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ABOUT JCBM

The **Journal of Construction Business and Management (JCBM)** is an open access journal published bi-annually by the University of Cape Town Libraries, South Africa. The Journal is hosted by the Construction Business and Management Research Group of the University of Cape Town. The journal aims to explore the experience of construction industry stakeholders and trends in the global system. It aims to publish peer reviewed and highly quality papers emanating from original theoretical based research, rigorous review of literature, conceptual papers and development of theories, case studies and practical notes. The journal also welcomes papers with diverse methodological research approaches including qualitative, quantitative, and mixed methods. Contributions are expected from academia, public administrators, professionals in the public sector and private practice (such as contracting organizations and consulting firms) and other related bodies and institutions (such as financial, legal and NGOs).

The scope of **Journal of Construction Business and Management (JCBM)** covers but is not limited to construction management and project delivery, strategic management, decision making, skills development, organizational practices and procedures in construction business. The specific areas in construction management, sustainability in construction and project delivery include project planning/feasibility studies, procurement, resource management, international construction, ethical issues, industrial relations, legislative requirements and regulations, construction education, information and communication technologies, housing policies, and urban design and development. Strategic management in construction covers risk management, quality management, resilience and disaster management, cultural and societal management, project life cycle management, and knowledge creation and management. Among issues in construction organizational practices and procedures covered are business development strategies, human resources and career development, continuous professional development, leadership systems, marketing strategies, gender issues and corporate social responsibility.

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Sustainable Improvement in Infrastructure Development in Developing Countries: Which way forward?

Editorial June 2023

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Introduction

Infrastructure development remains a key driver for improved productivity and economic growth globally, especially in developing countries. However, this encounters significant setbacks; hence, the United Nations has set relevant sustainable development goals. This may explain why the authors of the articles in this regular issue focus on construction tender price inflation, lean construction techniques, Crystalline Silica Dust, Sustainable Construction Transition (SCT) Policy, and building contract administration, demonstrating the challenges that infrastructure development globally faces but with a focus on developing countries. They argue that these challenges must be addressed for a sustainable improvement in infrastructure development in developing countries. For example, one of the authors (Musa et al. 2023) argues that a better understanding of the level of awareness and barriers to lean construction techniques in countries such as Nigeria will contribute to sustainable infrastructure development. However, the problems that developing countries face, including establishing a functional regulatory system that will facilitate such ambition, have been found to be complex by authors, for example, Umeokafor (2017). The question remains: 'Which way forward? How do developing countries ensure and sustain the development of their infrastructure? While the authors in this issue attempt to answer this question, they also highlight areas that require more attention for pragmatic and robust solutions.

Welcome to the eleventh issue of the Journal of Construction Business and Management and the collection of five articles by 18 authors from Kenya, Malaysia, Nigeria, South Africa, and Zambia. Following this introduction is the discussion of the papers, followed by the conclusion.

Discussion of the papers

Despite the positive contributions of the construction industry to infrastructure development, its negative impact on the environment (for example, air and noise pollution, high water consumption, dust and gas emission, and waste generation) is significant (Drager and Letmathe, 2022). Evidence suggests that the industry's contributions in developing countries are more than their developed counterparts. This calls for more attention. However, many aspects of sustainability, for example, the scope and implementation dynamics of SCT in Kenya, are poorly understood because of the associated knowledge gaps.

Using qualitative content analysis, Joseph, Ralwala, Wachira-Towey, and Mutisya (2023) examine 34 policy documents on SCT in Kenya to identify the nature of their priorities, the instruments, and stakeholder orientations, including any shortcomings. They found that the stakeholders' orientation mainly targets developers/owners/occupiers and governments. By implication, other stakeholders in the supply chain are overlooked. In terms of the regulatory instruments, they are mainly regulations, the constitution, acts of parliament, codes, and guidelines. The priorities are on the strategic and tactical implementation of environmental sustainability with little consideration for the socioeconomic objective and operational level of implementation. The authors conclude that one of the ways forward is improving the sustainability performance indicators by realigning the priorities of the SCT by focusing on addressing socioeconomic objectives and the operational level of implementation. They also recommend a centralised database that supports economic incentives, education, and information, among many competitions.

Despite the contributions of Joseph et al. (2023) to the burning issue, the need for further studies is evident. For example, while the authors acknowledge the need to go beyond policy regime evaluation, the scope of the study, the problems identification aspect of policymaking, agenda setting, policy development, and implementation require further examination; further research can focus on interviewing the stakeholders on the topic to gain a deeper understanding of their experiences.

Studies in the tenth issue of this journal focus on improving the construction industry's performance through education and training (See Windapo and Umeokafor 2022). The second paper in this issue, Tembo, Mwanauwo, and Kahanji (2023), slightly align with this by focusing on a significant contributor to the industry's poor performance: construction tender prices. Using content analysis, Tembo et al. (2023) examine data sources (such as annual reports, road sector reports, audit reports, and annual work plans (from 2008 to 2018) in two organisations. The aim is to define the behaviour of construction tender prices toward proposing the dimension of corrective priorities. Some of the findings in the study include a lack of collaborative working (for example, late engagement with consultants), late payment, poor quality of work, contract issues (such as poor contract practices and unethical contract awards), and poor design.

Further, an increase in tender prices was also found; for example, a 31.4 per cent increase was found in the case study firms from 2008 to 2018. They conclude that tender overpricing in construction is commonplace, which has negative implications for tender prince inflation and variability in public sector projects during the procurement stage. While this study is limited like others, for example, due to insufficient data, some of the suggested ways forward include that the government should develop practical policies to reduce construction prices and provide incentives to the public construction section (for example, by establishing reasonable tender pricing systems that are inclusive of all stakeholders and meet their needs).

The third paper is by Musa, Saleh, Ibrahim, and Dandajeh (2023), which appraises awareness and barriers to applying lean construction in Nigeria, using Kano as a case study. The principle of poor construction is eliminating waste in any production process and activities, resulting in a process cycle reduction by implication, improving the product quality and project efficiency (Balalola et al. 2019; Womack and Jones 2003). It is about the better use of resources in more efficient ways, above effectiveness. Meeting sustainable development goals directly or indirectly related to infrastructure development will be extremely challenging (if not impossible) without significantly reducing construction waste. The construction process needs to be more efficient in many ways, including using sustainable materials, meeting completion dates, staying within budget, and delivering energy-efficient and healthy buildings. Musa and colleagues argue that the limited understanding of lean construction techniques among construction practitioners remains a significant barrier to realising this. Hence, they assess the extent to which construction practitioners know the principles and other obstacles to its implementation. Their study found that construction practitioners' awareness and knowledge level in Kano, Nigeria, is low; the overall mean score for all the lean construction techniques is 2.52, less than the average score of 3. The barriers are not limited to the absence of a lean construction awareness programme (with a means score of 4.18), which ranks the highest, and the lack of education and training on its implementation, which is second with a means score of 4.09.

The fourth article focuses on Crystalline Silica Dust's sources and control measures in constructing buildings and roads in Zambia. Collecting qualitative data from trade workers such as tilers, bricklayers, labourers, and carpenters through observations, the study (Tente, Mwanaumo, and Thwala 2023) contributes to the dearth of qualitative research and occupational health in developing countries. Addressing occupational health problems (which significantly limit sustaining infrastructure development) will be challenging without a good understanding of the social reality. Tente et al. (2023) found that adequate personal protective equipment (PPE) is rarely provided to workers. They also found that control measures such as water and face masks are used, yet the workers' exposure to dust is high because they are inadequate or ineffective. For example, they found that some workers use COVID-19 facemasks, which are inadequate for silica dust control. In terms of the risk control hierarchy, only engineering controls and PPE were adopted. By implication, the more effective ones, such as elimination or substitution, and the complementary ones, such as administrative controls, are not adopted. The risk control hierarchy comprises five measures/strategies/levels, and the principle is that in controlling risks, the most effective is considered and adopted first where possible. The first and most effective is elimination, followed by substitution, engineering control, and administrative control, and PPE is the last and least effective. The combination of control measures is commonplace. For example, when using substitutions, training and supervision (administrative controls) and PPE can be adopted. The findings of Tente et al. (2023) explain some of the health problems workers in Zambia encounter. The authors conclude by recommending the provision of the relevant PPE to the workers. However, the risk control hierarchy must be applied. A key challenge for authors in construction health and safety, such as Umeokafor (2020), is the poor regulatory environment in developing countries.

The last article (Yee, Hashim, and Kalsum 2023) examines the knowledge requirements for graduate architects in building contract administration using Malaysia as a case study. By implication, the factors that influence graduate architects' work performance in building contract administration were identified. Yee et al. (2023) found four main knowledge requirements: project management, design management, claims and legal matters, and communication and relationship knowledge management. Of these factors, instilling communication and relationship knowledge management into graduate architects has the highest loading. Poor communications accounts for a significant amount of project failure. The study demonstrates the need to instil the four knowledge domains in graduate architects to improve building contract administration. It provides valuable insight into the complexities associated with work performance improvement of building contract administration in terms of graduate architects.

Conclusion

Despite the differences in the topics of the five papers in this issue, to which 18 authors from Kenya, Malaysia, Nigeria, South Africa, and Zambia contributed, this editorial has been able to show how they advance the discourse of sustainable improvement in infrastructure development by identifying issues that impact on it and suggesting ways forward. Focussing on construction tender price inflation, Lean construction techniques, building contract administration improvement, Crystalline Silica Dust, and Sustainable Construction Transition (SCT) Policy, the papers demonstrate the need for improved regulation in occupational health and sustainability, the urgency for governments to develop practical policies to reduce construction prices and provide incentives to the public construction sector; graduate architects knowledge requirements for building contract administration; and the extent of poor awareness and knowledge of lean techniques in a state in Nigeria which is critical for the efficient use of resources. Some of the burning questions that need to be answered are not limited to:

- How can the limited awareness and knowledge of lean construction in Nigeria be explained qualitatively?
- What are the characteristics of the relevant SCT policy documents in terms of the problem identification aspect of policymaking, agenda setting, development, and implementation?
- What are the experiences and perceptions of SCT stakeholders in using it?
- What are the workable strategies for improving workers' occupational health when exposed to silica dust and chemicals in Zambia?

We thank the authors for their contributions and the reviewers for their efforts to improve the quality of the papers published by the journal. We are also grateful to the journal editorial board and the panel of reviewers who play a critical role in ensuring the highest level of quality assurance of the manuscript and in keeping the journal on the path to attaining the expected standard and quality. Criticism, feedback, and suggestions from readers on improving the journal's quality are also welcome.

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Sustainable Construction Transition (SCT) Policy Regime in Kenya

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Abstract

The global construction industry is lagging in transitioning to sustainability, and the Kenyan construction industry is not excluded. As a result, and in response, there are Kenyan policies with specific provisions on SCT. Despite this progress, there is limited empirical research on their scope and implementation dynamics. Against this backdrop, this study examined Kenya's SCT policy regime regarding its priorities, instruments, and stakeholder orientation, including any inherent shortcomings. This aimed to make appropriate recommendations for an improved SCT policy regime to enhance and optimise industry SCT performance. Qualitative research design, specifically, qualitative content analysis technique, was used to analyse the 34 policy documents identified. The findings indicate that the regime: priorities – primarily focus on environmental sustainability targeting strategic and tactical implementation levels with minimal focus on SCT socio-economic objectives and operational level of implementation, which reduces its comprehensiveness; instruments – driven by regulations, the constitution, and Acts of Parliament, as well as codes, guidelines, and plans, from multiple sources, primarily aimed at regulation and control and not the other policy instruments functions hence not delivering on their full potential; and, stakeholder orientation – primarily targeting developers/owners/occupiers and government with less focus on the other stakeholders and thus not leveraging their specific roles in SCT supply chain. The resulting recommendations were: priorities – need for improved focus on SCT's socio-economic objectives and operational level of implementation; instruments – need for a central database and leveraging them to support economic incentives, supporting activities, liability compensation, education and information, voluntary programs, and management and planning; and, stakeholder orientation – improved targeting of contractors, suppliers/producers/manufacturers, professional consultants, non-governmental and civil society organisations, and media. Lastly, given that this study focused on SCT policy evaluation, future research can focus on other parts of the policy-making process.

Keywords: Business, Construction, Content analysis, Kenya, Performance, Planning, Policy regime, South Africa, Strategy, Sustainability, Sustainable Construction Transition (SCT).

1. Introduction

Construction industries worldwide are part and parcel of current sustainability concerns owing to their known negative sustainability impacts (economic, environmental, and social) (Dania, 2016:1). Economically, sustainable construction (SC) is aimed at enhancing profitability through efficiency in resource usage (Woodall et al., 2004). Resource usage inefficiency in the industry has been observed in relation to a large share of global energy use; greenhouse gas emissions related to energy use; waste generation; and natural resources usage, including undesirable resources fluctuation in the construction phase (United Nations Environment Programme (UNEP), 2021; Lamka et al., 2018). Kats (2003:85) argued that the benefits of ensuring economic sustainability as a priority include acceptable project lifecycle costs. Additionally, an economically sustainable entity is more likely to practice environmental sustainability due to implied resource efficiency (Du Plessis, 2002:16-17). Environmentally, SC is aimed at water, materials, land, and energy conservation (Woodall et al., 2004). According to UNEP (2011), "… the construction sector is also responsible for more than a third of global material resource consumption, including 12% of all freshwater use …" p.20. Additionally, "… the built environment accounts for a large share of energy (estimated to be about 40% of global energy use) …" (UNEP, 2021). Kats (2003:85) highlights that if environmental sustainability concerns are prioritised and appropriately implemented, they could enhance environmental quality and acceptable use of energy and natural resources.

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Socially, SC aims to ensure the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Adetunji et al., 2003; Woodall et al., 2004). According to Pocock et al. (2016), construction projects often fail to meet social expectations due to adopted sustainability approaches prevailing over local conditions. The social facet of SC focuses on legal land acquisition; local culture sensitivity; water and energy efficiency; safety of built facilities; thermal comfort; extent of local communities' engagement; extent of use of locally available materials; locally understood construction methods; and, use of sustainable and affordable local construction materials. Du Plessis (2002:15-16) postulates that disregard of these aspects is evidenced by unethical practices, such as corruption and gender discrimination, low compliance with pre-set health and safety regulations, and unjust labour practices. According to Kats (2003:67), the benefits of observing social sustainability as a priority include improved well-being of involved stakeholders; and an overall reduction in terms of turnover of employees and employee work absenteeism. This study adopted the view postulated by Joseph (2019:22) and Esezobor (2016:28) that the environmental facet houses the social facet, which in turn houses the economic facet.

A radical transformation in the design, construction, operation, and decommissioning phases of built facilities is needed if the identified socio-environmental concerns are to be significantly addressed (Green Africa Foundation, 2018:7). It is from this realisation that the need for the construction industry to shift from its conventional mode of operation (production and consumption) to a comparatively sustainable alternative, SC, emanates (Du Plessis, 2002:8-9; Ofori, 2007:5). This shift has been identified to be both radical and socio-technical, and is commonly referred to as sustainability transition (ST)/sustainability transformation (Elzen et al., 2004; Grin et al., 2010; Blythe et al., 2018) and by extension for the construction industry sustainable construction transition (SCT). This involves adopting SC practices throughout the lifecycle of constructed facilities or part thereof. According to Du Plessis (2002:8-9), SC is a wholesome process whose goal is to revitalise and ensure balance at the interface between natural and built environments while at the same time enhancing the quality of life by upholding the dignity and economic equity of the human populace individually and collectively. It has also been observed that the construction industry is lagging in transitioning toward sustainability compared to other sectors (Glass, 2012).

The Kenyan construction industry is not excluded from the lagging transition to sustainability in the global construction industry. This is exemplified by: economically – inefficient resource usage (Lamka et al., 2018:283-284; UNEP, 2018:21); environmentally – minimal uptake of green buildings. As of 16 June 2021, there were 28 green buildings totalling 1,319,390 square metres (GBIG, 2021) against a [projected] building stock of 41 million square metres (IFC, 2017), representing a mere 3.2% green building stock and socially – inefficiently meet legal and moral obligations to industry stakeholders on fronts such as gender inequity, including low skills and knowledge enhancement (NCA, 2014:7,8), low observance of construction site health and safety (Kemei et al., 2015:6) and sick building syndrome symptoms (SBSs) (Marete and Waweru, 2016:2). As a result, and in response, there are numerous Kenyan policies with specific provisions that support SCT. It is also worth noting that there is limited literature on SC and SCT in the Kenyan construction industry. This study sought to fill this gap by answering the research question – what is the nature of the Kenyan SCT policy regime in terms of its: (i) priorities; (ii) instruments; and (iii) stakeholder orientation, including (any) inherent shortcomings? This ultimately aimed to develop context-appropriate recommendations for an improved policy regime as an avenue for enhanced SCT performance by the Kenyan construction industry.

2. Sustainable Construction Transition (SCT)

The built environment is a complex system that supports societal needs such as housing and recreation, has a significantly longer lifespan and involves many stakeholders. Additionally, the interaction of the built environment system with the ecological system has resulted in well-documented negative impacts on the latter. Specifically, these negative impacts have been observed to be comparatively less noticeable and documented at constructed facility scale compared to the same but at the planetary scale over time (Vanegas and Pearce, 2000:406-407). This has led to an increased focus on the contribution of the built environment by the various stakeholders. Owing to its known direct and indirect contribution to this problem, the construction industry has seen increasing restrictions to minimise negative ecological impacts. These have assumed different forms, which include regulations, laws, standards and pressure from other stakeholders, such as civil society. However, some industry players, such as design and construction entities, see compliance with these restrictions as a challenge to be overcome as opposed to a means of reaping SC benefits for themselves and others (Kinlaw, 1992, as cited in Vanegas and Pearce, 2000:407). Drivers for SCT have been identified to include: negative ecological impacts; resource degradation and depletion; and, lastly, impacts on human health. It, however worth noting that SCT embeds the traditional project priorities of time, cost, quality and minimising adverse impacts in the context of sustainability (Vanegas and Pearce, 2000:407-408).

Negative sustainability impacts of the construction industry have been characterised as worse in developing nations, such as Kenya, compared to developed nations. This is exacerbated by comparatively fewer resources to deal with the sustainability challenges. On a positive note, underdevelopment in these nations offers room for a better and sustainable future. The urgency of ensuring SC in these developing nations has two main drivers: active ongoing construction activity implying continued unsustainability in case of inaction (failure to transition towards SC); and increased demand on already limited resources. It is also worth noting that the socio-economic sustainability dimensions have received more attention in practice compared to the biophysical dimension, which has been left mainly at the research and scholarly level

(Du Plessis, 2002:21). Joseph (2019:83) observed different findings where the ranking of the key SC priorities in the Kenyan construction industry ranked as social, environmental and economical in order of decreasing importance. It is clear in both that the environmental aspect of SC is not a major practice concern in developing nations which Du Plessis (ibid:21) associates with pressing socio-economic challenges.

For STs, such as SCT, and as advanced by Loorbach et al. (2017), change is from one state of dynamic equilibrium experiencing sustainability challenges to comparatively sustainable alternatives. They aim to change entrenched consumption and production patterns in society's ways of doing things (Geels, 2004; Kohler et al., 2019; Markard et al., 2012), including associated assumptions, rules and practices (Rotmans et al., 2001). Kemp and Lente (2011) postulate that STs also change how goods, services and systems are perceived and facilitate change in established socio-technical systems. STs are heavily biased towards the public good rather than individual gains (Geels, 2011; Kohler et al., 2019). These transitions involve many elements, such as infrastructure and supply chains, with complex interactions on matters such as economics and power (Unruh, 2000; Geels, 2011; Kohler et al., 2019). These transition processes take a long time to execute, ranging from one generation – 25 years (Rotmans et al., 2001), up to 50 years (Markard et al., 2012) or even decades, as discussed in Kohler et al. (2019). Their implementation requires the input of the stakeholders at individual, corporate and institutional levels drawn from learning/research institutions, civil society, political structure, sectors and households (Markard et al., 2012; Kohler et al., 2019).

Three implementation levels have been advanced for SCT: strategic – industry level and long-term; tactical – firm level and medium-term; and operational – project level and short-term (Cruz et al., 2019). Gilham (2010:126,140) emphasised the role of non-governmental organisations (NGOs) and civil society organisations (CSOs) in SCT as a driver through a watchdog role, collaborating with research institutions to craft and disseminate new practices and technologies; and independent monitoring and evaluation of industry performance. Graham et al. (2003:4) additionally emphasised the central role of media in governance, and by extension, SCT governance, as argued in this study, in the following ways: relaying information among sectors, resulting in opinion-shaping, and promoting accountability. Mechanisms and instruments employed to influence change, such as SCT, have been identified to have the potential to back: regulation and control; economic incentives; supporting activities; liability/damage compensation; education; information; voluntary programs; and, management and planning (Chang, 2016:106; Lafferty, 2004:6; OECD, 2001:132, 135-136). SC demand drivers in SCT have been identified as personal and selfless motivations; social responsibility; and economic and financial motivations (Onuaha et al., 2017:23-24). Additionally, drivers of SC supply in SCT have been identified as better returns; project financing incentives; positive price signals from existing SC investments; marketing strategies; lifecycle cost savings; attractive tax incentives; SC skills availability; supportive policies; SC certifications, awards and recognition; and, ethical motivations (Onuaha et al., 2016:500-502; Diyana and Abidin, 2013:916-917).

The Kenyan government's SCT plan for the period 2016-2030 was identified as follows: greening 75% of new and renovated private and public buildings, increasing stakeholders' green training programmes, and increasing the number of adopted green building standards. This aims to deliver a built environment that is: comparatively greener, more efficient and with rationalised water; and energy use. This is all aimed at ensuring sustainability in the design, construction and operation of constructed facilities. The key stakeholders in this plan were identified as National Construction Authority (NCA); universities; County governments; private actors; Architectural Association of Kenya (AAK); Institution of Engineers of Kenya (IEK); and the Ministry of Transport, Infrastructure, Housing and Urban Development (MTIHUD) under the leadership of Ministry of Lands and Physical Planning (MLPP). This 15-year plan was estimated to cost 5 billion Kenyan shillings (Ministry of Environment and Natural Resources, 2016a:38). According to Green Africa Foundation (2018:21), similar efforts at the national level are evident in the Kenya Building Research Centre's Strategic Plan 2017/2018 – 2021/2022. This plan, with specific reference to SC, is aimed at the mainstream green building; researching SC materials; and developing supporting policies, guidelines and regulations for the Kenyan construction industry. Irrespective of this progress, there is limited empirical research on its scope and implementation dynamics.

3. Research Methodology

This study adopted a qualitative research design approach. This was informed by inductive research reasoning used to answer the research question. This approach is comparatively less structured. There are no presuppositions, and it is aimed at gaining a deep understanding of a phenomenon (Sutrisna, 2009). Additionally, a 3-step policy system analysis approach from previous policy studies, and as employed in a similar study on the Chinese SC policy system (See Chang, 2016:102), was adopted: policy identification; description and analysis of identified policy; and lastly, discussion of inherent challenges. SCT-related policy documents with specific SCT specific provisions by the Kenyan government were identified through the manual screening. The identified SCT policy system components were described and analysed through qualitative content analysis. As postulated by Zhang and Wildemuth (2005:2-4) and adopted in Chang (2016:103), the qualitative content analysis took the following key steps: data preparation; definition of the unit of analysis/coding units; developing coding units' categories; coding; analysis; and, reporting findings.

The identified current policy documents were downloaded from relevant government authorities' databases and manually screened for data preparation. Only those with SCT-specific provisions were selected/found appropriate for further analysis.

