Quantitative Study of Quality Factors using Relative Importance Index Method in Construction Projects

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Abstract : Quality has now become a keystone feature in the construction of any project and has acquired worldwide attention. The aim of this paper is not only to identify the factors influencing the quality of the construction works but also to work for the better management of the quality. In a pursuit for a continuous quality improvement, a quantitative study approach has been adopted thereby knowing the relative importance of various factors critical to the quality of construction. During the preliminary stage, a questionnaire was developed with a total of 37 quality factors and categorized into five major groups. The data obtained were analyzed by the Statistical Package for Social Science (SPSS). The effect of various factors was discussed and various recommendations were put forth. Case studies on two buildings viz. multi-level car parking and girl's hostel of GCET in Jammu region of Jammu &Kashmir have been undertaken in which data obtained is statistically measured and analyzed.

IndexTerms **- Construction, quality, relative importance index, Jammu and Kashmir**

I. INTRODUCTION

Quality has turned into an incredibly outstanding known subject as of late because of applied changes in the business. Quality and quality frameworks are focuses which have acknowledged expanding consideration overall (Amer 2006). The finished items in any industry ought to be fabricated to a required standard, one that gives consumer loyalty and incentive to cash (Amer 2006; Sullivan 2011). In the pursuit of continuous quality improvement, productivity and optimizing profitability, it is essential to ensure the quality of construction works in order to elevate the reliability and stability of construction projects(Jowwad et al. 2017; K N Jha & Iyer 2006). The issue here is the variations in the set quality standards and specifications within construction execution processes which are critical to the quality(Han et al. 2008). The reasons of variability may incorporate; poor quality of construction materials, lack of experience of a consultant, inadequate contractor experience, inaccurate site investigation, unreliable suppliers, frequent change of subcontractors, equipment allocation problem, error in design documents, lack of quality policies, etc. Quality management is characterized as any methodology used to accomplish and sustain high-quality yields by fitting in with set standards and specifications by meeting customers loyalty prerequisites(Kumar. Neeraj. Jha & Iyer 2006; Koziołek & Derlukiewicz 2012). It is important that evaluation of quality plan should be done in an organized, formal manner, and is legitimately recorded in order to achieve quality objectives by introducing quality control and quality assurance within the quality framework.

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II. METHODOLOGY

2.1 Questionnaire development

In order to assess the quality of construction projects, a quantitative study method has been used. A questionnaire was developed based on primary data, secondary data and literature survey acts as a research tool for this study(Burgess 2001). A pilot survey was led to check the sample adequacy and validity of a questionnaire(Seshadhri & Topkar 2014). Therefore, 37 attributes affecting the quality of construction projects were identified after intently investigating these attributes with respect to the purpose of evaluation. Moreover, the questionnaire was divided into two sections. Section I comprises of demographic information of the participants and section II comprises of technical attributes, wherein all the questions were grouped in five subgroups as owner and consultant related factors, project and design related factors, contractor and labour related factors, material and equipment factors, and external related factors(Burgess 2001; Shrivastava & Pathak 2016). The main objective in questionnaire design was to make questions asked clear, brief and unambiguous(Seshadhri & Topkar 2014). The respondents were provided with a uniformly adopted Likert scale of 5 ranging from "Very Low" to "Very High" for all questions for eliciting data on respondent's perception.

3.2 Data collection

The quantitative study approach has been adopted in order to identify the attributes critical to the quality of the construction projects. The two different buildings chosen for the study included multi-level car parking and girl's hostel of GCET in Jammu. The profile of the buildings was examined and the sampling was led through a stratified arbitrary sampling method. The questionnaire was distributed to a sample size of 80 among junior engineers, assistant engineers, quality control and quality assurance engineers, etc. out of which 64 responses were received therefore used for data analysis.

