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Implications of Compromised Skilled Labour on RCC Bridge Construction in Pakistan

by

Kanzan Hayat

A thesis submitted in partial fulfillment for the
degree of Master of Science

in the

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Kanzan Hayat

Abstract

This research studies the impact of compromised skilled labor on RCC bridge construction in Pakistan. 16 labor skills involved in 11 major construction activities were evaluated for their availability, performance and impact on project time, cost, and quality parametric. The study employed a mixed-method approach with a dominant focus on quantitative data collected through a structured questionnaire. A total of 129 responses from professionals; including supervisors, engineers, project managers etc from contractors, consultants and clients; were received to assess their experiences / perceptions.

In shortage of qualified labor, Steel fixers ranked on top with Relative Importance Indexes (RII) ranging from 0.84 for pile cap and transom construction, to 0.82 for girder casting activities. Shortage of qualified formwork fixers ranked 2nd with RII ranging from 0.83 for girder casting and transom construction, to 0.82 for pile cap activities. Shortage of qualified surveyors ranked 3rd with RII of 0.82 for piling activity.

Mean frequency of issues attributed to lack of skilled labor across 11 activities involved in RCC bridge construction are found with mean analysis. Activities most affected by compromised skilled labor are pile cap construction (Mean 3.9), pier construction (Mean 3.8) and girder casting & prestressing (Mean 3.8).

Mean Impact of skill shortages in 16 x labor trades on key project metrics of time, cost, and quality are found through mean analysis. Top ranked skills contributing to project delays are poorly skilled prestressing workers (mean impact 3.65), formwork fixers (mean impact 3.56) and steel fixers (mean impact 3.47). Top ranked skills contributing to project cost overruns are poorly skilled formwork fixers (mean impact 3.58), steel fixers (mean impact 3.53) and surveyors (mean impact 3.50). Top ranked skills contributing to project quality issues are poorly skilled shuttering / formwork fixers (mean impact 3.89), concrete masons (mean impact 3.77) and prestressing workers (mean impact 3.70). To summarize, shortage of skilled formwork fixers, steel fixers and prestressing workers appears to be on top while analyzing their impact on key project parameters.

While seeking feedback on open ended statements related to the subject, “*tendency to hire cheapest labor rather than valuing skillsets*” impact the quality of construction was the most agreed upon statement (mean score 4.16), followed by the “*vocational training institutes impart insufficient practical training, emphasizing more on theoretical knowledge about skills*” (mean score 4.09), highlighting weaknesses in Pakistan’s Technical and Vocational Education and Training (TVET) ecosystem.

Based on the results, the research offers targeted recommendations for improving the quality of skilled labor in bridge construction. Addressing these issues is vital for improving construction outcomes, ensuring public safety, and achieving long-term sustainability in Pakistan’s infrastructure development. While this study contributes to academic literature and policy dialogue, by presenting empirical insights into workforce deficiencies and their direct impact on infrastructure performance; it also offers practical / managerial guidance for all those working on RCC bridge projects.

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List of Abbreviations

ANOVA	Analysis of Variance
CBT&A	Competency-Based Training and Assessment
CPEC	ChinaPakistan Economic Corridor
CTTI	Construction Technology Training Institute
GIATMARA	Government Industrial Training Institute MARA (Malaysia)
KPI	Key Performance Indicator
NAVTTTC	National Vocational and Technical Training Commission
QA/QC	Quality Assurance / Quality Control
RCC	Reinforced Cement Concrete
RII	Relative Importance Index
RPL	Recognition of Prior Learning
SIT	Sonic Integrity Test
SPSS	Statistical Package for the Social Sciences
SSW	Specified Skilled Worker
TEVTA	Technical Education and Vocational Train- ing Authority
TVET	Technical and Vocational Education and Training
VET	Vocational Education and Training

Chapter 1

Introduction

1.1 Background

Reinforced Cement Concrete (RCC) bridge construction is a critical component of Pakistan's national infrastructure development, supporting the movement of goods, services, and populations across urban and rural regions. With increasing urbanization and connectivity demands, particularly under initiatives like the ChinaPakistan Economic Corridor (CPEC), the construction of new highways, interchanges, and bridges has intensified across the country [1]. RCC bridges are particularly favored for their structural robustness and adaptability to various terrains. They form the backbone of strategic road networks, linking industrial zones, border crossings, and city centers. Yet, the quality and longevity of these infrastructure assets heavily depend on the competence of the construction workforce engaged in their development. The quality and longevity of RCC bridges are significantly influenced by the competence of the construction workforce. Workforce quality is a crucial factor affecting overall construction quality. Competent and certified workers are essential for successful project execution and can better compete in the global market [2]. Thomas et al (2003), studied four cases of highway bridge construction that were executed by established contractors who had little experience in construction of bridges, and found that the management of workforce had a significant negative impact on the productivity of labor. The lack of experience of the contractors in bridge construction was at the core of several

problems that plagued each of the four projects. For each of the project, baseline productivity was calculated in order to estimate the loss of labor efficiency which was found to be 80, 75, 32, and 70%, respectively for the projects. For the four case study project, the schedule slippage was estimated to be between 127 and 139% [3]. Figure 1.1 illustrates the loss of labor productivity with age, across various skill levels.

In Pakistan, however, the construction sector is beset with workforce challenges, most notably the widespread deficiency in skilled labor. The execution of RCC bridges demands a high level of precision in tasks such as formwork installation, rebar placement, concrete mixing and pouring, and structural alignment. These tasks require both technical knowledge and practical craftsmanship. Unfortunately, a substantial proportion of the labor force remains either semiskilled or entirely untrained, having acquired knowledge informally through apprenticeship or on-the-job exposure, often without certification or quality assurance [4]. The absence of properly trained workers in key trades such as steel fixing, formwork carpentry, concrete finishing, and machinery operation significantly increases the probability of structural flaws, cost overruns, and safety incidents [5].

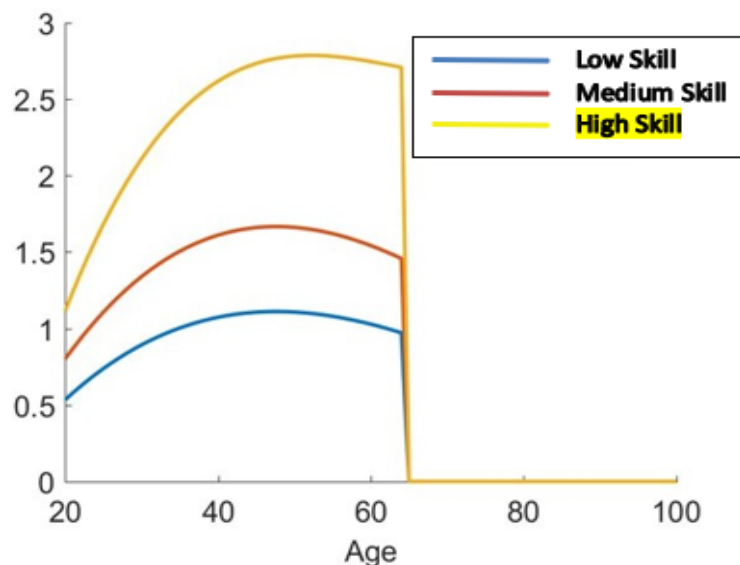


FIGURE 1.1: Labour productivity by age and skill type [6]

The ramifications of compromised labor skills in bridge construction projects are evident in various incidents across the country. For instance, the collapse of under-construction formwork during a bridge girder launching in Islamabad in 2023

tragically resulted in multiple fatalities and months of project delay [7]. Similar occurrences have been reported in Punjab and Khyber Pakhtunkhwa, where bridge deck failures and misaligned piers have necessitated reconstruction, raising serious concerns over the standard of workmanship [8]. These cases point toward systemic issues in vocational education, construction supervision, and labor regulation, which are yet to be comprehensively addressed by stakeholders. Despite the

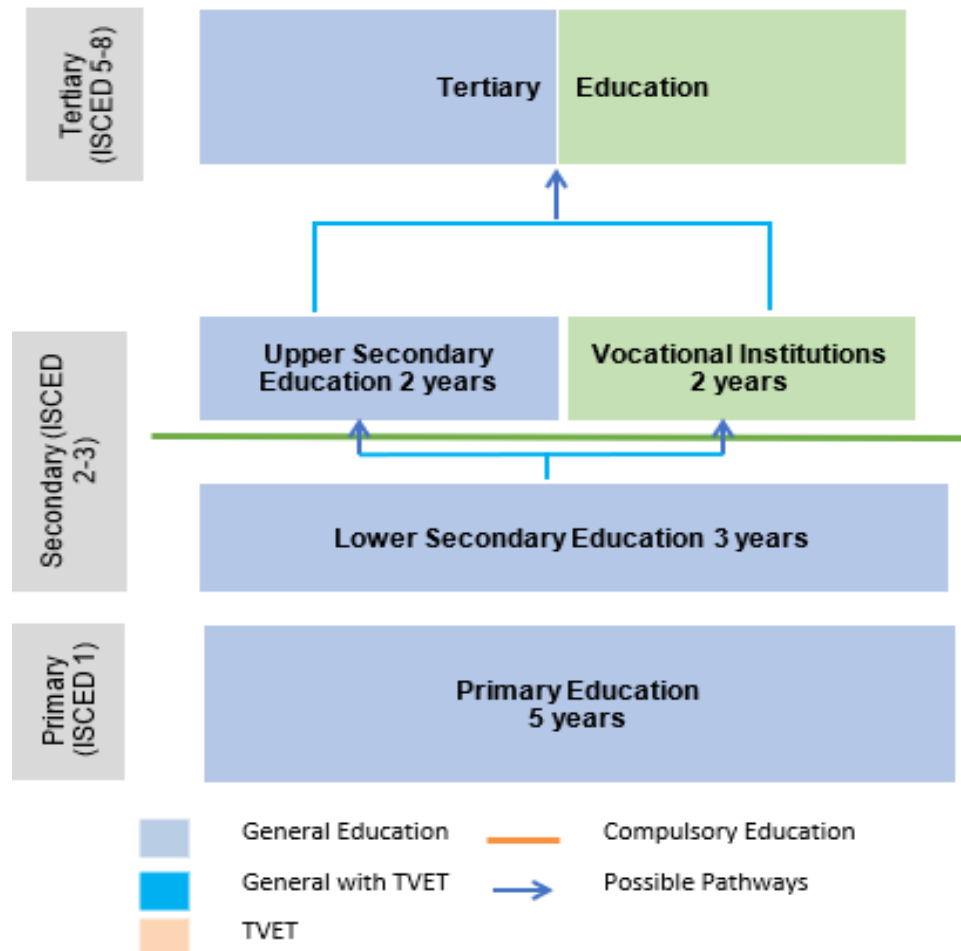


FIGURE 1.2: TVET formal, non-formal and informal systems scheme compiled by UNESCO-UNEVOC [11]

presence of national training authorities such as NAVTTC and provincial TEVTAs, Pakistan’s vocational training infrastructure remains fragmented and underfunded [9]. Most construction training programs do not adequately reflect current industry demands, especially in specialized domains like bridge construction. According to the Pakistan Skills Development Report [10], less than 15% of the construction workforce receives formal technical training. Moreover, where training exists, it often lacks alignment with site-specific tasks such as post-tensioning

procedures or high-rise scaffolding systems—skills critical for modern bridge engineering. Figure 1.2 describes the TVET formal, non-formal and informal systems scheme compiled by UNESCO-UNEVOC to be followed by developing countries.

This deficiency is particularly detrimental given Pakistan’s ambitious infrastructure agenda. Without a competent skilled workforce, these projects face heightened risks of delays, rework, structural compromise, and cost escalation. Furthermore, compromised labor skills have direct implications for occupational safety, as poorly trained workers are more likely to engage in unsafe practices leading to accidents and fatalities [12].

In sum, the construction of RCC bridges in Pakistan is deeply influenced by the skill profile of the labor force. The prevailing skill gaps undermine not only the quality and lifespan of bridge infrastructure but also the economic and social returns on public investment. Addressing this challenge requires an in-depth analysis of the causes, manifestations, and impacts of compromised skilled labor, with a view to recommending evidence-based strategies for workforce development and construction quality improvement.

1.2 Research Motivation

The strategic importance of RCC bridges in Pakistan’s infrastructure development cannot be overstated. These structures are essential for enhancing regional connectivity, reducing travel time, and promoting economic integration. With the government prioritizing the construction of highways, bypasses, and rural access bridges, there is unprecedented demand for timely and high-quality bridge delivery. However, this infrastructure ambition is increasingly at odds with the realities on the ground—most notably, the pervasive shortage of adequately skilled construction labor.

The growing frequency of structural failures, construction delays, and safety breaches in bridge projects across Pakistan underscores the gravity of the skills deficit. Whether in metropolitan centers like Karachi and Lahore, or in smaller cities and rural districts, project execution is often marred by errors traceable to underqualified or untrained workers. For instance, recent construction site

incidents-such as the collapse of an RCC girder during placement in Islamabad [7]-highlight the real and present risks posed by a compromised workforce. These incidents not only endanger human life but also damage public trust, increase financial liability, and impede the state's infrastructure delivery capacity.

Despite the visible impact of these issues, limited academic research has examined the root causes and implications of skilled labor shortages specifically within the context of RCC bridge construction in Pakistan. Most existing studies address general labor productivity or vocational training gaps in the broader construction sector, without isolating the high-stakes, technically complex domain of bridge works. Yet, bridges present unique engineering and safety demands that necessitate a focused examination.

Thus, the motivation behind this study is to fill the critical research gap by providing a structured, evidence-based analysis of how compromised skilled labor affects RCC bridge project outcomes in Pakistan. By identifying the most pressing skill gaps and assessing their real-world impacts on project performance, the research aspires to support the development of responsive training programs, improved site practices, and ultimately, safer and more resilient infrastructure across the country.

1.3 Problem Statement

Pakistan's construction industry is undergoing rapid expansion, spurred by large-scale infrastructure initiatives such as the China Pakistan Economic Corridor (CPEC), national highway expansions, and urban development schemes. In Pakistan's 2025-26 budget only, a total of Rs 1,000 billion has been earmarked for the Public Sector Development Program (PSDP), with a substantial portion dedicated to infrastructure projects including bridges (www.finance.gov.pk). Amid this growth, a critical constraint has emerged: the persistent shortage of adequately trained and skilled construction labor, particularly in specialized domains such as Reinforced Cement Concrete (RCC) bridge construction. This skills gap has become a structural bottleneck for the industry, undermining project execution, quality, safety, and cost-effectiveness across various regions of the country.

RCC bridge projects are particularly sensitive to workforce competence, as they require precise execution across multiple technical phases—from formwork carpentry and steel reinforcement to precise alignments and prestressing works. When these tasks are undertaken by inadequately trained personnel, the result is often sub-standard workmanship, structural inconsistencies, and rework. The implications are significant. Project delays become common when tasks require re-execution due to errors. Cost overruns escalate due to wastage of materials, inefficient labor hours, and contractual penalties. Most critically, public safety is jeopardized when foundational bridge elements fail to meet structural specifications. According to recent reports, several bridge-related incidents—such as girder collapses or deck failures during construction—have been linked to human error and inadequate workforce skills [7].

Although technical training authorities such as NAVTTC and provincial TEVTAs exist, current vocational training programs often fail to meet the evolving needs of modern infrastructure projects. The curriculum is frequently outdated, and institutional capacity is limited in terms of both faculty and equipment. Moreover, there is a weak interface between vocational institutions and employers, resulting in a misalignment between training and real-world site demands [9].

This thesis, therefore, addresses a pressing and under-examined issue in Pakistan’s infrastructure development landscape: the impact of compromised skilled labor on RCC bridge construction. Specifically, it investigates how labor skill deficiencies affect key project performance indicators—such as quality, safety, cost, and time—and seeks to identify the underlying gaps in training systems and on-site practices. By doing so, the study aims to contribute practical insights toward policy formulation, workforce development, and the sustainable delivery of bridge infrastructure in Pakistan.

1.4 Research Questions

This research work is designed to answer the following key questions:

- i. What are the critical skilled labor deficiencies currently affecting the successful execution of RCC bridge construction projects across Pakistan?

- ii. How do these skill gaps impact core project performance metrics such as construction quality, completion time, cost control, and site safety?
- iii. To what extent are current skills development programs in Pakistan aligned with the skill demands of RCC bridge projects?

1.5 Research Objectives

The objectives of this research work are:

- i. To identify key skilled labor deficiencies affecting RCC bridge construction projects in Pakistan.
- ii. To assess the impact of compromised skilled labor on project performance indicators including structural quality, construction timelines and cost overruns.
- iii. To evaluate the alignment between existing skills development programs and the skill requirements of RCC bridge construction sites across Pakistan.

1.6 Brief Methodology

Brief methodology of this research is illustrated in Figure 1.3 below:

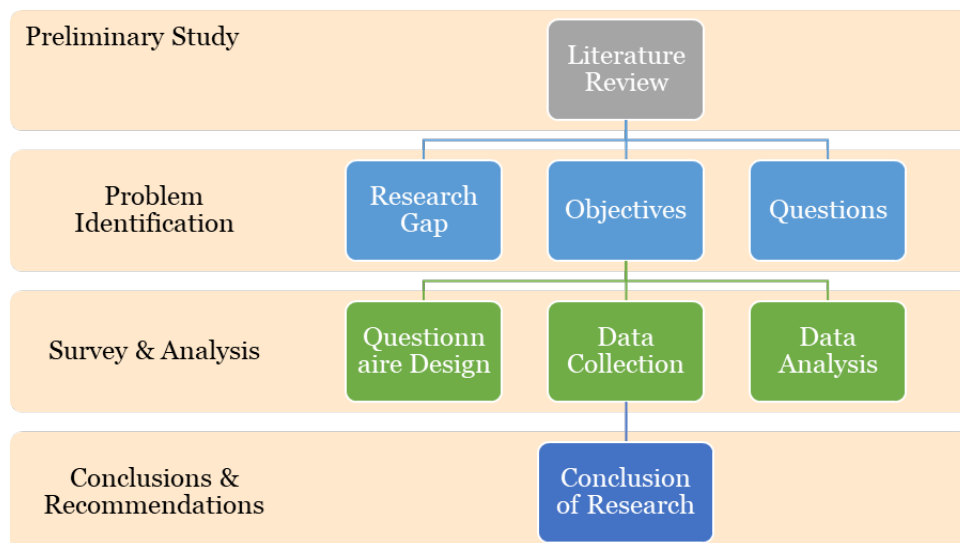


FIGURE 1.3: Brief Research Methodology

1.7 Scope of Research

This research focuses on the implications of compromised skilled labor within the specific context of Reinforced Cement Concrete (RCC) bridge construction projects across Pakistan. Geographically, the study is not restricted to a single city or province; rather, it encompasses projects from various regions of the country, including both metropolitan areas such as Islamabad, Lahore, and Karachi, as well as medium-sized cities where bridge infrastructure is expanding. The selection of locations aims to capture a representative picture of skilled labor dynamics across differing urban development contexts in Pakistan.

In terms of project type, the scope is limited strictly to RCC bridge construction. Other infrastructure categories, such as residential buildings, commercial structures, roadworks without elevated spans, or non-RCC bridge types (e.g., steel truss or pedestrian bridges), are excluded from this study. This focused scope ensures the research remains targeted and that findings are directly applicable to stakeholders involved in RCC bridge delivery and workforce development in Pakistan.

1.8 Study Limitations

There are certain limitations of this research which must be acknowledged. Firstly, there is limited availability of published, location-specific academic literature and empirical data related to skilled labor performance in the context of Pakistan's infrastructure sector, especially RCC bridge construction. Secondly, the study relies primarily on data collected through structured questionnaires distributed to only those professionals who have been actively involved in RCC bridge construction. These include project directors, project managers, site engineers and site supervisors from all kind of stakeholders i.e; client, contractor and consultants. While these professionals possess relevant insights, their responses may carry subjective bias or reflect individual project experiences rather than generalized industry-wide conditions.

While these professionals possess relevant insights, their responses may carry subjective bias or reflect individual project experiences rather than generalized industry-wide conditions.

