A Study on Quality Management in Construction Projects

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ABSTRACT - ***This paper presents an emprise study in construction industry in order to improve the quality performance. The main objective of this study is to identify the critical factors which are responsible for the implementation of quality management system in construction projects. This study was carried out by conducting questionnaire survey among the professionals of various construction projects, for testing their experience in quality management system. This study has indicated that a quality management can only be successful in a company if the users have a positive attitude towards the system and it is therefore required that the system be launched and maintained in a user-friendly manner, with the emphasis on real risk-reducing aspects. As one of the requirements of ISO 9001 is continuous improvement of the system, recommendations are made in this study towards improving the quality management system.***

Keywords - Quality management system

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1. INTRODUCTION

Construction sector is well known for its good management system. Quality management system (QMS) are being operated by some sectors in India. But it is rare to meet QMS in construction industry. By introducing quality management system, it could identify and mitigate most of the risks that might arise from any project. The QMS must conform to the requirements of International Organization for Standardization (ISO) in particular ISO 9001, which is a model for quality assurance systems in design, development, production, installation and servicing. The quality management system requirements of ISO 9001 are aimed at preventing nonconformity at all phases of the product life cycle from design to servicing. A common discussion is that the construction industry lacks efficiency, quality is poor, budgets are reliable and prices are excessive. Better management would result in increased efficiency with reduced quality failures while saving tremendous amount of money.

This study aims to identify and documenting the current status of the quality practices followed in construction industry. To identify the main problems and point out where the scope lies for improving and by what means it is possible to do so.

The study commenced with literature review which lead to descriptive study method, questionnaire was floated to construction companies in Tamil Nadu and responses were collected. The collected responses were subjected to statistical analyses using OriginPro software. This questionnaire has been divided into several factors and the analyzed results have been concluded.

The construction industry maintains low quality of standards, low level of communication, low level of inspection and testing low level of training and customer satisfaction. Hence proper care should be taken to improve the above factors by the way of proper maintenance of quality records, periodic meeting regularly improving lab facilities to test the materials and measure the standards according to Indian standards so that it improves quality of standards, level of communication, inspection and testing customer satisfaction in construction industry. This conclusion is both supported with literature research and the study results.
Hongyi Sun et al. (2000) investigated the empirical relationship between Employee Involvement (EI) and TQM. He views EI as that the people closest to a problem or opportunity are in the best position to make decisions for

improvement if they have control of the improvement process. The study is based on a survey of 180 manufacturing organisation in Norway. By using the questionnaire method, which covers questions related to employee involvement and people satisfaction.

Gallo et al. (2002) reported that lot of the quality and efficiency problems experienced during the design process are due to inadequate design management and poor quality control of the end product. Whilst modern construction projects range in their level of complexity, they all still require the skills of many diverse individuals to be brought together, coordinated and effectively managed as a team, to ensure the realization of the client's objective.

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.

SteynBasson, G,Carruthers, M, du Plesis, Y, Prozesky-Kuschke, B, Kruger, D, van Eck, S and Visser, K (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.

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.

Coffey (2005) stated about the culture of construction companies, adopts the following definition: "the informal shared values, norms and beliefs that control how individuals and groups in organisations consistently perform tasks, solve problems, resolve conflicts and interact with each other and with others outside the organisation."

Jaafari (2001) says that the construction industry has inclined towards confound TQM and Quality Control (QC) and Quality Assurance (QA), holding believe that acquiescence with QA Standards is all that there is to the claim of TQM on construction projects.

Low and Peh (1996) say that in establishing a total quality culture in construction, one crucial track is to expand construction team of the main contractor, subcontractors and suppliers who would ensure to the quality procedure and maintain an actual quality attitude.

2. OBJECTIVES

- To evaluate the effectiveness of Quality Management Systems(QMS) in construction projects.
- To investigate the implementation of quality management systems in construction projects using OriginPro.
- To improve the quality policy, quality system and quality procedure in construction projects.

3. LIKERT SCALE

The respondents were asked to give their responses against a five-point likert scale. The typical form of this scale is to ask participants to specify their level of agreement or disagreement with a statement. The ratings considered in this study were

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree
5. None

The likert scale proved to be very useful in measuring whether people have a positive or negative attitude towards an object or a statement and is therefore suitable for this research.

