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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.

Journal of Construction Business and Management (JCBM) is a peer reviewed journal. All research articles in this journal undergo rigorous peer review, based on initial editor and anonymised refereeing by at least two anonymous referees.

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IMPROVEMENT OF THE PERFORMANCE OF THE CONSTRUCTION INDUSTRY THROUGH EDUCATION AND TRAINING

Editorial December 2022

Introduction

This is the tenth issue of the Journal of Construction Business and Management, a combination of the regular issue and a special issue of selected papers from Construction Business and Project Management CBPM 2021 conference proceedings. This issue contains five blind double peer-reviewed articles by seventeen scholars in Nigeria, South Africa, and Malaysia covering strategic management, environmental pollution, compliance with building standards, dispute resolution, and performance management. Despite the difference in the topics, one of the key issues highlighted by the papers is the emphasis on improving education and awareness in the industry to address the issues identified in the papers. Following this introduction is the discussion of the papers, after which the conclusion follows.

Discussion of the papers

Compliance with construction regulations, standards and codes is fundamental to improving the key performance indicators, by implication, project performance (Umeokafor et al. 2022). Further, this means that it has implications for project risks. While developed countries still record compliance issues which have resulted in tragic events such as the Grenfell fire incident, the developing ones are not left behind, demonstrated to be worse in many indicators. Opawole, Alao, Yusuf, Adu and Ofoetan (2022) examine one of the major issues in building construction in Nigeria, construction materials-related building collapse. Using survey questionnaires, the authors assess the determinants of compliance with concreting materials standards in building projects in Nigeria, using one of the country's major cities, Lagos, as a case study. Being site-based and non-site based, the factors are in six categories, regulation, procurement, capacity, technical, performance and skills components. Production quality control, non-compliance with specified concrete mix, low concrete grade and supervision by incompetent persons are among the site-based factors. However, non-site-based ones include procurement policies and regulatory frameworks in efficiency and professionalism. It was also found that non-compliance with the national standards results in rework, project delays, additional costs, and environmental issues. To improve the quality of buildings through compliance with concreting materials and reduce or eliminate building collapse, the regulatory policies and enforcement mechanism, competencies and training, and ethical standards of stakeholders require more attention. While the generalisation of the findings is limited to Lagos state, given that it is one of the states with a high volume of construction, the study is, at least, indicative of what happens in major cities in Nigeria, such as Abuja and Port-Harcourt.

The second paper, by Rambaruth, Adam and Krishna (2022), on strategic management in construction small and medium enterprises (SMEs), addresses another pertinent issue. SMEs outnumber the large enterprises, the heart of the economies of countries. Yet, they face challenges, which in many cases are different from their large counterparts, for example, limited access to funds and competent persons. Many of these SMEs in construction lack strategic planning, one of the factors for early failure (Rambaruth et al., 2022). Many policies, strategies and studies are informed by large enterprises' views and contexts, overlooking the SMEs. Consequently, the authors examine the determinants of a company's decision to adopt a strategic plan, the role of strategic planning in improving a company's performance, and the challenges associated with a strategic plan in place. Using the eThekwini region of South Africa as a case study, the study found that key factors for strategic management in the construction SMEs examined include increased productivity, the quest to gain competitive advantage and improved decision-making. It was good to find that most of them adopted strategic management practices to improve business performance. The authors conclude that one of the ways of improving strategic management in construction SMEs is through improved education and awareness education and broadened skills curriculum by the government. Government and tertiary institutions can also integrate strategic management into SME training programmes. The need for education and awareness, consistent with the recommendations of Opawole et al. (2022), highlights the need for more attention to education and training in the construction and property industry.

Graduate architects are the future of tomorrow in the profession; they are yet to pass the professional examination but hold a Master's degree in Architecture. The need to exploit education to improve the construction industry's performance is furthered in the third paper by Tiew, Hashim and Zolkafli (2022). Tiew et al. (2022). investigate the major performance barriers that graduate architects encounter in project implementation. These factors are skills-based, poor project documentation management, lack of soft skills, inadequate quality assessment management, and a shortfall in design management. While it highlights the areas the universities can focus on, adequately integrating them into the curricula is consistent with the recommendations of Opawole et al. (2022) and Rambaruth et al. (2022) in this issue.

While education empowers the learners with knowledge, the process may have implications for their health and the environment. Addressing educational issues that have consequences for the environment and students' health is the focus of Nkeleme, Mbamali and Shakantu (2022). The authors measured the number of combustion pollutants generated while learning and teaching in laboratories at one of Nigeria's leading universities (Ahmadu Bello University Zaria) and their effect on indoor air quality. Nkeleme et al. found that the presence of CO during the combustion is above ASHRAE 62 and NAAQS limit of 9ppm reaching up to 45ppm at some points and oxygen at the critical level, 20.9 per cent or below 20.4 per cent. The authors also found that the laboratories are congested, and inadequate ventilation systems exacerbate the discomforting effects of combustion-generated pollutants. Adequate ventilation should be provided, which is one of the paper's recommendations. The students learning environment, including the physical ones, is one of the barriers to learning; it should facilitate and support education (Cleveland and Fisher 2014).

Undoubtedly, COVID-19 has socio-economic and health implications globally. However, it has increased attention on technology, mental health and some aspects of risk management in construction. Amoo, Lukman and Musa (2022) is the last paper, focussing on dispute resolution methods in construction during COVID-19, where South Africa is used as a case study. The aim is to determine their appropriateness and effectiveness. The findings demonstrate the negative implication of an interest-based approach rather than the right-based approach to resolving disputes in construction. Further, the study shows that negotiation, mediation, and conciliation were adopted to resolve unforeseen delays, claims, and added costs during the pandemic. The pandemic draws attention to pricing methods as a significant source of dispute in the supply and demand chain network during the period. It highlights the imperativeness of clear language in contracts, risk management training, communication improvement, and dynamic project schedule documentation as some conflict and dispute resolution tools post-COVID.

Conclusion

This issue which contains five papers from seventeen scholars in Nigeria, South Africa, and Malaysia, covers strategic management, environmental pollution, compliance with building standards, dispute resolution, and performance management. While the findings vary, one consistent key finding or implication of this is the need for education and training to improve the construction industry's performance. This is in terms of performance improvement skills of graduate architects, risk management training for those with contract and risk management responsibilities, integrating strategic management education in curricula, and building materials standard compliance training.

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

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Evaluation of Compliance of Concreting Materials to Standards in Building Projects in Lagos State, Nigeria

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Abstract

The incessant collapse of high-rise buildings has necessitated research into the compliance of materials — structural components and elements — to standards. This study evaluated compliance of concreting materials with standards in building project delivery. It examined the factors that influence compliance with standards of materials used for producing concrete elements. A quantitative approach was adopted in the study where structured questionnaires were administered to designers and constructors (such as architects, engineers/site supervisors and quantity surveyors) in consulting and contracting organisations in Lagos State, Nigeria. The data were analysed using frequency distribution, mean score, standard deviation, factor analysis and Kruskal Wallis test. Factors affecting compliance of materials with standards were categorised into construction site-based and procurement-based. These are technical, regulation, procurement, capacity, performance, and skill. The study provides implications for quality building production through improved compliance of concreting materials to standards. It also found the neglect of the use of structural engineers' services and limited standards observance on site. These lead to substandard components and elements production. It therefore, recommends efficient regulatory policies, enforcement mechanisms, improved training and instilling ethical standards among project stakeholders.

Keywords: Building projects, Compliance, Concreting materials, National standards, Project delivery.

1. Introduction

Construction materials are significant inputs in building project delivery. Performances in a building project are measured using the criteria, time, budget, and quality (Opawole, 2016). The quality component is consequently defined to a greater extent by the specification of materials and components. The number of large-scale building construction project failures and accidents in Nigeria in the recent past has raised the need for probing into several issues relating to the standards of materials for concrete component production. The products, mainly in the informal sector, often exhibit quality compromise. Recently, the Nigerian construction industry has faced many challenges, of which defects and collapse of buildings are inclusive. Most building defects and collapses ensued mainly due to non-compliance of the construction industry's professionals to the national standard on selected construction materials (Windapo and Rotimi, 2012; Adewoleet al., 2014). According to Adenike (2006), Grema (2006), and Bamisile (2004), compromise in building quality is mainly attributed to materials and workmanship. Akinyemi et al. (2016) grouped the causes of building collapse into three: types and quality of materials used and operational and personal problems. Where the cause of the collapse is traced to concrete quality, the fault is usually associated with poor aggregates and substandard cement grade (Olanitori, 2011; Adewole et al., 2014). Akinyemi et al. (2016) pointed out that poor concrete mix can lead to building collapse.

The issue of compliance with national standards in building projects is now a concern in the Nigerian building industry. Over the years, most collapsed buildings across the 36 States of Nigeria have been linked to poor quality materials and neglect of services of

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qualified professionals (Olanitori, 2011). Studies have shown that the Nigerian building construction industry is dominated by informal construction activities, in which operations are not professionally monitored. As a result, quality breaches in the building industry abound, with structural failures leading ultimately to building collapse (Akinyemi et al., 2016; Adewoleet al., 2014). The evaluation of some facets of the building industry in Nigeria reveals that the acknowledgment of compliance management strategies to national standards is at its low ebb. For example, Oludare and Oluseye (2016) found that the overall quality management system is the supervision of operatives and work processes. Hence, the degree of compliance with selected concreting material national standards in building projects attained is solely dependent on the mastery of the supervisor. This situation is commonly counter-productive, notably when the supervisor lacks knowledge and skills. The non-compliance with selected concreting materials to national standards in Nigeria has assumed an uncontrollable dimension. This attribute exhibited in the construction industry largely contributed to the bad image of the construction industry in Nigeria and thus suggested multidisciplinary investigations. Therefore, this study aims at evaluating compliance with concreting materials standards in building projects by assessing the factors influencing compliance with concreting materials, national standards and factors affecting compliance with national standards; also examining compliance with concreting materials to national standards and the effects of non-compliance on project delivery to enhance construction project delivery.

2. Component Standards Compliances Factors and Effects

According to Penn State University Libraries (2022), building codes specify minimum standards for the construction of buildings. They are not legally binding. They serve, instead, as "models" for legal jurisdictions to utilise when developing statutes and regulations. Building code becomes the law of a particular jurisdiction when formally enacted by the appropriate governmental or private authority. Ruya et al. (2017) opined that regulation is synonymous with law, and regulations are rules or norms adopted by the government and backed up by some threat or consequences, usually negative ones in the form of penalties. Designing Buildings (2022) stated that standards typically refer to published documents that are intended to define the common specifications, methods and procedures that are to be used, while building regulations establish minimum standards to be achieved in the construction of buildings. The National Building Code (NBC) is designed to be the master source of national standards in relation to the design and construction of buildings in Nigeria (Anigbogu and Anunike, 2014).

Building materials are materials or components used purposely to construct buildings (Omotehinshe et al., 2015). The two main categories of building materials are natural materials such as stone/granite/gravel or coarse aggregates, sand and the like or fine aggregates, and manufactured materials such as cement, reinforcement, irons, metals, tiles, blocks or bricks, concrete, and so forth. Building materials constitute the highest percentage of inputs in terms of volume and cost in building construction (Elkhalifa & Shaddad, 2018). Hamma-Adama and Kouider (2017) concluded that sub-standard building materials are one of the leading causes of building collapse. According to Twidale (1982), the final product of the crushing of rocks is simply granite chippings. Coarse aggregate (stones) is composed of quartz, feldspar, and mica. Biotite and muscovite are contained in mica, which are agents of oxidisation and might make concrete strength lesser or weaken over time (Bamigboyeet al., 2019). Since granite is good in strength, appearance and resistance to weathering, it should be void of excessive crystals of mica-biotite and muscovite.

Care should be taken to select suitable quality materials for building construction (Anthony, 2012). It is essential to carry out tests on the water to be used, sieve analysis on aggregates, tensile strength on reinforcement and also ensure there is a design mix to follow during construction (Bamigboyeet al., 2019). The key physical parameter used to classify and compare Portland cement includes bulk density, relative density (specific gravity), fineness, setting time, strength, soundness, the heat of hydration, and loss on ignition (Nwankwojike et al., 2014). In accordance with the specifications of the Bureau of Indian Standards (BIS) and European Standard EN 197-1, Portland cement used for intensive load-bearing superstructures is expected to exhibit a minimum of 3.1 specific gravity, maximum of 10% fineness, consistency range of 26 to 33% and initial/final setting time of not less than 30 minutes/not more than 600 minutes respectively.

2.1 Compliance with National Standards in the Construction Industry

The Nigerian construction industry has relied majorly on British and American Standards and Codes for construction materials and components. Professionals that specify materials (architects, engineers, and quantity surveyors), sometimes lack adequate knowledge of the function and performance of the materials and components they recommend (Adafin et al., 2011; Folorunsho and Ahmad, 2013). Several studies have been carried out on standards relating to construction materials. These studies include Voskresenskaya and Vorona-Slibinskaya (2018), focusing on the development of national standards pertaining to the safety and security of high-rise buildings in Russia; Angelino (2019), focusing on developing better design standards for the construction industry in the UK and Ndongo et al. (2020) concentrating on the current situation on the use of building construction standards in Congo-Brazzaville. In the last decades, much has not been done on the national standards relating to construction materials in the Nigerian construction industry as obtained in other countries (Anigbogu and Anunike, 2014).

Past studies on compliance with national standards include factors influencing compliance with safety standards guidelines in public secondary schools in Kitui Central Sub County, Kitui County (Muthiani, 2016); contextual, structural, and behavioural factors influencing the adoption of industrialised building system (Zakaria et al., 2018); analysis of some factors driving ecological sustainability in construction firms (Bamgbade et al., 2019). Also, there has been a lot of research evaluating compliance in various fields. Among these research works are sharia compliance in the construction industry (Annabi et al., 2017); an assessment of quality compliance using concrete test mechanism in Saudi Arabia (Al-Ghamdi, 2020); research on the construction of ecosystem in compliance risk management of foreign trade enterprises in Fujian Province (Hu, 2020); and Oludare and Oluseye (2016) focusing on quality management practices among construction firms. It is noteworthy to emphasise the impacts of non-compliance with national standards in the construction industry. These impacts are usually expected to affect products' quality negatively. Previous studies have also been conducted relative to the effects of non-compliance but not specifically on the impact of non-compliance with national standards. These studies include assessing the effects of non-compliance and enforcement of building safety regulations on construction sites in the Assin North Municipality (Dei, 2016), challenges facing building code compliance in New Zealand (Nwadike & Wilkinson, 2020) and antecedents and consequences of public procurement non-compliance behaviour (Tukamuhabwa, 2012).

The Nigerian construction industry is dominated by informal activities which often do not follow laid down procedures (Ezema and Olatunji, 2018). The industry's activities cannot be fully monitored due to the informality of their operations. As a result, quality breaches in the materials standards abound, with several structural failures leading ultimately to building collapse. A recurring theme is that lives are lost during simple, routine work. In many cases, an apparent lack of planning and compliance of construction materials with standards contributed to the tragedy (Ruya et al., 2017). Safety and safeguarding of life have been lacking in the Nigerian construction industry (Ndirangu, 2009). An underlying belief is that many accidents are not caused by careless workers but by poor adherence to materials standards and control, which ultimately is the responsibility of management (Ruya et al., 2017). Often collapses are attributed to several factors, including poor quality of materials and construction processes. In this respect, concrete, as an important structural component, deserves research attention if the challenges posed by building collapse (Ezema and Olatunji, 2018) are to be comprehensively addressed.

2.2 Concrete materials' standards: components, types, grades, and strength

Arayela and Adam (2001) stated that the first thing to question whenever any civil structure fails is the quality/strength of the concrete in it. The strength of any building component made of concrete depends on its two major components, reinforcing steel bars and concrete (Nwankwojike et al., 2014). Concrete is a composite material mostly used in building projects (Arum, 2008). It is a manufactured building material comprising cement, fine aggregates, coarse aggregates, and water with optional additives for improving performance. Concrete is the most versatile structural material that offers the flexibility of form not found in other structural materials (Ezema and Olatunji, 2018). It is composed of coarse granular material implanted in a hard matrix of material (cement or binder) that fills the space among the aggregates and binds them together (Gashemi, 2017; Arum, 2008). Alternatively, concrete can be said to be a compound material that consists of a binding medium, entrenched particles or fragments of aggregates. When freshly mixed, concrete tends to be flexible, therefore, can be used to form any shape.

The most common types of concrete in building projects are plain and lightweight concrete, which consists of natural minerals like pumice and Scotia and artificial minerals like expanded shales and clay with a density of less than 1920kg/m3 (Adewole et al. 2015). Others are high-density concrete, also called heavy-weight concrete and ranges in density between 3000 - 4000kg/m3. It is prepared using reinforcement and high-density crushed rocks as coarse aggregates (Ezema and Olatunji, 2018). This is also called Reinforced Cement Concrete (RCC). Steel in various forms is used as reinforcement to give varying high tensile strengths, and precast concrete refers to numerous shapes cast into moulds in a factory or at the site (Adewole et al. 2014). After placement, concrete gains strength quickly, particularly within the first seven days, which is crucial for achieving the needed strength. For determining the strength of concrete, the compressive strength at 28 days is usually considered (Arum, 2008). Ezema and Olatunji (2018) also stated that the strength of concrete primarily depends on the quality of constituent materials, namely cement, aggregates, and water.

Portland cement is one of the most common building materials on the building site. As stated earlier, cement acts as a binding agent in concrete (Odigure, 2009). Cement grade is a significant factor that contributes to concrete quality (Olanitori, 2011). It is essential in determining the compressive strength of concrete. The cement grades used generally for concrete production in Nigeria are grades 32.5, 42.5 and 52.5 (Kashim, 2014). The Standards Organisation of Nigeria (SON) approves grade 32.5 for plastering work and grade 42.5 for general concrete works, while the 52.5 grade is for special projects (Ezema & Olatunji, 2018). Adewole et al. (2014) investigated the effects of these cement grades on concrete compressive strength. The investigation indicated that the compressive strength of concrete produced with cement grade 42.5 is typically higher than that produced with grade 32.5. If the standard 1:2:4 concrete mix is to be utilised, the least cement grade would be 42.5. Adewole et al. (2014) noted that surveys supervised by the Standard Organization of Nigeria (SON) found that, during the construction of most privately-owned buildings, where concrete trial mixes were not conducted, the standard 1:2:4 mix ratio was used irrespective of the cement grade/strength class. The survey further disclosed that when concrete cubes were made with Portland cement grade 32.5 using 1:2:4 and 1:1.5:3 mix ratios, the compressive strengths were less than the 25 megapascals (MPa) and 30MPa cube strengths which are generally recommended for building superstructures and foundations respectively.

Anigbogu and Anunike (2014) discovered that ordinary Portland cement packaged in 50kg bags was found to vary from 35kg to 45kg in 53% of the shops surveyed. This wide variation in the weight of cement bags may contribute to the poor strength of work items where such cement bags are used. Nwankwojike et al. (2014) analysed different cement samples using methods of physical tests and conformity criteria for hydraulic cement specified by Indian Standards (IS 4031:1988), British Standards (BS 4550-3.4:1978) and European Standard (EN 197-1 2011). The results revealed that the respective fineness of the cement samples conforms with the standard specification of 10% maximum. However, the average specific gravity of the cement samples investigated was below the standard value of 3.1 minimum.

Contrary to general expectations, the 32.5 grade of some cement samples meant for lightweight construction exhibited higher concrete strength than the 42.5 grade of other cement samples designed to construct load-bearing superstructures. This is unexpected because the Standard Organization of Nigeria alleged that the two major grades of Portland cement used in Nigeria (32.5N/mm 2 and 42.5N/mm 2) are only being misapplied in some instances (Etim, 2014). In line with Enno and Mohsin (2001), the study concluded that all the five brands of Portland cement samples used for the study are short of international standards, and substandard 42.5-grade cement constitutes one of the major causes of the high rate of storey-buildings collapse in Nigeria (Nwankwojike et al., 2014).

Water is the main element of the concrete mix and plays a vital role in the chemical reaction of cement and aggregates (Roy, 2015). The quality and quantity of water used in concrete are also important. Roy (2015) asserts that the quality of hardened concrete is strongly impacted by the proportion of water used in concrete, as it influences compressive and flexural strength, permeability, and workability of concrete, as well as the bond between concrete and reinforcement. Odusote & Adeleke (2012) found that from the test carried out on reinforcement bars collected from collapsed buildings, the brittleness of reinforcement caused by the presence of high concentrations of sulphur and phosphorous with Iron (II) sulfide (FeS) and Iron phosphide (Fe3P) present (harmful materials) may have been responsible for many collapses of buildings in Nigeria. In a similar study, Bamigboye et al. (2019) discovered that the material's inherent flexibility had been significantly altered and compromised, which invariably aided the collapse of the buildings. Fine aggregates serve the purpose of filling the open spaces in between the coarse particles by reducing the porosity of the final mass. In some cases, granite quarry dust is often partially traded for sand in varying percentages to achieve satisfactory concrete strengths. This helps to reduce the intensity of sand mining which has adverse environmental implications (Ezema and Olatunji, 2018).

2.3 Factors influencing compliance with concreting materials national standards

Compliance with national standards in the construction industry is influenced by factors that may be intrinsic or extrinsic (DiMaggio and Powell, 1983). Tabish and Jha (2015) identified common factors influencing compliance: familiarity, monitoring, professionalism, sanctions, perceived inefficiency, and contractors' resistance. Mwelu et al. (2018) observed that non-compliance is induced by; self-interest, weak enforcement mechanisms, inefficient regulatory frameworks, and unprofessional conduct. Zadawa et al. (2015) concluded that misconceptions and unfamiliarity with procurement policies relatively undermined compliance in the Nigerian construction industry. Where building laws and regulations exist to achieve effective development control (Ezema and Olatunji, 2018), construction implementations still fall short of expectations because of unethical contract practices coupled with a weak regulatory framework (Longtau et al., 2016; Fernandez, 2014).

Another major challenge of the industry is the preponderance of informal activities. According to the International Labour Organisation (ILO), the informal sector in Sub-Saharan Africa, of which Nigeria is prominent, is globally regarded as the largest concentration of informality (ILO, 2002). The implication is that many industry activities are not completely captured in national economic accounting. This situation presents a considerable challenge to public programme planning and implementation. In Nigeria, this informality translates to a lack of regulations and is also primarily responsible for the high rate of building collapse (Ezema and Olatunji, 2018). Windapo and Rotimi (2012) had earlier attributed the major factors of building collapse to structural failure, poor supervision, workmanship, and use of substandard materials. Such factors characterise the Nigerian informal building and infrastructure procurement systems, eventually influencing non-compliance with standards. However, it is pertinent to note that most collapsed buildings are residential, procured in the unregulated system, calling on governments and professional bodies to act promptly for the safety of lives and property.

2.4 Effects of Non-compliance with National Standards on Building Projects Delivery

The effects of non-compliance with national standards have significantly depleted the effectiveness of the Nigerian construction industry. Lind and Brunes (2014) reported that non-compliance of construction materials and processes to standards in the public sector leads to extra cost and waste of time in procurement. Dei (2016) identified the effects of non-compliance with national standards on building project delivery to include accidents on site, loss of lives, decrease in productivity, project delay, and excess expenditure in the form of compensation. Building project research shows that Nigeria has experienced consistent building failures and collapses owing to non-compliance with prescribed standards. For example, 64 buildings collapsed between 1974 and 2011. These collapsed buildings reported include a guesthouse at Ikotun-Egbe, Lagos State, on 12th September 2014 and a three-storey building housing a school at Ita-Faaji, Lagos-Island, Lagos State. It is noteworthy that faulty designs and improper supervision, the leading cause of non-compliance of the approved construction materials to standards, predominantly caused these collapsed buildings in Lagos State. Incidences of collapsed buildings in Nigeria are only moderately recorded in literature; there has been persistent collapse of buildings in all parts of the country, but more in the civic areas in large numbers. Therefore, more failures have been recorded in Lagos State than in any other part of the federation (Windapo and Rotimi, 2012; Ebehikhalu and Dawam, 2014).

3. Research Methodology

3.1 Study Area

Lagos State in South-western Nigeria is the country's commercial nerve centre, which hosts many reputable consultancy and construction companies. As mentioned, the State has witnessed more building collapses than any other part of Nigeria (Ebehikhalu and Dawam, 2014). This study describes respondents' opinions on compliance with national standards regarding concreting materials forming the load-carrying elements in buildings.

3.2 Questionnaire design

A quantitative research strategy based on primary data considered suitable for the study was adopted (Cloete, 2002). According to Quinlan (2011), quantitative research usually involves gathering numeric data systematically. On that note, a structured questionnaire, an effective data collection instrument for measuring respondents' opinions and attitudes, was used (Van Laerhoven et al., 2004). The survey questionnaire was close-ended, which offers easy and relatively quick analysis (Kothari and Gary, 2004).

The questionnaire was developed based on the literature review's constructs and divided into two parts. Part 1 was designed to gather data on the respondents' academic and professional profiles, as well as respondents' experience in the construction industry. Part 2, used in collecting data on the study's objectives, was divided into three sections. Section one examined compliance with concreting materials national standards. Section two assessed construction site-based factors influencing compliance with standards of concreting materials and procurement-based factors affecting compliance with national standards. Section three sourced data on the effects of non-compliance with national standards on building project delivery. According to Leedy and Ormrod (2014), Likert-type or frequency scales use fixed-choice response formats designed to measure opinions. For compliance with concreting materials national standards, the assessment was such that 1= Very low, 2= Low, 3= Moderate, 4= High and 5= Very high. For construction site-based factors influencing compliance with standards of concreting materials and procurement-based factors affecting compliance with national standards, 1= Very insignificant, 2= Not significant, 3= Significant, 4= More significant and 5= most significant. For effects of non-compliance with national standards on building project delivery, 1= Very insignificant, 2= Not significant, 3= Significant, 4= More significant and 5= Most significant.