Additionally, due to the purposive sampling technique employed, the findings are based on a non-randomized respondent pool, which limits the generalizability of the results across the entire national construction sector. Moreover, there is lack of direct observational data from active construction sites, which could have added empirical depth to the analysis but was constrained by time limitations.

1.9 Research Significance

This study holds substantial academic and practical significance by addressing the critical yet under-researched nexus between skilled labor deficiencies and the quality, safety, and efficiency of RCC bridge construction in Pakistan. Academically, it contributes to the body of knowledge in construction workforce management by empirically analyzing how labor competency gaps influence project performance metrics—an area with limited localized research in developing countries. The findings will extend theoretical frameworks on human resource challenges in infrastructure projects, particularly in contexts with rapid industrialization but weak vocational training systems. Practically, the study provides actionable insights for policymakers, construction firms, and vocational training authorities (e.g., NAVTTC, TEVTAs) to reform skill development programs, align curricula with industry needs, and enforce competency-based certification. This research has broader implications for national economic growth, public safety, and sustainable development, offering evidence-based strategies to mitigate construction failures, reduce cost overruns, and enhance long-term infrastructure resilience.

1.10 Thesis Structure

This thesis is organized into five chapters, each contributing to a comprehensive understanding of how compromised skilled labor affects the construction of Reinforced Cement Concrete (RCC) bridges in Pakistan.

Chapter 1 introduces the study by outlining the background, problem statement, research motivation, objectives, research questions, scope, limitations, and a brief overview of the methodology. It establishes the foundational context for the investigation and frames the key issues that the study seeks to address.

Chapter 2 presents a detailed review of relevant literature, both local and international, concerning labor skills in the construction industry. It covers topics such as the critical roles played by skilled labor in RCC bridge projects, the consequences of skill shortages on project performance indicators (quality, cost, time, and safety), and the structure cum effectiveness of vocational training systems. The review also draws upon global best practices in workforce development and highlights the existing research gaps specific to Pakistan's bridge construction sector.

Chapter 3 explains the research methodology adopted in the study. It describes the mixed-method approach, the design of the structured questionnaire, the purposive sampling strategy used to select respondents, and the tools and techniques for data analysis. The chapter also addresses ethical considerations, including informed consent and confidentiality of participant responses.

Chapter 4 presents the results and analysis of the data collected through the questionnaire. It includes statistical summaries, correlation analyses, and thematic interpretations that link labor skill deficiencies to observed project challenges such as delays, cost escalations, and safety incidents. This chapter serves to empirically answer the research questions and validate or refute insights drawn from the literature review.

Finally, Chapter 5 concludes the thesis by summarizing the key findings, providing evidence-based recommendations for training policy reforms and industry practices, and suggesting areas for further research. The chapter reflects on the broader implications of the study for Pakistan's infrastructure development and the need for systemic improvements in skilled labor capacity.

Chapter 2

Literature Review

2.1 Introduction

The construction industry relies heavily on skilled workers and skilled human capital for improved project delivery, quality, and productivity [13]. Civil engineering skilled workers play crucial roles in various sectors, including bridge construction, requiring specific skills and knowledge [14]. The performance of construction projects is significantly influenced by the availability of skilled workers, making skilled labor a key resource for project success. However, the industry frequently experiences skilled labor shortages, which are defined as situations where the demand for qualified workers exceeds the available supply [15]. However, the rapid expansion of infrastructure has led to challenges in quality management and skilled human resources, resulting in some bridge failures during construction due to material issues and human errors [16]. Low labor performance has been a major obstacle to improve productivity in many developing countries [17]. H Randolph et al (2002) studied four cases of highway bridge construction performed by contractors who were well established but had little experience in construction of bridges and the results indicated a slippage between 127 and 329% [3].

Similarly, Figure 2.1 illustrates the factors limiting building activity in France from June 2015 to June 2022. In this study, labor shortage is one of the major obstacles faced during construction activities. Despite these concerns, little research

has been conducted in order to examine the contribution/ importance of skilled workers in the overall performance of the construction industry [13].

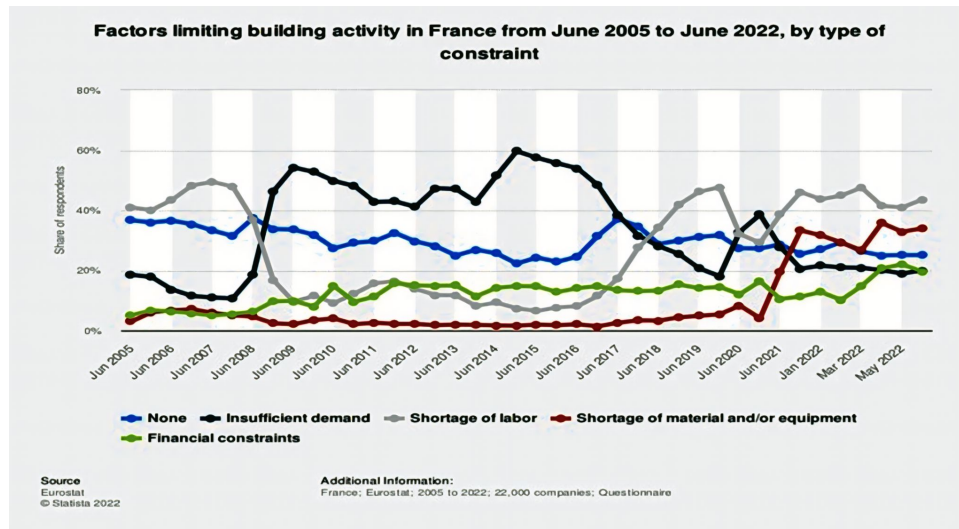


FIGURE 2.1: Factors Limiting Building Activity in France (2015-2022) [18]

2.2 RCC Bridge Construction and Required Skilled Labor Roles

The construction of Reinforced Cement Concrete (RCC) bridges is a multifaceted process that necessitates the coordinated efforts of various skilled labor roles at each stage. For instance, table 2.1 describes the distribution of skilled workers in housing projects; this table is an index of overall requirement of skilled workers across other types of projects.

Effective workforce management is crucial, as poor management can lead to significant productivity losses and schedule delays in bridge projects [20]. The primary phases include substructure construction (foundations and piers), superstructure construction (girders, decks, slabs), and finishing works (parapets, road surfaces, joints). Each phase demands specific trades and competencies to ensure structural integrity and project success. During the foundation and pier construction phase, formwork carpenters and steel fixers (bar benders) play pivotal roles. Formwork carpenters are responsible for constructing the molds that shape the concrete, ensuring they are accurately aligned and robust enough to withstand the pressure

TABLE 2.1: Distribution of Workers (%) by Occupation and Skill Level [19]

Occupation	Unskilled	Semi-Skilled	Skilled	Advanced Skilled	Total (N)	Col (%)
Mason/ Plasterer	32.9	25.3	27.5	14.3	1074	16.7
Rod Binder	29.7	31.4	32.5	6.4	879	13.6
Shuttering Carpenter	23.3	25.3	37.7	13.7	292	4.5
Tiller	19.2	25.5	43.6	11.6	447	6.9
Building Painter	17.2	30.1	42.5	10.3	379	5.9
Welder (Grill Maker)	17.9	31.1	37.8	13.2	296	4.6
House Wiring Electrician	12.9	29.1	44.0	13.9	302	4.7
Plumber	12.3	29.7	46.0	12.0	300	4.7
Aluminum Fitter	17.0	20.1	48.2	14.7	224	3.5
Finishing Carpenter / Dry Wall	22.5	27.2	37.1	13.2	151	2.3
Scaffolder	16.4	19.3	52.1	12.2	336	5.2
False Ceiling Carpenter	18.6	26.1	39.4	16.0	188	2.9
RAC Technician	22.7	22.7	36.2	18.4	163	2.5
Water Proofer	42.0	21.4	28.5	8.2	284	4.4
Pile Driver	20.1	28.1	39.3	12.5	399	6.2
Concrete Pump Operator	28.9	24.8	32.2	14.0	242	3.8
Soil Tester	19.6	22.1	41.7	16.6	163	2.5
Generator and Water Pump Technician	15.5	17.5	48.5	18.6	97	1.5
Lift Technician	21.6	23.2	37.6	17.6	125	1.9
Fire Sprinkler Technician	16.5	22.3	37.9	23.3	103	1.6
Total	23.6	26.3	37.5	12.6	6441	100

of poured concrete. Steel fixers cut, bend, and tie reinforcing steel bars (rebar) according to design specifications, which is crucial for the structural strength of the bridge. The precision in rebar placement and formwork alignment directly impacts the load-bearing capacity and durability of the structure [21].

In the superstructure phase, skilled crane operators and rigging crews are essential for the safe and precise placement of heavy components such as precast girders and in-situ spans. Their expertise ensures that these elements are correctly positioned, which is vital for the overall stability of the bridge. Additionally, surveyors and site engineers use specialized instruments to lay out alignments and levels, ensuring each component is placed accurately [22]. Concrete masons and finishers are tasked with mixing (or overseeing ready-mix delivery), pouring, vibrating for compaction, and finishing the concrete surfaces to the required smoothness or texture. Proper handling of concrete is critical to prevent issues such as honeycombing, weak spots, or uneven surfaces, which can compromise the structural integrity and longevity of the bridge [23].

Modern RCC bridge projects often incorporate advanced construction techniques requiring specialized skills. For instance, post-tensioning methods necessitate technicians proficient in tendon installation and stressing. Extensive scaffolding work

requires certified scaffold erectors to ensure safety and compliance with regulations. Quality control technicians, while often considered technical staff, play a crucial role in testing concrete samples (e.g., for slump and strength) and inspecting rebar or formwork prior to casting, thereby ensuring that construction meets engineering specifications [24].

A skilled RCC bridge construction worker is often expected to be versatile, capable of performing multiple tasks such as welding, carpentry, masonry, and equipment operation as needed. General construction laborers support these specialists by preparing materials, transporting supplies, and performing basic tasks. Even these roles benefit from training in safe tool usage and understanding instructions to maintain overall site safety and efficiency [4].

The coordination of diverse skilled trades is fundamental in bridge projects. Each role's competence level has a direct bearing on construction outcomes. A deficiency in any one of these roles can become a weak link in the construction chain, leading to structural risks and costly repairs. For example, insufficient skilled carpenters might lead to formwork that cannot hold concrete pressure, or a lack of experienced rebar fixers might result in incorrect bar spacing. Therefore, the integration and proficiency of various skilled labor roles are critical to the successful completion of RCC bridge construction projects.

2.3 Skilled Labor Needs and Challenges in Developing Countries Infrastructure Projects

Developing countries, including Pakistan, frequently encounter significant challenges in sustaining a skilled construction workforce, which directly impacts the delivery and quality of infrastructure projects [25]. Rapid urbanization and ambitious development agendas—such as the construction of highways, bridges, and urban transit systems—have intensified the demand for skilled builders. However, the supply of adequately trained labor often fails to meet this demand, resulting in a pronounced skills gap within the construction sector [4]. Table 2.2 describes the ranking of skilled labor shortage in Baltic region countries.

TABLE 2.2: Skilled labor shortage in the building construction industry within the central region [26]

SKILLED LABOUR	AVERAGE INDEX	RANK
Painters/ decorators	1.74	1
Electricians	1.7	2
Tile Workers	1.7	3
Steel benders	1.69	4
Plumbers	1.65	5
Glaziers	1.65	6
Masons	1.61	7
Roofers	1.6	8
Land scraper	1.55	9
Carpenters	1.55	10
HV AC installer technician	1.4	11
Piper fitter	1.44	12

Several studies have identified common factors contributing to skilled labor shortages in developing contexts. A recent survey-based study by Hassan and Riaz (2025) focusing on developing countries' construction industries found that the top causes of skilled labor shortfall included irregular or low wages, insufficient training opportunities, and broader economic shifts prompting workers to leave the construction field. Low wages and job instability drive many existing skilled workers to seek employment abroad or in other sectors, a phenomenon observed in Pakistan where construction workers might migrate to the Middle East for better pay [23]. Roads and bridges in developing countries often suffer from delays and quality issues partly attributed to labor inefficiency [27].

In the context of infrastructure projects, the need for skilled labor is particularly pronounced because such projects are complex, capital-intensive, and have little margin for error. Roads and bridges in developing countries often suffer from delays and quality issues partly attributed to labor inefficiency. Skilled labor is needed not just for executing tasks but also for problem-solving on-site, adapting to engineering challenges, and improving productivity. Unfortunately, many developing nations' construction sectors rely on a large base of unskilled or semi-skilled workers with only a small core of highly skilled supervisors or technicians. The gap becomes evident when introducing new technologies or construction techniques—for example, using advanced formwork systems or specialized concretes requires

training that local crews may lack [22].

In Pakistan, these challenges are evident in the persistent reports of project overruns and structural concerns. The construction industry's inefficiencies have been linked to labor productivity issues; a study on road projects in Pakistan noted that labor productivity is significantly hampered by lack of proper skills and training, which in turn affects project timelines and costs [23]. Furthermore, labor market dynamics in developing countries can exacerbate the issue: construction is often seen as a labor of last resort, and young people may be reluctant to enter the trades due to perceptions of low prestige or challenging working conditions. This social attitude results in fewer new skilled tradespeople to replace an aging workforce which exacerbates this issue, with older workers feeling threatened by automation and skill mismatches [28].

2.4 Impacts of Skilled Labor Shortages on Project Quality, Timeline, Safety and Cost

The shortage of skilled labor in the construction industry, particularly in developing countries like Pakistan, has multifaceted impacts on project performance. These impacts are most prominently observed in four critical areas: quality, timeline (schedule), safety, and cost. Skilled labor shortages in the construction industry significantly impact project performance, affecting cost, quality, productivity, and scheduling [29]. Table 2.3 shows the effects of skilled labor shortages on sustainable construction, as studied by A. Oke et al (2017).

Skilled labor is fundamental to achieving high-quality outcomes in construction projects. A deficiency in skilled workers often leads to substandard workmanship, resulting in defects such as uneven concrete surfaces, improper curing leading to cracks, misaligned structural components, and weak connections. These defects compromise the structural integrity and longevity of infrastructure projects. For instance, inadequate skills in mixing or pouring concrete can result in components with insufficient compressive strength, while misinterpretation of design drawings by untrained carpenters can lead to dimensional inaccuracies [15].

TABLE 2.3: Effects of Labor Shortage on Sustainable Construction [30]

Effects	Mean Item Score (MIS)	Standard Deviation (SD)	Rank
Increase in costs	4.68	0.471	1
Delays	4.61	0.494	2
Reduce quantity	4.61	0.494	2
Higher accident rates	4.54	0.778	3
More rework	4.51	0.597	4
Low productivity	4.44	0.502	5
Increase in cost of production	4.44	0.743	5
Reduce in organization's competitiveness	4.32	0.567	6
Enterprise failure	4.1	0.664	7
Decrease in size of the construction labor sector	4.05	0.835	8
Rise in construction worker's pay	3.61	1.159	9

Project timelines are significantly affected by the availability of skilled labor. Skilled workers are typically more efficient, reducing the likelihood of errors and the need for rework. In contrast, unskilled or less experienced workers may require more time to complete tasks and are more prone to mistakes, leading to project delays. The scarcity of skilled labor can also disrupt the scheduling of trades, as project managers may need to wait for specialized crews to become available, causing idle time and further delays [31].

Construction sites are inherently hazardous, and the presence of skilled labor is crucial for maintaining safety standards. Trained workers are more likely to adhere to safety protocols, correctly use personal protective equipment, and handle machinery appropriately. Conversely, untrained workers may inadvertently create unsafe conditions, leading to accidents and injuries. Empirical evidence suggests a correlation between lower skill levels and increased construction site accidents, as safety training is often integrated into skills training programs. A study by Karimi (2017) found that projects with skilled labor shortages experienced higher

TABLE 2.4: Malaysian Skills Certificate (SKM) details [35]

Level of Education	Job Function	Example Job Title	Skill level	SKM Definition of level 1-5
Advanced Diploma	Management Stage	Manager, Engineer	Level 5	Competent in applying a significant range of fundamental principles and complex techniques across a wide and often unpredictable variety of contexts. Very substantial personal autonomy and often significant responsibility for the work of others and for the allocation of substantial resources feature strongly, as do personal accountabilities for analysis and diagnose, design planning, execution and evaluation.
Diploma	Supervising stage	Executive, assistant engineer	Level 4	Competent in performing a broad range of complex technical or professional work activities that are performed in a wide variety of context with substantial degree of personal responsibility and autonomy. Responsibility for the work of others and the allocation of resources is often present.
Advanced certificate		Supervisor, technician	Level 3	Competent in performing a broad range of varied work activities, performed in a variety contexts, most of which are complex and non-routine. There is also a considerable responsibility and autonomy and control or guidance of others is often required.
Certificate	Operation and production stage	Assistant technician	Level 2	Competent in performing a significant range of varied work activities that are being performed in a variety of contexts. Some of these activities are non-routine and require individual responsibility and autonomy.
Certificate		Operator	Level 1	Competent in performing a range of varied work activities, most of which are routine and predictable.

rates of safety incidents, indicating a direct correlation between labor quality and project safety [32].

The financial implications of skilled labor shortages are substantial. Reduced productivity due to unskilled labor necessitates more worker hours to achieve the same output, increasing labor costs. Additionally, rework and quality corrections inflate material and labor expenses [29]. Project delays resulting from labor inefficiencies also contribute to cost overruns, as extended project durations lead to higher overhead costs and potential penalties for late completion. In extreme cases, structural failures due to poor workmanship can incur significant costs related to investigations, rebuilding, and litigation. Thus, while hiring skilled labor may involve higher upfront costs, it is widely acknowledged that these are offset by savings from improved productivity and quality, making it a cost-effective strategy in the long term [33].

2.5 Global Best Practices in Vocational Training

Vocational training in construction projects is crucial for addressing skilled labor shortages and improving project outcomes. Best practices include developing comprehensive career guidance plans and balancing academic achievement with technical skills to meet industry demands [34].

2.5.1 Malaysia

Quality education and training programs, such as those implemented by GIAT-MARA in Malaysia, support economic development in the knowledge-based construction industry. Table 2.4 presents a glimpse of Malaysian Skills Certifications in the context of labor training.

2.5.2 Germany

Germany's dual VET system is renowned for its integration of theoretical education and practical training. Approximately 60% of German students opt for

TABLE 2.5: The training system in the German construction industry [39].

Year I in weeks	Year 2 In weeks	Years 3 in weeks	Group 3 after 1 year	Trade Profiles
Payment according to collective agreement	Group 5	Group 4		
Foundation training	General Vocational training	Specialized vocational training		
15 weeks in firms and holidays			Building	Bricklayers Concreter Furnace and Chimney Builder Carpenter Plasterer
17 weeks training centers	11 weeks in training centers,	36 weeks in firms, 10 weeks in voc, schools	Finishing	Tiler Floor screeder Thermal and noise insulation fitter dry liner Road worker Piper layer
20 weeks in vocational schools	31 weeks in firms and holidays	10 in voc, schools with trade specialism	4 weeks in training centers	Canal worker Well worker Tracklayer Well builder
			Civil Engineering	

vocational education, with around 70% participating in the dual system, which combines classroom instruction with on-the-job training in companies [37]. In the construction industry, apprentices receive structured training under real work conditions, ensuring that the skills acquired are directly applicable to industry needs. The system is underpinned by strong collaboration between the government, industry chambers, and educational institutions, ensuring that curricula align with labor market requirements. Standardized examinations administered by industry boards certify the competencies of trainees, maintaining high standards across the sector [38].

2.5.3 China

Training in the construction industry in China is deeply entrenched in the local culture and history. Under the strong state dominance, it continually evolves to respond to the dynamic market, thus it can be theorized as market-in-state. In order to ensure that skill policies that are implemented are aligned with the industry policies, political stakeholders are embedded within the state. The reason for differences in the training regimes of China and its foreign counterparts can be attributed to the existence of divergent political-economic models between them [40].