Specifically, this study identified 34 SCT-related policy documents. For the unit of analysis, the basic coding unit was defined as the individual policy themes as recommended by Zhang and Wildemuth (ibid:3). As such, codes were assigned for texts of any length representing a singular theme. Lastly, the identified policy documents were coded, labelling text to facilitate analysis. Additionally, the resulting data was further analysed to categorise the coding units into a high-order category inherent in the research question: priorities, instruments, and stakeholder orientation. The categories were additionally analysed to reveal shortcomings, if any, and the resulting findings were reported.

4. Results

4.1 Overview

Green Africa Foundation (2018:16-21) identified some SCT-related policy documents that were not included in the 34 SCT policy documents analysed for the following reasons: replacement by newer versions (which have been included), not being explicit about the relationship between their provisions and SCT; and lastly, being draft guidelines that have now been ratified. Based on their specific SCT-related provisions, and priorities, the policy documents were first classified as focused on: economic, environmental, and social facets of SCT as the first coding stream. Additionally, based on document type and instruments, they could be further grouped as subsidiary legislation/regulations; constitution and Acts of parliament; and codes, guidelines and plans – the second coding stream. Lastly, based on their provisions and stakeholder orientation, they targeted different industry stakeholders: government (national and county); developers/occupiers/owners; professional consultants; contractors; and suppliers/manufacturers/producers – third coding stream. Tables 1 – 3 outline the specific SCT policy documentation identified as differentiated into the 3 coding streams identified above. This includes briefly describing the provision used to inform the coding decision for the second and third coding streams.

The preceding discussion, including contents of Tables 1-3, is summarised in Figure 1.

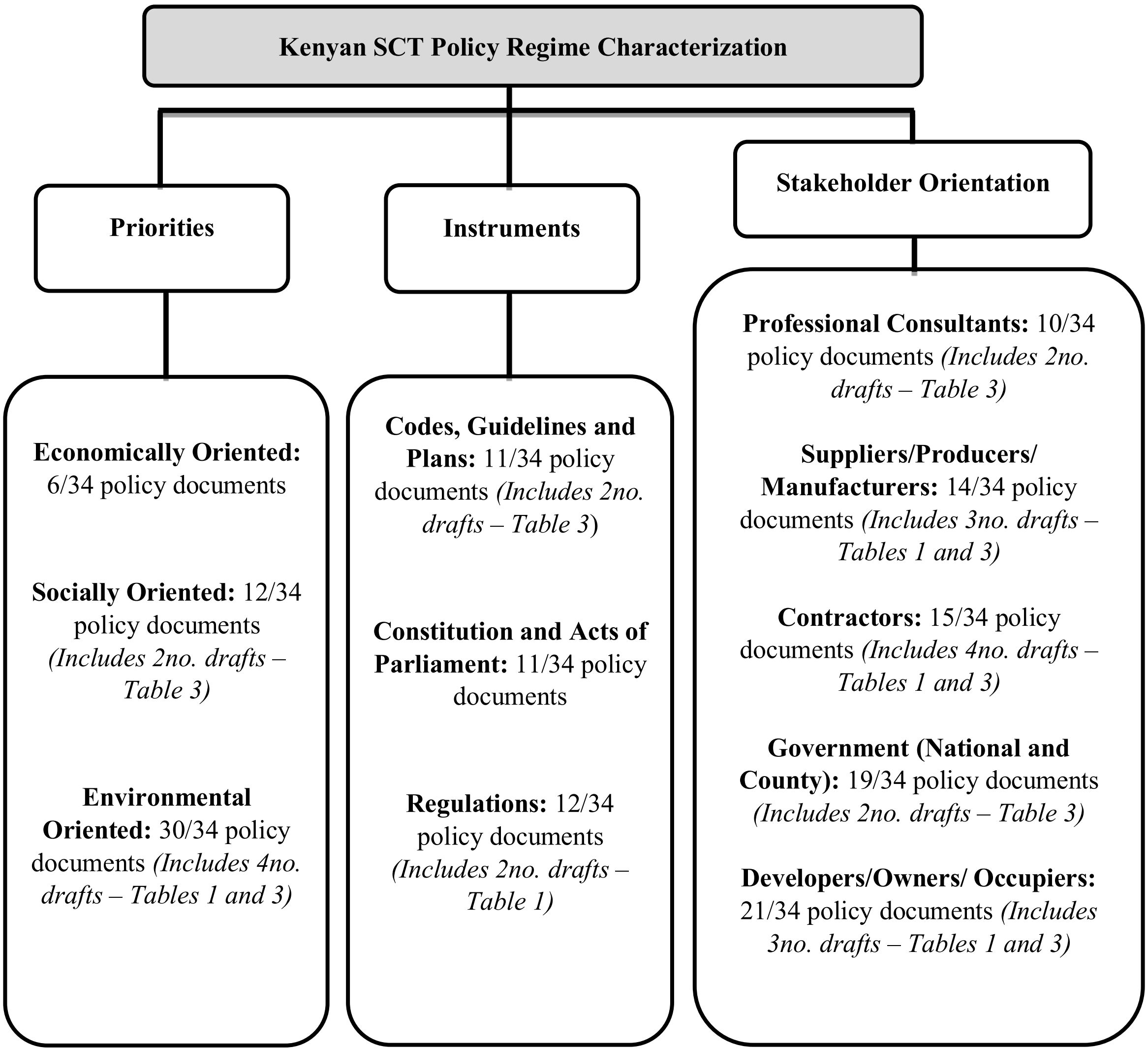

Figure 1: Kenyan SCT Policy Regime

Table 1: Kenyan SCT Policy Regime – Regulations/Subsidiary Legislation

Policy Instruments: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities**	**Stakeholder Target**
1. *The Environmental Management and Coordination (Conservation of biological diversity and resources, access to genetic resources and benefit sharing) Regulations 2006*	Prohibits all activities, such as construction, that have impact on any ecosystem. It also requires EIA for all activities, such as construction, that may lead to unsustainable use of natural resources	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets developers
2. *The Environmental Management and Coordination (Water quality) Regulations 2006*	Covers: prevention of water pollution/control of effluent discharge; acceptable domestic, industrial, wastewater for irrigation and recreation water standards; and, protection of water sources	Water conservation (Environmental)	Targets contractors, water suppliers, owners/operators of industrial facilities, irrigation schemes and water bodies used for recreation purposes
3. *The Environmental Management and Coordination (Waste management) Regulations 2006*	Guides the management of waste (solid, industrial, hazardous, pesticides and toxic substances, biomedical and radioactive), which are common/possible during the construction and operation phases of constructed facilities	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets developers/owners/occupiers and contractors
4. *The Environmental (Impact assessment and audit) (Amendment) Regulations 2009*	Outline the rules on EIA procedure (Including environmental auditing and monitoring), which applies to construction projects, including registration of EIA experts	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets developers and EIA experts/professionals
5. *The Environmental Management and Coordination (Noise and excessive vibration pollution) (Control) Regulations 2009*	Regulations provide standards on maximum allowable noise and vibrations from a constructed facility, construction site, demolition site, mines and quarries (Including associated licensing and exclusions)	Protecting human health and comfort (Social)	Targets developers/owners/occupiers of constructed facilities, contractors and suppliers of building materials (raw or finished) sourced from mines and quarries

6.	*The Environmental Management and Coordination (Wetlands, riverbanks, lake shores and sea shore management) Regulations 2009*	Requires Environmental Impact Assessment (EIA) for endeavours, such as construction, with adverse effects on wetlands, riverbanks and shores	Land and water conservation (Environmental)	Targets developers
7.	*The Energy (Energy management) Regulations 2012*	On energy consumption management in industrial, commercial and institutional constructed facilities	Energy conservation (Environmental) and operation cost rationalization (Economic)	Targets developers/owners/occupiers of constructed facilities
8.	*The Energy (Solar water heating) Regulations 2012*	Requires installation and use of solar water heating systems for all constructed facilities using above 100litres of hot water daily	Energy conservation (Environmental) and operation cost rationalization (Economic)	Targets developers/owners/occupiers and design phase professionals
9.	*The Environmental Management and Coordination (E-waste management) Draft Regulations 2013*	These draft regulations cover registration and responsibilities of e-waste producers and recyclers (Including generators such as constructed facilities or sites). They additionally outline the responsibilities of collection centres, refurbishers/repairers including guidelines on control and handling	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets developers/owners/occupiers and contractors
10.	*The Environmental Management and Coordination (Air Quality) Regulations 2014*	Provides guidelines on prevention, control and mitigation of air pollution from stationary sources such as paint manufacturing plants and mobile sources such as vehicles used in construction (Including indoor air quality)	Environmental	Producers, contractors and developers/owners/occupiers of premises
11.	*The Energy (Appliance's energy performance and labelling) Regulations 2016*	Standards on energy performance rating and labelling of appliances used during the construction and operation phases of constructed facilities such as lamps, refrigerators, motors, and, non-ducted air conditioners	Energy conservation (Environmental) and operation cost rationalization (Economic)	Targets suppliers/manufacturers/producers
12.	*The Draft Environmental Management and Coordination (Toxic and*	These regulations cover the management of hazardous industrial chemicals and materials, such as asbestos in construction, management on: classification;	Preventing damage and potential irreversible impacts on the natural	Targets contractors and suppliers

hazardous industrial chemicals and materials management) Regulations 2019	registration; labelling; packaging; advertising; manufacturing, importing; exporting; distribution; storage; transportation; and, handling	environment (Environmental)	

Table 2: Kenyan SCT Policy Regime – Constitution and Acts of Parliament

Policy Instruments: Constitution and Acts of Parliament			
Policy Document	**SCT Related Provision**	**SCT Priorities**	**Stakeholder Target**
1. *The Employment Act 2007*	Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages; basic minimum conditions in employment; protection of children; and, employment disputes	Ensuring the construction industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Social)	Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors and suppliers
2. *The Occupational Safety and Health Act 2007*	Outlines the duties of facilities occupiers, self-employed persons, employees, designers, manufacturers, importers and suppliers in ensuring health, safety and welfare in the context of workplaces	Ensuring human well-being (Social)	Targets contractors, consultants, developers/owners/occupiers, designers, manufacturers, importers and suppliers
3. *The Work Injury Benefits Act 2007*	Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases, disablement (temporary or permanent) and death	Ensuring human well-being (Social)	Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors and suppliers amongst other related employers
4. The Kenyan constitution 2010	Article 10 (2) – Identifies SD as a national governance value and principle Article 42 – Identify the right to clean and healthy environment for everyone	Covers the three dimensions of sustainability (economic, environmental and social)	All – Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors and suppliers/manufacturers/producers
5. *The National Construction Act 2011*	NCA (a national organization) is empowered to conduct/commission research and advise the relevant cabinet secretary on any matter relating to the construction industry, not excluding SC	This covers all the three facets of SC (economic, environmental and social)	Targets national government

6. *The Public Health Act 2012*	Requires prevention and removal of nuisance in relation to, but not limited to: unsafe accumulation of materials; chimney discharging significant amounts of smoke; land in state that poses health risk; factory or business facilities unsafe emissions; and, effluents and buildings situated, erected, used or maintained in a manner that is injurious to human health	Preventing damage and potential irreversible impacts on the natural environment (Environmental) and ensuring human wellbeing (Social)	Targets County governments and developers/owners/occupiers
7. *The Environmental Management and Coordination (Amendment) Act 2015*	Cabinet secretary in charge of environment mandated to set the national environment protection direction; NEMA and County Environment Committees established to supervise and coordinate all matters environment nationally and in counties respectively; specifies the nature of construction projects and construction related endeavours for which EIA is mandatory; and, environmental offences (such as inspection, EIA, pollution related)	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets government (national and county), developers, contractors, producers, and, EIA experts/professionals
8. *The Climate Change Act 2016*	One of the aims of the Act is to mainstream climate change sensitivity, including SD, in the planning, execution and decision making of developments	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments
9. *The Water Act 2016*	On regulation, management and development of sewerage and water services and establishes National Water Harvesting and Storage Authority partly charged with developing and enforcing water harvesting policy	Water conservation (Environmental)	Targets national and county governments
10. *The Energy Act 2019*	Cabinet secretary on energy to: promote the development and use of renewable energy such as biomass; and, energy efficiency and conservation nationally	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments
11. *The Physical and Land Use Planning Act 2019*	Sets out to, amongst other objectives, provide a multi-level (National, county and local) framework for sustainable land use, planning and management	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments

Table 3: Kenyan SCT Policy Regime – Codes, Guidelines and Plans

Policy Instruments: Codes, Guidelines and Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities**	**Stakeholder Target**
1. *Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*	Has provisions on: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety and weatherproofing	Preventing damage and potential irreversible impacts on the natural environment (Environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Social)	Targets professional consultants, owners, developers and occupiers, contractors, suppliers and local governments
2. Ministry of Lands (2009)	***Sessional Paper No. 3 of 2009 on National Land Policy*** – Sections 140 and 141 recommends: prohibition of untreated waste, a by-product of the operation phase of constructed facilities, into water bodies; promoting and mandating segregation and labelling of waste to ease its management; regulation of all quarrying and excavation activities; promoting re-use of urban waste; developing guideline on dumpsites rehabilitation; mandating EIA and environmental audit for development activities likely to degrade the environment; environmental degradation monitoring; polluter pays principle enforcement; and, ensuring public participation in environmental management	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets developers/owners/occupiers, contractors and suppliers/manufacturers/producers
3. *The (Proposed) Planning and Building Regulations 2009*	Partly aims at promoting optimal resource usage and enhancing convenience, health and safety in relation to construction sites and constructed facilities. It provides guidelines on: accessibility of constructed facilities; energy efficiency and thermal comfort; water harvesting; conducive indoor air quality; prohibition of objectionable sewerage discharge; prohibition of dangerous demolition methods; control of dust and noise from excavation, erection or demolition work; appropriate disposal of waste materials; and, standards for various installations such as water closets amongst other provisions	Preventing damage and potential irreversible impacts on the natural environment (Environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Social)	Targets government (national and county), professional consultants, building owners and occupiers, contractors and suppliers
4. Energy Regulatory Commission (ERC) (2013)	***ERC Baselines and Benchmarks and the Designation of Industrial, Commercial and Institutional Energy Users in Kenya*** – This study facilitated development of baselines and benchmarks for energy performance and designation of energy users (industrial, commercial and institutional). This was intended to raise awareness and facilitate	Energy conservation (Environmental)	Targets developers, owners, and occupiers of constructed facilities

	decision making on energy conservation and efficiency in line with *The Energy (Energy management) Regulations 2012* (See Table 1)		
5. Ministry of Environment, Water and Natural Resources (2013)	***National Environmental Policy*** – Section 5.6 requires the government to: conduct periodic EIA for all infrastructural projects; develop and implement an environmentally conscious infrastructure development strategy and action plan; and, conduct social impact assessment, public participation, EIA and strategic environmental assessment (SEA) in the approval and planning of infrastructural project	Preventing damage and potential irreversible impacts on the natural environment (Environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Social)	Targets national and county governments
6. NEMA (2014)	***National Solid Waste Management Strategy*** – Recognizes construction and demolition as one of the main sources of waste in Kenya. In a bid to ensure a healthy, safe and secure environment, this strategy seeks to achieve 80%, 50% and 30% waste recovery (in terms of compositing to energy and recycling) and the remaining 20%, 50% and 70% for sanitary landfilling by the years 2030, 2025 and 2020 respectively	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments
7. Ministry of Environment and Natural Resources (2016a)	***Green Economy Strategy and Implementation 2016-2030 (GESIP)*** – Requires promotion of sustainable built environment from design, through construction to operation phases of constructed facilities. Some of the specific strategies include: increasing share of renewable energy in the energy mix; and, promoting sustainable design, construction and operation of constructed facilities	Covers the 3 facets of SC (economic, environmental and social)	Targets national and county governments
8. Ministry of Environment and Natural Resources (2016b)	***Sessional Paper No.5 of 2016 on National Climate Change Framework Policy –*** Advocates for ***"… integration of climate change risks and opportunities in the design, operation and management of infrastructure" p. 11***	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments
9. Green Africa Foundation (2018)	***Kenya Building Research Centre's Strategic Plan 2017/2018 – 2021/2022***: Has the following key result areas – developing policies, regulations and guidelines on green buildings; conducting research on and gazetting SC materials; and, oversee mainstreaming of green building principles in the construction industry	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national government
10. Ministry of Environment and Forestry (2018)	***Kenya National Climate Change Action Plan (NCCAP) 2018-2022*** – This plan recommends, but is not limited to: promotion of green buildings; sustainable privately owned land timber production; and, enhanced energy conservation and efficiency	Preventing damage and potential irreversible impacts on the natural environment (Environmental)	Targets national and county governments

11. *The (Draft) National Building Code 2022 – Scheduled to be in operation from 2023*	Aims at enhancing order, health and safety in and around construction works (including resulting constructed facilities) and provides: guidelines related to all construction project phases (including requirement for conformance to sustainable design strategies); materials and other components standards; and, disaster management standards amongst other provisions	Preventing damage and potential irreversible impacts on the natural environment (Environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (Social)	Targets County governments, professional consultants, building owners and occupiers, contractors and suppliers

Source: Authors (2022)

4.2 SCT Policy Regime Priorities (Including Inherent Shortcomings)

Based on Figure 1 above, it is clear that the regime largely focuses on the environmental facet of SCT with comparatively less focus on the social and economic pillars (in decreasing order of focus). This ranking is in line with the ideal nesting of the three SCT facets as postulated by Joseph (2019:22) and Esezobor (2016:28). That notwithstanding, with each facet having a specific SCT objective (Woodall et al., 2004; Adetunji et al., 2003), no facet appears to be less important comparatively. Consequently, the regime can be enhanced along the economic and social facets to ensure enhanced and comprehensive SCT. Additionally, the specific provisions of the policy regime are largely geared towards strategic and tactical implementation levels with a lesser focus on the operational level, that is, at the construction project level and in the short term (See Tables 1-3). Consequently, the system can also be optimised through enhanced focus on the operational level of implementation. This aligns with three SCT implementation levels as recommended by Cruz et al. (2019) and would complement the current SCT implementation efforts through the policy regime at the industry and firm levels in the long and medium term, respectively.

4.3 SCT Policy Regime Instruments (Including Inherent Shortcomings)

Figure 1 also shows that the Kenyan SCT policy regime drives the SCT agenda through subsidiary legislation/regulations; constitution and Acts of parliament; and codes, guidelines and plans. Based on their respective numbers, they emerge to be employed approximately equally. This is generally in line with a developed nation such as China (See Chang, 2016:104-106). It must however be noted that given the multiplicity of policy documents, a database with all SCT-related policy documentation has the potential to inform comprehensive SCT practice, policy and research. Additionally, a closer look at the specific SCT provisions of the various policy instruments indicates that the regime largely backs SCT through regulation and control (See Tables 1-3). This leaves out other ways to back SCT, such as through: economic incentives – subsidies, awards and financial innovations; supporting activities – demonstration projects, publicity, standards and evaluation; liability/damage compensation – supporting mandated pollution insurance, extended producer responsibility, clear liability rules, and, compensation funds; education and information – on awareness drives, information dissemination, eco-labelling, and, publicising non-compliance penalties; voluntary programmes; and, management and planning (OECD, 2001b:132,135-136; Lafferty, 2004:6; Chang, 2016:106-115). This highlights part of the gap that the policy regime should seek to fill to realise its full influence potential towards SCT.

4.4 SCT Policy Regime Stakeholder Orientation (Including Inherent Shortcomings)

Lastly, Figure 1 indicates that the regime largely focuses on the role of developers/owners/occupiers and government (national and county) (in decreasing order of focus). Additionally, it focuses comparatively less on contractors, suppliers/producers/manufacturers, and professional consultants (also in decreasing order of focus). Though targeting the same group of stakeholders as the Chinese SCT policy regime (See Chang, 2016:106-109), more needs to be done, policy-wise, to back the implementation of SCT targeting professional consultants, contractors and suppliers/producers/manufacturers. This can be ensured through new policies and revision of current ones and can ultimately synchronise the entire construction industry supply chain for enhanced SCT performance. Additionally, it should be noted that there was no explicit mention of the role of NGOs, CSOs and media in SCT (See Tables 1-3). Given their well-documented potential to drive the SCT agenda, as postulated by Gilham (2010:126,140) and Graham et al. (2003:4), there is the implied need to leverage them for SCT through policy. Specifically, NGOs and CSOs' potential is in the watchdog role, crafting and disseminating new practices and technologies and independent monitoring and evaluation. On the other hand, media can support SCT: inter-sectorial information relaying, opinion-shaping; and promoting accountability.

5. Conclusion

This study sought to analyse the Kenyan SCT policy regime regarding priorities, instruments and stakeholder orientation, including (any) inherent shortcomings. Identifying the inherent shortcomings was ultimately aimed at making appropriate recommendations for improved SCT policy regimes to enhance and optimise industry SCT performance. The findings indicate that the regime: priorities – primarily focus on environmental sustainability targeting strategic and tactical implementation levels with minimal focus on SCT socio-economic objectives and operational level of implementation, which reduces its comprehensiveness; instruments – driven by regulations, the constitution, and Acts of Parliament, as well as codes, guidelines, and plans, from multiple sources, primarily aimed at regulation and control and not the other policy instruments functions hence not delivering on their full potential; and, stakeholder orientation – primarily targeting developers/owners/occupiers and government with less focus on the other stakeholders and thus not leveraging their specific roles in SCT supply chain. The resulting recommendations were: priorities – need for improved focus on SCT's socio-economic objectives and operational level of implementation; instruments – need for a central database and leveraging them to support economic incentives, supporting activities, liability compensation, education and information, voluntary programs, and management and planning; and, stakeholder orientation – improved targeting of contractors, suppliers/producers/manufacturers, professional consultants, non-governmental and civil society organisations, and media.

Irrespective of the notable and commendable progress, the previous discussion highlights room for an improved SCT policy regime as an avenue for optimised and enhanced SCT performance in Kenya. Lastly, given that this study was limited to current SCT policy regime evaluation, future research on the subject focus on other parts of the policy-making process system, such as problem identification; agenda setting; policy development; and implementation.

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An Investigation into Construction Tender Price Inflation: A Documentary Review

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Abstract

The essentiality of public infrastructure delivery cannot be over-stressed. However, there is a need to challenge existing practices and poor performance and focus on the value of public infrastructure to attain sustainable improvement in the public construction sector. Like many developing countries, Zambia's public construction sector experiences numerous challenges that create a vicious cycle. This research provides a base for further investigations regarding construction tender-price inflation and highlights the urgent need to manage the phenomenon. The data generated by this baseline study is critical to measure the degree and extent of construction tender price change between 2008 and 2018. The multiple-case design allows the study to perform a documentary review and cross-case analysis regarding the tender-price phenomena. The study also adopts a pattern-matching analysis to identify behaviours and practices of case firms regarding construction project implementation. The paper finds inherent project management challenges associated with case firms, including late engagement of supervising consultants, delayed payments, poor contract or project management practices, poor quality of works, a lack of detailed engineering designs, questionable award of contracts, and delayed project implementation. By comparing the construction-project-management approaches of case firms, the study finds that construction tender prices increased by an average of 31.4% per annum for upgrading roads to bituminous standards between 2008 and 2018. In addition, the study finds areas requiring prioritization to address construction tender price inflation include late engagement of supervising consultants, delayed payments, and poor contract or project management practices. Other notable factors requiring attention include poor quality of work, lack of detailed engineering designs, delayed project implementation, and questionable contract awards. The study offers a practical implication: addressing tender price inflation adds economic value to public projects and enhances public institutions' appetite for construction infrastructure development.

Keywords: construction, public sector, road projects, tender-price inflation.