3.3 Questionnaire administration and response rate

The study's target populations were construction professionals in consultancy and contracting organisations in Lagos State. Mouton and Prozensky (2001) indicated that the availability of data, population size, and balance between cost and the desired accuracy could significantly influence the sampling frame. For this reason, randomisation was employed to ensure an unbiased sample. Sixty randomly selected construction professionals comprising practising architects, engineers/site supervisors, and quantity surveyors formed the sample size. Each respondent was chosen entirely by chance, not biased systematically, and each member of the population had the same chance of being included in the sample (Kothari and Gary, 2004). Sixty structured questionnaires were self-administered on the randomly selected practising architects, engineers, and quantity surveyors. Forty (40) valid copies, which represent a response rate of 66.67%, were returned and considered adequate for analysis since Idrus and Newman (2002) recommend a minimum of 30.0% rate for construction management studies.

Cronbach Alpha was used to test the reliability of the responses provided for the study objectives. Since the Likert scale was adopted for the study, it was imperative to calculate and report Cronbach's Alpha coefficient for internal consistency and reliability of the scales. Cronbach's Alpha ranges between 0 and 1. The closer the coefficient is to 1 the higher the internal consistency of the items in the Likert scale. Bonett and Wright (2015) stated that Cronbach's Alpha (α) > 0.6 is adequate. The Cronbach's Alpha for compliance of concreting materials to national standards, construction site-based factors influencing compliance with standards of concreting materials, procurement-based factors influencing compliance with national standards, and effects of non-compliance with national standards on building projects delivery are 0.878, 0.632, 0.875, and 0.803 respectively. This implies that the responses provided are reliable for carrying out this research.

3.4 Factor analysis

Factor analysis is typically used to explore the underlying structure of the set of variables as the influence factors in this research. The study used the technique to reduce the factors to manageable components. There are three main steps in conducting factor analysis – step (i) assessment of the suitability of the data for factor analysis. The data was first assessed for suitability of use of factor analysis. It includes the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO index ranges from 0 to 1, with 0 .6 suggested as the minimum value for a good factor analysis (Tabachnick and Fidell, 2007; Oboirien, 2019). The value of the KMO (0.672) test is shown in Table 1, indicating the data obtained were sufficient for factor analysis, and Bartlett's test of sphericity (0.000) was very significant.

Table 1: KMO and Bartlett's Test for Factors Influencing Compliance with National Standards

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.672
Bartlett's Test of Sphericity	Approx. Chi-Square	412.825
	Df	190
	Sig.	.000

Step (ii) factor extraction involves determining the smallest number of factors that best represent the interrelationships among the set of variables. There are a variety of approaches that can be used to identify (extract) the number of underlying factors or dimensions. The most commonly available extraction technique is principal components. According to Field (2005), for factor analysis to yield precise and reliable results and to proceed to the factor extraction stage, only factors with an eigenvalue of 1.0 or more are retained for further investigation. Eigenvalues greater than 1.0 was the criterion on which factor extraction was based.

Step (iii) factor rotation and interpretation. Once the number of factors has been determined, the next step is to try to interpret them. To assist in this process, the factors were 'rotated'. This does not change the underlying solution. Instead, it presents the pattern of loadings in a manner that is easier to interpret—the rotation shows which variables clump together. From the content of the variables, component interpretations were proposed. The 20 procurement factors influencing compliance with standards were reduced to six principal components. The cumulative percentage of variance, as explained by the six components, accounted for 75.99%. This shows that six components can account for 75.99% of the common variance shared by the 20 variables. The obliquely rotated components matrixes of the six major components with their nomenclature and loading factors are presented in Table 5. SPSS version 20 was used in the analysis.

3.5 Kruskal-Wallis's test

Kruskal-Wallis's test is used to determine the difference in the opinions of the groups of respondents. The Kruskal-Wallis H test (sometimes also called the "one-way ANOVA on ranks") is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous scale or ordinal dependent variable (Ostertagova et al., 2014). It is considered the nonparametric alternative to the one-way ANOVA and an extension of the Mann-Whitney U test to allow the comparison of more than two independent groups. Kruskal-Wallis's influences, effects, factors' ranks, and response opinions are shown in Tables 3, 4, 5, and 7. SPSS version 20 was used in the analysis.

4. Data Analysis

4.1 Profile of the respondents

The results of the analysis are presented in Table 2. The profiles of the respondents comprise their organisations, highest academic qualifications, professional affiliations, years of experience, and several projects participated in the last five years. Most respondents (70.0%) work in contracting firms, while (30.0%) work in consultancy. On the highest academic qualifications of the respondents, about (75.0%) were First degree holders, (22.5%) were Higher National Diploma (HND) holders while (and 2.5%) had other academic qualifications. Of the profession, engineers/ site supervisors had the highest representation (45.0%), followed by quantity surveyors (40.0%). However, the least proportion of respondents were architects (15.0%). Professionally, 45.0% of the respondents were registered with the Nigerian Society of Engineers (NSE), about (40.0%) with the Nigerian Institute of Quantity Surveyors (NIQS), and (15.0%) with the Nigerian Institute of Architects (NIA). More than half of the respondents (55.0%) had more than ten years of experience in the construction industry. Respondents' years of experience in the industry fall into a modal class of 10-15 years on an average of 8 projects. It can be seen from the above analysis of respondents' profiles that they possessed adequate qualifications and experience to supply reliable data for this research.

4.2 Findings and discussions

4.2.1 Compliance of concreting materials to national standards

Results of the evaluation of compliance with concreting materials' national standards are presented in Table 3. Five of the identified factors have mean scores (MS) ranging from 3.50 and 4.30. Highest compliance is reported on a 0.45:0.60 water/cement ratio with 4.30 MS. This is followed by cement grade (42.5) with an MS of 3.65, reinforcement grade 3.60 MS, aggregates grading 3.53 MS and reinforcement grade 40 for concreting with an MS of 3.50.

The significant compliance of the water/cement ratio could be due to the concrete placement mode (usually by head pan) and satisfactory workability. Good water/cement ratio concretes are easier to place in formwork and workable. When concrete complies with the water-cement ratio standard, it prevents seepages through joints in the formwork. This result agrees with Roy (2015), who opined that the water/cement ratio is the ratio of the mass of water to the mass of cement added to concrete and found that the quality of hardened concrete is strongly impacted by the proportion of water used in the concrete; as it influences compressive and flexural strengths, permeability, workability and the bond between concrete and reinforcement. As posited by Adewole et al. (2014) and Ezema and Olatunji (2018), the Standards Organisation of Nigeria (SON) approves grade 32.5 for plastering, grade 42.5 for general concretes and grade 52.5 for special projects. Cement grade also ranks high, probably due to varied grades of cement and manufacturers' specifications

Table 2: Profile of the Respondents

Respondents' Profile	Frequency	%
Nature of the organisation		
Contracting firms	28	70.0
Consultancy firms	12	30.0
Total	40	100.0
Highest academic qualification of respondents		
OND/HND	9	22.5
B.Sc/B.Tech	30	75.0
Others	1	2.5
Total	40	100.0
Professional affiliation of respondents		
NIA	6	15.0
NEWS	16	40.0
NSE	18	45.0
Total	40	100.0
Years of experience the respondent in the construction industry		
0-5	6	15.0
5-10	12	30.0
10-15	5	12.5
15-20	4	10.0
Above 20	13	32.5
Total	40	100.0
Mean= 13.75 years		
Number of projects involved within the last five years		
1-5	10	25.0
5-10	11	27.5
10-15	3	7.5
15-20	3	7.5
Above 20	13	32.5
Total	40	100.0
Mean= 13 projects		

This result concurs with Adewole et al. (2014), who concluded that the compressive strength of concrete produced with grade 42.5 is typically higher than that of cement grade 32.5. The ranks of grade 60 reinforcement for concreting, aggregates grades and grade 40 reinforcement for concreting should be due to their importance in structural stability. Structural failures are difficult and expensive to correct; hence engineers avoid them in construction (Ruya et al. 2017).

Five materials whose compliances rank low are 12mm HY reinforcement bar for slabs 3.27 MS, 12mm HY reinforcement bar for concrete in foundation 3.17 MS, superplasticisers as concrete admixtures 3.13 MS, 16mm high yield (HY) reinforcement for beams and 8mm HY reinforcement as stirrups 2.92 MS and cement types (Ordinary Portland Cement) with 2.82 MS. The insignificant compliances of 12mm HY reinforcement bars for slabs and 12mm HY reinforcement bars for concrete in the foundation could be explained by the usual substitution of 12mm bars with 10mm bars by contractors who see little or no difference in the strength impact of the two sizes. This is usually among quacks that rely on experiences from previous similar projects where stability was achieved and sustained. This finding aligns with Olanitori (2011), who linked building collapse to the inappropriate placement of steel reinforcement. Many professionals in the industry rarely use admixtures except in extreme situations; this could account for using superplasticisers as concrete admixtures. Kruskal Wallis test was used to assess the difference in the opinion expressed by respondents on concreting materials compliance with national standards. The result shows no significant difference ($p \geq 0.05$) in their opinion.

4.3 Assessment of construction site-based factors influencing compliance with standards of concreting materials

The ranking and Kruskal Wallis test of construction site-based factors influencing compliance of concreting materials to standards are shown in Table 4. The overall ranking of 12 factors out of the identified 16 have mean scores ranging from 3.50 to 4.88. This implies that these 12 factors were more significant in influencing compliance with standards of concreting materials. However, the topmost five significant factors that influence compliance with standards in the materials are site quality control 4.88 MS, non-adherence to concrete mix ratio 4.82 MS, supervision by local authorities 3.83 MS, use of low cement grade 3.82 MS, and use of uncertified construction supervisors 3.78 MS ranking 1st, 2nd, 3rd, 4th, and 5th respectively. The least five significant factors are non-compliance with aggregate size 3.5 MS, non-compliance with reinforcement grade 3.45 MS, use of poor-quality materials 3.35 MS, polluted and unclean water 3.35 MS, artisans-based supervisions only

3.03 MS whose ranks are 12th, 13th, 14th, 15th, and 16th respectively.

Site quality control ranks high among the factors because actual executions occur on-site. Using standard-based specifications notwithstanding, if site production falls below the design, product quality becomes low. Poor product quality control has been identified in the informal construction sector. Previous research has drawn a relationship between the informal procurement routes and building collapse in Nigeria (Ebehikhalu & Dawam, 2014; Fagbenle and Oluwunmi, 2010). Although the construction industry differs from manufacturing, quality control is primarily used in manufacturing. Due to the free market nature of the Nigerian construction industry and the myriad of informal building and infrastructure procurement activities, construction sites using unskilled labour as quality controllers or officers are prevalent. This finding agrees with Ezema and Olatunji (2018) and Ruya et al. (2017), who identified the preponderance of informal activities in the construction industry as a significant factor and contributor to quality compromise.

Non-adherence to the specified concrete mix also ranked high, reflecting quality compromise, poor workmanship and lack of adequate technical expertise prevalent in most Nigerian construction sites. Many private clients and contractors usually do not engage professionals in construction projects. As an important constructional element, the type of concrete and the compressive or tensile strengths required determine the mix ratio and cement grade specified by the structural engineer. This finding agrees with Akinyemi et al. (2016), who observed that poor concrete mixes during construction result in weak load-bearing elements, eventually leading to collapses.

The use of low-grade cement and uncertified construction supervisors also rank high, reflecting the disposition of both clients and contractors to tow the paths of least resistance and embark on corner cuttings. Many clients are unwilling to purchase the right quality and quantities of the needed construction materials. Several contractors engaged in such unprofessional acts by cutting corners for profit maximisation. Ezema and Olatunji (2018) noted that the strength of concrete primarily depends on the quality of the constituent materials, namely, cement, aggregates, and water for mixing. Local authorities must uphold the public's interest and ensure compliance with statutory requirements.

In this study, the extent of supervision by local authorities again ranks high. This could be because of the state of the construction's public service, which is plagued by inefficiency, corruption, and kickbacks exhibited by members of the tendering board, contractors and their employees. This is corroborated by Longtau et al. (2016), who opined that construction implementation falls short of expectations due to unethical practices and weak regulatory frameworks.

As stated in the methodology, Kruskal Wallis was used in testing the difference in the opinions of groups of respondents. The result shows that 15 of the 16 identified factors had p-values greater than 0.05, implying that the respondents' opinions on the fifteen factors were not significantly different. However, there was a significant difference (p-value = 0.010) in the respondents' opinion regarding one of the factors, which was 'the use of uncertified construction supervisors.

4.4 Procurement-based factors influencing compliance with national standards

The results of the assessment of the procurement factors influencing compliance of the concreting materials to national standards are presented in Table 5. The overall ranking of the identified 20 factors has mean scores of between 3.12 and 3.72. The topmost five significant factors are procurement policies 3.72 MS, construction methodology 3.72 MS, professionalism 3.63 MS, inefficient regulatory framework 3.62 MS, and networking 3.62 MS. The least five significant factors are inadequate funding 3.26 MS, procurement stakeholders' training 3.26 MS, labour skills 3.20MS, supervision 3.13 MS and familiarity with regulatory framework 3.12 MS.

Procurement policies comprising ignorance, misconceptions, and unfamiliarity are rife in the informal procurement routes in the Nigerian building industry. This means that several building site participants are not conversant with the procurement policy. Hence, compliance becomes an arduous task. This could explain why procurement policy ignorance ranks highest among the most significant influence factors. This concurs with Zadawa et al. (2015), DiMaggio and Powell (2015), and Tabish and Jha (2015), who identified procurement policies as a significant factor influencing compliance with the standard of materials.

Construction methodology ranks high because it is a vital part of the method statement and an important document to the contractor. Project success hinges on the adopted construction methodology; unfortunately, many contractors skip the preparation and use of construction methodology. Construction methodology is vital for meeting compliance with materials standards because it considers risks, constraints, opportunities, and legal and contractual requirements.

Professionalism ranks high as it greatly influences compliance with standards. It comprises codes of conduct and professional ethics, which observance is mandatory for various professionals. Moreover, the status, methods, characters and standards expected of professionals align with national standards. Embracing professionalism by construction professionals enhances their production compliance with standards. This agrees with the findings of Hemström et al. (2017), who noted professionalism as a significant factor influencing compliance with standards.

Also, ranking high is an inefficient regulatory framework (system of regulations and means of work enforcement that are inefficient). This results from weak enforcement by the appropriate authority (Ruyaet al., 2017). The current regulatory framework in Nigeria results in professional supremacies (conflicts) due to inadequacy in the boundary specifications of the various professionals' responsibilities (Grimshaw, 2001). Ruya et al. (2017) and Mwelu et al. (2018) noted that self-interest, weak enforcement mechanisms, inefficient regulatory framework, and unprofessional conduct induce non-compliance.

Kruskal Wallis test was used to assess whether there is a statistically significant difference in the respondents' opinions. The result shows that the twenty factors had p-values greater than 0.05, which implies that the respondents are unanimous in their opinion.

4.5 Variables reduction

The total variances explained by the 20 variables evaluated are shown in Table 6. An eigenvalue greater than 1.0 was the criterion on which the factor analysis was based. Procurement factors influencing compliance with standards were reduced to six (6) principal components. The cumulative percentage of variance, as explained by the six components, accounted for 75.99%. This shows that six components can account for 75.99% of the common variance shared by the 20 variables. The rotated components matrixes of the six major components with their nomenclature and loading factors are presented in Table 6. As shown in Figure 1, the scree plots revealed the variables with an Eigenvalue of 6.196%, which accounted for 30.981% of the observed variance.

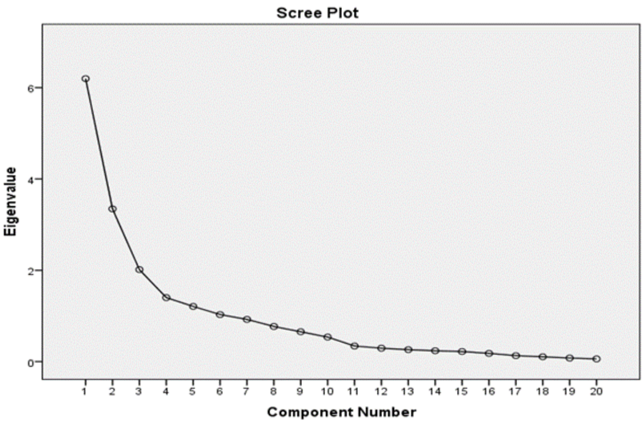

Figure 1: Scree Plot of Factors Influencing Compliance with National Standards

Technical-related factors explained 30.98% of the overall variance. The component is clustered with "faulty design" (0.538), "construction methodology" (0.775), "contractor's resistance" (0.882), "nature of the material" (0.661) and "ambiguity" (0.817). The significance of "contractor's resistance" explained to a greater extent the horrible experience that occurred when regulatory rules were not strictly adhered to. Deviations from structural engineering drawings and specifications as provided expose the client to financial risk and could cause major defects in the building project. The finding on "contractor's resistance" agrees with DiMaggio and Powell (1983), who identified contractor's resistance as a common factor affecting compliance in different fields. The ambiguity, which described the inability of the contractor or the supervisor to clearly understand what regulatory policies and contract documents stipulate before embarking on the project, agrees with Mwelu et al. (2018) that the regulatory framework should be written in plain language for clear translation.

Regulation-related factors explained 16.72% of the overall variance, and it consists of "familiarity with the regulatory framework" (0.782), "inefficient regulatory framework" (0.741), "monitoring" (0.847) and "professionalism" (0.709). The finding concurs with Mwelu et al. (2018) that non-compliance is induced by; inefficient regulatory framework and unprofessional conduct. Olayiwola and Adeleye (2005) also found the non-availability of an efficient regulatory framework and lack of a long-term policy plan for infrastructure development as key factors to non-compliance with standards. The Nigerian building industry faces an inefficient regulatory framework that undermines compliance with national standards.

Procurement-related factors explained 10.08% of the overall variance. The component is clustered with "misconception" (0.717), "procurement policies" (0.882), "weak enforcement mechanisms" (0.662), "self-interest" (0.702) and "inadequate funding" (0.559). The significance of "procurement policies" explains the extent of procurement policies made by the government to harmonise other existing government rules and strategies by regulating standards and formulating the legal framework guiding compliance. Consistency of government in regulations change in Nigeria almost with changes in administrations is supported by the results of Opawole et al. (2016). Thus, deliberate changes in procurement policies affect professionals' compliance with national standards. This finding concurs with Zadawa et al. (2015), which concluded that in Nigeria's public construction sector, misconception and unfamiliarity with procurement policies critically undermined compliance. Also, Mwelu et al. (2018) observed that non-compliance is significantly induced by self-interest and weak enforcement mechanisms. Forsythe (2015) and Isaac and Navon (2014) observed that continuous monitoring of construction projects enhances output by taking corrective actions that will boost compliance in procurement systems.

Capacity-related factors explained 7.10% of the overall variance. This comprises networking (0.695), supervision (0.741) and procurement stakeholder's training (0.854). The extent of supervision of building projects determines the efficiency of output. The study reveals that lack of supervision at the construction site is the cause of poor building project delivery, which couldalso lead to variations in the project cost. This finding agrees with the Public Procurement and Disposal of Public Assets Authority (PPDAAuthority, 2016), which suggested that training and instilling ethical standards among procurement stakeholders boost professionalism. This could be achieved via academic qualifications, skills, and networking.

Table 3: Compliance of Concreting Materials to National Standards

S/N	Factors	Overall			Contracting firm group			Architectural and Quantity Surveying consulting group			Engineering consulting firm group			KW Sig.
		Mean (MS)	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	
1	Water/Cement ratio (0.45:0.60	4.30	1.60	1	4.06	1.31	1	4.00	0.89	2	4.94	7.31	1	0.080
2	Cement grade used (42.5)	3.65	1.10	2	3.42	0.89	9	3.88	1.31	3	3.39	0.98	3	0.276
3	Reinforcement grade: grade 60 for concreting	3.60	1.55	3	3.01	1.93	14	4.19	1.17	1	2.94	1.63	14	0.051
4	Grades of aggregates (Well-graded aggregates)	3.53	1.09	4	3.50	0.97	6	3.56	1.21	7	3.39	0.98	3	0.621
5	Reinforcement grade: grade 40 for concreting	3.50	1.32	5	3.37	1.38	10	3.63	1.26	5	3.17	1.34	8	0.214
6	28 days curing period for 25N/mm2 compressive strength	3.48	1.13	6	3.83	0.98	3	3.50	1.21	9	3.33	1.14	5	0.608
7	Concrete Mix (1:2:4)	3.47	1.11	7	3.33	1.21	11	3.56	1.15	6	3.44	1.1	2	0.865
8	Size of aggregates: 20mm diameter for coarse aggregates	3.38	1.28	8	3.50	1.52	7	3.56	1.26	8	3.17	1.25	6	0.610
9	16mm HY reinforcement for columns and 10mm HY reinforcement as stirrups	3.35	1.49	10	4.00	1.55	2	3.38	1.54	12	3.11	1.45	11	0.431
10	Use of HY reinforcement bar for construction	3.35	1.39	9	3.83	1.60	5	3.44	1.50	11	3.11	1.23	10	0.423
11	4.75mm diameter for fine aggregates	3.33	1.46	11	3.50	1.76	8	3.44	1.46	10	3.17	1.43	9	0.792
12	12mm HY reinforcement for slabs	3.27	1.32	12	3.83	1.17	4	3.19	1.52	15	3.17	1.20	6	0.534
13	12mm HY reinforcement for concrete in the foundation	3.17	1.43	13	3.17	1.60	13	3.25	1.34	14	3.11	1.53	12	0.975
14	Superplasticisers as concrete admixtures	3.13	1.34	14	3.17	1.47	12	3.69	1.25	4	2.61	1.24	16	0.068
15	16mm HY reinforcement for beams and 8mm HY reinforcement as stirrups	2.92	1.46	15	2.67	1.63	15	2.94	1.61	16	3.00	1.33	13	0.889
16	Types of cement (Ordinary Portland Cement)	2.82	1.04	16	2.33	0.82	16	3.25	1.13	13	2.61	0.92	15	0.093

SD = Standard Deviation, Rk = Rank, KW Sig. = Kruskal Wallis Significance

Table 4: Construction Site-based Factors influencing Compliance with Standards of Concreting Materials

S/N	Factors	Overall			Contracting firm group			Architectural and Quantity Surveying consulting group			Engineering consulting firm group			KW Sig.
		Mean (MS)	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	
1	Quality control on site	4.88	1.42	1	4.98	1.28	1	4.69	1.56	1	3.61	1.38	9	0.925
2	Non-adherence to concrete mix by workmen	4.82	1.25	2	4.95	0.91	2	4.69	1.59	1	3.56	1.34	12	0.994
3	The extent of supervision by local authorities	3.83	1.08	3	3.97	1.08	6	3.69	1.08	6	4.06	1.11	1	0.317
4	Use of low cement grade	3.82	1.26	4	3.83	1.35	8	3.81	1.17	4	3.83	1.43	4	0.942
5	Use of wrong professionals for supervision	3.78	1.10	5	3.18	1.24	11	4.38	0.96	3	3.50	1.04	13	0.010*
6	Nature of consistent materials	3.72	1.20	6	4.33	0.82	4	3.50	1.37	8	3.72	1.13	6	0.388
7	Non-compliance with reinforcement bar size	3.65	1.33	7	2.83	0.98	13	3.81	1.17	4	3.78	1.52	5	0.179
8	Absence of sanctions for professionals for non-compliance	3.60	1.32	8	2.83	1.17	14	3.50	1.41	9	3.94	1.21	2	0.183
9	Cost of concreting materials	3.57	1.45	9	3.83	1.17	7	3.44	1.50	10	3.61	1.54	10	0.869
10	Absence of sanctions for labour for non-compliance	3.53	1.43	10	4.17	1.60	5	3.19	1.56	14	3.61	1.24	7	0.282
11	Level of training of labour	3.53	1.43	10	2.83	1.60	15	3.31	1.49	12	3.94	1.26	3	0.201
12	Non-compliance with aggregate size	3.50	1.41	12	3.50	1.05	9	3.44	1.55	11	3.56	1.46	11	0.952
13	Non-compliance with reinforcement grade	3.45	1.65	13	3.17	2.04	12	3.56	1.55	7	3.44	1.69	14	0.932
14	Non-use of quality materials	3.35	1.42	15	4.50	0.84	3	3.25	1.24	13	3.06	1.59	16	0.090
15	Lack of test of water	3.35	1.33	14	3.17	0.98	10	3.13	1.50	15	3.61	1.29	8	0.535
16	Dependence on artisans only for supervision	3.03	1.27	16	2.50	0.55	16	3.12	1.46	16	3.11	1.28	15	0.695

SD = Standard Deviation, Rk = Rank, KW Sig. = Kruskal Wallis Significance, *KW Significant factors with p-value ≤ 0.05

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Table 5: Procurement-based factors influencing Compliance with National Standards

		Overall			Contracting firm group			Architectural and Quantity Surveying consulting group			Engineering consulting firm group			
S/N	**Factors**	**Mean (MS)**	**SD**	**Rk**	**Mean**	**SD**	**Rk**	**Mean**	**SD**	**Rk**	**Mean**	**SD**	**Rk**	**KW Sig.**
1	Procurement policies	3.72	1.18	1	3.63	1.03	9	3.81	1.33	6	3.67	1.09	1	0.834
2	Construction methodology	3.72	1.21	2	3.37	1.20	13	4.07	1.22	1	3.44	1.10	5	0.229
3	Professionalism	3.63	1.37	3	3.76	1.23	1	3.50	1.51	14	3.39	1.34	9	0.125
4	Inefficient regulatory framework	3.62	1.30	5	3.30	1.31	17	3.94	1.29	3	3.39	1.34	9	0.419
5	Networking	3.62	1.17	4	3.43	1.17	12	3.81	1.17	5	3.44	1.15	6	0.657
6	Monitoring	3.60	1.17	6	3.83	1.17	3	4.00	0.89	2	3.17	1.30	15	0.126
7	Ethical standards	3.60	1.41	7	3.83	1.47	5	3.88	1.41	4	3.28	1.41	13	0.374
8	Contractor's resistance	3.55	1.22	9	3.83	1.17	3	3.44	1.59	16	3.56	0.86	3	0.839
9	Faculty design	3.55	1.06	8	3.33	0.82	14	3.75	1.24	8	3.44	0.98	5	0.533
10	Perceived inefficiency	3.55	1.43	10	3.50	1.76	10	3.81	1.38	7	3.33	1.41	12	0.598
11	Self-interest	3.53	1.26	12	3.83	0.98	2	3.56	1.55	12	3.39	1.09	7	0.653
12	Ambiguity	3.53	1.24	11	3.33	1.03	16	3.75	1.39	9	3.39	1.20	8	0.500
13	Misconception	3.50	1.38	13	3.67	1.63	7	3.31	1.58	18	3.61	1.15	2	0.855
14	Weak enforcement mechanism	3.49	1.21	14	3.83	0.98	2	3.60	1.45	11	3.28	1.07	13	0.503
15	Nature of materials	3.30	1.20	15	3.50	0.84	10	3.44	1.26	15	3.11	1.28	16	0.674
16	Inadequate funding	3.26	1.21	16	3.00	0.63	18	3.53	1.30	13	3.11	1.28	16	0.598
17	Procurement stakeholders' training	3.26	1.60	17	3.67	1.63	7	3.33	1.63	17	3.06	1.63	18	0.689
18	Labour skills	3.20	1.49	18	3.33	0.82	14	2.75	1.84	20	3.56	1.25	4	0.400
19	Supervision	3.13	1.44	19	3.67	1.21	6	3.19	1.47	19	2.89	1.49	19	0.493
20	Familiarity with the regulatory framework	3.12	1.40	20	3.00	1.67	19	3.63	1.26	10	2.72	1.36	20	0.148

SD = Standard Deviation, Rk = Rank, KW Sig. = Kruskal Wallis Significance.

