Proceedings of the 5th African International Conference on Industrial Engineering and Operations Management, Johannesburg, South Africa, April 23-25, 2024

Causes of delay in construction projects during the Fourth Industrial Revolution: A South African Perspective

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Abstract

The construction sector, a pivotal force in the state's economy, operates within a dynamic and intricate environment. Its profound impact extends beyond erecting structures to encompass strategic decisions on land allocation and new development placement. Despite technological investments, the industry grapples with challenges related to project timelines, business expansion, and the mitigation of factors contributing to project delays. This study investigates the significant causes of project delays in South African construction firms amid the Fourth Industrial Revolution (4IR). Objectives include recognizing adverse aspects affecting the industry's project completion, identifying delay-inducing factors, and proposing ways to fortify the sector by leveraging 4IR tools. The research employs a quantitative approach, utilizing both primary and secondary data sources. Both primary and secondary data have been collected in this study. The primary data collection process employed a questionnaire specifically designed based on the issues identified by the study's theoretical model as impacting the South African construction sector. Respondents completed an online questionnaire, and the collected responses were subsequently subjected to analysis. The secondary data have mostly been collected through academic databases such as Scopus, Web of Science, ERIC and IEEE Xplore. Validity and reliability were ensured through factor analysis and Cronbach's alpha coefficient. An inter-item correlation matrix evaluates the interconnectedness of constructs. Results underscore the interconnectedness of constructs, revealing significant relationships within the construction sector and 4IR. While the literature aligns with delays in the South African construction industry, survey outcomes indicate the underutilization of 4IR tools. Delays primarily stem from unskilled labour and regulatory inadequacies, emphasizing the sector's potential for improvement through strategic technological integration.

Keywords
Project management, Construction under COVID-19, Construction Management.

1. Introduction

Delays in construction projects refer to situations that result in the extension or exceeding of predetermined completion times established by involved parties (Venkateswaran et al., 2017). These delays, stemming from both internal and external factors, can have detrimental effects on an organization's reputation and may lead to missed opportunities for future ventures. Such uncertainties can significantly impact employees, potentially resulting in contract termination, reduced profit margins, and, ultimately, the insolvency of the construction company (Adam et al., 2017). This can manifest through project schedule extensions, increased costs, and compromised work quality.

According to Agyekum (2017), delays are events that deviate from and protract the initially projected project completion timeframe. Disruptions, unforeseen occurrences affecting project completion times, further compound these challenges. Timely execution is a critical aspect of any construction project, and neglecting to establish a viable timeframe may contribute to project failure. Zidane (2018) has confirmed that schedule delays are pervasive in numerous construction projects globally, resulting in wasted time, escalated costs, disruptions, and potential legal disputes leading to project withdrawal. Given the integral role construction plays in economic growth and employment, particularly in developing countries like South Africa, understanding the reasons for project delays becomes paramount. This study focuses on examining why certain projects in South Africa exceed their anticipated completion times. Considering the multifaceted nature of construction, encompassing various skills and industries such as electricity, plumbing, and more, it becomes essential to explore opportunities presented by Industry 4.0. In the context of the fourth industrial revolution, characterized by advancements in artificial intelligence, automation, digitization, and robotics, this study seeks to capitalize on technological solutions to address project delays in the South African construction industry. The research aims to provide valuable insights and recommendations on leveraging Industry 4.0 technologies to enhance efficiency and reduce delays in construction projects.

1.1 Problem statement

According to Statistics South Africa (Stats SA, 2020), the construction sector exhibited the most substantial underperformance among all industries in the national economy in 2020, marked by a year-over-year GDP contraction of a remarkable 20.3 percent. Throughout the challenging lockdown period in South Africa, particularly in April and May 2020, the construction industry faced considerable impediments, lacking adequate solutions to sustain regular operations. It is noteworthy that both the government and the private sector overlooked the severe challenges confronted by the construction industry during the lockdown, given its suboptimal performance across building and civil infrastructure segments (Stats SA, 2020). This is particularly pertinent as the construction industry, globally and in South Africa, is frequently beset by project delays. The prevalence of schedule overruns in construction projects has led to substantial delays, resulting in cost escalation (Matodzi, 2015). Numerous building projects have been halted due to delays within the construction sector, reflecting an industry-wide issue persisting throughout the project lifecycle, exerting negative implications on projects and enterprises (Kamandang et al., 2018). Similar to other sectors, the construction industry seeks sustainability, yet achieving this objective becomes challenging when projects face delays. Delays have contributed to the loss of clients, erosion of organizational reputation, and diminished competitive advantage for many construction firms (Xia et al., 2017).

