Examining the Expense of Quality Assurance in Construction Endeavors

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Abstract

This research focuses on assessing the cost of quality in the construction industry of Pakistan, particularly during the design and construction phase of building projects. Through a quantitative approach, data was collected from 125 questionnaires, group discussions, and interviews. The study aims to analyze critical factors influencing quality using the Relative Importance Index (RII) and Mean Item Score (MIS) method, as well as to calculate the total Cost of Quality as a percentage. Findings indicate a significant lack of emphasis on quality management practices within construction organizations, with many failing to allocate budgets for quality assurance and control. Critical factors affecting the Cost of Quality include project complexity and size, efficiency of quality management systems, contractor classification, supervision team experience, and project location. Furthermore, the total cost of quality for construction projects was found to be 54.32%, with prevention costs accounting for 15.5% of the budget, appraisal costs constituting 12.3% of the budget, internal failure costs amounting to 13.9% of the budget, and external failure costs totaling 12.6% of the budget. Recommendations include the development of clear quality policies, prioritizing critical factors affecting quality, proper allocation of budget for quality control, and establishment of dedicated quality control management departments within organizations. This study contributes to understanding the importance of quality management in construction projects and highlights the need for proactive quality assurance and control mechanisms to enhance project outcomes and mitigate financial risks.

Keywords: Cost of quality, construction industry, internal failure, external failure, quality control and quality assurance

Introduction

The word quality has so many definitions that range from conventional ones to those who are more strategic. There remains no unanimous agreement regarding a singular definition of quality; interpretations vary across products and services, industries, and dimensional scopes (Wicks & Roethlein, 2009). Some advanced definitions of quality define that quality does not require a higher degree of excellence. Instead, it requires to be met over some standard that is already set for some specific sort of work. For a product/service to be of high quality, it does not focus on including every possible feature in the product/service, rather it must reliably perform as per its design criteria, and it must be maintainable. Some of the definitions related to quality are: Quality is predictable degree of uniformity and dependability, at low cost and suited to market. Quality means meeting customer's requirements, formal and informal, at lowest cost first time and every time" (Deming, 1982), quality is fitness for use (Juran & Gryna, 1993), quality is conformance to requirements (Crosby, 1989). Nevertheless, there is ongoing discussion within the construction industry regarding the challenge of defining quality for construction projects, attributed to the absence of standardization, variations in project scale, and the diverse stakeholders involved (Hoonakker et al., 2010). A study conducted by Loushine et al. (2006) reviewed literature on the definition of construction quality and yielded five distinct definitions: meeting customer expectations, minimizing rework or defects, fostering repeat business, adhering to ISO 9000 standards, and achieving timely and budget-conscious project completion. As per the findings of Awan and Sadiq (2015), the quality perception revolves around aligning with the project's scope, being viewed as an additional expense in construction endeavors. It emphasizes

minimizing rework through the fulfillment of essential quality assessments and reducing defects by adhering to the specifications of supplied materials.

In most construction projects, cost and time are considered as one-dimensional concept. Also, we can say that we can express time and cost by simple value that generates a mutual insight between participants of project. In contrast, quality has its own vast dimensions and each of the dimensions causes different perceptions among the presenters. For instance, Foster (2004) introduced 5 different views for quality as follows: Transcendent view: Quality can be supposed naturally but it can't be stated effortlessly. Product-based view: The features and traits of any product define its quality. User-based view: If the product satisfies user/customer's needs, then it will be considered as a quality. Manufacturing-based view: If the product coincides with the standard design specifications then we will consider it as a quality product. Value-based view: If something provides you a good value for its price then it will be considered as a quality product. Keeping in view, there should be an equal perception of all dimensions of quality between the project participants (Foster, 2004). According to Heravitorbati et al. (2011), quality in construction projects involves meeting the diverse needs and requirements of all parties involved and affected by the project outcomes. When each step of the work process adheres to established standards and specifications, it significantly enhances the probability of the final product meeting the required standards. Notably, the primary factor contributing to quality problems is the occurrence of errors by workers (Rejeki et al., 2020). This underscores the importance of diligent adherence to quality protocols throughout the production process to mitigate potential errors and ensure the desired outcomes are achieved. As quality management theory has progressed, there has been a transition in objectives from aiming for complete elimination of defects to emphasizing the implementation of error prevention measures. This shift underscores a proactive approach to quality management, prioritizing strategies to anticipate and mitigate errors before they occur (Love et al., 2011; Psarommatis et al., 2022).

The cost associated with the quality in construction projects encompasses expenses related to ensuring adherence to standards and minimizing errors. Accurate estimation of this cost is vital for project planning, directly influencing budgeting and project success. There are many factors that influence the cost of quality. Neglecting to consider these factors can lead to financial losses and delays resulted in inaccurate estimates (Tawfek et al., 2012). Hence, understanding and accounting for the cost of quality enables informed decision-making, optimizing resources and ensuring project success within constraints.

Quality concerns persist in construction projects, manifesting as a range of imperfections such as waterproof roofing leaks, wall deformations, cracks, insufficient flooring thickness, floor base irregularities leading to bulging and cracking, and coating detachment. These issues recur intermittently, indicating ongoing challenges in maintaining quality standards within the construction industry (Forcada et al., 2016), (Alen-castro et al.,2018). Therefore, the construction industry often receives criticism for its poor delivery of projects, especially when it comes to the quality of finished products and the effectiveness of design and construction processes used (Marasini & Quinnell, 2010). Furthermore, despite the advancements in technology, the use of advanced tools for quality management in construction remains uncommon (Luo et al., 2022). Inadequate quality assurance and control measures in construction projects often result in costs exceeding initial projections. This prevailing disregard for prioritizing quality across projects leads to inflated expenses and extensive rework during later project stages. Addressing this challenge requires a focused effort on prioritizing factors that influence project quality and conducting comprehensive assessments of quality costs to preempt cost overruns. Investing in quality assurance and control measures early in the project lifecycle can mitigate the risk of cost overruns and minimize the need for costly rectifications. However, smaller-scale construction firms often struggle with insufficient budget allocations for ensuring quality standards, exacerbating the issue. Consequently, quality considerations take a backseat in the planning and execution phases, further contributing to inflated costs and project inefficiencies. To combat this, there is an urgent need to bridge the gap in assessing the cost implications of compromised quality. Equally important is quantifying the Cost of Quality as a percentage, providing invaluable insights into mitigating cost overrun and enhancing project outcomes. Through this research endeavor, the aim is to address these pressing issues and foster a culture of quality across construction firms, ultimately improving project management practices and reducing cost overruns. Therefore, the two main objectives of this research are:

1. Analyzing critical factors affecting quality of building projects using Relative Importance Index (RII) and Mean Item Score (MIS) method.
2. Calculating the total Cost of Quality in the form of percentage.

The next sections of the paper include literature review, research methodology, results and discussions, and conclusions. Literature review discusses each aspect of quality by defining different types of costs and equations to calculate costs. Research methodology section elaborates the methodology starting from initial phase till the results, including thorough explanation of all steps involved during the research. Results and discussions include results of the survey-based research. This research is based on a questionnaire survey and interviews conducted with the concerned authorities. The final section presents the conclusion of whole research work, limitations of this work and future work recommendations for implementation of quality costing system to prioritize quality in construction industry.

Literature Review

The productivity and overall performance of construction projects are significantly impacted by quality issues, often resulting in cost overruns, and missed deadlines (Alwi et al., 2002; Josephson et al., 2002). To address these challenges, many organizations have adopted Total Quality Management (TQM) strategies (Kanji & Wong, 1998). Therefore, calculating the cost of quality is crucial to mitigate factors leading to poor quality (Low & Yeo, 1998). This calculation helps in evaluating the effectiveness of a quality system within an organization (Love and Sohal, 2003), making it imperative for managers to prioritize this aspect (Schiffauerova & Thomson, 2006). Numerous researchers have contributed to understanding quality-related costs in the construction industry and have proposed various models for their calculation. For instance, Davis et al. (1989) developed a Quality Performance Tracking System (QPTS) to categorize and quantify different quality aspects in construction projects. Abdul-Rahman (1993) conducted a case study to analyze failure costs, while (Aoieong et al., 2002) introduced a simplified methodology for quality cost analysis. Similarly, Kazaz et al. (2005) examined construction quality costs in Turkey. Additionally, Barber et al. (2000) analyzed the cost of quality failure and developed a method to measure it. İren, Deniz, ad Bilgen (2014) introduced cost models for typical quality assurance methods in crowdsourcing. An approach is proposed for analyzing quality-related expenses through the utilization of a cost-of-quality framework. The study aimed to assess the financial implications of ensuring quality in crowdsourced projects, providing a systematic approach to evaluate and manage quality-related costs effectively. Furthermore, a study conducted by Kurdin, Magribi, and Dars Hats (2016) assessed the impact of enhancing the quality of national construction, a move often associated with heightened quality expenditures. To investigate this, researchers examined various factors influencing quality costs and employed multiple linear regression techniques for modeling. The findings indicated that specific components of the quality management system, namely appraisal cost and external failure cost, had the potential to lower overall quality expenses. Conversely, the study revealed that prevention cost and internal failure cost could potentially drive up quality costs according to the model's analysis. A detailed literature review has been carried out to study the cost of quality and discussed below.

Cost of Quality

By keeping in view different views of quality and finding out that what it is that actually causes costs, there are several concepts related to quality costs defined by many authors and researchers. One researcher defines the concept of cost of quality as the sum of prevention cost. i.e., cost invested in the prevention of non-conformance to the requirements, appraisal cost. i.e., cost invested in appraising a product for conformance to the requirements and failure cost. i.e., cost spent in failing to meet the requirements. According to him, quality costs and thus all the costs that are relevant to the working with quality are known as quality costs (Campanella, 1990).

