appropriate supplier management, including prudent procurement procedures. A further weakness identified is the internal communication within a contractor's organisation. The top management should continually take the lead in emphasising the company's core values and reminding staff of the company policies at appropriate times and frequency.

The correlation analysis shows high correlations between 11 of the 12 items in this part of the questionnaire, with the exception of Item 3.8 – 'mistakes being made due to misinterpreted or outdated information'. The low correlation value for the misinterpretation item implies that this item may develop independently if changes occur in other items in the group. As an example, an increase in the average score for a group

of respondents in agreeing that non-conformance is often due to contractors misinterpreting information may not increase the average score of the same respondents in agreeing that most staff cannot remember the cores values of the company (Item 3.2).

Mapping of the survey results to the eight TQM elements in a manner similar to the Part 2 questionnaire results reveals that contractors need Top Management & Leadership most. This result is in line with the recommendation cluster proposed by the CIRC for a knowledgeable and involved client. The other two highly ranked TQM elements are Supplier Management and Customer Management. The mapping results indicate that greater focus on Top Management & Leadership, Supplier Management and Customer Management is required to satisfy the short-term needs of the industry. The mapping details are presented in Appendix 5A - D.

5A.8 ***Summary of key results for Part 4 – Is the adoption of TQM principles appropriate for achieving quality enhancement?*** *(Full details of the survey results are included in Appendix 5A - C)*

The key results are presented in Figure 5A-5.

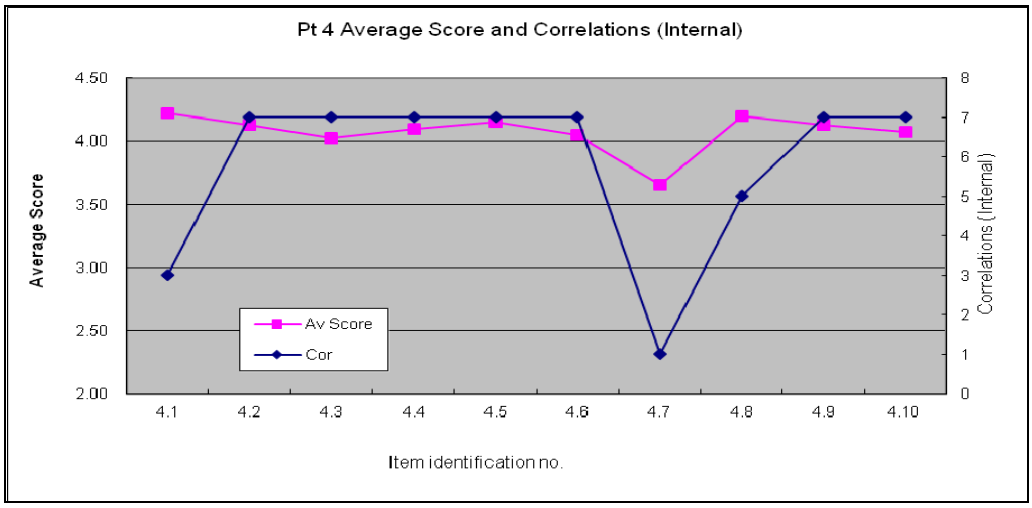

Figure 5A-5 – Questionnaire Part 4 Key Results (the maximum possible score is 5)

Observations on the results for Part 4

1. The key results for Part 4 are shown in Figure 5A-5. The highest scoring items are Item 4.1 – 'realistic construction period', Item 4.8 – 'life time learning', and Item 4.5 – 'reliable supply chain'. Item 4.7 – 'stop work decision by frontline team leaders' has the lowest scores. The implications of these scores are discussed in the following section.
2. With reference to the Pearson correlation analysis results (not shown due to space limitations), the respondents' score patterns indicate that high scores for Item 4.1 – 'realistic construction period', Item 4.8 – 'life time learning' and Item 4.5 – 'reliable supply chain' are generally correlated with the other TQM elements in Part 4, concerning appropriateness.
3. Respondents' scores for the various items in Part 4 range from 3.65 to 4.225. The overall scores are relatively high and the range is narrow compared to those for parts 2 and 3, indicating that all of the items in this part are quite appropriate for achieving quality enhancement for contractors.
4. The score pattern of the respondents indicates a low correlation between Item 4.7 – 'stop work support' and the other TQM elements.

5A.9 *Discussion on the results for Part 4*

The results highlight the appropriateness of realistic programming, continual learning and a reliable supply chain for enhancing quality in the construction business. A realistic construction period is a major prerequisite for a healthy construction contract. When such a contract is supported by continual learning and a reliable supply chain, the

likelihood of achieving success is high. Although the results indicate that the delegation of stop work decisions to frontline staff is not adopted in all organisations, the average score of 3.65 out of a maximum of 5 clearly indicates that some delegation has been exercised.

The correlation analysis shows that most items in this part of the questionnaire are highly correlated with the exception of the item relating to stop work decision delegation. The low correlation value for the stop work decision delegation item implies that this item may develop independently if changes occur in other items in the group. For example, if the average score for 'stop work decision delegation' were to increase, the average scores for other items in the same questionnaire set (e.g. Item 4.5 – reliable supply chain) may not increase.

Mapping the survey results to the eight TQM elements in a manner similar to the Part 2 and Part 3 questionnaire results reveals that contractors consider 'organisational learning' to be the most appropriate element for long-term quality development. This result is to be expected, as most recent reports on industry reforms recommend a culture change in the construction industry, in which continual learning is one of the crucial elements. The next two highest-ranking TQM elements are 'supplier management' and 'continual improvement', both of which are key components of typical long-term business strategies. The mapping details are presented in Appendix 5A - D.

5A. 10 Conclusion

The spirit of the government-commissioned CIRC report supports the investment of resources for the improvement of the Hong Kong construction industry through changes

in the quality culture. The improvement measures recommended by the CIRC in 2001 cover the majority of the TQM principles. Therefore, the level of application of the TQM principles in the construction industry provides an indication of the progressive achievement of the CIRC's intended improvements. The average score of 3.85 against a maximum of 5 in the questionnaire survey indicates that the existing level of application of TQM principles by most construction contractors in Hong Kong is moderately high, reflecting a moderately high achievement of the CIRC's intended improvements.

Apart from the TQM application levels (Part 2), the survey results also provide an indication of the most-needed short-term TQM elements (Part 3) and the most-needed long-term TQM elements (Part 4). An overall summary of these is presented below.

Most familiar TQM elements – Referring to priority rating developed in Appendix 5A – D (Ctr – Part 2)	Process Management
	Top Management Leadership
	Continual Improvement
Most needed Quality Management elements (Short term needs) – Referring to priority rating developed in Appendix 5A – D (Ctr – Part 3)	Top Management Leadership
	Supplier Management
	Customer Management
Most appropriate TQM elements for construction (Sustain long term business) – Referring to priority rating developed in Appendix 5A – D (Ctr – Part 4)	Organizational Learning (Internal error detection & correction and strategy for acquiring & applying up to-date external knowledge)
	Supplier Management
	Continual Improvement

The level of TQM application by the Hong Kong contractors is similar to that reported for contractors in Singapore, who also have the highest degree of application in process management. The level of TQM application in construction in mainland China and Taiwan is uncertain due to the limited international literature. There also appears to be a

lack of comprehensive structured assessment systems, such as CONQUAS in Singapore or PASS in Hong Kong, to provide a baseline for continual improvement and other TQM elements in these two Chinese-dominated political entities.

The findings further suggest that in Hong Kong, organisational learning and supplier management are the two major TQM principles that construction contractors should focus on to sustain their long-term business. The experience of Hong Kong should be of interest to other developing and developed countries, both regionally and globally, in search of a similar paradigm for raising their quality culture.

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Chapter 5 – Part B

Second Survey - TQM application by construction related organizations in Hong Kong

Part B – Report on survey for Engineering Consultants in Hong Kong

5B.1 Introduction

The construction sector is generally not a coherent entity, and the causes of its fragmentation are deeply rooted (Rabeneck, 2008). Fragmentation, which takes the form of an individual participant pursuing singular interests on a project, has a substantial hindering effect on the quality of the construction engineering industry, where the pace of improvement is considered to lag behind that of other industries (McCrary *et al*., 2006).

The technical quality of engineering consultant services comprises of accuracy of the buildability, cost effectiveness and accuracy of design details, (Burati et *al.* 1992; Stukhart 1987). The overall quality of service provided by engineering consultants is a function of the quality of the engineering design output, the procedures and timeliness of the service provided, and the quality of the manner shown to customers (Tang *et al.*, 2003). In engineering services, customers are highly concerned with the way that they are treated during service delivery. The successful integration of technical and interpersonal aspects ensures

the quality of engineering consultancy (Culp *et al*., 1993). Leong *et al.* (2012) further supported this integrative approach in striving for quality management excellence. Quality in construction and engineering also requires leadership and professional ethics (Abdul-Rahman *et al*. 2014). Amongst other commercial benefits, the effective application of TQM will streamline response to legal issues including professional indemnity which is typically a major risk for engineering consultants (Botha 2012; Chan 2012).

In 1990, the Hong Kong government launched a "quality awareness campaign" and the Hong Kong Housing Authority (HKHA) identified the need for a formal set of design and construction procedures and associated quality management systems for industry professionals (Kam and Tang, 1997; Tang *et al.*, 2005). In 1996, the Works Bureau required all engineering, architectural and associated consultants to be ISO 9001 certified (Tang *et al.*, 2005). Other public clients followed suit by adding similar ISO 9001 certification requirements to their procurement documents for design and construction service contracts (Tang and Lau, 2009).

The increase in the shortcomings of the industry's operations reported in the late 1990s drove the government and industry stakeholders to make further reforms and achieve total quality and excellence (HKHA, 2001). Tang and Kam

(1999) report that the quality improvement experienced by engineering consultants after the ISO 9001 implementation was below their own expectations. In 2000, the Government of the Hong Kong Special Administration Region commissioned the Construction Industry Review Committee (CIRC) to review the quality and performance of the entire construction industry (CIRC, 2001). The review report recommends improvements in the areas of product quality, efficiency, productivity, site safety, environmental sustainability and customer satisfaction for all stakeholders in the construction and engineering industry. Many of recommended improvement measures are related to total quality management (TQM) principles. It was reported that 84 of the 109 items had been fulfilled (The Standard Supplement, 11 March 2011, Page 19) and all remaining items were in good progress. While the progress of implementation appeared to be satisfactory, the author of this paper is not aware of any report published on the progressive achievements of the intended improvements or the corresponding application of TQM principles by the engineering consultants. This study investigates the extent to which TQM principles are applied by Hong Kong engineering consultants through a literature review and survey. The main TQM elements that engineering consultants should focus to achieve both short- and long-term sustainable business are also identified based on an analysis of the

survey results.

5B.2 TQM principles reflected in the CIRC review report

The CIRC review report echoes other national construction reform reports published within the last 15 years in other countries. In South Africa, the document “White Paper: Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry” (Department of Public Works 1999) proposes reinforcing programs to develop a stable delivery environment, enhance industry performance, enable human-resource development strategies, promote new industry capacity and develop the public sector as the cornerstone of the improvement strategy. The Egan report (1998) in the U.K. and the Building for Growth report (1999) in Australia similarly recommend construction industry improvements in the areas of team and process integration, committed leadership, commitment to people and customers, technology innovation, sustainable environments and best practice regulatory environments. The Construction 21 Review Committee’s study (1999) of Chinese cultural dominance over Singapore proposes six strategic focuses on improvement, including enhancing professionalism, raising skill levels, improving industry practices and techniques, adopting an integrated approach to construction, establishing a collective championing effort for the construction industry and

developing an external wing (i.e., internationalization). All of these reports attempt to address the performance issues in the construction industry and urge quality improvement to achieve excellence.

In Hong Kong, the CIRC review report identifies problems and weaknesses in the stakeholders of the construction and engineering supply chain. Design and engineering issues are discussed in many sections of the report. A list of areas related to the activities of engineering consultants that require improvement is given as follows:

i. improvement of buildability;
ii. improvement of design planning with due consideration of the time required for design and construction;
iii. improvement of onsite engineering supervision;
iv. better understanding of client and end user requirements;
v. increased focus on integrated input from different design disciplines at the outset of a design project;
vi. more effective communication with the site project team during both the design and construction stages;
vii. more effective communication with clients, including timely reporting and notification of design and site engineering issues; and

viii. increased awareness of the costs of construction plants and temporary materials during design.

In 2001, the CIRC assembled 109 recommendations under the following themes/strategic thrusts (CIRC, 2001): (1) fostering a quality culture; (2) achieving value in construction and engineering procurement; (3) nurturing a professional workforce; (4) developing an efficient, innovative and productive industry; (5) improving safety and environmental performance; (6) devising a new institutional framework for implementing the change program and (7) monitoring the progress of the change program. “Developing an efficient, innovative and productive industry” and “fostering a quality culture” are the two major themes for the construction industry in general, and consist of nine and seven sub-items, respectively (see Figure 5B-1 on pages 5B-8 to 5B-10).

The application of “total quality product” and “total system control” is highlighted in numerous sections of the report, which also evidently conveys the spirit of total quality management (TQM). TQM is defined as a management philosophy and company practices that aim to harness the human and material resources of an organization in the most effective way to achieve the organization’s objectives (BSI, 1992). TQM comprises a set of systematic activities carried out by the entire organization to effectively and efficiently achieve its objectives and thereby

provide products and services at a level of quality that satisfies customers and at the appropriate time and price (Union of Japanese Scientists and Engineers, 2011; Iruobe *et al*., 2012).

In parallel with the implementation of the CIRC recommendations, the Works Bureau required all construction and engineering organizations to be certified according to the 2000 version of ISO 9001 as of December 2003. Compared with its 1994 version (and the 1987 version), this version of ISO 9001 focuses on customer satisfaction, resource management, management responsibility, continual improvement and process approaches (Thermo Fisher Scientific, 2002). The 2000 version requires organizations to provide evidence of measurable improvements in their business processes and levels of customer satisfaction (Graham, 2002). Ho (2000) and Martinez-Costa *et al*. (2009) also recognize that the requirements of the 2000 (or 2008) version of ISO 9001 are more inclined toward the philosophy of TQM than the earlier ISO 9000 series standards. The 2000 version of ISO 9001 represents a big step forward in terms of quality management, as it includes some of the TQM elements that are absent from the 1994 (or 1987) version. The 2008 version is quite similar to the 2000 version; the former explains the ambiguities contained in the latter.

With the reference in the CIRC report to the basic TQM concept and engineering consultants' adoption of the ISO 9001 (2000 version or later) quality management system, it is apparent that the seven main themes of the improvement measures generally match the following eight construction engineering specific TQM elements (Culp *et al*., 1993; Ezeldin and Abu-Ghazala, 2007; Koh and Low, 2008): (a) process management; (b) customer management; (c) top management leadership; (d) supplier management (in the context of engineering consultancy, suppliers include outsourced engineering and drafting resources, external resources providing design briefs prior to design commencement and the specialist providing design and interface requirements); (e) people management; (f) continual improvement; (g) organizational learning (error detection and correction, lesson learning, updating of knowledge and application techniques) and (h) quality information management.

The TQM elements corresponding to the CIRC main themes are presented as follows.

CIRC report main theme	Theme sub-items	Corresponding TQM element related to design and engineering activities
(1) Foster a quality culture	I A knowledgeable and involved client	Top management leadership (c)
	II. Importance of the planning and design stages	Process management (a)
	III. Realistic project	Process management (a)

	programming	
	IV. Clear accountability	Supplier management (d)
	V. Subcontracting	Supplier management (d)
	VI. Site supervision and quality assurance	Continual improvement and quality information management (f and h)
	VII. Raising the quality standards of renovation contractors and decorators	Top management leadership (c)
(2) Achieving value in engineering procurement		Customer management (b)
(3) Nurturing a professional workforce		People management and organizational learning (e and g)
(4) An efficient, innovative and productive industry	I. Process re-engineering to achieve better integration	Process management (a)
	II. Wider use of standardization in component design and processes	Process management (a)
	III. Wider use of prefabrication	Process management (a)
	IV. Wider application of information technology (IT) in project implementation	Quality information management (h)
	V. Investment in engineering -related R&D	Continual improvement and customer management (h and b)
	VI. Facilitating regulators	Process management (f)
	VII. More reliable records of underground utilities	Process management (f)
	VIII. Lowering the cost of ready-mixed concrete	Supplier management and top management leadership (d and a)
	IX. Export potential of the construction industry	Customer management and top management leadership (b and a)
(5) A safer workplace and an environmentally responsible industry		Top management leadership and process management (a and f)
(6) Institutional framework for implementing the change		Top management leadership

program	(a)
(7) Review of implementation progress of the change program	Quality information management and continual improvement (e and h)

Figure 5B-1 – CIRC recommendations compared against TQM elements

As explained previously, both the CIRC recommendations and the requirements in the 2000 (or 2008) version of ISO 9001 align with the philosophy of TQM and thus contain many TQM elements. In this local and global quality-demanding environment, many Hong Kong construction and engineering companies have started to adopt TQM principles to make business improvements (Wong, 1999). Since the high-profile implementation of the CIRC recommendation by the construction and engineering supply chain in 2001 (The Standard Supplement, 2011) and engineering consultants' mandatory ISO 9001: 2000 certification in 2003, both of which contain TQM elements, no report has yet been published on the subsequent application of TQM principles by Hong Kong engineering consultants.

The main purpose of this paper is to investigate, through a comprehensive survey, the extent to which TQM principles are applied by engineering consultants in Hong Kong. The survey and analysis of the results are described in the following sections. The main TQM elements that engineering consultants should focus to achieve both short- and long-term sustainable business are also identified.

5B.3 Methodology

A full-scale survey was designed. The questions were developed primarily from the management principles in BS7850 (1992). Design and engineering elements were integrated into the questions, with reference made to the techniques and experiences mentioned in “Construction Quality Management” by Tang *et al*. (2005). The survey forms the core of the investigation, and was tailored to the specific quality of the culture of the Hong Kong engineering consultant industry, which consists of both local Hong Kong organizations and Hong Kong-based international organizations.

A pilot set of questionnaires was sent to five practitioners in January 2011 to test the relevance of the full-scale survey to the application of TQM principles and construction engineering industry elements, and to determine the effectiveness and ease of understanding of the survey questions. This pilot study was also used to establish the relevance of the TQM elements identified in my literature review to each of the questions for a priority assessment based on the survey results. The survey questionnaire was then modified accordingly, and the final version consisted of four parts. Part 1 collected the necessary information related to the companies at which the respondents were working and the nature of the respondents’ jobs. Part 2 (see Appendix 5B-A) focused on the respondents’

familiarity with TQM, reflecting the extent to which TQM principles were applied by engineering consultants. Part 3 (see Appendix 5B-B) was based on the design and engineering quality management principles applied to obtain immediate and short-term quality improvements. Part 4 (see Appendix 5B-C) sought the respondents' views on whether the adoption of TQM principles was appropriate for achieving long-term quality enhancement in the context of design and engineering activities. The final form of the survey was completed in May 2011 and sent to professionals working for architectural and civil engineering consultants approved by the Architectural Services Department (ASD, 2011) for tendering for structural and architectural service packages. In addition, surveys were sent to professionals working for member consultants of the Association of Consulting Engineers of Hong Kong (ACEHK, 2011) that were not on the ASD-approved consultant list. The last of the survey replies was received in January 2012.

The score scale adopted in the questionnaire was based on a 5-point Likert System (Hayes, 1998). This means that if a respondent agreed to a great extent to a question, s/he would get 5 scores, The data collected from the survey were analyzed using the Statistical Package for the Social Sciences (SPSS). Pearson's correlation analyses were conducted on the survey questions in terms of the scores

given by the respondents. The correlations referred to in the analysis are items with significance at the 0.05 level or below (2-tailed). The relative level of TQM principle application for each part of the survey was also analyzed based on the average score for each question in that part.

5B.4 *Summary of key questionnaire survey results for Part 1 – Return rates and background of the respondents*

Of 74 enquiries, 35 completed surveys were received, representing a return rate of 47.3%. The size of the organizations at which the respondents were working varied from 30 to more than 200 staff members. Of these organizations, more than one third (35.7%) had more than 200 employees.

	Architectural design and engineering	Civil design and engineering	Mixed architectural and civil engineering	Large size – more than 100 staff members	Medium to small size – staff of 100 employees or less
Proportion of organizations	48.6%	17.1%	34.3%	35.7%	65.3%

Figure 5B-2 – Business background of the organizations to which the respondents were attached

	Director	Design/technical manager	Resident engineer/senior engineer	Design engineer	Technician/ inspector
Proportion of respondents	8.6%	22.9%	45.7%	14.3%	8.6%

Figure 5B-3 – Individual responsibilities of the respondents

The 35 respondents worked for different engineering consultants, and were engaged in architectural design and engineering (48.6%), civil design and engineering (17.1%) and a mixture of architectural and civil design and engineering (34.3%) work. Figure 5B-2 shows the details of the basic business background of the surveyed organizations. The job responsibilities of the respondents ranged from technician to director, as summarized in Figure 5B-3.

5B.5 *Summary of the key survey results for Part 2 – How familiar are Hong Kong engineering consultants with TQM?* *(Full details of the survey results are included in Appendix 5B- A.)*

The key results are presented in Figure 5B-4.