1.2 Aim of the study

This research endeavours to conduct a comprehensive analysis of the primary causes of delays within the construction industry, along with proposing potential solutions. Furthermore, the study aims to underscore the significance of integrating contemporary automation technologies within the current landscape of the South African construction sector.

1.3 Objectives of the study

The objectives of this study are as follows: To identify and assess the factors contributing to delays in the South African construction sector (1); To highlight the use of the Fourth Industrial Revolution (4IR) in minimising delays in construction projects (2).

1.4 Scope and limitations of the study

This study is constrained to an examination of construction sites within South Africa, with a specific focus on the construction industry situated in Johannesburg. The limitation of the study's sample scope solely to the building industry in Johannesburg is acknowledged as a substantial constraint. To mitigate this limitation, a compensatory measure involved the development of a robust questionnaire, which was disseminated to a diverse array of respondents.

2. Literature review

2.1 Introduction

Samarghandi et al. (2016) define delays in construction projects as the extension of project duration beyond the initially planned timeline, often caused by unforeseen events that disrupt the predefined project schedule. Historical perspectives acknowledge that project delays have been inherent in construction endeavours; however, the contemporary landscape exhibits an accelerated frequency of such delays. Scholars such as Duke (2015) and Stoudt (2013), in their respective studies, advocate for the implementation of enhanced project management methodologies and adherence to robust engineering ethics to mitigate delays. The agricultural and construction sectors are identified as substantial contributors to the Gross Domestic Product (GDP), collectively constituting an average contribution of 10% based on extensive literature (Ofori-Kuragu et al., 2016). External factors beyond managerial control, such as adverse weather conditions, pose challenges to project timelines, as highlighted by Amoatey and Ankrah (2017). Additional obstacles encompass technical, political, social, cultural, and economic considerations.

Project delays can stem from various sources, including late scope revisions by clients or developers, design alterations by engineers, or delayed provision of drawings (Yang et al., 2013). Noteworthy contributors to delays, as identified by Zidane et al. (2018), encompass low worker productivity, inadequate availability of construction equipment, intricate designs demanding extended time, client payment delays, mismanagement of funds by contractors, preference for lowest bid prices over experienced contractors, and political interference. Major delay issues involve property acquisition, engagement with inexperienced contractors, relocation of existing services off-site at project commencement, refusal to grant timely site access to contractors, and protracted permit approval processes (Venkateswaran and Murugasan, 2017). Other factors can amplify delays, such as sudden increases in material prices, prolonged approval processes, substantial lead times for procured goods, immediate alterations to project scopes, preliminary pre-feasibility studies, and on-site mechanical breakdowns coupled with labor unrest.

2.2 Fourth industrial revolution implication in the construction industry

The Fourth Generation Construction Revolution incorporates key technologies such as SMAC (Social media, Mobility, Analytics, Cloud), AI (Artificial Intelligence), augmented and virtual reality, 3D printing, and the Internet of Things (IoT). This technological integration facilitates real-time coordination, collaboration, and communication among various stakeholders in the construction industry. The global economy has evolved significantly over the last century, with disruptive innovations driving digital transformations worldwide, as evident in the concepts of "Digital India," "Digital America," and "Digital Germany."

The progression of technology in construction has transitioned through historical foundations:

1. Construction 1.0: Predominantly labour-intensive with limited advanced disciplines.
2. Construction 2.0: Mid-20th century saw the growth of technical disciplines, yet site work remained labour-intensive, leading to productivity challenges.
3. Construction 3.0: The latter half of the 20th century witnessed technology-driven architecture, design innovations like Building Information Modeling (BIM), lean structures, and increased construction automation.
4. Construction 4.0: In the 21st century, particularly the last decade, four significant changes have emerged, including a technology-driven workforce, emphasis on mass adaptation, increased focus on sustainability, and a need for urgent transition due to industry challenges.

Construction 4.0, while presenting challenges, offers creative solutions to significantly reduce construction delays, as indicated by McKinsey Capital Projects & Infrastructure (Barbosa et al., 2017). Anticipated global investment in the construction industry is set to reach 10.3 trillion USD by 2022, constituting 13% of the global GDP. The wave of Construction 4.0 underscores the imperative to address industry challenges and leverage innovative solutions in the contemporary construction landscape.