Table 6: Factor Loading Points

Component	Loading	Total	% of variance	Cumulative %
Component 1: Technical-related factors		6.196	30.981	30.981
Faulty design	0.538			
Construction methodology	0.775			
Contractor's resistance	0.882			
Nature of materials	0.661			
Ambiguity	0.817			
Component 2: Regulation-related factors		3.345	16.723	47.704
Familiarity with the regulatory framework	0.782			
Inefficient regulatory framework	0.741			
Monitoring	0.847			
Professionalism	0.709			
Component 3: Procurement-related factors		2.015	10.076	57.779
Misconception	0.717			
Procurement policies	0.882			
Weak enforcement mechanism	0.662			
Self-interest	0.702			
Inadequate funding	0.559			
Component 4: Capacity-related factors		1.402	7.010	64.789
Networking	0.695			
Supervision	0.741			
Procurement stakeholders' training	0.854			
Component 5: Performance-related factors		1.210	6.048	70.837
Ethical standards	0.821			
Perceived inefficiency	0.756			
Component 6: Skill-related factors		1.031	5.154	75.990
Labour skills	0.803			

Table 7: Effects of Non-compliance with National Standards on Building Projects Delivery

S/N	Effects of Non-compliance	Overall			Contracting firm group			Architecture and Quantity Surveying consulting group			Engineering consulting firm group			KW Sig.
		Mean (MS)	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	Mean	SD	Rk	
1	Rework	3.97	3.25	1	4.61	1.60	1	3.33	1.50	10	4.67	4.50	1	0.724
2	Extra cost of rework	3.87	1.27	2	3.86	1.23	8	3.88	1.31	1	3.83	1.30	2	0.968
3	Late project delivery	3.74	1.29	3	3.61	1.22	12	3.87	1.36	2	3.61	1.34	4	0.772
4	Major defects in the building	3.68	1.27	4	3.61	1.54	13	3.75	1.00	3	3.56	1.42	5	0.847
5	Damage to the environment	3.60	1.37	5	3.70	1.37	10	3.50	1.37	8	3.56	1.46	6	0.746
6	Collapse of structures	3.55	1.43	6	4.17	0.98	3	3.63	1.36	5	3.28	1.60	8	0.469
7	Cost schedule implementation resulting from rework	3.51	1.36	7	4.00	1.27	6	3.07	1.49	14	3.72	1.23	3	0.249
8	Workmen's compensation increase	3.45	1.41	8	4.50	0.84	2	3.19	1.56	12	3.33	1.33	7	0.124
9	Government fines	3.32	1.31	9	4.00	1.27	6	3.44	1.26	9	3.00	1.33	12	0.252
10	Reduction in the Nation's GDP	3.31	1.44	10	4.00	1.10	5	3.53	1.51	7	2.89	1.41	13	0.251
11	License termination	3.30	1.76	11	3.50	1.98	14	3.75	1.53	4	2.83	1.86	15	0.381
12	Material wastage	3.28	1.49	12	4.17	1.60	4	3.06	1.53	15	3.17	1.38	9	0.263
13	Poor productivity	3.13	1.59	13	3.80	1.64	9	3.19	1.56	12	2.89	1.64	14	0.574
14	Image tarnishing	3.10	1.37	14	3.17	1.60	15	3.19	1.52	11	3.00	1.24	11	0.924
15	Partial disability of site workers resulting from structure collapse	3.08	1.47	15	3.67	1.51	11	2.87	1.59	16	3.06	1.39	10	0.496
16	Loss in revenue	3.07	1.51	16	2.83	1.47	16	3.56	1.41	6	2.72	1.57	16	0.252

SD = Standard Deviation, Rk = Rank, KW Sig. = Kruskal Wallis Significance.

Performance-related factors explained 6.048% of the overall variance. It comprises ethical standards (0.821) and perceived inefficiency (0.756). Concerning ethical standards, if continuous training and codes of professional ethics are significant factors among the stakeholders, a breach of ethical standards reduces and enhances contractor compliance with national standards. This concurs with Hemstromet al. (2017), who concluded that contractors could influence project output via professional skills.

Skill-related factors explained 5.15% of the overall variance. It is only clustered with labour skills (0.803). It emerged that the skill of the labour force employed on a building project impacts the outcome. Thus, a gang of skilled labour should be used where efficient building project delivery is paramount to the contractor and the client.

4.6 Assessment of effects of non-compliance with national standards in building projects delivery

The results of the assessment of the effects of non-compliance of materials for concreting components to standard on building project delivery are shown in Table 7. The 16 variables evaluated have 3.00 and above MS. This is interpreted as either significant or very significant in the assessment scale. The top five significant effects are rework 3.97 MS, rework cost 3.87 MS, late project delivery 3.74 MS, major defects on building 3.68 MS, and damage to the environment 3.60 MS. The least effects are also rated high; materials wastage 3.28 MS, poor productivity 3.13 MS, image tarnishing 3.10 MS, building collapse-induced accidents 3.08 MS and revenue losses 3.07 MS.

Rework as the effect of non-compliance with standards in the Nigerian construction industry is supported by the findings of Yusuf (2016) and Doloi et al. (2012). They identified rework as a significant contractor-related effect influencing construction project delivery and, eventually, a time overrun factor. Reworks are necessitated by poor performance, which in the first instance, is evidence of non-compliance with standards. The high ranking of rework cost reflects its financial implications, which Lind and Brunes (2014) found as an effect of non-compliance with the standard that lead to cost overrun and project delay. Project delivery behind schedule also ranked high, presumably because of extra time needed to remedy defects resulting from the use of sub-standard materials. Studies such as Yusuf (2016), Ameh and Osegbo (2011) and Aibinu and Odeyinka (2006) found project delay a common occurrence in the Nigerian construction industry. Non-compliance with concreting materials translates to poor quality structural members resulting in a building collapse, which is supported by the findings of Babatunde and Opawole (2009), and Ezema and Olatunji (2018).

Kruskal Wallis test was used to assess the difference in the opinions of the respondents on the effects of non-compliance with standards. The result shows no statistically significant difference ($p \geq 0.05$) in the respondents' views. This implies that respondents hold the same opinion on all the measured variables' effects on non-compliance with national standards in building project delivery.

5. Conclusion

The incessant cases of building collapse with its attendant devastating impacts, which have generated a lot of concerns, have been attributed to non-compliance with standards in the construction of buildings' structural components. Concrete members being major structural parts of buildings, therefore, necessitated the need to evaluate compliance with concreting materials to standards. This study evaluated the factors that influence compliance with standards of materials used for producing concrete elements. The study found that construction site-based and procurement factors influence concreting materials' compliance with standards in the study area. The site-based top factors are production quality control, non-adherence to the specified concrete mix, local authorities' supervision, low cement grade, and use of uncertified construction professionals for supervision. Others are water/cement ratio, cement grade, aggregates grading, grade 60 reinforcement for concreting, and grade 40 reinforcement bars. Low compliance with admixtures and cement types standards was found. The procurement-based factors are current procurement policies, construction methodology, professionalism, and inefficiency of the regulatory framework. Procurement factors influencing the extent of compliance of concreting materials to national standards enabled were compressed using the factor analysis technique. Six components were extracted; technical, regulation, procurement, capacity, performance, and skill component-factor, which relate to contractors, regulatory bodies, and construction professionals.

Finally, the effects of non-compliance with national standards found and ranked are reworked, the extra cost of rework, project delivery delay, remarkable building defects, and damage to the environment. The study provided implications for quality building production through improved compliance of concreting materials to national standards. Therefore, the study recommends that efficient regulatory policies and enforcement mechanisms be implemented to ensure compliance with national standards for concrete elements. These can be achieved and sustained through frequent training, sensitisation and instilling ethical standards among professionals by professional institutions such as the Nigerian Society of Engineers (NSE), Nigerian Institute of Building (NIOB), Nigerian Institute of Architects (NIA) and Nigerian Institute of Quantity Surveyors (NIQS).

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Contributing Elements and Issues to Strategic Management in the Construction Industry Among Small and Medium Enterprises: A Case Study in South Africa's eThekwini Region

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Abstract

Small and medium-sized enterprises (SMEs) are vital to the economy and have helped it grow, but they still have a high failure rate. Many businesses fail within the first few months of operation due to a lack of strategic planning. This study aimed to identify persuading factors that contribute to strategic management to improve performance and categorise challenges faced by SMEs in implementing a strategic plan in the eThekwini region of South Africa. The study adopted a quantitative research approach, and the population of interest for the research includes small and medium construction companies, which were sourced via the Construction Industry Development Board (cidb) registry. An online survey tool was used to distribute the questionnaire to 145 small and medium businesses. The data were analysed using descriptive and inferential statistical tools and exploratory factor analysis (EFA). The study's findings reveal that most eThekwini-based SMEs in the construction industry use strategic management practices to improve their business performance. The key factors for strategic management in SMEs, such as improving decision-making processes, increasing productivity, and gaining a competitive advantage, demonstrated high levels of agreement among participants regarding improving business performance. This study also found widespread agreement on the challenges of implementing a strategic plan in an organisation. Therefore, small and medium-sized enterprises (SMEs) must develop procedures and policies to deal with the difficulties that arise when drafting a strategic plan. This will ensure that strategic planning works in their operations. This can be accomplished by implementing strategic management into SMEs training programs offered by government and tertiary institutions that support SMEs. The government should also improve education and broaden its business skills curriculum.

Keywords: Business, Construction, Performance, Planning, Strategy, South Africa.

1. Introduction

Globally, the construction industry plays a substantial role in creating jobs and contributing to the economy. The construction industry lays the foundation for resources and trade to build infrastructure; these actions stimulate and grow the economy (Osunsanmi, Aigbavboa and Oke 2018; Odiba, Demian and Ruikar 2021). While the construction industry adds value to the economy, several threats are experienced that influence the industry's performance. For example, the laws governing the construction industry, the Preferential Procurement Policy Framework Act, 2000 which caters for Historically Disadvantaged Individuals (HDI) in South Africa and the Broad-Based Black Economic Empowerment Act 2004, which empowers black businesses (Oyewobi et al. 2019). In addition, the industry experiences poor competition, corruption, price fixing, manipulation and collusive tendering (Oyewobi et al., 2019). Effective management or planning in the industry can be achieved through strategic management. The emphasis placed on the need for strategic management in the construction industry has been noted by many researchers (Stanitsas, Kirytopoulos and Leopoulos 2021). There is a lack of interest or consideration in strategic management in the construction industry; many organisations do not feel it necessary to plan strategically, and as a result, construction projects are

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not managed effectively (Nduati, Kariuki and Wanjohi 2021).

Small and medium enterprises play a vital role in the social-economic growth of the country. In South Africa, SMMEs contribute approximately 52% of the country's gross domestic product (GDP). The industry has an impact on all categories. An SME is defined as a company with fewer than 200 employees, an annual turnover of less than R64 million ($3,733,803), and a total gross asset value of less than R19 million ($1,108,473), according to the National Small Business Acts (Berisha and Pula 2015; Nieuwenhuizen 2019). Furthermore, the National Small Business Act defines an SME in the construction industry as a company with fewer than 200 employees, an annual turnover of less than R26 million ($1,516,858), and a total gross asset value of less than R5 million ($291,703) (Nieuwenhuizen 2019).

SMEs have the capacity to reduce unemployment and poverty in the country through job creation and innovations (Kibuuka and Tustin 2019; Nuseeb et al. 2021). Small businesses tend to seize opportunities in the market and provide the necessary products and services to satisfy demand (Williams Jr et al., 2018). Even though Small to Medium Enterprises have contributed to the sector, many are plagued by high failure rates and poor performance (Singh 2019). Approximately 70% of South African SMEs fail in the first four years of operations (Bruwer, Siwangaza and Yolandé 2018). One of the contributing factors to the high failure rate is the macro environment. The failure of these businesses increases the country's social ills, unemployment, and crime (Jayasekaraa, Fernandob and Ranjani 2020).

Strategic management refers to the science of developing a competitive advantage through planning to create value for the organisation. The process involves making, applying, and reviewing decisions in the business (Abosede, Obasan and Alese 2016). Implementing a strategic management plan is necessary to manage the uncertainty in the environment. The features of strategic management, for example, strategic planning, stakeholder management and environmental analysis play a vital role in the development of an SME (Fitriasari 2020). Some organisational strategies are informal and unstructured. However, they have some direction as to where they are heading compared to an organisation with no plan (Nduati, Kariuki and Wanjohi 2021).

Notably, the use of strategic management in the various sectors supports the response to demands from the market, the change in technology and the variations in customers' preferences (Bakar et al. 2011). Technology in the fourth industrial revolution is transforming how businesses operate, and having the necessary digital tools or skills is critical to SMEs. Having a digitalisation strategy enables a small business to be more competitive; they can set business goals that are more aligned to digital transformation, provide products and services that are more technologically advanced or set out a phased approach in transforming their operations into a digital space (Fitriasari 2020).

The global economic crisis affects small businesses negatively, however, the necessary mitigating strategies could assist companies in better managing potential risks (Fitriasari 2020). Strategic management within SMEs is frequently ignored. Every business's goal is to be a "going concern," which means that it will continue to exist for an undetermined amount of time. A plan or strategy allows an organisation to survive and advance (Ekon and Isayas 2022). Going through a strategic management process allows an organisation to identify its challenges and opportunities and develop a competitive advantage over rivals to achieve its goals (Karadag 2015). SMEs that adopt a strategic objective tend to be more focused on growth within the business; it provides a formalised company structure. For example, an informal small business may want to formally register and create a business plan to attract investments (Kibuuka and Tustin 2019).

There is a link between environmental awareness and organisation performance (Hamdoun 2020). The environment and customer demands are forever changing, and adopting a strategic approach to deal with the changing climate may result in a competitive advantage for the business (Chiloane-Tsoka and Boya, 2014). Studies have shown that economic factors such as high inflation, high taxes, uncertainty, crime, volatile markets, poor service delivery, skill shortage, delay and non-payment of service providers, and high overhead costs create loss events which threaten the existence of South African SMEs (Bruwer, Siwangaza and Yolandé 2018). The internal controls and risk management methods are inadequate. Even though organisations customise their approach to dealing with risk, it still does not provide reasonable assurance in achieving their objective. The significance of this study is that it encompasses the identification of persuading factors that contribute to strategic management to improve performance and the classification of challenges SMEs face in implementing their strategic plans.

2. Literature review

Small and Medium Enterprises (SMEs) have contributed significantly to the growth of the economy, however, there is still a high failure rate (Anamalay 2014). The National Small Business Act of 1996 as amended in 2003 and 2004, ranks SMEs according to the number of employees employed, turnover and gross business value. In the construction sector, medium, small and micro enterprises consist of a total number between 5 to 200 full-time equivalents of a paid employee, a total turnover between R200 thousand to R26 million and a total gross asset to the value of R100 thousand ($5,835) to R5 million ($291,703) (fixed property excluded). Many of these small and medium enterprises (Kibuuka and Tustin 2019) face a threat of failure within the first few months, and the lack of strategic planning may prevent them from achieving their full potential (Lestari et al. 2020). When starting a business, success or failure is always possible (Anamalay 2014). Challenges involve the inability to hire qualified staff, lack of funds for expansion, limited or non-existence credit with suppliers and poor planning and management. Many of these disadvantages can be linked to improper planning and misuse of funds (Alshameri 2020).

3. Factors that impact the implementation of the strategic plan

3.1 Strategy management

The main characteristics of strategic management involve formulating, implementing, and monitoring strategies (Hansen 2020). A strategy is an organisation's plan to gain a competitive advantage over rivals. Furthermore, the strategic plans address several challenges an organisation may experience (Zsigmond, Machová and Zsigmondová 2021). Change in an organisation is inevitable. Therefore, strategic planning and organisational change are necessary (AlQershi et al., 2020).

Additionally, transformation within the organisation is required. The outdated procedures and plans must be replaced with new procedures to allow for unpredictable changes in the micro and macro environment. During this transition process, an organisation can deal with the challenges of organisational intricacies, globalisation, resource management, government regulations, and competitiveness.

Innovation and critical thinking are critical components in managing change (Thompson 2017). Through innovations, an organisation can improve its performance and take advantage of the opportunities presented in the markets. A lack of innovation and critical thinking leads to organisations not having new ideas to move them forward, which can also result in an organisation losing its competitive advantage.

Critical thinking and situation analysis of the organisation aid in establishing a vision/imaginary idea (AlQershi et al. 2020). A vision is a vital component of the strategic management process (Alshameri and Green, 2020). A vision statement is a shared idea by leaders; it displays the desired approach or image of the organisation (Alomian, Alsawalhah and Almarshad 2019). A vision statement is not a one-size-fits-all remedy; it may, at times, erode the organisation's credibility by not aligning with the organisation's desires, culture, and environment (Mashwama, Thwala and Aigbavboa 2020). It is a written communication of the organisation's vision. It supports the setting of objectives for employees and guides their actions(Allison 2019). Communication and implementation of this vision lie in visionary leadership, where leaders communicate the organisation's intentions and persuade the employees to contribute to the organisation's vision (Wenzel, Stanske and Lieberman 2020).

3.2 Strategy implementation

Strategy implementation is introducing a strategy to an organisation's various departments or divisions (David 2013). The traditional methods of the strategic formulation are based on planning, resourcing and ensuring that the organisation achieves its profit margin (Fuertes et al., 2020). Strategic formulation and evaluation complement each other and are equally important to an organisation (Ateş et al. 2020a). The implementation phase is applying the strategic plan; the process involves the application of budgets, policies, and programs; it is the translation of ideas into action in the hope of achieving a competitive advantage and success (Thompson 2017).

The implementation stage is considered more difficult than the formulation stage. At the formulation stage, senior management is the decision maker. The activities are controlled at the senior level compared to the implementation stage, where the strategic plans are introduced throughout the organisation (Ehlers and Lazenby 2010b). At this stage, the intention is to build and maintain a structure that delivers. Organisations tend to get the feel of staffing requirements, target markets and customer demands (Barbosa, Castañeda-Ayarza and Ferreira 2020).

Strategy implementation involves the employees' commitment to strategy and voluntary efforts in contributing to the organisation's goal (Ateş et al. 2020a). Even though strategy implementation plays a vital role in the strategic management process, there is no definitive formula for implementing these strategies. Each organisation has its way of deploying its strategy, and the context may differ from one organisation to another. However, the common thread remains; leadership and the organisation's alignment (Culture, policies, procedures, and resources) are critical for implementing strategies. Owning a good strategy necessarily means success; driving the strategy at implementation with the buy-in and contribution from employees remains a crucial aspect of strategy (Ateş et al. 2020b).

3.3 Strategic competitiveness

Strategy is a set of decisions and actions managers take to gain a competitive advantage over rivals. Strategic choice is the examination and selection of possible strategic alternatives (Parthasarthy, 2007; Orozco et al., 2014). A simple definition of competitive advantage is when an organisation develops capabilities to outperform its rivals (Alomian, Alsawalhah and Almarshad 2019). Usually, managers gain a competitive advantage by effectively managing internal resources and activities (Ateş et al. 2020a). Having a well-defined strategy aligned with the organisation's objectives enhances competitiveness (Oyewobi et al. 2019). According to Dikmen et al. (2009), a clear vision or plan must be established to achieve a competitive advantage.

A SWOT analysis provides insight into the organisation's Strengths, Weaknesses, Opportunities and Threats. From this analysis, the organisation can assess its core competencies, plan resources and identify trends in the market. Some construction companies use a hybrid method to outperform rivals compared to the traditional methods of quality, product and service innovations, time, and cost to achieve a competitive advantage. This hybrid mode offers construction companies to select one approach or have a variation of importance on modes (Oyewobi et al. 2019). A firm might adopt a differentiation strategy where the pricing power of the firm is low (Allison 2019). Formulating a strategy to gain a competitive advantage comes in various forms, for instance: 1) using innovative technology or processes. 2) The ability provides superior quality goods and services, offering faster delivery services or procuring materials of superior quality. 3) Being socially responsible by committing to cooperate with social responsibility policies (Lestari et al. 2020).

Strategic intelligence is the key factor in developing a competitive advantage. It provides valuable insight into technology developments, environmental changes, stakeholder management and strategies that create value. The two entrepreneurial strategy concepts that can be used to gain a competitive advantage are: 1) Knowledge acquisitions refer to the organisation's knowledge base and how a resource-based view strategy can assist the organisation in hiring competent staff and a formidable team. 2) Core competencies deal with the technical knowledge or knowledge that an entrepreneur may possess. This knowledge can improve the organisation's processes, which may result in a competitive advantage (Chiloane-Tsoka and Boya 2014).

3.4 Challenges faced by Small and Medium Enterprises

When starting a business, success or failure is possible (Anamalay 2014). However, the challenges SMEs face outweighs the benefits of managing a small business. SMEs tend to encounter challenges in all areas of the business environment, which are linked to poor planning and management (Corman and Lussier, 1996). According to Oyewobi et al. (2019), many of these businesses face challenges in recruiting skilled and qualified staff, limited excess financial resources, little or non-existence credit with suppliers and technological changes.

The South African construction industry is known to be competitive. Yet, government legislation such as Preferential Procurement Policy Framework Act (PPPFA) gives preference to designated groups, resulting in a competitive environment (Oyewobi et al. 2019). These regulations negatively impact the economy as well as foreign investment. In addition, SMEs in the South African construction industry face socio-economic challenges such as poverty, skills shortages, basic education, unemployment, crime, and racism (Nhleko, 2017). To overcome these challenges, small businesses must consider adopting a strategic approach to doing business (Oyewobi et al., 2019).

4. Research methods

4.1 Inquiry Form and Data Collection

This study adopts a quantitative research approach that employs a questionnaire for data collection. The data collection questionnaire was developed based on a previous study by Mori (2013). The questionnaire was divided into two parts. In the first section, the paper examines the demographics of the survey participants. Strategic planning questionnaires were included in the second section of the report, which inquired about the reasons behind businesses adopting a strategic plan, the contributing factors of strategic planning in improving the performance of the enterprise, and the challenges they face when implementing a strategic plan. All the questions were closed-ended, making it possible to perform statistical analyses on the data.

Furthermore, this study's Cronbach Coefficient Alpha was 0.876, which is an extremely high level of reliability (Msani 2011). The study focused on a sample population of eThekwini-based contractors registered with the Construction Industry Development Board (cidb) and actively involved in civil work. The questions were short, simple, and to the point. Data were retrieved using QuestionPro Software after an online questionnaire software was used to distribute the survey to participants. The online questionnaire was sent to 145 small and medium-sized businesses, but only 105 responses were returned. As a result, the response rate was 72%. These construction firms were also cidb-registered as active industry participants. Individuals involved in the company's strategic planning were asked to participate in the survey. After a week, three reminders were sent to ensure the responses were properly followed up.

