CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Development of a Quality Management Framework from Current Practices for Mid-Rise Building Construction in Local Industry

by

Hafiz Yousaf Shehzad

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To my beloved parents, your love, sacrifices, and unwavering support have been the cornerstone of my journey. This work is dedicated to you, the pillars of strength in my life. Your encouragement, guidance, and countless sacrifices have shaped me into the person I am today. Thank you for being my inspiration and for providing me with the tools to navigate life's journey. This is for you. With heartfelt gratitude,

CERTIFICATE OF APPROVAL

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(Hafiz Yousaf Shehzad)

Abstract

These days, one of the most significant sectors is construction. As it grows, so does the need for new equipment and methods of construction, which keeps growing daily. Researchers and engineers from all over the world are working hard to develop novel solutions for the issues encountered in the construction industry. Participants in construction sector are beginning to realize that taking the lowest bid does not always translate into best value. It is difficult to implement value based procurement strategy, especially for Pakistan public sector clients who are unable to assess competitive bids using lowest bid award procedure alone. The main issues faced includes substandard quality of material, high standard of litigation and claims, frequest schedule and cost overruns have emerged as principal characteristics of public construction works contracts in Pakistan. The objectives of this study are to detect and examine the major factors affecting low bid from contractors' perspective.

This work is based upon the feedback from contractors firms. The technique used for short listing the factor is delphi technique factors were identified through critical literature review. It took place in three rounds and different experts were selected for this cause and they shortlisted 52 factors. These factors were categorized into 5 tentative factors including bidding process, contractors characteristics, project characteristics, client characteristics and market conditions. Questionnaire was being developed and distributed among contractor firms for data collection.The response rate 74.3% which is satisfactory. Analysis was done using SPSS in which reliability test and normality test were examined. Reliability test was satisfactory so further proceeded to normality test. Normality test was to access data pattern which results in non-parametric test

For evaluation of perception of respondents Kruskal Walis test was applied which shows that the data is positive. Using AHP pair wise comparison was constructed for each group, consistency index and consistency ratio was also calculated which verified the data to proceed. Fuzzy comprehensive evaluation was used to evaluate the risk for this first and second level fuzzy evaluation was formulated. In case

of contractors characteristics is 65.957 which is greater then threshold that is 63.71. While the remaining factors bidding process, project characteristics, client characteristics and Market condition are 63.87, 63.669, 65.75 and 59.17. All the identified factors have the significant impact but contractors' characteristics have high impact on low bidding. This study has taught the bidders which are the factors to be focused more while bidding for smooth commencement of construction project to ensure quality, time and cost overrun.

Contents

List of Figures

List of Tables

Abbreviations

AHP	Analytical Hierarchical Framework
BIM	Building Information Modeling
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Consistency Index
CR	Consistency Ratio
CSFs	Critical Success Factors
FCE	Fuzzy Comprehensive Evaluation
FGDMA	Fuzzy Group Decision-Making Approach
FSE	Fuzzy Synthetic Evaluation
IOT	Ineternet of Things
ISO	International Organization for Standardization
MCDM	Multi Criteria Decision Making
OBS	Organization Breakdown Structure
RII	Relative Importance Index
TQM	Total Quality Management
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
RMR	Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling

Chapter 1

Introduction

1.1 Background

While the construction industry appears to be highly organized, it is actually quite erratic. Therefore, new methodologies at managerial or technological level take some time to reach local level. Nevertheless, there are extensive accusations on building sectors related to lack of quality in method utilization for designing projects, execution of projects and the overall outcome [1]. The comprehension and adoption of quality management techniques in construction industry have become crucial in recent years. There are frequent snags and errors, leading to use of more resources (money, equipment, people, materials) to solve the problems. This in turn leads to increased investment of time, or increased cost and sometimes both. Furthermore, the client is directly concerned about projects cost, timeline and overall quality. A number of key elements determine the attributes of finished project like expertise of worker, fast delivery and finish quality. Quality is increasingly recognized as an ongoing process rather than a final goal, requiring continuous effort, assessment, and improvement at every stage. As a matter of fact, adoption of TQM (Total Quality Management) has been reported to be difficult but small as well as large businesses [2].

There is a need for adaption and enhancement of ongoing improvement processes by organizations, in order to survive the current competitive environment. This guarantees appropriate planning and best use of resources. The competitive environment has also increased companies focus on quality and customer service. The outcome is meticulous planning and effective management to improve quality processes. This ensures consistency in provision of high quality service and high level of certainty in customer satisfaction expectations. The business, seen as a whole, can be seen as an effort to capitalize on organizational benefits through continuous improvement of the personnel, processes, goods, and services, as well as the environment. Quality management systems (QMSs) emerged as a result of this movement [3]. QMSs methodologies are used commonly in conjunction with quality assurance programms like ISO 9000 (International Organization for Standardization). Malaysian construction companies are obligated to follow ISO9000 since 2020 to improve quality [4].

The terms quality control and quality assurance are interchangeable. Quality Assurance (QA) refers to a process-oriented system aimed at preventing defects by ensuring that proper methods, procedures, and standards are established before and during execution. This includes preparing method statements, ITPs, SOPs, staff training, and structured checklists to maintain compliance [4]. In contrast, Quality Control (QC) is a product-oriented, reactive process that focuses on verifying whether the executed work meets specified standards through inspections and tests such as material sampling, welding checks, paint adhesion, and concrete cube testing. While QA ensures a culture of prevention and system compliance, QC provides measurable evidence of quality at the product level. Together, both complement each other in safeguarding quality in mid-rise building projects [5]. However, management and quality control are 2 very different processes. Quality control focuses on inspection and examination of finished products. Quality management focuses on prevention of flaws during task performance. Quality management is a difficult process as both people and equipment are of same importance in construction industry. Quality management is applied to every level of business from manual laborers to inspectors of top management. Quality management in construction sector is extremely lacking in regards to implementation of new policies and reforms, and faces plethora of obstacles [6]. The main focus of building industry should be quality as it ensures success of this sector.

This study highlights the current practices for quality management (QM) and development of QM framework for construction industry of Pakistan.

1.2 Research Motivation and Problem Statement

Quality prevention and detection remained an area of great interest of all industry stakeholders such as client, consultant, contractors and suppliers. This become more important since it has direct impact on triple constraints of project like time, cost and scope of the project. So this is kind of one of the most important issues for all stakeholders. A crucial aspect of building construction is quality. It has an impact on the timely completion of projects, customer satisfaction, cost reduction, worker health and safety, and the work and life of the users or occupiers, both directly and indirectly. As a result, quality must be prioritized. The various participants in the construction process are impacted by quality as well. So, it is essential to align time, quantity, and human resources with quality. Thus the problem statement is as follows:

The local construction industry is facing issues related to poor quality culture, impacting project performance and reliability. The major reasons behind the lack of a strong quality culture remain unidentified and under-researched. Current quality management practices in the local construction sector are unclear and may be outdated or insufficient. There is a need to explore practical and effective ways to promote and implement a quality-focused culture within the industry. Without addressing these issues, long-term improvement in construction quality and standards cannot be achieved.

1.3 Research Questions

1. What are the major reasons of poor quality culture in local industry?
2. What is the current practices which local construction industry is following?
3. How can quality culture can be promoted?

1.4 Aims and Objectives

The main purpose of this study is the timely completion of construction projects in the developing country like Pakistan. However, the specific aim of this MS thesis is to access the current quality practices used by local contractors for the identification of strength, weakness and opportunities for improvement. Accordingly this aims to develop a practical framework to promote a strong quality culture and raise construction standards. Moreover, this MS research specifically recommends quality control techniques to improve project efficiency in terms of time and cost.

1.5 Research Scope and Constraints

This study involves collection of data from approximately 100 experts of construction industry and focused mainly on mid-rise (G+6 storey) building projects. The data collection methodology involves use of electronic mail to acquire site information, with the objective to identify key factors leading to lack of quality in construction projects. A structured questionnaire is prepared and distributed to representatives from the client, consultant and contractor parties for assessment. Analysis is done on acquired data via SPSS tool. This analysis helped determine and rank the variables which cause cost overruns in construction programs. The input and output results from SPSS offer meaningful insights into the root causes of poor quality and increased costs, particularly in mid-rise building projects.

1.5.1 Research Constraints

- Data is collected from Rawalpindi and Islamabad only.
- This research collected data from only mid rise building projects.
- Current study uses AHP technique to identify challenges for quality management on construction projects. Findings do not provide cause and effect diagram of each factor.

1.6 Research Novelty, Significance and Operational use

To the best of my knowledge, there is a noticeable lack of research focusing on quality management within Pakistan's construction industry. This academic gap highlights the necessity of the present study, which seeks to explore the factors affecting quality management culture and practices in the local context. Given the limited existing literature, this research aims to offer a thorough analysis of current quality management approaches in Pakistan's construction sector. By investigating the elements that influence these practices, the study aspires to bridge the knowledge gap and provide valuable insights. These findings will not only contribute to academic understanding but also serve as a practical resource for industry professionals and policymakers.

This study tackles a critical issue in the prevailing quality management practices within Pakistan's construction industry. Given the limited academic focus on this topic, there is an urgent need to examine and enhance the quality management culture unique to this sector. The impact of this research extends well beyond academic circles. It holds practical significance for various industry stakeholders, such as construction companies, clients, and regulatory authorities. By pinpointing the key factors that affect quality management and proposing actionable improvements, the study aims to boost project performance, reduce risks, and increase overall efficiency in the construction field. The results of this research have the potential to influence policy making and regulatory initiatives focused on elevating quality standards and accountability within the construction industry. By offering evidence based insights, the study can support the formulation of policies and regulations that encourage a culture of quality excellence and promote positive transformation throughout the sector. Additionally, it adds to existing knowledge on QM in construction at both national and international levels. Through the dissemination of findings via academic publications and presentations, it can inspire further research and collaboration, thereby enhancing the overall understanding of QM practices across various contexts.

1.7 Brief Methodology

This study involves the identification of various factors influencing the current quality management practices and the development of a quality management Framework for the construction Industry of Pakistan. Literature review is comprehensively done to comprehend critical factors contributing to the existing quality management practices and framework development within the Pakistani construction industry. Literature review is followed by a pilot study for creating a draft questionnaire. Delphi experts are provided with draft questionnaire for evaluation, with the main focus on aspects such as wording, format, and question relevance. Based on questionnaire response acquired from delphi technique (with two rounds of evaluation to ensure clarity and accessibility), subsequent modifications are made to the questionnaire. The final questionnaire, tailored to attributes of the intended respondents, such as their level of education, workplace setting, and relevant industry experience, is sent out to audience for data collection. The questionnaire utilized a Likert scale to measure the degree of respondents' agreement or disagreement with statements related to quality management practices. The data is analyzed with various methods, including reliability analysis, factor reduction, correlation analysis, normality testing, and both parametric and non-parametric tests. Furthermore, structural modeling was done via AMOS software. These robust analytical techniques aim to deliver in-depth insights into the factors influencing quality management practices and the formulation of a suitable framework within Pakistan's construction industry.

1.8 Outline of Thesis

This work is arranged into 5 chapters as discussed below:

Chapter 1 includes background of the research, in addition to study motivation and problem statement. Furthermore, it also gives aims and objectives of MS thesis, scope and constraints of study, concise methodology overview and thesis structure.

Chapter 2 provides the background and a comprehensive review of the relevant literature.

Chapter 3 details the design of study. This includes method of data collection, and procedures for data analysis.

Chapter 4 provides the findings from the evaluation of critical factors, current quality management practices, and the development of a quality management framework for Pakistan's construction industry.

Chapter 5 discusses the research findings, drawing conclusions and offering recommendations based on the study's outcomes.

Chapter 2

Literature Review

2.1 Background

Quality deviation is among the most critical challenges affecting building projects. It is a complex and multifaceted issue, making thorough mitigation difficult. A major contributing factor is the variety of challenges faced during construction, such as resource shortages, fluctuating material and equipment costs, unexpected expenditures, and on-site accidents. Construction projects are significant undertakings with set performance goals regarding quality, specifications, timelines, allocated resources, and other limitations. Quality deviations in such projects can arise from numerous causes, as there is no singular source responsible for these inconsistencies [7].

2.2 Determinants of Success and Failure in Construction Projects

The construction sector plays a vital role in driving economic growth and development of countries like Pakistan. Identifying the factors that influence the success or failure of building projects is essential in this sector. It allows stakeholders to continuously improve project management, reduce risks, maintain quality standards, and increase client satisfaction. Although the construction sector has yet to reach its full potential, it remains a key area of national importance, contributing to economic output and employment. Moreover, it is the main indication of health of economy of Pakistan. However, due to the involvement of multiple stakeholders, the industry is more complex than many others. The collaborative and intricate nature of construction projects often leads to disputes and conflicts, which can hinder project outcomes. Hence, implementing effective claims management and prevention strategies from the beginning to the end of a project is critical [8].

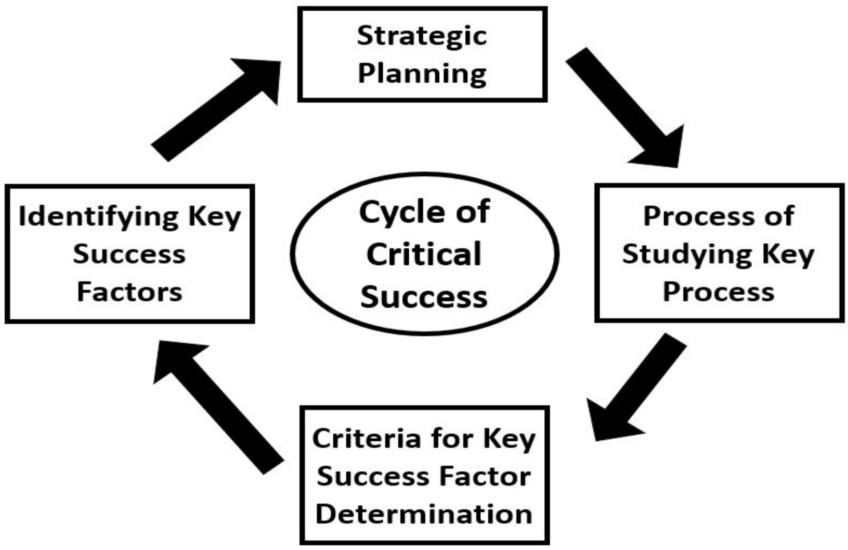

Figure 2.1: Life Cycle of project Success [8].

A detailed examination and evaluation of project plans, specifications, and contract terms at the initial stage can help resolve ambiguities and highlight potential areas of dispute. Addressing these issues early allows construction companies to gain a competitive edge, drive innovation, adhere to evolving industry regulations, support sustainability, and enhance collaboration among stakeholders. Applying quality control methods during the execution phase can prevent many problems that might later lead to claims. In construction projects, time, cost, and quality are the three core requirements that must be met. These elements are frequently compromised due to low bidding practices, a widespread issue not limited to the construction sector alone. As a result, fulfilling stakeholders' short-term expectations often demands prompt project delivery. However, delays, quality issues, cost overruns, and other complications continue to affect construction projects, presenting major challenges for professionals in the field. The repeated failure to complete projects on schedule and to the expected quality standard is a global concern [9, 10].

Critical success factors (CSFs) are the vital components or conditions necessary for ensuring the achievement of an organization's or project's goals. These foundational elements support strategic objectives and are often tracked through performance metrics. The practical application of CSFs includes using targeted tools and structured methods. The concept was initially presented by D. R. Daniel in 1961. Rockart later refined the idea into what we now recognize as CSFs between 1979 and 1981, and in 1995, James A. Johnson and Michael Friesen expanded its use to sectors such as healthcare [11].

CSFs serve as an adaptable framework that can be tailored for various organizational units, each focusing on its own priority areas. It's essential to distinguish CSFs from success criteria, as they serve different purposes [12]. While CSFs focus on the necessary conditions and practices required to deliver high-quality services to clients, success criteria define the measures by which success is judged. In construction projects, numerous elements influence success such as the capabilities of the project manager, the effectiveness of planning, and the roles of contractors, consultants, and clients. Additionally, external influences like government regulations and economic conditions also significantly impact outcomes. Successful planning requires identifying and addressing the CSFs that have the greatest effect on project performance [13].