In another research quality was categorized into two categories out of which the first one is the type of cost needed in order to confirm that requirements of quality are maintained, and the next one is related to the costs that comes from aberrations from the requirements (Song & Lee, 1990). Philip Crosby's (an American quality consultant) approach commences with disbelieving the hypothesis that there is a connection amongst cost and quality. Crosby laid stress over the classification of price of conformance and non-conformance. According to him, cost of quality is the sum of Conformance costs and Non-conformance costs. Cost of conformance is the price paid for making

certain things done right at the start while the Non-conformance cost is the price wasted when the work fails to meet the customer's requirements (Schiffauerova & Thomson, 2006). Abdul-Rahman (1995) also studies about quality costs and according to him it is defined as cost involved in confirming the quality requirements and evaluation that quality requirements are being met. It also involves any other costs occurred due to failure of quality or wasted as a result of failed product.

Cost of Quality Categories

In the beginning of year 1960 Armand Feigenbaum classified quality costs in the following categories as prevention cost, appraisal cost, failure cost (including internal failure and external failure cost). Many other followers followed in his footsteps. As given below, Fig. 01 indicates categories of cost of quality given by (Feigenbaum, 1983)

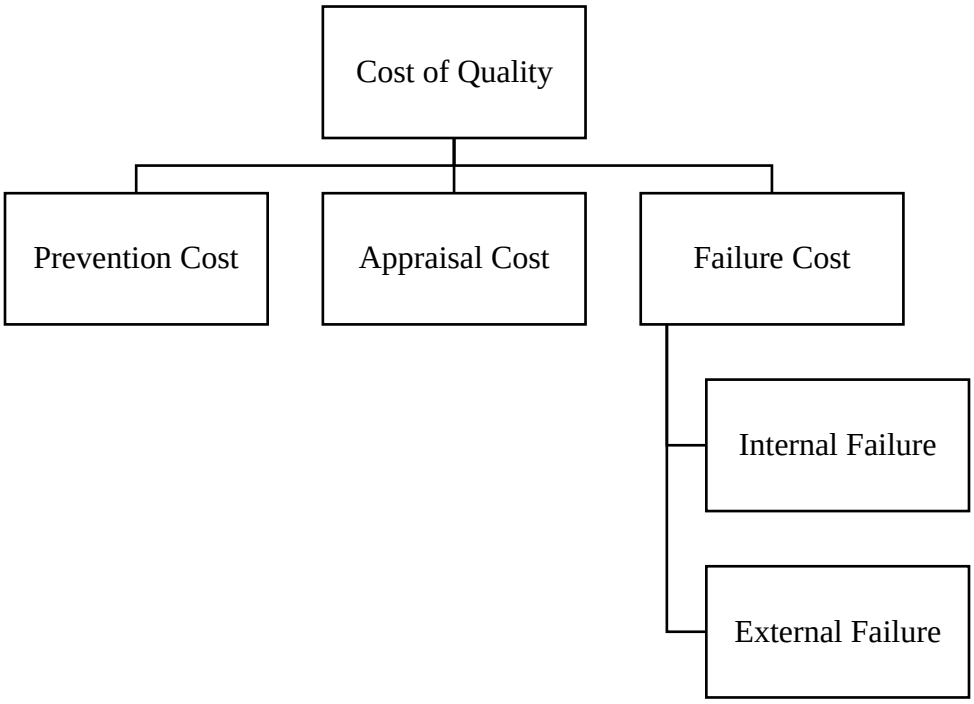

Figure 1 Categories of Cost of Quality

Prevention costs are basically those which are related to the prevention of defects from happening prior to implementation and keep the appraisal and failure costs at minimum level. Examples of such costs include: Review of new product, Planning quality, Supplier surveys, Reviews of processes, Teams for quality improvement, Education and training, etc. (Love & Irani, 2003). Appraisal costs, incurred during a project's operational phase, ensure adherence to quality standards. These include activities before, during, or after production, preventing the passage of faults and limiting the delivery of defective products to customers. While not eliminating errors, appraisal measures significantly reduce their occurrence. Examples encompass initial inspection, testing, process auditing, and supplier investigation (İren, Deniz, & Bilgen, 2014). Failure costs are defined as the costs occurred due to faulty products/services resulting in the loss of reputation of company. Failure occurs when the product/service is not as per customer's expectations. Failure costs are further divided as Internal and External failure costs. Internal failure costs are those caused as a result of defects found before delivering the products or services to the client which eventually result in client's dissatisfaction. Defects can occur because of faulty material, inefficiency of workers or due to inefficient process. These costs include: Rework cost, Cost occurred due to delays Redesigning cost, Shortage of material supply, Retesting due to failure, Equipment downtime, Lack of flexibility, Poor management control, Lack of skills. The external failure costs are the ones that arise after product/service delivery to the customer which causes a sense of dissatisfaction. External failure costs include: Cost for complaints, Repairing cost, Cost of recreating services, Warranty cost, Additional customer costs, Loss of sales, Cost of environmental degradation (Logothetis, 1992).

Mathematical functions to calculate cost of quality

Total amount of cost of quality (COQ) can be calculated by using the following equation (Mukhtar, 2010).

$$COQ_T = PC+AC+IFC+EFC \quad (1)$$

where,

COQ_T: Total Cost of Quality

PC: Prevention Cost
AC: Appraisal Cost
IFC: Internal Failure Cost
EFC: External Failure Cost

Most of the construction firms do not consider all the three categories of costs for calculating cost of quality. Instead, they just focus on the Failure costs. In general, field engineers examine the end product i.e., finished work, in order to measure the quantity of rework done or required on site. In construction industry, organizations spend most of their money on prevention and appraisal but the amount of these costs is quite lesser as compared to the total project's cost. It is broadly believed that if you spend more on prevention and appraisal costs i.e., conformance cost then you have to worry less about the failure/non-conformance cost. If conformance costs are manageable variables, then the non-conformance costs are resultant ones (İren, Deniz, & Bilgen, 2014; Mukhtar, 2010).

(The Cost of Quality - CQE Academy, n.d.) includes the Prevention and Appraisal costs of construction projects. Prevention and Appraisal costs in construction projects are often neglected which result in the failure costs. These costs play an important role in the success of construction projects, if taken notice of at the right time. These costs broadly include Planning quality, Surveys of suppliers, Process reviews, Training of team for quality management program, Testing during the execution, Timely maintenance of equipment, etc. Equation to find out the Cost of Good Quality can be written as:

$$COG_Q = PC+AC \quad (2)$$

where;

PC: Prevention Cost
AC: Appraisal Cost

Cost of Poor Quality (The Cost of Quality - CQE Academy, n.d.) includes Internal and External failure costs of construction projects. These costs result due to ignorance of Prevention and Appraisal costs. When there is ignorance of Prevention and Appraisal, Failure costs appear as a result of this ignorant behavior of the organization. These costs broadly include Reworking cost, Delay costs, Lack of knowledge, cost of complaints, Cost of repairing, etc. Equation to find out the Cost of Poor Quality can be written as:

$$COP_Q = IFC+EFC \quad (3)$$

where,

IFC: Internal Failure Cost
EFC: External Failure Cost

Most of the organizations consider quality improvement as finest way to improve the satisfaction level of customer, in order to reduce the manufacturing costs and to enhance productivity level. For quality improvement cost of quality must be reduced. Most critical activities in quality improvement program are monitoring and controlling the cost of quality (Boxer, 2004). In order to achieve a noteworthy impact on the total cost, the failure cost must be reduced and this could be done by spending more on prevention. Increment in prevention and appraisal costs will lead to a decrement in failure costs. Furthermore, spending more on prevention will reduce the appraisal cost. John R Parker presented 1:10:100 rule in order to reduce the cost of quality. According to his research, one dollar consumed over prevention will give you a benefit of $10 on appraisal and of $100 on failure costs. This rule will surely help to prioritize the cost spent over prevention, which will bring bigger profits at later stages.

According to Dale and Plunkett (1991) the percentage of quality cost consumed in appraisal and failure is 95%. Value spent on appraisal cost adds minor to the value of construction work. Appraisal cost just increases the construction cost. The cost that is avoidable is usually the failure cost. By reducing the causes of failure i.e., reducing the non-conformance cost can also help in reducing the appraisal costs at a substantial level. If any company/organization needs to cut off the defects and through this process reduction in cost of poor quality occurs. This will increase the cost of good quality which means higher funds needed in case of any kind of inspection, testing, monitoring and evaluation, training program for operators, etc. By keeping in view, the Six Sigma philosophy, preferring the quality and making things work right at initial stages, causing increment in cost of good quality, while rushing towards zero defect performance, can be smoothed if process becomes better.

Research Methodology

This research is survey based and the main focus is on evaluating the recent situation of the construction industry of Pakistan regarding the implementation of quality standards and assessment of cost of quality in construction projects. Flowchart of the tasks accomplished to successfully meet the research objectives as illustrated by Fig. 02. Literature review includes research from different research papers relevant to the topic of research and extraction of relevant data. Research gap is identified from the literature study by analyzing that which part needs to be addressed. Group discussion and interviews include discussions from the staff of different companies running inside Pakistan and conducting interviews from several people working in the construction industry of Pakistan and later sorting out of relevant data from the discussions and interviews. The questionnaire was prepared based on literature review, group discussion, and interviews etc. Pilot study is a process that asks whether something is possible to be done or not. It involves studying the behavior of the research that should it be further proceeded or not. Pilot study has a particular design feature; this study is usually conduction on a minor scale rather than doing a larger scale research. in addition, this study is conducted in order to identify the safety of inventions, enhances the experience of the researchers with different methods of study and most importantly it is helpful in providing estimated for the calculation of sample size for the research in case of quantitative analysis (In J., 2017). Pilot study held in this research tells us that our data is useful and research should be proceeded further to get useful results. The response rate came out as a result of pilot study was 80%.