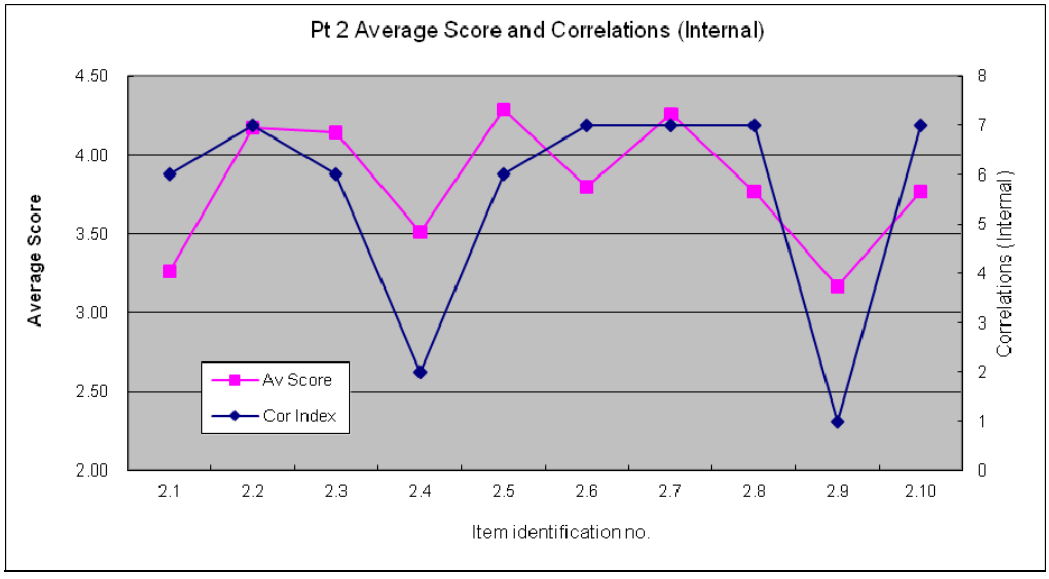

Figure 5B-4 – Key Results for Part 2 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 2

1. The key results for Part 2 are shown in Figure 5B-4. The high scoring items are Item 2.5 (concept of the internal customer), Item 2.7 (knowledge refreshment and experience sharing) and Item 2.2 (process management). The two lowest scoring items are Item 2.9 (employer-organized training) and Item 2.1 (quality of management). The score implications of these items are discussed in the next section.
2. The Pearson correlation analysis results for the respondents' average score pattern (see Appendix 5B-A1) are also presented in Figure 5B-4. Eight of the ten Part 2 items have correlation indices of 6 or above, suggesting that these eight items are highly correlated with each other. The high correlation of an item with other items in a group implies that the other items in the group may develop interactively if changes were to occur in that particular item. As an example, Item 2.7 is highly correlated with seven other items in Part 2 of the survey. When changes to the quality system cause an increase in the average score for Item 2.7, the average scores of the other seven co-related items may also increase as a result.
3. The Pearson correlation analysis also indicates that Item 2.9 (employer-organized training) and Item 2.4 (application of process control

tools) have low correlation indices. This implies that these two items may develop independently if changes were to occur in any other Part 2 item.

5B.6 *Discussion of the survey results for Part 2*

The average score results for Part 2 indicate a high degree of agreement that the concept of internal customer satisfaction, one of the TQM characteristics, is an acceptable criterion for achieving final engineering quality. The score results also show that knowledge refreshment and experience sharing are means of continual improvement. The score results further indicate that engineering consultants are placing more emphasis on process quality than on management technique, as shown in Items 2.2 and 2.1 of Appendix 5B-A, respectively.

The lowest score for Item 2.9 indicates that long-term investment in management training, including value engineering and risk management training, for employees by engineering consultants is lagging behind other TQM familiarization items. Item 2.1 (quality of management) has the second lowest score. These low scores are probably a result of the high percentage of qualified professionals in the engineering consultancy industry. As required by many professional institutions, these professionals must organize their own management and technical training as part of their continual personal development (CPD) progress, which may duplicate the training that employers may have considered.

The overall indication of familiarization with TQM is positive, as the average score is 3.81 and ranges from 3.17 to 4.29 out of 5.0. This reflects that TQM principles are applied by engineering consultants in Hong Kong to a moderately high extent.

The correlation analysis shows that eight of the ten items in this part of the questionnaire are highly correlated. This high correlation indicates that the familiarization improvement in any one of the eight items may induce familiarization improvement in the other items of the highly correlated group. The high percentage of correlated items may result from the respondents' similar level of knowledge of the TQM concept and its application, or because most of the respondents share a similar level of appreciation and acceptance for TQM.

Item 2.9 (employer-provided management training) and Item 2.4 (application of process control tools) show very low correlation indices. The average scores for these two items are comparatively low, and improvement measurement should be given a higher priority. These two items indicate that familiarization improvement in these areas may require specific effort in addition to the general improvement efforts required for the other Part 2 items.

The relevant TOM elements, out of (a) to (h), for each question have been discussed with the five engineering consultant practitioners in the pilot

questionnaire study and a matrix is established, the details of which are presented in Appendix 5B-D. Each of these TQM element(s) is assigned a sub-score, calculated as the average ratio of the actual score of the question to the maximum possible score (i.e., 5). The sub-scores for each relevant TQM element are added up to establish the relative level of application of that particular TQM element. As an example, the TQM element "continual improvement" is associated with Items 2.4, 2.5, 2.7 and 2.8 of Part 2, and the respondents' average scores for these items are 4.14, 3.51, 4.26 and 3.77, respectively. The respective maximum score ratios for Items 2.4, 2.5, 2.7 and 2.8 then become 0.8286 (4.14/5), 0.7029 (3.51/5), 0.8514 (4.26/5) and 0.7546 (3.77/5), respectively, and the sub-score for the continual improvement element becomes 0.7843 (the sum of 0.8286 + 0.7029 + 0.8514 + 0.7546 divided by 4). A high sub-score represents the respondents' high level of familiarization with a TQM element. The result of this mapping process reveals that the engineering consultants are most familiar with the "process management" element. This result is expected, as one of the main themes of the CIRC's improvement recommendations is to develop an efficient and productive industry. The second and third most familiar elements are "top management and leadership" and "continual improvement," respectively, which are in line with the main theme of "fostering a quality culture" in the CIRC recommendation package.

5B.7 ***Summary of the key survey results for Part 3 - What actions must be taken to improve the quality of the Hong Kong construction engineering industry?*** *(Full details of the survey results are included in Appendix 5B-B.)*

The key results are presented in Figure 5B-5.

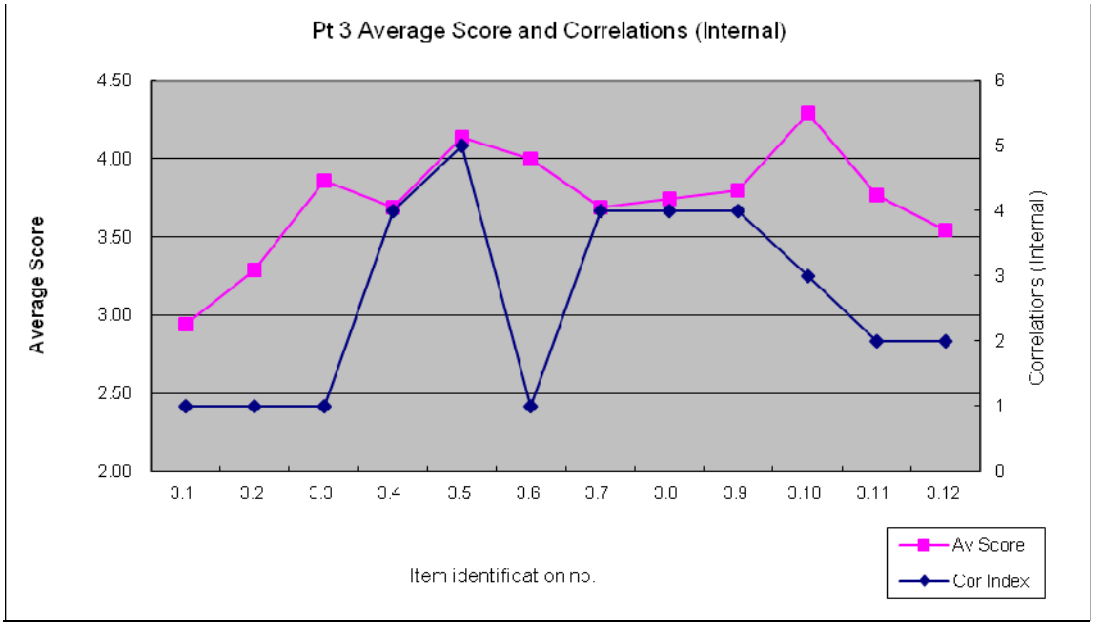

Figure 5B-5 – Key Results for Part 3 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 3

1. The Part 3 key results are shown in Figure 5B-5. The high scoring items are Item 3.10 (TQM tools supplementing the current quality assurance systems), Item 3.5 (frequent fire-fighting scenarios) and Item 3.6 (design approach and design program kick-off meetings). The two lowest scoring items are Item 3.1 (misinterpretation as the cause of design mistakes) and

Item 3.2 (negligence and uncertainties as the causes of design mistakes). The score implications of these items are discussed in the next section.

2. With reference to the Pearson correlation analysis of the average score pattern of the respondents in Appendix 5B-B1, a summary of the analysis result is also presented in Figure 5B-5. The Pearson correlation analysis shows that 6 of the 12 items in Part 3 of the survey are moderately correlated with the other items in Part 3, with correlation indices ranging from 3 to 5. Based on the characteristics of the Pearson correlations, each of these moderately correlated items is expected to develop interactively if changes occur within the group of these six items.
3. The Pearson correlation analysis indicates that the remaining six items in Part 3 have low correlation indices ranging from 1 to 2. The low correlation indices for these items imply that such items may develop independently if changes occur in any other of the items in Part 3.

5B.8 *Discussion of the questionnaire survey results for Part 3*

The Part 3 results indicate a high degree of agreement that TQM tools can supplement current quality assurance systems to ensure the continual improvement of design timeliness and efficiency. The need to decrease the number of fire-fighting scenarios (response to emergency occurrences) in the

management of engineering projects is important for improving overall design quality. The systematic co-ordination between general and specialist teams before design commencement is also essential to achieve the lowest project life costs and the highest customer satisfaction.

The relatively low scoring items are Item 3.1 (misinterpretation as the cause of making design mistakes) and Item 3.2 (negligence or uncertainties as the causes of making design mistakes). It appears that many respondents disagreed that mistakes can be caused by the misinterpretation of obtained information or by improper judgment during the selection of available information. The respondents might have believed that their professional training and experience provided them with the appropriate tools to prevent them from making mistakes when dealing with the use of information.

The correlation analysis results show that six of the twelve items in this part of the survey are moderately correlated. This moderate correlation suggests that improvement in the application of TQM principles in any one of these six items may induce similar improvements in the other items of the moderately correlated group. The percentage of correlated items is not as high as that in Part 2 of the survey. Although the respondents themselves generally agreed that TQM tools could supplement current quality assurance systems and ensure continual

improvement, the respondents' organizations might have adopted different quality management strategies.

The same analysis also shows that the remaining six items are poorly correlated with the other items. This poor correlation suggests that changes in the improvement of the application of TQM principles for other items are unlikely to improve the application for these items. To contribute to the overall improvement in the application of TQM principles, each of these six items would require specific improvement changes implemented in parallel with the general improvement changes in the other six items in Part 3.

Mapping the survey results to the eight TQM elements in a manner similar to that used to map the Part 2 results (see Appendix 5B-D) reveals that engineering consultants require continual improvement above all. This is in line with the recommendation cluster proposed in the CIRC report for achieving value in engineering and construction procurement. The other two highly ranked TQM elements are "top management and leadership" and "customer management," which also form the basis of the CIRC improvement recommendations shown in Figure 5B-1. In the context of the design-related activities of engineering consultants, suppliers are those who provide design briefs before the commencement of a design, and are specialists providing design and interface

requirements. Suppliers are also outsourced parties providing the drafting and component design deliverables. The overall mapping result indicates that more focus on continual improvement, top management leadership, and supplier management is required to satisfy the short-term needs of the construction engineering industry in terms of engineering design for current and scheduled projects.

5B.9 ***Summary of the key survey results for Part 4 - Is the adoption of TQM principles appropriate for achieving quality enhancement for engineering consultants?*** *(Full details of the survey results are included in Appendix 5B-C.)*

The key results are presented in Figure 5B-6.

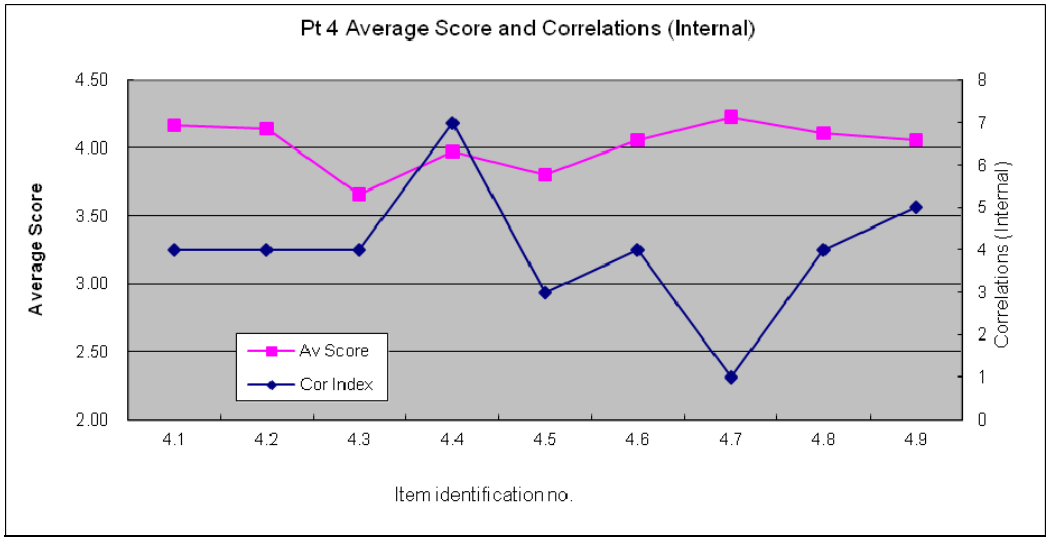

Figure 5B-6 – Key Results for Part 4 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 4

1. The key results for Part 4 are shown in Figure 5B-6. The three highest scoring items are Item 4.7 (long-term training in quality management and engineering skill), Item 4.1 (realistic design period) and Item 4.2 (including design output quality considerations when awarding engineering design contracts). The lowest two scoring items are Item 4.3 (project risk sharing) and Item 4.5 (free flow of opinion within the organization). The score implications of these items are discussed in the next section.
2. A summary of the results of the Pearson correlation analysis of the respondents' average score pattern is presented in Figure 5B-6. The Pearson correlation analysis shows that eight of the nine items in Part 3 are moderately to highly correlated with each other, with correlation indices ranging from 3 to 7. Based on the characteristics of the Pearson correlations, each of these eight items is expected to develop interactively if any change occurs within the group of moderately to highly correlated items.
3. Pearson correlation analysis indicates that Item 4.7 (long-term training in quality management and engineering skill) has a very low correlation

index of 1, implying that this item may develop independently if changes occur in the other items in Part 4.

5B.10 ***Discussion of the survey results for Part 4***

The Part 4 results indicate a high degree of agreement that the adoption of long-term training in both quality management and engineering skills should be adopted to achieve engineering design excellence. The results also indicate that the establishment of realistic design durations is essential for achieving quality improvement, and that engineering consultants should maintain a balanced focus on design output clarity, project buildability and design cost effectiveness to sustain high design quality.

The relatively low scoring items are Item 4.3 (project risk sharing) and Item 4.5 (free flow of opinion within the organization). Although their respective scores of 3.66 and 3.80 are relatively lower than those of the other items, such scores are not low when compared with the highest possible score of 5. It nevertheless appears that these two items are appropriate for sustaining long-term quality enhancement.

The correlation analysis results indicate that eight of the nine items in Part 4 are moderately to highly correlated. This high percentage of correlated items could be explained by the consistency of the respondents' positive attitude toward

TQM as an appropriate philosophy for achieving a sustainable quality improvement, which is reflected in the results for Parts 2 and 3.

The correlation index of Item 4.7 is 1, indicating a poor correlation with the other items in Part 4. This poor correlation suggests that changes in design quality improvement for the other items are unlikely to improve the design quality for this item. Contributing to overall design quality improvement would require specific improvement changes implemented in parallel with general improvement changes in the other items of Part 4.

Mapping the survey results to the eight TQM elements in a manner similar to that used to map the results for Parts 2 and 3 (see Appendix 5B-D) reveals that engineering consultants consider organizational learning to be the most appropriate element for sustaining long-term quality development. This result is expected, as many recent industry reform reports recommend a cultural change in the construction engineering industry, of which continual learning in an organization is a crucial element. The next two highly ranked TQM elements are “people management” and “continual improvement,” both of which are key components of typical long-term strategies.

5B.11 Conclusion

The full-scale implementation of the CIRC report's 109 improvement recommendations initiated the transformation of quality culture in the Hong Kong construction engineering industry, such that the previous quality assurance culture has gradually been replaced by the TQM philosophy. Some very critical TQM elements are emphasized in the ISO 9001 quality management standard (2000 or later version), compliance with which is mandatory for all government engineering design and architectural service contracts. These industry reform activities and mandatory quality system requirements have driven engineering consultants in Hong Kong to adopt the TQM philosophy and integrate TQM elements into their daily management procedures. Engineering consultants have made good efforts to effectively manage their human and material resources so that customers are satisfied with both the tangible design output and the manner in which they are treated.

The average score of 3.81 against a maximum of 5 in Part 2 of the survey indicates that the current extent to which TQM principles are applied by most engineering consultants in Hong Kong is moderately high, reflecting a moderately high achievement of the intended improvements initiated by the CIRC report.

Apart from the TQM application levels, the mapping of the TQM components in Part 2, onto the eight (a-h) established TQM elements as shown in Appendix 5B–D (Cst – Part 2), reveals that engineering consultants are most familiar with the TQM elements of process management, top management leadership and continual improvement.

The mapping of the Part 3 results, as shown in Appendix 5B–D (Cst – Part 3), indicates a short-term need to focus on continual improvement, top management leadership and customer management to raise the effectiveness of the application of TQM principles for current and scheduled projects. Furthermore, the mapping of the Part 4 results, as shown in Appendix 5B–D (Cst – Part 4), suggests that organizational learning, people management and continual improvement are the main TQM focuses for sustainable business development. Continual improvement is identified as the core of the TQM philosophy regardless of the maturity of its application. In terms of long-term business development, the elements of organizational learning and people management must be emphasized in an organization's management strategy.

The survey developed in this paper forms the basis of the paper's investigation. It was established based on the specific quality culture of the Hong Kong construction engineering industry, which comprises both local Hong Kong

organizations and Hong Kong-based international organizations. However, it is anticipated that the design and engineering services in other countries are facing a quality crossroads similar to that of engineering consultants in Hong Kong. The experience of Hong Kong should therefore be of interest to organizations in countries that seek to implement improvement frameworks to raise their quality culture.

5B.12 References

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Chapter 5 – Part C

Second Survey - TQM application by construction related organizations in Hong Kong

Part C – Report on survey for Client Organizations in Hong Kong

5C.1 Methodology

A full-scale survey was designed and carried out during the period from January 2011 to March 2012. The questions were developed primarily from the management principles in BS7850 (1992). Project development and construction management elements were integrated into the questions, with reference made to the techniques and experiences mentioned in “Construction Quality Management” by Tang *et al*. (2005). The survey forms the core of the investigation, and was tailored to the specific quality of the culture of the Hong Kong client organizations in the construction industry.

A pilot set of questionnaires was sent to five practitioners in January 2011 to test the relevance of the full-scale survey to the application of TQM principles and construction project elements, and to determine the effectiveness and ease of understanding of the survey questions. This pilot study was also used to establish the relevance of the TQM elements identified in my literature review to each of the questions for a priority assessment based on the survey results. The survey

questionnaire was then modified accordingly, and the final version consisted of four parts. Part 1 collected the necessary information related to the companies at which the respondents were working and the nature of the respondents' jobs. Part 2 (see Appendix 5C-A) focused on the respondents' familiarity with TQM, reflecting the extent to which TQM principles were applied by client organizations. Part 3 (see Appendix 5C-B) was based on the project development and construction quality management principles applied to obtain immediate and short-term quality improvements. Part 4 (see Appendix 5C-C) sought the respondents' views on whether the adoption of TQM principles was appropriate for achieving long-term quality enhancement in the context of project development and construction activities. The final form of the survey was completed in August 2011 and sent to professionals working for public or private client organizations. The last of the survey replies was received in March 2012.

The score scale adopted in the questionnaire was based on a 5-point Likert System (Hayes, 1998). This means that if a respondent agreed to a great extent to a question, s/he would get 5 scores. The data collected from the survey were analyzed using the Statistical Package for the Social Sciences (SPSS). Pearson's correlation analyses were conducted on the survey questions in terms of the scores given by the respondents. The correlations referred to in the analysis are

items with significance at the 0.05 level or below (2-tailed). The relative level of TQM principle application for each part of the survey was also analyzed based on the average score for each question in that part.

5C.2 *Summary of key questionnaire survey results for Part 1 – Return rates and background of the respondents*

Of 60 enquiries, 20 completed surveys were received, representing a return rate of 33.3%. The size of the organizations at which the respondents were working varied from 30 to more than 200 staff members. Of these organizations, more than half (55%) had more than 100 employees.

	Building Construction	Civil Construction	Mixed Construction	Large size – more than 100 staff members	Medium to small size – staff of 100 employees or less
Proportion of organizations	45%	30%	25%	55%	45%

Figure 5C-1 – Business background of the organizations to which the respondents were attached

	Project / Department Manager	Project Engineer	Project Co-ordinator	Site Representative
Proportion. of respondents	60%	20%	10%	10%

Figure 5C-2 – Individual responsibilities of the respondents

The 20 respondents were working for 20 different client organizations. The type of construction work executed by these client organizations in which the respondents were working were building works, civil works and a mixture of building and civil works. 45% of these organizations emphasize in building construction, 30% focus on civil construction and the remaining 23.8% execute both building and civil works. Figure 5C-1 shows the details of the basic business background of the surveyed organizations. Job responsibilities of the respondents ranged from site representatives to project managers, which are summarized in Figure 5C-2.

