

A Comprehensive Approach towards Managing Quality in the Construction Industry

Om Prakash Bawane
Professor, RV College of Engineering, Bangalore - 560 059, INDIA
opbawane@gmail.com

Dr. K.G. Krishnamurthy
Visiting Professor, Department of Architecture, University Visvsvaraysa College of Engineering
Bangalore - 560 056, INDIA
ka01uvce@rediffmail.com

Dr. P. Perumal
Professor and Head, Civil Engineering Department, Government College of Engineering, Salem, 636 011,
INDIA
perumal2012@yahoo.co.in

Abstract

Heterogeneity is the hallmark of the construction industry. The life cycle of a construction project is fragmented in several distinct phases. The requirements of each phase in terms of human and non-human resources may differ significantly. Quality management systems appropriate for other industrial sectors may not be found appropriate for the construction industry. These factors pose a difficult challenge to the construction industry to delivering quality in construction projects. However, a systematic and planned approach to quality can possibly meet the customers' needs and aspirations. The present study attempts to identify the quality related issues that need to be addressed by the industry in managing the quality of projects. This research is based on the premise that delivering quality in construction requires dealing with various issues at each phase of the project life cycle. A construction project can be typically split into seven phases viz. project initiation phase, design phase, procurement phase, construction phase, commissioning phase, contractual close-out phase, and the post-occupancy phase. The authors have undertaken the study of thirty four Indian construction organisations to identify the inadequacies in construction organisations in managing and delivering the quality in construction projects. The analyses of responses provide an insight into the existing deficiencies in the quality management approach. The paper deliberates on a comprehensive approach that could guide the industry in effective management of quality.

Keywords

Design Quality, Construction Quality, Quality Management, Life-Cycle Phases, Customer Satisfaction.

1. Introduction

Delivering quality in constructed projects has always been a challenge for the construction industry. In a customer driven economy, quality has emerged as the single most important factor to survive in the business. Despite the complex nature of the industry and the involvement of several stakeholders, the

industry has no option but to ensure the customer's satisfaction. The key to delivering quality in construction projects lies in appreciating the vital roles of design and construction organisations in the project procurement process. A comprehensive approach towards quality requires that design and construction are deemed as a seamless process and not as two separate phases. In a study, Bawane and Krishnamurthy (2010) have proposed a process model for achieving the quality in design. The construction industry needs to identify the factors that impede the deliverance of quality. This study is an attempt to highlight various factors and issues during different stages of the project life cycle that may have bearing on the quality of constructed projects, and the need for addressing the same by the construction industry.

2. The Concept of Quality in Architecture and Construction

The concept of quality is somewhat difficult to articulate since the term 'quality' itself is ambiguous and has different meanings in different contexts. Most dictionary definitions refers to quality as, *degree of excellence that something has; notion of benchmark that reflects excellence; or the characteristics or features of something*. Quality in the context of design can be defined as "*degree to which design fulfils the needs and expectations.*" (Nelson, 2006). The IS/ISO definition of quality which describes quality as "*the degree to which a set of inherent characteristics fulfils requirements,*" can be interpreted in the context of architecture by elaborating the meaning of word 'Requirement', which stands for 'need or expectation that is stated, implied or obligatory.' Accordingly, quality can be stated as "the degree to which a set of inherent characteristics fulfils stated, implied or obligatory needs or expectations." In architectural projects the word 'Obligatory' would mean compliance with codes, standards, byelaws and statutes. 'Expectations' means the requirements defined by the 'customer', which include client or end users. The Construction Industry Institute (1990) proposes a definition that has relevance and clarity for construction, accordingly quality is "*conformance to established requirements.*" The term 'requirement' in this definition refers to contractually established characteristics of the constructed projects.

3. Aspects of Quality in Construction Projects

A seamless process of realizing a construction project begins with a design concept originating in a design firm and translated into a reality on the site by a construction procurement firm. This implies that there are two integral and distinct aspects of quality in construction projects namely;

- Design quality
- Construction quality

Both aspects of quality in construction projects call for effective participation of several role players since delivering quality in construction means surpassing customers' expectations with regard to the architecture, construction, cost and schedule (Bawane and Krishnamurthy, 2010)

4. Purpose of the Study

The objective of this study was to establish the adequacy of quality measures being currently employed in the construction industry and to propose the measures that industry can adopt to achieve quality in construction projects. The study focuses on the scenario in the Indian construction industry.

