TQM application by engineering consultants in Hong Kong

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Received 12 June 2014
Revised 2 May 2015
2 August 2015
Accepted 17 September 2015

Abstract

Purpose – In 2000, the Hong Kong Government commissioned the Construction Industry Review Committee (CIRC) to provide a thorough review of the strengths/weaknesses of the Hong Kong construction industry and to recommend improvement measures. The CIRC's report, released in 2001, recommended many improvement measures related to total quality management (TQM) principles. Despite many of these improvement recommendations being fulfilled in the ten years following the release of the report, there is a lack of literature documenting these achievements and the corresponding level of TQM application. The purpose of this paper is to investigate the extent of TQM application by engineering consultants in Hong Kong using a questionnaire survey.

Design/methodology/approach – A literature review was conducted and a survey questionnaire was then designed for a full-scale survey. The data collected from the survey were analyzed using the Statistical Package for Social Sciences. Correlations between the respondents' scores on the survey questions were established.

Findings – The survey findings indicate a moderately high level of application of TQM principles, reflecting a moderately high achievement in implementing the CIRC's intended improvements. The survey findings further suggest that as a short-term need, focussing on top management leadership and supplier management is necessary for current and scheduled projects, and that organizational learning and people management are the two other major TQM principles that engineering consultants should focus on to sustain their long-term business.

Practical implications – The Hong Kong experience should be of interest to other countries, both regionally and globally, in search of an improvement framework to enhance their quality culture.

Originality/value – This paper is an original contribution. The content of the paper is unique. No one has done this before.

Keywords Total quality management, TQM, Hong Kong, Quality, Construction industry, Quality assurance, Quality management, CIRC, Consultancy, Quality awareness, Engineering consultants

Paper type Research paper

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,

The TQM Journal
Vol. 28 No. 4, 2016
pp. 561-587

1754-2731
DOI 10.1108/TQM-06-2014-0049

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). Among other commercial benefits, the effective application of total quality management (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 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 TQM principles. It was reported that 84 of the 109 items had been fulfilled (The Standard Supplement, 2011, p. 19) and all remaining items were in good progress. While the progress of implementation appeared to be satisfactory, the authors of this paper are 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.

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 (1998) report in the UK and the Commonwealth of Australia (1999) report 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 (1999) study of Chinese cultural dominance over Singapore proposes six strategic focusses 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:

(1) improvement of buildability;

(2) improvement of design planning with due consideration of the time required for design and construction;

(3) improvement of onsite engineering supervision;

(4) better understanding of client and end user requirements;

(5) increased focus on integrated input from different design disciplines at the outset of a design project;

(6) more effective communication with the site project team during both the design and construction stages;

(7) more effective communication with clients, including timely reporting and notification of design and site engineering issues; and

(8) 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): fostering a quality culture; achieving value in construction and engineering procurement; nurturing a professional workforce; developing an efficient, innovative and productive industry; improving safety and environmental performance; devising a new institutional framework for implementing the change program and 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 Table I).

The production of "total quality product" and "total system control" is highlighted in numerous sections of the report, which also evidently conveys the spirit of 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

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

Table I.
CIRC recommendations compared against TQM elements

to achieve the organization's objectives (British Standards Institution, 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 focusses 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 in Table I.

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.

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. The survey 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 Table AI) focussed on the respondents' familiarity with TQM, reflecting the extent to which TQM principles were applied by engineering consultants. Part 3 (see Table AIII) was based on the design and engineering quality management principles applied to obtain immediate and short-term quality improvements. Part 4 (see Table AIV) 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) (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. There were altogether 74 survey questionnaires that were sent out. The last of the survey replies was received in January 2012.

The score scale adopted in the questionnaire was based on a five-point Likert System (Hayes, 1998). This means that if a respondent agreed to a great extent to a question, s/he would get five scores. The data collected from the survey were analyzed using the Statistical Package for Social Sciences. 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 were significant at the 0.05 level or below (two-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.

Summary of findings

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 percent. 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 percent) had more than 200 employees.

The 35 respondents worked for different engineering consultants, and were engaged in architectural design and engineering (48.6 percent), civil design and engineering (17.1 percent) and a mixture of architectural and civil design and engineering (34.3 percent) work. Table II 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 Table III.

Table II. Business background of the organizations to which the respondents were attached

	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%

Summary of the key survey results for Part 2 – How familiar are Hong Kong engineering consultants with TQM?[1]

The key results are presented in Figure 1.