Total Quality Management (TQM) is a managerial approach that originated in Japan during the 1950s and later gained traction in Western countries in the 1980s. It emphasizes delivering the level of quality demanded by the market in an efficient manner. Deming argues that improving quality through better control of design, engineering, testing, and processes can lead to reduced costs and higher productivity [14]. Quality encompasses both human input and process efficiency [15]. From the customer's perspective, quality is not determined by what is offered by the supplier, but by what the customer actually receives and values enough to pay for [16]. A key indicator of an organization's dedication to quality is how

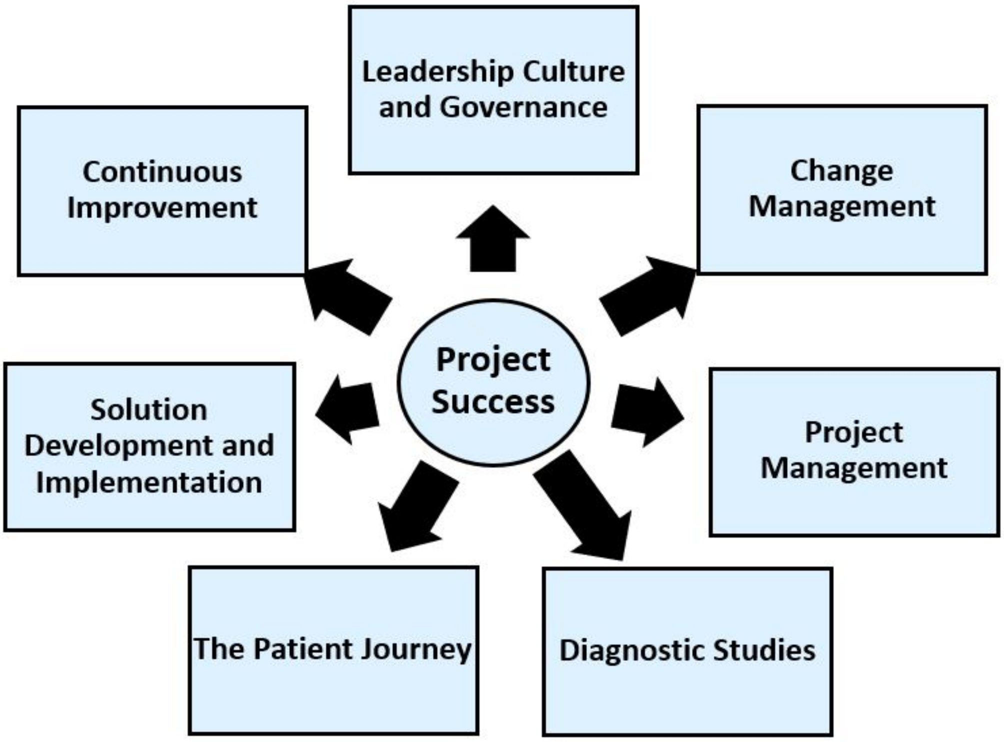

FIGURE 2.2: Project success of construction projects [11].

well it can implement, internalize, and standardize behaviors related to quality. Quality assurance is a continual effort that underpins the organization's routine functions. According to Motwani, the adoption of TQM involves major shifts in culture, strategy, processes, and values [17].

Pheng and Teo [18] highlight that the construction sector is often slow to adapt to economic, political, and technological changes, which contributes to underperformance. TQM promotes collaboration and a unified approach among employees, management, suppliers, and customers [19]. In a TQM focused organization, customer satisfaction takes precedence over internal operational efficiency [20]. Numerous studies have addressed recent initiatives aimed at boosting quality in construction. In this regard, the role of the supply chain is crucial. Gunaydin notes that although quality control developments in construction are similar to those in manufacturing, there are distinct challenges that must be acknowledged when applying quality frameworks in construction settings [21].

Sommerville & Robertson [22] highlight various challenges that obstruct the implementation and execution of TQM within construction firms. One major factor is the inherently customized nature of construction outputs, which are typically tailored to the specific requirements and expectations of individual clients, aiming primarily to achieve customer satisfaction. Additionally, the construction sector is prone to a high rate of business failures, especially during times of economic downturn. This leads to the perception that investing in TQM methods whose benefits may take years to materialize is an inefficient use of resources.

Griffith [23] emphasizes that, unlike manufacturing firms, construction companies often regard quality as an extra cost, failing to see it as a strategic investment with considerable returns. In construction, quality involves expenditures related to prevention and evaluation, along with the costs associated with nonconformance. Arditi and Gunaydin [24] argue that these unique traits contribute to the perception of the construction industry as fundamentally distinct from manufacturing. As a result, quality assurance techniques that are successful in mass production environments have not been widely adopted in construction, causing quality control systems in this sector to lag behind those in manufacturing.

Wassan et al. [25] propose that TQM has the potential to resolve challenges related to cost efficiency, productivity, and workplace safety within the construction sector. Al-Shadaifat et al. [26] emphasize that implementing TQM practices can significantly enhance construction performance. According to Elsherbiny [27], while most companies viewed TQM positively, the approaches and outcomes of its implementation varied widely across organizations over a three year span. Some companies discontinued their TQM initiatives entirely, whereas others achieved outstanding recognition for their efforts.

Reinaldo et al. [28] point out that many organizations become disillusioned with TQM when they focus solely on financial metrics, neglecting quality focused indicators. Additional research has also highlighted TQM failures, often attributing them to misguided and excessive efforts lacking a solid foundation or clear direction [29]. Therefore, it is essential for construction companies to identify and comprehend the critical success factors (CSFs) necessary for effective TQM implementation. Defining these TQM related CSFs has become increasingly important for construction enterprises.

TABLE 2.1: Key determinants of success and failure in construction projects.

Sr No	References	Categories	Success Factors
1	Khodeir and Ghandour 2019 [30]	Administrative and Legal	Well-defined Vision, Mission, and Objectives Competitive Strategy Structure of Organization Political Conditions No. of total permanent staff
2	Shah and Chandragade 2022 [31]	Technical	Usage of International Aspects (ISO) Access Knowledge Usage of IT Experience of Business Maintenance of Product
3	Shehu et al. 2014 [32]	Management	Workplace Culture and Environment Staff Compensation and Incentive Strategies Implementation of Total Quality Management Provision of Technical Skill Development and Training
4	Shoar et al. 2022 [33]	Market and Finance	Availability of Quick Liquid Assets Evaluation through Feedback Mechanisms Investment in Research and Development Conditions of Market Customer Interaction and Involvement

2.2.1 Factors Influencing Quality in Construction Projects

Quality in construction projects is a vital concern for all stakeholders, involving several aspects such as structural soundness, longevity, functionality, and visual appeal. Achieving high-quality results necessitates attention to numerous factors throughout the entire project life cycle. This literature review consolidates research on the key factors affecting quality in construction, which are grouped into management-related, technical, human, and environmental categories. Managing quality in construction projects is a complex task influenced by diverse elements during the project's progression.

Akintoye et al. [34] emphasize that strict adherence to industry standards and regulations is crucial for maintaining the structural soundness and safety of construction works. Compliance with these codes not only reduces potential risks but also builds stakeholder confidence in the reliability and durability of the infrastructure. Additionally, Chan and Chan [35] underscore that robust quality management systems establish a systematic approach for executing quality assurance and control measures, improving project performance and lowering costs related to rework caused by defects and shortcomings.

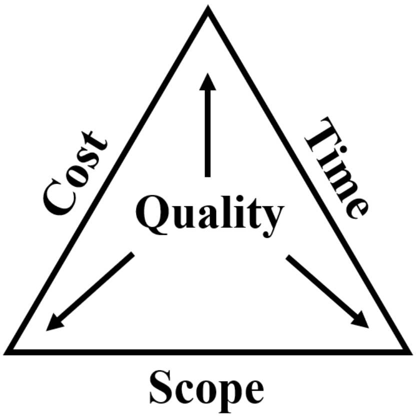

FIGURE 2.3: Triangle of Quality Management [35].

Project management practices significantly influence the quality outcomes of construction projects. Pinto and Nunes [36] highlight that thorough project planning and scheduling are vital for maximizing the use of resources, reducing delays, and ensuring projects are completed on time. In addition, El-Razek et al. [37] emphasize that proactive risk management enables project teams to foresee and address potential quality issues, thus protecting the project goals and interests of stakeholders. Moreover, clear communication and collaboration among all project participants including architects, engineers, contractors, and subcontractors are crucial for aligning quality expectations and resolving any inconsistencies in project specifications and requirements [36]. The integration of advanced construction technologies and innovative methodologies has also become a key factor in improving quality outcomes within construction projects.

Building Information Modeling (BIM), as noted by Succar [38], supports the visualization and simulation of project designs, allowing stakeholders to detect potential clashes and streamline construction workflows prior to execution. Likewise, Lean Construction principles focus on eliminating waste and inefficiencies throughout the project lifecycle, which leads to improved productivity, cost savings, and enhanced quality outcomes [39]. The skills and experience of the project team play a crucial role in achieving quality goals in construction projects. Koskela [40] states that combining multidisciplinary expertise with ongoing professional development promotes a culture of excellence and innovation within project teams, thereby boosting their ability to deliver superior quality work. Additionally, Senaratni et al. [41] stress that strong leadership and positive team dynamics are vital for creating a collaborative and inclusive environment that encourages creativity, problem solving, and knowledge exchange.

FIGURE 2.4: Cluster of Quality Management [41].

External factors, including environmental conditions, regulatory shifts, and stakeholder demands, significantly affect quality outcomes in construction projects. Halowell et al. [42] highlight that environmental sustainability concerns are increasingly influencing project design and construction methods, driving the adoption of green building standards and renewable energy solutions to reduce environmental impact and improve resource efficiency. Likewise, changing regulatory frameworks and stakeholder expectations emphasize the importance of flexible project management strategies that can adapt to evolving industry conditions and stakeholder needs [42].

Additionally, supply chain management practices play a crucial role in determining construction quality. Murekatete and Dushimimana [43] emphasize that robust procurement procedures, careful supplier selection, and sound contract management are vital for securing quality materials and services, minimizing procurement risks, and enhancing cost and schedule performance. Furthermore, Elghaish [44] points out that incorporating digital technologies such as blockchain and the Internet of Things (IoT) into supply chain processes improves transparency, traceability, and accountability, thus reducing risks linked to counterfeit products, supply interruptions, and contract disputes.

Continuous improvement efforts are vital for cultivating a culture of quality excellence and innovation within construction projects. Zavadskas et al. [45] note that feedback systems, lessons learned sessions, and post-occupancy evaluations offer important insights into project performance and highlight areas needing enhancement, allowing project teams to apply corrective measures and improve future project results.

Additionally, Chigangacha and Haupt [46] emphasize that benchmarking and performance measurement frameworks enable comparison of project outcomes against industry standards and best practices, helping identify opportunities to optimize and innovate quality management processes. Client involvement and satisfaction are key factors in achieving quality outcomes in construction projects.

Yazdani et al. [47] stress that comprehending and managing client expectations throughout the project lifecycle is crucial for aligning deliverables with stakeholder needs and preferences. Establishing effective communication channels and stakeholder engagement strategies allows project teams to gather feedback, resolve concerns, and make informed decisions that boost client satisfaction and project success.

Moreover, Halowell et al. [42] highlight that integrating client feedback mechanisms, such as satisfaction surveys and post-occupancy evaluations, supports continuous improvement and fosters lasting client relationships grounded in trust, transparency, and mutual respect.

TABLE 2.2: Factors affecting quality management in construction projects.

Sr. No	**Main Factor**	**Sub-Factors**
1	Project	Research Scope [48] Project Location Accessibility of site [49] Timeline of Project [50]
2	Design	Documents of Design are Complete and Consistent [51] Comprehensive Drawings [52] Compliance with Relevant Codes and Standards Specifications are Strictly Followed [53] Accurate and Detailed Bill of Quantity [54]
3	Contract	Cooperation between parties involved in contract [55] Prior successful collaborations Clear written contract [56] Use of standard contracts [57] Awarding system type [58]

Cultural and contextual elements significantly influence quality management practices in construction projects. Kharashi et al. [59] explain that cultural differences and organizational norms affect how quality management systems are adopted and implemented, requiring approaches that are sensitive to diverse stakeholder views and preferences. Additionally, contextual factors such as political stability, economic conditions, and regulatory environments affect project viability, resource accessibility, and risk levels, thereby impacting quality outcomes and overall project success. Implementing risk assessment and mitigation strategies that are specifically tailored to cultural and contextual nuances is crucial for managing project complexities and achieving quality performance across varied global markets [59].

Incorporating sustainability principles and practices is vital for improving quality outcomes and ensuring longterm resilience in construction projects. Fei et al. [60] highlight that sustainable construction methods emphasize environmental protection, social responsibility, and economic feasibility, which help reduce environmental impacts, improve community welfare, and optimize resource use throughout the project lifecycle. Additionally, Ugur et al. [61] note that green building certifications like LEED and BREEAM offer structured frameworks for applying sustainable design and construction practices, promoting innovation, distinctiveness, and competitive advantage in the market. Utilizing renewable energy technologies, energy efficient systems, and eco-friendly materials not only lowers carbon emissions and operating costs but also enhances occupant health, comfort, and productivity, thereby elevating the overall quality of the built environment.

2.3 Quality Management System in Construction Projects

Quality holds practical importance across industries, engineering, and manufacturing, signifying a product's or service's adequacy or excellence and its fitness for the intended use, consistent with customer expectations. In contrast, performance is a subjective and perceptual concept that varies among individuals. Consumers emphasize the consistency of performance and how a product or service compares to others in the market [62]. Producers focus on quality of conformance, which measures how accurately a product or service is produced, while support personnel evaluate its effectiveness, feasibility, and sustainability. Quality exists on multiple levels, highlighting a company's production of physical goods or specific services. These products, along with their production processes, techniques, equipment, workforce, and investments, together establish quality [63]. Rooted in fundamental quality principles, quality management has evolved significantly over time. The idea of organizational quality dates back to the early 20th century when pioneers like Frederick Winslow Taylor and Henry Ford recognized flaws in industrial manufacturing methods and the resulting performance inconsistencies, prompting the development of quality control, inspection, and standardization practices [64].

Quality control (QC) functions as a tool for organizations to evaluate the consistency of all factors influencing their output. As defined by ISO 9000, QC is a component of quality management that focuses specifically on fulfilling quality requirements. To implement an effective QC system, a company must first identify the fundamental criteria that the product or service needs to satisfy. Following this, the organization determines the scope of QC activities, such as the proportion of units to inspect within each batch [65]. This framework, highlighted in standards like ISO 9001, emphasizes three main elements. First, it stresses the need for clearly defined components including monitoring mechanisms, task management, and procedures that guarantee the identification and control of performance and quality standards, along with proper record-keeping for documentation. Second, it highlights the importance of competencies such as knowledge, expertise, experience, and skills in carrying out QC activities effectively. Third, it recognizes the value of intangible organizational aspects, such as employee traits like confidence, culture of workplace, employee integrity and motivation, and the quality of interpersonal relationships within the organization. Inspection is a vital aspect of quality assurance, involving the physical assessment of the final product or evaluation of service outcomes. During inspections, quality inspectors use checklists and clear descriptions of unacceptable defects like cracks or surface flaws to ensure compliance with quality standards and specifications. [64].

Quality assurance (QA) acts as a fundamental approach to preventing defects and failures in the production of goods, ensuring the delivery of flawless products or services to customers. ISO 9000 defines QA as a part of quality control dedicated to meeting quality standards [66]. Unlike quality management practices that primarily focus on identifying and rejecting defects, QA emphasizes defect prevention, often described as a "left shift," by prioritizing consistency earlier in the process within a linear workflow. The terms "quality assurance" and "quality control" are frequently used interchangeably to fulfill the overall goal of guaranteeing product or service quality. For example, Philips Semiconductors implemented systematic inspection as a QA technique for their projection screen software system. In the DMAIC methodology (Define, Measure, Analyze, Improve, Control), "Control" represents the final phase, highlighting data-driven processes for continuous quality improvement. QA covers logistical and operational activities within production systems designed to meet specified product, service, or performance criteria [67]. It entails systematic evaluation, comparative analysis, process monitoring, and feedback mechanisms to reduce errors, maintaining a close relationship with quality control, which focuses more specifically on process performance [68].

