



Review - A Study of Quality Management in Construction Projects

Ashmal Natchan¹, Dr. M.S. Kuttimarks², R. Mahadev Swamy²

ME Student¹, Construction Engineering Management, Civil Engineering SSJCET, Asangaon, Thane, MH – 421601

Associate Professor², Civil Engineering, SSJCET, Asangaon, Thane, MH – 421601.

drkuttimarks.ssjcet@gmail.com¹

ABSTRACT

Quality management systems are being operated in some sectors in India. But it is rare to meet this system in the construction industry. Many hindrances make it difficult to apply the system effectively due to the nature of construction and therefore, no objective way to measure the effectiveness of this system exist in the construction industry. The present research addresses three major concerns. The first is to evaluate the effectiveness of quality management system (QMS) in construction projects. The second is to identify the critical factors affecting the quality management system. The third one is to propose an implementation framework for quality management in construction projects. Through a survey questionnaire, an attempt has been made to explore the best quality management practices to be followed in construction projects. The main objective of this research work is to evaluate the critical factors that affect the quality management system on quality improvement and performance in construction projects.

Keywords: Construction Projects; Management; Organization; Quality; Quality Management Systems; Regression; Significance; Variance.

1. INTRODUCTION

Construction industry is a pillar of economy for every country including India. It is time bound and employs huge resources of men, material and machinery. As a result it contributes to a massive growth of the country's economic development. The technical break break through has greatly influenced the construction industry. Construction sector has undergone severe cycle changes day by day. Construction contributes to the growth of many related industries such as manufacturing of construction material, cement, pipes, sanitary wares, tiles, ready mix concrete, etc. Besides from being an important asset that generates profit to the country, construction encourages the development of human resources and generates more employment than other industrial sectors.

Considering the significance of construction, it is necessary to identify major issues affecting the efficiency of this sector. The poor state of technology adopted by the construction industry in many countries as well as fragmented relation between construction cost and time delay which in turn affects the quality. Many clients now-aprice and the time of delivering a final product of required quality. Now-a-days, management of construction companies is focusing on quality issue on a competitive edge. Delivering projects that satisfied client requirement has become a main priority in order to maintain business relationships and hence the construction industry should develop standards during every stage in order to deliver satisfactory outputs.

1.2 Quality

In general the quality may be defined as the ability of product or service to satisfy customers. As per international standard, the characteristics ability to satisfy stated and implied needs is defined as quality. The definition for the term quality given by various authors and authorities are presented in Table 1.1

Table 1.1 Definition of Quality

Author / Authority	Definition	Year
Deming	Aims at the needs of the customer, present and future	1986
Crosby	Conformance to requirements	1979
ISO 9000	Characteristics ability to satisfy stated and implied needs	1992
Juran	Conformance to specifications	1988

1.3 Construction Quality

Construction quality can be viewed as one part of a triangle as shown in Fig.1.1. The cost level as planned should be maintained by the contractor; at required level of quality schedule deadlines should meet. Balance should be maintained between the three aspects since they define the project scope. The component quality must be disregarded in favour of increased cost savings and time reductions. Quality is involved in every stage and every aspect of construction. Construction projects and quality are inseparable. Construction quality cannot exist without a construction project and a construction project cannot exist without quality. The modern construction market requires construction companies to guarantee the product quality to their clients.

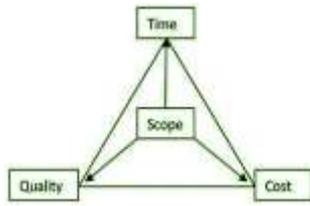


Fig. 1.1 Construction Triangle

1.4 Aspect of Construction Quality

Fig.1.2 shows various concepts that are considered to influence the quality of the product and that can be associated with quality in construction. The Fig. reflects the product features, processes of production and organization, as well as company business/industry issues.