2.3 Ways to reduce delays in construction using Industry 4.0 technologies

The construction industry is strategically embracing Industry 4.0 technology to achieve its goals, with potential benefits highlighted in the Industry 4.0 revolution (Sunjka and Jacob, 2013). This technological shift offers workers access to expertise and information, enabling them to assess the environmental impact of their operations and enhance effectiveness and sustainability. The global construction sector is progressively integrating digital technologies to advance operations and performance, with Construction 4.0 serving as a pivotal technology in this transformation (Bhattacharya and Momaya, 2021). This study explores the multifaceted research questions arising from the diverse activities on construction sites, aiming to leverage Industry 4.0 technologies for the development of a "connected" construction site. The investigation spans offshore operations, on-site activities, and post-construction activities, with a focus on enhancing productivity, sustainability, and worker safety. The report delves into various emerging technologies within the Industry 4.0 framework, encompassing robotics and automation, building information management, smart wearable technology, digital twins, and industrial connectivity. Additionally, the report addresses critical technical subjects such as data analytics and artificial intelligence. The discussion and future research section examines the primary challenges and forthcoming opportunities for the construction industry, culminating in a comprehensive review within the concluding remarks (Kumar et al., 2020).

a. Artificial Intilligence (AI) in construction

Artificial Intelligence (AI) is characterized as the capability of machines to emulate intelligent human behavior, utilizing human-inspired algorithms to address historically complex problems (Salehi et al., 2018). The implementation of AI represents a digital transformation, offering key benefits for businesses, including enhancing end-client experiences through intelligent insights, automating tasks to allow employees to focus on value-added work, and reducing human errors for more expedient benefits (Bolton et al., 2018). These advantages align with lean principles, emphasizing efficiency and respect. While the adoption of AI in the construction industry has historically been limited, recent advancements, particularly in software relevant to photo recognition and processing, indicate a growing interest (Dobbe et al., 2021). AI algorithms play a crucial role in project delivery, continually evolving schedules through historical data and human inputs. Image recognition can identify hazardous workers, contributing valuable insights for future planning and training. However, effective AI estimation relies on extensive training data and faces limitations related to acquiring massive datasets (Chu et al., 2018). AI has the potential to address challenging factors in the construction industry, including costs, planning, and health and safety.

Despite the transformative potential, the construction industry is in its nascent stages of adopting AI, with only a few projects incorporating these technologies. The practical implementation of Human-Artificial Intelligence collaboration remains a crucial challenge. Tools from the Fourth Industrial Revolution (4IR) demonstrate significant potential in optimizing tasks, improving efficiency, and ensuring timely project completion. For instance, architectural software like Autocad, Revit, Sketchup, and 3dsmax eliminates the need for manual drawing, streamlining tasks efficiently and rapidly.

b. Robotics and Automation

Quadruped robots and unmanned aerial vehicles (UAVs) represent cutting-edge robotics applications in construction, routinely scanning work sites for 3D model creation and facilitating the transportation of large tool sets for workers (Aripin et al., 2019). However, several challenges hinder the widespread adoption of robots and automation in the construction sector, primarily due to the higher complexity of tasks in dynamic and unpredictable construction sites compared to other industries. A potential solution is employing modern manufacturing methods to produce modular buildings offshore, ensuring compatibility with established manufacturing automation technology. Industry 4.0's digital advancements can be leveraged in production and the supply chain, enabling timely manufacturing of building modules and components. The interconnected construction site concept allows on-site activity information to be relayed to an off-site manufacturing plant, facilitating real-time adjustments in module production. Innovations in digital 3D printing technology, including block-laying robots, 3D structure welding robot arms, and concrete depositing robot arms, show promise in increasing output and efficiency in the construction sector. Additive building, employing Computer-Aided Design (CAD), is an emerging development that mitigates risks associated with traditional projects (Nardi et al., 2016). The future envisions the use of swarms of autonomous vehicles on large construction sites managed centrally. This central hive, employing digital twin technology, organizes tasks accurately, while Artificial Intelligence (AI) aids in conventional construction, helping workers adapt to changing climatic conditions and enhancing overall project efficiency (Zollmann et al., 2014). Beyond assisting with internal housing components, digital tools like Building Information Management (BIM) guide robots in the additive construction of structures, making certain aspects of the building process more reliable.

