QUALITY MANAGEMENT IN BUILDING CONSTRUCTION: PRACTICES AT SITE LEVEL

by

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Abstract

This Paper presents a research study carried out to identify quality management practices adopted by building contractors at site level. The prevailing situation with respect to these practices was assessed, using the ISO 9000 quality standards as the basis, and some shortcomings were identified. It was found that, in general, large contractors had better quality management practices than their smaller counterparts. According to the Study, the main barriers to achieving quality assurance at site level include: non-availability of specifications at site; lack of proper procedures for purchasing materials; contractors depending too much on experience of workmen rather than their skill levels; inadequate inspection and testing; non-existence of corrective action; and poor record keeping practices.

Keywords: Building construction, Quality management, Quality assurance, ISO 9000, Site practices

Introduction

Achieving quality of products and services is a widely discussed subject today. The approaches to managing quality can take various forms such as quality control, quality assurance and total quality management (TQM).

Quality control can be defined as 'the operational techniques and activities that are used to fulfil requirements for quality' (ISO 8402, 1994). This is considered as one of the simplest approaches to managing quality and includes activities such as inspection of materials and workmanship, tests on materials and other activities carried out during construction to show that requirements and specifications are being met (Olomolaiye, et al, 1998). In other words, quality control is essentially a matter of inspection and testing of materials or product output against a predetermined standard and rejecting those items that fail to conform, (Griffith, 1990).

Quality assurance has a broader scope than that of quality control and includes 'all those planned and systematic actions necessary to provide adequate confidence that product or service will satisfy given requirements for quality' (ISO 8402, 1994). This approach had been first applied to manufacturing processes as early as the beginning of modern industrialisation (Devos, et al, 1996), though it was only in 1979, a standard for quality assurance systems, referred to as British Standard (BS) 5750, was published (Seddon, 1994). BS 5750, (1987), introduced a framework or formal arrangements for quality assurance (Atkinson, 1987); the requirements of the standards, in its own language, were to 'prevent nonconformity' rather than to detect it as in quality control. In 1987 the International Organisation for Standardisation introduced the ISO 9000 series of standards, the international version of BS 5750, which is now universally adopted by organisations in implementing quality assurance systems. It is reported that at the end of 1998 - just eleven years since it was first published- more than 270,000 firms in over 143 countries have been certified to ISO 9000, (Dick, 2000).

Total quality management (TQM) is an approach to managing work based on the analytical evaluation of work processes, the development of a quality culture, and the empowerment of employees for the purpose of continuous improvement of the product or service (Hellard, 1993). Basically, TQM aims to address all aspects of a business including people, methodology and technology; it emphasises on customer satisfaction as well as continuous improvement (Jawahar-Nesan and Price, 1997). TQM has become popular in the manufacturing industry and is now also being used successfully in the building construction industry (Arditi and Gunaydin, 1999). However, it is known that construction companies that have addressed the issue of quality have been predominantly quality assurance-oriented and only a relatively few have embraced TQM for this purpose (Sommerville and Robertson, 2000).

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Although construction cannot be categorised as being strictly either a service or a manufacturing industry (Kabul, 1996), where the above approaches are well established, it is believed that the same concepts of quality from these two industries can still be used in the construction industry by appropriately blending them, (Landin, 2000).

Construction work is usually carried out as projects and requires the involvement of different parties: the client, the consultant and the contractor. Therefore, whatever the approach used for managing quality, unless all these parties play their own part at different stages of the project, the quality of the end project cannot be fully achieved. This essentially involves, at least, two parties: the consultant managing quality during design stage and the contractor, during the construction stage. The contractor's practices both at corporate level and site level affect quality during the construction stage.

The Research Study presented in this Paper was carried out in 2000 with the objective of identifying quality management practices adopted by contractors at site level. It considered only the contractors who had undertaken building construction projects and most of them (except for two) were ICTAD registered contractors with grades varying from M1 to M8.