Questionnaire Survey

After literature study, group discussion and interviews the questionnaire was finalized. Finalized questionnaire includes three major sections which are as follows:

1. Demographic section
2. Technical section
3. General section

The purpose of the demographic section is to collect Basic information of the respondent. This section is for collecting information about the Name of respondent, Size of organization the respondent is currently working in, Number of employees working in that organization, Annual turnover, Gender and Age of the respondent. The purpose of the technical section is to calculate the possible adverse impact of quality-related factors on total project cost. This section is useful in rating the factors that affect the cost of quality by ranking them as per the data collected from respondents. These factors can be helpful in identifying those critical factors that should be focused and should be eliminated in order to achieve high quality product/service. The purpose of the general section is to collect information about your knowledge related to quality and finding out the percentage of Conformance and Non-conformance costs incurred during Design & Construction phase. Apart from two main sections there are two sub sections as well: General Data and Project Specific Data. The sub-section of general data is related to the perception of the respondent related to the focus over providing quality products/services, the mindset of organization regarding quality that how do they perceive quality in their organization. On the other hand, the second sub section includes the percentage of total costs incurred during Design & Construction phase in the project. This is project specific data and relates to that specific project at which the respondent is currently working. This includes the types of costs: Prevention costs, Appraisal costs, Internal failure costs and External failure costs. These types collectively formthe Cost of quality in the construction projects. This data will give us

the percentage amount of cost incurred on quality in each of the construction projects. This has to be filled by the staff working on the project.

Data Collection

Sample size relates to the number of people i.e., participants involved in the study. In most of the cases, this number is denoted by n. Sample size impacts two major statistical properties: 1) Accuracy of estimates 2) Influence of the research to extract conclusions.

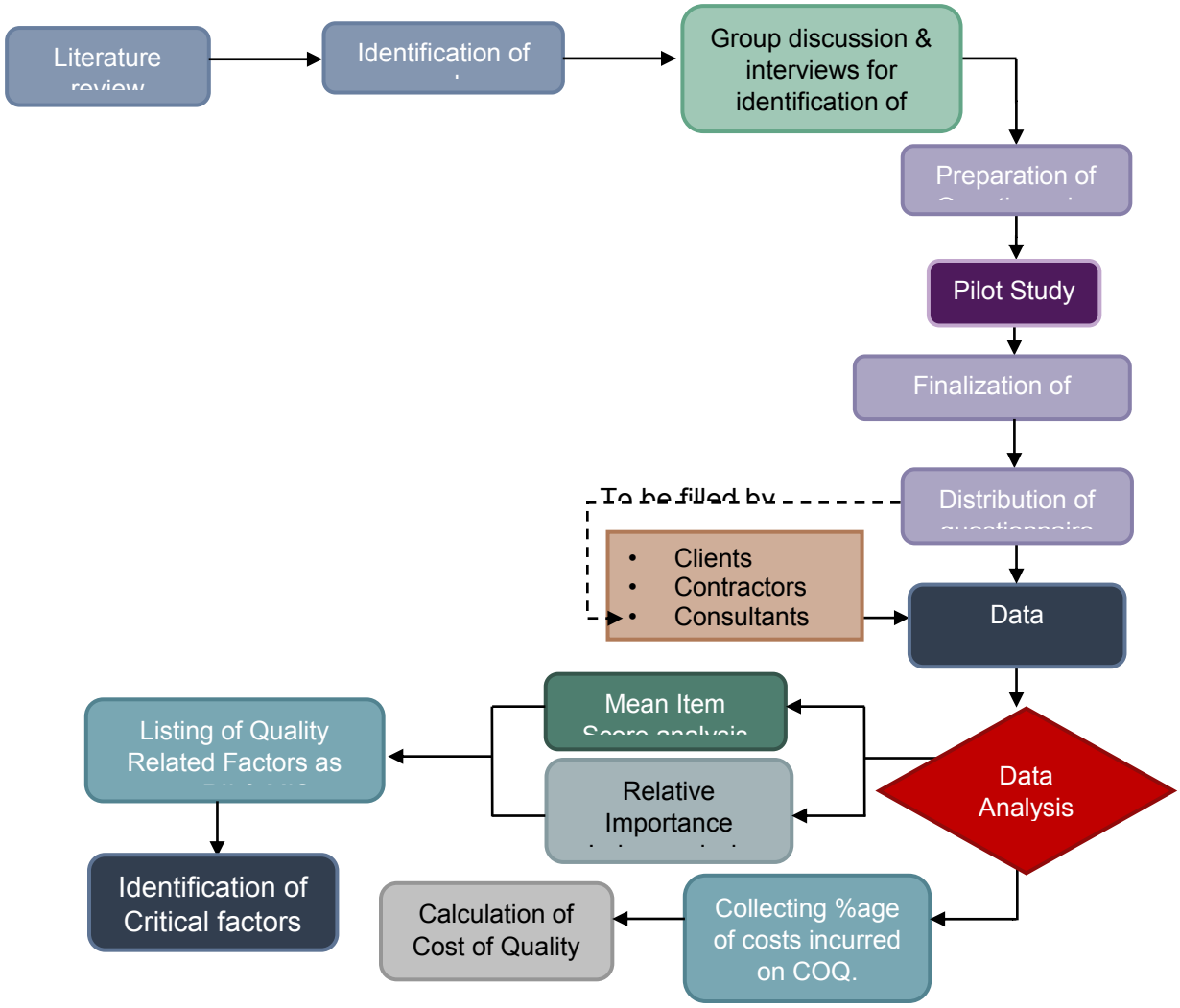

Figure 2 Methodology Flowchart

It is not a matter that how much we pay attention about choosing our population, there still exists a margin of error in the research study. This happens because we are unable to talk to each and everyone in the population of interest. This error is known as Sampling Error. Sampling error influences the precision of the data. This error is although unavoidable, can be improved by sample size. Larger the sample size, lesser will be the margin of error associated with the results. Yet, there is a point where increment in sample size no longer influences the results. This terminology is called as Law of diminishing returns.

Population size in our research is known. So, we can use Kothari's formula given by Kothari (2004). This formula is useful when the population size is known. Kothari's formula allows us to calculate sample size by keeping a precision level/margin of error of our own choice, population size of our own choice, and confidence level and response rate gathered using information from survey based on pilot study.

Mathematically, Kothari's formula is written as:

$$n = \frac{\left(\frac{P[1-P]}{\frac{A^2}{Z^2} + \frac{P[1-P]}{N}}\right)}{R} \quad (4)$$

Where; n = Sample Size required, P = Estimated variance in population, as a decimal; 0.5 for 50-50, 0.3 for 70-30 and 0.2 for 80-20, A = Precision desired, expressed as a decimal; 0.03, 0.05 and 0.1 for 3%, 5% and 10% respectively, Z = Based on Confidence Level (CL); 1.6449 for 90% CL, 1.96 for 95% CL and 2.5758 for 99% CL and N = Number of people in population

Questionnaire was circulated and made to be filled by Clients, Contractors, Consultants and Staff members of different companies pertinent to the construction industry of Pakistan using online platform of Google forms. The aforementioned stakeholders of a typical construction project were the target population of this study and the participants were selected based on their involvement in construction projects and their roles within their respective organizations. The questionnaire was distributed among the population with 20-80 variability as 80% of the population with whom the questionnaire was shared is working in the construction industry and includes engineers.

In this research, following data was assumed:

N = 50,000, A = 5%
For Confidence level = 95%, Z = 1.96
P = 20-80%, R = 80%

So, sample size for the research came out to be 101.

Conventionally, a response rate of 20% is considered as a good response rate, while a 30% response rate is considered to be really good. In our research study, 155 questionnaires were distributed and the number of filled questionnaires collected at the end came out to be 125 which shows the response rate of the study to be 80% which is good enough to rely on. For that purpose Pie charts and bar chats were developed using Microsoft excel. These charts depict the amount of cost spent over quality in specific organizations and also shows the critical factors that affect quality either in positive or negative ways. Charts show the result of the research work obtained from online and in hand questionnaire surveys and interviews conducted at different construction firms.

Data Analysis

Two different techniques were employed: Mean Item Score analysis and Relative Importance Index analysis. Mean Item Score analysis technique helps in giving a specific value to each factor/statement using summation method (J. Robert Warmbrod). Likert scale of 1 to 5 is used in this questionnaire, representing 1 – "Very Low", 2 – "Low", 3 – "Medium", 4 – "High", 5 – "Very High". The Likertscale is most commonly used and reliable method in the field of research. In this research study, Likert scale is use because of the fact that it allows the respondents to prompt that how much they agree or disagree with the provided situations or statements.

Equation to find out Mean Item Score is as follows:

$$MIS = (1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5) / \sum N \quad (5)$$

where;

n1 = Number of respondents responding with Very Low
n2 = Number of respondents responding with Low
n3 = Number of respondents responding with Medium
n4 = Number of respondents responding with High
n5 = Number of respondents responding with Very High
N = Total number of respondents

Relative Importance Index (RII) technique has been used in various studies to determine RII for various factors. The five-point scale ranges from 1 to 5 where; 1 indicates Very Low impact and 5 relates to Very High impact, respectively (Sambasivan and Soon, 2007).

Mathematical formula for finding out RII is as follows:

$$RII = \sum W / (A*N) \quad (6)$$

where,

W = Weight of each response given by the respondents. In our case, this data ranges from 1 to 5.