Observations on the survey results for Part 2:

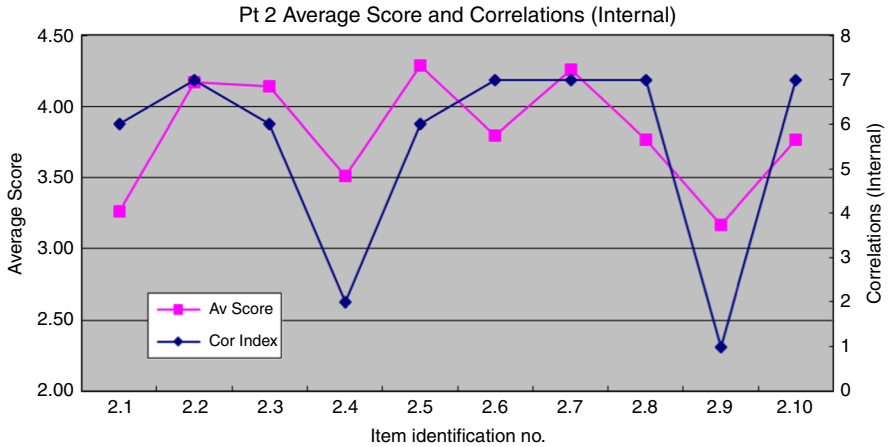
(1) The key results for Part 2 are shown in Figure 1. The high scoring items are Item 2.5 (concept of the internal customer), Item 2.7 (knowledge refreshment and experience sharing) and Item 2.2 (process management). The two lowest scoring items are Item 2.9 (employer-organized training) and Item 2.1 (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 Table AII) are also presented in Figure 1. 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.

	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%

Table III.
Individual responsibilities of the respondents



Note: Max. score is 5.00 and max. correlation is 9

Figure 1.
Key results for Part 2 of the survey

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 Table AI, 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 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)-(h), for each question are examined and a matrix is established, the details of which are presented in Table AV. 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.

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?[2]

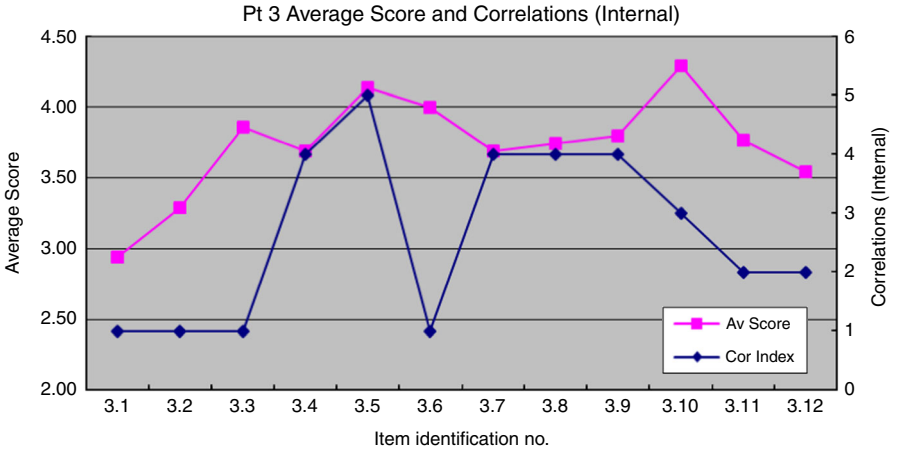
The key results are presented in Figure 2.

Observations on the survey results for Part 3:

(1) The Part 3 key results are shown in Figure 2. 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 B1 (this appendix is similar in nature to Table AII and is not shown in this paper due to space considerations), a summary of the analysis result is also presented in Figure 2. 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.



Note: Max. score is 5.00 and max. correlation is 11

Figure 2.
Key results for Part 3 of the survey

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.