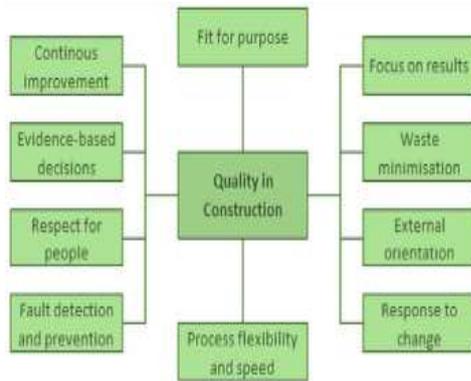


Fig. 1.2 Aspects Involved in the Concept of Construction Quality

1.5 Quality: Past VS Present

Quality has existed from the earliest decades as behaviour, so we can refer to quality as anything prepared or manufactured with a degree of "excellence" or as the worth of a product or service. For more than 25 years, there have been many change towards improved quality. As shown in Table 1.2, each civilisation has implemented a part of the concept of quality. The improvement can be seen in quality of product, leadership and management. The key issues could be extracted from comparison in Table 1.2 that the quality today is everyone responsibly focusing on the customer requirements and is the way of increasing profits by improving products quality.

Table 1.2 Changing View of Quality (Source: Kerzner, H, (2003))

Past	Present
Quality is the responsibility of blue collar workers and direct labour employees working on the product	Quality is everyone's responsibility, including white-collar workers, the indirect labour force and the overhead staff.
Quality defects to be hidden from the management and customers	Defects must be reported and subjected to corrective action.
Quality problem lead to blame, faulty justifications and excuses	Quality problems lead to cooperative solutions
Corrections to quality problems should be accompanied with minimum documentation	Documentation is essential for "lessons learnt" so that mistakes are not repeated
Increased quality will increase project costs	Improved quality saves money and increase business
Quality is internally focused	Quality is customer focused
Quality will not occur without close supervision of people	People want to produce quality products
Quality occurs during project execution	Quality occurs at project initiation and to be planned for within the project.

1.6 Quality Circle

A quality circle is a group of employees from the same work area and doing similar type of work, voluntarily meets for an hour

periodically either every week or fortnightly to identify, analyze and resolve work related problems in their own area. The structure of a quality circle is headed by the top management who has the responsibility to form the steering committee known as the quality council who in turn are responsible for monitoring all important activities in the organisation. The facilitator is the head of the coordinating agency which implements the quality circle. The non-members are the specialists in a particular area as detailed in Fig.1.3.

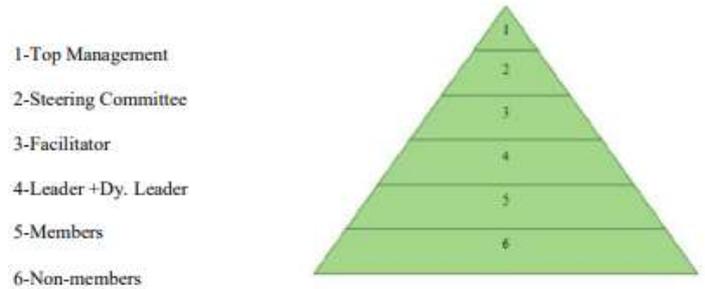


Fig. 1.3 Structure of Quality Circle

1.7 Objectives of the Present Study

1. To evaluate the effectiveness of quality management system in construction projects.
2. To evaluate the critical factors that affects the quality management system on quality improvement and performance in construction projects.
3. To propose an implementation framework for quality management system in construction projects.
4. To propose regression equation for the identified strongest predictor among the independent variables which have a cause and effect relationship on dependent variables.
5. To proposed suitable recommendation for effective quality management and quality system.

2. LITERATURE REVIEW

2.1 General

This chapter aims to build a theoretical foundation upon which the research is based, by reviewing the relevant literature to identify research issues in the area of quality management systems in construction industry.

2.2 Background

Garvin (1984) explained the phenomenon of quality as an integrated with multifaceted interests of process and product stakeholders. The author introduced five different views about quality as transcendent quality, product based quality, user based quality, manufacturing based quality and value based quality.