Once the survey is conducted, answers are analyzed using OriginPro tool and comparative study is done. Respondent's views can be easily studied using the graphs obtained through the analysis.

4. QUESTIONNAIRE

The questionnaire design was outcome of information that has been collected during the literature and the research question was designed. Respondents were chosen from engineering firms and contractors. The questionnaire was divided into sectors like respondents background quality systems and quality aspects.

The respondents were asked to respond against a 5 point likert scale. The purpose of questionnaire survey was to provide a deeper understanding of quality in general and quality systems followed in construction projects.

Once the survey is completed the respondents reply are analysed using OriginPro tool. The results and conclusions were then drawn out of this.

5. RESULT AND DISCUSSIONS

The factors mean value above was interpreted as positive response, mean value between 2.5 to 3 was interpreted as neutral response, and mean value below 2.5 was interpreted as a negative response.

Ordinal scale was considered in this study and can therefore fit the likert scale, mean and standard deviation fit properly to a distribution curve. Standard deviation was used as a measure of consistency.

Analysis of Data

For statistical analysis OriginPro software was adopted in this study. Descriptive statistics, one way ANOVA and factor analysis were the statistical analysis procedure adopted in the analysis.

Descriptive Statistics

The responses were in the form of ratings as 1, 2, 3, 4 and 5 (Strongly Agree, Agree, Disagree, Strongly Disagree and none). The means of the respondents and standard deviation of the mean for each factor was calculated. The factor for which the mean value of the response is more than 3 was treated as important factors in the view of all the respondents. The reason for selecting the mean value more than 3 is that more the value, more is the contribution of the factor which are responsible for the implementation of quality management system in construction projects. Its higher value indicates the criticality of factors.

One way ANOVA

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 received responses. The significance value less than 0.05 were treated important factor which needs close monitoring.

Identification of important factors

The important factors identified through descriptive statistics and one way ANOVA were studied. The factors with more number of appearances in both analysis were selected and considered as most important factors.

Factor Analysis

The most important factors so identified under each aspect were pooled together and subjected to factor analysis. In factor analysis large numbers of factors were reduced to small number of underlying factors by using principal component analysis method. Components with eigen value more than 1 were extracted. The factors based on their loading were grouped into each component. The method of rotation adopted was varimax rotation with Kaiser normalization criterion. The rotated sum of square loadings should normally explain a cumulative variance of morethan 60%.

Discussions

The means of responses for 49 factors and the standard deviation of their means are shown in Table 1.

Table 1. The Important Factors Identified through Descriptive Analysis and Oneway ANOVA.

Factor Number	Aspect / Factor Name	Mean	Standard Deviation	Significance value
	CUSTOMER SATISFICATION			
F1.	The project should have a customer complaint register, updated & reviewed	4.8	0.4	0
F2.	All the customer complaints should be segregated and responded within stipulated time (examine proof)	4.8	0.4	0
F3.	There is any repetitive nature of complaint identified; The CA should plan accordingly rectify it	4.8	0.4	0
F4.	Is there any unresolved complaints at the time of assessment the ratio to be noted	2.64	1.052	0.001
F5.	The site management should giving valid reasons for pending complaints	3.94	0.453	0
F6.	The customer complaint data should be used for enhancement of product or service quality	4.8	0.4	0
F7.	The project management should resolve the complaint within the agreed time frame. (look for evidence viz. corrective action intimated to customer)	4.79	0.406	0
F8.	The site has to report Customer complaints in monthly quality report.	4.08	0.279	0
	QUALITY MANAGEMENT SYSTEM			
F9.	The QMS orientation has to be given to all new staff & workmen	4.79	0.406	0
F10.	Company has to make the Staff understand the essence of QMS document	4.72	0.448	0.107
F11.	The Quality Objectives set and reviewed regularly and improvement plans drawn for individual process (evidence)	4.08	0.266	0
F12.	The audits must conducted as per the plan (evidence)	4.72	0.452	0.147
F13.	Audits should covered entire QMS requirement & areas identified for improvement	4.72	0.452	0.147
F14.	The MRMs conducted as per the plan and all agenda points are to be discussed in the MRM	4.92	0.266	0.000
F15.	A training plan prepared in all sections and conducted accordingly (for staff)	4.72	0.448	0.107
F16.	A training plan should be prepared for S/C workmen and conducted accordingly	4.13	0.339	0.002
F17.	A preventive action plan to be on Quality issues based on Work methods, ITP(Inspection & test plan) & checklist ?(evidenced)	4.86	0.352	0
	CONSTRUCTION COSTS			
F18.	The ACE to be prepared within One month as per company's guidelines	4.92	0.266	0.024
F19.	The construction Accepted cost estimate (ACE) to be accepted & approved by higher management (Within one month from preparation)	4.8	0.4	0
F20.	If there is any Risk identified, risk mitigation plan should be made.	4.22	0.412	0.004
F21.	The site has to review Risks every month and document regularly.	4.93	0.252	0.034
F22.	The site management has to be timely corrective action in case of costs going beyond provisions with reference to each activity in JCR	4.8	0.4	0
F23.	If escalation clause is made applicable as per contract The claims to be established & realized	4.8	0.4	0

