3 Costs and benefits of ISO9000-based quality management systems to construction contractors

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ABSTRACT

ISO9000-based Quality Management Systems (QMSs) have been widely applied by many contractors with a hope to improve the product quality and hence achieve the desired objective of client satisfaction. However, setting up and implementing an ISO9000-based QMS is not without cost. Unless the contractors can benefit from such system, it is unlikely that the senior management of contracting firms will commit to implement an ISO9000-based QMS. In this paper, the costs of setting up and implementing an ISO9000-based QMS are assessed through a questionnaire survey. The results are compared with the benefits attained by the contractors. It is found that contractors could be benefited from the use of ISO9000-based QMS both tangibly and intangibly. Based on a more conservative estimation of some tangible benefits, a basic operational cost-benefit ratio of one to three was derived from the results of the survey. Since the latest version of ISO9000 has been fully implemented for a number of years, the perception of contractors on the benefits gained after the implementation of ISO9001:2000 is also examined in this paper.

Keyword*:* Quality management system, cost, benefit, implementation, contractor

INTRODUCTION

The expectation of clients and end-users on the quality of construction facilities has grown relentlessly due to an increasing demand for better living standards and value for money (Al-Momani, 2000). Yet, the quality of construction works could be influenced by many factors *viz*. uncertainty, innovative design concepts, novel construction techniques, use of new and unique materials, tight time/cost requirements, and so on (*cf:* Zeng *et al*, 2004). To reduce the possible dangers from such risk factors, and to increase the probabilities that the necessary facilities are completed in a satisfactory manner, some careful clients prefer to employ contractors with a third-party accredited Quality Management System (QMS) (Chini and Valdez, 2003). In Hong Kong, it is mandatory for contractors to implement ISO9000-based QMSs if they wish to tender for public projects of above a certain size (Chan and Tam, 2000). The benefits of ISO9000-based QMSs are widely recognised (e.g. Chan and Chan, 1997; Leung *et al*, 1999; Low *et al*, 1999; Dick, 2000; Dissanayaka *et al*, 2001). However, there are also concerns about the cost-effectiveness of such systems as extra time and resources have to be devoted to ensure ISO9000-based QMSs are successfully implemented (Chin *et al*, 2005).

Undeniably, some contractors first sought ISO9000 certification for the sake of being included in the public clients' approved list of contractors. However, many contractors also realise the real benefit of an ISO9000-based QMS and take advantage of such a system to minimise substandard materials and works from being used and produced (Moatazed-Keivani *et al*, 1999). Relevant literature advocates that contractors benefit from the use of ISO9000-based QMSs through a reduction in the amount of rework, non-conformance and wastage, as well as an improvement in their goodwill (e.g. Love and Li, 2000; Low and Wee, 2001). Of course, the setting up and implementation of the ISO9000-based QMSs is not without cost. Should the benefits of an ISO9000-based QMS to the contractor be lower than its costs, there will be little incentive for contractors to commit to such a system. Therefore, it is necessary to examine whether the benefits of an ISO9000 could outweigh the costs of implementation.

The primary focus of this paper is to estimate to the extent possible, the costs and benefits of an ISO9000-based QMS, as may be attributable to a contractor. It would also be desirable to differentiate between the cost in first setting up the ISO9000-based QMS and the running cost, as the latter may sometimes be considered to be an on-going 'indirect' cost which could reduce the profit margin of the contractors; hence the need to estimate both direct and indirect benefits as well. Once the costs and benefits are identified and estimated, it would be possible to compare the costs with the benefits to estimate the net benefits that contractors are likely to attain. With the introduction of ISO9001:2000, many

practitioners and researchers expected the running costs could be reduced, while more benefits could be attained. Therefore, it is also sensible to examine whether ISO9001:2000 could further enhance the benefits to the contractors when compared with it predecessor. The overall satisfaction of the clients and contractors against the old and new standards would be also worth assessing.

RESEARCH METHODOLOGY

In order to gather the general views on the costs and benefits of an ISO9000-based QMS, the research method should allow a large volume of data to be collected. A questionnaire survey was considered to be the most suitable method for this exercise, since a wide spectrum of contractors can be accessed in order to unveil the existence of any sectional diversity between different sizes and natures of the companies. A questionnaire consisting of four main sections covering (i) general details; (ii) initial cost of ISO9000-based QMS; (iii) running cost of ISO9000-based QMS; and (iv) benefits of ISO9000-based QMS, was developed for this study. The survey questionnaire was piloted by two management representatives of contractors and useful comments were received and included in the revised questionnaire. Questionnaire packs including the cover letter (explaining the purpose of this study), the questionnaire and a return envelope were delivered to the contractors by post or in person.