A = It is the highest weightage of scale, which is 5 in our case.

N = Total number of the respondents, 125 in our case.

QRFs were later to be categorized using a quantification method known as Relative Importance Index (RII).

Results & Discussion

The results are based on the data collected from **125** filled questionnaires, group discussion and some of the company visits conducted to gather information about the assessment of cost of quality in Pakistan's construction industry. It also narrates the understanding of the personnel working in field about the value of quality standards in their organization. The results obtained are elaborated in the form of charts below.

Following information was collected through questionnaire:

Position of respondent

Q: Mention the position of respondent in your company.

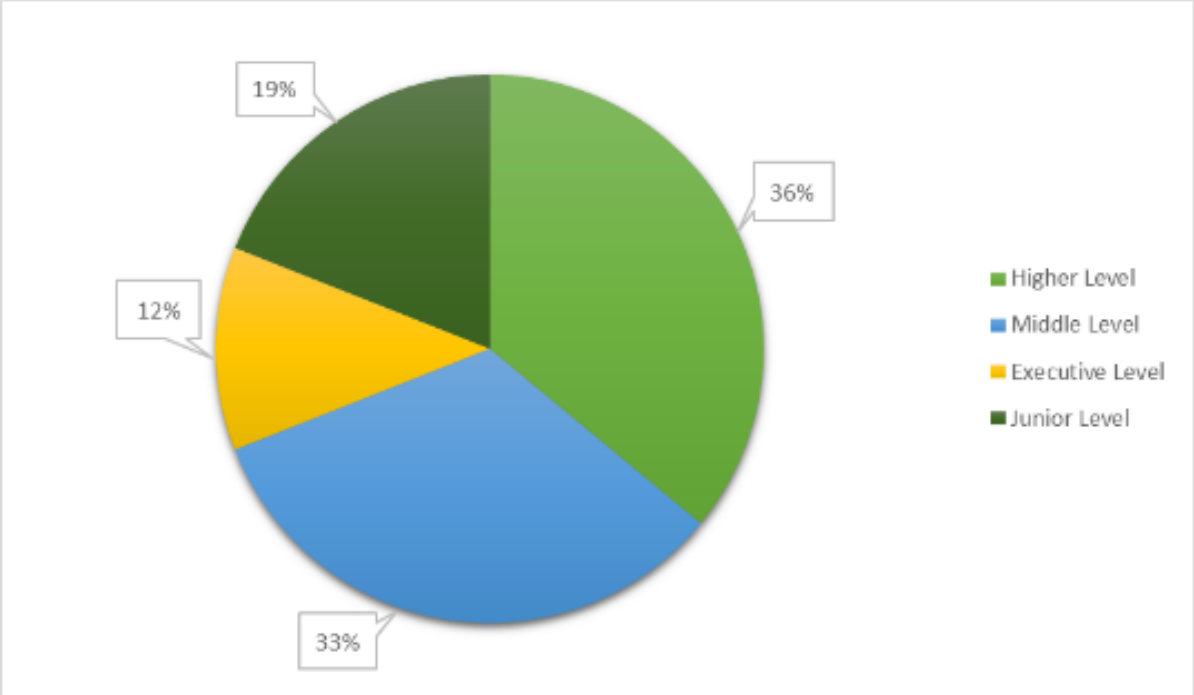

Figure 3: Showing the position and level of respondents in their respective firms who participated to our questionnaire.

This question is basically just to get the idea of respondent working in the construction industry. The position of the respondent tells us about the level of their experience in their organization. The higher the position, the more experienced the respondent will be.

Age of the respondents

Q: Age of the respondent filling out the questionnaire.

This question relates to the seniority of the respondent and it is directly related to the experience of that respondent

in the field of work. Most of the respondent lie under the range of 30-45% and that indicates that they have a high work experience and so it gives a better depiction of the construction industry of Pakistan.

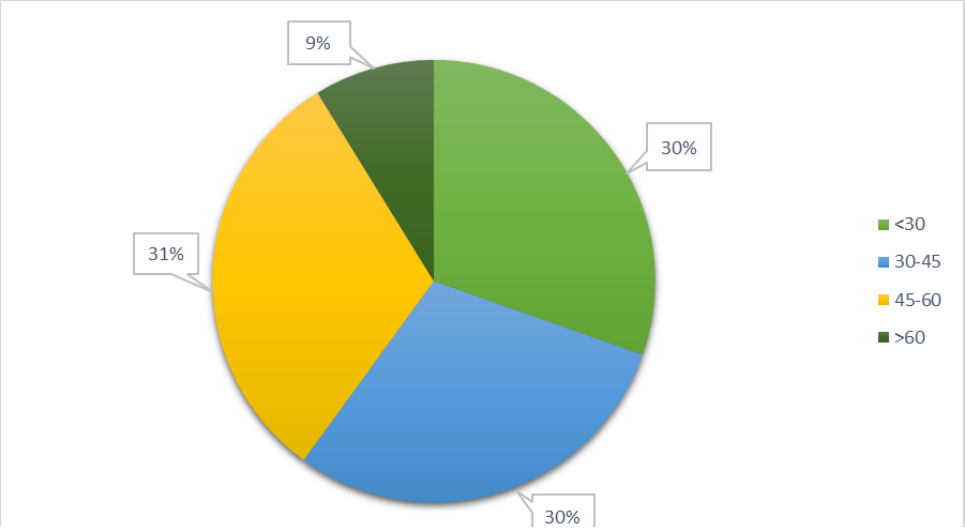

Figure 4: Ages of the respondents who participated in survey

Gender of the Respondents

Q: Gender of the respondent filling out the questionnaire.

This data somehow shows the ratio of females working in our construction industry. As in the construction industry of Pakistan, mostly male workers prefer to work on construction sites. Trend of females working as a site engineer or on site is quite low in the construction industry of Pakistan

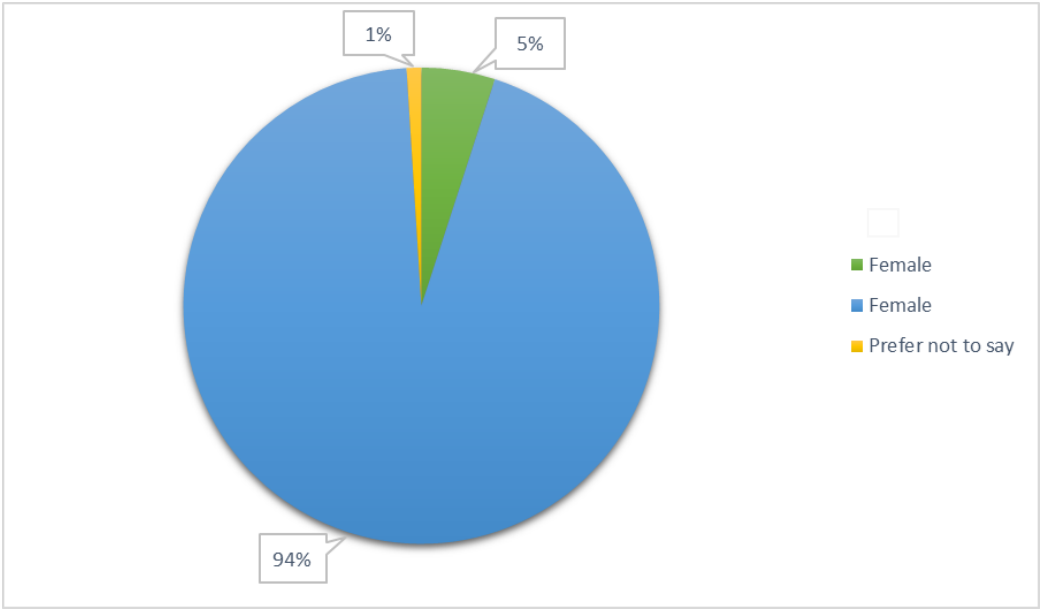

Figure 5: Shows the gender of the respondents

Perception of Quality

Q: What is your organization's perception of quality?

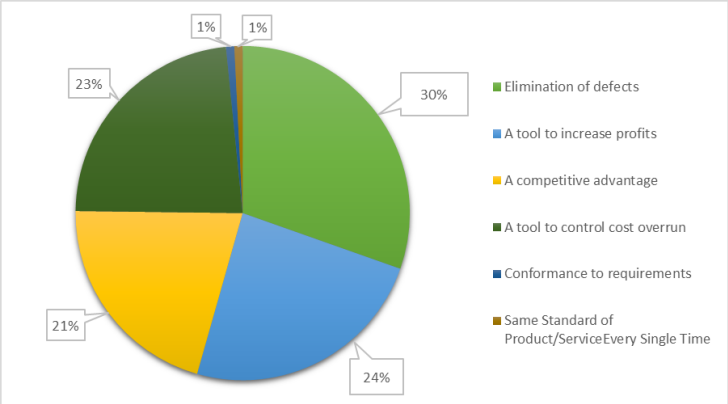

Figure 6: Shows the Perception of Quality

This data is about how different respondents perceive quality or what is the level of perception of quality in their organization. The results show that most of the people working in construction industry take quality as a tool for elimination of defects, then at the secondary position quality is considered as a tool to increase profits and the result obtained at third level is the consideration of quality as a competitive advantage as quality assurance and control helps the organization to maintain a good quality by increasing the profits and attracting the customers towards the organization following quality standards. At fourth position, it is considered that quality is a tool to control cost overrun and then at fifth rank as a tool for conformance to requirements, this shows that some organizations just follow quality in order to fulfill the customer's requirements, not as a part of their organization's policy. Least rating was given to the term that quality is followed to maintain same services every time.

Importance of Quality

Q: How would you rate importance of quality?