Edward Deming (1986) According to deminings definition, quality of output would have high degree of predictability from a production process, which is motivated on its target value with minimum variations, this consistency and process accuracy will cause to reduce rejection rate and increase production efficiency and hence will cause to reduce the production cost. Quality management model, proposed by Deming, was based on well-defined, effective, and valid quality management constructs. By applying this model of quality management, organizations could realize a cultural change that is mandatory for the successful implementation of quality management programs. Quality management programs should be aligned with culture of organization, and only those quality management practices should be adopted which do not have conflict with existing organizational culture, otherwise management should develop a new workforce by selective hiring to create new work culture

with minimum resistance from employees. Fig. 2.1 shows the theoretical aspects of deming quality management model.

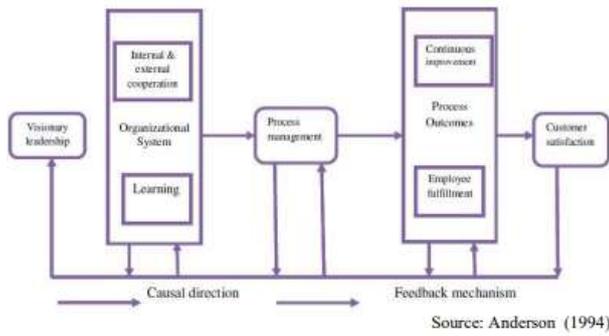


Fig. 2.1 Theoretical Aspects of Deming's Quality Management Model

Benson (1991) discussed the historical background of system structural view of quality management by referring the work of Astley and Van de Van (1983). System structural view defined that the quality management efforts made by an organization are driven and forced by the external factors and the role of management is to perceive and respond positively against customer demands, competitive pressures, government regulations, and expectations of other effective stakeholders of organization. Fig. 2.2 shows the system structural view of quality management.

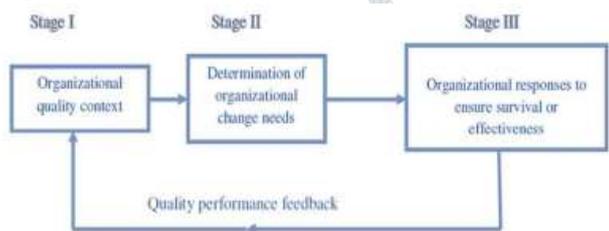


Fig. 2.2 System - Structural View of Quality Management

The author further modified the system structural view by incorporating the quality management concept of Smith (1988) to perform gap analysis between actual status of quality management and ideal or desired quality management status in organization by the managers. Fig. 2.3 describes the modified model of system-structural view of quality management.

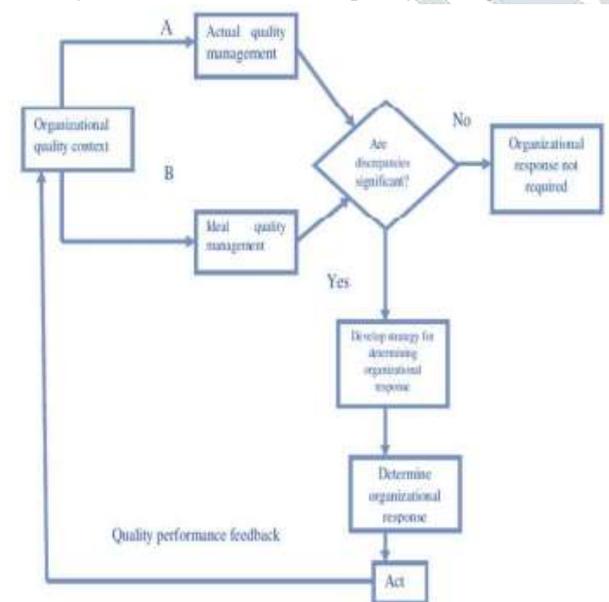


Fig. 2.3 The System Structural View of Quality Management Modified to Reflect Aspects of the Managerial Problem Solving Process

Burati (1992) collected data on quality deviation from nine completed construction projects. The data were collected to

identify the direct costs associated with work redesign, repair, and replacement. The data indicated that deviations in the project accounted for an average of 12.4% of the total project costs. Furthermore, design deviations averaged 78% of the total number of deviations, 79% of the total deviation costs, and 9.5% of the total project cost. The construction deviations averaged 16% of the total number of deviations, 17% of the total deviation costs, and 2.5% of the total project cost.