5. Methodology

A comprehensive approach towards quality will require addressing all possible issues that may arise at various stages of the project life cycle. Authors have drafted a questionnaire comprising of fifty two questions distributed over seven parts. Each part of the questionnaire addresses issues during the respective phases of the project life cycle, and may influence the project's quality. The questionnaire was circulated among the executives of 34 construction firms. The firms vary in size from small to large and are located in different parts of India. The responses have been carefully analysed and the summary of inferences from the same has been presented in this paper.

6. Model for Managing Design Quality

The consequences of design quality are obvious on the overall quality of a constructed project. A study conducted by Bawane and Krishnamurthy (2010) suggests that the design firms need to adopt a quality based process approach in design development. A six-stage model for managing the design quality is illustrated in Fig.1. The proposed model is an inclusive one which encompasses the issues pertaining to constructability and sustainability also.

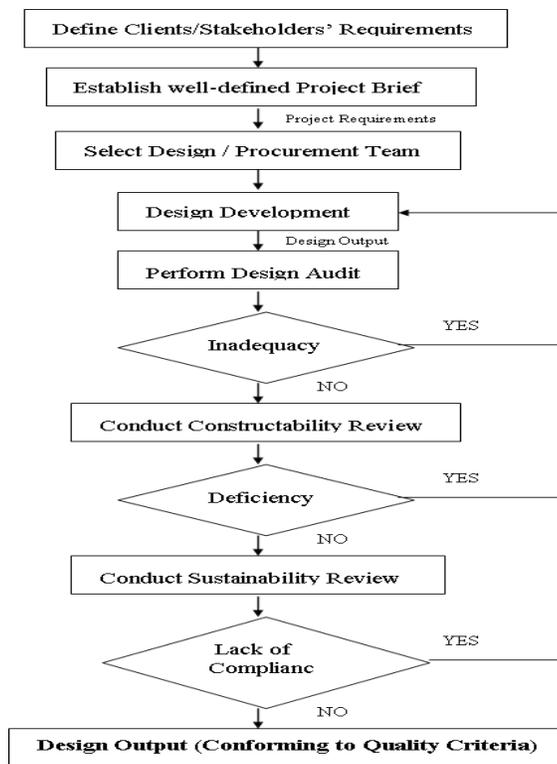


Figure 1: Model for Managing Design Quality

6.1 Establish Client's/Stakeholders' Requirements

An important definition of quality is “*meeting or exceeding the client/customer's needs/expectations.*” It is therefore crucial that the client's requirements are fully understood. The client must be clear about the

scope of the project. He must carefully define and assess the project priorities in consultation with all the stakeholders. An effective consultation among the stakeholders will help establish a clear and well defined project brief. It is crucial that sufficient time is allocated to the stakeholders to determine the design quality priorities.

6.2 Develop a Well-Defined Project Brief

A well-defined project brief is vital to achieve high quality design. The project objectives derived from stakeholders' aspirations forms the basis for establishing the project brief which serves as a reference throughout the design and construction stage. The project brief must clearly spell out the quality priorities as agreed by the stakeholders. A meticulous approach in drafting the project brief will enhance the capacities of the architects, consultants and the constructors to deliver a quality project.

6.3 Select Appropriate Design/Procurement Teams

Design and procurement teams play the key role in delivering the project quality. Every bid submitted by the design/procurement firms must be evaluated against the well defined quality criteria. A team that has a proven record of commitment and capability to deliver the quality within the agreed budget and schedule would rightfully deserve the award of the work. The client must adopt a quality based selection process, which emphasises an appropriate balance of design skills, experience, innovation, and an ability to perform within the criteria of quality, cost and schedule.

6.4 Perform Design Audits

Periodical auditing of design is crucial to quality design output. Design auditing is a systematically planned and documented activity to ensure the compliance with the objectives of the project as established in the project brief. The design input should confirm to the quality aspirations of the stakeholders. Auditing should be performed against the approved checklist. Thus it is necessary that a well planned quality audit program is developed before the commencement of the design process to assure conformity within the quality parameters. Audits should be scheduled periodically at the frequencies consistent with project and stakeholders' needs.

6.5 Conduct Constructability Reviews

Constructability refers to *“the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve the overall project objectives”* (CII, 1986). The objective of performing the constructability review is to verify that the project can be constructed according to the design assumptions, the intent of the contract documents and within the cost and schedule guidelines. Constructability reviews contribute significantly towards the enhancement of the design quality as it minimises the design related changes, helps developing a construction friendly specifications, improves contractors' productivity, promotes construction safety and reduces conflicts.