F24.	The site management has to monitor and control wastages (Evidence of month wise data on wastages – item wise, activity wise)	4.79	0.406	0
F25.	The inventories have to be planned and monitored regularly against norms (Evidence required)	4.92	0.266	0.024
F26.	Productivity data should be collected & monitored for improvement	4.92	0.266	0.024
	QUALITY ASSURANCE			
F27.	You have to possess a document to quality assurance system	4.92	0.266	0.034
F28.	This project is being done in the point of quality, time and economical	4.93	0.252	0
F29.	The project follows a written organizational policy to implement quality assurance	4.79	0.406	0.024
F30.	A fund is provided for performing quality assurance activities	4.92	0.266	0
F31.	Adequate resources are provided to perform the Quality assurance activities	4.08	0.279	0.034
F32.	Quality assurance activities are reviewed with senior management on a periodic basic	4.93	0.252	0.024
F33.	You have to give defined guidelines for customer satisfaction	4.92	0.266	0.024
	QUALITY CONTROL			
F35.	The quality training for employee exist in your company	4.8	0.4	0.034
F36.	You must take soil test before starting the work	4.93	0.252	0
F37.	You have train your labour regarding Quality control activities	4.93	0.252	0
F38.	You must inspect the incoming material standard	4.8	0.4	0.034
F39.	You have to soak the brick in water at least 1hour before using	4.93	0.252	0
F40.	Corrosive resistance action is carried out (like epoxy coating) to the steel	4.8	0.4	0.024
F41.	The cement should not store for long time	4.92	0.266	0.034
F42.	The sand, water & aggregate to be tested before using	4.93	0.252	0
F43.	You should conduct slump test for each mixed batch of concrete before using	4.8	0.4	0.024
F44.	The curing period has to be checked by the site engineer	4.92	0.266	0.034
F45.	You must check the size of rebar's before fabrication	4.93	0.252	0
F46.	You have to prepare your own check list	4.8	0.4	0
F47.	You must employ required skilled workers	4.79	0.406	0
F48.	Good communication between managers and employee to be provided	4.8	0.4	0.034
F49.	Your company must have to implement safety program	4.8	0.4	0

The factors with mean value more than 3 and significance value lessthan 0.05 are identified and considered as important factors and are presented in Table 2.

Table 2. The Most Important Factors Identified through Descriptive Analysis and Oneway ANOVA.