FIGURE 2.5: Principle of Quality Management [64].

Quality control is founded on two fundamental principles: ensuring products are "fit for purpose" and "made right the first time," aiming to meet expected outcomes while eliminating errors. Quality assurance (QA) oversees the quality control processes applied to raw materials, parts, finished goods, components, production and management support services, manufacturing workflows, and inspection procedures. In the development of technological products, project management is often concerned with achieving successful results in a single attempt, whereas QA focuses on ensuring consistent performance across all iterations [69].

In short, QA ensures systematic planning, compliance with standards, and preventive measures, while QC strengthens this thorough testing and inspection during execution. In addition, proactive risk management, continuous monitoring, stakeholder collaboration, and the use of modern technologies are essential to sustain quality. This combination not only reduces errors and delays but also enhances efficiency, safety, and client satisfaction across mid-rise construction projects [68, 69].

Total Quality Management (TQM), pioneered by William Deming, centers on minimizing or eliminating defects in production, optimizing supply chain processes, improving customer service, and ensuring employee competence. While TQM shares commonalities with Six Sigma as an improvement methodology, it uniquely emphasizes reducing errors through adherence to standards, guidelines, and process requirements. As a comprehensive approach to organizational excellence, TQM fosters continuous improvement of internal operations to enhance the overall quality of products and services. The specifications defined within TQM encompass internal expectations and technical standards, as well as the regulatory and industry specific requirements governing a company's operations [70].

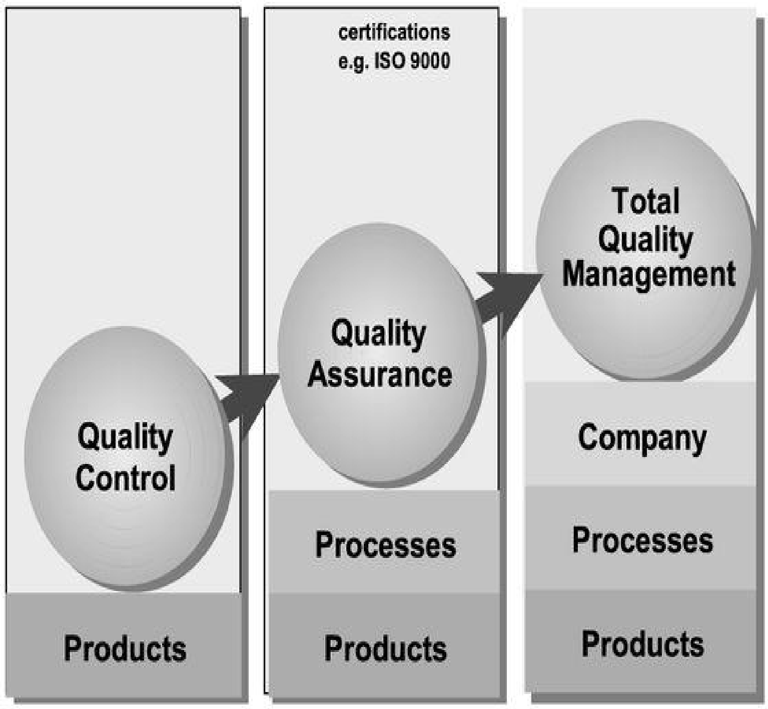

FIGURE 2.6: Difference in QC, QA and TQM [70].

Abdullah et al. [71] provided a comprehensive overview of the Quality Management System (QMS) and its application within the construction sector. A major challenge in implementing QMS is the lack of a unified definition among key stakeholders. QMS can be implemented at either the company or project level, with company-based QMS in manufacturing being particularly comprehensive due to the multiple project domains involved. While numerous studies have investigated company level QMS, research focusing on project based QMS remains limited. Although construction organizations report benefits from ISO 9000 certification, the primary objective of QMS achieving client satisfaction at the project level often remains unfulfilled. At project level, QMS requires the development of a Project Quality Plan (PQP). However, insufficient understanding of PQP among market participants significantly hampers its effective implementation. CFs in designing, implementing, and managing a PQP include aligning with project strategy and goals, engaging leadership teams, and defining appropriate work methods. PQPs can be customized individually for each project member or developed as a collaborative, interactive document shared among all project team members.

Rezaei et al. [72] developed a web-based bureau automation system called the Performance Measurement Support System (PMSS) to address operational inefficiencies. PMSS utilizes web-based automation to provide managers with real-time business information, eliminating paperwork and reporting issues through effective IT use and data centers. Moreover, PMSS overcomes connectivity challenges by leveraging Internet and mobile phone facilities, ultimately supporting organizations in achieving certification as part of their quality management programs. PMSS emphasizes a practical organizational breakdown structure (OBS) and efficiency measurements, requiring three key metrics: time, cost, and price.

Bubshait Abdulaziz et al. [73] conducted a study evaluating the quality system efficiency of 15 building contractors. Their findings revealed a range of quality system sophistication, from irregular audit programs to systems compliant with ISO 9002 standards. The primary motivations for registration included senior management's commitment to improving project efficiency and current or anticipated client demands. The ISO 9000 clauses most commonly cited focused on audit and inspection status, testing procedures, non-conformance quality control, and the processes for handling, storing, and protecting materials. Identified challenges included misunderstandings around quality program documentation, implementation methods, and inconsistencies between non-conformity behavior and corrective actions. Furthermore, firms faced difficulties in establishing clear development goals.

Anup et al. (2015) [74] conducted exploratory research aimed at providing insights into quality processes, methods, strategies, and management commitment

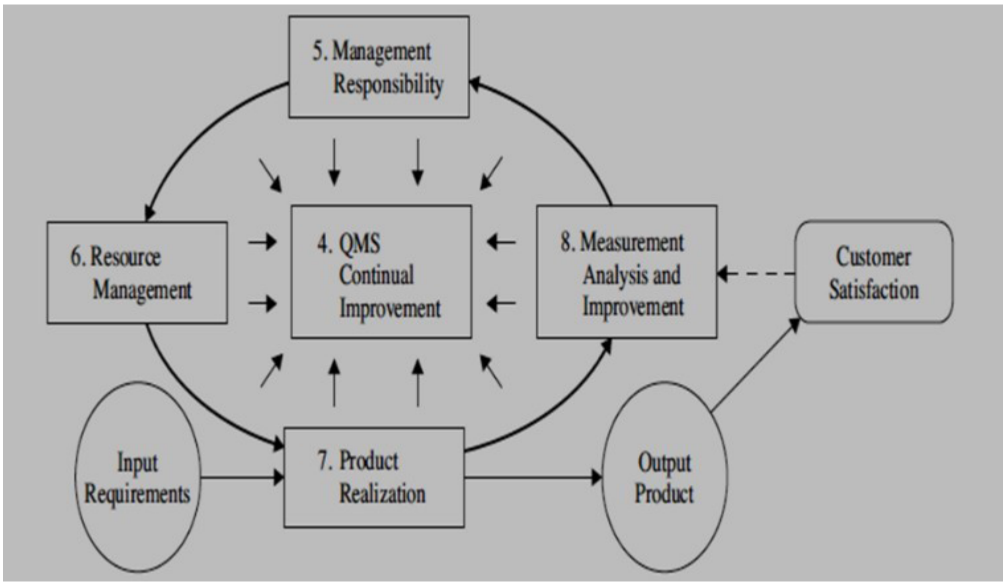

FIGURE 2.7: Model of QMS [74].

to quality implementation in construction projects. The study also examined challenges encountered during the deployment of Quality Control Systems (QCS). Data were gathered using a qualitative questionnaire approach, complemented by a case study that utilized content review tools to validate questionnaire responses. Further validation was achieved through professional interviews based on the review and case study data. The findings revealed concerns among professionals regarding the increased paperwork associated with QMS implementation. Significant challenges identified included staff's inability to comply with QMS protocols and limited technological proficiency. The study highlighted the frequent occurrence of quality problems in the local context and pointed to subcontractors' lack of professional experience as a critical obstacle to QMS implementation. Additionally, management factors such as responsibility assignment and evaluation processes showed strong correlations with QMS implementation difficulties.

The management system in Malaysian construction firms aimed to address the challenges faced in adopting the ISO 9001 Quality Management System (QMS) and to identify approaches used by ISO certified construction firms to mitigate these problems. Using a case study approach involving interviews with representatives from five construction companies, the research highlighted both the benefits and challenges associated with implementing ISO 9001 QMS. Improved management and work quality emerged as the most significant benefit, while a major challenge was identified as the lack of knowledge about the program among workers. To overcome these challenges, the study recommended enhancing preparation and audit processes, both internally and externally [75].

Abdirad et al. [76] focused on identifying and eliminating barriers to effective QMS implementation in construction projects, categorizing obstacles into seven main groups: managerial, organizational, communicational, financial, cultural, educational, and auditing. The study proposed critical success factors (CSFs) to facilitate more efficient QMS implementation, taking into account the impact of external factors such as economic, financial, political, cultural, and industrial influences. By modeling both internal and external variables, the study aimed to establish a comprehensive framework for successful QMS implementation in construction firms.

Pascal Bacoup et al. [77] proposed an approach based on the synergistic synthesis of ISO principles and core Lean Management concepts to achieve effective QMS implementation. Their study outlined a streamlined certification process, termed the Lean Quality Management System, which emphasized simplicity through maintaining just ten documents and experienced no significant non-conformities or consumer concerns over a two year period.

Erdil and Erbiyik [78] developed the principle of benchmarking as a means to continuously improve TQM within businesses. Their survey revealed variations in QMS maturity levels across industries, with oil and gas companies exhibiting higher maturity levels compared to construction and mining firms. Furthermore, firms operating internationally tended to demonstrate more mature QMS than those functioning at a regional level. The authors recommended further study to explore the relationship between sales performance and QMS maturity.

Yosep Hernawan et al. [79] examined the implementation of ISO 9001:2015 QMS in businesses, highlighting its benefits, challenges, and the necessary steps for successful integration. Using a qualitative descriptive approach, the study identified simplified division of authority and responsibilities and improved customer communication as key factors for effective QMS adoption.

Table 2.3: QMS in construction projects.

Unit of Analysis	**General**	**Management Responsibilities**	**Resource Allocation**	**Product Realisation**	**Measure, Analyze and Approve**
Input	Quality Policies and Objective PQP	Authorities, Objective and Communication	Training Plan and Procedure Awareness among Employees Competencies Employement Programs	Planning and Schedule Records Quality Design anf Customer Require Documents	Contract Documents Baseline Schedule Standards Master list of Checklist [80]
Mechanism	Quality Manager Steering Committee Process In charge	Cash flow Technique Senior Manager Management Representative at Site Deputy General Manager	HR Policies Recruitment Quality Manager Planning Engineer	Schedule Design of Experiments Laboratory Manual QA/QC Engineer	Customer Feedback Marketing Representative Engineer QC Engineer [81]
Control	Process Mapping Model Minutes of Meeting Control of Records and Documents	Agenda and Minutes of Meeting of Management review meeting	Skill Sets Evaluation Records Incentives Variable Pay	Monthly & Weekly Quality Statements MIS Test Certificates [82] Control and Monitoring Checklists	Internal and External Auditing Customer Feedback Comparison Statement Quality rating from Customers Audit Progress [83]
Output	Master List of Quality Records Formats and Controlled Documents	Detail Procedure Work Program Standard Operating Procedure and External Audit	Employee's Records of Training Qualification and Skills Record	Project Completion Report Maintenance Report Delivery Confirmation Project Manager's Report Relevant Checklists	Quality Assessment Report [84] Continual Improvements Report Corrective Action Reports [85] Non-Compliance Reports [86]

2.4 Quality Management Analysis

Quality deviation analysis entails a thorough examination and evaluation of the factors leading to the divergence of actual project quality from the initially estimated or expected quality standards in various projects, including building projects. It involves a methodical investigation into the underlying causes of quality deviations, aiming to comprehend the root reasons and consequences of these discrepancies. Kinebar et al. [87] highlighted the significance of efficient communication among stakeholders to promptly address issues. Their research underscored the need for transparent communication channels to facilitate collaboration and ensure timely identification and resolution of concerns, thus averting potential quality deviations arising from miscommunications.

Wyke et al. [88] noted that earlier research has recognized major contributors to quality issues in construction projects. By thoroughly examining prior studies, researchers have regularly identified key elements that influence quality deviations. Divakar et al. [89] underlined the value of ongoing supervision and control during the building process to uphold quality. Their findings stressed the need for strong monitoring frameworks to observe adherence to quality benchmarks, track the use of resources, and monitor overall progress allowing project leaders to intervene early and resolve problems before they impact quality.

Quality control involves a wide range of analytical tools and managerial approaches designed to improve quality performance through different methods. Common contributors to quality issues include high project complexity, poor planning and scheduling, lack of effective communication and collaboration among involved parties, uncontrolled scope changes, modifications in design or requirements, and outside factors like market trends or policy changes. Hsu et al. [90] investigated the Delphi method, which is a systematic process used to gather and refine expert opinions on a particular topic. The initial stage of this method involves selecting a group of professionals with substantial knowledge in the relevant area. These professionals then provide their perspectives on the main causes behind quality problems in construction projects.

During the second stage of the Delphi method, specialists are asked to prioritize the identified elements according to their level of significance, usually using surveys or one-on-one discussions. Sweis et al. [91] pointed out that this step involves a detailed review of the key factors recognized earlier to reach agreement within the expert group. Multiple feedback rounds are conducted, where participants are shown earlier results and encouraged to refine their judgments. Dixit et al. [92] examined how modern technological tools in project management contribute to improving workflows and minimizing mistakes. This repeated evaluation helps form a shared understanding of the main causes behind quality issues in construction. The finalized findings from the Delphi approach can then support the creation of targeted measures to address and reduce quality-related risks in building projects.

2.4.1 Different Survey Tool Comparison

Evaluating online and in person surveys means examining the techniques used to collect responses or insights from people. Online surveys are carried out through the internet, often using digital forms or online questionnaires, whereas physical surveys involve direct, in person communication with participants using printed forms or conducting interviews.

Qi et al. [93] focused on the preliminary phase of research aimed at analyzing the causes of quality issues in the construction industry. Etchegaray et al. [94] highlighted that conducting a pilot study can reveal flaws in the questionnaire, such as ambiguous items or limited answer choices. It also serves to evaluate the practicality of data collection approaches, including the chosen mode (such as digital or face-to-face) and the appropriate survey timing. Comparing digital and traditional survey formats plays a key role in selecting the most effective data gathering strategy.

Digital surveys offer multiple benefits to both researchers and organizations. One of the key benefits is reduced cost, as there is no need for printing materials, postage, or entering data manually. Insights from a pilot study can help improve the survey by modifying how questions are phrased, changing answer options, adding or deleting questions, or altering how the survey is delivered. Reviewing existing literature helps in selecting relevant items and organizing them into a coherent questionnaire. It's important to include a mix of open-ended and closed-ended items to collect a balance of numerical and descriptive information.

TABLE 2.4: Comparison of Survey Tools.

Sr. No	Nature of Survey	Target Audience	Response Rate	Valid Rate	Use of Software
1	Online and Physical	58	82%	93%	AMOS [95]
2	Online and Physical	300	89%	-	IBM SPSS [96]
3	Online and Physical	56	84%	-	IBM SPSS [97]
4	Physical	42	97%	97%	BN Model [98]
5	Online	79	-	68%	IBM SPSS [99]
6	Online and Physical	159	66%	-	MS Excel [100]
7	Snowball Sampling	87	87%	63%	MS Excel [101]

Survey items should be designed to reflect a wide range of factors known to influence quality problems in construction-related projects. A preliminary test with a small group can be performed to evaluate the clarity and usefulness of the questionnaire before launching it to the full participant pool. Online surveys are beneficial in accessing a wider and more diverse population, contributing to a larger and more accurate dataset. They also enhance respondent convenience by allowing completion at any time and from any location with internet availability. Evans and Mathur [102, 103] emphasize the adaptable nature of web-based surveys, which can take multiple forms. They note that the internet's rapid communication and global accessibility enable immediate engagement with participants in different regions as well as data sources. High speed internet also allows easy sharing of multimedia elements, broadening the reach and depth of digital survey tools.