This question is about the importance of quality in the construction industry. The obtained data shows that 57% of the firms consider quality as a very important part of their organization and try to provide quality services, the rest of 27% consider quality as important but they do not consider it as a priority and 16% of the firms follow quality just as per the requirement of the customer, not as an essential part of their organization's policy.

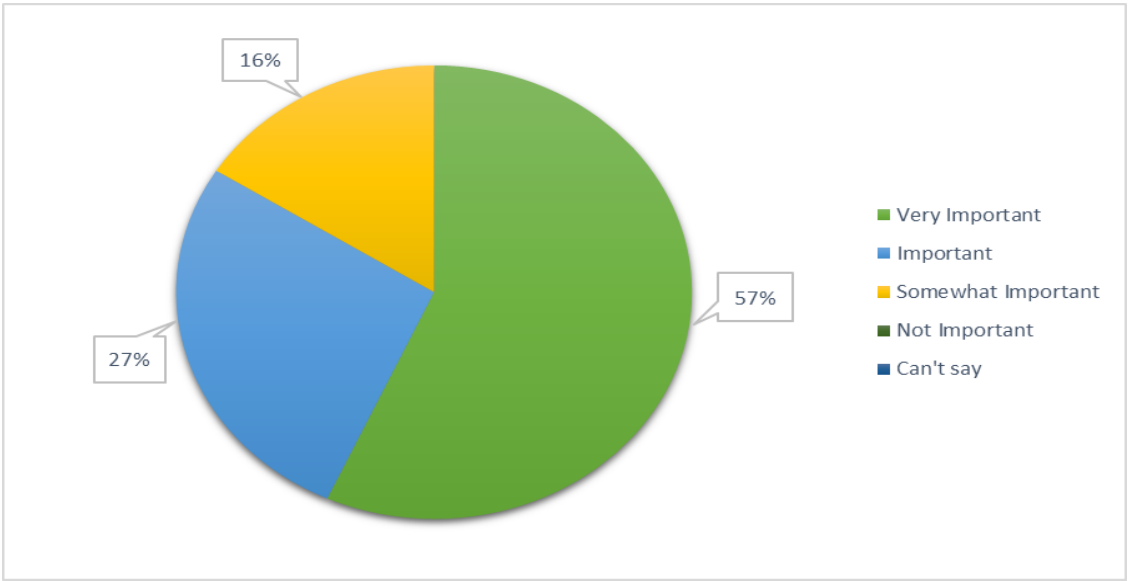

Figure 7: Importance of Quality

Order of importance

Q: Write down the order of importance of quality in your organization?

This question is about the order of importance of quality in the construction industry and is a sub-part of previous question asked by the respondents. This shows the ranking of factors that are part of the construction project and depicts the importance of quality in construction industry as per the point of view of respondents.

This data shows that first preference is scope in any construction project that project should be within the scope assigned to the project, at the second rank, comes the quality which is important in order to save the time and money in the construction projects, third important factor is the schedule as timeline of the project should be maintained, the fourth important factor came out to be the cost/budget of the project as it can be compromised due to reworks and operation and maintenance and unfortunately, the least important factor came out to be the safety in construction projects as it should be a priority but it is not considered as an important one in the construction industry of Pakistan as per the responses collected by the respondents working in the construction organizations.

In order of preference from 1 to 5, the results are:

Table 1: Order of the importance of quality

Factors	**Rating**
Scope	1
Quality	2
Schedule	3
Cost	4
Safety	5

Quality improvement program

Q: What type of quality improvement program do you have?

This data shows that how many construction organizations have a quality improvement program and the results obtained show that major number of organizations i.e., 49% follow quality assurance and quality control system which go side by side along the project, then at the second position Total quality management (TQM) program is followed in the construction industry which involves long term success of project through customer satisfaction, the third factor is ISO 9000 that is followed by 18% of the organizations as it involves quality management and quality assurance in order to maintain efficient quality system and 11% of the organization do not follow any kind of quality control program in their organizations.

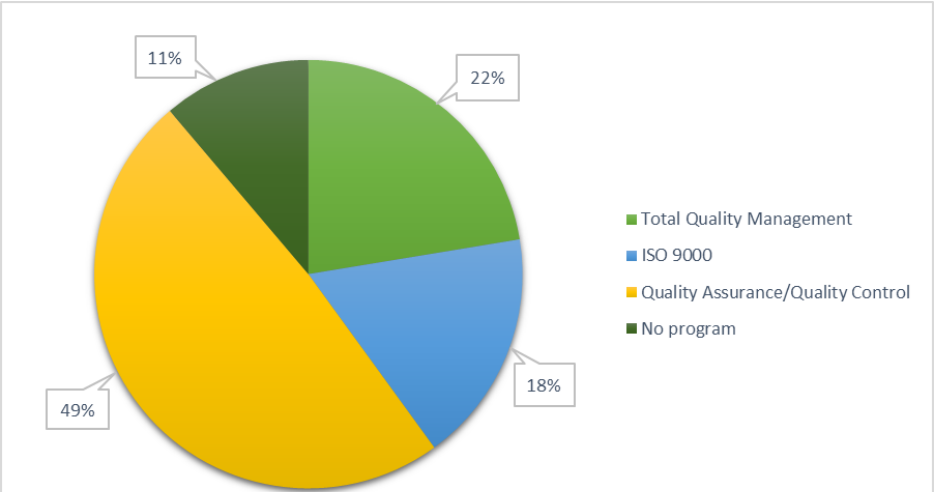

Figure 8: Quality improvement program

Major objectives of program

Q: What are the major objectives of your quality improvement program are?

This question is related to the previoue one and collects inforation about the objective of quality improvement program implememnted in the organziation. According to major number of respondents i.e., 27%, the purpose of quality management program is to increase the productivitiy in their firm/organization, 24% of the organizations follow quality management program for cost reduction as implementation of quality reduces the failure costs, rest of 24% of the respondents respond with the result that organziations do follow quality management program in order to comply with statutory authority i.e., to obey the law or to implement the quality policy as per standardization, other 23% of the organizations follow quality management progaram in order to involve their employees in quality building effort i.e., for the awareness of employees related to quality, less than 1% of the organizations follow quality program to reduce cost with maximu scope in least time.

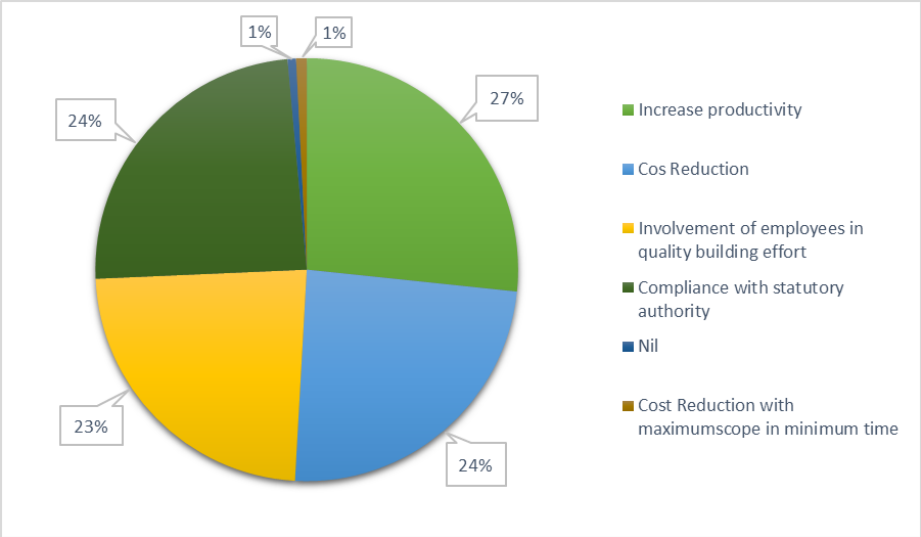

Figure 9: Objectives of Quality observed in different projects

Quality policy

Q: Has your organization developed a clear quality policy?

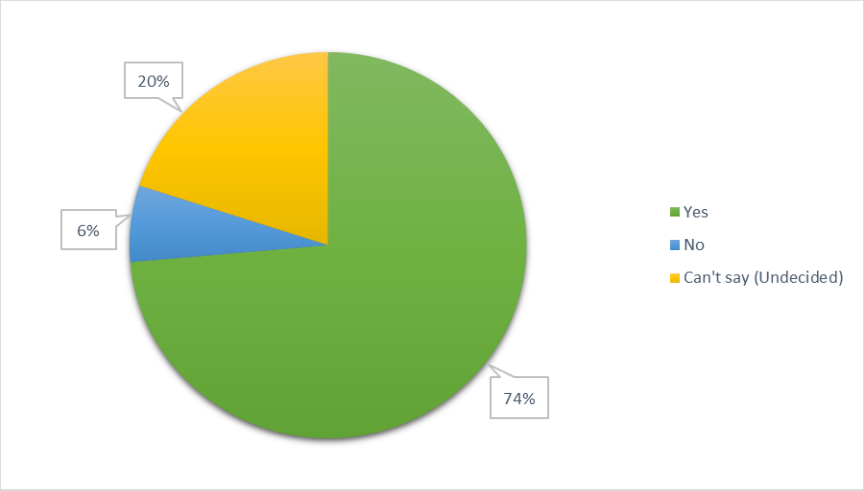

Figure 10: Response of different firms to the question on developing clear policy

This question relates to the fact that either your organization developed a clear quality policy or not. Results show

that 74% of the organization working for building construction have developed quality policy, 6% of the organizations have not developed any kind of quality policy in their organization and rest of the 20% organizations do not have yet a clear idea about the development of quality policy in their organizations.