6.6 Conduct Sustainability Reviews

Sustainability is the time-oriented quality characteristic and becomes extremely vital in light of the impact of building activities on the climate change. The buildings contribute up to 40% of greenhouse gas emissions and approximately one-third of CO₂ emissions mostly from energy use during their life time. Identifying opportunities to reduce these emissions has become a priority in the global efforts to reduce climate change. Hence, it is imperative that stakeholders address the issue of sustainability throughout the life cycle of the building. A sustainable design forms the basis for creation of buildings that will have minimum adverse affects on the natural environment. As much as 80% of operational costs of new

buildings can be saved through integrated design principles often at little to no extra costs (Vorsatz, 2007).

7. Quality Issues at Different Stages of the Construction Project Life Cycle

Typically, the life cycle of a construction project comprises of seven distinct phases namely; the initiation phase, design phase, procurement phase, commissioning phase, close out phase and the post occupancy phase. The authors attempted to identify quality related issues during each of the phases. Analysis of responses to these issues was duly carried out to derive the inferences and the same has been presented in forthcoming paragraphs of the paper.

7.1 Project Initiation Phase

It is vital that an organisation equips itself with implements necessary for realizing the quality aspirations of its customers. Well defined quality policy, quality management plan, quality oriented organisational setup etc. are the prerequisite to this endeavour.

Quality Policy: A well defined quality policy forms the foundation for ensuring the quality at every phase of the project. It was found that only 10% of the responding organisations have a defined quality policy. These firms are those with ISO certification.

Organising for Quality: The data show that the structure of construction organisations does not reflect quality as one of the important functions. Though, most participating firms claim to have a team that deals with the quality control, it was found that only 10% of the responding firms have a cell dealing with quality issues.

Gap Analysis: Inadequacy of resources is one of the causes that may affect the quality of the built project. The data reveals that only 40% of the responding firms perform the gap analysis whereas 60% of the organisations bid for the project without evaluating their technical and financial capabilities.

Quality Management Plan: The quality management plan outlines the procedure for dealing with the issues of managing quality at every phase of the project. About 10% of the organisations, mostly the ISO certified firms have a system in place to manage quality.

7.2 Design Phase

Deficiencies in design quality will have a cascading effect on the quality of the constructed project. A process approach during the design development stage can address quality concerns as highlighted hereunder.

Defining Project Requirements: A clear understanding of the project requirement is crucial in achieving quality in construction projects. It is important that the client or promoter has an explicit understanding of the project requirements. The study reveals that it takes several meetings among the stakeholders to arrive at the final project requirements.

Changes in Project Requirements: The data indicate that in 95% of the cases the changes in project requirements do take place, in 10% of the cases these changes occur even at a late stage. Uncertainty in project requirements may affect the spatial quality of the built environment. Structural changes may affect the project in terms of cost, time and quality.

Design Brief: The design brief is an important document that outlines the project requirements, design criteria, intangible requirements pertaining to aesthetical and spatial qualities, etc. The data show that 60 % of firms follow a good practice of maintaining and communicating the design brief in the form of a written document. Whereas, the remaining have a practice of communicating the design brief verbally.

Design Reviews: A comprehensive joint review of the design is vital in ensuring the compatibility among the structural and engineering systems of the project. The data show that in 50% of the cases only such reviews and consultations happen and in the remaining cases it takes place at the individual consultant level.

Compliance with Codes and Standards: The architectural, constructional/structural design of the project needs to comply with the mandatory provisions of various codes. Any non-compliance would only compromise on the project's quality. The study reveals that the design and construction practices comply with codal practices and standards to the extent of only 60%.

7.3 Project Procurement Phase

Several issues can be identified during the procurement phase that concerns the project's quality. Importantly, the clauses are incorporated into the contract document, including the selection process of the contractors and the vendors. Responses were sought on these issues from the participating firms. A summary of inferences is discussed hereunder.

Assessing the Capabilities of Contracting firms: The assessment of the project delivering capacity of a contracting firm is important in ensuring project quality. During the survey, 80% of the firms claimed that they have a process of assessing the capabilities of the contracting firms. But the discussion reveals that these processes are confined to having the list of empanelled contractors.

Selection criteria for Contractors: Various criteria are in practice that a contractor needs to qualify to bid a project. These considerations include the total costs of the projects executed in past, evidence of financial capabilities, and the quality of projects. The study reveals that most construction projects in the public sector and also many in the private sector are awarded to the lowest bidder. In 30% of the cases, the organisations give importance to capacity to deliver the project work in stipulated time.

Contractors' Quality Plan: A well defined quality plan is crucial in delivering quality in the construction projects. Contractors need to outline a clear approach towards quality in the form of a well defined quality document. The data show that only 50% of the organisations insist on contractors having a quality plan.