Juran et al., (1993) defined the quality as “fitness for use” provided most objective oriented approach and intended to satisfy the customers. The authors view of quality constricts the scope of quality management programs by profoundly focusing only on specific perceived purpose of product, however modern era definition encompasses the concept of exceeding the quality customer needs.

Kano (1993) described that Japanese total quality control is focused on customers to realize customer satisfaction through adopting quality assurance activities related to process and product, the Japanese total quality control model is aligned with industry specific theory and practices, known as intrinsic technology. The author further defined that “Intrinsic technology provides the necessary foundation upon which TQM is built”. Fig. 2.4 shows the structure of Japanese Total Quality Control based on existence of intrinsic technology in the industry.

Le Van Thong (2003) discussed about determination of quality management activities in the construction in the Oil and Gas Company and reviewed the effectiveness of quality management in construction of the Oil and Gas Company. Recommendations were given to improve the quality management system in oil and gas Construction Company.

Sasmita Palo and Nayantara Padhi (2003) examined role of training and its effectiveness in successful implementation of TQM concept in a leading Public sector enterprise in India. They collected data by using structured questionnaire from the employees selected on the basis of stratified random sampling method across the levels and department of the study organizations. The findings of the study indicate that there was a significant relationship between TQM training with teamwork and skill development. The results also implied that TQM training has not reduced the stress level of employees associated with TQM Implementation. Further, the analysis reveals that sufficient training was not provided to employees to manage and improve their communication competence, which constitutes the very essence of TQM. Finally the authors concluded that training is an effective medium of creating awareness, developing organizational communication, competence building, generating enthusiasm and commitment for effective TQM implementation.

Steyn Basson et al., (2004) stated that quality never happens by itself: it is always an outcome of careful research into the requirements of the deliverables that will meet all the needs of the customers as well as expectations of the stakeholders involved. Quality is one of the major areas in the construction industry that has to be looked into critically before a project is initiated.

Bhimarayametri (2005) studied the necessities of quality and its initiatives in the construction industries. The author analysed the critical success factors and examined the existing total quality management frameworks. The findings revealed that, out of 15 critical success factors 9 critical success factors were common in most of the frameworks, 14 critical success

factors were the most prominent total quality management frameworks and 10 critical success factors namely, top management commitment, quality culture, strategic quality management, design quality management, process management, supplier quality management education and training, empowerment and involvement, information analysis and customer satisfaction were proposed for construction firms.

Irianto (2005) considered implementation of quality management as a three-stage process of organizational change, at first stage organization defines the motives, principles, and practices that stimulate the quality management program, at second stage the organization adopts the well-defined principles and practices, and on third stage the lessons learned at second stage derive the organization to develop them as routine practices. The author proposed a model for quality management implementation comprised of implementation (based on process management), contents (critical success factors of quality management) and context (national and organizational cultural factors), shown in Fig. 2.6. The author stated that the companies learn about quality management through successful examples or cases from developed countries, and thus the implementation is motivated as a "me too" attitude.

Tilley (2005) reported that the inadequate and deficient design impacts directly on the efficiency of the construction process. Unfortunately, contractors are often supplied with project design documents that are considered to be substandard or deficient due to incomplete, conflicting or erroneous information. Also the author stated that projects that run over time and budget are often underpinned by faulty contractual documents but in fact does not properly specify or describe the built solution.

Turk (2006) discussed the characteristics of the contractor firms in the construction industry of Turkey, the perceptions, behaviour and experiences of the firms with respect to ISO 9000 quality management system. A field study has been executed and a questionnaire has been carried out. In total, 138 construction firms in Turkey were selected for this study. The evaluation of the data points to the fact that the surveyed construction firms generally have a positive approach towards ISO 9000 QMS and that ISO 9000 QMS provides important advantages for the firms. However ISO9000 QMS cannot be made widespread and applied effectively due to certain disadvantages and difficult in practice.

