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ASOCSA
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20TH BUILT ENVIRONMENT CONFERENCE

BUILDING ON OUR PAST, CREATING OUR FUTURE

13-14 JULY 2026
PREMIER HOTEL PRETORIA, ARCADIA, GAUTENG, SOUTH AFRICA

CALL FOR PAPERS

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The Association of Schools of Southern Africa (ASOCSA) celebrates its **20th Built Environment Conference** on the 15&16th July, 2026, in Pretoria, South Africa.

In celebration of this milestone ASOCSA has selected as the theme for this conference, ***Building on our Past, Creating our Future***. This theme provides the opportunity through a retrospective, progressive, transformative and visionary lens to examine through empirical research the historic, persistent and critical challenges and debates that face the construction industry locally, regionally and globally. The intent is that by reflectively looking back we may seek responses to the following questions:

- What does a resilient, future-ready construction industry look like in the face of deep technological, climate and regulatory uncertainty?
- How can all stakeholders embed adaptability, sustainability, innovation and foresight into design, planning and engineering of the built environment?
- What tools, data, and frameworks can help the construction industry to respond dynamically to climate, societal, and technological change?

Past conventional planning and engineering approaches are ill-suited in a dynamic and rapidly evolving landscape to respond to the challenges presented by, for example, extreme weather events, resource and skills shortages, health and safety crises, energy transitions, and workforce development. Emergent themes include consideration of adaptive and responsive design, resilience thinking, scenario planning, nature-based solutions, smart construction, robotics, artificial intelligence, and machine learning. Consequently, construction can no longer only be about durability, but must also take cognizance of flexibility, redundancy and responsiveness – all the while recognizing that there is no 'one-size-fits-all' response or solution.

In 2003, David Perkins at Harvard University in the opening lines of his article, *Making Thinking Visible*, stated the following:

Consider how often what we learn reflects what others are doing around us. We watch, we imitate, we adapt what we see to our own styles and interests, we build from there. Now imagine learning to dance when the dancers around you are all invisible. Imagine learning a sport when the players who already know the game can't be seen. Bizarre as this may sound, something close to it happens all the time in one very important area of learning: learning to think.

Therefore, Building on our Past, Creating our Future, challenges us to learn to think – and re-think about the construction industry as a living system amid uncertainty.

The construction industry must continue to deliver in terms of the following:

1. Increased profitability and efficiency
2. Environmental sustainability and compliance
3. Customization and competitive advantage
4. Adaptability to market dynamics

CALL FOR PAPERS

The 20th Built Environment Conference to be held on the 15th and 16th of July 2026 in Pretoria, seeks responses to questions related to current conversations, debates, and empirical research on the challenges of and opportunities presented by the theme Building on our Past, Creating our Future.
To aid researchers in identifying relevant research for the conference, the following sub-themes are provided.

SUB-THEMES

- Innovative use of technology
- Sustainable construction and environment
- Construction industry transformation and development
- Sustainable infrastructure design and delivery challenges
- Procurement innovation and transformation
- Smart cities and sustainable human settlements
- Innovative waste management
- Public and private sector procurement and contracting
- Legislative and regulatory challenges
- Labor challenges and issues
- Transformative education, training and skills development
- Construction health and safety innovation
- SME development
- Women in construction
- Government role in transformation and sustainability
- Project management in Construction
- Skills development
- Workforce diversity and development
- Nature-based solutions
- Near zero design and construction

The conference invites papers within the context of its theme & sub-themes that address, inter alia, in both the public and private sectors

- Past and current trends and developments
- Innovation
- Opportunities and challenges
- Policies and procedures
- Legislation and regulations
- Practices
- Case studies

Papers will be reviewed according to:

- Relevance to the conference theme
- Objectives and outcomes of the conference
- Originality of the subject matter
- Rigor and robustness of empirical research
- Research design and methods

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Selected papers will be published as book chapters and indexed in Scopus
It is intended that these papers will contribute significantly to the existing body of knowledge relative to the science and practice of construction not only in South Africa but everywhere where the products of construction are produced.

Final Paper Submission: 30 June 2026 | **20th BEC: 13 - 14 July 2026**

LETTER FROM THE EDITORS

This first normal issue in Volume 18 contains four papers. The paper by Khuzwayo, Elsaigh , Rankine and Walker assesses the compliance and structural efficiency of sand cement hollow blocks supplied by emerging manufacturers in Durban, KwaZulu Natal, where informal production practices dominate the low-cost housing material market. They found that none of the sampled blocks met the minimum regulatory strength requirement and that wide variability between suppliers revealed major quality inconsistencies in informal production. Consequently, the prevalent use of non-compliant masonry provides a means to identify potential performance risks when products such as these are used.

Mupondi, Moyo, Omer and Edwards argue in their paper that persistent gender disparities within the construction sector are influenced by systemic and anomalous workplace practices. They posit that there are significant forms and clusters of discrimination against female construction professionals and skilled operatives. These take the form of harassment, discrimination and welfare-related issues; and career-related forms for female construction professionals. For female construction skilled operatives, the discrimination clusters were recruitment, welfare and relations-related, workplace relations, safety and management-related, and physical attributes-related forms.

In their paper, Duvenhage and Grobbelaar examine key factors that influence the implementation of sustainability rating systems for road infrastructure, with emphasis on integrating sustainability and risk management principles. They identify critical risk factors, sustainability indicators, and stakeholder concerns to inform the development of a context-appropriate road sustainability framework. They found an absence of explicit risk-based frameworks for sustainable road rating systems and limited direct documentation of risk factors specific to sustainable road infrastructure.

In the final paper, Nkoe, Simpeh and Smallwood explore the key barriers to adoption and factors that will engender the adoption of Green Building Technologies (GBTs) in Lesotho. Their study showed that a lack of regulation and policy framework, as well as a lack of incentives, pose significant barriers to the adoption of GBTs in the country. They found that regulations and enforcement, the availability of demonstration projects, incentivising and rewarding, and creating an enabling environment would contribute to engendering the adoption of GBTs in the Lesotho construction industry.

The editorial team trust that you will enjoy reading the papers in this issue and invite any comments and critiques of the work presented.

Prof. Theo Haupt
Overseeing Editor for the Editorial Team

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AIMS AND SCOPE

The Journal of Construction (JOC) is the official journal of the Association of Schools of Construction of Southern Africa. ASOCSA has committed itself to foster excellence in construction communication, scholarship, research, education and practice and the Journal provides this medium to achieve this commitment. There are four issues of refereed Journal of Constructions per year serving all stakeholders and participants in the Construction and Engineering sectors.

The Journal of Construction publishes quality papers written in a conversation style aiming to advance knowledge of practice and science of construction while providing a forum for the interchange of information and ideas on current issues. JOC aims to promote the interface between academia and industry, current and topical construction industry research and practical application by disseminating relevant in-depth research papers, reviews of projects and case studies, information on current research projects, comments on previous contributions, research, innovation, technical and practice notes and developments in construction education policies and strategies. Some issues might be themed by topic.

Topics in JOC include sustainable construction, educational and professional development, service delivery/customer service, information and communication technology, legislation and regulatory framework, safety, health, environment and quality management, construction industry development, international construction, risk management, housing, construction related design strategies; material, component and systems performance, process control; alternative and new technologies; organizational, management and resource issues; human factors; cost and life cycle issues; entrepreneurship; design, implementing, managing and practicing innovation; visualization, simulation, innovation, and strategies.

In order to maintain and ensure the highest quality in JOC, all papers undergo a rigorous system of blind peer review process by acknowledged international experts.

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ASSESSMENT OF THE QUALITY OF SAND-CEMENT HOLLOW BLOCKS IN DURBAN, KWAZULU-NATAL

Bonga Khuzwayo[1], Walied Elsaigh[2], Roderick Rankine[3] and Mark Walker[4]

[1]Department of Civil & Environmental Engineering and Building Science, University of South Africa; Department of Civil Engineering and Geomatics, Durban University of Technology
ORCID: https://orcid.org/0000-0003-3967-7126

[2]Department of Civil & Environmental Engineering and Building Science, University of South Africa

[3]Rod Rankine Engineering Solutions cc

[4]Department of Mechanical Engineering, Durban University of Technology

[1]43570208@mylife.unisa.ac.za; bongak@dut.ac.za; [2]hussiwam@unisa.ac.za; [3]rod.rankine@telkomsa.net and [4]walker@dut.ac.za

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ABSTRACT

PURPOSE

This paper assesses the compliance and structural efficiency of sand cement hollow blocks supplied by emerging manufacturers in Durban, KwaZulu Natal, where informal production practices dominate the low cost housing material market.

DESIGN

A descriptive research approach was adopted. Fifteen suppliers were identified and anonymised. Five M140 or M150 hollow blocks from each supplier, produced using two common informal mix ratios of 1 to 3 and 1 to 4 cement to river sand by volume, were purchased as a consumer would. Seventy five samples were tested for compressive strength in accordance with SANS 1215 and evaluated against the 3.0 MPa requirement of SANS 10400 K. Structural efficiency was also calculated.

FINDINGS

None of the sampled blocks met the minimum regulatory strength requirement. Higher cement content improved strength significantly, yet wide variability between suppliers revealed major quality inconsistencies in informal production.

ORIGINALITY/VALUE

The study provides market representative evidence of non-compliant masonry units and offers a practical method for identifying performance risks in informal construction supply chains.

Keywords: *Sand-cement hollow blocks; Structural efficiency; Compressive strength; Concrete blocks; Masonry*

BACKGROUND & INTRODUCTION

South Africa continues to face a shortage of skilled professionals and technical expertise in the construction sector, particularly within the masonry industry[1]. This shortage has contributed to the growing reliance on informal masonry vendors, many of whom lack adequate training and understanding of material standards. Street-based construction material traders experience multiple constraints, including unemployment, limited infrastructure, insufficient capital, low awareness of regulatory requirements, managerial challenges and ongoing concerns about business sustainability[2]. As a result, construction materials such as sand and blocks are frequently sold along roadside markets[3]. The demand for river sand, a key constituent in the production of sand-cement hollow blocks, has increased alongside rising construction activity; however, the availability of high-quality river sand continues to decline due to extraction restrictions imposed by authorities[4].

Informal economic activities contribute significantly to national economies and play a major role in shaping the built environment[5]. The expansion of small-scale and informal activities is largely driven by high unemployment levels and household vulnerability, resulting in uncontrolled commercialisation of construction materials, including sand-cement hollow blocks[6]. Many emerging block manufacturers lack the capacity to test the quality of their products and are unaware of the technological specifications required for compliant block production[7]. Although block manufacturing is generally considered a simple process, sustained profitability requires consistent block quality and adherence to relevant material standards[8].

Masonry has historically exhibited lower levels of standardisation when compared to materials such as structural steel or concrete, partly due to the variety of masonry elements and construction practices[9]. Recent assessments of Reconstruction and Development Programme (RDP) houses revealed a prevalence of substandard concrete blocks, with compressive strengths far below the minimum 3 MPa required by SANS 10400-K: Walls[10]. This highlights a broader issue of non-compliant masonry units in the low-cost housing sector.

KNOWLEDGE GAP

Although several studies have been conducted regarding the compressive strength and durability of concrete masonry units, most of these focused on solid masonry units or those that were produced through a formal manufacturing process. There is a lack of empirical data regarding the structural integrity of sand-cement hollow masonry units commonly purchased from semi-formal and informal suppliers.

Furthermore, there is little available research evaluating structural efficiency and compressive strength concurrently, particularly among sand-cement hollow blocks that take mix proportions following the informal practice often observed among newer producers. Thus, there is little appreciation regarding whether these commonly produced blocks offer an acceptable combination between performance and efficiency.

This, in turn, clearly indicates the need for thorough evaluation among sand-cement hollow blocks available in the market in order to determine regulation adherence as well as structural efficiency performance.

PROBLEM STATEMENT

Sand-cement hollow blocks are commonly found in residential construction in KwaZulu-Natal. However, with the increasing numbers of new block manufacturers, especially in the informal sectors, the ability to provide blocks meeting the South African National Standards would seem to be questionable. This would result in the production of masonry units with insufficient compressive strength being introduced into the market.

The situation is further exacerbated by the lack of regular testing and public knowledge, which enables the usage of non-compliant blocks without assessment for performance. There is an urgent need for empirical information that can determine the level of non-compliance that exists in the most utilised sand-cement hollow blocks and whether non-standard practices yield products that meet minimum standards.

RESEARCH AIM, OBJECTIVES AND SCOPE

The aim of this study is to investigate the compliance of sand-cement hollow blocks produced by different manufacturers in Durban, KwaZulu-Natal, with a focus on emerging suppliers.

The study specifically aims to:

1. Compare the strength performance of sand-cement hollow blocks produced using two common sand to cement mix ratios and different manufacturers.
2. Evaluate the compliance of these blocks with SANS 1215[11] and the 3.0 MPa minimum requirement specified in SANS 10400-K: Walls[10].
3. Examine the structural efficiency of these blocks.

The investigation was conducted within selected areas of Durban. Fifteen suppliers were anonymised and designated A to O, operating within these identified zones. The study used a descriptive approach involving desktop review, supplier identification, sampling and laboratory testing of M140/M150 390 mm (Length) x 140 or 150 mm (Width/Depth) x 190 mm (Height) hollow blocks. No randomisation procedures were imposed by the researchers, as block selection reflected typical consumer purchasing behaviour at the point of sale. All samples were tested in accordance with SANS 1215:2008 compressive strength protocols.

The methodological contribution of this study lies in its market-representative approach, whereby masonry units were acquired as a consumer would purchase them and subsequently assessed using standard laboratory procedures. By coupling compressive strength testing with structural efficiency evaluation, the study provides a practical framework for identifying performance risks in informal construction supply chains. This approach bridges the gap between regulatory standards and actual material performance in low-cost housing contexts, where formal quality assurance mechanisms are often absent.

LITERATURE REVIEW

MASONRY BLOCKS

A significant proportion of the world's population lives in housing made of masonry because of its low-cost and ease of construction, especially in developing countries[12]. For example, in Sri Lanka, there are many masonry materials, such as country fired bricks, cement-sand blocks, hollow core fired bricks, hollow cement blocks, earth-cement blocks and compressed stabilised earth blocks, which are used for house construction[13].

The compressive strength of masonry units in Botswana was compared to the Botswana Standards Bureau[14] minimum requirements[15]. The investigation of the study was limited to concrete masonry bricks and burnt clay masonry bricks from large-scale manufacturers whose products were either certified by the Botswana Standards Bureau[14] or indicated the strength of the products they were selling to the public. It was discovered that only three products out of nine different product sets that were evaluated for the report met BOBS standards. According to these findings, Botswana's users of masonry units at the time were supplied with low-quality materials. Rapid industrialisation and urbanisation typically result in infrastructure development. This led to several issues, such as a scarcity of high-quality construction materials[16], including sand-cement hollow blocks, among others.

The structural integrity of concrete quarry dust blocks (CQDB), which were produced using a mix of cement, sand and quarry dust were assessed[17]. This study was undertaken in Matsapha, Swaziland and both structured questionnaires and laboratory tests were employed. To assess the compression strength, five structural masonry concrete quarry dust blocks were collected from each company. Before subjecting the blocks to testing, a layer of Plaster of Paris was placed on the blocks to promote even distribution of the load.

Their results showed that only one of the manufacturers, CM Concrete, achieved a CQDB with an average compressive strength of 4.0 MPa in five units, complying with the criteria set out in SANS 1215[11]. CQDB supplied from the other five manufacturers did not achieve the required minimum of 3.0 MPa of compressive strength, which is required of structural masonry units. Although the manufacturers required seven days of curing time, some of the manufacturers required less curing time of three days and four days.

In Nigeria, an effort to reduce the number of building collapses, the Standards Organisation of Nigeria and the Association of Block Moulders have agreed that a 50 kg bag of Ordinary Portland cement should be used to produce only 24 blocks, as opposed to the previous practise of producing 42 blocks using the same amount of cement[18]. The Standards Organisation then raised the awareness of the moulders of the vital role cement blocks play in construction. The price per unit of blocks has increased by 70 percent as a result of the trade association's decision to adopt the prescribed standards. The cost is widely acknowledged as a crucial factor in the majority of construction projects, leading certain clients to prioritise affordability[19],[20].

In Uganda, the study indicates that there are economic and environmental advantages in using hollow blocks as long as they are produced to statutory compliance levels[21]. However, where hollow blocks are not produced to standard requirements, the results indicate that it is better to use solid blocks. In the opinion of the authors, this is a surprising result as it seems to indicate that solid blocks prepared using low additions of cement might have sufficient functional quality for simple residential building applications, even though they might not meet current standard strength requirements and have low cement content.

In most cases, blocks are used to construct masonry walls which serve a variety of purposes and functions, including providing vertical support[22] and acting as thermal insulators[23]. When masonry walls are properly constructed, future maintenance expenses are reduced[24]. Masonry walls are constructed by laying mortar beds on bricks or blocks and head joints. This straightforward method requires precise execution skills[25]. Good monitoring helps prevent defects that could later necessitate corrective work, resulting in the loss of both construction funds and materials[26].

Volume or mass is used to measure mix ingredients (i.e. sand and Portland cement). However, there are challenges with bulking of wet sand that arise when using volume batching, so this method is typically reserved for smaller projects such as making sand-cement hollow blocks. In the South African context, the wheelbarrow used for civil engineering purposes should meet the requirements of the South African Bureau of Standards[27]. The standard size for the wheelbarrow pot is around 60 litres. Two 50 kg bags of Portland Cement fill one wheelbarrow. Despite its advantages (accuracy, flexibility and simplicity), weigh batching rarely sees use in smaller projects because it necessitates the use of costly measuring equipment. In addition, a major reward is that most batch plants keep records of the quantities of ingredients used in each batch of a given mixture, creating a virtual audit trail for quality assurance purposes.

Masonry construction does not necessarily require the use of expensive and heavy machinery. The history of concrete blocks as a modern building material begins around the turn of the twentieth century with innovations in block-making machinery[28]. Concrete masonry, also known as “sand-cement block,” represents a significant portion of the labour-intensive building construction process, particularly in developing nations such as the Middle East, North Africa region and South Africa[29]. The use of large masonry units, such as blocks, has the advantage of increasing the productivity in terms of building construction[30].

Among the inspection and testing procedures are tests for dimensions, squareness, compressive strength, drying shrinkage, rewetting expansion and soundness. The compression testing machine should comply with International Organization for Standardization - ISO 7500-1[31] in that the bearing faces of both platens are at least as large as the bed-face of the unit being evaluated, do not deviate from the plane by more than 0.05 mm and are capable of loading at a rate of about 15 MPa per minute. The compressive strength is computed using the maximum maintained load and the bed-face area of the unit being evaluated. To the nearest 0.01 MPa, each unit's compressive strength is calculated. The average compressive strength is calculated as the arithmetic mean of the five individual values with the same precision as the individual results.

THE SOUTH AFRICAN BUREAU OF STANDARDS

The South African Bureau of Standards (SABS) is a legislative body that was established in South Africa under the Standards Act of 1945 (Act No. 24 of 1945) and continues to function under the current version of the Standards Act 8 of 2008 - Department of Trade and Industry[32] Standards Act of 2008. In addition, as a domestic organisation, it promotes and maintains commodity-related standardisation, quality and service provision. SABS provides registration, monitoring, consignment inspection and additional services to the industry. The SABS Approval Mark ensures that products are safe and fit for use and provides consumers with recourse. In September 2008, the enactment of the Standards Act and the National Regulator for Compulsory Specifications Act took place.

The law resulted in the creation of the National Regulator for Compulsory Specifications (NRCS), a new agency within the Department of Commerce and Industry. This agency, established by the former SABS Regulatory Division, is responsible for enforcing regulations under the Legal Metrology Act[33]. Compliance of sand-cement hollow blocks can be ensured by conducting tests in SABS accredited laboratories, which are available in certain regions of South Africa[34]. This suggests regulating the quality of blocks to ensure sufficient strength, preventing breakages and customer rejection, while also optimising the cost-effectiveness of their mixtures. The quality control for masonry units should encompass assessments of strength, dimensions and drying shrinkage to guarantee their high quality. Nevertheless, the authors of this research project believe that implementing this approach may not be feasible for small-scale block manufacturers. Therefore, there is a need for alternative cost-effective testing methods that can produce similar outcomes, which can be used by sand-cement hollow block manufacturers and suppliers catering to the low-cost housing sector.