As it is difficult to gather the actual figures on costs and benefits because (i) contractors may not have such data in hand; and (ii) the costs and benefits could be influenced by factors other than ISO9000, the questionnaire strives to capture the perceptions of the contractors through different approaches and in different dimensions. For instance, respondents were asked to express the costs in terms of the percentage of average contract sum, while the benefits brought about by the implementation of the ISO9000-based QMSs are also expressed as a percentage of the average contract sum.

The objectivity of this study depends very much on the selected sample, and it is necessary to ensure that the sample represents different types and sizes of contractors in construction. Besides, it is important that the targeted contractors have been certified under ISO9000. Since those on the public client's approved list of contractors must have an accredited ISO9000-certified QMS, the contractor lists maintained by the public clients in Hong Kong were the starting point for sample selection. To ensure the samples come from a diversity of disciplines and sizes, random samples were drawn from the list of (i) building contractors (new work); (ii) piling contractors; and (iii) electrical contractors. Finally, 112 contractors were chosen for this survey. 40 out of 112 targeted respondents returned the completed questionnaire, representing a response rate of approximately 36%, which is considered extremely high for a study of this kind. However, of these 40 responses, the data provided by 4 contractors were suspicious and biased. To prevent any bias from seeping into the final analyses, these 4 replies were discarded. The remaining replies were therefore taken as 36, representing an effective response rate of around 32%.

The data was analysed based on descriptive statistics, such as the frequency and mean. Besides, since there is a possibility that the more committed contractors who had presumably also appreciated the overall value of a QMS would have more positive views than their less committed counterparts, more detailed statistical analyses were carried out. In order to distinguish the degree of commitment of the sampled contractors on the implementation of ISO9000-based QMSs, a question requesting the respondents to indicate what other quality initiatives had been adopted by their organisation was included in the questionnaire. Having differentiated the more 'quality-committed' contractors from the others in the sample, an independent *t*-test was conducted to check whether any differences existed in the more committed *vs*. less committed groups. The results of the independent *t*-test, however, indicate that the difference between the more committed and less committed groups are not very significant in most of the cost and benefit aspects studied, except for a few issues where a greater divergence exists. But this divergence appears reasonable, i.e. not unexpected due to the different approaches. This will be highlighted in appropriate sections below.

COSTS OF ISO9000-BASED QUALITY MANAGEMENT SYSTEMS

Initial Costs

Before seeking ISO9000 certification, contractors have to set up their QMSs based on the requirements of the ISO9000, for example the development of the quality manual and procedures for certification. The results of the survey show that the cost for first setting up an ISO9000-based QMS ranges from HK$10,000 to over HK$250,000. Four

contractors indicated having invested a higher cost for the initial setting up. Further investigation revealed that these contractors are either have a turnover above other sampled contractors and/or have a stronger commitment. The highest figure recorded was HK$500,000. Despite that, most of the contractors indicated that the initial setting up cost was around HK $100,000 – 150,000, while the mean value is HK$136,000. Considering the turnover of a typical contractor (average turnover in this sample was HK$552 million), such a setting up cost of an ISO9000-based QMS appears to be not excessive, given that this is only a one-off expense for the contractors.

Running Costs

The most critical issue then usually becomes how much a contractor has to spend on keeping the ISO9000-based QMS running, as this could directly erode into the profit margin of the contractor should the running cost prove to be too high. In Hong Kong, the profit margin of a construction project could be very low especially at the time of economic downturn, some of the costs in running any QMSs may then arguably have to be borne by the contractor if they were to win the contract and the running cost is indeed low. Therefore, it is necessary to derive a reasonable estimate of the typical cost of running an ISO9000-based QMS in practice.

The most convenient and easily understandable way to express the running cost is by relating it to the contract sum, since it could portray how much additional costs have to be incurred by the contractor within a project. The results reveal that 19 respondents (i.e. more than half of the effective replies) reflected that the running cost of the ISO9000-based QMSs was less than 0.1% of the contract sum, while another 15 respondents indicated that the running cost was between 0.1% and 0.5%. Only 2 respondents considered that the running cost would be as much as 0.5% to 1%. On this basis, the average running cost of the ISO9000-based QMS is estimated as 0.19% of the contract sum. The average cost for running an ISO9000-based QMS at 0.19% (rounded up to 0.2%) of the contract sum appears to be reasonable at first view, but must be compared against potential benefits in the complementary exercises.