Factor Number	Aspect / Factor Name	Mean	Standard Deviation	Significance value
	CUSTOMER SATISFICATION			
F4.	Is there any unresolved complaints at the time of assessment the ratio to be noted	2.64	1.052	0.001
	QUALITY MANAGEMENT SYSTEM			
F16.	A training plan should be prepared for S/C workmen and conducted accordingly	4.13	0.339	0.002
	CONSTRUCTION COSTS			
F18.	The ACE to be prepared within One month as per company's guidelines	4.92	0.266	0.024
F20.	If there is any Risk identified, risk mitigation plan should be made.	4.22	0.412	0.004
F21.	The site has to review Risks every month and document regularly.	4.93	0.252	0.034
F25.	The inventories have to be planned and monitored regularly against norms (Evidence required)	4.92	0.266	0.024
F26.	Productivity data should be collected & monitored for improvement	4.92	0.266	0.024
	QUALITY ASSURANCE			
F27.	You have to possess a document to quality assurance system	4.92	0.266	0.034
F29.	The project follows a written organizational policy to implement quality assurance	4.79	0.406	0.024
F31.	Adequate resources are provided to perform the Quality assurance activities	4.08	0.279	0.034
F32.	Quality assurance activities are reviewed with senior management on a periodic basic	4.93	0.252	0.024
F33.	You have to give defined guidelines for customer satisfaction	4.92	0.266	0.024
	QUALITY CONTROL			
F35.	The quality training for employee exist in your company	4.8	0.4	0.034
F38.	You must inspect the incoming material standard	4.8	0.4	0.034
F40.	Corrosive resistance action is carried out (like epoxy coating) to the steel	4.8	0.4	0.024
F41.	The cement should not store for long time	4.92	0.266	0.034
F43.	You should conduct slump test for each mixed batch of concrete before using	4.8	0.4	0.024
F44.	The curing period has to be checked by the site engineer	4.92	0.266	0.034
F48.	Good communication between managers and employee to be provided	4.8	0.4	0.034

Factor analysis was done to extract a small number of underlying factors from the 19 important factors identified from descriptive and one way ANOVA analysis. Factor analysis with Varimax rotation with Kaiser Normalization criterion extracted two factors with eigen values more than 1explaininga cumulative variance under rotated sum of squares loading of 95.13%. The components extracted with the cumulative percentage of variance explained under rotated sum of squared loadings are shown in Tables 3 and 4.

Table 3. Communalities and Component Matrix

Extraction Method: Principal Component Analysis. Communalities			**Component Matrix**	
	Initial	Extraction	Component	
			1	2
F4.	1.000	0.883	-0.377	0.861
F16.	1.000	0.707	0.108	0.834
F18.	1.000	0.969	0.984	-0.012
F20.	1.000	0.972	0.099	0.981
F21.	1.000	0.970	0.984	0.030
F25.	1.000	0.969	0.984	-0.012
F26.	1.000	0.969	0.984	-0.012
F27.	1.000	0.970	0.984	0.030
F29.	1.000	0.969	0.984	-0.012
F31.	1.000	0.970	0.984	0.030
F32.	1.000	0.969	0.984	-0.012
F33.	1.000	0.969	0.984	-0.012
F35.	1.000	0.970	0.984	0.030
F38.	1.000	0.970	0.984	0.030
F40.	1.000	0.969	0.984	-0.012
F41.	1.000	0.970	0.984	0.030
F43.	1.000	0.969	0.984	-0.012
F44.	1.000	0.970	0.984	0.030
F48.	1.000	0.970	0.984	0.030

Table 4. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	15.669	82.466	82.466	15.669	82.466	82.466
2	2.407	12.666	95.132	2.407	12.666	95.132
3	.539	2.835	97.967			
4	.386	2.033	100.000			
5	3.819E-16	2.010E-15	100.000			
6	7.384E-17	3.886E-16	100.000			
7	4.226E-17	2.224E-16	100.000			
8	8.495E-18	4.471E-17	100.000			
9	5.093E-18	2.681E-17	100.000			
10	4.324E-18	2.276E-17	100.000			
11	3.048E-32	1.604E-31	100.000			
12	-4.397E-34	-2.314E-33	100.000			
13	-7.733E-33	-4.070E-32	100.000			
14	-4.743E-18	-2.496E-17	100.000			

15	-7.037E-18	-3.704E-17	100.000			
16	-9.565E-18	-5.034E-17	100.000			
17	-1.344E-16	-7.072E-16	100.000			
18	-2.487E-16	-1.309E-15	100.000			
19	-4.640E-16	-2.442E-15	100.000			

6. CONCLUSIONS

The results suggested that quality is a important problem for the construction industry and revealed that there is gap in the use and knowledge of quality management systems.

- There were substantial organizational advantages that resulted from implementing a QMS.
- There seems to be a cap in training the employees.
- There was a positive view on the usefulness of Quality Management System (QMS)
- There is a cap in the collection of quality cost

This study revealed that training and teaching methods about QMS among engineering firm is in more comprehensive manner than among the contractor firms.

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