1. Introduction

The construction industry's contribution to economic growth and long-term national development is widely acknowledged (Isa, Jimoh & Achuenu, 2013; Lopes, Oliveira & Abreu, 2011; Berk & Biçen, 2018; Oladinrin, Ogunsemi, & Aje, 2012; and Khan, 2008) mainly to developing countries with the nature of construction industry and its importance in development being critical areas of primary concern (Oladinrin et al., 2012; and Osei, 2013). Elements of the process of construction industry development that include ways and means of improving the performance of construction firms, focusing on contractors, technology development, and the parameters of performance in the industry, such as productivity and environmental performance, are focal points in modern times. These areas of concern influence the formulation of policies and legislation for establishing construction industry management and process re-engineering development models. Historically, the construction industry has experienced continuous higher prices, a continued decline in productivity, and extremely high levels of waste. Actual socioeconomic needs to deliver a project with higher quality, lower cost, and quickly challenge the traditional way of managing construction projects (Soares, 2013). For the benefit of developing countries, it is crucial to investigate the nature, essential

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characteristics, and particular requirements of the construction industry and to use them to develop programs for its improvement.

The worldwide chronic problems associated with the construction industry include low productivity, poor safety, inferior working conditions, inadequate financing, and insufficient quality (Ramachandra & Bamidele-Rotimi, 2015; Proverbs & Cheok, 2000). Widespread problems in the construction industry in most developing countries also include project cost overruns and schedule delays, which affect the broader and general economy, ranging from poor allocative efficiency to total project abandonment (Gbahabo and Ajuwon, 2017). Wambui, Ombui, and Kagiri (2015) found that one of the significant factors affecting public-sector construction project completion is the availability of project funds. Several solutions relieve these problems in construction, with industrialization, prefabrication, and modularization being one direction of progress. Computer-integrated construction is a critical way to reduce fragmentation in construction, which is considered a significant cause of existing problems (Nawi, Baluch & Bahauddin, 2014). Other solutions include robotized and automated construction (Kamaruddin, Mohammad & Mahbuba, 2016), closely associated with computer-integrated construction. With several varying answers to the construction industry's challenges, all the long-standing solutions require developing a tailor-made methodology that constitutes problem identification, redesigning, implementation, and continuous change in the construction industry (Shakun & Deepa, 2018).

Higher construction prices have been one of the general challenges in the industry, which require devising methods by clients to control project cost from the onset of the project at the bidding stage (Zhang, Luo & He, 2015). As contractors develop strategies in pricing for projects, the clients are equally equipping themselves with capabilities to make informed decisions on individual prices (Stramarcos & Cattell, 2013). To that effect, Valence & Runeson (n. d.) researched to explore and understand decisive factors and contributory processes involved in pricing decisions by contractors. Research findings suggest that awarding construction projects follows a common criterion of price consideration. However, from an investment and project cost perspective, arguments support that tender competitions with a high focus on price by using the lowest bid criterion ironically result in the most expensive project (Meland, Robertsen & Hannas, 2011).

Like several developing countries, Zambia's public construction sector experiences numerous challenges that create a vicious cycle. The research has identified problems concerning the study country (Zambia), including marginal participation of local contractors, particularly on large projects; erratic funding of public infrastructure projects; and a lack of tangible results. Others include the multiplier effect in public projects, political interference, and general increases in bid prices (Tembo et al., 2020). The essentiality of public infrastructure delivery cannot be over-stressed. However, there is a need to challenge existing practices and poor performance and focus on the value that public infrastructure can deliver to attain sustainable improvement in the public construction sector. This research opines that the situation warrants developing a model that promotes ambitious performance targets in the delivery of public infrastructure by making radical changes to the process of public project delivery.

Successful construction project implementation requires making the right decisions during the tendering process by tightly managing tender procedures (Mohemad, Hamdan, Othman & Noor, 2010). The biggest problem at this point is attempting to execute a process holistically impacted by various factors. Some require judgmental projections into future broader markets and specific industry conditions. Since the construction industry is massive and highly competitive, the issues of contract pricing have become exceptionally complex matters to address (Akintoye and Skitmore, 1990). Broader economic conditions contribute to fluctuating construction tender prices, which increase expenditure uncertainties for clients who attempt to forecast construction prices in the sector (Kissi, Adjei-Kumi, Amoah, & Gyimah, 2018). In Zambia, negative perceptions of construction tender-price variableness threaten desirable infrastructure push in the public sector.

The damaging effects of escalating tender prices outweigh the socioeconomic benefits of such infrastructure. If not addressed, this harmful effect is destructive to construction sector productivity, causing it to lag behind other economic sectors, thereby decreasing the sector's value in the national economy. This paper addresses the issue regarding higher construction prices and allows for the devising of methods by clients to control project costs from the project's onset at the bidding stage. The paper correspondingly equips clients with the capabilities to make informed decisions on individual prices. Therefore, the study further aims to explore and understand decisive factors and contributory processes involved in tender pricing decisions by contractors.

This research aims to provide a base against which to investigate construction tender-price inflation and highlight the urgent need to manage the phenomenon. The data generated by this baseline study is critical to measure the degree and extent of construction tender price change between 2008 and 2018. In this case, the research collates the data from the documentary review and presents a case for further study. However, considering insufficient or incomplete data, the baseline study targets information that is already available, easy to access, and contrast. Thus, the study divided the collected data into two major categories relevant to the study to develop its case. These projects include upgrading roads to bituminous standards and periodically maintaining feeder roads.

2. Literature review

A construction company's strategy to establish its bid price and win in competitive tenders builds upon an analysis of the economic environment, the expected behaviour of competitors, and the contractor's capabilities (Jaśkowski & Czarnigowska, 2019). Contractors must ensure that the bid price is high enough to cover various costs, including profits, while being low enough to be considered the lowest priced among the competitors by the client.

2.1 The role of tender price in contractor selection in Zambia

Construction-sector uses construction cost indices or tender-price indices for monitoring price movements. It is achieved by measuring relative change over time in the prices of construction materials. Cruywagen (2014) argues that the establishment and the composition of the relevant tender price index are influenced by several factors, including the availability of data and selection of items to consider from the bills of quantities. Other significant factors include the base year or period selection, choices of weights, and construction method. All these factors begin to affect the accuracy of the index. Once established, the index works as a deflator for construction prices. In a free market, the bidder presents an item price uniquely dependent on the construction technique (Cattell et al., 2010). Historical data must be readily available to predict the bid price, coupled with necessary documentation and processes for adjusting unit costs. Underutilization of historical project cost data exacerbates cost control challenges during tendering (Zhang, Luo, & He, 2015).

Moreover, using pricing models is challenging for contractors because the models are unnecessarily complicated. Even the best-simplified and streamlined models involve the imposition of constants and price limits that are arbitrary and subjective (Cattell, Bowen, & Kaka, 2007). Using such arbitrarily chosen values fails to provide a scientific basis by which to construct the optimum price. Kissi et al. (2019) hypothesized the existence of a relationship between the different pricing strategies and the factors that influence the pricing of a tender. Evaluating bids is through a variety of criteria, but the key shared among the criteria is the total bid price; usually, considerations are that choosing a bidder with the lowest price is most beneficial to the client (Jaśkowski & Czarnigowska, 2019). Jaśkowski and Czarnigowska (2019) claim that the public sector is inclined to use the lowest-price bidding or low-bid model to make contract awards due to the perceived monetary benefits of transparency. In contrast, they overlook facts that the practice results in low quality of work, claims, disputes, time overruns, bid rigging, increased costs, unrealistically low price, and collusion.

Tender price management is the most crucial consideration for bid success; however, due to complex pricing interrelationships, it is much easier to generally express construction project success in terms of cost and budget variance (Yismalet & Patel, 2018). This trend, over time, has shifted the long-term focus to project cost management processes. In addition, research shows that project success depends on mitigating factors affecting tender pricing at the procurement stage. Aje et al. (2016) determined fifteen (15) factors that influenced the success rate of contractors in competitive bidding concerning tender price, which included material availability, labour productivity, and profit as the most significant. These factors significantly influence construction tender price (at tendering stage) and later affect how contractors perform exceptionally. The dilemma with competitive bidding is that the bid price must be low enough to win the bid yet high enough to ensure the contractor's profitability and reasonably sufficient to guarantee the quality of work. It is when the cost estimation function becomes essential, as it is the basis for most contractors to build their tender price (Akintoye & Fitzgerald, 2000). It is equally imperative to note that the availability of funds influences the client's decision to award a contract, the contractor's price, as well as prices of other contractors—excessively, the parties in construction view construction price through understanding and emphasizing the project cost. Hence, related pricing approaches are cost control measures through contracting delivery models. Clients resort to employing delivery models such as EPC to manage construction prices, which are slightly more regular (Zhong, 2011).

Tender price inflation is a severe problem in Zambia's public construction sector. It is propagated further by a situation in which contractors have become more informed than the client (government). As a result, contractors exaggerate their understanding of cost impacts and take advantage of the disproportionateness in information to skew unit prices in the bids and enhance their profits. Contractors do this by increasing the unit price of a quantity expected to go up and lowering the unit price of a quantity expected to decrease. It requires government as a client to optimize trend detection using already-developed models. However, this requires empirical studies that capture the magnitude of the problem in Zambia's context. Unbalanced bidding is one potential pitfall of unit price contracting (Nyström, 2015). Unit price contracting is used in Zambia's public construction sector. It manifests by the client/government paying too much for the final construction product.

2.2 Causes of Tender-Price Inflation in construction projects

Olawale and Sun (2010) establish that price inflation is one of the significant factors that affect cost control on a project. There are related factors in the pricing of each item in construction (Azizi & Aboelmagd, 2019). The main challenges to contractors come with identification methods by measuring the risk rate within an item price loading and achieving the highest profitability while accepting the most negligible risks (Azizi & Aboelmagd, 2019). Another concern when pricing for a bid is that the award of a construction contract depends on the total bid price without considering the variations in the item's unit price. This scenario leads to contractors deliberately manipulating unit prices (Nikpour et al., 2017).

Furthermore, they argue that price fluctuation and inaccurate estimates were the top variables causing cost overruns on a project. The ability to deploy strategies productively and effectively has a cost-decreasing impact. In the public-construction sector, developing and setting appropriate tender conditions following an in-depth investigation of how the factors affecting pricing mechanisms correlate enhance this ability.

When risk factors are uncertain on a project, contractors face the challenge or problem of deciding the bidding price for construction. The existing theoretical principles of project risk management lack more realistic considerations such that there is no transparent allocation and reasonable pricing of risks at the project onset (Zhang et al., 2006). At tendering stage, one of the main risks for consideration is the financial position of the client in such a manner as being unable to pay the contractor on time: A scenario often leading to project delays and wrong cost estimations (Naji & Ali, 2017). The failure of a construction firm to fully consider or estimate the risk event on a construction project could have a disastrous impact. Construction enterprises are mindful of this scenario, and due to a lack of appropriate knowledge on risk pricing and mitigation measures, they often subsequently overestimate their markups. It causes construction prices to escalate over time.

Laryea & Hughes (2008) establish no evidence suggesting that construction project pricing is systematic. Therefore, they doubt the justification of pricing models for contractors as their final price depends on a varying range of complex microeconomic indicators and risk factors. The argument is on efficient pricing for risk while encountering and estimating various contingencies. Contractors remain aware of the nature of the construction industry in which all competitors are "hungry for a job" such that if they were to consider and price for all realistic contingencies, they would remain uncompetitive. Table 1 shows some of the risk factors that contractors must contend with during pricing for a bid.

Paek & Lee (1993) propose a risk pricing method for analyzing and pricing construction projects, which consists of identifying risk factors and pricing for their consequences. They suggest using a fuzzy set approach to quantify and directly incorporate the implications into the bid price. They adopt a fuzzy set theory to present a risk-based pricing algorithm and computer-based software. However, since the selection of risk factors is project specific, the algorithm could not formulate generalizations. Therefore, it is advisable to ensure that all risk elements whose consequences might fatally flaw the project identification are accordingly priced for during the tendering phase (Paek & Lee, 1993). However, Laryea & Hughes (2008) argue that most models and pricing methods are desk-based and Lack knowledge of what contractors do during the bid pricing stage.

Table 1 Risk-related factors during pricing in construction

S/N	Risk factor(s)	Author
1	Value of liquidated damages	Towner & Baccarini (2012)
2	Clients' financial state	Naji & Ali (2017)
3	Project cost risk (range between 2.7% and 8.7% of project cost)	Xu (2014), Brokbals, et al. (2019)
4	Technical information or detailed specifications	Nketekete, et al. (2016)
5	Practical knowledge of the construction process	Akintoye & Fitzgerald (2000)
6	Contractor size	Dulaimi & Shan (2002)
7	Market competition	Laryea & Hughes (2008)
8	Contingency additions	Dada & Jagboro (2007)
9	Apportionment of contractual responsibilities	Al-Ajmi & Makinde (2018)
	• Material availability	Aje et al. (2016)
	• Labour productivity	
10	Project scope	Dziadosz, et al. (2015)

2.3 Tender selection process in Zambia

Literature shows that the Zambian public sector uses the lowest bid selection method. The government's primary concern during tendering is controlling production costs and quality when using the lowest bid method, while even the lowest bidder is concerned about securing their profit. Eger and Guo (2008, p.290) argued that this process leads to tensions between the parties during execution due to asymmetric information, which involves "the problems of moral hazard and adverse selection." When a project suffers from both adverse selection and dynamic moral hazard, the likelihood of its success depends on the amount of work completed by the contractor. As a result, "firms can siphon a portion of the funds intended for the project and use the rest to create an illusion of productivity" because inefficient firms bid to siphon and create unnecessary-unproductive competition for efficient firms (Johnson, 2013, p.1). The lowest bid method does not enable public construction administrators to select the most qualified contractor. "Choosing a contractor based on the lowest bid alone is inadequate and may lead to the project's failure in terms of time delay and poor-quality standards" (Alptekin, O. and Alptekin, N., 2017, p.1).

3. Methodology

This study aims to define the behaviour of construction tender prices and determine the focus of corrective priorities. The study utilizes a directed content analysis of documents from single-case research to offer more compelling evidence and a robust data set (Sanda et al., 2021; Rose et al., 2015). Numerous construction-related studies, such as Letza (1996), Moatazed-Keivani, et al. (1999), Gyi et al. (1998), Barrett et al. (2005), Barlow & Jashapara (1998), and Gibb (2001) adopted the case study approach for various purposes. The single-case design adopted (Fig. 1) allowed the study to analyze the tender price phenomena. The study establishes practices and behaviours surrounding project implementation in the case firms without depending on the interviewee's personal experiences and biases. Therefore, detailed historical records were the best alternative to obtaining accurate behaviours and practices.

The institution reviewed is the Road Development Agency under the Ministry of Infrastructure, Housing and Urban Development (MIHUD). Within the Ministry of Infrastructure, Housing and Urban Development (MIHUD), the study focused on road infrastructure works under the Road Development Agency (RDA). The reasons for choosing the firm included:

1. Its mandate with road infrastructure provision in Zambia
2. Provision of detailed annual reports
3. readily available audit reports
4. on easily obtainable road lengths
5. The already classified system regarding interventions on roads (unpaved. paved, gravel, upgrading, maintenance, rehabilitation)
6. The already classified system, the gazette (Urban, Feeder, Main, and Trunk Roads).

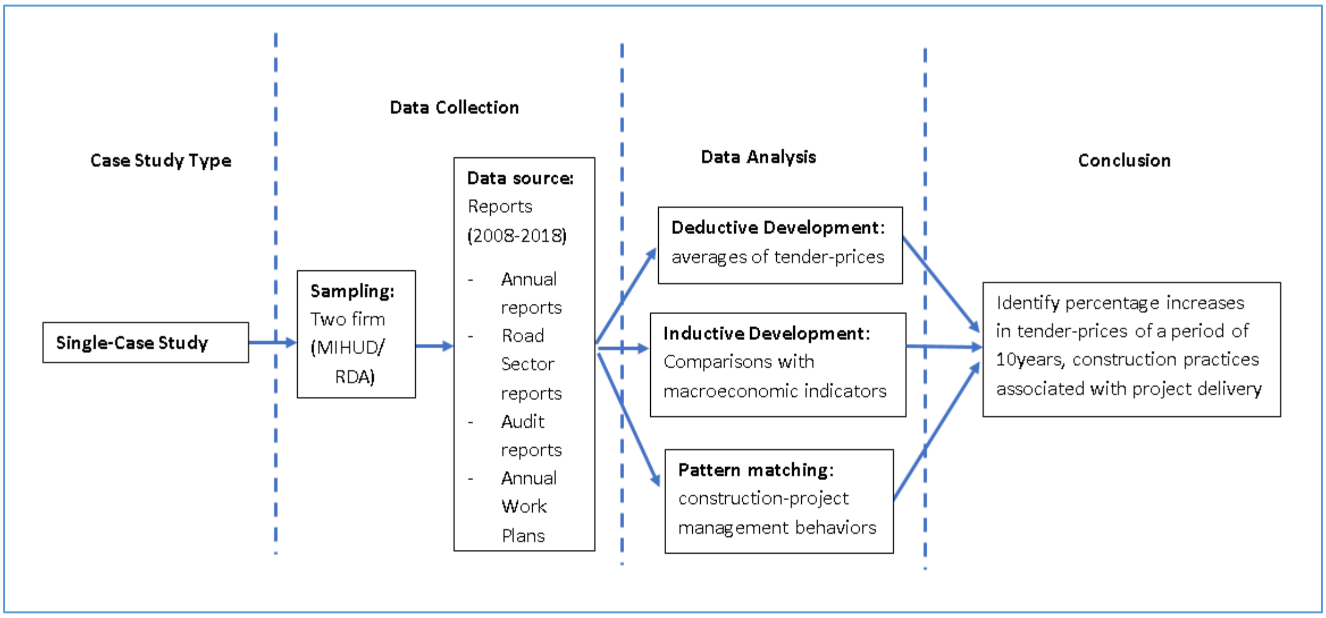

Figure. 1: Study research procedure and methods

The research utilizes a documentary review (Table 3) of the circumstances surrounding project implementation in case firms. Using a multiple-case study approach, the study holistically investigates project management behaviours and practices adopted by case firms between 2008 and 2018. The study employs a qualitative data analysis approach to construction projects within the case firm to develop averages of construction firms by examining various annual and audit reports. The analysis consists of directed, summative, and conventional content analysis. Based on existing information, the study identified 97 road construction projects from the case firm in directed content analysis.

Table 2. Details of the case firms and case project

Case Firm	Main project types	Scope	Intervention
MIHUD/RDA	Paved Roads – Main, Trunk, Urban, and District roads	Infrastructure design and construction	Upgrading to bituminous standards

The inquiry utilizes a conventional content analysis to identify project categories that comprised upgrading roads to bituminous standards and periodic maintenance of feeder roads. The study develops two coding categories of length and tender price at this analysis stage. Afterward, the investigation examines contracts based on these coding categories. The study adopts a summative analytical design to calculate averages and draw comparisons with macroeconomic trend lines. Due to limited literature, the design is appropriate in determining works of similar nature, type of intervention, and scope (Yin, 2009).

Table 3. List of documents reviewed

Institution	List of documents reviewed	Number of contracts reviewed
MIHUD/RDA	• Annual reports (2013-2018)	7
	• Final audit report (2008)	3
	• Final audit report (2012-2015)	4
	• 2008 RDA-PAC report	1
	• Contracts	92

The baseline study adopts the "before-and-after" activity method of measuring the change in tender prices across the study period. The comparisons include drawing out averages of tender price per kilometre of specific road categories per year, then contrasting to the preceding years to develop a trend line analysis. This analysis forms the basis for observing rises and falls in tender prices as part of the assessment of price inflation. The study achieves this by measuring the shift in tender prices for similar construction works or projects over time in the exact activity location (Zambia). The study focuses on a documentary review for replicability of the collected data, if necessary, for subsequent evaluations. This approach is critical in providing the minimum information required to assess and ascertain the reality or representativeness of construction tender-price inflation.

4. Findings

The study adopted a pattern-matching analysis to identify behaviours and practices of case firms regarding construction project implementation. By comparing construction-project management approaches of case firms, the study described in Table 4 provides an overall understanding concerning the implementation of project management and inherent contributing causes to tender-price inflation. The table indicates issues requiring prioritization, including late engagement of supervising consultant at 13.5%, ranked one, and delayed payments at 12.9%, ranked 2. Others are poor contract or project management practices at 11.9%, ranked 3; poor quality of works at 10.3%, ranked 4. Lack of detailed engineering designs at 8% ranked 5, questionable contract award at 7.1% ranked sixth, and delayed project implementation at 6.8%.

Table 4 Circumstances surrounding construction-management practices (2006-2020)

Observed Challenges	Frequency	Percentage (%)	Rank
Late engagement of supervising consultant	42	13.5	1
Delayed payments	40	12.9	2
Poor contract or project management	37	11.9	3
Poor quality of work	32	10.3	4
Lack of detailed engineering design	25	8.0	5
Excessive and questionable variations	22	7.1	6
Delayed project implementation	21	6.8	7
Questionable award of contract	17	5.5	9
Non-adherence to procurement procedures	16	5.1	10
Overpayment on claims	10	3.2	11
Failure to provide/renew contract bonds/guarantees	10	3.2	12
Interest claims	9	2.9	13
Unjustified single-sourcing	8	2.6	14
Poor quality materials	6	1.9	15
Lack of equipment	5	1.6	16
Questionable and uncompetitive rates	4	1.3	17
Inadequate budget provision	4	1.3	18
Irregular contract documents	1	0.3	19
Over procurement	1	0.3	20
Inconsistent application of evaluation criteria	1	0.3	21

(Source: data from Auditor-General, 2015; NRFA, 2022; PAC, 2009).

Table 4 presents significant factors affecting construction tender pricing development as observed from the documentary review. The study lists 21 factors under this category. The study graphed information gathered in Table 4 into a Pareto chart in Figure 2 to indicate the frequency of a challenge and its cumulative impact. It helps find areas to prioritize interventions for the most significant overall effect. The chart suggests areas requiring prioritization include late engagement of supervising consultants, delayed payments, poor contract or project management practices, poor quality of work, a lack of detailed engineering designs, delayed project implementation, and questionable contract awards. The study further identifies general features of construction projects in the case of firms by analyzing tender pricing behaviours. Consequently, the study employed a deductive development approach to develop specific annual tender pricing averages (Table 5).

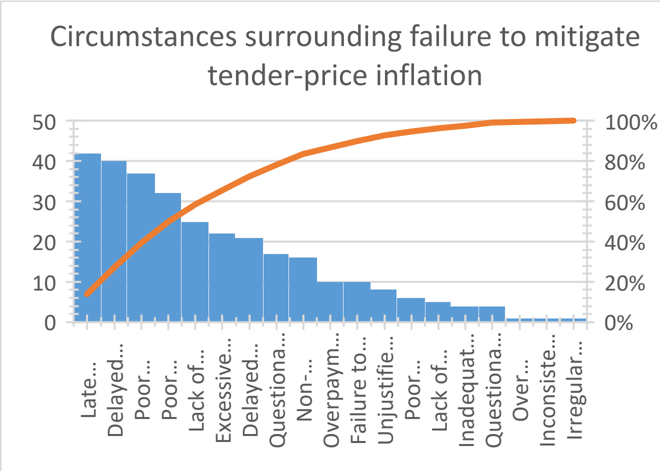

Figure 2: Pareto chart highlighting main challenges regarding construction tender-price inflation

Figure 2 indicates areas requiring prioritization, including late engagement of supervising consultant, delayed payments, poor contract or project management practices, poor quality of work, a lack of detailed engineering designs, delayed project implementation, and questionable contract award. The results show a steady increase in construction tender prices between 2008 and 2018. The study reviewed 92 contracts (N=92) for upgrading to bituminous standards between 2008 and 2018 (see Table 5). For upgrading roads to bituminous standards, construction tender prices increased from an average of ZMW1,438,825.8/km in 2008 to an average of ZMW14,395,749.5/km in 2018.