5C.3 ***Summary of the key survey results for Part 2 – How familiar are Hong Kong client organizations with TQM?*** *(Full details of the survey results are included in Appendix 5C-A.)* The key results are presented in Figure 5C-3

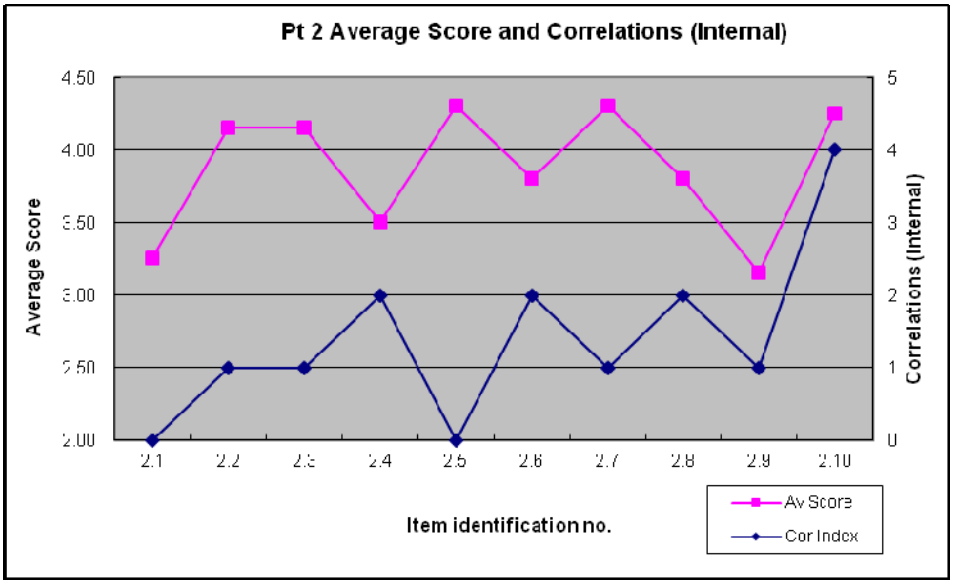

Figure 5C-3 – Key Results for Part 2 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 2

1. The key results for Part 2 are shown in Figure 5C-3. The high scoring items are Item 2.5 (concept of the internal customer), Item 2.7 (TQM tools supplementing QA inspections) and Item 2.10 (knowledge refreshment and experience sharing). The two lowest scoring items are Item 2.9 (employer-organized training) and Item 2.1 (quality of management). The score implications of these items are discussed in the next section.
2. The Pearson correlation analysis results for the respondents' average score pattern (see Appendix 5C-A1) are also presented in Fig. 1. Eight of the ten Part 2 items have correlation indices of ranging from 1 to 4, suggesting that these eight items only moderately correlated with each other. The moderate correlation of an item with other items in a group implies that the other items in the group may slightly develop interactively if changes were to occur in that particular item. As an example, Item 2.8 is highly correlated with seven other items in Part 2 of the survey. When changes to the quality system cause an increase in the average score for Item 2.8, the average scores of the other seven moderately co-related items may also slightly increase as a result.

3. The Pearson correlation analysis also indicates that Item 2.1 (quality of the management system in term of accountability and co-ordination) and Item 2.5 (concept of internal customer) have zero correlation indices. This implies that these two internal management items will develop independently and differently even if enhancement changes were to occur in any other Part 2 item.

5C.4 *Discussion of the survey results for Part 2*

The average score results for Part 2 indicate a high degree of agreement that the concept of internal customer satisfaction, which is a TQM characteristics, is a criterion for achieving final construction project quality. The score results also show the acknowledgement that TQM tools such as weakness count charts and improvement statistics would supplement process and product inspections for the overall construction project improvement. The score results further indicate that client organizations agree to pursue continual knowledge refreshment and experience sharing.

The lowest score for Item 2.9 indicates that long-term investment in management training, including value engineering and risk management training, for employees by client organizations is lagging behind other TQM familiarization items. The low score probably a result of the high percentage of qualified

professionals in the client organizations. As required by many professional institutions, these professionals must organize their own management and technical training as part of their continual personal development (CPD) progress. Item 2.1 (quality of management in terms of accountability and co-ordination) has the second lowest score. The low score is possibly due to some private construction clients put heavy emphasis on short term investment returns. The overall indication of familiarization with TQM is positive, as the average score is 3.87 and ranges from 3.15 to 4.30 out of 5.0. This reflects that TQM principles are applied by client organizations in Hong Kong to a moderately high extent.

The correlation analysis shows that eight of the ten items in this part of the questionnaire are moderately correlated. This moderate correlation indicates that the familiarization improvement in any one of the eight items may induce slight familiarization improvement in the other items of the highly correlated group. The high percentage of moderately correlated items may result from the respondents' similar level of appreciation and acceptance for TQM.

Item 2.1 (quality of the management system in term of accountability and co-ordination) and Item 2.5 (concept of internal customer) have zero correlation indices. The enhancement on the awareness and familiarization of management accountability, co-ordination and internal customer concept may therefore

require specific efforts in addition to general improvement efforts for the construction related activities for the other Part 2 items.

The relevant TOM elements, out of (a) to (h), for each question are examined and a matrix is established, the details of which are presented in Appendix 5C-D. Each of these TQM element(s) is assigned a sub-score, calculated as the average ratio of the actual score of the question to the maximum possible score (i.e., 5). The sub-scores for each relevant TQM element are added up to establish the relative level of application of that particular TQM element. As an example, the TQM element "continual improvement" is associated with Items 2.4, 2.5, 2.7 and 2.8 of Part 2, and the respondents' average scores for these items are 4.15, 3.50, 4.30 and 3.80, respectively. The respective maximum score ratios for Items 2.4, 2.5, 2.7 and 2.8 then become 0.830 (4.15/5), 0.700 (3.50/5), 0.860 (4.30/5) and 0.760 (3.80/5), respectively, and the sub-score for the continual improvement element becomes 0.7875 (the sum of 0.830 + 0.700 + 0.860 + 0.760 divided by 4). A high sub-score represents the respondents' high level of familiarization with a TQM element. The result of this mapping process reveals that the client organizations are most familiar with the "process management" "top management leadership" elements. This result is expected, as one of the main themes of the CIRC's improvement recommendations is to

develop an efficient and productive industry. Top management leadership is the driving force for productivity and efficiency and process management technically pave the way for project quality and the ultimate success.

5C.5 ***Summary of the key survey results for Part 3 - What actions must be taken to improve the quality of the Hong Kong client organizations?*** *(Full details of the survey results are included in Appendix 5C-B.)*

The key results are presented in Figure 5C-4.

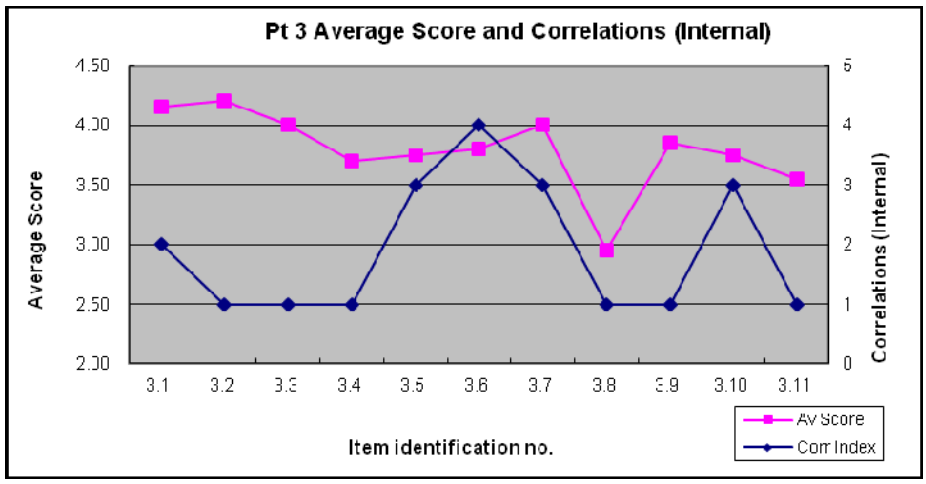

Figure 5C-4 – Key Results for Part 3 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 3

1. The Part 3 key results are shown in Fig. 2. The highest two scoring items are Item 3.2 (indication of low level internal management communication) and Item 3.1 (frequent fire-fighting scenarios), Two other high score items, scoring 4 of out of a maximum of 5, are Item 3.3 (close co-ordination for the initial project planning) and Item 3.7 (process and

product improvements since implementation of ISO 9000). The two lowest scoring items are Item 3.8 (most project planning mistakes are due to design limitations and uncertainties in authority approvals) and Item 3.11 (construction industry is lacking behind in adopting new technology and management concepts). The score implications of these items are discussed in the next section.

2. With reference to the Pearson correlation analysis of the average score pattern of the respondents shown in Appendix 5C-B1, a summary of the analysis result is also presented in Fig. 2. The Pearson correlation analysis shows that 4 of the 12 items in Part 3 of the survey are moderately correlated with the other items in Part 3, with correlation indices ranging from 3 to 4. Based on the characteristics of the Pearson correlations, each of these moderately correlated items is expected to develop together moderately if changes occur within the group of these four items.

3. The Pearson correlation analysis indicates that the remaining eight items in Part 3 have low correlation indices ranging from 1 to 2. The low correlation indices for these eight items imply that such items may develop together gradually if changes occur in any other of the items in Part 3.

5C.6 *Discussion of the questionnaire survey results for Part 3*

The Part 3 results indicate a high degree of agreement that internal communication between top management and the general staff is insufficient in client organizations. This result is unexpected and it may possibly be due to the communication emphasis of some private construction clients is mainly external and is on investment and returns. The peer level co-ordination is however strong as reflected by the high score for Item 3.3 in project planning amongst the different functional group. The respondents also generally agree that that there is a need to decrease the number of fire-fighting scenarios (response to emergency occurrences) in order to improve construction project quality. In addition, there is a high consensus in the respondents that quality attitude in client organizations have improved since the adoption of ISO 9000 in early 1990, in respect of process planning and product conformance.

The relatively low scoring items are Item 3.8 (most project planning mistakes are due to design limitations and uncertainties in authority approvals) and Item 3.11 (construction industry is lacking behind in adopting new technology and management concepts). These are positive results in the context of the quality for the construction clients in Hong Kong. Some respondents disagreed that project planning is affected by design limitations and authority

approval, which indicates the client organization are generally aware of the design limitation and constrains of authority approval at early stage and provisions have been allow for accordingly. Some respondents also expressed the construction industry in Hong Kong has not been always lacking behind for new technology and new management concepts. These positive indications would facilitate the establishment of a quality culture for an effective and innovative construction industry.

The correlation analysis results show that four of the twelve items in this part of the survey are moderately correlated. This moderate correlation suggests that improvement in the application of TQM principles in any one of these four items may induce similar improvements in the other items of the moderately correlated group.

The same analysis also shows that the remaining eight items are slightly correlated with the other items. This slight correlation suggests that changes in the improvement of the application of TQM principles for other items in Part 3 may gradually and slightly improve the application for any of these eight items. To contribute to the overall improvement in the application of TQM principles, each of these eight items would require specific improvement changes

implemented in parallel with the general improvement changes in the other four items in Part 3.

Mapping the survey results to the eight TQM elements in a manner similar to that used to map the Part 2 results (see Appendix 5C-D) reveals that client organizations require continual improvement above other elements. This is in line with the recommendation cluster proposed in the CIRC report for fostering a quality culture and establishing an effective, innovative and productive industry. The other two highly ranked TQM elements are “top management and leadership” and “supplier management,” which also form the basis of the CIRC improvement recommendations. In the context of project development and construction management, suppliers for the client organizations include planners, contract document consultants, design consultants, construction managers and contractors.

The overall mapping result indicates that more focus on continual improvement, top management leadership, and supplier management is required to satisfy the short-term needs of the construction management for current projects and project development for scheduled projects.

5C.7 ***Summary of the key survey results for Part 4 - Is the adoption of TQM principles appropriate for achieving quality enhancement for client organizations?*** *(Full details of the survey results are included in* ***Appendix 5C- C****)*

The key results are presented in Figure 5C-5.

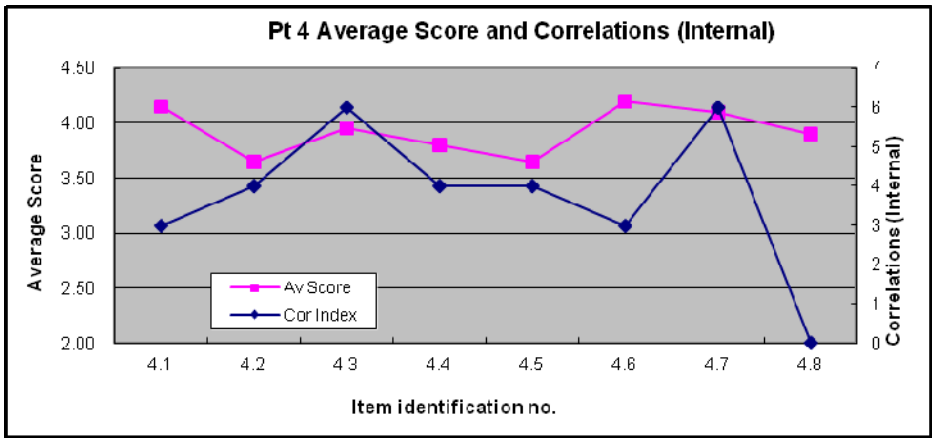

Figure 5C-5– Key Results for Part 4 of the Survey (maximum possible score is 5)

Observations on the survey results for Part 4

1. The key results for Part 4 are shown in Figure 5C-5. The three highest scoring items are Item 4.6 (life time learning in both management skill and technical skill), Item 4.1 (awarding contractors base on both price and tracked performance records including process and product quality) and Item 4.7 (government taking the lead in workers' registration and their refreshment training). The lowest two scoring items are Item 4.2 (contracts facilitating the risk sharing approach) and Item 4.5 (dedication

to the front line staff for stopping inappropriate activities). The score implications of these items are discussed in the next section.

2. With reference to the Pearson correlation analysis of the respondents' average score pattern of the respondents in Appendix 5C-C1; a summary of the analysis is also presented in Fig. 3. The Pearson correlation analysis shows that seven of the eight items in Part 4 are moderately to highly correlated with each other, with correlation indices ranging from 3 to 6. Based on the characteristics of the Pearson correlations, each of these seven items is expected to develop interactively if any change occurs within the group of moderately to highly correlated items.

3. Pearson correlation analysis indicates that Item 4.8 (the TQM approach is easier to apply than the QA procedures when apply to modern construction which is more dynamic and method driven) has a zero correlation, implying that this item will not interact with changes occur in the other items in Part 4.

5.8 ***Discussion of the survey results for Part 4***

The Part 4 results indicate a high degree of agreement that the life time training on both technical and management skills be adopted to achieve construction project excellence. The results also indicate the respondents' general agreement

that client organization should include the consideration of the tenderers' tracked performance records in both service delivery and product delivery, in addition to prices. These considerations will encourage the tender participants to invest on the long-term quality performance. The respondents also have a general view that the government shall organize registration for the skill workers and arrange refreshment training for these workers at appropriate intervals. The government actually has a dual role in the subject of construction quality enhancement, it is the biggest public client organization and at the same time it is the authority for any mandatory quality requirements and regulations.

The relatively low scoring items are 4.2 (contracts facilitating the risk sharing approach) and Item 4.5 (dedication to the front line staff for stopping inappropriate activities). Although both their scores are 3.65 which are relatively lower than those of the other items, such scores are not low when compared with the highest possible score of 5. It nevertheless appears that these two items are appropriate for sustaining long-term quality enhancement. Contracts facilitating fair risk sharing is an ultimate goal for all contract administrators in the construction society. It could only be achieves by participants including clients, contract administrators, suppliers, contractors and etc. who are committed to qualities in all aspects.

The correlation analysis results indicate that seven of the eight items in Part 4 are moderately to highly correlated. This high percentage of correlated items could be explained by the consistency of the respondents' positive attitude toward TQM as an appropriate philosophy for achieving a sustainable quality improvement.

The Pearson correlation analysis indicates that Item 4.8 (the TQM approach is easier to apply than the QA procedures when apply to modern construction which is more dynamic and method driven) has a zero correlation, implying that this item will not interact with changes occur in the other items in Part 4. Contributing to overall construction project quality improvement would require specific improvement changes implemented in parallel with general improvement changes in the other items of Part 4.

Mapping the survey results to the eight TQM elements in a manner similar to that used to map the results for Parts 2 and 3 (see Appendix 5C-D) reveals that client organizations consider organizational learning to be the most appropriate element for sustaining long-term quality development. This result is expected, as many recent industry reform reports recommend a cultural change in the construction industry, of which continual learning in an organization is a crucial element. The next two highly ranked TQM elements are "continual

improvement" and "people management", both of which are key components of typical long-term strategies.

5.9 Conclusion

The full-scale implementation of the CIRC report's 109 improvement recommendations initiated the transformation of quality culture in the Hong Kong construction industry, such that the previous quality assurance culture has gradually been replaced by the TQM philosophy. Some very critical TQM elements including continual improvement, process management and customer management are emphasized in the ISO 9001 quality management standard (2000 or later version), compliance with which is required for all government construction related departments and all government contracts for design and construction. These industry reform activities and mandatory quality system requirements have driven the construction stakeholders in Hong Kong to adopt the TQM philosophy and integrate TQM elements into their daily management procedures. Client organizations have made an effort to effectively manage their human and material resources so that other stakeholders are satisfied with the project planning at the tender stage and the project management at the design and construction stage.

The average score of 3.87 against a maximum of 5 in Part 2 of the survey indicates that the current extent to which TQM principles are applied by the client organizations in Hong Kong is moderately high, reflecting a moderately high achievement of the intended improvements initiated by the CIRC report.

Apart from the TQM application levels, the mapping of the TQM components in Part 2 onto the eight (a-h) research-established TQM elements reveals that client organizations are most familiar with the TQM elements of process management, top management leadership and continual improvement.

The mapping of the Part 3 results indicates a short-term need to focus on continual improvement, top management leadership and supplier management to raise the effectiveness of the application of TQM principles for current and scheduled projects. Furthermore, the mapping of the Part 4 results suggests that organizational learning, continual improvement and people management are the main TQM focuses for sustainable business development. Continual improvement is identified as the core of the TQM philosophy regardless of the maturity of its application. In terms of long-term business development, the elements of organizational learning and people management must be emphasized in an organization's management strategy.

5C.10 References

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Chapter 6 – Conclusions and Recommendations

6.1 The Research Work

The objective of this research study is to investigate the prospect of evolution from quality assurance to total quality management for the Hong Kong construction industry. In this thesis, there are four main contributions as follows:

a. Establishment of evidence of how the quality assurance (QA) efforts in the first 15 years (1991 to 2006) had impacted the quality management in the Hong Kong construction industry in evolving, and the identification of the degree of understanding of TQM principles by participants in the construction industry.

b. Completion of an investigation on whether the problems in implementing QA can be alleviated by adopting total quality management (TQM) philosophy for the existing cultural environment of the Hong Kong construction industry after 2006 (i.e. from 2007 to now).

c. Providing comments on that TQM could affect those evolving organizations and its effects on achieving “Excellence” in construction project quality.

d. With the achievement of objectives a, b, and c, an approach to achieve a sustainable construction quality management system is recommended to the industry.

6.2 The impact of QA in the first 15 years (1991 to 2006) and the degree of understanding of TQM

From the first survey carried out in 2007 to 2008, it is identified that the quality management of the construction contractors, engineering consultants and client organization were highly focusing on quality objectives, internal auditing and documentation procedures. The previous status of quality control culture by supervision and inspection had been transformed to a systematic quality assurance culture of comprehensive documentation and formalized auditing procedures. ISO 9001 year 2000 version, in which TQM elements such as customer satisfaction, continual improvement and process approach, etc. were introduced into the standard, had become mandatory in December 2003 for all government project. From this survey, it is however observed that the effect of the revised (year 2000) quality standard is not obvious. The scoring of items relating to process review, customer satisfaction survey and training for improvement was relatively low. The quality environment of reactive culture in the construction industry still prevailed.

The survey results also indicated that construction contractors, engineering consultants and client organizations all had considerable knowledge of TQM. They were aware of the need for customer management and process assessment for improvements. Further data analysis however indicated that the level of application of TQM elements was generally below that of QA principles. The integration of the TQM philosophy into the daily quality management has not yet been established.

A key summary for the result of the first survey is presented in Figure 6-1 below:

Stakeholder	ISO 9000 Certified	QA Section Average Score (Max. score is 5)	QA items Scoring 4 and above	TQM Section Average (Max. score is 5)
Contractors	90%	3.913	40%	3.734
Consultants	100%	3.843	25%	3.605
Clients	95%	4.030	48%	3.848
Overall Industry	95%	3.929	38%	3.729

Figure 6-1 Key summary for the result of the first survey

This key summary provides an indication that the Hong Kong Quality Control (QC) approach before 1990s has in 2007 transformed in a quality assurance (QA) culture. The data analysis of the survey results also indicates that the level of application of TQM elements is generally lower than that of the QA principles.

6.3 Alleviation of QA problem by adopting TQM

In parallel with the ISO 9000 accreditation requirement for the construction related organization, the major public housing client Hong Kong Housing Authority also implemented the Performance Assessment Scoring System (PASS) in Jan 1991,which was a quality indicator (Tang *et al*. 2005, Chapters 5 and 6) focusing on measuring the quality of construction. The PASS scoring formed part of the assessment criteria in preferential tendering eligibility scheme on which the public client had relied in stopping low quality performance organizations tendering public works. Many publications in the late 1990s pointed out the need for the

Hong Kong construction industry (contractors, consultants and clients alike) to adopt something more than the quality assurance (QA) approach. As commented by many researchers, QA is a systematic and static and hard approach as compared to the dynamic people TQM approach.

