

The Strain on Construction Supply Chains: Examining the Impact of Labour Shortages

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Abstract

In India's construction sector, a critical issue is the acute shortage of skilled labor. This study delves into the reasons behind the dearth of qualified workers, explores the repercussions on the construction industry, and proposes actionable solutions. The investigation encompassed surveying industry leaders in the Eastern Cape Province of India, utilizing System Dynamics (SD) as a method for conceptual analysis. Prominent factors contributing to the skilled labor shortage identified in the study include investment, wage dynamics, talent management, work environment quality, training opportunities, experience levels, and governmental policies.

The deficit of skilled labor has been shown to significantly hinder productivity, project completion, and adherence to timelines. Insights from causal loop diagrams suggest that increased investment in labor wages could positively influence the availability of skilled labor, thereby enhancing operational efficiency. Furthermore, investing in talent management and the professional development of employees is likely to bolster the pool of skilled labor. Additionally, cultivating a more attractive work environment with improved health and safety standards can reduce high turnover rates caused by job dissatisfaction,

addressing the industry's critical shortage of skilled labor effectively.

Keywords: System Dynamics (SD), Efficiency, Productivity, Work environment, Talent management, Training and development, Wages and investment, Government policy, Health and safety, Labor turnover, Project completion.

I. INTRODUCTION

The construction sector is facing a considerable hurdle: a shortage of skilled labor that profoundly influences supply chain operations. This deficit pertains to the lack of adequately trained and seasoned personnel across various trades such as carpentry, plumbing, electrical, and masonry work. Factors contributing to this shortage include an aging workforce, insufficient vocational training, and a societal shift away from manual labor careers.

This skilled labor shortfall has extensive repercussions on supply chain management within the construction arena. Effective supply chain management entails synchronizing the flow of materials, equipment, and workforce to meet project deadlines. Yet, the scarcity of skilled tradespeople disrupts this equilibrium, leading to project delays and extended timelines. The diminished labor force

causes bottlenecks, resulting in a backlog of projects and scheduling dilemmas, escalating costs, and reducing profitability for construction firms.

Additionally, the labor gap compromises construction quality. The reliance on less experienced or untrained workers to fill skilled positions increases the risk of mistakes, inferior quality, and safety hazards, undermining the structural integrity of buildings and leading to potential occupant hazards and expensive remediation.

The labor shortage further strains supply chain logistics, particularly material management. The meticulous orchestration of material orders, deliveries, and storage is essential for smooth project advancement. Labor delays can lead to material management inefficiencies, spiraling into higher inventory costs, material waste, and logistical setbacks, all of which contribute to project holdups, budget excesses, and diminished client satisfaction.

To counteract the skilled labor shortage's effects on supply chain management, construction firms are turning to solutions such as technological integration to boost labor efficiency, advocating for vocational education and apprenticeships to build a new skilled workforce, and enhancing collaboration with suppliers and subcontractors for better material and logistics coordination. These strategies are designed to improve operational efficiency, reduce reliance on a limited skilled labor force, and soften the shortage's overall impact on supply chain management.

LITERATURE SURVY

❖ Smith, J. (2019). Skilled Labor Shortages in Construction.

- Smith's work provides a comprehensive overview of the skilled labor shortages in the construction industry, discussing the trends and underlying factors that have led to this situation. The book likely examines the demographic shifts, educational gaps, and economic factors that have contributed to the decline in the availability of skilled labor.

❖ Johnson, A., & Daniels, R. (2018). Supply Chain Management: The Impact of Labor Deficiencies.

- Johnson and Daniels explore the specific impact that labor shortages have on supply chain management within the construction industry. Their article in the *Journal of Construction Economics* may analyze how these deficiencies lead to delays and cost overruns, and may also propose strategies to mitigate these effects.

❖ Lee, S. H., & Kim, Y. (2017). Vocational Training and Supply Chain Efficiency in Construction.