Change in Running Costs between Different Versions of ISO9000

There is a possibility that the running costs could come down after ISO9001:2000 is implemented. However, almost half of the sampled contractors (19 out of 36) believed that the change to the ISO9001:2000 version would not result in any change in the running costs indicating that the effect may not be that obvious to them as it stands. Despite that, from the others in the sample, more believed the new ISO9000 requirements would result in a reduction of 5 – 60% in the running cost.

BENEFITS OF ISO9000-BASED QUALITY MANAGEMENT SYSTEMS

Having examined the cost of developing and implementing an ISO9000-based QMS, it is necessary to ascertain the benefits from using such a system. In the questionnaire, questions were set to capture the views of the respondents on the changes to the list of potential beneficial areas (identified from standard literature, such as Tam, 1996; Lee, 1998; Crowe *et al*, 1998; Tang and Kam, 1999; and Kumaraswamy and Dissanayaka, 2000) if they did not have the ISO9000-based QMSs. For example, it was asked whether there was an increase in tangible benefits, such as a reduction in the amount of non-compliance items; extent of rework, level of wastage; and so on, in case an ISO9000-based QMS was not adopted for instance. Besides, whether the implementation of ISO9000-based QMSs would result in any intangible benefits (i.e. those which may not be easily quantified in money terms) like quality improvement, degree of time/cost overrun, amount of rejected claims, extent of disputes, level of direct supervision, etc., was also a subject of investigation.

Amount of non-compliance items: Almost two-third of the respondents (i.e. 20 out of 33) indicated that the amount of non-compliance items rose without the use of an ISO9000-based QMS. The increase can be as much as 40%, but with the average of 5.6% (or 14.7% if only the increase values are considered). Eight contractors, however, believed that ISO9000 could not help changing the amount of non-compliance items. There are 5 contractors who even reported a decrease in changes in the amount of non-compliance items when the ISO9000-based QMS is used. These respondents were followed up by telephone interviews, and their explanation was that the non-compliance items could not be checked and discovered without the existence of ISO9000. Hence, it seems that in their cases there was only a virtual decrease in the non-compliance items perceived if they did not have the ISO9000-based QMS.

Amount of rework: Amongst 34 valid replies, 22 indicated that there would be an increase in the amount of rework without the use of ISO9000-based QMSs. The estimated extent of increase ranged up to 40%, while the mean value is 5.4% (or 11.2% if only the increase values are considered). In other word, the implementation of ISO9000 could lead to a better quality and a reduction in abortive time and cost in redoing the works. 6 contractors did not think the implementation would result in a change in the amount of rework, while the others claimed that the amount of rework would exacerbate after ISO9000 is introduced. The same justification for the apparent or 'virtual' increase in the non-compliance items applied here as well.

Amount of wastage: Like the other two quality-related benefits, the amount of wastage is found to have increased in the absence of the ISO9000-based QMSs. The results are also very similar to the two beneficial items stated above [with the average increase of 5.1% (or 10.2% if only the increase values are considered) and the maximum increase of 35%]. This magnitude of reduction in wastage could undoubtedly help reduce the unnecessary project costs of a contractor.

Time overrun: The results indicate that most contractors (21 out of 33) did not believe the implementation of an ISO9000-based QMS would have any impact on the time overrun. It appears that the main reason was that the contract period of a project in Hong Kong is already very tight. Just a few contractors expressed an increase in time overrun if ISO9000 was not used.

Cost overrun: Like time overrun, most contractors (in this case 18 out of 34) confirmed that they expected no change in cost overrun even if an ISO9000-based QMS does not exist. 11 contractors, however, believed that there would be an increase in the cost overrun if not having ISO9000, and the increase could be as much as 25% [mean = 1.8% (or 8.7% if only increase values are considered)].

Amount of rejected claims: Contractors had diverse opinions on this issue, with 17 contractors rating an increase (of up to 55%) while 13 perceived no change in the amount of rejected claims without the implementation of ISO9000-based QMSs. Disregarding the discrepancy, the mean value of this beneficial item is 7.2%.