The Construction Industry Review Committee (CIRC) report issued in 2001 proposed 109 improvement measures under 7 main themes. Many of the improvement measures were related to the TQM philosophy and this report marked the determination of the Hong Kong Special Administration Region Government in striving for excellence of the Hong Kong construction industry. In the second survey (as described in this thesis) carried out from May 2011 to Jan 2012, the average TQM familiarization for all contractors, engineering consultant and clients was 3.829 out of a maximum of 5. This indicated that construction related organizations in Hong Kong had become more familiar with TQM. As compared to the first survey carried out in 2007 to 2008, the awareness and application of TQM had slightly increased. Such finding is also echoed by the paper Tang and Chen (2013). A detailed comparison is given in Figure 6-2 below:

First Survey (2007 to 2008) - Respondent Averaged Score (RAV) on TQM Application (Respondent averaged scores are transferred from Appendices 4A-B, 4B-B and 4C-B**)**

		Contractor Group (Ctr)	Consultant Group (Cst)	Client Group (Clt)	Average of the three groups (All)
Return Rate (Completed Returns / Enquiries Sent)		40/100 = 40.0%	30/75 = 40.0%	21/60 = 35.0%	
RAV - Part 2 TQM Application	Highest RAV	4.200	4.033	4.286	
	Lowest RAV	3.200	3.167	3.333	
	Average RAV	3.734	3.605	3.848	
Overall Average RFV					3.729

Second Survey (2011 to 2012) - Respondent Averaged Score (RAV) on TQM Familiarization (Respondent averaged scores transferred from Appendices 5A-D, 5B-D and 5C-D**)**

		Contractor Group (Ctr)	Consultant Group (Cst)	Client Group (Clt)	Average of the three groups (All)
Return Rate (Completed Returns / Enquiries Sent)		40/107 = 37.4%	35/74 = 47.3%	20/60 = 33.3%	
RAV - Part 2 TQM Familiarization	Highest RAV	4.275	4.286	4.300	
	Lowest RAV	3.000	3.171	3.150	
	Average RAV	3.808	3.814	3.865	
Overall Average RFV					3.829
Change as compared to the First Survey (2007 - 2008)		3.808 / 3.734 = 1.020	3.814 / 3.605 = 1.058	3.865 / 3.848 = 1.004	3.829 / 3.729 = 1.027

Figure 6-2: Comparison of TQM awareness and application (Between 2008 and 2012)

It is an indication that the effects of the ISO 9001 year 2000 version, in which TQM elements are introduced into the standard, and the CIRC improvement initiatives have started affecting the construction industry. Such increased adoption of the TQM approach has influenced and will continue to influence the industry towards a proactive attitude in managing total quality effectively.

6.4 The effect of TQM on evolving organizations in achieving "Excellence" in construction project quality.

In the competitive market, competent organizations evolve under a dynamic environment. The integration of learning with day-to-day work processes will allow organizations to react efficiently and effectively to a

changing environment. Organization members may have to solve unprecedented problems and grasp unpredictable opportunities. Therefore, employers are seeking ways of encouraging and enabling a learning culture within their organizations. TQM can provide an environment where continual learning can thrive (Love *et al.*, 2000). From the statistical analysis of the respondent scoring in the second survey (2011 to 2012) and a mapping process based on the relative TQM element relevancy of the questionnaire established during the pilot questionnaire study, a TQM element short term list for the current projects and a long term priority list for sustainable business have been identified.

The short term priority list is presented in Figure 6-3 below:

Short term focus priority (Priority level 1 represents the highest priority)

Short term focus priority	Contractors (Priory levels transferred from Appendix 5A-D)	Consultants (Priority levels transferred Appendix 5B-D)	Clients (Priority levels transferred from Appendix 5C-D)	Average
(a) Process management	7.0	6.0	5.0	6.0
(b) Customer management	3.0	3.0	5.0	3.7
(c) Top Management leadership	1.0	2.0	2.0	1.7
(d) Supplier management	2.0	4.0	3.0	3.0
(e) People management	5.0	7.0	7.0	6.3
(f) Continual improvement	6.0	1.0	1.0	2.7
(g) Organizational learning	4.0	5.0	8.0	5.7
(h) Quality information management	8.0	8.0	6.0	7.3

Figure 6-3: **Short term focus TQM Element Priority**

The short term focus is intended to manage and continually improve the current works in hand while the long term focus is intended to sustain the development of the organization.

For the short term focus, top management leadership is having the highest priority. The job of management is not supervision, but providing the leadership (Deming, 1986). The management needs to take the lead in embracing all activities to satisfy both the external and internal customer objectives, in the daily management agenda. At project level, the management needs to set a scene for motivating the human factor in achieving job pride and satisfaction. The second highest priority is continual improvement. It is always the core of the TQM philosophy to identify and continually review the process and cost control, company performance, and bench marking in the construction market.

For the long priority list, it is presented in Figure 6-4 below:

Long term focus priority (Priority level 1 represents the highest priority)

Long term focus priority	Contractors (Priory levels transferred from Appendix 5A-D)	Consultants (Priority levels transferred Appendix 5B-D)	Clients (Priority levels transferred from Appendix 5C-D)	Average
(a) Process management	7.0	7.0	8.0	7.3
(b) Customer management	4.0	4.0	4.0	4.0
(c) Top Management leadership	6.0	6.0	6.0	6.0
(d)Supplier management	2.0	5.0	5.0	4.0
(e)People management	5.0	2.0	3.0	3.3
(f) Continual improvement	3.0	3.0	2.0	2.7
(g) Organizational learning	1.0	1.0	1.0	1.0
(h) Quality information management	8.0	8.0	7.0	7.7

Figure 6-4: Long term focus TQM Element Priority

The long term focus mapping result shows that the highest priority switches to organizational learning. Organizational learning is crucial in sustaining the construction business. It is the growth and change of organizational knowledge. It involves a process by which organization members develop knowledge about action-outcome relationships and the effect of environment on the relationships (Love *et al.*, 2000). Continual improvement stays to be the second highest priority in the long term focus. During the organizational learning process, the concept of unlearning also contributes to the continual improvement. Unlearning involves the breaking of undesirable behavior and modifying existing mental mode (Love *et al.*, 2002).

The overall industry priority TQM element focus priority is summarized in Figure 6-5 below.

Overall Industry Averaged Priority Summary

Average of the priorities of construction contractors, consultants and client organizations	Short term focus priority level (1 indicates the highest priority)	Long term focus priority level (1 indicates the highest priority)
(a) Process management	6.0	7.3
(b) Customer management	3.7	4.0
(c) Top Management leadership	1.7	6.0
(d) Supplier management	3.0	4.0
(e) People management	6.3	3.3
(f) Continual improvement	2.7	2.7
(g) Organizational learning	5.7	1.0
(h) Quality information management	7.3	7.7

Figure 6-5: Overall Industry TQM Element Priority Summary (Developed from results of the Second Survey 2011 to 2012)

The methods of calculation for the values in Figure 6-5 are explained as follows:

Example one:

In Appendices 5A- D (Crt – Part 3), 5B-D (Cst – Part 3) and 5C-D (Cltn – Part 3), the respective priorities for Process management are 7 (Contractors), 6 (Consultants) and 5 (Clients). The average of 7, 6 and 5 is 6 and 6 is thus shown in Column 2 of Figure 6-5 for Item (a) Process management.

Likewise, in Appendices 5A- D (Crt – Part 4), 5B-D (Cst – Part 4) and 5C-D (Cltn – Part 4), the respective priorities for Process management are 7 (Contractors), 7 (Consultants) and 8 (Clients). The average of 7, 7 and 8 is 7.3 and 7.3 is thus shown in Column 3 of Figure 6-5 Item (a) Process management.

Example two

In Appendices 5A- D (Crt – Part 3), 5B-D (Cst – Part 3) and 5C-D (Cltn – Part 3), the respective priorities for People management are 5 (Contractors), 7 (Consultants) and 7 (Clients). The average of (5, 7 and 7) is 6.3 and 6.3 is thus shown in Column 2 of Figure 6-5 for Item (e) People management

Likewise, in Appendices 5A- D (Crt – Part 4), 5B-D (Cst – Part 4) and 5C-D (Cltn – Part 4), the respective priorities for People management are 5 (Contractors), 2 (Consultants) and 3 (Clients). The average of (5, 2 and 3) is 3.3 and 3.3 is thus shown in Column 3 of Figure 6-5 for Item (e) People management.

These priority lists could possibly help the industry stakeholders further understand the TQM philosophy, particularly when they are considering their commencement of the TQM application or their further advancement into the TQM approach.

6.5 Overall Conclusion and Study Limitations

The analysis of the two survey results indicates that TQM philosophy has been cultivate in the construction industry in Hong Kong and the positive effect of TQM awareness is becoming visible. The analysis of the second survey results indicates that element of top management leadership, continual improvement and organizational learning shall be given higher priorities when implementing TQM in Hong Kong. The top management needs to cultivate in an organization, for all its participants, a double loop leaning culture in which errors are detected and corrected in a manner that modifies the organization's implicit norms and objectives. The continual improvement concept would then reiterate detection and correction for both processes and organization culture, in revolving the construction

The results should help improve our understanding on whether the stake holders of the Hong Kong construction industry are ready to move towards the TQM systems. More importantly, decision makers can predict the effectiveness of TQM before they make a big decision to switch from QMS to TQM. The findings of this study are, therefore, new and useful to the construction industry.

From the trend the result shows in this research, there are indications that the Hong Kong construction industry is becoming more aware and

familiar with TQM through the efforts of the government and supports of the major client organizations. The prospect of evolution from quality assurance to total quality management for the Hong Kong construction industry is therefore positive.

There are a couple of limitations in this research study. This study is based on the results of a series of questionnaire surveys of which the method of sampling was based on an exhaustive sampling approach apart from the convenient sampling being used for the client organizations. The reason of adopting convenient sampling has been explained in the methodology chapter and its effect on the survey results is considered minor from a statistical perspective. The returned questionnaires also indicate that surveyed organizations were of variations in sizes. The size variation is worth to note as small size organizations might have a different strategy and practice for managing quality. The effect of this size variation should however be comparatively small as most small size organization are influence by large size organizations until they improve sufficiently well and become competitive in the market.

Such Hong Kong experience should however be of interest to organizations in countries that seek to implement improvement frameworks to raise their construction quality culture.

6.6 Recommendations

As the reactive culture is still reflected in many of the survey questionnaire, it is recommended to carry out a study for cause of this reactive culture behavior for the contractors, consultants and clients in

Hong Kong. Such study is also recommended to be expanded to cover those outsourced activities which are of large variations in both size and variety. Whilst this group of participants has been contributing to the Hong Kong construction industry, the room for improvement in its services and products is comparatively large.

Small size organizations usually have their specific practices in managing quality, as compared to those of large size companies. In countries or regions dominated by medium to small size organizations, an additional similar study is recommended to be carried out to justify the appropriateness of the proposed element priorities before taking on board the TQM management approach.

Despite that an industry wide priority recommendation is proposed in this research study, there are differences somehow among construction contractors, engineering consultants and client organizations. It is worthwhile conducting a further study after practicing the short term priority focus for the existing construction projects for some time, for each of the three stakeholder groups to verify and compare their effectiveness of the priority implementations. Such review and the associated appropriate improvement adjustments would further reinforce the concepts of continual improvement and dynamic approach inherited in the TQM philosophy.

6.7 References

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Chapter 7 APPENDICES

7.1 Appendices for Chapter 4A

Appendix 4A-A

Survey results for the application of the ISO 9000 quality management principles by Construction Contractors in Hong Kong

APPENDIX - QUALITY ASSURANCE QUESTIONNAIRE (Contractor / Contractor Representative)

The purpose of this questionnaire is to obtain detailed information of the existing quality system of your company, which is perceived to comply with the ISO 9001 standard. The questionnaire focuses on the application of the ISO 9000 quality management principles and the achievement of the quality assurance / management objectives.

Part 1: Application of the ISO 9000 quality management principles

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all.

The quality management system maintained by your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
1.1	The company's objectives for quality and its commitment to quality.	5	4	3	2	1	*4.400*
1.2	Defined responsibility of personnel who manage, perform and verify work that affects quality.	5	4	3	2	1	*4.000*
1.3	A communication system notifying all staff about the quality responsibilities of every individual (or party for activities undertaken by subcontractors or suppliers).	5	4	3	2	1	*3.825*
1.4	The adequate provision of appropriate resources for performance of work.	5	4	3	2	1	*3.750*
1.5	The appointment of a management representative for monitoring system performance and compliance with the ISO quality management standards.	5	4	3	2	1	*3.875*

1.6	Reviews on the system undertaken by top management at pre-defined intervals.	5	4	3	2	1	*3.900*
1.7	Comprehensive review of the tender document prior to technical and commercial submissions.	5	4	3	2	1	*4.125*
1.8	Procedures to record contract variations efficiently and to correctly transfer variation information to the function teams concerned.	5	4	3	2	1	*3.750*
1.9	Procedures to control the design of temporary and permanent (as required by the contract) works.	5	4	3	2	1	*4.075*
1.10	Review of drawings and specifications prior to authorization for construction.	5	4	3	2	1	*4.125*
1.11	Effective access to obtain the latest construction drawings and specifications.	5	4	3	2	1	*4.100*
1.12	Assessment of subcontractors for their ability to meet the subcontract requirements including commercial, statutory and technical aspects prior to selection.	5	4	3	2	1	*3.625*
1.13	Testing and inspection of incoming products for specification compliance.	5	4	3	2	1	*3.875*
1.14	Process flow chart and inspection & test plan (ITP) for activities that directly affect quality.	5	4	3	2	1	*4.125*
1.15	Identification system for components of the finished work.	5	4	3	2	1	*3.750*
1.16	Final inspection and test plan including checklist upon completion of the construction project or a predetermined stage of the work.	5	4	3	2	1	*3.975*
1.17	Control measures for ensuring the inspection and test equipment is capable of the necessary function and accuracy.	5	4	3	2	1	*4.000*
1.18	Documented procedure for reviewing the disposition of non-conforming products.	5	4	3	2	1	*3.875*
1.19	Documented procedure for implementing corrective and preventative actions.	5	4	3	2	1	*4.100*
1.20	Documented procedure for handling, storing and preserving raw materials and finish products.	5	4	3	2	1	*3.825*
1.21	Systematic filing and accessing procedures to enable efficient quality record retrieving.	5	4	3	2	1	*4.075*
1.22	Periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system.	5	4	3	2	1	*4.225*
1.23	Identification and provision of required training for staff who are involved in activities directly affecting quality.	5	4	3	2	1	*3.550*

1.24	Identification and application of statistical technique required for verifying process capability and product characteristics for repeating items (e.g. doors, windows, facades, concrete batches, re-bar batches, pipe and pile welding, soil compaction).	5	4	3	2	1	*3.525*
1.25	Scheduled survey for assessment of client's satisfaction.	5	4	3	2	1	*3.375*
	All Item Overall Average						*3.913*

Appendix 4A-B

Survey results for the application of Total Quality Management elements by Construction Contractors in Hong Kong

Part 2: Application of Total Quality Management elements which have not been included in Part 1 of the Questionnaire

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all. There may be occasions when a few questions in Part 2 appear to be similar to those in Part 1, the purpose of these appearing similar questions is to investigate in depth the difference between quality assurance and total quality control.

The quality management system and quality culture maintained in your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
2.1	Policies to encourage all employees to participate in quality improvement discussions	5	4	3	2	1	*3.600*
2.2	Practices to encourage project quality improvement discussions at internal site staff meetings	5	4	3	2	1	*3.600*
2.3	Practices to encourage process quality improvement discussions at subcontractor / trade contractor site meetings	5	4	3	2	1	*3.450*
2.4	Policies to encourage process optimization discussions during early construction planning, based on best methods and appropriate resources	5	4	3	2	1	*3.475*
2.5	Policies to ensure prompt review on processes to account for design changes during construction	5	4	3	2	1	*3.775*
2.6	Employees are introduced the principles and tools for total quality management at project commencement, in addition to contract specifications	5	4	3	2	1	*3.200*
2.7	Practicing continual review on construction safety and work place environment with a view for improvement.	5	4	3	2	1	*4.150*

2.8	Practicing continual review on process completion time with a view for improvement.	5	4	3	2	1	*3.925*
2.9	Practicing continual review on process costs with a view for improvement.	5	4	3	2	1	*3.775*
2.10	Employees feel the top management provides full support to process and project quality improvement	5	4	3	2	1	*3.600*
2.11	Conducting value engineering workshops with the Client at project commencement in order to highlight potential cost or time saving proposals	5	4	3	2	1	*3.375*
2.12	Policies for regularly reviewing the Client's project priorities	5	4	3	2	1	*3.450*
2.13	Explaining the proposed construction processes to the Client prior to construction commencement	5	4	3	2	1	*3.800*
2.14	Responding quickly to the Client's enquiries and complaints	5	4	3	2	1	*4.200*
2.15	Offering reasonable explanations and solutions to legitimate complaints	5	4	3	2	1	4.000
2.16	Establishing courteous attitude and efficient communication with the Engineer and Client	5	4	3	2	1	3.900
2.17	Establishing courteous attitude and efficient communication with subcontractors and suppliers	5	4	3	2	1	3.900
2.18	All internal and external quality audits are considered as constructive tools for improvement, but not solely as specific controls for system compliance	5	4	3	2	1	3.725
2.19	Most (more than 90%) of the activities pass the client's inspection without re-work	5	4	3	2	1	3.900
2.20	Employees feel positive about the company's quality policy	5	4	3	2	1	3.875
	All Item Overall Average						3.734

7.2 Appendices for Chapter 4B

Appendix 4B-A

Survey results for the application of the ISO 9000 quality management principles by Engineering Consultants in Hong Kong

QUALITY ASSURANCE QUESTIONNAIRE (Engineering consultant Consultant reprsentative)

The purpose of this questionnaire is to obtain detailed information of the existing quality system of your company, which is perceived to comply with the ISO 9001 standard. The questionnaire focuses on the application of the ISO 9000 quality management principles and the achievement of the quality assurance / management objectives.

Part 1: Application of the ISO 9000 quality management principles

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all.

The quality management system maintained by your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
1.1	The company's objectives for quality and its commitment to quality.	5	4	3	2	1	4.367
1.2	Defined responsibility of personnel who manage, perform and verify work that affect quality.	5	4	3	2	1	4.133
1.3	A communication system notifying all staff about the quality responsibilities of every individual (or party for activities undertaken by subconsultants or contractors).	5	4	3	2	1	3.633
1.4	The adequate provision of appropriate resources for performance of work.	5	4	3	2	1	3.733
1.5	The appointment of a management representative for monitoring system performance and compliance with the ISO quality management standards.	5	4	3	2	1	4.100
1.6	Reviews on the system undertaken by top management at pre-defined intervals.	5	4	3	2	1	3.967
1.7	Comprehensive review of the tender document prior to technical and commercial submissions.	5	4	3	2	1	3.733
1.8	Procedures to record contract variations efficiently and to correctly transfer variation information to the functional teams concerned.	5	4	3	2	1	3.833
1.9	Procedures to control design works from conceptual design stage to detailed design stage.	5	4	3	2	1	4.000
1.10	Review of drawings and specifications prior to authorization for despatch.	5	4	3	2	1	4.133
1.11	Effective access to locate drawings and specifications.	5	4	3	2	1	3.867
1.12	Assessment of sub-consultants for their ability to meet the subcontract requirements including commercial, statutory and technical aspects prior to selection.	5	4	3	2	1	3.700

1.13	Inspection and verification of incoming data for relevance to design.	5	4	3	2	1	3.800
1.14	Process flow chart and inspection & test plan (ITP) for activities that directly affect quality.	5	4	3	2	1	3.767
1.15	Identification system for elements of the produced design work.	5	4	3	2	1	3.700
1.16	Control measures for ensuring design software and hardware are capable of performing the intended functions.	5	4	3	2	1	3.533
1.17	Documented procedure for the disposition of obsolete design products (eg. calculations, drawings).	5	4	3	2	1	3.633
1.18	Documented procedure for implementing corrective and preventative actions.	5	4	3	2	1	3.900
1.19	Documented procedure for handling and storing design inputs and outputs.	5	4	3	2	1	3.700
1.20	Systematic filing and accessing procedures to enable efficient quality record retrieving.	5	4	3	2	1	4.100
1.21	Periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system.	5	4	3	2	1	3.933
1.22	Identification and provision of required training for staff who are involved in activities directly affecting quality.	5	4	3	2	1	3.800
1.23	Procedures for reviewing time and costs of processes with a view for improvement.	5	4	3	2	1	3.600
1.24	Scheduled survey for assessment of client's satisfaction.	5	4	3	2	1	3.567
	All Item Overall Average						**3.843**

Appendix 4B-B

Survey results for the application of Total Quality Management elements by Engineering Consultants in Hong Kong

Part 2: Application of Total Quality Management elements which have not been included in Part 1 of the Questionnaire

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all. There may be occasions where a few questions in Part 2 appear to be similar to those in Part 1, the purpose of these appearing similar questions is to investigate in depth the difference between quality assurance and total quality control.