c. Buildings Information Management (BIM)

Building Information Management (BIM) has gained prominence in the construction sector, providing digital accessibility to building blueprints and enabling real-time project tracking. Whyte and Hartmann (2017) emphasize BIM's potential to integrate and streamline design and construction phases, breaking down traditional process barriers. Zhang et al. (2015) explore the use of BIM and 4D models for automated identification and prevention of construction worker fall risks. An automatic rule-checking system is employed to identify building limits and safe working zones, contributing to enhanced safety and accident prevention (Malekitabar et al., 2016). Malekitabar et al. (2016) focus on safety management, analyzing risk factors and formulating guidelines based on accident records. They propose a framework for expert systems to support digitally automated compliance and risk identification approaches. Park and Kim (2013) present a safety management framework, emphasizing planning, inspection, and education. BIM is suggested for cost-effective training of low-skilled individuals, coupled with Virtual Reality for error tracking and progress planning. Li et al. (2018) advocate for the use of Augmented Reality (AR) to ensure real-time safety monitoring for construction workers. AR offers possibilities for on-the-job safety monitoring and danger identification. Wang et al. (2012) delve into the implementation of 4D CAD models and AR for in-person engagement with building designs and access to BIM data. They highlight AR's potential for real-time communication among employees and construction site management. Integration of the Internet of Things (IoT) with BIM, as noted by Park and Kim (2013), enables real-time data linkage. Intelligent goods, incorporating IoT with BIM, participate in supply chains and construction processes, reducing worker exposure to risks. Irizarry et al. (2013) emphasize that these technologies serve as real-time forums for discussing construction challenges throughout the design and construction phases. While sensing technologies are applied in worksite buildings, data on worker productivity, a critical element, remains insufficient. Love and Matthews (2019) propose focusing efforts on a comprehensive lifetime appraisal of construction projects, supporting relevant digital solutions, sensors, and wearable electronic technologies. In summary, BIM, combined with technologies like AR, IoT, and VR, plays a pivotal role in enhancing safety, communication, and productivity in the construction sector. Automated systems, real-time monitoring, and collaborative platforms contribute to a more integrated and efficient construction environment.

3. Methodology

3.1 Research design

This research adopts a quantitative approach to analyze trends in collected responses, utilizing numerical data, tables, and frequencies. It comprehensively details, documents, examines, and reports on the prevailing issues within South Africa's construction sector in the context of the Fourth Industrial Revolution.

3.2 Data collection

Both primary and secondary data have been collected in this study. The primary data collection process employed a questionnaire specifically designed based on the issues identified by the study's theoretical model as impacting the South African construction sector. Respondents completed an online questionnaire, and the collected responses were subsequently subjected to analysis. The secondary data have mostly been collected through academic databases such as Scopus, Web of Science, ERIC and IEEE Xplore.

3.3 Data analysis

Google Forms facilitated the compilation of the questionnaire, generating initial graphs and study findings. Subsequently, responses were transferred to SPSS version 29 for more in-depth analysis. The data's skewness and measures of central tendency, including mean, median, and frequencies, were scrutinized. Additionally, correlation analysis was utilized to explore the relationship between construction delays and Fourth Industrial Revolution instruments.

3.4 Population and sample

Focusing on the South African construction sector, a sample size of 100 respondents from Johannesburg was selected. Respondents included site managers, distribution site builders, operations managers, safety managers, civil engineers, architects, and various personnel involved in construction, collectively contributing to the comprehensive data collection for this study. Note that a purpose sample was used to collect the data. This was because the best way to get the responses needed for the study was to get the concerned party to take part in the study.

3.5 Reliability and validity

The study's reliability and validity are integral to the research design, allowing for potential comparative studies with similar instruments (Shelestak et al., 2014). The questionnaire underwent a reliability test, employing Cronbach's alpha, given that the authors devised it. A coefficient of 0.7 or above ensures the questionnaire's reliability for future investigations.

4. Results and Discussion

This section presents the outcomes and discussion derived from the collected data. A specific sample of 100 respondents was aimed for, resulting in the acquisition of 78 responses, equating to a response rate of 78%. This statistical figure holds significance and instils confidence, as asserted by Galvin (2015), who posits that a response rate of 60% is deemed marginal, 70% is considered acceptable, 80% is labelled outstanding, and 90% is characterized as remarkable.