4.2 Data Reliability

Cronbach's Alpha is a widely used method for determining reliability. For this study, the Cronbach Coefficient Alpha was 0.876, which is an acceptable level of reliability (Table 1)

Table 1: Cronbach Alpha Results

	Section	**Number of items**	**Cronbach's Alpha**
B2	Factors that drove your business to adopt a Strategic Plan	6	0.605
B3	Contributions of strategic planning in improving the performance of your enterprise	9	0.881
B10	Challenges facing the implementation of a strategic plan in an organisation	10	0.861
Reliability Statistics	Overall	25	0.876

Table 2: Factors that influenced the company's decision to implement a Strategic Plan

Factors	Perception of Impact*					No.	Mean Item Score	Rank	Level of Contribution
	1	2	3.	4	5				
Competitiveness	0	0	8	33	61	102	4.51	1	High
Limited firm resources	2	4	22	39	35	102	3.99	2	Average
Globalisation	1	7	22	43	28	101	3.89	3	Average
Organisation intricacies	3	8	23	44	26	104	3.79	4	Average
Government contribution	8	7	17	35	31	98	3.75	5	Average

*1= very low, 2 = low, 3= average, 4= high, 5= very high

4.3 Ethics Approval

The study was approved by the Durban University of Technology Ethics Committee (IREC: 18FREC). Before the study, each participant was given an informed consent form to complete, ensuring their safety and privacy.

4.4 Data analysis

The data for the study were analysed using descriptive and inferential statistics. The raw data is gathered and then transferred to a computer spreadsheet. The data for this study were analysed using descriptive and inferential statistics, including cross-tabulation, correlation, chi-square test, and Cronbach Alpha. The Cronbach alpha was used to determine the data's internal consistency within a group.

5. Results and Discussions

Only 105 of the 145 questionnaires sent to the samples were returned. As a result, 72% of participants responded to the questionnaires. Figure 1 illustrates the size of the company in terms of employees.

Figure 1: Number of employees

According to the study, 90.5 % of the companies had no more than 20 employees ($p < 0.001$).

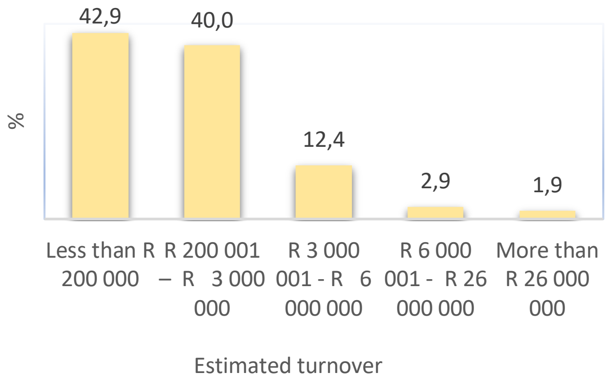

Figure 2: Estimated turnover for the financial year

Figure 2 presents the estimated turnover for the previous financial year. More than 80% of respondents said their companies' annual turnover was less than 3 million rands ($175,022). While 12.4 per cent of the respondents said their company's turnover was between 3 million and 6 million rands ($350,044), 2.9 per cent said it was between 6 million and 26 million rands ($1,516,818), and 1.9 per cent said it was more than 26 million rands. This trend could be explained by the fact that the government is not spending enough on infrastructure projects above 3 million, resulting in a significantly low contractor turnover for the financial year (van der Waldt and Fourie,2022).

5.1 Execution of strategic plans

Factors that drove small and medium enterprises to adopt a strategic plan are summarised in Table 2.

According to the results shown in Table 2, the major perceived contributors influencing the company's decision to implement a strategic plan are high-ranked factors such as competitiveness and leading-edge technology, which showed high levels of perception. The results for limited firm resources show average to high levels of perception, indicating that the factor impacts the decision to adopt a business strategy. This implies that businesses can effectively manage their limited resources and achieve organisational goals through strategic planning (Mori, 2013).

Table 3: Strategic Planning that ensures an organisation's success

Factors	Perception of Impact*					No	Mean Item Score	Rank	Level of Contribution
	1	2	3	4	5				
Enhanced decision-making	0	0	8	43	52	103	4.43	1	High
Competitive advantage	0	0	9	47	48	104	4.37	2	High
Improved turnover	0	3	13	41	46	103	4.26	3	High
Improved production	0	3	14	40	47	104	4.25	4	High
Enhanced customers experience	1	2	15	40	45	103	4.22	5	High
Enhanced quality of goods and services	0	4	15	40	43	102	4.19	6	High
Enhanced organisations capabilities	1	5	17	36	45	104	4.14	7	High
Enhanced brand credibility	0	4	20	38	42	104	4.13	8	High
Improved employee morale	1	2	26	33	42	104	4.08	9	High

*1= very low, 2 = low, 3= average, 4= high, 5= very high

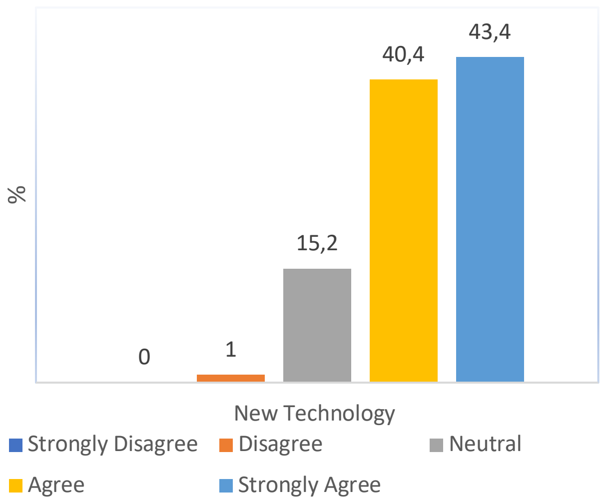

Figure 3: Improvement of new technology in adopting a new strategic plan

5.2 Factors affecting the organisation's ability to perform

The results suggest that approximately 92% (Table 3) of the respondents agree that strategic planning has improved the decision-making process of the business, and about 91% of the respondents concur that having a competitive advantage enhances the company's performance.

According to Table 3, all factors show high contribution levels that planning helped businesses make better decisions. According to the report, this factor significantly impacts the company's performance. When it comes to decision-making, strategic management uses a methodical decision-making process that is objective, systematic, and logical (Christou 2015). The organisation must make long-term decisions and plans as part of the strategic management process. Moreover, these decisions establish the organisation's vision, mission, and goals (Mori, 2013).

5.3 Challenges in implementing a strategic plan

The results in Figure 4 indicate that 33% of the respondents agree and 40.8% strongly agree that poor communication negatively influenced the implementation of a strategic plan. In comparison, 14.6% of the respondents remained neutral. The statement shows (significantly) higher levels of agreement, indicating that the factor contributes to improving the business performance. Communication and stakeholders play a vital role in creating organisational wealth. Moreover, communications are equally important in building relationships (Ehlers and Lazenby 2010a). Management needs to understand the needs or concerns of the stakeholders and have a clear communication channel when formulating strategic plans for the business. Also, the strategic plan must show employees how their roles impact the vision and success of the company (Mori 2013).

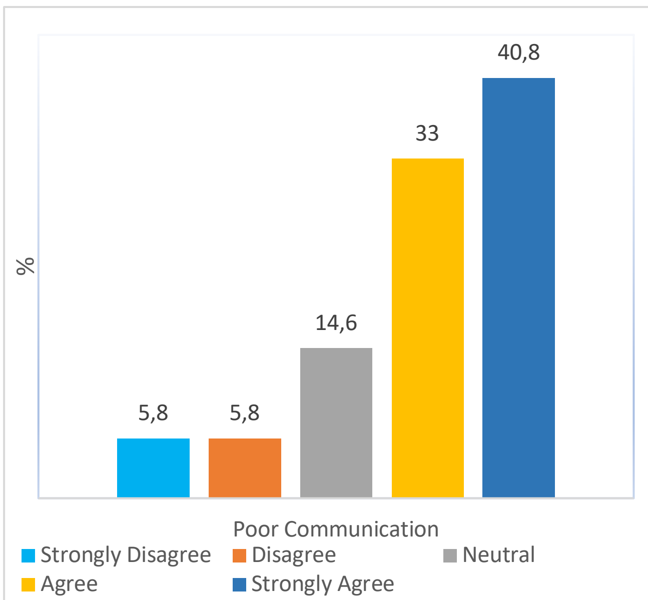

Figure 4: Communication skills' impact on strategic plan implementation

The results for lack of expertise indicate that 35.9% of the respondents agree and 46.6% strongly agree that a lack of expertise negatively influences the implementation of a strategic plan. In comparison, 12.6% of the respondents remained neutral. The construction industry is inexperienced in strategic planning procedures and lacks strategic managerial skills (Gunduz and Abdi, 2020). Managers and business owners should undertake the necessary entrepreneurial and management studies to gain an overall knowledge of strategic planning. Above and beyond, a lack of specialised expertise and inadequate knowledge of the planning process is harmful to a business (Wang, Walker and Redmond 2007). Other challenges and results are presented in Figure 5.

6. Conclusions and Recommendations

The current study focused on the factors that influenced a company's decision to adopt a strategic plan, the role of strategic planning in improving a company's performance, and the challenges associated with a strategic plan in place. According to the study's findings, eThekwini-based SMEs in the construction industry use strategic management practices in their businesses and have improved their performance because of this implementation. The study also found that strategic planning can reduce environmental uncertainty and provide a structured approach to addressing problems. Furthermore, strategic management encourages SMEs to plan and commit to short and long-term goals, which helps them grow. As a result, SMEs are more likely to achieve business success through strategic management. Small businesses should develop procedures and policies to deal with the challenges of implementing a strategic plan. Despite these findings, success is not guaranteed even when companies use strategic planning. Businesses may not achieve their objectives due to poor implementation or a lack of strategic management expertise. More research should be conducted to evaluate the need for strategic management to improve SMEs' business performance and long-term government investment in the construction industry. Furthermore, the study has three main limitations. 1) The study was conducted in the eThekwini region of South Africa and did not represent other municipalities or provinces. Furthermore, it does not represent the entire construction industry.2) The study has focused on SMEs in the construction industry and did not fully represent other industries in the country, such as manufacturing or agriculture. 3) The study only concentrated on SMEs registered with the cidb. This study recommends SMEs management the following recommendations

1. Regardless of their position within the company, every employee should be involved in the strategic management processes, and the organisation should provide the appropriate training and opportunities for professional growth.
2. The government and educational institutions at all levels need to emphasise the importance of strategic planning in business and provide training in this area to SMEs. In addition, training programs for SMEs that aim to foster the growth of small businesses need to incorporate strategic management.

Conflict of Interest:
The authors declare no conflict of interest.

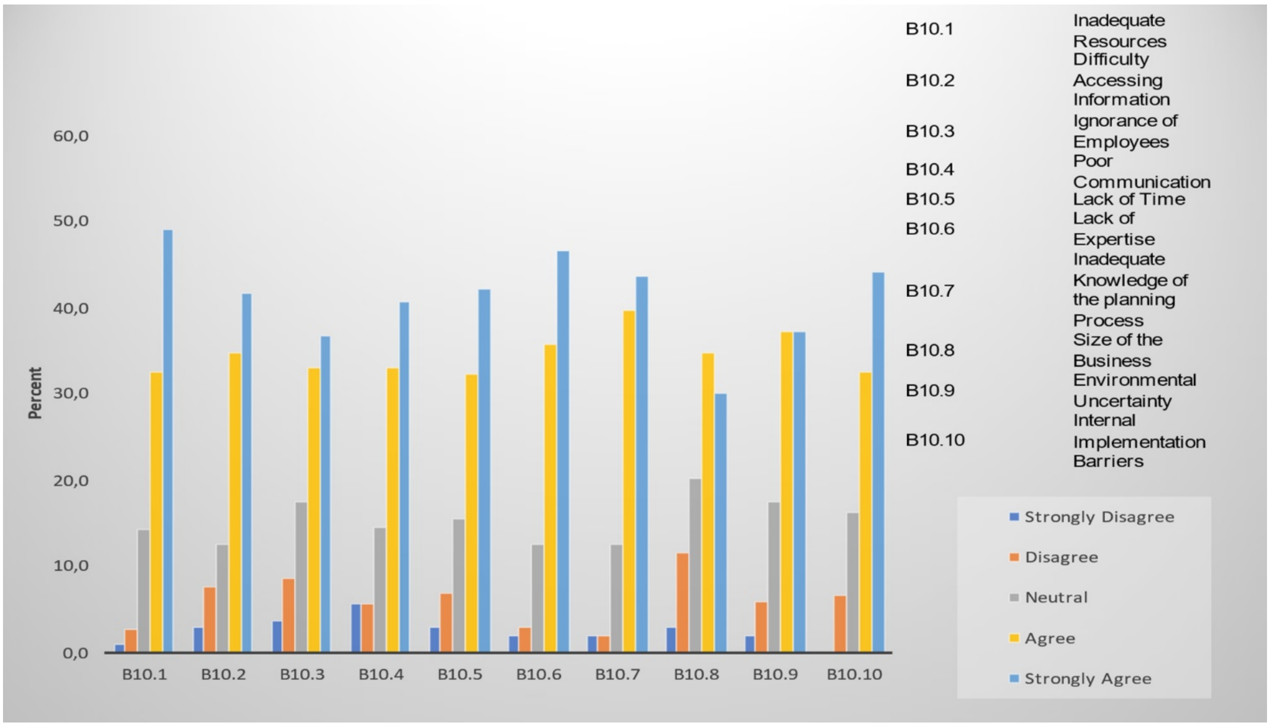

Figure 5: Challenges in the implementation of a strategic plan

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Performance Barriers affecting Graduate Architects in Architectural Firms: A Systematic Literature Review

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Abstract

Graduate architects assist architects in carrying out stage one work (design), stage two work (working drawings) and stage three work (site supervision) in Architectural Firms. Graduate Architects hold a Master's degree in Architecture and are yet to pass their professional examination. The capability of a graduate architect when assisting an architect in managing a project is critical in reducing performance barriers. This research aims to identify the most critical performance barriers that graduate architects face during project implementation. This paper examines the performance barriers that are faced by graduate architects and is a timely study as the increasing population and building construction developments will provide ample opportunities for them to perform better. A systematic literature review of credible sources from different databases, examining key issues related to performance barriers, has been carried out based on bibliographical variables and conceptual categories. Accordingly, a data set of fifty articles and five selected case studies were analysed using thematic analysis. The five most crucial performance barriers identified are external environment factors, poor project documentation management skills, lack of soft skills, inadequate quality assessment management skills, and a shortfall in design management skills. The study's outcome is expected to equip the graduate architects to devise proactive risk mitigation measures that will reduce the impact of these barriers and improve project delivery.

Keywords: Architectural Firms, graduate architect, management skills, performance barriers.

1. Introduction

An architect is a qualified professional who translates building requirements into practical reality. They act as an agent, advisor, or contract administrator for building projects (Ostime, 2019). When an architect starts on a project, they work on three key steps: define, design and refine (RIBA, 2020). The architect is responsible for defining the program after understanding the owner's written narrative statement of needs (Ostime, 2019). This statement is the project brief where the client explains their needs, budget, and requirements to the architect. The second step is the schematic and preliminary design in architectural agreements (RIBA, 2020). The schematic design, in the form of a bubble diagram, shows the flow of spaces to give an overall view of the concept design and is expanded to include alternative exterior elevations.

The design phase represents the required period to take the design and refine the details of appearance, structure, mechanical, electrical and plumbing systems and to select the finishes (RIBA, 2020). This is where the coordination with the various consultants takes place- to avoid any clashing of mechanical, electrical and plumbing (MEP) services with the building design. Building Information Modelling (BIM) is a medium utilised to detect 'clashing' in the building design. The final phase is where the work produced during the earlier designing and refining phases has been developed to such an extent that a contractor can build from the results (RIBA, 2020), whereby the architect translates the conceptual design into a buildable design through construction drawings. Accordingly, the architect will assume the duty as the contract administrator when the contractor is mobilised to the site and commences the construction.

As defined by RIBA, the graduate architect refers to a person yet qualified to be named an architect, albeit providing design or management services in the

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architectural consultancy practice (Demkin, 2001). They act as an assistant to the architect, carrying out tasks such as the submission of drawings, arranging and preparation of schematic design drawings, tender, construction, and contract drawings, coordinating with consultants and surveyors, chairing meetings, conducting site walks, handling discussion with the supplier and contractors (Ostime, 2019). Besides being an assistant, the graduate architect mainly administers the building contract on behalf of the architect during its construction (Chappell & Dunn, 2015).

The graduate architects are expected to perform during their practice- in line with the view that they undergo two types of training during their architectural education: architectural training and the practical training system (Gundes & Atakul, 2017). This practical training emerges as an important opportunity to gain real-world experience in higher education and to bridge the gap between the passive learning environment in academia and the changing demands of the workplace. There are two types of practical training; the first includes work practice in a typical architectural design office, and the second is the construction site internship, where the intern is required to monitor and actively participate in the execution of works (Gundes & Atakul, 2017). The significant contribution of this program is for the architecture students to acquire soft skills such as teamwork, leadership, communication, and problem-solving skills, which in their recruitment of graduates the employer values more than specialist subject knowledge. The program also improves the graduate architects' construction employability skills, enabling them to better fit in the working environment (Gundes & Atakul, 2017).

Khodeir’s (2020) research has however highlighted that employers have often given negative criticism regarding the graduates' attributes at the early stage of their careers. Architectural Firms are dissatisfied with the quality of the graduates and have noted that they have to re-train fresh graduates to make them fit for their jobs before starting their practice (Laila Mohamed Khodeir & Nessim, 2020). The best opportunity for practical training of students before they graduate is during six months of Industrial Training in Architectural Firms. This means that Architectural Firms are partly responsible if there is any gross inadequacy during practical training. There is a significant gap between education and practice that is faced by architecture students (Khodeir, 2018). The graduate architects' knowledge from education is insufficient to cope with the career's requirements. Thereby, some graduate architects spent more time exploring, through trial and error in administering building contracts to acquire the necessary skills and experience because of insufficient exposure or lack of guidance while at work (Açici, Ertaş, Aras, & Özdemir, 2014; Hai, 2010).

Previous literature indicated that a graduate architect failed to perform due to the inability to acclimatise to the working environment (Szumlic, 2017). The conditions, scenarios, and case studies described in education are far more idealistic than the real world. Hence, the transition from the safety of an academic environment to that of independent practice turns into a frightening experience, described as 'reality shock' in literature (Serafin, Danilewicz, Chyla, & Czarkowska-Pączek, 2020). The graduate architects are confused in this new environment where they are unsure of how to utilise the knowledge they have obtained from education in practice. This was proven by Alharbi, Emmitt and Demian (2015), who stated that education focused on creating a knowledge base but not on bringing such knowledge into practice. The graduate architects faced various performance barriers when managing a construction project. Therefore, it is crucial to identify the barriers that hinder the performance of graduate architects so that they can resolve them accordingly and perform more effectively in administrating building contracts.

2. Research Methodology

This research adopted a systematic literature review to summarise the available evidence with little or no bias. A systematic literature review is a well-planned review to answer specific research questions using an organised and explicit methodology to identify, select, and critically evaluate the results of the studies, including the literature review (Rother, 2007). The adopted review process for this study is based on the recommended Rother et al. (2007) and is summarised in the study eligibility flow chart in Figure 1.

2.1 Review question(s)

The research investigates the types of performance barriers faced by graduate architects when managing a building contract. The review questions are as follows:

1) What barriers hinder the graduate architects' performance when managing a building project?
2) What are the mitigation measures that enable them to perform while administering the building contract?

2.2 Inclusion and exclusion criteria

The inclusion criteria were defined as follows:

1. All articles related to the graduate architects' current practice in the construction industry and the barriers.
2. All available journals, conference papers, or theses related to the performance barriers in managing the construction project during the contract implementation and management phase.

The list was refined by establishing four selection criteria for exclusion:

1. The research was focused on the mitigation measures only.
2. Literature was written in a language other than English
3. Research on the perceived barriers by other non-construction professions was disregarded.
4. Studies of performance barriers in other phases, excluding the construction phase.

2.3 Search Strategy

The initial step was to identify the relevant literature through searches of several databases (ISI Web of Science, SCOPUS, and Google Scholar), combining the following series of keywords and search terms: 'graduate architect', 'construction industry', 'contract administrator', 'building contract', 'performance barrier' and 'architects'. Publications in the reference lists of the initial database supplemented this literature.

2.4 Screening

The screening process includes the following: -

1. The result obtained from the database search were listed based on relevance.
2. Each article's title and abstract were checked to determine their relevance.
3. Relevant articles were saved to a specific folder using a reference management program (EndNote).
4. The total number of relevant articles and types was recorded.

2.5 Results of the search

The search results were presented in the 'Findings' section.

2.6 Data Extraction

The data extracted from multiple research articles require organisation into themes and categories by the author to be understood. The content is coded based on different themes and is organised based on descriptive metrics for each reported case of performance barrier.

2.7 Quality/rigour evaluation

The sources of articles that have been collected include books, book sections, conference papers, journal articles, and theses that suggest the different levels of rigour which influence the findings. Hence, they are all taken into consideration for this study.

2.8 Synthesis

The content of each article was read, analysed and coded to a theme or subtheme relevant to the research.

2.9 Reporting findings

The findings of the systematic review are reported below.

2.10 Case Studies

Case study research is a fundamental research methodology for applied disciplines, contributing to understanding real-world phenomena. It allows the researcher to explore individuals or organisations simply through complex interventions, relationships, communities or programs and supports the deconstruction and the subsequent reconstruction of various phenomena.

A case study is used to illustrate and assess how the proposal meets the aims of creating purposeful mitigation measures and meeting the profession's demands in a supportive environment that fostered development. Details of the case studies are described in Table 1. The case studies were selected based on the following criteria:

1. Suite apartments or service apartments that are under the residential category.
2. Strata housing– high-rise buildings due to strata housing projects are long-term transactions with high uncertainty and complexity.
3. A project is under the contract implementation and management phase because this is the construction process where the architect's blueprint will be converted into reality.
4. Private development uses the PAM contract, whereby the superintendent officer will be the architect with a contract duration ranging from 30-36 months.
5. The architect had been appointed as the building contract administrator.

Five ongoing housing projects that met the above criteria were selected for this study.

3. Findings

3.1 Search results

The following tables sum up the databases included in this literature study: results from the database search stated in Table 2, the number of selected articles sorted by year of publication indicated in Table 3, and the main sources of articles shown in Table 4.

3.2 Documentation Analysis

Construction documents such as progress reports, request for information, and correspondence between consultants and contractors are a type of archival material that provides two sorts of information- observations of the obstacles faced during the construction stage and the possible mitigation measures.

The contract documents from the case studies shown in Table 5 were collected, thoroughly studied, and analysed to investigate the themes which can be classified and matched to the survey data collected. From the analysis, the types of barriers can be categorised into technical information, social and legal aspects, as shown in Table 6.

