CM50 CONFERENCE

BOOK OF ABSTRACTS

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Department of Construction Management 50th Anniversary Conference
'The Next 50 Years'
15-16 November 2021
Gqeberha (Port Elizabeth), South Africa

Editor
Fidelis Emuze

CM50 CONFERENCE

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15-16 November 2021
Garden Court, Kings Beach, Gqeberha (Port Elizabeth), South Africa

The Nelson Mandela University (NMU) was officially renamed on 20 July 2017, continuing a long legacy as a pioneering institute of higher learning. The only higher education institution in the world to carry the name of Nelson Rolihlahla Mandela, the name change provided an opportunity for the institution to rebrand and position itself continentally and globally as an African university for the future

In 2005, 3 institutions, namely the PE Technikon (PET), the University of Port Elizabeth (UPE) and the Port Elizabeth campus of Vista University (Vista PE), were merged to deliver a more equitable and efficient system to meet the needs of South Africa, the continent, and the world in the 21st century. The PE Technikon has its roots in the country's oldest art school, the PE Art School founded in 1882; the University of Port Elizabeth (UPE), was the country's first dual-medium residential university, having commenced operation January 1964; whilst the Port Elizabeth campus of Vista University, was formed in the early 1980s to ensure that urban black students seeking tertiary education would be accommodated within the townships of the then apartheid South Africa.

Mandela University brings together the best traditions of both technikon and university education and draws on more than a century of quality higher education. The university has embraced Mandela’s challenge to honour his name by providing a university diverse in its thinking in an era of transformative innovation, development, and change. As an innovative 21st century institution of higher learning, the university has taken responsibility for its legacy in ensuring that a diverse range of life-changing educational experiences for a better world is offered.

There are nearly 30 000 students and approximately 2 500 staff members, based on seven campuses across the Nelson Mandela Metropole and in George. The first Chancellor of the reconstituted university was Chief Justice Pius Langa, whilst Justice Ronnie Pillay was the first Chairperson of Council. The current Chancellor is Dr Geraldine Fraser-Moleketi, with Ms Nozipho January-Bardill the Chairperson of Council. Prof Sibongile Muthwa is the Vice-Chancellor and heads up the management team of the university.

THE DEPARTMENT OF CONSTRUCTION MANAGEMENT

In South Africa, degree courses in building management commenced in 1963 following far-sighted building personalities such as Harry Stirling, Harry McCarthy, and Thomas Pattullo. Foreseeing the future demands to which the South African building industry would be subjected due to rapidly increasing complexity in technology, business practices, and the social environment, these gentlemen also motivated the establishment of the National Development Fund for the Building Industry—administered by the Building Industries Federation South Africa (BIFSA), its purpose since inception was to assist in establishing university degree courses and to provide bursaries for students following the BSc (Building Management) courses.

After vigorous encouragement and support from the PE Master Builders Association (now the East Cape Master Builders Association), the BSc (Building Management) programme commenced at UPE in 1971. Initially, the course was presented within the Quantity Surveying Department, and thus, the first two years of the curriculum closely followed that of the BSc (QS) degree. The first Senior Lecturer in Building Management, Ben Willemse, was appointed in 1974. He was followed by Brian Eksteen, joined by Henk Venter as Lecturer in 1977.

In 1978, Building Management became an independent department within the Faculty of Economic Sciences. 1980 brought further changes when Brian Eksteen was promoted to Associate Professor. Two senior lecturers, Piet Vogel, and Ivan Steenkamp were assigned to the Department and offered specific architecture and quantity surveying courses. After this, André Malherbe joined in 1982, John Smallwood in 1990, the current senior academic in the Department. The department has seen the appointment of Brink Botha, Winston Shakantu, Chris Allen, and Katharina Crafford since the turn of the millennium, providing a full-time staff complement of five. The full-time staff members are assisted by a small number of part-time staff members from various disciplines, who perform selected lecturing roles in the Department. The Department is adding two additional full-time staff to the cohort from January 2022, enabling it to expand the current offering as it looks to provide the necessary education for the more digitised construction industry.

The name of the Department and the degree changed from 'Building Management' to 'Construction Management' in 1993. In the 50th Anniversary year, the Department introduced the first specialist Construction Health and Safety Management Honours degree, further adding to the legacy of the Department as the leading Construction Management department on the continent. As far as its lecturing and research are concerned, the Department's work embraces the disciplines of Construction Management, Construction Project Management, and Construction Health and Safety (H&S) Management. Research into building science and technology and the business of construction are a core focus for the Department, which continues to push the envelope on knowledge within the discipline.

VISION, MISSION AND VALUES OF THE DEPARTMENT

VISION

To be the preferred centre for construction management education and development.

MISSION

Our mission is to develop human potential and create knowledge at the highest academic level to serve the construction industry and society.

VALUES

- Professional conduct
- Personal growth
- Quality:
  - in education
  - in research
  - in service
  - of life
- Consumer satisfaction
- Development
- Community orientation
- Environmental sensitivity
- Academic accountability
- Fundamental focus

FOREWORD

The organising committee of the Department of Construction Management 50th Anniversary conference is delighted to welcome you to Gqeberha (Port Elizabeth), South Africa. It provides an international forum for researchers and practitioners from developed and developing nations to address fundamental construction management, construction project management, and construction health and safety (H&S) management issues. The objectives of the conference are to:

- Celebrate the 50th year of presentation of the BSc Construction Management programme at the NMU.
- Provide a forum for multi-disciplinary interaction between academics and practitioners.
- Provide an internationally recognised, accredited conference.
- Disseminate innovative and cutting-edge practices.
- Identify likely issues during the next 50 years.
- Contribute to construction management, construction project management, construction H&S management bodies of knowledge.

The conference topics include:

- Education and training.
- Continuing professional development.
- Professional registration / Candidacy / Mentoring.
- The business of construction, including projects.
- The business of consulting, including projects.
- Ethics.
- Health, Safety, and Wellbeing.
- People in construction issues.
- Sustainability.
- Digitalisation / Industry 4.0.
- Smart construction.
- Innovation.
- Construction sociology.
- Opportunities and challenges.

Fidelis Emuze
Academic Programme Chair
Bloemfontein, South Africa
09 November 2021

ACKNOWLEDGEMENTS

The preparation and hosting of the CM50 Conference is based on the goodwill from the Nelson Mandela University (NMU), the Central University of Technology, Free State (CUT), and other helpful individuals. The organising team is grateful to Chris Allen, Brink Botha, Katharina Crafford, Claire Deacon, Fidelis Emuze, Theo Haupt, George Mollo and John Smallwood for serving as Session Chairs at the conference. The team also recognises the support of tribute and keynote speakers in Greg Steele, Petra Devereux, Claire Deacon, Butcher Matutle, Theo Haupt, and PD Rwelamila.

The effort of the International Scientific Committee (ISC), who carefully reviewed both abstracts and papers that Fidelis Emuze afterwards edited, is warmly appreciated. The voluntary assistance of the ISC led to the published proceedings that fulfil the Department of Higher Education and Training (DHET) subsidy criteria in South Africa. I must mention the massive support from colleagues. At the academic institutional level, the support of Gerrit Crafford (NMU), Alfred Ngowi (CUT), and Herman Vermaak (CUT) is notable. Through voluntary indirect supports, Louise Engelbrecht, Mariana Botes, Chris Allen, Brink Botha, and Katharina Crafford in Gqeberha (Port Elizabeth); and Bankole Awuzie, Masabata Mokebe, George Mollo, Benny Ramafalo, and Nkuna Nhlanhla in Bloemfontein enriched the organisation of the event. The web support from Tiffiny Rayners (NMU) and Leandra Jordaan (CUT) is appreciated.

ORGANISING COMMITTEE

John Smallwood (Technical Programme Chair)
Fidelis Emuze (Academic Programme Chair)
Louise Engelbrecht (Administration – Nelson Mandela University)
Masabata Mokebe (Administration – Central University of Technology, Free State)

DECLARATION

The papers in this conference proceedings have been double-blind reviewed at abstract and full paper stages by the International Scientific Committee. This process involved all-inclusive reading of the abstracts and papers, reporting comments to authors, revising manuscripts by authors whose papers were not rejected by the reviewers, and re-evaluating revised documents to ensure the quality of content. The conference proceedings is made up of papers that experts in construction management research have reviewed. It is declared that multiple institutions contributed most of the papers in the proceedings.

THE PEER-REVIEW PROCESS

To assure the quality of the conference proceedings regarding compliance to the criteria for the Department of Higher Education and Training (DHET) subsidy in South Africa, a rigorous two-tier peer-review process by two recognised scholars was followed. In certain instances, three reviewers were used to assess the quality of a paper. The process was implemented by making sure that each abstract was twice blind reviewed concerning the applicability to the conference theme and originality of research. Authors whose abstracts were accepted after the stage one review were provided with anonymous review reports and requested to submit their full papers for peer review. The review of the full papers followed the two-tier blind review process. Authors whose papers were accepted after this second review was provided with second anonymous reviewers' comments and requested to submit their revised full papers. These final papers were included in the conference programme and the conference proceedings. The Easy Chair online system was fully utilised for the peer review of all submissions for the conference.
The submissions were made to:
https://easychair.org/conferences/?conf=cm50.

The conference was also hosted on the web through:
https://50thcm.mandela.ac.za
https://www.cut.ac.za/events/cm50th-conf-2021

The statistics shown below indicate that authors of accepted papers are affiliated to seven countries:

Country	**Authors**
Botswana	1
Ghana	1
Nigeria	12
Poland	3
South Africa	33
United Kingdom	1
United States of America	3
Total	54

The International Scientific Committee (ISC) members were not involved in the review related to their papers. The role of the editor was to ensure that the final papers integrated the reviewers' comments and position the papers into the last order as captured on the Table of Contents. A total number of 42 submissions were received through the abstract and paper submission stages. However, only 22 papers were accepted for inclusion in the proceedings. But 21 papers made it to the proceedings as one paper was not revised. This statistic results in an acceptance rate of 52.4% / rejection rate of 47.6%. The inclusion of a paper in the proceedings is predicated on acceptance consensus from the reviewers. All rejected papers failed the acceptance litmus test.

The table below also shows that the papers in the proceedings were contributed by scholars affiliated with 20 organisations.

#	Affiliation	Frequency	Country
1	Ahmadu Bello University, Zaria	2	Nigeria
2	East Carolina University	3	United States of America
3	Federal University of Technology, Akure	5	Nigeria
4	Federated Mutual Assurance Company (PTY)	1	South Africa
5	Kwame Nkrumah University of Science and Technology	1	Ghana
6	Mangosuthu University of Technology	1	South Africa
7	Nelson Mandela University	5	South Africa
8	Osun State College of Technology, Esaoke	1	Nigeria
9	Poznan University of Technology	2	Poland
10	University of Cape Town	6	South Africa
11	University of the Free State	3	South Africa
12	University of KwaZulu-Natal	1	South Africa
13	University of Lagos	3	Nigeria
14	University of Ilorin, Kwara State	1	Nigeria
15	University of Johannesburg	11	South Africa
16	University of Manchester	1	United Kingdom
17	University of Pretoria	2	South Africa
18	University of the Witwatersrand	2	South Africa
19	Tshwane University of Technology	1	South Africa
20	Walter Sisulu University	2	South Africa
	Total	54	

Based on the above analysis, the organising committee for the CM50 now states as follows:

- Peer-reviewed accepted papers with origins from seven countries were presented at the conference.
- Peer-reviewed accepted papers were included in the published conference proceedings where the authorship from a single institution did not exceed the 60% limit set by the DHET.
- The conference proceedings were published on 15 November 2021.
- The conference proceedings ISBN is 978-1-928472-51-3.
- The conference venue was Garden Court, Kings Beach, Gqeberha (Port Elizabeth), South Africa.

Best wishes,

Fidelis Emuze
Academic Programme Chair
Bloemfontein, South Africa
09 November 2021

INTERNATIONAL SCIENTIFIC COMMITTEE

The peer-review exercise for the CM50 Conference was expedited through the unpaid contributions of scholars from various international institutions. The editor sincerely appreciates the contributions of all reviewers listed below:

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HOSTS


NELSON MANDELA
UNIVERSITY


Central University of
Technology, Free State

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IDENTIFYING THE RISK FACTORS IN ZIMBABWEAN HEALTH PROJECTS

Simbarashe Buhlungu[1] and Nien-Tsu Tuan[1]

[1.] *University of Cape Town, South Africa*

This paper conducts a preliminary exploration of the risk factors in Zimbabwean health projects. The inquiry adopts a qualitative approach. The sampling technique used in the research process is purposeful sampling. Nine research participants versed in the research topic were interviewed. The interview transcripts were coded to elicit the risk factors existing in the Zimbabwean health projects, and the technique of frequency count is adopted to determine the ranking of the identified risk factors. The research findings reveal that the risk factors of the health projects in Zimbabwe mainly stem from its internal environment, e.g., inefficient use of resources, fragile institutions, tight recipient country budgets, lack of financial transparency, abuse of funds, lack of a comprehensive approach, sustainability problems, poor stakeholder commitment, and corruption. Among the identified risk factors, the top three risk factors concluded through the frequency count are 'fragile institutions', 'inefficient use of resources', and 'the lack of trust between donors'. This paper contributes to the understanding of risk factors in Zimbabwean health projects. The research outputs can be used as a vehicle for addressing the identified risk factors and improving the performance in Zimbabwean health projects.

Keywords: Risk Factors, Qualitative Research, Zimbabwean Health Projects.

INTRODUCTION

In Zimbabwe, most international development aid programs and development assistance funds are usually disbursed for specific purposes (MOHCC, 2016). Then, programs and projects are created to meet the intended purposes. The donors or development partners work with the Ministry of Health and Child Care (MOHCC) and selected nongovernmental organizations to implement and execute the programs and projects. Currently, there are more than fifteen donor organizations, in partnership with the Ministry of Health and Child Care to fund the health sector. These include BMGF, CDC, DFID, European Union, GAVI Alliance, Global Fund, Irish Aid, SIDA, Swiss Embassy, UNDP, UNFPA, UNICEF, USAID, WHO and World Bank. Although the partnership between the MOHCC, donor organizations and implementing partners has made significant progress towards fighting the HIV epidemic, there are challenges impeding the smooth execution of health programs and projects. The challenges need to be consciously addressed for the success of health projects in Zimbabwe. The quest for improving program/project performance is not complete without better understanding of program risk. The thrust of this research is to improve program performance through identifying the risk factors inherent in the Zimbabwean health projects.

The literature related to identifying the risk factors in the development projects is prevalent. For example, Muriithi and Crawford (2001) explores why the development projects in Africa are delayed. Ika and Saint-Macary (2014) investigates the factor threatening the success of development projects in Africa. Kakonge (2015) identifies the risk challenging the development projects in Africa. However, Afzal and Gauthier (2017) indicate that the research focuses on public health projects is little. Given their observation, the investigation

into the risk factors specific to the Zimbabwean health projects is not a prevalent topic. The objective of this research is to identify the risk factors existing in the Zimbabwean health projects. The investigation was conducted through surveying the professionals involved in the Zimbabwean health projects. The output of this research aims to promote the success of Zimbabwean health projects through identifying the risk factors inherent in them.

LITERATURE REVIEW

The research by Afzal and Gauthier (2017) reveals that there is limited research focusing specifically on public health projects. Afzal and Gauthier (2017) analysed the "importance given to project management in the health sector and the theme of health in project management". The authors reviewed eighty-one articles published on the ABI/INFORM bibliographical database between 1979 and May 2017. They found that little research on project management in the health sector is published in the main project management journals. This is the evidence of limited research in the area of project management in the health sector.

However, there are notable works identifying the risk factors arising from the international development projects in developing countries. For example, according to Ika and Saint-Macary (2014), 'lack of project management skills' is a factor threatening the success of development projects in Africa. Ika and Saint-Macary (2014) observe that, in Africa, most project managers are accidental and most project management training is either shallow or inadequate. 'Lack of project management skills' relates closely to lack of implementation capacity by donors and recipients because project management capacity is a key component of implementation capacity. Muriithi and Crawford (2001) indicate that 'lack of project management guidelines and literature' affects the development projects in Africa. According to them, the literature assisting project managers in Africa or developing countries is scarce. They argue that most studies on project management in developing countries assume that project management is "necessarily Western" applied to some "remote outpost of poor physical and social infrastructure." This does not equip the project managers to deal with practical issues on the ground.

'Lack of data' is another factor challenging the development projects in Africa. Kakonge (2015) maintains that lack of background research and baseline data is a problem challenging development projects especially in Africa. Sometimes donors feel that carrying out feasibility studies may require more resources and waste time, but there are no shortcuts or easy fixes to unlock the risks and the uncertainties in projects. Muriithi and Crawford (2001) observe that, in Africa, political institutions are weak and unstable. The political systems tend to depend on patronage. The system of patronage affects the way that leaders and managers run institutions, both public and private ones. Ika and Saint-Macary (2014) cite that corruption, bad governance, and lack of project management capacity are some of the chief causes of project failure in Africa.

'Delays during project implementation' is another risk factor affecting the development project in Africa. Muriithi and Crawford (2001) claim that in Africa some public projects are deliberately made to drag on, due to the scarcity of employment and the result of job losses occurring at project closure. Consequently, those employed by the project may view delays as working in their favour. The delay in project implementation is coupled with the 'lack of funds and resources'. Even though the international development industry is a multi-billion dollar industry (Moyo, 2009; Ika et al., 2012), projects often face serious resource constraints. The complex project environments, the fragile institutions, and other factors call for an extraordinary number of resources for the development efforts to be effective.

Authors such as Ika et al. (2012), Ika and Hodgson (2014), and Diallo and Thuillier (2004) have noted the prevalence of bureaucratic procedures and rules in international development projects. This can be attributed to the complex web of stakeholders and the complex environments that often exist in development projects. Bureaucracy undermines the efficient operation of project and program processes.

'Donor bias' is another risk factor affecting the international development projects. According to Kakonge (2015), donors engage in projects already set their priorities. This can cause bias especially if the priorities are rigid. This situation poses the risk of overlooking important factors in pursuit of donor priorities. Economic risks, such as inflation, come with unstable economies often found in recipient countries (Diallo and Thuillier, 2004). Currency issues, inflation, and unstable economies can make planning and execution of projects difficult.

