International Journal of Innovation Sciences and Research
Vol.4, No, 3, pp. 100-104 March- 2015

Available online at
http://www.ijisr.com

RESEARCH ARTICLE

ANALYSIS OF CRITICAL FACTORS AFFECTING PERFORMANCE OF QUALITY IN BUILDING CONSTRUCTION PROJECTS

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Accepted 13th February, 2015; Published Online 31st March, 2015

ABSTRACT

This research paper is intended to provide the clients, project managers, designers, and contractors with necessary information needed to better manage the quality of building construction projects. The paper reports the findings of a research study which was undertaken to determine the underlying factors affecting the quality of building construction projects. This study was conducted in a detailed manner through questionnaire and collecting the responses from various construction projects. Thirty five factors have been identified as critical factors of quality and based on this questionnaire were framed for survey. Detailed questionnaires were floated to quality Engineers, Site Engineers, Contractors and the responses were collected. It gives a background of the critical factors, Problems defining relative importance and constraints of the construction projects. Some factors were identified as critical factors of quality and responses were manually analyzed by using the software OriginPro.

Key Words: Construction Projects, Critical Factors, Originpro, Quality Performance

INTRODUCTION

Quality has become a very popular subject in recent years due to conceptual changes in the industry. Quality and quality systems are topics which have been receiving in more attention worldwide. The finished product in any industry should be manufactured to a required standard, one that provides customer satisfaction and value for money. The need for achieving quality of the finished product in the building construction industry is not less than in any other industry. The high cost of buildings makes it necessary to ensure the quality of the finished product. These have been accepted and ill-applied without any adaptation to suit the backgrounds of the developing countries. Efforts to improve quality in developing countries should be based on methods that stem from their economic and technological backgrounds. Therefore, determining the local construction industry's viewpoint on the factors which would improve the quality of construction projects, and the relative importance of each factor, is an essential first step towards establishing methods for a real improvement of construction projects. Therefore, the main objective of this study was to obtain the factors affecting quality improvement that represent the views of the construction industry and to determine the relative importance of these factors. The development of Indian construction industry features is almost equal to the construction industry development in other countries.

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It was founded by the Government and gradually it was taken over by the construction projects. The Indian construction industry is an essential part of the economy and a direct for a considerable part of its development involvement and is positioned for growth on account of urbanization, industrialization and profitable expansion and people's rising potential for better quality of living. The construction industry is one of the oldest industries in the world. It has many traditions and habits.

Across the whole, these habits and traditions have not changed drastically, As time has passed through, they have of course changed up to some level. Still, the basic concepts remain the same. The construction industry and its performance and productivity have been criticized over the years. The habits and traditions have become so ingrained the new methods towards improvement faced problems gaining a foothold. A common discussion within the construction industry is that the quality is poor, budgets are unreliable and the prices are excessive. The industry has been accused of lagging behind other industries when it comes to efficiency. It has been stated that there are great possibilities for improvements within the industry. Failures and errors in the construction industry have many manifestations and their reasons and causes vary. Failures are indeed occurring over all the diverse steps of the construction process. Raising the quality status within the industry, the construction process as a whole would improve, resulting in lower costs, less project time and increased productivity. According to international studies and researchers it seems as construction firms are increasingly realizing that the quality bar must be raised

higher, quality must be improved and defects and rework are reduced. The results of doing so would lead to better effectiveness and efficiency within the sector. Moreover, more emphasis must be put on creating value for the customer by meeting his needs and demands. Successfully implemented quality management has been proven to be useful tool helping to obtain these goals. Many organizations have been implementing quality management systems and by that, improving project performance (cost, time and quality). One desirable gain from implementing a quality management system is reduction in quality cost. Organizations are not clear on whether or not implementing the system has proven to be cost beneficial since very few of them measures their quality cost. By not measuring quality cost and linking it to non-conformance, knowledge is not being obtained on where the path for improving operations lies. 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 stages in order to deliver satisfactory outputs.

Dimensions of Quality

Performance: Quality of building, the use of building for which it has been planned.

Features: Secondary characteristics, added futures such as power generator, recycling plant for treating water, solar heating system.

Conformance: Meeting specifications of construction, workmanship, F.O.S of design.

Reliability: The probability of a structure failing within a specified period of time.