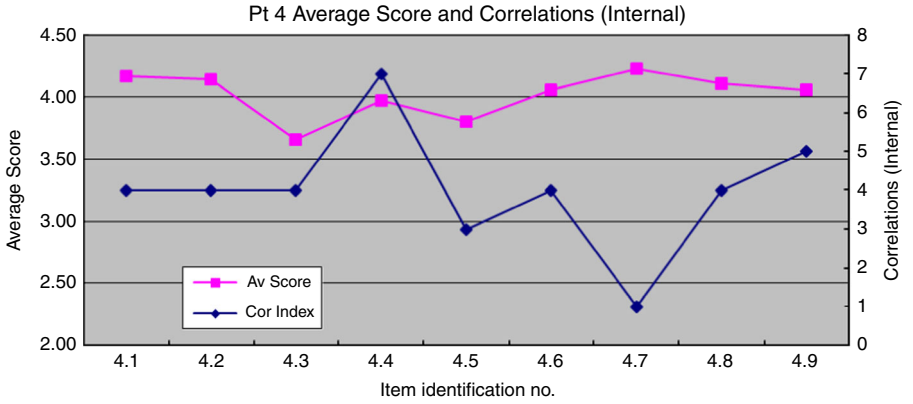
The correlation analysis results show that six of the 12 items in this part of the survey are moderately correlated. This moderate correlation suggests that improvement in the application of TQM principles in any one of these six items may induce similar improvements in the other items of the moderately 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 Table AV) 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 "supplier management," which also form the basis of the CIRC improvement recommendations shown in Table I. 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.

Summary of the key survey results for Part 4 – Is the adoption of TQM principles appropriate for achieving quality enhancement for engineering consultants?[3]

The key results are presented in Figure 3.



Note: Max. score is 5.00 and max. correlation is 8

Figure 3.
Key results for Part 4 of the survey

Observations on the survey results for Part 4:

(1) The key results for Part 4 are shown in Figure 3. 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 (see Appendix C1; not included in the body of the paper due to space considerations) is presented in Figure 3. 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.

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 Table AV) 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.

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)) research-established TQM elements 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 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, people management and continual improvement are the main TQM focusses 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 cross-roads 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.

Notes

1. Full details of the survey results are included in Table AI.
2. Full details of the survey results are included in Table AIII.
3. Full details of the survey results are included in Table AIV.

References

Abdul-Rahman, H., Hanid, M. and Yap, X.W. (2014), "Does professional ethics affect quality of construction – a case in a developing economy?", *Total Quality Management & Business Excellence*, Vol. 25 No. 3, pp. 235-248.

ACEHK (2011), "Association of Consulting Engineers of Hong Kong", available at: www.acehk.org.hk/ (accessed May 2, 2011).

ASD (2011), "Architectural and Associated Consultants Selection Board", available at: www.archsd.gov.hk/archsd_home01.asp?Path_Lev1=12&Status=C_LC_103 (accessed May 2, 2011).

Botha, D.V.R. (2012), "Total quality management in the civil engineering consultancy industry in South Africa", doctoral dissertation, Potchefstroom Campus, North-West University, Potchefstroom.

British Standards Institution (1992), *BS 7850 Total Quality Management*, British Standards Publishing Limited, London.

Burati, J.L. Jr, Farrington, J.J. and Ledbetter, W.B. (1992), "Causes of quality deviations in design and construction", *Journal of Construction Engineering and Management*, Vol. 118 No. 1, pp. 34-49.

Chan, E. (2012), "Management perspective for TQM solution", *Engineering Management Reviews*, Vol. 1 No. 1, pp. 7-19.

CIRC (2001), "Construction Industry Review Committee (CIRC) report", HKSAR Government, Hong Kong.

Commonwealth of Australia (1999), *Building for Growth: An Analysis of the Australian Building and Construction Industries*, Commonwealth of Australia, Canberra.

Construction 21 Review Committee (1999), *Reinventing Construction*, Ministry of Manpower and Ministry of National Development, Singapore.

Culp, G., Smith, A. and Abbott, J. (1993), "Implementing TQM in consulting engineering firm", *Journal of Management in Engineering*, Vol. 9 No. 4, pp. 340-356.

Department of Public Works (1999), "White paper: creating an enabling environment for reconstruction, growth and development in the construction industry", policy white

paper produced in collaboration with the Departments of Transport, Water Affairs and Forestry, Housing and Constitutional Development, Government Gazette No. 407 (20095), Pretoria, May.

Egan, J. (1998), *Rethinking Construction*, Department of the Environment, Transport and the Regions, London.

Ezeldin, A.S. and Abu-Ghazala, H. (2007), "Quality management system for design consultants: development and application on projects in the Middle East", *Journal of Management in Engineering*, Vol. 23 No. 2, pp. 75-87.

Graham, R.I. (2002), "ISO 9001:1994 and ISO 9001:2000 compared", *Manufacturing Engineer*, Vol. 81 No. 4, pp. 168-169.