In addition, Hermano et al. (2013) identifies that 'extreme social-political complexity' is a risk factor threatening the development projects. Ika (2012) alludes that 'lack of implementation capacity by donors and recipients' is a problem in development project.

Overall, the study of risk factors inherent in international development project is prevalent. The extant literature reveals various risk factors affecting the success of international development projects, ranging from 'lack of project management skills' to 'donor bias'. Yet, the investigation into the risk factors in Zimbabwean health projects is not common.

RESEARCH DESIGN

Since this research gathers information on project risk factors, it is important to get the understanding from the perspective and experience of those involved in the projects and those who have practical first-hand experience in dealing with the phenomena under investigation. According to Zhang (2011), risk identification falls on the subjective side of risk in the sense that the presence or absence of a certain risk depends on the perception of the actors involved. The focus of this research is on identification of risks and therefore becomes subjective in nature. The subjective nature of risk identification requires the use of methods that are capable of extracting meaning out of the subjective expressions expected from the research. Qualitative research allows the themes of the issue under investigation to emerge from the research participants' subjective interpretation. Therefore, this research adopts a qualitative approach.

Data collection methods

The research objectives suggest a guided discussion or interview that focuses on the specific objectives. This research uses semi-structured interview to elicit the risk factors inherent in the health development project in Zimbabwe. The semi-structured interviews offer better focus on specific issues as compared to in depth interviews which are more generalised. The major interview question used for eliciting the risk factors is " What are some of the challenges experienced in running donor funded programs and projects in the health sector?".

Sample selection

There are mainly two types of sampling, probability sampling and non-probability sampling (Merriam and Tisdell, 2016). Probability sampling is mostly used in quantitative research where the research seeks to make inferences and generalizations about the population based on the sample studied (Saunders et al., 2012). By contrast, non-probability sampling mostly applies to qualitative research where the research seeks to discover “what occurs, the implications of what occurs and the relationships linking occurrences,” (Merriam and Tisdell, 2016). As the foregoing discussion, this research takes a qualitative approach to identifying risk factors in projects. Therefore, non-probability sampling will be used to select the sample of research participants.

Among the various sampling techniques in non-probability sampling, purposeful sampling was used in this research. The reason is that it is important for research participants to be well versed with the research topic and be able to provide meaningful information. Since this research is about risk factors in programs and projects in the health sector, the purposeful samples were composed of staff involved with the programs in the Ministry of Health and Child Care (MOHCC), donor organisations such as UNDP, PEPFAR, Global Fund, DFID and their implementing partners. The choice of respondents from these organisations is based on the organisations' involvement with donor funded programs hence their relevance to the research. The Ministry of Health and Child Care (MOHCC) is at the centre of all activity around donor funded programs and the organisations mentioned above have been among the top donors in the Zimbabwean health sector for quite some time. The contribution by these organisations and their countries is also acknowledged and reflected accordingly in the National Budget for 2019 (MOFED, 2018). The combination of these respondents is a potential treasure of information on the subject area and makes quite a good sample for this research

Sample size

In most non-probability sampling, the question of sample size is not important. Instead, the relationship between the sample selection technique and the purpose or focus of the research is more important (Saunders et al., 2012). Notwithstanding these facts, for purposeful sampling, a guideline of between 5 and 25 interviews is given by some researchers to try and help guide researchers on the number of interviews to conduct (Saunders et al., 2012). Although the sample size for this research is estimated to fall well within the above guidance, the number of interviews to be conducted will be determined by the point of data saturation (Saunders et al., 2012; Saunders and Rojon, 2014). Data collection and analysis will continue until data saturation is achieved. At the data saturation point, new data coming in will not reveal anything new which the research would not have already found, signifying that the research has gathered enough data and continuing with data collection may not add value to the research. It is important that at each stage a researcher is fully aware of the themes emerging from the data collection process because that is the only way researcher will gauge whether saturation has been reached in the process of conducting data collection and data analysis simultaneously.

Data analysis

Merriam and Tisdell (2016) explain the steps involved in qualitative data analysis. Data analysis starts with identifying segments of data that are "responsive" to the research questions and breaking the text down into those segments. The segments are units of data that may answer part of the research questions. The research text or transcripts are continually broken down into units or interesting chunks and coded accordingly. Initially, the entire text is openly broken down into chunks so the process is sometimes referred to as "open coding", (Merriam and Tisdell, 2016). The coded chunks of data begin to fall under various categories depending on the phenomena under investigation. After the entire transcript has been coded, the codes are then grouped into similar categories (Merriam and Tisdell, 2016). The processes are performed iteratively from transcript to transcript. While the iterations are happening, categories get refined and re-organized. Furthermore, the coding frequency mirrors the weight of a coded unit (Margrit, 2012). As such, in this paper, the frequency count is adopted to determine the importance/ranking of coded risk factors.

FINDINGS

A total of nine respondents were interviewed. The respondents constitute a purposeful sample of professionals who have worked on various projects in the health sector in Zimbabwe. They

are well versed in the research topic and can provide relevant information to the research. Table 1 shows the profiles of the nine respondents. Although the research could not get responses from people currently affiliated to other key stakeholder organizations such as Global Fund, the strategy used in the selection of respondents was expected to compensate for this. A pool of experienced professionals working on donor funded projects was identified. They affiliated to some of the stakeholder organizations. These professionals were requested to participate in the research, and research respondents were selected from those who were available from the pool to participate in the research. In selecting respondents, the diversity of the respondents' experience and the richness of their backgrounds were considered. The respondents selected currently work with or have previously worked with key stakeholders such as PEPFAR, Global Fund and the Ministry of Health and Child Care. At least seven of the nine respondents selected have solid and cross-cutting experience, working in at least two stakeholder organizations, such as Global Fund, the Ministry of Health and Child Care or other PEPFAR affiliated organizations. The diverse and inclusive nature of respondents' experience are meant to reduce bias in the data gathered. Saturation, as discussed in the research design was achieved on or about the seventh interviewee at which point the interviews seemed to be dwelling on the same or similar themes.

Interview times ranged from about 17 minutes to just over 30 minutes. The codes were developed alongside the interviews. The frequency count was adapted to analyse the coded results. The number or frequency of references to certain risk factors found in the analysis can be an important metric. The number of references is the frequency of a risk factor being mentioned directly. It reveals the importance of a risk factor derived from the interviewees' subjective interpretation. This can be a good indicator of the prevalence of a risk factor. Table 2 shows the risk factors identified through this qualitative analysis and the frequency count of each risk factor.

Table 1: The profiles of research participants

RESPONDENT	BACKGROUND AND EXPERIENCE
R1	PEPFAR HIV Services Programs (Senior Program Officer)
R2	PEPFAR Strategic Information Programs and Ministry of Health (Senior Program Officer)
R3	PEPFAR Interagency Program Coordination and Global Fund programs (Senior Program Coordinator)
R4	PEPFAR HIV Services Programs – Voluntary Male Circumcision and Ministry of Health (Senior Program Officer)
R5	CDC/PEPFAR Program Communications and Stakeholder Coordination
R6	Ministry of Health (Program Officer)
R7	PEPFAR HIV Services and Ministry of Health (Senior Program Officer)
R8	PEPFAR Implementing partner (Program Manager)
R9	Local Municipality Health Department and Ministry of Health (Senior Health Officer)

Table 2: Analysis of coded responses

Risk Factor		References
1.	Fragile institutions and structures	38
2.	Poor or inefficient use of resources	33

3.	Lack of trust between donors and recipients/Donor mistrust/Stakeholder dishonesty	26
4.	Abuse of funds	25
5.	Economic issues	23
6.	Donor bias/Lack of consultation	20
7.	Lack of resources/Tight host or recipient country budgets	20
8.	Lack of a comprehensive approach/Fragmented programs	17
9.	Sustainability problems	17
10.	Poor stakeholder commitment/Lack of project ownership by recipients	16
11.	Donors' lack of agreement/ lack of shared accountability framework/Difficulties in collaboration	15
12.	Lack of financial transparency	14
13.	Poor accountability standards by some donors	14
14.	Corruption	13
15.	Differing donor and recipient priorities	11
16.	Socio political complexity	11
17.	Conflict between development aid approach and the problem-solving approach	10
18.	Politics - Host country politics/Political differences between donor and host government	10
19.	Poor coordination	10
20.	Risk of doing harm	10
21.	Risk of excessive or prohibitive control	10
22.	Project delays	6
23.	The elephant in the room	6
24.	Differences in management culture	5
25.	Assumption risk	4
26.	Conflicting donor, recipient, and stakeholder policies	3
27.	Infrastructural challenges	3
28.	Shallow exploitation of project benefits	3
29.	Poor project planning	2
30.	Slow decision-making processes	1

In Table 2, based on the frequency of references found in the analysis, the top 10 ranking of identified risk factors is as follows:

1. Fragile institutions and structures
2. Poor or inefficient use of resources
3. Lack of trust between donors and recipients/Donor mistrust/Stakeholder dishonesty
4. Abuse of funds
5. Economic issues
6. Donor bias/Lack of consultation
7. Lack of resources/Tight host or recipient country budgets
8. Lack of a comprehensive approach/Fragmented programs
9. Sustainability problems

10. Poor stakeholder commitment/Lack of project ownership by recipients

The analysis shows that 'fragile institutions and structures' is the top risk factor, receiving the highest frequency count, i.e., 38. It is followed by 'poor or inefficient use of resources', and 'lack of trust between donor and recipient'. The 'poor or inefficient use of resources' is referenced 33 times by the respondents. The risk factor 'lack of trust between donors and recipients' is placed at the third place, and it is referenced 26 times by the respondents. The three top risk factors identified in Table 2 are not prevalent in the reviewed literature. Besides they are mainly associated with the internal environment, particularly the top risk factor 'fragile institutions and structures' and the second-ranked risk factor 'poor or inefficient use of resources'. This result suggests the managers of Zimbabwean health project need to pay more attention to the internal issues.

CONCLUSIONS

The research identified the risk factors for donor funded projects and programs in the Zimbabwean health sector from the data gathered. An interesting observation is that the major risk factors are related to the project internal environment, such as 'Fragile institutions and structures', 'Poor or inefficient use of resources', 'Abuse of funds' and so forth. Project management issues such as time, cost, scope, and quality seem to be overshadowed by those internal factors. The risks stemming from its internal environment may aggravate the success of health project in Zimbabwe. The research findings revel that equipping the project managers of Zimbabwean health projects with the skills to alleviate the impact of the identified internal risks should be given attention.

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THE APPLICATION OF LEAN SIX SIGMA IN REAL ESTATE DEVELOPMENT

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Today's economic climate compels property development companies to work smarter. The Six Sigma concept was developed by Motorola and focusses on the "Define, Measure, Analyse, Improve and Control" (DMAIC) concept. Lean evolved from the Toyota production system that focusses on the reduction of waste and improvement of customer value. The aim of the study was to develop an implementation strategy based on Lean Six Sigma principles for implementation in a property development company that will lead to the optimized use of resources as well as the delivering of a higher quality end-product to the client. As little evidence could be found that these principles have been used in South Africa, an extensive literature search was conducted on the theory behind Lean Six Sigma, after which practical examples from industry were used on how existing projects would have benefitted from utilizing some of the principles. The findings indicate that, with some creative thinking, the tools of Six Sigma can be applied to great effect in a property development environment. An implementation strategy is also suggested that can be used by property development companies that wishes to embark on a LSS strategy

Keywords: DMAIC, DMADV, Kano model, Lean, Six Sigma.

INTRODUCTION

Lean Six Sigma (LSS) consists of two systems, namely ‘Lean’ and ‘Six Sigma’. It consists of a set of process enhancement tools with the aim of reducing waste and standardising workflow, thereby providing the customer with a higher quality product at a lower cost (Anthony, Vinodh and Gijo, 2016). Both Lean and Six Sigma were originally developed for manufacturing but has since been implemented with great effect in various other industries, including banking, insurance, procurement, accounting, sales and marketing, finance, food, hardware, software, data security, oil and gas, hospitals and retail distribution and logistics (Martin, 2021). Lean principles have also been implemented by construction companies. A model which specifically targets the unique challenges associated with property development could not be found in literature. The focus of this study is therefore to investigate whether LSS can also be implemented in the property development industry.

LITERATURE REVIEW

In 1948 Toyota’s debt was eight times its total capital value (Liker, 2021). The Japanese car maker was too small and demand for its cars too fragmented to support high production volumes. It also did not have the cash to invest in mass produced parts that could stay on the shelf until it was needed. Its US rival, Ford, at the time produced 9,000 units a month of a limited number of models. Toyota, who only produced about 900 units per month, had to churn out low volumes of different models using the same assembly line. Toyota needed to adopt Ford’s manufacturing system, but adapted to achieve high quality, low cost, and short lead time items. This led to the development of the Toyota Production System (TPS).

In September 2020, Forbes listed Toyota as the biggest car company internationally based on 12-month trailing data, with a revenue of $248.6 billion, and a net income for the period of $14.4 billion. Ford only managed to land a fourth spot, with a revenue of $130.4 billion. The company in fact published a net loss for the period of $2.1 billion.

The TPS system, which led to the development of Lean, not only played a vital role in the financial successes at Toyota, but also led to the development of more reliable cars. In February 2021, JDPower.com listed Toyota as the fourth most reliable motor brand, behind its sister company Lexus, as well as Porsche and Kia (www.jdpower.com, 2021)

Snee (2010) reviewed 20 case studies on Lean and Six Sigma, published in countries such as the US, China, Malaysia, New Zeeland, India, Taiwan, and the Netherlands, and found that the combination of these systems in various manufacturing settings led to the following top ten benefits:

- Increased profits and financial savings;
- Increased customer satisfaction;
- Reduced operational cost;
- Reduced cycle time;
- Improved key performance metrics;
- Reduced defects in processes;
- Reduced machine breakdown time;
- Reduced inventory;
- Improved quality, and
- Increased production capacity.

What is Lean?

The core idea of Lean is to maximise customer value while minimising waste. In simple terms this means creating more value for customers with fewer resources (Lean Enterprise Institute, n.d.).

The key focus of Lean is to enhance customer value by improving, smoothing out and standardising the process flow, thereby eliminating waste. The Lean system has been in development from Henry Ford's first production line, but much of the development has been led by Toyota through the TPS. Although Lean thinking is often associated with manufacturing, many of the tools and techniques it utilises, such as spaghetti diagrams and visual systems used by supermarkets to replenish shelves, were developed in the service industry (Morgan and Brenig-Jones, 2015).

Toyota's own Taiichi Ohno describes the TPS approach as follows:

"All we are doing is looking at a timeline from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that timeline by removing the non-value-added wastes."

In the Lean system the customer, not the organisation, specifies value. Value is what a customer is willing to pay for. To satisfy a customer the organisation must provide the right products and services at the right time, of the right quality, and for the right price. To achieve this consistently one firstly must understand the process flow, and then improve the process

by reducing unnecessary steps and waste. Lean thinking has five key principles (Morgan and Brenig-Jones, 2015):

- Understand the customer and his perception of value;
- Identify and understand the value stream for each process and the waste within it;
- Enable the value to flow;
- Let the customer pull the value through the processes, according to his needs, and
- Continuously improve the process.

What is Six Sigma?

Six Sigma is a set of management tools and techniques designed to improve business by reducing the likelihood of errors occurring. It is a data-driven methodology that provides tools and techniques to define and evaluate each step of the process to improve efficiencies in the business structure, improve the quality of the process and increase profits (Sixsigmadaily.com, 2020).

The quest to achieve Six Sigma had its origin at Motorola in 1979. Motorola at the time was facing extreme pressures from overseas competition, particularly Japan. American companies believed that quality cost money, and Motorola was spending between 5 – 10% of annual revenue, and in some cases as much as 20%, correcting poor quality products. This translated into $800 – 900 million in lost revenue each year (Harry and Schroeder, 2000).

Motorola executives began to look for ways to cut waste. At the same time Bill Smith, an engineer at Motorola's Communications Sector, was studying the correlation between the field life of Motorola's products and how often that product had been repaired during manufacturing. Smith concluded that if a product was found defective and was corrected during manufacturing, other defects were often also missed, defects which were discovered by the customer during early use of the product. However, when a product was manufactured error-free, it rarely failed during use by the customer. Smith's finding ignited a debate within Motorola. Further analysis showed that a concerted effort at detecting and fixing defects would lead Motorola only to four Sigma, only slightly better than the average American company. At the same time Motorola found that their Japanese competition were already producing products which required no repair or rework during manufacturing. Motorola therefore set their target on a Six Sigma deviation. Although this target was specific to what Motorola was trying to achieve during their manufacturing process, Six Sigma became the norm as other companies also began to adopt the system.

Motorola was the first American company to realise that, if done right, improving quality would not increase costs, but would reduce it. Motorola began its quest to improve quality, while simultaneously reducing production time and cost, by focusing on how the product was designed and manufactured. The link between higher quality and lower cost led to the development of Six Sigma, where the focus was on improving quality through the use of exact measurements to identify problem areas early on. This allowed the business to be proactive, rather than reactive, with regards to quality.

Motorola set a goal of tenfold improvement in five years, with a plan focused on global competitiveness, quality improvement and training. All employees underwent training, and Six Sigma became the standard for all Motorola business processes (Morgan and Brenig-Jones, 2015:17).

A quantum leap in manufacturing technology occurred at Motorola when it applied Six Sigma to the development of its Bandit pager (Harry and Schroeder, 2000:11). Within eighteen months, Motorola manufactured a pager than could be produced in its factory in

Florida within seventy-two minutes from the time an order was placed at the Motorola sales office. The superior design and manufacturing process of these pagers resulted in a product with an average life expectancy of 150 years. These pagers were so reliable that the company after a while stopped product testing on them, as it was more cost-effective to just replace it in the unlikely event that one failed.

What is Lean Six Sigma?

Introducing Six Sigma in isolation cannot remove all types of waste from the business process and deploying Lean management in isolation cannot bring a process into the state of statistical control and remove variation from the process (Corett, 2011). Some companies therefore decided to merge both methodologies to overcome the weaknesses of these two continuous improvement methodologies, and to come up with a more powerful strategy for continuous improvement and optimisation (Bhuiyan, Baghel and Wilson, 2006). The integration of these two approaches lead to greater efficiency and assisted to achieve superior performance faster than the implementation of each approach in isolation (Salah, Rahim and Carretero, 2010).