3.3 Questionnaire reliability

In order to determine precisely whether the respondents have similar opinions and the internal consistency or reliability of the scale, Cronbach's Alfa analysis was used by using SPSS. Cronbach's Alfa value ranges from o to 1 with a higher value indicating greater internal consistency(Gliem & Gliem 2003). Acceptable value for Cronbach's Alfa must be greater than 0.7 indicates that the research data is valid for further analysis as can be seen below table 1.

Table 1: Cronbach's Alpha value

S.No	Description	Cronbach's Alpha value
1	Owner and consultant related factors	0.974
2	Project and design related factors	0.966
3	Contractor and labour related factors	0.961
4	Material and equipment related factors	0.973
5	External-related factors	0.981

3.4 Data analysis

The RII (Relative Importance Index) method was adopted in this study to determine the relative importance of various factor affecting the quality of the construction works. RII value ranges from 0 to 1(Gündüz et al. 2013). The higher the RII value greater is the impact or frequency of occurrence of the variables. RIIs are calculated for each factor as in equation below

$$RII = \frac{\sum W}{(A * N)}$$

Where RII = relative importance index; W = weighting given to by respondents (ranging from 1 to 5); A = highest weight (i.e. 5 in this case) and N = total number of respondents. The RII value,mean RII, and ranking of all groups of a quality factor are shown in table 2 below:

Table 2: RII and Ranking of quality factor groups

Factor group	Factors critical to quality (Q. No.)	Respondent scores					RII	Average	Rank
		1. Very Low	2. Low	3. Medium	4. High	5. Very High			
Owner and consultant related factors	1. Change order	16	29	15	0	4	0.434	0.568	4
	2.Conflict between joint owners	27	21	5	11	0	0.4		
	3. Delay in approving design documents, progress payments, and site delivery	8	32	15	5	4	0.490		
	4. Poor communication and coordination with other parties	10	14	23	17	0	0.547		
	5. Lack of experience of consultant in construction project	2	3	5	42	12	0.784		
	6. A conflict between consultant and design engineer	0	16	24	20	4	0.637		
	7. Inaccurate site investigation	2	6	18	30	8	0.712		
	8. Late in reviewing and approving design documents	4	22	26	12	0	0.543		
Project and design related factors	1. Project complexity	4	28	28	0	4	0.512	0.591	3
	2. Legal disputes between project participants	10	26	10	18	0	0.513		
	3. Shortness of original contract duration	0	12	40	12	0	0.6		
	4. Complexity of	0	18	35	11	0	0.578		

	project design								
	5. Design changes by the owner or his agent during construction	4	4	44	8	4	0.612		
	6. Design errors made by designers	3	9	26	22	4	0.647		
	7. Mistakes and delays in producing design documents	4	8	24	16	12	0.675		
Contractor and labour-related factors	1. Frequent change of subcontractors	3	9	22	30	0	0.645	0.603	2
	2. Inadequate contractor experience	4	8	8	44	0	0.687		
	3. Poor site management and supervision	3	9	31	21	0	0.619		
	4. Unreliable subcontractors	4	8	23	29	0	0.640		
	5. Absenteeism of labours	0	20	26	10	8	0.619		
	6. Personal conflict among workers	4	24	32	4	0	0.512		
	7. Slow mobilizations of labour	4	12	44	4	0	0.550		
	8. Strike	16	20	4	12	12	0.550		
Material and equipment related factors	1. Changes in material types and specifications during construction	0	15	23	26	0	0.634	0.670	1
	2. Escalation of material prices	4	14	26	12	8	0.618		
	3. Poor quality of construction materials	2	2	8	20	32	0.844		
	4. Shortage of construction materials	0	4	4	52	4	0.775		
	5. Unreliable suppliers	4	7	17	24	12	0.703		
	6. Equipment allocation problem	4	4	15	41	0	0.691		
	7. Frequent equipment breakdown	4	4	36	20	0	0.625		
	8 Low efficiencies of equipment	5	11	29	19	0	0.594		
	9. Shortage of equipment	8	10	36	10	0	0.550		
External related factors	1. Accident during construction	8	24	16	8	8	0.55	0.555	5
	2. Changes in government regulations and laws	8	26	14	10	6	0.537		
	3. A conflict, war, and hostilities	14	16	24	8	2	0.5		
	4. Delay in obtaining permits from the municipality	8	16	25	7	8	0.572		
	5. Natural disaster (flood, earthquake etc.)	8	11	17	24	4	0.616		

