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Critical Success Factors for Reduction of Cost of Poor Quality from Construction Projects

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Abstract
Failure in preventing reworks and wastages during work execution in construction projects results in quality failure costs. In most of the projects the quality costs remain hidden because they are not measured, resulting in wastage of more than 25% of company revenues. As whole it is a loss of national resources and the construction industry which contributes significantly to socio-economic development and employment in any country. Critical Success Factors (CSFs) can be made a part of risk management to check the losses on account of quality failure costs or Cost of Poor Quality (COPQ). There are some CSFs having potential to reduce COPQ from construction projects during every stage. They have been identified in this study for the benefit of construction industry. The two groups of CSFs planning and organizing have 51% share in the top ten CSFs. Therefore, planning and organizing are the most important areas that must be given due attention before taking up construction projects at site.

Keywords
Critical Success Factors, Quality Failure Costs, Cost of Poor Quality, Construction projects, risk management

1. Introduction

Project objectives and deliverables are generally not clearly defined in most of the public sector projects in developing countries; it adversely affects the project planning, designing and execution. It leads to substantial variation in project cost, time and scope (the triple constraints), thereby inducting reworks, delays and wastages or quality failure cost; it is also called Cost of Poor Quality (COPQ). COPQ can be reduced from the construction projects with effective use of many critical success factors.
COPQ can be avoided, if the work is done right the first time. There are four categories of quality costs; (i) prevention costs (costs incurred to keep failure and appraisal costs to a minimum), (ii) appraisal costs (costs incurred to determine the degree of conformance to quality requirements), (iii) internal failure costs (costs associated with defects found before the customer receives the product or service), and (iv) external failure costs (costs associated with defects found after the customer receives the product or service), (Brisco and Gryna; Dian et al., -2010).
The COPQ can be controlled in construction projects using two approaches, first by proactive preventive measures before project execution and the other one is during project execution, as a

mitigation measure. Proactive preventive measures are the low cost processes for COPQ reduction; it can also be called risk management to control future anticipated losses. Identification of Critical Success Factors (CSFs) forms the basis of proactive preventive measures. This study has focused to identify the CSFs having potential to reduce the COPQ from the construction projects. A survey has been conducted on companies of various categories working on private and public sector projects for shortlisting and ranking of CSFs.

1.1 Significance of Research

The CSFs point out the areas requiring proactive preventive measures before taking up a project as risk management so that minimum failure incidents and costs are faced during project execution. Identification of CSFs for reduction of COPQ would be helpful for the construction companies as it would be an opportunity for them to initiate low cost proactive preventive measures on the identified most effective CSFs to reduce COPQ from their projects and enhance their profitability, productivity, compatibility and quality along with enhancing the sustainability of national economic growth and strength of construction industry.

2. Literature Review

2.1 Construction Industry

The construction industry includes all companies primarily engaged in construction as general contractors, operator builders, heavy construction (airports, highways, and utility systems), and construction by specialty trades. The industry contributes significantly to socio-economic development and employment. Pakistan's construction industry significantly contributes toward the GDP of 2.4% and employs about 9% of the total labor force (Farooqui et al – 2008, Ahmad -2009). According to Khan (2008) the sector through linkages supports about 40 building material industries, investment and growth climate and helps reduce poverty by generating income opportunities for poor household. It provided jobs to about 5.5 per cent of the total employed labor force or to 2.43 million persons, (2.41 million male and 0.2 million female) during 2003- 04.

2.2 *Cost of Poor Quality (COPQ)*

Most suitable definition for Quality in the construction industry, according to Goetsch and Devis is that, it is a dynamic state associated with products, services, people, processes and environment that meets or exceeds customer expectations and contract requirements/standards or Quality can be defined as conformance to the standards and fitness for purpose. Crosby in his book "*Quality is Free"*, defines that the cost of quality has two main components: the cost of good quality (or the cost of conformance) comprise of appraisal and preventions costs and the cost of poor quality (or the cost of non-conformance) comprise of internal and external failure costs. Cost of Quality (COQ) analysis enables organizations to identify, measure and control the consequences of poor quality.