4.1 Descriptive analysis

a. Respondents

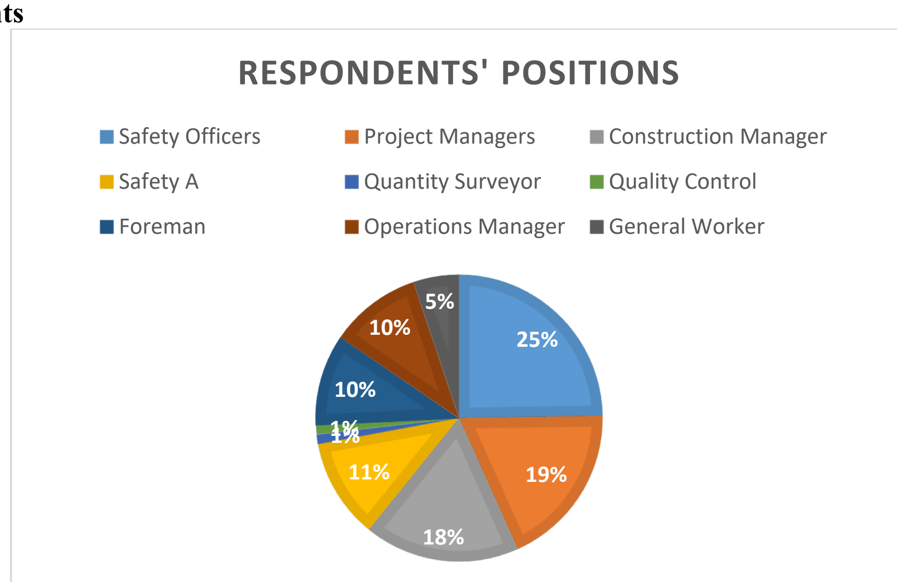

Figure 1 Respondents' positions

As illustrated in Figure 1 above, a considerable proportion of respondents held the role of Safety Managers, constituting 25% of the total respondents. Following closely were project managers, representing 19% of the respondents. Construction managers secured the third position, with 18% given their dual roles as operations managers in the majority of firms, there were 13 respondents, accounting for 16.9% of the overall sample. The remaining group comprised various positions such as site agent, foreman, and operation manager. This group of respondents was well distributed to provide the researchers with the appropriate responses

b. Employment duration

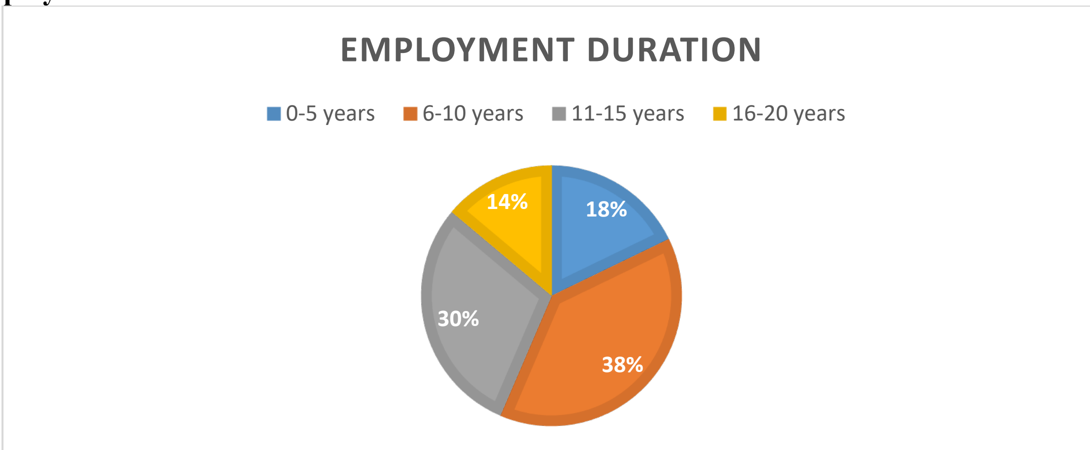

Figure 2 Respondents' employment duration

As depicted in Figure 2, the majority of respondents reported holding their positions for a tenure ranging from 6 to 10 years. Subsequently, individuals with work experience spanning 11 to 15 years constituted the second-largest group. Those with an employment duration of 0 to 5 years followed, and the smallest cohort consisted of respondents with a work experience ranging from 16 to 20 years.