The quality management system and quality culture maintained in your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
2.1	Policies to encourage all employees to participate in quality improvement discussions	5	4	3	2	1	3.633
2.2	Practices to encourage project quality improvement discussions at internal project staff meetings	5	4	3	2	1	3.500

2.3	Practices to encourage process quality improvement discussions at subconsultants / contractors project meetings	5	4	3	2	1	3.167
2.4	Policies to encourage process optimization discussions during early design management planning, based on best design tools and appropriate resources	5	4	3	2	1	3.233
2.5	Policies to encourage prompt review on engineering processes to account for criteria variations during the design stage and the construction stage	5	4	3	2	1	3.433
2.6	Employees are introduced the principles and tools for total quality management at project commencement, in addition to contract specifications	5	4	3	2	1	3.367
2.7	Practicing continual review on design completion time with a view for improvement	5	4	3	2	1	3.767
2.8	Practicing continual review on design costs with a view for improvement	5	4	3	2	1	3.600
2.9	Employees feel the top management provides full support to process and project quality improvement	5	4	3	2	1	3.667
2.10	Conducting value engineering workshops with the Client at project commencement in order to highlight potential cost or time saving proposals	5	4	3	2	1	3.467
2.11	Policies for regularly reviewing the Client's project priorities	5	4	3	2	1	3.467
2.12	Explaining the proposed engineering concepts and principles to the Client prior to design commencement	5	4	3	2	1	3.567
2.13	Responding quickly to the Client's enquiries and complaints	5	4	3	2	1	3.867
2.14	Offering reasonable explanations and solutions to legitimate complaints	5	4	3	2	1	3.800
2.15	Establishing courteous attitude and efficient communication with the Client	5	4	3	2	1	3.833
2.16	Establishing courteous attitude and efficient communication with contractors and specialist suppliers	5	4	3	2	1	3.733
2.17	All internal and external quality audits are considered as constructive tools for improvement, but not solely as specific controls for system compliance	5	4	3	2	1	3.700
2.18	Most (more than 90%) of the design work are achieving the specified intents and purposes without re-work	5	4	3	2	1	4.033
2.19	Employees feel positive about the company's quality policy	5	4	3	2	1	3.667
	All Item Overall Average						**3.605**

7.3 Appendices for Chapter 4C

Appendix 4C-A

Survey results for the application of the ISO 9000 quality management principles by Client Organizations in Hong Kong

Part C – Report on survey for Construction Clients in Hong Kong

QUALITY ASSURANCE QUESTIONNAIRE (Client / Client Representative)

The purpose of this questionnaire is to obtain detailed information of the existing quality system of your company, which is perceived to comply with the ISO 9001 standard. The questionnaire focuses on the application of the ISO 9000 quality management principles and the achievement of the quality

Part 1: Application of the ISO 9000 quality management principles

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all.

The quality management system maintained by your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
1.1	The company's objectives for quality and its commitment to quality.	5	4	3	2	1	4.619
1.2	Defined responsibility of personnel who manage, perform and verify work that affect quality.	5	4	3	2	1	4.190
1.3	A communication system notifying all staff about the quality responsibilities of every individual (or party for activities undertaken by consultants and contractors).	5	4	3	2	1	4.048
1.4	The adequate provision of appropriate resources for performance of work.	5	4	3	2	1	3.905
1.5	The appointment of a management representative for monitoring system performance and compliance with the ISO quality	5	4	3	2	1	3.905
1.6	Reviews on the system undertaken by top management at pre-defined intervals.	5	4	3	2	1	4.048
1.7	Procedures to efficiently record variations in project requirements and to correctly transfer variation information to	5	4	3	2	1	3.619
1.8	Review of project requirements and performance specifications prior to authorization for instruction despatch.	5	4	3	2	1	3.762
1.9	Effective access to locate project requirements and performance specifications.	5	4	3	2	1	3.952
1.10	Assessment of consultants and contractors for their ability to meet the project requirements including commercial, statutory and technical aspects prior to selection.	5	4	3	2	1	4.095
1.11	Inspection and verification of submissions and offers for relevance to the project.	5	4	3	2	1	3.905
1.12	Flow chart and check list for activities that directly affect achievement of the performance specification.	5	4	3	2	1	3.857
1.13	Documented procedure for implementing corrective and preventative actions.	5	4	3	2	1	4.095
1.14	Documented procedure for handling and storing project requirements and performance specifications..	5	4	3	2	1	4.238
1.15	Systematic filing and accessing procedures to enable efficient quality record retrieving.	5	4	3	2	1	4.190

1.16	Periodic internal auditing of the system by independent personnel to ensure effectiveness of the quality system.	5	4	3	2	1	4.476
1.17	Identification and provision of required training for staff who are involved in activities directly affecting quality.	5	4	3	2	1	4.048
1.18	Procedures for reviewing time and costs (e.g. value engineering) of projects with a view for improvement.	5	4	3	2	1	3.667
1.19	Scheduled surveys for assessment of customer satisfaction.	5	4	3	2	1	3.952
	All Item Overall Average						**4.030**

Appendix 4C-B

Survey results for the application of Total Quality Management elements by Client Organizations in Hong Kong

Part 2: Application of Total Quality Management elements which have not been included in Part 1 of the Questionnaire

Please respond to each of the items by circling the number you think best describes your company as it is today. Five (5) means that your company satisfies the criterion to a great extent. One (1) means that your company does not meet this criterion at all. There may be occasions where a few questions in Part 2 appear to be similar to those in Part 1, the purpose of these appearing similar questions is to investigate in depth the difference between quality assurance and total quality control.

The quality management system and quality culture maintained in your company / organization comprises the following:

		Great extent				*Not at all*	*Averaged Survey Results*
2.1	Policies to encourage all employees to participate in quality improvement discussions	5	4	3	2	1	3.810
2.2	Practices to encourage project quality improvement discussions at internal project meetings	5	4	3	2	1	3.524
2.3	Practices to encourage process quality improvement discussions at designer / contractor meetings	5	4	3	2	1	3.905
2.4	Policies to encourage processes optimization discussions during early project planning, based on best methods and appropriate resources	5	4	3	2	1	3.905

2.5	Policies to encourage prompt review on project requirements to account for changes in the project or company objectives	5	4	3	2	1	3.714
2.6	Employees are introduced at project commencement the principles and tools for total quality management focusing on the specific porcesses of the project	5	4	3	2	1	3.333
2.7	Practicing continual review on project completion time with a view for improvement while maintaining the latest project requirements	5	4	3	2	1	3.905
2.8	Practicing continual review on project costs with a view for improvement while maintaining the latest project requirements	5	4	3	2	1	3.571
2.9	Employees feel the top management provides full support to process and project quality improvement	5	4	3	2	1	3.667
2.10	Conducting value engineering workshops with the designers and contractors at project commencement in order to highlight potential cost or time saving proposals	5	4	3	2	1	4.048
2.11	Responding quickly to enquiries and complaints raised by project related parties	5	4	3	2	1	4.238
2.12	Offering reasonable explanations and solutions to legitimate comp	5	4	3	2	1	4.286
2.13	Establishing courteous attitude and efficient communication with the project related parties	5	4	3	2	1	4.143
2.14	All internal and external quality audits are considered as constructive tools for improvement, but not solely as specific controls for system compliance	5	4	3	2	1	3.905
2.15	Employees feel positive about the company's quality policy	5	4	3	2	1	3.762
	All Item Overall Average						**3.848**

7.4 Appendices for Chapter 5A

Appendix 5A-A

Survey Results for - Part 2 – How familiar with TQM are Hong Kong Construction Contractors

Ctr - Part 2 - How are construction contractors familiar with TQM?		Comment on score (Based on the range of actual score - 75% high, 65% to 75% , moderately high, 45% to 65% average, less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 2 (from SPSS)
2.7	Process and product inspection carried out by the clients' representative could be supplemented by TQM tools to improve the overall quality management of the Hong Kong construction industry. (TQM tools for CI)	Highest score - agreeing that TQM could be added to the process control (with more emphasis on management quality).	4.275	Highest	7
2.2	Quality in construction should include process quality, that is, process planning, process monitoring, process improvement, end product control and reliability/durability. (Process quality)	Much higher score as compared to Item 2.1 (121%). An indication that process quality is receiving much more attention than management quality.	4.225	2nd Highest	6
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity – the concept of internal customer in the context of customer satisfaction. (Internal customer)	High score - indicating agreement on internal quality is a criteria for getting external and final quality	4.225	3rd Highest	7
2.3	TQM fosters the culture of monitoring and improvements at all levels in a construction organization in every functional aspect and is integrated into the daily management activities while QA system sets distinctive written procedures for process control and product assurance. (Integration of TQM to daily management)	High score - an indication on the agreement that TQM fosters the integration of quality into daily management activities.	4.100		5
2.6	Minimum life cost is the ultimate goal for project cost control. (Project life cost)	Moderately high score - Life for construction is generally longer than typical manufacturing, life cost assessment is a more long term prediction for infrastructure construction. For contractor, their focus is more on the overall cost of completing a construction contract.	3.875		7
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for technology and craftsmanship.	Average score - Agreeing on training for fundamental skill as a basis for continuous improvement and thus provide the industry with more long term benefits.	3.800		7
2.10	In the PASS system, more focus should be placed on general (management) assessment than on works (product) assessment. Web Site: http://www.housingauthority.gov.hk/en/businesspartners/buildingpass/0,,,00.html Note: General assessment includes Mgmt Input Assmt (Mgmt & Organzn, Resources, Co-ordination & control, Document) (Management quality in PASS)	Average score - both product and management are equally important	3.725		6
2.1	Quality in construction should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries. (Management quality in CI)	Components affecting the quality of relationship - score is significantly lower as compared to Item 2.2 which relates to tangible quality components (product or service quality)	3.500	3rd Lowest	2
2.4	All technical and management staff should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and Graph - For visually displaying data, e.g., in a pie chart (Quality control tools)	Low score - indicates the little focus on the knowledge on systematic monitoring tools, hindering continuous improvements.	3.350	2nd Lowest	7
2.9	My employer often (at least twice per year on average) provides management staff and subcontractors training in any of the following items: Value engineering, progress and programme review, process control, environmental control, safety management, risk management. (Staff training)	Lowest score - reflecting the focus on training is insufficient.	3.000	Lowest	0

Discussions for Part 2 - The survey identified the following specific observations

1	The Part 2 results indicate that process quality is still dominating well over management quality in the current culture of the contractors in Hong Kong. It is also indicated that the concept of internal customer is also well developed.
2	Through SPSS, the score pattern of the respondents indicates that high score Items 2.7 for TQM tools for improvements, 2.2 for process quality and 2.5 for internal customer concept are highly correlated with other TQM elements in the familiarization survey.
3	The investment by contractors on long term management training is very limited. (Indicated by Item 2.9)
4	The quality control tools which are key improvement tools for TQM are not adequately applied by the Hong Kong contractors, despite the high degree of agreement on TQM tools being used as a supplementary tool for improvement.(Indicated by Item 2.4 amd Item 2.7)
5	Through SPSS, the score pattern of the respondents also indicates that low score Items 2.1 for quality of management and 2.9 for management training have little or no strong correlation with the other TQM elements in the familiarization survey.
6	Having applied the survey results to the related TQM elements in each question, the contractors are indicated to be most familiar with the element "Process management", while the 2nd and third most familiar elements are "Top management & leadership" and "Continual improvement" respectively.
7	Having applied the survey results to the related CIRC main themes in each question, the contractors are indicated to be most familiar with theme "Achieving value in construction procurement", followed by the theme "Fostering a quality culture".

Appendix 5A-B

Survey Results for - Part 3 – What actions needed to be taken to improve construction quality by construction contractors (Focusing on current projects)?

Ctr	Part 3 - What actions need to be done for the HK CI quality?	Comment on score (Based on the range of actual score - 75% high, 65% to 75% , moderately high, 45% to 65% average, less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 3 (From SPSS)
3.1	Fire fighting scenarios (response to emergency happenings) happen frequently (averagely more than 2 times per week) in my organization.	Highest score - fire fighting situations are common (due to work type, staff adequacy, company culture)	4.250	Highest	9
3.10	Ditto but due to conscious risk taking by the subcontractor who is possibly under budget or time constraints.	High score - subcontractors are tempted to take chances due to budget and time constraints. Main contractors should control by exercising close monitoring of the risk level and maintaining adequate supervision.	4.225	2nd Highest	8
3.2	Most staff could not remember most of the core values of the company (an indicator of internal communication effectiveness).	Most employees do not remember the company core values, which indicates low communication effectiveness	4.200	3rd Highest	9
3.3	The preparation of subcontractor procurement plan, project programme and method statement should be kicked-off with meetings amongst the team leaders from every functional team.	High score indicates general agreement on importance on active pre-planning.	4.100		9
3.6	Customer satisfaction survey during and at the end of a project duration is required to obtain others' views on contractors' overall performance.	High, majority would agree to conducting the survey.	3.950		10
3.12	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	Moderately high score.	3.925		9
3.5	As a contractor's staff, I agree that clients should continuously play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	Moderately high - according to the CIRC report , client should take the lead in demanding excellence.	3.875		8
3.4	Relationships with the fragmented but extensive participating teams, both internal and external, should be maintained fairly and amicably (in a friendly and peaceful manner) to prevent the development of an adversarial project culture.	Moderately high - according to the CIRC report, room for improvement in industry integration	3.850		10
3.11	The senior members of the company should encourage free flow of information and demonstrate openness to others' views and opinions.	Average score - free flow of information is not restricted. Good communication, thorough analysis and practical solution developments, a criteria for TQM	3.800		9
3.7	Since the implementation of the ISO 9000 system in the early 1990s, workers' attitude towards process planning and product conformance has only limited improvements.	Low - quality culture is being established for the front line workers although their priorities are usually influenced by cost and time.	3.375	3rd Lowest	11
3.9	Ditto but due to negligence, uncertainties or unconscious risk taking.	Low - indicates little consensus on unconcious risk taking	3.325	2nd Lowest	5
3.8	Mistakes (non-conformance as described in quality management systems) made on sites are often due to misinterpretation by the contractor of given information (drawings and specifications) or due to superseded information.	Lowest - survey result may reflect contractors subjective thinking that their interpretation of the information is always correct.	3.025	Lowest	3

	Discussions for Part 3 - The survey identified the following specific observations
1	There is still a need to substantially reduce the possibility of fire-fighting scenarios in project management. More emphasis on realistic construction time should be put into the subcontractor procurement process to reduce the opportunity of subcontractor taking high programme risk . More effort should be spent on internal communication for company core values and policies.
2	Through SPSS, the score pattern of the respondents also indicated that high score items 3.1. for fire fighting frequency, 3.10 for mistakes caused by taking risks consciously and 3.2 for not remembering the company core values are correlated strongly with great majority of TQM elements in the action needed survey.
3	The higher than average score of 4.1 for Item 3.3 for team leaders not participating in procurement and programming planning indicates that the focus on advance planning has to be reinforced further. It is also a means to reduce "fire fighting" scenario.
4	Contractors do not quite agree that mistakes are caused by unconscious risk taking and misinterpretation of given information.(Indicated by Item 3.9)
5	Contractors general consider that mistakes are caused more by risks associated with budget or time constraints than by misinterpretation of given information. (Indicated by Item 3.10 and Item 3.8)
6	The influence of the ISO Quality Management System on construction workers attitude towards quality improvement is quite noticeable. (Indicated by Item 3.7)
7	Through SPSS, the score pattern of the respondents also indicated that low score Item 3.8 for mistakes caused by misinterpretation of information has little correlation with the other TQM elements.
8	Having applied the survey results to the related TQM elements in each question, the contractors need improvement most in the element "Top management leadership", with "Supplier management" and "Customer management" being the second and third most needed TQM elements.
9	Having applied the survey results to the related CIRC main themes in each question, the contractors need improvement most in the theme "Nurturing a professional workforce", followed by the theme of "An efficient, Innovative and productive industry ".

Appendix 5A-C

Survey Results for - Part 4 – Is the adoption of TQM principles appropriate for achieving long term quality enhancement for the construction contractors?

Ctr -Part 4 - Would the adoption of TQM principles be appropriate for achieving quality enhancement?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 4 (From SPSS)
4.1	As a contractor, your company agrees that clients should consider realistically the specified construction period in the contract. (Realistic construction period)	High - client is the key driver for quality improvement (in line with CIRC report)	4.225	Highest	3
4.8	The industry should encourage life time learning in quality management, craftsmanship and technology in order to practice continual improvement. (Continuous learning)	High - believing that there is always room for continual improvement	4.200	2nd Highest	5
4.5	Each contactor should establish his reliable supply chain with due respect to contractual rights and responsibilities. (Reliable supply chain)	High - reliable (committing and performing) suppliers contributing to an overall quality performance.	4.150	3rd Highest	7
4.2	As a contractor, your company agrees that client organizations should award construction contracts based on tenderers' experience and management in project delivery, construction process and final product in addition to price consideration. (Award to both management and price considerations)	High - in line with the CIRC report recommnedation	4.125		7
4.9	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology. (Trained workers)	High - may be associated with government's requirement on 1 Sept 2007 (http://www.cwra.org.hk/aboutus/background.asp) that all contractor worker in construction site are to be registered, fostering a quality culture in the construction indsutry	4.125		7
4.4	Contractors should establish long term business relationship with the project clients , with due respect to the contractual positions of the parties. (Relationship with clients)	High - a principle to maintain business with clients	4.100		7
4.10	The total quality criterion listed in the above statements 4.1 - 4.9 are comparatively easier than the QA procedures when applied in modern construction which is dynamic, and creativity & methodology driven. (TQM in construction)	Moderately high - varying according to degree of understanding of TQM in the construction industry	4.075		7
4.6	Contractors' senior and top management should encourage free flow of opinion, including the internal customer satisfaction feedback survey, and foster trust within the organization. (Openness)	Moderately high - see Q 3.11 Note - Q3.11 reflects employee's observation on company's openness while Q4.6 seeks employee's view on how to create openness in an organization	4.050	3rd Lowest	7
4.3	Construction contracts should facilitate balanced sharing of construction risks between contractors and clients. (Balance of risks)	Average - risk management is being the control factor for survival.	4.025	2nd Lowest	7
4.7	The person in charge of a project should give his full support to stop work decisions made by his team leaders in the contractor's team due to issues in safety, environmental pollution, construction methodology and design that critically affect the project quality. (adequate delegation)	Low - it is generally considered that only the person in charge of a project could determine the balance betyween cost, time, quality and risk. Authors experience - PIC leadership should include some degree of subjectiveness.	3.650	Lowest	1

Discussions for Part 4 - The survey identified the following specific observations	
1	The Part 4 results highlight the appropriateness to quality enhancement in construction of realistic programme consideration by the client, the importance of continuous learning and the reliable supply chain. (Indicated by Item 4.1, 4.8 and 4.5)
2	Through SPSS, the score pattern of the respondents indicates that high score Items 4.1 for realistic construction period, 4.8 for life time learning and 4.5 for reliable supply chain are generally correlated with other TQM elements in the appropriateness survey.
3	Respondents' score for the various items in Part 4 ranges from 3.65 to 4.225. The overall scores are relatively high and the range is narrow as compared to Parts 2 and 3. It indicates that all items in this part are quite appropriate for achieving quality enhancement for contractors.
4	Although the delegation of stop work decision to front line team leaders is not highly adopted, the average score of 3.65 indicates stop work decision is not solely exercised by the project in charge, but is sometimes made by the front line leaders. (Indicated by Item 4.7)
5	Through SPSS, the score pattern of the respondents also indicated that item 4.7 for stop work support have little correlation with the other TQM elements the Part 4 survey.
6	Having applied the survey results to the related TQM elements in each question, the most appropriate TQM element for quality enhancement for contractors is "Organizational learning", with "Supplier management" and "Continual improvement" being the second and third most appropriate elements.
7	Having applied the survey results to the related CIRC main themes in each question, the most appropriate theme for quality enhancement for contractors is "Nurturing a professional workforce", followed by the theme "An Efficient, Innovative and productive industry ".