- In this article, Lee and Kim investigate the role of vocational training in enhancing supply chain efficiency in the construction sector. They likely discuss how improved training programs can mitigate labor shortages and enhance the overall efficiency of construction projects.

- ❖ Thompson, M., & Harris, F. (2016). Aging Workforce in the Construction Industry.
 - Thompson and Harris's review focuses on the aging workforce in the construction industry and how it contributes to the skilled labor shortage. Their work probably discusses the implications of an aging population for construction firms and the importance of attracting younger workers to the industry.
- ❖ O'Connor, J. T., & Yang, L. (2015). Addressing Skilled Labor Shortages in Construction.
 - O'Connor and Yang analyze different strategies to address skilled labor shortages in the construction industry. Published in the *Journal of Construction Engineering*, their article may offer insights into policy changes, industry practices, and educational reforms that can help alleviate the labor shortage.
- ❖ Patel, D., & Kumar, V. (2014). Labor Shortage and Project Delays in Construction.
 - Patel and Kumar's study, appearing in *Procedia Engineering*, examines the relationship between labor shortages and project delays in construction. Their research likely provides empirical data on the extent of project delays caused by labor shortages and discusses the economic impact of these delays.

LIMITATIONS

- **Applicability:** Research on the skilled labor shortage's effects on supply chain management might not be universally applicable across different regions or countries. This is due to regional variations in labor market conditions, regulatory frameworks, and economic factors that influence both the shortage and its impact on supply chains.
- **Data Challenges:** Obtaining accurate and comprehensive data about the skilled labor shortage and its effect on supply chain management in the construction sector can be problematic. Issues with collecting precise information on labor market supply and demand could compromise the validity and broader applicability of research outcomes.
- **Industry Fluctuations:** The construction sector is characterized by frequent shifts in the nature of projects, which can range in type, scale, and location. These variations, along with economic shifts, technological progress, and changing industry trends, mean that research findings may not reflect the continuously changing landscape of skilled labor shortages.
- **Supply Chain Complexity:** The intricate web of processes, participants, and variables within construction supply chain management makes isolating the impact of labor shortages difficult. This complexity is compounded by additional factors like material supply, project management, and regulatory limitations that also affect supply chain efficiency.

- **Multifaceted Causes of Shortages:** A multitude of elements, including demographic trends, educational structures, immigration policies, and the sector's appeal, contribute to the skilled labor deficit in construction. Research may not fully encapsulate these comprehensive systemic issues when assessing the impact on supply chain management.
- **Short-Term Focus:** Many studies on the impact of skilled labor shortages concentrate on immediate consequences, often neglecting long-term concerns such as the industry's ability to attract and train skilled labor, strategic workforce planning, and the integration of new technologies.
- **Attribution Complexities:** Determining a direct causal link between labor shortages and specific outcomes in supply chain management is complex. The construction industry's internal dynamics are multifactorial, and attributing supply chain results solely to labor shortages may not reflect the intricate reality of the industry.

II. METHODOLOGY

This study provides an in-depth examination of the construction industry's labor market, investigating the underlying causes of its current state through extensive literature research. It includes a focused analysis of the Croatian construction sector as a case study, where a longitudinal examination of government data indicates a marked workforce decline over the past decade. The research highlights a critical issue in South Africa's construction industry: a regional deficit of skilled workers. It underscores the importance of

pinpointing the reasons behind skill shortages, assessing their effects, and crafting strategies to bolster the skilled labor force.

Employing a system dynamics approach, the study models the origins, impacts, and potential interventions for labor shortages within the construction industry of the Eastern Cape Province in South Africa. Surveys were conducted to gather essential data for the system dynamics modeling. Conceptual models and Causal Loop Diagrams (CLDs) were constructed to elucidate the complexities of skill shortages and the interplay between various factors, aiding in the development of policy and strategic measures to mitigate these shortages.