Table 5 shows average construction tender prices for upgrading roads to bituminous standards. The results show a steady increase in construction tender prices between 2008 and 2018. For upgrading roads to bituminous standards, construction tender prices increased from ZMW1,438,825.83/km in 2008 to an average of ZMW14,395,749.54/km in 2018 (N=92). An example of calculation for the standards in Table 5 is as follows:

For 2010:

For tender-price-code:

Average tender–price:

(33,397,491+80,002,657+101,286,041+47,562,388)÷4 = ZMW65,562,144

For-length-code;

Average length: (23.5+65+50+52.4)÷4 = 47.725Km

Therefore, construction tender-price/km: 65,562,144 ÷47.725= ZMW 1,373,748.44/Km

Figure 3, a graphical representation of the observations in Table 5, compares the construction tender price incremental behaviour with each passing year. The observations indicate a positive upward trend, with tender prices steadily rising during the period under review between 2008 and 2018. This behaviour is observable from the sampled contracts, as not all were readily available for review. Figure 3 aggregates values of construction tender prices for the stated year. From the analysis, the average construction tender price from four observed contracts in 2008 is ZMW1,438,857.72/Km. The highest increment was in 2011 when tender prices rose by 95.4%.

The observations indicate that decreases of -24.5% in 2010 were the lowest during the period under review. This value increased by 71.3% in 2012 to ZMW4,599,107.96/Km. The incremental trend continued by another 2% in 2013 to at least ZMW4,690,770.68/Km. The study calculates the average construction tender-price increase over this period to be at least 31.4%. At the same time, the macroeconomic indicators (independent variables) are observed to increase minimally at 3.3% (interest rates), 11.8% (Forex), 2.6% (inflation rate), and 8.9% (FDI) apart from external government debt that is observed to increase by 45.1%.

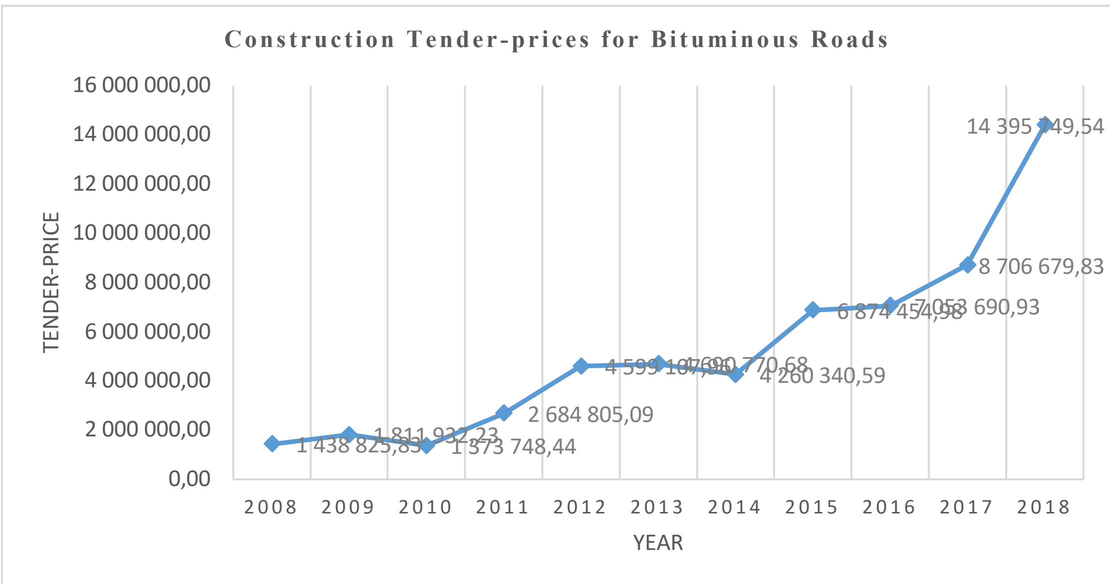

Figure 3: Average construction tender prices for upgrading roads to bituminous standards

Table 5. Construction Tender-Prices for upgrading roads to bituminous standard (2008-2018)

Year	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**	
	Km	Tender Price	Km	Tender Price	Km	Tender Price	Km	Tender Price	Km	Tender Price	Km	Tender Price
	14.4	14,143,540	52.4	47,562,388	23.5	33,397,491	90	213,805,420	402	1,797,195,724.20	54	221,212,397
	45	77,741,065	104	290,063,867	65	80,002,657	14.6	59,004,963	43.8	242,296,469.00	48.5	205,807,776
	73.19	90,097,344	96	192,695,237	50	101,286,041	171.9	180,000,000	14.6	59,004,963.00	16	208,241,515
	17.78	34,379,087	225	319,160,884	52.4	47,562,388	131.5	707,400,000	64	290,287,688.00	91	314,958,672
			82	164,112,515			171	421,706,455	34.47	165,827,800.00	45.5	561,813,606
							7	11,491,187	86	371,478,276.00	27.32	139,270,689
							131.5	332,939,624	115	466,731,196.00	65	175,787,988
									40	118,441,534.00	100	295,906,766
									70	278,824,387.00	158	385,583,452
									175	1,067,928,906.52	114	361,187,528
									15	72,236,835.00	105	529,047,639
									14.1	61,562,946.64	90	856,110,428
									22.6	51,427,095.02	18	118,370,863.31
Average	37.5925	54,090,259	111.88	202,718,978	47.725	65,562,144	102.5	275,192,521	84.35154	387,941,832	71.71692	336,407,640
ZMW/Km	**1,438,857.72**		**1,811,932.23**		**1,373,748.44**		**2,684,805.09**		**4,599,107.96**		**4,690,770.68**	

Year	**2014**		**2015**		**2016**		**2017**		**2018**	
	Km	Tender Price	Km	Tender Price	Km	Tender Price	Km	Tender Price	Km	Tender Price
	98	690,958,848	84	585,556,978.00	270	2,061,451,626.00	85	959, 189,051.33	220	4,205,527,260.00
	8	41,999,823	84	417,108,471.00	109	546,877,969.00	257	1,839,580,493.66	179	3,994,919,827.00
	111.2	285,886,120	5	57,014,787.00	69.9	282,394,736.00	25.63	294,310,644.73	258	3,994,919,827.00
	94	264,798,761	56	417,108,471.29	78.2	291,105,602.00			103	784,279,480.62
	118	429,962,249	84	585,556,977.51	58.2	529,938,197.00			107	713,664,926.91
	93	396,624,924	83.9	367,218,609.29	194	1,695,918,648.00			88.3	1,162,942,884.00
	90	332,824,438	82	631,194,336.31	112	607,349,167.00			4	32,078,862.69
	71	229,969,700	15	123,936,213.56	10.65	160,270,962.37			95	289,105,667.00
	107.5	592,500,000	20.2	123,142,060.36	9.37	108,575,278.37				
	115.7	500,040,614	11.4	109,660,183.91	15.04	250,374,945.86				
	113	439,062,227	9.27	115,405,395.11						
	117	540,831,955	20.5	220,867,715.90						
	17	168417173	9.6	129,403,184.05						
Average	88.72308	377,990,526	43.45154	298,705,644.87	92.636	653,425,713.16	122.5433	1066945569	131.7875	1,897,179,841.90
ZMW/Km	**4,260,340.59**		**6,874,454.98**		**7,053,690.93**		**8,706,679.83**		**14,395,749.54**	

Table 6. Correlation between macroeconomic indicators and tender prices for upgrading of roads to bituminous standards

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Averages	Coefficient (r) Pearson's	Comment
Tender-price (ZMW'million/km)	1.438826	1.811932	1.373748	2.684805	4.59911	4.690771	4.260341	6.87446	7.053691	8.7066798	14.39575	5.262734	-	-
Forex rates	4.2	4.9	4.8	7.3	5.14	5.39	6.15	8.63	10.31	9.54	10.45	6.98	**0.84**	strongly positive
Inflation rates	12.5	13.4	8.5	8.7	6.6	7	7.8	10	18.2	6.6	7.5	9.71	**-0.18**	no correlation
Interest rates	19.1	22.1	20.9	18.8	19.1	16.3	18.7	21.1	28.1	26.9	24	21.37	**0.54**	moderately positive
FDI (US $ 'Bn)	0.94	0.69	1.73	1.11	1.73	2.1	1.51	1.58	0.66	1.11	0.41	1.23	**-0.39**	weakly negative
External Debt (US $ 'Bn)	0.91	2.25	1.72	1.68	0.92	2.13	5.02	8.08	9.21	12.45	12.1	5.13	**0.88**	strongly positive
% Change (forex)	0	16.7	-2.0	52.1	-29.6	4.9	14.1	40.3	19.5	-7.5	9.5	**+11.8%**	-	-
% Change (Inflation)	0	7.2	-36.6	2.4	-24.1	6.1	11.4	28.2	82.0	-63.7	13.6	**+2.6%**	-	-
% Change (Interest)	0	15.7	-5.4	-10.0	1.6	-14.7	14.7	12.8	33.2	-4.3	-10.8	**+3.3%**	-	-
% Change (FDI)	0	-26.6	150.7	-35.8	55.9	21.4	-28.1	4.6	-58.2	68.2	-63.1	**+8.9%**	-	-
% Change (Debt)	0	147.3	-23.6	-2.3	-45.2	131.5	135.7	61.0	14.0	35.2	-2.8	**+45.1%**	-	-
% Change(Tender-price)	0	25.9	-24.2	95.4	71.3	2.0	-9.2	61.4	2.6	23.4	65.3	**+31.4%**	-	-

The results in Table 6 indicate an average percentage increment per annum of 31.4% of construction tender prices for upgrading roads to bituminous standards between 2008 and 2018. It shows a tender price increment of 900.52% over the ten years under review.

Figure 3 shows that construction tender prices increased for upgrading roads to bituminous standards from ZMW1,438,825.83/km in 2008 to an average of ZMW14,395,749.54/km in 2018. Construction tender prices increased by an average of 31.4% per annum for upgrading roads to bituminous standards between 2008 and 2018. For paved roads, construction tender prices increased by ZMW12,956,923.7/km from ZMW1,438,825.8/km in 2008 to ZMW14,395,749.5/km in 2018. The data confirms a positive trend line or the steady increase in construction tender prices in the period (2008-2018). Moreover, results show a positive correlation between construction tender prices to foreign exchange rates (0.84), commercial interest rates (0.54), and external debt stock (0.88) (Trading-Economics, 2022). However, there is a negative correlation between construction tender prices and foreign direct investment of -0.39. At the same time, the results show a lack of correlation between construction tender prices and an inflation rate of -0.18. The correlation sign defines relationship direction such that a positive signal on the exchange rate correlation coefficient means that construction tender prices increase as the exchange rate value increases: and as it decreases, tender prices drop. It means that the variables change together in the same direction. At the same time, the correlation coefficient's absolute value indicates the correlation's magnitude such that the smaller the final value, the weaker the correlation.

Table 7. Summary of variables

Year	Tender-price (ZMW'million/km)	Forex rates	Inflation rates	Interest rates	FDI (US $ 'Bn)	External Debt (US $ 'Bn)
2008	1.438825829	4.2	12.5	19.1	0.94	0.91
2009	1.811932233	4.9	13.4	22.1	0.69	2.25
2010	1.373748439	4.8	8.5	20.9	1.73	1.72
2011	2.684805086	7.3	8.7	18.8	1.11	1.68
2012	4.599107964	5.14	6.6	19.1	1.73	0.92
2013	4.690770679	5.39	7	16.3	2.1	2.13
2014	4.260340586	6.15	7.8	18.7	1.51	5.02
2015	6.874454978	8.63	10	21.1	1.58	8.08
2016	7.053690932	10.31	18.2	28.1	0.66	9.21
2017	8.706679835	9.54	6.6	26.9	1.11	12.45
2018	14.39574954	10.45	7.5	24	0.41	12.1
Mean	5.263	6.9827	9.709	21.373	1.2336	5.1336
Std. Deviation	3.888	2.36470	3.6231	3.6519	0.53474	4.51533
Valid N (listwise) = 11						

Table 7 summarizes the variables used in multinomial regression analysis. The variable values are annual averages, which may affect the significance and prediction level of the model. However, the investigation is in accordance and appropriate with regression model development. Table 7 presents averaged values for the stated variables. The second row, 'tender-price,' represents averages per annum of total tender prices divided by the entire length of contracts reviewed in each particular year. Other rows represent annual variable values as obtained from documentary reviews as well. The analysis presents respective means and standard deviations for all 11 valid observations.

Table 8 shows that out of all variables entered. The analysis considered all variables and removed no during the regression analysis.

Table 8. Model variables

Model	Variables Entered	Variables Removed	Method
1	External Debt (US $ 'Bn), Inflation rates, FDI (US $ 'Bn), Interest rates, Forex rates	.	Enter
a. Dependent Variable: Tender-price (ZMW'million/km)			

Table 9. Correlations of variables

		Tender-price (ZMW'million/km)	Forex rates	Inflation rates	Interest rates	FDI (US $ 'Bn)	External Debt (US $ 'Bn)
Tender-price (ZMW'million/km)	Pearson Correlation	1	.844**	-.183	.538	-.391	.876**
	Sig. (2-tailed)		.001	.590	.088	.234	.000
	N	11	11	11	11	11	11
Forex rates	Pearson Correlation	.844**	1	.136	.749**	-.491	.918**
	Sig. (2-tailed)	.001		.691	.008	.125	.000
	N	11	11	11	11	11	11
Inflation rates	Pearson Correlation	-.183	.136	1	.449	-.531	.024
	Sig. (2-tailed)	.590	.691		.165	.093	.944
	N	11	11	11	11	11	11
Interest rates	Pearson Correlation	.538	.749**	.449	1	-.651*	.779**
	Sig. (2-tailed)	.088	.008	.165		.030	.005
	N	11	11	11	11	11	11
FDI (US $ 'Bn)	Pearson Correlation	-.391	-.491	-.531	-.651*	1	-.462
	Sig. (2-tailed)	.234	.125	.093	.030		.153
	N	11	11	11	11	11	11
External Debt (US $ 'Bn)	Pearson Correlation	.876**	.918**	.024	.779**	-.462	1
	Sig. (2-tailed)	.000	.000	.944	.005	.153	
	N	11	11	11	11	11	11

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

The correlation between construction tender prices and macroeconomic indicators such as external debt and foreign exchange rate is +0.876 and +0.844, respectively, indicating both strong and positive (Table 9). The p-value results from a 2-tailed test significance are zero, thus $p<0.005$. It means that the two variables are significantly positive. Therefore, higher foreign exchange rates and government debt levels are strongly associated with higher construction tender prices.

Table 10 indicates an R-Squared value of 0.742. The variance of the macroeconomic indicators under study defines at least 74.2% of the construction tender-price variance.

Table 10 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.933[a]	0.871	0.742	1.9739

a. Predictors: (Constant), External Debt (US $ 'Bn), Inflation rates, FDI (US $ 'Bn), Interest rates, Forex rates

Table 11 Analysis of Variance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	131.670	5	26.334	6.759	0.028[b]
	Residual	19.480	5	3.896		
	Total	151.150	10			

a. Dependent Variable: Tender-price (ZMW'million/km)
b. Predictors: (Constant), External Debt (US $ 'Bn), Inflation rates, FDI (US $ 'Bn), Interest rates, Forex rates

The analysis of variance (ANOVA) summarizes information regarding multiple correlations to test the significance of the model regarding the extent to which asset of macroeconomic indicators (independent variables) predict construction tender prices (Table 11). The null hypothesis states that macroeconomic indicators are not significantly related to construction tender prices. The Sig. column represents the p-value for the test of significance of the model. Since $p<0.05$ for a p-value of 0.028, we conclude that the indicator variables are significantly related to construction tender prices. The other columns provide the detail from which the p-value is determined. The sum of squares for regression (26.334) is the mean of the square for regression. The sum of squares labelled residual (19.480) is the sum of differences between the predicted values and the actual values of y, which is the sum of squared deviations of the data around the regression line. The square root of the variance of residuals, 3.896, is 1.974, which is the standard error of the estimate.

To estimate the regression equation, the coefficients table, Table 12 presents the least squares estimates of the intercept and slope of the regression line. Five values of regression weights (b, 0.638, -0.241, -0.334, -1.561, 0.577) are listed in column headed B, while the regression intercept is (a, 9.255). Respectively, the equation of the least squares is the therefore: $y=9.255+0.638x_1-0.241x_2-0.334x_3-1.561x_4+0.577x_5$. In which x1 = forex rates, x2 = inflation rate, x3 = interest rates, x4 = FDI and x5 = government debt. The negative sign of the regression coefficients (on inflation rates, interest rates, and FDI) indicates negative correlations between each indicator variable and construction tender price. Positive coefficients regarding forex rates and government debt indicate that as their values increase, the mean of the construction tender price also tends to increase. On the other hand, the p-values in the Sig. Column of Table 12 is much greater than the significance level of 0.05.

It indicates insufficient evidence in the data set sample to conclude that a non-zero correlation exists between independent and dependent variables. Keeping variables that are not statistically significant thereby reduces the precision of the model. Considering all other model-fit criteria, this finding may create a possibility of either type I or type II statistical error that could lead to a false rejection or acceptance of the null hypothesis. Increasing the sample size would address the risk of encountering type I and type II statistical errors. Larger sample sizes allow the stud to increase the significance level of the findings as higher sample sizes have a higher possibility of accurately mirroring the population's behaviour. The research suggests using more samples to draw out the model since the regression line appears not flat and many points fall within. The correlations of some variables are not small (r = 0.876, r =0.538, and r = 8.44) and significant (p = 0.000 and p = 0001), and more than 70% variability is attributable to macroeconomic indicators. Therefore, the study argues that there is significance in predicting construction tender prices from macroeconomic indicators.

Areas requiring prioritization when addressing construction tender-price inflation include late engagement of supervising consultants, delayed payments, and poor contract or project management practices. Others include poor quality of work, lack of detailed engineering designs, delayed project implementation, and questionable contract awards. Figure 4 of the study presents a continuously improving construction-tender price management process developed through a relevant literature review on the subject matter. The study argues that the process includes at least five separate steps:

1. Step 1: involves identifying all factors affecting construction-bidding price. This step starts from identifying predetermined objectives of bidders to existing economic conditions at a particular time. This step allows an institution to develop an understanding of both internal and external factors.
2. Step 2: This step draws down the most significant project-specific risk-pricing factors, which according to (Baccarini, 2012), may include the type of contract, type of procurement method used, value of liquidated damages, completeness of documentation, and current workload.
3. Step 3: involves deriving cost-per-unit information for setting prices to generate profits adequately. This step allows the bidder or client to derive variable and fixed costs. During this step, Oberholzer & Ziemerink (2004) perfectly underscores the significance of the "high-low method" in determining cost levels. Consideration of direct material costs, greater-volume discounts, and additional capacity constitute prudent choices.
4. Step 4: Literature findings by Laryea (2018) and Ekung et al. (2013) best prescribe essential issues of concern regarding this step to include flexibility, quality requirements, payment certainty, price-competition, problems of autonomy and responsibility, dispute resolution procedures and project duration.
5. Step 5: This requires a government economic policy of imposing floors (minimums) and ceilings (maximums) to public construction prices at both materials and services levels to make them affordable and reflective. A study by Majumdar (2003) discusses this step in detail and proposes using and adopting price controls as incentive mechanisms to achieve social-economic benefits.

Table 12 Regression coefficients

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**95.0% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
1	(Constant)	9.255	8.105		1.142	.305	-11.581	30.091
	Forex rates	0.638	0.699	0.388	0.913	.403	-1.158	2.435
	Inflation rates	-0.241	0.262	-0.225	-.920	.400	-.915	.433
	Interest rates	-0.334	0.385	-0.314	-.868	.425	-1.325	.656
	FDI (US $'Bn)	-1.561	1.661	-0.215	-.940	.390	-5.831	2.709
	External Debt (US $ 'Bn)	0.577	0.447	0.670	1.290	.253	-.573	1.727

a. Dependent Variable: Tender-price (ZMW'million/km)

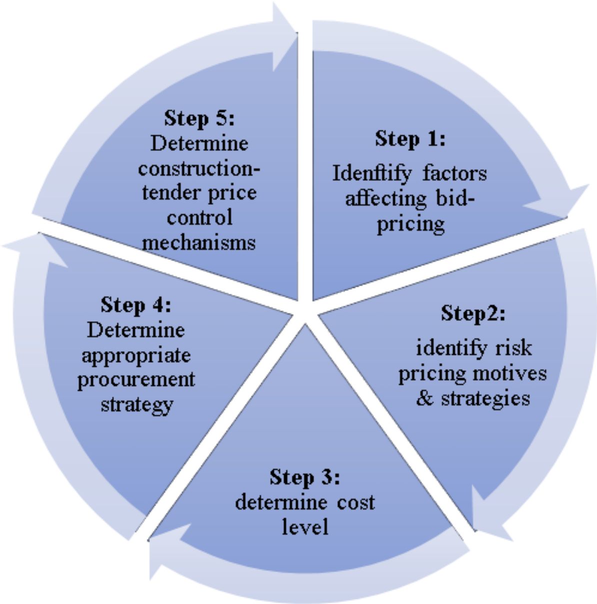

Fig. 4: Construction-price management process (by the authors: based on previous studies by Paek & Lee, 1993: 743-756; Gudienė et al., 2013: 392 – 397)

5. Discussion of Findings

The results suggest inherent poor project management practices in the Zambian public construction sector, constituting process need areas within case firms that could benefit from implementing strategic planning. It implies a need to identify and manage country-specific factors affecting construction infrastructure management and weaving together country-specific strategies for addressing tender-price variability and perceived overpricing. Occurrences of late engagement of supervising consultants indicate management negligence and a lack of strategic planning. It also confirms the existence of interference and indecision by top management.

The study demonstrates that least-price bidding does not ensure maximum value in construction. Therefore, evaluating bids solely based on the lowest-bid system creates challenges in achieving a value-based procurement system. Khan and Khan (2015) found the lowest-bid procurement approach to be undesirable due to; “inferior quality of constructed facilities, high incidence of claims and litigation, and frequent cost and schedule overruns.”

Results in Table 4 confirm the existence of cost and schedule overruns. The study finds excessive and questionable variations in implementing projects in the Zambian context. An optimal bid price is significant in winning a construction contract. However, Wang et al. (2012) affirm that making accurate pricing in a bid is enormously expensive and time-consuming. Hence, contractors determine the bid price by maximizing expected profit while assessing the probability of winning, underlying conditions on bid items, client characteristics, and competition level.

Table 4 highlights the dangers of this simplified approach to bidding as it leads to questionable and uncompetitive rates. The trend contributes highly to price volatility and uncertainty. Price volatility is a significant risk in construction projects (Abdulrazaq, 2017). Every construction industry is unique and thus requires the development of industry-specific strategies to address price volatility. Abdulrazaq (2017) argues that managing price volatility must ensure the “inclusion of price adjustment clauses, fast track and Lean project delivery method, risk management method, contingencies, early procurement method, and use of price cap contract and use of ICT.”

Second, poor-quality projects confirm inadequacies in detecting contractor malpractices at the procurement stage. Unbalance pricing strategies are illegal methods that reduce the client’s position and contractors’ incentive to complete the project as they lose their financial motivation. Research regarding unbalanced bidding dates back to 1959 when Martin Gates proposed an alternative model to the then-balanced model by Friedman (1956). These unbalanced pricing strategies usually result in client overpayment on the project as contractors aim to increase profit and cash flow (Nikpour et al., 2017). Nikpour et al. (2017) found that unbalanced pricing methods are challenging to detect, posing significant consequences on the client’s cost liability of implementing a project. Unbalanced bidding hurts competition by getting rid of genuine bidders by placing extremely low bids. Low-priced bids may earn the contractor huge profits.