3.3 Graduate Architects in Contract Management and Implementation Phase

Graduate architects have been found to be active in managing building contracts ever since they were permitted to do so under By-law 5 in the Uniform Building by-law (UBBL, 2013). However, due to inexperience and a lack of skills, e.g. negligence in supervision, insufficient

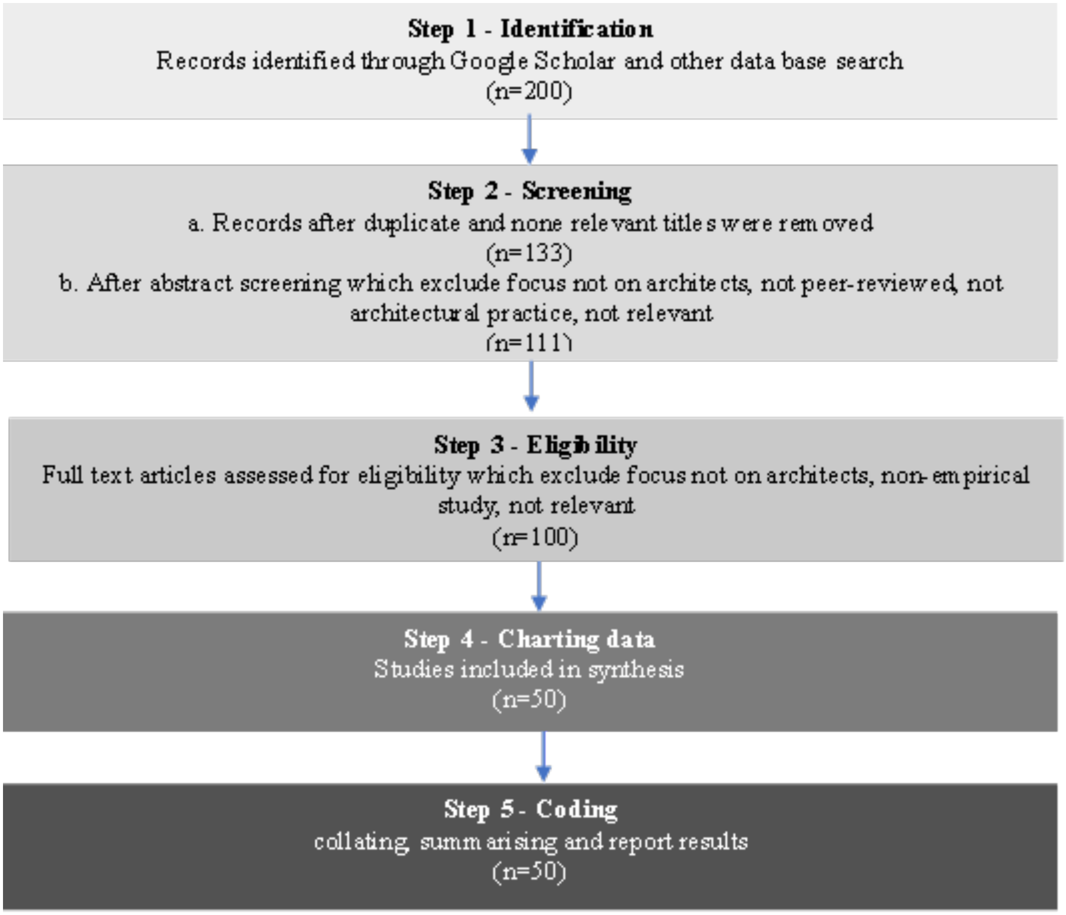

Figure 1: Study eligibility flow chart

Table 1: Case studies selection

Name of Project	Location of Project	Size of Project
Project A	Kuala Lumpur	Three blocks 33 floors apartments
Project B	Kuala Lumpur	Two blocks, 23 floors of apartments
Project C	Kuala Lumpur	One block 31 beds affordable apartment
Project D	Kuala Lumpur	Two blocks 42 floors service apartments
Project E	Kuala Lumpur	Two blocks, 32-45 floors service apartments

Table 2: Result from Database searches

Number of Articles	Web of Science	Scopus	Google Scholar
Deemed relevant	65	56	79

Table 3: Number of Articles by year of publication

Year	Articles
Before 2000	5
2001 – 2010	14
2011 - 2016	17
2017	4
2018	1
2019	3
2020	1
2021	5

Table 4: Source of Articles

Source	No. of articles
Conference proceedings paper	7
Book	8
Theses	4
Journals	
Procedia Social and Behavioural Science	2
Journal of Construction, Engineering Management	3
Engineering, Construction and Architecture Management	2
Journal of Project Management	1
Civil Engineering & Environmental	1
Transaction of Engineering Management	1
International Journal of Sustainable Construction Engineering and Technology	1
Journal of Education and Arts	1
Journal of Performance Constructed Facilities	1
Interdisciplinary Journal	1
Journal of Built Environment	2
Journal of Construction in Developing Countries	1
Journal of Research in Engineering	1
Journal for Theory & Practice of Socio-Economic Development	1
Journal of Construction Project Management	1
International Journal of Project Management	1
Journal of Management in Engineering	1
International Journal of Applied Engineering Research	1
International Journal of Innovation & technology management	1
Procedia Engineering	1
Frontiers of Architectural Research	1
Alexandria Engineering Journal	1
Journal of Legal Affairs & Dispute Resolution in Engineering & Construction	1
Emerging Science Journal	3

Table 5: Details of the selected housing projects for case studies

	Project A	Project B	Project C	Project D	Project E
No. of blocks	3	2	1	2	2
No. of storey	33	23	35	34	32-45
Types of building	Residential	Service apartment	Residential	Service apartment	Service apartment
Gross Floor area (sq ft)	2,280,635	485,199	450,286	692,205	830,090
No. of unit	2000	429	515	584	705
Location	Mukim Setapak	Mukim Kuala Lumpur	Mukim Setapak	Mukim Batu, KL	Mukim Batu, KL
Month of construction	36 months	72 months	25 months	72 months	30 months
Contract period / Completion Date	15 August 2017 – 14 August 2020	15 August 2016 – 15 February 2021	8 June 2018 – 8 July 2020	1 November 2014 – 31 July 2021	3 August 2020 – 5 June 2023
Construction cost	300,000,000	Confidential	80,800,000	638,000,000	161,000,000
Building layout	L shaped	Cluster form	Linear	Linear	Linear
Current status	Completed	Completed	Completed	Completed	Under construction

Documentation of the designer's work, failure to comply with the authority requirement, unclear detailed results, contradictory information, unbuildable details, uncoordinated systems and coordination errors, the graduate architects perform poorly in management, which led to chaos in the construction projects (Mohamed, Ridwan, Saoula, & Issa, 2019).

Professionals who the Board of architects represents regularly critique the incomplete education of the students they employ after graduation. Notably, the graduates' deficiencies are viewed to be related to their insufficient skills, which they also fail to reflect upon during their office work (Szumlic, 2017). As Duffy and Bowe (2010) claim, older architects sometimes lament what they see as a decline in technical skills among their younger colleagues. Also, schools of architecture report failure by their graduates to meet employers' expectations (Tzonis, 2014). Many have enumerated that the missing skill is the notoriously exhibited incapacity to communicate effectively with professionals at building sites while supervising activities on behalf of the architecture office. In addition, poor technical knowledge and the misunderstanding in professional communication with construction management and the project team retard the construction progress (Celadyn, 2020).

4. Discussion of findings

Numerous barriers were common to graduate architects, including the points shown in Table 7.

4.1 Poor Project Documentation Management Skill

The most crucial performance barriers identified from the literature and case studies are 'poor project documentation management skill'. This theme comprises five barriers: ' PB7-inexperienced', 'PB21-lack guidance proper documentation', 'PB25-conventional management protocol', 'PB28-ineffective management', and 'PB36-incomplete documentation during award'.

Proper documentation of a construction project includes generating sufficient records to affect the history of the construction process. Documentation of an event should consist of "what happened, when it happened, how it happened, when it was discovered, whose responsibility, who was notified, to whom and when was notification is given, what was the impact of the event, what immediate action is required, what longer-term action is required and which party will be responsible for resolving the problem" (Gallo, Lucas, McLennan, Parminter, & Tilley, 2002).

The significant impacts of proper documentation are to have a future case study for problem reference; to date ease for tracking of job history; a reduced possibility of future misunderstandings, disagreements, or disputes by committing important events into writing; to possess supportive documents if mediation, arbitration or litigation is pursued (Senaratne & Mayuran, 2015). Arbitrators gave the example of problems they encountered the most- concerning documentation, where one party failed to provide documentary evidence, which in their opinion, could have altered the outcome of the case (Kangari, 1995). The party with the most comprehensive and detailed records will have the decided advantage in any dispute resolution proceeding (Arditi & Robinson, 1995).

Inadequate and deficient design and documentation directly impact the construction process's smoothness (Aiyetan, 2013). Correspondingly, Tilley et al. (2002) have identified that the lack of briefing by the client and the graduate architects who furnish preliminary detail design has caused constructability problems for the contractor. They have also identified information deficiencies and poor coordination between the design disciplines as the main issues affecting the project documentation. According to Love et al. (1997), rework and non-conformance costs are due to the lack of design and documentation to transfer information during the design process.

The study from DeFraites (1989) has stated another point of view, where a decline in the design fee levels and the reduction in the amount of time for design, especially a complex construction project, have contributed as factors to poor design and documentation performance (Trach, Pawluk, & Lendo-Siwicka, 2019). A preliminary design violates the quality of documentation (Laila Mohamed Khodeir & Nessim, 2020; Love & Edwards, 2004). The situation becomes worse with the appointment of inexperienced staff who lack technical knowledge, which could lead to errors and omissions in the contract documentation (Love & Edwards, 2004). The most frequent causes of severe deviations during design were poor planning or resource allocation and deficient or missing input and changes (Gallo et al., 2002; Jaffar, Tharim, & Shuib, 2011).

To resolve this issue, proper documentation involves and requires the creation of sufficient records to affect the history of the construction process (Fawzy & El-Adaway, 2012; Levy, 2018). Proper documentation means important events are accurately and promptly recorded. The prompt receipt, review, transmission, distribution and tracking of the documents are critical elements of project administration (Rochegova & Barchugova, 2016). Documentation of this process must be complete, accurate, and timely. For example, shop drawing submission, request for information (RFI), material or sample or the method of the submission of the statement should be recorded in the list of submissions, which consists of the tracking number, date as to when the request was created, date sent to the architect, date when a response is required, a brief description of the question and the answer from the consultants, (Oke, Bhekisia, & Aigbavboa, 2016; Heerkens, 2002). A regular review of an outstanding contractor's submission should occur during the site meeting, where the status should be documented accordingly (Agbaxode, Dlamini, & Saghatforoush, 2021; Oke et al., 2016). Close monitoring of the RFI status is required as it will affect either the cost or time, which will generate

Table 6: Identified graduate architects' performance barriers through literature

No.	Performance Barriers	No. of studies
1	External environment factors	8
2	Poor project documentation management skill	16
3	Lack of soft skill	9
4	Inadequate quality assessment management skill	11
5	The shortfall in design management skill	11

Table 7: Performance barriers faced by graduate architects identified from the case studies

Code	Performance barriers summarised from case studies	Project A	Project B	Project C	Project D	Project E	Code	Performance barriers summarised from case studies	Project A	Project B	Project C	Project D	Project E
PB1	Miscommunication				*	*	PB22	Insufficient design details	*		*		
PB2	Slow decision	*		*			PB23	Design & detail error	*		*		
PB3	Lack coordination				*	*	PB24	Lack of info in drawings				*	*
PB4	Delay reply queries	*	*	*			PB25	Conventional management protocol	*	*	*	*	*
PB5	Poor contract management knowledge	*		*		*	PB26	Impractical design	*		*		
PB6	Lack Information				*	*	PB27	Incomplete design info				*	*
PB7	Inexperienced	*	*	*	*		PB28	Ineffective management	*			*	
PB8	Construction complexities	*		*			PB29	Poor design management	*		*		
PB9	Design degrade				*	*	PB30	Error during design	*		*		
PB10	Discrepancy contact form	*		*		*	PB31	Complex details	*		*		
PB11	Searching for Alternative building material	*	*	*			PB32	Non-compliance to specification	*	*	*		
PB12	Inadequate site inspection	*	*	*			PB33	Lack of understanding of clients' requirement				*	*
PB13	Confirming alternative materials	*	*	*			PB34	Design changes	*		*		
PB14	Alternative design proposal	*	*	*			PB35	Poor info use				*	*
PB15	Unaware legal policy	*		*		*	PB36	Incomplete documentation during the award	*	*	*		
PB16	Unclear building contract	*		*		*	PB37	Poor site supervision & inspection	*				
PB17	Inappropriate performance measurement	*	*	*			PB38	Uncertainty advising other stakeholders				*	*
PB18	Poor specification	*		*			PB39	Attending to client-driven design changes	*		*		
PB19	Non-integrated project delivery	*	*	*			PB40	Low priority to quality performance measure	*	*	*		
PB20	Keep track of inspection.	*	*	*									
PB21	Lack of guidance and proper documentation	*	*			*							

A variation in the order proposal. If the contractor proposes a construction detail or the graduate architect requests a change during the site visit, this should be documented in the revised construction drawings (Rochegova & Barchugova, 2016). An email requesting an inspection is a verification that the inspection has been conducted, and a report of the results of the inspection should be documented (Levy, 2018; Stanton, 1990). All cost estimates for extra work must be confirmed in writing to avoid misunderstanding the amount of the quotation or the scope of work involved (Rochegova & Barchugova, 2016). All variation orders should be numbered sequentially for ease of identification, tracking, and so forth (Heerkens, 2002).

4.2 Inadequate Quality Assessment Management Skill

The second crucial barrier identified through this study is inadequate quality assessment skills. In this category, there are barriers such as 'PB4-delay reply queries', 'PB13-delay confirm alternative material', 'PB14-unsure alternative material proposal', 'PB17-inappropriate performance measurement', 'PB19-none integrated project delivery', 'PB20-keep track of inspection', 'PB37-poor site supervision and inspection', and 'PB40-low priority to quality performance', 'PB11-searching alternative building material' and 'PB32-non-compliance to specification', as well as 'PB12-inadequate site inspection'.

Several factors hamper the construction quality of buildings; these include the fact that the site management has not been allocated sufficient time for quality management, which the consultants provide. Consequently, time limitation has restricted the contractor's ability to achieve quality; among the project stakeholders, a low priority is given to quality performance measures, and the scarce involvement of the architect in the project has also hindered quality achievements (Asadi, Wilkinson, & Rotimi, 2021; Tilley, 2005).

Incidents of a graduate architect who seldom carried out a site visit and was unsure what item to inspect during an inspection had caused design detail to be overlooked, which ended with a variation order with additional cost (Weinberger, 2005). Some architects don't have a clear idea of what to expect or look for when they go on-site inspection (Mohammadi, 2021).

Nevertheless, the unfamiliarity of design detail by the graduate architect will cause the contractors to make their own decision, which is to use the most straightforward method and the shortest time to resolve a design problem, whereby the majority will sacrifice aesthetics and functionality (Nicol & Pilling, 2000; Rounce, 1998). Hence, basic knowledge of the construction method and material specification is important for the graduate architect (Tzonis, 2014).

Problems arise when there are unclear technical requirements of the materials, construction techniques during quality control (Pooworakulchai, Kongsong, & Kongbenjapuch, 2017), and no proper guidelines on the workmanship quality (Love & Edwards, 2004). Graduate architects face difficulties inspecting workmanship quality due to the lack of detailed guidelines for reference (Mahdavinejad, Ghasempourabadi, Ghaedi, & Nikhoosh, 2012).

To improve quality management, additional drawings and details may be issued from time to time during the contract (Heerkens, 2002). The graduate architect should give greater attention to the following quality management practices: the requirements of the clients and end-users, producing correct and complete drawings and specifications, coordinating and checking contract documentation, conducting design verification, controlling changes, and committed to providing quality service (Levy, 2018; Mahdavinejad et al., 2012).

The modification of the design, quality or quantity of the works, the correction of discrepancies between the contract documents, the removal of materials from the site, the opening up of covering work, the condemnation, replacement and remediation of defective work, the postponement of work, the dismissal of incompetent or misconducting personnel, and any other matters that are related to the contract shall be formalised with an instruction (Agbaxode et al., 2021). Moreover, an intensive review of plans and specifications is a must between the consultants to counter-check discrepancies and for practicality (Heerkens, 2002). All parties must thoroughly examine the documents to uncover problems at the early stage, which reduces the impact and associated costs (Tilley, 2005). Conducting a regular site inspection is necessary to discover poor workmanship. Site inspection allows the detection and rectification of defects and non-compliance work in an early stage (Pressman, 2006). Visits may be at regular intervals, programmed to coincide with particular events on-site, or unannounced spot checks (Weinberger, 2005). According to Ling (2004), a site inspection checklist developed for all architectural components will ease supervision and monitoring. Prompt notification to the contractor of acceptable work, materials, or equipment will improve the workmanship quality on site (Ling, 2004). Sample panels and mock-ups will be required to be submitted to the graduate architects for study and to change complicated details before production work begins so as not to impede the progress (Heerkens, 2002).

4.3 Shortfall in Design Management Skills

The third significant barriers that are measured within the literature that constitute design management include- ‘PB2-slow decision’, ‘PB18-poor specification’, ‘PB22-insufficient design detail’, ‘PB29-poor design management’, ‘PB31-unworkable detail’, ‘PB34-constant design changes’, ‘PB39- attending to employer drive design changes’, ‘PB23-design and detail error’, ‘PB8-construction complexities’, ‘PB26-impractical design’, and ‘PB30-error design drawing’.

Many quality and efficiency problems have been experienced during the design process due to inadequate design management (Wang, Tang, Qi, Shen, & Huang, 2016). According to Tzortzopoulos and Formoso (1999), poor design management contributes to poor design process performance, with the following being the main problems: poor communication, unbalanced resource allocation, lack of adequate documentation, lack of coordination between disciplines, deficient or missing input information, erratic decision making (Lopez, Love, Edwards, & Davis, 2010; Tilley, 2005). From a construction perspective, design is a complex process (Enshassi, Sundermeier, & Zeiter, 2017; Tilley, 2005). Graduate architects spend inadequate or inappropriate effort planning and controlling the design process (Tilley, 2005). Subsequently, the design team lacks a common direction; thus, information cannot flow efficiently between the parties to resolve design problems (Levy, 2018). Levy (2018) stated that incidents of delays in completing design tasks or missing information in design documents appeared when graduate architects failed to plan the information flow concerning the various tasks.

The architect should be able to step in and advise accordingly when a defective design causes variation (Warnock, 2019). There are circumstances where the contractor has highlighted unworkable design yet has obtained further input on the next course of action from the architect (Jaffar et al., 2011). This case occurs when there is a poor design or an incomplete design by the project's designer, poor management expertise, various technological and social issues, site-related problems, and the application of improper tools and techniques (Gunduz & Elsherbeny, 2020). The scarcity of professional construction knowledge or relevant professional foundations had rendered the graduate architect who ran the building contract unsuitable in making the appropriate resolutions (Pooworakulchai et al., 2017) and had caused lots of trials and errors at the site, which subsequently delayed the entire work progress.

In this regard, the graduate architect should focus on four factors- planning and executing, resolving disputes, optimising design and promoting techniques (Wang et al., 2016). This factor indicates the need to understand and commit to the client's interest. A feasible design plan should be prepared to meet the client's requirements (Wang et al., 2016). Clients should freeze the project's scope as early as possible to minimise the risk of cost and an increase in the schedule (Heerkens, 2002). While executing the design plan, adequate resource input is necessary to achieve the required design quality and time schedule (Levy, 2018).

Resolving disputes is a type of design-related claim management whereby the client raises additional requirements during the construction, and the variations are not adequately recorded. (Wang et al., 2016). The graduate architect should appropriately deal with design-related claims with the support of well-managed design documents (Arditi & Robinson, 1995).

The third factor, optimising design, is related to the cost of design options (Rounce, 1998). This primarily relies on design change management through approaches such as value engineering (Wang et al., 2016). Constructability and value engineering (VE) exercises should be undertaken after the baseline scope has been developed (Rounce, 1998). VE study should be undertaken with the entire project team, including the contractors and relevant subcontractors, to improve project constructability and reduce the potential of change at a later stage (Douglas III, 2003).

The fourth factor is promoting techniques, which comprises advanced technologies in design changes for cost reduction (Wang et al., 2016). The graduate architects may utilise BIM to improve coordination among the project stakeholders since using general and conventional two-dimensional CAD drawings does not support a truly collaborative approach (Arayici et al., 2011). These drawings are not integrated and usually pose a clash of information. Building Information Modeling (BIM) is a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle (Arayici et al., 2011). It assists the project stakeholders to visualise what is to be built in a virtual environment and to identify potential design, construction or operational clashes and problem, which invariably improves the quality of design, and construction and reduces rework.

The graduate architect should manage the design team by providing them with an assessment of the design status and the potential for change. Important changes should be reviewed and authorised through a systematic and structured scope. At the same time, the client should 'sign off' work as the design progresses and be alerted to the consequences associated with initiating a change (Levy, 2018; Nielsen, 2010).

4.4 Lack of Soft Skill

From the study, the lack of soft skills emerged as the fourth barrier to the graduate architect, according to previous studies. This theme consists of 'PB1-miscommunication', 'PB6-lack information', 'PB3-lack coordination', 'PB9-design degrade', 'PB24-lack information on drawings', 'PB27-incomplete design information', 'PB33-lack understanding of the client requirement', 'PB35-poor information use', and 'PB38-uncertainty advise from other stake holders'.

Communication is one of the fundamental aspects of the construction industry and is the key to project success (Sahlstedt, 2012; Zerjav & Ceric, 2009). Communication covers all tasks related to producing, compiling, sending, storing, distributing and managing project records (Oke et al., 2016; Romano & Nunamaker, 2001). It also includes an accurate report on project status, performance, change and earned value (Emmitt & Gorse, 2009; Hayes & Westrup, 2014). However, communication among project stakeholders is not always concise and effective, which is unsuccessful and has resulted in poor communication (Hoezen, Reymen, & Dewulf, 2006).

Zerjav and Ceric (2009) posit that most construction professionals know communication in construction projects is reasonably inefficient compared to other industries. Factors of poor communication include the fear of communicating, delayed notification of the change, lack of sector experience, individual barriers, slow information flow among parties, the lack of an effective communication system and platform, lack of confidence, informality, improper communication channel, a lack of mutual trust among team members, poor communication management, inaccessibility of project information, incorrect delivery of instructions or technical information, the lack of communication procedure and training, poorly detailed drawings and complexities of the construction industry (Gamil & Rahman, 2017). Most construction practitioners have policies relating to written communication, but guidelines for verbal communication are generally less regulated. Poor communication and communication overload among the project stakeholders are shown to directly correlate with the project delivery outcomes, adverse events and undesirable additional costs or time (Emmitt & Gorse, 2006).

To combat these, a practical guide to arm the graduate architect with effective tools is crucial to ensure a satisfactory exchange of information in the context of contract administration. Accordingly, a structured approach to communication has significant advantages (Dainty, Moore, & Murray, 2007). When confronting an issue, the graduate architect may use the approach of introduction, situation, background, assessment and recommendation (Dainty et al., 2007). This tool can be useful for the graduate architect as a means of communicating with project stakeholders about the change in design or details and prompts them to state the current situation, give relevant background, state assessment or study findings and recommendations in any situation (Anumba & Evbuomwan, 1997). This means of communication involves the usage of construction terms. There are a lot of circumstances where graduate architects cannot keep up with the conversation due to unfamiliarity with common building jargon (Sak, 2021). Hence, understanding construction terms or terminology is essential to enable them to navigate the construction industry and communicate without obstruction among the project members (Sak, 2021).

4.5 External Environmental Factors

According to the study, external environmental factors are an insignificant barrier to graduate architects. This theme comprised four types of obstacles: ' PB5-poor contract management knowledge', 'PB10-discrepancy of contract forms', 'PB15-unaware legal policy', and 'PB16-unclear building contract'.

Fraudulent certification has happened in the following scenarios- when the contract administrator has signed a certificate which they did not prepare or supervise, has over-certified a housing project which is incomplete or prematurely certified vacant possession which is unfit for occupation or is without the supportive documents (Abotaleb & El-Adaway, 2017). Incidents of wrongful certification have occurred due to the graduate architect being unaware of the architect's legal responsibilities and scope of duties (Abidin, 2012). These incidents occurred due to an increase in building developments while there was a limited number of architects in the country. Thus, the architects were unable to commit hands-on to a lot of projects. Therefore, they must rely on the graduate architect to furnish site progress information and prepare the certificates.

Besides certification, it was found that the graduate architects also faced the problem of understanding a contract document (Mohamed et al., 2019). This issue occurs when the contract documents are too thick and consist of many legal jargons and phrases that are irrelevant to the associated materials, the use of difficult languages, unclear specifications that are illogical in nature, being unfamiliar with the form of contract that is used, and requirements that are not clear and are too general, and so on (Mohamad & Madon, 2006; Ndekugri & Rycroft, 2014).

This will lead to misinterpretation and misunderstanding of the facts in contract obligations that cause construction risks such as disputes, claims, litigation, shoddy works, and reworks (Ajator, 2017; Bell, 1958). The detrimental effects cause project delays, undermine team spirit, and increase project costs. Therefore, it is necessary to understand the contents of the contract documents as this will significantly influence the smooth and good performance of the construction project.

A proper understanding of the contents of the contract documents is essential to the enhancement of contractual relations and assurance of the intended deliverance of the product. The graduate architects must check on contract documents to see whether the content matches the contract drawings or specifications and an understanding of the sales and purchase agreement before the commencement of the administration work (Bin Zakaria, Binti Ismail, & Binti Yusof, 2013; Kavanagh & Miers, 2021; Ostime, 2019). To improve the legal knowledge of the graduate architects, some suggestions have been made: the drawing must be clear and checked by all parties, clarity in the contract documents for better understanding, contract documents are to be written in simple language, contract documents must be precise, objective and practical, the regulatory requirement has to be clearly explained, bill of quantities are to be clearly and objectively detailed, minimise the use of complicated legal phrases, the general condition of the contract has to be made familiar (Kasi, 1998; Mohamad & Madon, 2006).

5 Conclusion

Graduate architects who take part in administering the building contract during the construction stage have increased in recent years as the rate of building construction and development in Malaysia has grown tremendously. The graduate architect will be dominant in managing building contracts under construction if the architect has been given authorisation. The role of the contract administrator will drive the success of the project implementation. Hence, the capability of a graduate architect as a contract administrator is critical in reducing the challenges encountered. Accordingly, identifying these barriers is essential in sourcing mitigation measures as resolutions.

This study aims to identify graduate architects' most crucial performance barriers to graduate architects in their career development in project management through a comprehensive perspective of the literature and case studies on the subject. Correspondingly, a thematic analysis has been conducted through a literature search along with selected case studies. A group comprising five types of barriers has been identified and summarised in Table 8. Each barrier has been described in detail in Appendix, and a specific list of references has been provided.

To uncover the underlying barriers, five main groups of barriers are manifested, where the most crucial performance barrier that has been identified is the limitation in project documentation skills. The second critical performance barrier to graduate architects is the inadequate quality of assessment management skills, followed by a shortfall in design management skills. The fourth barrier that has been identified is the lack of soft skills. In contrast, external environment factors are an insignificant barrier to the graduate architect during the contract administration phase.

This paper provides insights into the contemporary issues that are relevant to graduate architects' management of construction projects. The presented findings would assist the graduate architects in planning better, sensible, and efficient measures to ease a crisis. By taking care of these potential barriers in their present and future projects, graduate architects can reduce the additional cost and time implications and eventually increase the possibility of the project's success in the market.

This review benefits the project delivery for the architecture practitioners and the construction team. By understanding the performance barriers faced by graduate architects, solutions can be sorted out. Through timely project delivery, the graduate architects will move a step closer to acquiring their professional qualifications and ease the tension among the construction team.