Hayes, B.E. (1998), *Measuring Customer Satisfaction: Survey Design, Use, and Satistical Analysis Method*, ASQ Quality Press, Milwaukee, WI.

HKHA (2001), "Quality housing: partnering for change", Memorandum for the Housing Authority HA 15/2001, Hong Kong.

Ho, S.K.M. (2000), "ISO 9000 and TQM for the new millennium: imperatives for change", *Proceedings of the Fifth International Conference on ISO 9000 and TQM "Action 2000: Imperatives for Improvement", Singapore*, pp. 10-15.

Iruobe, O.J., Ojambati, T.S., Akinpade, J.A. and Iruobe, T. (2012), "An investigation into the impact of total quality management application in the construction industry (a case of training)", *Journal of Emerging Trends in Engineering and Applied Sciences*, Vol. 3 No. 2, pp. 344-348.

Kam, C.W. and Tang, S.L. (1997), "Development and implementation of quality assurance in public construction works in Singapore and Hong Kong", *International Journal of Quality & Reliability Management*, Vol. 14 No. 9, pp. 909-928.

Koh, T.Y. and Low, S.P. (2008), "Organizational culture and TQM implementation in construction firms in Singapore", *Construction Management and Economics*, Vol. 26 No. 3, pp. 237-248.

Leong, T.K., Zakuan, N. and Saman, M.Z.M. (2012), "Quality management maintenance and practices-technical and non-technical approaches", *Procedia-Social and Behavioral Sciences*, Vol. 65 No. 2012, pp. 688-696.

McCrary, S.W., Smith, R.R. and Callahan, R.N. (2006), "Comparative analysis between manufacturing and construction enterprises on the use of formalized quality management systems", *Journal of Industrial Technology*, Vol. 22 No. 3, pp. 1-8.

Martínez-Costa, M., Choi, T.Y., Martínez, J.A. and Martínez-Lorente, A.R. (2009), "ISO 9000/1994, ISO 9001/2000 and TQM: the performance debate revisited", *Journal of Operations Management*, Vol. 27 No. 6, pp. 495-511.

Rabeneck, A. (2008), "A sketch-plan for construction of built environment theory", *Building Research and Information*, Vol. 36 No. 3, pp. 269-279.

Stukhart, G. (1987), "Construction management responsibilities during design", *Journal of Construction Engineering and Management*, Vol. 113 No. 1, pp. 90-98.

Tang, S.L. and Kam, C.W. (1999), "A survey of ISO 9001 implementation in engineering consultancies in Hong Kong", *International Journal of Quality & Reliability Management*, Vol. 16 No. 6, pp. 562-574.

Tang, S.L. and Lau, A.W. (2009), "An investigation on the change from QA culture to TQM culture for engineering consultants in Hong Kong", *HKIE Transactions*, Vol. 16 No. 1, pp. 38-44.

Tang, S.L., Lu, M. and Chan, Y.L. (2003), "Achieving client satisfaction for engineering consulting firms", *Journal of Management in Engineering*, Vol. 19 No. 4, pp. 166-172.

Tang, S.L., Ahmed, S.M., Aoieong, R.T. and Poon, S.W. (2005), *Construction Quality Management*, Hong Kong University Press, Hong Kong.

Thermo Fisher Scientific (2002), "How does ISO 9000:2000 compare to ISO 9000:1994?", available at: www.eutechinst.com/iso9001vs_ver2000.pdf (accessed January 27, 2012).

The Standard Supplement (2011), "Hong Kong construction industry review committee report update", March 11, p. 19.

Union of Japanese Scientists and Engineers (2011), "Enhancement of organizational vitality", available at: www.juse.or.jp/e/education_training/55/attachs/ISTQ09_1stAnnouncement.pdf (accessed January 27, 2012).

Wong, A. (1999), "Total quality management in the construction industry in Hong Kong: a supply chain management perspective", *Total Quality Management*, Vol. 10 No. 2, pp. 199-208.

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(The Appendix follows overleaf.).

Appendix

Table AI.
Survey results for how familiar Hong Kong engineering consultants are with TQM

Cst-Part 2 – How familiar with TQM are Hong Kong engineering consultants?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% 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 websites 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

(*continued*)

Table AI.

Cst-Part 2 – How familiar with TQM are Hong Kong engineering consultants?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% average, less than 45% low)	Mean score	Score relative comparison	No. of strong correlation items within Part 2 (from SPSS)
2.8	The overall industry training has been transforming from focussing 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

(*continued*)

Table AI.