There are models capable of identifying a combination of item prices to generate high profit for the contractor at the client’s and the project’s expense. On the other hand, should they turn negative, they put the client under a significant financial burden by challenging the economic stability of the project through poor quality work and increased corruption (Prajapati & Bhavsar, 2017: 159). In agreement, this study establishes significant procurement-related challenges, including the questionable award of contracts, non-adherence to procurement procedures, unjustified single sourcing, over-procurement, inconsistent application of evaluation criteria, and irregular contract documents. The study further argues that these factors significantly influence construction tender-prices development. In Table 5 and Table 7, the study finds that, on average, construction tender prices increased by an average of 31.4% per annum for upgrading roads to bituminous standards between 2008 and 2018.

Third, delayed payments confirm a lack of financial planning, ring-fencing practices, and benchmarking due to poor utilization of technology and record-keeping on other projects (Table 4). Initiating procurement quality controls generate improved competitiveness from a price viewpoint through the value-added competencies of the procurement function. In construction, procurement quality controls allow for significantly high procurement performance leading to the best possible price to meet the client’s needs (Munyimi, 2019). However, procurement functions in the public face numerous challenges. Extraordinary challenges include a significant lack of empirical research on the impact of public procurement systems on price or cost levels in the construction sector. Gray et al. (2020) argue that current procurement decisions are too focused on cost minimization at the expense of stakeholder value. They propose a new approach known as "total value contribution" as an extension of "total cost of ownership" methods that broaden the factors during a procurement exercise. They argue that putting value first through procurement would increase organizational outcomes.

Fourth, the lack of detailed engineering designs and questionable project awards are evidenced by increased project costs during construction via variations (Table 4 and Figure 2). An evaluation of literature findings shows the complexities of establishing adequate controls for managing construction-tender pricing. Nový et al. (2016) argue that a precise determination of construction-tender price is essential for project success. However, the process is tedious and insists on developing correct tools for pricing based on the specific situation and detailed designs for the project. Literature relating to investigations into factors affecting tender-price determination in construction, current tender price controls in practice, and effects of public procurement warrants a particular focus on how contractors' price for construction at tendering and highlighting significant risk-related factors. However, a lot of research explores project risk-related issues from a project implementation perspective, thereby ignoring the implementation of procurement strategies that consider price reduction implications at the tender stage. The trend leads to the development of contract delivery models that inadequately address the potential value of pricing in construction projects and fail to establish possible strategies to overcome overpricing.

7. Conclusion

The impact resulting from rising prices in the construction industry establishes matters of principle applicable to sustainable development and the general economics of the country. The government requires the development of practical policies that could significantly curtail construction prices while incentivizing the public construction sector by establishing a more rational tender pricing system that meets all stakeholders' needs. In developing countries like Zambia, governments emphasize the cost of construction projects and the price of construction contracts. One of the principal achievements in that regard has been implementing the lowest bid selection/or procurement approaches. However, the client's attitude towards cost-benefit analysis remains an important influence on whether a project comes with an acceptable price tag. In this regard, construction price is critical in delivering public-sector construction projects.

Construction tender overpricing is a commonplace practice contributing to tender price inflation and variability during the procurement phase of public sector projects. The building process itself is uncertain, particularly concerning ground conditions. Construction tender-price inflation reduces public investments' effectiveness and requires governments to raise additional finance to execute a similar quantum of private construction works. This negatively affects the general economy as public works contract overpricing diverts funds from other projects. Developing nations such as Zambia fund additional construction overpricing from reserves or borrowed funds to meet their planned developmental obligations. In extreme cases, this may lead to the contraction of enormous domestic and foreign debts. Therefore, construction overpricing is a significant problem for developing nations and construction sectors. It is a source of political disagreements, frustrates project intentions, and strains public confidence. Therefore, preventing construction overpricing is a crucial objective during contracting construction projects.

7.1 Recommendations

This study recommends further investigations into common causes of overpricing on public sector projects. The inquiry should include a detailed analysis examining how contractors prioritize projects and identifying critical factors preventing construction project overpricing. Considering that there are various solutions to the construction industry's challenges, the long-standing solutions require developing a tailor-made methodology that constitutes problem identification, redesigning, implementation, and continual change in the processes in the construction industry. Thus, there is a need to provide a model that proposes a collective practical solution to eminent and country-specific construction sector challenges.

The study recommends designing a tailor-made industry-specific model prescribing a country-specific key to improving tender prices. It entails the government identifying country-specific factors affecting tender prices to develop a better-managed and more controlled tender–price inflation model.

7.2 Limitations

The lack of detailed project data from the case firm led to the use of limited factors such as length and tendered prices only. More specific information regarding road width; layer thickness; loading capacity; number and type of culverts; number and type of bridges are required. It would have permitted better project categorization for analyzing more similar projects and improved model prediction significantly. However, the study took caution in using such available data to successfully demonstrate the model's operational principles.

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An Assessment of Awareness and Barriers to the Application of Lean Construction Techniques in Kano State, Nigeria

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Abstract
Generally, the construction industry in most developing countries perform below acceptable quality standard and it is associated with cost and schedule overruns. To improve the efficiency and effectiveness of the construction process, many countries adopt lean construction. However, previous studies indicated that the application of lean construction techniques is low in developing countries. This study aims to assess the level of awareness and barriers to the application of lean construction techniques in Kano State, Nigeria. The study adopted a quantitative approach, whereby 200 questionnaires were administered to construction practitioners in the study area. A total of 159 were returned completed, representing a 79.5 percent response rate. The data collected were analyzed using the mean score. The results reveal that the level of awareness/knowledge of lean techniques among construction practitioners in the study area is low. In addition, the study found that the major barriers to the application of lean techniques in construction projects are the absence of awareness workshops to enhance understanding of LC and the lack of education and training required to implement lean construction. This study can contribute to improving the understanding of construction practitioners and other stakeholders in the industry on barriers to the application of lean construction techniques and how to tackle them.

Keywords: Awareness; Barriers; Construction projects; Lean techniques; Questionnaire survey.

1. INTRODUCTION

The construction industry helps in improving the quality of life of people by providing the necessary socio-economic infrastructure such as roads, hospitals, and schools (Towey, 2012; Aje et al., 2009). However, the industry is known for low performance (concerning project quality, budget, and schedule), poor project management, and an increase in rework and defects (Ameh et al. 2010; Aje et al., 2009; Ramani and Lingan, 2021; Albalkhy and Sweis, 2022 Aslam et al. 2022). In developing countries where a significant percentage of materials and equipment are imported, these problems can be especially costly.

To improve construction project delivery, many countries adopt lean construction (Ballard and Howell, 2003; Albalkhy and Sweis, 2022). Lean construction (LC) is a method that improves effectiveness and efficiency in construction delivery processes. It focuses on waste reduction, value maximization, and meeting end users' satisfaction, through continuous improvement (Forbes and Ahmed, 2011; Koskela 2002, 1999; Pinch, 2005; Sarhan et al., 2017; Mohammadi et al. 2022). Generally, lean construction facilitates effective management of the three goals of production that is transformation, flow and value (Koskela, 1992; Mano et al., 2021).

The term "lean" was coined by a research team working on the international automobile industry (Ballard and Howell, 2003). The original thinking was to develop a delivery process that met customers' needs with very little inventory, and failure to meet customers' needs was considered as waste (Forbes and Ahmed, 2011). The drivers of lean include waste elimination, process control, flexibility, optimization, people utilization, continuous and efficient improvement, and value to customers (Ogunbiyi et al., 2013).

The basic principles of lean thinking are: specifying a value for specific products from the perspective of a customer; identifying the value stream for each product (all steps in the process that add value based on customer perspective); creating process flow without interruptions; allowing customers pull production (produce only what the customer wants just in time) and manage continuous improvement and perfection (Womack and Jones, 2003; Ghosh and Burghart, 2021).

The application of lean principles in construction projects results in better utilization of resources. It also results in better construction quality in completed facilities,

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eliminates waste, increases value/client satisfaction, and ensures higher levels of safety (Ayarkwa et al., 2011; Aziz and Hafez, 2013; More et al., 2016; Shurrab and Hussain, 2018; Albalkhy and Sweis, 2022, Ghosh and Burghart, 2021; Mano et al., 2021). Thus, lean construction is an effective management tool to enhance productivity in construction. However, despite the benefits of lean principles in improving construction project performance, it has been reported that there are poor or non-application of most of them in Nigeria (Oladiran, 2017; Babalola, et al., 2018). Thus, there is a need to address this problem.

This study aims to assess the level of awareness and barriers to the application of lean construction techniques in Kano State, North-west Nigeria, intending to improve construction projects' performance there. Most of the studies (Igwe et. al., 2022; Ghosh and Burghart, 2021; Shurrab and Hussain, 2018) on lean construction were conducted overseas. Limited studies had been conducted in Nigeria, and those studies concentrated on assessing the extent of implementing lean construction in Nigeria while failing to assess the awareness and barriers to the application of lean construction techniques. Thus, the present work is set to address this gap.

This study is intended to answer the following research questions:

1. What is the level of awareness/ knowledge of various lean construction techniques among construction practitioners in Kano State, Nigeria?
2. What are the barriers to the application of lean techniques in construction projects in Kano State, Nigeria?

The present study contributes to the body of knowledge by identifying barriers to the implementation of lean construction techniques in Nigeria. As suggested by Mano et al. (2021), understanding the barriers will help construction firms to concentrate their efforts towards determining the best way to tackle them for a better chance of success.

2. LITERATURE REVIEW

2.1 Lean Construction Techniques

Several studies were conducted in various countries to assess the level of applications of lean construction techniques. Enshassi et. al. (2019) investigated the application of eight lean construction techniques in reducing accidents in construction projects in Gaza Strip. The techniques studied includes last planner system, increased visualization, 5S, poka-yoke, daily huddle meetings, first run studies, kaizen, and 5 why's. The results of the study revealed that, lean construction techniques were poorly applied in construction projects in Gaza Strip.

Aslam et al. (2022) developed a framework for the selection of appropriate lean tools based on their objectives and functionalities. The lean tools/ techniques presented in the study includes last planner system, just in time, concurrent engineering, daily huddle meeting, visual management, first run studies, six sigma, fail-safe for quality and safety, value stream mapping, 5S, and kaizen, among others.

Babalola et al. (2018) assessed the awareness and adoption of 32 lean tools/ techniques in the Nigerian construction industry. The tools studied comprised of total quality management, last planner system, visualization tools, just-in-time, six sigma, concurrent management, kaizen, fail safe for quality and safety, and first run study among others. The study concluded that, the level of adoption of lean techniques in Nigerian construction industry was low.

Ogunbiyi et al. (2013) conducted an empirical study of the impact of lean construction techniques on sustainable construction in the UK. The identified lean techniques include just-in-time, visualisation tool, daily huddle meetings, value analysis, value stream mapping, total quality management, fail safe for quality, 5S, total preventive maintenance, first run studies, last planner system, concurrent engineering, pull approach, kanban, kaizen, and six sigma. Earlier, Salem et al. (2005) conducted a similar study to test the effectiveness of some lean construction techniques including last planner, increased visualization, daily huddle meetings, first run studies, 5S process, and fail safe for quality.

Aziz and Hafez (2013) assessed the application of lean thinking in construction industry in Egypt. The study concluded that, lean construction can be achieved using the following techniques: concurrent engineering, last planner, daily huddle meetings, kanban system, quality management, and visual inspection. Sarhan et al. (2017) investigated state of lean construction implementation in Saudi Arabia. The identified techniques that support lean implementation includes last planner, value stream mapping, standardized work, the 5S process, kaizen, total quality management, increased visualisation, fail-safe for quality and safety, daily huddle meetings, first run studies, the five why's, just in time, plan of conditions and work environment in the construction industry, concurrent engineering, kanban system, poka-yoke, target value design, and partnering. The study concluded that, lean construction techniques were not adequately implemented in Saudi Arabia.

From the above literatures it can be noted that lean construction can be achieved through applications of several techniques. Table 1 presents 12 lean construction tools/ technique which have been mentioned in several studies.

2.2 Barriers to the Application of Lean Construction Techniques

Several barriers to the application of lean construction were identified by previous researchers. For instance, Alarcon et al. (2006) explore barriers to implementation of lean construction to include lack of time for implementing LC techniques in projects, lack of training, lack of self-criticism to learn from errors, low understanding of LC concepts, Weak communication, and transparency among participants. Shang and Pheng (2014) identified 22 barriers to implementation of lean construction, these were categorized into six groups namely people and partner barriers, managerial and organizational barriers, lack of support and commitment barriers, cultural and philosophical barriers, government related barriers and procurement related barriers.

More et al. (2016) concluded that the major barriers to implementing lean in Indian construction industry were lack of lean awareness and understanding, cultural and human attitude issues, commercial pressure, lack of proper training, long implementation time required, lack of top management commitment, and educational issues.

Table 1: Summary of Lean Construction Tools/Techniques

Lean Tools/Techniques	Description	Sources
Last Planner System (LPS)	This is a lean tool/technique for planning and control. It smooths workflow and addresses project variability to increase productivity in construction. The components of last planner system are look ahead planning, commitment planning, and learning.	Enshassi *et.* al. (2019), Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Salem et al. (2005), Aziz and Hafez (2013), Sarhan et al. (2017), Ballard and Howell (2003)
Daily Huddle Meetings	These are short daily start-up meetings held as a means for continuous improvement. The project team members discuss issues related to the progress of the work plan, as well as challenges. The tool enables members to plan ahead and address problems before affecting project's progress.	Enshassi *et.* al. (2019), Aslam *et* al. (2022), Ogunbiyi et al. (2013), Salem et al. (2005), Aziz and Hafez (2013), Sarhan et al. (2017),
Value Stream Mapping	This tool facilitates evaluation of present state and planning a future state for a sequence of activities that make a product or services, from the start to finish. Any non-value adding activity in the present state will be removed or make it more efficient when planning future state.	Aslam *et* al. (2022), Ogunbiyi et al. (2013), Sarhan et al. (2017), Forbes and Ahmed (2011), Ramani and Lingan (2021).
Just-In-Time	This is a method of production that ensures delivery of actual material, manpower and equipment etc needed, at the exact time needed and of the actual quantities needed. This tool reduces flow times: production times and response times.	Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Sarhan et al. (2017), Howell and Ballard (1998), Forbes and Ahmed (2011).
Increased Visualization	This technique is about using visual tools such as sign, diagrams and labels to display important information to workers at construction site. This comprises progress charts and schedules, as well as safety signs. The technique can lead to high level of participation among the workforces.	Enshassi *et.* al. (2019), Babalola et al. (2018), Ogunbiyi et al. (2013), Salem et al. (2005), Aziz and Hafez (2013), Sarhan et al. (2017), Forbes and Ahmed (2011).
Total Quality Management	This technique enables organizations and their workers to concentrate on findings new methods to continuously improve the quality of their products and services.	Babalola et al. (2018), Ogunbiyi et al. (2013), Aziz and Hafez (2013), Sarhan et al. (2017), McGeorge and Palmer (2002), Forbes and Ahmed (2011).
Five (5) S Process	The tool facilitate workflow and reduces various forms of wastes and thus improve the construction project performance. It also supports standardization of work processes which should be sustained for continuous improvement. The 5S words stands for (Sort, Straighten, Shine, Standardise and Sustain).	Enshassi *et.* al. (2019), Aslam *et* al. (2022), Ogunbiyi et al. (2013), Salem et al. (2005), Sarhan et al. (2017), Abdelhamid and Salem (2005), Forbes and Ahmed (2011).
First Run Studies	First Run Studies (Plan-Do-Check-Adjust) involves planning critical or repetitive activities, implement the plan and study the activities, analyses and determine the most effective method of doing the work. The work method is then redesign and become new standard, and this process are repeated.	Enshassi *et.* al. (2019), Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Salem et al. (2005), Sarhan et al. (2017),
Kaizen	Kaizen is a continuous improvement tool that maximize value and reduce waste. It seeks to standardize processes and eliminate or reduce waste. It starts with recognizing a problem, and subsequently a need for improvement.	Enshassi *et.* al. (2019), Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Sarhan et al. (2017), Forbes and Ahmed (2011),
Fail Safe for Quality and Safety	This is a technique that prevents defective parts from flowing through the process. Fail safe for quality depends on the generation of ideas that signify for potential defects. The project manager selected the activity that had potential quality defect problems to further study for prevention purposes.	Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Salem et al. (2005), Sarhan et al. (2017),
Concurrent Engineering	Concurrent engineering (CE) is a systematic approach in which activities in design and manufacturing phases of products and their related processes are integrated and manage concurrently. The aim of CE is to reduce time, and cost and uncertainties in project development.	Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Aziz and Hafez (2013), Sarhan et al. (2017), Gunasekaran and Love (1998), Ngowi (2000).
Six- Sigma	Six- Sigma is an improvement strategy that reduces variation in any process to eliminate defects or faults. One of the fundamental components of this strategy is the DMAIC methodology (define, measure, analyse, improve and control).	Aslam *et* al. (2022), Babalola et al. (2018), Ogunbiyi et al. (2013), Maciel-Monteon et al. (2020), Shankar, (2009).

Fadeke et al. (2016) presented 22 barriers to the implementation of lean construction, with absence of awareness program, and lack of adequate training as major barriers.

Enshassi et al. (2021) identified 39 barriers to application of lean construction techniques and categorized them into six groups namely management barriers, financial barriers, educational barriers, government barriers, technical barriers, and human attitudinal barriers. Mano et al. (2021) identified the following as barriers to lean construction: lack of commitment to the team, difficulty in focusing the business on the customer, resistance to change arising from the fear of unknown practices, difficulty getting support and commitment from top management, resistance to change by the leadership, centralization of decisions, insufficient knowledge of managers to manage the change process, and inability to measure project progress. These barriers were synthesized and presented in Table 2.

3. RESEARCH METHODOLOGY

3.1 Method of Data Collection

The study was conducted in Kano State, North-west Nigeria. This state was chosen because it has high concentration of construction activities in the region, as well as for accessibility of data. A questionnaire survey was employed as a method of data collection. According to Sekaran and Bougie (2009), questionnaire is widely used by researchers as an efficient means of data collection, because it can collect data fairly and easily. Initially literature review was carried out in which 12 lean techniques that were severally mentioned in previous studies and 22 barriers to the application of lean techniques in construction were identified and used in the development of the research instrument. The lists of the identified lean techniques and barriers are presented in Table 1 and Table 2 respectively.

A draft questionnaire was then designed and presented to eight experts who have experience or knowledge on lean construction (four professionals and four academicians) for validation. All the observations made by the experts were affected before the development of preliminary questionnaire. Subsequently, a pilot survey was performed to pre-test the preliminary questionnaire. The purpose of the pilot test was to refine the questionnaire to ensure clarity of the questions in the research instrument. This process was suggested by Sekaran and Bougie (2009).

A final questionnaire was then developed and divided into three main sections. Section I is related to the general information of the respondents. Section II includes the list of identified lean techniques. Respondents were required to specify their opinions on the level of awareness/ understanding of the lean techniques using a Five Point Likert Scale ranging from 1 to 5, where 1 represents not aware; 2= less aware; 3= moderately aware; 4= aware; and 5= very aware, this scale was used in a similar study by Babalola, et al. (2018).

Section III contains the list of barriers to the application of lean techniques in construction projects. Respondents were asked to rate the effects of the barriers to the application of lean techniques in their projects using a Five Point Likert Scale ranging from 1 to 5, where 1 represents no effect, 2= low effect, 3= moderate effect, 4= strong effect and 5= very strong effect, this scale was used in a similar study by Enshassi et al. (2021).

The target population of this study was construction professionals with experience in building construction projects who are domiciled in the study area. These comprise architects, builders, civil engineers, and quantity surveyors. The total population was found to be 320 construction professionals as obtained from the directory of members of the respective professional institutions, (Nigerian Institute of Architects, Nigeria Institute of Builders, Nigerian Society of Engineers, and Nigerian Institute of Quantity Surveyors) Kano state chapter.

The study used a sample size 175 construction professionals determined using Krejcie and Morgan's (1970) table. However, 200 questionnaires were administered to take care of non-return ones. The study used the simple random sampling technique to identify and select samples from the population as recommended by Saunders et al. (2012). Internal consistency for the responses of the data collected was calculated using Cronbach’s alpha test as suggested by Pallant (2011).

3.2 Method of Data Analysis

The data obtained from the questionnaire survey were evaluated for normality using statistical means (skewness and kurtosis). All the skewness and kurtosis range from -1 to +1 indicating that they are normally distributed as suggested by Pallant (2011). Subsequently, the data were analyzed using descriptive statistics (frequency, percentages, standard deviation and mean score)

Descriptive analyses (frequency and percentage) were used to analyze the demographic information of the respondents. And in determining the level of awareness of lean techniques in the study area mean score ranking was employed. The same analysis was used in determining the effects of barriers to the application of lean techniques in the study area. This approach was adopted in a similar study by Fadeke et al. (2016). The effect of each barrier was calculated through the following formula used by Fadeke et al. (2016).

$$\boldsymbol{MS} = \frac{\sum_{i=1}^{5} aixi}{\sum xi} \qquad \text{………eq. (1)}$$

Where

- ai = constant expressing the weighting assigned to response i; (ranging from 1 for no effect to 5 for very strong effect),
- xi = frequency of the responses

i = 1, 2, 3, 4, 5.

4.0 DATA ANALYSIS AND RESULTS

This section analyses the data collected from the field survey and presents the results obtained. Out of the 200 questionnaires administered, 159 were returned completed, representing a 79.5% response rate. The response rate is considered good as it is above that of previous studies of Igwe et al. (2022) who reported a response rate of 55%, Rosli et al. (2023) reported 74.3%, while Albalkhy and Sweis, (2022) reported 52.9%.

Table 2: Barriers to the Application of Lean Construction

S/N	Barriers	Sources
1	Lack of management support and involvement in the implementation of lean in construction	Enshassi et al. (2021), Alarcon et al. (2006), Mano et al. (2021), Shang and Pheng (2014), More et al. (2016), Fadeke et al. (2016)
2	Centralization of decision making	Enshassi et al. (2021), Mano et al. (2021)
3	Resistance to change by the management	Enshassi et al. (2021), Mano et al. (2021), Shang and Pheng (2014)
4	Long implementation time required for LC techniques application	Enshassi et al. (2021), Alarcon et al. (2006), Fadeke et al. (2016), More et al. (2016)
5	Poor communication among project parties	Enshassi et al. (2021), Alarcon et al. (2006), Fadeke et al. (2016)
6	Poor coordination among project parties	Enshassi et al. (2021), Alarcon et al. (2006), Fadeke et al. (2016)
7	Inadequate planning to apply LC techniques	Enshassi et al. (2021),
8	Absence of long-term philosophy for construction improvement	Enshassi et al. (2021), Shang and Pheng (2014), Fadeke et al. (2016)
9	High implementation cost of lean construction.	Enshassi et al. (2021),
10	Lack of incentives and motivation to encourage employees to apply innovative strategies	Enshassi et al. (2021), Shang and Pheng (2014)
11	Difficulty in understanding LC concept	Enshassi et al. (2021), Alarcon et al. (2006), Shang and Pheng (2014), More et al. (2016), Fadeke et al. (2016)
12	Lack of knowledge and expertise needed to apply lean construction techniques.	Enshassi et al. (2021), More et al. (2016)
13	Lack of education and training required to implement lean construction.	Enshassi et al. (2021), Alarcon et al. (2006), Shang and Pheng (2014), More et al. (2016), Fadeke et al. (2016),
14	Absence of awareness program to enhance understanding about LC	Enshassi et al. (2021), Fadeke et al. (2016)
15	Lack of government support to construction firms towards implementation of lean construction	Enshassi et al. (2021), Shang and Pheng (2014)
16	Difficulty in the implementation of LC	Enshassi et al. (2021), Fadeke et al. (2016)
17	Resistance to change by employee	Enshassi et al. (2021), Mano et al. (2021), Shang and Pheng (2014)
18	Lack of self-criticism to evaluate oneself shortcomings	Enshassi et al. (2021), Alarcon et al. (2006)
19	poor performance-measurement strategies	Enshassi et al. (2022), Mano et al. (2021)
20	Lack of interest from the client	Enshassi et al. (2021), Fadeke et al. (2016)
21	Lack of agreed methodology for implementing LC	Enshassi et al. (2021), Fadeke et al. (2016)
22	Lack of knowledge sharing among construction organizations.	Enshassi et al. (2021), Fadeke et al. (2016)

4.1 Reliability Test

The reliability of the data collected from the field survey (Internal consistency) was calculated through Cronbach's alpha reliability test as suggested by Pallant (2011). Overall, Cronbach's alpha for the questionnaire was 0.949, meaning that the participants' responses were consistent and the reliability of the scale was very good as suggested by Pallant (2011).