The COPQ cannot be traced or identified from the existing accounting reports and auditing system (Dian et al -2010; Barbará et al - 2008). According to Barbará et al (2008) losses on account of COPQ range from 10 to 40% of the revenue of organizations whereas Juran (1992) contends that in the US about a third of what we do consists of redoing work previously "done". Mahmood et al. (2014) have concluded with the help of literature that COPQ ranges from 22.23 to 32.83% of company revenues, whereas it should be between 2 to 4% (Campanella-1990). There is a big gap between the existing and required COPQ, therefore, it is an opportunity to do something to narrow this gap. In an experimental study of 60 days on a construction project Mahmood et al. (2014) managed to reduce COPQ from 40.43% to 16.65% of value of executed work. Their study elaborated a high percentage of COPQ in construction projects. Identification of CSFs for reduction of quality failure costs will also certainly help to initiate proactive preventive measures to reduce the COPQ.

2.3 *Critical Success Factors*

Success is the degree to which a company's goals and expectations are achieved (Arslan, and Kivrak- 2008). Every individual or groups of people associated with a project, have diverse needs and expectations, it is not very unusual that they translate project success in their own way of thinking/understanding (Cleland & Ireland-2004). For the individuals involved with a project, project

success is normally considered as the accomplishment of some pre-determined project objectives (Lim & Mohamed-1999).

The concept of "success factors" was developed by Daniel D Ronald of McKinsey & Company in 1961. "Success factors are the contributions in the management system which contribute directly or indirectly to the success of the project or business" (Cooke-Davies-2002).

Advantages of the approach of the CSFs are that they focus on critical high-payoff factors, it is comparatively fast and inexpensive for the management, and regularly exposes new insights to the executives involved. The major disadvantages include that it is not comprehensive and often results in a snapshot of the business that can rapidly become obsolete, in case there is any major change in the business (Rowe et al., 1985).

2.4 Critical Success Factors for reduction of Quality Failure Costs or COPQ from Construction projects

There are some studies available on CSFs of construction projects and construction companies etc. but so far no study has been conducted on identification of CSFs for reduction of COPQ.

Following success factors have been identified on the basis of literature, discussions and unstructured interviews with the experts/project managers of various construction companies. They have been divided into five groups or clusters according to activities of project management cycle (Planning, Organizing, Executing, Monitoring and Controlling) as listed in many books including PMBOK Guide. These success factors fall under the category of prevention and appraisal measures, they are low cost measures to prevent high costs of failure. Table-1 shows the identified and shortlisted CSFs that influence the reduction of COPQ at construction projects.

Table 1: Critical Success factors that influence the reduction of COPQ at construction projects

S#	Success factors that influence the reduction of COPQ	
	Planning Stage	**Executing stage**
1.	Clearly defining the project objectives (scope, time and cost)	Providing effective leadership
2.	Defining quality objectives (standards and specifications)	Team work and employee involvement
3.	Defining measurement and testing procedures	Optimum use of resources
4	Defining communication process and channels	Fulfilling environmental protection requirements
5	Identification of processes and skills for activities	Fulfilling health and safety requirements
6	Identifying technology requirement for processes	Protecting stakeholder rights
7	Anticipating risks and developing mitigation plan	Fulfilling contractual obligations
8	Cash flow planning	Exercising transparency in procurement process and transactions
	Organization stage	**Monitoring stage**
1	Defining organizational structure	Measuring performance of activities on critical path
2	Providing effective project management process	Measurement and testing of executed works
3	Defining the decision making process and empowerment	Measure Variation in planned and actual resource utilization
4	Induction of appropriate technology	Audit of expenditure and procurement process
5	Deployment of required resources	Measurement of productivity of resources
6	Team development and deploying skilled work force	Measurement of wastage and reworks (COPQ)
7	Training, development and quality awareness of HR	Measure performance of environment protection measures
8	Defining quality control mechanism	Measure performance of Health and safety measures
	Controlling stage	
1	Reducing the gap in planned and actual resource utilization	
2	Reducing the gap in planned and actual cost	
3	Reducing the gap in planned and actual schedule	
4	Reducing the gap in planned and actual scope	

5	Reducing the leakage and wastage of resources and reworks	
6	Improving the quality of input materials and resources	
7	Improving the productivity of resources	
8	Initiating accountability process	

Forty (40) critical success factors have been identified in all five groups, i-e eight CSFs in each group.