Durability: Maximum structure life considering both economic and technical dimension.

Services: Ease of repair in building, resolution of problem and complaints.

Aesthetics: Good exterior finish and appearance of the building which increases the attraction of the building.

Reputation: Past performance of the building such as being ranked first.

Literature Review

Low, Tan and Ang, (1999) analyzed the effectiveness of ISO 9000 in raising construction quality standards in the Singapore construction industry (a developing country like South Africa) and they concluded that the construction firms certified by the ISO 9000 quality standards achieved higher Construction Quality Assessment System (CONQUAS) scores than non-certified firms. However, the implementation of the ISO 9000 quality management system has not improved the Construction Quality Assessment System scores of those construction firms that have adopted the system. Low and Darren, (2001), examined the factors that may cause failure to realize quality under the sub-systems. The authors reported that the deficiencies in three organizational sub-systems, namely Technical, Human Resource and Management, were found to cause defects in buildings. Construction defects were caused by poor design or lack of use of specified materials. They reported that the quality and availability of resources used by the contractor dictates the ease of execution of projects. Quality may be compromised when the client pressurizes the contractor on costs, trying to reduce initial costs, by making the contractor use cheap and non-durable materials, which can be prone to failure, during execution. Yasamis *et al*. (2002), investigated the implementation of quality management system in construction industry. The authors reported that Quality management system consists of two main components, the first being the framework for guiding quality related actions by all employees (design of quality system) and the second, means of assessing how well these actions are carried out (delivery of quality system). Companies are increasingly being persuaded to adopt quality management systems in order to meet the globalized marked demands.

Love, Li, Irani and Faniran (2000), commented that ISO 9000 certification was not an option but rather a reality for construction companies that wish to retain and sustain their competitiveness in today's highly competitive markets. Li, Cheng, Love and Irani (2001) indicated that the market and organizational structure of the construction industry is highly fragmented and divisive. Construction projects are organized by different parties linked hierarchically together by contracts. These parties include clients / owners, architects, engineers, general contractors, sub-contractors, suppliers etc. They possess various skills and knowledge although they belong to the same industry. Because of the diversity of these parties, they tend to have their own goals and objectives, which can be conflicting and may induce adversarial relations. Hoonaker, (2006), examined the possible benefits of implementing quality and barriers in the implementation of quality in construction industry. The data were collected through interviews and questionnaire surveys.

The author concluded that the successful implementation of quality in construction projects was mainly depended on culture of team work and co-operation at both intra-organizational and inter-organizational levels in construction. Tan Chin-Keng, (2011), conducted semi-structured interview among 12 project management practitioners to explore the practices of quality management, management commitment in quality management and quality management implementation problems in construction projects in Malaysia. The author concluded that total quality management was not common in practice and allocation of financial and human resources were the barriers in implementing quality management in construction projects. 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

organisations in Norway. By using the questionnaire method, which covers questions related to employee involvement and people satisfaction. 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 per cent, 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. Tahir Nawaz (2013) studied the benefits and impediments in implementing total quality management in Pakistani construction sector. Through questionnaire survey the author suggested that adequate awareness and training must be imparted through effective quality policy and top management support. Hosseinali (2014) studied the application of total quality management ideas in construction projects. Using the combination of both questionnaires and interviews the author identified the most critical factors affecting the implementation of total quality management and concluded that there is faint evidence of successful implementation which means the full benefit of the process yet to be exploited.

MATERIALS AND METHODS

The study adopted questionnaire survey as a method to identify the underlying factors affecting the quality of building construction projects.

Survey through questionnaires were found effective because of the relative case of obtaining standard data appropriate for achieving the objectives of this study. Based on the literature cited, various factors were selected. The study was conducted by developing a questionnaire and collecting the responses from construction firms. Questionnaires were framed for the survey based on identifying the critical factors. Detailed questionnaires were floated to quality engineers, site engineers, contractors and the responses were collected. The methodology of the study is as presented in Fig.1.

Objectives

To evaluate the effectiveness of Quality Management Systems (QMS) in construction projects. To identify the underlying factors affecting the quality in construction projects. The responses were obtained in the form of ratings as 1,2,3,4 and 5(1-Strongly Agree, 2-Agree, 3-Disagree, 4-Strongly Disagree and 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. The data collected through questionnaire survey were analyzed using OriginPro tool. Respondent's views can be easily studied using the results obtained through the analysis.