Lean Six Sigma (LSS) was first introduced into the literature in 2002 as part of the evolution of Six Sigma (Timans, Anthony, Ahaus and Solingen, 2012). Since then, there has been a noticeable increase in its popularity and deployment in especially large business, for example Motorola, Honeywell, and General Electric (Laureani and Antony, 2012).

Arnheiter and Maleyeff (2005), state that in a competitive environment, diminishing returns may result when either Lean or Six Sigma is implemented in isolation. There is however no universal determinant of when to use Lean or when to use Six Sigma. Both offer complementary tool sets which, together and in combination with best management practices, offer a comprehensive means of transforming a business to operational excellence.

Bertels (2003) also argues that using either one of them in isolation has limitations: Six Sigma will eliminate defects in processes but will not assist with the optimisation of process flow. Lean, on the other hand, are not particularly useful in achieving high capability and high stability processes.

Implementing the Lean methodology in combination with Six Sigma will not only lead to quick process improvements but will also allow the company to leverage such improvements companywide, as the infrastructure will then exist to do this quickly and efficiently, resulting in a quantum increase in product quality, process performance or organisational performance (Sharma, 2003).

According to Morgan and Brening-Jones (2015) the seven principles of Lean Six Sigma are:

- Focus on the customer;
- Identify and understand how the work gets done;
- Manage, improve and smooth the process flow;
- Remove non-value-adding steps and waste;
- Manage by fact and reduce variations;
- Involve and equip the people in the process, and
- Undertake improvement activity in a systematic way.

Lean six sigma and the property industry

Although no literature could be found pertaining to LSS in the property industry, there are information of using the lean concept in the construction industry. Koskela (1992) wrote a

technical report detailing the application of what he called the "New production philosophy" to the construction industry.

In this report, he likened the traditional model of the construction process with that of the traditional manufacturing model, where processes were regarded as “conversion type” processes only. In the new production philosophy, manufacturing processes were considered as consisting of both “flow” and “conversion” activities. As only conversions add value to the product, these activities need to be made as efficient as possible while the “flow” processes must be eliminated or shortened as far as possible in order to increase process efficiency. Koskela, (1992) argued that given the similarities between manufacturing and construction, a similar paradigm shift from the traditional view of construction processes as conversion processes was necessary. The same principles of eliminating or shortening the wasteful “flow” activities (as in the new manufacturing production philosophy) could then be applied to construction activities to increase efficiency.

METHODOLOGY

While investigating the possible deployment of LSS in a property development setting, as mentioned no specific research on the topic could be found, although some studies do exist on lean construction. Although the reason for this absence of previous studies is not clear, it can be speculated that (especially) the South African property development industry is fairly conservative and therefore reluctant to invest time and money into a relaively complicated theoretical process. Implementation strategies tailored to various other industries have however been published by various authors. Although the principles of LSS are broad enough to allow universal implementation by almost any type of business (Villanova University: 2020), it will in the first place be necessary to test the premise that LSS can be tailored to property development. If this is the case, scenarios of such application can then be constructed, and a possible implementation road map designed. To thereafter test this implementation strategy in the marketplace would be the ideal solution. However, such a study could take years to conduct, as is evident from the opening paragraphs of ‘The Toyota way’ (Liker, 2021), which states that the two pillars of TPS are “continuous improvement” and “respect for people”. As a study of LSS deployment and the tracking of the continuous improvements made to such a program falls outside the scope of what is possible with this study, a more theoretical and philosophical approach will be followed. If the outcome of this study yields positive results, leading to implementation by property developers, a future study could focus on the results of development of specific case studies.

This study will predominantly make use of secondary data, namely literature on the topic of Lean, Six Sigma and LSS. This data will be analysed to determine its possible application in a property development environment, after which its implementation and possible success will be discussed based on scenarios often encountered in practice. A number of practical applications based on LSS principles, as applied by a real estate development firm, will also be included.

PRACTICAL IMPLEMENTATION

Due to the vast number of applications of Six Sigma and Lean, only a few of the practical aspects of LSS that relates to property development will be looked at.

In property development to be successful at marketing products and services, it is necessary to understand not only the needs customers are able to articulate, but also what they are unable to express (Mahoney, 2003). To understand customer needs, two aspects are important: value (one of the five principles of Lean), and customer focus (one of the principles of LSS). Value, according to Thompson (1993) can be defined as the "amount for

which a thing can be exchanged in the open market; therefore, the amount a customer is willing to pay for something. To better understand customers' requirements and their perception of value, the Kano model developed by Professor Kano from the Tokyo University, can be used (Morgan and Brening-Jones, 2015).

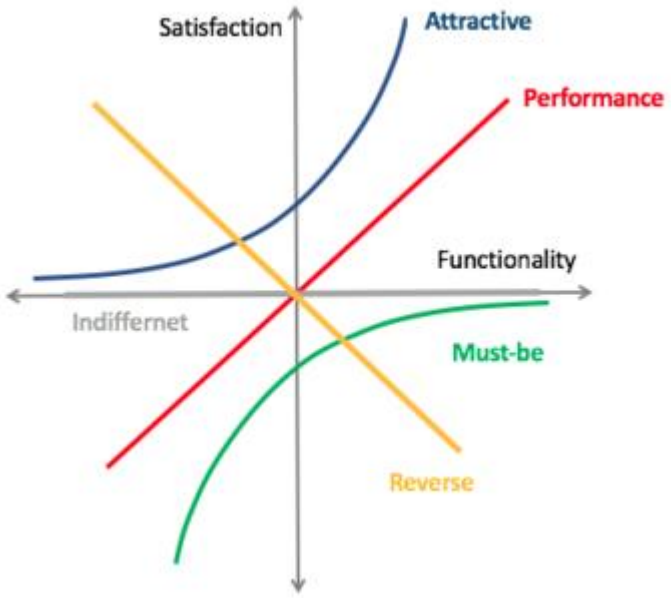

Figure 1. The Kano model (Trebin, 2018)

The Kano model uses the y-axis to indicate the degree of satisfaction of the customer: a very satisfied customer is indicated in various degrees above the x-axis, a neutral customer where the y-axis intersects with the x-axis, and a dissatisfied customer in various degrees below the x-axis.

The x-axis in turn indicates the level of execution of the requirement by the company or organisation. Here the left most point of the graph is indicating a product or service that was executed very poorly, or not at all. To the right of the y-axis a product that was executed to various degrees of success is shown

To find out what customers want, developers must talk, listen and observe them (Morgan and Brening-Jones, 2015). In property development, the "voice of the customer" (VOC) is normally that of the end user of a building. CTQs, or "Critical to quality", is a measurable way to analyse VOC requirements. . A CTQ is not a prescribed solution to an issue, but rather a positive statement about what the customer wants. It should be measurable and, where appropriate, have an upper and lower specification limit as target value (Morgan and Brenig-Jones, 2015).

Scenario application

Assume the estate agent marketing a new townhouse development currently under construction in Johannesburg from a housing developer, have asked potential buyers who visited the show unit for their opinion of the units on offer and their motivations and perceived value the development offers. Their comments summarised in a CTQ table are as follows:

Table 1: An example of a CTQ scenario

Voice of the customer	Key issue	CTQ	C	Type I	Type II	Type III	Type IV
I am looking for a 3-bedroom townhouse with 2 bathrooms for not more than R1.2 million. Yours are R1.35 million	Townhouse too expensive	Provide 3-bedroom, 2-bathroom for not more than R1.2 million		12	123	24	46
You provide a melamine kitchen counter where other units have granite kitchen tops	Kitchen worktop inferior to competition's	Worktops in kitchens must be upgraded to granite in line with others'		14	12	25	32
Can I add burglar proofing and a gas stove to my unit? Your brochure does not mention it	Marketing brochure is incomplete	Address buyers' options in marketing material		18	16	21	45

In Six Sigma there are two sequential processes that can be applied to solve the above problems namely DMAIC (define, measure, analyse, improve, control) and DMADV (define, measure, analyse, design, verify)

Table 2: DMAIC vs DMADV

DMAIC	DMADV
Minimise variation in an existing process	Producing a standardised process that is done right the first time
Corrective action	Preventive action
Quantitative statistical tools	Qualitative tools
Focus on one or two critical QTC parameters	Focus on all QTC's
Often take a short time to fix the problem and improve the process	Projects often larger and take longer
Short-term business needs for QTC improvement	Long-term need for new products and services
Measures current performance and process	Measures customer specification and needs
Improve the process by eliminating defects	Design and optimise the process to meet customer's needs

If one looks again at the CTQ scenarios as indicated previously in Table 1, the scope of this paper does not allow extensive discussion around these scenarios. Only a broad outline of the methodology proposed to resolve each will be presented.

CTQ 1: "I am looking for a 3-bedroom townhouse with 2 bathrooms for not more than R1.2 million. Yours are R1.35 million".

The customer indicated that the unit is too expensive if compared to that on offer by the competition. The customer therefore does not consider the cost of the unit in line with its perceived value.

Possible solution: DMAIC combined with Lean principles. This example requires that significant changes be made to the development and construction processes, to produce a better product at a reduced cost. To initiate the process the existing development process can be interrogated using the DMAIC technique. What are the main cost factors during development and how do they influence the final sales price? The factors which must be identified will not be site specific, for example the cost of the land or connection fees but will be factors which will apply to all developments by the developer. The following are examples of what may be found to be the most predominant cost factors when looking at a residential development:

- Bond raising fee by bank too high;
- Finance charges too high;
- Sales agent commission too high;
- Professional fees too high, and
- Construction cost per square meter too high.

Each of the reasons identified must then be investigated to see if and how they can be addressed. High interest charges can for example be addressed by utilising just-in-time production. A high construction cost can be improved on by making use of Lean principles. Which materials are the biggest cost drivers? Are there alternatives? An A3 process can be used to find solutions. A value-added flow chart can be used to determine non-value add stops in the development process. Waste in the process can be determined and flow improved (note that aspects such as just-in-time, A3, value-added charts and waste management have not been discussed in the paper, but are all part of the LSS process)

After identification of the factors which have the most influence on the return and its influence measured and analysed, it must be improved upon, and the success of the solution monitored (Controlled).

CTQ 2: " You provide a melamine kitchen counter where other units have granite kitchen tops".

In this example the customer indicated that the specification used by the developer is not comparable to that on offer in the rest of the market.

Possible solution: DMAIC. The design of the units must be improved. The specification of the kitchen worktop is outdated and must be revised. Kano modelling can be used to determine what customers consider to be a basic minimum requirement in a residential unit. Here the biggest issue is not the cost of the material used, as the difference between a melamine and granite worktop is marginal in relation to the overall cost of the unit and holding cost if not sold. Rather the issue is that the design lacked a feature considered to be a basic requirement in the market. The process of how and by whom building specifications are approved must be investigated. It might be necessary to get the sales department involved earlier on in the development process, or to obtain the Voice of the Customer through market research, or a market survey, before specifications are finalised.

CTQ 3: " Can I add burglar proofing and a gas stove to my unit? Your brochure does not mention it"

In this example the problem is two-fold: the design of the unit must be investigated to determine whether a gas connection might be possible. If this is the case the marketing material must be updated to reflect this option. Possible solution: DMADV and DMAIC. Use DMADV to design future units that are capable of being converted to receive gas cooking units. Use DMAIC to create a process where all possible optional extras are indicated in the sales material.

Other applications

One application that must be mentioned is the identification and management of waste, which is an important Lean application. What is worth mentioning on this topic is the different types of waste that are most associated with Lean production and that can be related to the property development market:

Inventory: Inventory, in a manufacturing setting, refers to goods that are finished beyond the immediate need. This not only locks in capital and hampers cash flow, but also requires space to store. This form of waste can be eliminated by utilising a just-in-time (JIT) approach (Anthony et al, 2016). In property development the best example of JIT would be the ability to anticipate market demand so that the right product for the right market segment can be offered when the demand for that product is high

Waiting: In Lean terminology this refers to the idle time generate when two interdependent processes are not absolutely synchronised. Waiting is considered a waste as it disturbs flow (Anthony et al.,2016).

In property development waiting on information often occurs between the professions in the professional team: the engineer waits for the basic design from the architect, the quantity surveyor waits for the engineering design. Waiting is almost impossible to omit from property development entirely, as design time is involved. However, recognising the waste due to waiting and deliberately planning activities around it could limit its effect on a business

Over-production: This occurs while producing a product or service before the customer requires it. This leads to high levels of inventory and increased storage cost. In property development an example of this type of waste would be an architect who develops drawings to town council submission detail, even though the preliminary design has not been approved by the developer (Anthony et al., 2016)

Over-processing is caused by non-standardisation of processes and unclear information about the specifications of the product (Anthony et al., 2016). An example of over-processing in property development is where an architect creates 3-D presentations for a development where only a preliminary design is needed.

Defects: in manufacturing defects refer to that part of production that is considered scrap or require re-working. With residential developments defects can be caused by drawings that are not adequately checked before construction and lead to defective work

Other applications of DMAIC in practice

DMAIC is also used to improve an existing process that is not running optimally. An example of this is the following:

Design phase: A construction company investigates their building cost on a new development. The development is found not to be constructed at the profit margins originally envisaged and an investigation is launched to find the reason.

Measure phase: during the measure phase it is found that that the cost to construct the brickwork is running over budget. The QS measured the following brickwork areas when originally costing the project:

Total scope of project brickwork:

Superstructure brickwork 0 - 3m high 6 500m2
Superstructure brickwork 3 - 6m high 6 500m2
Superstructure brickwork 6 - 9m high 6 500m2 Total brickwork area 19 500m2 By applying these quantities to the construction firm's cost build-up for a one brick wall, it culminated in the following budget for brickwork: Cost of brickwork: R334,84 per m2 excluding VAT; total cost of brickwork for the development: 19 500m2 x R334,84/m2 = R6 529 432.

Analyse phase: during this phase it is discovered that the original costing did not consider the additional labour cost, due to a reduction in daily output, for building on the upper floors. The actual cost therefore should be as follows:

Superstructure brickwork 0 - 3m high R 2 176 477 (no change form original)
Superstructure brickwork 3 - 6m high R 2 428 815
Superstructure brickwork 6 - 9m high R 2 512 928 Total cost of brickwork (actual) R 7 118 220. This therefore results in a budget overrun on the brickwork cost of R558 788

Improve phase: in this phase options are investigated to improve the situation. During a brainstorming session the site foreman suggests the following two possible options:

a) the hiring of a telehandler to lift the bricks to the upper floors, or

b) the hiring of a conveyor belt to transport the bricks to the upper floors.

The QS is tasked to investigate the two options. He found that, due the high cost of the telehandler (R5 058 per day), this will not be a viable option. In contrast, the conveyor belt's cost is only R360/day and does not require a skilled operator. If the cost for the conveyor belt is therefore considered, the overall cost for the brickwork comes to R6 658 132, reducing the budget overrun to R128 700.

Control phase: in this phase the output of the bricklayers is monitored to ensure that the original envisaged production of 4 000 bricks per day is maintained.

Application of DMADV in practice
An application of DMADV in property development would be as follows:

Design phase: a VOC conducted on the target market demographic for a new middle-income housing development in Tshwane revealed that prospective owners are concerned about the rising cost of electricity. The new generation of first-time home owners also want to contribute to a healthier environment and therefore prefer developments where green energy is being utilized, if it not too expensive. To stay competitive in the market, the developer has identified solar panel technology as a possible installation to be used.

Measure phase: the electrical engineer calculates that the estimated power consumption for the new development will be as follows:

Number of units: 30

Estimated usage (units): 450kWh/unit

Estimated usage (common areas):1 215kWh

Total usage: (30 x 450) + 1215 = 14 715 kWh.

The above usage will amount to the following estimated annual electricity charge from the municipal council:

Period: 12 months

Total kWh: 14 715

Basic monthly rate charge: R1 430.79

kWh tariff: R1.70

Vat: 15%

Estimated total annual charge: (((14 715kWH x R1.70) + R1 430.79) x 12 months) x 1.15 = R364 958.80 (inclusive of VAT).

Analyse phase: on a development of 30 units an electricity bill of R364 958.80 would amount to a monthly levy by each owner of:

R364 958.80 /12 months / 30 units = R1 013.77 per unit per month

Design phase 2: a solar energy specialist is contacted and a system consisting of solar roof panels, with temperature probes in the geysers, are proposed. The energy supplement generated by the above system is estimated to be:

Period: 12 months

Total kWh: 11 286 (reduced from 14 715)

Basic monthly rate charge: R1 430.79

kWh tariff: R1.70

Vat: 15%

Estimated total annual charge: (((11 286kWH x R1.70) + R1 430.79) x 12 months) x 1.15 = R284 514.46 (inclusive of VAT).

The total annual saving is therefore: R364 958.80 - R284 514.46 = R80 444.34 including VAT. The monthly levy charge will therefore be reduced from R1 013.77 per unit per month, to R790.32 per unit per month, a saving of 22%.

The system will cost R426 000.00 including VAT to install. If paid off monthly by the body corporate over a period of 20 years with a loan at 7% interest, the monthly instalment will be R3 302.77 per month, or R110.09 per unit.

The net saving per unit is therefore R1 013.77 - R790.32 + R110.09 = R113.36 per month. It is also important to consider that with electricity rates bound to increase in future, the first-year saving will only increase with time.

Verify phase: during this phase the effect of the system is monitored to ensure that the reduced consumption is within an acceptable margin of error of the design specification of the system.

AN LSS IMPLEMENTATION STRATEGY

The question that was asked at the start of the paper was whether LSS can be implemented in an organisation such as a real estate company. Kumar, Anthony and Tiwari (2011) introduced what they called ' "road map" on how LSS can be implemented in small and medium sized

enterprises. Based on this road map, such an implementation strategy can be based on the following five phases:

1) Assessment of readiness
The implementation of Lean Six Sigma in an organisation for the first time requires significant commitment and contribution from all levels within the organisation, as it aims to transform the culture in the organisation towards process improvement. For some organisations, external factors, such as a high level of customer complaints or diminishing market share may leave them with little choice but to consider the change. For others the driving considerations might be factors such as performance improvement, process improvement and employee satisfaction.

Regardless of the specific reason the fact remains that, if the organisation is not ready for LSS, it can not only cause the implementation to fail, but can also cause frustration among the workforce and create a resistance towards any similar initiatives in future. Anthony, Vinodh and Gijo (2016) therefore suggest that the following Readiness Factors (RF's) be considered before embarking on the LSS journey:

Senior management's commitment and involvement: LSS is a top-down initiative, and it is therefore vital for senior management to commit time and resources to the process. The commitment of senior management must be visible, and it is also important for leadership to acknowledge and encourage workers by implementing a recognition and reward system.