Despite SANS 1215:2008 and SANS 10400-K:2015 not being in conflict regarding either definition or testing methodology, a technical inconsistency is implicit in product compliance versus regulatory requirements. The SANS 1215:2008 product specification standard specifies nominal compressive strength requirements for concrete masonry hollow units by strength class (Clause 3.6 and Table 2). Furthermore, this document does not specify limits regarding these units in constructing buildings. It stands in stark contrast to SANS 10400-K:2015, which is effectively a 'deemed to satisfy' document regarding minimum average compressive strength standards as specified in different building configurations. The minimum average required strength is thus indicated to be 3.0 MPa for hollow units in single-storey buildings or in the upper storey of double-storey buildings (4.2.1.1(a)(4)), while in double-storey buildings this requirement is postulated as 7.0 MPa in hollow units in walls in the lower storey (4.2.1.1(b)(7)). One may thus conclude that to fully comply with SANS 1215:2008 standards, a hollow concrete masonry unit is legal for delivery as an approved product; yet in practice, this delivery may result in an unlawful product regarding required strengths in walls as per SANS 10400-K:2015 standards. This observation clearly establishes that while compliance is required regarding SANS 1215 standards, complete adherence to Part K National Building Regulations is not guaranteed.

STRUCTURAL EFFICIENCY

Sand-cement hollow blocks must be structurally efficient. Structural efficiency is defined as the ratio of the load that a structure can withstand to its self-weight. The maximum possible loading on a structure and the minimum structural mass result in an efficient structural component[35]. In another study, the structural efficiency is defined as the ratio of the load supported by the material to its weight[36]. Structural efficiency is a frequently overlooked aspect of construction materials and little research is being conducted to address this issue. Sustainability transformations in the building sector, as well as innovative building designs, productive materials and technologies, supportive policies and new types of business practices and services, are required[37].

At present, the construction regulations do not determine a specific, measurable and standardised level of the structural efficiency of the masonry units, either hollow or solid. According to the authors of this research project, the development of criteria for determining the minimum required level of the structural efficiency of concrete masonry units, which are hollow, would enhance the predictability of structures, enhance safety margins, enhance assurance of structure quality, as well as optimise costs. Efficient structural masonry is now a top priority and a holistic approach must be considered. Buildings cause an environmental crisis ranging from overuse of natural resources during construction to material creation. The design engineer must ensure that the structure can safely withstand the applied forces and load effects while using as few resources as possible.

In another study, structural efficiency revealed some interesting insights into what engineers should consider when designing masonry[38]. The structural efficiency of the bricks was evaluated by the ratio of the average compressive strength of burnt clay bricks to their average dry density. The results of structural efficiency are consistent with the results of compressive strength. The higher the compressive strength, the higher would be the structural efficiency. The structural efficiency of the burnt clay brick used in their study is calculated as the compressive strength divided by the dry density. Density is determined by the rate of compaction during the moulding process, whereas compressive strength is determined by the internal stresses generated by the brick's particles and their ability to withstand external loads.

UTILISATION RATIO

Ideally, sand-cement hollow blocks should be designed to withstand a high utilisation ratio. The utilisation ratio measures the extent to which a structural component is used in relation to its maximum capacity. For instance, in the context of masonry walls, if a wall has a utilisation ratio of 100%, it means that it is bearing the maximum load that it is designed to support. The utilisation ratio can also be defined as the proportion of the applied load divided by the capacity to resist the load. In the field of structural engineering, this ratio is crucial in determining the design of structural elements and also plays a significant role in selecting the appropriate types of masonry for structural masonry design.

RESULTS & DISCUSSION

A considerable amount of variation was observed in the average result for the compressive strength of the sand-cement hollow blocks. A greater amount of cement in the mixture caused the strength to increase; however, not a single block produced using the commonly used 1:3 or 1:4 informal mix ratios was found to meet the minimum average strength requirement of 3.0 MPa specified in SANS 10400-K:2015.

Notably, a lack of strength compliance with regulation cannot be immediately construed as a structural failure condition even with light loads. However, reduced compressive strength could potentially be detrimental to durability, resistance to cracking and safety factors, especially during accidental loads or when materials naturally deteriorate over time. Such findings are significant with respect to low-cost housing constructed using masonry units with unverified strength qualities.

It was decided to acquire M140/M150 sand-cement blocks composed of a particular mix ratio. Clients typically request "strong" blocks. It is recognised that "strong" blocks are created with the mix ratio of one bag of cement to three wheelbarrows of river sand (1:3), whereas a "weak" mix comprises one bag of cement and four wheelbarrows of river sand (1:4). Numerous factors, including the water-to-cement ratio, compactive effort, curing conditions, quality of raw materials, type of cement utilised and casting temperature, can affect the compressive strength of sand-cement blocks; however, these factors were outside the purview of this study for the aforementioned reasons. The compressive strength was assessed and structural efficiency was computed as demonstrated in Table 1 below.

Table 1: Results of the structural integrity of sand-cement hollow blocks

Marking	*Mix Ratio (Cement Type: CEM II 42.5 N)	Average Mass (kg)	σ_m (kg)	**Average Compressive strength (MPa)	σ^2_m (kg^2)	Compliance SANS 10400-K: 2015	***Structural efficiency
A1 to A5	01:04	12.1	0.15	1.3	0.02	No	598.2****
B1 to B5	01:04	12.2	0.16	1.3	0.03	No	593.3
C1 to C5	01:04	13.1	0.18	1.3	0.03	No	552.5
D1 to D5	01:03	13.7	0.20	1.7	0.04	No	690.9
E1 to E5	01:03	11.3	0.17	2.9	0.03	No	1428.8
F1 to F5	01:04	13.1	0.18	1.3	0.03	No	552.5
G1 to G5	01:03	11.6	0.16	2.1	0.03	No	1007.9
H1 to H5	01:04	13.0	0.19	1.0	0.04	No	428.3
I1 to I5	01:03	12.0	0.17	1.7	0.03	No	788.7
J1 to J5	01:03	13.9	0.21	2.6	0.04	No	1041.4
M1 to M5	01:04	11.75	0.15	1.3	0.02	No	616.0
N1 to N5	01:03	12.33	0.16	1.6	0.03	No	722.5
O1 to O5	01:03	11.95	0.17	2.3	0.03	No	1071.6

*Mix Ratio: one bag of cement and three wheelbarrows of river sand (1:3), or one bag of cement and four wheelbarrows of river sand (1:4).
**Compressive strength values were calculated using the gross bed-face area of the blocks (390 mm × 140 mm) in accordance with SANS 1215:2008.
***presented as a score, rather than a percentage.
****Structural efficiency was calculated as the ratio of ultimate compressive load to self-weight.

$$\textit{Structural efficiency} = \frac{\sigma_c \times A}{m \times g}$$

where σ_c is the average compressive strength (Mpa), A is the gross bed-face area of the block (390 × 140 mm^2), g is the acceleration due to gravity (9.81 m/s^2).

It is pertinent to point out that for the sake of completeness, the findings for Suppliers K and L are presented below, though Suppliers K and L were excluded from comparison and correlation analysis, as explained in Section 3.1.

As indicated in Fig. 1, the relationship between the mix ratio used in the preparation of the sand-cement hollow blocks and average compressive strength has a positive value of 0.78, which shows that the relationship is fairly strong. When the values of the average compressive strengths were correlated with the corresponding cement-sand mix ratios using the Pearson correlation analysis, the correlation coefficient was found to be 0.78. This indicates a positive association whereby increased cement content is generally accompanied by higher average compressive strength values. However, it also highlights the need for manufacturers to improve their product in terms of certain aspects, which fall outside the scope of this study. A correlation coefficient of 0.78 signifies a positive relationship, indicating that as the Portland cement in the mix increases (i.e., from 1:4 to 1:3), the compressive strength also increases.

An independent samples t-test confirmed that blocks produced using the 1:3 mix ratio achieved significantly higher mean compressive strength than those produced using the 1:4 mix ratio ($p < 0.05$), confirming that increased cement content results in a statistically meaningful improvement in compressive strength.

For manufacturer D, I and N, it is evident that although a positive correlation exists, it does not imply that an increase in cement content necessarily results in an increase in compressive strength. Although the correlation coefficient depicts a high degree of association, it does not prove direct causality. The variation in the compressive strength of blocks made by different manufacturers with the same proportion of mix components in each combination demonstrates that other variables also affect the characteristic. The factors that were not considered in the investigation and could be contributing elements are compaction forces, curing conditions, water content and operator skills. This invites further consideration and may require additional investigation. The correlation analysis is therefore indicative rather than predictive and serves to highlight usual performance trends within the informal block manufacturing sector.

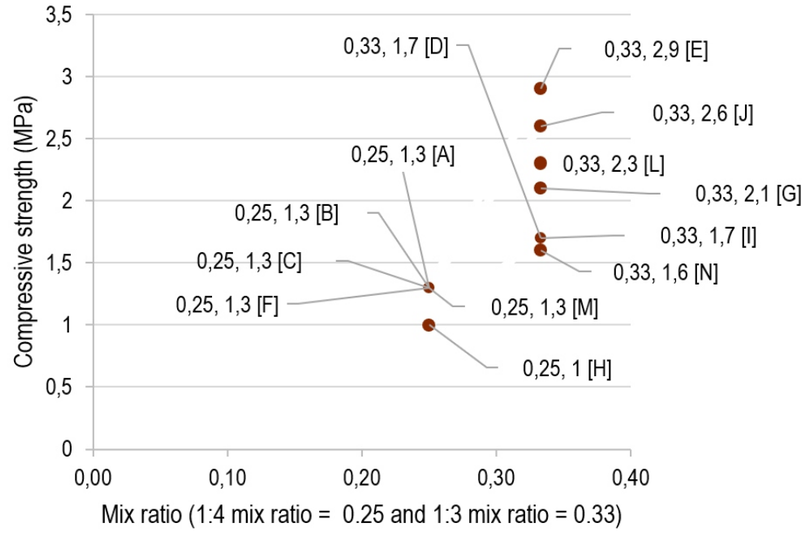

Figure 1: Mix ratio vs. compressive strength.

Referring to Figure 2, the examination of compressive strengths and structural efficiency demonstrated a robust positive correlation of 0.98, indicating that an increase in compressive strength corresponds with an enhancement in the structural efficiency of the blocks. This aligns with the research indicating that increased compressive strength correlates with enhanced structural efficiency[36],[38]. However, it can be observed that manufacturers D and, in particular, J fall below the anticipated level of structural efficiency. This may signify a gap that can be addressed through intervention methods, such as improved compaction, controlled curing and refined mix proportioning.

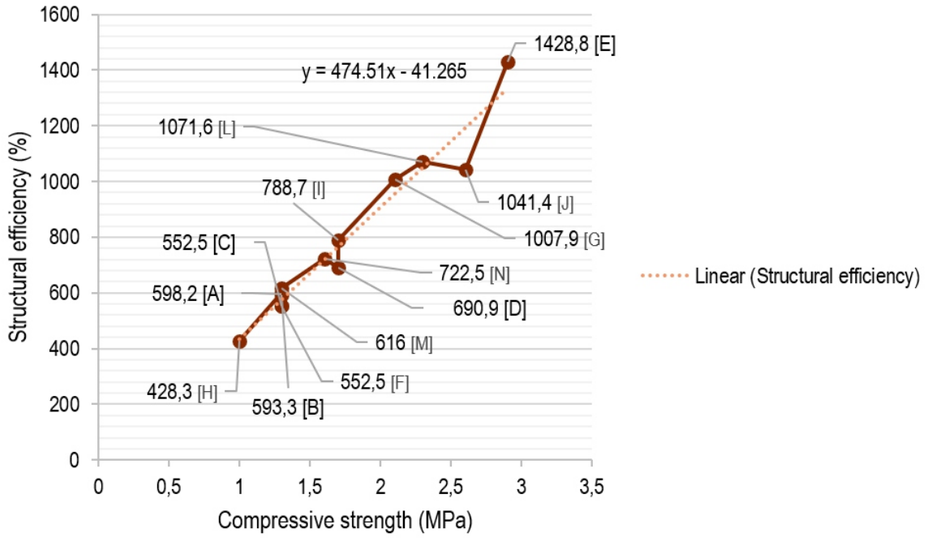

Figure 2: Compressive strength vs. structural efficiency.

Therefore, it is evident that this straightforward method implemented in this study offers a means of identifying manufacturing issues with sand-cement hollow blocks produced by manufacturers albeit in an indicative manner. This method enables the comparison of products and allows for a more efficient method of identifying and prioritising intervention means to help manufacturers of sand-cement hollow blocks improve the quality of their products.

Except for manufacturers K and L, it is evident that all other manufacturers did not meet the minimum compressive strength requirements referenced in SANS 10400-K:2015. The National Building Regulations SANS 10400-K:2015 mandate that hollow masonry units must possess a minimum average compressive strength of 3.0 MPa. However, it should be noted that this does not appear to hinder the sale of these sand-cement hollow blocks to the public for several reasons that fall outside the scope of this study. Nevertheless, it is suggested that consumers may purchase these blocks due to their perceived suitability for intended use, combined with limited awareness of standard requirements and potential catastrophic consequences. Many individuals buy these blocks to construct single-storey homes, as the loads are significantly lower than those of multi-storey buildings. Using hollow blocks, provided they are manufactured to statutory compliance levels, has environmental and financial benefits[42].

One could contend that the prevailing social and economic challenges are the impetus for individuals acquiring these blocks. However, it is also reasonable to assert that they would not purchase them if they were so ineffective that they failed to perform their intended function. Therefore, it should be established what compressive strength is appropriate for low-load structures. Furthermore, it is pertinent to enquire whether the minimum strength of 3 MPa mandated by National Building Regulations SANS 10400-K:2015 is justified for these lightly loaded structures. Another question to consider is why the structures constructed with these so-called “substandard blocks” are not collapsing if they are indeed unsuitable for their current use. If the restricted use of these “substandard blocks,” is permitted, what limitations would they impose regarding their application? If high strength is necessary for reasons such as durability, are there alternative methods that could be employed to attain equivalent durability, such as sealing the blocks, plastering them, or ensuring adequate roof overhang to shield them from the elements? These questions necessitate resolution through the execution of objective research.

CONCLUSION AND RECOMMENDATION

The study assessed the quality of M140/M150 sand-cement hollow blocks supplied in Durban, KwaZulu-Natal, focusing on two commonly used informal mix ratios. Laboratory results revealed that all sampled blocks did not meet the minimum compressive strength requirement of 3.0 MPa prescribed by SANS 10400-K:2015. This indicates clear performance differences between the two mix ratios and highlights widespread quality inconsistencies in blocks used for low-cost housing. The study advances understanding of sand-cement hollow block quality in South Africa by providing empirical evidence of non-compliance within the informal and semi-formal manufacturing sector, an area where limited data currently exists. By linking mix ratios to structural performance, the study offers insights that can inform material selection, regulatory enforcement and capacity-building initiatives for small-scale producers. The importance of this paper lies in its contribution to construction safety and housing resilience. Substandard blocks may pose long-term risks, including reduced durability and diminished safety margins. The findings underscore the need for targeted interventions to improve manufacturing practices, strengthen municipal oversight and raise consumer awareness regarding compliant materials. There is also an urgent need for the establishment of a formal monitoring and regulatory framework by relevant authorities to oversee sand-cement hollow block manufacturing.

Regulators are urged to ensure increased compliance with SANS 1215 and SANS 10400-K through regular inspections or random sampling of sand-cement hollow blocks produced by small-scale manufacturers. Decentralised testing laboratories or simplified field-testing methods should be developed by local governments or trade associations to assist in ensuring product quality within the informal sector.

It would be important for priority programmes or initiatives to be conducted in the area of capacity building, with the aim of improving knowledge about mix design, curing processes and basic quality control. There is also the need for public education in order to enable consumers to make the right purchasing decisions and opt for masonry units that are structurally sound.

PRACTICAL IMPLICATION

The study shows that many sand-cement hollow blocks used in low-cost housing do not meet the required strength standards. This highlights the need for better quality control among small-scale block manufacturers and stronger enforcement of SANS requirements. The findings also show that common informal mix ratios affect block strength, suggesting the need for basic training and guidance for local producers. Finally, the results emphasise the importance of educating consumers and builders so they can identify and purchase compliant, structurally safe blocks.

LIMITATIONS OF THE STUDY

The scope of the study was limited to determining the compressive strength of M140/M150 hollow blocks constructed using sand and cement as the building materials. Due to the constraints of the study and the ethical considerations involved, it was only possible to use a small dataset as sources, which required the acquisition of these blocks. For this reason, it was decided to purchase sand-cement blocks that were made up of a specific mix ratio.

Despite this limitation, the use of compressive strength as a proxy variable provides a conservative and safety-relevant basis for assessing the structural adequacy of sand-cement hollow blocks used in low-cost housing.

NOVELTY OF RESEARCH METHOD

The novelty of this research does not lie in the development of new test methods but in the application of standardised laboratory testing to market-acquired masonry units combined with structural efficiency metrics. Unlike studies based on controlled or laboratory-manufactured blocks, this work evaluates materials exactly as supplied to end-users in informal and semi-formal markets. This consumer-end performance assessment enables regulators and practitioners to identify manufacturing deficiencies, prioritise interventions and assess structural risk under real-world conditions.

FURTHER RESEARCH

Additional research is required to uncover the following: (1) Is it feasible to utilise sand-cement hollow blocks with a compressive strength lower than 3 MPa under specific conditions, particularly in low-income housing scenarios where load requirements are minimal? (2) If such usage is not viable, what is the safety status of structures constructed with these substandard sand-cement blocks for human occupancy? If they are deemed unsafe, what retrofitting measures can be implemented to enhance their health and safety? (3) Finally, what strategies can be adopted to facilitate socially and economically responsible methods to ensure future adherence to relevant standards? In addition, future studies should assess shape, appearance, colour and surface texture inspection, squareness test, drying shrinkage test, expansion on re-wetting test, and soundness of sand-cement hollow blocks. Furthermore, laboratory and field work should adjust the sand-cement mix proportion that results in blocks that meet the strength requirements.

CONFLICT OF INTEREST

The researchers affirm that they have no conflicts of interest.

ETHICAL STATEMENT

The research was conducted with ethical approval. Ref #: 2183.

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EXAMINING FORMS OF DISCRIMINATION AGAINST WOMEN IN ZIMBABWE'S CONSTRUCTION SECTOR

M Mupondi[1], T Moyo[2*], MM Omer[3] and DJ Edwards[4]

[1]Department of Construction Economics and Management, National University of Science and Technology

[2*]Department of Quantity Surveying, Nelson Mandela University, +27715805100, tirivavi.moyo@mandela.ac.za

[3]Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia and Department of Civil Engineering, Higher Institute of Science and Technology, Tiji, Libya,

[4]School of Engineering and the Built Environment, Birmingham City University, and Faculty of Engineering and the Built Environment, University of Johannesburg,

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ABSTRACT

PURPOSE

Persistent gender disparities within the construction sector are influenced by systemic and anomalous workplace practices. Therefore, this study sought to reveal the significant forms of discrimination against female construction professionals and skilled operatives.

METHOD

A questionnaire survey collected primary quantitative data from available construction professionals situated in all construction organisations (consultants and contractors). Skilled operatives were purposively sampled from selected construction sites in the major city of Zimbabwe. Data analysis utilised mean score analysis, factor analysis and agreement analysis.

FINDINGS

Factor analysis revealed significant clusters of prejudice for professionals: harassment, discrimination and welfare-related issues; and career-related forms for female construction professionals. For female construction skilled operatives, clusters of discrimination were recruitment, welfare and relations-related, workplace relations, safety and management-related, and physical attributes-related forms. Agreement analysis revealed that both the gender and experience of respondents did not contribute to any statistically significant differences regarding their insights.

ORIGINALITY / VALUE

The study revealed forms of discrimination for female construction professionals and skilled operatives through a gender-inclusive approach.