2.5.4 Singapore

Singapore has transformed its vocational training landscape by establishing institutions like the Building and Construction Authority (BCA) Academy, which provides comprehensive training programs for the built environment sector. The BCA Academy offers courses ranging from diploma programs to specialist certifications, focusing on areas such as construction productivity and quality [41]. To ensure a steady supply of skilled workers, Singapore mandates that construction workers, including foreign laborers, undergo specific training and certification processes. For instance, migrant workers must attain Basic-Skilled status through the Skills Evaluation Certificate (SEC) or Accelerated Learning Program (ALP) before employment in the construction sector. This structured approach ensures that

all workers meet the necessary competency standards, enhancing overall industry performance [42].

2.5.5 Japan

Japan's construction industry places a strong emphasis on formal certification and continuous on-the-job training. Workers are encouraged to obtain certifications through national skill tests, which assess competencies in various construction trades. These certifications are often prerequisites for employment, ensuring a baseline of quality and safety across the industry. Additionally, Japan has introduced programs like the Specified Skilled Worker (SSW) visa to address labor shortages. This program requires foreign workers to pass both theoretical and practical exams, demonstrating their proficiency in specific construction skills [43]. Such initiatives underscore Japan's commitment to maintaining high standards in its construction workforce.

In essence, effective vocational training systems are pivotal in cultivating a skilled workforce, particularly in the construction sector. The vocational training models of Germany, Singapore, and Japan share common elements: integration of theoretical and practical training, strong collaboration between government and industry, and emphasis on certification and continuous skill development. These systems ensure that workers are well-equipped to meet industry demands, contributing to higher productivity and quality in construction projects. Examining these established models offers valuable insights for enhancing vocational training frameworks in developing countries like Pakistan.

2.6 Pakistan's Vocational Training Ecosystem: NAVTTC, TEVTA and Industry Initiatives

Pakistan's Technical and Vocational Education and Training (TVET) ecosystem is primarily governed by two main bodies: the National Vocational and Technical Training Commission (NAVTTC) at the federal level, and Technical Education

and Vocational Training Authorities (TEVTAs) at the provincial level. NAVTTC was established in 2005 to act as the apex policy-making and regulatory body overseeing skill development across Pakistan. It introduced key frameworks such as the National Vocational Qualifications Framework (NVQF) and has worked to implement Competency-Based Training and Assessment (CBT&A) curricula aligned with labor market needs [9]. Figures 2.3 and 2.4 show the total number of TVET institutions and number of enrollments in Pakistan from 2000 to 2021.

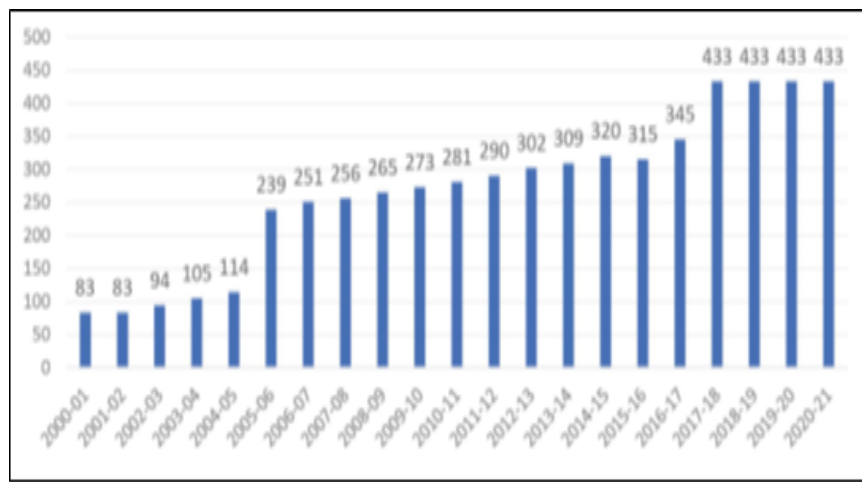


FIGURE 2.2: Number of TVET institutions in Pakistan (2000-2021) [44]

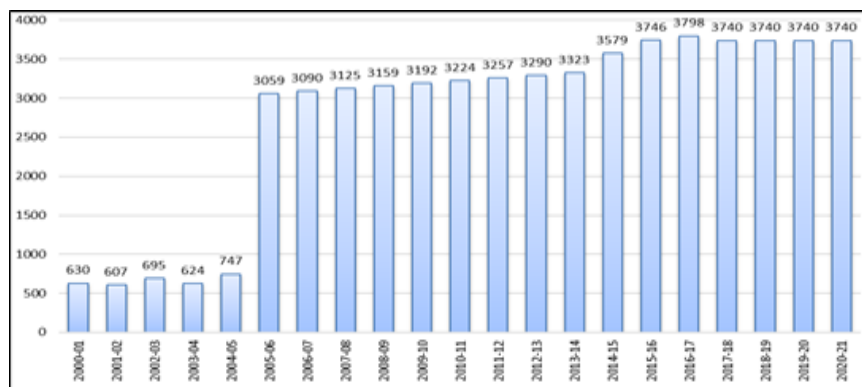


FIGURE 2.3: Number of Enrollment (in thousands) in TVET institutions in Pakistan (2000-2021) [44]

At the provincial level, organizations like Punjab TEVTA and KP TEVTA manage extensive networks of technical colleges and vocational centers. These institutes offer programs in trades including civil drafting, welding, masonry, and surveying [45]. While these institutes aim to prepare youth for employment in construction and other technical sectors, evidence suggests there is often a mismatch between

training delivery and the competencies demanded by industry, particularly in specialized areas such as RCC bridge construction [46].

To improve relevance, NAVTTC has introduced reforms through the Skills for All Strategy, including the Prime Minister's Hunarmand Pakistan Programme launched in 2020. This initiative offers free or subsidized vocational training in high-demand trades, including several construction-related occupations, aiming to bridge the youth skills gap [9]. Additionally, NAVTTC has deployed Recognition of Prior Learning (RPL) frameworks to formally certify informally trained workers, a step toward integrating the large informal workforce into the formal economy. Despite these developments, challenges persist. Training curricula are often outdated, and many instructors lack industry exposure or pedagogical training. Moreover, many vocational institutes suffer from inadequate infrastructure and lack modern tools or materials required for construction trade training [44]. A 2018 sectoral report noted that many trainees are not exposed to new construction technologies such as post-tensioned concrete systems or modular formwork, which limits their employability on modern project sites [46].

There have been efforts to involve the private sector in vocational training delivery. Large construction organizations, such as the Frontier Works Organization (FWO), operate their own training facilities and occasionally partner with government institutes for practical training. Furthermore, collaborations with international development agencies, including GIZ (Germany), have supported curriculum development, instructor training, and establishment of model training centers [48]. The Construction Technology Training Institute (CTTI) in Islamabad is one such example where technical training for construction workers is imparted under both national and donor-supported programs.

Table 2.7 highlights the demand / Supply Gap of skilled workforce in Pakistan Vocational training landscape noted in the TVET Skills Gap Analysis [56]. Furthermore, systemic constraints limit the effectiveness of Pakistan's TVET system. These include low public investment in technical education, social bias against vocational careers, and weak coordination between NAVTTC, TEVTAs, and industry employers [44]. Consequently, a significant share of construction workers still enter the labor force informally-learning on-site as helpers without receiving

TABLE 2.6: The Demand-Supply Gap

Aspect	Demand (2025)	Supply (2025)	Gap/Issue
Annual skilled labor	Over 1 million (domestic + overseas)	450,000/500,000 graduates	Shortfall of 500,000+ per year
Industry alignment	High demand in IT, construction, health care	Limited relevant training, outdated curricula	Skills mismatch, low employability
Overseas placement	172,000+ skilled workers sent abroad (Q1 2025)	Many graduates lack required certifications	Missed opportunities, underutilized workforce
Employer satisfaction	47% satisfied with TVET graduates	18% dissatisfied, 35% no response	Quality and relevance concerns

formal instruction or certification. Although RPL initiatives are a step in the right direction, uptake remains slow due to limited awareness and logistical hurdles.

2.7 Curriculum vs. Site-Specific Skill Demands in Construction

A persistent issue within Pakistan's technical and vocational education and training (TVET) sector is the misalignment between formal curricula and the practical skills required on construction sites. This discrepancy contributes significantly to the skills gap observed in the construction industry.

Many vocational programs offer a broad overview of construction trades but often lack depth in specialized areas such as reinforced cement concrete (RCC) bridge construction. For instance, a diploma in civil technology may cover general topics like surveying and concrete technology; however, graduates frequently find themselves ill-prepared for specific tasks such as tensioning cables in prestressed girders or employing slip-forming techniques for bridge piers. This gap arises because such specialized modules are either absent from the curriculum or not emphasized sufficiently [49].

The rapid evolution of construction technologies-introducing new materials, formwork systems, and mechanization further exacerbates this issue. Training programs often struggle to keep pace with these advancements, leading to a workforce

that is not adequately equipped to handle modern construction demands. Consequently, adaptability and problem-solving skills become crucial; however, these competencies are challenging to cultivate in environments where teaching remains predominantly theoretical [50].

On-the-job learning frequently serves as a stopgap, allowing workers to acquire necessary skills through practical experience. While this experiential learning is valuable, its effectiveness is inconsistent, heavily reliant on the presence of knowledgeable mentors and a culture that promotes skill transfer. In Pakistan's largely informal construction sector, the variability in skill transmission can perpetuate outdated or incorrect practices [49].

The World Economic Forum has highlighted that public sector-led skills training efforts in Pakistan are often fragmented, resulting in a significant disconnect between training provided and industry requirements. Employers frequently find that graduates of vocational institutes require additional training to meet practical job demands. As a result, construction companies often implement their own induction programs to bridge this gap, focusing on practical skills and safety protocols absent from formal curricula [49].

In the context of RCC bridge construction, site-specific demands include strict adherence to quality control procedures, effective teamwork during high-risk operations, and familiarity with relevant codes and standards. Vocational curricula may not explicitly cover these aspects or provide sufficient simulation of site environments to build student confidence. While internships or site visits during training could address this, not all programs incorporate such experiential learning systematically [49].

In summary, addressing the misalignment between vocational training curricula and site-specific skill demands is crucial for enhancing the effectiveness of Pakistan's construction workforce. By identifying and rectifying these mismatches, particularly in specialized areas like RCC bridge construction, training programs can be better tailored to meet industry needs, thereby improving project outcomes and worker proficiency.

2.8 Research Gap

A comprehensive review of the literature reveals a significant gap in research specifically addressing skilled labor challenges within Reinforced Cement Concrete (RCC) bridge construction in Pakistan. While there is a considerable body of work focusing on construction delays, cost overruns, labor productivity, and general skill shortages in the broader construction sector, few studies have narrowed their focus to infrastructure sub-sectors such as RCC bridge construction.

Most national studies aggregate data across construction types, treating vertical building projects (e.g., residential or commercial construction) and horizontal infrastructure projects (e.g., roads and bridges) as a single analytical category [46]. However, RCC bridge construction presents distinct structural, procedural, and safety-related complexities that differentiate it from other construction forms. It involves high-risk operations such as heavy lifting of precast elements, use of tensioning systems, and stringent quality control in concrete placement and curing-tasks that require specialized technical skills and precision. Consequently, the implications of deficient skills in such projects are potentially more severe, with a higher risk of structural failure or safety incidents [44].

This underrepresentation of bridge-specific labor skill analysis in empirical research constitutes a clear gap. The limited studies available focus on either generic vocational training policy or broad performance indicators without disaggregating by infrastructure type or construction methodology. This study aims to address that void by providing a focused assessment of the implications of compromised skilled labor in RCC bridge construction in Pakistan. Such a targeted analysis contributes nuanced insights that are often lost in aggregated data models and can support infrastructure-specific workforce development strategies.

2.9 Summary

This chapter has reviewed existing literature to establish the foundational importance of skilled labor in the successful construction of Reinforced Cement Concrete (RCC) bridges and to highlight the significant challenges faced by Pakistan in developing and sustaining a competent construction workforce. It has been demonstrated that RCC bridge projects depend on the coordinated input of multiple

specialized trades, such as formwork carpentry, steel fixing, concrete handling, machinery operation, and quality control. Deficiencies in any of these trades can become critical bottlenecks, compromising structural integrity, delaying timelines, and elevating costs and safety risks.

Within the broader context of developing countries, Pakistan's construction sector reflects many common labor-related challenges, including insufficient training infrastructure, outdated curricula, lack of industry input in program design, and the migration of skilled workers to more lucrative overseas markets. Pakistan's own vocational training efforts, led by NAVTTC and provincial TEVTAs, have made some progress through initiatives such as the Skills for All program and the adoption of Competency-Based Training (CBT). However, implementation gaps remain. Key issues include a mismatch between training content and site-specific requirements, uneven training quality across institutions, and limited integration of practical learning components such as internships or apprenticeships.

With the literature landscape mapped and the research gap defined, the thesis now transitions to Chapter 3, which outlines the methodology employed to investigate these issues. The next chapter details the research design, sampling strategy, data collection instruments, and analysis techniques used to examine the implications of compromised skilled labor on RCC bridge construction performance in Pakistan.

Chapter 3

Research Methodology

3.1 Background

This chapter defines the methodical strategy employed to tackle the research challenge and fulfill the study's objectives. Research methodology is an essential component of any study, offering a systematic framework that directs the complete process of data gathering, analysis, and interpretation. This chapter provides a detailed account of the research process, commencing with the selection of the suitable study design and the identification of the principal components affecting the phenomenon being studied. This chapter explains the method used to establish the sample size and outline the demographic traits of the participants. After that, it looks at the questionnaire development process, outlining how the survey tool was created to gather crucial information on the relevant factors. This chapter also describes the methods for gathering and analyzing data, ensuring that the approaches are suitable for solving the research challenge.

3.2 Framework of the Research Methodology

This research adopts a mixed-method approach, with a primary emphasis on quantitative data, to examine the implications of compromised skilled labor on RCC bridge construction across Pakistan. The mixed-method paradigm was selected

to capture both the measurable trends in labor skill deficiencies and the underlying contextual factors influencing these issues at site level. Quantitative data enables objective analysis of patterns-such as how frequently certain skill gaps correlate with project delays, cost overruns, or safety incidents-while qualitative insights offer interpretive richness by capturing stakeholder perspectives, industry experiences, and site-specific observations.

To conduct the research, a questionnaire has been created, and insights from the respondents are collected through a review of the literature. After conducting a statistical analysis of the data, the major skillsets affecting labor productivity in RCC bridge construction are prioritized through the relative importance index method. The flow chart and methodologies utilized in the present study are illustrated in Fig 3.1.

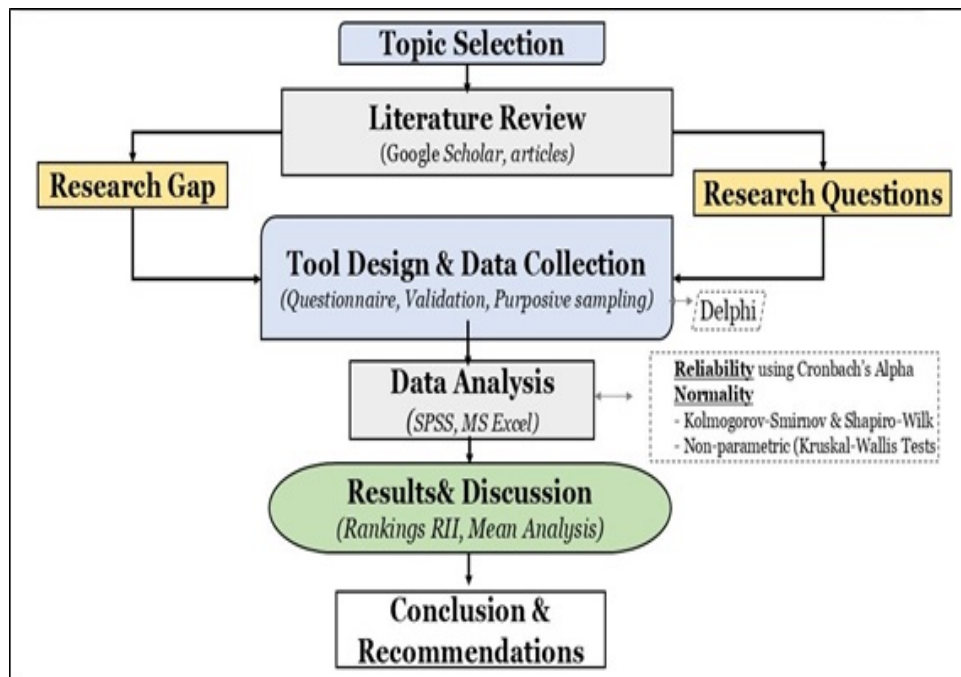


FIGURE 3.1: Flow chart of Research Methodology

3.2.1 Stage 1 Problem Identification & Research Design

Initially, preliminary literature review was conducted to identify and select an appropriate and impactful topic for carrying out research. This study adopts an exploratory, cross-sectional research design to investigate the implications of compromised skilled labor on RCC bridge construction projects in Pakistan. The

exploratory nature of the design is appropriate given the limited academic focus on this subject within the Pakistani context. While general labor productivity and construction performance have been studied, focused analyses on skilled labor deficiencies specific to RCC bridge projects remain scarce. Hence, the research aims not to test pre-established hypotheses but to uncover patterns, relationships, and thematic areas that can inform both academic discourse and practical recommendations.

3.2.2 Stage 2-Literature Review

The initial phase of the research process entails performing a comprehensive literature review. This phase is essential as it establishes a fundamental comprehension of the research issue and situates the study within the current body of knowledge. The review not only informs the formulation of the issue statement but also assists in delineating the research objectives by emphasizing critical themes and deficiencies in existing research.

3.2.3 Stage 3-Defining the Problem

Based on the conclusion of the thorough literature review, problems in the area of labor productivity in Pakistan were summarized and RCC bridge construction related problems were defined. Given the technical nature of the topic and the need for informed insights into skilled labor deficiencies, purposive sampling was selected as the most appropriate method. This non-probability sampling technique, also referred to as judgmental sampling, enables the researcher to deliberately select participants based on their expertise and involvement in bridge construction, rather than relying on randomized selection, which may include respondents lacking the necessary context.

3.2.4 Stage 4-Aim and Objectives

Following the identification of the problem, the study's aim and objectives were established to tackle the issue of enhancing the skillsets of labor involved in bridge

construction in Pakistan's construction industry.

3.2.5 Stage 5-Design of Data Collection Tool

This research utilizes purposive sampling to identify and engage individuals who possess direct and relevant experience with RCC bridge construction projects in Pakistan. The investigation employed a quantitative methodology for data gathering to fulfill its aims through a structured questionnaire as the main instrument for data collection.

The study targets professionals actively involved in the planning, supervision, or execution of RCC bridge projects, including civil and site engineers, project managers, construction supervisors, foremen, contractors, and where relevant-trainers or administrators from vocational institutions. All respondents were selected based on their experience with bridge projects either currently in progress or completed within the last five years, ensuring that the data collected reflects recent and relevant field conditions. The process was conducted primarily online. Survey links were distributed through professional networks, civil engineering associations, WhatsApp forums and through referrals within the industry. This approach was particularly useful in reaching a mobile and geographically dispersed workforce, allowing the study to tap into expertise beyond a single organization or locality.

3.2.6 Stage 6-Data Collection

The primary tool used for data collection in this research was a structured questionnaire, designed to capture both quantitative and qualitative data from professionals involved in RCC bridge construction across Pakistan. The questionnaire was developed using Google Forms and distributed digitally to maximize accessibility and participation across different regions. It was designed with careful attention to content validity, ensuring that all items directly related to the study's research objectives and reflected key themes emerging from the literature review, such as labor skill gaps, training exposure, project performance outcomes, and on-site challenges.

The instrument was divided into multiple sections. The first section gathered demographic and professional information about the respondents, including their role in construction (e.g., engineer, supervisor, contractor), years of experience, and geographic location. This helped contextualize responses and allowed for subgroup analysis across different roles and regions.