Monitoring of Work: An effective approach towards managing quality will eliminate the task of inspecting the quality of workmanship. The data show that most construction firms (65%) follow the system of inspection and rework. It was also found that 35% of the firms employ project management consultants(PMCs) to manage the quality aspects of the projects.

Effectiveness of Conditions of Contract in Ensuring Quality: All responding organisations believe that quality can be effectively ensured under the prevailing clauses of contract.

Organisational Inadequacies: Organisations to the extent of 50% expressed difficulties in maintaining a balance between cost and quality, for 15% of the firms keeping pace with the fast changing technology was a major challenge. Remaining firms were non-specific in their responses.

Selection of Subcontractors and Vendors: Selection of vendors has a significant bearing on the quality of constructed work. Considering the fact that material contributes to 70% of the cost of the constructed

work, the vendors need to be selected carefully. The data reveal that 50% of the organisations rely on past record of the vendors, 30% of the organizations give weightage to the capacity of the vendor to deliver and the remaining 20% go by cost and quality.

7.4 Construction Phase

Quality issues during the construction phase primarily deal with labourers, workmanship, construction techniques, mechanisation, etc. this part of the research intends to investigate the factors that may influence the quality of the constructed projects.

Manpower Capacity: Achieving quality in constructed projects is greatly influenced by the capabilities of the manpower employed on the construction operations. Approximately 64% of the participating organisations opine that the construction sector in India faces acute shortage of the skilled human resources to deliver quality in construction projects; the remaining 36% of the respondents express satisfaction with the present scenario.

Technical Adequacy: Quality control mechanisms require a well equipped setup on the part of the construction organisations to check and enforce the quality during the construction phase. Significantly most organisation i.e. 48% claim to have the necessary technical facilities and expertise to ensure quality, 32% of the firms admit inadequacy and the rest rely on PMCs for technical support to monitor the quality.

Attitude towards Quality: Most organisations agree to the facts that low education, low wages, a lack of motivation, and job uncertainties are some of the major factors responsible for developing an indifferent attitude towards quality. Approximately 80% of the respondents consider the low education and low wages of workers the reasons for indifference towards quality.

Mechanisation of Construction Operations: The survey reveals the slow pace of mechanisation of the construction sector as only about 20% of operations employ construction equipment. While relating the mechanisation to the quality, 52% of the respondents think that mechanisation can yield better quality, 32% of respondents think that quality may partially improve, whereas 16% were not sure of the possible impact of mechanisation on quality.

Documentation of Quality Control Process: Effective documentation systems help when building a database. The history of errors could help when analysing the causes which impede quality. Documentation will facilitate the formulation of procedure that would in turn help in delivering the project quality. The data show that 50% of the organisations do not have a formal system of documentation, 33% of the organisations have a formal documentation system and 17% of the firms rely on PMCs for this task.

Acceptable Level of Quality: The responding executives of construction organisations admit the fact that there are tendencies among the responsible personnel to compromise with the acceptable quality of work in order to avoid reworking. It is significant to note that 70% of the respondents admitted that executives are willing to compromise the acceptable level of quality.

Inaccurate Drawings: Discrepancies and errors in architectural and structural drawings may cause deviations leading to client-dissatisfaction. The respondents admit inaccuracies to the extent of up to 20% in the drawings supplied by the architectural and structural consultants.

Role of Consultants during Construction Phase: The consultants play a crucial role in ensuring quality in constructed projects. The data show 85% of the responding firms expressed their satisfaction with the role played by different consultants during the construction stage.

Establishing the Quality of Material: Good quality material is vital in ensuring long term client satisfaction. The study reveals that most i.e. 60% organisations lack the necessary facilities to establish the quality of material supplied by the vendors and the assessment of quality is based on the personal wisdom of the site engineer.

7.5 Commissioning Phase

Commissioning is a process for the validation of building equipment and systems. In the commissioning phase the commissioning team is entrusted with the responsibility to ensure that the documentation, manufacturing requirements, and systems, equipment and operations are integrated, validated and accepted.

Commissioning Plan: For achieving better quality in a constructed project it is important to develop a detail commissioning plan. The study reveals that only 68% of organisations would have a commissioning plan ready to support the project management plan.

Inclusion of Commissioning Plan in Tender Document: Commissioning plans would bring better clarity about the scope of work involved at the design and construction stages. The study shows that only 18% of the firms have a good practice of incorporating the commissioning plan with standard tender documents. The data indicates that 35% of the firms responded negatively and the remaining offered no response to the question.