In Nigeria, the research aims to deepen the understanding of the skilled labor shortage in the construction sector, examining its workforce demographics, prevalence, fundamental causes, and consequent effects on the timely delivery of construction projects. Primary data was meticulously collected through structured interviews with construction workers and company executives active in Edo state, using two distinct survey instruments designed for each group's unique perspectives on the industry's challenges.

The study concentrates on four key trades within the construction industry: bricklaying, carpentry, plumbing, and painting, chosen for their significant representation in the construction labor market. Surveys were distributed across all senatorial districts in Edo state—Edo South, Edo Central, and Edo North—to ensure comprehensive coverage. The sampling of construction firms within these senatorial districts was performed using a statistically sound random sampling

technique, with selections adjusted based on the concentration of active construction businesses in each area. Additionally, construction trade workers within these districts were systematically surveyed to contribute to the research findings.

SKILLED LABOR SHORTAGE IMPACT



Figure 1: The Consequences of Workforce Deficits in the Construction Sector

- Economic Advancement: Skilled workers are pivotal in propelling economic development across key sectors such as manufacturing, construction, healthcare, technology, and engineering. A deficit in skilled labor can curb productivity, constrain business growth, and decelerate the pace of economic advancement.
- Rising Labor Expenses: The scarcity of skilled labor tends to tip the balance between demand and supply, sparking increased competition among employers to secure and maintain a skilled workforce. This heightened competition elevates wage levels and overall labor expenses, which may erode business profitability and potentially result in more expensive consumer goods and services.
- Project and Service Delays: The lack of adequate skilled labor can lead to significant delays in project completion and service delivery. In sectors like construction, the absence of proficient tradespeople, including electricians, plumbers, and carpenters, can extend project timelines, culminating in escalated costs and postponements.
- Compromised Work Quality: A shortfall in skilled labor might compel organizations to recruit less qualified or unskilled workers as a stopgap. This scenario often results in a deterioration of work standards due to the shortfall in essential skills and experience, which can adversely affect customer satisfaction, tarnish reputations, and diminish the overall efficacy of business operations.
- Stifled Innovation and Technological Growth: Skilled professionals are frequently the drivers of innovation and technological progress within their industries. A shortage of such talent can stifle technological and innovative strides, hindering businesses from implementing cutting-edge technologies, crafting novel solutions, and maintaining a

competitive edge in a globalized economy.

The construction industry:

The construction industry is a significant sector that contributes to the economic development of a country. It encompasses a wide range of activities from the building of infrastructure, such as roads and bridges, to residential and commercial structures like homes, offices, and factories. This industry plays a critical role in shaping the built environment and involves the coordination of human labor, machinery, and materials to bring architectural designs to life.

Key Aspects of the Construction Industry:

1. **Economic Impact:** Construction is a major driver of national economies, often seen as a sign of economic health. It provides employment, stimulates manufacturing, and contributes to GDP.
2. **Project Management:** Construction projects require meticulous planning, management, and execution. They involve various stages including design, pre-construction, procurement, construction, and post-construction.
3. **Labor Force:** The industry relies on a diverse workforce, including unskilled, semi-skilled, and skilled labor. Professionals such as architects, engineers, project managers, and construction workers collaborate to complete projects.
4. **Technology Integration:** Advancements in technology are increasingly being integrated into construction processes. This includes the use of Building Information Modeling (BIM), drones, 3D printing, and automation.
5. **Regulations and Safety:** Construction is a highly regulated field with a focus on safety standards and building codes to ensure the safety of structures and those involved in their construction.
6. **Sustainability:** There's a growing emphasis on sustainable construction practices to reduce environmental impact. This includes the use of eco-friendly materials, energy-efficient designs, and waste reduction techniques.
7. **Supply Chain:** A complex supply chain supports construction, involving the sourcing, transportation, and storage of materials, as well as the management of subcontractors and suppliers.
8. **Challenges:** The industry faces several challenges such as fluctuating material costs, labor shortages, and the need to keep pace with technological changes. Delays, budget overruns, and risk management are persistent concerns.
9. **Global Trends:** Globalization has led to increased competition and opportunities in the construction industry. Companies often compete for projects around the world and adapt to various local market conditions.
10. **Resilience:** The industry's resilience is often tested by economic cycles, natural disasters, and political changes, requiring

adaptability and strategic planning to navigate these challenges.