Subsequent sections of the questionnaire focused on core variables. Respondents were asked to rate the adequacy of skilled labor available for specific construction trades relevant to RCC bridge projects—such as formwork carpentry, steel fixing, concrete finishing, heavy equipment operation, and scaffolding. Questions also assessed the respondents' perception of how skill deficiencies have impacted project outcomes, including construction quality, timelines, cost, and safety. Most of these questions were formatted using Likert scales (typically ranging from Strongly Disagree to Strongly Agree) to facilitate quantitative analysis.

3.2.7 Data Validation

After collecting responses, a validation process is conducted to ensure the quality and reliability of the data. This process included checking for completeness (i.e., whether all required questions were answered), consistency (i.e., logical flow of answers), and accuracy of responses. Any responses with excessive missing data, random or contradictory answers, or evident response bias were excluded from further analysis. Furthermore, a reliability analysis (using Cronbach's Alpha) is conducted after data collection, which led to the exclusion of two responses that compromised the internal consistency of the dataset. Only the final set of 129 responses that met all quality criteria is retained for the main analysis. This multi-step validation approach ensured the credibility and robustness of the dataset used in this research.

3.2.8 Data Analysis

The data that was collected through the structured questionnaire was analyzed using a combination of descriptive and inferential statistical techniques, supported

by thematic analysis of qualitative responses. The primary goal of the analysis was to identify prevalent patterns in skilled labor availability, evaluate the perceived impact of skill deficiencies on key project performance indicators, and explore correlations between labor competency and construction outcomes in the context of RCC bridge projects across Pakistan. The aim of data analysis was to categorize and rank all the parameters that were there in the investigation. Data that was collected was first converted and then transformed into SPSS format in order to conduct analysis. SPSS version 2025 and Microsoft Excel were used for analysis in this study.

3.3 Conduct of Survey

The questionnaire is distributed among a wide range of stakeholders involved in the construction industry, including clients, developers, contractors, consultants, etc. The questionnaire was developed using Google Forms and distributed digitally to maximize accessibility and participation across different regions. It was designed with careful attention to content validity, ensuring that all items directly related to the study's research objectives and reflected key themes emerging from the literature review, such as labor skill gaps, training exposure, project performance outcomes, and on-site challenges.

To assess the significance of stakeholder engagement, a five-point Likert scale was used, where respondents rated the importance of different aspects of engagement, from "strongly not agree" to "strongly agree." To enrich the data and allow for contextual insights, each section also included optional open-ended comment fields. Respondents were encouraged to elaborate on their experiences, provide examples of challenges faced on construction sites, or suggest improvements to the current training and workforce development systems.

3.4 Sample Size

Among the various sample guidelines available, Harris (1975) provided one of the most direct and widely used rules for regression-based studies. The formula is:

$$N > 50 + m$$

N is required minimum sample size

m is the number of predictor variables.

For the present study, $m = 52$ variables

Number of respondents required $N > 50 + 52 = 102$

Furthermore, Conroy (2021) states that a sample size of 100 is often considered a minimum for meaningful results, as a Rule of thumb. The study iterates that if the population size 5000 or larger, then a sample size of 96 to 98 would yield results within 10 percent margin error which is good enough to infer the results. Since the population of construction professional within Islamabad is around 5000, therefore, minimum sample size i.e. 98 is deemed suitable for our evaluation. Total 129 responses were received with 2 responses discarded due to incomplete answers, hence meeting requirement of minimum sample size.

3.5 Scale for Data Measurement

The questionnaire was specially designed for statistically analyzing the data. A 5 point Likert scale was used in this survey to measure the level of adoption and level of effectiveness for parameters that were investigated in this study. The measurement scale that was used for investigation of different parameters is presented in table 3.1. 5-point Likert scale enables the respondents to provide the appropriate answers/ solutions to the questions raised. It was developed to collect quantitative data, which used stratified random sampling technique to determine the sample size that was representative of the entire population.

TABLE 3.1: Likert Measurement Scale

Level of Adoption	Scale
Strongly not agree	1
Not agree	2
Neutral	3
Agree	4
Strongly Agree	5

3.6 Method of Data Analysis

3.6.1 Reliability Test

A reliability test is performed to assess the consistency of the collected data. The measurement is determined by the value of Cronbach's alpha (α). The Cronbach Alpha value was calculated using the SPSS software package and evaluated according to specific criteria: a value below 0.5 is deemed unacceptable, between 0.5 and 0.6 is considered poor, between 0.6 and 0.7 is questionable, above 0.7 is acceptable, and values between 0.8 and 0.9 are regarded as good to excellent, as illustrated in table 3.2 there range from unacceptable to excellent as referenced from [52].

TABLE 3.2: Ranging Scale of Cronbach's Alpha [53].

Internal Consistency	Cronbach's Alpha
Excellent	$\text{Alpha} \geq 0.9$
Good	$0.8 \leq \text{Alpha} < 0.9$
Acceptable	$0.7 \leq \text{Alpha} < 0.8$
Questionable	$0.6 \leq \text{Alpha} < 0.7$
Poor	$0.5 \leq \text{Alpha} < 0.6$
Unacceptable	$\text{Alpha} < 0.5$

3.6.2 Normality Test

Shapiro-W-test Wilk's (1965) is a well-established and reliable technique for determining normality. The Shapiro-Wilk test, often known as the normality test, is used to determine whether or not the data obtained is normal. If data is normally distributed (parametric data), then the significant level should really be larger than 0.05, but a value less than 0.05 indicates that the data range is not normal (nonparametric data).

3.6.2.1 Parametric and Non-parametric Evaluation

In statistical analysis, the choice between parametric and nonparametric tests is made when the results do not confirm the test hypothesis. The parametric test is

valid for a stable, regularly distribution pattern with precisely defined spreads for each group, as well as for linear data. However non-parametric tests are performed when data is examined on ordinal and ordered scales, it doesn't really follow a specific distribution and exhibits non - linear behavior [54]. Non-parametric tests reveal that the data are not distributed normally, whereas parametric tests demonstrate that the data are distributed normally. When the data doesn't have a normal distribution, Kim and Park [55] demonstrated that a non-parametric test is utilized. The null hypothesis of normality is rejected if p-value is less than or equal to 0.05. The normality assessment hypothesis is as follows: H0: The data follows a normal distribution if p-value greater than alpha level. H1: The data does not follow a normal distribution if p-value less than alpha level.

3.6.3 Relative Importance Index

This study methodology consisted of identifying and evaluating the intensity level of results associated with accidents and hazards, harmful behaviors, unsafe settings, management systems and social groups, and natural factors. The value of each component was calculated by averaging the data set values supplied by respondents. Therefore, the intensity level selected by respondents was used to compute the relative significance index for each piece. The 1-to-5 ranking scale was converted into a relative relevance index for each component in order to quantify the ranks of all the elements. RII is determined by the equation (3.2).

$$RII = \frac{W}{A \cdot N} \quad (3.2)$$

Where:

W = Weightage given to each factor by respondents ranges from 1 to 5 using Likert scale

A = Highest value for factors (which is 5 on the Likert scale)

N = Total number of respondents.

3.7 Summary

This chapter outlined the methodological framework adopted to investigate the implications of compromised skilled labor on RCC bridge construction in Pakistan. The research employed a mixed-method approach, with a dominant emphasis on quantitative data, supported by qualitative insights gathered through open-ended survey responses. This pragmatic methodology was deemed appropriate to address the complex and multifaceted nature of labor skill deficiencies in infrastructure construction. The study adopted an exploratory and cross-sectional design, enabling a structured yet flexible investigation into prevailing workforce challenges across diverse project settings and professional roles.

Purposive sampling was employed to select industry practitioners with direct experience in RCC bridge construction, ensuring that the insights gathered were both relevant and informed. The primary data collection instrument—a structured questionnaire—was carefully developed to assess the availability and adequacy of skilled labor, training exposure, and perceived impacts on project outcomes such as quality, cost, time, and safety. The questionnaire’s design allowed for quantitative analysis while also incorporating open-ended fields to capture contextual explanations and expert commentary.

The analysis plan involved the use of descriptive statistics and correlation analysis to interpret quantitative data, while qualitative responses were examined thematically to support triangulation and enrich the findings. Throughout the research process, ethical standards were strictly observed, ensuring participant anonymity, voluntary participation, and responsible handling of all data collected.

Collectively, the methodological decisions taken in this chapter provide a sound and credible basis for answering the research questions posed in Chapter 1. With the research design now fully defined, the next stage of the thesis will focus on data analysis and presentation of findings, which will be discussed in Chapter 4.

Chapter 4

Results and Discussion

4.1 Introduction

The present chapter focuses on the analysis and interpretation of data collected through structured questionnaires administered to professionals involved in RCC bridge construction projects. The aim of the research was to evaluate how the presence of inadequately skilled labor affects the quality, cost, schedule, and safety of reinforced cement concrete (RCC) bridge structures. As established in the earlier chapters, the construction of RCC bridges is a highly technical process that requires precision in activities such as steel reinforcement fixing, formwork installation, and concrete pouring. These tasks demand a skilled workforce to ensure compliance with design specifications and engineering standards.

However, in many infrastructure projects across Pakistan - particularly in public-sector developments - the availability of adequately trained laborers remains limited. This results in compromised construction quality, frequent rework, safety hazards, and delays in project delivery. To quantitatively assess the extent of these challenges, a structured survey was developed and distributed among engineers, site managers, contractors, and consultants who have practical experience with bridge projects. The survey captured their perceptions on various skill deficiencies and their observed implications on site.

This chapter first outlines the demographic profile of the respondents to contextualize the reliability of the data. It then presents a statistical breakdown of

responses using descriptive analysis, Relative Importance Index (RII) and mean analysis calculations. Finally, it discusses the results in relation to the research objectives and compares them with existing literature. The combination of quantitative rankings and qualitative observations provides a comprehensive understanding of how compromised skilled labor influences the performance and outcomes of RCC bridge projects in the local context.

4.2 Demographic Profile of Respondents

Understanding the demographic characteristics of the respondents is crucial for establishing the credibility, relevance, and context of the data collected in this study. The participants of the survey were selected based on their direct involvement in the planning, execution, supervision, or oversight of RCC bridge construction projects in Islamabad. The questionnaire was distributed among professionals representing contractors, client organizations, and consultants. The objective was to capture a broad spectrum of perspectives regarding the impact of skilled labor shortages on various components of bridge construction.

A total of 129 responses were obtained, making the sample statistically robust for the purpose of this study. The demographic profile was assessed through parameters including the type of organization, designation or role, total professional experience, and experience specifically in bridge projects. The summary of these findings is discussed below.

4.2.1 Type of Organization

To understand the influence of organizational roles on perceptions of labor-related challenges in RCC bridge construction, the respondents were categorized based on their organizational affiliation. The three main categories were: Contractors, Clients, and Consultants. Each of these stakeholders plays a critical role in the lifecycle of infrastructure development and provides a unique perspective on the implications of compromised skilled labor.

A breakdown of the responses is presented in table 4.1 below:

TABLE 4.1: Distribution of Respondents by Organisation Type

Type of Organization	Number of Respondents	Percentage
Contractor	75	58.10%
Client	30	23.30%
Consultant	24	18.60%
Total	129	100%

As shown in the table above, the majority of the participants (58.1%) were affiliated with **contractor organizations**. This is particularly relevant to the research, as contractors are primarily responsible for managing on-site activities, including labor deployment, supervision, quality control, and task execution. Their insights offer first-hand accounts of the performance and shortcomings of field labor in real-time construction conditions.

Clients, comprising 23.3% of the total responses. Their responses reflect an emphasis on timelines, cost control, and compliance with specifications - all of which are impacted by the skill level of the workforce.

Consultants, who made up 18.6% of the respondents, include design engineers, quality control specialists, and site supervisors engaged in monitoring and technical advisory roles. They provided objective assessments of construction quality, safety protocols, and labor deficiencies from a compliance perspective.

The following pie chart visually illustrates the organizational distribution of respondents:

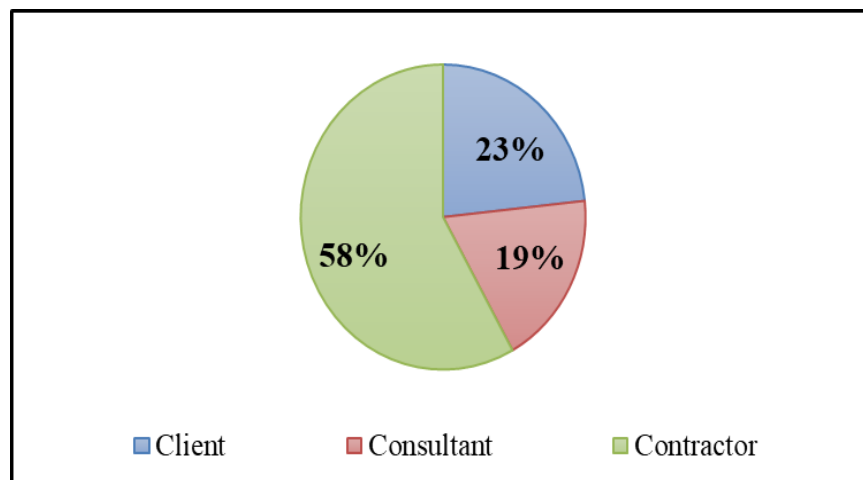


FIGURE 4.1: Distribution of Respondents by Organization Type

The diversity in respondent profiles across these three organizational types ensures that the data reflects a well-rounded understanding of the challenges posed by compromised skilled labor in the context of RCC bridge construction. This balanced representation enhances the reliability of the subsequent statistical analysis and the overall robustness of the study.

4.2.2 Designation and Role

The designation or professional role of each respondent was assessed to ensure that the collected data reflected both field-level execution experiences and managerial-level strategic insights. Understanding the role of the respondent is essential for contextualizing their perspective on how skilled labor deficiencies affect RCC bridge construction in Islamabad. The distribution of respondents by designation is shown below in table 4.2: The largest group of respondents (35.7%) were

TABLE 4.2: Distribution Of Respondents By Designation

Designation/Role	Number of Respondents	Percentage
Site/Resident Engineer	46	35.70%
Project Manager	32	24.80%
Project Director	14	10.90%
Other (Supervisor, Advisor, QA/QC, etc.)	37	28.60%
Total	129	100%

Site/Resident Engineers, who are directly responsible for supervising construction activities, resolving field-level issues, and interacting with labor on a daily basis. Their insights are especially valuable as they witness first-hand the execution quality and challenges faced due to unskilled or semi-skilled workers.

Project Managers constituted 24.8% of the sample and contributed strategic insights into project scheduling, cost control, and coordination with subcontractors. Their role often includes monitoring labor productivity, approving execution plans, and managing resources - all of which are impacted by the availability of skilled workers.

Project Directors, who accounted for 10.9% of respondents, provided high-level managerial and policy perspectives. Their focus was typically on compliance with

contractual obligations, alignment with client expectations, and ensuring safety and performance benchmarks.

The ‘Other’ category (28.6%) includes roles such as Site Supervisors, Technical Advisors, QA/QC Inspectors, and Quantity Surveyors. These professionals are involved in day-to-day operational and quality assurance tasks and offered important observations on safety practices, material handling, and workmanship standards. The organizational role distribution is visually presented in the following pie chart in figure 4.2:

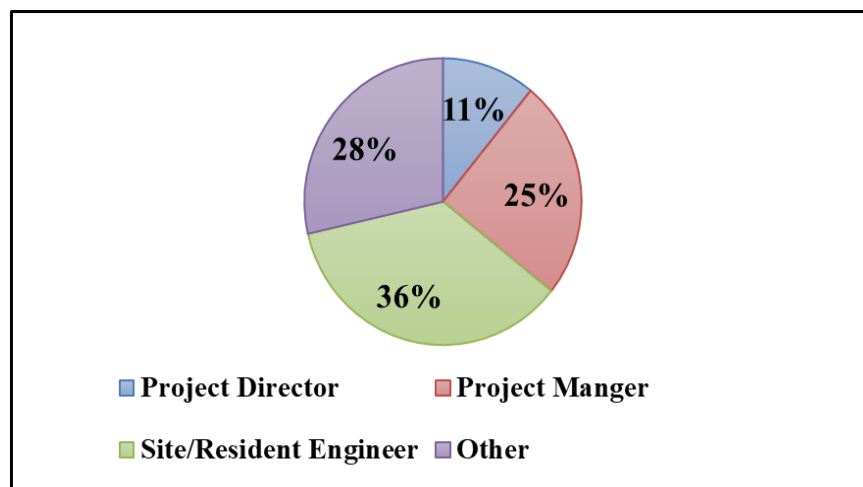


FIGURE 4.2: Distribution Of Respondents By Designation/ Role

The variety of designations represented in the survey demonstrates that the data incorporates both tactical and strategic dimensions of RCC bridge construction. The perspectives offered by professionals across this role spectrum collectively enhance the reliability and richness of the research findings.

4.2.3 Years of Experience

Professional experience is a vital indicator of a respondent’s exposure to field conditions, understanding of construction complexities, and ability to assess the impact of skilled labor on infrastructure projects. In this study, the participants were grouped based on their total years of experience in the construction industry, allowing for an evaluation of the depth and reliability of their insights.

The distribution of respondents by years of experience is outlined in the table 4.3 below:

TABLE 4.3: Distribution Of Respondents By Experience

Total Years of Experience	Number of Respondents	Percentage
1 to 5 years	40	31.00%
6 to 10 years	37	28.70%
11 to 20 years	34	26.40%
More than 20 years	18	14.00%
Total	129	100%

The majority of the respondents (59.7%) had between **6 to 20 years** of experience in the construction industry. This is significant because professionals with this level of experience are typically involved in both field execution and managerial roles, giving them a comprehensive understanding of project delivery dynamics and labor performance.

Approximately **31% of the respondents** had **1 to 5 years** of experience. While they may be considered early-career professionals, their responses offer recent, first-hand exposure to on-site realities, especially in terms of quality control and safety practices.

A considerable segment of the respondents - **14%** - had **more than 20 years of experience**, bringing high-level insights shaped by decades of involvement in infrastructure development. Their responses were particularly useful in evaluating the long-term patterns of skill shortages and their evolution over time.

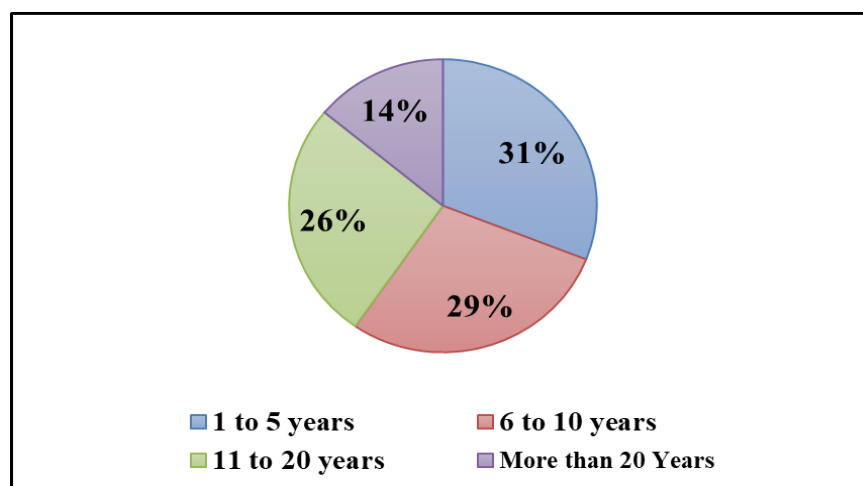


FIGURE 4.3: Distribution Of Respondents By Experience

The balanced distribution of experience levels among respondents enhances the robustness of the data. It ensures that the research findings are informed by both

operational site-level realities and broader strategic perspectives accumulated over extensive careers.

