Construction in Hong Kong: Success Factors for ISO9000 Implementation

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Abstract: This paper examines the success factors for the implementation of ISO9000 in the Hong Kong construction industry. The critical factors for construction contractors to successfully implement ISO9000 were identified. An analytic hierarchy process model was then developed to determine the relative importance among those factors. The findings showed that the top management commitment is the most critical factor for the successful ISO9000 implementation, whilst the common goal, teamworking, education and training, and the cultural changes are also the important factors.

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Introduction

Background

ISO9000 quality system was first developed in 1987 on the basis of the U.K. quality management system standard BS5750 aimed at promoting the quality of services and goods provided by different sectors of the industry. With the revisions in 1994 and 2000, the ISO9000 now becomes the basis for the development of quality management systems for assuring quality in the manufacturing and services sectors on an international scale (Moatazed-Keivani et al. 1999). In addition, Michalisin et al. (2001) pointed out that ISO9000 certification indicates an emphasis on quality for companies that have devoted the efforts and resources to obtain certification. Moatazed-Keivani et al. (1999) reported that an increasing number of construction companies are going to adopt ISO9000 as the basis for their quality management systems. Based on a study on the U.K. construction industry, Moatazed-Keivani et al. (1999) stated the main reasons for the adoption of the ISO9000 are, namely, achieving client requirement, improving quality of management, improving quality of service/product, improving customer satisfaction, and sharpening market and competition advantages. According to Moatazed-Keivani, the reported benefits of ISO9000 certification in construction industry are found to be: retaining business, less failure of work, better management, increased customer satisfaction, and less wastage on site.

Adoption of ISO9000 by Hong Kong Construction Industry

In 1984, the Hong Kong Housing Authority (HKHA) had decided to knock down 26 public housing blocks which were built between 1963 and 1975 (Ming Pao 2000d) because these buildings suffered from serious structural problems. It reflects that the Hong Kong construction industry has much room for improvement in quality. In 1988, the HKHA announced the ISO9000 was compulsory for all its contractors and this requirement was officially enforced in 1993. Nowadays, in Hong Kong, most construction companies adopt ISO9000 as the quality assurance system (Chan and Tam 2000). Despite many pitfalls on the implementation of ISO9000, many governments (e.g., Sweden, Singapore, Hong Kong, etc.) have adopted a compulsory policy for the ISO9000 certification for the contractors and consultants in the construction industry (Low and Lim 2000). The writers have conducted a survey to obtain the information about the current quality management practice in Hong Kong construction industry (Choi and Chin 2001). A summary of the key issues includes the following:

1. Most local construction organizations adopt ISO9000 with an intention to improve their performance and to meet the client's demand;
2. Top management's genuine commitment is needed for a successful implementation of ISO9000;
3. In some organizations, the employees just treat the ISO9000 system as a paperwork exercise;
4. During the construction period, a continual training in technical skills is needed for the enhancement of quality performance;
5. Internal audit is an effective practice throughout the construction project;
6. Implementation of ISO9000 needs a quality supporting culture;
7. Problems found in a construction organization imply that there is a need of cultural and structural changes in the organization; and

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8. Cultural and structural changes can improve the quality performance in a construction organization.

Further to the result of the survey done by the writers and in order to help the planners for ISO9000 implementation, two questions may need to be considered, namely, what are the critical success factors in ISO9000 implementation in Hong Kong construction industry? and what are the priority areas of implementation should be focused? In fact, answers to these questions are important for the management of an organization in making a decision in the planning of ISO9000 implementation in the construction industry. In this paper, we consider the above problems and investigate the success factors for implementing ISO9000 in the Hong Kong construction industry. It introduces the analytical hierarchy process (AHP) approach to evaluate the critical factors. We built an AHP model to determine the relative importance of these critical success factors and to prioritize them. The subsequent results can facilitate the development of plans for the ISO9000 implementation in Hong Kong construction industry.

Success Factors for Implementing ISO9000 in Hong Kong Construction Industry

Based on the literature reviews, including the previous studies by the authors (e.g., Chin and Pun 1999; Choi and Chin 2001), it is found that the top management commitment, systems, practices and techniques, human resource aspects and organizational changes are the main factors influencing the implementation of ISO9000 in the Hong Kong construction industry. Details of the discussions are elaborated as follows.

Top Management Commitment

In fact, many studies have supported the importance of senior management's commitment to quality. Michalisin et al. (2001) pointed out the importance of quality commitment and leadership to quality performance, and claimed that companies that truly committed to quality should make customer service and satisfaction an important priority. In the Hong Kong construction industry, Tam and Ho (2000) argued that since the HKHA had mandated its contractors to be ISO9000 certified, the contractors considered the certification is a gateway for inclusion on the tender list. Hence their commitment to quality appeared not genuine. In order to implement ISO9000 successfully, a genuine commitment is necessary to generate the effective leadership, strategic planning for quality and human resource development (Sun 2000). From the writers previous survey result (Choi and Chin 2001), it was found that management commitment is a critical factor for the successful implementation of ISO9000. In fact, the implementation of the ISO9000 cannot exist unless the top management is committed. Low and Omar (1997) pointed out that top management commitment and their supports are important and essential for an integrative organization to function and to implement change and innovation for improvement. This view was also shared by Dale and Duncalf (1985). In this paper, there are four main elements considered in the category of top management commitment (TMC), namely, common goal (CG), management review and continuous improvement (MRCI), management involvement and leadership (MIL), and Management attitude to changes (MAC).