Customer focus: Customer satisfaction is a key aspect of the LSS process and ways to fulfil customer expectations must be embedded in the LSS framework. Projects must be implemented only after the perception and expectations of the customer regarding products or services are clearly understood. Otherwise LSS will not necessarily create an impact on the organisation or the customer.

Select the right people: Anthony, Vinodh and Gijo (2016) state that the success of LSS deployment depends on selecting the right task force members. Each team must consist of a team leader and team members, made up out of the best people from respective departments. While the team leader is responsible for the timely completion of the project with expected results, the team members are selected from respective sub-processes and must have the skills needed to assist in the collection of data and contribute in terms of process knowledge. Overall, the team should act as change agents in the organisation as part of the cultural transformation towards data-based decision-making

Education and training: The success of LSS depends on its effective integration within a business unit. For LSS to be effective the workforce must have a clear understanding of the LSS framework and must be trained on the deployment states. Training must be planned for the different LSS levels, for example black belts, green belts, yellow belts, and ordinary workforce. For each project the right LSS matrix must be selected, and team members must be trained on its use.

2) Conceptualisation.
During the Conceptualisation phase the foundation for LSS deployment is initiated. LSS is implemented with a top-down approach. Top management must therefore evaluate the urgency and competitive advantage that could be gained through the implementation of LSS. If a need is identified, management should take the initiative to communicate with employees the reasons and significance of LSS implementation. It is also during this phase where the budget and other resources necessary for LSS implementation must be budgeted and planned for.

3) Initialisation.
During this phase the criteria for selecting LSS projects and identifying the resources needed to execute each project are identified. LSS projects can be selected from a customer or business perspective. LSS implementation teams are selected during this phase.

4) Implementation.
In the Implementation phase the tools discussed earlier on in this study is identified and utilised. Depending on the type and complexity of the problem the project team is tasked with, different types of tools and techniques need to be applied for analysis and decision-making.

5) Sustenance.
The biggest challenge in any process improvement initiative is sustaining the achieved results (Anthony, Vinodh and Gijo, 2016). Barriers to sustainability include factors such as high staff turnover, lack of skilled manpower and limited resources to invest in automation equipment.

Anthony, Vinodh and Gijo (2016), argue that the only way to achieve sustainable results is through standardisation, monitoring and training. If an organisation is certified by the International Organisation of Standardisation (ISO), it is a good idea to bring all modified or newly introduced documents into this document control system, to ensure that everyone in the organisation follows the improved process. A report of LSS implementation success stories must be prepared by the team who successfully executed the project and must be communicated within the organisation. Employees must also be motivated with suitable rewards schemes for projects which were successfully completed. This will create a positive culture within the organisation towards LSS.

CONCLUSION AND RECOMMENDATIONS

Although Lean and Six Sigma were both created to solve problems relating to the product manufacturing process, the principles of these two systems, separate or in combination, have been applied in many different industries. The conclusion of this study is that, with a little creative thinking, these tools can also be applied to great effect in a property development environment. Lean Six Sigma is not a magical “quick fix” solution and will take years to implement and a lifetime to perfect. Indeed, the statistical bar is set so high with Six Sigma that for most organisations it will remain a goal to strive for as long as the business exists. At the core of Lean Six Sigma is therefore the dream to better an organisation every day in a quest to achieve the almost impossible.

Since one of the limitations of this study was that it focussed mainly on residential developments, a recommendation for further studies will be that other property development markets such as retail and office developments should also be investigated for the possible implementation of LSS. As there are some construction companies in South Africa that have started to explore the possibility to implement the principles of lean construction in their businesses, a recommendation can also be made that property developers, who employ outside construction companies, make use of such firms with the aim of combining resources towards implementing LSS.

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AN EVALUATION OF EDUCATION CURRICULA FOR FULL IMPLEMENTATION OF INDUSTRIALISED BUILDING SYSTEMS IN THE NIGERIAN CONSTRUCTION INDUSTRY

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An Industrialised Building System (IBS) is an integrated approach that combines manufacturing and construction processes, with an attempt to limit delays, dependence on labour and a reduction in the cost of construction. Implementation of IBSs could be a viable means of limiting infrastructural deficit in developing countries including Nigeria. Lack of adequate knowledge and skills of project personnel have been noted to be a major barrier for the adoption and implementation of IBSs, and therefore, formal education and training provides an avenue for learning, and ultimately improving IBS adoption. The study seeks to determine the extent IBSs are addressed in the curricula and compare with what is expected for effective implementation of IBS with a view to establishing the knowledge gap. The aim of this research is to assess course curricula content in four public universities situated in the Northern part of Nigeria offering all four construction related programmes, namely Architecture, Building, Civil Engineering, and Quantity Surveying using content analysis. Thematic areas of knowledge requirements for IBS implementation were determined from the literature and validated by construction professionals. The results showed that IBSs are mostly seen in the curricula as part of a departmental course content. The Department of Building had the highest percentage inclusion of 38.1%, while the Department of Architecture had the lowest percentage inclusion of 19.1% in the curriculum. The study also determined that knowledge with respect to placing / handling components, storage of IBSs' components and challenges faced during IBSs' implementation are largely lacking in the curricula across the various departments considered. The study concludes that IBSs' knowledge inclusion in the curricula of the Nigerian universities is below average and needs improvement so as to bridge the gap in terms of knowledge required for the effective implementation of IBSs in the Nigerian construction industry.

Keywords: Construction, Conventional Building Systems, Curricula, Industrialised Building Systems, Universities.

INTRODUCTION

The construction industry is very important and has been considered as the most complex and dynamic sector that requires skilled labour, effective management, and efficiency of design input (Nawi, 2012; James et al., 2012). The industry plays an essential role in the economic development of any developing nation (Kheni, Gibb and Dainty, 2008), and especially in a growing economy such as Nigeria (Shittu and Shehu, 2010; Ibironke, 2004).

It has been verified that traditional and conventional technologies used for construction and maintenance of buildings are inefficient and result in waste due to their nature and resources

used, which has led to the need for the development of alternative technologies in most developed countries (Ayoola and Aghimien, 2017). Furthermore, Bankole (2008) believes that human taste and needs have transcended beyond having a structure as a shelter, and have evolved focusing attention on durability, flexibility, functionality, rapid construction processes, cost effectiveness, aesthetics, and comfortability.

In Nigeria, access to affordable housing has greatly remained an unfulfilled dream to the vast majority, particularly the middle and lower classes of society (Moore, 2019). The housing deficit issue dates from the time of Nigeria's independence, however, it has worsened, and successive governments have continued to battle with the problem. A recent study of the housing situation in Nigeria, estimated the existing housing stock at 23 per 1 000 inhabitants. The country's present housing deficit as of January 2019 is estimated at a staggering 20 million units, which is approximately a 15.0 per cent increase relative to December 2018. This is a clear indication that there is need for a radical approach to mitigate the housing shortfall (Moore, 2019).

Mohd and Nuzul (2013) assert that the Conventional Building System (CBS) is not the best solution to housing issues as the method is much more expensive especially in terms of labour, raw materials, transportation, and the duration of construction. With these various disadvantages of using the CBS the need for a new system of building construction cannot be overemphasised, and one such development is the IBS.

Lessing (2006) states that the IBS is an integrated manufacturing and construction process with well-planned organisation for efficient management, preparation, and control over resources used, activities and results supported by the used of highly developed components. Inherent benefits of the IBS are not limited to reduced general labour, reduced wastage, and the volume of building materials, increased environmental and construction site cleanliness, and enhanced quality management, but also healthier and safer and more organised construction sites, reduced construction time, and reduced wastage (Construction Industry Development Board (cidb), 2003a; Mohamad Kamar, Alshawi and Hamid, 2009; Nawi, 2012). The IBS is a method that needs high construction precision and key players among the industry lack knowledge in executing IBS projects (Hamid et al., 2008).

Ayoola and Aghimien (2017), Nawi et al., (2014), Samari et al., (2012), Mohamad kamar et al., (2009) and Hamid et al., (2008) concluded in their findings that most local professionals and contractors lack technical knowledge and experience to execute IBSs. Hassim, Jaafar and Sazalli (2009) point out that IBSs requires more skills from workers when compared to CBSs. Unlike CBSs, skills required in IBSs are more machine-oriented on and off sites. According to Hamid et al. (2008), this leads to a need for transformation requiring the education and training of human resources in an organisation to enhance the use of IBS. According to Omolola and Natali (2019), and Ibrahim et al. (2017), improving the educational curricula and adopting intensive training for the prospective IBSs' practitioners is a strategy that could help in improving IBS implementation in Nigeria. The study therefore sought to determine the extent to which IBSs' knowledge is included in the architectural, building, civil engineering, and quantity surveying curricula of public universities in northern Nigeria with a view to establishing the knowledge gap.

LITERATURE REVIEW

Historic definitions of Industrialised Building Systems

The earliest definition of IBS identified in the literature is a definition by Dietz (1971) as a total integration of all subsystems and components into an overall process fully utilising industrialised production, transportation, and assembly methods. But the definition was

improved by Junid (1986) by adding ‘structured planning’ and ‘standardisation’. The system includes a balanced software and hardware component. The software element includes system design, which is a process of studying the requirement of the end user, the development of a standardised component, and market analysis. Esa and Nurudin (1998) defined an IBS during the first IBS colloquium in Malaysia as a continuum starting from utilising craft workers for all aspects of construction to a system that uses manufacturing production to minimise resource wastage and enhance value for end users. The term building system is defined by Warszawski (1999) as a set of interconnected elements that join to enable the designated performance of building. It is also characterised as a set of interrelated elements that act together to enable the designated performance of a building. Haron et al. (2005) and Marsono et al. (2006) define IBS as one of the construction methods that can upgrade productivity and assure the quality of the constructed product by using better machinery, equipment, materials, and extensive project planning, while Abdullah and Egbu (2009) state that an IBS can be classified as a modern construction method, prebuilt system, entailing advance automation, and volumetric construction.

Classification of IBSs

IBSs have various classifications based on the materials, processes, and systems. For further exploration and discussion between academics and researchers in this field, a general classification for IBSs as stated by (Kamar et al., 2011) are frame system (pre-cast or steel), panel system, onsite fabrication, sub-assembly and components, block work system, hybrid system, and volumetric / modular system.

However, over the years, the classification of IBS has consistently been improved upon to capture current needs and challenges as shown in Table 1.

Table 1. Classification of IBSs over the years in Malaysia

IBS Introduced in	Authors	Types of IBS Classifications
Early 60's	Badir et al. (2002)	1. Frame system
		2. Panel system
		3. Box system
Early 90's	Badir et al. (1998)	1. Precast concrete framing, panel, and box systems
		2. Load bearing block
		3. Sandwich panel
		4. Steel frame
2003	CIDB (2003b)	1. Pre-cast concrete framing, panel, and box systems
		2. Formwork system
		3. Steel framing system
		4. Prefabricated timber framing system
		5. Block work system
2010	CIDB (2010)	1. Pre-cast concrete system
		2. Formwork system
		3. Steel framing system
		4. Prefabricated timber framing system
		5. Block work system
		6. Innovative system

In the current Malaysian context, the CIDB has classified IBSs into six types as depicted in Table 1 and further described in Table 2.

Table 2. Current IBS classifications

Classification	Description
Pre-cast concrete system	The common IBS used includes precast concrete elements (precast concrete columns, beams, slabs, walls, and 3D components), lightweight precast concrete and permanent concrete formworks.
Formwork system	Considered as one of the low level or the least prefabricated IBS. The system involves site casting, offers quality finishes, and fast construction with less labour and materials required.
Steel framing system	Commonly used with precast concrete slabs, s steel framing system has always been a popular choice and used extensively in fast-track construction of skyscrapers. Recent developments of this IBS include the usage of light steel trusses consisting of cost effective profiled cold formed channel and steel portal frame system. These are the alternatives to the heavier traditional hot rolled section.
Prefabricated timber framing system	This system consists of timber building frames and timber roof trusses. Timber building frame systems also have their market and demand, offering attractive designs from simple dwelling units to buildings that required high aesthetical value such as resorts and chalets.
Block work system	The construction method of using traditional bricks has been revolutionised by the development of interlocking concrete masonry units and lightweight concrete blocks. The tedious and time-consuming traditional bricklaying tasks is vastly simplified by the usage of these effective solutions.
Innovative system	To classify new systems introduced in the Malaysian construction industry that are not included in the five main IBSs in the CIDB's IBS classifications (2003), the CIDB introduced an innovative system to classify the new and innovative IBSs.

Adopted from the CIDB (2010).

Advantages of IBSs

The advantages or benefits of IBSs in construction have been highlighted by various researchers (Kamali and Hewage, 2016; Abdulaziz, 2010; Bing et al., 2001; Zaini, 2000; Warszawski, 1999) over the years since the adoption of their use by developed countries, and some developing countries. These are discussed below.

Eco-Friendly

Modular construction is often recommended for energy efficiency, and sustainable construction. Traditional construction methods require more usage of materials that lead to increased waste. However, since prefabricated sub-assemblies are constructed in a factory, waste materials can be recycled in-house, more accurate construction, tighter joints, and better air filtration, which allows for better wall insulation, and an increase in energy efficiency.

Financial savings

One of the greatest advantages of prefabricated construction is financial savings. Although, the perception of custom-made pieces may seem expensive, with prefabricated or modular construction, this is not the case. Prefabrication manufacturers often receive bulk discounts from material suppliers, which then lowers the cost of a construction project. In addition, modular construction also minimises the possibility of unreliable contractors, reduction in construction time, and unproductive staff which can significantly result in cost savings.

Flexibility

Modular construction can easily be disassembled and relocated to different sites. This significantly reduces the demand for raw materials, minimises expended energy, and

decreases overall time. Also, modular construction allows for flexibility in the design of the structure allowing for a limitless number of opportunities.

Consistent quality
Since prefabricated construction occurs in a controlled manufacturing environment, and follows specified standards, the sub-assemblies of the structure are built to a uniform quality. With prefabrication, each sub-assembly is built by an experienced crew in a weather-resistant factory, and multiple quality checks throughout the entire process. Some components of the building are constructed using precise machine equipment to ensure conformity to building code.

Reduced site disruption
Since many components of a building are completed in the factory, there is significantly less truck traffic, equipment, and material suppliers traversing the construction site. This limits the disruption of traditional jobsites that experiences noise pollution, waste, and other common irritants.

Shorter construction time
Modular construction uses significantly less time to build than on-site construction. In many instances, prefabrication consumes less than half the time compared to traditional construction. This is due to better upfront planning, elimination of on-site weather factors, subcontractor scheduling delays, and quicker fabrication as multiple pieces can be constructed simultaneously.

Health and Safety
Since sub-assemblies are created in a factory-controlled environment utilising dry materials, there is minimal risk for problems associated with moisture, environmental hazards, and dirt. This ensures that participants on the construction site are less likely to be exposed to the weather-related health risks. Furthermore, an indoor construction environment presents considerably fewer risks for accidents, and other liabilities. There are precise factory processes and procedures that protect the workers from on-the-job injury on construction sites.

FINDINGS AND DISCUSSION

The study sought to determine the extent to which the knowledge required to ‘manage’ IBSs are included in the curricula of construction-related programmes in Nigerian universities, and to compare with what is expected for an effective implementation of IBSs in construction. Hence, the study adopted a qualitative research approach. According to the National Universities Commission (NUC), there are presently 97 public universities in Nigeria, owned by both Federal, and State Governments, however, only 10 of these universities offer all four construction-related programmes in the form of Architecture, Building, Civil Engineering, and Quantity Surveying, which were of interest to the study. Four of the ten universities domiciled in Northern Nigeria were considered for the study, namely Ahmadu Bello University Zaria, Abubakar Tafawa Balewa University Bauchi, Federal University of Technology Minna, and University of Jos. The curricula of the construction-related programmes for the institutions included in the study were requested, perused, and analysed using content analysis. Texts and concepts were examined for existence, and frequency. The thematic areas of knowledge expected were determined from the literature and validated by construction experts. The results for the study are presented in tables below.

Source of Knowledge

The NUC is saddled with the responsibility of providing a benchmark minimum academic standard (BMAS) for all programmes taught in the Nigerian universities and would have been relied on for the curricula of all construction-related programmes considered for the study. However, the various departments are expected to review the curricula every 5 years by adding new knowledge areas and phasing out areas that are seen to be irrelevant. The review is usually done within such department by a team of competent professors, hence the reason for the study relying on the latest reviewed curricula for the content analysis.

Expert Panel

The team of experts used for the validation comprised of 5 project managers from 5 large construction firms in Nigeria. The firms selected are registered with the Federation of Construction Industry (FOCI), an umbrella body for renowned construction firms in Nigeria, and which are known to have commenced partial implementation of IBSs through extensive use of precast concrete components, steel framing system, and formwork system. The experience of the project managers was relied on for the validation. The project managers had on average 20 years' experience ranging from 18-22 years for all the participants. An initial list of 9 thematic areas of knowledge expected were gathered from the literature and validated by the construction experts. The required knowledge areas were streamlined to 7 after the validation and were adopted for the study.

DISCUSSION

The background knowledge of the nature of IBSs inclusion in the curricula of various construction-related programmes in the form of Architecture, Building, Civil Engineering, and Quantity Surveying were discussed initially. Furthermore, the IBSs inclusion, and extent of inclusion in terms of percentage for all the departments were later summarized in Table 3 and 4 respectively and discussed to develop an understanding and appreciation of the related issues.

Nature of IBSs as taught in the construction-related programmes

Department of Architecture
IBSs are not addressed in a standalone subject, nor taught as part of a subject, however, IBSs are addressed as part of other subjects. IBSs are addressed in modules such as building construction, building components and methods, building materials, and building structures. However, it was noted that Universities of Technology include IBSs as a heading in the content of some subjects. The subjects where IBSs or its contents are taught, are mandatory for the student to register, and pass before graduation.

Department of Building
The department addresses IBSs, and its content as part of some core subjects required before graduation. However, it was noted in one of the institutions that IBSs are addressed in a standalone subject, which was an elective. Health and safety (H&S) included in the curricula was discussed as common construction site H&S, and not specific to the various classifications of IBSs.