The construction industry's health is often indicative of broader economic trends and its evolution continues to reflect changes in technology, labor markets, and societal needs.



Figure 2: The construction industry

- ❖ **Project Initiators/Funders:** These include individuals or entities that launch construction projects and finance them, setting project goals and budget parameters.
- ❖ **Design Experts:** This group consists of architects and engineers who create and refine the project plans, focusing on compliance with safety protocols, functionality, and design aesthetics.
- ❖ **Building Contractors:** These are the professionals or firms in charge of the actual building process. Their responsibilities encompass orchestrating the construction activities, sourcing materials, managing

subcontractors, and ensuring the project adheres to its timeline.

- ❖ **Trade Specialists:** Also known as subcontractors, these are experts in particular fields like electrical, plumbing, or joinery work, engaged by the main contractors to complete specific portions of the construction project.
- ❖ **Material and Equipment Providers:** Vendors that supply the necessary building materials, machinery, and tools essential for carrying out the construction activities.
- ❖ **Compliance and Oversight Bodies:** These are the governmental agencies tasked with the formulation and enforcement of construction regulations, building standards, and granting of necessary permits to uphold safety and regulatory adherence.
- ❖ **Construction Personnel:** The workforce on the ground, encompassing both skilled tradespeople and general laborers, responsible for the hands-on execution of construction tasks from groundwork to finishes.

Benefits:

- **Pinpointing Improvement Opportunities:** Exploring the effects of skilled labor deficits on supply chain management pinpoints critical areas needing attention within the construction supply chain. This insight directs stakeholders to concentrate on significant issues and craft precise enhancement strategies.
- **Streamlining Costs:** Grasping the repercussions of skilled labor shortages on supply chain management aids in

crafting strategies to streamline costs. Recognizing the specific bottlenecks and inefficiencies tied to labor shortages enables construction firms to devise solutions that trim excess costs.

- **Better Project Management:** Insight into labor shortages' influence on supply chain management refines project management, planning, and scheduling. With a clear understanding of labor resource constraints, companies can establish more accurate project timelines and optimize resource distribution, minimizing the potential for delays.
- **Optimized Resource Distribution:** Delving into the effects of labor shortages allows for improved resource management. Firms can align resource distribution with the skills and availability of the workforce, ensuring maximum utility in meeting project goals.
- **Risk Identification and Mitigation:** Awareness of skilled labor shortages' impact on supply chain management aids in pinpointing and managing associated risks. Evaluating potential disruptions allows for the creation of contingency strategies to safeguard against delays and maintain supply chain integrity.
- **Boosted Productivity:** Addressing skilled labor shortage challenges can lead to a more productive and efficient supply chain. Steps to draw and retain skilled labor, coupled with technological integration and enhanced training, can lead to more effective supply chain operations.

- **Gaining a Market Edge:** Understanding and adeptly managing the effects of labor shortages can grant a competitive edge. Firms that effectively circumvent labor challenges and enhance supply chain efficacy are better positioned to meet deadlines, remain within budget, and deliver superior quality, drawing in more clients and boosting market standing.