Questionnaire Survey

A survey is an appropriate tool for this research since it is a system for collecting information to describe, compare and predict attitudes, opinions values and knowledge and behaviors. Design for survey studies can be categorized as experimental or descriptive. The questionnaire used in this research is descriptive. The descriptive design produces information on groups and phenomena that exist. The survey gives information collected from a group of participants in a standardized form.

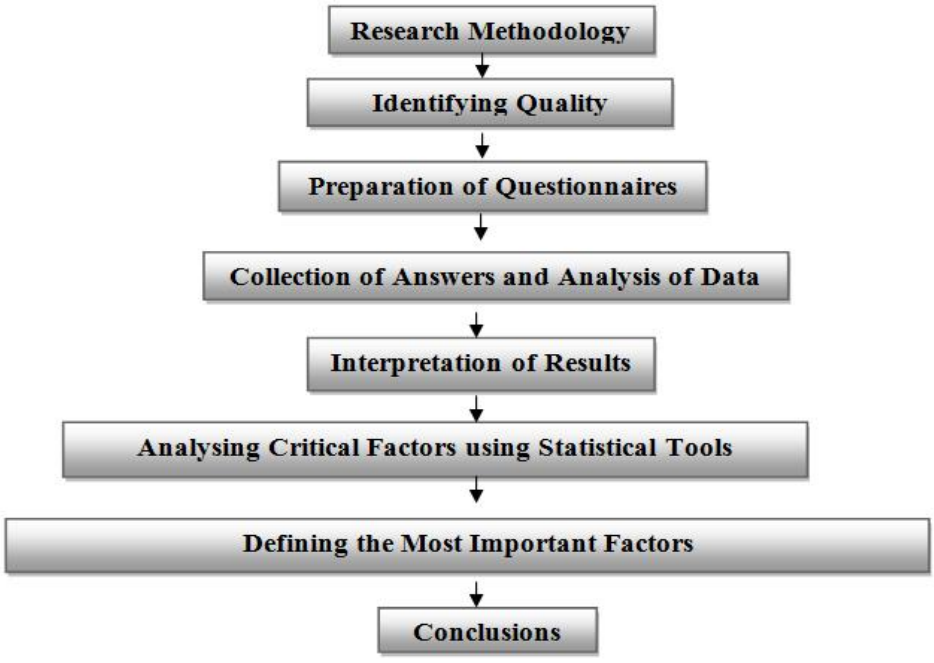

Fig. 1. Research Methodology

Table 1. Aspects and Factors

Factor Number	ASPECTS / FACTORS
	Management
F1.	A Qualified MANAGEMENT to be employed.
F2.	The MANAGEMENT should have experience in the concerned field.
F3.	He should posses adjustable quality with attendants.
F4.	He should be capable of doing test in the absence of any technicians.
F5.	He must be ready to work, whenever his assistance is needed.
	Lab
F6.	The lab should be well protected with fire proof material.
F7.	The basement of every machine should have adequate hold.
F8.	The power supply for every apparatus should be well guarded.
F9.	The lab should be made of dust proof material.
F10.	It should be above the flood level of the nearest water source.
	Appropriate Machinery
F11.	The space around every equipment should be enough to keep the testing material.
F12.	The least count of every apparatus should be proper to the requirements.
F13.	The calibrations should be done periodically.
F14.	Every apparatus should be capable to withstand the specimen resistance.
F15.	The wear and tear should not frequently occur.
	Training and Education
F16.	The technician should be well qualified.
F17.	The technician should be aware of the apparatus in every nook and corner of the parts.
F18.	The operator should know the default function and adjusted ones.
F19.	The operator should show interest in maintaining the machine.
F20.	Must be aware of the principle of the machine and specimen.
	Execution
F21.	During the concrete pouring the compaction should properly be done.
F22.	Proper joint protection between pours should properly be done.
F23.	Suitable type of vibrators to be used.
F24.	The framework should thoroughly be checked.
F25.	The fabrication should be done and guarded against greasy material and plastic waste.
	Records
F26.	The records from the manufactured company should be kept safely.
F27.	The test records conducted in the lab should be maintained.
F28.	The records to be sent periodically to the higher authority.
F29.	Apart from periodic calibration, the current status, should be informed to the MANAGEMENT.
F30.	The operator should update the apparatus for the data from superior.
	Tools and Techniques
F31.	If any new device are introduced by the company that should be fixed in the existing apparatus.
F32.	The new theory developed by company should be followed.
F33.	The machine should be adjusted according to the their requirements.
F34.	Any new methods found by expert to get more accuracy to be followed.
F35.	To enhance the operation of the machine any idea by anybody should not be hidden.