4.2 Demographic Distributions of Respondents

Table 3 presents demographic distributions of the respondents. The results show that, 44% of the respondents work in construction firms, 32.7% in public sector, while 23.3% work in consultancy firm.

In terms of Academic qualification, 48.4% of the respondents hold bachelor's degree and about 20% hold postgraduate degrees in relevant field. The results also reveal that, about 30% of the respondents have 5-10 years of experience in construction industry, 50% have 10-15 years of experience, and 14% have more than 15 years of experience. Thus, based on these results, the respondents have adequate knowledge and experience to provide reliable information.

4.3 Awareness/ knowledge of Lean Construction Techniques among Construction Practitioners in Kano State Nigeria

Table 4 presents the level of awareness of lean construction techniques among construction practitioners in Kano State, Nigeria.

Table 3: Demographic characteristics of respondents

S/N	Variables	Attributes	Frequency	Percentage
1	Organization	Construction firm	70	44.0
		Consultants firm	37	23.3
		Public sector	52	32.7
		Total	**159**	**100**
2	Qualification	National Diploma	17	10.7
		Higher National Diploma	33	20.8
		Degree (B.Sc.)	77	48.4
		Master's Degree	31	19.5
		Ph.D. Degree	1	0.6
		Total	**159**	**100**
3	Experience	< 5 years	9	5.7
		5-10 years	49	30.8
		10-15 years	79	49.7
		Above 15 years	22	13.8
		Total	**159**	**100**
4	Profession	Architect	35	22.0
		Quantity surveyor	46	28.9
		Builder	30	18.9
		Civil engineer	48	30.2
		Total	**159**	**100**

Table 4: Level of Awareness of Lean Construction Techniques

SN	Techniques	Mean	Std. Deviation	Rank
1	Last planner system	3.37	1.265	1
2	Daily huddle meetings	3.17	1.384	2
3	Increased visualization	2.83	1.223	3
4	Total Quality Management	2.80	.964	4
5	First run studies	2.53	1.168	5
6	Just-In Time	2.33	1.139	6
7	5S (Visual Work Place)	2.29	1.172	7
8	Fail Safe for quality and safety	2.24	1.198	8
9	Concurrent engineering	2.23	1.148	9
10	Value stream mapping	2.22	1.215	10
11	Six sigma	2.14	1.084	11
12	Kaizen	2.03	1.124	12
	Average	**2.52**		

The results reveal that the overall mean score of awareness level of lean construction techniques among construction professionals in the study area was 2.52, which is less than the average mean score of 3 (for a 5- point Likert Scale ranging from 1-5) (Enshassi et al., 2019). The results in Table 4 also indicated that the two top-rated lean techniques with awareness levels above average (mean score of 3) were the last planner system (mean score = 3.37) and daily huddle meeting (mean score = 3.18). Whereas the awareness levels of the respondents in the remaining ten lean techniques were below average (mean scores range from 2.03- 2.83). The last three ranked lean techniques in terms of awareness were value stream mapping, six-sigma, and Kaizen.

4.4 Ranking Barriers to the Application of Lean Construction

Table 5 presents the respondents' views on the effects of barriers to the application of lean construction techniques in the study area. The Table indicates that the mean effect values of the 22 barriers identified from the literature range from 2.26 to 4.18. Analysis of the results show that two barriers have mean scores greater than 4.00, ten barriers have mean scores between 3.00 and 4.00, and the remaining ten barriers have mean scores below average (less than 3.00).

Table 5: Barriers to the Application of Lean Construction

Barriers	Mean	SD	Ranking
Absence of awareness program to enhance understanding about LC	4.18	0.73	1
Lack of education and training required to implement lean construction.	4.09	0.61	2
Lack of management support and involvement in the implementation of lean in construction	3.97	0.53	3
Resistance to change by employee	3.86	1.01	4
Lack of knowledge and expertise needed to apply lean construction techniques.	3.78	0.84	5
Resistance to change by the management	3.72	0.91	6
Absence of long-term philosophy for construction improvement	3.59	0.70	7
Lack of incentives and motivation to encourage employees to apply innovative strategies	3.46	0.86	8
Lack of government support to construction firms towards implementation of lean construction	3.39	0.59	9
Lack of knowledge sharing among construction organizations.	3.22	1.20	10
Centralization of decision making	3.20	0.63	11
Poor performance-measurement strategies	3.17	0.68	12
High implementation cost of lean construction	2.87	0.78	13
Difficulty in understanding LC concept	2.79	0.54	14
Inadequate planning to apply of LC techniques	2.72	0.68	15
Difficulty in the implementation of LC	2.66	0.92	16
Poor coordination among project parties	2.56	0.73	17
Lack of interest from the client	2.54	1.19	18
Lack of self-criticism to evaluate oneself shortcomings	2.51	0.83	19
Poor communication among project parties	2.31	1.07	20
Long implementation time required for LC techniques application	2.29	0.79	21
Lack of agreed methodology for implementing LC	2.26	0.69	22

5. DISCUSSION OF FINDINGS

The results from this study indicated that there was a low level of awareness of lean techniques among construction practitioners in the study area (overall mean score was 2.52). Awareness and knowledge of lean techniques among construction practitioners can increase the level of applications of the techniques in construction projects which will result in waste minimization and improve performance (Babalola, et al., 2018). The finding agrees with Oladiran (2017) that lean construction techniques were poorly implemented in Lagos State, Nigeria. However, the finding is contrary to that of Babalola, et al. (2018) and Fadeke et al. (2016) who found that there was an appreciable level of awareness and knowledge of lean construction and its techniques among construction practitioners in their study area. The contradiction of these findings with the current study may be as a result of different study areas. The practitioners in their study areas may be ahead in terms of the level of awareness of lean tools and techniques. Value stream mapping, six-sigma, and Kaizen were the least ranked techniques in terms of awareness level by the respondents. These are important lean construction techniques that reduce process variability, eliminate defects, and ensure continuous improvement (Maciel-Monteon et al., 2020; Forbes and Ahmed, 2011).

On the other hand, one of the objectives of this study is to explore barriers to the application of lean construction techniques in the study area. The results in Table 5 revealed that the absence of awareness workshops to enhance understanding of lean construction among construction practitioners has been ranked the first (most important) barrier. This result is in line with the finding reported in Table 4 that there was a low level of awareness of lean construction techniques in the study area. Lack of awareness of the benefit of lean in value addition and waste reduction in construction projects can have a significant influence on the level of implementation of lean techniques in construction projects. This barrier can be overcome by organizing regular conferences and seminars for construction practitioners to enlighten them on the benefits of the application of lean techniques in their projects. The finding is consistent with previous studies (Fadeke et al., 2016; Enshassi et al., 2021 .

The second most important implementation barrier is the lack of education and training needed by construction practitioners to implement lean construction. Without adequate education and training on lean construction techniques, construction practitioners will not be able to have the required knowledge and understanding to apply the concept in their projects. To overcome this barrier, the lean construction concept should be incorporated into the curriculum of higher institutions of learning in Nigeria. This can assist in producing potential construction professionals with adequate knowledge of lean thinking. This finding agrees with previous studies (Alarcon et al., 2006; Fadeke et al., 2016; Enshassi et al., 2021).

Lack of management support and involvement in the implementation of lean in construction has been ranked as the 3rd barrier to lean techniques application. The successful application of lean construction techniques depends on management support and commitments (Enshassi et al., 2021). To overcome this barrier, top management should support their employees with the necessary training and resources required for the effective application of lean techniques in their projects. This finding is in line with the previous studies (Shang and Pheng, 2014; Enshassi et al., 2021; Mano et al., 2021).

Resistance to change by employees has been ranked as the 4th barrier to the application of lean construction techniques. Several construction practitioners in the study area are unfamiliar with most of the lean techniques. Thus, fear of new practices may generate resistance to the application of the techniques by the employees. This barrier can be overcome by organizing training workshops for construction practitioners on lean construction to be equipped with adequate knowledge and skills for the effective application of the techniques in their projects. This barrier was ranked 19 of 22 barriers by Shang and Pheng, 2014; and 22 of 39 barriers by Enshassi et al. (2021).

The lack of knowledge and expertise needed to apply lean construction techniques has been ranked as the fifth barrier in order of importance. Some construction practitioners in the study area do not have adequate technical skills to apply most of the lean techniques in their projects. Without adequate knowledge and experience in lean, construction practitioners cannot apply lean techniques in their projects. The finding is consistent with previous studies (Enshassi et al., 2021 ; More et al., 2016; Shang and Pheng, 2014).

Resistance to change by the management has been ranked as the sixth barrier in order of importance. Fear of unfamiliar practices may generate resistance to the implementation of lean construction by top management due to a misunderstanding of the concept. To overcome this barrier, top management of construction companies should be prepared to accept changes in terms of the adoption of innovation and management techniques. This result is in agreement with previous studies (Mano et al., 2021; Shang and Pheng, 2014).

The seventh-ranked barrier was the absence of long-term philosophy for construction improvement. The absence of a long-term vision for construction improvement is a major hindrance to the implementation of lean construction. This barrier was ranked 1 of 22 barriers by Shang and Pheng (2014), and 12 of 22 barriers by Fadeke et al. (2016).

Long implementation time and lack of agreed methodology for implementing lean construction were the lowest-ranked barriers to the application of lean techniques. These were ranked 36 and 13 of 39 barriers by Enshassi et al., (2021), and ranked 14 and 9 of 22 barriers by Fadeke et al. (2016). The results implied that the respondents do not consider these barriers as important in the application of lean construction techniques in the study area.

6. CONCLUSION

This study was conducted to determine the level of awareness and barriers to the application of lean construction techniques in Kano State, Nigeria. The finding from the study indicated that the level of awareness/ knowledge of lean techniques among construction practitioners in the study area was low with an average score of 2.52 on a scale of five. It can be concluded that construction firms in the study area are still using traditional approaches in project management instead of adopting innovative approaches that improve project performance. The study also found that the major barriers to the application of lean techniques were the absence of awareness workshops to enhance understanding about lean construction, lack of education and training required to implement lean construction, and lack of management support and involvement in the implementation of lean in construction. To address these challenges, regular workshops and seminars should be organized for all stakeholders of the construction industry to be enlightened on the benefits of the application of lean techniques in their projects. In addition, there is a need for the establishment of a Lean Construction Institute in Nigeria to promote and monitor lean construction practices in the country.

This study helps improve the understanding of construction practitioners and other stakeholders in the construction industry on barriers to the application of lean construction techniques, as well as the best way to tackle them. The study also provides a basis for evaluating barriers to the adoption of innovation or new management techniques in construction projects and adds to the existing barriers to the application of lean construction techniques. Despite the objective of the study was achieved, the followings are some limitations of the study. Firstly, the sample size used for the conduct of this study was not large enough, however, it is sufficient for statistical analysis. Secondly, descriptive statistics (Mean scores) were used in data analysis. Thus, the findings of this study cannot be generalized. And thirdly, the geographical boundaries of the study cover only the northwest of Nigeria. Thus, a future study could be conducted with a larger sample size that covers the entire country.

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Sources and Control Measures of Crystalline Silica Dust in a Road and Building Project in Zambia

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Abstract

Construction works bring about silica dust hazards, part of the dust produced by staple materials such as concrete and sand. Silica dust, when inhaled in high quantities or for an extended period, is lethal to workers as it causes silicosis, which has no known cure. Several studies have reported high exposures of silica dust in construction, especially where there are no controls. As Zambia sets to become a middle-income country by 2030, increased projects have increased exposure to silica dust and chemicals that cause diseases. There is a likelihood of an increase in the generation of dust and possible contact with silica dust and chemical irritants. Therefore, the paper examines the controls used in the construction industry in Zambia and recommends improvements for silica dust exposure controls to safeguard workers' health. A cross-sectional study was conducted on a building and a road project as two case studies. Carpenters, butchers, tilers, bricklayers, demolition workers, painters and labourers were purposively sampled. The total sample size was 100 workers, 50 for each case study. The sample size was established at 10% of the estimated population of 1012. Moreover, the sample size was limited to 100 because the number of workers was reduced due to Covid-19 by the Ministry of Health. Data was collected using overt observation using an observation schedule and a camera as data collecting tools. The data were qualitatively analysed using the constant comparative method. The results showed that the combination of water and dust or face masks was the common control used on both sites. Despite the use of water and facemasks, there was still high exposure to dust and chemicals because of inadequate controls. Skilled well-fitted, recommended personal protective equipment was rarely provided. Moreover, the respiratory masks commonly used were Covid-19 facemasks which were inadequate for silica dust reduction. The only controls used were engineering control and the use of PPE. The findings suggest that workers are at risk of health problems in the Zambian construction industry brought about by inhaling dust. The combination of all methods in the hierarchy of controls and the incorporation of all construction stakeholders in ways of silica dust exposure controls are recommended. The study serves as an awareness to construction stakeholders of the health concern of high dust exposure levels and inadequate controls. There is a need for measuring actual concentrations of crystalline silica dust with and without controls.

Keywords: Controls, Construction, Observation, Silica Dust, Zambia

1.0 Introduction

The importance of the construction industry is evidenced in many infrastructure developments, such as roads, bridges, housing units and shopping malls (Tente and Muya, 2014). However, a staple hazard of construction activities is respirable crystalline silica dust (RCS). The RCS is part of dust, which is generated from many processes in different industries of the world economies, such as agriculture, mining, construction and manufacturing. During land tilling, agriculture dust is generated (Swanepoel, 2012). The mining industry generates dust from crushing, extraction, drilling and stone breaking. Gholami et al. (2012) found high dust concentrations in the Iron-stone mine in Iran. The construction industry generates dust from breaking, cutting and crushing concrete (Normohammadi et al., 2016). Dust is also generated in the dental laboratory from sanding and sandblasting through porcelain and polishing (Kim et al., 2002). As part of construction dust, silica dust is the most hazardous part of dust (Li et al., 2019). It is contained in commonly used construction materials such as concrete and sand. Silica dust is produced when materials that contain

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silica are being worked on, like cutting, breaking and grinding (Flanagan et al., 2003). However, silica dust has not been well characterised because of the frequent turnover of personnel and continually changing workplaces, tasks and environmental conditions (Flanagan et al., 2003). Several studies, such as Kirkeskov et al. (2016), Normohammadi et al. (2016) and Li et al. (2019), have shown that construction dust contains high silica concentrations that pose health risks of occupational diseases such as renal disease, tuberculosis, chronic obstructive pulmonary disease, lung cancer and silicosis (HSE, 2012).

The evidence of the prevalence of respiratory symptoms and skin diseases in Zambia's construction industry indicates that workers are exposed to dust and chemical irritants that are harmful to them (Nsunge, 2019; Tente, 2016). Inhaling silica dust above Permissible Exposure Limits (PELs) causes symptoms of respirable diseases. When exposure is high, or for a long time, it leads to silicosis, which has no known cure. On the other hand, exposure to chemical irritants causes skin disease symptoms common in construction in Zambia (Tente, 2016). Symptoms of respirable and skin diseases are caused by exposure to silica dust and chemical irritants that affect workers' health. Moreover, they may lead to death and cost projects regarding lost man-hours, hospital bills and compensations.

Reduction in exposure levels to silica dust and chemical irritants reduces symptoms of respirable and skin diseases. This, in turn, safeguards workers' health and improves production on construction projects (Tente and Mwanaumo, 2022). Moreover, in line with Sustainable Development Goal number three of achieving good health and well-being by 2023, it is a requirement that the number of deaths and illnesses caused by hazardous chemicals and air pollution and contamination are reduced. The high global estimated number of workers exposed to silica dust in the construction industry is a serious concern (Bello et al., 2019; IOM, 2011; Motshelanoka, 2005). As Zambia sets to become a middle-income country by 2030, there has been an increase in construction projects and a likelihood of an increase in the generation of dust and possible contact with silica dust and chemical irritants. This is evidenced in the studies by Nsunge (2019) and Tente (2016), who reported 43% and 22% prevalence of symptoms of respiratory diseases, respectively. The prevalence of respiratory diseases was attributed to exposure to dust.

The symptoms of respiratory and skin diseases affect workers' health and negatively impact projects through lost man-hours, low productivity, hospital bills and compensations. Therefore, the study examines the sources of silica dust and controls used in a road and building project in Zambia. The findings and recommendations would provide knowledge on the dust prevalent on projects towards enhancing good safety culture among construction stakeholders in the construction industry in Zambia.

2. Literature Review

2.1 Respirable Crystalline Silica Dust Exposures in Construction

Silica is found in construction materials such as sand, stone, brick, mortar and concrete (Occupation Safety and Health Administration-OSHA, 2017). Therefore, when working with these materials, silica dust is produced. Since silica dust is produced from construction staple materials, it is one of the important hazards in the industry (Flanagan et al., 2003; Wiebert et al., 2012; Kirkeskov et al., 2016). Some of the common construction activities that produce silica dust are surface grinding and finishing, tuck-point grinding (mortar removal), rock and surfacing grinding, sanding of drywalls, tile cutting, brick and concrete block cutting and abrasive blasting (HSE, 2012).

Several studies have found that skilled construction workers such as demolition workers (Lumens & Spee, 2001; Normahammadi et al., 2016; Kirkeskov et al., 2016), abrasive blasters, surface and tuck-point grinders, jackhammers, rock drills, masons and labourers (Flanagan et al.,2003); and painters (Rappaport et al., 2003) experience silica dust concentrations higher than the PELs. In addition, several countries have recorded high silica exposures that pose a high risk of respiratory diseases to construction workers. In Switzerland, 80% of the measurements of exposure levels for demolition and reconstruction were above the PEL (Moser, 1992), Finland recorded high silica exposure levels during the dry season (Riala, 1988), and the Netherlands recorded high silica exposure concentrations (Lumens and Spee, 2001).

2.2 Respirable Crystalline Silica Dust Controls in Construction

There are five controls in the hierarchy of controls for respirable crystalline silica dust, namely, elimination, substitution, engineering control (use of Local Ventilation Exhaust (LEV), administration control (provision of training/personal hygiene) and the use of Personal Protective Equipment (PPE) (Tente et al., 2022). The order of importance or most effective controls are from the bottom up to the top, as shown in Figure 1.

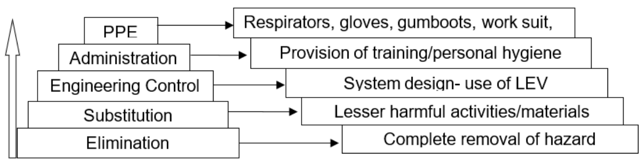

Figure 1: Hierarchy of controls (Source: Tente et al.2022)

According to Thorpe et al. (1999), the method of elimination is the most effective control, yet it is not recommended in construction as silica-content materials such as sand and cement are staples. The second in the hierarchy is the substitution method. One example of a substitution method is the replacement of the onsite mixing of concrete with ready-mix concrete (Wu et al., 2016). Engineering control involves the removal of the hazard at the source before it enters the air, such as wet suppression (Thorpe et al., 1999; Lumens and Spee, 2001; Flanagan et al., 2003) and the use of LEV (Hasan et al., 2012). An LEV system consists of a hood or enclosure to capture a contaminant, an air pollution control device to clean the air, and an air mover to provide airflow through the system (Raynor and Peters, 2016).

Another exposure control is administrative control, which involves training the workers on the risks of silica dust and chemical irritant hazards to reduce exposures (NIOSH, 2009; Mwanaumo et al., 2014). Also, training is recommended in terms of effectively using the tools to reduce exposure to silica dust (HSE, 2012). One example of administrative control is ensuring that workers rotate the activity in terms of shifts to keep exposure under PEL (Tente and Mwanaumo, 2022). For silica dust exposure reduction, properly selecting the Respirable Personal Equipment (RPE) and proper storage is key (Radnoff and Kutz, 2013). The last in the controls that are used is the use of adequate PPE. According to Flanagan et al. (2003), using PPE alone is inadequate in controlling the exposures experienced in construction. Despite this fact, to reduce levels of exposure, it is recommended that management provide full proper PPE (Tente and Mwanaumo, 2022). This would work with other methods, especially since PPE is the most commonly used control in construction (Reed et al., 1987). Nevertheless, in Kirkeskov et al. (2016), few workers used personal respiratory protection during the dustiest work.

According to authors (Kirkeskov et al. 2016, Mwanaumo et al. 2018; Mambwe et al. 2021), exposure levels to silica dust differ from profession to profession and task to task despite working in the same environment. The fact that most studies that have been done concerning respirable crystalline silica exposure controls have been on the on-tools controls such as grinders, cut-off saws, and hand-held saws is evidence that engineering control is a practical method (Tente et al., 2022). However, in Tente et al. (2022), where results from eight studies by different researchers were analysed, no single control method adequately reduced silica dust below the PELs, as shown in Table 1. The results showed that the water control method had a higher silica dust reduction percentage compared to LEV and the use of silica substitute materials.

Carlo et al. (2010) had few concerns with water regarding slip hazards and decolouring when cutting tiles with the saw during roofing installation. According to HSE (2012), there was no statistically significant effect on control efficiency for factors such as water volume, flow rate and blade size when the water control method was used. The other control which reduced exposure to 99% was LEV on-tool. The advantage of LEV is that it reduces exposure to nearby workers and minimises clean-up due to dust exposure (Tente et al., 2022). The problem with LEV on-tool is that it adds more weight to the equipment or tool. The use of silica substitute materials is reduced by 60% of exposure. This entails that silica substitute materials should be incorporated into construction to help reduce exposure levels. The combination of LEV and water significantly reduced, below the PEL of 0.075mg/m3. This clearly showed that combining all controls, namely, LEV, water, silica substitute materials, training and the proper use of quality RPE, would reduce exposure to safeguard the workers' health which is paramount (Tente et al., 2022).

Silica content materials in their wet state produce chemicals that are irritable to the skin, and in their dry state produce silica dust during grinding, cutting, sanding and other construction activities (Tente et al., 2022; Tente and Mwanaumo, 2022). According to Tente et al. (2022) 's findings, the most common dust control method was a combination of water and dust masks (52%), followed by dust masks only (24%). The control by use of water only was 10%, and no control was five per cent. The results show that the use of PPE was common.