Quality definition

In your opinion, which of these words best define quality?

This data defines quality as per the perception of respondents working in the construction industry of Pakistan. The data shows that the main purpose of following quality in their organization is to satisfy the external customer i.e., clients, in order to get a positive response from the external customer, at the second ranking comes the factor Value for money as by following the quality the customer can get the valuable services, the third preferred factor is the appearance which means that by following the quality appearance of the product/service gets much better and we can clearly predict good quality by the appearance of product/service. Fourth ranked factor is the increase in profits i.e., for the success of any firm/organization the important factors is customer's satisfaction which usually results in profit enhancement. Teamwork is the fifth ranked factor which means that quality can be achieved by teamwork and proper communication, quality can also be considered to satisfy internal customer (within organization) and by survey this factor came out to be the seventh important one, the least factor that is considered by reading the word quality is the high cost because sometimes it is expensive to follow the quality or plan quality management in short term construction projects.

In order of preference from 1 to 7, the results are:

Table 2: Responses of difference organizations on the question of what quality means to them

Factors	**Rating**
Satisfying external customer (Outside organization)	1
Value for money	2
Appearance	3
Increased profit	4
Teamwork	5
Satisfying internal customer (Within organization)	6
High cost (Expensive)	7

Factors affecting Project's COQ

This question relates to the Possible adverse impact of some factors on Projects' cost of quality. Following are the results obtained from the Questionnaire survey about the factors that affect cost of quality of a construction project after calculating their Relative Importance Index and Mean Item Score method.

These factors are collected from the literature review, group discussion and interviews and are noticed as the ones that affect the projects' cost of quality in a positive or negative way. Some factors may have a low impact on projects' cost while others affect highly on projects' cost of quality and result in the increment of the failure costs, if not properly mitigated at the initial stage.

Ranked factors affecting COQ using RII & MIS

Some of the factors were selected in order to find out their impact on the cost of quality of construction projects. The method used for the calculation of their criticality index is Relative importance index and Mean item scoring method. The results are displayed in tabular form in Table 3.

These factors are extracted from group discussions, literature study and interviews and later weighted as per the responses of the respondents from questionnaire survey. As per the response given by the respondents the factors are arranged as per their sequence in the questionnaire, providing them a weighted average named as Relative importance index. Relative importance index ranks the factors as per their relative importance by using a specific formula and putting down the values into the formula provided by the respondents.

Factors that affect the project's cost of quality include the duration of the project, it's location and size. Also, these factors include the experience of supervision team, wages of labors, skill level of labors, type of client and

class of contractor as these factors play important role for the successful completion of the project.

Factors like design errors. Condition of weather, accidents happening on site, equipment downtime, defect in materials and execution errors also play an important role in construction projects as minor defects in any of these factors can cause major effects on the total cost of the project and also can cause a delay in the timeline of the project which in the end results in the increment of the cost of the project and project goes over budgeted.

Also, some factors like plan of improvement of quality, advanced construction techniques and planned cost for the quality control system play significant role in construction and can cause a tremendous change in the cost of quality of a construction project.

All these factors play their own part in the cost of quality of a construction project and these should be focused during initiation of the project so that loss can be minimized at maximum rate and project can end with proposed budgeted rate and proposed timeline.

For ranking of the factors that affect the cost of quality of the project in construction industry, Relative importance index and Mean item score method is used, as these methods are effective for extraction of results from the questionnaire and are reliable to be used in the research work. Relative importance index is a weighted average method and Mean item score is a simple mean method which includes summation of the results and taking average of their sum.

Results are then ranked I the same order of the circulated questionnaire as per their Relative importance index (RII) and Mean item score (MIS) in tabular form as given in Table 3 and Table 4.

Table 3: Factors affecting COQ with their RII (Unsorted)

Factors	**RII**
Project Duration	55.84
Efficient quality management system	63.2
Supervision team experience	61.92
Project complexity & size	64
Project location	61.28
Awareness of quality for project team	60.32
Class of contractor	62.24
Prequalification of contractor	59.52
Client type	59.52
Labor skills	59.36
Percentage of Rejected Submittals	53.12
Prequalification of Suppliers	59.2
Type of contract	55.2
Wages of labor	56.32
Labor turnover	55.52
Design errors	60.96
Plan of improving quality	59.68
Accidents on site	54.56
Defected material	54.56

Equipment downtime	52.8
Execution errors	56
New construction techniques	58.4
Weather conditions	55.84
Procurement & Supply chain	59.36
Special construction engineering requirements	56

Table 4: Factors affecting COQ with their MIS (Unsorted)

Factors	**MIS**
Project Duration	2.792
Efficient quality management system	3.16
Supervision team experience	3.096
Project complexity & size	3.2
Project location	3.064
Awareness of quality for Project team	3.016
Class of contractor	3.112
Prequalification of contractor	2.976
Client type	2.976
Labor skills	2.968
Percentage of Rejected Submittals	2.656
Prequalification of Suppliers	2.96
Type of contract	2.76
Wages of labor	2.816
Labor turnover	2.776
Design errors	3.048
Plan of improving quality	2.984
Accidents on site	2.728
Defected material	2.728
Equipment downtime	2.64
Execution errors	2.8
New construction techniques	2.92
Weather conditions	2.792
Procurement & Supply chain	2.968
Special construction engineering requirements	2.8

Categorization of Factors affecting COQ

Factors affecting Cost of quality are above discussed using Relative importance index and Mean item scoring method and below is the categorization of these factors given in Table 5. Each project is unique in nature and carries its own properties and all these factors vary from project to project.

Factors are collected from literature study, group discussions and interviews and later categorized as per their nature. As it can be seen that the nature of the project involves the study of its size, geographical location, planned budget for controlling quality and the planned timeline of the specific project.

The next category is about contractual terms which includes procurement of either materials or machinery, supply chain management, prequalification of the suppliers and of contractors, contract type involved in the project and plan of quality improvement.

The next category defines factors related to the execution of the project and it involves errors in design stage, advanced construction techniques, errors during the execution phase, special engineering construction techniques

requirements, weathering conditions, accidents and hazards on site, delivery and identification of defected material on site, percentage of the rejected submittals and equipment downtime.

Last category involves workforce required for the construction project which involves following factors: experience of the team supervising the project, type of the contractor hired for the construction, project team's awareness related to the quality, type of client involved, skill level of labor and their wages and rate of turnover of labors.

These categories are part of the projects' cost of quality as the factors involved in these broad categories are effective on the construction and could be a reason of criticality of the construction project. These factors, if not properly mitigated, could result in horrible affects in the form of over budgeting and exceeding timeline.

Table 5: Categorization of factors affecting COQ

Factors
Project Nature
Project complexity & size
Project location
Efficient quality management system
Project Duration
Contracts
Procurement & Supply chain
Prequalification of Suppliers
Prequalification of contractor
Type of contract
Plan of improving quality
Execution
Design errors
New construction techniques
Execution errors
Special construction engineering requirements
Weather conditions
Accidents on site
Defected material
Percentage of Rejected Submittals
Equipment downtime
Workforce
Supervision team experience
Class of contractor
Awareness of quality for Project team
Client type
Labor skills
Wages of labor
Labor turnover

Ranking of factors from Highest to Least RII value

Factors that have an impact on cost of quality are important to be identified before time so that they can be rectified and cost of quality can be minimized too. Ranking of these factors as per their Relative importance index (RII) is provided in Table 6 and their Mean item score (MIS) is shown in Table 7. Both of these methods are effective to find out the importance index of any kind of factors and are reliable for the research purposes.

The factors are ranked as per their criticality as per the responses of the respondents collected from the questionnaire survey. The factors that are ranked as highly critical include Project complexity & size, Efficient

quality management system, class of contractor, supervision team experience, project location, design errors, awareness of quality for project team, plan of improving quality, prequalification of contractor and client type. These factors are marked as critical for the construction purpose as they effect the cost of quality at higher rates.

The factors having medium effect over the projects' cost of quality are ranked in the following sequence including labor skills, procurement & supply chain, prequalification of suppliers, new construction techniques, wages of labor, execution errors, special construction engineering requirements, project duration, weather conditions and labor turnover. These are the factors that should be focused after the most critical ones in any construction project.

The ones who have least impact on the projects' cost of quality include type of contract, accidents on site, defected material, percentage of rejected submittals and equipment downtime. These factors have not a high impact on projects' cost of quality but still they can play their role by increasing the budget or timeline so they should be carefully handled at the start of the project in order to minimize the losses ate the end.

Factors having ranking from 1 to 10 are termed as critical ones, numbering from 11 to 20 are the ones having medium impact and rest of the factors numbering from 21 to 25 are termed as the least critical ones for the projects in construction industry.

The factors that have highest impact on the projects' cost of quality are discussed in detail below:

Project complexity & size is the most critical factor having highest impact on projects' cost of quality as by increasing the size of the project chances of errors increase and quality should be of main focus in such cases as a minor mistake can result in a huge loss.

Proper budget comes at the second rank that should be allocated for quality controlling system before initiating the project so that if any error occurs in the project there won't be an over budgeting. A specific amount of budget as per the size of the project should be kept safe at side for quality control purposes.

Selection of the project is also an important factor and is rated as the third important factor that should be mainly focused before project commencement. As the relevant contractor can do the construction more efficiently, also he will be able to control the team in more productive way. In the contrast, if the contractor is not relevant to the work or not able to manage the team properly then major losses will occur which can be worse for the reputation of the organization.

The fourth important factor is the team built up for supervision, so this team should have maximum experience so that it would be easy for the team to manage the project efficiently. This will promote the teamwork in the organization and under the right supervision each team member will focus on his own work in a much better way which will result in the growth of the construction industry.