Keywords: *Discrimination, Female Construction Professionals, Female Construction Operatives, Forms of Discrimination, Zimbabwe*

INTRODUCTION

The construction industry is characterised by numerous challenges associated with implementing Sustainable Development Goals (SDGs)[1]. Gender equality is notably topical and dominates discourse within both industry and academia[2;3]. According to the United Nations Global Goals, achieving this goal will alleviate the tremendous waste of the world's human potential and concomitant inequality[3]. This is particularly pertinent because the construction industry is one of the largest sectors in with socio-economic impact of deliverables (i.e. buildings and infrastructure)[4]. Despite calls for gender equality through international and national legislation, discrimination and occupational segregation are widespread within the Zimbabwean construction sector[5]. Within such a developing country, the problem of inequality is manifest and further exacerbated by unacceptable cultural norms and beliefs that engender passive acceptance of lower cultural status for women[6].

To address this social injustice, the Zimbabwean government ratified the fundamental conventions designed to achieve gender equality across all sectors[7]. However, Haupt and Ebner[8] report that heavy industrial occupational trades such as construction are not popular career choices for women due to gender discrimination and a culture predetermined by men. Hence, such conventions had low implementation and impact within the sector[7]. In addition, gender pay gaps[9] and gender diversity management[10] have been proffered. Johansson and Norbeg[11] state that the variety of calls and legislation for gender equality in male-dominated trades has been insufficient to encourage female participation. One major issue is that legislative remedies are retrospective and only seek resolution after the inequality has occurred - and even then, the claim lodged may be unsuccessful[12].

Although attempts have been made by scholars[7;9;11] to address challenges faced by female construction workers, greater clarity, comprehensiveness and relevance is required to resolve this omnipresent predicament. It is not enough to relay that women are affected by harassment and discrimination[5] and to report that their participation in construction activities is constrained in Zimbabwe[11], forms of discrimination that they face must be identified to generated more effective resolutions. In addition, both the purported victims and the perpetrators must contribute to the crafting of consensual interventions, as encapsulated in the gendered organisation theory' and the 'hegemonic masculinity theory'[13]. Therefore, this study sought to determine the forms of discrimination experienced by female construction workers in Zimbabwe by considering insights from both female and male professionals and skilled operatives. This was facilitated through

Objective 1- to determine forms of discrimination that affect female construction professionals
Objective 2- to determine forms of discrimination affecting female construction skilled operatives
Objective 3- to determine the existence of statistically significant differences due to gender and experience on the forms of discrimination insights affecting female construction professionals
Objective 4- to determine the existence of statistically significant differences due to gender and experience on the forms of discrimination insights affecting female skilled operatives

From the objectives, the following hypotheses were derived.

$1H_0$ The insights regarding the forms of discrimination that affect female construction professionals are not multidimensional and cannot be grouped into distinct factors
$1H_1$ The insights regarding the forms of discrimination that affect female construction professionals are multidimensional and can be grouped into distinct factors
$2H_0$ The insights regarding the forms of discrimination that affect female construction skilled operatives are not multidimensional and cannot be grouped into distinct factors
$2H_1$ The insights regarding the forms of discrimination that affect female construction skilled operatives are multidimensional and can be grouped into distinct factors
$3H_0$ There is no statistically significant difference regarding the insights on the forms of discrimination affecting female construction professionals due to gender and experience
$3H_1$ There is a statistically significant difference regarding the insights on the forms of discrimination affecting female construction professionals due to gender and experience
$4H_0$ There is no statistically significant difference regarding the insights on the forms of discrimination affecting female skilled operatives due to gender and experience
$4H_1$ There is a statistically significant difference regarding the insights on the forms of discrimination affecting female skilled operatives due to gender and experience

The study envisages contributing towards the development of an effective strategy development towards eliminating discrimination against women in the construction environment (3). Cumulatively, creating inclusive and safe working environments that enhance and widen female participation is anticipated.

THEORETICAL FRAMEWORK ADOPTION

Two main sociological theories were considered relevant to the study of gender equality in the working environment viz.: 'gendered organisation theory' and the 'hegemonic masculinity theory'[13]. Both theories propose to shape and understand gender equality in society and specifically, the working environment[14]. The gendered organisation theory claims that organisational structures are not gender-neutral and that gendered characteristics are embedded in the organisation's structure and work[15]. The hegemonic masculinity theory purports that male dominance is legitimised in society and female subordination is justified through that legitimacy[13]. Connell and Messerschmitt[16] assert that the existent cultural background, institutions and persuasion are tools which aid the attainment of hegemonic masculinity, which benefits men who may inadvertently (or proactively) participate in the complicit subordination of women. Under this scenario, harmful stereotypes are then propagated to create unfavourable working environments for women[17]. These theories cumulatively offer an understanding of gender perceptions, gender role assignment and the status of women in the workplace. In addition, the two theories introduce a two-pronged application. While the hegemonic masculinity theory explains the behaviour and cultural script of the workers (by introducing the views of both genders on forms like biased recruitment practices), the gendered organisation theory explains how the structure of the organisation contributes to this perpetuated anomaly of discrimination (like the gender pay gap and stereotyped positions). As such, the forms of discrimination revealed in the next section reflect the importance of these two theories. They are thus, significant for interrogating the foundations of the existence and the conditions that promote the forms of discrimination in construction environments.

DISCRIMINATION AND ITS MYRIAD FORMS

The International Labour Organisation Discrimination (Employment and Occupation) Convention[18] define discrimination as:

"any distinction, exclusion or preference made based on race, colour, sex, religion, political opinion, national extraction or social origin, which has the effect of nullifying or impairing equality of opportunity or treatment in employment or occupation."

This definition is still recognised as holistic by the International Labour Organisation[19]. Despite the expansive coverage of discrimination inherent within the quote, this study focused on discrimination due to gender in employment and more specifically, perpetrated on female workers. Various forms of discrimination reviewed hereafter have such injustices inherent in their propagation.

Biased recruitment practices fall under procedural injustice[20]. Grau and Zotos[21] lamented that advertisements for construction labour contribute to the sector's gender disparities because they promote sexism. The requirements for high muscle strength expectations often exclude women from qualifying for certain sector positions, yet not all activities require brute strength[22]. Biased recruitment practices further exert a negative influence on the implementation of policies that create a conducive work environment for women, such as access to adequate sanitary facilities at construction sites[23]. Nyanga and Chindanya[24] noted that sexual harassment has increasingly become a common feature in various workplaces, especially the construction industry. In congruence. Mulgund et al.[20] classified communication and interaction under interactional justice as a form of harassment. Adinyira et al.[26] noted that the use offensive language is a difficult challenge because what is entirely subjective offensive language to one person may be tolerable to the next. However, profanity can represent an indication of potential workplace violence that intimidates or bullies a colleague. Crude language is a form of sexual harassment that can deliberately or unintentionally interfere with a female colleague's performance and/or career aspirations[27]. Young et al.[28] highlight that legislation and supportive policies designed to counter sexual harassment has metamorphosed contemporary harassment into avert non-obvious incidents where odd comments over time build up to create discriminatory working environments against women or others. Markson[29] established that sexual harassment is prevalent in the construction industry however, Nyanga and Chindanya[24] reported that sexual harassment's effect on job satisfaction is underreported in developing countries like Zimbabwe. Consequently, the targeted victims often leave their jobs, which negatively affects their career progression, organisation-specific work skills and gender gaps in employment[30]. This causes women to shun the industry, further reinforcing the misconception that women do not belong in the sector[31].

The question of stereotyped positions and job responsibilities is problematic to answer, especially concerning women. Given the rarity of women in the construction industry, it is not surprising that stereotypes against females exist[17]. Holdsworth et al.[32] further argued that so long as this prejudice remains, women continue to be actively discouraged from taking roles on construction sites, and this further compound inequality. Female operatives often experience a set of assumptions about activities and interests associated with males or females on construction sites because of the prevailing cultural society in Zimbabwe[33]. Consequently, women's construction work as operatives is often casual and lowly paid[34].

Hodzic et al.[35] stated that managers in developing countries often avoid hiring female engineers due to natural life processes and factors. Such gendered perceptions have a long-lasting impact in that few women will feel the urge to break the barriers and glass ceilings in the industry[19]. Properly fitting personal protective clothing and equipment (PPE) are essential components for ensuring construction workers' safety. Oo and Lim[36] posit that women are a minority group in the construction industry, and there is evidence of difficulties in accessing appropriate PPE. Industry stakeholders often adopt “one size fits all” regarding female PPE, which can lead to less optimal fitting and use thus, increasing the risk of ill health or accidents[37;38]. Onyekebe et al.[38] revealed that employers were indifferent about their employees, whereas Wagner and Gordon[37] proffered those procurers of PPE were unlikely to purchase PPE designed specifically for women. Because construction projects are temporary, some less enlightened contractors may be unwilling to invest in PPE for a transient workforce[39:40].

Gender wage gaps and a lack of fair income doggedly persist in the construction industry[41]. Muthambi and Agumba[41] relay that these unfair practices undermine the ability of the female construction professionals and contributes to their disdain for the industry. For example, research undertaken in India[34], illustrates that women earn less than men and engenders low representation of females in managerial positions. Harvey[42] attributed the gender pay gap to the overall time women invested in their work compared to men, and women gravitate towards spending time with their families and children. Also, Blau and Kahn[43] identified education and skills as a possible factor for the existing gender wage gap. Hill[44] opined that female leadership is often entrusted with older age, where long experience matters to avoid costly construction mistakes. Jimoh et al.[45] states that in Ghana, the construction industry is lucrative and expanding yet, young female labour remains scarce due to the sector's 'male dominated' image. However, scant studies specific to female professional roles at different stages of their career in the construction sector are notably ominous by their absence[46].

The Women Research Institute[47] stated how reproductive rights are an integral human right for women as upheld in international agreements and laws worldwide yet, discrimination against females who seek maternity leave can include contract termination[5]. According to Patel and Pitroda[48], women employed on construction sites remains uncommon and being pregnant is an entirely new topic of conversation. Therefore, women with prospects and career development plans or young mothers tend to shun the industry. Salihu[49] noted that an employer's lack of support for family medical leave policies is a major barrier to women's entry and retention in the construction trade; therefore, women must be supported to work in the sector and to have a family. Zimbabwe's judiciary is acutely aware of the need to interrogate construction-related disciplinary appeals due to gender biases[50]. Knight et al.[51] proposed that disciplinary actions must be applied fairly and consistently with proper policies and procedures being utilised. This ensures that organisations are not open to attacks from employees concerning rights violations. In this vein, Jones and Saundry[52] noted that the effectiveness of disciplinary actions also depends on their implementation circumstances. Furthermore, Ibrahim et al.[23] revealed that adequate measures were not taken against contractors on Malaysian construction sites regarding the welfare of workers (including females) on construction sites.

Regarding upward mobility to leadership and decision-making, women encounter difficulties as they progress towards leadership positions; these is despite Muthambi et al[53] revealing that women are motivated by job promotion, among others, towards achieving sustainable careers in construction. Holdsworth et al.[32] stated that leadership and management cannot be conceptualised without gender and ethnicity. Molina et al.[54] note that women are underrepresented in the upper echelons, emphasising the 'glass ceiling' metaphor. Norberg and Johansson[55] opine that the industry has invisible barriers that block women from executive positions, ranging from failure to have their contributions recognised, not being taken seriously, isolation in the industry and lack of promotion ahead of them. Furthermore, the paradox of meritocracy must reward good job performance to female employees[53]. Although managers may be impartial on merit-based performance appraisal, they may unknowingly reinforce the inequalities through the stereotypes or affirmation bias they hold[54]. Ellemers[17] opined that organisational work and culture facilitate or inhibit female leadership advantage and reaping the benefits of female leadership in construction relies on the organisation's ability to combat numerous barriers female leaders face. Northouse[56] notes that if women are elevated in the workplace (bearing in mind their importance in society) social changes, such as a sense of belonging, will occur in the working environment.

GENDER & EXPERIENCE DEMOGRAPHIC ATTRIBUTES ALIGNED WITH FORMS OF DISCRIMINATION

The consideration of the differences of insights regarding the forms of discrimination are pertinent as they align with the theoretical underpinning of the study. Although that study focuses on females, the views of males provide a holistic assessment and realisation of interventions. In addition, establishing consensus is paramount if suitable intercessions are to be reconciled. The literature survey revealed limited authors like Curtis et al[57], Ramadan et al[58] and Holdsworth et al[59], who have attempted to reflect on these aspects. Curtis et al[57] revealed significant differences on discrimination bullying and sexual harassment experiences of women. Ramadan et al[58] also reported that females significantly experienced adverse outcomes compared to their male counterparts on aspects of unprofessional treatment and derogatory treatment. Holdsworth et al[59] collected data from both male and females experience levels, but did not report on statistically significant differences across these categories. Yet, Hill[44] opines that age and experience are pertinent for female leadership roles. As such, both gender and experience demographic variables are relevant for further analysis of the respondents' insights. Achieving this analysis provides additional information that can generate targeted responses within the various demographic considerations.

RESEARCH METHODOLOGY

A positivist philosophy was adopted to interrogate female discrimination within the Zimbabwean construction industry[60;61]. Deductive reasoning was therefore employed to test an expected pattern significant forms of discrimination against observations made[62]. Primary quantitative data was accrued via a semi-structured questionnaire survey administered by hand and online[63].

A preliminary (pilot) survey was first deployed to ascertain the relevant forms of discrimination for female construction professionals and skilled operatives. A secondary goal was to ensure whether the initial data collection instrument (developed from literature) gave sufficient coverage of the phenomena under investigation as well as check for clarity of expression and ease of use. Purposive and convenience sampling of ten individuals participated in this pilot and comprised of five construction professionals and five skilled operatives. Females (frequency (f)= 6) and males (f= 4) participated for both respondent groups. Both genders were surveyed to buttress the gendered organisation and hegemonic masculinity theories - two reasons are offered. First, as organisations are constituted by both genders, their configured interactions are important to tackle inherent gender inequalities. Second, the role of males and their dominant positioning can only be understood if they participate in the determination of the existent forms of discrimination. After the responses were evaluated via content analysis, the forms of discrimination in Table 1, were considered relevant and delineated. Table 1 also reveals that, FOD5 – 'inadequate provision of appropriate construction safety wear' was considered relevant to female construction skilled operatives only, while FOD11 – 'limited career advancement' was considered relevant for female construction professionals only. All other forms of discrimination were considered relevant for both respondent groups.

Table 1: Brief descriptions of reviewed and relevant forms of discrimination

Form of discrimination	Brief description as they relate to construction operations	Source	Female construction professionals	Female construction skilled operatives
FOD1- Biased recruitment practises	These are recruitment practices that propagate injustices against females. They aim to exclude females from acquiring employment in the construction sector through the implementation of biased policies.	64,21, 65, 23, 66; 22, 20	x	x
FOD2- Sexual harassment	This is a form of discrimination grounded on sex, gender, among other attributes. It contributes to a toxic environment for females and can include intimidation and compelling for sexual favours.	67, 65, 25, 66, 24, 68, 69	x	x
FOD3- Use of crude and harmful language	This entails the use of toxic language in the workplace. It includes uttering profanities or intimidatory words in the workplace for the purposes bullying, belittling, or oppressing workmates.	29, 30 65, 70, 69, 20	x	x
FOD4- Stereotyped positions and job responsibilities	This pertains to discriminating females through allocating them jobs that supposedly align with their assumed preferred activities and interests.	67, 65, 34, 66,35,32, 41, 71	x	x
FOD5- Inadequate provision of appropriate construction safety wear	This relates to construction companies failing to procure and allocating female construction professionals and operatives with appropriate construction safety wear that promote their dignity in the workplace.	37, 36; 38, 66		x
FOD6- Gender pay gap	This pertains to the purposeful implementation of wage differences due to the gender of the workforce. Female workers are indiscriminately paid much lower wages than their male counterparts regardless of similar experience and competency.	65, 41, 71	x	x
FOD7- Age discrimination	This is discrimination associated with the age of the female workers. It may pertain to those of childbearing age being discriminated against due to their ill perceived career and family trajectories.	72, 44, 46	x	x
FOD8- Limited Reproductive Rights	This pertains to construction organisations discriminating against females due to expectations that they will exercise their lawful maternity rights, to the detriment of their construction contractual obligations.	49, 48	x	
FOD9- Unfair disciplinary action	Disciplinary hearings in the construction industry are considered biased against females due to the construction organisations' failure to uphold their rights in the workplace. In addition, a reluctance to fully implement labour laws, as they pertain to females is considerable.	50,51		x
FOD10- Inadequate provision of gender appropriate restrooms	Construction organisations fail to comply to appropriate laws by providing restrooms which do not fully cater for the needs of females.	23, 41, 66	x	x
FOD11- Limited career advancement	Female construction workers are not treated fairly and are availed limited opportunities to advance their careers in the male-dominated construction industry.	41,54,56,65,53,63,55, 69,71	x	

The questionnaire comprised three sections. Section one gave a brief overview of the research purpose and stringent ethical considerations governing it (e.g., assurances of strict confidentiality and data protection) to secure informed consent[73,74]. Section two requested demographic information on gender, age, marital status, professional qualification/level of competence and experience. Section three required respondents to rate forms of discrimination (they had witnessed or experienced) against female construction professionals and operatives using a five-point Likert scale where 1-never, 2- rarely, 3-sometimes, 4- often and 5-always. Likert scales were more appropriate to grade the responses and to achieve highly satisfactory and reliable data[62].

All the available organisations were included in the survey due to the low population[60]. Although census sampling was attempted, only those who could conveniently participate, responded. Insights were gathered from 280 firms drawn from the Architects Council of Zimbabwe (f= 54), Zimbabwe Association of Civil Engineers (f= 43), Zimbabwe Institute of Quantity Surveyors (f= 22) and Construction Industry Federation of Zimbabwe (f= 161). The sampling frame was comprised of Architects, Civil /Structural Engineers, Project Managers and Quantity Surveyors. The skilled construction workers (f= 190) were recruited purposively from six identified active construction sites which were purposively sampled from the Harare local authority. The sampling frame comprised male and female construction operatives, with levels of competence ranging from skilled worker grade 1 to 4 and those graded as worker exempted, on construction sites. According to the National Employment Council of the Construction Industry in Zimbabwe, skilled workers are trade tested and graded in 5 categories; grade 1 being the most competent and grade 4 and worker exempted being the least competent. It was prudent to include both genders as they can be dual change agents to enable a collective effort to drive greater workplace diversity and equality[75]. Data was only collected after ethical clearance for a low-risk study was granted by a university in the study area. All participants were requested to give their consent before completing the survey and anonymity and confidentiality were upheld throughout the data processing, analysis and dissemination stages.

Cronbach's Alpha was utilised to measure the reliability of the developed instrument. According to Streiner[73], an alpha value of at least 0.60 shows that the instrument is reliable and consistent. The Shapiro-Wilk test for normality for a sample of > 50 was used to test normality[77]. Results indicated the data was not normally distributed for professionals and operatives, with a p-value of 0.000 and 0.001, respectively. Consequently, a non-parametric Mann-Whitney U tests and Kruskal-Wallis test was undertaken to determine statistically significant differences due to gender (male and female) and experience (0-5 years, 6-10 years, 11-15 years and more than 15 years) demographic variables, where a minimum of 5 observations per group is recommended for reliable results[77], respectively. Field[77] reports that the Mann-Whitney U test is a non-parametric test used for ordinal data where two independent samples' means are determined as equal or not. In addition, Kruskal-Wallis one-way analysis of variance is a non-parametric test that is used to test the null hypothesis that more than two independent random samples come from identical universes against the alternative hypothesis that their means are not equal. Rank analysis was undertaken using the mean score, standard deviation and normalisation value. The forms of discrimination were evaluated as concerning for means >1.000. This is due to the expectation of zero tolerance to discrimination[5]. The normalisation value was used to reveal critical forms of discrimination where the value is ≥0.500[78].

Exploratory factor analysis was utilised due to its ability to cluster similar variables into the same factors and identify the underlying patterns in a set of data[79]. The Kaiser-Meyer-Olkin (KMO) measure was employed to measure the adequacy of sampling to conduct factor analysis, and the numeric representation of the score acceptable for a study is > 0.500[80]. The Barlett sphericity test indicates if the variables were adequately correlated with an expected measure of < 0.05[79]. Principal component analysis with varimax rotation was utilised to maximise the correlation between variables and factors and to derivate high factor loadings[77]. Factors with eigenvalues >1.000 were retained. Factor loadings of ≥ 0.400 and a cumulative frequency of 60% were considered significant for allocating in derived components[80]. The revealed components were named using the constituent factors.