4.3 Descriptive Statistics

To provide a foundational understanding of how skilled labor deficiencies are perceived across various RCC bridge construction activities, this section presents descriptive statistics derived from the survey responses. These include measures of **central tendency** (mean), **dispersion** (standard deviation and variance), and **range** (minimum and maximum). The analysis was performed using **SPSS** software, ensuring reliability and academic rigor. Each item in the survey was rated on a **5-point Likert scale** (1 = Very Poor to 5 = Excellent), evaluating **16 labor skills** for their availability, performance, impacts etc across **11 major construction activities of RCC Bridge construction** - ranging from site preparation to finishing works. Detailed questionnaire and the shortlisted construction activities are mentioned in Appendix 1 and 2.

4.3.1 Overview of Key Metrics

- i. Mean Values: Most mean scores lie between **3.5 and 4.2**, indicating that respondents generally perceived skill levels to be slightly above average but not uniformly satisfactory.
- ii. Standard Deviation: Ranged from **0.81 to 1.28**, suggesting a moderate degree of variation in perceptions - potentially influenced by project type, location, or respondent role.
- iii. Minimum Scores: Many activities received a **minimum score of 1**, indicating that some respondents perceived very poor performance in certain labor categories.
- iv. Maximum Scores: All activities had respondents who rated them as **5**, reflecting excellent performance - possibly under supervision or in better-organized projects.

4.3.2 Top-Ranked Labor Tasks by Mean Score

The top-ranking tasks primarily involve **steel fixing and formwork**, indicating that these trades are seen as highly sensitive to skill deficiencies. Even small errors in these components can compromise the structural integrity of RCC bridges, explaining the critical evaluation by professionals.

TABLE 4.4: Top-Ranked Labor Tasks

Task	Mean	Std. Deviation
Pile Cap Construction [Steel Fixer]	4.22	0.89
Diaphragm & Deck Slab Construction [Steel Fixer]	4.14	0.82
Transom Construction [Steel Fixer]	4.21	0.86
Girders Casting & Prestressing [Steel Fixer]	4.12	0.95
Pile Cap Construction [Formwork Fixing]	4.11	0.91
Pier Construction [Steel Fixer]	4.13	0.91
Transom Construction [Formwork Fixer]	4.13	0.96
Girders Casting & Prestressing [Formwork Fixer]	4.13	0.99

4.3.3 Lower-Ranked Labor Tasks by Mean Score

Equipment operations and **finishing works** have lower averages, suggesting areas where training and supervision may be lacking. Variability in scores may reflect inconsistent project conditions or the prevalence of informal/untrained workers in these roles.

TABLE 4.5: Lower-Ranked Labor

Task	Mean	Std. Deviation
Site Preparation [Safety Supervisors]	3.47	1.28
Plant Machinery Operators (Site Preparation)	3.62	1.2
Concrete Pump Operators (Piling)	3.58	1.19
Crane Operators (Girders Casting & Launching)	3.68	1.2
Finishing Works [Electricians]	3.77	1
Foreman/Manual Launching Labor (Girders Launching)	3.75	1.14

4.3.4 Summary of Observations

The results revealed several important insights:

- i. The highest-rated activity was Pile Cap Construction [Steel Fixer], with a mean score of 4.22 and a relatively low standard deviation of 0.886, suggesting strong agreement among respondents regarding the critical importance and skill deficiency associated with this role. Other top-rated tasks include:
 - Transom Construction [Steel Fixer] Mean: 4.21, SD: 0.863
 - Diaphragm & Deck Slab Construction [Steel Fixer] Mean: 4.14, SD: 0.817
 - Girders Casting & Prestressing [Steel Fixer] Mean: 4.12, SD: 0.952
- ii. These results indicate that steel fixing roles across various RCC components are perceived to be the **most skill-sensitive** and, consequently, the most affected by compromised labor quality.
- iii. On the other end, relatively lower mean scores were observed in roles such as:
 - Site Preparation [Safety Supervisors] Mean: 3.47, SD: 1.278
 - Plant Machinery Operators (Site Preparation) Mean: 3.62, SD: 1.200
 - Crane Operators (Multiple Stages) Mean ranges from 3.68 to 3.84
- iv. These figures suggest that the perceived skill gap in these roles, while present, is comparatively less critical than those directly involved in structural integrity (e.g., steel fixing, formwork setting).

4.3.5 Level of Consensus

Standard deviation values across most items fall between **0.80 and 1.10**, indicating moderate variability in responses. Roles such as **Pile Cap Construction [Formwork Fixing]** and **Barriers/Parapets [Steel Fixer]** exhibit relatively low standard deviations, implying strong respondent consensus on their criticality.

4.3.6 Representative Entries Summary

The descriptive statistics support the conclusion that **skilled labor is most crucial in tasks directly influencing the structural integrity and quality of RCC bridge components**, particularly **steel fixing, formwork setting, and concrete handling**. For illustration, table 4.6 highlights a few representative entries:

TABLE 4.6: Representative Entries Summary

Labor Task	Mean	Std. Dev	Min	Max
Pile Cap Construction [Steel Fixer]	4.22	0.886	2	5
Transom Construction [Steel Fixer]	4.21	0.863	2	5
Diaphragm & Deck Slab Construction [Steel Fixer]	4.14	0.817	2	5
Girders Casting [Steel Fixer]	4.12	0.952	1	5
Site Prep [Safety Supervisors]	3.47	1.278	1	5
Piling [Concrete Pump Operator]	3.58	1.19	1	5

The relatively high mean scores in these areas justify further analysis through Relative Importance Index (RII), presented in the next section.

4.3.7 Summary of Item-Level Statistics

A total of **51 labor-related items** were analyzed across 11 major RCC bridge construction activities such as piling, pile cap construction, girder launching, transom erection, diaphragm casting, and finishing works. The **complete descriptive statistics** are mentioned in **Appendix 3**, however, the aggregate statistics observed are shown in table 4.7.

TABLE 4.7: Aggregate Item-Level Statistics

Statistics	Mean	Min.	Max.	Range	Max. /Min.	Variance	N of Items
Item Means	3.944	3.472	4.244	0.772	1.222	0.028	51
Item Variances	1.026	0.678	1.632	0.954	2.407	0.05	51
Inter-Item Covariances	0.449	0.08	1.002	0.922	12.532	0.023	51
Inter-Item Correlations	0.443	0.085	0.841	0.756	9.887	0.017	51

These results indicate that the **average perception** of labor adequacy across the sample is slightly below **4.0**, indicating a **general concern** among industry

professionals regarding the quality or reliability of skilled labor across multiple roles.

4.4 Reliability Test

Reliability in quantitative research refers to the consistency, stability, and repeatability of a data collection instrument in capturing accurate and dependable information. In this study, the reliability of the structured questionnaire was assessed using **Cronbach's Alpha**, a statistical measure that determines internal consistency among multiple items in a scale. High internal consistency implies that the various survey items measure the same underlying construct-in this case, the implications of compromised skilled labor on RCC bridge construction.

To test this, responses from 51 labor-related items across the survey instrument in 11 major RCC bridge construction activities and 16 skills; were analyzed using SPSS Version 21.

4.4.1 Case Summary

The total number of participants in the survey was **129**. However, after excluding two incomplete or inconsistent responses due to missing data, the reliability analysis was conducted on **127 valid cases**, constituting **98.4%** of the total sample. This ensures the statistical robustness of the reliability test.

TABLE 4.8: Validity Statistics

Cases	N	%
Valid	127	98.40%
Excluded	2	1.60%
Total	129	100.00%

4.4.2 Cronbach's Alpha Results

The SPSS reliability output yielded a **Cronbach's Alpha coefficient of 0.975**, indicating **excellent internal consistency** among the 51 items included in the

survey. Additionally, the alpha based on standardized items was 0.976, further reinforcing the robustness of the instrument. With a coefficient well above 0.9, the instrument used in this research demonstrates **excellent reliability**, meaning that the questionnaire items are highly consistent and dependable in capturing perceptions about skill deficiencies across various RCC bridge construction activities. This level of reliability adds to the **credibility and reproducibility** of the findings presented in this study.

TABLE 4.9: Reliability Statistics

Statistic	Value
Cronbach's Alpha	0.975
Cronbach's Alpha (Standardized Items)	0.976
Number of Items	51

4.5 Normality Test

Before proceeding with inferential statistical analysis, it is essential to assess whether the collected data follows a normal distribution. The assumption of normality determines the appropriateness of using parametric or non-parametric tests. In this study, normality testing was conducted for all 51 items related to labor skill adequacy in RCC bridge construction using two standard statistical techniques:

- i. KolmogorovSmirnov Test (KS)
- ii. ShapiroWilk Test (SW)

Both tests are widely employed in social science and engineering research to determine if data significantly deviates from a normal distribution.

4.5.1 Test Results and Interpretation

The excerpts from the normality output are depicted in Appendix 4. The SPSS outputs indicate the following:

- i. For all 51 items, the ***p*-values were less than 0.05** in both the KolmogorovSmirnov and **Shapiro-Wilk** tests.
- ii. This means the null hypothesis (H_0) - that the data is normally distributed - is **rejected**.
- iii. Therefore, the data does not follow a normal distribution.
- iv. As all significance values are less than the threshold of 0.05, it is concluded that the data violates the assumption of normality.

4.5.2 Implications for Analysis

- i. Given the non-normal distribution of the data:
 - Parametric tests (e.g., *t*-tests, ANOVA) are not suitable for this dataset.
 - Instead, non-parametric statistical methods will be employed to ensure analytical accuracy. These may include:
 - Relative Importance Index (RII) already used in this study.
 - Kruskal-Wallis Test, Mann-Whitney *U* Test, or Spearman Rank Correlation if comparisons between groups or correlation assessments are needed.
 - This confirms the methodological decision to apply **RII-based ranking and descriptive interpretations**, which are robust and unaffected by the distributional shape of the data.

4.6 Kruskal Wallis Tests

4.6.1 Based on Designation and Role

Given that the dataset does not satisfy the assumption of normality, the **Kruskal Wallis H test** was applied as a non-parametric alternative to one-way ANOVA. This test assesses whether there are **statistically significant differences** in

perception scores of labor skill adequacy across different designation categories of respondents, such as **Site/Resident Engineer**, **Project Manager**, **Project Director**, and **Others**. Each group was evaluated independently to determine whether **role-based variation** exists in assessing the adequacy of skilled labor in specific RCC construction activities.

The test revealed that for **48 out of 51 labor-related activities**, there were **no statistically significant differences** in perceptions across designation categories. In these cases, the p -values were greater than 0.05, leading to the retention of the **null hypothesis**. This suggests a **high level of consensus** across roles such as engineers, managers, and directors in identifying where skill gaps exist.

However, **three specific tasks** showed **statistically significant differences** in perception based on designation. These are summarized in **Table 4.10** below:

TABLE 4.10: Sig. Values for Designation/ Role

Construction Activity	Sig. Value (p)	Decision
Girders Casting & Prestressing [Steel Fixer]	0.02	Reject null
Diaphragm & Deck Slab Construction [Concrete Labor]	0.001	Reject null
Diaphragm & Deck Slab Construction [Concrete Pump Operator]	0.017	Reject null

These results imply that **perceptions significantly vary across designations** for the above three tasks. For instance, **project managers** may place greater emphasis on **concrete labor performance**, while **site engineers** may focus more critically on **pump operation quality** and **real-time execution**. The overall pattern confirms that:

- i. Designation does not significantly influence perception for most construction roles.
- ii. However, role-specific experience and accountability may shape perception for highly sensitive tasks such as diaphragm slab concreting and girder prestressing.

4.6.2 Based on Total Experience

To determine whether **perceptions regarding labor skill adequacy** varied significantly across respondents with different levels of total professional experience, the **KruskalWallis H test** was applied. Respondents were grouped based on total years of experience: upto 5 years, upto 10 years, upto 20 years, and **more than 20 years**. The test aimed to uncover whether **experience levels influence how critically skilled labor shortages are perceived** across the spectrum of RCC bridge construction activities.

Out of **51 variables tested**, only **four items** were found to be **statistically significant at the 0.05 level**, indicating that **perceptions significantly differ across experience groups** for these items. For the remaining **47 items**, **no significant differences** were observed, suggesting **general alignment in perceptions across professionals** regardless of their years in the industry.

TABLE 4.11: Sig. Values for Experience

Construction Activity	Sig. Value (p)	Decision
Piling [Sonic Integrity Test (SIT) Operator]	0.045	Reject null
Girders Launching [Winch Machine Operator Manual Launching]	0.047	Reject null
Diaphragm & Deck Slab Construction [Form-work Fixer]	0.046	Reject null
Finishing Works [Masons]	0.035	Reject null

These **four tasks** are considered **labor-intensive and technically sensitive**, and respondents with varying levels of experience may have differing degrees of exposure or expectations from these operations. For instance:

- i. Junior professionals may rely on observed outcomes (e.g., visible defects),
- ii. Senior professionals may emphasize long-term durability and code compliance.

The majority of responses across total experience groups showed **homogeneity**, indicating shared concerns and assessments. However, the **four significant exceptions** suggest that **experience can influence** how specific technical roles (such as **testing operators** or **masons**) are evaluated, possibly due to **cumulative site exposure, inspection experience, or learning curve effects**.

4.6.3 Based on Years of Experience in Bridge Projects

To investigate whether **practical field experience in RCC bridge projects** significantly affects professional perceptions about **labor skill adequacy**, Kruskal-Wallis H test was conducted. Respondents were divided into four experience-based groups:

- i. Only One Project
- ii. 2 to 5 Projects
- iii. 6 to 10 Projects
- iv. More than 10 Projects

This **non-parametric test** assessed whether different levels of **bridge-specific exposure** yield variations in judgment regarding 51 skill-focused construction tasks.

The KruskalWallis test showed **statistically significant differences in 7 out of 51 items**, meaning that for these items, **perceptions varied depending on bridge-specific experience**. For the remaining **44 items**, the test did not detect significant differences, indicating a **shared perception of skill adequacy** across different experience levels. These findings reveal that **perceptions differ substantially based on hands-on bridge construction experience**, especially in tasks related to:

- i. Girder-related operations (casting, prestressing, adjusting)
- ii. Concreting work for diaphragms

TABLE 4.12: Sig. Values for Experience in RCC Bridges

Construction Activity	Sig. Value (p)	Decision
Girders Casting & Prestressing [Steel Fixer]	0.02	Reject null
Girders Casting & Prestressing [Profile Adjustment Labor]	0.015	Reject null
Girders Casting & Prestressing [Formwork Fixer]	0.025	Reject null
Girders Casting & Prestressing [Stressing Cables Pulling Labors]	0.005	Reject null
Diaphragm & Deck Slab Construction [Concrete Labor]	0.004	Reject null
Finishing Works [Painters]	0.049	Reject null
Finishing Works [Electricians]	0.030	Reject null

iii. Final-stage finishing trades

This variance can be attributed to the **complexity and precision** required in these stages, where experience tends to sharpen awareness of skill deficiencies and quality implications.

For most tasks, the **null hypothesis was retained**, suggesting consistent perceptions of labor performance across all bridge experience levels. However, for the **seven significant items**, those with greater exposure to bridge construction (e.g., >10 projects) likely possess **deeper insights into execution errors, tolerances, or defects** associated with labor performance.

This underscores that **accumulated project experience can shape judgment** about the adequacy of skills in **high-risk construction elements**.

4.6.4 Based on Educational Qualification

To evaluate whether perceptions regarding **skilled labor deficiencies** vary across respondents with different academic backgrounds, the **Kruskal–Wallis H test** was applied. Participants were categorized into qualification levels like *Diploma*, *Bachelor's*, *Master's*, and *Others*.

Out of the 51 items tested, **six items revealed statistically significant differences across education groups** ($p < 0.05$), implying that respondents with differing qualifications assessed those labor-related tasks differently.

TABLE 4.13: Sig. Values for Qualification

Construction Activity	Sig. Value (p)	Decision
Site Preparation [Surveyor]	0.024	Reject null
Site Preparation [Plant Machinery Operators]	0.017	Reject null
Piling [Rig Operator]	0.011	Reject null
Piling [Concrete Pump Operator]	0.035	Reject null
Girders Launching [Girder Transporter / Mover Operator]	0.01	Reject null
Finishing Works [Painters]	0.01	Reject null

These results suggest that respondents' **academic training** may shape their evaluation of certain technical roles. For instance:

- i. Professionals with field-oriented *diplomas* may view equipment operators (e.g., rig or pump operators) differently from those with engineering degrees.
- ii. Those with higher education (*Bachelor's* or *Master's*) may have deeper theoretical exposure or code-based standards that inform more critical assessments, particularly in finishing works.

Notably, the significant variance in roles such as **rig operators**, **transporters**, and **painters** points to the interaction between academic exposure and site-based observation, particularly in *finishing and machinery tasks*.

4.7 Relative Importance Index Analysis

The Relative Importance Index (RII) analysis yielded insightful rankings of skill deficiencies among various labor trades involved in reinforced cement concrete (RCC) bridge construction in Pakistan. The RII scores, which reflect the collective perceptions of experienced professionals, indicate clear patterns regarding the most pressing workforce challenges within this sector. The figure 4.1 lists the **Top 10 skilled labor tasks** ranked by RII, reflecting where skill deficiencies are perceived as most critical for RCC bridge construction success. Full table of all 51 tasks and their RII values is provided in Appendix 5.

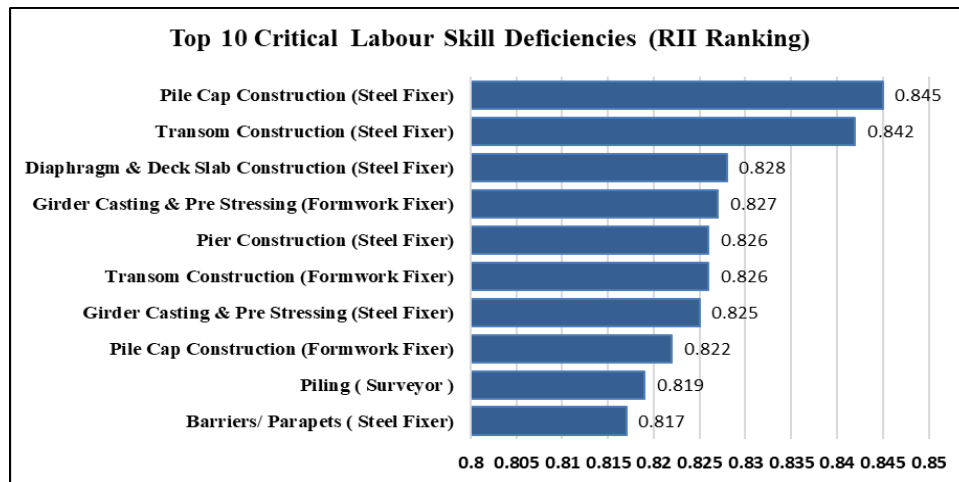


FIGURE 4.4: Top 10 Skilled Labor Deficiencies

4.7.1 Key Findings from RII Rankings

Critical Skill Deficiencies Identified

- i. **Steel Fixers:** Foremost among the findings is the prominence of steel fixer roles, particularly in pile cap construction (**RII = 0.84**), transom construction (**RII = 0.84**), and diaphragm and deck slab works (**RII = 0.83**). These high RII values underscore the industry-wide recognition of the crucial importance of steel fixing in ensuring structural safety, durability, and compliance with engineering standards. This result aligns with previous literature highlighting the centrality of skilled steel fixing to quality assurance in concrete structures (Hassan & Riaz, 2025)
- ii. **Formwork Fixers:** Formwork fixer positions consistently appeared in the upper tier of the RII rankings, reflecting their criticality in RCC bridge construction. Specifically, formwork fixing for girders (**RII = 0.83**), transoms (**RII = 0.83**), and pile caps (**RII = 0.82**) all received high scores. This trend indicates recurring challenges in achieving proper alignment, rigidity, and surface finish-factors essential for both structural integrity and aesthetic quality.
- iii. **Technical Roles:** The importance of technical precision and know-how in construction trades is further substantiated by high RII values assigned to technical roles such as surveyors and profile adjustment labor. For instance,

the RII for piling surveyors was **0.82**, and for girders' profile adjustment labor, the RII was **0.81**. The consistent presence of these roles among the top 15 ranked deficiencies highlights a recognized industry need for technical accuracy during the layout and post-tensioning phases of bridge construction.