Questionnaire Survey

Although, the implementation of ISO 9000 standards, in Sri Lanka, is still at infancy stage - only a handful of contractors certified so far (De Silva and Goonatillake, 2001) - ISO certification has become a matter of survival for contractors in some other countries. In fact, there are countries where it is a mandatory requirement for contractors; for example, in Australia, all contractors wishing to do business with government agencies and major companies should have the ISO certification (Love and Li, 2000). Similarly, contractors in countries such as the UK (Moatazed-Keivani, 1999), Hong Kong (Tam, et al., 2000), and Singapore (Low and Henson, 1997) are increasingly adopting ISO 9000 as the basis for managing quality. It can be reasonably assumed that ISO 9000 will, sooner or later, become the yardstick for measuring quality in the local construction industry as well, though it is unlikely to become a mandatory requirement in the near future. For this reason, it was decided to develop the questionnaire necessary for the study using the ISO 9000 standards as the basis for capturing quality management practices at site level.

Ten quality elements (requirements) of the ISO 9001, (1994), were selected for the questionnaire; they were selected from the twenty quality elements in the standard. As most of the contractors participated in the survey were non-ISO certified companies, only the requirements considered to be more relevant at site level were included in the questionnaire. These were:

(a) Document and Data Control
(b) Purchasing
(c) Product Identification and Traceability
(d) Process Control
(e) Inspection & Testing
(f) Inspection & Test Status
(g) Control of Nonconforming Product
(h) Corrective and Preventive Action
(i) Handling, Storage and Delivery
(j) Quality Records

Of the twenty ISO quality elements ten were not included 2 in the questionnaire; some of these were directly related to implementing and maintaining a quality system and the rest were found to be more relevant to practices at design stage, tender stage or at corporate level during the construction stage.

The selected quality elements were then divided into a large number of sub-elements and the questionnaire had, at least, one question regarding each of these sub-elements. A pilot survey conducted among few sites proved that the data for these sub-elements could be collected successfully at site level. However, care was taken not to ask questions using the sub-elements exactly in the same format given in the standard; the questionnaire was so designed that the contractors could provide information on whatever the quality practices they had at sites within the broad categories of these sub-elements. The level of quality management at site level was computed based on the number of the sub-elements practiced by the contractors; the assumption here was that ISO 9000 would assure quality of processes in an organisation and could be used as a benchmark for determining the adequacy of any quality management system.

It could be argued, whether ISO 9000 is the only criteria available to evaluate quality management practices in building construction. There may be other criteria as well; however, the use of ISO 9000 for this purpose can be justified as it not only allows contractors to identify problem areas with respect to quality but also provides an effective management system to overcome these problems.

The questionnaire was administered to 36 contractors who were randomly selected using a list of building construction sites. Except for two contractors, others were all contractors registered with the Institute for Construction and Training (ICTAD) and their distribution with respect ICTAD Grade is shown in Table

1. The majority (69%) of the contractors surveyed had grades between M5 and M8 and the rest were M1 to M4 contractors. Of the actual population of ICTAD registered contractors, 70 % are M5 - M8 contractors (ICTAD, 2002). This indicates that the study has considered a representative sample of the actual population of contractors in terms of the distribution of grades; particularly, the M5 - M8 contractors, who form the majority, have more or less the same proportion in the sample and the actual population. It is reasonable, therefore, to assume that the findings of the study are applicable to all the contractors from M1 to M8.

Table 1: ICTAD Grade of Contractors participated in the Survey

ICTAD Grade	Number of Contractors
M1	2
M2	5
M3	1
M4	1
M5	10
M6	8
M7	6
M8	1
Other*	2

* The two contractors in this category did not have ICTAD registration, but they were large enough to be categorised above Grade M2.

Document and Data Control

Proper control of documents at site level is vital for achieving quality of the works. Documents that should be controlled at site level, according to ISO 9000 requirements, include both quality system and project specific documents (Lam, et al, 1994).