Common Goal

In ISO9000, a common goal between the top management and employees is related to the ''management responsibility.'' Quality scholars, such as Deming (1994), pointed out that strategy planning is essential for integrating quality requirements and targets improvements into all operation activities in an organization. The strategy plan includes the mission, vision, values, goals, objectives etc. Without a common goal between the management and employees, and across various departments, the ISO9000 implementation can hardly succeed in an organization (Choi and Chin 2001). Moreover, Atkinson (1998) claimed that conflicting goals within an organization lead to the generation of human errors in various departments that in turn result in failure of the organization. Furthermore, a common goal among different levels and functions in the organization will reduce the barriers in implementing the ISO9000. In order to survive in the ever-changing environment, both the company and its employees must understand this external threat and work towards this common goal. Hence, it is obvious that only through by setting a common goal, ISO9000 can be successfully implemented smoothly and bring improvement in both quality and production. In order to have a realistic common goal, some management review and continuous improvement activities are essential.

Management Review and Continuous Improvement

Continuous improvement is related to 'management responsibility and corrective action' of the ISO9000. It is the responsibility of the management to demonstrate its desired goal in continuous improvement by active involvement in quality improvement activities. According to the International Organization for Standardization (ISO), a continuous improvement of the organization's goal should be an alignment of improvement activities at all levels and flexibility to react quickly to opportunities. Burati et al. (1991) reported that the top management commitment is paramount for any improvement in quality. This has been reflected in the new ISO9000 (2000 version) that management review and monitoring of performance is included into the ''management responsibility'' section. Management review aims to ensure the adopted quality system to be evaluated at a regular duration. With these, effective decisions can be made based on the analysis of data and information to check the effectiveness of the quality system as well as the quality performance. All these monitoring data can be used for initiating and identifying rooms for improvement in key areas (e.g., production, safety) and improvement projects within the organization (Low and Lim 2000). In the review and monitoring operation, tools such as review meetings, audit reports, and interviews can be used. Moreover, to support the management review and continuous improvement, management must have an open attitude towards changes.

Management Attitude to Changes

There are many ineffective practices in the Hong Kong construction industry such as multilayer subcontracting, indifferent to work safety at site (Ming Pao, 2000b,e). Y. C. Tong of the Hong Kong Construction Industry Training Council (CITC) claimed that the subcontracting system must be abolished and replaced by a better system as adopted by other nations such as UK and Japan (Ming Pao 2000e). This may help reducing the defects in the construction industry such as using substandard construction materials, malpractice to safety, using unskilled workers and quit from uncompleted works, etc. As for the management attitude to change, Low and Lim (2000) pointed out that subcontractors play a very important role in the construction industry. However, the Hong Kong Government Report (Ming Pao 2000a) pointed out that the real cause is the awarding of contracts to the lowest tender without any consideration to the contractor's past perfor-

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mance [South China Morning Post (SCMP) 2000g]. In this aspect, Dr. T. K. Liu, former chief executive of the Singapore Housing Development Board, suggested that the Hong Kong Government must go for the lowest tendering price integrated with builders' grading system in order to shortlist contractors prior to the offer of tenders (SCMP 2000a). Therefore, as suggested by Tam and Ho (2000), ultimate success in quality can be achieved only when the quality system is fully integrated into the construction industry's culture. In short, this shows that the management should adopt an open attitude to changes so that flexibility (e.g., an integration of quality management and safety management) can bring improvement to quality. In order to make it success, effective management involvement and leadership appear to be vital.

Management Involvement and Leadership

This factor is related to the 'management responsibility' in the ISO9000 system. Top management participation in the implementation process is an essential ingredient of any quality improvement program (Burati et al. 1991; Michalisin et al. 2001). Atkinson (1998) argued that visible, participative and approachable senior staff in checking, inspection and control activity is a principal indicator of a quality-orientated organization. In Hong Kong, Tam and Ho (2000) claimed that genuine commitment to quality management is preferred to enforcing the IS 9000 through administrative power. Effective leadership is needed in order to direct the organization to achieve the objectives of the organization. In addition, Burati et al. (1991) found that leadership is strongly related to the organization and quality performance. Low and Omar (1997) stressed that critical leaders should be able to negotiate, set directions, renegotiate and reset directions within the company.

Systems and Techniques

Barad and Raz (2000) outlined some important systems and techniques (e.g., quality management system, quality control, benchmarking) which may attribute a successful quality management. Likewise in construction industry, systems (e.g., audits and monitoring, safety programs) and practices (e.g., subcontractor management, procurement, reviews) and techniques (e.g., technical skills, managerial skills) are necessary in a construction project in order to ensure its quality performance (Chan and Tam 2000). This view is also supported by the writers' previous survey (Choi and Chin 2001). Hence, an effective implementation of ISO9000 must employ some systems and techniques (ST), including internal audit and monitoring (IAM), teamworking (TW), coordination and communication (CAC), and computer technologies (CT).

Internal Audit and Monitoring

This factor is related to the ''internal quality audits'' in the ISO9000. Landin (2000) claimed that internal audits are important in the construction sector. Without audits, one cannot check whether the systems function well or where more resources may be required. Via internal audits, the management of a contractor may reveal that the effects of inaccurate project time estimation, absence of operations instructions, and unavailability of detailed cost estimates are typical causes of poor quality (Tan and Lu 1993; Abdel-Razek 1998). As to the shop floor staff, the President of Hong Kong Construction Association, L. L. Tse said ''You see a lot of different types of workers doing jobs for which they have not received any training'' (SCMP 2000h). To reduce the poor workmanship, site supervision is a traditional yet an effective monitoring for preventing shoddy construction work (SCMP 2000b). Likewise, the Buildings Department of the Hong Kong Government recommended setting out the duties of engineers, specialists, and site supervisors in the supervision of a building project (SCMP 1999, 2000d). This view was shared by Y. Y. Tang, the Chairman of the Hong Kong Construction Industry Review Committee (CIRC), who proposed carrying out regular independent technical audits during the construction duration (SCMP 2001a). Hence internal audit and monitoring (e.g., supervision) are the two primary means that are appropriate to identify the real needs and to determine the practical corrective actions in a construction organization. In short, as pointed out by Bradley (1992) that regular internal auditing serves as an effective method for introducing necessary changes and improvements to the quality system in an organization, the activities on internal audit and monitoring should be supported by an effective teamworking as stated in the followings.