Department of Civil Engineering
IBSs as a heading are not included in the curriculum as a standalone subject, or part of subjects. However, some of the IBS knowledge areas are included in a few modules entitled timber structures, precast concrete structures, civil engineering materials, and construction management. H&S issues specific to the classification of IBSs were not included in the

curricula similarly to the Departments of Building, except that it was considered generally as construction site H&S.

Department of Quantity Surveying
From the content analysis conducted, IBSs are not included in the curricula as a standalone subject, but rather as a heading taught in a subject titled construction technology during the fourth year in the respective universities. However, some knowledge areas of the IBSs were included in some other core and elective subjects. Construction site H&S is addressed in the curricula, but, not specific to the classification of IBSs.

IBSs' content in construction-related programmes

The knowledge of IBSs as included in the curricula of Architecture, Building, Civil engineering, and Quantity Surveying based on the knowledge areas are indicated in Table 3. The round bullet is used to indicate inclusion while the blank cell is used to indicate non-inclusion.

Table 3. Summary of IBSs content in construction-related programmes

KA	Classification of IBSs																							
	Pre-cast concrete system				Steel framing system				Formwork system				Prefabricated timber framing system				Block work system				Innovative system			
	A	B	C	Q	A	B	C	Q	A	B	C	Q	A	B	C	Q	A	B	C	Q	A	B	C	Q
KA1																								
KA2																								
KA3																								
KA4																								
KA5																								
KA6																								
KA7																								

Note: A = Architecture, B = Building, C = Civil Engineering, and Q = Quantity Surveying, KA = Knowledge area, KA1 = Properties of material to be used and behaviour, KA2 = Jointing/Assembly methods, KA3 = Transportation of components from factory to site, KA4 = Methods of placing/handling components, KA5 = Storage, KA6 = Challenges, KA7 = H&S measures.

Table 3 indicates that knowledge of transportation of components from factory to site, method of placing/handling components, method of storage, and challenges faced when using IBSs, are deficient in the curricula across the various departments for the various types of IBSs, however, departments of quantity surveying addressed the challenges faced when using precast concrete systems, and steel framing systems in their curricula. Methods of storage for precast concrete systems, and prefabricated timber framing systems are included in departments of civil engineering curricula. Properties of materials to be used and their behaviour, and jointing/assembly methods for the respective types of IBSs except innovative systems, are mostly addressed by all the departments as seen in Table 3. Innovative systems as a type of IBS are not included in the curricula for all the knowledge areas across all the

departments. The poor adoption of IBSs on construction projects as stated by Ayoola and Aghimien (2017) might be the reason for the lack of inclusion of IBS innovative systems in the curricula, because the implementation of IBSs in construction projects would realise the development of innovative methods.

Extent of inclusion of IBSs' knowledge areas in the curricula

This section presents an overview of the extent to which IBSs are addressed in the curricula of construction-related programmes. The number of expected knowledge areas (7) was multiplied by the number of types of IBSs considered for the research (6). This resulted in an expected total of 42, which would represent 100% inclusion in the curricula. This expected number was used as the basis to determine the percentage inclusion for the respective departments (Table 4).

Table 4. Summary of the extent of inclusion of IBS knowledge areas relative to types of IBSs in curricula

Department	Expected (No.)	Included (No.)	Included (%)
Architecture	42	8	19.1
Building	42	16	38.1
Civil Engineering	42	12	28.5
Quantity Surveying	42	12	28.5

Table 4 shows that the Departments of Building recorded the highest level of inclusion (38.1%) of IBS knowledge areas relative to types of IBS among all the construction-related programmes, followed closely by the Departments of Civil Engineering and Quantity Surveying with 28.5% respectively. The Departments of Architecture recorded the lowest percentage, namely 19.1%. This implies that the addressing of IBSs in the curricula is below average for all the construction-related programmes. This finding supports the claims by Ayoola and Aghimien, (2017), Nawi et al., (2014), Samari et al., (2012), Mohamad Kamar et al., (2009), and Hamid et al., (2008) that most professionals and contractors lack technical knowledge to implement IBSs on construction projects.

CONCLUSION

The findings lead to the conclusion that the extent to which IBSs are addressed in the curricula of construction-related programmes in Nigerian universities is below average and needs improvement to enable the effective implementation of IBSs in the Nigerian construction industry. IBSs, or some of its contents are mostly being taught as part of modules in all the departments, rather than as a standalone subject. H&S issues specific to the various types of IBSs should be included in the curricula, and not only addressed in the context of common construction site H&S. The study further concludes that knowledge with respect to placing/handling components, storage of IBSs' components, and challenges faced during the implementation of IBSs are mostly lacking in the curricula across the various departments addressed during the study. The results of the study can be used by construction-related programmes in Nigeria Universities to improve the curricula and pave the way for the full implementation of IBSs in the Nigerian construction industry. Prioritising IBSs by making it a standalone, and core course in the various departments might help to enhance the knowledge gained. Further studies should be conducted to determine the adequacy of knowledge in the knowledge areas addressed during the research.

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A SYSTEMATIC LITERATURE REVIEW OF TRADITIONAL INSPECTION PROCESS CHALLENGES AFFECTING QUALITY HOUSING

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Abstract. Poor-quality housing delivery is a global concern. In the South African housing sector, an effort was made to remedy this situation, but customers remain dissatisfied with the quality housing delivery. This paper reviews relevant peer-reviewed articles to explore inspection process challenges hindering quality housing delivery. Following the systematic literature assessment methodology, six (6) databases were queried, based on the specific search string. Specifically, 33 journal articles satisfying a set of inclusion criteria were reviewed, the results highlighting the challenges experienced with the traditional inspection process. The review of the journal articles revealed that quality housing delivery is compromised by challenges such as time spent to inspect, inadequately trained inspectors, complex and labour-intensive inspection process as well as the shortage of inspectorates which hinders the achievement of an efficient and effective inspection process. The outcome of this study will open new doors to understanding key challenges that hinder an efficient and effective inspection process for quality housing delivery as the topic has received little attention in South African research literature.

Keywords: Inspection process, traditional, housing construction, challenges

INTRODUCTION

Housing delivery is a global concern where most people are still living in poorly constructed houses which pose threat to their lives (Zukin et al., 2015). It is evident that in African developing countries in which South Africa is inclusive, the quality housing delivery is still a huge challenge (Musa et al., 2015). This is despite the growing awareness and interventions to mitigate poor quality housing delivery in the world (Buys & le Roux, 2013; World Economic Forum (WEF), 2019).

For instance, in South Africa, most customers are still reporting defects such as cracks, roof leakages on the delivered houses (Zunguzane et al., 2012; Buys & le Roux, 2013; Khoza and Kabir, 2014). However, it is still expected that 3 billion people worldwide, particularly those in developing countries will need decent houses by the year 2030 (Musa et al., 2015). In South Africa alone, the government already experience housing construction cost overrun due to remedial works with the government utilising their raised warranty funds to rectify poorly constructed houses that could have been avoided with an effective and efficient inspection process during the construction phase (Nqentsu, 2017). This also makes it difficult for the government's intention to eradicate the current housing backlog sitting at 2.1 million (Olojede et al., 2019) which might also delay the country in partaking towards the year 2030 agenda. As a result, the previously disadvantaged people might remain without shelters.

Similarly, this traditional inspection process is usually a time-consuming, labour-intensive, and costly process that depends on the experience of the inspectors. In South Africa, the lack of experienced inspectors contributes to an inability to deliver quality housing (Olojede et al.,

2019). For example, to assure quality housing delivery, a trained inspector makes a tour of duty to the site and assesses the ongoing housing construction project by looking over the structure and record the compliances or non-compliances according to technical specifications (Khoza & Kabir, 2014).

Accordingly, the systematic review reported here aims to explore the challenges of the traditional inspection process for construction of houses following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement for systematic review reporting format (Moher et al., 2009; Albeaino et al., 2019). To explore the inspection process for housing construction with its challenges, peer-reviewed journal articles published from 2013 to 2020 were reviewed. This is to improve and assist in finding the solution to current challenges of the inspection process resulting in poor quality housing delivery in developing countries of which South Africa is inclusive.

METHODOLOGY

The study analysed the past literature systematically. The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement template is used to explain the overall process of selection and exclusion of articles for review of inspection process challenges during housing construction. The PRISMA statement helps with the improvement of the reporting paper review. The systematic review is limited to published peer-reviewed literature. The complete process of PRISMA 2009 for a systematic review is shown below in figure 1.

For this study, a research strategy to identify relevant literature was developed. This strategy was tailored to six databases: Scopus, Ebscohost, Google scholar, African Journals (Formerly: SA ePublications), American Society of Civil Engineers (ASCE), Springer and the terms used were the following: “inspection process” OR “inspection systems”, “housing” OR “building infrastructure” AND delivery, “quality delivery” OR quality assurance, “inspection challenges” as advised by the Boolean operator (Aghajafari et al., 2013). The search span was from the year 2013 to 2020, included journal articles published in English and in full text only. Identified possible journal articles were 355.

The PRISMA statement template is used to explain the overall process of selection criterion and exclusion criterion of the articles (Moher et al., 2009; Albeaino et al., 2019; Khan & Qureshi, 2020) as shown below in figure.1. The research focused mainly on mapping the existing literature on the challenges of the traditional inspection process in the housing construction sector. All journal articles before 2013, not full text, and not written in English were excluded from the search. The search was focused on both developed and developing countries looking specifically on inspection process challenges during housing/building construction.

The study is based on peer-reviewed article journals. A thorough check of duplicated articles was carried out on Microsoft excel (Khan & Qureshi, 2020) to maintain the quality of the review and 12 articles were removed. Also, the abstract and conclusion of the articles were thoroughly checked to ensure the quality and relevance of academic literature included in the review process. At the later stage, the careful evaluation of each research paper was carried out. The next was to consider exclusion and inclusion criterion where the study was only limited to English written articles. For the exclusion criterion, only five (5) articles were not written in English and therefore was excluded from the study.

The final 33 journal articles are used after assessing each article based on the above-mentioned exclusion and inclusion criteria. These articles are used for the final process and to

find the direction and research done by the researchers in the year 2013 to 2020. Figure 1 below shows the exclusion and inclusion of literature at every stage.

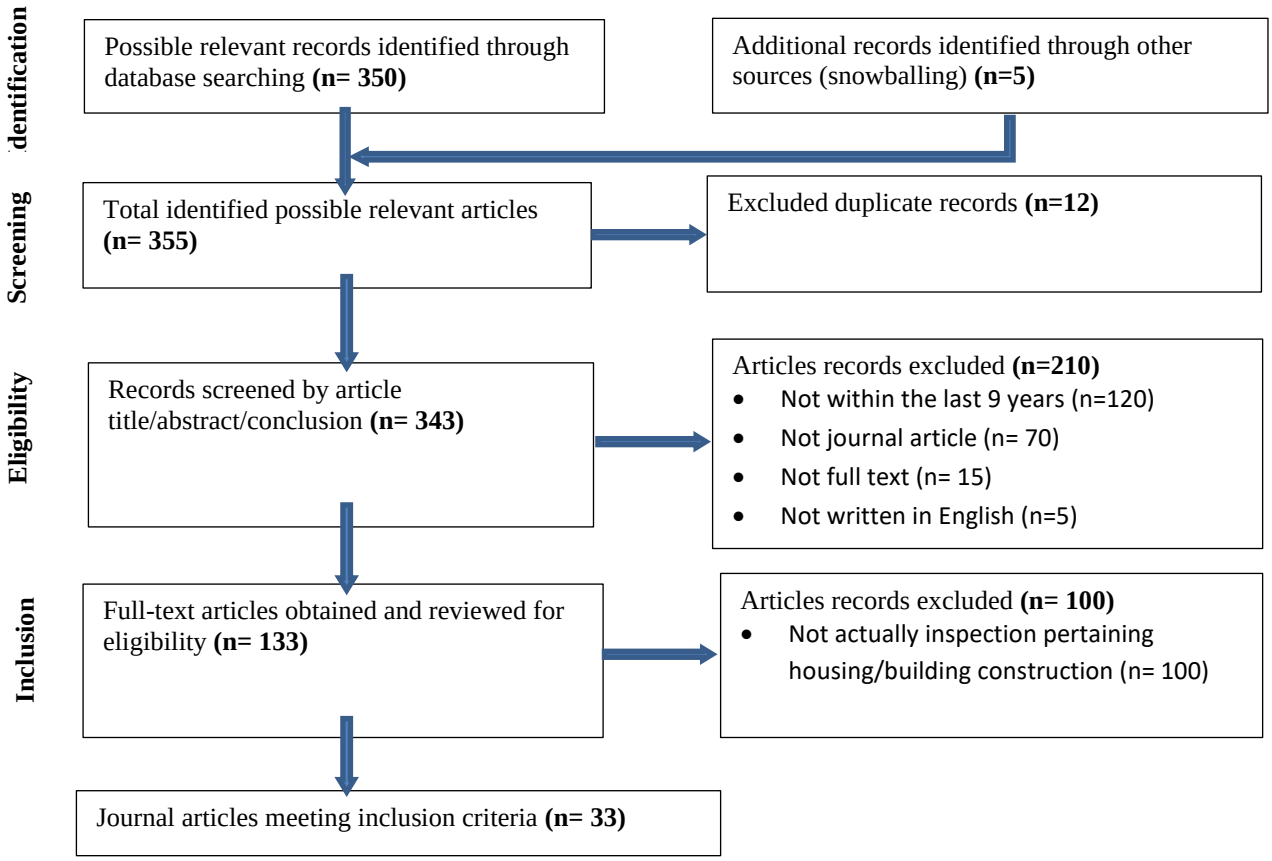

Figure 1: Study selection results using PRISMA chart

RESULTS

Journal article year-wise publications

The journal article year-wise publications focusing only on traditional inspection process challenges are shown in figure 2 below with 2013 to 2017 selected papers being the lowest. Out of these papers, only two papers were identified in 2016 and in 2013 and three papers in 2013, 2014 including 2017 were identified respectively while 2015 publications were higher with five papers. 2018 selected publications were higher with 9 papers while 2019 and 2020 publications showed a decline. This could be due to the Coronavirus pandemic which shut down numerous countries across the globe and therefore prevented, amongst other activities, research, and academics.

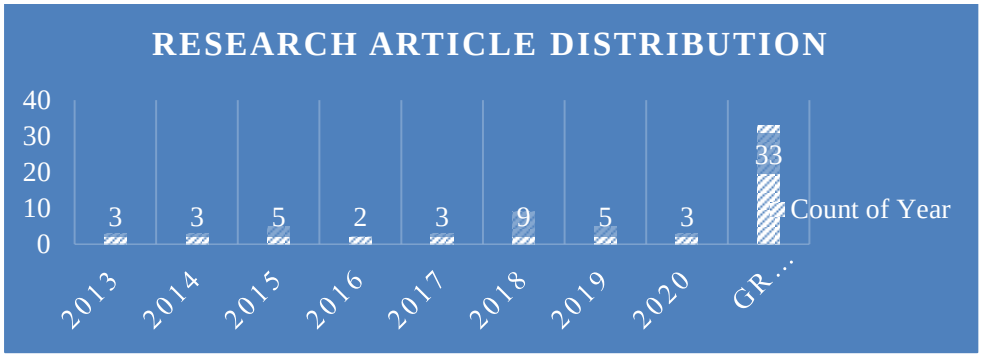

Figure 2: Journal articles year-wise publications on traditional challenges of housing construction inspection process (2013-2020)

Journal based publications

The other important assessment that is made for the study is article journal area identification in the study. Most of the papers are selected from the automation in construction with 11 papers. The second journal area identification is the journal of Computing in Civil Engineering, Journal of Construction Engineering and Management, and SAGE Journal with 2 publications and finally, one (1) paper is selected from each remaining journal area identification contributed to the study. The results are shown in figure 3 below.

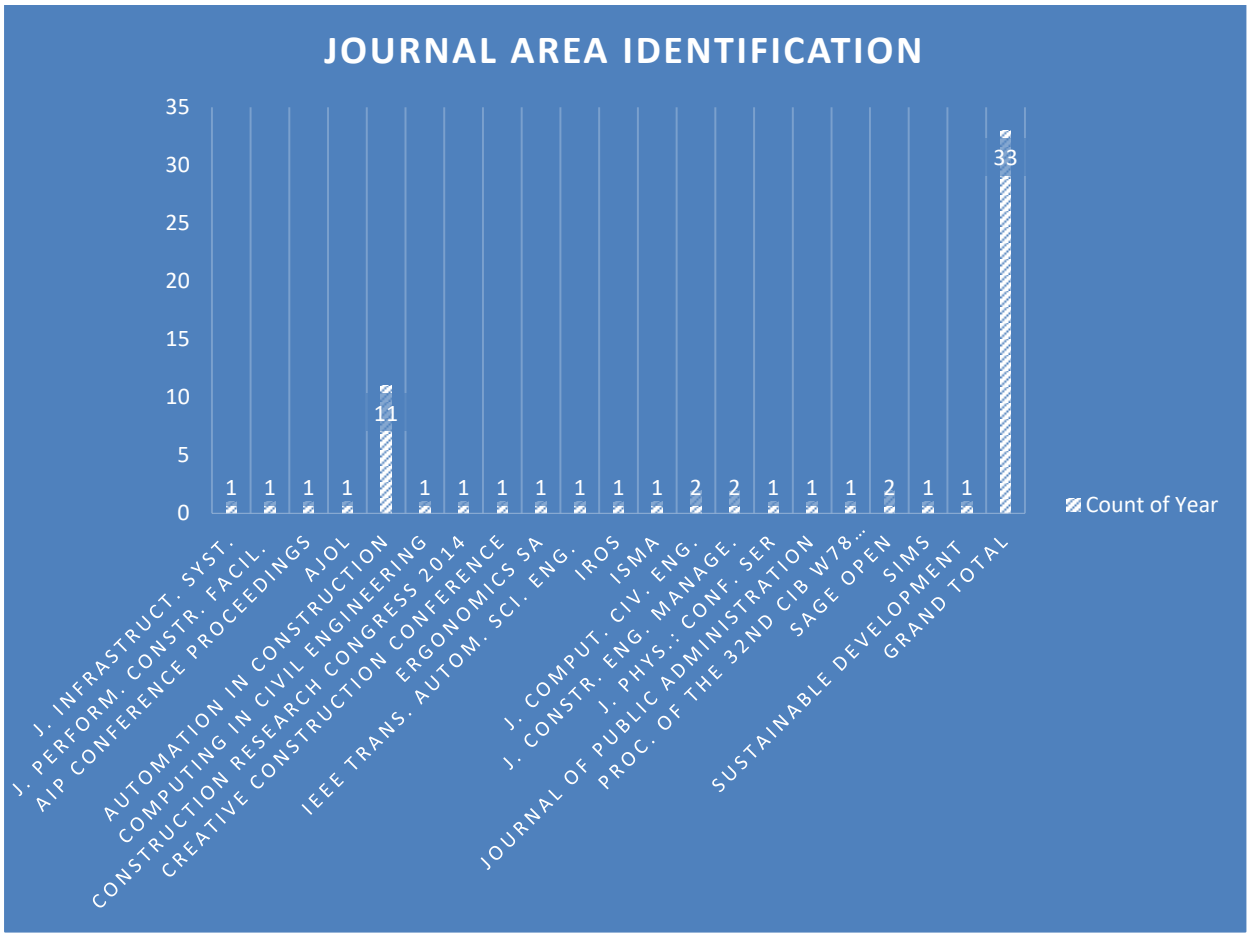

Figure 3: Journal based publication

Article full name	*Abbreviations*
Journal of Performance of Constructed Facilities	J. Perform. Constr. Facil.
Journal of Physics: Conference Series	J. Phys.: Conf. Ser.
Journal of the Ergonomics Society of South Africa	Ergonomics SA
Journal of Construction Engineering and Management	J. Constr. Eng. Manage.
2018 2nd International Symposium on Small-scale Intelligent Manufacturing Systems	SIMS
2015 10th International Symposium on Mechatronics and its Applications	ISMA
Journal of Computing in Civil Engineering	J. Comput. Civ. Eng.
African Journals OnLine	AJOL
IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING	IEEE Trans. Autom. Sci. Eng.
2017 IEEE/RSJ International Conference on Intelligent Robots and Systems	IROS
Proceedings of the 32nd CIB W78 Conference on Construction IT	Proc. of the 32nd CIB W78 Conference 2015
Journal of Infrastructure Systems	J. Infrastruct. Syst.