The fifth one is the project's location. Geographical location of the project is of great importance as when it comes to procurement then the remote sites have to face some difficulties in this process. So, location of the project should be identified and budget should be allocated as per the location factor including all the additional amounts that are going to be consumed during the travelling of the materials or machineries. Also, in some areas, there are no experienced worker available so proper training is also required in such cases which eats up much amount of the budgeted cost. Each and everything should be kept in notice in order to successfully complete the project.

Design errors come at the sixth preference but are as critical as the above factors are. Errors during the design phase should be mitigated as early as possible because if these errors continue into the execution phase of the project then it becomes more difficult to mitigate them and it demands more budget and additional time. There should be proper check of the errors in design phase so that each of the team member work properly and do not have to do additional work over dismantling and redesigning.

Another important factor, ranked as seventh one, is the awareness of project team regarding to quality. The team should be trained enough to pay focus on the quality of the project. Quality of the project should not be minimized in any case as it can be much more harmful as it seems in the start. Every team member should be well aware of the fact that quality is of great importance and it cannot be set aside.

The eight importantly ranked factor is the plan for improvement of quality. There should be a proper plan designed

for continuous improvement of quality by making amendments as the time passes by. Plans should not be static, rather they should be improved as per the advanced techniques.

Prequalification of contractor is the ninth ranked important factor to be focused on. Prequalification of contractor is an important process to be carried out for selecting the appropriate contractor for the execution of the construction project. Only a properly well trained and relevant to the project contractor can do his work efficiently and can hold the team in an efficient way through proper communication and guidance.

The factor that came u as the tenth critical one is client type. Client is an entity that provides funding for carrying out the construction either in a direct or an indirect way. Client can be a single person or group of persons taking part in the project's funding. Client can be of a private sector project or a public sector project. In case of public sector projects, the budget is defined and project should have to be completed within the allocated budget and timeline and is more restrictive while in case of private projects, there can be a chance of additional payment over changing of the nature of work. So, as per the type of client, proper processes should be followed in order to minimize the failures and losses in the construction projects.

Table 6: Ranking of factors affecting COQ using RII (sorted)

Factors	**RII**	**Rank**
High Effect		
Project complexity & size	64	1
Efficient quality management system	63.2	2
Class of contractor	62.24	3
Supervision team experience	61.92	4
Project location	61.28	5
Design errors	60.96	6
Awareness of quality for Project team	60.32	7
Plan of improving quality	59.68	8
Prequalification of contractor	59.52	9
Client type	59.52	10
Medium Effect		
Labor skills	59.36	11
Procurement & Supply chain	59.36	12
Prequalification of Suppliers	59.2	13
New construction techniques	58.4	14
Wages of labor	56.32	15
Execution errors	56	16
Special construction engineering requirements	56	17
Project Duration	55.84	18
Weather conditions	55.84	19
Labor turnover	55.52	20
Low Effect		
Type of contract	55.2	21
Accidents on site	54.56	22
Defected material	54.56	23
Percentage of Rejected Submittals	53.12	24
Equipment downtime	52.8	25

Table 7: Ranking of factors affecting COQ using MIS (sorted)

Factors	MIS	Rank
High Effect		
Project complexity & size	3.2	1
Efficient quality management system	3.16	2
Class of contractor	3.112	3
Supervision team experience	3.096	4
Project location	3.064	5
Design errors	3.048	6
Awareness of quality for Project team	3.016	7
Plan of improving quality	2.984	8
Prequalification of contractor	2.976	9
Client type	2.976	10
Medium Effect		
Labor skills	2.968	11
Procurement & Supply chain	2.968	12
Prequalification of Suppliers	2.96	13
New construction techniques	2.92	14
Wages of labor	2.816	15
Execution errors	2.8	16
Special construction engineering requirements	2.8	17
Project Duration	2.792	18
Weather conditions	2.792	19
Labor turnover	2.776	20
Low Effect		
Type of contract	2.76	21
Accidents on site	2.728	22
Defected material	2.728	23
Percentage of Rejected Submittals	2.656	24
Equipment downtime	2.64	25

Critical Factors effecting COQ

Most crucial factors for a construction project that affect the cost of quality of a construction project in Pakistan are categorized using data collected from questionnaire surveys, group discussion and interviews in Table 8 also they are ranked as per their Relative Importance Index and Mean Item Score that is also presented in the same table.

The most critical factor in Pakistan's Construction industry is the Project complexity & size as per the result of Questionnaire survey. As the construction industry of Pakistan is under development so our most of the focus should be on controlling the budget and timeline of the project as per the size of project. For large size projects, it becomes difficult to control the projects' budget and timeline inside the limitations.

Project complexity & size should be at first priority, everything should be managed in accordance with the size of the projects. Budget for controlling quality should be allocated as per the size of the project because when the

larger sized project is constructed, the more it will become important to spend most of the budget or to allocate the budget for the prevention purposes.

Proper budget comes at the second rank that should be allocated for quality controlling system before initiating the project, selection of the project is also an important factor and is rated as the third important factor that should be mainly focused before project commencement, the fourth important factor is the team built up for supervision, so this team should have maximum experience so that it would be easy for the team to manage the project efficiently, the fifth one is the project's location. Geographical location of the project is of great importance as when it comes to procurement then the remote sites have to face some difficulties in this process, design errors come at the sixth preference but are as critical as the above factors are because they also play an important role in over budgeting and exceeding timeline at later stages, another important factor ranked as seventh one, is the awareness of project team regarding to quality, the eight importantly ranked factor is the plan for improvement of quality. There should be a proper plan designed for continuous improvement of quality, prequalification of contractor is the ninth ranked important factor to be focused on. Prequalification of contractor is an important process to be carried out, the factor that came out as the tenth critical one is client type. Client is an entity that provides funding for carrying out the construction either in a direct or an indirect way.

Table 8: Top Critical factors as per RII & MIS method

Factors	RII	MIS	Rank
Project complexity & size	64	3.2	1
Efficient quality management system	63.2	3.16	2
Class of contractor	62.24	3.112	3
Supervision team experience	61.92	3.096	4
Project location	61.28	3.064	5
Design errors	60.96	3.048	6
Awareness of quality for Project team	60.32	3.016	7
Plan of improving quality	59.68	2.984	8
Prequalification of contractor	59.52	2.976	9
Client type	59.52	2.976	10

Types of Costs with their Percentages

Q: Select the specific range of percentage of total cost incurred during Design & Construction phase in your project in following categories.

This section is about the percentages of total budgeted costs incurred on conformance to quality i.e., prevention and appraisal costs and non-conformance to quality i.e., Internal failure and External failure costs.

Overall Cost of Quality categories along their percentages

Using data from questionnaires the following result has been concluded in the form of percentage of the total budget spent over Prevention, Appraisal, Internal failure and External failure costs. The data is collected out directly from the questionnaire without sorting out and is presented in Table 9.

Prevention costs come under the conformance costs and include those costs which are to be planned before the commencement of the construction project. These are the costs that should be planned at the start in order to minimize the losses.

Appraisal costs are the ones which move side by side along with execution process and are important to be planned as remodifying the errors as soon as the defect occurs can be much helpful then leaving the errors unmodified.

Internal failure costs are the ones that happen before handing over of project in the forms of reworks and repairing and maintenance either due to inefficient labor, defective materials or faulty machinery used during the construction of the project.

External failures are the ones that occur after handing over the project and theses kind of errors result in the loss of profits by delivering the faulty products, loss of reputation and in the forms of repairs that come inside warranty timing.

Summation of all the percentages of all of these costs spent during the construction of building projects is calculated by simply adding up the responses and dividing them by the total number of responses. All the factors have their own percentages as per the perception of the respondents.

Table 9: COQ categories with their percentage

Conformance Quality	
Prevention Costs	**Percentage**
Filling out documents	17.104
Education/Training	21.368
Review of contract	18.312
Review of design	18.672
Prequalification of contractor	18.664
Quality team build-up	19.728
Supervision of Prevention	20.032
Technical support to suppliers	19.64
Appraisal Costs	**Percentage**
Cost of testing & inspection of materials	14.16
Cost of final product's testing & inspection	13.904
Quality Supervisor's cost	16.088
Equipment cost (used for quality testing)	15.784
Field testing	17.192
Test vehicles	15.504
Non-Conformance Quality	
Internal Failure costs	**Percentage**
Rework	15.728
Repair	14.984
Retesting	14.136
Disposal of defective product	15.984
Design Errors	20.48
Scope changes/Change orders	20.68
Poor Supervision	18.008
Material losses/Defective material	17.752
Material Overrun	17.496
Equipment downtime	17.848
Rework labor and Overhead cost	17.928
Delay in schedule	19.28
Over-budgeting	19.416
Fatalities	16.384
Retesting/Reinspection	16.616
Accidents on site	14.144
External Failure costs	**Percentage**
Repair after handing over	11.96

Cost of servicing & handling complaints	12.648
Warranty repairs	16.176
Replacement costs	19.456
Lost sales due to poor quality manufactured products	15.32
Returns and allowances	17.712

Cost Categories with highest to least percentages

Types of costs that have an impact on Project's cost of quality were identified and organized in tabular form and their respective percentages were being collected using questionnaire survey and the data is sorted out from highest to least percentage as given in the Table 10.

The costs that are having highest percentages and come under the first ten include training or education of the employees, change orders or changes in scope, errors occurring during the design phase, supervision of the team for prevention, building up the team as per quality standards, provision of technical support to the suppliers, cost for replacement, over budgeting, schedule delaying and design review. These costs are the ones that eats up high percentages out of the budget assigned to the project.