Key contributing elements include workforce competence, effective material management, and financial stability, supported by strong supervision and transparent communication. The survey also emphasizes the role of modern technology adop-

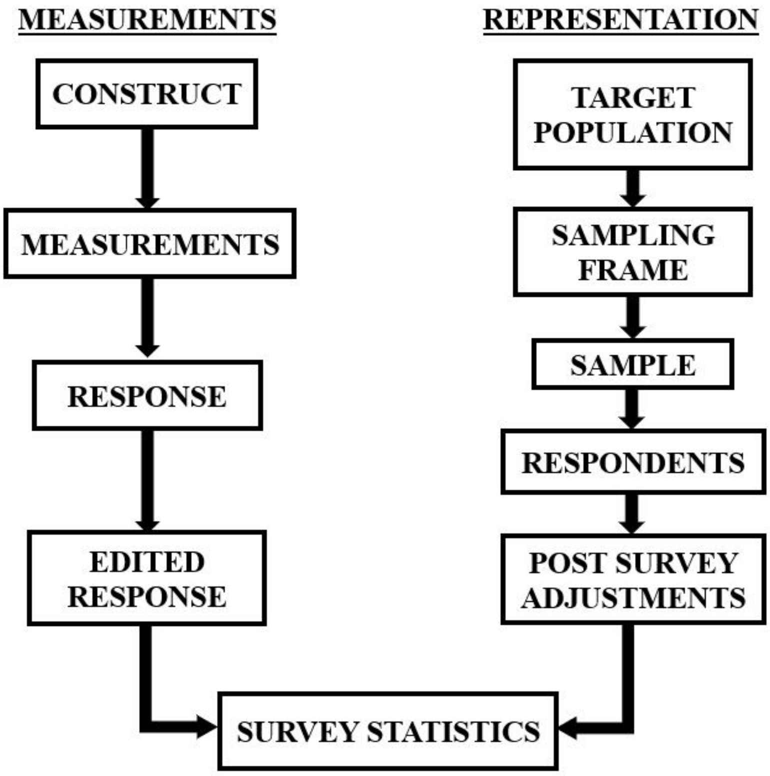

FIGURE 2.8: Characteristics of Online Surveys [100].

tion and a robust safety culture in maintaining standards. These factors create an enabling environment where QA/QC processes become more effective, leading to higher reliability, reduced rework, and project success [93, 94, 102].

2.4.2 Different Quality Overrun Approaches

Construction projects often face the critical issue of quality deviations, highlighting the need to examine and understand the causes for effective project oversight. Several methods are applied to evaluate, forecast, and control these deviations, including Delphi, SWARA (Step-wise Weight Assessment Ratio Analysis), FGDMA (Fuzzy Group Decision-Making Approach), BIM (Building Information Modeling), Fuzzy Logic, and Structural Equation Modeling. Afzal et al. [93] offer an in depth summary of these approaches as presented in existing research for exploring the origins of quality related issues.

The absence of quality in mid-rise building projects is mainly attributed to human

-related challenges such as limited workforce skills and weak supervision. Resource constraints, including shortages in materials, finances, and time, further aggravate the issue. Additionally, ineffective QA/QC systems, poor communication channels, and resistance to modern technologies undermine quality performance. Together, these factors create gaps in execution, leading to rework, delays, and compromised project outcomes [93, 104]

According to Yuan et al. [110], SEM an approach for statistical analysis allows researchers to examine the relationship between variables within a single cohesive model Gunduz et al. [104] studied significance of "0.9" threshold value in SEM, highlighting its importance in pinpointing key factors contributing to quality deviations in construction projects. By applying this threshold, researchers underscore the significance of factors that substantially affect project budgets and their pronounced impact on overall project performance and results.

Earlier research, such as that by Gunduz and Elsherbeny [109] and Geng et al. [111], also utilized the 0.9 threshold in SEM to pinpoint the most influential factors. This cutoff helps establish a definitive benchmark for selecting key variables that strongly affect the studied outcomes. Using this standard, researchers can efficiently prioritize and recognize factors with the greatest effect on observed phenomena, thereby deepening the understanding of underlying processes [112].

The threshold value "0.9" highlights the emphasis on factors with considerable importance and influence concerning quality deviations, as discussed by Gavareshki [113] and Fedrizzi [114]. Criteria like 0.9, 0.8, and 0.7 are commonly used to classify and differentiate levels of individual performance [111].

Additionally, Geng explored the Fuzzy Synthetic Evaluation (FSE) method, which leverages fuzzy logic to assess construction project effectiveness and the impact of various factors on quality deviations. This approach has been applied in prior studies to identify key contributors to quality deviations, such as project scope changes, insufficient experience, and design errors. The FSE framework supports clearer interpretation of performance disparities and helps categorize quality deviations into high, medium, and average levels.

Table 2.5: Various Techniques from Literature.

References	**Tools**	**Advantages/Disadvantages**
Jowward and Gupta 2019 [105]	Statistical Method (Relative Importance Index)	The project risk variables underwent ranking utilizing the relative relevance index technique. Additionally, reliability and correlation coefficient tests were carried out to further assess the data.
Sourani et al. 2015 [106]	Delphi-SWARA Method	The Delphi-SWARA method combines the benefits of Delphi, which is effective for generating estimations or forecasts, with SWARA, a step-wise weight assessment ratio analysis. By providing group members with controlled feedback, Delphi minimizes noise based on alternative rankings. Importantly, there is no predetermined right or wrong response in this process.
Evans and Mathur 2018 [103]	Expert Judgment	Data transmission is rapid, facilitating reasonable turnaround times and instant connectivity with the audience. Online surveys incur no expenses. However, latency may present an issue, and respondents may withhold honest responses.
Fong and Law 2014 [107]	Structural Equation Modeling	Structural Equation Modeling (SEM) enables researchers to assess numerous interconnected relationships between variables within a unified model, facilitating the examination of intricate, multi-variable theories in a single framework.
Das et al. 2025 [108]	Building Information Modeling	Building Information Modeling (BIM) enhances collaboration among all stakeholders engaged in a construction project. However, the adoption of BIM can entail substantial costs, which could pose a significant hurdle for smaller construction firms.
Gunduz et al. 2020 [109]	Fuzzy group decision-making approach (FGDMA)	The factors contributing to cost overruns are evaluated based on the fuzzy probability of independent risks. FGDMA calculates the defusing scores of nonconformities. To address the limitations of expert assessments, defuzzified scores are derived by associating them with relevant fuzzy numbers.
Gunduz al. 2017 [104]	Fuzzy Synthetic Evaluation	Fuzzy Synthetic Evaluation provides advantages in handling intricate assessments involving diverse criteria and levels. While Fuzzy logic may not provide a universal solution to all problems in a systematic manner, it relies on human expertise.

Using various methods like Delphi, SWARA, FGDMA, BIM, Fuzzy Logic, and Structural Equation Modeling brings valuable advantages to the construction industry. These tools offer an organized, evidence-based approach for uncovering the root causes behind quality issues in construction activities. They help stakeholders effectively recognize and rank the most significant risks impacting quality.

Surani and Sohail [106] examined the Delphi-SWARA approach, which integrates the Delphi method with the SWARA (Simple Additive Weighting And Ratio Analysis) process. This hybrid technique functions as a multicriteria decision making tool that effectively identifies and ranks factors impacting quality deviations. It has been previously utilized to detect key contributors such as poor project management, scheduling delays, and unexpected scope changes. The Fuzzy Group Decision Making Approach (FGDMA) was found to facilitate collaborative identification and prioritization of quality deviation factors by a group of decision makers. By employing fuzzy logic, FGDMA addresses the uncertainty and ambiguity commonly present in complex decision making environments.

Shoar et al. [33] highlighted the use of FGDMA in pinpointing factors like inadequate team coordination, insufficient budget allocation, and weak project management as drivers of quality deviations. BIM, as a digital representation of construction projects, enables stakeholders to visualize and simulate projects prior to execution, fostering proactive quality management and control. Through early identification of potential quality deviation factors during the project lifecycle, these techniques allow stakeholders to formulate mitigation strategies, minimize deviations, and optimize resource distribution. Overall, these methods enhance decision making by delivering both quantitative and qualitative insights into the causes of quality deviations, supporting more informed choices in planning of projects, developing budgets and allocation of resources.

These techniques greatly enhance the precision of assessing quality outcomes. By combining expert opinions, multicriteria evaluation techniques, and advanced modeling tools, they enable the generation of more precise initial quality forecasts, which helps to minimize the occurrence of quality discrepancies. Furthermore, these approaches help in promotion of collaboration among stakeholders of project by provision of structured framework that allows establishment of communication and consensus among stakeholders. This fosters transparency and cooperation throughout the project lifecycle. Anil et al. [115] highlighted that BIM serves as a practical tool for pinpointing possible triggers of quality problems and enhancing the efficiency of design and construction workflows.

Prior studies have utilized BIM to uncover major contributors to quality concerns, including errors in design, repeated construction work, and high levels of material waste. Asamaoh and Nyako [116] emphasized the utility of the Relative Importance Index (RII) as a method of statistical analysis for ranking factors contributing to quality deviations.

According to Jowward and Gupta [105], RII calculates the relative significance of each factor by analyzing stakeholder surveys, including inputs from project managers and contractors. Prior studies have used RII to highlight major causes of quality deviations like lack of proper project planning, Insufficient financial planning and poor risk mitigation. The literature encompasses a range of techniques for identifying and analyzing factors that influence quality deviations in construction projects such as SEM, FSE, Expert opinion, Delphi-SWARA, FGDMA, BIM, and RII are among the various techniques used. Each of these approaches offers unique advantages and faces certain constraints, with the selection largely influenced by the project's specific needs and the nature of accessible data. Utilizing these strategies plays a vital role in ensuring the effective and timely completion of construction efforts. By effectively controlling quality deviations, projects are more likely to be completed within the planned schedule and budget, which enhances profitability, boosts client satisfaction, and strengthens the project's reputation within the industry.

2.5 Summary

One of the major obstacles faced by the construction industry is the occurrence of quality deviations. Tackling this problem is particularly challenging due to its evolving and complex nature. The sector's intensive use of materials and resources often causes scarcities, unpredictable material pricing, rising equipment costs, and unplanned financial burdens that impact several developments. Builders often encounter difficulties in minimizing waste, managing poorly structured plans, and implementing environmentally friendly measures. Similarly, smaller construction ventures struggle with sustainable practices, ineffective site coordination, and weak cost oversight, which frequently cause schedule overruns and compromise quality. This section explores different aspects of quality issues within the building domain, focusing on influential elements that determine project outcomes such as defining the scope, budget distribution, effective resource use, and engaging stakeholders. It also outlines the categorization of construction related expenses, distinguishing among direct and indirect costs, overheads, contingency reserves, and funding-related charges. Key reasons behind quality problems are identified, including lack of thorough planning, poor information flow, shifts in project scope, and unexpected conditions at the site. Several evaluation techniques are covered, including Structural Equation Modeling (SEM), Fuzzy Synthetic Evaluation (FSE), expert assessments, Delphi-SWARA, FGDMA, and the use of Building Information Modeling (BIM). Additionally, the section covers the importance of conducting pilot studies and refining data collection tools to enhance reliability. In summary, this chapter stresses the necessity of deeply understanding the contributing elements behind quality deviations, which is essential for managing construction work effectively and achieving project goals successfully.

Chapter 3

Research Methodology

3.1 Background

Despite its seemingly organized framework, the construction industry tends to be erratic and unpredictable. This inconsistency often leads to delays in the adoption of new technological or administrative approaches, particularly at the grassroots level. The sector has faced continuous scrutiny for its shortcomings in effectively applying quality standards during design, construction, and delivery stages [117]. Over time, the need to implement structured quality management methods has grown significantly within construction workflows. Recurring problems and inefficiencies typically consume extra materials, manpower, finances, and equipment, which in turn heighten both the overall cost and duration of projects. Clients remain highly focused on three main aspects: cost control, on time delivery, and quality outcomes. The end result is greatly influenced by the experience of the labor force, the speed of execution, and attention to finishing details. Rather than being a one time target, quality is now acknowledged as an ongoing effort that requires constant evaluation and upgrades at every step. Although TQM is difficult to fully implement, it is gaining traction among organizations of various scales [118].

This section presents the overall research framework as well as the instruments and approaches used to fulfill the study's aims. The investigation is centered on recognizing multiple elements that affect quality management in construction, particularly emphasizing those with the highest impact. The research design features an early evaluation of project needs, discussions with key stakeholders, and the use of flexible planning methods to enable rapid and efficient modifications. A comprehensive literature review is carried out to identify key factors impacting quality control, particularly in residential construction. From the broad list of factors gathered, attention is directed toward those most pertinent to building-based projects. In designing the research instrument, special consideration is given to the characteristics of the target audience such as their age and professional experience. Based on this understanding, a well structured set of questions is developed. The questionnaire is designed to ensure a logical flow and ease of response for participants. Both the questions and the response options are carefully formulated, with a Likert scale applied to measure respondents' perceptions and opinions accurately. This structure enables a more nuanced analysis of stakeholder views. To ensure clarity and functionality, the questionnaire undergoes a pilot study to detect any issues related to language, layout, or technical elements. Adjustments are made as necessary based on feedback from this preliminary testing phase.

The completed survey instrument is used to obtain the necessary information. To verify the validity and usefulness of the collected data, various statistical procedures are applied, including tests for reliability, dimensionality reduction, correlation, and data distribution. The choice of parametric or non-parametric techniques depends on the characteristics of the dataset. Following this, AMOS software is utilized to develop a structural equation model (SEM), which helps assess both the direct and indirect links between the variables.

3.2 Research Design

An in-depth analysis is conducted through a comprehensive review of existing literature on quality management practices in building construction projects. This detailed examination of recent studies aims to determine the primary factors affecting quality management in such projects. Questionnaire surveys are used to collect data from stakeholders. A descriptive research design is adopted to evaluate the key components influencing quality management practices. The causes identified are further refined through the Delphi technique, resulting in the development of a customized questionnaire. To improve the clarity and relevance of the questionnaire, two rounds of the Delphi method are carried out. Data analysis is carried out using statistical methods, with SPSS facilitating smooth data entry, import, and organization across multiple formats like Excel and CSV. To determine the key elements affecting quality control in construction, AMOS software was utilized. Insights drawn from the analysis formed the basis for the study's conclusions and suggestions. The research approach adopted in this investigation is illustrated in Figure 3.1.