Appendix 5A-D TQM priority analysis for survey results of construction contractors

Ctr - Part 2 - How are construction contractors familiar with TQM? TQM element relevancy is based on the comments received from the pilot questionnaire			Respondent's Mean Score (Relative to a max of 5)	TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0) (a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
2.1	Quality in construction should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries. (Management quality in CI)	(b)Customer management, (d)Supplier management; (e)People management	3.500		0.700		0.700	0.700			
2.2	Quality in construction should include process quality, that is, process planning, process monitoring, process improvement, end product control and reliability/durability. (Process quality)	(a) Process management (Also the Q of process mgmt); (d)Supplier management	4.225	0.845			0.845				
2.3	TQM fosters the culture of monitoring and improvements at all levels in a construction organization in every functional aspect and is integrated into the daily management activities while QA system sets distinctive written procedures for process control and product assurance. (Integration of TQM to daily management)	(c) Top Management leadership;(f) Continual improvement; (g) Organizational learning	4.100			0.820			0.820	0.820	
2.4	All technical and management staff should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and Graph - For visually displaying data, e.g., in a pie chart (Quality control tools)	(f) Continual improvement; (h) Quality information management	3.350						0.670		0.670
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity -- the concept of internal customer in the context of customer satisfaction. (Internal customer)	(b)Customer management;(d)Supplier management; (e)People management	4.225		0.845		0.845	0.845			
2.6	Minimum life cost is the ultimate goal for project cost control. (Project life cost)	(b)Customer management; Customer Mgmt (Ext)	3.875		0.775						
2.7	Process and product inspection carried out by the clients' representative could be supplemented by TQM tools to improve the overall quality management of the Hong Kong construction industry. (TQM tools for CI)	(f) Continual improvement;	4.275						0.855		
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for technology and craftsmanship.	(f) Continual improvement; (g) Organizational learning	3.800						0.760	0.760	
2.9	My employer often (at least twice per year on average) provides management staff and subcontractors training in any of the following items: Value engineering, progress and programme review, process control, environmental control, safety management, risk management. (Staff training)	(d)Supplier management;(e)People management; (g) Organizational learning	3.000				0.600	0.600		0.600	
2.10	In the PASS system, more focus should be placed on general (management) assessment than on works (product) assessment. Web Site: http://www.housingauthority.gov.hk/en/businesspartners/buildingpass/0,,00.html Note: General assessment includes Mgmt Input Assmt (Mgmt & Organzn, Resources, Co-ordination & control, Document) (Management quality in PASS)	(a) Process management; (b)Customer management (ext); (c) Top Management leadership; (e)People management;	3.725	0.745	0.745	0.745		0.745			
		Average	3.808	79.50%	76.63%	78.25%	74.75%	72.25%	77.63%	72.67%	67.00%
				1	4	2	5	7	3	6	8

Ctr -Part 3 - What actions need to be done for the HK CI quality? TQM element relevancy is based on the comments received from the pilot questionnaire			Respondent's Mean Score (Relative to a max of 5)	TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0) (a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
3.1	Fire fighting scenarios (response to emergency happenings) happen frequently (averagely more than 2 times per week) in my organization.	(a) Process management; (c) Top Management leadership; (e)People management	4.250	0.850		0.850		0.850			
3.2	Most staff could not remember most of the core values of the company (an indicator of internal communication effectiveness).	(c) Top Management leadership; (e)People management	4.200			0.840		0.840			
3.3	The preparation of subcontractor procurement plan, project programme and method statement should be kicked-off with meetings amongst the team leaders from every functional team.	(a) Process management; (d)Supplier management	4.100	0.820			0.820				
3.4	Relationships with the fragmented but extensive participating teams, both internal and external, should be maintained fairly and amicably (in a friendly and peaceful manner) to prevent the development of an adversarial project culture.	(a) Process management; (d)Supplier management; (e)People management	3.850	0.770			0.770	0.770			
3.5	As a contractor's staff, I agree that clients should continuously play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	(c) Top Management leadership; (d)Supplier management	3.875			0.775	0.775				
3.6	Customer satisfaction survey during and at the end of a project duration is required to obtain others' views on contractors' overall performance.	(b)Customer management; (f) Continual improvement	3.950		0.790				0.790		
3.7	Since the implementation of the ISO 9000 system in the early 1990s, workers' attitude towards process planning and product conformance has only limited improvements.	(a) Process management; (f) Continual improvement; (h) Quality information management	3.375	0.675					0.675		0.675
3.8	Mistakes (non-conformance as described in quality management systems) made on sites are often due to misinterpretation by the contractor of given information (drawings and specifications) or due to superseded information.	(a) Process management; (e)People management	3.025	0.605				0.605			
3.9	Ditto but due to negligence, uncertainties or unconscious risk taking.	(a) Process management; (e)People management	3.325	0.665				0.665			
3.10	Ditto but due to conscious risk taking by the subcontractor who is possibly under budget or time constraints.	(d)Supplier management	4.225				0.845				
3.11	The senior members of the company have not encouraged free flow of information and have not demonstrated openness to others' views and opinions.	(c) Top Management leadership; (g) Organizational learning	3.800			0.760				0.760	
3.12	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	(g) Organzn learning - influenced by the society / industry leaders	3.925							0.785	
		Average	3.825	73.08%	79.00%	80.63%	80.25%	74.60%	73.25%	77.25%	67.50%
				7	3	1	2	5	6	4	8

Ctr -Part 4 - Would the adoption of TQM principles be appropriate for achieving quality enhancement? TQM element relevancy is based on the comments received from the pilot questionnaire			Respondent's Mean Score (Relative to a max of 5)	TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0) (a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
4.1	As a contractor, your company agrees that clients should consider realistically the specified construction period in the contract. (Realistic construction period)	(d)Supplier management	4.225				0.845				
4.2	As a contractor, your company agrees that client organizations should award construction contracts based on tenderers' experience and management in project delivery, construction process and final product in addition to price consideration. (Award to both management and price considerations)	(a) Process management; (d)Supplier management	4.125	0.825			0.825				
4.3	Construction contracts should facilitate balanced sharing of construction risks between contractors and clients. (Balance of risks)	(c) Top Management leadership; (d)Supplier management; (h) Quality information management	4.025			0.805	0.805				0.805
4.4	Contractors should establish long term business relationship with the project clients , with due respect to the contractual positions of the parties. (Relationship with clients)	(b)Customer management	4.100		0.820						
4.5	Each contactor should establish his reliable supply chain with due respect to contractual rights and responsibilities. (Reliable supply chain)	(d)Supplier management	4.150				0.830				
4.6	Contractors' senior and top management should encourage free flow of opinion, including the internal customer satisfaction feedback survey, and foster trust within the organization. (Openness)	(c) Top Management leadership; (e)People management; (f) Continual improvement	4.050			0.810		0.810	0.810		
4.7	The person in charge of a project should give his full support to stop work decisions made by his team leaders in the contractor's team due to issues in safety, environmental pollution, construction methodology and design that critically affect the project quality. (adequate delegation)	(a) Process management; (c) Top Management leadership; (e)People management; (h) Quality information management	3.650	0.730		0.730		0.730			0.730
4.8	The industry should encourage life time learning in quality management, craftsmanship and technology in order to practice continual improvement. (Continuous learning)	(c) Top Management leadership; (e)People management; (f) Continual improvement; (g) Organizational learning	4.200			0.840		0.840	0.840	0.840	
4.9	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology. (Trained workers)	(e)People management; (g) Organizational learning	4.125					0.825		0.825	
4.10	The total quality criterion listed in the above statements 4.1 - 4.9 are comparatively easier than the QA procedures when applied in modern construction which is dynamic, and creativity & methodology driven. (TQM in construction)	Overall comparison (not affecing the element ranking calculations)	4.075								
		Average	4.075	77.75%	82.00%	79.63%	82.63%	80.13%	82.50%	83.25%	76.75%
				7	4	6	2	5	3	1	8

Appendix 5A-A1 – Pearson Correlation Chart

Ctr-Part 2- How familiar with TQM are Hong Kong construction contractors?

Part 2 - Are construction contractors familiar with TQM?

Correlations Ctr Q2 N=40

		2.1 Quality in construction should include quality of management	2.2 Quality in construction should include quality of the process	2.3 TQM is routine & daily approach against QA's specific procedure approach	2.4 Degree of knowledge of process control tools	2.5 know about the internal customer concept	2.6 agreement of the min. life cost concept	2.7 the addition of TQM to intensive inspection could improve the overall project QM	2.8 Industry quality focus has been transforming from QA only to long term development on technology and craftsmanship	2.9 Employer often provide min. 3 TQM element training	2.10 More emphasis on management than on product for refining the HK PASS
2.1	Pearson Correlation	1	0.546	.112	.235	0.547	.269	.289	.174	.202	.197
	Sig. (2-tailed)		.000	.491	.144	.000	.093	.071	.284	.212	.222
2.2	Pearson Correlation	0.546	1	.311	0.477	0.348	0.461	0.362	0.469	.062	.180
	Sig. (2-tailed)	.000		.051	.002	.028	.003	.022	.002	.706	.267
2.3	Pearson Correlation	.112	.311	1	0.663	.236	0.423	0.402	0.329	.131	0.388
	Sig. (2-tailed)	.491	.051		.000	.143	.007	.010	.038	.422	.013
2.4	Pearson Correlation	.235	0.477	0.663	1	0.426	0.682	0.494	0.518	.154	0.393
	Sig. (2-tailed)	.144	.002	.000		.006	.000	.001	.001	.341	.012
2.5	Pearson Correlation	0.547	0.348	.236	0.426	1	0.52	0.553	0.419	.083	0.352
	Sig. (2-tailed)	.000	.028	.143	.006		.001	.000	.007	.610	.026
2.6	Pearson Correlation	.269	0.461	0.423	0.682	0.52	1	0.756	0.608	-.036	0.361
	Sig. (2-tailed)	.093	.003	.007	.000	.001		.000	.000	.824	.022
2.7	Pearson Correlation	.289	0.362	0.402	0.494	0.553	0.756	1	0.663	-.092	0.42
	Sig. (2-tailed)	.071	.022	.010	.001	.000	.000		.000	.573	.007
2.8	Pearson Correlation	.174	0.469	0.329	0.518	0.419	0.608	0.663	1	.000	0.634
	Sig. (2-tailed)	.284	.002	.038	.001	.007	.000	.000		1.000	.000
2.9	Pearson Correlation	.202	.062	.131	.154	.083	-.036	-.092	.000	1	.307
	Sig. (2-tailed)	.212	.706	.422	.341	.610	.824	.573	1.000		.054
2.10	Pearson Correlation	.197	.180	0.388	0.393	0.352	0.361	0.42	0.634	.307	1
	Sig. (2-tailed)	.222	.267	.013	.012	.026	.022	.007	.000	.054	
Total Strong Correlation		2	6	5	7	7	7	7	7	0	6

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5A - B1 – Pearson Correlation Chart

Ctr-Part 3- What actions needed to be done for Hong Kong construction industry quality (current projects)?

Part 3 - What needs to be done for the Hong Kong construction industry quality?

Correlations Ctr Q3 N = 40

		3.1 More than 2 fire fighting scenarios per week	3.2 Knowledge of company core values	3.3 Team leaders to kick off major project activities	3.4 Amicable relationship rather than adversarial	3.5 Cleints should be active in project and quality management	3.6 Conduct customer satisfaction survey	3.7 Workers' attitude is improved towards the importance of project planning and product conformance	3.8 NCs arise from misinterpretation of dwgs/specs or outdated information	3.9 NCs arise from negligence and uncertainties	3.10 NCs arise from intended risk taking	3.11 Mgmt support free flow of info and openess to opinions	3.12 HKCI lacks behind in adopting creative concepts
3.1	Pearson Correlation	1	0.395	0.466	0.651	0.618	0.702	0.54	.095	.209	0.512	0.603	0.784
	Proximity		.012	.002	.000	.000	.000	.000	.559	.195	.001	.000	.000
3.2	Pearson Correlation	0.395	1	0.318	0.423	0.482	0.423	0.496	.247	.223	0.361	0.506	0.479
	Proximity	.012		.046	.007	.002	.007	.001	.125	.166	.022	.001	.002
3.3	Pearson Correlation	0.466	0.318	1	0.38	.105	0.35	0.651	0.339	0.357	.236	0.329	0.411
	Proximity	.002	.046		.016	.517	.027	.000	.032	.024	.143	.038	.008
3.4	Pearson Correlation	0.651	0.423	0.38	1	0.703	0.872	0.64	.256	0.346	0.523	0.544	0.896
	Proximity	.000	.007	.016		.000	.000	.000	.111	.029	.001	.000	.000
3.5	Pearson Correlation	0.618	0.482	.105	0.703	1	0.782	0.416	-.039	.039	0.329	0.392	0.725
	Proximity	.000	.002	.517	.000		.000	.008	.812	.812	.038	.012	.000
3.6	Pearson Correlation	0.702	0.423	0.35	0.872	0.782	1	0.659	.137	0.354	0.46	0.526	0.885
	Proximity	.000	.007	.027	.000	.000		.000	.400	.025	.003	.000	.000
3.7	Pearson Correlation	0.54	0.496	0.651	0.64	0.416	0.659	1	0.417	0.545	0.373	0.545	0.637
	Proximity	.000	.001	.000	.000	.008	.000		.007	.000	.018	.000	.000
3.8	Pearson Correlation	.095	.247	0.339	.256	-.039	.137	0.417	1	0.486	.232	.275	.213
	Proximity	.559	.125	.032	.111	.812	.400	.007		.001	.150	.086	.187
3.9	Pearson Correlation	.209	.223	0.357	0.346	.039	0.354	0.545	0.486	1	.141	.285	.292
	Proximity	.195	.166	.024	.029	.812	.025	.000	.001		.386	.075	.068
3.10	Pearson Correlation	0.512	0.361	.236	0.523	0.329	0.46	0.373	.232	.141	1	0.419	0.543
	Proximity	.001	.022	.143	.001	.038	.003	.018	.150	.386		.007	.000
3.11	Pearson Correlation	0.603	0.506	0.329	0.544	0.392	0.526	0.545	.275	.285	0.419	1	0.668
	Sig. (2-tailed)	.000	.001	.038	.000	.012	.000	.000	.086	.075	.007		.000
3.12	Pearson Correlation	0.784	0.479	0.411	0.896	0.725	0.885	0.637	.213	.292	0.543	0.668	1
	Proximity	.000	.002	.008	.000	.000	.000	.000	.187	.068	.000	.000	
Total Strong Correlation		9	9	9	10	8	10	11	3	5	8	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5A-C1 – Pearson Correlation Chart

Ctr -Part 4- Would the adoption of TQM principles be appropriate for achieving long term quality enhancement?

Correlations Ctr N=40

		Item4.1	Item4.2	Item4.3	Item4.4	Item4.5	Item4.6	Item4.7	Item4.8	Item4.9	Item4.10
Item4.1	Pearson Correlation	1	.501**	.146	.513**	.442**	.183	.086	.011	.261	.282
	Sig. (2-tailed)		.001	.368	.001	.004	.259	.599	.948	.104	.078
Item4.2	Pearson Correlation	.501**	1	.400*	.989**	.990**	.420**	.300	.103	.424**	.394*
	Sig. (2-tailed)	.001		.010	.000	.000	.007	.060	.528	.006	.012
Item4.3	Pearson Correlation	.146	.400*	1	.371*	.414**	.975**	.134	.471**	.904**	.897**
	Sig. (2-tailed)	.368	.010		.019	.008	.000	.411	.002	.000	.000
Item4.4	Pearson Correlation	.513**	.989**	.371*	1	.979**	.392*	.293	.076	.397*	.400*
	Sig. (2-tailed)	.001	.000	.019		.000	.012	.066	.641	.011	.011
Item4.5	Pearson Correlation	.442**	.990**	.414**	.979**	1	.434**	.267	.099	.435**	.406**
	Sig. (2-tailed)	.004	.000	.008	.000		.005	.095	.542	.005	.009
Item4.6	Pearson Correlation	.183	.420**	.975**	.392*	.434**	1	.144	.449**	.928**	.923**
	Sig. (2-tailed)	.259	.007	.000	.012	.005		.375	.004	.000	.000
Item4.7	Pearson Correlation	.086	.300	.134	.293	.267	.144	1	.316*	.233	.162
	Sig. (2-tailed)	.599	.060	.411	.066	.095	.375		.047	.148	.317
Item4.8	Pearson Correlation	.011	.103	.471**	.076	.099	.449**	.316*	1	.489**	.452**
	Sig. (2-tailed)	.948	.528	.002	.641	.542	.004	.047		.001	.003
Item4.9	Pearson Correlation	.261	.424**	.904**	.397*	.435**	.928**	.233	.489**	1	.949**
	Sig. (2-tailed)	.104	.006	.000	.011	.005	.000	.148	.001		.000
Item4.10	Pearson Correlation	.282	.394*	.897**	.400*	.406**	.923**	.162	.452**	.949**	1
	Sig. (2-tailed)	.078	.012	.000	.011	.009	.000	.317	.003	.000	
strong Correlation		3	7	7	7	7	7	1	5	7	7

**. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed).

7.5 Appendices for Chapter 5B

Appendix 5B-A

Survey Results for - Part 2 – How familiar with TQM are Hong Kong Engineering Consultants

Cst - Part 2 - How familiar with TQM are Hong Kong engineering consultants?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 2 (from SPSS)
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity – the concept of internal customer in the context of customer satisfaction.	Highest score - indicating agreement on internal quality is a criteria for getting external and final quality	4.29	Highest	6
2.7	I often refresh my project and quality management knowledge by attending external courses or visiting construction engineering related web sites such as those for Hong Kong Institute of Engineers, Construction Industry Council and the Institute of Building.	Very high score - agreeing that knowledge enhancement and experience sharing for project and quality management is taking place.	4.26	2nd Highest	7
2.2	Quality in construction engineering should include process quality, that is, process planning, process monitoring, process improvement, design output control and design optimization.	Much higher score as compared to Item 2.1 (4.17 against 3.26). An indication that process quality is receiving much higher attention than management quality.	4.17	3rd Highest	7
2.3	Total Quality Management (TQM) fosters the culture of monitoring and improvements at all levels in an engineering consultant organization. TQM is integrated into the daily management activities while Quality Assurance (QA) system sets distinctive written procedures for process control and product assurance.	High range score - an indication on the agreement that TQM fosters the integration of quality into daily management activities.	4.14		6
2.6	Minimum life cost is the ultimate goal for project cost control	Average score - Life for construction is generally longer than typical manufacturing, life cost assessment is a more long term prediction for infrastructure construction.	3.80		7
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for engineering and design skill.	Average score - Agreeing on training for fundamental skill as a basis for continuous improvement and thus provide the industry with more long term benefits.	3.77		7
2.10	My employer is treating staff as assets and training them for efficient application of resources in an innovative and sustainable manner.	Average score - the valuation of people being a critical asset of a construction organization is not high.	3.77		7
2.4	Project control team members should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and Graph - For visually displaying data, e.g., in a pie chart	Low score - indicates the little focus on the knowledge on systematic monitoring tools, hindering continuous improvements.	3.51	3rd Lowest	2
2.1	Quality in construction engineering should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries.	Components affecting the quality of relationship - low score as compared to Item 2.2 for tangible quality components (product or service quality)	3.26	2nd Lowest	6
2.9	The employer often (at least twice per year on average) organize induction and training on any of the following items: Value engineering, programme control, engineering process control, risk management and calculation software management.	Lowest score - reflecting the focus on training is insufficient.	3.17	Lowest	1
Discussions for Part 2 - The survey identified the following specific observations					
1	The Part 2 results indicate a high degree of agreement that internal customer satisfaction is a criteria for achieving final engineering quality. They show that knowledge refreshment and experience sharing are being used as a means for continual improvement. It is also indicated that the engineering consultants are placing more emphasis on process quality than on management quality.				
2	Through SPSS, the score pattern of the respondents indicates that high score Items 2.5 for internal customer concept, 2.7 for management knowledge refreshment and item 2.2 for process are highly correlated with other TQM elements in the familiarization survey.				
3	The long term investment on management training for employees by engineering consultants is limited.				
4	The consideration of quality of management is relatively low as compared to that of quality of process.				
5	Through SPSS, the score pattern of the respondents also indicates that low score Items 2.9 for employer providing management training and item 2.4 for the application of process control tools have little correlation with the other TQM elements in the familiarization survey.				
6	Having applied the survey results to the related TQM elements in each question, the engineering consultants are indicated to be most familiar with the element of "Process management", while the second and third most familiar TQM elements are "Top management & leadership" and "Continual improvement" respectively.				

Appendix 5B-B

Survey Results for - Part 3 – What actions needed to be taken to improve construction quality by engineering consultants (Focusing on current projects)

Cst - Part 3 - What needs to be done for the HK Construction Industry?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 3 (from SPSS)
3.10	Quality assurance system could be supplemented with TQM tools to improve the systematic planning of the design process which is crucial to the timely delivery of economic and buildable design.	Highest score - TQM is appreciated by engineering consultants	4.29	Highest	3
3.5	Fire fighting scenarios (response to emergency happenings) happen frequently (averagely more than 2 times per week) in my organization.	Highest score - fire fighting situations are common (due to work type, staff competency, company culture)	4.14	2nd Highest	5
3.6	Project programme and design approach preparations should be kicked-off with meetings amongst the general teams and the specialist teams when required.	High score - agreement that systematic planning is required.	4.00	3rd Highest	1
3.3	Ditto but due to inaccurate design under budget or time constraints.	Average score - indicates accuracy of design are sometimes affected by budget and time constraints .	3.86		2
3.9	Customer satisfaction survey during and at the end of a project duration is required to reflect consultants?overall performance.	Average score - many respondents agree conducting of the customer satisfaction survey.	3.80		4
3.11	The senior members of the company should encourage free flow of information and demonstrate openness to others' views and opinions.	Average score - free flow of information facilitate good communication, which is generally considered a criteria for advancing improvements in construction.	3.77		2
3.8	As a consultant's staff, I agree that clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	Average score - try to make reference to the CIRC report , client should take the lead in demanding excellence.	3.74		4
3.4	Ditto but due to uncontrolled out sourced design activities.	Average score - indicates design mistakes sometimes occur due to inadequate management of outsourcing.	3.69		4
3.7	Relationships with the fragmented but extensive participating teams, both internal and external, should be maintained fairly and amicably (in a friendly and peaceable manner) to prevent the development of an adversarial project culture.	Average score - there is room for improvement in industry integration which is also a recommendation in the CIRC report	3.69		4
3.12	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	Moderately high - agreement is weak that the construction industry is lacking behind other industries for adopting new technology and management.	3.54	3rd Lowest	1
3.2	Ditto but due to negligence and uncertainties.	Low score - indicates mistakes resulting from negligence and uncertainties are unusual.	3.29	2nd Lowest	1
3.1	Mistakes (non-conformance as described in quality management systems) made are often due to misinterpretation of design brief or due to superseded information.	Lowest score - indicates strong disagreement. It appears that respondents are considering their interpretation is usually correct.	2.94	Lowest	1

Discussions for Part 3 - The survey identified the following specific observations

1	There is a high degree of agreement that TQM tools could supplement QA systems for the continual improvement of design processes. The need to reduce the possibility of fire-fighting scenarios in the management of engineering projects is substantial. The systematic co-ordination between general team and specialist teams before design commencement is essential.
2	Through SPSS, the score pattern of the respondents also indicates that high score Items 3.10 for TQM tools as improvement tools and 3.6 design process kick-off meetings are weakly correlated with other TQM elements in the action needed survey.
3	Engineering consultants on the average disagree that mistakes are caused by the misinterpretation of the design brief given by the project initiator or the lack of awareness of superseded design information.
4	Engineering consultants occasionally disagree that mistakes are caused by negligence or uncertainties.

Appendix 5B-C

Survey Results for - Part 4 – Is the adoption of TQM principles appropriate for achieving long term quality enhancement for the engineering consultants?