An appropriate sample of people was formed and respondents were asked to give their answers in a standard form. However, there is always a limitations in survey case studies, since people evaluations, and opinion values and knowledge vary. But it is expected that the questionnaire as a whole will give a good indication and information regarding the subject and could therefore provide meaningful results on the subject. The questionnaire design was a result of information that had been collected during the literature research and its goal was to shed further light on the research topics and the research questions asked. Aspects and factors are given in Table 1.

RESULTS AND DISCUSSION

The factors mean value above 3 was interpreted as positive response and mean value below 3 was interpreted as negative responses. 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.

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 received responses. The significance value less than 0.05 were treated as an important factor which needs close monitoring. The important factors identified through descriptive statistics and one way ANOVA are studied and presented in Table 2.

The factors with more number of appearances in both analysis were selected and considered as most important factors. In factor analysis large numbers of factors are reduced to small number of underlying factors by using principal component analysis method. Components with eigen value more than 1 are extracted and are presented in Table 3. The factors based on their loading are grouped into each component. The method of rotation adopted is varimax rotation with Kaiser normalization criterion. The rotated sum of square loadings should normally explain a cumulative variance of more than 83%.

Table 2. Descriptive Statistics and ANOVA Test results

Factor Number	N	Mean	Std. Deviation	Sig.
F1	70	3.46	1.961	.837
F2	70	3.17	2.007	.000
F3	70	1.86	1.653	.011
F4	70	1.91	1.692	.000
F5	70	2.26	1.870	.430
F6	70	4.54	.502	.255
F7	70	4.47	.503	.036
F8	70	4.44	.500	.012
F9	70	4.44	.500	.340
F10	70	4.00	0.000	.000
F11	70	3.34	1.985	.000
F12	70	4.39	.490	.000
F13	70	4.33	.473	.106
F14	70	4.37	.487	.554
F15	70	4.06	.234	.000
F16	70	4.06	.634	.020
F17	70	2.20	1.682	.000
F18	70	3.71	.819	.000
F19	70	1.91	1.692	.001
F20	70	4.29	.455	.011
F21	70	2.54	1.961	.000
F22	70	4.36	.723	.000
F23	70	3.31	1.681	.740
F24	70	4.00	0.000	.068
F25	70	1.97	1.551	.625
F26	70	4.07	.259	.000
F27	70	4.04	.576	.036
F28	70	1.49	.756	.445
F29	70	4.53	.503	.000
F30	70	2.54	1.603	.000
F31	70	2.54	1.961	.000
F32	70	1.97	1.728	.000
F33	70	1.49	.864	.372
F34	70	4.24	.432	.000
F35	70	2.29	1.704	0.372

Table 3. Factor Analysis Test Results

Communalities		
	Initial	Extraction
F22	1.000	.784
F7	1.000	.912
F8	1.000	.979
F18	1.000	.653
F21	1.000	.862

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.232	44.642	44.64	2.232	44.64	44.642
2	1.958	39.151	83.79	1.958	39.15	83.793
3	0.554	11.081	94.87			
4	0.244	4.888	99.76			
5	0.012	0.23	100.00			

Extraction Method: Principal Component Analysis.

Component Matrix

	Component	
	1	2
F22	-.410	.785
F7	.024	.955
F8	.932	.332
F18	.669	-.453
F21	.864	.338

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Conclusions

The underlying critical factors which are responsible for the implementation of quality management in construction projects have been identified. The identified critical factors are to be given much priority in the real time monitoring. The identified critical factors revealed that the quality training is more important among all employees in construction industry. Also to reduce the construction cost, productivity data should be collected and monitored for which quality training for all the employees must be given. This study revealed that there is a gap in training about quality management among employees of construction projects.

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