Cst-Part 2 – How familiar with TQM are Hong Kong engineering consultants?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% average, less than 45% low)	Mean score	Score relative comparison	No. of strong correlation items within Part 2 (from SPSS)
2.9	The employer often (at least twice per year on average) organize induction and training on any of the following items: value engineering, program 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

Table AII.
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-activitedcontinuous learning in project and quality management	2.8 The overall industry training has been transforming from focussing 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	0.344*	0.738**	0.177	0.321	0.469**	0.351*	0.482**	0.272	0.511**
	Sig. (2-tailed)		0.043	0.000	0.310	0.060	0.004	0.039	0.003	0.114	0.002
2.2	Pearson Correlation	0.344*	1	0.382*	0.568**	0.373*	0.407*	0.337*	0.452**	0.066	0.248
	Sig. (2-tailed)	0.043		0.023	0.000	0.027	0.015	0.048	0.006	0.707	0.151
2.3	Pearson Correlation	0.738**	0.382*	1	0.153	0.312	0.484**	0.440**	0.340*	0.188	0.360*
	Sig. (2-tailed)	0.000	0.023		0.381	0.068	0.003	0.008	0.046	0.281	0.033
2.4	Pearson Correlation	0.177	0.568**	0.153	1	0.476**	0.188	0.269	0.212	0.233	0.225
	Sig. (2-tailed)	0.310	0.000	0.381		0.004	0.278	0.117	0.222	0.177	0.195
2.5	Pearson Correlation	0.321	0.373*	0.312	0.476**	1	0.592**	0.653**	0.471**	0.113	0.363*
	Sig. (2-tailed)	0.060	0.027	0.068	0.004		0.000	0.000	0.004	0.517	0.032
2.6	Pearson Correlation	0.469**	0.407*	0.484**	0.188	0.592**	1	0.723**	0.637**	−0.077	0.498**
	Sig. (2-tailed)	0.004	0.015	0.003	0.278	0.000		0.000	0.000	0.660	0.002
2.7	Pearson Correlation	0.351*	0.337*	0.440**	0.269	0.653**	0.723**	1	0.662**	−0.078	0.563**
	Sig. (2-tailed)	0.039	0.048	0.008	0.117	0.000	0.000		0.000	0.657	0.000

(*continued*)

Table AII.

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-activitedcontinuous learning in project and quality management	2.8 The overall industry training has been transforming from focussing 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
2.8	Pearson Correlation	0.482**	0.452**	0.340*	0.212	0.471**	0.637**	0.662**	1	0.142	0.768**
	Sig. (2-tailed)	0.003	0.006	0.046	0.222	0.004	0.000	0.000		0.415	0.000
2.9	Pearson Correlation	0.272	0.066	0.188	0.233	0.113	−0.077	−0.078	0.142	1	0.374*
	Sig. (2-tailed)	0.114	0.707	0.281	0.177	0.517	0.660	0.657	0.415		0.027
2.10	Pearson Correlation	0.511**	0.248	0.360*	0.225	0.363*	0.498**	0.563**	0.768**	0.374*	1
	Sig. (2-tailed)	0.002	0.151	0.033	0.195	0.032	0.002	0.000	0.000	0.027	
Total strong correlation		6	7	6	2	6	7	7	7	1	7

Notes: Correlation charts for Appendices B1 and C1 are not shown in this paper for space saving. *,**Correlation is significant at 0.05 and 0.01 levels, respectively (two-tailed)

Cst-Part 3 – What needs to be done for the HK construction industry?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% 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 program and design approach preparations should be kicked-off with meetings among 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 have not encouraged free flow of information and have not demonstrated 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	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 outsourced design activities	Average score – indicates design mistakes sometimes occur due to inadequate management of outsourcing	3.69		4

(*continued*)

Table AIII.
Survey results for actions to be taken by engineering consultants focussing on current and scheduled projects

Cst-Part 3 – What needs to be done for the HK construction industry?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% average, less than 45% low)	Mean score	Score relative comparison	No. of strong correlation items within Part 3 (from SPSS)
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
5. Through SPSS, the score pattern of the respondents also indicated that Items 3.1 for mistakes caused by misinterpretation of information and 3.2 for mistakes caused by negligence and uncertainties have little correlation with the other TQM elements
6. Having applied the survey results to the related TQM elements in each question, the engineering consultants need improvement most in the element "Continual improvements," with "Top management & leadership" and "Supplier management" being the second and third most needed TQM elements

Table AIII.