3. Research Methodology

The questionnaire surveys was conducted from contractors, engineers, professional working in various construction companies to obtain their assessment on the identified CSFs. The respondents pertained to construction companies, public sector organizations, and some other developing countries including Palestine, Uganda, Vietnam, Philippine and Syria. Engineers of these countries attended a training workshop with the researcher at Beijing China in August 2011, it gave a chance to collaborate with them, and questionnaires were E-mailed to them for giving their response. 150 questionnaires were distributed only 85 received back, making about 57%. The analyses have been based on the evaluation carried out on Relative Importance Index (RII) and results of Likert scale.

The RII is a technique to compute the strength of index familiarity, frequencies and agreements of the specific question. This method transforms the five-point Likert scale to determine the ranking of each factor using the following expression (Tam et al.-2000):

$$RII = \frac{\sum_{i=1}^{5} a_i x_i}{5 \times N}$$

Where ai is a constant expressing the weight of the ith response, xi is the frequency of the ith response of the total responses for each cause, i is the response category index where i = 1, 2, 3, 4 and 5 respectively, and N is the total number of respondents. The RII value ranges from 0 to 1 (Tam et al.-2000). The computation of the RII using this formula yielded the value of RII ranging from 0.2 to 1. The value 0.2 represented the lowest and the value 1 represented the maximum strength. The mean response for the Relative Index (RI) was allocated as in Table-2:

Table-2: Detail of Evaluation scales used

Likert scale	Equivalent of Likert scale and assessment of Relative Index (RI)
1.	0 ≤ RI ≤ 0.2 Strongly Disagree
2.	0.3 ≤ RI ≤ 0.4 Disagree
3.	0.5 ≤ RI ≤ 0.6 Neutral
4.	0.7 ≤ RI ≤ 0.8 Agree
5.	0.9 ≤ RI ≤ 1 Strongly Agree

Mahmood et al., (2012) and Tam et al. (2004) have also used this method for evaluation and ranking of their success factors.

4. Results and Discussion

According to the frequency of the respondent and their positions in the construction companies, the highest number of questionnaires were returned by Engineers (32 %) followed by supervisors (27 %), Chief Executive Officer (23 %) and Directors (18 %). The respondents belonged to Pakistan, Palestine, Uganda, Vietnam and Syria. A diversified response received from respondents of various developing countries has contributed to develop a meaning full and realistic conclusion.

Ranking of the CSFs based on Likert scale and also on Relative Importance Index (RII) is available at Annexure-A. Summary of ranking of five groups of CSF is given in Table-3:

Table 3: Summary of CSF groups according to the Rank of Importance

Overall Ranking	Critical Success Factor Groups	Overall rating of 40 factors			17 Factors in the list of Top ten on Likert scale	
		Average of Likert Scale	RI	RII	Frequency	Contributing share
1	Planning Factors (P)	4.50	0.90	0.85	6	35.29%
2	Organization Factors (O)	4.22	0.81	0.81	3	17.65%
3	Controlling Factors (C)	3.92	0.79	0.79	2	11.76%
4	Monitoring Factors (M)	3.87	0.73	0.73	2	11.76%
5	Execution Factors (E)	3.04	0.66	0.66	4	23.53%

Planning is the most important area with 35.29% share in the CSFs. Kerzner (1987) has also identified "Commitment to planning and control" as an important CSF for construction projects. Zwikael and Globerson (2007) with the help of literature review have also rated the project planning as number one CSF. According to the PMBOK (PMI 2004), out of the 44 processes required to manage a project, 21 pertain to planning process making about 47% of total processes. The CSFs listed under Planning stage in table-1 have been identified as part of the planning process by Zwikael and Globerson (2007). 10 CSFs were identified in a major research study by Pinto and Slevin (1987) on "critical factors in successful project implementation" that also included project planning, leadership support, and customer involvement.

Discussion

Out of total forty, only top ten ranked CSFs have been discussed.