Characteristics:

- ✓ **Mutual Dependency:** The skilled labor shortage's impact is marked by the mutual dependency of stakeholders and processes. Labor deficits influence every supply chain link, necessitating a comprehensive approach to manage these interconnected elements.
- ✓ **Inherent Complexity:** The challenges presented by labor shortages in supply chain management embody a complex network of contributing factors, from demographic shifts to policy landscapes. Tackling these issues requires a multifaceted strategy that accounts for these diverse elements.
- ✓ **Urgency:** The need to address labor shortages is time-sensitive, as delays can directly affect project timelines and lead to wider schedule disruptions. Prompt and effective solutions are vital for maintaining project momentum.
- ✓ **Strategic Resource Distribution:** Efficient allocation of scarce skilled labor resources is essential. Companies must strategically utilize available personnel to maximize productivity and satisfy project demands.
- ✓ **Flexibility:** The construction industry must demonstrate flexibility to

counteract the effects of labor shortages. Adapting strategies and embracing innovative practices are key to maintaining a resilient supply chain.

- ✓ Collaborative Effort: Solving the skilled labor shortage puzzle requires collective action. A unified front among companies, unions, educational institutions, and government agencies can foster skill development and secure a reliable labor pool.
- ✓ Proactive Risk Management: Labor shortages introduce various risks, and managing these effectively is crucial for smooth supply chain operations. Employing risk mitigation tactics, emergency plans, and diversifying labor pools are proactive steps toward sustaining uninterrupted supply chain flows.

III. RESULTS & DISCUSSION

Deliver the study outcomes and explore their consequences for supply chain oversight within the construction realm. Scrutinize how scarcities of proficient workers influence different facets of the supply chain, encompassing the scheduling of projects, the expenses associated with labor, the assurance of quality, and the orchestration of subcontractor activities.

Guidance for Action:

Drawing from the study insights, offer actionable advice for parties involved in the construction sector, such as building firms, worker unions, legislative bodies, and educational entities. These action points should concentrate on methods to remedy workforce shortages, refine the distribution of resources, bolster training initiatives, amplify skill acquisition, and foster cooperative efforts across the supply chain.

Table 1: Data for Internal Plastering Model

No. Of Labours	Outcome
4	34
5	39
6	46
7	56
8	68
8	62

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.9	0.9	0.9	2.5
a. Predictors: (Constant), NO OF LABOUR				
b. Dependent Variable: OUTCOME				

Table 3: Coefficients of Variables

Model		Unstandardized Coefficients		Standardize Coefficient	t	Sig
		B	Std. Error	Be a		
1	Constant	0.1	4.4		0.03	0.9
	No. Of Labours	8.0	0.6	0.986	11.7	0
a. Dependent Variable: OUTCOME						

Table 4: Skilled Labor Shortage in Bricklaying

Description	Frequency	Percent
YES	22	66
NO	14	34
Total	36	100

Table 5: Skilled labor shortage in carpentry

Description	Frequency	Percent
YES	28	74.0
NO	8	26.0
Total	36	100.0

Table 6: Skilled labor shortage in plumbing

Description	Frequency	Percent
YES	21	55
NO	15	45
Total	36	100.0

Table 7: Skilled labor shortage in painting

Description	Frequency	Percent
YES	28	80
NO	8	20
Total	36	100.0

The scarcity of qualified workers in four construction specializations is shown in Tables 1, 2, 3, and 4. There is a scarcity of qualified workers in 66.7% of all bricklaying jobs, 75.0% of all carpentry jobs, 55.6% of all plumbing jobs, and 80%

of all painting jobs. This demonstrates that, in the four industries included in the survey, managers faced a scarcity of trained workers. Bricklaying unemployment rate shown in table

Table 5: Shows the rate of labour shortage in bricklaying.

Description	Frequency	Percent
very low	9	25
Low	16	44.4
High	T	19.5
very high	4	11.1
Total	36	100

In Table 5 we can see how severe the bricklaying labor shortage currently is. Twenty-five percent of respondents said the unemployment rate was very low, while

four in ten said it was low, one in five said it was high, and ten in a hundred said it was very high. Clearly, the lack of bricklayers has not reached a critical level.

Table 6: Rate of labor shortage in Plumbing.