RESULTS & DISCUSSIONS

The response rates were: 59.64% for professionals, representing 167 valid responses from a population of 280 potential participants; and 36.84% for skilled operatives, representing 70 valid responses from a population of 190. The overall response rate was 50.42%. According to Schutt[81], a response rate of at least 40% constitutes an acceptable representation. That said, the 50.42% response rate is well above the minimum acceptable and potentially represents the general views of the population of construction professionals and skilled operatives.

PROFILE OF RESPONDENTS

Table 2 shows that 21.43% of the skilled operatives and 33.53% of professionals are female illustrating that there are more female construction professionals than operatives. This finding is in congruence with Daniels[22] who found low participation of female skilled operatives on site and Marimo[50] who found that female professionals are better represented in the upper echelons than operatives. Professional qualifications indicate that most professional respondents were Quantity Surveyors (f = 71), and the least were Architects (f = 26). Most of the skilled operatives were in the skilled worker grade 1 at 38.57% and all grades were represented. Most skilled workers had experience levels of ≤ 5 years for operatives (32.86%) while the level of experience for most professionals was 6-10 years (55.69%).

Table 2: Demographic information of the dataset

Variable	Category	Construction professionals		Skilled operatives	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	111	66.47%	55	78.57%
	Female	56	33.53%	15	21.43%
Age	1981-1990	56	33.53%	18	25.71%
	1991-1999	49	29.34%	16	22.86%
	1960-1970	32	19.16%	13	18.57%
	1971-1980	28	16.77%	17	24.29%
	2000+	2	1.20%	6	8.57%
Professional Qualification	Quantity Surveyor	71	42.51%	–	–
	Architect	26	15.57%	–	–
	Civil /Structural Engineer	52	31.14%	–	–
	Project manager	18	10.78%	–	–
Level of competence	Skilled worker grade 1	–	–	27	38.57%
	Skilled worker grade 2	–	–	15	21.43%
	Skilled worker grade 3	–	–	12	17.14%
	Worker Exempt	–	–	12	17.14%
	Skilled worker grade 4	–	–	4	5.71%
Experience	6-10	93	55.69%	20	28.57
	≤ 5	38	22.75%	23	32.86
	11-15	25	14.97%	15	21.43
	15+	11	6.59%	12	17.14
	Total	***167***	***100%***	***70***	***100%***

FORMS OF DISCRIMINATION FOR PROFESSIONALS AND OPERATIVES

Using Cronbach alpha, data reliability from professionals was 0.857 and 0.774 for skilled operatives, indicating acceptable reliability. Table 3 reports upon the mean score, normalisation values, ranking and agreement analysis for discrimination that affects female professionals. All the variables have means >1.000, indicating that the forms of discrimination are existent. However, 'use of crude and harmful language' (FOD3), 'limited career advancement' (FOD11) and 'stereotyped positions and job responsibilities' (FOD4) were critical. There were no statistically significant differences due to gender and experience, indicating that both males and females and various experienced professionals acknowledge the presence of these forms of discrimination.

Table 3: Forms of discrimination ranking- female construction professionals and skilled operatives

Female construction professionals (Cronbach alpha= 0.857)									
Code	**Forms of discrimination**	**Ranking analysis**				**Mann Whitney U test**	**Mean Ranks**		**Kruskal-Wallis *H* test**
		Overall Mean	SD	NV	R	Gender	Males Mean	Females Mean	Experience
FOD3	Use of crude and harmful language	3.509	0.870	1.000	1	0.893	-	-	0.212
FOD11	Limited career advancement	3.078	1.075	0.768	2	0.324	-	-	0.341
FOD4	Stereotyped positions and job responsibilities	2.814	1.033	0.627	3	0.346	-	-	0.249
FOD10	Inadequate provision of gender appropriate restrooms	2.503	0.911	0.460	4	0.418	-	-	0.134
FOD1	Biased recruitment practices	2.204	1.027	0.299	5	0.852	-	-	0.877
FOD6	Gender pay gap	2.132	0.909	0.260	6	0.724	-	-	0.935
FOD8	Limited reproductive rights	1.802	1.088	0.084	7	0.874	-	-	0.239
FOD7	Age discrimination	1.743	0.975	0.051	8	0.721	-	-	0.839
FOD2	Sexual harassment	1.647	0.932	0.000	9	0.902	-	-	0.978
Female construction skilled operatives (Cronbach alpha= 0.857)									
FOD4	Stereotyped positions and job responsibilities	3.714	0.542	1.000	1	0.605	-	-	0.513
FOD3	Use of crude and harmful language	3.343	0.740	0.847	2	0.682	-	-	0.083
FOD5	Inadequate provision of appropriate construction safety wear	3.029	0.868	0.718	3	0.327	-	-	0.201
FOD10	Inadequate provision of gender appropriate restrooms	2.243	0.859	0.394	5	0.147	-	-	0.980
FOD1	Biased recruitment practices	2.000	0.933	0.294	6	0.021*	2.467	1.873	0.657
FOD6	Gender pay gap	1.829	0.701	0.224	7	0.138			0.503
FOD7	Age discrimination	1.629	1.038	0.141	8	0.004*	2.067	1.509	0.440
FOD9	Unfair disciplinary actions	1.571	0.772	0.118	9	0.264	-	-	0.288
FOD2	Sexual harassment	1.286	0.684	0.000	10	0.252	-	-	0.311

*Notes: SD = Standard deviation; NV = Normalisation value; R= Ranking (Equation 1,). * < 0.05 Significant difference. Only means for statistically significant differences were added.*

The results in Table 3 also show the mean score, normalisation values, ranking and agreement analysis for discrimination that affects female skilled operatives. All the variables have means >1.000, indicating that the forms of discrimination are existent. However, '*stereotyped positions and job responsibilities*' (FOD4), '*use of crude and harmful language*' (FOD3), and '*inadequate provision of appropriate construction safety wear*' (FOD5) were critical. There were statistically significant differences due to gender for '*biased recruitment practices*' (FOD1) and '*age discrimination*' (FOD7). There were no statistically significant differences in experience for any variable, indicating that various skilled operatives acknowledge the presence of these forms of discrimination.

FACTOR ANALYSIS RESULTS ON FORMS OF DISCRIMINATION FOR FEMALE CONSTRUCTION PROFESSIONALS AND SKILLED OPERATIVES.

Table 4 reports upon exploratory factor analysis results for the significant forms of discrimination for female professionals and reveals that the data was adequate for analysis with a KMO of 0.856, which was >0.500. Bartlett's sphericity test was significant at 0.000 <0.050, suggesting a correlation in the data. Two components, with acceptable reliability of >0.600, were revealed and named '*harassment and discrimination-related forms*'; and '*welfare and career-related forms*'. The factor loadings ranged from 0.480 to 0.887.

Table 4: Factor analysis from insights of construction professionals on forms of discrimination for female construction professionals

Forms of discrimination for female construction professionals						
Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 3 iterations.						
Factors/subgroups	**Description**	**Factor loading**	**Eigenvalues**	**% of Variance**	**Cumulative %**	**Cronbach alpha**
Harassment and discrimination -related forms			4.347	48.304	48.304	0.874
FOD7	Age discrimination	0.887				
FOD2	Sexual harassment	0.885				
FOD8	Limited reproductive rights	0.839				
FOD4	Stereotyped positions and job responsibilities	0.698				
FOD6	Gender pay gap	0.631				
FOD1	Biased recruitment practises	0.480				
Welfare and career-related forms			1.339	14.880	63.184	0.645
FOD10	Inadequate provision of gender appropriate restrooms	0.813				
FOD11	Limited career advancement	0.763				
FOD3	Use of crude and harmful language	0.597				
Forms of discrimination for female construction skilled operatives.						
Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 5 iterations						
Factors/subgroups	**Description**	**Factor loading**	**Eigenvalues**	**% of Variance**	**Cumulative %**	**Cronbach alpha**
Recruitment, welfare, and relations - related forms			3.514	35.140	35.140	0.810
FOD6	Gender pay gap	0.866				
FOD10	Inadequate provision of gender appropriate restrooms	0.812				
FOD1	Biased recruitment practises.	0.781				
FOD9	Unfair disciplinary actions	0.648				
Workplace relations, safety, and management			1.873	18.730	53.870	0.696
FOD3	Use of crude and harmful language	0.801				
FOD5	Inadequate provision of appropriate construction safety wear	0.751				
FOD4	Stereotyped positions and job responsibilities	0.700				
Physical attributes-related forms			1.091	10.913	64.783	0.663
FOD7	Age discrimination	0.849				
FOD2	Sexual harassment	0.839				

Table 4 also presents exploratory factor analysis results for the significant forms of discrimination for skilled operatives and shows that the data was adequate for analysis with a KMO of 0.709, which was >0.500. Bartlett's sphericity test was significant at 0.000 < 0.050, suggesting a correlation in the data. Three components, with acceptable reliability of >0.600, were revealed and named 'recruitment, welfare and relations-related forms'; 'workplace relations, safety and management'; and 'physical attributes-related forms'. The factor loadings ranged from 0.648 to 0.866.

DISCUSSION

The critical forms of, and relationships among variants of discrimination for female professionals and skilled operatives are now discussed in some further detail.

CRITICAL FORMS OF DISCRIMINATION FOR FEMALE PROFESSIONALS

The critical forms of discrimination shown in Table 3 for female professionals FOD3, FOD11 and FOD4 – all three had normalisation values of ≥0.500. Specifically, female professionals have experienced abuse and harassment[20] via crude and harmful language (FOD3). Hence, construction sites must be transformed into workplaces where civility is practised, and the right of others upheld. Female professionals are also constrained regarding their progression (FOD11) in the construction industry and therefore, meritocracy must be implemented[54] to ensure they are taken seriously in the workplace. For this to happen, any gender-related barriers that their male colleagues perpetuate must be swiftly dealt with. For example, biased promotion procedures and failure to recognise their contribution must be eradicated. Connected to this, stereotyping positions (FOD4) must be eradicated[35].

RELATIONSHIPS IN THE FORMS OF DISCRIMINATION FOR FEMALE PROFESSIONALS

Table 4 reveals two components viz. 1) harassment and discrimination-related form; and 2) welfare and career-related forms.

Component 1 - harassment and discrimination-related forms

This component accounts for eigenvalues of 4.347 and a percentage variance of 48.304%. The components included in this category include 'age discrimination' (FOD7), 'sexual harassment' (FOD2), 'limited reproductive rights' (FOD8), 'stereotyped positions and job responsibilities' (FOD4), 'gender pay gap' (FOD6) and 'biased recruitment practices' (FOD1). Construction professionals need to attain their worthy promotions and relevance due to age discrimination and limited reproductive rights. Hill[44] suggests that older women have more opportunities of being considered for leadership roles. However, the author (ibid) opined that this is due to the need to avoid costly construction mistakes that require experience; this may be linked to entrusting women past their childbearing age. Whatever the reasons, this form of discrimination is retrogressive as the best professionals may be excluded from performing better for the organisation. Female professionals must not be restricted concerning maternity leave and must be protected from unsatisfactory actions[5]. Sexual harassment of professionals may be less obvious and take the form of interpersonal mistreatment[68]. Female professionals may be more knowledgeable concerning their rights but may still fall prey to sexual predators. Hence, they need to be made aware of the various forms of sexual harassment and encouraged to expose such perpetrators. All construction professionals need such awareness training as this may have more positive outcomes (for example, female professionals may be trained on the various representations of sexual harassment they may be exposed to. Hodzic et al.[35] and Ahuja and Kumari[34] proffer that female professional are exposed to gendered perceptions about their positions in the workplace and unequal remuneration in managerial positions. Stereotyping job positions and responsibilities prevent organisations from potentially gaining from the varied insights females present in the workplace. On the other hand, gender pay gaps lead to low staff retention and may contribute to unfavourable construction project outcomes in the short to long term. Recruiting professionals must be based on competence. However, procedural injustice[20], is perpetrated within the construction environment. Female professionals must currently excel more than their male counterparts, to secure placements. Construction organisations must improve their procedures by implementing transparent recruitment procedures and actively inculcating the necessary awareness in their recruitment departments.

Component 2 - welfare and career-related forms

This component accounts for eigenvalues of 1.339 and a percentage variance of 14.880%. The forms of discrimination included in this component include 'inadequate provision of gender-appropriate restrooms' (FOD10), 'limited career advancement' (FOD11) and 'use of crude and harmful language' (FOD3). These findings are in congruence with the earlier work of Ibrahim et al.[23] regarding the influence of biased recruitment policies and the provision of inadequate gender-appropriate restrooms. An organisation's reluctance to provide appropriate restrooms for females is connected to their biased recruitment practices. This needs holistic intervention which will include amendments to contract documentation which must allocate specific resources to ensure gender-appropriate restrooms are constructed and well maintained. Female professionals must be allowed to advance their careers uninhibited[17] because constraining their career progression leads to them shunning the construction environment. Although quotas that quantitatively regulate the inclusion of females within a construction project may attract strong opposition, they are necessary to bridge the gap in the short term. The use of crude and harmful language in the workplace[27] contributes to a toxic environment for female construction professionals. Care must be taken to ensure construction environments are not intimidating to females but rather, conducive to attaining positive outcomes for the professionals and the project.

Hypotheses testing

$1H_0$ The insights regarding the forms of discrimination that affect female construction professionals are not multidimensional and cannot be grouped into distinct factors
$1H_1$ The insights regarding the forms of discrimination that affect female construction professionals are multidimensional and can be grouped into distinct factors

The EFA results in Table 4 do show that forms of discrimination that affect female construction professionals are multidimensional and can be grouped into distinct factors. As such, the null hypothesis is not supported by the findings and the alternative hypothesis is supported.

Agreement analysis regarding the insights on the forms of discrimination insights affecting female construction professionals due to gender and experience

It is noteworthy that both male and female construction professionals agree on discrimination, either through witnessing or experiencing it. These findings make it easier to promote any awareness campaigns or training on gender discrimination aspects. Advocating for gender equality in the male-dominated construction industry, as alluded to by Norbeg and Johansson[55], can be more effective if such consensus is realised, which was not the case with Curtis et al[57]. Indeed, Edstrom et al.[15] noted that gender equality can only be achieved if men and women actively participate in the change process, albeit, offering diverse views. Further, the work experience of respondents did not contribute to any statistically significant differences in their insights of forms of discrimination. The evolution of traditional and cultural backgrounds, as purported by Connell and Messerschmitt[16], has yet to have an apparent effect on divergent views.

Hypothesis testing

$3H_0$ There is no statistically significant difference regarding the insights on the forms of discrimination affecting female construction professionals due to gender and experience
$3H_1$ There is a statistically significant difference regarding the insights on the forms of discrimination affecting female construction professionals due to gender and experience

The results of the agreement analysis testing in Table 3, shows that there is no statistically significant difference regarding the insights on the forms of discrimination insights affecting female construction professionals due to gender and experience, for all the variables. As such, the findings support the null hypothesis.

Critical forms of discrimination for female skilled operatives

The three critical forms of discrimination, shown in Table 3, for female skilled operatives were FOD4, FOD3 and FOD5, with normalisation values ≥0.600. Stereotypes cause females to desist from taking up roles in the construction sector[32], contributing to it being one of the most unequal sectors. Due to an uncontrolled use of crude and harmful language on construction sites, victims end up performing poorly in the workplace[27]. This further compound female operatives' challenges, as the traditionally held perspectives of their low performance are upheld by male colleagues. Every worker must be protected from such abuse and effective mitigation must be implemented that range from training workers on workplace relations to proactive actions to tackle perpetrators. The challenge of providing appropriate construction safety wear stems from the nature of construction contracts and supply chain limitations[39]. Adequate contracts administration may resolve some of these challenges.

RELATIONSHIPS IN THE FORMS OF DISCRIMINATION FOR FEMALE SKILLED OPERATIVES

The three components shown in Table 4 are: 1) recruitment, welfare and relations-related forms; 2) workplace relations, safety, and management; and 3) physical attributes-related forms. Each component is now discussed in further detail.

Component 1- recruitment, welfare and relations-related forms

This component accounts for 3.5140 eigenvalues and a total percentage variance of 35.140. Forms of discrimination included are the 'gender pay gap' (FOD6), 'inadequate provision of gender-appropriate restrooms' (FOD10), 'biased recruitment practices' (FOD1) and 'unfair disciplinary actions' (FOD9). Seidu[41] revealed that the gender pay gap continues to widen in the construction industry with male workers being paid better for the same skills. If construction companies envisage an inclusive and diverse complement of skilled operatives that may contribute to productivity gains, they must rectify their recruitment strategies for female operatives and provide appropriate facilities for women on site. For example, gender appropriate restrooms are a regulatory requirement internationally[23] and firms that violate these statutes must be sanctioned while workers must be empowered to voice their concerns without facing retribution. Biased recruitment practices and unfair disciplinary actions need effective reporting. Construction companies must align with the existing labour laws, and if this is not sufficient, an amendment may be necessary to ensure the rights of female skilled operatives are protected[21;51].

Component 2 - workplace relations, safety and management

This component accounts for 1.873 eigenvalues and a total variance percentage of 18.730%. The components in this component include the recurrent themes of 'use of crude and harmful language' (FOD5), 'inadequate provision of appropriate construction safety wear' (FOD5) and 'stereotyped positions and job responsibilities' (FOD4). Proper communication must be promoted on construction sites to ensure disputes do not arise from the use of foul language. Adinyira et al.[26] proffered that company policy must address inappropriate verbal communication and implement measures to continually monitor its use effectively. PPE is a requirement under labour law and construction companies must ensure they meet this requirement[42]. Female skilled workers' absence of effective lobbying contributes to its continuous violation. Stereotyped positions and job responsibilities against female labour and the prejudice[32], can only be addressed by encouraging more females to participate. Hence, any gains may be in training their male counterparts on treating females through inclusive workplace management.

Component 3 - physical attributes-related forms

This component accounts for 1.0913 eigenvalues and a percentage variance of 10.913%. The forms of discrimination included in this component include 'age discrimination' (FOD7) and 'sexual harassment' (FOD2). Promoting young females to take up construction trade skills is fundamental to equal opportunities and treatment in the workplace. However, the construction environment is currently not secure or affable for young female workers who are likely to be exposed to unwarranted abuse by their male counterparts[45]. Such discrimination may be effectively remedied by encouraging young female workers to report such abuses to raise wider awareness amongst male counterparts. Sexual harassment has no place in the workplace yet unfortunately, it is rife in Zimbabwe's construction environment and so drastic action is warranted to address this form of discrimination[24]. It is important to note that sexual harassment can be perpetrated by either males or females on female construction operatives. Construction companies have the prerogative to report and ensure perpetrators' prosecution[25]. However, establishing mentorship programmes for female construction operatives led by dedicated “buddies” may be beneficial because this may encourage them to report and expose sexual harassment.

Hypothesis testing

$2H_0$ The insights regarding the forms of discrimination that affect female construction skilled operatives are not multidimensional and cannot be grouped into distinct factors
$2H_1$ The insights regarding the forms of discrimination that affect female construction skilled operatives are multidimensional and can be grouped into distinct factors

The EFA results in Table 4 do show that forms of discrimination that affect female construction skilled operatives are multidimensional and can be grouped into distinct factors. As such, the null hypothesis is not supported by the findings and the alternative hypothesis is supported.

Hypothesis testing

$4H_0$ There is no statistically significant difference regarding the insights on the forms of discrimination affecting female construction skilled operatives due to gender and experience
$4H_1$ There is a statistically significant difference regarding the insights on the forms of discrimination affecting female construction skilled operatives due to gender and experience

The results of the agreement analysis testing in Table 3, shows that there is no statistically significant difference regarding the insights on the forms of discrimination insights affecting female construction skilled operatives due to experience, for all the variables. However, the findings show statistically significant differences for two out of the nine forms of discrimination. As such, the overall findings support the null hypothesis.