Cst - Part 4 - Would the adoption of TQM principles be appropriate for achieving quality enhancement?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 4 (from SPSS)
4.7	In order to practise continual improvement, the industry should encourage life time learning in both quality management and engineering skill and applications.	Highest score - life time learning is supported by consultants, who are practicing contemporary engineering ideas	4.23	Highest	1
4.1	As an engineering consultant, your company agrees that clients should consider realistically the specified design period in the contract.	High - Mostly agreed that clients should set the requirements based on realistic design periods (refer to the CIRC report)	4.17	2nd Highest	4
4.2	As an engineering consultant, your company agrees that clients should award engineering design contracts based on tenderers?track record in quality management, the delivery of design deliverables and clarity, completeness and buildability of design output, in addition to price consideration.	High - Mostly agreed that clients should assess performance in parallel with the cost proposals (in line with the CIRC report)	4.14	3rd Highest	4
4.8	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology.	High score - worker registration and continuous training is supported by consultants who has the role of introducing appropriate new construction technology into the design.	4.11		4
4.6	Consultants?should obtain systematically feed back on possible synergic improvements (i.e. improvements that are beneficial to all parties) from contractors or other users of the design.	Moderately high score - indicates the synergic improvement approach is agreed by many consultants	4.06		4
4.9	The total quality criterion listed in the above statements 4.1 to 4.8 are comparatively easier than the QA procedures when applied in engineering design which is dynamic, and methodology & creativity driven.	Moderately high - TQM in the construction industry is supported by engineering consultants	4.06		5
4.4	Engineering consultants should establish long term business relationship with the project clients, with due respect to the contractual positions of the parties.	Average - an unanticipated result that the score is relatively low. Despite the relative comparison, a score of 3.97 still indicate that consultants usually maintain good business relationships with clients including government clients and contractors clients.	3.97	3rd Lowest	7
4.5	Consultants?senior and top management should encourage free flow of opinion and foster trust within the organization, including the internal customer satisfaction feed back survey.	Low - design is considered as an intellectual property which might restrict the free flow of opinions on technical justifications and applications but does hinder discussions on principles and approaches.	3.80	2nd Lowest	3
4.3	Contract documents should facilitate balanced sharing of project risks between designers, project supervisors and clients.	Lowest - concept and application of risk sharing are still weak in Hong Kong, probably due to overemphasizing commercial considerations.	3.66	Lowest	4
	Discussions for Part 4 - The survey identified the following specific observations				
1	The Part 4 results highlight the appropriateness to quality enhancement for engineering consultants of long term training in quality management and engineering skills, realistic design period consideration by the client and the quality of design output consideration at tender stage by the client.				
2	Through SPSS, the score pattern of the respondents indicates that high score Items 4.1 for realistic design period and 4.8 design output consideration are generally correlated with other TQM elements in the appropriateness survey while Item 4.7 for long term training in quality management and engineering skill is only slightly correlated with other TQM elements.				
3	Respondents' score for the various items in Part 4 ranges from 3.66 to 4.23. The overall scores are relatively high and the range is narrow as compared to Parts 2 and 3. It indicates that all items in this part are quite appropriate for achieving quality enhancement for contractors.				
4	Although the score for Item 4.3 regarding the sharing of risks in engineering consultancy contracts is the lowest, the appropriateness of risk sharing is still within the positive score range as reflected by the score of 3.66.				

Appendix 5B-D TQM priority analysis for survey results of engineering consultants

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Cst - Part 2 - How are engineering consultants familiar with TQM? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
2.1	Quality in construction engineering should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries.	(b)Customer management; Customer Mgmt (Int Customer); (d)Supplier management; (e)People management	3.257		0.651		0.651	0.651			
2.2	Quality in construction engineering should include process quality, that is, process planning, process monitoring, process improvement, design output control and design optimization.	(a)Process Mgmt (Also the Q of process mgmt); (d)Supplier management	4.171	0.834			0.834				
2.3	Total Quality Management (TQM) fosters the culture of monitoring and improvements at all levels in an engineering consultant organization. TQM is integrated into the daily management activities while Quality Assurance (QA) system sets distinctive written procedures for process control and product assurance.	(c) Top Management leadership; (f) Continual improvement; (g) Organizational learning	4.143			0.829			0.829	0.829	
2.4	Project control team members should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and Graph - For visually displaying data, e.g., in a pie chart	(f) Continual improvement; (h) Quality information management	3.514						0.703		0.703
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity – the concept of internal customer in the context of customer satisfaction.	(b)Customer Mgmt;(d)Supplier management; (e)People management	4.286		0.857		0.857	0.857			
2.6	Minimum life cost is the ultimate goal for project cost control	(b)Customer Mgmt (Ext)	3.800		0.760						
2.7	I often refresh my project and quality management knowledge by attending external courses or visiting construction engineering related web sites such as those for Hong Kong Institute of Engineers, Construction Industry Council and the Institute of Building.	(f) Continual improvement; (h) Quality information management	4.257						0.851		0.851
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for engineering and design skill.	(f) Continual improvement; (g) Organizational learning	3.771						0.754	0.754	
2.9	The employer often (at least twice per year on average) organize induction and training on any of the following items: Value engineering, programme control, engineering process control, risk management and calculation software management.	(e)People management; (g) Organizational learning	3.171					0.634		0.634	
2.10	My employer is treating staff as assets and training them for efficient application of resources in an innovative and sustainable manner.	(a) Process management; (c) Top Management leadership; (e)People management	3.771	0.754		0.754		0.754			
		Average	3.814	79.43%	75.62%	79.14%	78.10%	72.43%	78.43%	73.90%	77.71%
				1	6	2	4	8	3	7	5

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Cst -Part 3 - What actions need to be done for the HK CI quality? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
3.1	Mistakes (non-conformance as described in quality management systems) made are often due to misinterpretation of design brief or due to superseded information.	(a) Process management; (e)People management; (h) Quality information management	2.943	0.589				0.589			0.589
3.2	Ditto but due to negligence and uncertainties.	(a) Process management; (e)People management; (h) Quality information	3.286	0.657				0.657			0.657
3.3	Ditto but due to inaccurate design under budget or time constraints.	(d)Supplier Mgmt; (h) Quality information management	3.860				0.772				0.772
3.4	Ditto but due to uncontrolled out sourced design activities.	(d) Supplier Mgmt; (h) Quality information management	3.686				0.737				0.737
3.5	Fire fighting scenarios (response to emergency happenings) happen frequently (averagely more than 2 times per week) in my organization.	(a) Process management; (c) Top Management leadership; (e)People management	4.143	0.829		0.829		0.829			
3.6	Project programme and design approach preparations should be kicked-off with meetings amongst the general teams and the specialist teams when required.	(d)Supplier management	4.000				0.800				
3.7	Relationships with the fragmented but extensive participating teams, both internal and external, should be maintained fairly and amicably (in a friendly and peaceable manner) to prevent the development of an adversarial project culture.	(a) Process management; (d)Supplier management; (e)People management	3.686	0.737			0.737	0.737			
3.8	As a consultant's staff, I agree that clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	(c) Top Management leadership; (d)Supplier management	3.743			0.749	0.749				
3.9	Customer satisfaction survey during and at the end of a project duration is required to reflect consultants' overall performance.	(b)Customer management; (f) Continual improvement	3.800		0.760				0.760		
3.10	Quality assurance system could be supplemented with TQM tools to improve the systematic planning of the design process which is crucial to the timely delivery of economic and buildable design.	(f) Continual improvement	4.286						0.857		
3.11	The senior members of the company have not encouraged free flow of information and have not demonstrated openness to others' views and opinions.	(c) Top Management leadership; (g) Organizational learning	3.771			0.754				0.754	
3.12	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	(g) Organizational learning - influenced by the society / industry leaders	3.540							0.708	
		Average	3.729	70.29%	76.00%	77.71%	75.90%	70.29%	80.86%	73.11%	68.87%
				6	3	2	4	7	1	5	8

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Cst -Part 4 - Would the adoption of TQM principles be appropriate for achieving quality enhancement? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
4.1	As an engineering consultant, your company agrees that clients should consider realistically the specified design period in the contract.	(a) Process management; (c) Top Management leadership; (d)Supplier	4.171	0.834		0.834	0.834				
4.2	As an engineering consultant, your company agrees that clients should award engineering design contracts based on tenderers' track record in quality management, the delivery of design deliverables and clarity, completeness and buildability of design output, in addition to price consideration.	(c) Top Management leadership; (d)Supplier management	4.143			0.829	0.829				
4.3	Contract documents should facilitate balanced sharing of project risks between designers, project supervisors and clients.	(a) Process management; (c) Top Management leadership; (d)Supplier management; (h) Quality information	3.657	0.731		0.731	0.731				0.731
4.4	Engineering consultants should establish long term business relationship with the project clients, with due respect to the contractual positions of the parties.	(b)Customer management	3.971		0.794						
4.5	Consultants' senior and top management should encourage free flow of opinion and foster trust within the organization, including the internal customer satisfaction feed back survey.	(c) Top Management leadership; (e)People management; (f) Continual improvement; (g) Organizational learning	3.800			0.760		0.760	0.760	0.760	
4.6	Consultants' should obtain systematically feed back on possible synergic improvements (i.e. improvements that are beneficial to all parties) from contractors or other users of the design.	(f) Continual improvement; (g) Organizational learning; (h) Quality information management	4.057						0.811	0.811	0.811
4.7	In order to practise continual improvement, the industry should encourage life time learning in both quality management and engineering skill and applications.	(e)People management; (f) Continual improvement; (g) Organizational learning	4.229					0.846	0.846	0.846	
4.8	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology.	(e)People management; (g) Organizational learning	4.114					0.823		0.823	
4.9	The total quality criterion listed in the above statements 4.1 to 4.8 are comparatively easier than the QA procedures when applied in engineering design which is dynamic, and methodology & creativity driven. - score is evenly spread over all elements	Overall comparison	4.057	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811
		Average	4.022	79.24%	80.29%	79.31%	80.14%	81.00%	80.71%	81.03%	78.48%
				7	4	6	5	2	3	1	8

Appendix 5B-A1 – Pearson Correlation Chart

Cst-Part 2- How familiar with TQM are Hong Kong engineering consultants?

Correlations Cst Q2 N=35

Correlation Matrix by SPSS		2.1 Quality in construction engineering should include the quality of the management.	2.2 Quality in construction engineering should include quality of processes.	2.3 TQM is routine 2 daily approach against QA's specific procedure approach.	2.4 Degree of knowledge of process control tools.	2.5 Knowledge about the concept of internal customer in the context of customer satisfaction.	2.6 Degree of agreement on the minimum life cost concept	2.7 Self-activited continuous learning in project and quality management.	2.8 The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for engineering and design skill.	2.9 The employer often (at least twice yearly) organize induction and training on quality and project management topics.	2.10 My employer is treating staff as assets and training them for efficient application of resources in an innovative and sustainable manner.
2.1	Pearson Correlation	1	.344*	.738**	.177	.321	.469**	.351*	.482**	.272	.511**
	Sig. (2-tailed)		.043	.000	.310	.060	.004	.039	.003	.114	.002
2.2	Pearson Correlation	.344*	1	.382*	.568**	.373*	.407*	.337*	.452**	.066	.248
	Sig. (2-tailed)	.043		.023	.000	.027	.015	.048	.006	.707	.151
2.3	Pearson Correlation	.738**	.382*	1	.153	.312	.484**	.440**	.340*	.188	.360*
	Sig. (2-tailed)	.000	.023		.381	.068	.003	.008	.046	.281	.033
2.4	Pearson Correlation	.177	.568**	.153	1	.476**	.188	.269	.212	.233	.225
	Sig. (2-tailed)	.310	.000	.381		.004	.278	.117	.222	.177	.195
2.5	Pearson Correlation	.321	.373*	.312	.476**	1	.592**	.653**	.471**	.113	.363*
	Sig. (2-tailed)	.060	.027	.068	.004		.000	.000	.004	.517	.032
2.6	Pearson Correlation	.469**	.407*	.484**	.188	.592**	1	.723**	.637**	-.077	.498**
	Sig. (2-tailed)	.004	.015	.003	.278	.000		.000	.000	.660	.002
2.7	Pearson Correlation	.351*	.337*	.440**	.269	.653**	.723**	1	.662**	-.078	.563**
	Sig. (2-tailed)	.039	.048	.008	.117	.000	.000		.000	.657	.000
2.8	Pearson Correlation	.482**	.452**	.340*	.212	.471**	.637**	.662**	1	.142	.768**
	Sig. (2-tailed)	.003	.006	.046	.222	.004	.000	.000		.415	.000
2.9	Pearson Correlation	.272	.066	.188	.233	.113	-.077	-.078	.142	1	.374*
	Sig. (2-tailed)	.114	.707	.281	.177	.517	.660	.657	.415		.027
2.10	Pearson Correlation	.511**	.248	.360*	.225	.363*	.498**	.563**	.768**	.374*	1
	Sig. (2-tailed)	.002	.151	.033	.195	.032	.002	.000	.000	.027	
Total Strong Correlation		6	7	6	2	6	7	7	7	1	7

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5B - B1 – Pearson Correlation Chart

Cst-Part 3- What actions needed to be done for Hong Kong construction industry quality (current projects)?

Correlations Cst Q3 N=35

		3.1 Mistakes (non-conformance as described in quality management systems) made are often due to misinterpretation of design brief or due to superseded information.	3.2 Ditto but due to negligence and uncertainties.	3.3 Ditto but due to inaccurate design under budget or time constraints.	3.4 Ditto but due to uncontrolled out sourced design activities.	3.5 Fire fighting scenarios (response to emergency happenings) happen frequently (averagely more than 2 times per week) in my organization.	3.6 Project programme and design approach preparations should be kicked-off with meetings amongst the general teams and the specialist teams when required.	3.7 Relationships with the fragmented but extensive participating teams, both internal and external, should be maintained fairly and amicably (in a friendly and peaceable manner) to prevent the development of an adversarial project culture.	3.8 As a consultant's staff, I agree that clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	3.9 Customer satisfaction survey during and at the end of a project duration is required to reflect consultants' overall performance.	3.10 Quality assurance system could be supplemented with TQM tools to improve the systematic planning of the design process which is crucial to the timely delivery of economic and buildable design.	3.11 The senior members of the company should encourage free flow of information and demonstrate openness to others' views and opinions.	3.12 As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.
3.1	Pearson Correlation	1	.441**	.185	.135	-.050	.320	.135	-.206	-.024	.148	-.024	.006
	Sig. (2-tailed)		.008	.288	.440	.776	.061	.440	.236	.890	.396	.891	.973
3.2	Pearson Correlation	.441**	1	.162	.315	.147	.306	.315	-.034	.325	.088	.231	-.039
	Sig. (2-tailed)	.008		.354	.065	.400	.074	.065	.848	.057	.615	.182	.823
3.3	Pearson Correlation	.006	-.039	1	.153	.313	-.062	.153	.151	.232	.359*	.096	.252
	Sig. (2-tailed)	.973	.823		.380	.067	.722	.380	.388	.179	.034	.582	.144
3.4	Pearson Correlation	.135	.315	.137	1	.520**	.259	1.000**	.607**	.812**	.009	.088	.153
	Sig. (2-tailed)	.440	.065	.433		.001	.133	.000	.000	.000	.958	.614	.380
3.5	Pearson Correlation	-.050	.147	.049	.520**	1	.382*	.520**	.511**	.592**	-.195	-.136	.313
	Sig. (2-tailed)	.776	.400	.778	.001		.024	.001	.002	.000	.263	.437	.067
3.6	Pearson Correlation	.320	.306	.091	.259	.382*	1	.259	-.053	.221	.157	-.096	-.062
	Sig. (2-tailed)	.061	.074	.605	.133	.024		.133	.761	.201	.367	.584	.722
3.7	Pearson Correlation	.135	.315	.137	1.000**	.520**	.259	1	.607**	.812**	.009	.088	.153
	Sig. (2-tailed)	.440	.065	.433	.000	.001	.133		.000	.000	.958	.614	.380
3.8	Pearson Correlation	-.206	-.034	-.132	.607**	.511**	-.053	.607**	1	.722**	-.230	-.126	.151
	Sig. (2-tailed)	.236	.848	.448	.000	.002	.761	.000		.000	.184	.471	.388
3.9	Pearson Correlation	-.024	.325	.120	.812**	.592**	.221	.812**	.722**	1	.000	.089	.232
	Sig. (2-tailed)	.890	.057	.491	.000	.000	.201	.000	.000		1.000	.611	.179
3.10	Pearson Correlation	.148	.088	.652**	.009	-.195	.157	.009	-.230	.000	1	.439**	.359*
	Sig. (2-tailed)	.396	.615	.000	.958	.263	.367	.958	.184	1.000		.008	.034
3.11	Pearson Correlation	-.024	.231	.670**	.088	-.136	-.096	.088	-.126	.089	.439**	1	.096
	Sig. (2-tailed)	.891	.182	.000	.614	.437	.584	.614	.471	.611	.008		.582
3.12	Pearson Correlation	.185	.162	.252	.137	.049	.091	.137	-.132	.120	.652**	.670**	1
	Sig. (2-tailed)	.288	.354	.144	.433	.778	.605	.433	.448	.491	.000	.000	
Total Strong Correlation		1	1	2	4	5	1	4	4	4	3	2	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5B-C1 – Pearson Correlation Chart

Cst-Part 4- Would the adoption of TQM principles be appropriate for achieving long term quality enhancement?

Correlations Cst Q4 N=35

		Item 4.1 As an engineering consultant, your company agrees that clients should consider realistically the specified design period in the contract.	Item 4.2 As an engineering consultant, your company agrees that clients should award engineering design contracts based on tenderers' track record in quality management, the delivery of design	Item 4.3 Contract documents should facilitate balanced sharing of project risks between designers, project supervisors and clients.	Item 4.4 Engineering consultants should establish long term business relationship with the project clients, with due respect to the contractual positions of the parties.	Item 4.5 Consultants' senior and top management should encourage free flow of opinion and foster trust within the organization, including the internal customer satisfaction feed back survey.	Item 4.6 Consultants' should obtain systematically feed back on possible synergic improvements (i.e. improvements that are beneficial to all parties) from contractors or other users of the design.	Item 4.7 In order to practise continual improvement, the industry should encourage life time learning in both quality management and engineering skill and applications.	Item 4.8 The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and	Item 4.9 The total quality criterion listed in the above statements 4.1 to 4.8 are comparatively easier than the QA procedures when applied in engineering design which is dynamic, and methodology &
Item4.1	Pearson Correlation	1	-.368*	.164	-.452**	.213	.328	.330	-.367*	.362*
	Sig. (2-tailed)		.030	.346	.006	.220	.054	.053	.030	.032
Item4.2	Pearson Correlation	-.368*	1	-.206	.384*	-.296	-.426*	-.183	.917**	-.237
	Sig. (2-tailed)	.030		.235	.023	.084	.011	.293	.000	.170
Item4.3	Pearson Correlation	.164	-.206	1	-.514**	.856**	.209	.583**	-.168	.742**
	Sig. (2-tailed)	.346	.235		.002	.000	.228	.000	.333	.000
Item4.4	Pearson Correlation	-.452**	.384*	-.514**	1	-.593**	-.396*	-.330	.390*	-.540**
	Sig. (2-tailed)	.006	.023	.002		.000	.019	.053	.021	.001
Item4.5	Pearson Correlation	.213	-.296	.856**	-.593**	1	.250	.290	-.314	.742**
	Sig. (2-tailed)	.220	.084	.000	.000		.148	.091	.066	.000
Item4.6	Pearson Correlation	.328	-.426*	.209	-.396*	.250	1	.328	-.362*	.335*
	Sig. (2-tailed)	.054	.011	.228	.019	.148		.055	.033	.049
Item4.7	Pearson Correlation	.330	-.183	.583**	-.330	.290	.328	1	-.114	.326
	Sig. (2-tailed)	.053	.293	.000	.053	.091	.055		.516	.056
Item4.8	Pearson Correlation	-.367*	.917**	-.168	.390*	-.314	-.362*	-.114	1	-.126
	Sig. (2-tailed)	.030	.000	.333	.021	.066	.033	.516		.471
Item4.9	Pearson Correlation	.362*	-.237	.742**	-.540**	.742**	.335*	.326	-.126	1
	Sig. (2-tailed)	.032	.170	.000	.001	.000	.049	.056	.471	
Total Strong Correlation		4	4	4	7	3	4	1	4	5

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6 Appendices for Chapter 5C

Appendix 5C-A

Survey Results for - Part 2 – How familiar with TQM are Hong Kong Client Organizations

Clnt -Part 2 - How familiar with TQM are Hong Kong construction clients?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 2 (from SPSS)
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity ?the concept of internal customer in the context of customer satisfaction.	Highest score -	4.3	Highest	0
2.7	Process and product inspection carried out by the clients?representative could be supplemented by TQM tools to improve the overall quality management of the Hong Kong construction industry.	Highest score -	4.3	Highest	1
2.10	I often refresh my project and quality management knowledge by attending external courses or visiting construction engineering related web sites such as those for The Hong Kong Institute of Engineers, Construction Industry Council and the Institute of Building.	3rd Highest	4.25	3rd Highest	4
2.3	TQM fosters the culture of monitoring and improvements at all levels in a construction developer organization in every functional aspect and is integrated into the daily management activities while QA system sets distinctive written procedures for process control and product assurance.	High range score -	4.15	High	1
2.2	Quality in construction should include process quality, that is, process planning, process monitoring, process improvement, end product control and reliability/durability.	High range score -	4.15	High	1
2.6	Minimum life cost is the ultimate goal for project cost control.	Moderate High	3.8	Mod High	2
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for technology, craftsmanship and engineering design skill.	Moderate High	3.8	Mod High	2
2.4	Project control team members should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and Graph - For visually displaying data, e.g., in a pie chart	Low score -	3.5	3rd Lowest	2
2.1	Quality in construction should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries.	2nd Lowest	3.25	2nd Lowest	0
2.9	The employer often organize induction and training on at least 3 of the following items: Value engineering, cost control, programme control, process control and risk management.	Lowest	3.15	Lowest	1

Appendix 5C-B

Survey Results for - Part 3 – What actions need to be taken to improve construction quality by client organizations (Focusing on current projects)

Clnt -Part 3 - What actions need to be done for the Hong Kong construction industry quality?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 3 (from SPSS)
3.2	Most staff could not remember most of the core values of the company (an indicator of internal communication).	Highest score – Indiction of insufficient communication with the general staff	4.20	Highest	1
3.1	Fire fighting scenarios (urgent response to emergency happenings) occur frequently (averagely more than 2 times per week) in my organization.	Highest – fire fighting situations are common (due to work type, staff competency, company culture)	4.15	2nd Highest	2
3.3	The preparation of project master plan, design consultant procurement plan and construction tendering document is kicked-off with meetings amongst the team	High	4.00	3rd Highest	1
3.7	Since the implementation of the ISO 9000 system in the early 1990s, attitudes of the industry's participants towards process planning and product conformance have been improved.	High	4.00	High	3
3.9	Ditto but due to unrealistic expectations in attempts to overcome budget or time constraints.	Mod Hign	3.85	Mod Hign	1
3.6	Customer satisfaction survey is required regularly to reflect end users?level of satisfaction.	Mod Hign	3.80	Mod Hign	4
3.10	The senior members of the company have not supported free flow of information and have not demonstrated openness to others?views and opinions	Average score	3.75	Average	3
3.5	Clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	Average	3.75	Average	3
3.4	Relationships with the fragmented but extensive participating teams, both internal and external, is maintained fairly and amicably (friendly and peacefully) to prevent the development of an adversarial project culture.	Average	3.70	Average	1
3.11	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	Moderately high – agreement is weak that the construction industry is lacking behind other industries for adopting new technology and management.	3.55	2nd Lowest	1
3.8	Mistakes (non-conformance as described in quality management systems) made on project planning are often due to design limitation, misunderstanding of the construction sequences or uncertainties in the statutory approvals.	Low score – indicates mistakes resulting from negligence and uncertainties are unusual.	2.95	Lowest	1

Appendix 5C-C

Survey Results for - Part 4 – Is the adoption of TQM principles appropriate for achieving long term quality enhancement for the client organizations?