Country wise publication

The country-wise publications give an overview of research output by regions and countries in the world. This is essential to know government efforts and funding towards advancing research. As government funding centrally drives research in most countries, this is imperative if research in identifying challenges of the traditional inspection process is to be studied. The review found that China was the highest with publication followed by Canada. The second highest publishing country was Korea and USA respectively followed by South Africa with 3 publications. And finally, the remaining countries published one paper respectively as shown below in figure 4.

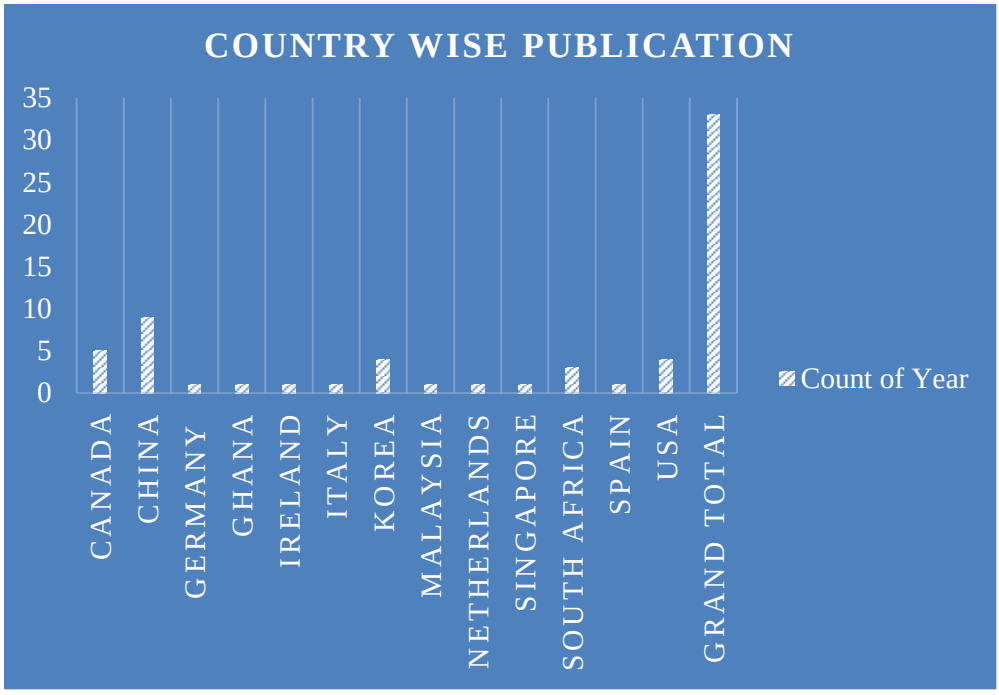

Figure 4: Country-wise publication

LITERATURE CLASSIFICATION

The Microsoft Excel sheet was used to process the published journal articles and open the process of literature classification for further review. To analyse and understand the work that has been done, the table of traditional inspection challenges classifications is tabulated below. A detailed discussion of the past published literature is done to find out the required information and the future agenda for upcoming researchers.

Table: 1: Table of classifications

ID	Variables	Source
1.	Complex and labour-intensive inspection process	Liu et al. (2015); Hamledari et al. (2017); Hamledari et al. (2018); Bortolini & Forcada (2018); Comiskey et al. (2018); Ciampa et al. (2019); Agnisarman et al. (2019); Kim et al. (2020); Cai et al. (2020)
2.	Time-consuming inspection process	Kim et al. (2013); Park et al. (2013); Maalek et al. (2014); Kwon et al. (2014); Kim et al. (2015); Hegazy et al. (2015); Zulkifli et al. (2018); Ma et al. (2018); Yan et al. (2018); Liu et al. (2018); Hamledari et al. (2018); Freimuth & König (2018); Asante & Sasu (2018); Ciampa et al. (2019); Wang & Luo (2019); Kim et al. (2020); Asadi et al. (2020)
3.	Shortage of inspectorates	Xiao (2016); Yan et al. (2017); Lattanzi & Miller (2017); Mkuzo et al. (2019)

4.	Inadequately trained inspectors	Buys & le Roux (2013); Frauley (2014); Liao (2015); Kopsida et al. (2015); Ma et al. (2016); Olojede et al. (2019)

Complex and labour-intensive inspection process

The traditional inspections are labour intensive (Comiskey et al., 2018; Cai et al., 2020) and require experienced inspectorates inspecting complex housing structures possibly risking their lives under hazardous working environment (Lattanzi & Miller, 2017). For example, fitting the scaffoldings wastes a lot of time and can be labour intensive with the possibility of it to can collapse leaving inspectors with injuries or death (Ciampa et al., 2019). In addition to labour intensiveness, inspectors can spend a minimum of one hour to collect data during the inspection then three hours in the office for data capturing (Hegazy & Gad, 2015; Kwon et al., 2014) which is also time-consuming. Also, working long hours of inspectors trying to inspect all houses leads to mental fatigue adding to possible inaccurate data collection (Agnisarman, et al., 2019). Without accurate data collection on-site, the data capturers in the office can struggle to make informed decisions pertaining to housing quality assurance. These challenges highlight the inefficiency and ineffectiveness of the traditional inspection process.

The study conducted by (Bortolini & Forcada, 2018) further highlighted that the traditional inspection process can be complex and labour intensive hence a lack of housing construction inspection. This is supported by Buys & le Roux (2013) who reported that lack of inspection during the housing construction leads to poor quality housing delivery.

Time-consuming inspection process

The traditional inspection processes are usually time-consuming, requiring interruptions during construction progress with builders having to wait for inspectorate decision on inspected structures with the approval letter to proceed (Ciampa et al., 2019). As a result, builders work under pressure to deliver housing projects according to the predefined project schedule. These issues, especially the stage inspection approval, result in inspection process delays leading to possible miss inspections which could also cause defects (Kwon et al., 2014). Moreover, the time spent to carry out inspection can add to cost which was reported to be higher for the traditional inspection process (Lattanzi & Miller, 2017).

Shortage of inspectorates

The government's intention to mitigate housing backlog remains a huge challenge due to continuing poor quality housing delivery in South Africa with customers dissatisfaction highly publicised. For example, it was found in the study by Mkuzo et al. (2019) that poor quality housing delivery in South Africa is due to the shortage of inspectors that should be on-site to assure compliance on each stage of construction. Similarly, in Taiwan, the government employs temporary inspectors as the management system support towards inspections due to a shortage of inspectorates conducting inspections Liao (2015). With the daily workload and high demand of inspectors to inspect all houses under construction, there is a need to capacitate the inspection process to improve the quality delivery of housing.

Inadequate trained inspectors

To deliver quality housing, inspectors are required to carry out the task of quality assurance. However, it’s has been highlighted that inspectorate are inadequately trained to carry out a thorough inspection (Olojede et al., 2019: 165). According to Frauley (2014), building inspectors in Canada are not well trained and do not have certification or license to conduct an inspection and this leads to clients being responsible for checking the quality of their own

houses. Furthermore, Liao, (2015) posited that the majority of government inspectors are underequipped, not well trained, and incapacitated to carry out the inspections like those of South Africa, Singapore, New Zealand, Brazil, Latvia, Vietnam, Spain, and Cyprus which is the challenge for inspectors to contribute towards the quality of inspections looking at the workload of homes to be inspected in these countries.

As a result, if these challenges faced during housing construction are not resolved the customer's dissatisfaction will persist, government housing backlogs will also persist, and the inspection organisations will spend a lot on remedial works as a result of poor-quality housing delivery which could be avoided with the more efficient and effective inspection process

CONCLUSION AND FUTURE WORK

Research trends indicate that the inspection process for housing construction is experiencing challenges with the traditional approach of inspecting. In this study, a systematic search and screening procedures following the PRISMA chart were used to identify relevant studies on inspection process challenges for housing construction. After filtering the journal articles, 33 papers were selected for further analysis, and we cannot avoid the evidence that most articles are dominant in inspection process based on traditional method. However, an automated inspection process is still needed to improve inspection process and mitigate the current challenges of traditional inspectional process. The results of the literature show that the traditional method of inspection process is time-consuming, complex, and labour-intensive with the shortage of inspectors and inadequately trained inspectors which hinder the ability to deliver quality housing. While more challenges are being identified with the use of the traditional inspection process, the main existing gap is the adoption of an automated inspection process and monitoring its benefits as an alternative to traditional ways of inspecting. The existing studies show that the main challenge is the implementation of an automated inspection process during the housing construction to mitigate the challenges of the traditional inspection process where data can be collected effectively and efficiently without the need for the inspectorate to interrupt construction progress.

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APPROACH OF PRIORITISING LECTURE THEATRES MAINTENANCE REQUIREMENTS

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Facilities Management (FM) plays a strategic role in the management of the built assets of all organisations including universities. Thus, the need for effective FM practices is important. The research aimed to explore the approach adopted by a university's FM department in the management of the lecture theatres. A qualitative research approach was adopted for the study. The data were collected through interviews and observations. Thematic content analysis method was used to analyse the data. The findings indicate that the management of the lecture theatres and/or classrooms affects the performance of students and academic staff. It also became evident that the FM Department does not have an established mechanism for prioritising the maintenance requirements of the lecture theatres. The recommendations proffered could help the facility department to improve on the approach adopted for maintaining the university lecture theatres. Data was collected from only one university; therefore, the findings of the research may not be generalised. A future study can, however, use many cases (universities) and resolve this generalisation weakness.

Keywords: lecture theatres, maintenance, prioritising, university.

INTRODUCTION

Facilities Management (FM) plays a prominent role in workplace/space management. The phenomenon is interpreted differently, and different entities provide different interpretations about what the phenomenon is and what it is about, thereby providing subjective understanding of what FM really is. However, there is a consensus that FM places emphasis on the two fields of 'Space and Infrastructure' and 'People and the Organisation'. These two big operating fields are usually known as hard and soft FM. The hard FM is the physically constructed area concentrating on workspace and constructed facilities. In an arena like the university, FM is a complex unit organised to ensure, protect, and sustain the university's core functions (Edoghogho, 2011). The role that FM plays have a large influence on how both students and employees perform within universities (Abd Elghany & Elharakany, 2017).

The facilities required to promote the activities of a university are wide ranged. Some facilities, e.g., cafeteria play a support role whereas others, e.g., lecture theatres play a direct role towards the achievement of a university’s core business. Lecture theatres are an integral part of the physical learning environment of every university and an aspect that influences the whole learning process. Effective management of the lecture theatre is thus imperative. Olanrewaju (2010) emphasises that a well-maintained lecture theatre promotes the core objectives of a university; however, university facilities departments are usually constrained by limited funds (Buys and Nkado, 2006; Olanrewaju, 2010). Consequently, the need for effective prioritization becomes crucial. It is on this premise that this study seeks to explore the approach adopted by a university's FM department in the management of the lecture theatres.

LITERATURE REVIEW

Facilities required in universities

Tertiary education institutions, like other institutions, are meant to provide a specific service, which is regarded as their core business. An organisations' core business or activity is linked with its competences (De Toni and Nonino, 2009). The core business gives indication of why the organisation was established. In the case of a tertiary education institutions e.g., universities, the core business is to promote teaching, learning and research activities (Kärnä and Julin 2015). Thus, the core business cannot be compromised in any way. However, for the core business to be successfully achieved, tertiary education institutions require the integration of several resources and support services. The environment of a university is created by the interaction of many elements. The broader environment including the physical facilities creates an appropriate environment for teaching and learning (Abdullahi and Yusoff, 2018). Zakaria and Wan Yusoff (2011), and Olanrewaju (2010b) believe that the elements that contributes to the success of higher education are human resources e.g., educators, technology e.g., ICT, finance e.g., budgeting for the purchase of equipment, and facilities e.g., buildings. If all these elements or resources are provided adequately and interact positively, the learning environment could be enhanced. However, a deficiency in any of these elements or resources could hinder the teaching, learning and research process carried out in the institution (Olanrewaju et al., 2010). Without these fundamental resources the core business of any university will be jeopardised.

One of the resources required to ensure the success of education in a university is facility resources. In fact, facilities represent most an organisation's capital assets (Abdullahi and Yusoff, 2019). These physical facilities play a significant role in creating an enabling environment to promote the core services provided by institutions (Kärnä and Julin 2015). To fulfil its core business, a tertiary education institution would require a wide range of physical facilities. The wide-ranging nature of physical facilities is an indication of the uniqueness of tertiary education institutions' environment and hints on the need for a coordinated approach to their management. The range of a tertiary education institutions physical facilities may include but not limited to; administrative buildings, library, offices, hostel and staff accommodation, laboratories, workshops, lecture theatres, refectories, sports centres, general grounds, and other support facilities (Gruber et al., 2010; Olanrewaju et al., 2010; and Kärnä and Julin, 2015; Abdullahi and Yusoff, 2018). Some of these facilities are used exclusively by specific students or staff while others are common or shared. The exclusive facilities are those that are used by specific students because of their program of studies, e.g., laboratories for lab technology students and engineering workshops for engineering students, whilst the common or shared facilities are used by all students regardless of their program of study e.g., lecture theatres, library, IT centre and classrooms as well as the support facilities and the sports and leisure facilities. Furthermore, it can be argued that each physical facility plays a specific function e.g., lecture theatre for the purpose of teaching.

Lecture theatres

Shamaki (2015) believe that the learning environment refers to all the components and activities in which learning takes place. The learning environment therefore considers many variables that affect students directly and indirectly (Shamaki, 2015). Kok's (2015), revealed that some aspects of so-called micro design, such as seat configurations, scheduled maintenance, and day-to-day cleaning and wireless or wired IT influence teaching or learning processes. Duyar (2010) posits that conditions related to natural lighting, air conditioning, indoor air quality, acoustics or noise, the physical condition of ceilings, floors, walls, windows and doors and the scale or layout of the lecture theatres significantly influence

planned teaching in schools. All environmental factors such as room temperature, seating comfort, background noise and visual disturbances affect learning because they influence focus and motivation (Hutchinson, 2003). The more physical infrastructure and resources impact the educational process, the greater the future commitment to contribute to educational achievements (Kok, 2015). Thus, any inadequacy of the university lecture theatres would have a significant effect on the achievement of the primary goal of the university, since the lecture theatres are a contributing factor in the engagement of students and academic staff (Kok, 2015)

Prioritisation of maintenance need

Resource management is FM's main role, both at the strategic and operational levels. It is traditionally important for the FM to manage financial resources, physical resources, human resources and information and knowledge resources (Boyle, 2016; Nutt, 2000). The cost of all required maintenance requirements in any one year may exceed the budget (NSW Heritage Office, 2004). In fact, studies reveal that maintenance budget are usually the first to be cut when a university experience budget cut (Simpeh et al 2014). The need for the FM department to develop effective prioritization system is thus crucial. Although priority setting differs based on the use of the building and context, Horner, El-Haram and Munns (1997) explain that depending on the significance of the consequences of failure, the maintenance tasks or items in a building can be divided into two groups: significant and non-significant items. In essence, the understanding of the significance of the item within a building influences prioritisation. Shen and Spedding (1998) give the following chronological guideline for prioritising maintenance: high risk of health or safety; serious disruption of the normal activities in the building, or health or safety problems, but the defect does not pose immediate danger to the building users; serious discomfort to the building users; damage to the image of the organisation; and finally minor problems relating to aesthetics or convenience. Similarly, Wood (2009) believe that health and safety should be accorded the priority, followed by wind and water tightness of the building, then continuity of business operation, fourth is comfort of occupants, and finally efficiency, effectiveness, and economy of operation.

RESEARCH METHODOLOGY

The aim of this research is to examine the approach adopted by the FM department in the management of the lecture theatres of a university. Therefore, exploratory research design was adopted. A South African university was used as a case; however, the observations were further narrowed down to three lecture theatres used by the School of the Built Environment and Civil Engineering Departments. For reasons of confidentiality, the name of the institution is not disclosed. The study adopted a qualitative research approach, where interview and observations were used to collect the data. According to Mohajan (2018), qualitative research method allows researchers to explore the experiences of individuals/respondents to develop a better understanding of a complex phenomenon.