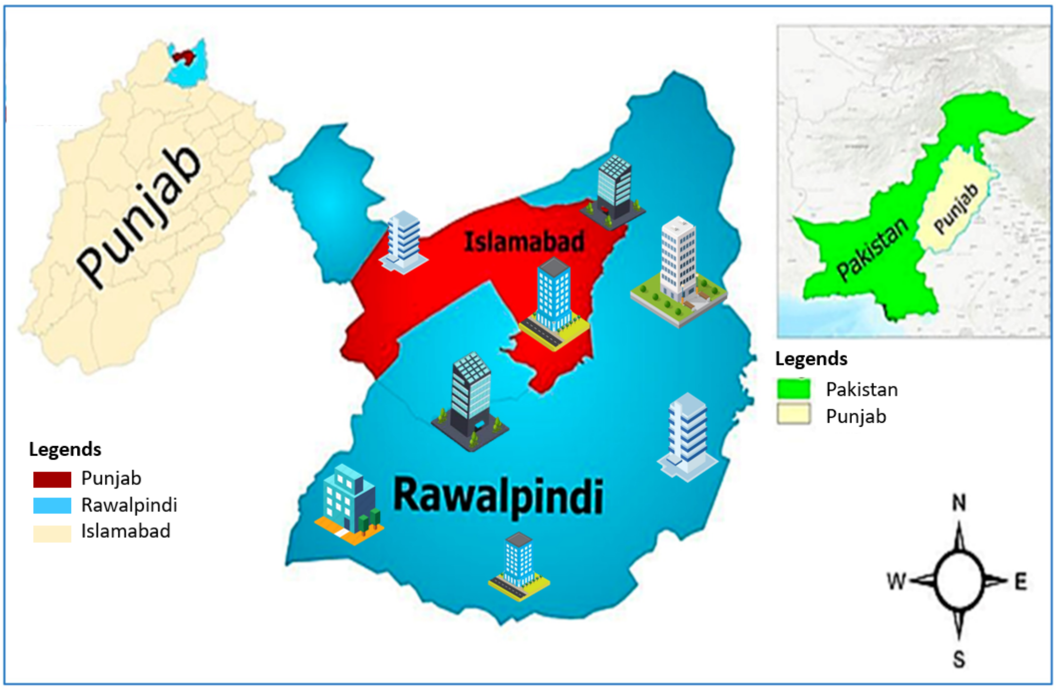

FIGURE 3.1: Study Area

3.2.1 Study Area

This research is limited to a defined area, focusing specifically on Zone V of Islamabad and Tehsil Rawalpindi within Pakistan. It concentrates solely on residential buildings with heights ranging from 4 to 7 storeys, including configurations such as B+G+2 or G+3 to B+G+5 or G+6. These limitations must be acknowledged when interpreting the study's findings, as the construction methods, building reg-

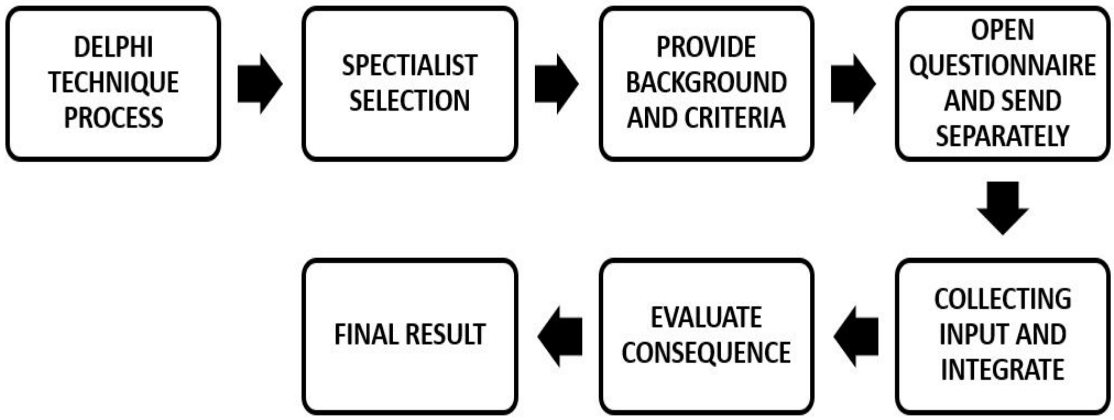

FIGURE 3.2: Delphi Technique process.

ulations, and codes in this area may differ from those in other locations, potentially affecting the key factors related to quality management practices. These constraints are crucial when considering the generalizability of the results to other regions or countries. Furthermore, the research is confined to residential structures falling within a certain height category, as quality management factors may vary in buildings of different heights, like low rise or high rise developments. As a result, the conclusions may not be applicable to construction projects outside the defined height parameters.

3.2.2 Identification of Key Factors via Literature Review

A thorough review of existing literature is done to identify the main components affecting quality management in construction activities. The most influential factors are chosen based on how often and how strongly they are highlighted across various sources. This process required a detailed assessment of each element to ensure its critical contribution to quality control in the building sector. Factors with limited relevance or inconsistent presence in previous studies are excluded. To validate the selected components, the Delphi method is used, confirming their applicability and significance. In this research, the Delphi approach is implemented in two separate rounds.

In the first stage, a survey form is created and sent to a group of professionals chosen for their expertise in construction related projects. After collecting responses from the initial round, a summary is compiled to highlight consensus and differing views among participants. This summary is provided to the expert panel, allowing them to reconsider and potentially adjust their earlier assessments. During the second stage, the revised questionnaire is redistributed, and participants are requested to reassess the key elements. The focus of this research is on developing a questionnaire grounded in the critical factors identified through the Delphi process.

3.2.3 Likert Scale

Respondent's opinion in regards to major elements that affect quality management in construction is acquired via Likert scale. Individuals rate their agreement or disagreement with various statements about each key factor using a 5-point scale. These responses are examined to identify which factors have the greatest influence on quality control within building projects.

Table 3.1: Likert Scale

Sr. No	**Description**	**Range**
1	Strongly Agree	5
2	Agree	4
3	Neutral	3
4	Disagree	2
5	Strongly Disagree	1

3.2.4 Design of Questionnaire and Size of Sample

Once the questions are structured, an initial version of the survey was created and examined. This phase focused on drafting items that directly reflected the study's aims and the variables impacting quality control in construction. A preliminary test is conducted to assess how clear, relevant, and practical the questionnaire is. Respondent's feedback is used to refine the content, making it more accessible and easy to complete. The items were crafted to capture both numerical and descriptive insights, with response choices selected to provide meaningful depth. A limited number of individuals participated in the trial run to identify any issues such as confusing wording or unsuitable answer formats. Revisions were made based on their input, resulting in a final version capable of effectively collecting key data on quality management influences in building projects.

In research that relies on surveys, gathering data is a crucial step, since the reliability of the results depends heavily on how accurate and well collected the information is. After making necessary improvements, the questionnaire was completed and prepared for use in the main stage of the investigation. The finalized version went thorough review to ensure it effectively addressed the principal factors influencing quality management practices. The survey is directed at industry professionals across both public and private sectors. Participants are selected in alignment with the aims and scope of the questionnaire survey. The finalized questionnaire is then disseminated to a broader audience, and the resulting data is analyzed to uncover the most impactful factors affecting quality management in building construction. Respondents are drawn from an online survey platform, allowing for the inclusion of participants from a wide range of demographic and professional backgrounds. The accessibility and convenience of the online format encouraged broader engagement, thereby increasing the volume and diversity of data collected. This respondent pool offered real time insights into the perceptions, attitudes, and behaviors relevant to the study's objectives, enabling a thorough and meaningful analysis.

Singh and Masuku [119] advised that for each major category or subgroup in a sample, at least 100 responses should be collected, whereas smaller groups might need around 20 to 50 responses. Their recommendation emphasizes the need to strike a balance between meaningful statistical results and the realistic constraints involved in gathering data. Features of broader population can be reflected accurately by significant No. of data points per group. The recommendation also acknowledges that smaller subgroups, due to their limited variability, can yield valid insights even with smaller sample sizes. Adopting this approach supports more reliable results while making efficient use of available resources.

The formula for determining sample size is as follows:

$$n = \frac{Z^2 \times p \times (1 - p)}{E^2}$$

Where:

- n = sample size.

- Z = Z-score corresponding to the desired confidence level.

- p = estimated proportion of the population with a specific characteristic.

- E = desired margin of error.

3.3 Data Collection Procedure

A preliminary study is conducted to verify that participants met the required criteria, specifically confirming their experience with structures between B+G+2 and B+G+7 floors. Individuals involved in the study had experience working on seven storey construction projects at 50 locations spread across six housing societies in Zone V of Islamabad and Rawalpindi. Physical visits were made to each site, during which email contacts were obtained to facilitate the distribution of survey forms and ensure smooth communication. Subsequently, tools and procedures for gathering data are developed and applied during the pilot phase. Participants were chosen, and responses are collected through digital surveys. The gathered information is then examined and used to draw conclusions and offer suggestions for enhancing quality control in upcoming construction projects.

3.3.1 Conduct of Survey

An online survey is created and shared with construction stakeholders based in the Islamabad and Rawalpindi areas. The goal is to gather at least 100 responses from industry experts actively involved in building projects. In total, 106 valid responses were collected from relevant stakeholders. A 5-point ordinal Likert scale is employed, ranging from ”Strongly Disagree” to ”Strongly Agree,” enabling industry professionals to convey their perspectives. Given the considerable variation in construction methods, a score of 1 indicated minimal significance, while a score of 5 reflected the highest level of importance.

Table 3.2: Stakeholders Background

Sr. No	**Stakeholders**	**Experience**
1	Clients, Contractors, Consultants	10 - 15 Years
2	Clients, Contractors, Consultants	05 - 10 Years
3	Clients, Contractors, Consultants	01 - 05 Years

After developing the questionnaire, a survey is carried out asking participants to respond to questions about the key factors affecting quality management practices in building projects. The questionnaire utilizes a Likert Scale, allowing respondents to express their level of agreement or disagreement with statements related to each critical factor. Statistical analysis is conducted on the collected data to determine the key elements that have a major impact on quality control. To achieve a well rounded and varied sample, outreach was carried out through both personal contacts and broader distribution strategies. A database of professionals and specialists engaged in construction activities is prepared, and the questionnaire is sent to them through email. Additionally, two followup messages were issued after the first round to encourage greater participation.

3.3.2 Response Rate and Valid Responses

In surveys that rely on questionnaires, the credibility and usefulness of the results largely depend on two key metrics: how many people respond and how many of those responses are usable. The participation rate reflects the share of recipients who completed the survey, while valid entries are those that align with set criteria, including completeness, consistency, and uniqueness. In this study, the response rate is closely monitored to gauge the survey’s effectiveness, with a target set at a minimum of 100 completed responses. To further ensure the accuracy and dependability of the dataset, rigorous quality control procedures were applied, which involved systematically identifying and excluding incomplete questionnaires and any duplicate entries. These steps collectively helped maintain the integrity of the data, strengthening the validity of subsequent analyses.

3.4 Data Analysis Procedures

Information collected from experts in the construction field is examined using SPSS software. This evaluation involved tests for reliability, reduction of variables, examination of relationships, assessment of data distribution, and the use of both parametric and non-parametric methods. Reliability testing is used to determine the dependability and consistency of the tools applied for measurement. The step by step analysis of the dataset is outlined in the following sections.

3.4.1 Reliability Analysis Procedure

It is used to assess how stable and consistent data or measurements are across time. In this research, survey responses were examined to verify the dependability of the collected information. Cronbach's alpha is calculated by reviewing how individual items within each question group are correlated. The analysis specifically focused on computing Cronbach's alpha for sets of items related to the main factors affecting quality control in construction practices. A Cronbach's alpha coefficient of 0.7 or higher is generally viewed as satisfactory, showing that the related questions are dependable and suitable for continued analysis. Confirming reliability is a crucial step to ensure the data is trustworthy and that the resulting findings are accurate.

Table 3.3: Reliability Analysis Scale,

Internal Consistency	**Cronbach's Alpha**
Excellent	$\alpha \geq 0.9$
Acceptable	$0.9 \geq \alpha \geq 0.7$
Unacceptable	$0.5 \geq \alpha$

3.4.2 Factors Reduction Analysis Procedure

Factor reduction is a statistical approach used to detect hidden constructs or factors from a set of measured variables. Its main purpose is to simplify complex data by identifying a smaller number of components that account for the correlations among variables. This method offers several benefits: it reduces the number of dimensions by highlighting common influences, making the dataset easier to interpret; it also helps reveal structural patterns and key relationships within the data, guiding researchers toward meaningful insights. Additionally, this process clusters variables that share variance, aiding in the interpretation and organization of the data for further investigation.

Despite its usefulness, factor analysis comes with notable constraints that should be acknowledged. If the core assumptions of the method are not satisfied, the reliability of the results can be compromised. Additionally, interpretation involves a degree of subjectivity, as analysts must determine how many components to keep, select a rotation strategy, and make sense of the factor loadings. Selecting too many components may result in overly complex or unclear factors, while too few can overlook essential patterns. The outcome is also affected by data issues such as missing entries, extreme values, or non-normal distributions. While the goal is to summarize the variability in the data using fewer dimensions, a portion of the variance typically remains unexplained. As a result, researchers need to verify that all assumptions are fulfilled and approach the interpretation process with caution, considering the subjective nature of some decisions.

3.4.3 Correlation Analysis Procedure

Correlation analysis serves as a technique to assess how variables are related to one another. It identifies the level and nature of associations between variables, offering insights into patterns present in the dataset. In this research, the method is used to analyze how key factors relate to quality control practices in construction. The correlation coefficient is calculated to indicate the strength and direction of each identified relationship.

This analysis employs the Pearson correlation coefficient as the primary metric, where a value of zero shows no association, +1 signifies a complete positive relationship, and -1 represents a complete negative relationship. The findings from the correlation analysis highlight the factors most strongly linked to effective quality management in building projects. These insights are crucial for devising targeted strategies to enhance quality management practices and proactively address potential challenges in upcoming projects.

3.4.4 Normality Test Procedure

A normality test is a statistical method used to evaluate if a dataset follows a normal (Gaussian) distribution. It helps determine whether it is suitable to apply techniques that assume normality, including parametric tests like ANOVA, regression, and t-tests. Verifying this assumption is essential for reliable and accurate statistical analysis. The outcome of the test typically includes a p-value or statistic indicating how much the data deviates from a normal distribution.

It is important to acknowledge the limitations inherent in normality tests. Normality is essentially an assumption and a simplification that may not fully capture the complexities of real-world data. While many statistical methods rely on the assumption of normality, they often still yield dependable results even when this assumption is mildly breached, particularly in large datasets. Normality tests, however, can be highly sensitive to small irregularities, often flagging significant differences simply due to the large sample size rather than any real issue. This can cause the normality assumption to be rejected unnecessarily, even when the impact on analysis is minimal. Moreover, these tests are generally more affected by outliers or extreme values in the tails than by changes near the center of the distribution.

Therefore, interpreting the results of normality tests requires careful consideration of the data's overall distribution and characteristics. Since normality tests are sensitive to the specific sample being analyzed, results can vary depending on the particular dataset. Consequently, a dataset that meets normality criteria in one instance may not necessarily do so for other samples or populations. Ensuring that the normality assumption holds is vital for the validity and reliability of statistical analyses, and for drawing accurate and meaningful conclusions regarding the critical factors affecting quality management practices in building projects.

3.4.5 Parametric and Non-parametric Test Procedure

Parametric tests are statistical methods that rely on certain assumptions about the underlying population from which the sample data is drawn. These assumptions typically include normal distribution of the data, homogeneity of variances (homoscedasticity), and interval or ratio-level measurement. When these conditions are met, parametric tests are considered to be more powerful and efficient, offering greater sensitivity in detecting true effects or differences. Common examples of parametric tests include t-tests (used to compare means), analysis of variance (ANOVA), and linear regression models, all of which provide robust results under the right conditions.

In contrast, non-parametric tests are distribution free methods that do not require the data to follow a specific distribution. These tests are particularly useful in situations where data violates the assumptions required by parametric tests, such as when it is ordinal, skewed, contains outliers, or exhibits unequal variances. While non-parametric methods may be less sensitive in detecting small differences due to their conservative nature, they offer greater flexibility and applicability in real world scenarios with complex or messy datasets. Common non-parametric tests include the Mann-Whitney U test (used for comparing two independent groups), the Wilcoxon signed rank test (for related samples), and the Kruskal-Wallis test (an alternative to one-way ANOVA for non-normal data).

This research incorporates both parametric and non-parametric methods for analyzing the data. When the dataset adheres to required assumptions, parametric techniques such as t-tests and regression are applied to evaluate hypotheses concerning averages and inter-variable associations. Conversely, in instances where these assumptions are violated, non-parametric options like the Wilcoxon rank-sum test and Spearman's correlation are employed. Utilizing both approaches ensures that the findings remain dependable and valid, irrespective of the data's distribution. This approach facilitates the identification of essential elements affecting quality management in construction projects and contributes to the development of effective quality assurance strategies. Parametric results indicate the presence of a normal distribution, while non-parametric outcomes reflect non-normality. A p-value equal to or below 0.05 signifies the rejection of the normality assumption. The standards used to evaluate normality are outlined as follows:

- When the p-value is equal to or exceeds the chosen alpha level, the dataset is assumed to be normally distributed.
- On the other hand, if the p-value falls below or is equal to the alpha level, it suggests that the data deviates from a normal distribution.

3.4.6 Structure Equation Modeling Procedure

Structural equation modeling (SEM) is a method used to analyze intricate associations among several variables. It investigates causal relationships and assesses how well theoretical models align with the data. In this research, SEM analysis is carried out using AMOS software, chosen for its intuitive interface that supports model development and evaluation through techniques such as path analysis and confirmatory factor analysis. SEM analysis consists of multiple phases, such as model identification, estimation, and evaluation. Its main purpose is to determine the crucial components affecting quality management practices in construction projects and to explore the interactions among these variables. By applying SEM, the significance of each factor can be measured, allowing for the recognition of possible actions or strategies to enhance quality management and overall project outcomes. In this phase, it is important to specify the variables, their connections, and the theoretical basis supporting the model. Precisely defining the variables and their measurement scales is necessary, along with proposing the relationships grounded in existing research or theoretical perspectives. Ensuring the model is identifiable is also vital, meaning there must be sufficient variability in the data to allow reliable parameter estimation. It is also essential to assess potential problems like multicollinearity, which can influence the accuracy of the estimated parameters.