According to ranking carried out on RI technique, "*Clearly defining the project objectives*" with RII of 0.93 is the most important success factor and pertains to Planning stage. The triple project constraints i-e scope, cost and time are derived from project objectives. There would be fewer chances of variation when as a protective measure, the project objectives are well defined, which thereby will reduce the chances of variation in triple constrains and induction of COPQ. Pinto (1986) has also ranked this CSF as number one in his list of top ten CSFs, while analyzing the manufacturing companies in Malaysia.

The second most important success factor is "*Defining quality objectives*" with RI = 0.91 and also a proactive protective measure. Defining the acceptable limits of standards and specifications for the work going to be executed, makes it possible to plan and organize the work processes to achieve the quality objectives. It will prevent and reduce the chances of wastage and failure costs. It is essential to achieve the desired quality objectives with minimum variation and wastage. Zwikael and Globerson (2007) have placed this CSF at number fourteen.

Two CSFs, (i) "*Identifying technology requirement for processes*" and (ii) "*Cash flow planning*" with an RI of 0.90 share the 3rd position and are also preventive measures. Selection of an appropriate technology for value addition and execution process not only makes it possible to execute the project expeditiously but also make it possible to achieve high degree of quality standards and thereby reduces chances of failure and wastage. "Cash flow planning" is also an important CSF because all the activities are dependent on availability and timely release of finances. Project completion might get delayed if the "cash flow" is not adequate. A company cannot implements its construction schedule without having adequate finances resources and stable cash flow. Pinto (1986) has ranked "availability of the required technology and expertise" at number six.

"*Identification of processes and skills for work activities*" is at the 4th position with RII of 0.89. There are numerous work activities during project execution. Identification of appropriate work processes and skills for the execution of various project activities will prevent the chances of reworks and wastages. It is a part of planning and a proactive preventive measure.

"*Defining measurement and testing procedures*" is at the 5th position with RII of 0.87; this CSF pertains to planning and is an appraisal measures. It would not be possible to verify the quality conformance of executed works without measurement and testing. Black and Porter (1996) identified "Quality improvement measurement systems" as an important CSF for TQM and placed it at 9th position.

There are two CSFs at the 6th position. (i) "*Team development and deploying skilled work force*" pertains to organizing factors and (ii) "*Providing effective leadership*" is an executing factor. Both of these CSFs have relation with human resource management i-e recruiting, deploying and leading. They are very important for employee motivation and to maximize productivity. Abdel-Hamid et al. (1999) during identifying CSFs for software organizations observed that defining the project team with specific project goals is an important CSF.

There are three CSFs at the 7th Position i-e (i) "*Defining the decision making process and empowerment*" pertaining to organization, (ii) "*Exercising transparency in procurement process and transactions*" pertaining to executing group and (iii) "*Audit of expenditure and procurement process*" pertaining to monitoring factors. All the three CSFs have relation with arrangement of resources for the project. They also advocate implementing appropriate procedures/processes of decision making and procurement through a transparent process, to ensure that the final outcome is without rework and wastage.

Again there are three CSFs at 8th position. (i) "*Training, development and quality awareness of HR*" pertain to organizing factors, (ii) "*Fulfilling contractual obligations*" relates to executing factors and (iii) "*Initiating accountability process*" pertains to controlling factors. The CSF (i) and (iii) both relate to human resource, appropriate training and development of HR as a preventive measure will reduce the chances of failure incidents and thereby reduce the need for accountability process. Fulfillment of contractual obligations according to required quality standards and specifications is also important to prevent the reworks and wastages. Pinto (1986) has rated "training and development" at number five.

"*Team work and employee involvement*" is at the 9th position and pertains to executing factors. It again relates to human resource management and is important for employee motivation to achieve batter quality and productivity.

There are two CSFs at the 10th position (i) "*Measurement and testing of executed works*" pertaining to monitoring and (ii) "*Improving the productivity of resources*" related to Controlling factors. Measurement and testing is an appraisal activity and is carried out to verify if the quality of executed work conforms to quality standards, it actually decides if any rework is required? Capability and calibration of test equipment and training of laboratory staff is very important in this regards as a preventive measure. Finding the problem areas that are hampering and badly effecting productivity of resources will helpful to address the causes of problems.