Teamworking

This factor is related to the shopfloor activities in ''process control, inspection and testing, purchaser supplied product, inspection and test status, and control of nonconforming products'' in the ISO9000. Deming (1994) proposed breaking down barriers between departments to build teamworking and teamwork should be based on knowledge, design, and redesign. Examples of teamwork are: quality circle, task force, and cross-functional teams. A report from the Hong Kong Vocational Training Council pointed out that teamworking is an important system within an organization, but it is not properly practiced in the construction industry due to the lacking of training (Ming Pao 2000c). Additionally, in a study for teamworking, Yukongdi (2001) claimed that team members have a higher level of satisfaction in an organization. Hence, teamworking is important for any innovation within the company. However, training is needed for building effective teamworking but it has been always ignored or neglected due to the organizations' placing a focus on the short-term financial profit. To achieve effective teamworking, coordination and communication must be considered.

Coordination and Communication

Effective coordination and communication is another critical factor for a successful implementation of ISO9000. A company-wide communication channel is always preferable to support the operations in an organization (Atkinson 1998), and an organization needs to improve its communication and information system in order to enhance the employee's performance (Abdel-Razek 1998; Barad and Raz 2000, Sun 2000). In this way, an effective two-way communication channel will be desired for the top management and the employees. According to Dale and Duncalf (1985), the following steps are suggested for effective communication: keep up-to-date information, prioritize and determine the time constraints, decide whom and means to inform, followup the communication, and get the feedback. Hiyassat (2000) claimed that strengthening the communication channels within an organization would increase productivity and reduce the resistance to change. To match an effective coordination and communication, computer technologies cannot be ignored nowadays.

Computer Technologies

This factor is closely related to the ''product identification and traceability, quality records, and statistical techniques'' in the ISO9000. Computer technologies and information technologies can help to simplify the management system to operate, because it

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can save much paperwork (Ming Pao 2000b). Furthermore, it can be applied for improving the quality control and assurance system. Low and Lim (2000) stated that paperwork in ISO9000 can be reduced greatly by means of information technology. In fact, some organizations in Singapore have adopted paperless quality management systems by documenting and updating the quality system procedures on-line.

Human Resource Aspects

Admittedly, there is always a need for greater coordination and integration (e.g., people and technology, people and quality) to achieve improved quality within the construction industry. Human factor is a ''soft'' element that can have a paramount effect on the implementation of ISO9000, because it influences the teamworking, the discipline, the leadership, as well as the development of human resources. The effective implementation of ISO9000 is much influenced by human aspects such as education and training (ET), employee involvement and commitment (EIC), and incentive, rewards and recognition (IRR).

Education and Training

This factor is related to the 'training' of the quality resources in the ISO9000 quality system. Training and education of the employees play an important role in the enhancement of quality in an organization (Burati et al. 1991). Burati proposed the following topics should be highlighted: quality concept (e.g., TQM), interpersonal relations, team development, leadership, and problem solving. Tam and Ho (2000) claimed that a certain proportion of certified employees is needed for maintaining the quality of a construction project. In other words, training of employees in communication, job and problem solving skill is a must for the implementation of ISO9000 in a construction project. This view is also shared by Y. Y. Tang the CIRC Chairman, that a lack of training of employees is one of the main causes for the substandard construction quality in Hong Kong. To this end, he proposed to carry out a central registration of skilled laborers. Only certified employees are allowed to work in a construction site. He claimed that the quality of the Hong Kong construction industry can only be upgraded if the construction projects are being undertaken by companies with certified employees (Ming Pao 2000a). With regular review and monitoring to check its suitability to meet the company's changing needs, problems of insufficient manpower support, high employee turnover, and lack of capability and motivation of staff can be reduced (Tan and Lu 1993; Abdel-Razek 1998). Y. Y. Tang even pointed out that sufficient training and education may reduce the high rate of accident in the Hong Kong construction industry (Ming Pao 2000b). It is obvious that an upgrade of education and training is more effective for a quality management in a construction organization. To be successful in education and training, the involvement and commitment of employees are necessary.

Employee Involvement and Commitment

This factor is related to the operating process of the shopfloor in the ISO9000. As for the involvement of employees, Tummala and Cheng (1998) found that employee involvement of all levels is critical in ISO9000 implementation. With regard to the employee attitudes, Tam and Ho (2000) claimed that workers in Hong Kong no longer care about the consequence of their service/product. In fact, this elaborates the influence of such culture on quality in the construction industry (Ming Pao 1999). Tam and Ho (2000) pointed out that the conscience of employees is a critical factor for upgrading the quality of Hong Kong construction industry. Unless the employees are committed, their conscience toward their organizations is hardly genuine. Additionally, Atkinson (1998) claimed that social factors such as incompetent management, selective blindness, and conflicting goals are causes of human errors that generate defects in construction projects. This is because these human errors may lead to confrontational and win–loss relationships among the employees.

Incentive, Rewards and Recognition

A good and fair reward system can certainly affect the employee involvement and commitment in an organization. Incentive is preferred for the employees to give positive effort or support to the operation systems within the company. The incentive can be in many forms and is not necessary in monetary terms in order to improve the employees' satisfaction and to boost staff morale. Abdel-Razek (1998) argued that improving employees' satisfaction can enhance quality improvement in the construction industry. According to Ian Large, the Director of Asia Market Intelligence, a large number of Hong Kong people are unhappy and unsatisfied at work (SCMP 2000i). It is not always the salary driving commitment for work. A more harmonic relationship between the management and the employees is needed. This relationship needs to be treated fairly and the employees are returning the loyalty. Examples of such incentives are means to improve employees' financial standard, delegation, increase employees' participation in improvement efforts, etc. (Abdel-Razek 1998). Y. C. Tong of CITA pointed out that the subcontracting system of the Hong Kong construction industry is usually up to seven or eight layers. It is always the lowest-layer subcontractor that undertakes most of the works. He pointed out that for every $100.00 paid for construction works, only half of such goes to the subcontractor who actually carries out the work. Under such reward conditions, the contractor will just focus on completing the works as soon as possible without caring about the consequence of poor quality (e.g., poor workmanship, substandard material). Therefore Y. C. Tong suggested that the Hong Kong Government should use administrative power to limit the subcontracting to one or two layers such as the subcontracting system in other nations (e.g., U.K., and Japan) in order to improve the financial situation of the subcontractors (Ming Pao 2000e).