- iv. Barriers/Parapets: Although barriers and parapets are considered secondary from a structural standpoint, they nonetheless require a skilled workforce to ensure quality and safety. This requirement is evident in the high RII scores for steel fixers (**RII = 0.82**) and formwork fixers (**RII = 0.81**) associated with these elements.

4.7.2 Practical Implications

- i. Project Performance: The dominance of steel fixing and formwork-related deficiencies aligns with observed quality problems (honeycombing, insufficient cover, misalignment) and supports findings in previous literature and the qualitative field responses.
- ii. Schedule and Cost: Skill gaps in these trades often result in rework, delays, and higher project costs, especially where rework affects critical path activities.
- iii. Safety: Inadequate skills in formwork and steel fixing also pose serious safety risks, with poorly installed formwork or steel potentially leading to collapses or accidents.

4.8 Perceptions and Impacts of Skilled Labor Shortages

Apart from the RII values obtained for 51 activities, respondents were also asked opinion based questions on the challenges and impediments being faced during RCC bridge construction activities. Purpose was to gather a qualitative insight

into actual impact on various key metrics and parameters of construction like time, cost, quality, risk factors etc. Detailed questionnaire is described in Appendix 1.

4.8.1 Frequency of Issues Attributed to Lack of Skilled Labor

Apart from the RII values obtained through 51 questionnaire items for 16 skills across 11 major RCC bridge activities; respondents were asked to rate, on a Likert scale from 1 (Never) to 5 (Very Often), how frequently they encounter issues in various bridge construction activities due to a lack of skilled labor. Figure 4.5 presents the mean frequency scores for each activity.

As seen in Figure 4.5, the activities most frequently affected by labor shortages are Pile Cap Construction ($M = 3.9$), Pier Construction ($M = 3.8$), and Girder Casting & Prestressing ($M = 3.8$). This aligns with the earlier RII results, underscoring that skill deficiencies are most critical in structural and core construction activities. The consistently moderate-to-high mean scores across all activities indicate that skilled labor shortages are a pervasive challenge throughout the bridge construction process.

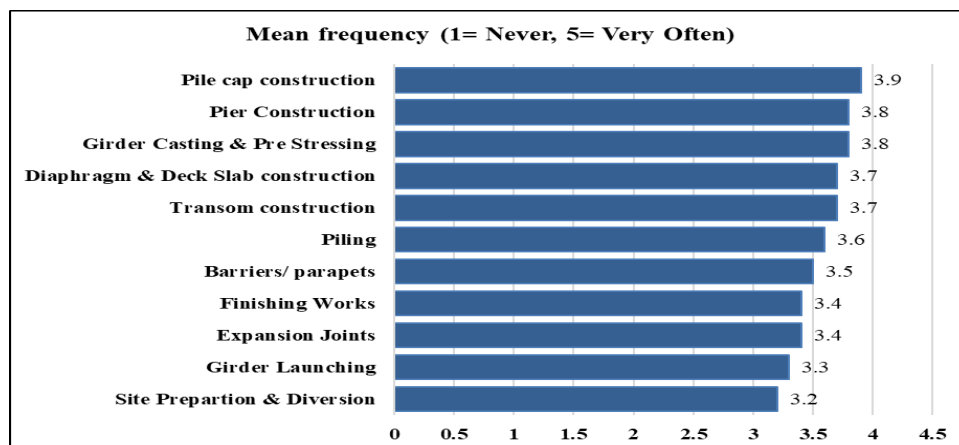


FIGURE 4.5: Mean Frequency of Issues Caused by Labor Skill Shortages, by Activity

4.8.2 Impact of Skill Shortages on Delays, Cost Overruns and Quality

Participants were also asked to rate the extent to which shortages in specific trades (e.g., steel fixers, formwork fixers, surveyors, etc.) lead to project delays, cost

overruns, and quality issues. The results, summarized below reflecting mean Likert scores (1 = Never, 5 = Very Often).

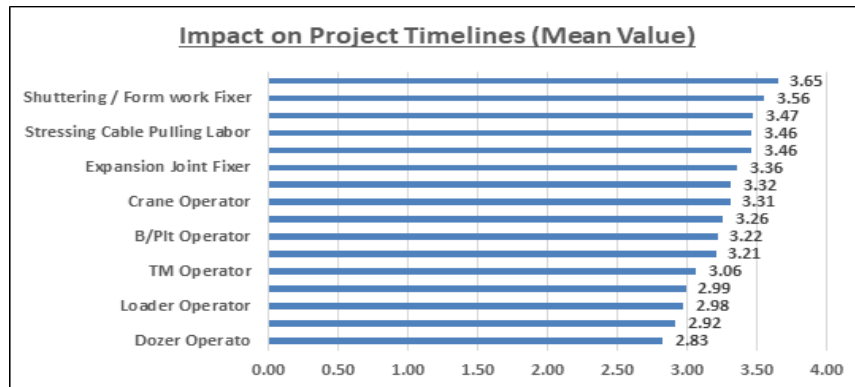


FIGURE 4.6: Mean Impact of Compromised skill labor on project timeline (1 = Never, 5 = Very Often)

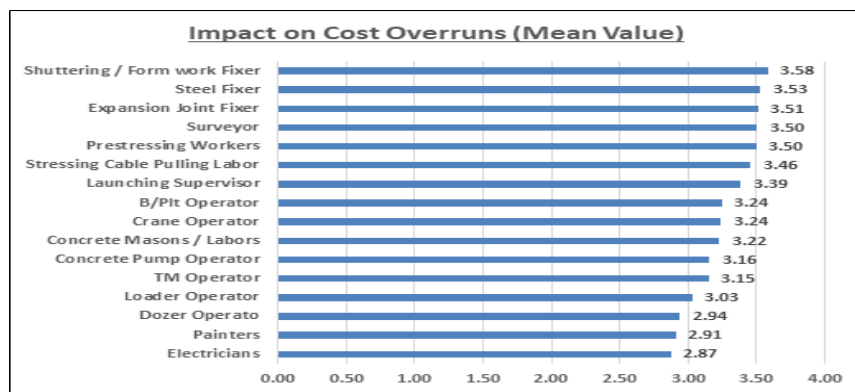


FIGURE 4.7: Mean Impact of Compromised skill labor on project Cost Overruns (1 = Never, 5 = Very Often)

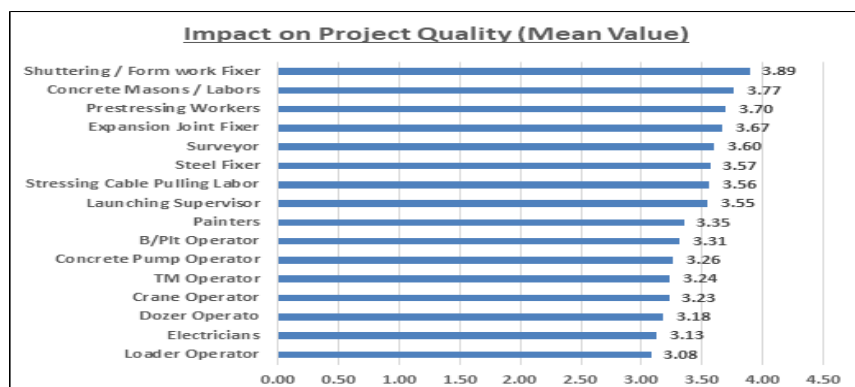


FIGURE 4.8: Mean Impact of Compromised skill labor on project Quality (1 = Never, 5 = Very Often)

Steel fixers and formwork fixers were identified as the trades where skill shortages most severely impact delays (M = 4.2 and 4.1, respectively), cost overruns, and

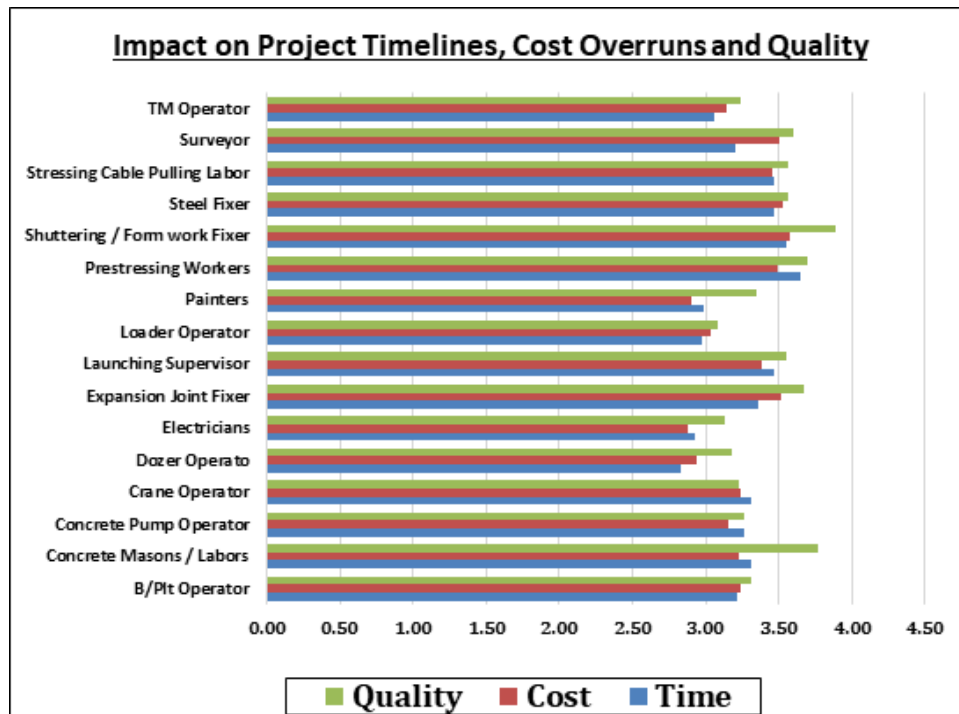


FIGURE 4.9: Combined Mean Impact of Compromised skill labor on project timelines, cost overruns and Quality (1 = Never, 5 = Very Often)

especially quality issues ($M = 4.3$ and 4.2). This further confirms the results of the RII analysis and the frequency ratings above, suggesting an industry-wide recognition of the criticality of these roles for project performance. Trades with lower mean scores, such as launching supervisors and painters, still show moderate impacts, suggesting that even non-core trades contribute to overall project outcomes when skill levels are compromised.

4.9 Agreement with Statements on Labor, Skills, and Industry Practice

Respondents were asked to indicate their level of agreement (1 = Strongly Disagree, 5 = Strongly Agree) with several statements relating to skilled labor and industry practice. Figure 4.10 summarizes the responses.

The high mean scores and strong agreement percentages across all statements reflect a robust industry consensus on the negative implications of poor labor skills and systemic issues in training, recruitment, and workforce management.

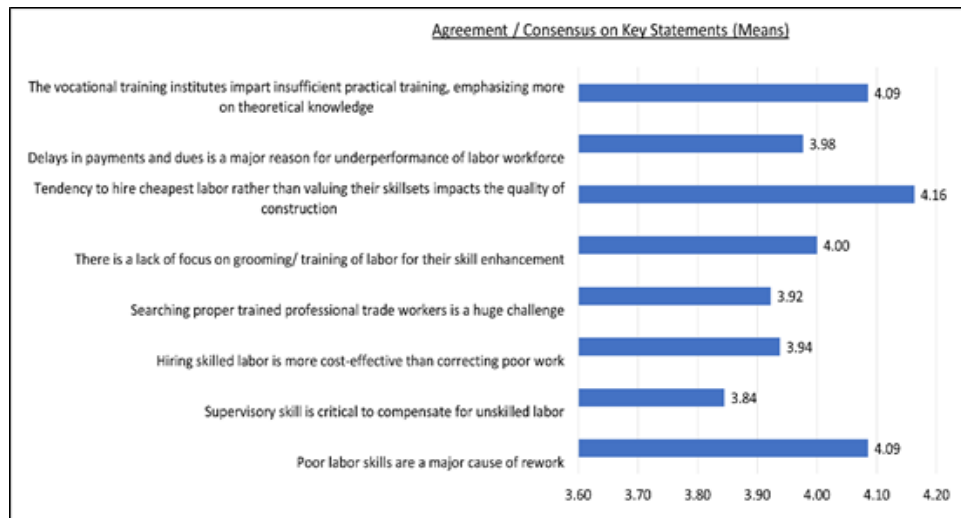


FIGURE 4.10: Agreement with Key Statements about Skilled Labor and Bridge Construction (Mean Scores)

Notably, the statement Poor labor skills are a major cause of rework ($M = 4.09$, 81.8%) and Tendency to hire cheap labor rather than valuing their skillset impacts the quality of construction ($M=4.16$, 83.2%) received highest agreement.

4.10 Summary of Major Findings from Research

The results of this study present a multidimensional view of the challenges created by skilled labor shortages in RCC bridge construction. These findings are based on (1) rigorous RII-based prioritization of skill gaps by task, (2) respondent perceptions regarding the frequency and impact of such gaps, and (3) broad agreement on underlying causes and industry.

4.10.1 Critical Skill Gaps

The RII-based ranking obtained through 51 questionnaire items for 16 skills across 11 major RCC bridge activities; highlights the paramount importance of steel fixing and formwork fixing in bridge construction quality and safety. The highest RII scores were observed for Pile Cap Construction [Steel Fixer] ($RII = .84$), Truss Construction [Steel Fixer] ($RII = .84$), Diaphragm & Deck Slab Construction [Steel Fixer] ($RII = .83$), and Girders Casting & Prestressing [Formwork Fixer] ($RII = .83$). These results indicate a strong industry consensus that deficiencies in these roles present the most critical risks to project success.

The prevalence of technical roles such as surveyors and profile adjustment labor among the top-ranked deficiencies (Piling [Surveyor], RII = 0.82; Girders Casting & Prestressing [Profile Adjustment Labor], RII = 0.81) underscores the necessity for technical precision in both the preparatory and post-tensioning stages of bridge construction. Furthermore, roles associated with barriers and parapets, though secondary in the structural hierarchy, also attained high RII values (Barriers/Parapets [Steel Fixer], RII = 0.82; [Formwork Fixer], RII = 0.81), highlighting that quality and safety concerns extend to all project phases and elements.

Out of 11 RCC bridge activities, most affected by compromised skilled labor are pile cap construction (Mean 3.9), pier construction (Mean 3.8) and girder casting & prestressing (Mean 3.8).

4.10.2 Impacts on Project Performance

The study demonstrates a robust relationship between skill shortages and negative project outcomes. Across all surveyed trades, respondents attributed high levels of project delays, cost overruns, and quality issues to inadequate skilled labor. For example, steel fixers and formwork fixers were rated above 4.0 (on a 5-point Likert scale) for all three outcomes, while surveyors and concrete workers followed closely.

The perception data (Section 4.8) reveal that the consequences of these gaps are not only technical, but also economic and reputational. Quality deficiencies such as honeycombing, misalignment, and insufficient cover often require costly rework and can compromise long-term durability. Meanwhile, project schedules are routinely affected by the need to repeat or correct substandard work, leading to contractual penalties and budget overruns. Deduced several practical implications are:

- i. Project Quality: Skill gaps in steel fixing and formwork fixing are directly linked to critical quality failures. The frequency with which these issues are reported and their high impact on all key project outcomes suggests that addressing them should be a first-order priority for industry improvement.
- ii. Project Schedule and Cost: High mean scores for delays and cost overruns indicate that skill shortages are a central driver of rework, inefficiency, and

contractual disputes. Interventions focused on upskilling and certification could yield substantial time and cost savings.

- iii. Safety: The high agreement with safety-related statements highlights the risk of accidents and non-compliance associated with unskilled labor. Improving training and supervision is essential to protect both workers and public users of bridge infrastructure.
- iv. Sector-Wide Challenge: The spread of moderate-to-high frequency and impact scores across a broad range of activities and trades confirms that labor shortages must be addressed comprehensively, not just for core structural trades but throughout the project cycle, including finishing and technical roles.

4.10.3 Agreement on Underlying Causes

This section highlights overwhelming consensus among construction professionals on several key points:

- i. Poor labor skills are a major cause of rework (Mean = 4.09; 81.7% agree/strongly agree).
- ii. Supervisory skill is critical to compensate for unskilled labor (Mean = 3.84).
- iii. Hiring skilled labor is cost-effective compared to correcting poor work (Mean = 3.94).
- iv. The tendency to hire the cheapest available labor rather than valuing skillsets negatively impacts construction quality (Mean = 4.16).
- v. There is insufficient focus on labor grooming and practical skill training (Mean = 4.0), and vocational institutes are seen as too theoretical (Mean = 4.09).

This broad agreement signals that industry practitioners are not only aware of the technical deficiencies but also recognize their root causes in recruitment practices, institutional training gaps, and broader sectoral attitudes.

4.11 Discussion and Analysis

The data analysis conducted in this study provides a comprehensive perspective on the implications of compromised skilled labor in RCC bridge construction projects in Pakistan. The results, particularly the Relative Importance Index (RII) rankings, yield several significant insights into where the greatest skill gaps exist, how these affect project performance, and what interventions are most urgently required.

4.11.1 Discussion and Analysis - Quantitative Results

The detailed RII rankings, supported by descriptive and inferential statistics, enable a robust thematic analysis of the implications of compromised skilled labor in RCC bridge construction. Four major themes emerge from the results: **structural integrity and quality, project delays and cost overruns, safety concerns, and cross-cutting skill gaps across all project stages.**

i. Structural Integrity and Quality

The analysis reveals that skill shortages are most acute in trades directly responsible for the structural core of bridge construction. The top five RII-ranked roles-Pile Cap Construction [Steel Fixer] (RII = 0.84), Transom Construction [Steel Fixer] (RII = 0.84), Diaphragm & Deck Slab Construction [Steel Fixer] (RII = 0.83), Girders Casting & Prestressing [Formwork Fixer] (RII = 0.83), and Pier Construction [Steel Fixer] (RII = 0.83)-highlight a striking consensus among professionals. These tasks are central to the durability, safety, and performance of RCC bridges. The high RII values for these trades directly correlate with common site-level quality issues observed during construction, including honeycombing, poor compaction, inadequate cover, and frequent rework.

ii. Project Delays and Cost Overruns

A second prominent theme is the impact of skill deficiencies on project schedule and financial outcomes. The quantitative data-supported by open-ended

responses-shows that errors by inadequately skilled laborers frequently necessitate rework, which not only delays project milestones but also inflates costs. This is especially problematic in public-sector projects with tight deadlines and fixed budgets. Roles with high standard deviations in responses (such as Finishing Works [Painters], $SD = 1.0$; Plant Machinery Operators, $SD = 1.2$) suggest variable performance and the need for intensive supervision.

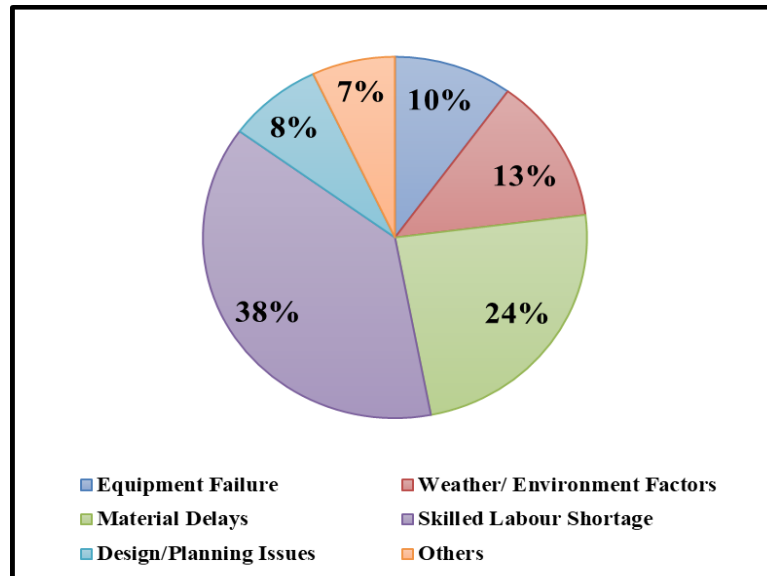


FIGURE 4.11: Main Causes of Delay/Cost Overruns

iii. Safety Concerns

Safety is a recurring concern highlighted by both RII rankings and qualitative feedback. Inadequate skill in formwork and steel fixing often results in safety hazards, including collapses of formwork, dropped rebar, and improper use of scaffolding. Open-ended responses specifically noted that laborers lack proper technical understanding, especially in steel fixing and vibration of concrete, leading to situations where supervisors must intervene repeatedly to avoid accidents. These concerns echo international standards, which link high accident rates to poor skill levels and inadequate training (ILO, 2021).

iv. Cross-Cutting Skill Gaps Across Project Elements

Although structural elements (pile caps, girders, transoms) attract the highest RII scores, the data reveal that skill deficiencies are not confined to these domains. Roles such as Piling [Surveyor] ($RII = 0.82$), Girders Casting &

Prestressing [Profile Adjustment Labor] (RII = 0.81), and Barriers/Parapets [Steel Fixer] (RII = 0.82) are also highly ranked. This suggests that the need for technical precision extends throughout the project life cycle—from initial layout and surveying, through structural assembly, to finishing and handover as shown in figure 4.6.