Model parameters are typically estimated through maximum likelihood or another suitable statistical technique. The main goal is to identify a model that effectively reflects the structure and relationships within the observed data. After estimating the parameters, their significance is evaluated to determine whether the proposed relationships between variables hold and to judge the model's overall performance. This involves examining model fit statistics that indicate how closely the model aligns with the actual data. Common measures include the chi-square statistic, which tests for differences between observed and expected values; RMSEA, which assesses the model's simplicity and error; and CFI, which evaluates the model's performance relative to a baseline. High-quality model fit is shown through strong values on these metrics, confirming that the model reliably captures the data's underlying relationships.

SEM analysis is carried out using EMOS software, chosen from its intuitive interference that supports mode development and evaluation through techniques such as path analysis and confirmatory factor analysis. SEM analysis in this research was conducted using AMOS (Analysis of Moment Structures) software, selected due to its user-friendly interface and strong graphical modeling capabilities. It supports both the development and evaluation of structural models, allowing test relationships between latent and observed variables. Specifically, it facilitates path analysis, which examines direct and indirect relationships among variables, and CFA, which validates whether the observed data fit the hypothesized measurement model. The software's built-in reliability and validity tools further ensured that my model met statistical rigor, making it well-suited for analyzing complex interrelationships in quality management factors of mid-rise building projects [39].

3.5 Summary

This research adopted a systematic approach to uncover the key factors influen cing quality management practices in building projects. The process began with an extensive literature review aimed at identifying recurring issues and variables contributing to quality related challenges within the construction sector. To evaluate the significance of these factors, frequency analysis was conducted, which helped to isolate the most prominent ones affecting quality outcomes.

Following this, the Delphi method is employed in two iterative rounds to refine expert consensus on the shortlisted factors. The data was then subjected to factor reduction analysis to eliminate redundancy and to extract a concise set of factors specifically pertinent to building projects. To explore the relationships among these variables, correlation analysis was conducted.

In the next phase, normality testing is carried out to examine whether the dataset followed a normal distribution. Depending on the outcomes of this test, appropriate non-parametric methods are applied for further statistical validation. The final stage of analysis involved the use of structural equation modeling (SEM) to examine the structural relationships among the critical variables. SEM enabled the identification and ranking of the ten most influential factors, which were highlighted in the SEM matrix based on their strength of impact on quality management practices in building projects.

The modeling process entailed specifying the variables, their mutual associations, and the theoretical foundation underpinning the analysis. The model's estimability is examined based on the available data, and the maximum likelihood estimation technique is employed to estimate the parameters. The model's fit is assessed using a range of fit indices. The study focuses on a specific region, namely Zone V of Islamabad and Tehsil Rawalpindi, concentrating on residential structures ranging from four to seven floors, such as B+G+2 or G+3 up to B+G+5 or G+6. Information is collected through a Likert scale, providing meaningful observations from the analysis.

Chapter 4

Results and Discussion

4.1 Introduction

Although the construction sector may appear structured, it is often unpredictable in practice. As a result, the implementation of innovative managerial or technological practices typically experiences delays before becoming widespread at the local level. The industry is frequently criticized for inadequacies in applying quality practices across project planning, execution, and outcomes [120]. In recent years, understanding and integrating quality management strategies has become vital for construction activities. Persistent issues and mistakes often result in additional usage of financial, material, and human resources to resolve them, which increases both project timelines and costs. Clients are particularly attentive to factors such as budget, schedule, and the standard of work delivered. The final quality of a project largely depends on factors such as the skills of the workforce, timely completion, and the level of finish. Quality is now seen as a continuous journey that requires regular monitoring, effort, and improvement across all phases. While adopting TQM presents challenges, it is increasingly being explored by companies of all sizes [121].

This chapter presents the results derived from a questionnaire administered to stakeholders in Rawalpindi and Islamabad, aiming to determine the primary factors affecting present quality management practices in Pakistan's construction industry. The gathered data is comprehensively analyzed using SPSS, with the outcomes displayed through detailed graphs and tables. The core aim of the study is to assess the relative significance of crucial components contributing to quality management issues within the construction field. The analysis included feedback from a diverse group of respondents, such as contractors, consultants, and clients from both regions.

For the purpose of data analysis, AMOS is employed, offering a range of analytical techniques including structural equation modeling (SEM), confirmatory factor analysis (CFA), multigroup confirmatory factor analysis (MGCFA), means and covariance structure analysis (MACS), and path analysis. These methods allow researchers to evaluate the measurement characteristics of latent variables and to analyze both direct and indirect variable effects. They also facilitate the examination of mediation and moderation, comparisons across groups, and model evaluation. In this study, SEM is used to explore the intricate relationships between observed and latent variables. Consequently, a comprehensive framework is established to pinpoint the key factors influencing quality management practices. Additionally, the study outlines a set of recommendations aimed at enhancing existing quality management approaches within Pakistan's construction sector, offering actionable solutions for quality improvement and issue prevention.

4.2 Response Rate

Of the 120 surveys distributed to stakeholders in the construction industry, 104 are returned, resulting in a strong response rate of 86%. This rate is considered highly reliable and offers a solid basis for drawing meaningful insights from the study. When the population size is relatively limited, a sample size of more than 95 responses is generally viewed as both adequate and sufficient to ensure the trustworthiness of the results. As per the criteria defined by Ashley and Boyd, a 50% response rate is seen as acceptable, 60% as good, and 70% or above as excellent. Since this study achieved a notable response rate of 86%, it exceeds the benchmark for excellence, confirming that the collected data is both dependable and representative. Such strong participant involvement enhances the study's credibility and reinforces the groundwork for creating a comprehensive and effective Quality Management Framework for Pakistan's construction sector.

4.3 Demographic Characteristics of the Respondent

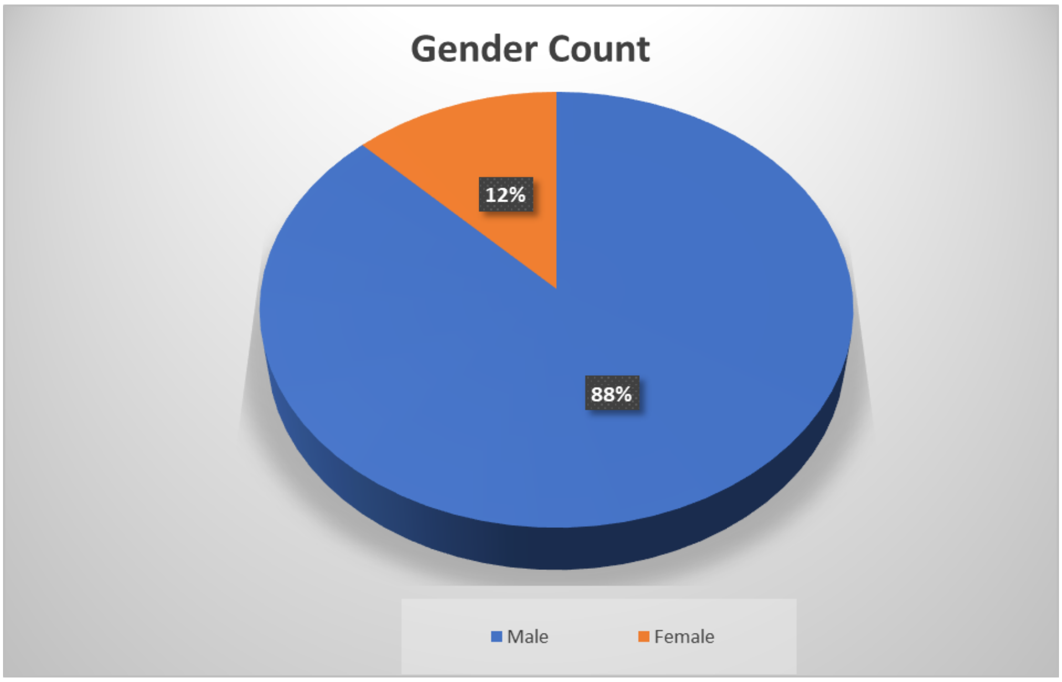

FIGURE 4.1: Gender classification

Figure 4.1 illustrates the demographic profile of the respondents who completed the questionnaire. It indicates that 88% of participants are male, whereas 12% are female. This information reveals the gender distribution among individuals who shared their views on existing quality management practices within Pakistan's construction industry. The predominance of male respondents mirrors the typical gender dynamics prevalent in the sector. This demographic structure is important, as it frames the viewpoints collected throughout the study and supports the formulation of a more comprehensive and inclusive Quality Management Framework for the country's construction field. Additionally, the observed gender imbalance may provide meaningful insights into the differing ways quality management practices are understood and applied across various groups in the industry.

Out of the total sample, percentage females were much less than males, reflecting the male-dominated nature of Pakistan's construction industry. The inclusion of female respondents, though smaller in proportion, ensured diversity and avoided gender bias in the survey. Statistical tests showed no significant difference in responses between genders regarding quality perceptions, indicating that both male and female professionals share similar views on QA/QC practices. However, highlighting gender diversity is important, as the role of female engineers and managers is gradually increasing in Pakistan's construction sector, contributing to inclusivity and broader perspectives in quality management

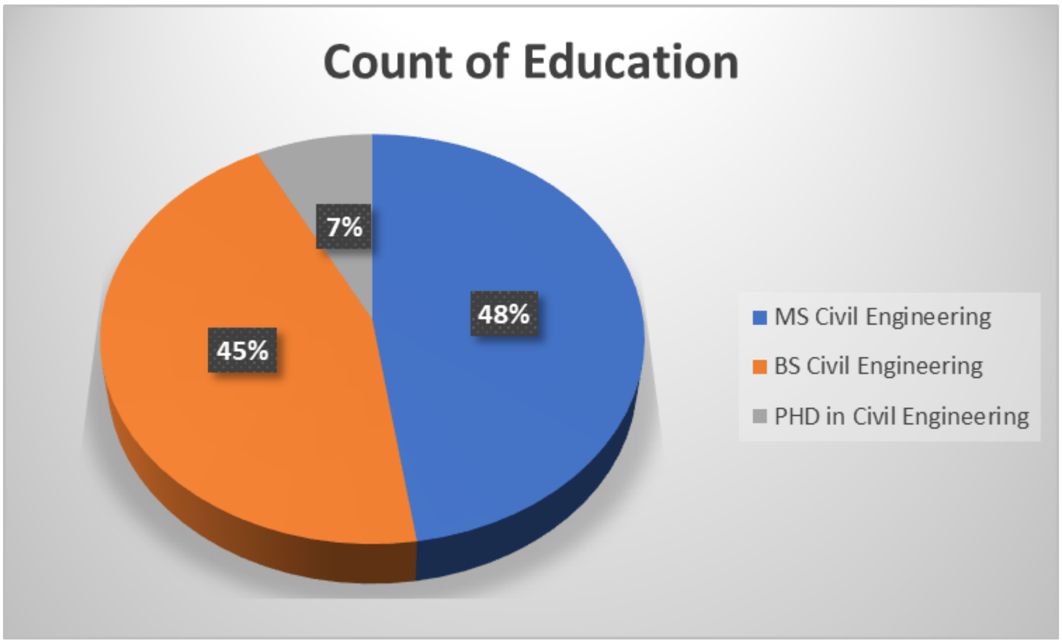

FIGURE 4.2: Classification of Education

Figure 4.2 displays the educational backgrounds of the respondents who took part in the survey. The data shows that 45% of participants held a bachelor's degree, representing the largest proportion. Additionally, 48% possessed a master's degree, while 7% had earned a PhD. This distribution highlights the academic qualifications of the individuals whose insights contributed to evaluating current quality management practices within Pakistan's construction industry. The substantial presence of respondents with higher education indicates that the feedback is grounded in a well informed and knowledgeable sample. This is crucial for shaping a well rounded and insightful Quality Management Framework that addresses the unique requirements and challenges of the sector in Pakistan.

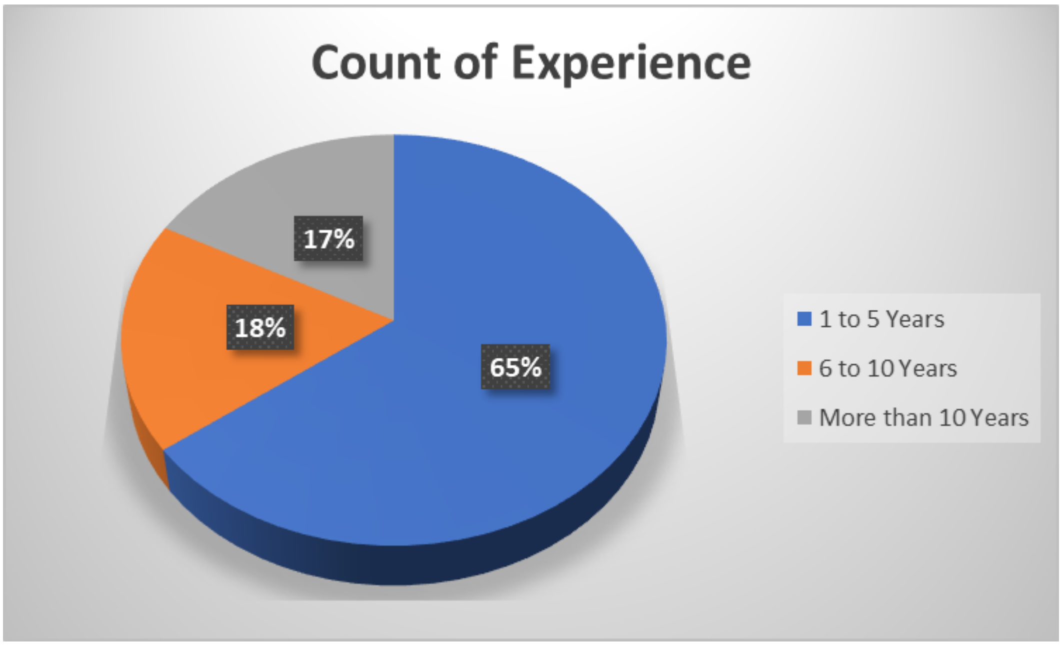

FIGURE 4.3: Count of experience

The expertise of professionals in the construction industry is strongly influenced by their years of experience with building projects. Many of the respondents had prior engagement in such projects, lending credibility to their input on current quality management practices. Figure 4.3 depicts the distribution of participants' experience levels: 65% reported having less than five years of experience, 18% had between six and ten years, and 17% had more than ten years of experience. This variation in experience offers a broad perspective on QM, as individuals with differing levels of industry exposure are likely to contribute diverse insights. Recognizing this spectrum of professional experience is essential for creating a Quality Management Framework that is both applicable and effective, addressing the challenges and requirements of professionals across all career stages.

4.4 Reliability of the MS Research

Within the scope of this study on current quality management practices and the formulation of a Quality Management Framework for Pakistan's construction industry, data reliability plays a vital role in determining the research's quality and trustworthiness. Reliability pertains to the consistency and dependability of the data collection process, ensuring that the instruments and techniques employed accurately represent the concepts being measured. Simply put, a reliable process yields consistent results when repeated under identical conditions. In this research, achieving a high level of data reliability is essential for drawing meaningful conclusions about quality management practices and for designing a framework that can be effectively applied throughout the industry. Reliable data ensures that the study's outcomes reflect actual patterns and issues within the sector, thereby enhancing the strength and applicability of the proposed Quality Management Framework.

4.4.1 Reliability of the Questionnaire

This study utilizes Cronbach's alpha test to evaluate the reliability of the questionnaire designed to investigate current quality management practices and inform the development of a Quality Management Framework for Pakistan's construction industry. As a widely accepted measure of internal consistency, Cronbach's alpha is particularly useful for assessing the coherence of multiple Likert scale items that comprise a scale. By applying this statistical test, we confirmed the reliability of our measurement scales, verifying that the questionnaire items consistently captured the intended aspects of quality management practices. The reliability of the questionnaire is essential in this research context, as it underpins the accuracy of the collected data and informs the development of a robust Quality Management Framework that accurately reflects the challenges and practices prevalent in the construction industry.