Organizational Changes

This factor is related to the ''management responsibility'' in the ISO9000. Low and Lim (2000) argued that ISO9000 certification alone would not enable companies to obtain world-class quality. Hence, companies should always search for new ways or changes to continuously enhance themselves to remain competitive. Examples of changes are: improve documentation and develop information systems; improve relations with clients and consultants; and improve company's operation and procedures (Abdel-Razek 1998). The findings of the writers' previous survey also supported the fact that changes will enable the employees to improve their performance in production as well as in quality (Choi and Chin 2001). A successful implementation of ISO9000 usually requires changes, such as cultural changes (CC), structural change (SC), and organizational learning (OL).

Cultural Changes

A reform of the fragmented construction is vital to curb the shoddy work in the Hong Kong construction industry (SCMP 2001b). Tam and Ho (2000) claimed that even though the

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ISO9000 had been implemented by the contractors undertaking public housing projects in Hong Kong, the quality culture has not yet improved. They stated that the lack of a cultural foundation in the current ISO9000 system accounts for the current rejection of quality initiatives in the Hong Kong construction industry. This view has been supported by Tam and Ho (2000). Cultural change is a long journey and organizational restructure is necessary. For example, campaigns and promotions are needed to be continuously carried out to promote and enforce the quality concepts in employees' minds (Tam and Ho 2000). In addition, incentives that are stated earlier are needed to promote the employees' satisfaction (Abdel-Razek 1998). Along the cultural change journey, some recognition for those who bring forward quality improvement appears to be appropriate. In addition, Michalisin et al. (2001) claimed that the top management is the main driver of organizational culture.

Structural Changes

To be successful in cultural change, some structural changes are necessary in the organization. For example, with respect to the procurement process in a construction organization, John Hill, the President of the Institution of Structural Engineers, U.K., pointed out that construction procurement procedures are changing rapidly and fundamentally. To this end, partnership and inclusion are crucial to the entire construction team, including the client. These changes in procurement work may present us with challenges, but also with opportunities (Chrystostomou 2001). The adoption of best practice is one kind of structural change with the benefits, namely, enhancing the image of the company, gaining respect within the industry, and improving competitiveness in a market. Regarding the restoring of the image of the Hong Kong construction industry, 130 construction firms out of 380 firms in the Hong Kong Construction Association committed to carry out structural change in their organizations in order to improve in seven areas: professional ethics, safety, environmental protection, construction quality, employment and training, productivity and partnering (SCMP 2000e). In this respect, the organizations shall develop and implement some structural changes such as developing a research and development department, improving company's documentation, communication, and information systems in the company.

Organizational Learning

In order to meet the changing environment of construction industry, Chrystostomou (2001) stated that it is up to a company to promote, inspire, and participate vigorously in the changes (e.g., cultural and structural). The alternative is to be left beached and become extinct. This signals the importance of organizational learning in order to meet the changes in the Hong Kong construction industry. As pointed out by the CIRC chairman, Y. Y. Tang, the building costs in Hong Kong were higher than other markets in Southeast Asia, except for Japan, partly because of inefficient building methods (SCMP 2000f). To this end, options such as design-and-build systems, including precast concrete and metal formwork, are recommended to increase efficiency and improve quality. For example, Henderson Land Development (Hong Kong) adopted new construction methods for new housing and commercial projects in a bid to increase efficiency and cut labor costs. As a result, the company is considering adopting different design-and-build systems, including wall formwork, column formwork, climbform, stairform, posttensioning, and precast concrete. In fact, all such systems are not only cost effective, but also improve quality and environmental aspects (SCMP 2000c). Additionally, Abdel-Razek (1998) claimed that a construction company can learn from advanced international construction organizations through joint-ventures contracts, cooperation with universities and business organizations, and through working with experts for introducing new expertise into the company.

Research Methodology: Analytic Hierarchy Process

Process

After identifying the critical factors for construction contractors to implement ISO9000, an AHP approach is used to determine the relative importance among those factors. The AHP, as advocated by Saaty (1980), is a problem-solving tool, with a structure that systematically represents the elements of a specific problem into a hierarchy, that is appropriate for studying complex systems in different applications (e.g., physical, behavioral, and system science). With pairwise comparison, the process will result in a list of priorities in the hierarchy framework. The AHP has been reported in many applications in various fields of different industries in Hong Kong as well as overseas. Good examples are: the evaluation of logistics factors in construction materials supply in the U.K. construction industry (Muya et al. 1999); the determination of employee involvement in Hong Kong manufacturing industry (Pun et al. 2001); the ISO 14000 implementation in Printed Circuit Board manufacturing industry in Hong Kong (Chin and Pun 1999); the implementation of concurrent engineering in Hong Kong electronic industry (Tummala et al. 1997); the selection of contractor in Hong Kong construction industry (Fong and Choi 2000); and the evaluation of advanced construction technology (Skibniewski and Chao 1992).