CONTRIBUTIONS TO THEORY, RESEARCH AND PRACTICE

The contribution to theory and research is predicated on the study's inclusion of male respondents and the consequent agreement analysis. Hence, to the Gendered Organisation theory, a contribution was made through using gender interactions among construction professionals to tackle the forms of discrimination faced by female professionals. Despite the seemingly high-level status of female professionals, construction organisations present a unique environment where dominant male professionals are key protagonists and participants in revealing remedies. In addition, through the Hegemonic Masculinity theory, the extent of abuse of male power is revealed, through their participation, to resolve the forms of discrimination faced by female skilled operatives within workplaces. Enhancing the construction workplace is achievable when males are made aware of their contribution to discrimination of females and participate in the incidental crafting of remedies. The interrogation of statistically significant differences supports in-depth analysis that potentially included male-to-female and female-to-female considerations. However, future analysis must include female-to-male and male-to-male discrimination if effective and lasting remedies are to be found.

In terms of contributions to practice, there is need to destigmatise the construction sector as an unequal (gender) industry. Efforts must commence at tertiary level education. Programmes that promote gender inclusivity and diversity must be deployed and are pertinent for adequately inculcating graduates with requisite awareness. Female construction professionals must be protected from harassment and discrimination in the workplace by increasing their representation in leadership positions. They also need to be empowered and protected by improved legislation that will amplify their voice in the workplace. Encouraging younger females to take up construction trades may be a game-changer for female construction skilled operatives. The notable change will likely be realised with their increased participation in the construction environment. Considerable training and awareness are necessary for their male counterparts if the anticipated targets of eliminating discrimination are met. Workplace training can only engender a separation of traditional ideologies and the expected workplace environment performance.

CONCLUSIONS

Female construction professionals and skilled operatives have historically been exposed to various forms of discrimination in the construction sector. This has affected their participation in the industry, despite an inclusive and diverse construction sector being envisioned. Improving their representation requires an interrogation of the forms of discrimination they face. Therefore, this study sought to determine contextually significant forms of discrimination against female professionals and skilled operatives in the developing country of Zimbabwe. Critical forms of discrimination against professionals are the use of crude and harmful language; limited career advancement; and stereotyped positions and job responsibilities. For female skilled operatives' critical forms are discrimination are stereotyped positions and job responsibilities; the use of crude and harmful language; and inadequate provision of appropriate construction safety wear. For both female designations, appropriate personal verbal communication on sites and desegregation of jobs due to gender is critical.

The factor analysis revealed significant clusters of inter-related forms of discrimination: harassment and discrimination-related, and welfare and career-related forms for female construction professionals. While recruitment, welfare, and relations-related; workplace relations, safety, management; and physical attributes-related forms were revealed for female skilled operatives. Evidence shows that professionals and skilled operatives face varying magnitudes and forms of workplace discrimination. The evidence supports a heterogeneous approach to crafting policies against discrimination for professionals and operatives. There is a need to enact legislation specific to the construction industry that addresses challenges unique to construction trades. A proactive approach is pertinent so key institutions can avoid ad-hoc responses and actions against workplace harassment. The implementation of basic harassment and discrimination training, creating independent third-party reporting systems, flexible work arrangements, and establishing family-friendly site policies that encourage new mothers to return to work, is supported for female construction professionals. For female skilled operatives, implementing blind recruitment and skills testing, competency-based task allocation, participatory ergonomic assessments where females are involved in procurement of tools and equipment, are all recommended. The introduction of a quota system on all government and private construction projects, as a temporary measure to improve the representation of women, may positively impact the reduction of discrimination against females in the construction environment. At the company level, there is a need for continuous training and support of both genders on the need for equality in workplaces. The study has presented evidence that males are cognisant of the discrimination actions against females and may also be positive participants in its eradication.

A further interrogation of statistically significant differences due to gender and experience of respondents was undertaken. Generally, no differences due to gender and experience were revealed in the prevalent forms of discrimination against all females in the industry. Biased recruitment practices and age discrimination did show statistically significant differences due to gender for female construction operatives, with males acknowledging the existence of these forms of discrimination more than their female counterparts. This reveals that males significantly acknowledge, more than females, that unfair recruitment practices have disadvantaged females. In addition, males contend that age is a significant factor for exclusion of females from participating in the construction sector. Companies can also implement structured competency-based interview processes and apprenticeship programs that target females. These findings encourage construction companies to combat ageist language in performance reviews and encourage intergenerational mentorships that break down ageism mentalities. Cumulatively, companies must align their recruitment policies with existing labour laws and desist from perpetuating the exclusion of females due to their gender and age.

The limitation of the study was the existence of few female artisans engaged in the actual building or civil works. However, the inclusion of males allowed for varying perspectives which either buttressed or contradicted the views of the female participants. This enhanced the validity of the study. Further studies may explore the efficacy of suggested construction site improvements to promote gender inclusivity and improve female workers' participation in the Zimbabwean construction industry.

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RISK FACTORS AND SUSTAINABILITY CONSIDERATIONS LINKED TO ROAD RATING SYSTEMS: A BIBLIOMETRIC AND SYSTEMATIC REVIEW

Theunis J Duvenhage[1] and Dr Schalk Grobbelaar[2]

[1]Correspondence: u25167678@tuks.co.za
Department of Engineering and Technology Management, University of Pretoria
Orcid.org/0009-0001-5373-6594

[2]Correspondence: schalk.grobbelaar@up.ac.za
Department of Engineering and Technology Management, University of Pretoria
Orcid.org/0000-0001-8148-2440

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ABSTRACT

PURPOSE

This study examines key factors influencing the implementation of sustainability rating systems for road infrastructure, with emphasis on integrating sustainability and risk management principles. The paper aims to identify critical risk factors, sustainability indicators, and stakeholder concerns to inform the development of a context-appropriate road sustainability framework.

METHOD

A systematic literature review was undertaken using Scopus and Web of Science, complemented by keyword co-occurrence analysis in VOSviewer. Peer-reviewed studies on sustainable construction, green building rating systems, and sustainable road frameworks were analysed to extract risk themes, sustainability indicators, and implementation barriers.

FINDINGS

The review revealed an absence of explicit risk-based frameworks for sustainable road rating systems and limited direct documentation of risk factors specific to sustainable road infrastructure. While sustainability indicators and stakeholder concerns were discussed, existing studies did not integrate risk considerations into road sustainability assessment models. Evidence from the green building and sustainable infrastructure literature provided sufficient theoretical grounding to derive a comprehensive set of risk factors, establish sustainability indicator categories, and identify key barriers to implementation.

ORIGINALITY / VALUE

This paper contributes to knowledge by synthesising fragmented insights into structured outputs that support the development of a risk-integrated sustainability assessment framework for road infrastructure.

Keywords: *Sustainability, Rating System, Roads, Risk Management.*

INTRODUCTION

Sustainable development emphasises the need to meet present societal needs without compromising the ability of future generations to meet their own, ensuring harmony between development and natural systems[1]. The triple bottom line (TBL) model reinforces this principle by highlighting that sustainability extends beyond environmental protection to include social well-being and economic viability[2]. In developing regions, investment in infrastructure plays a critical role in stimulating economic activity and improving social conditions[3]. However, the expansion of infrastructure and human settlements also accelerates land conversion, raw material extraction, and waste generation, placing pressure on ecological systems and long-term resource security[4]. Within the road construction sector, the continued consumption of raw materials and ongoing environmental impacts underscore the need to integrate sustainability principles into planning, design, and construction practices[5].

Although sustainability efforts in construction initially focused on building projects, the agenda has expanded across the broader civil engineering sector[6]. Green building initiatives have demonstrated tangible benefits, including reduced energy use, lower carbon emissions, and resource conservation, supporting wider adoption of sustainability frameworks[7,8]. Roads are fundamental to economic and social systems, and the past decade has seen a rise in sustainability-oriented road rating systems to guide environmentally responsible and socially beneficial road delivery[9]. Road projects that make use of sustainability rating tools demonstrate measurable improvements compared to conventional approaches, highlighting the potential value of structured sustainability assessment frameworks[10]. This momentum has driven green practices in civil infrastructure, supported by green finance and policy interventions [11].

Given the growing importance of sustainable transport infrastructure and the increasing interest in road sustainability rating systems, there is a need to synthesise existing knowledge on the factors that shape successful implementation in diverse contexts. The construction sector remains inherently complex and risk-intensive due to project uncertainty, diverse stakeholder environments, and dynamic external factors[12]. The inherent risks necessitate a context-sensitive sustainability framework that reflects local political, economic, environmental, and social conditions while addressing risks across the project stages. Developing such a framework requires a clear understanding of how risk management aligns with sustainability objectives within road infrastructure systems. A targeted review can support efforts to adapt rating systems to local conditions where a formal framework is not yet established. This study conducts a systematic literature review to examine the integration of sustainability and risk management principles into road rating systems and sustainable construction practices.

The following research questions guide the review:

- What are the key risk factors that influence the implementation of a road sustainability rating system?
- What sustainability indicators should be prioritised in a road rating system?
- What are the key stakeholder concerns associated with implementing a road sustainability rating system?

By addressing these questions, the study aims to identify critical knowledge gaps, contribute to the discourse on sustainable road development, and provide foundational insights for the potential development of a locally responsive sustainability rating framework for road infrastructure.

METHOD

This Systematic Literature Review (SLR) aims to identify and analyse published literature on the integration of risk management into road sustainability rating systems. The review will follow a structured and transparent method linked to the PRISMA 2020 approach that promotes reproducibility, reduces bias, and improves the quality of the findings[13].

A structured search was performed in Scopus and Web of Science, using combinations of keywords related to sustainability rating systems, risk assessment, stakeholder perceptions, and road infrastructure (e.g., “sustainability rating,” “road infrastructure,” “risk management,” “stakeholder concerns,” “sustainable construction”). Pilot searches were undertaken to refine Boolean operators and improve search sensitivity. Given the limited number of road-focused publications, relevant green building studies on risk and stakeholder issues were included to support conceptual transferability.

Inclusion criteria restricted studies to peer-reviewed journal articles and conference papers published in English from 2005 onwards, aligned with contemporary sustainability frameworks. Excluded studies focused solely on buildings (unless offering relevant risk insights), non-infrastructure contexts, non-English publications, or were inaccessible due to database restrictions.

RESULTS

SEARCH OUTCOMES AND STUDY SELECTION

Screening was conducted using the PRISMA flow process, as shown in Figure 3.1. The screening included title or abstract screening and full-text eligibility assessment. Mendeley was used for reference management, and Excel for data extraction. The final dataset comprised 29 studies, 24 identified through database searches and an additional 5 through snowballing. The extracted data included the study aim, context, methodology, risk factors, sustainability indicators, stakeholder concerns, and key findings.

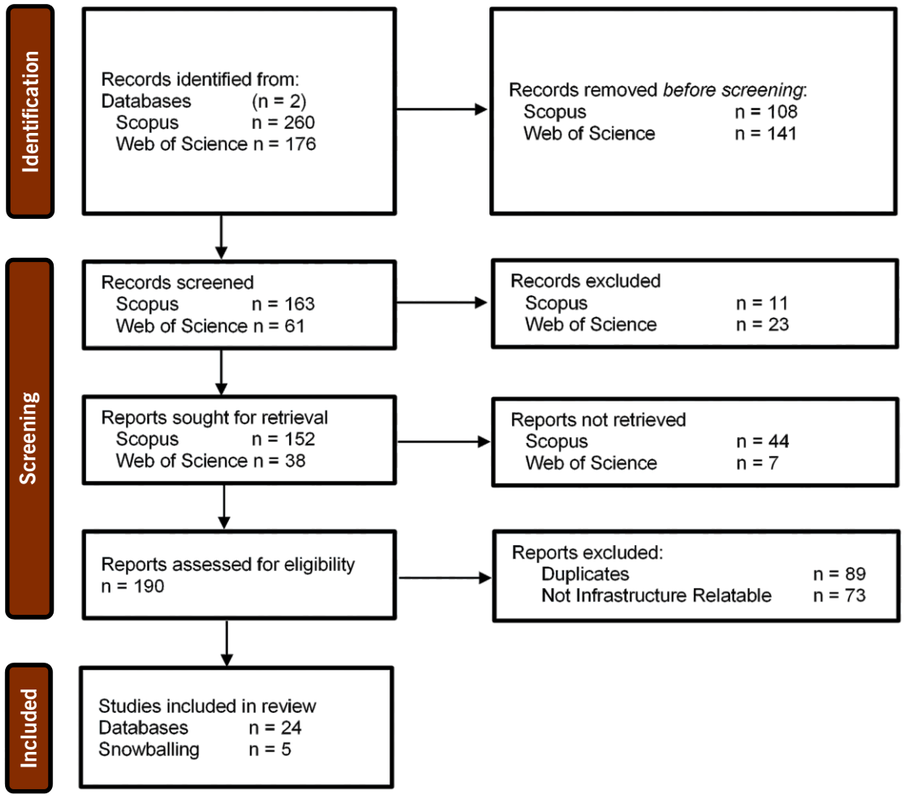

Figure 3.1 - PRISMA 2020: Study identification flow chart

A thematic synthesis approach was applied, supported by bibliometric mapping. This was done to identify dominant research clusters, emerging trends, and knowledge gaps in sustainable road rating systems.

PUBLICATION TRENDS

The temporal analysis of the selected literature shows a gradual increase in academic interest across the themes of risk in sustainability, stakeholder concerns, and sustainability indicators in infrastructure projects. The earliest included study on sustainability indicators dates to 2007, followed by sporadic research activity in 2009 and 2010, and a more consistent annual publication pattern emerging from 2014 onwards. Publications addressing risk factors appeared later, with the first included study published in 2014, followed by approximately one publication per year until a noticeable rise after 2019. Research focused on stakeholder concerns began in 2013, with a gap until 2018, after which publications appeared more regularly. Notably, all three thematic groups showed a peak in activity in 2023, reflecting growing attention to sustainable transport systems and risk-informed infrastructure development.

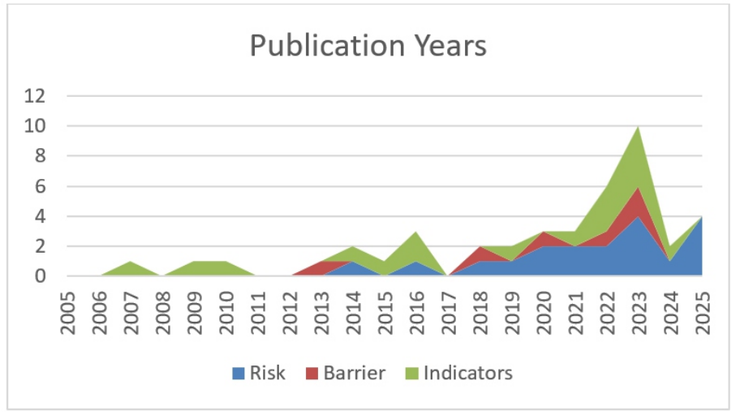

Figure 3.2 - Reviewed Studies Publication Years

The geographic distribution of the incorporated articles is shown in Figure 3.3. The studies included in this review are globally distributed, with notable representation from China (12%), Australia (10%), the United Arab Emirates (7%), and Egypt (7%). Countries such as Nigeria, South Africa, Saudi Arabia, Spain, Taiwan, and Vietnam each contributed approximately 5% of the reviewed studies. The remaining countries, including the United Kingdom, the United States, Greece, Italy, Malaysia, and others, each contributed 2% of the publications.

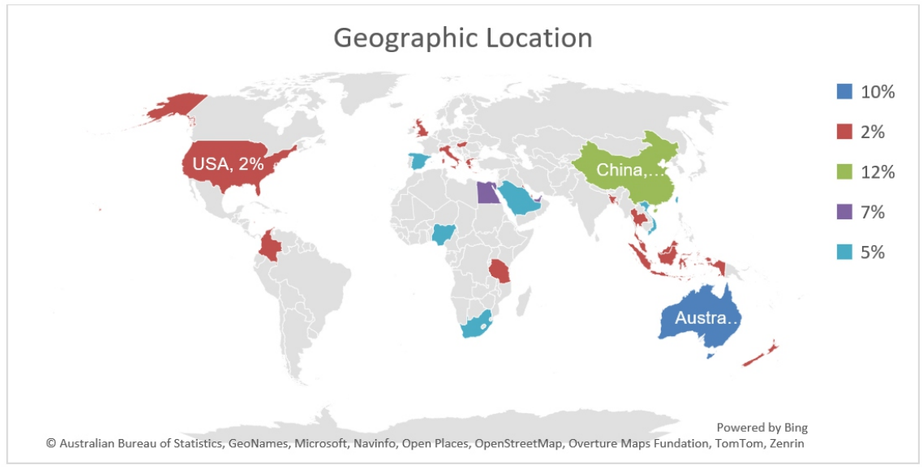

Figure 3.3 - Reviewed Studies Location

When comparing these geographic patterns against the global distribution of sustainability rating systems, noteworthy observations emerge. The primary regions responsible for the development of established road sustainability ratings are North America, Canada, the United Kingdom, and Australia[9]. The highly utilised tools identified were Envision, Greenroads, INVEST, GreenLITES, CEEQUAL, and GreenPave. The current review shows that Australia and the UK are represented in the academic literature. It is also noted that research outputs from the United States and Canada, regions that host major active rating systems, are relatively limited in the screened dataset. Several countries with no nationally adopted road sustainability rating systems, including South Africa, Egypt, Saudi Arabia, and Nigeria, are actively contributing to the scholarly discourse. The growing research presence in such regions may signal increasing strategic interest in adapting or developing region-specific road sustainability assessment methods aligned with local socio-environmental priorities and risk contexts.

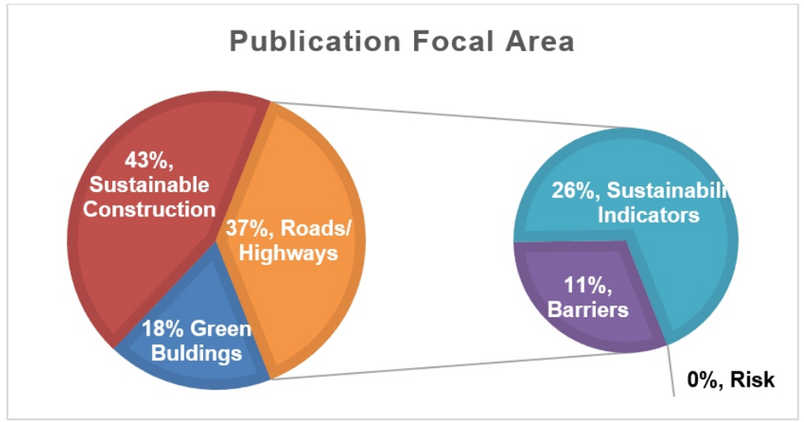

Figure 3.4 - Publication Focal Area

The review of published studies shows noticeable thematic and geographic concentration patterns, along with a clear gap in risk considerations in sustainable road assessment. Overall, 18% of the reviewed studies focused on green buildings, 43% on sustainable infrastructure or construction, and 37% on sustainable roads or highways. Despite roads' relevance within broader infrastructure systems, sustainable road research remains comparatively underrepresented, with significantly more literature available on green buildings and green building certification schemes.

Among the 37% of studies on sustainable roads, further classification reveals a substantial knowledge deficit in risk considerations. None (0%) of the sustainable road studies explicitly considered risk factors related to sustainability outcomes or sustainability rating systems. Only 11% of the reviewed studies identified barriers to sustainable road implementation, and 26% focused on sustainability indicators for roads or highways. This demonstrates that, while progress has been made in identifying sustainability indicators, few empirical studies have incorporated risk dimensions into sustainable road frameworks.

A recent study comparing road sustainability rating systems found minimal integration of international standards (ISO, EN, ASTM), thereby reducing global consistency and relevance. Their analysis of eight sustainability rating systems highlighted an imbalance across the three sustainability pillars, with a stronger emphasis on environmental (43%) and social factors (42%) but limited focus on economic criteria (15%)[14]. The knowledge base for green buildings remains far more developed, both in volume and methodological maturity. Although sustainable infrastructure research is growing globally and shares conceptual linkages with sustainable road development, most publications do not explicitly examine the implications of sustainability rating systems for road networks, nor do they evaluate risk exposure and mitigation within those rating frameworks.

Overall, the publication trends suggest an evolving academic agenda that increasingly recognises the importance of stakeholder considerations and sustainability metrics in transport infrastructure planning. However, there is uneven representation relative to the adoption of formal rating frameworks. The results underscore a need to expand research toward risk-informed sustainability assessment for road projects. Publication trends suggest that existing sustainability assessment approaches for roads do not adequately address risk-related dimensions. This limits their ability to reflect real-world uncertainty, resource constraints, and environmental resilience considerations.