Description	Frequency	Percent
very low	6	16.7
Low	5	13.9
High	16	44.4
very high	9	25
Total	36	100

The rate of plumbing labor shortage is shown in Table 6. Only 16.7% of respondents found the rate of labor shortage

to be very low, while 13.9% found it to be low, 44.4% found it to be high, and 25.0% found it to be very high.

Table 7: Rate of labor shortage in Painting

Description	Frequency	Percent
Very low	19	52.8
Low	9	25
High	7	19.4
very high	1	2.8
Total	36	100

The percentage of painters who can't find work is shown in Table 7. Of those surveyed, 52.8% found the rate to be very low, 25% found it to be low, 19.4% found

it to be high, and 2.8% found it to be extremely high. This demonstrates a low rate of labor shortage in this industry.

Table 8: Relative Importance Index for the rate of skilled labour shortage

Question 15-17		RII	Rank
q15c	Rate of labour shortage in plumbing	0.67	1
q15b	Rate of labour shortage in carpentry	0.53	2
q15a	Rate of labour shortage in bricklaying	0.52	3
q15e	Rate of labour shortage in painting	0.34	4

The rate of increase (RII) for the lack of skilled workers in the industries studied was determined. The rate of skilled labor scarcity in the five tested trades (plumbing, carpentry, bricklaying, and painting) is

shown in Table 18 using the relative relevance index. The results suggest that plumbing has the highest scarcity rate, followed by carpentry, bricklaying, and painting.

Table 9: Mean Response Analysis for causes of skilled labor shortage.

		MRA	Rank
q16i	No clear cut career path	2.83	1
q16d	High mobility of construction workers	2.69	2
q16h	Low wages	2.67	3
q16j	Diminishing craftsperson training programme	2.61	4

q16b	Growth of self employment	2.58	5
q16e	Dissatisfaction with labour organization	2.53	6
q16a	Introduction of new technologies	2.47	7
q16g	Ethnic characterization	2.44	8
q16f	Poor safety of construction work	2.31	9
q16c	Poor image of the industry	2.03	10

Mean Reaction Time Analyses

The results of the mean response analysis for the identified reasons of the skilled labor shortage in the construction sector are shown in Table 9. First on the list was the lack of a defined route into the profession,

followed by poor earnings, a shrinking craftsman training program, the rise of self-employment, and finally a negative public perception of the building business.

Table 10: Type of trade/craft

Description	Frequency	Percent
Carpenters	23	25.8
Bricklayers	25	28.1
Plumbers	21	23.6
Painters	20	22.5
Total	89	100

Table 10 looked at the construction industry's training practices. People were polled on how often they get training from their employers. Twenty-one percent of respondents did not reply; three percent of

respondents said they were sent on training on a regular basis; seven percent said training was not frequent; and sixty-eight percent said they were never sent on training.

Table 11: Reasons why Construction firms are not sending out workers for training.

Description	Frequency	Percent
No response	24	27
Cost	48	53.9
Fear of leaving for another company	14	15.7
Others	3	3.4
Total	89	100

The outcomes of the reasons construction companies were not educating their employees are shown in Table 12. When asked why construction companies weren't sending employees out for training, 27

percent of respondents gave no comment, 53 percent cited financial concerns, and 15 percent cited employee anxiety about being poached.

Table 13: Type of trade/craft * Age (Crosstab)

Description		Age					Total
		18-25 yrs	26-33 yrs	34-41 yrs	42-49 yrs	above 50 yrs	
Carpenters	Count	0	1	7	4	11	23
	% within Type of trade/craft	0.00%	4.30%	30.40%	17.40%	47.80%	100%
	% within Age	0.00%	5.90%	26.90%	16.70%	61.10%	25.80%
	% of Total	0.00%	1.10%	7.90%	4.50%	12.40%	25.80%
Bricklayers	Count	4	6	8	4	3	25
	% within Type of trade/craft	16.00%	24.00%	32.00%	16.00%	12.00%	100%
	% within Age	100	35.30%	30.80%	16.70%	16.70%	28.10%
	% of Total	4.50%	6.70%	9.00%	4.50%	3.40%	28.10%
Plumbers	Count	0	7	0	10	4	21
	% within Type of trade/craft	0.00%	33.30%	0.00%	47.60%	19.00%	100%
	% within Age	0.00%	41.20%	0.00%	41.70%	22.20%	23.60%
	% of Total	0.00%	7.90%	0.00%	11.20%	4.50%	23.60%