Table 1: Control Measures and their Silica Dust reduction Percentage

Item	**Control Method**	**No Control (mg/m^3)**	**With Control (mg/m^3)**	**% Reduction**	**PEL (mg/m^3)**	**Source**
1	LEV	1.0	0.3	70	0.075	Lumens and Spee (2001)
2	Pressure Tank	21.2	1.3	95	0.04	Thorpe et al. (1999)
	Mains Water	14.4	0.6	93		
	LEV	8	0.7	91		
3	LEV and Water	14.3	Below 0.075	99	0.075	Nij, et al. (2003)
4	LEV	4.5	0.14	92	0.075	Croteau et al. (2004)
5	LEV on-tool & Box Fan	4.87	1.42	71	0.075	Flanaga et al. (2003)
6	LEV on-tool	25.4	0.95	99	0.025	Akbar-khanzadeh, et al. (2007)
	Wet grinding	61.7	0.11	98		
7	LEV	1.4	0.13	91	0.075	Carlo, et al. (2010)
	Water suppression	3	0.03	99	0.075	
8	Silica substitute	0.074	0.049	66	0.025	Radnoff and Kutz (2013)

However, in the study by Mashqoor et al. (2017), 78% of the workers had no PPE. Similarly, in Bedoya-Marrugo et al. (2017), 70% of respondents did not use PPE. Moreover, Shah and Tiwari (2010) found that 50% of the workers did not use PPE. This meant that the workers without PPE experienced high exposure to chemical irritants and were likely to develop symptoms of skin diseases (Tente and Mwanaumo, 2022). This would have been the reason for the construction industry's high rate of skin diseases.

Periods of exposure to chemical irritants have also been associated with symptoms of skin diseases. Shah and Tiwari (2010) found an association between increased exposure duration (8-10 hours) and skin conditions. The skin symptoms were work-related and were aggravated by work. The study by Bedoya-Marrugo et al. (2017) found that the period of exposure to cement was directly proportional to the likelihood of developing dermatitis. A prolonged duration of exposure was associated with more morbid skin conditions (Moshqoor et al., 2017).

3. Methods

The data was collected between May and November 2021 in a cross-sectional study. One road and one building project were used as two case studies. The two case studies were selected to get experience on roads and building projects to represent the construction industry accurately. Bricklayers, carpenters, butchers, tilers, demolition workers, painters, road construction workers and handymen were purposively sampled. The estimated study population for building and road project sites was 1,012 workers. The sample size was established at 10% of the estimated population. Moreover, the sample size was limited to 100 because the number of workers was reduced due to Covid-19 by the Ministry of Health. Therefore, the total sample size was 100 workers, 50 for each case study.

The qualitative data was collected using observation schedules and a camera. What was observed in the schedule were the dust levels in terms of plumes of dust, sources of dust, dusty environment, the methods of controls according to the hierarchy of controls and the types of PPE provided. In this study, the appearance of a plume of dust (a large quantity of dust that rises into the air in a column) was considered high exposure, and the absence of a plume was considered low exposure to dust. Overt and direct observations were used. Overt observation is when participants know they are being observed (Lugosi, 2006). The workers were consulted, and observations were only done after workers consented to take part in the study. The overt observation ensured ethical issues were adhered to according to the ethical clearance approval by the Natural and Applied Sciences Research Ethics Committee (NASREC). Moreover, observations revealed interactions between workers and management regarding control measures in silica dust and chemical irritants exposure reduction.

Observations were accompanied by the photographs, which were taken using Tecno Canon 17 phone camera (6.6 "-720x1600 pixels). According to Pain (2012), photographs are used in data collection to get appropriate tacit data for providing cues for understanding the topic. In this research, photographs were used to complement what was being observed. The plume of dust was captured to enhance the description of dust exposure levels. In this case, text from the observations and photographs enhanced the meaning of the data (Johnson, 2004).

It was deduced from the literature review that some skills or activities experienced high exposures to silica dust; therefore, using observation, silica dust was observed in the form of dust. Photographs were taken with the consent of the participants. In addition, the researcher gave the participants assurance that faces would be avoided and only capture the activity or interest of observation according to NASREC ethical approval. Data was collected during the eight hours - full-day shift. The data were qualitatively analysed using the constant comparative method. This method of data analysis involves constantly comparing data points to other data points to form categories and concepts (Anderson and Jack, 2015).

4. Results and Discussion

The findings revealed that the workers were exposed to dust as a plume of dust was observed. The exposure depended on the activities being performed and if there were any controls used. The findings of the dust exposures and controls observed are presented in Table 2.

Table 2: Summary of the Observed Key Concerns

Key Concerns	Description of observed
Dust exposure levels and sources	• Offloading of gravel • Loading of spoil • Dry concrete grinding • Quarry loading for batching • Dry sweeping during housekeeping • Cement bag opening during manual mixing • Demolition works
Dust controls	• Water spray to suppress dust (at intervals and whenever water was available) • Water on-tool/machine • Dust nets on road works • Few work-suits (building project) • Few dust masks • Covid-19 masks (mandatory) • Few proper gloves • No gloves • Torn gloves (not suited for the skill so easily torn) • Exchangeable gumboots depending on activity

All the activities observed had high exposure levels as the plume of dust was seen as shown in Figures 2, 3, 4, 5, 6, 7 and 8. Dust exposures were observed during the damping of gravel during road constructions, dry concrete grinding, quarry loading for batching, dry sweeping during housekeeping, and cement bag opening during manual concrete or mortar mixing and demolition works.

Figure 2 shows a tipper truck offloading gravel during the road construction works. A plume of dust was seen escaping in the open air. Road workers, passers-by pedestrians, cyclists and traffic were exposed to the dust, thereby posing a health risk to the exposed. There was no dust control observed during these activities. Therefore, the road workers, passers-by pedestrians, cyclists and traffic were exposed to the same amount of dust emanating from offloading the gravel. The excavator was loading a tipper truck with spoil to transport it to the damping site. A plume of dust was seen from loading the spoil during the road construction in Figure 3. Road workers and road users were exposed to the dust in the process, posing a health hazard. The dust exposure in Figure 3 extended to the nearby truck business premises.

Figure 2: Picture showing dust exposure during offloading of gravel

Figure 3: Picture depicting dust exposure during loading of spoil

This is similar to Normohammadi et al. (2016), who found that cutting and breaking concrete produce hazardous dust for workers. The worker performed dry grinding during concrete drain shaping, and the plume of dust was seen during the activity in Figure 4. The worker was seen without the recommended PPE, such as a dust mask, gloves, work suits, safety boots and a hard hat. This is similar to Kirkeskov et al. (2016) 's finding that few workers wear RPE even when performing activities that produce high dust levels in the construction industry.

Figure 4: Picture showing dust exposure during dry concrete grinding

In Figure 5, the workers were loading quarry dust for batching. The dust was seen as a result of loading. The loading worker was seen without a dust mask, and the other was wearing a Covid-19 facemask. The workers were likely to be exposed to dust which is harmful to their health. Dry sweeping was another activity seen as a source of construction dust, as shown in Figure 6. Dust came from the concrete and mortar remains as they were swept during housekeeping. Other controls like water should be used with the recommended PPE to reduce dust exposure, especially dust masks. The worker was seen in the PPE but had a facemask instead of the recommended dust mask. The Covid-19 face mask was inadequate in reducing exposure to dust as it was specifically made for Covid-19 prevention.

Figure 5: Picture showing workers loading quarry dust for batching

Figure 6: Picture showing dust exposure during dry sweeping

There was cement dust escaping into the open air as the worker in Figure 7 opened a bag of cement while manually mixing plaster and mortar at a building site. The worker was noticed wearing a black cloth face mask which was recommended for Covid-19 prevention. Face masks are not recommended for silica dust reduction as their particles are so tiny that they penetrate surgical and cloth face masks designed for Covid-19 prevention.

Figure 7: Picture showing cement dust exposure during dry mixing

Workers in Figure 8 were performing demolition works. One worker broke the wall using a hammer, and the other manually loaded the rubble. Dust was produced from both activities, especially when manually loading the rubble. The workers were wearing Covid-19 recommended face masks.

Figure 8: Picture showing dust exposure during demolition and loading of rubble

The results in Figure 4 are similar to the findings of Flanagan et al., 2003 and HSE (2012), who found that grinding concrete produces high exposure to silica dust. Also, the findings on demolition workers being exposed to silica dust are similar to Lumens and Spee (2001), Normahammadi et al. (2016) and Kirkeskov et al. (2016) 's findings. The difference was that in this research, silica dust exposure was qualitatively considered in terms of observed dust, and it was established from the literature that similar activities in construction recorded high levels of silica dust, which was above the permissible limits. In Lumens and Spee (2001), Normahammadi et al. (2016) and Kirkeskov et al. (2016), silica dust concentrations were quantitatively measured using air sampling methods.

The controls that were observed in the two case studies were spraying of water to suppress dust, water on-tool/machine, dust nets on road works, few dust masks, mandatory Covid-19 face masks, few work suits, few gloves, torn gloves and changeable gumboots depending on the activities being performed. The findings on the controls are shown in Figures 9, 10, 11 and 12. The combination of water and face masks/dust masks was similar to the findings by Tente et al. (2022). The common use of facemasks on both road and building projects was mandatory for Covid-19 prevention during the pandemic by the Ministry of Health.

During data collection, Covid-19 was prevalent, and as a preventive measure, all workers were mandated to wear face masks during COVID-19. The face masks were surgical masks and cloth face masks, as evidenced in Figures 4, 5 and 7. Nevertheless, despite the facemasks being worn constantly, they did not reduce silica dust exposure adequately. This is because face masks were designed to reduce exposure to Covid-19 and not silica dust RPE. Other masks recommended for silica dust exposure reduction, such as disposable dust masks, industrial dust masks and N95, were rarely used on sites. This can be seen in Figure 11, where only a worker operating the concrete mixer was spotted wearing the recommended dust mask.

The worker in Figure 9 removed some wetted gravel back on the road base during base processing. The worker sprayed water to suppress dust, thereby reducing dust exposure for himself and the traffic, as shown in Figure 9.

Figure 9: Picture showing dust control using water for base processing

Despite the water suppression control, the worker did not wear the recommended full PPE to reduce dust and chemical exposure.

Workers in Figure 10 were cutting asphalt roads using concrete cutters. The concrete cutter had a water tank mounted on its back. As the concrete cutter was cutting asphalt, water was dripping on the cutting blade, suppressing the dust which was being produced. Therefore, less dust escaped into the open air during the cutting activity. This meant that water control was able to reduce dust, similar to the findings of Carlo et al. (2010), who found that water control was able to reduce dust control by up to 99%.

Figure 10: Picture showing the use of a cutter with water on the road project

The lesser the dust emanating from the source, the lesser the dust exposure and the lesser the likelihood of workers developing respiratory diseases.
The worker in Figure 11 was seen in a surgical face mask, yet he was working on a dusty activity. The worker was loading quarry dust in a wheelbarrow for batching. The loading activity produced dust, as seen in Figure 11.

Figure 11: Picture showing a worker wearing a face mask while working

The other worker in Figure 12 was seen wearing a recommended dust mask. He was seen opening the bag of cement to load in the concrete mixer to make concrete. Since the dust mask was one of recommended RPE, it meant that it could protect the work from inhaling all the dust around the breathing zone. What was not known was whether the dust mask was good quality or well-fitted, as advised by Flanagan et al., (2003); Ahmed and Abdullah, (2012). The effectiveness of the dust mask in terms of quality could not be done by observation method as some practice tests are carried out to establish the quality.

Figure 12: Picture showing a worker wearing a dust mask while working

The findings on the use of the facemasks are contrary to some researchers who advised from their findings that to reduce exposure to silica dust, a suitable and well-fitted RPE is required (Flanagan et al., 2003; Ahmed and Abdullah, 2012). However, from the literature review, it can be concluded that despite using RPE as a control to reduce exposure to silica dust, it does not reduce silica exposure levels to below PEL (Tente et al., 2022). This is why it is recommended that the use of RPE and PPE should be the last in the hierarchy of controls (Flanagan et al., 2003).

Despite the recommendation that RPE and PPE should be used in combination with other control methods, findings of this study revealed that in some instances, no or inadequate PPE was being used, as shown in Figures 13 and 14. The worker in Figure 13 had no PPE and was fully exposed from head to toe to silica dust and chemical irritants. The worker is likely to develop skin disease symptoms, as shown in Figure 13.

The worker in Figure 14 has no gloves or dust masks, exposing him to silica dust and chemical irritants. The worker performs plastering without gloves, exposing his hands to wet cement, which burns the skin.

Figure 13: Picture showing a worker without any PPE

Figure 14: Picture showing a worker without gloves and a dust mask

Despite water being a commonly used control type, it had its challenges. According to the workers, the use of water as dust control in the building project had its challenges of messing the place and making an activity difficult to perform, similar to findings of Carlo et al. (2010). The challenge of using water made workers avoid it to ease their work activity. On the road project, the challenge of using water for dust control or suppression was that workers had to keep spraying every hour or more depending on the weather condition. This was a serious challenge as spraying water was not done as often because they preferred to use water for road works such as base processing rather than dust control. In addition, water was fetched far from the road sites and transported in the heavy traffic of Lusaka city, making water erratic on sites. This led to inadequate dust controls on the road sites on the road project.

5. Conclusion

The study assessed the dust levels, sources and controls for silica dust in the construction industry in Zambia. This was done using overt observation, an observation schedule, and a camera to capture the photographs. The observations showed that the dust levels were high as all the activities which were observed produced a plume of dust. The sources of dust, in terms of activities, on the road project, were offloading, loading of spoil and dry concrete grinding. The dust sources on the building project were; the loading of quarry dust for batching, dry sweeping, and opening of cement during dry mixing for concrete. The common controls were water and dust or face masks. Another control which was rarely used was dust nets that were also used as holding for the two sites. However, from the dust plume observed, the methods of control and the improper PPE suggest that the controls were inadequate. This may mean that the sampled skilled workers and their labourers were likely to be exposed to high levels of silica dust and chemical irritants in the construction industry in Zambia. Findings indicate that workers are at risk of health problems brought about by inhaling dust.

6. Recommendations and Limitations

Findings showed that only engineering control and PPE were utilised from the hierarchy of controls. A combination of controls should be implemented for effective silica dust reduction and reduced risk of ill health. Therefore, there is a need for improved ways that incorporate all controls in the hierarchy of controls and the participation of all construction stakeholders in reducing silica dust to safeguard workers' health and the possible effects on the projects. The study serves as an awareness to construction stakeholders of the health concern of high dust exposure levels and inadequate controls. Therefore, government and construction stakeholders must ensure that the controls are improved to mitigate dust and protect the workers.

The study was limited to observations. There is a need to measure the actual dust concentrations with and without controls using dust sampling to establish to what extent the workers are exposed to dust. This would help in policy formulation regarding exposure limits and adequate ways of dust control.

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Factor Analysis-Based Studies on Effectiveness of Graduate Architects in Building Contract Administration (BCA)

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Abstract

Graduate architects play a vital role in building contract administration (BCA) when architects are assigned partly of their tasks to graduate architects due to being unable to cope with the massive development in the nation. Hence, graduate architects' capability in BCA affected the project team and the project delivery process. This study aims to identify factors that affect graduate architects' work performance in BCA associated with housing projects. A comprehensive literature review was conducted to establish the questionnaire to test 127 practising graduate architects in Malaysia. Data collected from the survey are evaluated using principal component analysis to understand the crucial factors affecting graduate architects' work performance. The variables within the factors are tested to confirm the reliability and validity of the constructs. Four types of knowledge with 19 indicators were extracted after iteration. The result from the study showed that the types of knowledge required by graduate architects to work effectively in BCA are communication and relationship management knowledge, design management knowledge, project management knowledge, and claims and legal matters knowledge. The contribution of this study is to improve graduate architects' work performance in BCA. Educators may utilise this study to enhance the syllabus according to market niche and nurture graduate architects to become a catalyst in the construction industry.

Keywords: graduate architect, building contract administration, knowledge, factor analysis

1. Introduction

The primary objectives of the individual appointed to administer a building contract include delivering the project safely, to specified quality standards, on time, and within the employer's budgetary constraints (Cunningham, 2016). The building contract administrator (BCA) has two distinct functions: an agent and a certifier (Bin Zakaria, Binti Ismail, & Binti Yusof, 2013). The role of building contract administrator commenced when the building contract between the employer and contractor was in place (Chong, Balamuralithara, & Chong, 2011). The most popular and widely used standard building contract throughout the private sector is the Pertubuhan Akitek Malaysia (PAM) form of contract, where the architect traditionally fills the role of contract administrator (Bin Zakaria et al., 2013).

Recently, many studies related to housing projects have been investigated due to the increasing number of housing projects experiencing delays for various reasons (Mezher & Tawil, 1998). Mezher et al.(2018) identify that consultant-related related is one factor in delays in housing projects. Other studies also verified that many housing projects suffered disastrous outcomes linked with the attitudes of professionals from the intricacy and the magnitude of the work, multiple prime contracting parties, poorly prepared, unsure about roles and responsibilities, inadequate planning, financial issues, and communication problems (Alaghbari, Kadir, & Salim, 2007). These factors derail a project, leading to complicated litigation and arbitration, increased costs, and damaged business relationships.

Consultants are led by the building contract administrator (Bin Zakaria et al., 2013). The building

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contract administrator's task is to orchestrate and motivate the project team to deliver the best possible performance individually and as a team member (Thomas & Ellis Jr., 2007). This task is complicated by the nature of traditionally procured building contracts, where project teams are assembled by members who have little or no previous experience working alongside each other (Mydin, Sani, Salim, & Alias, 2014). Individuals suspect each other's motives and have diverged, conflicting objectives that delay the project. Hence, the administrator must have an effective strategy to ensure the project delivers as committed to the employer. Ideally, The building contract administrator should be carried out by someone with expert technical knowledge of the construction process, strong leadership qualities, and highly developed interpersonal skills (Katz, 2009).

An architect is the building contract administrator since he is the designer of the project and the person who has a better understanding of PAM contract and communication among the team, able to conduct proper planning and monitoring and consist special skills to lead and handle problems at construction sites (Yadollahi, Mirghasemi, Mohamad Zin, & Singh, 2014). Indeed, a GA may be appointed to play the leading role in building contract administration. This may occur when there is a lack of architects in Malaysia and subsequently encourage the architects to delegate their supervision and monitoring duty to their representatives, which is the GA permitted under Uniform Building By law-5 (UBBL, 2013).

Based on research carried out by Khodeir (2020) aimed at disclosing the attributes of graduate architects from the Malaysian industry's point of view, employers have often given negative criticism regarding the attributes that graduates have at the early stage of their careers. Architectural firms are dissatisfied with the quality of the graduates and still note that they have to re-train fresh graduates to make them fit for their jobs before starting their practice (Khodeir & Nessim, 2020). Incidents of missing scope, unclear or insufficiently detailed work, contradictory information, incorrect dimensions or unbuildable details, uncoordinated systems, and other failings plague design professionals and vex owners; coordination errors resulting from a team of consultants preparing documents from three or more disciplines are always presented when graduate architects involved in administering building contract (RIBA, 2020). Consequently, the building contract administrator will bear the legal responsibilities as misconduct/negligence is taken as a serious offence under the provisions of the Architects Act 1967.

Therefore, this study examines the knowledge required for graduate architects in BCA to increase their professional development. To achieve this objective, the types of knowledge were first identified through a literature review, followed by a questionnaire survey with 127 practising graduate architects, and analysed with factor analysis to categorise the result into significant themes. The significance of this study is that housing projects delayed caused by consultant-related factors will be minimised, and the findings also contribute to the body of knowledge on the features of job satisfaction for graduate architects.

2. Literature Review

2.1 Building contract administration

The administration of a contract is necessary to ensure the contract is performed according to the articles of agreement and conditions of the contract and within the framework of related laws and the practices of the construction industry (Bin Zakaria et al., 2013).

Building contract administrators refer to people who ensure the contract between employer and contractor is executed and adhered to the contract terms (Cunningham, 2016). They undertake any necessary design changes, advise on any particular program and sequence of work implications, advise on any costing for their field of expertise, produce and supply design documentation, inspect works to ensure design/specification met by the contractor, prepare documents to issue instructions under the building contract, coordinate and advise on the adequacy of information provided, certify the number of interim payments to be made by the employer to the contractor, approve the quality of materials or goods or of the standard of workmanship (Cunningham, 2016). In addition, the administrator's task covers orchestrating and motivating various consultants and contractors to deliver the best possible performance individually and as team members (Ostime, 2019; Ricchini, 1979).

In a PAM contract, the contract administrator is the architect (Tan, Low, Sum, & Chee, 2010). They undertake the decision-making, advisory, and information roles in the context of the PAM contract forms and contribute to achieving the primary project objectives (Tan et al., 2010). Building contract administration scope of work can be categorised as project governance and start-up, contract administration team management, communication and relationship management, quality and acceptance management, document and record management, financial management, changes control management, claims and disputes resolution management, control risk management, and contract closeout management (Ricchini, 1979). Since the scope of work as a building contract administrator is vast, the involvement of graduate architects is required to reduce the workload of architects.

2.2 Graduate architect

As illustrated by LAM, a graduate architect (GA) is a person who holds a qualification recognised by the LAM or sit and pass the Part I and Part II examination before being qualified to be registered as a graduate architect with LAM (Malaysia, 2006). They act as assistants for architects and carry out tasks such as understanding client design briefs, coordinating with designers, preparing and submitting drawings to authorities, and arranging and preparing schematic/tender/construction/ contract drawings (Chappell & Dunn, 2015). Besides performing as assistants in the design phase, graduate architects also assist admin building contracts on behalf of architects during the construction phase (Malaysia, 2006).

2.3 Underperformance of Graduate Architects in BCA

Graduate architects support the building contract administrator in housing projects. The employer relies on them to properly manage and control the construction activities on site (Hayes, 2014). However, they are among the graduate architects who have poor planning, poor communication and coordination, lack of system, misunderstand the process, lack of skills, unclear roles, lack of training, and lack of performance measurement, which cause inefficient construction processes, delays, reworks, un-necessary variations, poor communication among team players, conflicts and disputes for both employer and contractors (Yadollahi et al., 2014).

Traditional methods imposed by computer-aided design (CAD) in the development of new projects have evolved towards the use of Building Information Modelling (BIM) methodologies, enabling the control of different aspects such as design, construction and monitoring of a building (Arayici et al., 2011). The documentation for the construction of buildings has been classified into three main phases: the manual phase, the digital phase and the BIM phase (Diaz, 2016). Each phase needs a period of adaptation between the project stakeholders in the construction sector. This is where graduate architects cannot cope due to a lack of skills and training for BIM-oriented projects. As a result, investments in the construction industry suffer damages when the graduate architects in BCA do not adequately perform (Mari, Srirangam, Gunasagaran, Kuppusamy, & Ang, 2019). The types of knowledge required in BCA must be identified to assist the graduate architect in elevating their work performance.

2.4 Types of Knowledge Required for BCA

Project success depends on the performance of the graduate architects entrusted to execute the project (Walker, 2015). Previous studies identified 38 types of knowledge to be competent to support building contract administrators (Alias, Ahmad@Baharum, & Idris, 2012). Mistakes and pitfalls can be avoided by engaging a graduate architect who is knowledgeable and appropriate for the job. Understanding the types of knowledge required in BCA will encourage graduate architects to acquire that knowledge to enhance their work performance (Harmon & Stephan, 2001).

Types of knowledge required by graduate architects in BCA had been categorised into five themes: to instil claims and legal matters management knowledge, project management knowledge, communication and relationship management knowledge, design management knowledge, and quality and assessment management knowledge.

2.4.1 Claims and Legal Matters Management Knowledge

Most standard-form contracts provide mechanisms and contain clauses explaining the process of giving notices and the likely consequences for failure to deliver, as stated in the contract (Abotaleb & El-Adaway, 2017). Therefore, most construction contracts require written notice for changes, differing site conditions, extra work, or other events that may affect the contractor's time and cost performance (Hamzah, Khoiry, Arshad, Tawil, & Che Ani, 2011). Graduate architects familiar with claims and legal matters knowledge would be able to advise contractors/employers to fulfil the conditions of the notice clause by responding promptly to prevent unnecessary disputes.