Interpreting these results, it can be inferred that a significant portion of the respondents have acquired substantial experience within their respective roles, particularly within the 6 to 15 years range. This might suggest a level of stability and expertise within the workforce, potentially contributing to a knowledgeable and seasoned workforce in the construction industry. However, it is noteworthy that there is a smaller representation of individuals with an employment duration exceeding 15 years, possibly indicating a decrease in the number of professionals at more advanced career stages within the surveyed population.

c. Organizational classifications

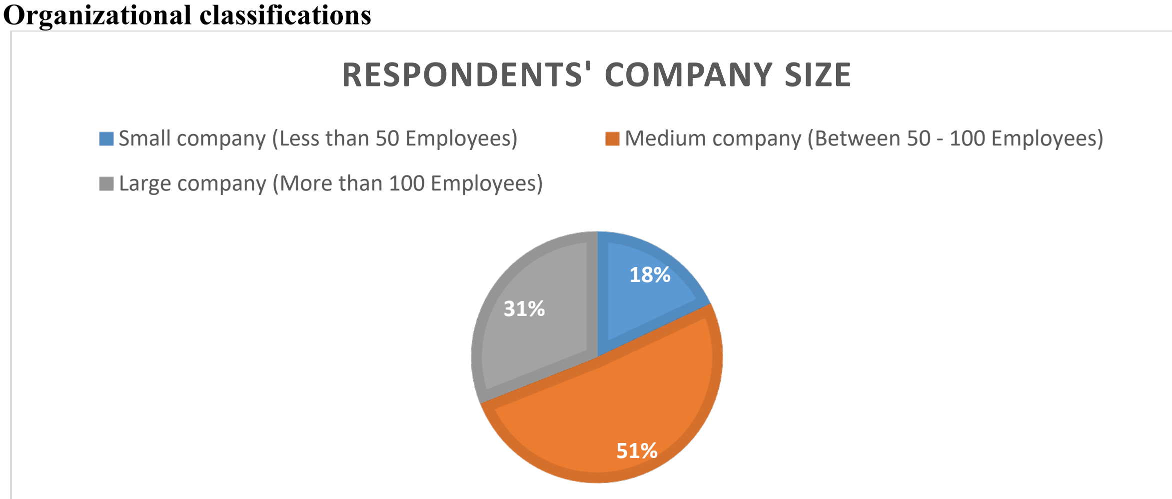

Figure 3 Respondents' company size

Figure 3 illustrates the distribution of questionnaire responses across various categories of workers and companies within the construction industry. The data indicates that a significant proportion of respondents are employed in medium-sized construction companies, constituting 51% of the total. Subsequently, individuals working in larger construction companies represent 31% of the respondents, and those in smaller companies account for 18%.

Upon interpretation, it is noteworthy that the majority of survey participants are associated with medium-sized construction firms. This may suggest that the study's sample is more representative of the experiences and perspectives prevalent in this particular segment of the construction industry. The relatively lower percentages for larger and smaller companies could imply a less extensive representation of these organizational scales in the surveyed population. Further analysis and consideration of these distribution patterns could provide valuable insights into the prevalence and impact of various factors on construction workers across different company sizes within the industry.