The AHP is applied via three main problems solving approaches: decomposition, comparative judgements, and synthesis of priorities (Saaty 1980; Saaty and Vargas 1991). Decomposition structures a complex problem into its basic elements, working from the goal objective down through various levels; from the more general to the particular and definite elements. It provides an overall view of the complex relationships within the situation. Comparative judgments are used to determine priorities among elements of every level. This is achieved by asking the decision makers or the experts to evaluate level elements pairwise with respect to elements in the next higher levels. Saaty (1980) suggested using a nine-point scale for making numerical judgements in the AHP pairwise comparisons. Using the scale, the decision makers or the experts exercise judgement about the priorities such that the factors and the subfactors can be compared among themselves in relation to the elements of the next higher level. This leads to the construction of matrices from which relative weights of the elements with respect to each element of the level above can be determined. As for the synthesis of priorities, the constructed matrices are used for computing weighted priorities for elements of a given level over the other elements of the same level with respect to each element of the level just above. In this way, the priorities of the factors can be determined. Priorities can be calculated by a software package called *Expert Choice* (1986). In short, the AHP process is as follows:

1. a complex scenario is structured by decomposing it into a hierarchy with sufficient levels to include all attribute elements to reflect the goals and the concerns of the decision maker;
2. elements are compared in a systematic manner using the

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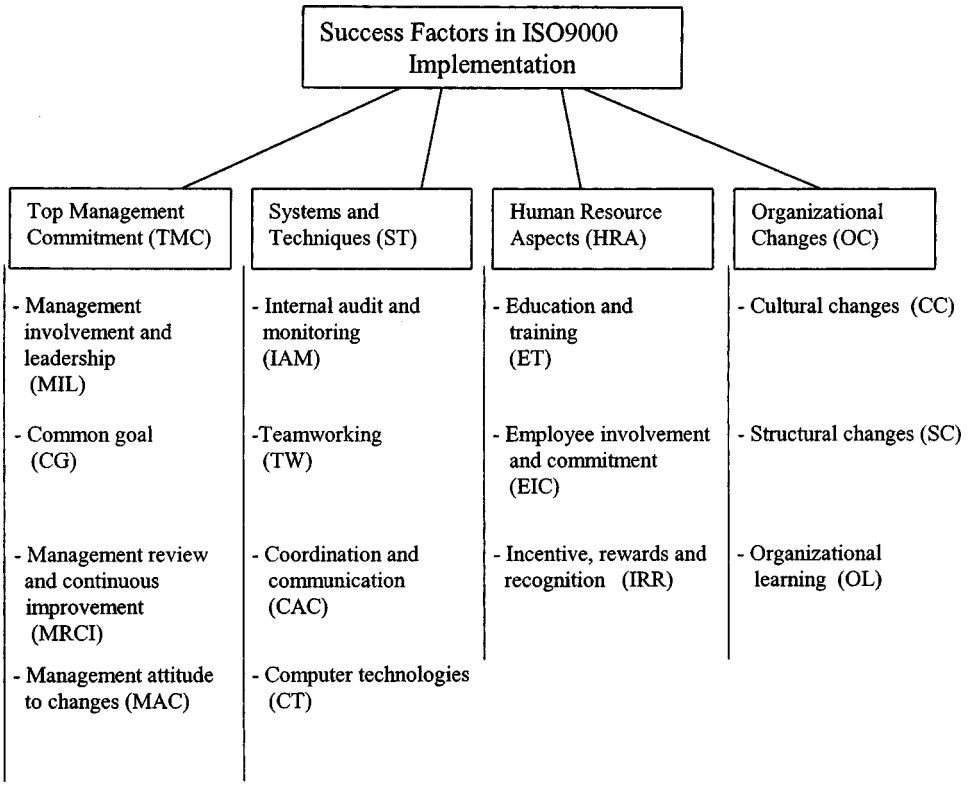

Fig. 1. Hierarchy of success factors of ISO9000 implementation in Hong Kong construction industry

same scale to measure their relative importance and the overall priorities among the elements within the hierarchy are developed;

3. the relative standing of each alternative with respect to each criterion element in the hierarchy is determined using the same scale; and
4. the overall score for each alternative can then be determined.

Evaluating Success Factors for ISO9000 Implementation in Hong Kong Construction Industry by Analytical Hierarchy Process

Structuring ISO9000 Implementation Problem

In this process, a decision model for evaluation factors in the implementation of ISO9000 for Hong Kong contractors is structured into a two-level hierarchical structure where each level represents a set of success factors as shown in Fig. 1. The success factors at different levels of the hierarchy structure for ISO9000 have been identified, as discussed in ''Success Factors for Implementing ISO9000 in Hong Kong Construction Industry.'' In Level 1, the ''goal'' defines the success factors for implementing the ISO9000 in the Hong Kong construction industry. Based on this goal, the strategic issues and the corresponding success factors are put in ''Level 2.'' There are four categories of critical factors, namely, TMC, ST, human resource aspects (HRA), and organizational changes (OC). Each category is further elaborated into a number of subfactors in ''Level 3.''

Measurement and Data Collection

The collection of data was carried out in accordance with the nine-point scale as suggested by Saaty (1980) to determine the relative importance of factors or subfactors used in the different levels of the hierarchies. The data collection was based on interviews with seven experts; three were contractors and four were from the consultant firms (structural and architectural services), see Table 1. The contractors could provide their first-hand experience on the implementation of ISO9000 in their own companies, while the opinions from consultants contribute to this study with their wide exposure to the industry. Based on their rich experience and expertise, we can assume that their opinion could represent reasonably well the Hong Kong construction industry. Each of these experts was asked to evaluate and assign relative scales in a pairwise fashion with respect to the subfactors of one level of hierarchy given the criteria at the next higher level of hierarchy. As a result, a set of pairwise comparison judgement matrices corresponding to the success factors and subfactors were used in all levels of the hierarchy. Then, the priority weights of these factors were determined.