Clnt -Part 4 - Would the adoption of TQM be appropriate for achieving quality enhancement?		Comment on score (Range levels description - 75% high, 65% to 75% , moderately high, 45% to 65% average, Less than 45% low)	Mean Score	Score relative comparison	No. of strong correlation items within Part 4 (from SPSS)
4.6	In order to practice continual improvement, the industry should encourage life time learning in craftsmanship, comprehensive project management and contemporary engineering design skills.	Highest score - life time learning is supported by client organizations	4.20	Highest	3
4.1	Client organizations should award construction contracts based on tenderers experience and management in design delivery, construction delivery, construction process and final product in addition to price consideration.	High	4.15	2nd Highest	3
4.7	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology.	High	4.10	3rd Highest	6
4.3	Designers and contractors should establish long term business relationship with the project clients through partnering, with due respect to the contractual positions of the parties.	Average	3.95		6
4.8	The total quality criterion listed in the above statements 4.1 - 4.7 are comparatively easier than the QA procedures when applied in modern construction which is dynamic, and creativity & methodology driven.	Average	3.90		0
4.4	Client organizations' senior and top management should encourage free flow of opinion, including the internal customer satisfaction feedback, and foster trust within the organization,	Low	3.80	3rd Lowest	4
4.2	Construction and engineering contracts should facilitate balanced sharing of risks amongst designers, contractors and clients.	Low	3.65	2nd Lowest	4
4.5	The person in charge of a construction project should give his full support to stop work decisions made by his team due to issues in safety, environmental pollution, construction methodology and design that critically affect the project quality.	Low	3.65	Lowest	4

Appendix 5C-D TQM priority analysis for survey results of client organizations

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Clnt -Part 2 - How familiar with TQM are Hong Kong construction clients? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
2.1	Quality in construction should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries.	(b)Customer management; (d)Supplier management; (e)People management	3.250		0.650		0.650	0.650			
2.2	Quality in construction should include process quality, that is, process planning, process monitoring, process improvement, end product control and reliability/durability.	(a) Process management; (d)Supplier management	4.150	0.830			0.830				
2.3	TQM fosters the culture of monitoring and improvements at all levels in a construction developer organization in every functional aspect and is integrated into the daily management activities while QA system sets distinctive written procedures for process control and product assurance.	(c) Top Management leadership; (f) Continual improvement; (g)Organizational learning	4.150			0.830			0.830	0.830	
2.4	Project control team members should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable causes, Scatter Diagram - For identifying correlation and suggesting causation, Control Chart - For identifying processes that are out of control, and	(f) Continual improvement; (h) Quality information management	3.500						0.700		0.700
2.5	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity – the concept of internal customer in the context of customer satisfaction.	(b)Customer management; (d)Supplier management; (e)People management	4.300		0.860		0.860	0.860			
2.6	Minimum life cost is the ultimate goal for project cost control.	(b)Customer management	3.800		0.760						
2.7	Process and product inspection carried out by the clients' representative could be supplemented by TQM tools to improve the overall quality management of the Hong Kong construction industry.	(f)Continual improvement	4.300						0.860		
2.8	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for technology, craftsmanship and engineering design skill.	(f)Continual improvement; (g)Organizational learning	3.800						0.760	0.760	
2.9	The employer often organize induction and training on at least 3 of the following items: Value engineering, cost control, programme control, process control and risk management.	(e)People management; (g)Organizational learning	3.150					0.630		0.630	
2.10	I often refresh my project and quality management knowledge by attending external courses or visiting construction engineering related web sites such as those for The Hong Kong Institute of Engineers, Construction Industry Council and the Institute of Building.	(h)Quality information management	4.250								0.850
		Average	3.865	83.000%	75.667%	83.000%	78.000%	71.333%	78.750%	74.000%	77.500%
				1	6	1	4	8	3	7	5

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Clnt -Part 3 - What actions need to be done for the Hong Kong construction industry quality? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
3.1	Fire fighting scenarios (urgent response to emergency happenings) occur frequently (averagely more than 2 times per week) in my organization.	(a) Process management; (c) Top Management leadership; (e)People management	4.150	0.830		0.830		0.830			
3.2	Most staff could not remember most of the core values of the company (an indicator of internal communication).	(a) Process management; (e)People management; (h) Quality information	4.200	0.840				0.840			0.840
3.3	The preparation of project master plan, design consultant procurement plan and construction tendering document is kicked-off with meetings amongst the team leaders from every functional team.	(d)Supplier management	4.000				0.800				
3.4	Relationships with the fragmented but extensive participating teams, both internal and external, is maintained fairly and amicably (friendly and peacefully) to prevent the development of an adversarial project culture.	(a) Process management; (d)Supplier management; (e)People management	3.700	0.740			0.740	0.740			
3.5	Clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	(c) Top Management leadership; (d)Supplier management	3.750			0.750	0.750				
3.6	Customer satisfaction survey is required regularly to reflect end users' level of satisfaction.	(b)Customer management; (f) Continual improvement	3.800		0.760				0.760		
3.7	Since the implementation of the ISO 9000 system in the early 1990s, attitudes of the industry's participants towards process planning and product conformance have been improved.	(a) Process management; (f) Continual improvement; (h) Quality information management	4.000	0.800					0.800		0.800
3.8	Mistakes (non-conformance as described in quality management systems) made on project planning are often due to design limitation, misunderstanding of the construction sequences or uncertainties in the statutory approvals.	(a) Process management; (e)People management; (h) Quality information management	2.950	0.590				0.590			0.590
3.9	Ditto but due to unrealistic expectations in attempts to overcome budget or time constraints.	(d)Supplier management; (h) Quality information management	3.850				0.770				0.770
3.10	The senior members of the company have not supported free flow of information and have not demonstrated openness to others' views and opinions	(c) Top Management leadership; (g) Organizational learning	3.750			0.750				0.750	
3.11	As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.	(g) Organizational learning	3.550							0.710	
		Average	3.791	76.000%	76.000%	77.667%	76.500%	75.000%	78.000%	73.000%	75.000%
				5	4	2	3	7	1	8	6

				TQM component score ratio = Question Score / 5 (Note: Highest ratio = 5/5 = 1.0)							
Clnt - Part 4 - Would the adoption of TQM be appropriate for achieving quality enhancement? TQM element relevancy is based on the comments received from the pilot questionnaire study.			Respondent's Mean Score (Relative to a max of 5)	(a) Process management	(b)Customer management	(c) Top Management leadership	(d)Supplier management	(e)People management	(f) Continual improvement	(g) Organizational learning	(h) Quality information management
4.1	Client organizations should award construction contracts based on tenderers' experience and management in design delivery, construction delivery, construction process and final product in addition to price consideration.	(c) Top Management leadership; (d)Supplier management	4.150			0.830	0.830				
4.2	Construction and engineering contracts should facilitate balanced sharing of risks amongst designers, contractors and clients.	(a) Process management; (c) Top Management leadership; (d)Supplier management; (h) Quality information management	3.650	0.730		0.730	0.730				0.730
4.3	Designers and contractors should establish long term business relationship with the project clients through partnering, with due respect to the contractual positions of the parties.	(b)Customer management	3.950		0.790						
4.4	Client organizations' senior and top management should encourage free flow of opinion, including the internal customer satisfaction feedback, and foster trust within the organization,	(c) Top Management leadership;(e)People management; (f) Continual improvement; (g) Organizational learning	3.800			0.760		0.760	0.760	0.760	
4.5	The person in charge of a construction project should give his full support to stop work decisions made by his team due to issues in safety, environmental pollution, construction methodology and design that critically affect the project quality.	(a) Process management; (c) Top Management leadership; (e)People management	3.650	0.730		0.730		0.730			
4.6	In order to practice continual improvement, the industry should encourage life time learning in craftsmanship, comprehensive project management and contemporary engineering design skills.	(e)People management; (f) Continual improvement; (g) Organizational learning	4.200					0.840	0.840	0.840	
4.7	The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology.	(e)People management; (g) Organizational learning	4.100					0.820		0.820	
4.8	The total quality criterion listed in the above statements 4.1 - 4.7 are comparatively easier than the QA procedures when applied in modern construction which is dynamic, and creativity & methodology driven.	All elements	3.900	0.780	0.780	0.780	0.780	0.780	0.780	0.780	0.780
		Average	3.925	74.67%	78.50%	76.60%	78.00%	78.60%	79.33%	80.00%	75.50%
				8	4	6	5	3	2	1	7

Appendix 5C-A1 – Pearson Correlation Chart

Clnt-Part 2- How familiar with TQM are Hong Kong client organizations

Correlations Clnt Q2 N=20

		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10
Correlation Matrix by SPSS		Quality in construction should include the quality of the management, that is, staff inspiration, internal / external accountability, proactive problem solving, prevention of complaints and reaction to complaints or queries.	Quality in construction should include process quality, that is, process planning, process monitoring, process improvement, end product control and reliability/durability.	TQM fosters the culture of monitoring and improvements at all levels in a construction developer organization in every functional aspect and is integrated into the daily management activities while QA system sets distinctive written procedures for process control and product assurance.	Project control team members should know how to apply at least five of the following process control tools: Check Sheet - To count occurrences of problems, Histogram - To identify central tendencies and any skewing to one side or the other, Pareto Chart - To identify the significant few (around 20%) and the trivial many (around 80%), Cause and Effect Diagram (Fish-bone diagram) - For identifying assignable	A party carrying out an activity is the customer of the upstream party carrying out the preceding activity – the concept of internal customer in the context of customer satisfaction.	Minimum life cost is the ultimate goal for project cost control.	Process and product inspection carried out by the clients' representative could be supplemented by TQM tools to improve the overall quality management of the Hong Kong construction industry.	The overall industry training has been transforming from focusing on quality assurance management only to formulating a long term development for technology, craftsmanship and engineering design skill.	The employer often organize induction and training on at least 3 of the following items: Value engineering, cost control, programme control, process control and risk management.	I often refresh my project and quality management knowledge by attending external courses or visiting construction engineering related web sites such as those for The Hong Kong Institute of Engineers, Construction Industry Council and the Institute of Building.
2.1	Pearson Correlation	1.000	0.305	0.358	0.430	0.104	0.000	(0.271)	0.309	0.199	0.325
	Sig. (2-tailed)		0.192	0.121	0.058	0.664	1.000	0.249	0.186	0.401	0.163
2.2	Pearson Correlation	0.305	1.000	0.125	.481*	0.221	0.138	0.101	0.360	0.125	0.400
	Sig. (2-tailed)	0.192		0.599	0.032	0.349	0.561	0.673	0.119	0.599	0.080
2.3	Pearson Correlation	0.358	0.125	1.000	0.257	0.260	0.365	0.333	.515*	0.242	0.249
	Sig. (2-tailed)	0.121	0.599		0.275	0.269	0.113	0.151	0.020	0.305	0.290
2.4	Pearson Correlation	0.430	.481*	0.257	1.000	0.000	0.110	0.000	.598**	0.359	.539*
	Sig. (2-tailed)	0.058	0.032	0.275		1.000	0.645	1.000	0.005	0.120	0.014
2.5	Pearson Correlation	0.104	0.221	0.260	0.000	1.000	0.159	0.309	0.384	0.012	0.216
	Sig. (2-tailed)	0.664	0.349	0.269	1.000		0.503	0.186	0.095	0.959	0.359
2.6	Pearson Correlation	0.000	0.138	0.365	0.110	0.159	1.000	.484*	0.217	0.365	.592**
	Sig. (2-tailed)	1.000	0.561	0.113	0.645	0.503		0.031	0.359	0.113	0.006
2.7	Pearson Correlation	(0.271)	0.101	0.333	0.000	0.309	.484*	1.000	0.438	0.011	0.314
	Sig. (2-tailed)	0.249	0.673	0.151	1.000	0.186	0.031		0.053	0.964	0.178
2.8	Pearson Correlation	0.309	0.360	.515*	.598**	0.384	0.217	0.438	1.000	0.331	.644**
	Sig. (2-tailed)	0.186	0.119	0.020	0.005	0.095	0.359	0.053		0.154	0.002
2.9	Pearson Correlation	0.199	0.125	0.242	0.359	0.012	0.365	0.011	0.331	1.000	.470*
	Sig. (2-tailed)	0.401	0.599	0.305	0.120	0.959	0.113	0.964	0.154		0.037
2.10	Pearson Correlation	0.325	0.400	0.249	.539*	0.216	.592**	0.314	.644**	.470*	1.000
	Sig. (2-tailed)	0.163	0.080	0.290	0.014	0.359	0.006	0.178	0.002	0.037	
Total Strong Correlation		0	1	1	2	0	2	1	2	1	4

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5C - B1 – Pearson Correlation Chart

Clnt-Part 3- What actions needed to be done for Hong Kong construction industry quality (current projects)?

Correlations Clnt Q3 N=20

Correlation Matrix by SPSS		3.1 Fire fighting scenarios (urgent response to emergency happenings) occur frequently (averagely more than 2 times per week) in my organization.	3.2 Most staff could not remember most of the core values of the company (an indicator of internal communication).	3.3 The preparation of project master plan, design consultant procurement plan and construction tendering document is kicked-off with meetings amongst the team leaders from every functional team.	3.4 Relationships with the fragmented but extensive participating teams, both internal and external, is maintained fairly and amicably (friendly and peacefully) to prevent the development of an adversarial project culture.	3.5 Clients should continually play an active role in project and quality management to achieve both the short term project success and long term supply chain relationship.	3.6 Customer satisfaction survey is required regularly to reflect end users' level of satisfaction.	3.7 Since the implementation of the ISO 9000 system in the early 1990s, attitudes of the industry's participants towards process planning and product conformance have been improved.	3.8 Mistakes (non-conformance as described in quality management systems) made on project planning are often due to design limitation, misunderstanding of the construction sequences or uncertainties in the statutory approvals.	3.9 Ditto but due to unrealistic expectations in attempts to overcome budget or time constraints.	3.10 The senior members of the company have not supported free flow of information and have not demonstrated openness to others' views and opinions	3.11 As compared to other industries, the construction industry in Hong Kong generally lacks behind in the adoption of new technologies and management concepts.
3.1	Pearson Correlation	1.000	0.041	(0.377)	0.183	(0.359)	0.045	0.000	.485*	.574**	(0.028)	0.201
	Sig. (2-tailed)		0.865	0.101	0.440	0.120	0.852	1.000	0.030	0.008	0.908	0.395
3.2	Pearson Correlation	0.041	1.000	0.135	(0.186)	0.000	(0.334)	-.521*	(0.100)	(0.045)	(0.355)	(0.385)
	Sig. (2-tailed)	0.865		0.572	0.433	1.000	0.150	0.018	0.675	0.850	0.124	0.094
3.3	Pearson Correlation	(0.377)	0.135	1.000	0.128	.587**	.492*	0.258	0.155	(0.140)	0.147	0.227
	Sig. (2-tailed)	0.101	0.572		0.591	0.007	0.027	0.272	0.514	0.557	0.537	0.336
3.4	Pearson Correlation	0.183	(0.186)	0.128	1.000	0.394	0.287	0.297	0.439	0.225	.731**	0.287
	Sig. (2-tailed)	0.440	0.433	0.591		0.086	0.220	0.203	0.053	0.340	0.000	0.220
3.5	Pearson Correlation	(0.359)	0.000	.587**	0.394	1.000	.520*	0.341	0.238	(0.215)	.484*	0.075
	Sig. (2-tailed)	0.120	1.000	0.007	0.086		0.019	0.141	0.311	0.363	0.031	0.754
3.6	Pearson Correlation	0.045	(0.334)	.492*	0.287	.520*	1.000	.534*	0.348	0.033	0.433	.616**
	Sig. (2-tailed)	0.852	0.150	0.027	0.220	0.019		0.015	0.133	0.890	0.056	0.004
3.7	Pearson Correlation	0.000	-.521*	0.258	0.297	0.341	.534*	1.000	0.120	0.108	.568**	0.439
	Sig. (2-tailed)	1.000	0.018	0.272	0.203	0.141	0.015		0.614	0.650	0.009	0.053
3.8	Pearson Correlation	.485*	(0.100)	0.155	0.439	0.238	0.348	0.120	1.000	0.110	0.238	0.163
	Sig. (2-tailed)	0.030	0.675	0.514	0.053	0.311	0.133	0.614		0.644	0.311	0.491
3.9	Pearson Correlation	.574**	(0.045)	(0.140)	0.225	(0.215)	0.033	0.108	0.110	1.000	0.154	(0.033)
	Sig. (2-tailed)	0.008	0.850	0.557	0.340	0.363	0.890	0.650	0.644		0.518	0.889
3.10	Pearson Correlation	(0.028)	(0.355)	0.147	.731**	.484*	0.433	.568**	0.238	0.154	1.000	0.275
	Sig. (2-tailed)	0.908	0.124	0.537	0.000	0.031	0.056	0.009	0.311	0.518		0.242
3.11	Pearson Correlation	0.201	(0.385)	0.227	0.287	0.075	.616**	0.439	0.163	(0.033)	0.275	1.000
	Sig. (2-tailed)	0.395	0.094	0.336	0.220	0.754	0.004	0.053	0.491	0.889	0.242	
Total Strong Correlation		2	1	1	1	3	4	3	1	1	3	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5C-C1 – Pearson Correlation Chart

Clnt-Part 4- Would the adoption of TQM principles be appropriate for achieving long term quality enhancement?

Correlations Clnt Q4 N=20

Correlation Matrix by SPSS		4.1 Client organizations should award construction contracts based on tenderers' experience and management in design delivery, construction delivery, construction process and final product in addition to price consideration.	4.2 Construction and engineering contracts should facilitate balanced sharing of risks amongst designers, contractors and clients.	4.3 Designers and contractors should establish long term business relationship with the project clients through partnering, with due respect to the contractual positions of the parties.	4.4 Client organizations' senior and top management should encourage free flow of opinion, including the internal customer satisfaction feedback, and foster trust within the organization,	4.5 The person in charge of a construction project should give his full support to stop work decisions made by his team due to issues in safety, environmental pollution, construction methodology and design that critically affect the project quality.	4.6 In order to practice continual improvement, the industry should encourage life time learning in craftsmanship, comprehensive project management and contemporary engineering design skills.	4.7 The government should take the lead in enhancing the skilled worker registration system with regular refreshment training requirements to cope with new developments in material and construction technology.	4.8 The total quality criterion listed in the above statements 4.1 - 4.7 are comparatively easier than the QA procedures when applied in modern construction which is dynamic, and creativity & methodology driven.
4.1	Pearson Correlation	1.000	0.426	.697**	0.298	0.216	.900**	.555*	0.033
	Sig. (2-tailed)		0.061	0.001	0.201	0.361	0.000	0.011	0.890
4.2	Pearson Correlation	0.426	1.000	.632**	.586**	.766**	0.386	.801**	0.404
	Sig. (2-tailed)	0.061		0.003	0.007	0.000	0.093	0.000	0.077
4.3	Pearson Correlation	.697**	.632**	1.000	.601**	.537*	.584**	.756**	0.289
	Sig. (2-tailed)	0.001	0.003		0.005	0.015	0.007	0.000	0.217
4.4	Pearson Correlation	0.298	.586**	.601**	1.000	.586**	0.268	.742**	0.214
	Sig. (2-tailed)	0.201	0.007	0.005		0.007	0.254	0.000	0.366
4.5	Pearson Correlation	0.216	.766**	.537*	.586**	1.000	0.298	.709**	0.404
	Sig. (2-tailed)	0.361	0.000	0.015	0.007		0.202	0.000	0.077
4.6	Pearson Correlation	.900**	0.386	.584**	0.268	0.298	1.000	.525*	0.129
	Sig. (2-tailed)	0.000	0.093	0.007	0.254	0.202		0.018	0.589
4.7	Pearson Correlation	.555*	.801**	.756**	.742**	.709**	.525*	1.000	0.308
	Sig. (2-tailed)	0.011	0.000	0.000	0.000	0.000	0.018		0.186
4.8	Pearson Correlation	0.033	0.404	0.289	0.214	0.404	0.129	0.308	1.000
	Sig. (2-tailed)	0.890	0.077	0.217	0.366	0.077	0.589	0.186	
Total Strong Correlation		3	4	6	4	4	3	6	0

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).