Two CSFs (i) *"Performance of Health & safety measures" and (ii) "Environmental protection measures"* are at the bottom of the ranking list showing unawareness or lack of interest in public convenience and fulfilling corporate social responsibilities by the construction companies. Mahmood et al (2010) have established that cost of poor quality on account of external failure or cost of inconvenience can be more than the cost of the project. Construction companies therefore need to re-visit their existing policies and positions with respect to CSFs identified in this study for improvement of their performance, profitability, productivity and quality of their executed projects.

Ranking carried out on the basis of average of Likert scale also has the same sequence but the number of CSFs in top ten are 17 as compared to 19 ranked by RII. Therefore the evaluation carried out on the basis of Likert scale is equally good.

6. Findings and Conclusion

The CSFs that can reduce quality failure cost or COPQ from Construction projects have been divided into five groups according to project management stages i-e (i) Planning (ii) Organizing (iii) Executing (iv) Monitoring and (v) Controlling. Eight CSFs pertained to the each group, making a total of 40 CSFs on which response was collected through questionnaires and ranking has been carried out on RI.

According to ranking of importance, these groups of CFSs are sequenced as (i) Planning factors, (ii) Organizing factors, (iii) Controlling factors (iv) Monitoring factors and (v) Executing factors. There are 17 Factors in the list of top ten on Likert scale, out of which 6 pertain to planning, 3 to organizing, 2 each to controlling and monitoring and 4 to executing group. There are six CSFs at top five positions and all of them pertain to planning category.

This ranking has highlighted the importance of planning and organizing before project execution, these two groups have 51% share in the top ten CSFs. Therefore, planning and organizing are the most important areas that must be given due attention before taking up construction projects at site.

7. *References*

Abdel-Hamid, T.K., Sengupta, K. and Swett, C., The impact of goals on software project management: an experimental investigation. MIS Quart., 1999, 23(4), 531.

Ahmad M. (2009) Pakistan Construction industry's performance worst in 37 years" Daily Times, Friday, October 30, 2009.

Arslan G. and Kivrak S., (2008) Critical Factors to Company Success in the Construction Industry, International Journal of Social, Education, Economics and Management Engineering Vol:2, No:9.

Barbará, C., Eutrópio E., De Souza C., Catunda R., (2008) "*MODELING THE COST OF POOR QUALITY*" Proceedings of the 2008 Winter Simulation Conference. 978-1-4244-2708-6/08/$25.00 ©2008 IEEE

Briscoe N. R., Gryna F. M., "Assessing the Cost of Poor Quality in a Small Business" Qimpro Quarterly Special.

Campannela J. (1990), Principles of Quality Costs: Principle, Implementation and Use, 2nd ed., ASQC Quality Cost Committee, Milwaukee.

Cleland & Ireland (2004) Project Manager's Portable Handbook, 2nd Edition, McGraw-Hill, USA, p- 210

Cooke-Davies, The "real" success factors on projects, International Journal of Project Management" vol.20, pp. 185–190

Crosby P. B., (1978) "Quality is Free: The Art of Making Quality Certain" McGraw-Hill Co. Inc.

Dian R. M, Rapi A., and Nilda (2010) , The Measurement of Quality Performance with Sigma Measurement and Cost of Poor Quality as a Basis for Selection Process of Quality Improvement, IMECS 2010, proceedings Hong Kong

Farooqui R. U, Dr. Lodi S. H., Dr. Kayani K. R., (2008) Pakistan Construction Industry – Total Quality Management? CBM-CI International Workshop, Karachi, Pakistan.

Goetsch D. L., Davis B. S., Quality Management-Introduction to Total Quality Management of Production, Processing and Services 3rd Addition Prentice-Hall, New Jersy

Juran J.M (1992) Juran on Quality by Design, The New Steps for Planning Quality into Goods and Services, Free press

Kerzner, H. (1987). In search of excellence in project management. *Journal of Systems Management*, 38(2), 30 – 40

Khan R. A., (2008) "Role of Construction Sector in Economic Growth: Empirical Evidence from Pakistan Economy. "First International Conference on Construction In Developing Countries (ICCIDC–I) "Advancing and Integrating Construction Education, Research & Practice" August 4-5, 2008, Karachi,, Pakistan