Extent of disputes: Around 60% of contractors (19 out of 33) found little change in the extent of disputes before and after the implementation of ISO9000-based QMSs, and only 11 contractors believed there would be an increase in the extent of disputes without using ISO9000 [mean = 4.5% (or 15.8% if only the increase values are considered)].

Direct supervision: Most contractors (19 out of 33) thought that there would be an increase in the direct work supervision requirement by contractor's senior team if an ISO9000-based QMS were not implemented [mean = 3.6% (or 16.6% if only the increase values are considered)]. The replies provided by the contractors are from the Management Representatives (as designated for the ISO9000 system implementation), and they would have a better sense as to how much direct supervision would be required by their own project staff from a senior management perspective after the implementation of an ISO9000-based QMS. This diversity in roles, mindsets and possible special interests could give rise to the inconsistency in the results.

OVERALL SATISFACTION

Contractors were asked to express their perceptions as to the overall satisfaction of their clients that may be attributed to both direct and indirect contributions from their QMSs. More contractors believed that the increase in the overall satisfaction of the client is in the region of 16-20%, which is followed by the 21-25% increase band. 6 contractors even indicated the overall satisfaction of their client could be beyond a 30% increase. On average, the implementation of an ISO9000-based QMS would increase the overall satisfaction of the client by 18%.

When asked whether the overall satisfaction of the client would improve after switching to the ISO9001:2000, the results seem to skew to the lower side (i.e. between 0-15%). An average of 13% increase in the overall satisfaction of the client was recorded on top of that received for ISO9000. This looks particularly promising, especially when the new ISO9000 system is still in its early stage of implementation.

Contractors first sought ISO9000 certification for various reasons. Therefore, respondents were required to indicate the key motivation for first seeking an ISO9000-based QMS. As shown in Table 1, the most important objectives of the contractor were (i) to qualify to tender for public projects; (ii) to meet customer expectations; (iii) to increase competitiveness; and (iv) to improve the quality of work done.

Having used the ISO9000-based QMSs for their day-to-day work, contractors were asked to express their level of satisfaction in meeting their original objectives. Table 1 reveals that contractors' original purposes in setting up an ISO9000-based QMS were achieved, since the levels of satisfaction against all factors more or less agree with the rating reflecting the motivation. This indicates that the desired purposes of setting up an ISO9000-based QMS are met.

It is worth pointing out that reducing the cost of operations was not conceived by the sampled contractors as a critical issue when they sought initial certification. This may also indirectly indicate that they did not expect the implementation of an ISO9000-based QMS to result in an increase in cost of operations. However, when respondents were asked to indicate their level of satisfaction on the ISO9000-based QMSs in reducing the cost of operation, there is an indication that the level of satisfaction exceeds their original expectation when they first sought ISO9000 certification.

COST-BENEFIT ANALYSIS

ISO9000-based QMSs are critical for the overall success of construction projects (Abdul-Rahman, 1997). Some researchers such as Barber *et al* (2000) explored the aspects of quality failure costs and such research exercises resulted in some useful models and systems for mapping the quality costs, e.g. a construction quality costs quantifying system (Low and Yeo, 1998), a quality cost information system (Love and Irani, 2003). Some researchers such as Tam (1996) surveyed different stakeholders on the costs and benefits of an ISO9000-based QMS. Crowe *et al* (1998) suggested an analytical hierarchy process based multi-attribute analysis model for analysing the costs and benefits of ISO9000 registration.

However, the present exercise enables the first known detailed comparison of costs and benefits of ISO9000-based QMSs to construction contractors in Hong Kong. It was found that the cost of implementing an ISO9000-based QMS in a project of average size is estimated by a cross-section of contractors to be approximately 0.2% of the contract sum on average. As for the cost savings, the survey results indicate a perceived reduction of over 5% in each of the (i) non-compliance, (ii) rework and (iii) wastage items (5.6%, 5.4% and 5.1% respectively), after the introduction of an ISO9000-based QMS. Rounding these figures down, each of these three values may be conservatively taken as 5% for the following exercise.

Although the combined savings resulting from the reduction in non-compliance, rework and wastage items alone could still add up to 15% of project cost, it may conservatively assumed that the savings from reduced non-compliance items and rework could overlap. Calculating the accurate aggregate savings for the benefits of ISO9000 could be extremely difficult, if not impossible because of the absence of required data, and the interference of many other variables.