Limitations of this study are that although much effort has been employed to produce a comprehensive and exhaustive review, further studies are required on identifying knowledge, skills, roles, and responsibilities in construction projects for better professional practice development in building contract administration.

Table 8: Tabulation of the types of barriers, root causes and solutions

Problem	**Types of barriers**	**Root Causes**	**Solutions**
Graduate architects unable to perform during administrating building contract	Poor project documentation management skill	a. information deficiencies and poor coordination b. incomplete design c. deficient planning or resource allocation	a. creating sufficient records b. regular review of contractors' submission c. all changes should be formalised with instructions/letters
	Inadequate quality assessment management skill	a. insufficient time for quality management b. insufficient information provided by consultants c. no proper guideline on workmanship quality d. unclear technical requirements of material, construction techniques during quality control e. unsure what item to inspect during the site walk f. unfamiliar design detail	a. pay greater attention to clients' requirement b. producing correct and complete drawings and specification c. conducting design verification d. controlling changes e. intensive review of drawings for counter checking f. conduct a regular site walk g. submission of mock-up sample
	The shortfall in design management skill	a. unbalanced resource allocation b. lack of coordination between disciplines c. deficient or missing input information d. erratic decision making e. failing to plan information flow	a. planning and executing b. resolving disputes c. optimising design d. adopts BIM in design
	Lack of soft skill	a. fear to communicate b. delay notification of change c. lack of sector experience d. individual barrier e. slow information flow among parties f. lack confidence	a. adopt a structured approach to communication b. understanding construction terms/terminology
	External environmental factors	a. Unaware of the architect's legal responsibility and scope of duties b. difficult to understand contract document c. misinterpretation and misunderstanding of facts in contract obligations	a. drawing must be clear and checked by all parties b. the clarity in contract documents/contract documents written in simple language c. the regulatory requirement to be clearly explained d. to ensure contract documents match with contract drawings and specifications

Declaration of Interests
The authors report that there are no competing interests to declare.

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Appendix

Definition of the performance barriers

PB1- Miscommunication in terms of verbal/graphic

PB2- Slow decision-making/weak design

PB3- Lack of coordination between tasks when there is zero communication, and team players work in isolation

PB4- Delay reply to contractor queries/submission due to lack of technical knowledge

PB5- Poor contract management knowledge that unable to resolve the dispute between clients/consultants/ contractor

PB6 - Lack of documents/info which obstructed construction work progress

PB7 - Improper relevant training or is inexperienced when managing building contract

PB8- Complexities in the construction process where the work sequence on-site is unclear and caused complications during construction

PB9- Degrading design due to budget constraints and cost-saving purpose

PB10- Discrepancy in contract forms when there is a discrepancy between drawings and BQ

PB11- Searching for alternative building materials when developers intend to save cost

PB12- Inadequate examination of the site when site inspection is not carried out regularly

PB13- Difficulty in the selection of alternative materials which match with the original design intended

PB14- Design alteration proposed due to the client's requested

PB15- Unaware of latest Government policy/regulations as constantly changed and updated

PB16- Unclear about building contract / unfamiliar with the clauses in the contract

PB17- Inappropriate performance measurement where the architect is unable to assess the workmanship quality due to a lack of base standard

PB18- Poor specification when detail provided is unworkable

PB19- Non-integrated project delivery when the outcome of the end product is not similar to the original design

PB20- Keep track of inspections/work done on-site to track construction progress

PB21- Lack guidance on proper documentation and procedures when filing is not done properly and no record of correspondence

PB22- Insufficient design details, e.g. missing drawing details, specifications

PB23- Conventional management protocol - Stickiness of old methods / common practice

PB24- Impractical design caused difficulties during implementation / over-design scaled model displayed

PB25- Lack of information exchange platform/communication breakdown

PB26- Unsure of alternative methods/material submitted by contractors

PB27- Incomplete design information when some detail drawings or specifications are missing

PB28- Ineffective management where everything decision based on protocol and inflexible during decision making

PB29- Poor design management when the designer produced an unpractical design and the project team is yet to review it and advise accordingly

PB30- Error during design, such as detail provided is not workable or impractical design

PB31- Complex details where details were copied and pasted from a foreign designer, which is unworkable in the local context

PB32- Non-compliance to specification when unfamiliar with the original design intended

PB33- Lack of understanding of the client's requirement due to lack of experience and unfamiliarity with the current market's needs

PB34- Design changes when architect failed to comply with authority requirement / as per client's request

PB35- Poor info use when the correct information failed to convey to the right person

PB36- Incomplete documentation during award when tender drawings and documents are prepared within a tight time frame

PB37- Poor site supervision and inspection when an architect is unsure what to inspect during the site walk

PB38- Uncertainty in advising other stakeholders when lacking knowledge and experience

PB39- Attending to client-driven design changes when the architect is unable to make a firm decision and advise the client accordingly

PB40- Low priority to quality performance measure due to budget constraints and no standard of workmanship being set

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A Measure of Combustion-Generated Pollutants in University Laboratories and their Effects on the Indoor Air Quality

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Abstract

Combustion is one of the fundamental processes in learning and teaching in laboratories that leads to the release of gaseous pollutants that are both hazardous and a threat to the environment and health of individuals. This paper sought to measure the amount of combustion pollutants generated and their effects on the indoor air quality of a typical university laboratory using some selected laboratories in Ahmadu Bello University Zaria as a case study. The Combustion pollutants were measured using an IMR 1400C gas analyser. At the same time, its effects were assessed using a well-structured questionnaire designed and administered to hundred and twenty-seven laboratory users who were randomly selected. Data collected from the questionnaires were analysed using computer-based SPSS software. The results revealed that CO during combustion exceeded the ASHRAE 62 and NAAQS limit of 9ppm, reaching up to 45ppm at some points; also, oxygen was observed to be at a critical level of 20.9% and at some point falling below the limit to 20.4%. It was also observed that fatigue (RII: 0.81) is the most prominent symptom of poor indoor air quality during combustion, among other symptoms like coughing and sneezing, dryness and irritation of eyes and throat, sinus congestion, shortness of breath and headache, arranged in the order of intensity. The absence of functional fume hoods, laboratory congestion, and inadequate ventilation systems intensify the discomforting effect of combustion-generated pollutants in laboratories. Thus, it is recommended that fume hoods should be well maintained for functionality and installed in Laboratories where they do not exist (chemistry lab I). Finally, providing adequate ventilation systems in the laboratories would help increase safety in labs for learning and teaching purposes.

Keywords: Combustion Generated Pollutants, Indoor Air Quality, Measurement of Pollutants.

1. Introduction

Interest in the role of air quality in health and disease dates back to antiquity. In the treatise on "Airs, water, and places", Hippocrates drew attention to the impact of polluted air, among other transmission media, on disease burden. For centuries, the emphasis on pollution-associated air problems was mainly placed on outdoor air; concerns about indoor air quality are relatively recent in comparison (David, 2010).

The National Health and Medical Research Council (NHMRC, 2009) defines indoor air as air within a building occupied for at least one hour by people of varying states of health. This can include the office, classroom, transport facility, shopping centre, hospital, and/or home. Indoor air quality (IAQ) can be defined as the totality of attributes of indoor air that affect a person's health and well-being. Similarly, the Environmental Protection Agency (EPA) defines IAQ as the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (USEPA, 2020)

Indoor air pollution refers to indoor air's chemical, biological and physical contaminations (NHMRC, 2009). It may result in adverse health effects. In developing countries like Nigeria, the primary source of indoor air pollution is biomass which contains suspended particulate

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matter like nitrogen oxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), formaldehyde, and polycyclic aromatic hydrocarbons (PAHs). However, in industrialised countries, in addition to NO2, CO and formaldehyde, radon, asbestos, mercury, human-made mineral fibres, volatile organic compounds, allergens, tobacco smoke, bacteria, and viruses are the main contributors to indoor air pollution (David, 2010).

A growing body of scientific evidence indicates that the air within homes and other buildings can be more polluted than the outdoor air in even the largest and most industrialised cities. In addition to daily human activities that lead to the generation of indoor air pollutants, combustion sources and activities, especially in laboratories, contribute to carbon dioxide (CO2), sulfur dioxide (SO2), CO, nitrogen dioxide (NO2), and particulate matter (PM) emissions into indoor air environments (Awbi, 2003).

The intrinsic nature of the health effects from indoor air pollutants is that they may be experienced soon after exposure or, possibly, years later. Immediate effects may appear after a single or repeated exposure (Tran, Park and Lee, 2020). These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment eliminates the person's exposure to the source of the pollution if it can be identified.

The World Health Organisation, as of 2002, estimated that indoor air pollution is responsible for roughly 1.6 million deaths each year. However, the recent update, as of 2020, shows that indoor air pollution (IAP) is responsible for the deaths of 3.8 million people annually (WHO, 2020), with its symptoms ranging from acute lower respiratory infections, chronic obstructive pulmonary disease, lung cancer, and other diseases. Indoor air pollution from biomass contributes to about 2.6 per cent of the global disease burden. Hromadka, Korposh, Partridge, James, Davis, Crump, and Tatam (2017) indicated that decreased IAQ could negatively affect human health by causing building-associated illness.

In an academic environment, laboratories are a significant place where combustion activities are mainly carried out, usually during experimental activities. According to Merriam-Webster, a laboratory is a room or building equipped for scientific research, teaching, or manufacturing drugs and chemicals. From the definition, it can be established that combustion is one of the basic processes in a laboratory. Thus, the question now is: 'how safe is the indoor air quality of such laboratories owing to the activities carried out in them? This paper measures the combustion-generated pollutants in a typical university laboratory after an experiment requiring combustion activities. It also examines the laboratory users' perception of the impact of combustion-generated pollutants on the indoor air quality of the laboratories, considering the users' length of exposure during experimental activities.

2. Literature review

The concept of indoor air pollution is a contemporary one, which has stirred up much research with the general aim of emphasising the health impact of poor indoor air and the identification of the major pollutants of indoor air. Previous studies are reviewed in this section. Saravanan (2004), in a general study of indoor air, established that the significant factors that determine indoor air quality are:

i) The nature of outdoor air quality around the building;

ii) The ventilation rate of the building;

iii) The materials used in the construction of the building (presence of chemicals);

iv) The activities that go on inside the interior (cleaning, cooking, heating, etc.); and,

v) The use of household chemicals.

Saravanan (2004) identified some of the sources of the pollutants as; radioactivity (the emissions from uranium in the soil or rocks on which the houses are built, Volatile Organic Compounds (VOCs) usually from aliphatic and aromatic compounds, chlorinated compounds with formaldehyde being in many locations). The emphasis of the sources of indoor air pollutants was on indoor combustion activities. The combustion of fuels, such as oil, gas, kerosene, and so forth, inside a building contributes to the concentration of VOCs and is also a source of stable inorganic gases. The common indoor pollutants due to the combustion of fuels are particulate matter, oxides of nitrogen, oxides of sulphur, carbon monoxide, hydrocarbons, and other odour-causing chemicals. Saravanan (2004) concluded that indoor air pollution is one of the significant problems that must be solved since a large part of human life is spent indoors. All necessary precautions to eliminate or minimise the harmful effects of indoor air pollution need to be taken.

To help elucidate more fully the extent of hazards caused by the combustion of pollutants in China, Smith and Zhang (2005) studied indoor air pollution from household fuel combustion. They estimated that air pollution from solid waste in China is responsible for 420,000 premature deaths annually, with more than 300,000 attributed to the pollution of the urban outdoor environment.

Smith and Zhang (2005) reviewed nearly 200 publications in China reporting health effects, emission characteristics, and/or indoor air pollutants concentrations associated with solid fuels. Smith and Zhang (2005) also took measurements in 122 individual studies, concluding that indoor air pollutant concentrations exceeded health standards in many households.

In like manner, Stanley (2010) assessed the environmental suitability of electric power generators for power supply to buildings to devise appropriate control measures for a cleaner environment. The assessment was for buildings within the Kaduna metropolis, and the approach adopted was the use of a well-structured questionnaire and an IMR 1400C combustion gas analyser. The research results showed that the level of awareness of health hazards caused by generators was high and that the mean concentration of SO_2 and NO_x

indoors was higher than the FEPA limits (0.01 ppm and 0.04-0.06 ppm), respectively. The research also revealed that none of the ambient pollutants at the point source met the WHO and FEPA limits.

The above review itemises the contribution of various researchers in evaluating the impact of combustion activities on indoor air quality and environmental conditions. And at this point, it can be seen that combustion is a significant source of pollutants generation in the environment. Thus, this paper seeks to evaluate the impact of combustion activities in the laboratories on the indoor air quality of the laboratories.

2.1 HVAC requirements for a laboratory

Several types of research have been done into the heating, ventilation and air conditioning (HVAC) requirements for a laboratory, emphasising the energy usage common to laboratories and the comfort requirements. According to Lindsay (2010), an HVAC engineer's prime concern when planning or constructing any laboratory building is the safety of the building's occupants. The system must operate to specification and meet appropriate regulations. To this end, many older laboratories were designed with little regard for energy efficiency. That's no longer obtaining, and designers must account for operating costs and functionality (Lindsay, 2010).

A laboratory building consumes five to ten times more energy than a typical office building or school. HVAC systems consume almost 70% of a laboratory's energy. According to Labs21 (2010), a voluntary partnership program is dedicated to improving U.S. laboratories' environmental performance. The majority of this HVAC energy consumption originates from cooling (22%), and ventilation (44%) loads that help the laboratories function safely (Lindsay, 2010).

The high energy use can be attributed to high air-change requirements, large internal heat gains from laboratory equipment, and, in many cases, continuous hours of operation (Gordon, 2010). Vendors are developing new technologies or adapting older ones to help reduce HVAC energy consumption with a push toward a more energy-efficient laboratory environment. Lindsay (2010)'s emphasis was more in line with HVAC requirements for laboratories as an energy-saving measure and not on the adequacy of indoor air quality for laboratories.

3. Methodology

A measure of the amount of the combustion-generated pollutants in selected laboratories was conducted with the help of a sensitive gas analyser, the "IMR 1400C", to establish the presence and amount of the combustion pollutants present in the air before, during, and after the combustion processes. The gas analyser was used to measure and calculate the amount of the following: oxygen (O_2), carbon monoxide (CO), Carbon dioxide (CO_2), Oxides of Nitrogen (NO_x), and Sulfur dioxide (SO_2).

In addition to the measurement, a survey of laboratory users' (Staff and students) perception of the impact of combustion-generated pollutants on indoor air quality was conducted. A well-structured questionnaire was designed and administered to staff and students (laboratory users) of Ahmadu Bello University, Zaria. A total of 140 questionnaires were distributed, of which 127, representing 90.7%, were completed correctly and returned. The major issues addressed in the survey include the presence of the necessary Heating, Ventilation and Air Conditioning System; the presence and functional state of the fume hoods; and other related factors like the frequency of maintenance of the HVAC system that can influence the effects of combustion pollutants on the indoor air quality.

3.1 Data analysis procedure

The presence and the number of pollutants determined by the IMR 1400C gas Analyser were tabulated along with the acceptable limit provided by the ASHERA Standard 62 for a healthy environment. Also, most of the questionnaire questions assessed some indices of utilisation on a five (5) point Likert scale. The data analysis, therefore, employed the following steps.

a. Computation of the mean using the weighted average formula

Relative importance index (RII) $= \frac{\sum fx}{\sum f} \times \frac{1}{k}$

Where,

$\sum fx$ = is the total weight given to each attribute by the respondents.
$\sum f$ = is the total number of respondents in the sample.
K = is the highest weight on the Likert scale.

Results were classified into three categories as follows (Othman *et al*., 2005) when:

RII<0.60 -it indicates low frequency in use
0.60≤RII<0.80 -it indicates high frequency in use.
RII≥0.80 – it indicates a very high frequency in use.

4. Data presentation, analysis, and discussion

The results of the measurements and analysis of the questionnaires are presented in this section under two broad headings - the presentation of the combustion-generated pollutant measurement and the results of the questionnaire analysis.

4.1 Presentation of Measurements of the Combustion-Generated Pollutants

Data from the result of the measurements taken are presented in Tables 1-6

From Table 1, it can be observed that CO often exceeded the permissible limit, especially during the combustion process, rising to (45ppm against the 9ppm limit). It can also be observed that the oxygen levels were at the critical level and even a few points below the limit, increasing the tendency of incomplete combustion.

Table 2 shows that the most reoccurring pollutant that exceeds the limit is CO, especially during the combustion process rising to (45ppm). Table 2 shows the measurement of the pollutants at three different points before the combustion activities and during and after the combustion activities. The trend of rising and falling of the amount of pollutants within the interior is also presented in Table 2. These measurements are peculiar to the SBRS Lab II.

Table 3 presents the number of pollutants measured at three different points within the chemistry SBRS Lab III before, during, and after the combustion activities in the laboratory. From Table 3, it can be observed that CO is the pollutant that is constantly generated beyond the provision of the limit (9ppm) in the three different sessions of the experiments. It is observed that there was no SO pollutant recorded throughout the first session of experimentation, and there is a varying level of oxygen, usually falling below the limit.

Table 4 presents the amount of pollutants measured at three different points within the Chemistry Multi-Purpose Lab before, during, and after the combustion activities in the laboratory. From Table 4, it can be observed that CO is the pollutant that is more generated even in the three different sessions of the experiments.

Table 1: Results of the Combustion Pollutant Measurement in Chemistry Lab I along with ASHRAE Requirement and NAAQS Standard

		Chemistry Lab I									
Session	Pollutants (O_2 in % others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in % others in ppm)
		A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	
1	**O_2 (%)**	20.90	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0.0	0.0	0.0	7	13	23	02	03	02	≤9ppm
	NOx	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.2	2.1	1.0	2.1	3.2	4.2	1.0	0	0.0	≤ 1000ppm
2	**O_2 (%)**	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
	NOx	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.1	0.0	0.1	02	0.0	0.1	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	2.1	1.1	2.1	1.3	1.1	3.1	2.0	1.0	2.1	≤ 1000ppm
3	**O_2 (%)**	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0.0	1.0	0.0	7.0	11.0	13.0	4.0	2.0	0.0	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm

Source: Field Survey (2020)
Where: A1, A2, A3, B1, B2, B3, C1, C2, and C3 are all measurement points, while 1, 2, and 3 are experiment sessions.

Table 2: Results of the Combustion Pollutant Measurement SBRS LAB II along with ASHRAE Requirement and NAAQS Standard

Session		**SBRS LAB II**									
	Pollutants (O_2 in% others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in % others in ppm)
		A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	
1	**O_2 (%)**	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	0	0	7	13	23	02	03	02	≤9ppm
	NOx	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		≤ 0.14ppm
	CO_2	2.1	4.2	2.0	21.						≤ 1000ppm
2	**O_2 (%)**	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2										≤ 1000ppm
3	**O_2 (%)**	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0.0	0.0	0.0	0.0	13.0	14.0	11.0	0.0	0.0	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm

	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	2.1	3.2	4.2	2.1	2.3	4.2	2.1	2.1	3.1	≤ 1000ppm

Source: Field Survey (2020)

Table 3: Results of the Combustion Pollutant Measurement IN SBRS LAB III along with ASHRAE Requirement and NAAQS standard

Session		**SBRS LAB III**									
	Pollutants(O_2 in% others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in% others in ppm)
		A1	**A2**	**A3**	**B1**	B2	**B3**	**C1**	**C2**	**C3**	
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	0	0	7	13	23	02	03	02	≤9ppm
1	**NOx**	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
2	**NOx**	2.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	1.2	3.2	2.1	3.2	6. 5	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
3	**CO**	0.0	0.0	0.0	45.0	25	13	3.0	5.0	1.0	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm

Source: Field Survey (2020)

Where: A1, A2, A3, B1, B2, B3, C1, C2, and C3 are all measurement points, while 1, 2, and 3 are experiment sessions.

Table 4: Results of the Combustion Pollutant Measurement IN CHEMISTRY MULTI-PURPOSE LAB along with ASHRAE Requirement and NAAQS standard

Session		**CHEMISTRY MULTI-PURPOSE LAB**									
	Pollutants (O_2 in% others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in% others in ppm)
		A1	**A2**	**A3**	**B1**	B2	**B3**	**C1**	**C2**	**C3**	
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	0	0	27	43	88	8	03	02	≤9ppm
1	**NOx**	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	4.3	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
2	**NOx**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.1	0.1	2.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2										≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
3	**CO**	0.0	0.0	0.0	32.0	45	76.0	32.0	0.0	0.0	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0		≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm

Source: Field Survey (2020)

Table 5: Results of the Combustion Pollutant Measurement PHYSICAL CHEMISTRY LAB Along With ASHRAE Requirement and NAAQS Standard

Session	**PHYSICAL CHEMISTRY LAB**										
	Pollutants (O_2 in% others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in% others in ppm)
		A1	**A2**	**A3**	**B1**	B2	**B3**	**C1**	**C2**	**C3**	
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	0	0	7	13	23	02	03	02	≤9ppm
1	**NOx**	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
2	**NOx**	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	≤ 0.14ppm
	CO_2	3.1	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
3	**CO**	0.0	0.0	1.0	14.0	38.0	42.0	2.1	3.2	1.2	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	4.2	3.2	2.1	3.2	1.2	≤ 1000ppm

Source: Field Survey (2020)

Where: A1, A2, A3, B1, B2, B3, C1, C2, C3 are all points of measurements while 1,2,3 are sessions of experiment.

Table 6: Results of the Combustion Pollutant Measurement CHEMISTRY MASTERS STUDENT LAB along with ASHRAE Requirement and NAAQS standard

Session	**CHEMISTRY MASTERS STUDENT LAB**										
	Pollutants (O_2 in% others in ppm)	Measurement 3 hours Before Combustion			Measurement During Combustion			Measurement 3 hours After Combustion			ASHRAE Acceptable Limit (O_2 in% others in ppm)
		A1	**A2**	**A3**	**B1**	B2	**B3**	**C1**	**C2**	**C3**	
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	0	0	7	13	23	02	03	02	≤9ppm
1	**NOx**	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	≤ 0.14ppm
	CO_2	4.2	3.1	1.0	3.2	5.6	3.2	2.1	3.2	1.2	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
	CO	0	1	0	45	23	11	09	02	07	≤9ppm
2	**NOx**	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	≤ 0.14ppm
	CO_2	0.0	0.0	0.0	11.0	9.0	13.0	5.0	6.0	4.0	≤ 1000ppm
	O_2 (%)	20.9	20.9	20.4	20.7	20.7	20.9	20.9	20.8	20.9	≥ 20.9%
3	**CO**	2.1	3.1	2.1	12.0	45.0	32	4.0	2.0	2.0	≤9ppm
	NOx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	≤0.053ppm
	SO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	≤ 0.14ppm
	CO_2	1.2	2.1	2.1	3.2	4.5	32.7	2.0	4.9	3.2	≤ 1000ppm

Source: Field Survey (2020)

Table 5 presents the amount of pollutants measured at three different points within the Physical Chemistry laboratory before, during, and after the combustion activities in the laboratory. Table 5 shows that, similar to the other laboratories studied, CO is a pollutant frequently generated beyond the limit provision (9ppm). It can also be observed that the oxygen content as measured was not consistent throughout the measurement.

While Table 6 presents the amount of pollutants measured at three different points within the chemistry masters' student laboratory before, during, and after the combustion activities in the laboratory. Also, it was observed that CO is the pollutant that is more generated even in the three different sessions of the experiments.

4.2 Presentation of the Results of the Questionnaire Analysis

Data from the expert opinion survey are presented in Table 7. Table 7 shows that most respondents opined that their work entails combustion (74.0%). Also, as opined by the respondents, the gas burner is the major heat-generating device frequently used in laboratories (70.1%). Concerning the presence of a functional fume hood installed in the laboratory, most respondents (with a frequency of 47.2%) were unaware of its existence and functional status; this corresponds to 47.2% of the respondents.

Combustion and ventilation in laboratories

The respondents' perceptions concerning the impact of combustion activities in the laboratory and the evaluation of the adequacy of the ventilation system were also assessed. Table 8 below presents the results of the assessment.

Table 8 reveals that combustion is a source of discomfort, as observed by 92.1% of the respondents. Also, Table 8 shows that combustion was more discomforting of all the processes identified (54.3%). The ventilation system is inadequate, as attested to by 79.5% of the respondents.