KEYWORD CO-OCCURRENCE NETWORK

The keyword co-occurrence network, as shown in Figure 3.5, was generated through VOSviewer. The keyword network revealed three dominant thematic clusters, reflecting the intellectual landscape of sustainability assessment in infrastructure development. The first cluster was centred on sustainable development, which emerged as the most influential term in the network (32 links; 20 occurrences). Strong associations with keywords such as sustainability (24 links; 16 occurrences), stakeholder (16 links; 5 occurrences), and rating system (13 links; 5 occurrences). This indicates a sustained research emphasis on holistic sustainability principles, stakeholder involvement, and assessment frameworks. Notably, transportation-specific terms, including road planning, highway projects, and road construction, appeared within this cluster but showed limited link strength and frequency (3 occurrences each). This suggests that, despite the search strategy being explicitly focused on sustainable road rating systems, the literature remains dominated by broader sustainability discourse rather than sector-specific contributions to transport infrastructure.

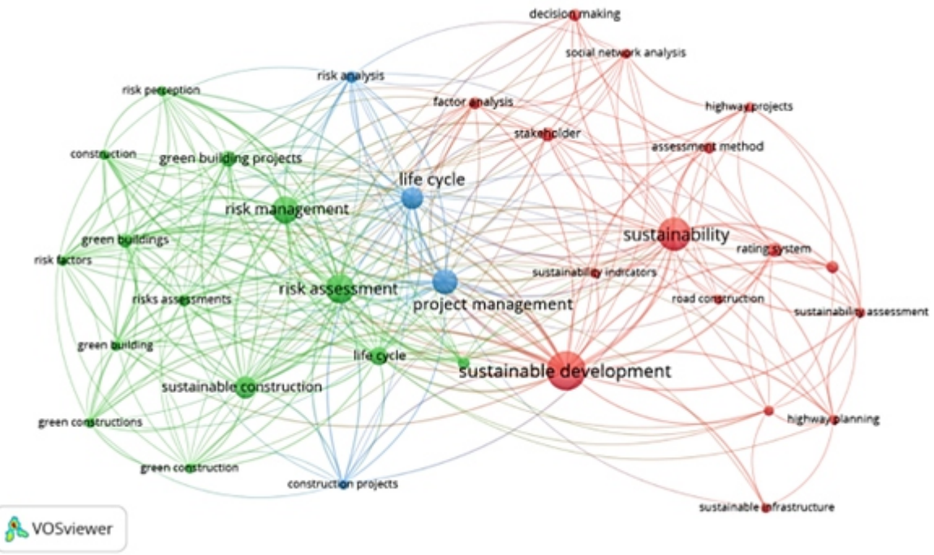

Figure 3.5 - Keywords Co-occurrence Network

The second cluster was led by the term risk assessment (27 links; 13 occurrences), linking strongly to risk management (24 links; 12 occurrences), sustainable construction (22 links; 9 occurrences), and green building projects (21 links; 6 occurrences). Supporting keywords, such as green buildings, risk perception, and risk factors, were present but with comparatively low linkages and occurrences. A noteworthy observation is that, although the study sought to explore risk-related work within road sustainability rating systems, the network exhibited stronger ties to the green building domain. This highlights a transfer of methodological and conceptual advances from green building construction to sustainable road research, but also underscores a persistent knowledge gap, as road-focused risk studies remain comparatively underdeveloped.

The third cluster was structured around project management (28 links; 9 occurrences), with strong links to terms such as construction industry (24 links; 9 occurrences), risk analysis (19 links; 4 occurrences), and construction projects (13 links; 3 occurrences). This cluster reflects the operational dimension of sustainability, emphasising project delivery, governance, and risk considerations within construction practice. Yet again, road-specific terminologies appeared with low connectivity, reinforcing the pattern observed in the first two clusters.

Taken together, these clusters illustrate a research landscape in which sustainability, risk, and project management themes are well-established and increasingly interconnected. However, the limited frequency and weak linkages of road-specific terms, despite deliberate search constraints, reveal a clear research gap in sustainable road rating systems. The gap is particularly evident in relation to risk-integrated assessment frameworks. The findings suggest that while sustainability and risk discourse in the built environment is robust, there remains substantial scope to strengthen scholarship focused explicitly on sustainable road infrastructure, develop dedicated indicators and rating approaches, and advance empirical applications in the transport sector.

IDENTIFIED RISK FACTORS FOR SUSTAINABLE ROAD DEVELOPMENT

The risk factors were consolidated from findings of multiple international studies. A summary of the key risk factors obtained is indicated in Table 3.1. The studies considered were primarily focused on sustainable construction and green buildings, as no literature was found that directly identifies risks specific to sustainable roads or road sustainability rating systems. The risk landscape for sustainable road projects was inferred from broader sustainable infrastructure studies, highlighting a gap in specialist research on road rating-related risks. The identified risks were classified into the following categories: Management & Financial, Technical, Stakeholder-related, Green Materials & Technology, Environmental, and Regulatory & Legal. These categories reflect the complex, multi-dimensional nature of transitioning to sustainable road delivery.

Table 3.1 - Summary of Risk Factors

Dimension	Summary of Priority Risk Factors	Source
Management & Financial Risks	Limited sustainability management expertise. High upfront and material costs. Budget uncertainty and cost overruns. Insufficient time for sustainability goals. Poor coordination and unclear roles. Limited financial incentives Weak feasibility planning	15-26
Technical & Design Risks	Insufficient sustainability design information Lack of clear codes and specifications Frequent design changes Limited experience with sustainable techniques Constructability challenges Technology and material performance uncertainty	15-26
Stakeholder & Collaboration Risks	Low sustainability awareness Limited expertise across project teams Late involvement of sustainability experts Poor communication and collaboration Slow decisions and low commitment Misaligned sustainability goals	15-26
Green Materials & Technology Risks	Limited availability of sustainable materials Uncertain performance of new materials, Limited technical documentation Long procurement lead times	15-26
Environmental & Climate Risks	Exposure to climate and extreme weather risks Environmental compliance challenges Limited climate -resilience planning	15-26
Regulatory & Legal Risks	Lack of supportive sustainability policies Complex approval processes Limited regulatory incentives Lack of local certification systems Unclear dispute resolution processes	15-20, 22-25

The results reveal several key risk factors that could influence the successful implementation of a road sustainability rating system. A prominent challenge is the lack of sustainability management expertise across the value chain, including clients, consultants, contractors, and suppliers, which constrains informed decision-making and the practical application of sustainability principles. Financial risks also emerge, particularly high initial investment requirements, budget uncertainty, and limited incentive structures to support sustainable practices. In addition, inadequate sustainability-related design information and unclear technical specifications or regulatory guidance create uncertainty during planning and design. Market-related risks include limited availability or uncertain performance of sustainable materials and technologies. Stakeholder-related risks, such as fragmented coordination, slow decision-making, and limited awareness, further hinder implementation. Regulatory risks are also notable, with complex approval procedures and the absence of established local sustainability certification systems. Finally, internal project management risks, including unclear roles, quality control challenges, and feasibility or constructability constraints, may impede successful execution. Collectively, these factors highlight that implementing a sustainability rating system for road infrastructure extends beyond technical considerations and is strongly influenced by institutional capacity, financial feasibility, regulatory readiness, and market maturity.

SUSTAINABILITY INDICATORS FOR ROAD RATING SYSTEMS

Similarly, the sustainability indicators were grouped into environmental, economic, social, and governance categories. The analysis of sustainability indicators revealed that road sustainability assessment requires a multidimensional approach integrating environmental, social, financial, and governance considerations. The literature emphasised environmental performance elements such as resource efficiency, ecosystem protection, climate resilience, and lifecycle-based material selection, demonstrating that environmental sustainability remains the most mature domain in current research[6,27-34]. Social indicators were also widely represented, particularly community health and safety, stakeholder engagement, equitable labour practices, and reduced disruption to local communities[6,28-31,33]. Economic indicators, while less prevalent, focused on lifecycle cost efficiency, long-term asset performance, and financial benefits to local communities[6,27-33]. Governance factors emerged as essential enablers of successful sustainability implementation, including transparent decision-making, regulatory compliance, stakeholder accountability, and collaborative procurement frameworks[6,29,31,32]. Although these indicators were identified across multiple studies, the findings suggest that existing frameworks do not fully address an integrated, balanced approach tailored to road infrastructure, particularly in emerging economies. Based on the literature synthesis, practitioner relevance, and alignment with sustainability and risk management principles, a set of priority sustainability indicators for road rating systems was developed. These prioritised indicators, presented in the Table 3.2, provide a structured foundation for establishing a context-appropriate, risk-sensitive sustainability evaluation framework for road infrastructure.

Table 3.2 - Sustainability Factors Summary

Dimension	Summary of Priority Indicators	Source
Environmental	Climate resilience, biodiversity protection Stormwater management Emissions reduction, Waste and resource efficiency	6,27-34
Economic	Lifecycle cost efficiency Infrastructure maintenance Cost-benefit value Resource allocation Innovation adoption	6,27-33
Social	Community engagement Job creation Mobility improvement Safety Socioeconomic benefits Cultural heritage protection	6,28-31,33
Governance	Clear responsibilities Dispute resolution Transparency Regulatory compliance Stakeholder collaboration	6,29,31,32

STAKEHOLDER BARRIERS

An alignment between risk themes and stakeholder-identified barriers was observed. The 15 most frequently occurring stakeholder barriers, such as lack of expertise, coordination failures, high cost, and conflicting stakeholder priorities, directly correspond to major risk categories[35-39]. This reinforces the conclusion that capacity, collaboration, economic feasibility, and governance maturity are central to success[40,41]. Additionally, the barriers highlight social outcomes such as job creation, local economic growth, environmental harmony, worker safety, and cultural heritage preservation, underscoring the community-level expectations tied to sustainable road delivery[35].

Key stakeholder concerns include:

- Limited capacity and lack of expertise in sustainable road delivery
- Resistance to change and low buy-in from contractors and clients
- Need for transparent governance, transparency, and communication
- Ensuring economic benefits, job creation, and community value
- Safety and environmental protection during construction and operation
- Alignment of stakeholder goals and technical vision
- Certainty and reliability of green material supply chains
- Regulatory support and incentives for certification and compliance

These concerns highlight that, beyond technical performance, stakeholder trust, capability building, and socio-economic contributions are central for sustainable road adoption.

CONCLUSIONS & RECOMMENDATIONS

This study critically examined existing literature on sustainability assessment across the built environment, with a particular focus on sustainable roads and highway rating systems. The bibliometric and systematic review confirms that while research on sustainable infrastructure and construction continues to grow, sustainability frameworks for road infrastructure remain underdeveloped and fragmented. A notable finding is the absence of studies explicitly integrating risk factors into road sustainability rating methodologies, despite the extensive use of sustainable assessment frameworks in green buildings and general infrastructure. Only a small portion of the literature discussed implementation barriers, and existing road sustainability studies primarily focus on environmental and social dimensions without systematically incorporating economic and risk considerations; an imbalance also highlighted in prior comparative analyses.

Addressing the first research question, the study identified key risk factors influencing the implementation of sustainable road rating, including limited sustainability expertise among project stakeholders, high upfront costs and budget uncertainty, insufficient design information and standards, supply-chain immaturity for green materials, and regulatory and institutional constraints. These findings underscore that challenges are not purely technical but rooted in financial, organisational, and governance capabilities.

Regarding sustainability indicators, the review revealed a broad set of environmental, social, economic, and governance-related metrics relevant to road projects. By synthesising the literature on green building and sustainable infrastructure, a structured, prioritised sustainability indicator set was derived, providing a foundation for future road-specific sustainability evaluation.

For stakeholder concerns and barriers, the study observed strong alignment with the identified risks, particularly capacity constraints, lack of collaboration, unclear roles, insufficient planning, and low awareness of sustainability principles. These challenges reflect entrenched institutional and knowledge-driven barriers that can impede the adoption of road sustainability systems.

Overall, this review confirms a meaningful knowledge gap at the intersection of sustainability rating systems and risk management in road infrastructure. At the same time, it demonstrates that sufficient conceptual groundwork exists through adjacent sectors, such as green building, to inform the development of a risk-integrated sustainability assessment model for roads.

Study limitations should be acknowledged when interpreting these findings. The systematic literature review was restricted to publications indexed in Scopus and Web of Science. While these databases are widely recognised, additional publications might have been indexed in other databases. As a result, some of the content might be underrepresented. The review focused on English-language publications, which may have excluded important information published in other languages. Although the bibliometric and thematic synthesis provided an overview of research trends and conceptual gaps, the study lacks empirical validation through case studies or practitioner engagement. The limitations suggest that the results should be interpreted as indicative rather than exhaustive.

To advance the development and implementation of sustainability rating systems for road infrastructure, this study recommends a coordinated research and practice agenda that emphasises integrated sustainability and risk-based assessment. Future studies should prioritise the development of comprehensive evaluation frameworks that incorporate environmental, social, economic, and resilience-oriented performance dimensions across the project lifecycle. Emphasis should be placed on embedding explicit risk identification, assessment, and mitigation processes within sustainability criteria to improve project certainty, adaptability, and long-term performance. Additionally, sustainability indicators must be hierarchically prioritised to reflect their relative significance in shaping road performance and sustainable development outcomes, supported by empirical evidence and expert input. Pilot studies and real-world applications are necessary to validate emerging models, test applicability across diverse contexts, and assess user experience and policy alignment. Finally, capacity-building initiatives that enhance stakeholder knowledge, technical competency, and collaborative decision-making are essential to overcome current capability and communication barriers and to ensure effective adoption and operationalisation of sustainability-risk frameworks in road infrastructure delivery.

In conclusion, while sustainability research has matured across several built-environment domains, road infrastructure assessment remains conceptually fragmented and insufficiently risk-oriented. Developing comprehensive, prioritised, and risk-sensitive sustainability approaches for road infrastructure presents a necessary step toward achieving resilient, cost-effective, and environmentally responsible transport networks globally.

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A THEMATIC ANALYSIS OF FACTORS INFLUENCING THE APPLICATION OF GREEN BUILDING TECHNOLOGIES: INSIGHTS FROM A DEVELOPING COUNTRY

Rethabile Nkoe[1], Eric Kwame Simpeh[2] and John Smallwood[3]

[1,2,3]Department of Construction Management, Nelson Mandela University,

Email: [1]s216988098@mandela.ac.za, [2]eric.simpeh@knust.edu.gh, [3]john.smallwood@mandela.ac.za

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ABSTRACT

PURPOSE

The application of green building technology (GBT) has become a cornerstone of sustainable development, motivated by the pressing need to reduce environmental degradation and maximise resource usage. This study explores the key barriers to adoption and factors that will engender the adoption of GBTs.

DESIGN

The qualitative research approach was used, and interviews were conducted with construction stakeholders, who were asked a series of questions. Respondents were chosen purposively based on their expertise, availability and willingness to participate in the study. The qualitative data were analysed using content analysis.

FINDINGS

The findings revealed that a lack of regulation and policy framework, as well as a lack of incentives, pose significant barriers to the adoption of GBTs in Lesotho. Furthermore, the findings revealed that regulations and enforcement, the availability of demonstration projects, incentivising and rewarding, and creating an enabling environment will all help in terms of engendering the adoption of GBTs in the Lesotho construction industry.

RESEARCH LIMITATIONS

The study is limited to construction professionals and general contractors registered with the Ministry of Public Works and Transport in Maseru, Lesotho.

PRACTICAL IMPLICATIONS

Understanding the factors influencing the adoption of GBTs can provide a comprehensive framework for policymakers, developers, and stakeholders to accelerate the transition to sustainable construction practices, particularly in the achievement of goals 11, 12, and 13 of the SDGs.

VALUE

The study's findings are a valuable resource for stakeholders such as the government, municipal assemblies, professional bodies, and green building professionals who want to put in place a mechanism to identify barriers and enablers to green building projects, which will lead to the development of effective mechanisms to promote GB adoption.

Keywords: *Construction Industry; Enabling Environment; Green Building Technology; Lesotho; Mandatory Policy.*

INTRODUCTION

The construction industry is considered to be one of the sources of greenhouse gas (GHG) emissions, which harm both humans and the environment. According to the United Nations Environment Programme (UNEP), buildings and construction accounted for more than 36% of total global energy consumption and nearly 37% of total global GHG emissions in the year 2020 [1]. Islam[2] contends that green transformation is crucial for a cleaner global environment since it incorporates new technologies, social behaviours, and business models. For this reason, various researchers[3,4,5,6], have advocated for the adoption of green buildings to mitigate the negative environmental impacts that construction activities may have. A green building is a subset of sustainable development that has a minimum impact on the built environment throughout its lifecycle[3,43]. The green building footprints have increased from 20 000 square feet in 2004 to 3 billion square feet in 2015[3]. The pressure to shift to green building is anchored by the rising evidence that the building sector is a major consumer of resources and energy, including approximately 44% of society's total material use, and more than 50% of primary resources[4].

Buildings improved with GBTs and green building materials[5], and other construction procedures show better performance as they consume less energy and water compared with traditional buildings. A study conducted by Dwaikat and Ali[6] reported a 60% decrease in the consumption of energy and water in green buildings, which implied a significant reduction in the building's annual utility bills. There is a possibility that the high energy consumption by traditional buildings can be reduced with the application of GBTs in the buildings. Chan et al.[7] pointed out that the application of high-energy-efficient windows and green wall technology in a housing development can help save between 14 to 20% and between 33 to 60% of operational energy, respectively. Muwanga et al.[8] also reveal that technologies such as solar systems for water heating have been beneficial in providing energy services even in rural places where the national grid does not reach. In addition, an evaluation conducted by Dall'O' et al.[9] indicated that through retrofitting existing traditional buildings with high energy-efficient wall technologies and materials, there is potential for the housing industry to reduce 24.8% of the energy used. Despite the tangible and intangible benefits associated with green building, the adoption and application of GBTs are lagging in the Lesotho construction industry. The slow rate of application of GBTs in the Lesotho construction industry is attributed to, inter alia, limited participation of the local private sector and cooperative associations, limited energy efficiency programmes and activities, undeveloped energy sector coordination and limited clarity regarding institutional responsibilities leading to loss of accountability[10].

With the foregoing background in mind, the research problem states that 'Many developing countries are confronted with growing environmental issues exacerbated by rapid urbanisation, resource depletion, and climate change. Although green building technologies have been advocated as a viable option for sustainable construction, the key factors influencing the adoption decision in the Lesotho construction industry have not been explored extensively, contributing to limited adoption and application. As a result, the study's significance is to examine the application of GBTs in the Lesotho construction industry with the goal of interrogating the key barriers preventing their adoption and identifying factors that will engender GBT adoption.

The objectives are to:

- investigate participants' views regarding the awareness of GBTs in Lesotho;
- determine the factors limiting the adoption of GBTs in the Lesotho construction industry, and
- identify the enablers that could engender the adoption of GBTs in the Lesotho construction industry.

In consonant with the foregoing problem statement and objectives, the following research questions were raised:

- What is the level of awareness with respect to the application of GBTs among construction professionals in Lesotho?
- What are the factors limiting the adoption of GBTs in the Lesotho construction industry?
- What are the enablers that can be adopted to engender the adoption of GBTs in the Lesotho construction industry?

LITERATURE REVIEW

BARRIERS TO THE ADOPTION OF GBTS

According to Zailani et al.[11], one of the key factors influencing the low interest and implementation of green initiatives in the construction industry is the fact that industry stakeholders have limited information regarding the benefits associated with the application of GBTs. The lack of information and understanding, therefore, hinders the construction industry practitioners from implementing the green concept due to limited knowledge of the application of the concept. Furthermore, construction industry stakeholders are resistant to change towards green practices, which is mostly influenced by a traditional mindset, causing reluctance to adopt green practices[12]. Zailani et al.[11] found that resistance to change will hinder the adoption of green practices due to fear of failure. If the information concerning GBTs is ambiguous and not clearly articulated, a barrier to implementation thereof wil result, which will cause fear amongst stakeholders and bring about resistant to adjustment when they are facing the fear of unknown and feel uncomfortable with the new practices.