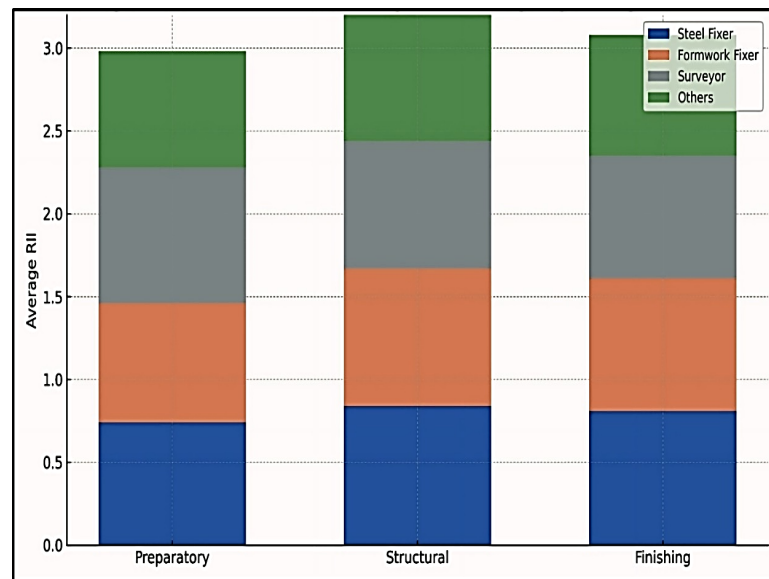


FIGURE 4.12: Distribution of high RII scores across different project stages

v. Stakeholder Consensus and Professional Alignment

A noteworthy finding from the KruskalWallis test is the high level of consensus among contractors, clients, and consultants regarding the most critical skill gaps. For 48 of 51 labor-related roles, perceptions were statistically aligned across all professional designations, indicating that these challenges are industry-wide rather than organization-specific. This consensus adds credibility and weight to the identified priorities and strengthens the case for sector-wide interventions.

4.11.2 Discussion and Analysis - Open-ended Questions

These survey results provide crucial contextual evidence supporting the statistical findings of this research. The frequent occurrence of skill-related issues across almost all construction activities, coupled with the clear perception of their impact on delays, costs, and quality, highlights the pervasive nature of this problem.

Respondents overwhelmingly agree that improving labor skills-through better recruitment, focused training, and improved management practices-would have a positive impact on project outcomes.

The alignment between the quantitative RII analysis and these perception-based results further strengthens the validity of this studys recommendations for targeted upskilling, certification, and industry reform. The findings also underline the urgent need for systemic changes in vocational training curricula, site management practices, and industry hiring norms to address the root causes of skilled labor shortages in Pakistans bridge construction sector.

4.12 Synthesis with Literature

The convergence between statistical findings (RII, mean frequency, and impact scores) and perception-based data provides strong empirical support for both local and international literature. Studies from South Asia and other developing regions (e.g., Hassan & Riaz, 2025; Thomas et al., 2003) consistently report that labor skill gaps are primary contributors to construction quality failures, inefficiency, and safety incidents.

The current findings reinforce and extend these insights by providing specific evidence from Pakistan's bridge sector. The alignment among contractors, clients, and consultants-as evidenced by the Kruskal-Wallis results-also supports the view that these issues are deeply embedded and cross-cutting, rather than isolated to individual organizations. The convergence of present results with extant literature reinforces the reliability and validity of the RII method and highlights the urgent need for targeted intervention in these trades

4.13 Summary

In summary, the results presented in Chapter 4 offer a comprehensive assessment of the implications of compromised skilled labor on RCC bridge construction in Pakistan. Through detailed statistical analysis and RII-based ranking, this study

has identified steel fixing and formwork fixing-particularly in critical structural elements such as pile caps, transoms, girders, and diaphragms-as the most significant skill gaps within the sector. Technical roles, such as surveyors and profile adjustment labor, also emerged as essential to construction quality and safety. These findings highlight the pervasive impact of workforce deficiencies on project quality, schedule, cost, and safety outcomes. The thematic interpretation, supported by multiple graphical representations, demonstrates a clear consensus among industry professionals regarding the urgent need for targeted training and certification initiatives. Collectively, the evidence from this chapter lays a robust empirical foundation for the practical recommendations and policy interventions that will be addressed in the following chapter.

Chapter 5

Conclusion and Recommendations

This chapter draws together the main research findings concerning the implications of compromised skilled labour on reinforced cement concrete (RCC) bridge construction in Pakistan. Synthesizing both the statistical (Relative Importance Index) and perceptual survey data from the previous chapters, this chapter articulates broad and specific conclusions, addresses the research questions, and offers targeted recommendations for practice, policy, and future research. The discussion is contextualized within Pakistan's construction sector, but the implications may extend to similar environments in other developing countries.

5.1 Conclusion

Compromised skilled labor is a major challenge in RCC bridge construction in Pakistan. While the challenge is across all 16 x skills involved; yet the most critical skills are steel fixers, formwork / shuttering carpenters and prestressing workers. Shortage of skilled labor contributes to time delays, cost overruns and quality issues. Furthermore, vocational training landscape of Pakistan has entirely missed specialist training of such a key field of infra structure development. Key findings Agreed opinions gathered from those having bridging experience has brought forward key managerial lessons.

5.2 Recommendations

Following recommendations are offered to practitioners, policymakers, and educators:

5.2.1 Strengthening Workforce Development and Training

Policy should require mandatory certification for key skills like steel fixers and formwork carpenters, with periodic re-certification to ensure ongoing competency. To cater for specialized RCC bridge skills like pre-stressing workers, expansion joint fixer, launching supervisors etc.; Bridge specialist course may be started. Vocational institutes and contractors should revise curricula to emphasize hands-on, site-based skill development. Partnerships with experienced professionals and on-the-job training should be central. Contractors should offer regular refresher courses, on-site demonstrations, and safety workshops. Peer-to-peer learning and mentorship be encouraged.

5.2.2 Enhancing Site Supervision and Management

As established through consensus of specialists, a key take away for project managers is that quality assurance should be reinforced by placing skilled supervisors on site, particularly for critical activities. Their oversight helps compensate for un- avoidable gaps and reduces the risk of serious defects or incidents. Project managers are suggested to use structured checklists, routine inspections, and feedback loops to monitor worker performance, promptly identify weaknesses, and adapt training or support as needed. The widespread practice / mindset of hiring cheapest labor be replaced with value-driven approaches that recognize and reward skill.

5.2.3 Policy Initiatives and Reforms

Government to work on changing low class mindset / stigma attached with blue-collar works, still persistent in our society. Ministry of information to run Skill

Recognition Schemes through media houses, to attract talented youth into technical trades. Policy incentives-such as tax breaks or recognition programs-should reward contractors who invest in upskilling their workforce through introduction of Labor Competence Index (LCI) for civil engineering firms registered with PEC. Persistent effort / policy on transformation to Competency Based Training and Assessment (CBT&A) model through budget allocations and focus shall bridge the gap between theory and practice.

5.2.4 Future Research

By employing same survey tool for other construction industry fields like high rise construction, tunneling, mining etc to identify critical shortage of skills. Consolidation of this data will be a guiding tool for NAVTTC to prioritize skills training in Pakistan. Future research must also explore the effectiveness of digital and remote training technologies.

5.3 Implications

5.3.1 Theoretical Implications

Bridges construction is a major area of public spending across Pakistan, still no focus has been given to formal training / certification of skills involved. The research forms first tangible database highlighting major on ground challenges faced in RCC bridge construction due to compromised skilled labor in Pakistan.

5.3.2 Managerial Implications

5.3.2.1 For Clients

Compromised skilled labor, especially steel fixers and formwork carpenters, are a major challenge in achieving time, cost, and quality parameters in RCC bridge construction. Clients need to place increased emphasis on the quality of human resource skills and qualification criteria in the procurement process. Project costs

and rate analyses must cater for reasonably good labor rates while aiming for a high-quality product. Competency-based training certifications must be ensured, especially for labor working on critical activities.

5.3.2.2 For Contractors

Value high-skill labor parties and maintain skill logs of labor, especially steel fixers, shuttering carpenters and prestressing workers. Highly skillful steel fixers and shuttering carpenters need to be employed on critical RCC bridge activities such as pier shafts, transoms, and girder casting. It is advisable to pay higher rates to skilled labor rather than wasting time and incurring additional costs due to rework caused by compromised quality. The shortage of skilled manpower must be compensated by deploying higher quality supervisory staff. Strict internal quality control measures must be implemented. Training for critical skilled labor must be planned and executed periodically.

5.4 Limitations and Directions for Future Research

While this study presents robust findings, certain limitations are highlighted. Most respondents were drawn from Islamabad and surrounding regions; findings may not fully generalize to all of Pakistan or other countries. The analysis is based on a single round of data collection; longitudinal studies would offer deeper insights into changes over time. Though purposive sampling was resorted to, some results rely on subjective perceptions, which may be influenced by individual bias or organizational culture. Any future research on the subject must endeavor to address these limitations by exploring diverse environments and longitudinal methods.

5.5 Summing Up

This research has established a clear and urgent case for addressing skilled labor shortages in Pakistans RCC bridge construction sector. The combination of statistical evidence (RII, frequency, and impact scores) and strong industry consensus

demonstrate that skill deficiencies, particularly in steel fixing, formwork fixing are major drivers of rework, delays, cost overruns, and safety risks. Non availability of trained workers for bridging specific tasks likes prestressing and expansion joints are also a major challenge. Interventions focused on practical training, mandatory certification, improved supervision, and consistent policy focus are necessary to safeguard project outcomes and public safety. Sustained commitment from industry, policymakers, and educators will be vital for transforming the workforce and enabling Pakistan to meet its infrastructure ambitions.

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Appendix-1 - Questionnaire

Appendix 1 - Questionnaire

Implications of Compromised Skill Labor on RCC Bridge Construction in Islamabad

Section 1 of 5: Introduction

This research is focused on examining the significant impact that compromised skilled labor has on the construction of Reinforced Cement Concrete (RCC) bridges in Islamabad, specifically looking at how labor influence project quality, timelines, and costs. RCC bridges are crucial to Islamabad's infrastructure, facilitating connectivity and supporting the city's economic growth. However, a persistent shortage of skilled labor in Pakistan's construction sector has resulted in multiple challenges, including delays in project completion, increased costs, and compromised safety standards. This study will identify the key skill gaps that affect RCC bridge construction in Pakistan.

If you have been involved in RCC bridge construction process. Please spare your 5 minutes to fill this survey

Section 2 of 5: Demographics / Personal Information

1. Name

2. Organization Name

3. Email Address

4. Type of Organization *(Please mark only one option)*

- Client
- Contractor
- Consultant

5. Designation / Role *(Please mark only one option)*

- Project Director
- Project Manager
- Site / Resident Engineer
- Other

6. Experience (Total) *(Please mark only one option)*

- 1 to 5 years
 6 to 10 years
 11 to 20 years
 More than 20 years

7. Years of Experience in Bridge Projects *(Please mark only one option)*

- 1 to 5 years
 6 to 10 years
 11 to 20 years
 More than 20 years

8. Number of RCC Bridges Involved In *(Please mark only one option)*

- Only One
 2 to 5
 5 to 20
 More than 20

9. Qualification *(Please mark only one option)*

- PhD
 Masters
 Bachelors
 Diploma

Section 3 of 5: **Hands-On Skills Required & Their Availability**

Objective:

This section aims to ascertain **which labor skills are essential** for each RCC Bridge Construction Activity and what are the respective **levels of their availability**. Respondents are requested to rate the **availability of skilled labor** for the following technical tasks involved in bridge projects.

Rating Scale:

1 = Very Poor, 2 = Poor, 3 = Average, 4 = Good, 5 = Excellent

10. Site Preparation & Diversion *(Mark one option per row)*

Skill Category	1	2	3	4	5
Surveyor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plant Machinery Operators	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety Supervisors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. Piling *(Mark one option per row)*

Skill Category	1	2	3	4	5
Surveyor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rig Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixer for Cages Fabrication	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crane Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Pump Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Piling Concrete Labor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sonic Integrity Test (SIT) Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

12. Pile Cap Construction *(Mark one option per row)*

Skill Category **1 2 3 4 5**Pile Head Breaker Formwork Fixing Steel Fixer Concrete Labor **13. Pier Construction** *(Mark one option per row)***Skill Category** **1 2 3 4 5**Formwork Fixer Crane Operator Steel Fixer Concrete Labor **14. Transom Construction** *(Mark one option per row)***Skill Category** **1 2 3 4 5**Welder Formwork Fixer Steel Fixer Crane Operator Concrete Pump Operator **15. Girders Casting & Prestressing** *(Mark one option per row)***Skill Category** **1 2 3 4 5**Crane Operator Steel Fixer Profile Adjustment Labor Formwork Fixer Concrete Labor Stressing Cables Pulling Labors Prestressing Jacks Operators Grouting Machine Operator **16. Girders Launching** *(Mark one option per row)***Skill Category** **1 2 3 4 5**Crane Operator Girder Transporter / Mover Operator Launching Supervisor Surveyor Winch Machine Operator (Manual Launching) Foreman (Manual Launching) **17. Diaphragm & Deck Slab Construction** *(Mark one option per row)***Skill Category** **1 2 3 4 5**Formwork Fixer Steel Fixer Concrete Labor Concrete Pump Operator

18. Barriers / Parapets *(Mark one option per row)*

Skill Category	1	2	3	4	5
Formwork Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Mason & Labor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

19. Expansion Joints *(Mark one option per row)*

Skill Category	1	2	3	4	5
Expansion Joint Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Formwork Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Laborers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20. Finishing Works *(Mark one option per row)*

Skill Category	1	2	3	4	5
Painters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electricians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Masons	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 4 of 5:

Impact of Compromised Skill Labor on Bridge Construction Activities

Objective:

This section aims to identify RCC bridge activities most affected by compromised skill labor, particularly in terms of issues, delays, and cost overruns.

21. How frequently do you encounter issues in the following bridge construction activities due to lack of skilled labor?

(Rate: 1 = Never, 5 = Very Often)

(Mark only one option per row)

Activity	1	2	3	4	5
Site Preparation & Diversion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Piling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pile Cap Construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pier Construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transom Construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Girder Casting & Prestressing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Girder Launching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diaphragm & Deck Slab Construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Barriers / Parapets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Expansion Joints	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finishing Works	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

22. In your experience, to what extent do the following skill shortages result in project delays?

(Rate: 1 = Never, 5 = Very Often)

(Mark only one option per row)

Skill Category	1	2	3	4	5
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Skill Category	1	2	3	4	5
Surveyor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shuttering / Formwork Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prestressing Workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Masons / Laborers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Painters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electricians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Launching Supervisor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crane Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Pump Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transit Mixer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dozer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Batching Plant Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Loader Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stressing Cable Pulling Labors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Expansion Joint Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

23. In your experience, to what extent do the following skill shortages result in cost overruns?

(Rate: 1 = Never, 5 = Very Often)

(Mark only one option per row)

Skill Category	1	2	3	4	5
Surveyor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shuttering / Formwork Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prestressing Workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Workers / Masons	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Painters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electricians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Launching Supervisor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crane Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Pump Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transit Mixer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dozer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Batching Plant Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Loader Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stressing Cable Pulling Labors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Expansion Joint Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

24. In your experience, to what extent do the following skill shortages result in quality issues?

(Rate: 1 = Never, 5 = Very Often)

(Mark only one option per row)

Skill Category	1	2	3	4	5
Surveyor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steel Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Skill Category	1	2	3	4	5
Shuttering / Formwork Fixers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prestressing Workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Workers / Masons	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Painters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electricians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Launching Supervisor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crane Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Concrete Pump Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transit Mixer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dozer Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Batching Plant Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Loader Operator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stressing Cable Pulling Labors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Expansion Joint Fixer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 5 of 5:
Open-Ended Feedback

25. To what extent do you agree with the following statements?

(1 = Strongly Disagree, 5 = Strongly Agree)

(Mark only one option per row)

Statement	1	2	3	4	5
Poor labor skills are a major cause of rework	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Supervisory skill is critical to compensate for unskilled labor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hiring skilled labor is more cost-effective than correcting poor work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Searching proper trained professional trade workers is a huge challenge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
There is a lack of focus on grooming/training of labor for skill enhancement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tendency to hire cheapest labor rather than valuing their skillsets impacts the quality of construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Delays in payments and dues is a major reason for underperformance of labor workforce	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The vocational training institutes impart insufficient practical training, emphasizing more on theoretical knowledge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Appendix-2 - Shortlisted Construction Activities

Appendix 2 - Shortlisted Construction Activities

1. Site Preparation & Diversion
2. Piling
3. Pile Cap Construction
4. Pier Construction
5. Transom Construction
6. Girders Casting & Prestressing
7. Girders Launching
8. Diaphragm & Deck Slab Construction
9. Barriers / Parapets
10. Expansion Joints
11. Finishing Works