d. Projects completion

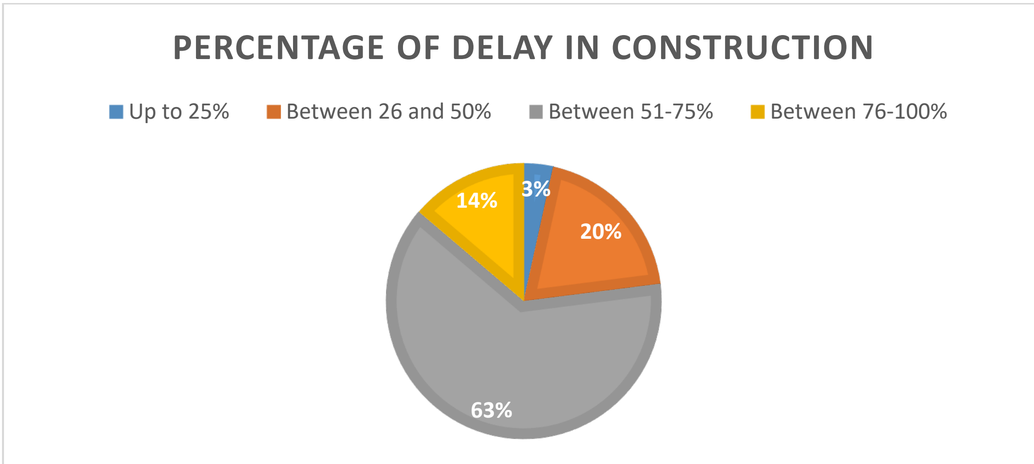

Figure 4 Delays in construction projects

Figure 4 delineates that project delays are occurring at a significant rate, ranging from 51% to 75% in South Africa, indicating a substantial and noteworthy issue warranting further investigation. The data reveals that the highest incidence of delays falls within the specified range of 51% to 75%. This figure serves as a comprehensive illustration of the prevailing circumstances in the country. This suggests a prevalent challenge in the construction industry that demands attention and potential interventions to enhance project timelines and overall efficiency. Further analysis of the factors contributing to delays within this range could provide valuable insights for addressing and mitigating these issues in the South African construction landscape, hence the rationale behind this study.

e. Factors that negatively impact construction projects

Table 1 Factors that negatively impact construction projects

Factors	**Mean**	**Std. Deviation**	**Ranking**
Lack of required skills in the local community	4.67	0.767	1
The requirement that a proportion of employees from the local community work on the project	4.47	0.936	2
The requirement to consult about the project with the local community	4.38	1.165	3
The requirement to share 30% of the project with the Business Community Forum	4.5	0.849	4
Appointment of poorly qualified managers who cannot do the job	3.97	1.248	5
Long-time delay to acquire the construction working permit	3.08	1.042	6
Lack of regulations on tender issuing	3.1	1.135	7

Table 1 above provides a comprehensive summary of the respondents' feedback, offering insights into the significant factors negatively impacting the construction industry. The top five challenges were identified based on the rankings provided by the respondents. Notably, the most prevalent issue, as indicated by the respondents, was the lack of required skills within the local community, obtaining a mean score of 4.67 and a standard deviation of 0.767. The second-highest concern, with a mean score of 4.47 and a standard deviation of 0.936, pertained to the necessity of consulting with the local community to get them involved in the construction project. Following closely, a challenge about sharing 30% of the project with the Business Community Forum is involved. Lastly, the appointment of inadequately qualified workers or managers who are incapable of completing the job was identified as a significant concern, with a mean score of 3.97 and a standard deviation of 1.248.

Interpreting these results, it is evident that issues related to the local community, particularly the lack of necessary skills, consultation requirements, and workforce inclusion, are paramount concerns affecting the construction industry. The findings underscore the need for strategic interventions and collaborative efforts to address these challenges and foster sustainable development in the construction sector. Further exploration of the underlying causes and potential solutions to these identified problems would contribute to informed decision-making for industry stakeholders.

f. Factors that cause delays in construction projects

Table 2 Factors that cause delays in construction projects

Factors	**Mean**	**Std. Deviation**	**Ranking**
Labour Disputes and strikes	2.53	1.527	**1**
Poor communication among workers	2.08	1.222	**2**
Delay in delivering the site	2.0	1.203	**3**
Delay in furnishing the site	1.83	1.24	**4**
Delay in revising design documents	1.42	0.853	**5**
Delay in approving design documents	1.4	0.827	**6**
Inadequate Planning and Scheduling	1.3	0.708	**7**

The presented table above illustrates that the "Labour dispute" emerged as the most prominent concern, securing the top position with a mean score of 2.53 and a standard deviation of 1.527. Following closely, "Poor communication among workers" was ranked second, receiving a mean score of 2.08 and a standard deviation of 1.222. The variable "Delay in delivering the site" occupied the third position, with a mean score of 2.0 and a standard deviation of 1.203. Subsequently, "Delay in furnishing the site" secured the fourth position, garnering a mean score of 1.83 and a standard deviation of 1.24. The fifth-ranked variable was "Delay in revising design documents," registering a mean of 1.42 and a standard deviation of 0.853. Moving further down the rankings, "Delay in approving design documents" was positioned sixth, with a mean score of 1.4 and a standard deviation of 0.827. The variable "Inadequate planning and scheduling" claimed the seventh and final position, recording a mean score of 1.3 and a standard deviation of 0.708.