Quality system documents include the quality manual and quality assurance procedures, which are essential for any ISO certified company. Most of the project specific documents are in the form of contract documents: the Conditions of Contract, drawings, specifications, bill of quantities (BOQ), etc.

The questionnaire considered all aspects of the documents, including the use of proper procedures for review and approval of documents, making changes to them, withdrawal of obsolete documents, and the availability of a correct version of the documents at site. The responses were not very encouraging: only one contractor, an ISO certified company, satisfied all these aspects for both quality system and project specific documents. Other contractors did not have quality system documents, as none of them had any formal quality system in place. The availability of project specific (contract) documents at site was not very satisfactory either. The availability of various documents at site is shown in Table 2. Only the contractors, who had these documents available at site, interestingly though, positively responded to the practices regarding review and approval of both the original documents and subsequent changes made to them. The main finding, with respect to document control, was the non-availability of construction specifications at most of the sites surveyed. However, the availability of documents at site alone does not ensure proper document control if the other aspects stated above are not be practiced by the contractors.

Table 2: Availability of Quality System and Contract Documents

Type of Document	Contractors having the document at site (%)
Quality System Documents	2.8
Drawings	100.0
Bill of Quantities (BOQ)	100.0
Site Procedures	2.8
Work Instructions (for some work)	52.8
Specifications	36.1

Purchasing

Purchasing of materials and services of subcontractors can take place at site level as well as at higher level through the head office. The questionnaire assumed that the site personnel were aware of the purchasing practices whether or not they were directly involved with the process.

The questionnaire was aimed at obtaining these practices on certain aspects highlighted in the ISO 9001 standard: selection of suppliers and subcontractors, purchase documents, extent of control exercised by the company (contractor), and verification of quality at the source. Of these aspects, the first two were thought be very important prerequisites to assure quality as, (Chung, 1999):

(a) suppliers and subcontractors should be capable of providing materials and services of intended quality; and

(b) it is necessary to specify the required material or service in sufficient details to avoid ambiguity.

Accordingly, the contractors should evaluate the suppliers of major materials and maintain lists of those

who are selected; only from these suppliers quotations should be obtained (Lam, et al, 1994). It should be noted, however, that the purchasing requirement is only applicable for selection of suppliers; the incoming inspection of materials is covered by the Inspection and Testing requirement of the ISO 9000 standard, and it should be carried out for all materials received at the site.

The Survey revealed that only 52.8% of the contractors had some form of evaluation and selection procedure. The basis of evaluation used by most of the contractors, as shown in Table 3, was not as comprehensive as that an ISO 9000 certified company would have adopted. Only 5.6% of the contractors appeared to consider all the important factors in the evaluation: evidence of quality of materials, previous performance, (if any), and inspection of materials and quality assurance measures at suppliers' premises.

In the case of subcontractors, most of the contractors (69.7%) were using some method of evaluation. However, their evaluation would be mainly based on the previous performance of the subcontractors (60.9%); only very few of them used evidence of quality of work (perhaps through letters of recommendation) and inspection of the work and quality assurance measures at subcontractors' premises.

contractors specify main materials with written purchase orders; the rest them relied on verbal orders. The situation regarding subcontractors appeared to be better with 22% of the contractors specifying the service requirements in subcontracting agreements.

The extent of control to be exercised by the contractors on their suppliers and subcontractors, to assure quality, should depend upon the type of product or service purchased and the records of their previously demonstrated capability and performance, (ISO 9001, 1994). The Survey results do not indicate the use of such records of supplier (or subcontractor) capability and performance; however, all the contractors used visual inspection of every delivery of material and some of them adopted verification of material quality at the source or supplier premises as a means of their control over the suppliers. Table 3 shows the percentage of contractors using verification at the source or supplier premises.

According to the survey, 25% of the contractors obtained the approval of the consultant prior to use (or purchase) of major materials while others did this only for some of these materials (Table 4). It is difficult to comment on the adequacy of this practice adopted by the contractors; however, it should be noted that neither the consultant's approval, (ICTAD, 1989) nor the verification by himself at the source or supplier's premises as above would absolve the contractor's responsibility to provide an acceptable product.