Also, the Ishikawa (fishbone) outline was used to exhibit the elements that are critical to quality in construction projects. The Ishikawa outline, otherwise called the fishbone diagram or, Cause and effect diagram is a tool utilized for deliberately recognizing and displaying all the conceivable reasons for a specific issue in graphical format. The conceivable causes were exhibited at different dimensions of detail in associated branches, with the dimension of detail expanding as a branch goes outward, i.e., an external branch is a reason for the inward branch it is connected to(Gündüz et al. 2013). In this manner, the outer branches normally show the main drivers of the issue (root cause). The Ishikawa diagram of categories and variables that were critical to the quality of construction in this paper are shown in figure 1.

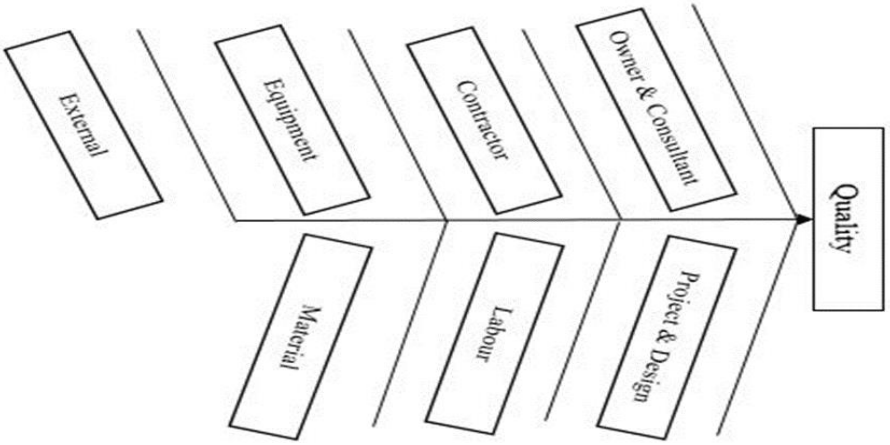

Fig. 1: Ishikawa diagram (categories and factors affecting the quality)

III. RESEARCH FINDINGS AND RESULTS

As the mean RIIs and rankings of all groups are depicted in table 1, the top 10 most important factors critical to the quality of construction works are shown in table 3. According to the rankings of the factor groups, the four factors of each group that contribute most in affecting the quality of construction works are discussed in what pursues.

3.1 Material and equipment related factors (RII = 0.670)

The material and equipment related group of quality factors was the most important group to affect the quality. This was mainly due to the factors poor quality of construction materials (RII = 0.844), Shortage of construction materials (RII = 0.775), Equipment allocation problem (RII = 0.691), Frequent equipment breakdown (RII = 0.625)

3.2 Contractor and labour related factors (RII = 0.603)

The second most important group was a contractor and labour related factors, whose significant factors were inadequate contractor experience (RII = 0.687), Frequent change of subcontractors (RII = 0.645), Poor site management and supervision (RII = 0.619), Absenteeism of labours (RII = 0.619).

3.3 Project and design related factors (RII = 0.591)

After the contractor and labour related group, the third most important group of quality factors was a project and design related factors. Some of the significant factors are mistakes and delays in producing design documents (RII = 0.675), design errors made by designers (RII = 0.647), design changes by the owner or his agent during construction (RII = 0.612), shortness of original contract duration (RII = 0.6).