Knowledge and technical expertise of practitioners have been identified as two key barriers influencing the adoption of GBTs. Sern et al.[13] indicate that even though green skills are important for the green industry, it is not well articulated. Moreover, Zolkifli et al.[14] demonstrated that most people are familiar with the generic, technical and employability skills, but have very limited knowledge relating to green skills. These issues will impact on organisations embarking on green practices due to limited professionals with green skills to be implemented by the organisation. Hence, the absence of skilled professionals in the field of green building impedes the adoption of GBTs by stakeholders. Furthermore, the lack of access to information is a deterrent to the adoption of GBTs, as it leads to a lack of interest from stakeholders due to inadequate knowledge about GBTs[15]. Simpeh et al.[16] and Chan et al.[15] also identified higher GBT costs as the major barrier influencing the adoption of green buildings in developing countries. For instance, Simpeh et al.[16] used a survey to investigate the factors limiting green building implementation in South Africa. According to the study, higher up-front costs for GB, as well as costs associated with green technologies and materials, and certification for GBs, were identified as major barriers to implementing GB.

STRATEGIES FOR PROMOTING GBTS

To encourage the adoption and development of GBTs, Li et al.[17] argue that it is critical to enhance the environmental awareness of stakeholders, strengthen technology research and communication, and formulate relevant policies and regulations. Chan et al.[7] indicate that to effectively and efficiently promote the adoption of GBTs, appropriate strategies and policies must be formulated to overcome the barriers in the industry. While IEA and UNEP[18] report that realising the potential of the building and construction sector to meet the SDGs and avoid the lock-in of inefficient buildings requires global efforts, ranging from policy, technology, and financing tools to increased international co-operation, greater education and awareness, and better training and capacity building are required across the buildings value chain. Choi[19] recommends documenting and communicating the benefits, costs, and performance of green buildings as part of the strategy to increase the wider adoption of green development practices. The governments could lead the adoption and implementation, for example, by encouraging and allowing the municipalities and local governments to develop and adopt their own mandatory GB codes, which might be stricter than the national code. Furthermore, Kontokosta[20] contends that government policies are critical for the efficient and extensive deployment of innovative energy-efficient building technologies, materials, and design and construction practices. Kontokosta[20] further opines that the policies act as a baseline standard for building energy performance and motivate new product and process innovations that can result in greater efficiencies in the long run. Furthermore, Harris et al.[21] advocate for the promotion of locally produced materials because these materials have lower embodied energy and are derived from sustainable sources. According to Dykstra[22], there is an increased understanding of the benefits of green building. Similarly, the number of green standards and codes addressing high-performance materials, products, and systems has also increased.

THEORETICAL UNDERPINNING

This study is underpinned by the innovation adoption theories, such as the diffusion of innovation (DOI) model and the technology-acceptance model (TAM), to assist in conceptualising the factors influencing the adoption of GBTs. The DOI model, postulated by Everett Rogers, is a theory that describes the process through which new ideas, technologies, or practices are diffused within a social system over time[23]. The theory determines the determinants of adoption that are important, including awareness, perceived benefits, social influence, and economic capacity[23, 24]. The theory is relevant in this study because it addresses the extent of awareness and factors influencing the adoption of GBTs. The difference in the degrees of awareness seen among the respondents is an indication of the diverse stages of the diffusion process, such as knowledge to persuasion, and finally adoption. Other aspects, such as the barriers that affect the adoption of GBTs, are in alignment with the focus of Rogers' on the social system that influences the uptake of innovations. In the context of the study, GBT can be regarded as an innovation in the construction industry of Lesotho, the uptake of which can be determined by the extent of change agents' promotion efforts, such as regulations and enforcement, availability of demonstration projects, as well as incentives and reward schemes[7,17,18,19].

The technology-acceptance model (TAM), coined by Davis[25], was designed to predict information technology acceptance and usage on the job. Venkatesh and Davis[26] posit that the model has been tried and tested and extensively applied to a diverse set of technologies and users. Venkatesh and Davis[26] further note that the core constructs include: perceived usefulness, perceived ease of use, and subjective norm. Marikyan and Papagiannidis[27] add that the primary objective of TAM was to explicate the processes associated with the acceptance of technology, to predict the behaviour of and provide a theoretical explanation for the successful implementation of technology. In the context of the study, the TAM model informed construction practitioners regarding the measures to put in place before the adoption of GBTs. By applying TAM in this manner, construction professionals can systematically analyse how perceptions, context-specific constraints, and institutional factors interact to influence the adoption of green building technologies. It is important to note that this approach provides a structured framework for identifying barriers and developing targeted interventions to promote GBTs adoption.

RESEARCH METHODOLOGY

RESEARCH APPROACH

The research was conducted following the concepts of Saunders, Lewis, and Thornhill's[28] research onion. The research onion stages encompass philosophical stances, research approaches, strategies, research methods, time horizons, and techniques and procedures for data collection and analysis employed to achieve the study's aims and objectives. In terms of the research approach, the inductive method was adopted due to the data collected through the interviews from the smaller sample size to assist in improving the current state of the Lesotho construction industry's green building initiatives (GBIs) and to raise awareness that would influence the use of GBTs in the Lesotho construction industry. With regard to the research method, a mono-method research was adopted. According to Saunders et al.[28], mono-method research uses a single data collection technique and analysis for either a quantitative or qualitative study. Specifically, the qualitative research method was employed, as it aligns with the inductive research approach. Creswell[29] explains that qualitative methods rely on text and image data, have unique steps in data analysis, and draw on diverse designs. Furthermore, in qualitative research, data collection can be an interview analyzed using a qualitative data technique. In connection with the time horizon, a cross-sectional approach was adopted since the study was academic in nature and restricted to a particular time frame. Saunders et al.[28] contend that cross-sectional studies may use qualitative research, mixed methods, or survey strategies. Hence, this time horizon was adjudged to be the most suitable approach for this study.

TARGETED POPULATION AND METHOD OF DATA COLLECTION

The primary data for this study were collected through semi-structured interviews (SSIs) conducted with construction firms and professionals in both the private and public sectors. A purposive sampling approach was employed since this study is one of the few conducted in Lesotho. The purposive sampling technique is a useful method consisting of soliciting information from a sample of the population that one thinks knows most about the subject matter[29]. The targeted population comprised category A general contractors registered with the Ministry of Public Works and Transport that have undertaken projects from the value of 50 000 000 to 500 000 000 maloti from 2015 to date, architectural firms, clients / developers as well as from government departments such as the Building Design Services and Maseru City Council. The construction firms in this category were selected due to the likelihood that they might have an in-depth understanding and knowledge regarding the study. It should be noted that all the organisations included in this study are key stakeholders that manage the construction and building sector in Lesotho. To obtain valid and reliable data for this study, the selection criteria included construction playmakers who are professionally registered with professional bodies with three or more years of experience. The semi-structured interview protocol was therefore divided into four section. Section A examined the perceptions of respondents regarding their understanding of GBTs and factors influencing the limited adoption thereof;Section Bwas designed to gather information pertaining to effective ways to raise awareness of GBTs among construction stakeholders;Section C was designed to identify the measures that public and private sectors have in place to encourage the adoption of GBTs, andSection Dsolicited information relative to the impact of government framework and policy on the adoption and application of GBTs.

The key objective of the interviews was to guide the researcher during the interview session to assist in collecting relevant information concerning the study. The interview questions were presented in a simple language to avoid misunderstanding and to facilitate the understanding and appreciation of the questions by the interviewees.

INTERVIEWS ADMINISTRATION

The interview guide and the covering letter which explained the purpose of the study were sent to the sample stratum to familiarise themselves with the interview questions and for preparation. The interviews were conducted face-to-face and, in some instances, telephonically due to the geographical spread of the interviewees. Notably, telephone interviews may present major advantages such as eliminating travelling costs to meet with the interviewees. Furthermore, responses can be received swiftly and faster, although they can pose difficulty where the interviewer cannot observe the body language and prompt the interviewees during interview sessions[29]. The researcher aimed to obtain a minimum of 20 responses since a larger population would result in a more balanced perspective and reliable data. However, in the end, only 19 respondents were interviewed, although several efforts were made for the identified candidates to participate in the study, but with little success due to their other commitments. Both the face-to-face and telephonic interviews conducted with each respondent lasted approximately 40 minutes. The interviews were digitally recorded to avoid spending time writing and typing down the notes, which may impact the time of the interview. To avoid inconvenience, the interviews were conducted at the offices of the interviewees upon scheduling the appointments.

ANALYSIS OF THE DATA

Since the interview data was in the form of audiotape recordings from the field interviews conducted during data collection, the audiotape recordings were converted to a more user-friendly format where audio files are not on .mp3 files. Furthermore, for analysing data from interviews, the audiotape interviews were transcribed verbatim, organised and formatted into transcripts for easy reading and making notes. The audiotape recordings were played back and forth to make notes for easier development of codes. Additionally, the audio playback was to enhance an understanding of data by the researcher and help with the development of a deeper understanding of the data in the early stage of transcription. The coding process underwent numerous iterations to facilitate the development of a better understanding of the data. This involved reading the text and recording general observations and impressions as codes. The transcripts were prepared using Microsoft Word and included notes of pauses, hesitations and interruptions in the interviews for more detailed analyses[30].

RESULTS AND DISCUSSION

DEMOGRAPHIC DATA OF RESPONDENTS

Table 1 presents the demographic details of the respondents, which include the organisation type, years of experience of the respondents in construction, formal qualification, gender and age of respondents.

Table 1: Participants' demographic details

Participant	Organisation type	Experience in construction (Years)	Qualification	Gender	Age (Years)
P1	Construction	7	B-Tech	Male	30
P2	Construction	12	BSc	Male	33
P3	Municipality	18	MSc	Female	42
P4	Municipality	25	NDip	Male	51
P5	Local Government	Not provided	MSc	Female	Not provided
P6	Architect / BDS	33	RIBA/MA	Male	56
P7	Architect	20	MA	Male	Not provided
P8	Construction	25	NDip	Male	45
P9	Parastatal	14	Honours	Female	43
P10	Government	5	BSc	Male	35
P11	Construction	12	MA	Male	37
P12	Academic Institution	5	MA	Male	35
P13	Academic Institution (Quantity Surveyor)	4	MTech	Female	35
P14	Parastatal	5	Honours	Female	29
P15	Government	11	MSc	Female	38
P16	Academic Institution	19	MA	Male	41
P17	Government	21	BSc	Female	50
P18	Academic Institution (Construction Manager)	20	MSc	Female	Not provided
P19	Construction	28	Honours	Female	50

PARTICIPANTS' LEVEL OF AWARENESS OF GREEN BUILDING TECHNOLOGIES (GBTS)

This section examines stakeholders' opinions regarding their level of awareness of GBTs. Most of the interviewees (95%) declared their awareness of the GBTs, which is essential in respect of adopting these technologies and may subsequently drive their eagerness to incorporate them in building designs.

PARTICIPANTS' VIEWS REGARDING THE SOURCE OF INFORMATION RELATING TO GBTS

The lack of access to information may contribute to a lack of interest due to the difficulty of accessing and obtaining the relevant information related to GBTs. Therefore, as a follow up question regarding the level of awareness of GBTs, the source of information is an essential factor that could contribute to stakeholders' knowledge. As indicated in Table 2, 43.0% of the interviewees agreed that they learnt about GBTs while studying in higher educational institutions. Again, 17.0% of the interviewees claimed that they acquired knowledge through newspapers and magazines. On the contrary, 9.0% of the participants stated that they obtained knowledge via electronic media such as television, abroad, various workplaces, and participating in green building accredited courses organised by the Green Building Council of South Africa (GBCSA). Only 4.0% indicated that the source of information was via the internet.

Table 2: Participants' views regarding the source of information

Source	Frequency	Percentage (%)
Newspapers and magazines	4	17.0
Electronic media (e.g., television)	2	9.0
Higher educational institutions	10	43.0
Abroad	2	9.0
Workplace	2	9.0
Green building accredited course with GBCSA	2	9.0
Internet	1	4.0
Total	23	100.0%

PARTICIPANTS' VIEWS REGARDING FACTORS LIMITING THE ADOPTION OF GBTS

This section was meant to collect and present data concerning the factors negatively influencing the adoption and application of GBTs. The questions posed under this section were aimed at revealing the factors limiting the adoption of GBTs by the construction stakeholders. Table 3 indicates that 31.0% of the interviewees stated that lack of regulation and policy framework as well as lack of incentives pose a significant challenge to the adoption of GBTs in Lesotho. 18.0% of the respondents also consider high initial investment as a limiting factor to the adoption of GBTs. Other factors identified by the respondents include lack of knowledge and skills (16.0%) and resistance to change (4.0%).

Table 3: Participants' views regarding factors limiting the adoption of GBTs

Factor	Frequency	Percentage (%)
High initial investment	9	18.0
Lack of knowledge and skills	8	16.0
Resistance to change	2	4.0
Lack of regulation and policy framework	15	31.0
Lack of incentives	15	31.0
Total	49	100.0%

PARTICIPANTS' VIEWS REGARDING THE MEASURES THAT ENGENDER THE ADOPTION OF GBTS

This section explored the measures that may be employed by both the private and public sector to promote and encourage the adoption of GBTs. Most of the interviewees believed that the public sector has the most responsibility of ensuring the adoption of GBTs by the construction industry via the implementation of appropriate measures that will create an enabling environment for the private sector in terms of implementing these technologies. It is notable from Table 4 that 39.0% of the participants believed that regulations and enforcement will promote the adoption of GBTs in Lesotho construction industry. 19.0% indicated that the availability of demonstration projects will assist in terms of engendering the adoption of GBTs, whilst 13% opined that incentivising and rewarding as well as creating enabling environment will help propel the adoption of GBTs.

Table 4: Participants' views regarding the measures that engender the adoption of GBTs

Measure	Frequency	Percentage (%)
Regulations and enforcement	12	39.0
Demonstration projects	6	19.0
Corporate social responsibility	3	10.0
Incentivising and rewarding	4	13.0
Ease of transformation or innovation	2	6.0
Creating enabling environment	4	13.0
Total	31	100.0%

PARTICIPANTS' VIEWS REGARDING THE PRESENCE OF A DEFINED FRAMEWORK AND POLICY ON THE ADOPTION AND APPLICATION OF GBTS

The presence of a defined framework and policy can contribute immensely to the adoption of GBTs. Participants were given the opportunity to express their general views concerning whether the standards and regulations should be mandatory or voluntary. Notably, the majority (79.0%) stated that standards and regulations concerning GBTs should be mandatory, 10.5% of the respondents agreed that standards and regulations should be voluntary, whereas 10.5% intimated that the standards and regulations should be partly mandatory and partly voluntary. The results are presented in Table 5.

Table 5: Participants' views regarding the presence of a defined framework on the adoption and of GBTs

Nature	Frequency	Percentage (%)
Standards and regulations should be mandatory	15	79.0
Standards and regulations should be voluntary	2	10.5
Part mandatory and part voluntary	2	10.5
Total	19	100.0%

DISCUSSION

THE SOURCES OF INFORMATION REGARDING GBTS

The source of information is an essential factor that could contribute to stakeholders' knowledge. Therefore, the lack of access to information may contribute to a lack of interest due to the difficulty of accessing and obtaining the relevant information related to GBTs. These ideas are supported by the following quotes from the interviews:

"I do not know, I cannot certainly say I heard it from a specific source, it is a common knowledge you read about in newspapers, magazine and see it on television and see it everywhere." (P2)

"I have seen them on news on television." (P3)

"I have heard about them abroad when I was studying." (P4)

"….so, I have read about them through the literature, except that we have not had any modelled house, which has used these technologies." (P5)

"I first heard about them while I was in university, mostly from the module called environmental science, secondly it was through construction detailing as well when I was still a student at the university. Thirdly, it was through following the architectural firms that I love while I was still a student at the university. Lastly, it was when I was doing my treatise in my final year of masters – my treatise followed the patterns of green building technologies mostly therefore I had to learn more about them." (P11)

FACTORS LIMITING THE ADOPTION OF GBTS

The interviewees expressed their views regarding the factors limiting the adoption and application of the GBTs. The interviewees stated lack of regulation and policy framework, lack of incentives, high initial investment, lack of knowledge and skills, and resistance to change as major factors limiting the adoption of GBTs. Nonetheless, these finding are different to studies in other developing markets, in which the economic related factors such as high initial investment cost is highly ranked.

LACK OF REGULATION AND POLICY FRAMEWORK

Lack of regulation and policy framework was identified as the top limiting factor to the adoption and application GBTs in Lesotho construction industry. Some of the interviewees expressed their sentiments regarding why this situation is a problem affecting the green agenda. Examples of the quotes are presented below:

"Not that I heard of or seen any government framework or policy, all that we hear is talk from our bosses regarding these GBTs, not that the government itself has something that says we must follow or do that. Absolutely if we had the framework or policy, we were going to see a difference in the application of GBTs." (P4)

"No, I don't think there is any legislation regarding GB. I am saying this because so far this year we have compiled about three to four proposals and no hint proposes that the buildings should incorporate GBTs. So, I am not aware of any legislation because if there is, I could have contributed towards that. If the framework or policy was to be brought forward it will drive the application for GB practice. That is what is needed right now in the country." (P7)

"There is no framework or policy that I am aware of; I am only aware of the NGOs that the government has brought to promote the GB practices. I think it cannot necessarily influence the application, remember we are talking about instable governments because of their short term in office. You then find incoming administration not implementing some of the policies because they were not drafted or brought in by them. Knowing Basotho very well I don't think the framework or policy can have that force." (P8)

"None that I am aware of. I have not heard of any laws relating to green building, unless I haven't across them." (P9)

The finding is in consonant with previous studies conducted in a developing countries context[16; 31; 32]. For instance, Nguyen et al.[32] affirmed that the lack of a comprehensive regulation and policy package to guide action on the application of sustainability principles is considered as one of the barriers to green building in a developing country such as Vietnam. Hence, in efforts to promote the adoption of GBTs, governments can play a vital role by developing and implementing the framework as guidance for assisting in recognising factors that inspire or compel GBTs adoption among construction stakeholders[33]. Chan et al.[7] opine that governmental policies and regulations are major factors for driving GBTs adoption and implementation.

LACK OF INCENTIVES (LACK OF ECONOMIC BENEFITS)

The interviewees declared their unawareness concerning the benefits of green building associated incentives that will help support the green agenda, but they believe if this is put in place, they can improve the implementation of the GBTs. The bottom line is on the benefits part; therefore, the interviewees believe that tax incentives and other non-financial incentives can be influential factors that can stimulate the interest of construction stakeholders. Some of the respondents were cited as saying:

"I am not aware of any tax incentives, there is no such thing. But if we can have tax incentives everyone will be eager to participate or come on board in terms of adopting the GBTs. Like what Lesotho Revenue Authority (LRA) is doing for people who pay their tax on time there are some incentives offered for early filing." (P4)

"I have not heard of any. Again, I think even if we do not have tax incentives, the benefits are enough to promote the application of GBTs. The incentives can be there and can drive the adoption, but I do not think they can be powerful or can influence as much as the benefits." (P7)

"No, I have not heard. Yes, it would be different. Everyone has an optimistic approach; everyone looks at what is the benefit they are going to gain. No gain no interest." (P8)

"No, I am not aware of any but I think if incentives can be introduced everyone would be interested to incorporate GBTs." (P18)

"Not aware of them at all. But I think the rebates boost the morale of the people and the extent of GBTs adoption could change." (P19)

The views expressed by the participants are supported by Agyekum et al.[34] who affirm that the lack of incentives is one of the key obstacles that hinder green building project financing. For this reason, Mulligan et al.[35] suggest that policymakers should consider embarking on programmes that incentivise the stakeholders who are building green and promote programmes that improve the economic literacy associated with green buildings. Furthermore, they should promote policy awareness, particularly concerning policies that provide economic incentives for building green, such as tax incentives, certification and award opportunities, and public funding opportunities.