Barbara and Brook (2006) conducted a research study to assess the significance of quality management constructs, used in Malcolm Baldrige quality award, in global perspective of cultural differences. The authors compared the quality management constructs used in Baldrige quality award with construct used in national quality awards like Hong Kong Management Association Award, European quality award, New Zealand business excellence award, Japan quality award, and Egyptian quality award to identify the impact of national culture on prioritizing the influential quality management constructs. Table 2.3 shows comparison of quality management constructs used in above mentioned quality awards along with their standardized weights on a scale of 1-1000 points. The distribution of weights depicts the relative importance given to quality management constructs in the particular quality management model and in quality management award.

Burcuakincia and Frank Boukampa (2006) stated that effects experienced during construction are costly and

preventable. However, inspection programs employed today cannot adequately detect and manage defects that occur on construction sites, as they are based on measurements at specific locations and times, and are not integrated into complete electronic models. Emerging sensing technologies and project modeling capabilities motivate the development of a formalism that can be used for active quality control on construction sites. In this paper, we outline a process of acquiring and updating detailed design information, identifying inspection goals, inspection planning, as-built data acquisition and analysis, and defect detection and management. We discuss the validation of this formalism based on four case studies.

Chini and Valdez (2006) stated that the ISO 9000 series, developed by the International Standards Organization (ISO) is a standard related to implementing better quality management, control and assurance in companies. It focuses on customer focus, leadership, people involvement, process approach, systems approach, continual improvement, and promotes a factual approach to decision making.

Ekambaram Palaneeswaran (2006) reported that the construction industry is predominantly quality based and it is one of the clients prime concern in their construction projects. Many clients require their contractors to have a Quality Management System (QMS) certified under ISO 9000. This paper portrays the key findings from a focused study that relate to the client satisfaction aspects from implementation of the ISO9000- based QMSs.

Ka Chi Lam and Thomas (2006) reported that the failure of construction projects can be minimized if quality is closely scrutinized and controlled throughout the design and construction stages. However, some organizations treat quality management as a routine exercise and pay little attention to the implementation of quality management systems. As a result, the expected improvement in quality at both project and organization levels has not been truly realized. Concurrent checking, reporting and auditing are necessary to improve the quality of an organization and its works. However, an immense amount of time and effort is required to report, input, retrieve, analyze and disseminate the data instantaneously. Therefore, an automated and user friendly QMS system would be helpful. A web-based QMS could be an effective tool for gathering, Filtering, managing, assessing and sharing quality data at project and corporate levels. The aim of this study is to examine the potential for applying the web-based techniques to collect, manage, assess and distribute quality-related data. A prototype system has been developed, and the results indicate that quality management data can be collected from various projects participants to improve the transparency and efficiency of a construction projects.

Sharma (2006) performed an empirical study to establish the quality management dimensions and contextual factors which contribute significantly in enhancing organizational performance in Queensland business by incorporating quality management programs like TQM, ISO 9000, and both TQM and ISO 9000, simultaneously. The author replicated same 12 quality management factors suggested by Powell (1995) as comprehensive dimensions of a complete quality management program.

Turk (2006) reported that the development of an ISO9001certified QMS requires a huge amount of written

documentation and needs a long time to integrate into a management system, leading to potential substantial increases in operating costs. The author further notes other significant problems confronting the ISO9001 certification process within the Turkish construction firms that prolongs the registration process as well as making it expensive. Some cement is not open to research and criticism, while in others the personnel systems needs restructuring for the establishment of quality management system.

Wan Yusoffwan Mahmood, et al., (2006) discussed the problems related with quality culture and its development in construction industry. The authors reported that the current organizational culture must shift to total quality culture. Dimensions of quality culture like top management commitment, communication, quality planning, training and education, teamwork and supplier partnership were adopted by organization towards the implementation of total quality management for its continuous improvement.