Appendix-3 - Descriptive Statistics

Appendix-1 - Questionnaire

Appendix 3 – Descriptive Statistics

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Site Preparation & Diversion [Surveyor]	129	1	5	4.02	1.082	1.172
Site Preparation & Diversion [Plant Machinery Operators]	129	1	5	3.62	1.200	1.441
Site Preparation & Diversion [Safety Supervisors]	127	1	5	3.47	1.278	1.632
Piling [Surveyor]	129	1	5	4.09	0.939	0.882
Piling [Rig Operator]	129	1	5	3.91	1.042	1.085
Piling [Steel Fixer for Cages Fabrication]	129	2	5	4.02	0.848	0.719
Piling [Crane Operator]	127	1	5	3.80	1.011	1.021
Piling [Concrete Pump Operator]	129	1	5	3.58	1.190	1.417
Piling [Piling Concrete Labour]	127	1	5	3.83	1.040	1.081
Piling [Sonic Integrity Test (SIT) Operator]	127	1	5	3.76	1.137	1.293
Pile Cap Construction [Pile Head Breaker]	127	1	5	3.69	1.073	1.151
Pile Cap Construction [Formwork Fixer]	129	2	5	4.11	0.912	0.832
Pile Cap Construction [Steel Fixer]	129	2	5	4.22	0.886	0.785
Pile Cap Construction [Concrete Labor]	129	2	5	4.06	0.900	0.810
Pier Construction [Formwork Fixer]	129	2	5	4.03	0.943	0.890
Pier Construction [Crane Operator]	127	1	5	3.73	1.036	1.071
Pier Construction [Steel Fixer]	129	2	5	4.13	0.905	0.818
Pier Construction [Concrete Labour]	129	2	5	4.03	0.883	0.780
Transom Construction [Welder]	129	1	5	3.88	1.075	1.156
Transom Construction [Formwork Fixer]	129	2	5	4.13	0.963	0.928
Transom Construction [Steel Fixer]	129	2	5	4.21	0.863	0.745
Transom Construction [Crane Operator]	129	1	5	3.84	1.052	1.106
Transom Construction [Concrete Pump Operator]	127	1	5	3.83	1.052	1.107
Girders Casting & Prestressing [Crane Operator]	129	1	5	3.68	1.199	1.437
Girders Casting & Prestressing [Steel Fixer]	129	1	5	4.12	0.952	0.906
Girders Casting & Prestressing [Profile Adjustment labor]	127	1	5	3.98	1.061	1.127
Girders Casting & Prestressing [Formwork Fixer]	127	1	5	4.13	0.967	0.974
Girders Casting & Prestressing [Concrete Labor]	129	1	5	4.06	0.921	0.849
Girders Casting & Prestressing [Stressing Cables Pulling Labours]	127	2	5	4.03	0.917	0.840
Girders Casting & Prestressing [Prestressing Jacks Operators]	129	1	5	3.98	1.111	1.234
Girders Casting & Prestressing [Grouting Machine Operator]	127	1	5	3.96	1.097	1.204
Girders Launching [Crane Operator]	129	1	5	4.01	1.100	1.211
Girders Launching [Girder transporter / mover operator]	127	1	5	3.97	1.083	1.174
Girders Launching [Launching Supervisor]	127	1	5	3.86	1.106	1.223
Girders Launching [Surveyor]	127	1	5	3.98	1.091	1.190
Girders Launching [Winch Machine operator Manual Launching]	127	1	5	3.83	1.047	1.097
Girders Launching [Foreman Manual Launching]	127	1	5	3.75	1.141	1.301
Diaphragm & Deck Slab Construction [Formwork Fixer]	129	1	5	4.06	1.041	1.083
Diaphragm & Deck Slab Construction [Steel Fixer]	129	2	5	4.14	0.817	0.668
Diaphragm & Deck Slab Construction [Concrete Labor]	129	2	5	4.02	0.910	0.828
Diaphragm & Deck Slab Construction [Concrete Pump Operator]	127	1	5	3.91	1.050	1.102
Barriers/ Parapets [Formwork Fixer]	129	1	5	4.01	0.948	0.898
Barriers/ Parapets [Steel Fixer]	129	2	5	4.09	0.848	0.719
Barriers/ Parapets [Concrete Mason & Labor]	129	2	5	4.02	0.875	0.765
Expansion Joints [Expansion Joint Fixer]	127	1	5	4.02	1.080	1.166
Expansion Joints [Steel Fixer]	127	2	5	3.93	0.865	0.749
Expansion Joints [Formwork Fixer]	127	1	5	3.86	0.960	0.922
Expansion Joints [Concrete Labours]	127	1	5	3.89	0.911	0.829
Finishing Works [Painters]	129	1	5	3.86	1.039	1.080
Finishing Works [Electricians]	129	1	5	3.77	1.004	1.008
Finishing Works [Masons]	129	2	5	3.98	0.923	0.851
Valid N (listwise)	127					

Summary Item Statistics							
	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.944	3.472	4.244	0.772	1.222	0.028	51
Item Variances	1.026	0.678	1.632	0.954	2.407	0.050	51
Inter-Item Covariances	0.449	0.080	1.002	0.922	12.532	0.023	51
Inter-Item Correlations	0.443	0.085	0.841	0.756	9.887	0.017	51
Scale Statistics							
Mean	Variance	Std. Deviation	N of Items				
201.17	1198.107	34.614	51				

Appendix-4 - Results of Normality Tests

Appendix 4 - Results of Normality Tests

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Site Preparation & Diversion [Surveyor]	0.271	127	0.000	0.811	127	0.000
Site Preparation & Diversion [Plant Machinery Operators]	0.219	127	0.000	0.870	127	0.000
Site Preparation & Diversion [Safety Supervisors]	0.168	127	0.000	0.886	127	0.000
Piling [Surveyor]	0.256	127	0.000	0.822	127	0.000
Piling [Rig Operator]	0.235	127	0.000	0.844	127	0.000
Piling [Steel Fixer for Cages Fabrication]	0.241	127	0.000	0.841	127	0.000
Piling [Crane Operator]	0.218	127	0.000	0.875	127	0.000
Piling [Concrete Pump Operator]	0.190	127	0.000	0.886	127	0.000
Piling [Piling Concrete Labor]	0.193	127	0.000	0.865	127	0.000
Piling [Sonic Integrity Test (SIT) Operator]	0.216	127	0.000	0.861	127	0.000
Pile Cap Construction [Pile Head Breaker]	0.219	127	0.000	0.876	127	0.000
Pile Cap Construction [Formwork Fixing]	0.259	127	0.000	0.817	127	0.000
Pile Cap Construction [Steel Fixer]	0.287	127	0.000	0.784	127	0.000
Pile Cap Construction [Concrete Labor]	0.223	127	0.000	0.835	127	0.000
Pier Construction [Formwork Fixer]	0.230	127	0.000	0.828	127	0.000
Pier Construction [Crane Operator]	0.232	127	0.000	0.878	127	0.000
Pier Construction [Steel Fixer]	0.248	127	0.000	0.807	127	0.000
Pier Construction [Concrete Labor]	0.227	127	0.000	0.837	127	0.000
Transom Construction [Welder]	0.244	127	0.000	0.845	127	0.000
Transom Construction [Formwork Fixer]	0.269	127	0.000	0.791	127	0.000
Transom Construction [Steel Fixer]	0.270	127	0.000	0.791	127	0.000
Transom Construction [Crane Operator]	0.247	127	0.000	0.855	127	0.000
Transom Construction [Concrete Pump Operator]	0.271	127	0.000	0.847	127	0.000
Girders Casting & Prestressing [Crane Operator]	0.196	127	0.000	0.867	127	0.000
Girders Casting & Prestressing [Steel Fixer]	0.269	127	0.000	0.808	127	0.000
Girders Casting & Prestressing [Profile Adjustment labor]	0.232	127	0.000	0.832	127	0.000
Girders Casting & Prestressing [Formwork Fixer]	0.259	127	0.000	0.797	127	0.000
Girders Casting & Prestressing [Concrete Labor]	0.233	127	0.000	0.831	127	0.000
Girders Casting & Prestressing [Stressing Cables Pulling Labors]	0.233	127	0.000	0.835	127	0.000
Girders Casting & Prestressing [Prestressing Jacks Operators]	0.241	127	0.000	0.813	127	0.000
Girders Casting & Prestressing [Grouting Machine Operator]	0.234	127	0.000	0.828	127	0.000
Girders Launching [Crane Operator]	0.261	127	0.000	0.811	127	0.000
Girders Launching [Girder transporter / mover operator]	0.239	127	0.000	0.829	127	0.000
Girders Launching [Launching Supervisor]	0.229	127	0.000	0.850	127	0.000
Girders Launching [Surveyor]	0.234	127	0.000	0.824	127	0.000
Girders Launching [Winch Machine operator Manual Launching]	0.219	127	0.000	0.867	127	0.000
Girders Launching [Foreman Manual Launching]	0.202	127	0.000	0.865	127	0.000
Diaphragm & Deck Slab Construction [Formwork Fixer]	0.249	127	0.000	0.810	127	0.000
Diaphragm & Deck Slab Construction [Steel Fixer]	0.237	127	0.000	0.822	127	0.000
Diaphragm & Deck Slab Construction [Concrete Labor]	0.227	127	0.000	0.837	127	0.000
Diaphragm & Deck Slab Construction [Concrete Pump Operator]	0.229	127	0.000	0.843	127	0.000
Barriers/ Parapets [Formwork Fixer]	0.221	127	0.000	0.840	127	0.000
Barriers/ Parapets [Steel Fixer]	0.235	127	0.000	0.829	127	0.000
Barriers/ Parapets [Concrete Mason & Labor]	0.229	127	0.000	0.833	127	0.000
Expansion Joints [Expansion Joint Fixer]	0.242	127	0.000	0.811	127	0.000
Expansion Joints [Steel Fixer]	0.218	127	0.000	0.855	127	0.000
Expansion Joints [Formwork Fixer]	0.208	127	0.000	0.867	127	0.000
Expansion Joints [Concrete Labors]	0.210	127	0.000	0.863	127	0.000
Finishing Works [Painters]	0.213	127	0.000	0.861	127	0.000
Finishing Works [Electricians]	0.193	127	0.000	0.874	127	0.000
Finishing Works [Masons]	0.211	127	0.000	0.846	127	0.000

a. Lilliefors Significance Correction

Appendix-5 - Ranking of Labor Tasks Based on RII

Appendix-5 - Ranking of Labor Tasks Based on Relative Importance Index (RII)

Rank	Labor Task	N	Count of 1	Sum 1s	Count of 2	Sum 2s	Count of 3	Sum 3s	Count of 4	Sum 4s	Count of 5	Sum 5s	Total Sum (ΣW)	Max Score (A)	RII
1	Pile Cap Construction [Steel Fixer]	129	0	0	7	14	18	54	43	172	61	305	545	5	0.84496124
2	Transom Construction [Steel Fixer]	129	0	0	7	14	16	48	49	196	57	285	543	5	0.841860465
3	Diaphragm & Deck Slab Construction [Steel Fixer]	129	0	0	4	8	23	69	53	212	49	245	534	5	0.827906977
4	Transom Construction [Formwork Fixer]	129	0	0	11	22	19	57	41	164	58	290	533	5	0.826356589
5	Pier Construction [Steel Fixer]	129	0	0	9	18	18	54	49	196	53	265	533	5	0.826356589
6	Girders Casting & Prestressing [Formwork Fixer]	129	3	3	5	10	21	63	43	172	57	285	533	5	0.826356589
7	Girders Casting & Prestressing [Steel Fixer]	129	1	1	7	14	24	72	40	160	57	285	532	5	0.824806202
8	Pile Cap Construction [Formwork Fixing]	129	0	0	7	14	26	78	42	168	54	270	530	5	0.821705426
9	Piling [Surveyor]	129	1	1	6	12	27	81	41	164	54	270	528	5	0.818604651
10	Barriers/ Parapets [Steel Fixer]	129	0	0	4	8	29	87	48	192	48	240	527	5	0.817054264
11	Diaphragm & Deck Slab Construction [Formwork Fixer]	129	4	4	6	12	24	72	40	160	55	275	523	5	0.810852713
12	Girders Casting & Prestressing [Concrete Labor]	129	1	1	7	14	24	72	49	196	48	240	523	5	0.810852713
13	Pile Cap Construction [Concrete Labor]	129	0	0	8	16	25	75	49	196	47	235	522	5	0.809302326
14	Pier Construction [Formwork Fixer]	129	0	0	10	20	25	75	45	180	49	245	520	5	0.80620155
15	Girders Casting & Prestressing [Stressing Cables Pulling Labors]	129	0	0	7	14	30	90	44	176	48	240	520	5	0.80620155
16	Pier Construction [Concrete Labor]	129	0	0	7	14	27	81	50	200	45	225	520	5	0.80620155
17	Expansion Joints [Expansion Joint Fixer]	129	5	5	6	12	24	72	40	160	54	270	519	5	0.804651163
18	Barriers/ Parapets [Concrete Mason & Labor]	129	0	0	4	8	36	108	43	172	46	230	518	5	0.803100775
19	Site Preparation & Diversion [Surveyor]	129	2	2	12	24	26	78	31	124	58	290	518	5	0.803100775
20	Diaphragm & Deck Slab Construction [Concrete Labor]	129	0	0	7	14	31	93	44	176	47	235	518	5	0.803100775
21	Piling [Steel Fixer for Cages Fabrication]	129	0	0	6	12	27	81	55	220	41	205	518	5	0.803100775
22	Girders Launching [Crane Operator]	129	4	4	9	18	26	78	33	132	57	285	517	5	0.801550388
23	Barriers/ Parapets [Formwork Fixer]	129	2	2	5	10	30	90	45	180	47	235	517	5	0.801550388
24	Girders Casting & Prestressing [Prestressing Jacks Operators]	129	5	5	9	18	23	69	38	152	54	270	514	5	0.796899225
25	Girders Launching [Surveyor]	129	4	4	10	20	22	66	41	164	52	260	514	5	0.796899225
26	Girders Casting & Prestressing [Profile Adjustment labor]	129	3	3	10	20	24	72	41	164	51	255	514	5	0.796899225
27	Finishing Works [Masons]	129	0	0	9	18	29	87	47	188	44	220	513	5	0.795348837
28	Girders Launching [Girder transporter / mover operator]	129	2	2	14	28	22	66	39	156	52	260	512	5	0.79379845
29	Girders Casting & Prestressing [Grouting Machine Operator]	129	5	5	9	18	22	66	44	176	49	245	510	5	0.790697674
30	Expansion Joints [Steel Fixer]	129	0	0	6	12	34	102	52	208	37	185	507	5	0.786046512
31	Piling [Rig Operator]	129	2	2	9	18	37	111	32	128	49	245	504	5	0.781395349
32	Diaphragm & Deck Slab Construction [Concrete Pump Operator]	129	5	5	6	12	28	84	47	188	43	215	504	5	0.781395349
33	Expansion Joints [Concrete Labors]	129	1	1	6	12	36	108	49	196	37	185	502	5	0.778294574
34	Transom Construction [Welder]	129	4	4	12	24	23	69	47	188	43	215	500	5	0.775193798
35	Girders Launching [Launching Supervisor]	129	2	2	15	30	31	93	33	132	48	240	497	5	0.770542636
36	Finishing Works [Painters]	129	3	3	10	20	32	96	42	168	42	210	497	5	0.770542636
37	Expansion Joints [Formwork Fixer]	129	2	2	7	14	36	108	47	188	37	185	497	5	0.770542636
38	Transom Construction [Concrete Pump Operator]	129	5	5	10	20	22	66	56	224	36	180	495	5	0.76744186
39	Transom Construction [Crane Operator]	129	5	5	9	18	26	78	51	204	38	190	495	5	0.76744186
40	Girders Launching [Winch Machine operator Manual Launching]	129	2	2	14	28	28	84	45	180	40	200	494	5	0.765891473
41	Piling [Piling Concrete Labor]	129	3	3	9	18	36	108	40	160	41	205	494	5	0.765891473
42	Piling [Crane Operator]	129	2	2	12	24	32	96	47	188	36	180	490	5	0.759689922
43	Finishing Works [Electricians]	129	1	1	13	26	38	114	40	160	37	185	486	5	0.753488372
44	Piling [Sonic Integrity Test (SIT) Operator]	129	3	3	16	32	34	102	31	124	45	225	486	5	0.753488372
45	Girders Launching [Foreman Manual Launching]	129	3	3	19	38	27	81	38	152	42	210	484	5	0.750387597
46	Pier Construction [Crane Operator]	129	4	4	11	22	32	96	50	200	32	160	482	5	0.747286822
47	Pile Cap Construction [Pile Head Breaker]	129	6	6	9	18	35	105	47	188	32	160	477	5	0.739534884
48	Girders Casting & Prestressing [Crane Operator]	129	9	9	11	22	32	96	37	148	40	200	475	5	0.736434109
49	Site Preparation & Diversion [Plant Machinery Operators]	129	5	5	24	48	24	72	38	152	38	190	467	5	0.724031008
50	Piling [Concrete Pump Operator]	129	8	8	16	32	33	99	37	148	35	175	462	5	0.71627907
51	Site Preparation & Diversion [Safety Supervisors]	129	11	11	18	36	36	108	28	112	36	180	447	5	0.693023256

Appendix-6 - Hypothesis Testing Results (Kruskal - Wallis)

Appendix 6 - Hypothesis Results

(Kruskal Wallis w.r.t Qualification)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Site Preparation & Diversion [Surveyor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.024	Reject the null hypothesis.
2	The distribution of Site Preparation & Diversion [Plant Machinery Operators] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.017	Reject the null hypothesis.
3	The distribution of Site Preparation & Diversion [Safety Supervisors] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.345	Retain the null hypothesis.
4	The distribution of Piling [Surveyor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.066	Retain the null hypothesis.
5	The distribution of Piling [Rig Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.011	Reject the null hypothesis.
6	The distribution of Piling [Steel Fixer for Cages Fabrication] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.186	Retain the null hypothesis.
7	The distribution of Piling [Crane Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.264	Retain the null hypothesis.
8	The distribution of Piling [Concrete Pump Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.035	Reject the null hypothesis.
9	The distribution of Piling [Piling Concrete Labour] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.004	Reject the null hypothesis.
10	The distribution of Piling [Sonic Integrity Test (SIT) Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.189	Retain the null hypothesis.
11	The distribution of Pile Cap Construction [Pile Head Breaker] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.031	Reject the null hypothesis.

12	The distribution of Pile Cap Construction [Formwork Fixing] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.162	Retain the null hypothesis.
13	The distribution of Pile Cap Construction [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.930	Retain the null hypothesis.
14	The distribution of Pile Cap Construction [Concrete Labor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.759	Retain the null hypothesis.
15	The distribution of Pier Construction [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.182	Retain the null hypothesis.
16	The distribution of Pier Construction [Crane Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.751	Retain the null hypothesis.
17	The distribution of Pier Construction [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.900	Retain the null hypothesis.
18	The distribution of Pier Construction [Concrete Labour] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.710	Retain the null hypothesis.
19	The distribution of Transom Construction [Welder] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.084	Retain the null hypothesis.
20	The distribution of Transom Construction [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.219	Retain the null hypothesis.
21	The distribution of Transom Construction [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.927	Retain the null hypothesis.
22	The distribution of Transom Construction [Crane Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.137	Retain the null hypothesis.

23	The distribution of Transom Construction [Concrete Pump Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.092	Retain the null hypothesis.
24	The distribution of Girders Casting & Prestressing [Crane Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.115	Retain the null hypothesis.
25	The distribution of Girders Casting & Prestressing [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.401	Retain the null hypothesis.
26	The distribution of Girders Casting & Prestressing [Profile Adjustment labor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.929	Retain the null hypothesis.
27	The distribution of Girders Casting & Prestressing [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.915	Retain the null hypothesis.
28	The distribution of Girders Casting & Prestressing [Concrete Labor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.079	Retain the null hypothesis.
29	The distribution of Girders Casting & Prestressing [Stressing Cables Pulling Labours] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.942	Retain the null hypothesis.
30	The distribution of Girders Casting & Prestressing [Prestressing Jacks Operators] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.247	Retain the null hypothesis.
31	The distribution of Girders Casting & Prestressing [Grouting Machine Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.530	Retain the null hypothesis.
32	The distribution of Girders Launching [Crane Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.212	Retain the null hypothesis.
33	The distribution of Girders Launching [Girder transporter / mover operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.328	Retain the null hypothesis.

34	The distribution of Girders Launching [Launching Supervisor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.028	Reject the null hypothesis.
35	The distribution of Girders Launching [Surveyor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.010	Reject the null hypothesis.
36	The distribution of Girders Launching [Winch Machine operator Manual Launching] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.144	Retain the null hypothesis.
37	The distribution of Girders Launching [Foreman Manual Launching] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.203	Retain the null hypothesis.
38	The distribution of Diaphragm & Deck Slab Construction [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.659	Retain the null hypothesis.
39	The distribution of Diaphragm & Deck Slab Construction [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.522	Retain the null hypothesis.
40	The distribution of Diaphragm & Deck Slab Construction [Concrete Labor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.844	Retain the null hypothesis.
41	The distribution of Diaphragm & Deck Slab Construction [Concrete Pump Operator] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.061	Retain the null hypothesis.
42	The distribution of Barriers/ Parapets [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.051	Retain the null hypothesis.
43	The distribution of Barriers/ Parapets [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.399	Retain the null hypothesis.
44	The distribution of Barriers/ Parapets [Concrete Mason & Labor] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.563	Retain the null hypothesis.

45	The distribution of Expansion Joints [Expansion Joint Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.652	Retain the null hypothesis.
46	The distribution of Expansion Joints [Steel Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.188	Retain the null hypothesis.
47	The distribution of Expansion Joints [Formwork Fixer] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.380	Retain the null hypothesis.
48	The distribution of Expansion Joints [Concrete Labours] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.648	Retain the null hypothesis.
49	The distribution of Finishing Works [Painters] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.048	Reject the null hypothesis.
50	The distribution of Finishing Works [Electricians] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.121	Retain the null hypothesis.
51	The distribution of Finishing Works [Masons] is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.643	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.