HIGH INITIAL INVESTMENT

The interviewees mentioned high initial investment as one of the influencing factors that contributes to the limited application of GBTs. The cost of acquiring a building incorporating GBTs present a high cost in comparison to a conventional building, which discourages their use in the construction industry. The verbatim quotations of some of the interviewees are presented below in support of the discussion:

"I think the main thing is GB is expensive initially, obviously running cost is cheaper, but also green materials are expensive, therefore, I think the cost is the main factor limiting the application in my opinion." (P1)

"The most influential factor here is about the funding (financial constraints basically) because most of the buildings we do or design as architects within the ministry must be standard or type of, for example, if you think of putting a double-glazed window, it costs a little bit more than an ordinary glazed window... Like I am saying financial resources is the main element that inhibits people from knowing or applying such technologies." (P6)

"Limiting factors in comparison to those that are not green, green materials for housing are expensive; for example, solar system that's what people would opt for in comparison to the national grids because of less costs even though its installation is very expensive in comparison to initial cost." (P9)

"…., their initial cost is high but cheaper in the long run i.e., solar geyser is expensive to buy and install but cheaper to run." (P15)

"Yes, people can be reluctant because of the cost, because everything that deals with technology doesn't come cheap. Hence most people can be resistant due to cost." (P19)

Green initiatives often involve a high initial cost, which can be in the form of direct and transaction costs (TCs), posing a considerable hindrance to the adoption of green practices[17; 36]. The high cost of construction of GB is a discouraging factor among construction industry players in adopting GBTs. In comparison with conventional buildings, buildings incorporating GBTs are generally more expensive, with extra costs ranging from acquisition to installation[3].

FACTORS THAT ENGENDER THE ADOPTION OF GBTS

It is evident from the findings that the four predominant measures that will encourage the adoption of GBTs include regulations and enforcement, availability of demonstration projects, incentivising and rewarding, and creating an enabling environment.

Regulations and enforcement

It is clear from the interviews that the introduction of regulations and green standards can play a crucial role in the application of GBTs by both the industry and individuals. The interviewees believed that the only way to move away from the conventional practices to adopting GBTs is through the government intervention by developing regulations that will govern the construction industry. The construction industry must be standardised and regulated through a proper medium, and there should be enforcement of such policies to ensure the increase in the application of these technologies. The government should, on the other hand, ensure the policy targets certain buildings such as state-owned / government buildings, before enforcing the policy onto the private sector buildings. It is through the implementation of the regulation in the construction industry that will help propel the adoption of GBTs. The quotes in support of these ideas are provided below:

"I think the government should introduce the legislation and ensure the enforcement of such legislation. If there are no regulations, people will adopt the GBTs for short term, i.e. during sensitisation period and lose interest once that phase passes." (P4)

"There should be policy guidance regarding GBTs, be incorporated in housing policies and the national building code. That is what the government should do as leading policy development. These measures or policies should be for all the stated owned or public buildings for the government to save a lot in terms of energy usage, and not target only certain buildings." (P5)

"Regulations, regulations and regulations, this is what countries are doing and have been doing while we are lagging. I think the approach should target certain buildings especially government buildings." (P7)

"I think the GBTs should be integrated into the policies and regulations and should be really enforced and ensure people comply. I think the public sector is more powerful in this regard because it can enforce the regulations upon the private sector to adopt green technologies, they have such power." (P13)

The views expressed by the interviewees are supported by the literature. Potbhare et al.[37] found that the crucial driving factors for the successful adoption and implementation of GBTs are via the introduction and implementation of mandatory regulations by the government and non-governmental organisations such as green label scheme and establishment of green standards or green specification. Chan et al.[7] emphasised that the formulation of the regulations is important for motivation and exerting pressure on the industry practitioners as well as stimulating their interest in GBTs.

Demonstration projects

Demonstration projects can be a better approach for encouraging the adoption and application of GBTs. Modelled buildings must be constructed to demonstrate to stakeholders what buildings incorporating the GBTs look like and what it feels like to be in such facilities. The experience that can be felt in these facilities may play a significant role in driving the green agenda in the construction industry, as the benefits can also be experienced during a visit to the facilities. The quotes in support of these ideas are:

"First and foremost, there should be house models where a building which has incorporated the GBTs has been built for people to see it physically. Because most people want to see and familiarise themselves with what is exactly happening as well as how to incorporate these technologies in their already existing buildings to improve energy efficiency and building performance." (P5)

"I think it will, I remember some years back I visited a house somewhere, the green technology was used. So, I think that is one thing which aroused my sensitivity approach in ensuring that buildings which I design although I cannot do to that extent, I try to capture some of the things." (P6)

"If people can be taken into a building that has incorporated GBTs, they will understand if they are told that these technologies enhance the building performance in this way and that. Therefore, experiencing a building that incorporated these technologies and seeing the benefits of incorporating such technologies could be a contributory factor in raising awareness." (P7)

"Also, we need to start giving examples, because people do not understand giving these long conversations we have. But if we show people a building that uses green utilities spending versus a building that does not use green utilities, it is more likely to convince people. Just coming up with theory, people will not really buy into the idea." (P14)

"I think so, everywhere you must lead by an example. If they feel that this is the way to go and there are some government buildings which are going to be constructed very soon, the government can set an example for adoption and uptake of this idea." (P19)

It is evident from the interviewees that another approach that can be employed by the government for ensuring the increase in the adoption of GBTs is by embarking on demonstration projects[37], which assist in terms of validating the effectiveness of GBTs to the public, hence they are a critical means of accelerating the pace of the adoption of green buildings. Sadiq[38] adds that the government may employ certain improved strategies, such as providing incentives and funds, for practical demonstration projects that have incorporated GBTs to educate and persuade the public. This finding is consistent with that of Simpeh et al.[39], who determined that establishing green building demonstration projects in various neighbourhoods to demonstrate the benefits and effectiveness of eco-friendly architecture and / or energy-saving innovations will encourage homeowners and developers to adopt green concepts and technologies.

Incentivising and rewarding

This section presents the incentives and rewards that can be provided to promote the adoption of GBTs. To encourage the adoption of GBTs, stakeholders, especially developers, should consider the benefits that will accrue in terms of employing such technologies in their projects. If incentives are available, then the stakeholders are likely to be keen to employ the GBTs in their buildings as these will help reduce the cost of the building. Another aspect is the provision of reward schemes that can serve as motivation for incorporating GBTs in buildings. The reward scheme can be in the form of certificates to honour stakeholders (consultants, client / developers) for buildings that have acquired certain ratings. In this way, the stakeholders can be motivated to adopt and apply GBTs in their future construction projects. The following quotes are provided in support of these ideas:

"Obviously when you want to encourage anything in a person or industry you should lower the cost, make it easier and affordable, so if they could give some incentives in terms of cost. Then stakeholders in the construction industry can implement GBTs as an incentive." (P2)

"By way of giving rewards even if it is just a publication that a certain building has acquired a GB certificate. The private sector can come together and agree that if we can get a certain rating to award certain building for acquiring certain GB rating." (P7)

"Let's talk about expenses; providing subsidy, if government provides subsidy for people like me who wants to install solar, it implies that I am going to buy it cheaper." (P9)

Darko et al.[33] reveal that incentives can contribute positively to the adoption of GBTs, and they can inspire and compel the stakeholders to adopt GBTs in their projects. In a similar vein, Chan et al.[40] and Olanipekun et al.[41] indicate the importance of economic and advocatory incentives as well as motivation as a major factor to stimulate the interest of the stakeholders on GBTs adoption. This is also corroborated by Simpeh et al.[39], who state that providing fiscal incentives, such as tax credits, reductions, or low-interest loans, to homeowners and developers will help promote the use of green concepts and technologies.

Creating enabling environment

The findings revealed that the government should first create an enabling environment by setting standards and providing policies to govern the adoption of GBTs. Thereafter, the government must provide the playing field for the private sector, which hass the resources and might have the skills to implement it. Where there are limited skills, the government should lead by example by providing the necessary training to help stakeholders familiarise themselves with GBTs, as well as guidance on how to incorporate them into existing buildings. In support of the ideas, the responses from the interviews are:

"I think if there are measures from both public and private sectors, the measures will be influential because if the government were to create and provide enabling environment the private sector would do the implementation." (P3)

"When the government has set standards and drafted policy guidance, the private sector should effectively implement the adoption of GBTs. There are two of them (public and private), the government should first implement policy guidance and endorse the GBTs so that the message can be disseminated to the public. Then, the private sector helps in the implementation of the policy." (P5)

"We as private sector need infrastructure that can be created by the government for these laws to pass and reach parliament and senate. These laws should be binding to both private and public sectors to work together to keep changing things over time to make Lesotho a better country." (P11)

"The public sector should take more responsibility. The government sector should provide an enabling environment and an open field for private sector to undertake this initiative. It would sink more if the private sector could undertake the initiative and could provide more influence than the public sector." (P19)

From the findings, it is important to note that if there is a playing field that is provided by the government after the introduction of the legislation, then there will be a smooth transition of the industry in terms of adopting the GBTs. Ametepey et al.[42] and Kibert[43] concur with the views expressed by the interviewees by asserting that without the full commitment of the government, green building practices in terms of design and delivery cannot be successfully implemented. As a major stakeholder, the government should take full responsibility for providing the enabling environment for effective implementation.

PRESENCE OF DEFINED FRAMEWORK AND POLICY ON ADOPTION AND APPLICATION OF GBTS

The nature of the standards was based on whether the standards and regulations should be mandatory or voluntary. It is notable from the findings that the majority of the respondents opine that the standards and regulations should be mandatory, a few advocated voluntary standards, and a negligible number were undecided whether or not the standards and regulations should be mandatory or voluntary. In support of the ideas, some examples of quotes from the interviews are provided:

"Yes, these should be mandatory. Because if you make it voluntary it will not be implemented as people do not voluntarily change." (P2)

"The legislation should be mandatory if we have robust outreach, where everyone understands even the need to promote GBTs. As our economy is still developing, some people may not understand or who may not afford catering for GBTs. I, therefore, think it should be both mandatory and voluntary, and which it would be voluntary if we all understand and appreciate the benefits. But if it were mandatory, it is then going to be so hard on some people who would love but cannot afford. I feel it could be mandatory for institutions or government partners and depending on the size of the proposed project but be voluntary for individuals." (P3)

"The regulations should be mandatory to see the end-product or the benefits of these GBTs like reducing the operating costs." (P4)

The legislation could be a driving factor for the application of GBTs, and they should be mandatory, as legislations are mostly mandatory." (P5)

"They must be mandatory and if the policies are there, there must be people who must ensure that they are adhered to or followed." (P6)

"The legislation should be mandatory because our planet earth is now doing things that we were never expecting which are repeating themselves." (P7)

"I think they should be mandatory because every country wants the well-being of its people." (P8)

"They should be mandatory, reason being, we cannot have the same directions all of us and if we are aiming somewhere where the world is heading." (P10)

"These should be mandatory because if we are serious and want to adopt these GBTs, it must be binding to everybody, it must be a culture. For us to fulfil that, our market should be ready, currently our market is not ready." (P11)

"They should be mandatory, because if it is voluntary, people are going to continue with their normal ways because there is nothing forcing them to adopt GBTs. And, to be honest we are damaging our Mother Nature." (P12)

"These should be mandatory; they should be enforced because that is what we want to achieve." (P13)

"I think it should be part mandatory and part voluntary. I mean there are things you cannot enforce people to implement something that could be too expensive for them, as well that could be difficult to implement based on where we are right now as a country. I think where it should be mandatory is where there are not too much cost implications to bear. I still maintain there are a few things that could be mandatory if any, but I believe for the most part they should be voluntary." (P14)

"I believe it should be voluntary. We can only raise awareness and let people decide since these technologies are a bit expensive especially when it is not against any law." (P15)

"I think it should be mandatory to reduce the carbon footprint, especially if these can be the solution to minimise the emission of greenhouse gases. This should be enforced at least for everyone to contribute to reducing certain percentage using GBTs." (P18)

It is evident that respondents have differing opinions concerning whether the standards should be mandatory or voluntary. Nonetheless, more than three-quarters of the interviewees declared that standards and regulations should be mandatory as this is the only way the GBTs will be adopted and incorporated in buildings. Chan et al.[7] affirm that the formulation of mandatory policies is important for motivation and exerting pressure on industry practitioners as well as stimulating their interest in GBTs. Lesotho as a developing country needs mandatory standards placed on major institutions undertaking major projects, and government institutions, as they have the responsibility to lead by example. With respect to voluntary standards, stakeholders are likely to incorporate GBTs in their buildings if such standards are accompanied by examples of cost benefits.

CONCLUSIONS AND RECOMMENDATIONS

Lesotho construction industry stakeholders are no different from those in other developing countries in terms of conventional buildings that consume resources and rely solely on electricity. The issue of reliance on electricity as the sole source of building operation may result in high operating costs. New technologies have been adopted and integrated into the design and construction of buildings. Although the incorporation of GBTs in buildings has increased globally, the Lesotho construction industry lags in this regard. The study determined that there are factors that influence the limited application of GBTs in Lesotho. The factors include the lack of a regulation and policy framework, a lack of incentives, the requirement of higher initial investment, a lack of knowledge and understanding with respect to these technologies, a shortage of experts and skills required for application and industry role players' resistance to change over time. As a result, stakeholders in the construction industry must act to address the issues affecting the implementation of GBTs in the Lesotho construction industry.

Furthermore, the findings revealed that regulation and enforcement, the availability of demonstration projects, incentivising and rewarding, and creating an enabling environment all contribute to the adoption of GBTs in the Lesotho construction industry. Notably, some interviewees suggested that the first step in regulating the construction industry should be the implementation of policy and standards. Policy and standards will establish a precedent that all stakeholders must follow. Nonetheless, the majority of interviewees stated that the standards and regulations should be mandatory because this is the only way for GBTs to be adopted and incorporated into buildings. While some interviewees believe the private sector should take the lead in facilitating easy transformation and improving their public image and reputation, others opined that the government should create an enabling environment for stakeholders to begin implementation. The overall conclusion of the research is that the current level of knowledge with respect to GBTs is not convincing enough to stimulate the interest of stakeholders. More must be done to stimulate stakeholders, and both the private and public sectors must work together to change the current state of GBT application in the Lesotho construction industry.

Based on the findings, the following recommendations are made to help promote the adoption of GBTs in the Lesotho construction industry:

- The construction industry should band together to form a professional body to regulate the green building industry, with representation from all professions;
- The government should set a good example by implementing green initiatives such as energy and water performance certification for monitoring state-owned and commercial buildings consumptions in terms of energy and water, which will encourage the use of GBTs;
- Improving the energy performance of existing buildings through retrofitting, and
- Before implementing its own green standards to realize the GB practice, the government should consider using existing green standards from other countries.

PRACTICAL IMPLICATIONS, LIMITATIONS, AND RECOMMENDATIONS FOR FUTURE WORK

Given that this study is among the few studies conducted in Lesotho to identify key factors influencing the adoption of GBTs, the findings have practical implications for design and construction firms and may serve as a good reference for other provinces in Lesotho. Furthermore, the findings are likely to assist in terms of broadening construction professionals' understanding regarding the key barriers to adoption and factors that will engender the adoption of GBTs. Understanding the interconnected factors could provide a comprehensive framework for policymakers, developers, and stakeholders to accelerate the transition to sustainable construction practices.

The study is limited to construction professionals and general contractors registered with the Ministry of Public Works and Transport in Maseru, Lesotho. Furthermore, the qualitative approach and cross-sectional design nature of the study limits the findings' causal inference and the capacity to monitor change longitudinally. Hence, generalisation and adoption of the findings to other provinces in Lesotho as well as other sub-regions should be done with caution.

Based on the limitations, recommendations for future work could include firstly conducting further studies in other provinces of Lesotho to engender comparison. Secondly, a future study could adopt a quantitative or mixed-mode approach, and a longitudinal time horizon to engender the robustness of the findings and conclusion.

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The paper should be written and arranged in a style that is succinct and easily followed. An informative but short title, a concise abstract and keywords of no more than 150 words and a well written introduction will help achieve this. Simple language, short sentences and a good use of headings all help to communicate information more effectively. Discursive treatments of the subject matter are discouraged. Figures should be used to aid the clarity of the paper. The reader should be carefully guided through the paper.

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The pages should be numbered consecutively. There should be no loose addendum or notes or other explanatory material. The manuscript should be arranged under the headings and subheadings.

TITLE PAGE (PAGE 1):

The first page of the manuscript must contain a concise and informative title, the name(s), the affiliation(s) and the address(es) of the author(s) and the name, address, telephone and email of the author who will be responsible for the correspondence and corrections. The title should be in 12-pt bold capitals, the name(s) of the author(s) in 10-pt bold upper and lower case with a single line spacing between each.

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To produce a structured abstract, complete the following fields about the paper. There are four fields which are obligatory (Purpose, Design, Findings and Value); the other two (Research limitations/implications and practical implications) may be omitted if they are not applicable to the paper. Abstracts should contain no more than 150 words. Write concisely and clearly. The abstract should reflect only what appears in the original paper. Provide no more than 5 keywords.

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What are the reasons for writing the paper or the aims of the research?

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What outcomes and implications for practice, applications and consequences are identified? Not all papers will have practical implications, but most will. What changes to practice should be made because of this research/paper?

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What is new in the paper? State the value of the paper and to whom. All headings and subheadings should be in 10-pt bold capitals and the keywords themselves should be in 10-pt bold upper and lower case.

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The introduction should clearly state the purpose (aims and objectives) of the paper. It should include key references to appropriate work but is NOT the place for a comprehensive historical or literature review.

DISCUSSION:

The discussion should emphasize the implications and practical significance of research findings, their limitations and relevance to previous studies.

ACKNOWLEDGEMENT:

A short acknowledgement section of one paragraph is permissible at the end of the text.

CONCLUSIONS:

Conclusions should state concisely the most important propositions of the paper, as well as the recommendations of the authors based on the propositions.

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Illustrations must accompany the manuscript and should be included in the text. Photographs, standard forms, and charts must be referred to as Figure 1, Figure 2, etc. They should be numbered in the order in which they are referred to in the text. The figure identification and accompanying description and any reference should be one line space immediately below the figure and linked to the left margin.

Illustrations should be submitted in a form ready for reproduction, preferably as high-resolution jpg files. Diagrams and drawings should be drawn in black ink on white background. Alternatively, it should be high quality laser computer printouts from a reputable computer software drawing package.

Drawings and diagrams must not exceed 140mm in width and all dimensions must be in mm. Annotation must be in upper- and lower-case lettering, the capital of which must be 3mm high. Figures will normally be reduced in size on reproduction and authors should draw this with this in mind. With a reduction of 2:1 in mind the authors should use the lines not less than 0.25mm thick and upper- and lower-case lettering, the capitals of which should be 4mm high. Typewritten annotations are not acceptable.

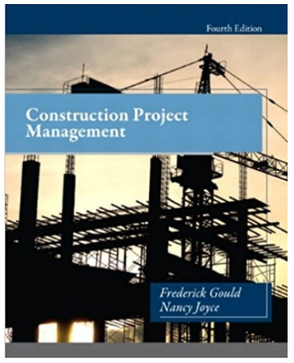

Figure 1. Prescribed text book[1]

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Tables must be located close to the first reference to them in the text and must be referred to as Table 1, Table 2, etc. and be numbered in the order in which they are referred to in the text. The table identification and accompanying informative description on and any reference should be one line space immediately above the table and linked to the left margin. The table identification should be in bold. Identify all statistical methods and sources of data.

Tables should only have horizontal lines, the heading and the bottom lines being in bold, all words should be in upper and lower case lettering. The headings should be aligned to the left of their column, start with an initial capital and be in bold. Units should be included in the heading. Any explanations should be given at the foot of the table, not within the table itself.

Table 1: Components and Expenditure

Component	Expenditure
Cleaning works	40,9
Mechanical Services	37,7
Building Works	13,6
Civil Works	7,8
Total	100,0

Source [1]

SYMBOLS, ABBREVIATIONS, AND CONVENTIONS:

Symbols, abbreviations, and conventions in papers must follow the recommended SI units. Where non-standard abbreviations are used, the word(s) to be abbreviated should be written out in full on the first mention in the text, followed by the abbreviation in parentheses.

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[1] Bon, R. (1997) "The future of international construction." Building Research and Information 25, 137-41.
[2] Stone, P.A. (1980) Building Design Evaluation: Costs-in-use. E & FN Spon, London.
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If no person is named as the author the body should be used (for example: Royal Institution of Chartered Surveyors (1980) *Report on Urban Planning Methods, London*.

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