Table 3: Purchasing Practices of Contractors

Practice	Contractors adopting the Practice
Evaluation of suppliers	52.8
Basis for evaluation of suppliers	
(a) Evidence provided by supplier on quality of material	22.2
(b) Previous performance	25.0
(c) Inspection of materials and quality control measures at supplier premises	13.9
(d) All above	5.6
Type of purchase order, mainly *	
(a) Written	11.1
(b) Verbal	88.9
Type of control exercised on existing suppliers	
(a) Visual inspection	100
(b) Performance records	19.4
(c) Quality audit reports	8.3
Contractor's verification at supplier's premises	
(a) All material	2.8
(b) Some materials (mainly, bricks, timber and metal)	86.1

* Materials considered area timber, cement, steel and bricks

The practices with respect to the other important prerequisite (i.e. specifying the required materials or service in sufficient details) are not very satisfactory according to the Survey results. Eleven percent of the

Table 4: Contractors Obtaining the Consultant's Approval

Material	Contractors obtaining Consultant's Approval
Timber	96.3
Cement	70.4
Steel	70.4
Bricks	44.4
All above	25.0

Product Identification and Traceability

In building construction, product identification is mainly applicable to prefabricated components, (Chung, 1999); for mass production, even the use of a bar-coding system can be considered, (Baldwin, et al, 1994). However, it is not realistic to expect that contractors would identify all materials from receiving stage through construction till the completion of the works as specified in the ISO 9001, (1994), standard.

The traceability materials and work is important as it allows each part of construction work to be related back to the particular batch of materials or components used. Out of the contractors surveyed only one contractor (2.8 %) maintained traceability records for all items of work and two of them (5.6%) keep such records only for concrete work. The results are not surprising as it is necessary to maintain detailed site records as well as inventory systems if traceability is required. It is hard to believe that local contractors would adopt such a level of record keeping when contractors in such developed countries such as the United Kingdom, do not seem to have considered the specific requirement of traceability under any of the four main categories of site records: financial, quality, as-built and progress records (Scott and Assadi, 1995).

Even the ISO 9001, (1994), appears to be less stringent on this issue; according to which, the supplier (contractor) shall implement traceability 'where and to the extent' it is a specified requirement in the contract. Particularly, when suppliers and subcontractors are engaged for the same items, traceabilty should be established for the purpose of identifying the people responsible whenever non-conformances are detected in materials, products or workmanship. Therefore, it is incumbent upon the contractors to identify the situations and levels of traceability required in his work; without traceability, it may not be possible to undertake Corrective Action, which is another important requirement in quality assurance.

Process Control

Process Control deals with the execution of the works at site. Its main purpose is to ensure that processes are carried out under controlled conditions. These include:

(a) documented work instructions defining the manner of execution;

(b) monitoring and control of suitable process and product characteristics during execution;

(c) approval of processes and equipment as appropriate; and

(d) criteria of workmanship to be stipulated, as need be, in written standards or via representative samples.

In quality assurance, the need for documented work instructions cannot be understated; incorrect methods used in any operation or process very often lead to below-standard products. According to the Survey, only 16.7% of the contractors agreed that they were using documented procedures defining the manner of execution of work. The ISO 9001 standard is very specific on this matter and says that work instructions are required where the absence of such instructions would adversely affect quality. As revealed by a survey carried out (prior to the implementation of ISO 9000) in Singapore, the cost of doing things wrong and rectifying them was between 5 - 10 percent of the project costs (CIDB, 1989); the lack of method statements in detailing work procedures could be considered as one of the most common causes associated with this problem (Au and Yu, 1999). On this basis, the majority of contractors surveyed were not likely to end up with high quality work or would have to spend a considerable amount of money on rectifying defective work.