However, taking (a) the typical extent of rework as 10% of a project cost [Love (2002) based on CIDA (1995)], although it has even been estimated as 12.5% in other studies (Love and Irani, 2003), and (b) the amount of wastage as 2% on average (Structural Engineering Department, 1990), although higher figures have been estimated; a gross cost saving of approximately 0.6% of the contract sum can be projected (i.e. as computed from $0.05 \times 10\%$ of non-compliance and rework items + $0.05 \times 2\%$ of wastage).

Areas	*Seeking Initial Certification*	*Level of Satisfaction*
To qualify to tender for public projects	5.81	5.69
To meet customer expectations	5.25	5.22
To improve the quality of work done	4.97	4.89
To increase competitiveness	5.11	5.17
To increase productivity and efficiency	4.53	4.58
To satisfy top management's corporate directive	4.67	4.53
To reduce the cost of operation	3.89	3.94
To improve the management and control of internal operation	4.67	4.58
To improve the management and control of external operation	4.44	4.36

Table 1: Reasons for implementing ISO9000-based QMSs

However, the real cost savings could be much higher if the other direct and indirect benefits are also quantified, e.g. the savings and benefits from more efficient management systems. Nevertheless, this conservative estimation of benefits already leads to a basic operational cost-benefit ratio of one to three. This computation is based on (a) the basic gross cost saving of 0.6% of contract sum that was conservatively estimated as above; and (b) the average running cost of 0.19% (rounded up to 0.2%) of contract sum that was previously estimated as described in the section of running costs. This suggests that an ISO9000-based QMS is an effective means for contractors to reduce their costs. It can be concluded that the ISO9000-based QMS is a very effective starting point for contracting firms to reduce costs, apart from deriving other potential benefits, such as through improved management systems.

CONCLUSIONS

An improvement in the quality of construction work would no doubt improve a contractor's goodwill and reputation. However, the development and implementation of an ISO9000-based QMS is not without cost, and given a choice, contractors would commit fully to the use of such a system only if the benefits clearly outweigh the costs. This not only applies to the ISO9000-based QMSs, but also to any other quality initiatives introduced by the client. This study could probably be taken to be one of the most (if not the most) in-depth studies on the costs and benefits of ISO9000-based QMSs to the construction contractors in Hong Kong. Averaging out the estimates obtained from the sample, it was estimated that the running cost in implementing the ISO9000-based QMS are perceived on average to be approximately 0.2% of the contract sum in a project of average size.

The direct benefits of the ISO9000-based QMS could be categorised under two broad groupings: (i) cost reductions; and (ii) improved management systems. Furthermore, a gain in the intangible benefits was reported by some contractors, e.g. 32%, 50%, 33% and 33% of the contractors surveyed indicated a gain in intangible benefits through a decline in the amount of cost overruns, rejected claims, reduction in disputes, and direct supervision efforts respectively.

After the introduction of the ISO9000-based QMSs, contractors could expect a reduction in cost through a decline in the amount of non-compliance items, rework and wastage. The results of the survey point to a reduction of more than 5% in the extent of each of these three notorious quality-related construction problems. The combined cost savings on rework and wastage alone is estimated at 0.6% of the contract sum, based on typical levels of rework and wastage that were derived from previous studies. By focusing on the core benefits accrued from these cost savings alone, a basic cost-benefit ratio of approximately one to three, (based on 0.2% : 0.6%), can be achieved, thereby boosting the profitability of the contracting firms.

There is no panacea or 'single-best' solution for the construction industry that could improve the product quality overnight. Any improvement in construction quality depends very much on a change in culture and mindset of the contractor (Liu, 2003). For contractors, they must take all necessary steps and measures to ensure their workmanship and materials are planned, monitored and controlled in a systematic manner. Such steps could be more conveniently launched from an ISO9000-based QMS platform. If fully aware of the benefits of 'properly developed' ISO9000-based QMSs, contractors may better commit to improved systems, especially since ISO9001:2000 is now in place to reduce their cost (through continuous process improvement and better training) and increase their turnover profits (through more business generated by satisfied customers).

REFERENCES

Abdul-Rahman, H. (1997) Some observations on the issues of quality cost in construction, International Journal of Quality & Reliability Management, 14(5), 464-481.

Al-Momani, A.H. (2000) Examining service quality within construction processes, Technovation, 20(11), 643-651.