3.4 Owner and consultant related factors (RII = 0.568)

Following the project and design related group, the owner and consultant related group of quality factors rank as the fourth most important group. The notable factors were lack of experience of consultant in construction project (RII =0.784), inaccurate site investigation (RII = 0.712), the conflict between consultant and design engineer (RII =0.637), poor communication and coordination with other parties (RII = 0.547)

3.5 External related factors (RII = 0.555)

The external related group of quality factors was the last and least important group. The prominent factors were **a** natural disaster (RII = 0.616), delay in obtaining permits from the municipality (RII = 0.572), changes in government regulations and laws (RII = 0.537), accidents during construction (RII= 0.55).

Table 3: 10 Most Important Factors affecting the quality

S. No.	Factor group	10 most important factors affecting the quality	RII	Rank
1	Material and equipment related	Poor quality of construction materials	0.844	1
2	Owner and consultant related	Lack of experience of consultant in construction project	0.784	2
3	Material and equipment related	Shortage of construction materials	0.775	3
4	Owner and consultant related	Inaccurate site investigation	0.712	4
5	Material and equipment related	Unreliable suppliers	0.703	5
6	Material and equipment related	Equipment allocation problem	0.691	6
7	Contractor and labour related	Inadequate contractor experience	0.687	7
8	Project and design related	Mistakes and delays in producing design documents	0.675	8
9	Project and design related	Design errors made by designers	0.647	9
10	Contractor and labour related	Frequent change of subcontractors	0.645	10

IV. CONCLUSION

This report documents the results of a quantitative study of the factors influencing the quality of construction projects. An extensive literature survey and review, observation methods, and interviews of junior and senior engineers was performed to determine the factors critical to the quality of construction projects. A total of 37 different quality factors were identified and categorized into five groups as follows: owner and consultant related quality factors, project and design related quality factors, contractor and labour related quality factors, material and equipment related quality factors, external related quality factors. The exhibit of these groups of quality factors was accomplished utilizing the Ishikawa (fishbone) diagram since it is fit for showing factors, interrelations between various groups of variables, and outcomes following from the factors. Also, the data obtained from the respondents was quantified by using the RII method and the relative importance of quality factors was obtained thereby, demonstrating the ranking groups according to the importance of levels for quality of construction projects. The paper addresses the most vital factors and groups affecting the quality. Thus, the ten important factors have been achieved through ranking results.

V. RECOMMENDATIONS

According to the research findings, the following recommendations can be made for the continuous quality improvement of construction projects.

1. The construction material obtained must be obtained from reliable sources only after meeting the set standards in terms of quality, strength, durability, and performance in order to attain the desired quality of construction works.

2. The owner should engage the consultants in the very beginning of the project in order to utilize the services of consultants in choosing the construction professional/contractors and in assessing the plans, project cost. It is impressed that the consultants engaged must be highly skilled and experienced in the relevant field.

3. Since, the contractors with inadequate experience cannot plan and execute the projects properly, which may result in undesirable consequences during the execution phase, such contractors should not be awarded the projects of importance.

4. Poor material inventory can result in project delays which in terms have its impact on the quality of construction work by compromising the set standards and specifications. Therefore Materialhandling, which incorporates procurement, inventory, and stores require special consideration to be maintained while executing the project.

5. Insufficient site investigations may lead to faulty design, improper dimensioning, and thereby incurring huge project costs. The appropriate data or information is a key to any successful design. Therefore any project primarily requires a competent approach for a site specific examinations.

6. Efficient and optimum utilization of equipment's and other resources will leads to better project execution and delivery.

7. Design errors and delays in producing design documents results in omissions and ambiguities within the plan and specifications which further influence the quality, cost, and duration of construction. Therefore timely design evaluation and people involved must be highly skilled, well trained and having expertise in the relevant field in order to minimize or eliminate the errors.

8. Frequent changes in sub-contractors also result in project delays and may have an impact on the quality of construction. Sub-contractors should be only awarded jobs related to their experience and expertise in similar working areas. Since numerous parties are associated with the project (consultants, contractors, and subcontractors, etc.), effective communication and coordination with different parties is a pivotal factor for the timely completion of the tasks and adhering the set standards and specifications. Appropriate communication and coordination among the different parties ought to be built up amid each stage of construction.

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