Determining Normalized Weights

In accordance with Saaty (1980), the eigenvalue approach was used to combine the pairwise comparison judgement matrices obtained from each expert. During the process of the determination

Table 1. Profile of Respondents for Evaluation of Analytical Hierarchy Process Model

Respondents	Business field	Position	Experience (years)
1	Consultant	Senior engineer	22
2	Consultant	Project engineer	20
3	Contractor	Project manager	25
4	Contractor	Senior project manager	25
5	Contractor	Construction manager	20
6	Consultant	Senior project manager	25
7	Consultant	Senior project manager	25

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Table 2. Normalized Priority Weights

	Consultant			Contractor		
		Local weights	Global weights		Local weights	Global weights
Level 1: Goal ISO9000 Implementation in Hong Kong Construction Industry						
Level 2: Critical factors	**TMC**	**0.477**	**(0.477)**	**TMC**	**0.403**	**(0.403)**
	ST	0.182	(0.182)	ST	0.390	(0.390)
	HRA	0.233	(0.233)	HRA	0.136	(0.136)
	OC	0.108	(0.108)	OC	0.076	(0.076)
Level 3: Subfactors						
TMC	MIL	0.234	(0.112)	MIL	0.234	(0.094)
	CG	**0.411**	**(0.196)**	**CG**	**0.366**	**(0.147)**
	MRCI	0.181	(0.086)	MRCI	0.282	(0.113)
	AC	0.174	(0.083)	MAC	0.119	(0.048)
ST	IAM	0.267	(0.048)	IAM	0.320	(0.125)
	TW	**0.406**	**(0.074)**	**TW**	**0.325**	**(0.127)**
	CAC	0.210	(0.038)	CAC	0.229	(0.089)
	CT	0.117	(0.021)	CT	0.125	(0.049)
HRA	**ET**	**0.551**	**(0.128)**	**ET**	**0.464**	**(0.063)**
	EIC	0.283	(0.066)	EIC	0.371	(0.050)
	RR	0.167	(0.039)	IRR	0.166	(0.023)
OC	**CC**	**0.596**	**(0.064)**	**CC**	**0.499**	**(0.036)**
	SC	0.251	(0.027)	SC	0.343	(0.025)
	OL	0.153	(0.016)	OL	0.157	(0.011)

Note: Figures in parentheses of the Level 3 are the global weights relative to goal.

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of normalized weights, ''Expert Choice'' was used to transfer the pairwise comparison judgement matrices into the largest eigenvalue problems and then the normalized local and global weights for each factor and subfactor was determined. Based on these normalized priority weights, the relative importance of success factors can be assessed according to their importance in ISO9000 implementation. In general, the greater the priority weight is, the more critical the decision criterion will be.

Study Results

In order to study whether the business nature has a direct influence on the view on the success factors of the ISO9000 implementation, comparisons of professionals in both the consultant and contractor sectors are performed in this paper. Table 2 shows the normalized local and global weights for each success factor and subfactor for the implementation of ISO9000 in the consultant and contractor sectors of the Hong Kong construction industry. The overall consistency of the input judgments at all levels was within the acceptance ratio of 0.10. According to Saaty, this implies that the pairwise comparison judgments supplied by the experts were not bias and thus acceptable (Saaty 1980).

Critical Factors for ISO9000 Implementation

As for the normalized local weights in the Level 2 (Table 2), the consultant sector considers that the TMC (i.e., TMC = 0.477) is identified to be the most important factor in the ISO9000 implementation. Its relative importance is two times (i.e., 0.477/0.233) greater than the second factor of HRA, and 2.3 times (i.e., 0.477/0.204) of ST, and 4.4 times (i.e., 0.477/0.108) of OC. On the other hand, the contractor sector considers that the TMC (i.e., TMC = 0.403) is identified to be the most important factor in the ISO9000 implementation. Its relative importance is 1.03 times (i.e., 0.403/0.390) greater than the second factor of ST, and 2.9 times (i.e., 0.403/0.136) of HRA, and 5.3 times (i.e., 0.403/0.076) of OC.

This result shows that both the consultant and contractor sectors agree that ''TMC'' is the most critical factor for a successful implementation of ISO9000 in the Hong Kong construction industry. The consultant sector considers that HRA should be the second critical factor. On the other hand, the contractor sector considers that ST should be the second critical factor. Moreover, the OC factor is considered to be less critical as compared with the other three specified factors in affecting the implementation of ISO9000. As pointed out by Arditi and Gunaydin (1997) the success of a quality management system (e.g., ISO9000 and TQM) can thrive only under the top management that establishes the adopted quality management system as a top priority. In short, top management commitment is crucial to quality and to continuous quality improvement in each phase of the construction process. Management must participate in the implementation process and be fully committed to it. The top management needs to direct the employees to the continual improvement in their performance. With demonstrated management commitment, the organization will be easier to obtain employee involvement. For example, the top management will need to commit time and resources for the ISO9000 implementation. They may take the initiative to locate areas for improvement within the organization, motivate the employees, and develop an employee-led operation for improvement.

Priority of Subfactors

Referring to the weights in the Level 3 of Table 2, the relative importance of the subfactors is computed and prioritized in terms of local and global priority weights.

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Top Management Commitment

For the consultant sector, the leading subfactors with respect to the TMC were: CG (i.e., CG=0.411), MIL (i.e., MIL=0.234), MRCI (i.e., MRCI=0.181), and MAC (i.e., MAC=0.083). In short, CG has a relative importance of 1.7 times (i.e., 0.411/0.234) greater than the second subfactor of MIL, 2.2 times (i.e., 0.411/0.181) of MRCI, and 4.9 times (i.e., 0.411/0.083) of MAC. Referring to TMC this finding suggests that CG critical compared to other factors (i.e., MIL, MRCI, MAC) for the consultants to consider in the implementation of ISO9000. The corresponding global priority weights determined as shown in Table 2 also support this observation.