Lim & Mohamed (1999) Criteria of project success: an exploratory re-examination, International Journal of Project Management Vol. 17, No. 4, pp. 243-248, [Electronic]

Mahmood S, Ahmed S. M., Panthi K., Ishaque N. K., (2014) "Determining the cost of poor quality and its impact on productivity and profitability", Built Environment Project and Asset Management, Vol. 4 Iss: 3, pp.296 – 311

Mahmood S., Shahrukh, and Sajid A. Dr. (2010) "*Cost of Poor Quality in Public Sector Projects***"** Journal of Marketing and Management, 1 (1), 70-93, November 2010 70

Pinto, J. K. (1986). Project Implementation: A determination of its critical success factors, moderators, and their relative importance across the project life cycle. Doctorate dissertation, University of Pittsburgh.

Ronald R. D., (1961) "Management Information Crisis," *Harvard Business Review*, Sept.-Oct.

Tam, C.M., Zeng, S. X. & Deng, Z. M., (2004), Identifying elements of poor construction safety management in China. *Safety Science*, 42: 569–586.

Zwikael, O., and Globerson S,.(2007) Globerson From Critical Success Factors to Critical Success Processes, International Journal of Production Research

Annexure-A

Ranking of Factors having potential to reduce Quality Failure Costs in construction projects.

S #	Factor group	Rank	Critical Success factors that influence the reduction of COPQ	Likert Scale Average	RII
1	P	1	Clearly defining the project objectives (scope, time and cost)	4.88	0.93
2	P	2	Defining quality objectives (standards and specifications)	4.80	0.91
3	P	3	Identifying technology requirement for processes	4.75	0.90
4	P	3	Cash flow planning	4.75	0.90
5	P	4	Identification of processes and skills for activities	4.68	0.89
6	P	5	Defining measurement and testing procedures	4.59	0.87
7	O	6	Team development and deploying skilled work force	4.50	0.85
8	E	6	Providing effective leadership	4.50	0.85
9	O	7	Defining the decision making process and empowerment	4.45	0.84
10	E	7	Exercising transparency in procurement process and transactions	4.45	0.84
11	M	7	Audit of expenditure and procurement process	4.45	0.84
12	O	8	Training, development and quality awareness of HR	4.34	0.82
13	E	8	Fulfilling contractual obligations	4.34	0.82
14	C	8	Initiating accountability process	4.34	0.82
15	E	9	Team work and employee involvement	4.29	0.81
16	M	10	Measurement and testing of executed works	4.21	0.79
17	C	10	Improving the productivity of resources	4.21	0.79
18	O	11	Induction of appropriate technology	4.11	0.77
19	M	11	Measurement of productivity of resources	4.11	0.77
20	M	12	Measurement of wastage and reworks (COPQ)	4.04	0.76
21	C	12	Reducing the leakage and wastage of resources and reworks	4.04	0.76
22	O	13	Defining organizational structure	4.02	0.75
23	O	13	Providing effective project management process	4.02	0.75
24	O	13	Deployment of required resources	4.02	0.75
25	C	13	Improving the quality of input materials and resources	4.02	0.75
26	C	14	Reducing the gap in planned and actual resource utilization	3.96	0.74
27	O	15	Defining quality control mechanism	3.91	0.73
28	C	16	Reducing the gap in planned and actual cost	3.84	0.72
29	P	17	Anticipating risks and developing mitigation plan	3.79	0.71
30	P	18	Defining communication process and channels	3.75	0.70
31	E	19	Optimum use of resources	3.71	0.69
32	E	19	Protecting stakeholder rights	3.71	0.69
33	M	20	Measuring performance of activities on critical path	3.64	0.68
34	C	20	Reducing the gap in planned and actual schedule	3.64	0.68
35	E	21	Fulfilling environmental protection requirements	3.59	0.67
36	E	22	Fulfilling health and safety requirements	3.46	0.65
37	M	23	Measure Variation in planned and actual resource utilization	3.43	0.63
38	M	23	Measure performance of environment protection measures	3.43	0.63
39	M	24	Measure performance of Health and safety measures	3.21	0.59
40	C	24	Reducing the gap in planned and actual scope	3.21	0.59