Population is defined as the totality of individuals who are of interest to the researcher and from whom inferences are drawn and generalised (Sekaran and Bougie, 2009). The sample is chosen from the research population. The sample population of the study was purposive. Data was obtained not only from the Facility Management staff, but also by means of observations of the lecture theatres. This boosted the validity and accuracy of the analysis. The interviews, which were conducted telephonically, solicited opinions about the FM systems used and the impact on their teaching and learning infrastructure. Furthermore, questions on the approach to setting priorities, were included. The participants were non-academic employees in the institution. Observations in qualitative research capture data in true-life context because the

observer does not tamper with the natural setting of the environment; the exercise may require walk-throughs and inspections (Adama and Michell, 2017; Struwig and Stead, 2013). Personal on-site observations of the lecture theatres of the university were carried out. The observation gathered data relating to structural protection, fire safety and exits, ventilation and temperature, sound control, lighting, cleanliness, and aesthetics/design of the lecture theatres. The collected data was prepared, coded, structured, and analysed. Both the data gathered from the interview and observations were analysed by means of a thematic content analysis.

ANALYSIS AND DISCUSSION

Presentation of respondent interviews

The interviews were conducted on three separate dates: Monday 7th, Wednesday 9th, and Friday 18th of December 2020. A semi-structured interview was used to allow the interviewer to explore the views of the interviewees, ensuring that clearly defined responses were obtained from the questions, thus allowing the answers to be further elaborated. The respondents were first told of the emphasis of the interview prior to the meeting to give them enough time to prepare for the interview in advance. The interview was conducted via Microsoft Teams and recorded. After the interviewer had finished, the recording was typed, the typed copy was then sent to the interviewees for verification via electronic mail; after verification, the interviewees returned the transcript by the same means.

Interview 1: Senior Director Infrastructure Services and Space Optimisation
The firs interview was with the Senior Director Infrastructure Services and Space Optimisation. The appointment was first booked via an email. The interviewer then sent the questionnaire to the Senior Director, Infrastructure Services and Space Optimisation, on 2 December 2020 to enable him to prepare well in advance for the interview. The date of the interview was set telephonically. The interview was held on 7 December 2020 between 3:00 p.m. and 4:00 p.m. on Microsoft Teams. The interviewer transcribed the data and submitted it for review by e-mail on 24 December 2020. The Director gave minor feedback and sent it back to the interviewer on 29 December 2020.

The Senior Director provided the University's history and indicated that the university has increased the skilled staff of the Estate and Facilities Management (EFM) Division by employing surveyors, construction managers and project managers. He stated that the vision and mission of the Estate and Facilities Management (EFM) Division, is to integrate physical and digital infrastructure use, to manage space, infrastructure, people (staff and students) and organisation to add value to the institution.

He mentioned that the EFM is currently split into two, hard and soft divisions. Hard FM division controls Planning, Design, Office, Renovation, Leasing, Occupancy, Repair, Furniture, Mechanical, Electrical, Ventilation, Air Conditioning, Sanitation, Building Control, Administration, Fire and Life Protection Systems whereas the Soft FM division is concerned with laundry, cooking, food service, mailroom security and hospitality service. He further stated that the EFM Directorate is also responsible for the maintenance and repair of buildings and plans as well as facilities for utilities and services on many campuses and all regulatory criteria for the safe functioning of machines and systems. He revealed that they have a Strategic Facilities Development/Plan (SFP), and its duration is from 2020 to 2030. The SFP plan contains a roadmap on how to blend physical and digital infrastructure use, to manage space, infrastructure, people (staff and students) and organisation to give value to the institution. The main contributors when formulating the plans are the ICT department, students, academic and non-academic staff, and the leadership of the University. The

execution of the SFP is monitored in constant feedback sessions or meetings, while digital trackers measure the performance of SFP. Additionally, he pointed out that the FM software package being used by estate and facilities management is Integrated Tertiary Software (ITS). It runs finances for EFM, with ARCHIBUS integrated Facilities Management software about to be introduced for future purposes.

Interview 2: Manager Building and Engineering Service
The second interview was with the Manager Building and Engineering Service. On 2 December 2020, the interviewer sent the questionnaire so that the interviewee would better prepare for the interview. The interview on Microsoft Teams took place on 9 December 2020 between 11:00 am and 12:00 pm, and the interviewer transcribed and submitted the data by email on 24 December 2020 for verification.

The interview revealed that the EFM has guidelines for maintenance priority; but does not currently have a public prioritisation policy or framework for maintaining the lecture halls. The Building & Engineering Service Manager confirmed that the security requirements are attended to first, followed by safety, ventilation, lighting, temperature, cleaning followed by aesthetics in decreasing order. However, he emphasised that cleaning is health-related and thus needs equal attention as safety and health requirements. He also reported that the EFM has no systematic lecture theatre maintenance plan. Although the department does not have a full plan, an integrated maintenance strategy is implemented (planned, reactive and condition-based). The EFM uses the following techniques, he explained: "HVAC systems approach is both expected and reactive (a contractor services the HVAC system regularly); A proposed cleaning strategy (occurring every day); expected and receptive aesthetic strategy; and a reactive lighting solution".

It also became evident that there is no prescribed method of user engagement in the maintenance management process. The manager stated, however, that meetings are coordinated for each department; thus, the lecturers and students participate in maintaining the theatres through the departmental meetings.

Interview 3: Director: Technical Services
The third interview was with the Director: Technical Services. An appointment was made via email first with the Technical Services Director, followed by a telephone discussion for the interview. The interviewer then submitted the interview guide, allowing the interviewee to better prepare for the interview in advance. The interview guide was sent on 2 December 2020. A date was set for the interview by telephone. The interview was held between 3 p.m. and 4 p.m. on Microsoft Teams on 18 December 2020. On 24 December 2020, the interviewer transcribed the data and emailed it for clarification. On 29 December 2020, the director provided the interviewer with minor feedback and e-mailed the document.

The interview revealed that the EFM currently does not have a maintenance priority management strategy or framework for the lecture theatres. The director noted that the maintenance priorities are currently focused on the internal guidelines, the seriousness or urgency of the maintenance obligation and the effect on building users that the maintenance work needed could have. It is the responsibility of the maintenance manager and subordinates to ensure that the work is done. In case of budgetary constraints, he claimed that first maintenance criteria relating to safety conditions would be considered, followed by ventilation, lighting, and temperature, respectively.

The director said that the EFM had a maintenance scheme in place but that the scheme is a general scheme for all the facilities not for lecture venues. The department has no formal inspection programme but mainly relies on building users. Although the department does not

have a full plan, an integrated maintenance strategy is implemented (planned, reactive and condition- based). According to him, the HVAC systems in the lecture theatres are run from an installation which must be enhanced considerably. The technique used in HVAC systems is conditional and the HVAC system is routinely serviced in compliance with the requirements and schedules set out in the operation manual of the original equipment manufacturer (OEM). The techniques used for lighting are condition control and user dependency in reporting the lighting. About aesthetics, the director pointed out that the schedules are not formalised but that the painting is usually carried out after at least five years, but that the problem of floors and ceilings depends on their use. He added that cleaning was done every day; the intended technique was employed. He noted that a computer is used to manage maintenance records. The repair department tracks job status by detecting whether the working cards are closed. If the work cards are not closed, the respective person who has been assigned to the work is listed to allow for effective tracking.

The Director also pointed out that the maintenance methods of the department are hampered by issues such as a shortage of manpower, relentless budget reductions, tedious and time-consuming procurement process, and the lack of a computerised maintenance management system. The small workforce leads to high dependence on external staff. In addition, the director suggested that the EFM do not deal directly with students, but rather with the Department of Student Affairs. There is currently no standardised framework for user involvement. However, according to him, the academic department provision may be one way to include students in maintaining lecture theatres.

Presentation of observations

The data provided by the employees were supplemented by observations of the conditions of the lecture theatres. It also helped develop a different view of problems and gain a better understanding of what is being studied. The researcher selected three lecture halls. To avoid disclosing the name of the university the lecture theatres are represented as lecture theatre A, B and C. The observations were carried out on Monday 21 December 2020. The following are the findings of the observations. transcript by the same means.

Lecture Theatre A

This lecture theatre has a total of 166, 80 m2 floor area with 140 seats in capacity. It is used by students and staff of the Faculty of Engineering, the School of Built Environment and Civil Engineering for lectures and meetings. The venue appears very stable structurally and has no cracks. It has double exit doors (two in front, indicated with a clear EXIT mark at the top), but there are no lighting marks on the floor which led to the doors. There are two fire extinguishers and a fire pad outside the lecture theatre entrance. A fire detector, fire rogue system and fire alarm system are also available in the hall.

The lecture theatre does not have any windows, but has a central plant operated HVAC system. Inside the lecture theatre the HVAC system can be controlled. The hall is built to absorb sound. Ground acoustic wooden panels are fixed around the walls, except in front of the hall. The hall is also fitted with an amplifier, microphone for each seat and speaker's system for public address (PA), all of which work but are not typically used in lectures.

There is appropriate lighting inside the venue, all the open lights and board lamps are operational. The position of the hall does not however, permit daylight into the venue. Usually, the lecture theatre is clean and neat (the theatre was also neat and clean during the observation). The floor is covered in carpeting, the walls are tongue and groove acoustic wood panels; the ceiling is finished with white coated acoustic tiles, with open lights, and a screen for the lecture projection. The lecture theatre is modern and especially elegant.

Lecture Theatre B

The lecture theatre B has a total floor space of 166, 80 m2 and a capacity of 140 seats. The lecture theatre is used by students and academic staff of the Faculty of Engineering, the School of the Built Environment and Civil Engineering. The venue appears very stable structurally and has no cracks. It has double exit doors (two in front, indicated with a clear EXIT mark at its top), but there are no lighting marks on the floor which led to the doors. There are two fire extinguishers and one fire hose reel located outside the lecture theatre entrance. Fire detectors, fire alarm and fire sprinkler system are also installed in the lecture theatre.

The lecture theatre does not have windows, but a central plant operated HVAC system is installed. Inside the lecture theatre the HVAC system can be controlled. The lecture theatre is built to absorb sound; tongue and groove acoustic wooden panels are fixed across the walls except in the front of the classroom. The lighting is sufficient in the lecture theatre: both open lights and board lights are operational. The architecture of the lecture theatre does not however, permit daylight into the venue. Normally the lecture theatre is tidy and clean (it was neat and clean during the observation).

The floor is finished with carpeting, the walls are tongue and groove wooden acoustic panels, the ceiling is white-coloured acoustic panels with open lights and projectors and the classroom is fitted with a table, white board, and electric screen projection.

Lecture Theatre B

The lecture theatre C (classroom) has a floor area of 61.0m2 with a space for 46 seats. The classroom is used by the staff and students of the Faculty of Engineering, the School of Built Environment and Civil Engineering for lectures. The classroom is neat and has no cracks. It has one exit door, but there are no exit signs on the floor to the door. One fire extinguisher is placed inside the classroom and no fire panel is available. There is no fire detector, sprinkler, and fire alarm system in the classroom.

The classroom has windows, and no HVAC system is available for ventilation. The lighting is sufficient in the classroom: both the fluorescent lights and board lights are operational. The structure of the classroom permits daylight into the venue.

Normally the classroom is tidy and clean (the classroom was neat and clean during the observation). The floor comes with carpet tiles, white walls, white-coloured acoustic ceiling and fluorescent lights, and a table and a white board are available in the front of the classroom.

Discussion

The literature review demonstrates that any inadequacy of the university lecture theatres would have a significant effect on the achievement of the primary goal of the university, since the lecture theatres are a contributing factor in the engagement of students and academic staff (Kok, 2015 and Naeem, Azhar, Khan & Parveen, 2014). The literature further reveals that a variety of factors such as indoor air quality, noise control, privacy, lighting comfort, spatial comfort, seating comfort, amount of personal seating and writing space, quality of audio-visual equipment, thermal comfort, and ergonomics are among the parameters that influence the overall output of a lecture theatre. It became evident from the observations that structural safety, lighting, cleanliness, acoustics, and fire safety were performing satisfactorily, whereas ventilation and temperature were observed to be comparatively the least satisfying parameters. Simpeh et al (2014) conducted a similar study and found that temperature and ventilation were lowest performing parameters.

The interview reveals a trend where the top management seem to have a positive outlook of the FM systems than the middle and lower-level management. For example, the Senior Director revealed that the university has a Strategic Facilities Development/Plan (SFP), and that the execution of the SFP is monitored in constant feedback sessions, while digital trackers measure the performance of SFP. He further indicated that the estate and facilities management use an FM software package. However, the responses from the other respondents (i.e., Manager: Building and Engineering Service and Director: Technical Services) suggest lapses in the FM strategies. The problem of budgetary cut also came to the fore. Other studies also found that maintenance budget of the university is often cut when budget shortfalls are encountered (Buys and Nkado, 2006; Olanrewaju, 2010; Simpeh et al 2014).

With regards, to the approach of maintaining the lecture theatre, the Manager: Building and Engineering Service reported that the department does not have a systematic lecture theatre maintenance plan. These sentiments were echoed by the Director: Technical Services. He further revealed that there is no maintenance priority management strategy or framework for the lecture theatres. This in not particularly surprising as other studies also found lapses in the approach to university infrastructure maintenance. Faced with budget constraints both the Manager: Building and Engineering Service and Director: Technical Services indicated that safety would be prioritised first. Cleaning could have a health implication and should also be accorded high priority as revealed by the respondents. According to Shen and Spedding (1998), safety items have a high risk on the health or safety of building occupants. Similarly, Atkin and brook (2015) and Chong et al. (2019) believe that safety ought to be giving high priority in facilities management. Thus, it is quite encouraging that the safety measures provided in the lecture theatres were adequate.

Both the Manager: Building and Engineering Service and Director: Technical Services agreed that ventilation should be accorded the second priority followed by lighting and temperature. To buttress, Shen and Spedding (1998) revealed that the next category of factors that need attention after safety are those that could result in a serious disruption of the normal activities in the building, or health or safety problems. If any of these parameter's malefaction or do not perform satisfactorily, building users ability to perform their activities would be seriously affected. Imagine a lecture theatre with poor ventilation or lighting. Moreover, there will be a health implication if any of these parameters do not perform satisfactorily. For example, Bishop (2009) opines that any inadequacy regarding the HVAC systems in a building can cause unnecessary distraction for students. Poor lighting could result in eye strain resulting in fatigue and subsequently affect the mental concentration of students. Acoustics should be added to this list because noise could have a negative effect on the activities carried out in a lecture theatre. Good lecture theatre acoustics make learning easier, more sustained, and less stressful, while excessive noise and reverberation inhibit speech communication thereby hindering the learning process (Sutherland and Lubman, 2001). Thus, it is important to accord these parameters second priority.

Aesthetics was perceived as the least important on the list. This correlate with other authors who believe that issues relating to aesthetics or convenience should be accorded the least priority in the event of budget constraints (Shen and Spedding, 1998; Simpeh et al 2014).

CONCLUSIONS

The case study for this research is a university, situated in South Africa. A sound state of mind supports a student's academic excellence, and a well-maintained learning and working environment provides physical security and a base for a healthy social and behavioural stability. FM is a key issue in managing university infrastructure because it supports the

university's strategic goal (human capital development) and sustains the quality of the built assets. The findings reveal that the university FM department has measures in place to ensure the effective management of the lecture theatres. However, some lapses in the approach were identified such the lack of a systematic lecture theatre maintenance plan and the absence of lecture theatre prioritisation system. Moreover, budget constraints contribute to the challenges related to the FM systems adopted for the lecture theatres. Both university management and policymakers could benefit from the findings of this study. This study also contributes to the body of knowledge in the field of maintenance prioritisation. The research was confined to three lecture theatres of the selected university. The research focused on unique building parameters of lecture theatres rather than all teaching and learning facilities. Furthermore, the interview focused solely on the prioritization of building repairs, user engagement, and maintenance strategies. The major limitation of this study is using only one case and not being able to generalise the findings obtained. A future study can, however, use many cases (universities) and resolve this generalisation weakness. A comparative study of the Facilities Management of universities in different geopolitical zones would establish whether there are differences and variability in strategies employed.

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IMPACT OF COST OVERRUNS ON CONTRACTUAL DISPUTES

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Cost overruns are a significant problem in the construction industry, as cost overruns seem to be more of the norm than the exception. Not only is the reality of frequent additional cost and time claims experienced in the construction industry, but it also leads to disputes. This study aims to determine the highest contributors to cost overruns and the preferred methods to deal with disputes resulting from cost overruns. The primary research approach adopted in this study is the quantitative research approach. Purposive sampling was used to distribute a structured questionnaire to architects, clients, contractors, engineers, and quantity surveyors in the construction environment. The results were analysed in terms of percentages according to the response of each category of construction professionals. The responses were further graphically illustrated by comparing the responses from the different fields. The key findings show that cost overruns are rampant in projects, and the client contributes the most to cost overruns. The preferred method of dealing with disputes in projects is alternative dispute resolution. Amongst the consultants, the preferred method of alternative dispute resolution method is agent resolution and arbitration. Amongst the contractors, the preferred alternative dispute resolution method was agent resolution. Thus, project role players should take necessary steps to examine project scope and requirements before commencement to reduce scope alterations, leading to cost overruns. Alternative dispute resolution methods should be the preferred method to resolve disputes that arise in projects. Only respondents available and operating from Johannesburg, Pretoria, Cape Town, and Bloemfontein participated in the survey, and hence the findings may not be generalizable as the views of all the construction professionals. The implication is that most project cost overruns are attributable to the client who pays for the project cost. Therefore, clients should properly examine project scope and requirements before commencement to minimize changes, which mainly cost the project to exceed the approved budget and cause disputes.

Keywords: Alternative disputes resolution, cost overruns, disputes, contractual remedies

INTRODUCTION

The construction industry is considered a very complex industry globally, and cost overruns seem familiar (Abdul-Rahman et al., 2013). Although commonly, time and cost are well-known issues in any construction project (Bhargava et al., 2010), studies show that many claims and disputes result from cost overruns (Baloyi and Bekker, 2011). Disputes result from disagreements between parties to a contract on a particular issue. These parties then have to pursue other means to resolve the matter. Disputes may arise from claims relating to time, cost, quality, or other parameters. When disputes result from cost overruns, the means for resolving it may contribute to its impact on cost, time, and ultimately the success of the project (Fletcher, 2013). In every industry where people must work together and cooperate, there is a possibility of disputes arising, and the construction industry is not an exception. The highest contributors to cost overruns in construction projects are not well established. Further methods for resolving disputes that result from claims seem to be unclear. The lack of knowledge among construction professionals on the most effective method for resolving

disputes that arrive from claims is a tremendous challenge in the construction industry (Dangrochiya et al., 2015).