The extent of use of documented procedures by the contractors, those who claimed to have adopted them was also very low. Only one contractor (2.8%) used documented procedures for monitoring and controlling relevant process and product characteristics according to the survey; all of them, however, agreed that they used their experience for such activities and also to achieve proper workmanship. It is quite common even in other industries, that documented procedures are not properly used because the workers have so many years of "experience". But experience alone is not sufficient to assure quality of as pointed out by Lamprecht, (1993):

".... when operatives (workers) are interviewed they often will confess of not knowing why things are done a particular way. No doubt they all have experience and know what needs to be done when, but they often do not fully understand why it is important that a particular set of instruction is done in a particular order."

Only a small number of contractors (8.3%) obtained written approval from the consultant for all work as required in ICTAD specifications for building works. A majority of the contractors (86.1 %), however, obtained such approval only for some types of work; a detailed breakdown of this practice is given in Table 5. However, it should be noted that the consultant's approval does not affect the contractor's responsibility to meet the quality requirements under the contract; the quality requirements for important elements of work are stipulated in the Specifications.

Table 5: Consultant's Written Approval for Some Work

Work	Breakdown of contractors who obtained approval for some work (%)
Reinforced concrete	100%
Timber	64.5%
Excavation	16.1%
Steel	6.5%

In the case of ISO 9000 certified contractors, the workmanship criteria for work should be well defined in their own procedures; in addition, the specifications generally stipulate these for important elements of work. However, it was revealed that 36.1% of the contractors had specifications at site; only less than half of them (16.7%) were using the specifications during execution of work. Further, only few contractors (11.1%) had qualification criteria for their workmen, but 75% of them had specified qualifications criteria for technical staff.

This may be mainly due the fact that in Sri Lanka, there is no grading system for craftsmen and only very small percentage of them have passed the National Trade Test; whereas over 85% of the civil engineers and 65% of technical officers have formal qualifications obtained from universities and technical institutes respectively (Jayawardane and Gunawardena, 1996). Although availability of engineers and technical officers in the industry in the last few years appeared to be adequate (Gunawardena and Jayawardane, 2001), only 30.5 % of the sites surveyed had qualified engineers and 52.8 % of them had technical officers for supervision of work; 41% of the sites did not have either of these categories. The categories of staff in-charge of supervision at the sites are shown in Table 6. Experienced practitioners in the industry identify the availability of qualified supervisory staff at the site as a critical factor in achieving quality (Arditi and Gunaydin, 1999). Therefore, the level of supervision on building sites, particularly with respect to contractors without any proper criteria for employing workmen with required skill levels or qualifications could not be considered as satisfactory. In any case, non-availability of skilled and qualified personnel should only be taken as a possible reason, but not as an excuse, for the lack of proper process control at sites surveyed.

Table 6: Staff In-charge of Construction Supervision

Category of Staff	Contractors with this category of staff in-charge of supervision (%)
Civil Engineer	30.5
Technical Officer	27.8
Forman or Contractor himself	41.7

Inspection and Testing

Inspection and testing are contractual obligations of the contractor, (ICTAD, 1989); these should be carried out as described in the specifications or in accordance with the instructions of the Engineer (consultant). However, the results of the survey indicate that only a few (5.6%) of the contractors used ICTAD specifications for inspection and testing activities; one of them was in fact an ISO 9000 certified company which used its own documented procedures as well for this purpose.

In line with ISO 9001 classification inspection and testing could be divided into three categories based on the stages of the work during which they are carried out:

(a) Receiving;
(b) In-process, and;
(c) Final inspection and testing.

The receiving inspection and testing practices adopted by the contractors are shown in Table 7. Accordingly, most of the contractors (91.7 %) would rely on visual inspection whenever materials are received at site.

Table 7: Receiving Inspection and Testing Practices

Type of Inspection/Testing	Contractors carrying out Inspection/Tests (%)
Testing of materials as required in specifications	2.8
Visual inspection with a check list	8.3
Visual inspection without a checklist	91.7

Only 27.8% of the contractors surveyed were undertaking in-process testing; this appeared to be carried out mainly for controlling the quality of reinforced concrete work. However, all contractors reported that they carried out visual inspection of work during the in-process stage. Similarly, on completion of the works, they would undertake the final inspection of

the structure for visible defects; apparently, this was the main verification activity carried out by the contractors on the final product.