Table AIV.
Survey results for actions to be taken by engineering consultants for long term and continual improvement

Cst-Part 4 – Would the adoption of TQM principles be appropriate for achieving quality enhancement?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% 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 feedback 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 4.1-4.8 are comparatively easier than the QA procedures when applied in engineering design which is dynamic, and methodology and creativity driven	Moderately high – TQM in the construction industry is supported by engineering consultants	4.06		5

(*continued*)

Table AIV.

Cst-Part 4 – Would the adoption of TQM principles be appropriate for achieving quality enhancement?		Comment on score (Range levels description – 75% high, 65-75% moderately high, 45-65% average, less than 45% low)	Mean score	Score relative comparison	No. of strong correlation items within Part 4 (from SPSS)
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 feedback 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
5. 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 "People management" and "Continual improvement" being the second and third most appropriate elements

Table AV.
Current status of TQM application by the engineering consultants and priorities for TQM element application

		TQM component score ratio = Question score/5							
		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
Cst-Part 2 – How are engineering consultants familiar with TQM?										
2.1	People management; customer management (Int Customer)	3.26		0.6514		0.6514	0.6514			
2.2	Process management (also the Q of process management)	4.17	0.8343			0.8343				
2.3	Top management support; organization learning; improvement	4.14			0.8286			0.8286	0.8286	
2.4	Information management; improvement	3.51						0.7029		0.7029
2.5	Customer management; people management	4.29		0.8571		0.8571	0.8571			
2.6	Customer management (Ext)	3.80		0.7600						
2.7	Improvement; quality information management	4.26						0.8514		0.8514
2.8	Improvement; organization learning	3.77						0.7543	0.7543	
2.9	People management; organization learning	3.17					0.6343		0.6343	
2.10	Top management support; process management; people management	3.77	0.7543		0.7543		0.7543			
	Average	3.81	79.43% 1	75.62% 6	79.14% 2	78.10% 4	72.43% 8	78.43% 3	73.90% 7	77.71% 5

(*continued*)

Table AV.

	Respondent's mean score (Relative to a max of 5)	TQM component score ratio = Question score/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
Cst-Part 3 – What actions need to be done for the HK CI quality?									
3.1 Process management; people management	2.94	0.5886				0.5886			0.5886
3.2 Process management; people management	3.29	0.6571				0.6571			0.6571
3.3 Supplier management	3.86				0.7720				0.7720
3.4 Supplier management; process management	3.69				0.7371				0.7371
3.5 Top management support; process management; people management	4.14	0.8286		0.8286		0.8286			
3.6 Supplier management; process management	4.00				0.8000				
3.7 Supplier management; process management; people management	3.69	0.7371			0.7371	0.7371			
3.8 Top management support; supplier management	3.74			0.7486	0.7486				
3.9 Customer management; improvement	3.80		0.7600				0.7600		
3.10 Improvement	4.29						0.8571		
3.11 Top management leadership; organization learning	3.77			0.7543				0.7543	
3.12 Organization learning – influenced by the society/ industry leaders	3.54							0.7080	
Average	3.81	70.293% 6	76.00% 3	77.71% 2	75.90% 4	70.29% 7	80.86% 1	73.11% 5	68.87% 8

(*continued*)

Table AV.

		Respondent's mean score (Relative to a max of 5)	TQM component score ratio = Question score/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
Cst-Part 4 – Would the adoption of TQM principles be appropriate for achieving quality enhancement?										
4.1	Supplier management	4.17	0.8343		0.8343	0.8343				
4.2	Supplier management	4.14			0.8286	0.8286				0.8286
4.3	Supplier management	3.66	0.7314		0.7314	0.7314				
4.4	Customer management	3.97		0.7943						
4.5	Organization learning; people management; improvement	3.80			0.7600		0.7600	0.7600	0.7600	
4.6	Organization learning; Q information management; improvement	4.06						0.8114	0.8114	0.8114
4.7	People management; organization learning; improvement	4.23					0.8457	0.8457	0.8457	
4.8	People management; organization learning	4.11					0.8229		0.8229	
4.9	Overall comparison	4.06								
	Average	3.81	78.29% 7	79.43% 5	78.86% 6	79.81% 4	80.95% 2	80.57% 3	81.00% 1	77.14% 8

Note: Highest ratio = 5/5 = 1.0