4.4.2 Reliability Analysis

To validate the data's integrity, this research utilizes Cronbach's alpha coefficient analysis, a standard assessment tool for gauging the consistency of data measurements. Through this statistical evaluation, it is confirmed that the survey's constituent parts cohesively measured the desired outcomes, thereby guaranteeing the responses' accuracy and reliability. By scrutinizing the interrelatedness of the survey's components, Cronbach's alpha enables the confirmation of the dataset's trustworthiness, an essential prerequisite for formulating a robust and credible Quality Management Framework tailored to Pakistan's construction sector.

Table 4.1: Reliability Statistics

Value of Cronbach's Alpha	**Total questions (N of Items)**
.975	18

The reliability of internal consistency of the questionnaire's items is assessed through Cronbach's alpha statistic, which measures the degree of interrelatedness among the test items. A higher alpha value signifies a more robust association between the items, whereas a lower value implies a less cohesive relationship. Generally, alpha values ranging from 0.70 to 0.99 are deemed satisfactory, with values exceeding 0.70 indicating adequate internal consistency for subsequent analysis. This study yields a Cronbach alpha value of 0.975, verifying the exceptionally high consistency of the data. This outcome confirms that the data gathered on quality management practices in Pakistan's construction industry exhibit strong internal reliability, making them suitable for in-depth analysis and supporting the development of a robust Quality Management Framework grounded in valid findings.

A study identifies key sustainability practices critical to the success of Pakistan's manufacturing sector using exploratory factor analysis. It gathered data from 82 respondents and achieved a Cronbach's alpha of 0.957, indicating excellent internal consistency. The findings support the development of reliable frameworks for sustainable industrial performance [122].

Another study investigates key factors that impact construction quality, including materials, workforce skills, planning, and supervision. A questionnaire was distributed to 150 professionals, with 139 valid responses. Data analysis via SPSS revealed Cronbach's alpha values ranging from 0.880 to 0.893, confirming strong internal consistency of the survey tool. The study highlights the importance of proactive quality management to minimize rework and cost overruns [123].

Another research explores stakeholders' perceptions of prefabricated construction technology adoption in Pakistan. It collected 260 valid responses from 300 surveyed industry professionals. The constructs measured (e.g., benefits, barriers, and readiness) achieved a Cronbach's alpha of 0.890, indicating high reliability. Findings support prefabrication as a viable solution for improving construction efficiency and sustainability [124].

4.5 Factor's Coding

In this research, coding denotes the methodical process of recognizing and establishing relationships between core concepts. It entails categorizing and labeling data to construct a coherent framework rooted in thematic ideas. This organized coding approach enables a methodical examination of the data and supports the creation of a thorough Quality Management Framework specifically designed for Pakistan's construction sector.

4.6 Normality Test

The Shapiro-Wilk test, a normality assessment tool, is utilized in SPSS to examine the distribution pattern of the gathered data. A p-value at or below 0.05 indicates rejection of the assumption that the data follows a normal distribution. In this study, the obtained p-value is 0.000, clearly suggesting non-normality in the dataset, consistent with the findings reported by Kim and Park. This outcome suggests that the collected data deviates from normality, which is a crucial consideration when selecting suitable statistical methods for further analysis in the development of a QM Framework for Pakistan's construction industry.

Factor coding entails consolidating questionnaire data and allocating corresponding grouping codes to variables for streamlined analysis. Out of 120 surveys disseminated, 104 were fully completed and returned. The normality tests, comprising the Shapiro-Wilk and Kolmogorov-Smirnov tests, produced significance values below the 0.05 alpha threshold, resulting in the rejection of the null hypothesis. This suggests that the data deviates from a normal distribution. Consequently, non-parametric tests will be employed for further analysis to guarantee the findings' reliability and validity, especially in the development of a Quality Management Framework tailored to Pakistan's construction industry.

Table 4.2: Test for Normality test

Tests of Normality						
	Kolmogorov-Smirnova			**Shapiro-Wilk**		
	Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
1	.211	95	.000	.826	95	.000
2	.235	95	.000	.821	95	.000
3	.220	95	.000	.971	95	.000
4	.212	95	.000	.817	95	.000
5	.227	95	.000	.813	95	.000
6	.234	95	.000	.827	95	.000
7	.212	95	.000	.841	95	.000
8	.201	95	.000	.897	95	.000
9	.261	95	.000	.812	95	.000
10	.274	95	.000	.812	95	.000
11	.269	95	.000	.857	95	.000
12	.218	95	.000	.841	95	.000
13	.274	95	.000	.847	95	.000
14	.212	95	.000	.814	95	.000
15	.232	95	.000	.821	95	.000
16	.187	95	.000	.847	95	.000
17	.201	95	.000	.817	95	.000
18	.223	95	.000	.828	95	.000

4.7 Kruskal Wallis Test

Validating respondents' perceptual levels following the normality test is an essential analysis step. The normality concept helped determine the data's non-parametric characteristics. Consequently, the Kruskal-Wallis test is utilized to assess the degree of perception among respondents. This test is applied to ascertain whether respondents' perceptions of each defined component varied significantly, as per the methodology described by Kruskal and Wallis. If the p-value obtained from the test is less than 0.05, the null hypothesis is rejected, signifying that notable differences exist in perceptions. The findings related to respondents' perceptions are presented in Table 4.3, offering insightful information on how diverse groups perceive different facets of quality management practices in Pakistan's construction industry.

TABLE 4.3: Result for Kruskal-Wallis Test

Sr No	**Description**	**Factor code**	**Magnitude of impact (Sig)**
1	Formulation and Implementation of Quality Standards	S1	0.284
2	Develop Skilled Labor	S2	0.363
3	Define and Implement Testing Procedures	S3	0.422
4	Use of Modern Technology	S4	0.896
5	Efficient use of resources	S5	0.537
6	Follow Condition of Contract	S6	0.741
7	Analyze the Productivity	S7	0.642
8	Measuring Waste Quantity	S8	0.243
9	Continuous Improvement	S9	0.233
10	Team Work	S10	0.523
11	Employee Empowerment	S11	0.052
12	Top Management Commitment and Support	S12	0.069
13	Customer Satisfaction	S13	0.379
14	Providing Effective leadership	S14	0.028
15	Management skills	S15	0.878
16	Fulfilling HSE Requirements	S16	0.795
17	Measuring Performance of Activity on Critical Path	S17	0.868
18	Level of technical expertise	S18	0.068

The outcomes of the Kruskal-Wallis test pertain to the null hypothesis about respondents' viewpoints. The results reveal that, apart from a handful of distinct components cataloged in the outcome table, respondents largely attribute comparable levels of influence to most bidding factors. This non-parametric test effectively compares multiple autonomous samples, discerning whether they stem from an identical distribution. A significance value surpassing 0.05 implies a lack of substantial disparity in respondents' perspectives, signifying uniform perceptions of the factors. In contrast, a significance value below 0.05 denotes divergent perceptions among respondents regarding specific factors.

4.8 Challenges of Quality Management in Pakistan

In this study, a Kruskal-Wallis test is conducted to examine the differences in the perceived impact of various causes contributing to poor quality in the construction sector as shown in Table 4.3. The test is employed due to the ordinal nature of impact magnitudes and the assumption that the data did not follow a normal distribution. A total of 20 key causes are identified and evaluated based on their magnitude of impact on quality performance. The results revealed notable variability in how respondents rated the influence of these causes, with impact magnitudes ranging from 0.012 to 0.487. This range illustrates the diverse perspectives within the construction industry regarding the severity of different quality-related issues.

4.8.1 High-Impact Factors

Among the factors, the most impactful challenges were primarily human resource and management-related:

- Worker attitude (B8) is identified as the most significant factor, with a mean impact magnitude of 0.487. This suggests that behavioral aspects and motivation of on-site personnel play a critical role in determining quality outcomes.

• Lack of recognition and rewards system (B15) followed closely, scoring 0.478, indicating that insufficient employee appreciation and incentives may undermine morale and work quality.

• Unskilled labor (B2) also emerged as a prominent concern, with a value of 0.421, reflecting the persistent issue of inadequate vocational training and the employment of workers lacking the necessary skills.

Other high-ranking factors included:

• Pressure of deadlines and productivity (B12) – 0.398

• Change of culture (B11) – 0.368

• Poor storage of materials (B4) – 0.352

These findings underscore the substantial impact of workforce-related, managerial, and cultural aspects on construction quality, suggesting that technical solutions alone may be insufficient to address quality challenges.

In construction, Bahr & Laszig (2021) [125] noted that management quality and worker behavior are key drivers of productivity, with skill gaps harming quality and schedules. Hussain et al. (2021) [126] found that rewards and recognition significantly boost employee performance, with organizational support mediating this effect. Yang et al. (2022) [127] reported that recognition improves both task performance and extra-role behaviors, mediated by positive emotions like pride

4.8.2 Moderate to Low-Impact Factors

On the other end, several factors are perceived as having a relatively lower impact on quality issues:

• Contract awarding method (B7) – 0.012

• Lack of top managers' commitment (B16) – 0.015

• Unrealistic deadlines (B10) – 0.145

- Use of latest tools (B19) – 0.147

These results imply that while administrative and procedural issues (e.g., contract strategies) are important, they are not seen as the most critical factors affecting project quality by practitioners surveyed.

A study by Vilkonis et al. (2023) [128] using Analytic Hierarchy Process (AHP) confirmed that procurement method significantly influences contract quality assurance, supplier coordination, and dispute potential, indirectly affecting outcomes. Furthermore, BIM adoption literature repeatedly emphasizes that up-to-date digital tools (e.g., BIM, real-time monitoring) drive quality, reduce errors, and enable lean workflows (Alsofiani,2024) [129].

4.8.3 Statistical Significance

The Kruskal-Wallis H test yielded a test statistic of H = [insert calculated value], with degrees of freedom (df = 19). The associated p-value is found to be < 0.05, indicating a statistically significant difference in the perceived magnitudes of impact among the 20 quality related factors. This confirms that not all challenges are perceived equally and validates the necessity of prioritizing specific issues for targeted quality improvement interventions.

4.8.4 Implications of the Findings

The results provide critical insight into the construction sector's internal quality dynamics. The emphasis on workforce capability, motivation, and recognition suggests that addressing human-centered factors could yield significant improvements in overall project quality. Meanwhile, the relatively lower concern for structural or procedural issues such as contract methods and executive commitment suggests that these may either be under-recognized or considered less controllable at the operational level.

These findings offer a foundation for developing evidence based strategies aiming at enhance quality management systems, particularly by investing in labor training, improving organizational culture, and fostering better worker engagement through reward mechanisms.

Table 4.4: Challenges/Causes of Poor Quality Management on Construction Projects in Pakistan

Sr No	Causes of Poor Quality	Factor code	Magnitude of impact (Sig)
1	Lack of an equipment management system	B1	0.273
2	Unskilled labor	B2	0.421
3	Non-availability of quality assurance manuals	B3	0.265
4	Poor storage of materials	B4	0.352
5	Lack of HSE Requirements	B5	0.152
6	Disputes among stakeholders	B6	0.324
7	Contract awarding method	B7	0.012
8	Worker attitude	B8	0.487
9	Performance based on critical path	B9	0.241
10	Unrealistic deadlines	B10	0.145
11	Change of culture	B11	0.368
12	Pressure of deadlines and productivity	B12	0.398
13	Lack of customer feedback system	B13	0.254
14	Insufficient quality training and education	B14	0.284
15	Lack of recognition and rewards system	B15	0.478
16	Lack of top managers' commitment	B16	0.015
17	Waste generation	B17	0.154
18	Poor information sharing	B18	0.247
19	Use of latest tools	B19	0.147
20	Technical knowledge	B20	0.248

4.9 Current Practices of Quality Management in Pakistan

In Pakistan's construction industry, a range of quality assurance strategies are being implemented across project sites. Based on insights gathered from experienced field professionals, the following measures have been identified as key practices adopted by the local industry to upload and ensure high quality standards.

4.9.1 Strict Adherence to Contractual Specifications

Quality standards in mid-rise projects can be enhanced by aligning international benchmarks with competent workforce capabilities, robust QA/QC practices, and dependable materials. Incorporating advanced technologies, strong project management, and a proactive safety culture further ensures consistency, reliability, and long-term improvement in construction quality [90].

All construction work is executed in accordance with the detailed specifications outlined in the project contracts. These specifications serve as the foundation for maintaining quality and ensuring that the final construction aligns with the approved designs, structural requirements, and engineering standards. By strictly following these guidelines, deviations are minimized and the integrity of the project is preserved.

In a study of Lagos megacity projects, 93.3% of respondents agreed that specifications are "crucial for clarifying design intent and ensuring quality control," and 86.7% said they help reduce errors and rework, both critical to preserving project integrity [130]. In Pakistan, the commonly used contract types are Lump Sum, Item Rate, Cost Plus, EPC, and FIDIC-based agreements. Their application depends on project nature private projects often rely on Lump Sum or Item Rate contracts, while public and donor-funded projects typically adopt EPC or FIDIC frameworks. This variation ensures that contractual mechanisms align with project scale, funding, and risk allocation [90].

4.9.2 Regular Testing and Verification of Construction Materials

To guarantee the quality and suitability of materials used onsite, routine laboratory testing is conducted in accredited facilities. These tests confirm that materials such as cement, aggregates, steel, and other building components comply with the relevant codes and specifications. This process helps in identifying and eliminating substandard or non-compliant materials before they are incorporated into the construction work. Ali et al. (2022) [131], in a study on material compliance in public infrastructure projects, found that inadequate testing and use of non-compliant materials were major contributors to early-life structural failures. They concluded that pre-use verification testing significantly reduces long-term risks.

4.9.3 Engagement of Competent and Qualified Site Inspectors

The recruitment of technically proficient and experienced site inspectors is a critical aspect of quality assurance. These professionals are responsible for continuous on-site monitoring of construction activities. They ensure that work progresses according to approved plans, complies with safety regulations, and meets established quality benchmarks. Their presence serves as a vital check to catch and correct issues in real time. Zhang et al. (2021) [132] highlighted that the presence of competent human inspectors, even alongside digital monitoring systems, remains essential for detecting nuanced issues that automated tools may miss especially in complex or high-risk environments.

4.9.4 Approval of Samples and Product Specimens Prior to Use

Before proceeding with the bulk procurement and installation of materials or equipment, samples and specimens are submitted for formal approval by the client or project consultants. This step is crucial in verifying that the selected items meet the aesthetic, functional, and technical requirements of the project. It also reduces the likelihood of costly changes or replacements during later stages of construction.

Memon et al. (2021) [133] noted that pre-approval of material samples significantly reduces disputes and delays by ensuring mutual agreement between stakeholders on the expected standards.

4.9.5 Routine Site Supervision and Inspection by Quality Control Teams

Continuous supervision and regular site inspections are conducted by project engineers and dedicated quality control personnel. These inspections help identify any discrepancies, construction flaws, or deviations from the approved plans at an early stage. Timely detection enables prompt corrective actions, thus minimizing rework and maintaining the desired construction quality.

Hwang et al. (2014) [134] concluded that early-stage error detection through on-site quality checks is one of the most effective strategies for improving construction performance and maintaining schedule compliance.

4.9.6 Utilization of Pre-Approved Vendor and Supplier List

To ensure the reliability of materials and equipment sourced for the project, contracts often include a list of vetted and approved vendors. Only suppliers who meet strict criteria regarding quality, reliability, and past performance are included. This measure minimizes the risks associated with inferior products and promotes consistency in material quality.

Alaloul et al. (2021) [135] highlighted that selecting vendors based on historical reliability and third-party certifications contributes to consistent quality control throughout the construction process.

4.9.7 Controlled Storage of Sensitive and Perishable Construction Materials

Certain construction materials, such as cement, chemicals, paints, and electrical components, are highly sensitive to environmental factors like humidity, temperature, and exposure. These materials are stored in specially designated areas under controlled conditions to prevent degradation. Proper storage ensures that the materials retain their original properties and deliver optimal performance when used.

According to Li et al. (2021) [136] in Construction and Building Materials, improper storage of cement in high humidity leads to premature hydration and strength reduction. The study emphasized that material storage under controlled environments improves shelf-life and performance reliability.