Yang (2006) investigated the relationships between HRM practices and TQM practices, the relationships between HRM practices and quality performance and the effect of HRM practices on the implementation of TQM. The questionnaires were sent to 300 high tech companies located in the science-Based Industrial Park in the So-called "Silicone Valley" of Taiwan. There were 62 valid questionnaires in the 64 responses, representing a response rate of 20.66 percent, which is moderate given a relatively lengthy questionnaire. The results of the study on the effect of various HRM practices on individual TQM practices show that the implementation of HRM has a positive and significant effect on the performance of TQM except the practice of 'employee relations', which has a tiny influence on all TQM practices.

Oztas et al., (2007) reported the differences and uniqueness of the construction industry from other industries (e.g., a long time for project completion; human relationships generally formed once; difficulty in defining quality standards and feedback relating to the construction processes) make it difficult for construction companies to implement quality management system, which can be fragmented and slow in their attempts at quality improvement. The author concluded that, fact that the construction industry has historically been reluctant to deal with changes is reflected in slower implementation of ISO 9001 especially in developing countries.

Karuppusami and Gandhinathan (2007) assessed the status of quality management in Indian Industries. The survey based on Visual Basic (VB) software has been developed for collecting responses through convenience of answering and also for a faster response rate. Three hundred e-mails with the survey questionnaire file attached were sent to selected ISO 9001 certified companies in India. A total of 104 responses were received and were analyzed using the SPSS statistical package. The analysis indicates that top management in Indian manufacturers expressed a high commitment to quality management. Managers had strong quality awareness and were willing to take responsibility for quality improvement. Further the study found that Indian manufacturers provide enough on-the-job training in quality management for employees. Most Indian manufacturers have implemented effective quality management

programmes and have set clear specifications for their products and services.

Coffey, Yong and Low (2008) examined how a company's strong organizational culture profile can actually improve construction outcomes and organizational effectiveness when operated in conjunction with proper QMS implementation. It has been undertaken focusing on QMS implementation in construction companies globally, as well as more specifically in Indonesian construction firms.

Raji Al-Ani and Firas (2008) examined the effect of total quality management on client satisfaction, employee satisfaction, quality of construction implementation and project performance. Through questionnaire survey the findings revealed that supplier quality management has positive effect on the performance of construction projects in Yemen construction projects. The findings further indicated that project teamwork satisfaction show positive effects on construction project implementation and construction project implementation show positive effects on client satisfaction.

Rodney (2008) incorporated grounded theory research method and developed a quality management model that encompasses quality aspects maintained by traditional quality management models and strategic aspects of quality management. Fig. 2.7 shows the operational and strategic quality drivers model proposed by the author. From quality management models, it is observed that there is strong homogeneity in theoretical understanding of quality management irrespective of significant impact of difference in national cultures and other contextual factors on applicability of quality management.

Raji and Adhmawi (2011) reported that the literature pertinent quality management concepts and its application in construction industry has formulated the definition of standards and specification. This definition can be realized through the application of quality management concepts which are represented by TQM. The authors also recommended a proposed quality management system for construction site aiming firstly to raise the quality level of works in construction projects secondly to improve the construction staff consciousness in different managerial levels about quality management concepts and its importance for improving the quality of construction works.

Muhammad Asim et al., (2013) conducted a study to explore the issue of appropriateness and degree of implementation of quality management practices in Pakistan construction industry. The key issues were evaluated through questionnaire survey conducted among 30 contractor firms in Pakistan construction industry. The authors concluded that construction contractors were the decision makers and majority of them were unsure about the implementation of total quality management system in construction industry. The results further indicated that effective communication and improvement in project coordination improves the employees work performance.

Faisal Talib (2013) reported that there is sudden shift in the application of Total Quality Management (TQM) from manufacturing to service organization and luminous studies have been undertaken in it. TQM has taken a strong place in all sectors and emerged out as an approach for process improvement was the reduction, business optimization and quality performance, he also explores the literature on TQM in service organizations as well as reasons for its failure lastly the study provides systematic

guidelines for effective implementations of TQM in the service organizations. Kindly the study proposes a ten STP approach for effective implementation of TQM in the service organization. This study provides a framework for better understanding the fundamentals of TQM in service organizations and seeks knowledge of TQM theory to the service managers and practitioners.