On the other hand, for the contractor sector, the leading subfactors with respect to the TMC were CG (i.e., CG=0.366) MRCI (i.e., MRCI=0.282), MIL (i.e., MIL=0.234), and MAC (i.e., MAC=0.119). Hence, CG has a relative importance of 1.3 times (i.e., 0.366/0.282) greater than the second subfactor of MRCI, 1.6 times (i.e., 0.366/0.234) of MIL, and 3.1 times (i.e., 0.366/0.119) of MAC. Likewise, for TMC, this finding suggests that CG is critical compared to the other factors (MRCI, MIL, MAC) for the contractors to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation.

Moreover, it is obvious that the consultant and contractor sectors have a different view regarding the second relative important factor (i.e., MIL for consultant sector and MRCI for contractor sector). It is obvious that most respondents were aware of the importance of management involvement, leadership, and open attitude towards changes. It is true that a common goal with the employees can attribute to: common language for communicating quality, as a tool for an organization to develop an effective quality management system; an increase in client's confidence and satisfaction on quality; an increase in competitive advantage for better quality service; and continuous improvement.

Systems and Techniques

Regarding the consultant sector, the leading subfactors with respect to the ST were: TW (i.e., TW=0.406); IAM (i.e., IAM =0.267); CAC (i.e., CAC=0.210); and CT (i.e., CT=0.117). So, TW has a relative importance of 1.5 times (i.e., 0.406/0.267) greater than the second subfactor of IAM, 1.9 times (i.e., 0.406/0.210) of CAC, and 3.5 times (i.e., 0.406/0.117) of CT. Referring to ST, this finding suggests that TW is critical compared to the other factors (i.e., IAM, CAC, CT) for the consultants to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation.

As for the contractor sector, the leading subfactors with respect to the ST were: TW (i.e., TW=0.325), IAM (i.e., IAM =0.320), CAC (i.e., CAC=0.229), and CT (i.e., CT=0.125). Therefore, TW has a relative importance of 1.01 times (i.e., 0.325/0.320) greater than the second subfactor of IAM, 1.4 times (i.e., 0.325/0.229) of CAC, and 2.6 times (i.e., 0.325/0.125) of CT. From this, it is also observed that T*eamworking* is only slightly more important than I*nternal Audit and Monitoring*. Similarly, regarding the *Systems and Techniques*, this finding suggests that T*eamworking* is critical compared to the other factors (i.e., I*nternal Audit and Monitoring*, *Coordination and Communication*, *Computer Technologies*) for the contractors to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation. It is obvious that both the contractors and consultants hold a similar view regarding ST

According to Arditi and Gunaydin (1997), teams provide companies with the structured environment necessary for successful implementation of quality management system. In a study of U.S. construction projects, they found that an extent of teamwork of parties participating in the design phase was identified as the most important factor that affects quality and can achieve higher customer satisfaction. The construction industry acts in project basis, so improved quality performance would be project-oriented and included in the project team. In general, the suppliers, subcontractors, main contractors, project engineer, and client must all be involved in the process. Hence, effective teamworking between these parties will enhance quality performance.

Human Resource Aspects

As for the consultant sector, the leading subfactors with respect to the HRA are: ET (i.e., ET=0.551), EIC (i.e., EIC=0.283), and IRR (i.e., IRR=0.167). In short, ET has a relative importance of 1.9 times (i.e., 0.551/0.283) greater than the second subfactor of EIC, and 3.3 times (i.e., 0.551/0.167) of IRR. Referring to HRA, this finding suggests that ET is critical compared to the other factors (i.e., EIC, IRR) for the consultants to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation.

On the other hand, for the contractor sector, the leading subfactors with respect to the HRA are: ET (i.e., ET=0.464), EIC (i.e., EIC=0.371), and IRR (i.e., IRR=0.166). In fact, ET has a relative importance of 1.3 times (i.e., 0.464/0.371) greater than the second subfactor of EIC, and 2.8 times (i.e., 0.464/0.166) of IRR. Likewise, regarding the HRA, this finding suggests that ET is critical compared to the other factors (i.e., EIC, IRR) for the contractors to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation. By and large, the consultants and the contractors hold a similar view on HRA.

The importance of education and training is recognized by every quality expert and that training must be targeted for every level of the organization. ISO9000 underlines the activities demanding required skills should be identified and the necessary training should be provided. Arditi and Gunaydin (1997) stressed that employees should acquire skills in human interaction, leadership which are necessary to the success of any quality improvement programs. Hence, it is important for the top management to design and provide a company-wide education and training program in order to promote the awareness and the introduction of ISO9000 practices. The program may cover quality management concepts and team practices (e.g., quality costs, quality culture, leadership, quality circle, etc.).

Organizational Changes

The consultant sector considers the leading subfactors with respect to the OCs as: CC (i.e., CC=0.596), SC (i.e., SC=0.251), and OL (i.e., OL=0.153). In short, CC has a relative importance of 2.4 times (i.e., 0.596/0.251) greater than the second subfactor of SC, and 3.9 times (i.e., 0.596/0.153) of OL. Referring to OC, this finding suggests that CC is more critical compared to the other factors (i.e., SC, OL). The corresponding global priority weights determined as shown in Table 2 also support this observation.

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Table 3. Ranking of Subfactors on Global Weight

Consultant			Contractor		
Rank	Factor	Weight	Rank	Factor	Weight
1	CG	0.196	1	CG	0.147
2	ET	0.128	2	TW	0.127
3	MIL	0.112	3	IAM	0.125
4	MRCI	0.086	4	MRCI	0.113
5	MAC	0.083	5	MIL	0.094
6	TW	0.074	6	CAC	0.089
7	EIC	0.066	7	ET	0.063
8	CC	0.064	8	EIC	0.050
9	IAM	0.048	9	CT	0.049
10	IRR	0.039	10	MAC	0.048
11	CAC	0.038	11	CC	0.036
12	SC	0.027	12	SC	0.025
13	CT	0.021	13	IRR	0.023
14	OL	0.016	14	OL	0.011

On the other hand, as for the contractor sector, the leading subfactors with respect to the OC are: CC (i.e., CC=0.499), SC (i.e., SC=0.343), and OL (i.e., OL=0.157). Hence, CC has a relative importance of 1.5 times (i.e., 0.499/0.343) greater than the second subfactor of SC, and 3.2 times (i.e., 0.499/0.157) of OL. Similarly, referring to OC, this finding suggests that CC is critical compared to the other factors (i.e., SC, OL) for the contractors to consider in the implementation of ISO9000 in the Hong Kong construction industry. The corresponding global priority weights determined as shown in Table 2 also support this observation. To sum up, it appears that both the consultant sector and the contractor sector hold a similar view in OC.