A complete and robust claim document is essential in presenting a claim and resolving disputes (Ahmed, Tahir, & Ismail, 2019). For solid documentation, the information should be contemporaneous, documenting and closing out the work as it is performed; information should be consistent and transparent (Harmon & Stephan, 2001). The claim must be supported with all the required documents in dispute with a simple, complete, and comprehensive approach. The documents mentioned earlier refer to charts, graphs, drawings, photographs, and videos of completed work, testing conducted, quality control activities, detailed pricing of the claim, specifications, special conditions, specific instructions, contractor's calculation, project diary with record the weather,d manpower, visitors, and contractors on site, key deliveries and notable event (Harmon & Stephan, 2001). The problem resolution will respond more effectively if all the above considerations are appropriately addressed.

2.4.2 Project management knowledge

Construction projects naturally grow in scale, involving vast numbers of professionals, long life cycles, complex interfaces, highly specialised knowledge, and experiential feedback (Alaloul, Liew, & Zawawi, 2016). Project management was developed to address these challenges by facilitating project implementation and delivery. PMBoK proposed ten knowledge areas for project management, and Construction extension proposed an additional four that consist of project integration management, project scope management, project time management, project cost management, project quality management, project human resources management, project communication management, project risk management, project procurement management, project stakeholder management, project safety management, project environmental management, project financial management and project claim management (Alaloul et al., 2016). The Project Management Body of Knowledge Guide (PMBoK) concepts and areas are useful in devising better project management solutions.

2.4.3 Communication and relationship management knowledge

Most communication during a construction project is spent on speaking and listening, with less time on reading and writing (Emmitt & Gorse, 2006). Reluctant communicators are unlikely to hold influential positions or be perceived by the team members as leaders. Graduate architects in BCA who coordinate the team should enable, foster, and create the understanding and trust necessary to encourage others to follow a leader (Dainty, Moore, & Murray, 2007). As a project develops, the graduate architect must improve communication and relationship management knowledge to become more effective. There are three types of communication: core communication, managerial communication, and corporate communication (Wahyuni, Masih, & Rejeki, 2018).

2.4.4 Design management knowledge

With the increasing building production and technical complexity, the number of design specialists involved rises, leading to the need to manage the design process (Cooper & Press, 1995). In this context, they are mainly interpreted as the management of information handling between the participants in the design team. This knowledge includes planning the design process backwards from when these deliverables are due to be released to the client or contractor (Wang, Tang, Qi, Shen, & Huang, 2016). A master program is produced and distributed to the design team, who plan their work within the framework of the master program. In addition, design management knowledge also includes concurrent working, targeted solution workshops, and timely design reviews, which encompasses design planning, scheduling, and control (Ling, 2004).

2.4.5 Quality and assessment Management Knowledge

Quality and assessment management knowledge are to concur issues such as lack of proper planning during the design phase, under reinforcement, not adhering to project specifications, lack of use of standard materials, use of unqualified professionals, insufficient management staff, and the team responsible for controlling quality, errors owing to poorly detailed design, speedy construction and ignorance (Oyedele & Tham, 2007). The benefits of implementing quality and assessment management knowledge are improved communication problems, minimised mistakes, reduced rework and wastage of materials, and exercised better control over main contractors and consultants (Burati Jr., Farrington, & Ledbetter, 1992). Thus, productivity, profitability, and market share gradually increased, which enabled contractors to meet employers' requirements.

3. Research Methodology

3.1 Selection of Respondents

In this research, a purposeful sampling method was adopted to gather more detailed information regarding the perception of types of knowledge required by graduate architects in BCA for housing projects in Malaysia. To select respondents for purposeful sampling, a particular criterion has been identified. The criterion for selecting respondents is as follows: a graduate architect who has worked two years and above in the construction industry, in the BCA during the construction phase and who manages strata housing projects. While the following were excluded: those who do not meet the inclusion criteria and those who are unwilling to participate in the study (Chen, Nakatani, Liu, Zhao, & Xie, 2020).

Purposive sampling was used to select an accessible population of 2444 graduate architects registered under the Board of Malaysia as of December 2020. In accordance with the Architect's Act 1967, graduate architects are defined as those with Part II accreditation in Architectural education and are registered with the Board. Based on Krejcie and Morgan's (1970) table for determining sample size, for a given population of 2444, a sample size of 331 would be needed to represent a cross-section of the population. However, Sekaran and Bougie (2009) noted that the return rates of online survey questionnaires are typically low. A response rate of 30% is acceptable for the research (Sekaran & Bougie, 2016). The response rate for online surveys should not be less than 30% to ensure its adequacy (Hoxley, 2008). Therefore, the minimum sample size for this research was set at 100.

3.2 Pilot study

The literature review formed the basis of the questionnaire. A pilot study was carried out before finalising the main questionnaire. The ten experts selected include experienced professional architects who have managed housing projects for over ten years. This preliminary pilot survey assisted in offering the respondents the opportunity to add further types of knowledge required beyond the points identified in the literature to construct a robust list of types of knowledge for graduate architects in BCA for the final questionnaire. The final version of the questionnaire was done after modifications and shortenings according to the comments obtained in the pilot study.

3.3 Distribution of the final questionnaire

The questionnaire was distributed via a link emailed to 313 selected participants in March 2022. The email address was obtained from the Architect Association website. After one month, 27 completed questionnaires were returned. Reminder emails were sent to respondents who had yet to reply. The following month after the reminder, the number of completed questionnaires increased to 130. Filtration was undertaken to scrutinise the questionnaire that could be used to form a database for the final data analysis. One hundred and twenty-seven questionnaires were identified as appropriate for the final data analysis. Table 1 shows the response rate for the present study.

Table 1: Response rate

Item	Description	Frequencies
1	Number of questionnaires sent out	313
	Total questionnaire returned	130
3	Incomplete questionnaire returned	3
4	Complete questionnaire returned	127
5	Valid percentage returned	**40.58%**

In this study, close-ended questions that include multiple choice questions and Likert-scale questions were used. Saunders et al.(2009) stated that close-ended questions are simple and easy to answer for respondents while assisting the researcher in coding the information easily for data analysis (Sekaran & Bougie, 2016). Researchers arrange the choices on a continuum in Likert-scale questions, with extreme positions at the endpoints. A five (5) point scale is the most used scale in the questionnaire (Sekaran & Bougie, 2016). For this questionnaire, the importance of each type of knowledge was rated on a five-point scale, where 1 represents 'strongly disagree', and 5 represents 'strongly agree'.

4.0 Result and Analysis

The collected data were analysed using IBM SPSS Statistics 28.0 Software and descriptive to gain insights. SPSS was used to assess the data's reliability and examine the types of knowledge required to improve BCA. Descriptive analysis was used to assess the respondents' demographic profile and better understand the sample composition.

An analysis of the graduate architects' profile in Table 2 showed that 50% have construction experience spanning 5-9 years, and 45% of the graduate architects have construction experience of over ten years. This suggests the respondents have sufficient industry experience to provide valuable insights into graduate skill expectations and observed competencies. Further, the result showed that 60% of the graduate architects have five or more housing projects, suggesting that the graduate architects are actively engaged in BCA. The graduate architects' profile results revealed that 36% were 30 years and below, 31% of the respondents were in the 31-40 years age bracket, and 33% were above 40 years of age. Regarding the duration of employment, 10% have had 1-5 years of BCA work experience, 65% between 6 – 10 years, and 26% of the respondents have worked in BCA work for more than ten years. Hence, they are expected to be conversant with BCA's graduate architects' knowledge requirements.

Table 2: Analysis of Respondents' Background Profile

Years of Experience in architectural practice	**Frequency**	**% of total**
Below 5 years	6	5%
5-9 years	63	50%
10-14 years	31	24%
15 years or above	27	21%
Total	**127**	**100%**
Age	**Frequency**	**% of total**
25 – 30 years	46	36%
31 – 40 years	39	31%
41 – 50 years	24	19%
Above 50 years	18	14%
Total	**127**	**100%**
Number of housing projects involved	**Frequency**	**% of total**
Below 3	26	20%
3	16	13%
4	9	7%
5 or above	76	60%
Total	**127**	**100%**
Years in building contract administration work	**Frequency**	**% of total**
1 – 5 years	13	10%
6 – 10 years	82	65%
11 – 15 years	1	1%
16 – 20 years	30	24%
Above 20 years	1	1%
Total	**127**	**100%**

4.1 Data Screening - Mean & Standard Deviation

The respondents' input was screened against careless responses and outliners. The careless response pattern for which a respondent might indicate the same response option for several consecutive items, while outliers indicate different or dissimilar observations. Careless responses were measured through standard deviation and group rating compared to average factor ratings. Table 3 presents the mean scores (M) and standard deviations (SD), which summarise the central tendency and dispersion of the variables related to the work performance of graduate architects.

Table 3: Mean (M) and Standard Deviation (SD) of variables (n=127)

Variable	Mean (M)	Standard Deviation (SD)
Instil claims and legal matters management knowledge	4.43	0.55
Instil project management knowledge	4.50	0.65
Instil communication and relationship management knowledge	4.04	0.69
Instil quality and assessment management knowledge	4.38	0.61
Instil design management knowledge	3.95	0.65

There are five types of knowledge to be instilled to enhance the effectiveness of graduate architects in BCA. To instil claims and legal matters, management knowledge had a mean score of 4.43 (SD=0.55). This means that respondents agreed that instilling legal knowledge in graduate architects will assist in resolving the majority of the certificate claims and dispute issues. Instil project management knowledge had a mean score of 4.50 (SD=0.65). Respondents felt that this knowledge would assist the graduate architects to be more organised and systematic in BCA. Instil communication and relationship management knowledge had a mean score of 4.04 (SD=0.69). This result reflects that knowledge in networking for graduate architects is crucial in teamwork. Instil quality and management knowledge had a mean score of 4.38 (SD=0.61).

Respondents agreed that quality assessment knowledge is essential for graduate architects to assess contractor's submission and ensure the end product is constructed per design intention. Instil design management knowledge had a mean score of 3.95 (SD=0.65) because respondents felt that graduate architects capable of furnishing workable design details are important for construction. A total of 127 respondents rated the group that the data points tend to be close to the mean of the factor (i.e. standard deviation was <1.00- clustered around the mean) within each corresponding group. Therefore, the normality test would be used to test distribution.

4.2 Data Normality

A normality test was conducted to assess the data distribution. The normality of data for this research was examined by Skewness and Kurtosis. Skewness measures the balance or lack of balance in the data. Kurtosis exhibits normal distribution and measures its symmetry or lack thereof. Based on a study by Garson (2012), data is considered normal distribution when the skewness value is near zero and the kurtosis falls within the range of ±3.0. Table 4 summarises the skewness and kurtosis values for each variable.

Table 4: Summary of skewness and kurtosis

Variable	N	Skewness		Kurtosis	
		Statistic	Std. Error	Statistic	Std. Error
Instil claims and legal matters management knowledge	127	-.702	.215	.192	.427
Instil project management knowledge	127	-1.14	.215	.932	.427
Instil communication and relationship management knowledge	127	-.537	.215	.555	.427
Instil quality and assessment management knowledge	127	-.571	.215	-.593	.427
Instil design management knowledge	127	-.413	.215	.257	.427

The skewness values ranged from -0.413 to -1.14, indicating a negative skewness and a longer left tail. The kurtosis values ranged from 0.932 to -0.593, indicating a leptokurtic distribution with heavier tails than a normal distribution. All the variables fall under the acceptable range of ±3.0. Therefore, the variables meet the benchmark for normal distribution of skewness and kurtosis, and the variables demonstrate approximate normality, allowing for further statistical analysis and interpretation.

4.3 Reliability analysis

Reliability analysis (Cronbach's alpha reliability coefficient) was performed to measure the consistency of variables and scales using SPSS. The alpha coefficient does not assume data normality and is based on the average correlation between the attributes and the number of total attributes. The value of Alpha varies from 0 to 1, and a higher value indicates greater internal consistency. The higher the value of Cronbach's Alpha beyond the threshold of 0.6, the more confidence is shown for these obstacles/root causes/ measures (Nunnally, 1978). All items and variables were reliable in measuring the intended constructs, enhancing the confidence in the validity of the data obtained as consistent and dependable as shown in Table 5.

Table 5: Reliability Coefficient of Research Instrument

Variable	**No. of items**	**Cronbach's Alpha (α) (n=127)**
Instil claims and legal matters management knowledge	6	0.73
Instil project management knowledge	7	0.73
Instil communication & relationship management knowledge	10	0.84
Instil quality and assessment management knowledge	6	0.73
Instil design management knowledge	9	0.63

In the sample (n=127), the variables demonstrated high internal consistency, with Cronbach's alpha values ranging from 0.60 to 0.84. This indicates that the items measuring the types of knowledge required by graduate architects in BCA consistently captured respondents' replies. From the result in Table 4.4, all Cronbach's alpha coefficients are above 0.6, hence acceptable, making all factors reliable.

4.4 Preliminary Analysis

Factor analysis was initially performed on all 38 variables related to the types of knowledge required by graduate architects in BCA. To ensure suitability for conducting factor analysis, this research used the Kaiser-Meyer-Olkin (KMO) index and Barlett's test of sphericity. The KMO test measures the adequacy of a sample in terms of the distribution of values for the execution of factor analysis. Bartlett's test of sphericity must be significant ($p<0.05$), indicating the presence of relationships among variables, and the KMP index should have a minimum value of 0.50 (Pallant et al., 2016) to indicate an adequate level of sampling adequacy. Both of the tests' acceptable values should be greater than 0.5.

Table 6: KMO and Bartlett's Test

Kaiser-Meyer-Olkin measure of sampling adequacy		.802 (p>0.5)
	Approx. Chi-Square	211.339
Barlett's test of sphericity	df	10
	Sig.	.000 (<0.05)

Table 6 shows the results of the KMO measures and Bartlett's test. The KMO value is 0.802, which is above 0.5. This indicates a good level of sampling adequacy. Barlett's test had an approximate chi-squared value of 211.339 with 10 degrees of freedom. The associated p-value is 0.000 ($p<0.05$), indicating that the correlation matrix significantly differs from an identity matrix. Both tests indicated the suitability of the variables for factor analysis.

4.5 Factor Analysis

Factor loadings are the correlations of the variables with the factor. High factor loading implies that the factors and variables are critical. The eigenvalues and the percentage of variance approach were used to determine the number of factors. In the eigenvalues approach, factors with relatively large eigenvalues are ignored. One criterion that has been suggested is that the eigenvalues for a factor greater than 1.00 should be retained. For the percentage of variance approach, all factors extracted should account for at least 60% of the total variance. Based on this rule, the initial eigenvalues for this research are referred to.

Principal components factor analysis with Varimax rotation conducted on the 38 controllable variables produced four underlying components. Table 7 shows the factor loadings of these controllable variables on these four components. The factor loading is the correlation coefficient between an original variable and an extracted component. The larger the factor loading, the greater the variable contributes to the component. Usually, factors with loadings greater than 0.5 are considered significant in contributing to the interpretation of the component. As shown in Table 7, all factor loadings extracted were more significant than 0.5. The extracted four components were renamed based on the results of the analysis.

In summary, the four components were summarised as follows:

Component 1 consists of six variables: electrical engineering (FL=0.856), mechanical engineering (FL=0.834), geotechnical engineering (FL=0.742), structural engineering (FL=0.714), civil engineering (FL=0.707), and quantity surveying (FL=0.558). These variables are closely related to the knowledge required for coordination purposes. Therefore, this component can be termed communication & relationship management knowledge. This component accounts for the most significant variance (45%) among all the components.

Component 2 includes seven variables: interior design (FL=0.779), financial planning (FL=0.715), valuation study (FL=0.699), landscape (FL=0.625), building material (FL=0.609), environmental studies (FL=0.574), and construction methods (FL=0.501). These variables all emphasise the knowledge required when graduate architects manage design. Hence, this component is termed design management knowledge.

Component 3 has three variables: architecture (FL=0.782), project management (FL=0.725), and town planning (FL=0.681). This knowledge is crucial for graduate architects when managing housing projects. Consequently, this component can be considered project management knowledge.

Component 4 comprises three variables: feasibility studies (FL=0.820), authority approving process (FL=0.708), and IT construction (FL=0.484). Disputes could be minimised if graduate architects conducted feasibility studies and IT construction and were familiar with the authority approving process. Thus, this component is called claims and legal matters management knowledge. This knowledge accounts for the least variance (5.74%) among all the variables from a statistical point of view.

5.0 Discussion of Findings

Instil communication & relationship management knowledge

Instil communication and relationship knowledge has the highest factor loading voted by respondents as several problems always arose during each project no matter how thorough the briefing process, how clear the drawings were, and how good the site management was. In every case, the problem could be related to a communication breakdown where one party fails to convey his or her intentions to another, which leads to misunderstanding and associated problems that such a state may bring about (Emmitt & Gorse, 2006). How the project participants communicate through formal and informal communication channels is critical to a successful project (Dainty et al., 2007). The faster graduate architects communicate effectively, the faster they establish good working relationships, hence the stronger the likelihood of a successful project. Communication channels between parties depend on how the building team is comprised and the procurement route selected, particularly between client and design team members, design team members, design team and construction team and construction team members (Rahman & Gamil, 2019).

Table 7: Factor loading for types of knowledge for graduate architects in BCA

Components	**Code**	**Types of knowledge**	**Factor loading (FL)**
Communication & relationship management knowledge	MM6	Electrical engineering	.856
	MM5	Mechanical engineering	.834
	MM8	Geotechnical engineering	.742
	MM7	Structural engineering	.714
	MM4	Civil engineering	.707
	MM9	Quantity Surveying	.558
Design management knowledge	MM14	Interior design	.779
	MM15	Financial planning	.715
	MM16	Valuation study	.699
	MM13	Landscape	.625
	MM12	Building material	.609
	MM17	Environmenta l studies	.574
	MM11	Construction methods	.501
Project management knowledge	MM2	Architecture	.782
	MM1	Project management	.725
	MM3	Town planning	.681
Claims & Legal matters management knowledge	MM19	Feasibility studies	.820
	MM18	Authority approving process	.708
	MM20	IT Construction	.484

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. a. Rotation converged in 8 iterations.

Graduate architects who manage the project must be aware of group dynamics and responsibilities throughout the project's diverse stages. Seven measures to ideal communications according to Dainty et al. (2007) are: careful assembly of a multi-skilled team with managerial, technological, and analytical abilities; removal of artificial barriers, designers become part of the site management team; use of management tools to ensure programming and progress data is continually revised and available to all parties; abolition of conflicting interests through incentives to minimise defensive action; adequate resources for obtaining information held off-site; limit disruption brought about by other projects; record all events and actions for later analysis and feedback into future projects.

Instil design management knowledge

Clients are demanding better value from contractors to deliver a physical artefact. The need to manage design activity has been recognised for some time, whether in industrial product design, architecture, or, more lately, construction (Best, 2006). Management of architectural design is essential to deliver design intent and optimising value to project stakeholders (Wang et al., 2016). This type of knowledge could be instilled through establishing links with various stakeholders to facilitate open communication to assist necessary information to be effectively integrated into the design process, team building, effective communication, timely responsiveness, partnering with the employer to fully understand the employer's expectations and requirements, partnering with designers to solve complex technical problems, especially for handling design changes, adopting optimisation design initiatives and improving constructability (Cooper & Press, 1995).

Instil project management knowledge

Project management is an exercise in control over quality, schedule, and costs that includes the following aspects of management: integration, scope, time, cost, quality, human resources, risk, communication, and procurement (Alaloul et al., 2016). Project management knowledge in academic programs covers many of the outlined knowledge areas (Levy, 2018). This knowledge is important for graduate architects to deliver the owner's physical development within the constraints of cost, schedule, quality, and safety requirements. Besides that, the graduate architects should obtain information such as finance and accounting, sales and marketing, strategic planning, tactical planning, operational planning, organisational behaviour, personnel administration, conflict management, personal time management, stress management, economic analysis, social trends, political developments, IT advancements, legal framework, statistics, probability theory, and risk to effectively deal with the many forces that bear on the construction process (Gido & Clements, 2014).

Instil claims and legal matters management knowledge

This knowledge is crucial for graduate architects to understand the contents of the documents and the spirit of the contractual relationships (Ahmed et al., 2019). A detailed understanding of the claims and legal matters is essential to minimise the construction risks that may lead to unnecessary problems such as disputes, claims, litigation, shoddy works and reworks, and even loss of future business relations (Vidogah & Ndekugri, 1997). The effects of construction disputes are detrimental as they may cause project delays, undermine team spirit, increase project costs, and damage continuing business relationships (Odeh & Battaineh, 2002).

To instil this type of knowledge is through a better understanding of contract documents such as sincerity in contracting, the drawing must be precise and checked by all parties, clarified in the contract document for better understanding, the employer's requirement is stipulated, contract document was written in simple language, contract document is precise, objective and practical, qualified personnel to prepare the contract document, regulatory requirement stipulated, minimise the use of complicated legal phrases, familiar general condition of the contract, and simplify construction work specification.

Results show that respondents prefer project management knowledge more efficiently than claims and legal matters knowledge for graduate architects. This result is aligned with previous findings from Heagney (2016) that graduate architects' master's in project management knowledge will have a profound impact on project performance. Results showed that instil claims and legal matters knowledge is the least effective knowledge for graduate architects to perform in BCA. Under the claims and legal matters knowledge, the authority approving process is a must-know for graduate architects. This result agrees with Rahim (2004) that the authority approving process is necessary for graduate architects as it will affect the overall master program planning. Their finding is parallel with findings by Marzukhi (2020), who confirmed that authority submission is a lengthy process and some various forms and permits that need to be submitted and obtained respectively before construction.

6.0 Conclusion

Graduate architects play a central role in building contract administration. Their performance affected the entire project team. Thus, graduate architects need to work effectively in BCA. This paper has presented the results of types of knowledge required by graduate architects in BCA associated with housing projects. A total of 38 knowledge variables were identified through literature. Based on the knowledge variables, a questionnaire was designed to gather data from the practising graduate architects. Data were analysed using factor analysis to understand the requirement to be effective in BCA. Results suggested that 19 knowledge variables could be grouped into four categories of knowledge types. Factor analysis results show four types of knowledge required for a graduate architect in BCA: to instil claim and legal matters management knowledge, design management knowledge, project management knowledge, and communication and relationship management knowledge.

Instilling communication and relationship management knowledge is efficient in BCA for graduate architects. According to Zerjav and Ceric (2009), this is categorised as tacit knowledge that could be gained through experience. Best (2010) pointed out that instil design management is the ability to translate design intent to building end products. Cooper (2009) added that design management knowledge is crucial for graduate architects to correctly convey end users' feedback to designers for future improvement.

The research findings would enable architects to focus on the types of knowledge required by graduate architects in BCA and develop appropriate strategies to successfully nurture them to be more effective in their work performance. In addition, BIM assists in addressing the issues. Therefore, further research into designing a building contract administration framework to improve graduate architects' performance in BCA is required, which serves as a guideline emphasising construction-related needs and competencies for graduate architects' professional development.

This research utilised the quantitative approach based on a survey questionnaire to identify the types of knowledge required by graduate architects in BCA. The quantitative method is known to lack insight into thoughts and accuracy. This, however, could be mitigated by a triangulated data collection process, which utilises multiple data sources, including semi-structured interviews, documentation reviews, and focus group studies.

Data Availability Statement

Some or all data, models, or codes that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Competing Interest

The authors report no declaration of interest.

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