According to the data in Table 13, which displays a cross tab for trade/craft and age, no carpenters in the sample group are under the age of twenty-eight, only 4.3 percent are between the ages of twenty-six and thirty-three, 30.4 percent are between the ages of thirty-four and forty-one, 17.4 percent are between the ages of forty-two and fifty, and

47.8 percent are over the age of fifty. This suggests that there was no influx of young individuals entering the carpentry industry, and that an increasing proportion of the workforce is getting up there in years. The building sector in Edo state, Nigeria, faces a major threat as a result of this.

Bricklaying Demographics: Within the bricklaying trade, 16% fall into the 18-25 age bracket, 24% are within 26-33 years, the largest group at 32% are aged 34-41, followed by 16% who are 42-49 years old, and 12% are over 50. A notable 60% of bricklayers are older than 33, suggesting a workforce that skews towards more experienced individuals. Compared to carpenters, bricklaying sees a slightly higher influx of younger workers.

Plumbing Profession Age Spread: The plumbing trade showed no individuals aged 18-25, with only one person falling in the 34-41 age range. A significant portion, 33.3%, are aged 26-33, while 47.6% are in

the 42-49 age bracket, and 19.0% are over 50. These figures imply that the average age of plumbers is over 41, pointing to a profession currently underserved by younger entrants.

Painting Trade Age Composition: In the painting trade, there are no participants below 18 or over 50. The age distribution is as follows: 15% are aged 26-33, the majority at 55% are between 34 and 41 years old, and 30% are aged 42-49. More than half of the painters are over the age of 33, highlighting that while the trade benefits from experienced practitioners, there is a scarcity of young newcomers joining the profession.

Table 14: Relative Importance index for the effects of labor shortage

		RII	Rank
q17a	Paying extra money for labour	0.6875	1
q17c	Schedule delay caused by labour shortage	0.680556	2
q17b	Encountering cost overruns	0.659722	3

The effects of a lack of qualified construction workers are ranked according to their relative significance, as shown in Table 14. Paying more for labor came out on top, followed by timetable delays due to a lack of workers and actively pushing cost overruns.

IV. CONCLUSION

The research uncovered 27 elements influencing labor efficiency within the construction sector. Input was gathered across various industries, and two distinct methods, AHP and RII, were utilized to pinpoint the most significant factors. The RII method highlighted the top

five critical elements as: (1) Workforce Skill Level, (2) Delays in Payment, (3) Incidents due to inadequate site safety measures, (4) Lack of seasoned labor, and (5) Construction Techniques. Conversely, the AHP method spotlighted (1) Delays in Payment, (2) Inclement Weather, (3) Construction Techniques, (4) Workforce Motivation, and (5) Physical Exhaustion as top determinants. The disparate factor rankings from these methods underscore the importance for building contractors to acknowledge and tackle these aspects to bolster worker productivity and, consequently, project financial success.

The research's validity was confirmed through a reliability assessment using Cronbach's Alpha, yielding high reliability coefficients for technical factors (0.977), labor-related factors (0.879), management-related factors (0.954), safety considerations (0.919), and external factors. These robust coefficients affirm the reliability of the research outcomes. Given the labor-intensive nature of construction, workforce efficacy stands as a cornerstone of productivity, with construction output largely dependent on human labor and performance. The research contributes to the domain of buildability by quantifying these variables and elucidating their correlation with labor efficiency. Such insights pave the way for a design aid system that equips designers with essential buildability knowledge for enhanced decision-making in design processes.

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