Compliance with Commissioning Plan: Commissioning of engineering services requires direction and monitoring by the respective consultants. The study reveals the lack of integrates monitoring of the commissioning operations. The data shows only 40% of organisations have a specialist to monitor the commissioning operations.

System Validation: Satisfaction of the user can be ensured if commissioned facilities are performing at their expected efficiency. The validation of installed systems can be carried out by operating the same simultaneously. The data reveal that only 65% of firms insist on integrated testing of facilities.

System Certification: Conformance to quality requires adherence to norms and standards. It was revealed from the data that only 64% of firms insist that their consultants obtain necessary certification, in 16% cases the certification is asked only in special cases.

7.6 Contractual Closeout Phase

This is a crucial stage in a construction project when the final examination of look at the quality aspects can be made. Any issue pertaining to a deficiency in quality on part of the contractor or subcontractors can still be addressed before the final settlement of bills take place.

Composition of Final Inspection Team: The data reveals that the inspection teams usually comprise of engineers from different cadres such as Assistant Engineers, Assistant Executive Engineers, and Executive Engineers along with PMC personnel. Significantly, it was observed that the final inspection teams do not include the Architect.

Inspection Procedure: A systematic inspection at the closing stage would require a well defined procedure. The organisations claim to have a set procedure but failed to show the proforma/document that could explain the procedure followed.

Degree of Non-compliance: Final inspection will expose the extent of non-compliance with quality norms. The organisations admitted to the fact that deviations are frequent and 80% of firms admit resorting to rework.

Imparting Training to Operating Staff: Interruption free functioning of engineering services is an important requirement in meeting the users' expectations. The terms of procurement and commissioning should incorporate the clause of training the necessary manpower to operate and maintain the engineering services. The survey indicates that in the case of 65% of the organisations, vendors do provide the necessary training to the operating staff.

7.7 Post-occupancy Phase

Post-occupancy evaluation has emerged as one of the well-established tools of evaluating the project quality. This part of research was aimed at establishing whether post-occupancy evaluation is practiced by the construction organisations in India. The questions posed in survey and their responses are as follows;

Application of Post-occupancy Evaluation Techniques in Construction Organisations: Post-occupancy evaluation techniques could serve as an effective tool for continuous improvement in the process of delivering quality to the customers. Despite its proven usefulness none of the responding firms practice POE.

Acceptance of Post-occupancy Evaluation Technique by Contractors: The responses reveal reluctance on part of the contractors and subcontractors to accept the POE technique to evaluate their work. Only 40% of the responding firms agree with the idea of conducting POE.

Seeking Client's Feedback: A significant finding of the survey is the absence of a client feedback system in Indian construction organisations. The feedback from the end user is gathered in an informal manner only. It can be seen as a serious lacuna in managing the quality in construction projects.

8. Conclusions

Managing and delivering quality in construction projects calls for a comprehensive approach. The construction industry needs to appreciate that the concept of quality should not be mistaken with the act of defect prevention in construction. The construction industry should adopt a well defined quality policy and structure the organisation to implement the same. A stringent policy should be adopted while selecting the contractors, subcontractors and vendors. The industry needs to upgrade its human and non-human resources to keep pace with changing technologies. A comprehensive commissioning plan is vital in integrating various engineering systems into the built facilities. A meticulous closeout plan must be in place to ensure that contractor has fulfilled all quality obligations before making an exit from the project. Finally, the quality is certified by the client and the end user of the facility. The construction industry must embrace the practice of post occupancy evaluation of their projects to assess their own capabilities to deliver the quality.

References

- Bawane, O. P., and Krishnamurthy, K.G., "Quality Management in Architectural Projects: Imperatives on Architecture/construction Community." Proceedings of the Fifth International Conference on Construction in the 21st Century, May 20-22, 2010, Istanbul, Turkey, ISBN: 1-884342-02-3. pp. 796-801.
- Bawane, O. P., and Krishnamurthy, K.G., "Redefining the Roles of Project Participants in Architectural/Construction Projects Under Changing Perception of Quality." The Journal of the Indian Institute of Architects, July 2010, pp. 22-26.

Construction Industry Institute (CII). "Constructability: Primer Constructability: A Primer". University of Texas, Austin. 1986.

IS/ISO 9000: 2005, "Quality Management Systems – Fundamentals and Vocabulary." Bureau of Indian Standards.

Nelson, Charles. Managing quality in Architecture. Architectural Press, Elsevier Ltd. 2006.

Vorsatz, D. U. Climate Change Mitigation in Buildings Sector. 4th Assessment Report, IPCC, 2007.