Table 7: Laboratory combustion activities

S/N	Variable	Option	Frequency	Percentage (%)
1	Combustion in laboratories:	a) Yes	94	74.0
		b) No	33	26.0
		Total	**127**	**100**
2	Heat generating device frequently used :	a) Stove	16	12.3
		b) Gas burner	89	70.1
		c) Hot plates	22	17.3
		d) Candle	0	0
		Total	**127**	**100**
3	Presence of functional fume hood:	a) Yes	40	31.5
		b) No	27	21.3
		c) Not Aware	60	47.2
		Total	**127**	**100**

Source: Field survey (2020)

Table 8: Combustion and ventilation in laboratories

S/N	Variable	Option	Frequency	Percentage (%)
1	Combustion as a source of discomfort:	a) Yes	117	92.1
		b) No	10	7.9
		Total	**127**	**100**
2	The process that poses more discomfort:	a) Combustion	69	54.3
		b) Filtration	0	0
		c) Lab cleaning	58	45.7
		d) Distillation	0	0
		Total	**127**	**100**
3	Presence of ventilation system:	e) Yes	40	31.5
		f) No	87	68.5
		Total	**127**	**100**
4	Adequacy of ventilation system during combustion:	a) Yes	26	20.5
		b) No	101	79.5
		Total	**127**	**100**

Source: Field survey (2020)

Table 9: Ranking of the health symptoms of poor indoor air quality

Symptoms	Weighting/Response Frequency 1	2	3	4	5	(∑f)	∑fx	MEAN	RII	RANK
Dryness and irritation	-	16	8	86	17	127	485	3.82	0.76	3RD
Headache	11	10	20	66	20	127	455	3.58	0.72	8TH
Fatigue	-	3	15	80	29	127	516	4.07	0.81	1ST
Shortness of breath	-	23	26	50	28	127	464	3.65	0.73	6TH
Hypersensitivity and allergies	14	07	28	78	3	127	439	3.46	0.69	10TH
Sinus congestion	10	08	02	90	17	127	477	3.76	0.75	4TH
Coughing and sneezing	03	17	-	82	25	127	490	3.85	0.77	2ND
Dizziness	15	10	12	74	16	127	447	3.52	0.70	9TH
Nausea	8	17	34	63	05	127	421	3.31	0.66	13TH
Blurred vision	16	02	22	57	30	127	464	3.65	0.73	6TH
Pains and discomfort	06	17	22	78	04	127	438	3.45	0.69	10TH
Heartburn	10	29	04	67	17	127	433	3.41	0.68	12TH
Sneezing and chest tightness	02	26	07	68	24	127	467	3.68	0.74	5TH
Fainting	29	60	22	07	09	127	288	2.27	0.45	14TH

Source: Field Survey, (2020)
Where: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

Table 10: HVAC and Combustion Related

Causes	Weighting/Response Frequency 1	2	3	4	5	(∑f)	∑fx	Mean	RII	Rank
Overcrowding in labs	-	-	07	40	80	127	581	4.57	0.91	1ST
Combustion activities	-	-	02	73	52	127	558	4.39	0.89	2ND
Inadequate ventilation	-	10	06	67	44	127	526	4.14	0.83	3RD
Prolonged and reoccurring combustion	05	20	12	58	30	127	463	3.65	0.73	4TH
Non-functional fume hoods	12	13	12	68	22	127	456	3.59	0.72	5TH
Too humid air	03	26	70	28	-	127	377	2.97	0.59	6TH
Faulty burners	04	40	62	21	-	127	354	2.79	0.56	7TH
Poor air Movement	-	54	67	06	-	127	333	2.62	0.52	8TH
Unvented combustion equipment	58	20	13	27	09	127	290	2.29	0.46	9TH

Source: Field survey (2020)
Where: 1= not a cause, 2 = not a major cause, 3 = barely a cause, 4 = a cause, 5 = always a cause

Table 11: Remedy to poor indoor air quality

Remedy	Weighting/response frequency 1	2	3	4	5	(∑f)	∑fx	MEAN	RII	RANK
Provision of adequate HVAC system	07	-	10	32	78	127	555	4.37	0.87	1st
Use and maintenance of functional fume hoods	14	-	15	40	58	127	509	4.00	0.80	3rd
Adequate airflow during combustion	-	13	14	28	72	127	540	4.25	0.85	2nd
Use of excellent combustion equipment	14	-	21	32	60	127	505	3.98	0.79	4th
Orientation of both staff and students on the danger of poor indoor air quality	32	-	9	28	58	127	461	3.63	0.73	5th

Source: Field Survey (2020)
Where: 1 = not Effective, 2 = no effect, 3 = slightly effective, 4 = Effective, 5 = very effective

Health symptoms of poor indoor air quality

Several health symptoms of poor indoor air quality were assessed, and the respondents ranked these symptoms. Table 9 presents the ranking of the various health symptoms that serve as indicators of poor indoor air quality.

Table 9 shows that the respondents ranked fatigue (with RII= 0.81) as the most reoccurring health symptom. Also, it is observed that only symptoms like fainting and nausea had a relative importance index of less than 0.6, indicating that they are not commonly observed symptoms. Also, from the mean values, it can be deduced that the values were closer to the Likert weighting of four, indicating that the respondents' general opinion was that the symptoms indicated poor indoor air quality.

HVAC and combustion-related factors that alter laboratories' indoor air quality

The questionnaire also sought the opinion of the respondents concerning how the heating, ventilation and air conditioning (HVAC) system, as well as combustion, contribute to the poor indoor air quality of laboratories. The respondents' opinions and ranking thereof are presented in Table 10.

Table 10 shows that overcrowding in labs (RII=0.91) was ranked the first cause of poor indoor air quality. This is followed closely by combustion activities (RII=0.89). It can also be seen that other factors, such as faulty burners, too-humid air, and unvented combustion, though factors, did not have an intense effect owing to their relative importance indexes (RII), which are below 0.6. Regarding the mean, it can be observed that the values were closer to the weighting four (4), indicating that the respondents' opinion was that the identified factors are all causes of poor indoor air quality.

4.3 Remedial action to poor indoor air quality in laboratories

Table 11 gives the respondents' ranking of the various remedial measures for the poor indoor air quality identified. It also provides the percentage with response per option and the mean.

Table 11 shows that the respondents' highest-ranked remedy to the poor indoor air quality is the provision of adequate heating, ventilation and air conditioning systems (RII= 0.87). Also, from the mean values, it can be observed that, in general, the respondents opined that the identified remedy were all feasible options as the mean value is closer to the Likert weighting of four.

4.4 Discussion of Results

The discussions are based on the experimental survey of the laboratories under study. The study revealed that combustion-generated indoor air pollutants in the laboratory were more CO and NOx (Table 4); the mean value of SO was within the normal range as specified by the ASHRAE 62 and within the requirements for WHO and FEMA limits. However, the limit for pollutants like CO was above the limit specified by this standard, thus making exposure to such gaseous pollutants very hazardous to the health of both the students and the staff. Results of the measure (Tables 1 to 4) reveal that during the combustion activities, the amount of CO increases far beyond the NAAQS standard of 9ppm for all the labs except the Master's lab, where a water bath is used as a source of heat generation as against others that used gas burners. Also, from the result, it can be observed that the multi-purpose chemistry lab had the highest amount of pollutants owing to the population of students and the non-functional fume hoods. Also, from the experimental results, it can be established that the laboratory oxygen level was at the critical limit (20.9%), with the value dropping at specific points. This can account for the incomplete combustion leading to the massive generation of CO (up to 45ppm), which is far beyond the limit (9ppm).

5. Conclusions and Recommendations

The following can be concluded from the results of the experimental work and questionnaire survey undertaken in the research. The major reoccurring pollutant during combustion activities exceeds ASHRAE provision for a working area in CO. To a large extent, other pollutants are present but at a bearable level. Carbon monoxide is dangerous because it inhibits the blood's ability to carry oxygen to vital organs such as the heart and brain. Inhaled CO combines with the oxygen-carrying haemoglobin of the blood and forms carboxyhemoglobin (COHb) which is unusable for transporting oxygen. Combustion activities are practically unavoidable in teaching and learning practical science courses. The primary source of heat for the combustion activities is the gas burner, except in a few cases of a limited gas supply when the water bath is used as an alternative heat generating source.

Fatigue is one of the most reoccurring health symptoms of poor indoor air quality due to combustion activities. However, other health symptoms are headache, dryness and irritation, sinus congestion, blurred vision, sneezing, and chest pain.

The study recommends that Lab managers should pay proper attention to maintaining the laboratories' Heating, Ventilation, and Air Conditioning (HVAC) systems, particularly the fume hoods. It is also recommended that a fume hood be installed in the laboratories without the fume hoods, such as Chemistry Lab I, where there are no fume hoods. This is to take care of the gaseous pollutants from combustion activities.

As a matter of urgency, the school authority should try and construct new laboratories to address the overcrowding challenges in the laboratories that have intensified the effect of combustion activities which in turn affect the indoor air quality. This would also help accommodate teaching and learning.

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Dispute resolution methods adopted by contractors during COVID-19 in Eastern Cape South Africa: A Case Study

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Abstract

Over the past months, the socioeconomic consequences of the ravaging COVID-19 pandemic reverberated through and affected all segments of life. The construction industry is not left out. The severe impacts of COVID-19 have not only witnessed tragic human losses but have also caused colossal devastating implications for construction procurement and general contract condition. The study examined the dispute resolution methods adopted by contractors in Eastern Cape, South Africa, during the COVID-19 experience to determine their appropriateness and effectiveness. The study employed a snowballing, purposive, non-probability sampling technique with a mixed research design driven by respondents' participatory action. Twelve senior personnel were interviewed, while questionnaires were administered to 30 referred employees on the sites. XLSTAT statistical software and thematic analysis were used for the aggregated questionnaire and qualitative respondents' interviews in drawing inferences. The results revealed that an interest-based rather than a right-based approach are two sides of a coin that can make or mar the wheel of progress in arriving at an amicable agreement to contract terms in construction. The need for re-negotiation in billing, which is at variance with the various construction claim, cannot be over-emphasised. At the same time, the intuitive assertions of negotiation, mediation, and conciliation were used in resolving unforeseen delays, claims, and added costs due to disruptions of COVID-19. The study's main contribution lies in mastering and deploying appropriate dispute resolution methods in project execution. The study is of utmost importance in planning, restoring, and deriving optimal societal benefit from conflict management amidst the adverse effect of Covid -19 on any construction project.

Keywords: Conciliation, Construction dispute, COVID-19; mediation, negotiation

1. Introduction

Several countries have slowly started to emerge from one of the most severe lockdowns in the world due to COVID-19, which might not go away too soon. The South African construction industry is one of the industries that was severely affected not only by the national lockdown but also by unforeseen circumstances on construction sites ranging from late material delivery, difficulty in work implementation, and project time completion elongation to sudden retrenchment of the casual construction workers who sourced their livelihood from the sectorial activities. Experts have said South Africa is likely to witness still the 5th wave of infections going by the records of the fully vaccinated people at 30,559,431 out of the estimated mid-year population of 60.14 million people (Stats SA, 2021). The newly reported cases of 1,094 infections as of Monday 14 February 2022, brought the total reported cases to 3,642,905 of death toll increased to 97,250 (+257) with a recovery rate of 96.3% for a balance of 37,406 active cases in circulation (SA-Official COVID-19 portal). Both the past occurrence and the new Covid -19 variants seem like a mirage to some industries to abide by the five-level COVID-19 alert system introduced to manage the gradual easing of the restrictions. The stringent regulations include remote working, reduced commuting, and observed social distancing as part of measures to curb the spread of the disease (Bodenstein et al., 2020). These measures have drastically transformed many industries and business

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working landscapes to adapt to new measures. For the construction industry, this presents a plethora of opportunities and challenges in alternative dispute resolution for the client and the construction team in reaching an amicable compromise middle position.

Critical infrastructure, such as bridges, ports, rail, and roads, are key competitive economic development of a nation. Many researchers have asserted that infrastructure development can create new employment opportunities both directly and indirectly, attracting investment. It provides the necessary stimulus for economic growth (Agénor and Moreno-Dodson, 2006; Bhattacharya et al. 2015; Yu, 2017). However, the impaired irregularity arising from the unforeseen COVID-19 pandemic has caused conflict and disparity between the initial guidelines for the project completion timeline and the client's assumed contractual sum (Johnson and Babu, 2020). Other contending issues are payment modality, work quality assurance, material delivery to the site, and workers' safety during the pandemic (Alsharef et al. 2021). These emerging issues affect the client who had budgeted a contractual sum for the completion of the project and the contractors who could result from working quality compromise in standards and poor-quality infrastructure delivered in other to maximise gain. These circumstances posed risks and justified deviation from the basic rule in theoretical conciliation and expert assessment in bringing amicable resolution. This brings the need for arbitrators to mediate and decide on different cost awards, which the Movement Control Order (MCO) has brought to the varying construction site works.

Moreso, in this era of different driven political interests in South Africa, where the government representative agent proclaimed additional unauthorised jobs, deviation from contracts award sum as jointly agreed with the contractors' legal officer, chief executive officer, and financial representative of the government in determining the overall project cost. Most contractors are suspicious of carrying out additional work, even if necessary. Thus, there must be a revised procedure step in authorisation before contractors can claim variation in the total contractual sum with the application of the relevant contractual clause. COVID-19 has exposed the inadequacy of the established norms in project execution.

COVID-19 may have affected many projects; however, one primary process the pandemic may have unveiled to the universe is the similarity increase in the amount of time construction professionals spend handling disputes. The global construction sector has found over 40% of professionals reporting disputes since the onset of the COVID-19 crisis (King et al. 2021; Ogunnusi et al., 2021). Construction conflicts and delays have had a wide range of effects on global productivity (Johnson and Babu, 2020). Among its leading impacts are: - overrunning costs, extensions in stalling time, delays in the delivery of projects, and a potential loss of business viability (Salami et al. 2021). Although several construction projects have come under severe threat within a short period of the lockdown, many are still basking in the euphoria of recovery from the outbreak. Also, every project has its desired outcome and subsequent challenges the pandemic has brought into the construction industry where ongoing construction site works are at variance to the different degrees and stages of work (Alfadil et al. 2022; Harris and Moss, 2020). It is noteworthy to assess the impacts of the COVID-19 lockdown, and gradual easing on construction sites vis a vis due to unforeseen delays, the need for additional claims, and added incurred costs as postmortem derivative of COVID-19 hazard.

Among the arising argument is the work quality assurance, material delivery to site, time to project completion, need for additional claims, and additional elongated work, to who bears the cost/risk. Other emerging issues for further discussion and re-negotiation include logistics for workers' safety under the pandemic without jeopardising the standard quality of work requirement.

The recourse to no casualty and enforcing the "force majeure" in risk claims has not helped resolve the other emanating disputes (Lai, 2020). Project managers' daily tasks include leading project-related decisions and actions. A manager's actions and inactions have a direct impact on projects. One of the difficulties that a Project Manager mainly faces is decision-making. Some decisions may seem trivial, but they can determine a project's success or failure. The devotion of the project team is one of the decisive elements in project success or failure. Lack of teamwork and project members' dedication can cause problems. A project can be lost due to poor project team selection and a lack of desire among the team members. In this regard, a project manager should learn how to use the social exchange, motivation, and equity theories to boost productivity in common decision-making issues on construction sites (Lukman et al. 2022). Thus, the conception, design, and implementation of contractors' action for identifying both protective and risk factors affecting project execution in an unforeseen natural setting and the client's understanding of contractors' exposure to danger relates to timely project completion and how these affect cost incident rates signpost the contribution of this manuscript.

This study aims to appraise the extent to which the various dispute resolution methods contractors adopted during COVID -19 experience in a South African construction site. It sheds more light on contract budget optimisation, which advanced misconception concerning force majeure or frustration as a dispute resolution cluster term for settling and managing disputes amid the COVID -19 Era. Furthermore, the study emphasises the role of participatory action research (PAR) philosophy that "individuals are more motivated when involved in the decision-making process about their workplace" (Whitehead and McNiff, 2006). Six (6) Contractors and the Employer (Government of South Africa) were used in this study, supported by Tellis (1997). Tellis argued that using multiple case studies allows an in-depth exploration of cases within identified cases. Also, Baxter and Jack (2008) posit that this approach enables a researcher to forecast similar outcomes between cases and could also predict different outcomes based on a theory.

2. Theoretical background and Related work

A background review of related work shows that the COVID-19 pandemic has been explored from the perspectives of epidemiology, infectionlogy, immunology, and virology (Chan et al. 2005; Ruiz Estrada et al. 2019; Harris and Moss, 2020; Diallo and Bordea, 2021)). Epidemics and pandemics are, at the same time, the factors affecting individuals but the social relationships among them, the societies, and organisational structure. The emergence of the COVID-19 pandemic outbreak has unveiled a new dimension in society. It continues to put the construction industry into socioeconomic, technical, and legal systems consideration at an unprecedented dispute rate (Ivanov, 2021; Alfadil et al., 2022). Even though dispute resolution may not be uncommon across the construction industry, the astounding increase during the COVID-19 pandemic is a cause for concern (Alsharef et al. 2021).

In addition, the measure is taken to contain the viruses such as quarantine, self-isolation, and restrictions on human and vehicular movements have a far-reaching effect on the ability of contractors to finish the project on time and within budget (Alsharef et al. 2021). In addition, a measure taken to contain the viruses, such as quarantine, self-isolation, and restrictions on human and vehicular movements, have a far-reaching effect on the ability of contractors to finish the project on time and within budget (Alsharef et al. 2021).

Maiketso and Maritz (2012) have postulated adjudication as the most popular alternative dispute resolution method in the South African and global construction industries (;Van der Merwe, 2010; Bvumbwe and Thwala, 2011; Alfadil et al., 2022). However, Povey et al. (2005) and Brett (2007) argued negotiation is the cheapest and most effective way to resolve disputes on sites. This method engages worried parties and often promotes meaningful dialogue engagement. However, some have reasoned about its effectiveness in dispute resolution in the construction industry based on the circumstances and peculiarity of the project (Baffour-Awuah et al. 2011; Abeynayake, 2015; Mazani et al. 2019; Ogunnusi et al. 2021; King et al. 2021). Adopting any particular method could be tasking and demanding in a completely new environment like COVID-19 in delivering resilient infrastructure while boosting the industry growth process.

Having raised some of the above critiques, there seems to be no specific or exclusive best method for resolving disputes on construction sites; instead, there are various ways to resolve disputes in the construction industry. Thus, there is a need to appraise the extent to which the contractors could adopt the different dispute resolution methods during COVID -19 experience.

Most of the research efforts on dispute resolution over the past decade have been aimed at improving public discourse on conflict management; for example, Yussof et al. (2020), Butteriss et al. (2001), Harrison and Wendorf Muhamad (2018), and Hodgson et al. (2018). Most of these studies simulate the impacts of a deliberate breach of contract and arouse public interest in shoddy substantial services delivery work. However, the recent COVID -19 outbreak has stripped the construction industry of service delivery-in, paying greater interest to technical details, especially in underground infrastructure, which had stripped the embedded structure of the required maintenance.

Emerging research suggests that negotiators with a primarily cooperative style are more successful than hard bargains at reaching novel solutions that improve everyone's outcomes (Caputo, 2016; Low, 2020; Harrison and Wendorf Muhamad, 2018; Iyiola and Rjoub, 2020). Most of the studies on conflict management had addressed dispute resolution based on the precautionary principle and segmented phased practice, not stating the roles, rights, obligations, and remedies for the Employer, Contractor, and Subcontractor amidst conflicting disagreement during the COVID-19 pandemic. Furthermore, the absence of research on the lack of social cohesion (virtual meetings, online interactions) impacts the construction industry towards impacting the teamwork spirit required for the timely completion of a project call for action and practical demonstration of real work required by experts toward prompt defect correction under unforeseen circumstances. Thus, dispute resolution mechanisms are intended as suitors in small or large works either of short or long duration to resolve conflicts, more especially on components of costs (Barsky, 2016).

Looking at rules for the conduct of arbitrations (the Arbitration Act 42 of 1965), justice, fairness, and equity are tri-part pillars upon which social exchange theory in dispute resolution mechanism is based (Cortez and Johnston, 2020; Etim and Okudero, 2019). Social exchange theory presents two yardsticks of comparison. The theory underpins the case study approach adopted in assessing a given outcome, whether in a difficult situation or under normal circumstances. This scenario is also known as game theory. Game theory entails the intersection of mutual knowledge through willingness, learning, and autonomous collaboration of the people as the engine of problem-solving in an organisation (Zomorodian et al. 2017). The game theory conceptualisation in dispute resolution has helped make negotiations more structured by bringing both parties on the same page (Beltran, 2020). Therefore, to understand the application of justice in an unforeseen circumstance like COVID-19, it is imperative to dissect and conceptualise the social exchange theory in link with the equity theory (Bayat et al. 2019). A negotiator's adaption of these concepts brings clarity to the entire process. It ensures the political will of all parties to enforce the agreed terms while still preserving their respective interests (Beltran, 2020). It provides a rationale for achieving both the physical and economic robustness required for development in a goal-oriented industry (Bayat et al. 2019). Many dispute-resolution mechanisms among dissatisfied experts in project management require the game theory concept of giving and taking (Liu et al. 2017). The individual's compromise in dispute resolution depends on their expectation which is determined by the prior experience of past events. Although, the worried parties believe that the fairness of the negotiators determines the outcome of the service recovery initiative (Jeong et al. 2019; De Filippi et al. 2020).

Thus, this study highlights major dispute resolution strategies useful for COVID-19 pandemic-affected projects in Eastern Cape, South Africa, to determine their appropriateness and effectiveness. The six selected construction sites shed more light and advanced misconceptions concerning force majeure or frustration as a dispute resolution cluster term for settling and managing disputes amid the Covid -19 Era. The study appraised the various dispute resolution mechanisms and determined their appropriateness and effectiveness using deductive reasoning in project management to mitigate unforeseen delays, disruptions, and unnecessary additional costs.

3. Research Methods

The research adopted the snowball sampling method. It is often relevant when participants of a study are difficult to locate, or constrained by time, cost, or convenience of collecting the data (Emerson, 2015). In the sampling method, a researcher collects data from a few people (participants) whom they can find, then ask the same people (participants) to recommend where potential participants may be found or people to whom such participants relate (Mitchell and Education, 2018; Sharma, 2017). The nature of this research, which requires the insights of experts from the construction industry and pandemic scientists who are well-grounded in assessing impacts on construction sites, would give credence to the subject matter. Also, in action research, the research is conducted with the intent to improve researchers' practice and design a practicable line of action; while implementing this design (Ngwenya, 2018). Hence, action research is a societal process that interrogates the nexus between people and their immediate society. It recognises the significance of perceiving society as a unit of identification (Ngwenya, 2018). Adopting the mixed design gives credence to the approach employed, whereby qualitative and quantitative methods were utilised to gather relevant data (Little et al., 2011, Onwuegbuzie et al., 2009).

The online structured interviews were conducted with senior personnel via zoom scheduled meetings for the selected company representatives. This was followed up with a recorded telephone interview. Before this, the researcher obtained permission to record and transcribe the interview sessions. Twelve senior personnel were interviewed, while questionnaires were administered to 30 referred employees on the sites in drawing inferences. The engagement of these stakeholders helps give an in-depth understanding of maneuvering COVID-19 impacts on construction cost, quality, and time to projection completion.

Quantitative data consists of numerical data, which can be quantified, while qualitative data help affirm and clarify the quantitative collected data. The triangulation method was used to justify the acceptable opinion where the qualitative and quantitative responses are in opposing positions. The triangulation technique uses multiple data collection methods to increase the observation's reliability (Tellis, 1997; Bush, 2012). This was used due to some findings that require the personal assessment of the information collected from respondents. Also, it offers sufficient statistical indices for the reliability and validity of the data collected. The research used the questionnaire distributed and the interview schedule to test the hypothesis that sought to affirm/negate the assertion that COVID-19 impacts the overall cost and time to project completion, irrespective of the lockdown stages.

3.1 Sampling Design and Procedure

To guide the inquiry into the impact of COVID-19 on a construction site, the design of the interview and the questionnaire was done in such a way that it elucidates useful information from respondents. It has six basic information headings: demographic information, the initial and aftermost COVID -19 impact on the cost; time variation responses to project completion, which dispute resolution mechanism they are aware of, and which one they believe ameliorated the arising conflict best while stating other advert effects for unforeseen circumstances. Furthermore, the validity of the research instrument was underpinned by ensuring that the questions posed were not at variance with the study' s aim and objectives.

The content of the questionnaire instrument used was structured in the modified Likert fashion on a 5-point scale ranging from Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), to Strongly Disagree (SD). Participants were then instructed to respond to their degree of agreement with the statements contained in the instrument. These questions were sufficient in confirming the respondent's response to the interview conducted. Furthermore, all forms of ambiguity were avoided while explaining the aim of the research to the selected stakeholders. To communicate effectively, the researcher tried to explain in English to senior personnel, who later referred the researcher to other community members after assisting by translating it into IsiXhosa, which was the mother tongue of this locality. Such translation into IsiXhosa increased their level of comprehension of the project and helped maintain the researcher's aim.

Based on Mason (2017), Building Information Modelling (BIM) has enabled architecture, engineering, and construction professionals to improve collaboration, reduce errors and ultimately deliver better projects. It has justified added benefits for infrastructure projects and opened new opportunities for construction engineering professionals. However, the Movement Control Order (MCO) has imposed restrictions on humans and the delivery of goods to the construction site.

This had hindered mutual joint construction professionals' assessment and input to quality delivery of the projects. Thus, the research design adopted a snowball sampling approach where relevant stakeholders and experts in project management and the construction industry were consulted. The contacted individuals were briefed about the process and likely questions before the commencement of the interview. Also, permission was sought by the researcher to audio-record and transcribe the interview sessions conducted. The action-based philosophy was employed in the selection of the construction sites' participants. This enables a more precise and accurate analysis of a community's reality. The triangulation method was used to validate the hypothesis from the qualitative and quantitative research strands.

Using the Chinyio and Olomolaiye (2009) influence grid model as depicted in Figure 1, the research design process considered the participating company representatives and the government negotiating stakeholders in examining the choice and role of selected stakeholders determining the relevant dispute resolution mechanism, types, and range in examining the different cases in question. The involvement of stakeholders chosen enables an easy-to-follow procedural step based on Pryor's (2015) criteria where the current knowledge of trends in dispute resolution, the different types, and the range was employed to examine the different cases in question-based in Table 1 stakeholder engagement (inform, consult involve and empower) to systematic name potential stakeholders who were to be involved in the project.