Kanter (see Low and Omar 1997) stressed the importance of the environment, organizational structure, and corporate culture to initiate changes in an organization. During the cultural change, the company needs to introduce and accept the employees, groups, and organizational changes. Cultural changes may attribute for: open company-wide communication; motivated employees; training and education on quality, safe, and healthy working environment; satisfied customers; and continuous improvement.

Discussion

The AHP is a good and suitable tool to assess relevant criteria in order to make sensible decisions. With the AHP, we can organize the thoughts, knowledge, and technical know-how in terms of the goal, factors, and subfactors by structuring the problem in a hierarchy framework. In this way, we can assess and evaluate these factors systematically so as to obtain an ultimate solution.

Since 1993, the adoption of ISO9000 quality standard by the Hong Kong construction organizations is unavoidable. Many companies, however, are still standing at the cross road of an effective ISO9000 implementation. In this study, the findings show that TMC is found to be the most critical factor; the CG, TW, ET, and CC are the important subfactors to implement ISO9000 in the Hong Kong construction industry. As expected, the views shared by the consultants only vary slightly from that of the contractors as shown in Table 2. The probable reason is that the lower education level of the middle and the shop floor employees of the contractor sector, and a higher staff turnover rate in the front line employees tend to lead the management of the contractor sector to focus more on systems and techniques.

In terms of ranking for global weight, Table 3 summarizes the rankings of the consultant and contractor sectors, respectively. The consultant's result shows that CG (0.196), ET (0.128), and MIL (0.112) are the most important; and that these subfactors dominate the remaining subfactors MRCI (0.086), MAC (0.083), TW (0.074), EIC (0.066), and CC (0.064) are next in priority and are significantly less important than the previous three factors. OL (0.016) has the lowest priority. Likewise, in the contractor sector, the result shows that CG (0.147), TW (0.127), IAM (0.125), and MRCI (0.113) are most important, while the MIL (0.094), CAC (0.089), and ET (0.063) are the next important in priority; and OL (0.011) has the lowest priority. In fact, both the consultant and contractor sectors agree that CG is the most critical and that OL is the lowest priority. This means that CG should be emphasized in the ISO9000 implementation in a construction organization.

In this paper, case studies were also conducted to link the AHP findings to the best practices being adopted by some Hong Kong construction companies. In-depth interviews were used to identify such best practices from the industry. In view of time limitation, resource constraint, and simplification for the interviewees, the interviews were conducted only on the four top priority factors identified from the finding of the AHP analysis, namely, CG, TW,

Table 4. Best Practices for Implementing Critical Factors

Critical factor	Company A	Company B	Company C
Common goal	Newsletters, meetings, value drivers, training, open communication, performance indicators	Posters, newsletters, promotion meetings, internal training, key process indicators	Briefing, internal training, well-documented procedures, close supervision
Teamworking	Training, two-way communication, recognition, focus team, team building activities	Two-way communication, recognition, commitment, briefing, team building activities, motivation, job rotation,	Training, two-way communication, briefing
Education and training	Training, team training, on-job training, appraisal	Internal training, on-job training, appraisal	Internal training, on-job training, topdown appraisal
Cultural change	Posters, newsletters, recognition, survey and feedback, suggestion scheme, training, harmony	Posters, newsletters, training, recognition, feedback, two-way communication, fairness	Briefing, feedback, two-way communication suggestion scheme, training

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ET, and CC. In this respect, three construction companies A, B, and C, who were awarded with quality awards in the past 3 years, were interviewed. It is expected that their practices can serve as good references for the other Hong Kong contractors in their planning for ISO9000 implementation. The interview results show that some common practices can be identified as shown in Table 3. As illustrated, different companies adopt different practices in order to match their own needs. By a closer look, there are some common practices that we can apply in order to focus on the critical factors (i.e., CG,TW,ET,CC) for the implementation of ISO9000 in the Hong Kong construction industry (Table 4). Best practice is a knowledge based management tool that may encourage the reuse of a proven solution. By adopting and adapting the best practices from some other organizations, a company may achieve business excellence.

Conclusion

Success in the construction business in Hong Kong is no longer solely dependent on luck. It depends on many factors such as the genuine top management commitment towards quality and strategic decision making, and effective implementation of decisions. Those organizations enjoying their success and survival are usually characterized by the ability to develop and sustain the company wide commitment in all levels for quality and continuous improvement under the ISO9000 environment. Top management commitment in ISO9000 may generate better company performance, identify and apply employees' effective technical skills, and produce better solutions to problems. It may also enhance less resistance to change via having company-wide common goal, teamworking, education, and training, and changing traditional culture. According to Pun et al. (2001), organizations with high involvement can have an empowering culture and the continuous improvement never ends.

The findings from AHP and the result of the case studies have provided some insights for the identification of success factors for ISO9000 implementation in both consultant and contractor sectors. It has led to the formation of decisions and reliable guides for a further development and improvement on the existing environment in the Hong Kong construction industry. Therefore, this may contribute to enhance the competitive strengths in this industry.

It should be noted that the priority weights among critical factors and subfactors presented in this paper are based on the expert opinions of a group of experienced engineers from Hong Kong construction organizations. Yet the reliability and repeatability may need to be verified with another group of experts if the AHP model is applied in another environment, say in another country, this paper does provide a foundation for carrying out similar studies in this aspect.

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