Interpreting these results, it is evident that issues related to labour disputes and communication challenges hold paramount importance in the construction industry, as reflected by their higher mean scores and standard deviations. Delays in site-related activities, design document processing, and planning also emerged as noteworthy concerns. Addressing these issues could contribute significantly to enhancing the efficiency and productivity of construction projects. Further exploration of the underlying causes and targeted interventions is recommended to mitigate these challenges effectively.

4.2 Correlation analysis

Table 3 Relationship between 4IR and delays in construction

	Use of 4th Industrial Revolution technologies	**Site related delays**	**Document related delays**	**Labour related delays**
Use of 4IR	1	0.257*	0.040	-0.113
Site related delays	0.257*	1	0.312**	0.429**
Document related delays	0.040	0.312**	1	0.273*

Labour related delays	-0.113	0.429**	0.273*	1

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Table 3 presents a correlation analysis examining the relationship between the adoption of Fourth Industrial Revolution (4IR) technologies and delays within the construction industry. The analysis reveals noteworthy correlations among various factors. A positive correlation coefficient of 0.257 is observed between the use of 4IR and site-related delays. This indicates that as the adoption of 4IR technologies increases, there is a corresponding increase in delays related to site activities. Similarly, a positive correlation of 0.040 is identified between the use of 4IR and document-related delays. This implies that an escalation in the implementation of 4IR technologies is associated with an uptick in delays pertaining to document-related processes within construction projects. Conversely, a negative relationship is identified between the use of 4IR and labour-related delays, with a correlation coefficient of -0.113. This suggests that higher integration of 4IR technologies is linked to a decrease in delays attributed to labour-related factors. In essence, companies that embrace 4IR experience fewer delays related to labour-intensive activities.

This correlation analysis underscores the nuanced impact of 4IR adoption on different facets of construction project timelines. While the utilisation of 4IR technologies appears to exacerbate delays in the site and document-related aspects, it serves as a mitigating factor for delays associated with labour-related activities. These findings suggest that careful consideration and strategic implementation of 4IR technologies are crucial for optimising construction processes and minimising delays. Future research could delve deeper into the mechanisms through which 4IR technologies influence these delays, providing actionable insights for construction industry practitioners aiming to enhance project efficiency.

4.3 Reliability analysis

Table 4 Cronbach's analysis results

Items	Cronbach alpha	Number of scales
Factors that Negatively Impact Construction projects	0.853	7
Factors that Cause Delays in Construction projects	0.742	7

The reliability of the study was assessed using Cronbach's alpha, a measure of internal consistency. According to Adadan and Savasci (2012), a Cronbach's alpha value of 0.7 or above is considered acceptable for ensuring internal consistency. However, alternative interpretations of alpha values exist, and various studies suggest different cut-off points. For instance, Van Griethuijsen et al. (2015) categorized alpha values as follows: Excellent (0.93–0.94), Strong (0.91–0.93), Reliable (0.84–0.90), Robust (0.81), Fairly high (0.76–0.95), High (0.73–0.95), Good (0.71–0.91), Relatively high (0.70–0.77), Slightly low (0.68), Reasonable (0.67–0.87), Adequate (0.64–0.85), Moderate (0.61–0.65), Satisfactory (0.58–0.97), Acceptable (0.45–0.98), Sufficient (0.45–0.96), Not satisfactory (0.4–0.55), and Low (0.11).

In the present investigation, the constructs employed yielded Cronbach's alpha scores of 0.742 and 0.853. Following the criteria established by Van Griethuijsen et al. (2015), these values are deemed "High" and “Reliable” indicating a high level of internal consistency and reliability for the study. The Cronbach's alpha coefficients for all constructs in the research instrument affirm their validity and reliability in measuring the intended constructs. These results provide confidence in the robustness of the study's measurement tools and support the credibility of the findings.

6. Conclusion

This research aimed to conduct a comprehensive analysis of the primary causes of delays within the construction industry, along with proposing potential solutions. Furthermore, the study aimed to underscore the significance of integrating contemporary automation technologies within the current landscape of the South African construction sector. This was achieved through these objectives: The objectives of this study are as follows: To identify and assess the factors contributing to delays in the South African construction sector (1); To highlight the use of the Fourth Industrial Revolution (4IR) in minimising delays in construction projects (2). Findings suggest that careful consideration and strategic implementation of 4IR technologies are crucial for optimising construction processes and minimising delays. Future research could delve deeper into the mechanisms through which 4IR technologies influence these delays, providing actionable insights for construction industry practitioners aiming to enhance project efficiency.

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