Table 1: Stakeholder engagement

	Inform	**Consult**	**Involve**	**Empower**
Project participation goal	To provide balanced and objective information to assist stakeholders in understanding the project's drivers, alternatives, opportunities, solutions, and progress.	To obtain stakeholder feedback on issues, analysis, alternatives, and/or decisions.	Work directly with stakeholders throughout the process to ensure that their concerns and aspirations are consistently understood and considered.	To place final decision-making in the hands of stakeholders
Promise to project stakeholders	We will keep you informed about the project's progress.	We will keep you informed, listen to and acknowledge your concerns, and provide feedback on how your input influenced the decision.	We will work with you to ensure that your issues and ideas are directly reflected in the alternatives developed. We'll also provide feedback on how your input influenced the decision.	We will implement what you decide.
Example techniques for engagement and consultation	Newsletters/email, intranet, presentations	Focus groups, surveys, online forums	Workshops, polls, email feedback, document sharing	Project papers, steering group meetings, formal approvals

Source: International Association for Public Participation (2014)

The names of potential stakeholders were written out for each category identified above. The comprehensive list is comprised of these categories: beneficiaries, municipality employees, members of the ruling party, engineers, artisans, and health professionals. A representative was chosen for each category as a potential head who was served the questionnaire and later called for confirmation. A review followed this to ensure no potential stakeholder has been omitted from the list.

The engagement of these stakeholders and site managers was used to explore how the national lockdown and its aftermath impacted the construction site (Pryor, 2015). Furthermore, the stakeholders were engaged using the model designed by the International Association for Public Participation (2014), cited in Quick and Bryson (2022). This is illustrated in Table 1.

4. Data collection and analysis

Table 2 presents the expert demographic data analysis for the interview, while Table 3 depicts respondents' feedback collation among the six contractors in assessing COVID-19 impacts during the Movement Restriction Order (MRO). Table 4 summarises the respondent's interview feedback on the impacts of COVID-19 in executing the project.

The coefficient of variability (CV), expressed as the percentage ratio of the standard deviation to the mean measures the dispersion of a probability distribution (Martinez-Pons, 2013). The range value of 0.26 to 0.61 depicts a fair sample representation for the different construction work. A minimum of two personnel were interviewed per site. The respondents' experiences ranged from 3 to 20 years, while amongst these 12 interviewees, 3 were company directors, 2 were senior managers, and the rest (7) were site Engineers/representatives. Most respondents had more than three years of work experience whom the researchers considered fit for the study. Also, to strengthen the data validity, the saturation of the qualitative data collected was verified. This ensured no new information or opinions were obtained amongst the different respondents, which often resulted in the emergence of vital information.

Using a subjective judgement in selecting the participant and a purposive sampling criterion in choosing the "typical case" studies. Five people were administered the questionnaire in each case study to obtain participants'(independent) views and experiences. Amongst the 30 questionnaires dispatched within A, B, C.D, E, and F sites, 20 were fully completed, and ten were voided. The 20 respondents translate to a 67 percent response rate with a confidence level of 95%.

Table 2. Respondent Years of experience and the resulting feedback

Company Label	Years of Experience	Project construction type	Completion Time **Before COVID-19** (Yrs)	Expected completion Time **After COVID-19** (Yrs)	Project Cost **Before** MRO (Million Rands)	Expected projected Cost **After** MRO (Million Rands)
A	6	Roads	2	3	30.50	40.00
B	11	Housing	4	5	40.00	70.00
C	22	Housing	4	5	65.00	95.00
D	10	Water infrastructure rehabilitation	2	3	25.00	35.00
E	3	Building rehabilitation.	4	6	25.00	30.00
F	17	Building Construction	3	4	44.00	51.80
Mean	11.5		3.17	4.33	38.25	47.63
Std. Dev.	6.40		0.90	1.11	13.92	29.26
CV	0.56		0.28	0.26	0.36	0.61

Key: Std. Dev. = Standard Deviation; CV = Coefficient of Variability

A reliability coefficient of 0.60 for the Cronbach's alpha score of six (6) for all the items that constituted the questionnaire depicted acceptable reliability for a newly developed construct. The analysis in Table 3 shows that most of the responses were synonymous across the sites. There were high levels of disagreement in the summary of the cost and time impacts of the COVID-19 lockdown assessment. Still, a sizeable portion of respondents did allege over-bearing implications for cost and time, while the quantity of material delivery to the site was a significant issue. A chi-square cross-tabulation sectional analysis across the Table helps to know which variables are statistically significant in assessing the national lockdown and its aftermath impacts on the construction site. The results show that most statements (the column marked p-value) are significantly at higher levels of agreement. A P-value less than 0.05 signify a substantial contribution and vice visa. In all, the contractor's response impact ranges from material delivery delay, work know-how implementation, and project time to completion elongation and sudden retrenchment of the casual construction worker who found their daily livelihood from the sectorial activities.

Furthermore, the aggregated respondent interview responses to the telephonic interview conducted were summarised in Table 4. The response shows variant causes of dispute, irrational changes in work schedules, and sometimes unrationed cost claims by contractors, despite the government's limited resources to meet the rising various project requirements.

Many respondents said that COVID-19 has caused them to re-evaluate their existing contractual sum. The inability and failure of the client to intervene in a timely and effective way resulted in many disputes arising. Among the most-cited cause of disputes is non-compliance to initial prescripts and improper understanding of the contract law and licenses, even though large percentages of the respondents were aware of contract terms and obligations. This is consistent with findings by Barsky (2016), Bayat et al. (2019), and Alsharef et al. (2021) argue that future dispute resolution for an unforeseen event like COVID-19 should emphasise the need for re-negotiation in billing, which is at variance with the various construction claims.

Table 5 highlights the bottleneck impacts of COVID-19 found in the traditional workflow and relates solutions to address each one of the emanating challenges in reciprocating the construction company's best solution response to arising conflict.

All contacted contractors stated additional costs and project time elongation due to the pandemic. To explain the role of stakeholder, mediator, and negotiator, in alignment with the construction company workforce matrix, time to completion, and rescheduling budget compromised. The inter-relationship in dispute resolution mechanism demands the integration of different stakeholders whose impact can be evaluated using the 'Influence grid' model as depicted by Chinyio and Olomolaiye's (2009) influence grid model in Figure 1.

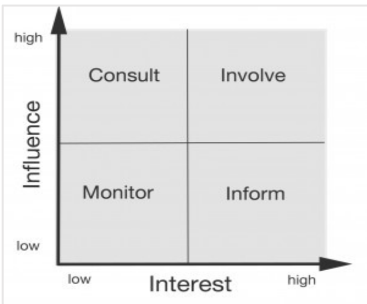

Figure 1: Influence grid model (adopted from Chinyio and Olomolaiye, 2009)

Table 3: Respondents' size to questionnaires among the six contractors' site

Statement Description	SD	D	N	A	SA	Chi-square-value
There is variation in procurement costs during the COVID-19 lockdown	4	4	4	3	5	0.000
There is variation in time to project completion after the COVID-19 lockdown	5	5	4	3	3	0.000
There is variation in total contractual sum and expected project sum during and after the COVID-19 lockdown	4	4	3	4	5	0.000
The work schedule guarantees workers' safety and minimum risk-bearing in the workforce during the COVID-19 lockdown	4	5	4	2	5	0.000
Overhead and the indirect cost was sufficiently affected during the lockdown	4	2	5	4	5	0.000
Which approach works best for you during the lockdown-interest-base or right-based approach?	3	4	3	5	5	0.000

Key: SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Disagree

The subsequent section relates to how the influence grid model can be used to resolve disputes based on the technical causes, impacts, and re-evaluation claims by the government agency in executing the project.

This four-levelled quadrant served as a determinant towards ascertaining stakeholders' level of engagement' in the construction and execution of the project. The first category in the quadrant was stakeholders classified as 'High influence/ high interest'. This set of stakeholders was fully involved, and thus they reciprocated accordingly (Mgemane, 2012). The second classification was those classified as 'High influence/lower interest'. With consideration of their disinterest, limited consultations were made with them. However, this category of stakeholders was still consulted as they were highly influential citizens in the rural community (Bourne and Walker, 2005). The third category was the 'Low influence/high-interest group. This set of stakeholders was resourceful and played an essential role in mobilising and engaging other project beneficiaries. Their active participation instigated some community members who were previously not interested in the project (Fassin, 2009). Lastly, the group was classified as 'Low influence/ low interest'.

Although this group of stakeholders barely played any contributory role, they were occasionally updated with relevant information. Thus, based on this precept, these classified sets of stakeholders were engaged at different levels and had differing inputs bringing clarity in achieving the project aim with a high level of satisfaction among beneficiaries.

5. Application of conflict resolution amongst the stakeholders

The construction of the various facilities was facilitated using the following steps supported by Siyongwana and Mayekiso (2011).

- Negotiation
- Mediation and conciliation
- Expert assessment
- Adjudication
- Litigation
- Building bridges

The intervention of a middleman brings a value chain transition to a more collective community bargaining and professionalism in tolerating each other. The series of negotiations were considered useful mainly because the project manager involved these four qualities – wisdom, fairness, stability, and efficiency. A previous win-lose situation was converted into a win-win bargain (Bal et al. 2013). Mediation and conciliation were also used amongst disagreeing stakeholders, which eventually was resolved after a month. As regards disputes regarding the quantification and valuation of work done at the site, the opinion of a structural engineer and quantity surveyor was consulted; hence through their expertise, they gave sound and justifiable reasons why the increased bill should be honoured regarding the construction work done at the site location. Adjudication and litigation were also exercised when a community member intended to sue one of the stakeholders. Amicable settlement of casual workers' wages and salary was resolved through part payment, food subsidies, and promised to note later when financial institutions open to reduce the social poverty and inequality caused by COVID-19.

Table 4: Respondent's feedback summary.

Question	**Respondents /feedback**
Highlight some of the Covid -19 impacts you notice on your sites.	*Field changes, prolonged procurement delivery, project delays, and potential claim issues.*
Which methods are most effective in resolving time-to-project completion in construction disputes?	*answered (in order): party-to-party negotiation; mediation; and, finally, arbitration.*
Is there any discrepancy in the contractual sum/expected contract sum? And if so, do you subscript to follow the dispute resolution administrative process mentioned in the contract?	*Parties' ability to adhere to contractual notice requirements as well as the dispute resolution administrative process in the contract*
List common causes of disputes you know arising/affecting workers' safety.	*– owner-directed changes and errors and/or omissions in the contract documents.*
Are you familiar with the overhead and indirect cost impacts on contract terms and obligations?	*intimately knowing the contract terms and obligations,*
Which approach will you suggest works best for managing a future unforeseen event like COVID-19? Interest-based approach or right-based approach	*Both approaches work well if well-coordinated and completed expeditiously; likewise, the importance of timely design documentation and dynamic work scheduling*

Table 5: Company label technical issues and bottlenecks related impact of COVID-19

Company label and work type	**Major Bottlenecks Encountered**	**Solutions**
A-Road	Necessary equipment movement to the side resulted in the delay in the filtered bed construction to repair the base and sub-based layered in the road section for water seepage control.	Negotiation
B-Hous1	The resilience of semi-labourers to indulge in menial work and access to in-house changes to the schedule of work and work re-evaluation.	Negotiation
C-Hous2	Traditional use of manual adjustment in retrofitting several workers to report and lack of platform for communication.	Mediation
D- Water	Underground leakages control without the mobile app to state precise GIS location and for cost wastage estimation.	Mediation
E-Building	Fewer participants in stakeholders' meetings conducted during weekdays as compared to weekends.	Conciliation
F- Building construction	Advises and strategies for communicating with the community members were lacking, culminating in some material missing or stolen on site.	Conciliation

6. Discussion of the Results

Testing the formulated hypothesis: HO1: There is no significant difference between the national lockdown and its aftermath impacts on the construction site.

The employed online questionnaire distribution and the posed interview schedule were used to test the hypothesis that affirmed/negated the assertion that COVID-19 impacts the overall cost and time to project completion, irrespective of the lockdown stages. Both the qualitative and quantitative methods substantiate the significance associated with the subject matter in assessing the impacts before and after movement restrictions and on contractors' payment. Respondent response affirmed a positive/significant level of effectiveness in the cost and time, irrespective of the lockdown period or stage. The probability value for the Chi-square test (0.000) is less than 0.05 (5% level of significance), which negates the hypothesis assertion that there is no significant difference between the national lockdown and its aftermath impacts on the construction site but concludes that the arising dispute call for claims and a fair negotiation strategy in achieving an amicable settlement that meets the different stakeholder and company needs irrespective of their different projects' execution.

A general discussion on the analysis of the results was validated with qualitative inferences supported by the literature review. The responses obtained from the questions show litigation was not listed as the top effective method of resolving disputes on construction sites. Some contractors' response to the additional cost claim shows the difference in site, while claims on time to project completion was minimal. Although. The stakeholder response shows that workers' safety was at minimum risk compared to realistic options for an out-of-court settlement. Both the initial contractual sum and the expected project cost have not been complied with, irrespective of the contractual obligations required from the client. However, like criticisms made by participants in Site B, C, and E., their responses do attest that there is an increased dispute rate, but the response rate has not been accorded the urgency required. Cortez and Johnston (2020) further mention that mutual representation of needs promotes fairness and justice in satisfactory work done by both parties, while the failure to understand the impacts of the MCO and/or comply with contractual obligations represents the more significant cause of disputes.

6.1 Categorised themes discussion

The data obtained from the annotated ABCDEF sites' respondents through the questionnaires and interviews were captured and categorised into a set of themes in line with the aim and objectives of this study. In a further attempt to unravel the above six themes, an effort was made to further group them into two general themes: negative consequences and positive consequences, in exploring the different dispute resolution mechanisms for the project's success. The negative impacts denote time to project completion with varying opinions due to miscellaneous logistics as per consideration for workers' safety during the COVID-19 pandemic. Thus, the positive consequences highlight work quality assurance both in quantity, and quality of material delivery to the site, new payment modality, and additional indirect cost incurred due to delay in project time to completion.

6.2 Procurement modality conflicts resolution among the Stakeholders

Among the aftermath of COVID-19 disruption of work are disputes which emanated due to inadequate or lack of priority set-up in regulating procurement of construction goods/materials while still maintaining standard quality in the procurement delivery. Furthermore, a series of conflicts arose among stakeholders regarding who should bear the risk among the contending construction workers. Thus, causing an ideological clash between the consulting engineer (senior) and other construction fraternity workers (junior) on whom overtime claims are awarded. In contrast, a percentage overhead cost is awarded to the professional staff.

Conflicts of interest among stakeholders in resolving the bottleneck of separating construction procurement from the general procurement acts of government are all emerging gaps to be dealt with in this era of COVID-19. The influence of money-bag politicians to capitalise on sub-standard contract execution and design guidance aberration for their selfish campaign propaganda in the electioneering process are emerging issues that conflict resolution diplomats must pay recourse to. Since there was no agreement amongst either party, the problem was later dealt with in a court of law. Furthermore, the well-detailed contract document averted a series of disputes. A poor or incomprehensive contract document may have resulted in a conflict between the structural engineer and the project manager (Bal et al. 2014).

- **Time to project completion**

According to Mohammed et al. (2018), many successful projects should meet not only the required quality output standards but also be cognizant of the budget and time constraints. Both the clients and the contractor commit to an agreed time term in satisfying their demands and needs. More often than not, disputes occur due to irregular contract terms and conditions, which can lead to unabated litigation due to divergent alternative views in meeting the overall organisational and individual contractor goals. The resolution mechanism organ examines all positive and negative side-effects characterising the bone of contention before arriving at a timely resolution mechanism that appeals to all.

- **Contraction sum and Expected project cost dispute resolution.**

COVID-19 presents the construction industry with the challenge of disrupting strategies for planning, coordinating, and executing various projects, from the initial conceptual cost to the addition of expected indirect project cost to completion variables. To achieve a desirable dispute outcome, negotiation and mediation provide a useful, structured approach to resolving disputes in the construction site's situation, as supported by Xu et al. (2018). The mediator arranged or called for a meeting in which all parties involved can come together through conflict management stages not limited to preparation, discussion, clarification of goals, readiness towards a Win-Win outcome, compromise agreement, and implementation of the agreed line of action. Though, the execution of the negotiation process is dependent on many determinant factors, such as the mediator's personality, skills, and education level capacity. These chosen design paths may lead to diverse views before arriving at amicable solutions.

- **Worker safety and minimum risk guarantee**

Stakeholder engagement enhances efficiency and effectiveness while implementing the construction project. Since the engagement of stakeholders permits the involvement of other parties' commitment to facilitating transparent decision-making, the involvement of stakeholders was no doubt significant in the construction project as their participation had some advantages. The stakeholder involvement in the project was predominantly two sets of individuals. On one side were technocrats, experts, and political authorities; on the other were community members who were the beneficiaries of the intended project (Bal et al., 2014). The decision on the project's minimum risk and sustainability stakeholders was premised upon the stakeholder's view, which recommended that stakeholders be involved at the project's inception. Such early involvement will create a sense of ownership of the project, enhance commitment amongst involved parties, increase expertise, and contribute intuitive knowledge towards making sense of belonging in the community.

- **Overhead and indirect cost resolution**

The middleman ensures value for money, work quality satisfaction, personal ego elimination, and inadequate compromise scandal for both the contractor and the client with minimal loss. It proves saving chances for the contractors, which are more likely to continue the work with the other party in the future without rancour (Jiang and Zhao, 2019). The overhead and indirect costs incurred are usually embedded in the miscellaneous, but this does not arise. Thus, the intervention of a mediator provides a note to take this risk from the contract sum without the need for negotiation or an arbitration panel.

An announced end of COVID -19 restrictions will mean no more laws on social distancing; No curfews or gathering limits; No mask mandates, and zero limits on social gatherings. This slogan of social distancing is a stylish way of dogging work, and casual workers take time to maximise their daily wages. Likewise, the arbitration process takes longer appointments fixing all in the name to avoid being infected by the diseases. All these increase the overhead cost and, invariably, the time construction professionals spend handling disputes.

- **Building bridges through an interest-based approach and right-based approach**

According to Oghenechuko and Godbless (2018), the interest-based approach seeks parties to bargain and a negotiating process by identifying the individual shared interests rather than dwelling much on their log of claims, while the right-based approach conversely shares the mutual understanding from the other side with a series of rules to guide the conversation. The negotiator leans toward co-operational altitude in achieving an amicable resolution, which tends to reach a satisfactory process of getting the desired results. Cooperation has been a pointer in the avoidance mechanism before negotiation efforts by the parties. However, the mediator's task is constrained by some drawbacks when mistrust, emotional barriers, and concerned parties are compelled to participate, thereby shifting the focus from the real issues to an unwillingness to negotiate in the dispute when payment is involved. The egoism tendency to participate cannot be compelled except when ordered by Court.

The unique experience gained with negotiation, arbitration, and mediation under the interest-based and right-based approaches help in bargaining and bringing professionalism in tolerating each other. Negotiation after fracas or disagreement makes the work remain to stand. Still, it harms and deters the value gain, thereby rendering the work quality not to appease a common goal (Iyiola and Rjoub, 2020). However, the three main dimensions of negotiation (procedural, interactional, and distributive justice) are not independent. Procedural negotiation refers to the fairness of the process used to address the different party's complaints or problems. In a distributive negotiation, the parties are only looking for their gain. In contrast, integrative negotiation is more difficult because the concern is about the relationship's sustainability with the other person.

The legal process dealing with construction disputes is usually tailored to answering why there should be a process and how the process should be applied (Chukkol, 2021). It viewed dispute resolution from three perspectives: power, rights, and interests. The legal perspective seeks redress in a law Court. The arbitration court process tends to ensure that the concerned parties should be in control of how to deal with the dispute instead of only bystanders in control. The arbitrator dwells on different scales of costs and elongates the case process, which is later reviewed by the courts to award costs. Although the recourse to out-of-court settlement is with minimal cost while disaffection on some of the arising irregularity caused by COVID-19 is resolved gradually, this line of action entails continuous engagement, dialogue, and involvement of other stakeholders for this non-confrontational approach in determining the management of the crises.

On the other hand, the pros of arbitration enjoy the confidentiality and finality of the Court. The likelihood of a future relationship may jeopardise with your opposing party, except if an experienced mediator was protracted, then an amicable resolution may not lead to total failure (Caputo, 2016). Mediations tend to be quicker than litigation, but if an agreement is not made, both parties may have to waste their time fulfilling the agreement.

Though litigation or arbitration may not be cost-effective, it is usually the last option in dispute resolution caused by Covid -19.

- **Misconceptions about Force Majeure**

The construction industry must also be aware of the serious consequences concerning the assertion of force majeure or frustration in a contract. Controversial arguments exist about whether the coronavirus outbreak has frustrated the contract or caused an anticipatory breach regarding project completion time, material delivery logistics, new working environment, and additional costs incurred (Lai, 2020). Either of these legal rights claims may amount to a breach of the contract. On the contrary, the inclusion of frustration is generally more severer than a force majeure clause insertion. Frustration may result in the contract automatically being forfeited or discharged by the law court (Casady and Baxter, 2020). It can suddenly change the face of the contract rather than suspending performance. The parties affected by force majeure "shall give written notice to the other party immediately upon the occurrence of a Force majeure event, and if the said event is of such a nature that it will: "Result in the impossibility of performance of an obligation going to the root of the particular contract, the party not so affected (: the other party") shall be entitled, upon receipt of notice of the Force majeure event, to terminate further performance of the agreement.

The COVID-19 pandemic has undoubtedly affected construction companies whose parties construct the negotiation power and ability to read the government argument as matters were resolved through a consultative meeting in defining the issues or receiving force majeure claims—this bargaining strategy help to resolve the conflict through proper communication and understanding of the situation. The negotiation modality approach requires changing emotive supply and demand needs into a customise and refined based on empathy, understanding, and invoking a claim of frustration or force Majeure.

7. Charting way forward

The exploration of the game theory concept will serve as an expert solution in the avoidance of conflict and resolving many of the controversies resulting in the dispute caused by the pandemic in the already weak construction industry. The study cases suggest internal restrictions have been removed or downgraded to 'recommend' where robot technology could be deployed to deliver essential materials, providing advanced relief in managing time to complete the different building projects.

Also, mastering the act of mediation, negotiation, and reconciliation techniques are evolving innovative means that have not been exhausted in dispute resolution. The distinct roles of negotiators can be compelling if collaborating, compromising, and accommodating what is right are avoided, all in the name of self-ego and personal aggrandisement. Hence, Low (2020) advocates mediation, negotiation, and reconciliation as promising tools for resolving and minimising construction disputes toward their successful execution.

Social responsibility and sustainable development are concepts whose integration during COVID-19 has led to significant progress in how the construction industry perceives dispute resolution through arbitration and litigation operations mechanisms in project management. It is not only about policies or steps taken to meet legal redress requirements but also about social equality, justice and accountability, bearing in mind the links between service delivery decline and improved policy in support of poverty alleviation and the well-being of workers are paramount.

Covid -19 has compelled contractors and other stakeholders (the bricklayer, welder, carpenter, clerk of work, and labourer) to work under a stringent strange environment that calls for collaboration among the various parties concerning their wages and compensation. Each artisan could compromise and accommodate each other in the interest of the work.

The invocation of a force majeure claim with the advent of coronavirus may not constitute part of its concept assumed in the contract's general conditions, intended to fulfill and used in arbitration among the dissatisfied experts in project management. As a general matter of fact, the client representative and the contractors must seek legal advice before a force majeure event or a contract has been frustrated to enjoy the immunity to continue the project instead of being discharged. Thus, the design action steps of the research could be deployed by contractors in consultation with the government (client) stakeholders in reaching an amicable solution.

8. Conclusion and Recommendation

Regardless of the issues facing the contracted construction projects, this study has explored multi-tier dispute resolution mechanisms not limited to arbitration and mediating adjudication but to other emerging contractors' adopted dispute methods. The study explores different approaches to construction disputes in the context of the COVID-19 pandemic experience in a South African environment. Using an action research approach where a mixed method was used in showcasing the different styles of negotiations to serve as a managerial intervention in the planning and coordination of the project. The study has provided a broad overview of contractors' adopted dispute resolution methods of mediating adjudication during an unforeseen situation like the COVID-19 pandemic.

Furthermore, the study has shed more light on why successful projects require careful upfront planning to achieve timely project completion within budget while still giving the client the best value for the expended money. The COVID-19/pandemic has exposed pricing as a significant contract dispute in the supply and demand chain networks. Thus, unlocking new funding options to measure work as emerging lessons learned in COVID-19. This will go a long way to curb the discrepancy witnessed towards a peaceful dispute resolution for the construction industry.

The study has highlighted the role of negotiation, mediation, and arbitration rather than litigation as a viable future scenario in resolving conflict. Thus, a successful negotiation is about constant engagement and discussion to reach an amicable agreement, compromise to excuse a party's non-performance, or justify the termination of the contract. The study reinvigorates the need for: - clear contract language, better design drawings in the hope of unforeseen, risk management training, dynamic processes in project schedule documentation, and the need for proper communication as an effective tool for dispute avoidance and resolution in the post-COVID. The study recommends further constructive and robust discourse within the arbitration system to appease the contractors and clients where mediators and negotiators failed to resolve the disputes.

Limitations of the study

This study did not consider the projects on a case-by-case basis based on the contract term, facts, and circumstances but on a lump case. Also, the adopted mixed methods are time-consuming, costly, and could be subjected to biased from interviewers. Furthermore, the study did not consider the interdisciplinary nature of the different projects. Subsequence studies may take broader and similar projects in the same geographical location for key consideration of different styles of negotiations.

Conflict of interest

No conflict of interest was presented.

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