Inspection and Test Status

In construction, like in manufacturing, it is necessary to distinguish products that are satisfactory from those which have been identified unsatisfactory through inspection and testing. Therefore, anything that will become part of the completed works should have its inspection and test status identified (Chung, 1999). This identification has to be maintained from receipt of incoming materials, during construction process, and up to handing over of the completed works; this is to ensure that only product that has passed the required inspections and tests is used or installed, (ISO 9001, 1994).

In manufacturing, large numbers of identical parts or items are produced in a factory;. Therefore, it is obvious that items, which have been accepted by inspections and tests, should be marked, labelled or separate from the rest so as not to be confused with those that have been rejected. However, in construction it is difficult to find direct parallels to this practice (Landin & Persson, 1998); instead the inspection and test status is usually shown in inspection and test records, (Chung, 1999).

To obtain information on the actual practices of at site level, some questions on inspection and test records were included in the questionnaire. According to the results, the majority of quality records maintained by the contractors surveyed were related to inspection and tests; this aspect, therefore, is discussed under the section on Quality Records.

Control of non-conforming product

Non-conforming product includes incoming material as well as any part of the works during the in-process stage.

At all sites, the consultant's supervisory staff mainly did identification of non-conforming work and material; about 86% of the contractors reported that their own staff too identify such nonconformities during inspection activities.

The majority (86.1%) of the contractors reported that they would carry out rectification of defective work mainly according to the instructions given by the consultant; the rest had more involvement of their own staff in the form of instructions issued or investigations carried out on such work.

Handling and Storage of Materials

At site level none of the contractors had documented procedures for handling and storage of material and plant that were to be incorporated into the work.

There were designated storage areas or storerooms for selected materials at all the sites. Table 8 indicates the percentage of the building sites that had designated storage areas for some important materials identified in the survey.

Table 8: Sites with Designated Storage Areas for Materials

Material	Sites with Designated Storage Areas (%)
Cement	100.0
Steel	61.1
Timber	69.4
Lime	19.4

The ICTAD specifications give certain requirements for handling and storage of some selected materials such as bricks and corrugated asbestos cement sheets, (ICTAD, 1988). It was found that none of the contractors, had given due consideration to ICTAD specifications in deciding the requirements for handling and storage of materials. The question arises whether designated storage areas are required for materials at site strictly in accordance with specifications, if there is no adverse effect on quality without them; the contractors may have used other practices such as storing materials in a central store or in a yard closer to the site. The space availability at site is another factor, which affects their storage practices. Further, certain high value items are usually delivered to the site when the contractor is ready to incorporate them into the permanent works.

Corrective and Prevention Action

The purpose of Correction Action in quality management is to prevent or minimise recurrence of nonconformities identified or detected through verification activities such as inspection and testing (Lam, et al, 1994). The investigations carried out to determine the root cause of nonconformities is considered as part of corrective action according to ISO 9001 (1994). According to the survey, the only contractor undertaking such work was an ISO 9000 certified company.

Although the requirement for corrective action was included in ISO 9000 standards since their inception as action taken to eliminate the causes of actual nonconformities, (ISO 9001, 1987), 'Preventive Action' was included, approximately, seven years later (ISO 9001, 1994). According to the latest definition,

preventive action is taken to eliminate the cause of a potential nonconformity or other undesirable potential situation, (ISO 9000, 2000). This involves identification of potential nonconformities and very often the use of statistical techniques to analyse inspection and test data. None of the contractors surveyed, showed any evidence of analysing historical inspection and test data to identify potential nonconformities let alone any preventive action. Most of the contractors surveyed did not have any quality assurance procedures, work instructions, or records to prove that they were undertaking preventive action. In the case of corrective action, the situation appeared to be marginally better with 2.8% of contractors having documented procedures for this purpose; however, compared to the whole sample of contractors, this was quite insignificant.