Tahir Nawaz and Amjadaliikram (2013) highlighted the benefits and obstructions in the implementation of total quality management in Pakistan construction industries. The authors analysed the data collected through questionnaire survey and reported that training program among employees and managerial staff as major critical factor in implementing total quality management in construction industries of Pakistan. The results further indicated that cost and schedule were the most important factors in the performance of projects.

Ashok kumar (2014) reported that small scale construction industries not have that much of awareness on quality management system and developed a measurement methodology for customer satisfaction with continuous improvement in construction process. The questionnaire survey was conducted among various small scale construction industries and the collected data were analysed using SPSS. Questionnaires were mainly focused on execution process of super structure. The author identified the critical factor that affects the construction quality which in turn increases the construction cost due to defect in quality. The results further give remedial measures to minimize the wastage of material, workmanship, time and indirect cost.

Heshammagd (2014) validated the critical success factors in implementing total quality management. The author reported that top management commitment was the driving force for the implementation of total quality management. Findings further stated that organizational infrastructure and training and education should be considered by the decision makers for effective implementation of total quality management.

Hosseinalidehghan et al., (2014) enumerated the application of total quality management in small and medium size construction projects. The author conducted questionnaire survey as well as interview among various construction organisations to identify the critical factors affecting the implementation of total quality management and barriers in implementation process. The author proposed a framework for the implementation of quality management in construction industry. The findings on critical success factors and primary barriers indicated that top management commitment followed by customer satisfaction were the most critical success factors in implementing total quality management in construction projects. Top management involvement to improve ways of performing task and primary focus were the main barriers in total quality management implementation process.

3.0 Methodology

A survey questionnaire was prepared based on background information, general quality aspect and standard quality aspect. A total of 500 questionnaires have been sent to the respondents through e-mail, directly through hardcopy, softcopy, postal and courier. The types of projects involved in this survey are multi-storied corporate / commercial buildings, residential buildings and industrial buildings. The project cost varied from 1crore to

100 crores. The private sector has been considered in this survey. Period for collection of data took 14months.

3.1.1 Literature survey

A wide range of areas were surveyed to identify and understand the various critical factors affecting quality in construction projects of Various Locations.

3.1.2 Expert Consultation

Professionals and experts with more than 20 years of experience in construction projects such as project engineers, quality engineers, safety engineers and site engineers in construction projects were consulted for data collection and gaining information from their past experience. The identified factors for quality from literature survey were scrutinized with the experts to the present work situation and their opinions and suggestions were incorporated in the questionnaire survey.

3.1.3 Questionnaire survey approach

Due to the non - availability of information about the completed projects, the questionnaire survey was considered for data exploration / collection. This approach is well recognized and widely used in the area of construction management. The reliability of survey results is expected to be high because all the respondents are top level experienced management officials in their organizations. The questionnaire survey acted as an important data collection tool to analyse the quality in construction projects. The questionnaire was designed and formulated into three distinct parts namely background information of the respondents, general quality aspects and standard quality aspects. The questionnaire is presented in Annexure I.

ANALYSIS OF DATA

In order not to lose the significance of any important factor each aspect was dealt separately while doing the descriptive statistics and the one way ANOVA. However Factor Analysis and Regression was done considering all the important factors identified through descriptive statistics and ANOVA. Statistical analysis is the most powerful tool for making appropriate decisions in the interpretation of such data and hence it is adopted as the method of analysis in this research. OrginPro, the most newly adopted software was used for the analysis. The version used was OrginProVer 8.5 for windows evaluation. Descriptive statistics, one way ANOVA with post Hoc Test, Factor Analysis and Multiple Regression are the statistical analysis procedure adopted in the analysis.