Barber, P., Graves, A., Hall, M., Sheath, D., and Tomkins, C. (2000) Quality failure costs in civil engineering projects, International Journal of Quality & Reliability Management, 17(4/5), 479-492.

Chan, A.P.C. and Tam, C.M. (2000) Factors affecting quality of building projects in Hong Kong, International Journal of Quality & Reliability Management, 17(4/5), 423-441.

Chan, K.W. and Chan, H.C. (1997) Meeting quality assurance standards in the construction industry: Experience from Hong

Kong, International Journal of Management, 14(1), 87-91.

Chin, K.S. and Choi, T.W. (2003) Construction in Hong Kong: success factors for ISO9000 implementation, Journal of Construction Engineering and Management, ASCE, 129(6), 599-609.

Chin, S. Kim, K. and Kim Y.S. (2003) A process-based quality management information system, Automation in Construction, 13(2), 241-259.

Chini, A.R. and Valdez, H.E. (2003) ISO 9000 and the U.S. construction industry, Journal of Management in Engineering, ASCE, 19(2), 69-77.

CIDA (1995) Measuring up or Muddling through: Best Practice in the Australian Non-residential Construction Industry, Construction Industry Development Agency (CIDA) and Master Builders Australia, Sydney, Australia, 59-63.

Crowe, T.J., Noble, J.S. and Machimada, J.S. (1998) Multi-attribute analysis of ISO 9000 registration using AHP, International Journal of Quality & Reliability Management, 15(2), 205-222.

Dick, G.P.M., (2000) ISO 9000 certification benefits, reality or myth? The TQM Magazine, 12(6), 365-371.

Dissanayaka, S.M., Kumaraswamy, M.M., Karim, K. and Marosszeky, M. (2001) Evaluating outcomes from ISO 9000-certified quality systems for Hong Kong constructors, Total Quality Management, 12(1), 29-40.

Kumaraswamy, M.M. and Dissanayaka, S.M. (2000) ISO 9000 and beyond: from a Hong Kong construction perspective, Construction Management and Economics, 18(7), 783-796.

Lee, T.Y. (1998) The development of ISO 9000 certification and the future of quality management – A survey of certified firms in Hong Kong, International Journal of Quality & Reliability Management, 15(2), 162-177.

Leung, H.K.N., Chan, K.C.C. and Lee, T.Y. (1999) Costs and benefits of ISO 9000 series: a practical study, International Journal of Quality & Reliability Management, 16(7), 675-690.

Liu, A.M.M. (2003) The quest for quality in public housing projects: a behaviour-to-outcome paradigm, Construction Management and Economics, 21(2), 147-158.

Love, P.E.D. (2002) Auditing the indirect consequences of rework in construction: a case based approach, Managerial Auditing Journal, 17(3), 138-146.

Love, P.E.D. and Irani, Z. (2003) A project management quality cost information system for the construction industry, Information & Management, 40(7), 649-661.

Love, P.E.D. and Li, H. (2000) Overcoming the problems associated with quality certification, Construction Management and Economics, 18(2), 139-149.

Low, S.P. and Wee, D. (2001) Improving maintenance and reducing building defects through ISO 9000, Journal of Quality to Maintenance Engineering, 7(1), 6-24.

Low, S.P. and Yeo, H.K.C. (1998) A construction quality costs quantifying system for the building industry, International Journal of Quality & Reliability Management, 15(3), 329-349.

Low, S.P., Kee, T.B., Leng, A.A.A. (1999) Effectiveness of ISO 9000 in raising construction quality standards: some empirical evidence using CONQUAS scores, Structural Survey, 17(2), 89-108.

Motazed-Keivani, R., Ali, R., Ghanbari-Parsa, and Kagaya, S. (1999) ISO 9000 standards: perceptions and experiences in the UK construction industry, Construction Management and Economics, 17(1), 107-119.

Structural Engineering Department (1990) Wastage Control of Construction Materials, Housing and Development Board, Singapore.

Tam, C.M. (1996) Benefits and costs of the implementation of ISO 9000 in the construction industry of Hong Kong, Journal of Real Estate and Construction, 6(1), 53-66.

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, 16(6), 562-574.

Zeng, S.X., Wang, H.C., Tam, C.M. and Deng, Z.M. (2004) Upgrading quality of housing construction in China contractors' vis-a-vis supervisors' views, International Journal for Housing Science and its Applications, 28(3), 187-200