Quality Records

Maintaining site records is a daily routine in any construction project. These records are kept for different reasons which range from providing a means of monitoring the project in terms of cost, quality and progress to supporting claims for additional payments or extension of time, (Ashford, 1989).

Site records can be classified into four main categories (Scott and Assadi, 1995):

(a) Financial records which consist of all relevant particulars necessary for making payments to the contractor;

(b) As-built records which provide documentation of all works as constructed and completed;

(c) Progress records which identify the work carried out during the construction stage along with all related matters affecting the construction process; and

(d) Quality records that provide necessary verification that the materials used in construction and the workmanship comply with specifications and other quality requirements.

The questionnaire considered only the quality records maintained at site level by the contractors with respect to (i) inspection and tests performed on materials and works, (ii) nonconformities (defects), and (iii) identification and traceabitilty.

Table 9: Level of Record Keeping

Type of Record	Contractors keeping records (%)
(a) Inspection of works	5.6
(b) Testing	
* All material	2.8
* Some material	13.9
* Concrete work only	11.1
(c) Nonconformities	5.6
(d) Identification and traceability	
* All works	2.8
* Concrete work	5.6

Table 9 shows the levels of record keeping adopted by the contractors surveyed with respect to some important quality records. As seen in the Table, the level of record keeping at site by the contractors could not be considered as satisfactory; only a few companies had record keeping practices of acceptable level to demonstrate that the materials and the workmanship were in compliance with specified requirements.

Conclusions

Using ISO 9000 as the basis, it was possible to assess the quality management practices of a sample of building contractors. The results, though do not indicate a very satisfactory situation, would be useful to contractors as well as others in the industry to take necessary measures to improve the existing quality management practices at building sites.

One of the main findings of this Study is that only about 20% of the contractors surveyed satisfied, at least, one third of the sub-elements (quality requirements) presented in the questionnaire; they were all large companies: three M2 contractors, two M1 with one having ISO 9000 certification, and two large companies with foreign collaboration or ownership. The contractors who satisfied less than one third of the above sub-elements were predominantly small companies: more than 85% of them were contractors with ICTAD registration of Grade M5 or lesser.

Assuming that the sample selected for the survey was representative of the population of building contractors in the country - of course, subject to the limitations of the Study given in the following section - it would be possible to draw conclusions for the industry as a whole:

1. Large contractors appear to have better quality management practices at site level than smaller contractors.

2. Non-availability of construction specifications at site or the lack of proper use of these in executing work could be seen as a major barrier in achieving quality during the construction stage. Even if specifications were available, there would be other issues such as their adequacy, completeness, clarity and practicability that need to be addressed; a recent survey indicates that both contractors and consultants have agreed on certain drawbacks of the specifications currently being used for building construction (Dayaratne, et al., 2002).

3. Evaluation of suppliers, prior to purchasing of materials, could hardly be seen among contractors; the practice with respect to subcontractors is found to be somewhat better. (However, if the contractors are compelled to select suppliers identified by others, then obviously the contractors cannot be blamed for not carrying out proper evaluation of suppliers.) The use of verbal means in ordering materials as opposed to written purchase orders could be seen as the weakest area as far as purchasing is concerned; this situation - the lack of purchase documents to specify the required quality of materials in sufficient detail - could seriously affect the quality of the works.

4. Many contractors depend too much on the experience of workmen in achieving quality of workmanship; they do not seem to have proper criteria for recruitment of workers. This is not a very desirable situation, particularly, when there is a lack of qualified supervisory staff at building sites. But, there may be another side to the story as well. That is whether our training institutions produce personnel with the skills and knowledge required by the industry; if not, the contractors can do nothing but to rely on experienced workmen for achieving quality.