4.10 Framework for Development of Quality Management for Construction Industry of Pakistan

AMOS offers various statistical tools such as Structural Equation Modeling (SEM), Confirmatory Factor Analysis (CFA), Multi-Group CFA (MGCFA), Means and Covariance Structure Analysis (MACS), and Path Analysis. These methods assist researchers in confirming the properties of latent variables and exploring both direct and indirect variable associations. Additionally, AMOS supports testing for mediation, moderation, group differences, and model comparisons.

This research employs Structural Equation Modeling (SEM) to explore complex associations involving both observed and latent constructs, where latent constructs are inferred through patterns among measured variables. These connections are illustrated in the model using directional arrows to represent proposed relationships. Model adequacy is evaluated using multiple fit metrics, such as the chi-square value, Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA).

SEM proved especially useful for examining the primary factors impacting the construction industry, such as construction delays, execution challenges, project risks, and existing quality management practices, alongside the development of a Quality Management Framework for Pakistan's construction sector. Latent variables are unobservable factors such as management efficiency, material quality, or supervision that cannot be measured directly but are represented through observable survey indicators. In SEM, they form the core of the model by enabling statistical testing of relationships among quality-related factors in mid-rise building projects. Using SEM, both direct and indirect relationships among these factors are assessed, facilitating the refinement and validation of the theoretical model. The intuitive interface of IBM's AMOS software streamlined the SEM analysis and aided in result interpretation. In SEM, variables are categorized as observed or latent, where observed variables are directly measured, while latent variables represent hidden constructs inferred through their relationships with the observed variables [137].

4.10.1 Hierarchical Framework

The evaluation framework for assessing current quality management practices and developing a Quality Management Framework within Pakistan's construction sector is organized in a hierarchical manner. This approach tackles complex challenges by dividing the process into multiple levels, each with its own focus namely goals, criteria, and indicators. In this study, the highest level is called the target layer, which consists of eighteen distinct factors grouped together as the criterion layer.

The Development of a Quality Management Framework and Quality Management Practices for Pakistan's Construction Industry focuses on three main components: Management, Requirements, and Challenges. A detailed framework is created to thoroughly comprehend these practices and to tackle quality management issues efficiently. Prompt adjustments have been successfully applied, resulting in

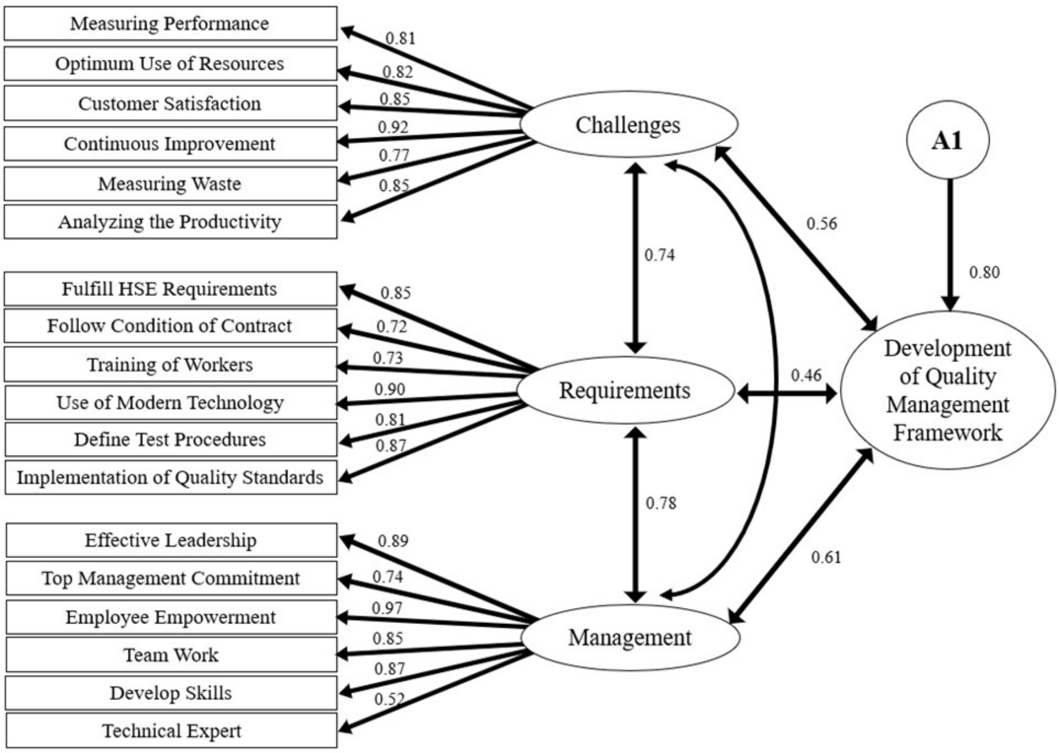

Figure 4.4: Hierarchical framework

enhanced project flexibility, greater stakeholder contentment, and on time completion despite changing project conditions. This framework takes into account multiple elements, such as the interaction between execution challenges, project management, and requirements.

The development of the framework through a systematic process, identifying quality factors from literature, refining them with expert input via the Delphi method, validating their relationships through survey data and SEM analysis, and finally structuring the framework to illustrate how these factors interrelate and influence quality in mid-rise building project, also the coefficients, such as 0.74, indicate the strength and direction of influence between factors. For example, supervision has a strong impact on overall project value of 0.74. These insights guided the framework's structure and helped prioritize the most influential factors [88].

The framework aims to detect and monitor indicators that may point to potential problems in quality management practices. Prior to finalizing the framework, extensive checks for content and construct validity were performed to guarantee its precision and efficiency. The finalized framework, illustrated in Figure 4.4, embodies these efforts and offers a thorough tool for evaluating and managing quality management. Structural equation modeling was applied to determine the key factors essential for developing and enhancing quality management practices within Pakistan's construction sector.

The technical strength of this framework is that it operationalizes research findings into a structured quality management tool. It provides contractors and consultants with measurable QA/QC procedures, checklists, and monitoring mechanisms to ensure compliance in mid-rise projects. For clients and regulators, it offers a benchmarking and evaluation mechanism to refine existing standards and enforce accountability. From an academic perspective, the framework formalizes critical quality factors through validated SEM analysis, bridging the gap between theory and practice. Thus, it serves both as a practical implementation model for the industry and a validated References framework for future research [138].

4.10.2 Hypothesis

The null hypothesis, denoted as "H0," is a key concept in statistical testing, proposing that there is no significant relationship or difference between variables or groups. It suggests that any detected changes are likely due to randomness. In this research, a benchmark value of 0.9 was adopted, as values close to 1 indicate strong importance. This cutoff was chosen to emphasize factors with notable influence, particularly in the context of enhancing quality management systems and developing frameworks in the construction industry.

Thresholds like 0.9, 0.8, and 0.7 are commonly applied to classify and distinguish the performance levels of various factors systematically. This system facilitates the identification of differences in impact, allowing the separation of high, moderate, and average influence levels. The hypothesis testing outcomes offer important understanding of the connections between key factors involved in shaping a Quality Management Framework for the construction industry. These findings clarify how the factors interact and affect each other. Results indicate a positive correlation between project risk and quality management results, although the effect of project risk on quality management practices appears to be less significant than that of other elements.

The first hypothesis (H1) reveals a strong positive link between Challenges and Requirements, indicated by a coefficient of 0.74. Hypothesis (H2) examines the association between Requirements and Management, showing a significant positive correlation of 0.78. The third hypothesis (H3) investigates the relationship between Challenges and Development, resulting in a notable coefficient of 0.56.

The fourth hypothesis (H4), which investigates how Requirements affect Current Quality Management Practices and the formulation of a Quality Management Framework for Pakistan's Construction Industry, indicates a moderate positive association with a coefficient value of 0.46. The fifth hypothesis (H5), which studies the link between Management and Development, results in a coefficient of 0.61, reflecting a positive correlation. This indicates that issues faced during project implementation, such as scheduling setbacks or coordination difficulties, can moderately affect the progress and application of quality management methods. It also highlights that although project-related risks can affect the quality framework, their effect is relatively smaller compared to other elements. Using the collected data, the value for each factor was determined based on participant input. Consequently, the relative importance index for each item was calculated according to the intensity selected by respondents. The relative importance index figures and the ranking of variables under the Contractors characteristics category are shown in Table 4.5.

Table 4.5: Hypothesis Results

Description	**Results**	**Decision**
Challenges to Requirement	0.74	Accepted
Requirement to Management	0.78	Accepted
Challenges to Development Network	0.56	Accepted
Requirement to Development Network	0.46	Accepted
Management to Development Network	0.61	Accepted

In a study by Dulaimi et al. (2014) [138] in International Journal of Project

Management, the authors found a statistically significant correlation between clearly defined requirements and the successful adoption of quality frameworks in Middle Eastern construction projects, supporting the moderate association observed in your H4 result.

4.10.3 Model Fit

The model fit indicators provide essential information regarding the suitability of the statistical framework applied in the evaluation. A Chi-squared score of 546.981 signifies an acceptable alignment between the proposed model and the actual dataset. Furthermore, the Root Mean Square Residual (RMR) score of 0.669 denotes the mean difference between observed values and those estimated by the model, highlighting how effectively the model captures data relationships. These metrics imply that the model fairly reflects the dataset, although refinements could further enhance its alignment.

Table 4.6: Modeling Results

Sr No	Description	Results
1	CMIN (Chi-Sqaure Value)	546.981
2	DF (Degree of Freedom)	387
3	RMR (Root Mean Square Residual)	0.067
4	GFI (Goodness of Fit Index)	0.752
5	(Comparative Fit Index)	0.887
6	MSEA (Root Mean Square Error Adjusted)	0.669

A lower RMR value reflects a stronger model fit, and the current value of 0.669 demonstrates a fairly accurate match between actual data and the model's projections. The Goodness of Fit Index (GFI) stands at 0.752, indicating a reasonable level of fit, though it does not reach the optimal benchmark of 0.90. The Comparative Fit Index (CFI), which assesses the model against a baseline model, is calculated at 0.887. Since values nearing 1 denote a strong fit, this result implies the model performs well. The Root Mean Square Error of Approximation (RMSEA) also records a value of 0.669, reinforcing the notion of a satisfactory model alignment.

Collectively, the values for Chi-squared, Degrees of Freedom (DF), RMR, GFI, CFI, and RMSEA indicate a satisfactory model fit, implying that the statistical framework aligns well with the observed dataset. These indicators together validate that the model is appropriate for capturing the associations present in the data.

4.11 Summary

The background segment outlines the research setting, emphasizing the purpose and aims of the investigation. An important element in evaluating the study's credibility is the response rate obtained. This rate represents the proportion of participants who submitted complete responses, reflecting their involvement and willingness to participate. Information about the respondents' demographic traits and job related backgrounds within the construction field was analyzed. These insights offered a detailed view of the study sample.

The findings derived from the gathered data are detailed in the analysis results section. Several components related to the overall reliability of the research are examined. The dependability of the questionnaire was analyzed to verify its ability to consistently and accurately reflect the constructs being studied. Reliability testing methods are applied to assess the internal structure of the instrument, supporting the authenticity of the collected information. To reveal hidden factors within the observed variables, factor analysis was conducted, shedding light on unseen elements involved in shaping the Current Quality Management Practices and the Quality Management Framework for the Construction Industry of Pakistan.

Correlation analysis is applied to explore the connections among multiple variables, highlighting both the type and intensity of these links. To confirm the appropriateness of statistical methods, normality assessments are conducted to check if the dataset followed a normal distribution. When the assumptions of normality were not met or when variables were ordinal, non-parametric techniques are utilized. Structural equation modeling (SEM) served as a detailed analytical tool to investigate intricate associations and evaluate theoretical frameworks, focusing on Quality Management Practices and the formulation of a Quality Management Framework for the Construction Industry of Pakistan. SEM enabled the analysis of both direct and indirect influences among variables, offering enhanced insight into the structural connections defined in the study.

The dependability of both the research procedure and the questionnaire is confirmed through thorough assessment. Multiple statistical methods such as factor reduction analysis, correlation studies, normality checks, non-parametric procedures, and structural equation modeling are utilized to derive significant patterns and associations in the dataset. These findings offer a clearer perspective on Quality Management Practices and aid in structuring a Quality Management Framework specific to the Construction Industry of Pakistan, laying the groundwork for further exploration in this area. Key elements that reduce the success of quality management systems in construction projects include faulty quality criteria, insufficient planning, delays in quality checks, design flaws, inexperienced contractors, lack of synchronization, limited resources, and broader managerial shortcomings.

Chapter 5

Conclusion and Recommendations

5.1 Conclusion of the Study

The aim of this research is to enhance quality management procedures in the construction sector by recognizing the elements affecting existing methods and designing a practical framework to manage them. Structural Equation Modeling is applied to pinpoint the primary contributors to difficulties in quality control within construction initiatives. The outcomes of this work have supported the creation of strategies aiming at boosting the efficiency of quality oversight, which in turn facilitates the proper completion and handover of construction undertakings in line with predefined criteria. The research highlights several elements impacting quality control procedures and applies frequency analysis to determine which are most influential in construction activities. An extensive review of existing literature is carried out to uncover the aspects affecting current quality control approaches. A Likert scale was used to measure the degree of respondents' agreement or disagreement with specific statements. The analysis involved evaluating reliability, assessing normality, and conducting both parametric and non-parametric evaluations. AMOS software supported the modeling process. Through structural equation modeling, the study provides deeper insight into how these elements relate to and affect the results of construction projects.

Demographic analysis revealed that the majority of respondents are affiliated with held a bachelor's degree (45%), and had 1-5 years of experience (65%). The following conclusions are made based on the conducted study:

- Current study identified several key factors that impact quality management practices like poor planning, lack of proper quality control systems, insufficient risk management, selection of contractors, ineffective communication among stakeholders and lack of resources. These factors collectively highlight the need for a robust quality management framework in the Pakistani construction industry, emphasizing the importance of effective planning, enhanced risk management, and systematic quality control to improve overall project quality and performance.

- In Rawalpindi and Islamabad, several significant factors affect the current quality management practices and the development of a quality management framework for the construction industry in Pakistan like market fluctuations, inconsistent quality control practices, poor coordination between stakeholders, design errors and delays in resource procurement. These factors consistently present challenges in maintaining and improving quality standards, highlighting the need for a comprehensive quality management framework that addresses these issues and provides a structured approach to enhancing quality in construction projects across the region.

- To improve quality management practices in the construction industry, the study recommends a multi-faceted approach that focuses on several key factors including comprehensive project planning, implementation of effective quality control systems, clear contract management practices, strategic contractor selection (based on experience, expertise, and past performance), sufficient resource allocation and regular project monitoring. By addressing these factors, the development of a comprehensive quality management framework for the construction industry in Pakistan can enhance the consistency and effectiveness of quality practices, leading to better project outcomes.

- Enhancing quality in mid-rise building projects calls for a multi-stakeholder Quality Forum, led by PEC/IEP, Developing Authorities and supported by consultants, contractors, academia, and regulators. Such a forum would provide a structured platform for collaboration, policy alignment, and standardization. Strengthening it with digital knowledge-sharing tools would further promote transparency, innovation, and continuous improvement across the industry.

5.2 Recommendations

Multiple opportunities exist for advancing research and enhancing quality management approaches in the construction industry. This study promotes a comprehensive quality management approach in mid-rise projects by integrating systematic QA/QC, a skilled workforce, strong supervision, and reliable materials. It further emphasizes realistic planning, clear communication, technology adoption, and a safe work culture to ensure efficiency, compliance, and sustainable project outcomes. While contracts influence how quality is managed, my framework is not restricted by contractual limitations. It complements all contract types by providing a universal quality roadmap adaptable to different legal and financial structures. The recommendation for future contracts explicitly integrates QA/QC requirements aligned with this framework, ensuring that quality remains safeguarded regardless of contractual constraints. Based on the study's findings, the following suggestions are offered for future exploration:

- This study primarily focuses on construction projects located in Islamabad and Rawalpindi. However, a similar analysis can be extended to a broader geographical context, encompassing other regions within Pakistan.

- One promising area for future research is the integration of advanced technologies, such as Building Information Modeling (BIM) and artificial intelligence, into the quality management processes of construction projects.

- Future research can also investigate the impact of quality management practices across various types of construction projects, such as residential buildings, commercial complexes, highways, bridges, power plants, and infrastructure projects like airports and tunnels.

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