3.2.1 Descriptive Statistics

The responses were obtained in the form of rating as 1, 2, 3, 4 and 5 (1-Agree, 2- Strongly Agree, 3-Disagree, 4-Strongly Disagree and 5-None). The means of the respondents for each factor is calculated. Also the standard deviation of the mean is calculated for each factor. The factor for which the mean value of response is more than 2.5 is treated as an important factor in the views of all respondents. The criteria for selecting the mean value more than 2.5 is that more the value, more is the contribution of the factor affecting quality and it has to be monitored very carefully. Its higher value indicates the criticality of the factor affecting quality in construction projects.

3.2.2 One Way ANOVA (Analysis of Variance)

One way ANOVA compares the means of each group of respondents. It gives significance for each factor varying from 0 to less than 1, based on the responses received. If the significance

for any factor converted as a percentage when it is less than 5% then we can interpret atleast one group of respondent perceive differently or in other words more importance to that factor must be given. This factor is treated as an important factor which needs close monitoring.

3.2.3 Post Hoc (Turkey's B) Test

Post Hoc test is conducted for those factors whose significance value is less than 5%. The purpose of this test is to find which group of the respondents perceives the factor differently. This test calculates the means of each group it in the form of subsets. The mean of the group perceiving differently is taken in one separate subset and the means of the remaining group are included under another subset.

3.2.4 Identification of Important Factors

The important factors identified through descriptive statistics and one way ANOVA under each aspect are studied. Those factors with more number of appearances in all the analysis are selected to be the most important critical factors in that aspect.

3.2.5 Factor Analysis

The important factors so identified under each aspect are pooled together. One factor from each aspect is pooled together. One factor from each aspect is selected to be the dependent variable for regression. The criterion normally adopted is to select those factors for which the mean value of the respondents is the maximum.

The important factors are subjected to factor analysis which is a method of factor extraction, where large numbers of factors are reduced to a minimum number of underlying factors. The method of analysis is Principal Component Analysis method. Components with Eigen Values more than 1 are extracted. The factors based on their loading are grouped into each component. Since the components extracted are initially orthogonal, the axes are rotated. The method of rotation adopted is Varimax Rotation with Kaiser Normalization Criterion. The rounded sum of square loadings should normally explain a cumulative variance of more than 60%. Scree plot which is a graph with components on the horizontal axis and the Eigen value on the vertical axis is used for selecting the best number of components. A scree plot displays the eigenvalues associated with a component or factor in descending order versus the number of the component or factor. You can use scree plots in principal components analysis and factor analysis in order to visually assess which components or factors explain most of the variability in the data. The ideal pattern in a scree plot is a steep curve followed by a bend and then a flat or horizontal line. Retain those components or factors in the steep curve before the first point that starts the flat line trend. The steeper slope is selected to give a fair number of components to be extracted.

3.2.6 Stepwise Linear Multiple Regression

The factor extracted through factor analysis are subjected to stepwise linear multiple regression with each of the dependent variable selected separately. For each regression a cause and effect relationship between the dependent variable and the extracted factors may have an effect on the dependent variable. Only those factors which are more significant will be included in the relationship.

IDENTIFICATION OF CRITICAL FACTORS

From the result of regression those extracted factors which exhibit a cause and effect relationship with maximum number of

dependent variables are considered as the most critical factors. Those extracted factors exhibiting relationship with lesser number of dependent variables are treated as significant factors and those factors exhibiting a relationship with least number of dependent variables are treated as less significant factors. For these factors appropriate attention and close monitoring is to be paid at various stages of the project for effective time management.

4.0 Summary / Conclusion

The critical factors which are likely to affect the implementation of total quality management in construction projects have been identified. They are grouped under three categories based on their significance as highly critical, significant and less significant. The highly critical factors are to be given top priority in the real time monitoring. The significant factors are also to be addressed with equal importance. The less significant factor should not be neglected but given due importance. With all these aspects properly addressed at the appropriate stage of the project, project can be successfully completed within the stipulated time. The critical factors identified reveal that the quality management team members have a crucial role to play. The site engineers otherwise known as engineers also have an equal role to play.

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