5. Inspection and testing activities carried out by most of the contractors are not adequate. Relying heavily on visual inspection without a checklist and not sticking to specifications for testing of materials and works are apparently the major problems in this regard. It should also be noted that inspection by the consultant only is merely a quality control activity, which does not necessarily assure quality of the final product.

6. 'Corrective Action' - identifying the root causes of nonconformities and eliminating them - is found to be practiced only by ISO certified contractors; 'Preventive Action' to eliminate potential nonconformities is almost non-existent. It should be noted that without these being practiced by contractors, it would not be possible to achieve quality assurance in building woks.

7. Quality records - which are central to any quality assurance system in providing evidence that quality is being achieved - are found to be limited to inspection and test records maintained by contractors with respect to materials used for some parts of the works such as concrete work. As it was evident during the Survey, contractors with ISO certification are bound to maintain quality records on both materials and workmanship with respect to all aspects of the works executed; only the contractors with such level of record keeping would be able to prove that they have complied with construction specifications and all other requirements of quality.

8. Finally, it is suggested that the contractors should be encouraged to implement a quality management system such as ISO 9000 in order to improve their quality management practices at site level. But, how can they be motivated to embrace ISO 9000? According to the experiences of other countries, 'client pressure or requirement' is found to be the main motivating factor for construction companies to implement ISO 9000 standards. The government, being the largest client in the construction industry, could take the initiative in this regard. This is obviously not to make ISO 9000 certification mandatory overnight; instead, some mechanism must be found to encourage companies to implement formal quality management systems. One way to do this would be to offer financial assistance for them to cover, at least, part of the certification costs; this type of grant aid programmes had been implemented in even developing counties such as the UK, (Giles, 1997).

Limitations of the study

1. The majority (69%) of contractors surveyed were small contractors between ICTAD Grade M5 and M8. Therefore, the results of the research might be a little biased towards such contractors; this was mainly due to the selection of a random sample of sites instead of a stratified sample of contractors. They might have been different if the sample had consisted, predominantly, of large contractors. However, the majority (70%) of the contractors in the actual population of ICTAD registered contractors are also in the grades between M5 and M8, (ICTAD, 2002).

2. The sites were selected from one geographical region, (Southern Province), of the country. However, it was assumed that there would not be any bias due to this as the contractors surveyed had their main offices and work sites in other regions as well.

3. The questionnaire was meant to capture data on quality management practices at site level only. The output of the Survey, therefore, does not cover such practices of the contractors at head office (at corporate level) or during different stages of work: pre-contract and defects liability period.

4. The Study was aimed at identifying quality practices of contractors at site level using some selected requirements of the ISO 9001 standard as the basis. The results therefore do not indicate the level of compliance with the ISO standard as a whole.

5. Although, it is suggested that ISO 9000 would improve quality practices of contractors, no research has been carried out to identify costs and benefits of ISO certification in the construction industry; perhaps, it may be too early for such a survey as there are only a handful of ISO certified contractors in the country (De Silva and Goonatillake, 2001).

Notes:

1. Contractors can get themselves registered with the Institute for Construction, Training and Development, (ICTAD), in one of ten grades that range from M1, being the largest, to M10, which is the smallest grade; the following table shows the size of construction work recommended for the contractors in each of these grades.

Grade	Size of Construction Work (X) in Rs. Millions
M1	X > 300
M2	300 > X > 150
M3	150 > X > 50
M4	50 > X > 20
M5	20 > X > 10
M6	10 > X > 5
M7	5 > X > 2
M8	2 > X > 1
M9	1 > X
M10	0.5 > X

Source: Guidelines for Grading of Construction Contractors, ICTAD

2. The other ten quality elements of the ISO 9001,(1994), standard that were not included in the questionnaire are given below:

   (a) Management Responsibility
   (b) Quality System
   (c) Contract Review
   (d) Design Control
   (e) Customer Supplied Product
   (f) Control of Inspection and Testing Equipment
   (g) Internal Quality Audits
   (h) Training
   (i) Servicing
   (j) Statistical Techniques

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