Training/education takes 21.4% of the budgeted cost and thus ranked as the first one coming under prevention category, at the second rank comes the change order or changes in the defined scope which can cause you a cost of 20.7% that is very high and it is categorized as internal failure cost, then the third one is about the design errors and it takes 20.5% of the total budget and comes under internal failure costs occurring in the project, then at the fourth rank comes the supervision of prevention which relates to the prevention costs and costs 20% of the budgeted cost, at the fifth rank comes quality team build up process which take 19.7% of the total budget and includes making up a quality team for the successful completion of the project and is referred as prevention cost, provision of technical support to the suppliers have sixth highest percentage amount of 19.6% and is related to the prevention category; this cost includes educating the suppliers about the technical issues arising during their work, seventh important cost is the cost for replacement and causes 19.5% of the total budget; this cost includes replacement of any existing faulty product or removal of the low quality product by replacing it with a high quality one an comes under external failure costs, 19.4% of the total cost exceeds due to over budgeting and this comes under the costs that occur due to internal failures of the organization, at the ninth rank comes the schedule delay which is related to the internal failure cost and mostly happening in almost every construction project; this cost exceeds 19.3% of the total budget allocated for the construction project, the tenth critical cost came out as review of design and is located under the prevention category; the cost spent over this cost is 19.3% of the total budgeted cost; this cost is basically related to reviewing of the design proposed for the construction project as it should be an essential part of the project to review the errors beforehand so that they can be mitigated on time without delaying the schedule.

Rest of the costs include prequalification of contractor, review of contract, poor supervision, rework labor and overhead cost, equipment downtime, material losses/defective material, returns and allowances, material overrun, field testing, filling out documents, retesting/reinspection, fatalities, warranty repairs, quality supervisor's cost, disposal of defective product, equipment cost (used for quality testing), rework, test vehicles, lost sales due to poor quality manufactured products, repair, cost of testing & inspection of materials, accidents on site, retesting, cost of final product's testing & inspection, cost of servicing & handling complaints, repair after handing over.

All of these costs carry out some specific percentage as per the nature and the complexity of the project. This data shows that you have to spend more on prevention for saving a large amount of internal and external failures at later stages. Most of the companies ignore the prevention costs as they take a part of budget to be allocated specifically for the prevention purpose but these costs save the internal and external failure costs by saving the time spent in remodifying the errors and by saving much amount of the budget allocated to that specific project.

Table 10: Overall COQ from High to Low percentage

Cost of Quality (COQ)	Percentage
Education/Training	21.368
Scope changes/Change orders	20.68
Design Errors	20.48
Supervision of Prevention	20.032
Quality team build-up	19.728
Technical support to suppliers	19.64
Replacement costs	19.456
Over-budgeting	19.416
Delay in schedule	19.28
Review of design	18.672
Prequalification of contractor	18.664
Review of contract	18.312
Poor Supervision	18.008
Rework labor and Overhead cost	17.928
Equipment downtime	17.848
Material losses/Defective material	17.752
Returns and allowances	17.712
Material Overrun	17.496
Field testing	17.192
Filling out documents	17.104
Retesting/Reinspection	16.616
Fatalities	16.384
Warranty repairs	16.176
Quality Supervisor's cost	16.088
Disposal of defective product	15.984
Equipment cost (used for quality testing)	15.784
Rework	15.728
Test vehicles	15.504
Lost sales due to poor quality manufactured products	15.32
Repair	14.984
Cost of testing & inspection of materials	14.16
Accidents on site	14.144
Retesting	14.136
Cost of final product's testing & inspection	13.904
Cost of servicing & handling complaints	12.648
Repair after handing over	11.96

Broad categorization of COQ categories

Using results from the questionnaire survey and after the collection of the respective percentage of different types of costs consumed during the construction of a building project the following table is formed having collective percentages of various types of costs spent over quality during their construction.

This data shows that cumulative Prevention cost is higher than the Appraisal, Internal failure and External failure cost, which shows that if you spend over prevention which is before the initiation of the project you can save the amount to be spent later on the failures.

Most of the construction companies do not plan prevention before the initiation of the construction projects and eventually they have to face failure costs in an amount double to the prevention cost.

Prevention costs are higher in amount but they are refundable i.e., if you plan prevention on time you will save the failure cost eventually which usually comes out to be the double of prevention cost.

All the four broad types of costs are given in Table 11. This data includes prevention costs which carries 15.5% of the total budget to be specifically allocated for prevention purposes, then we have the appraisal costs which move along with the execution process and takes 12.3% of the total budgeted amount, internal failure costs are the ones that occur before handing over the project and takes 13.9% of the total budget and the category named as external failure costs that are related to the cost occurring after handing over the project to the client, these costs eat up to 12.6% of the total budgeted cost also causing many other disadvantages to the organization that tare unhidden at the moment but appear as the time passes by i.e., loss of reputation.

Table 11: Broad categorization of COQ categories

Type of Costs	**Percentages**
Prevention Costs	15.52
Appraisal Costs	12.3
Internal Failure Costs	13.9
External Failure Costs	12.6

Cost of Quality calculation

Cost of quality spent over a building project can be find out in the form of controlling costs and controlling failure costs, using data from questionnaire surveys, can be calculated using various formulas as already elaborated.

Total Cost of Quality (COQ_T)

Total cost of quality is the sum of all costs including all kind of Prevention costs, Appraisal costs, Internal failure costs and External failure costs. All of the types of costs spent over quality combine to make total cost of quality.

Total cost of quality can be found using *Equation 1*

COQ_T = Prevention Cost + Appraisal Cost + Internal Failure Cost + External Failure Cost

COQ_T = 15.52+12.3+13.9+12.6

COQ_T = 54.32%

This calculation shows that half of the cost of construction of a building project is consumed by the quality. This shows the importance of quality and this clearly shows that quality should be of prime importance during the construction of any kind of project. Ignorance of quality can lead to disastrous effects including lost sales, poor repute and also can cause complete shutdown of the organization.

Cost of Good Quality (COGQ)

Cost of Good Quality includes only Prevention costs and Appraisal costs which means that this cost is related to the quality control before handing over the project. This cost basically involves the budget reserved for the omission of the failures and for rectification of the failures during the project completion process i.e., operational phase.

Cost of Good Quality can be found using *Equation 2*

COGQ = Prevention Cost + Appraisal Cost

COGQ = 15.52+12.3

COGQ = 27.82%

This result shows that almost 28% of the cost of project is consumed in controlling the quality in construction project of Pakistan. Cost of Good Quality includes the prevention and appraisal costs which are an important part of the projects' budget. Specified budget should be allocated for the Cost of Good Quality which can be utilized during the project and if remain untouched then it can be considered as the increase in profit.

Cost of Poor Quality (COPQ)

Cost of Poor Quality includes only Internal failure costs and External failure costs and these costs always result in the budget overrun of the construction project and should be minimized in order to avoid poor services and products.

Cost of Poor Quality can be found using *Equation 3*

COPQ = Internal Failure Cost + External Failure Cost

COPQ = 13.9+12.6

COPQ = 26.5%

This data shows the cost spent over controlling the failure done by the organization either in the form of any kind of loss. This cost includes internal and external failure cost of a project. This shows that if you are not willing to spend on prevention then you will have to loss almost 27% of your total budget over controlling the failure.

Conclusion

In conclusion, the research conducted offers critical insights into the state of quality management practices within Pakistan's construction industry, specifically focusing on the design and construction phases of building projects. Through a robust quantitative methodology involving data collection from 125 questionnaires, group discussions, and interviews, a pervasive lack of emphasis on quality management practices has been revealed, with numerous organizations failing to allocate adequate budgets for quality assurance and control. This dearth is compounded by the absence or ineffective enforcement of clear quality policies.

The identified critical factors affecting the Cost of Quality (COQ), notably project complexity and size, efficiency of quality management systems, contractor classification, supervision team experience, and project location, elucidate the multifaceted nature of quality challenges prevalent within the sector. Particularly pertinent is the recommendation to pay heightened attention to project size and complexity in Pakistan's context, given the exigency for heightened safety measures on-site.

This study significantly contributes to the existing body of knowledge by quantifying the total COQ and delineating its constituent elements: prevention costs, appraisal costs, internal failure costs, and external failure costs. These findings provide empirical evidence of the financial repercussions associated with overlooking quality management.

Practitioners within the construction industry are strongly encouraged to prioritize quality improvement initiatives by formulating clear quality policies, judiciously allocating resources, and establishing dedicated quality control management departments within their organizations. Such actions, underpinned by empirical insights, advocate for a transformative shift towards proactive quality management methodologies.

In summary, this research underscores the imperative of prioritizing quality assurance and control mechanisms within construction organizations to bolster project outcomes and mitigate financial risks. By addressing the identified deficiencies and implementing the recommended strategies, stakeholders can endeavor to elevate standards of quality in construction endeavors, thereby fostering sustainable development and ensuring the safety and satisfaction of all involved stakeholders.

Limitation of work and future work recommendations

While this research provides valuable insights into the construction industry of Pakistan, it's important to acknowledge its limitations. The focus on structural design and construction phase, as well as exclusively on building projects, may limit the applicability of findings to broader contexts. However, the inclusion of both private and government construction companies in the questionnaire survey enriches the data diversity. Moreover, the comprehensive assessment of the cost of quality through multiple data collection methods demonstrates the thoroughness of the research. These limitations present opportunities for future studies to expand the scope and enhance the depth of understanding within the field.

Research efforts should focus on assessing the long-term impact of quality management practices on project outcomes, conducting benchmarking studies to identify best practices, exploring the integration of emerging technologies in quality management, investigating cross-cultural perspectives on quality management, examining sustainability integration in quality management frameworks, and studying the human factors that influence the effectiveness of quality management initiatives.

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