According to Schilling (2018), the construction industry represents over 10% of the world's economy, making it one of the most dynamic industries in the world. The industry also is a significant contributor to employment and economic growth, especially in third-world countries (Garbharran et al., 2012). The above suggests that capital expenditure in the industry is of a large extent. According to Garbharran et al. (2012), three factors influence the successful completion of construction projects: time, cost, and quality. Therefore, this study seeks to investigate who contributes the most to cost overruns and how cost overruns affect claims and disputes in construction projects and help institute measures to minimize cost overruns to avert the occurrence of contractual claims and disputes.

Research objectives

1. To find out how often cost overruns occur in construction projects.

2. To assess the methods used by construction professionals to address contractual disputes arising from cost overruns.

3. To identify the effective ways of resolving contractual disputes arising from cost overruns

LITERATURE REVIEW

Contributors to cost overruns

With the frequent occurrence of cost overruns in construction projects, likely, a significant number of projects would not be considered successful (Albalushi et al., 2013). Major construction projects were undertaken when South Africa was announced as the host nation to the 2010 International Federation of Association Football (FIFA) Soccer World Cup. During that time, a survey was done concerning time delays and cost overruns (Baloyi and Bekker, 2011). Construction of stadiums such as Soccer City, Green Point, and the Moses Mabhida was amongst the selected projects that were all newly built. Costs for the projects chosen in the study were budgeted at R8,267 billion but were completed at R12,667 billion. This was 53% more than the budgeted cost. The factors contributing to cost overruns on the World Cup projects were categorized as external-related, client-related, contractor-related, and cost overruns factors ranked. The top cause for cost overruns was the escalation of material prices in the external-related category. The second-highest ranked reason for cost overruns was the lack of adequate material estimates under the client category, while the lack of skilful labour under the contractor category was ranked third.

In another study based on cost and time overruns in South Africa, inadequate planning by the client ranked the highest overall, causing cost overruns in projects. Other factors such as unrealistic contract duration and requirements imposed by the professional team were also identified as the main contributors to cost overruns (Mulenga, 2014). Comparing the FIFA World Cup in South Africa (Baloyi and Bekker, 2011) study based on cost and time overruns in South Africa by Mulenga (2014), some cost overrun factors were identified as occurring more frequently than others, as shown in Table 1.

Table 1: Factors causing cost overruns on the 2010 FIFA World Cup stadia

Cost overrun factor	Percentage	Rank	Category
Escalation of material prices	79%	1	External

Lack of adequate material estimates	60%	2	Client
Lack of skillful labour	58%	3	Contractor
Delayed contract award	56%	4	Client
Project complexity	55%	5	External
Escalation of labour costs	54%	6	External
Lack of accurate quantity take-off	53%	7	Client
Difference between selected bid and the consultants' estimate	52%	8	Client
Variation orders by the client during construction	51%	9	Client
Shortage of manpower	51%	9	External

Source: Baloyi and Bekker (2011: 60).

As seen in Table 2, the factors contributing the most to cost overruns include lack of skilful labour, lack of accurate quantity take-off, and variation orders by the client during construction. Four out of the top five causes for cost overruns are client related. The other cause is with regards to the contractor.

Similarly, a study by Ramabodu and Verster (2010) in South Africa found changes in the scope of work made by the client ranked the highest overall cause of cost overruns in projects. Other factors, such as incomplete design at the tender time, were also identified as the main contributors to cost overruns (Ramabodu and Verster, 2010). In another study based on cost and time overruns in South Africa, inadequate planning by the client ranked the highest overall cause of cost overruns in projects. Other factors such as unrealistic contract duration and requirements imposed by the professional team were also identified as the main contributors to cost overruns (Mulenga, 2014). The ranking of cost overrun factors from some studies is shown in Table 2.

Table 2: Ranking of the top cost overrun factors from multiple projects.

Cost overrun factor	Baloyi & Bekker (2011)	Mulenga (2014)	Overall	Category
Lack of skilful labour	3	8	1	Contractor
Lack of accurate quantity take-off	7	4	1	Client
Variation orders by the client during construction	9	2	1	Client
Difference between selected bid and the consultants' estimate	8	4	4	Client
Lack of adequate material estimates	2	11	5	Client
Delayed contract award	4	10	6	Client
Escalation of material prices	1	14	7	External
Project complexity	5	10	8	External
Shortage of manpower	9	8	9	External

Escalation of labour costs	6	15	10	External

Sources: Baloyi and Bekker (2011:60); Mulenga (2014:80).

Other studies contradict these findings, such as a study conducted on road construction projects in Namibia, which concluded that the factors contributing most to cost overruns are contractor related (Shimete and Wall, 2017). Determining the most significant contributing factor to cost overruns is difficult as certain factors contribute to specific projects and not to all projects. This is due to different studies having found contradicting evidence regarding the contribution of the different factors. However, for the studies reviewed, changes in the scope of work, inadequate planning, lack of adequate estimates, and labour-related factors appear to occur more frequently than others regarding cost overruns.

Disputes in the construction industry

Disputes have become an inherent feature of construction industry projects (Baloyi and Agumba, 2014). When it comes to disputes in the built environment, these are often very complicated and involve multiple levels, which would take enormous time and money to resolve in the courts. According to Fletcher (2013), it's a fact of life that disputes have the potential to cause damage to finances, reputations, and relationships, and resolving them as quickly and cost-effectively as possible is increasingly vital to individuals and the business sector. Looking at disputes in general within the construction industry, it is therefore evident that cost overruns and time delays are key influences to be considered. Among other causes such as poorly drafted contracts, variations, final account disagreements, and poor workmanship, cost overruns and time delays have also been major contributing factors to disputes (Bvumbwe and Thwala, 2011). The most suggested cost-related factors contributing to disputes include adjusting the contract value due to specific time extensions and additional work (Bvumbwe and Thwala, 2011).

Dispute resolution methods

With disputes having the potential to determine the success of a project, the primary purpose of using alternative dispute resolutions (ADR) is, as Fletcher (2013) states, to resolve it "as quickly and cost-effectively as possible." There are various methods to be considered in resolving disputes. Each method has its benefits and weaknesses. While arbitration has initially been the only method of dispute resolution in South Africa, there has since been a development of several other methods that could be used. This may be due to the different needs among the individuals in the industry (Verster et al., 2010). Common ADR methods used have been included in the JBCC Series 2000, Principal Building Agreement 2007. These ADR methods include adjudication, mediation, conciliation, and agent resolution (Verster and Du Preez, 2012a). Considering the methods mentioned, Verster and Du Preez (2012a) point out that arbitration, adjudication, and mediation are the core methods for ADR in the South African construction industry. Due to the limitations placed on the agent's authority by the client, agent resolution might only be used at a preliminary stage (Verster and Du Preez, 2012a).

Preferred method of dealing with disputes

Verster et al. (2010) note that two options are available when seeking to resolve a dispute. These are litigation or one of the ADRs. With disputes having the potential to determine the success of a project, the main purpose of using ADR is to resolve it as quickly and cost-effectively as possible (Fletcher, 2013). Common ADR methods used have been included in the JBCC Series 2000, Principal Building Agreement 2007. These ADR methods include

adjudication, mediation, conciliation, and agent resolution (Verster and Du Preez, 2012a). Verster et al. (2009) to determine the preferred method of dispute resolution amongst consultants and contractors. The study considered the ADR methods of adjudication, arbitration, conciliation, and mediation. Arbitration was found to be preferred by 60% in both categories (consultants and contractors). In contrast, mediation was preferred by 80%, together with agent resolution as the most preferred ADR method amongst consultants and 0% amongst contractors. Adjudication was found to be preferred by 65% of the consultants and 60% of the contractors. The highest average between the professionals was agent resolution, with an average of 85%.

RESEARCH METHODOLOGY

The research approach adopted for this study is quantitative research approach. Creswell (2009) states that quantitative research is a means for testing theories by examining the relationship among variables. As the name suggests, a quantitative approach concerns data that can be counted or quantified and typically uses surveys and experiments. In the present study of the impact of cost overruns on contractual disputes, the emphasis is on obtaining information from various stakeholders concerning their experiences in the construction environment. Data was gathered using a structured questionnaire. Purposive sampling was used to select 25 construction professionals, including architects, clients, contractors, engineers, and quantity surveyors operating from Bloemfontein, Cape Town, Johannesburg, and Pretoria. According to Crossman (2017), purposive sampling is a non-probability sample selected based on specific characteristics of the population and objectives of the study. It can be advantageous in situations where a researcher needs to reach a targeted sample quickly and where the proportionality of the sample is not the main concern. In purposive sampling, the researcher carefully selects participants based on the study purpose, expecting that each participant will provide unique and rich information of value to the study (Suen et al., 2014). The purposive sampling method also provides a diverse range of cases relevant to a certain phenomenon and gives as much insight as possible into the phenomenon under review (Crossman, 2017). Thus, the purposive sampling method ensured that individuals with specific characteristics were included to present their views on the effects of cost overruns on contractual disputes. Researcher selected participants who have been in the construction industry for at least 3 years and have experienced cost-related disputes in their projects. All the participants, except the clients and the contractors, needed to be registered members of the relevant regulatory bodies in their field of practice to be included in the survey. The questionnaire was circulated to the sampled subjects through email. They were requested to complete the form and email it back to the researcher. The 23 completed useable questionnaires received back were analysed according to the responses of the identified individual professions and overall responses to specific questions. Basic descriptive statistics were used to illustrate the findings of the survey. The results were analysed using excel statistical tool in terms of percentages according to the response of each category of construction professionals. The responses were further graphically illustrated by comparing the responses from the different fields with each other. Data were discussed with the aid of tables and graphs to ascertain the prevalence of certain responses. The profile of the respondents is shown in Table 3.

Table 3: Features of the respondents

The profession of the respondents		
Profession	No. of respondents	Percentage
Architects	4	17%

Clients	5	22%
Contractors	5	22%
Engineers	4	17%
Quantity Surveyors	5	22%
Total	23	100%

Work experience of the respondents

Years	No. of respondents	Percentage
0 - 5	4	17%
6 - 10	5	22%
11 - 15	9	39%
Over 15 years	5	22%
Total	23	100%

A total of 23 participants completed the questionnaire. Table 3 illustrates that the questionnaires were fairly distributed among the construction professionals who participated in the study. Respondents also have experience in the construction industry with an average of 8 years' experience; therefore, their views on the study topic are appropriate.

FINDINGS AND DISCUSSIONS

Level of knowledge of alternative dispute resolution methods used in construction disputes

The level of knowledge of the different ADR methods used in construction disputes was enquired to ascertain the reliability of the respondents' responses. The respondents were asked to indicate their level of knowledge regarding ADR methods used in construction disputes, and their responses are indicated in Figure 1.

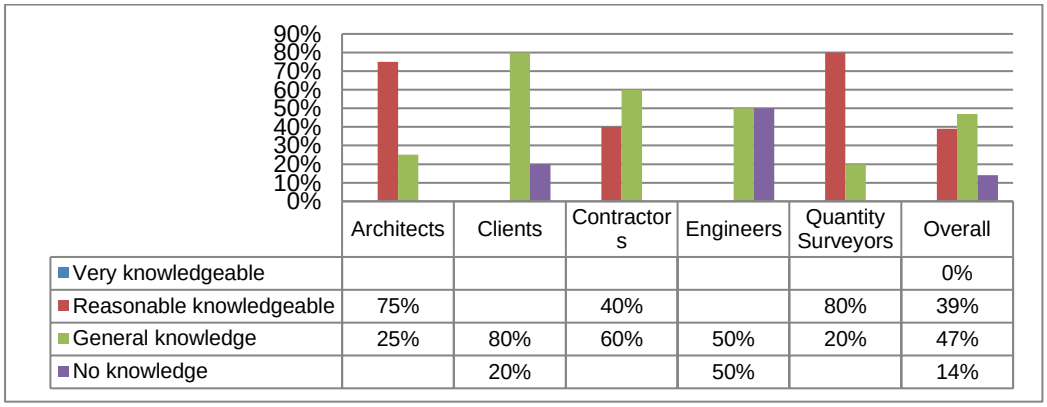
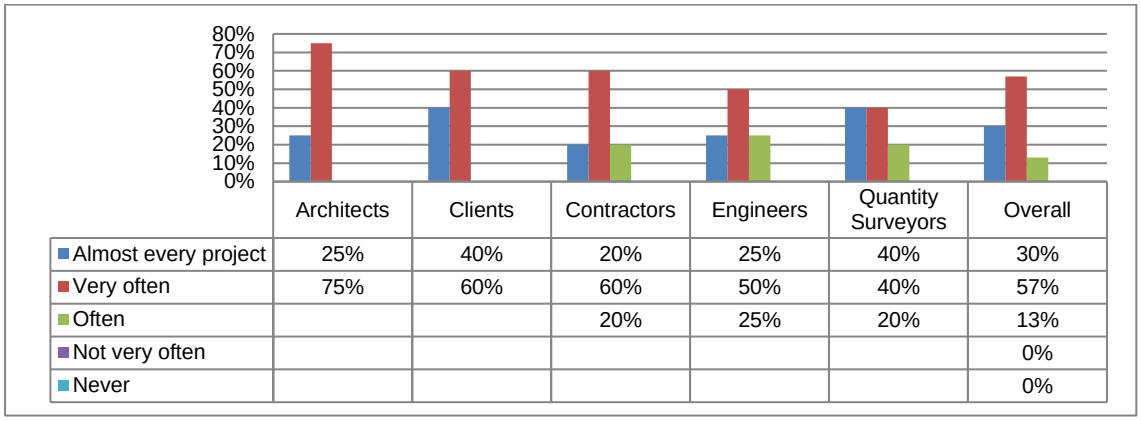


Figure 1: Level of knowledge of alternative dispute resolution methods used in construction disputes.

Figure 1 shows the respondents' familiarity with alternative dispute resolution methods, with 47%, of the respondents having general knowledge with dispute resolution methods whilst 39% have reasonable knowledge, and 14% have no knowledge regarding these methods.

Frequency of cost overruns occurring in construction projects

By determining the frequency of cost overruns in construction projects, the extent of the problem may be established. The respondents' perceptions of the frequency of cost overruns occurring in construction projects were enquired. The respondents were given the following options; almost every project, very often, often, not very often, and never as shown in Figure 2. Figure 2 shows the perception among the participants of how frequently cost overruns occur in construction projects. Thirty percent (30%) of the respondents indicated that they believed cost overruns occur in every project, whilst most (57%) of the respondents think that cost overruns occur very frequently in the project.



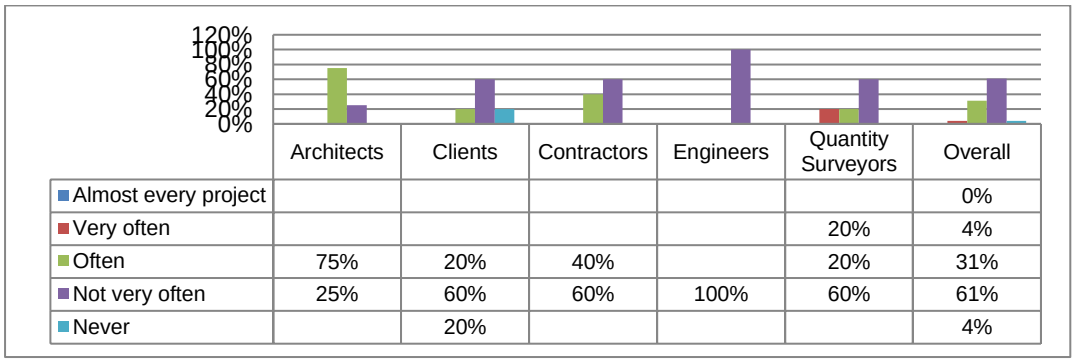
	Architects	Clients	Contractors	Engineers	Quantity Surveyors	Overall
Almost every project	25%	40%	20%	25%	40%	30%
Very often	75%	60%	60%	50%	40%	57%
Often			20%	25%	20%	13%
Not very often						0%
Never						0%

Figure 2: Frequency of cost overruns occurring in construction projects.

On the other hand, 13% of the respondents indicated that cost overruns occur often. These results are in line with the findings of Baloyi and Bekker (2011), as they established that cost overruns frequently occur, especially in large projects. No participants believed that cost overruns never happen or that it does not often happen, which was again similar to the findings of Baloyi and Bekker (2011), which concluded that not one project in their research finished within the budget.

Frequency of disputes occurring in construction projects

The purpose of asking the respondents this question was to determine the frequency of disputes in construction projects and determine the problem's degree.



	Architects	Clients	Contractors	Engineers	Quantity Surveyors	Overall
Almost every project						0%
Very often					20%	4%
Often	75%	20%	40%		20%	31%
Not very often	25%	60%	60%	100%	60%	61%
Never		20%				4%

Figure 3: Frequency of disputes occurring in construction projects.

The responses from the respondents are shown in Figure 3. Figure 3 shows how frequently disputes occur in construction projects. The occurrence of disputes in construction projects was thought not to occur very often, as the majority (61%) of the respondents agreed with this. However, 31% of the respondents believe disputes often occur in construction projects.

Contributors to cost overruns in projects

Respondents were asked to indicate who they perceived to be contributing the most to cost overruns amongst the client, the consultants, and the contractor. Figure 4 shows the parties regarded as making the most contribution to cost overruns according to the different categories of professionals. The architects believe that the client contributes 75% of the project cost overruns whilst the contractor contributes 15%, with the consultants contributing to only 10% of project cost overruns. These may be a result of numerous changes requested by clients during project execution. However, the client believes the consultants are the main culprit contributing 60% of the project cost overruns, followed by the contractor and the client. Each contributes 20% respectively to cost overruns in projects. Again, contractors attribute 80% and 20% of the project cost overruns to the client and the consultant, respectively. Likewise, the Engineers believe the client should take 50% blame for the contributors of the project cost overruns. Also, consultants and contractors should be blamed for 35% and 15%, respectively. Quantity surveyors, however, opine that the clients contribute 80% whilst the consultants and the contractors contribute 10% respectively to project cost overruns.

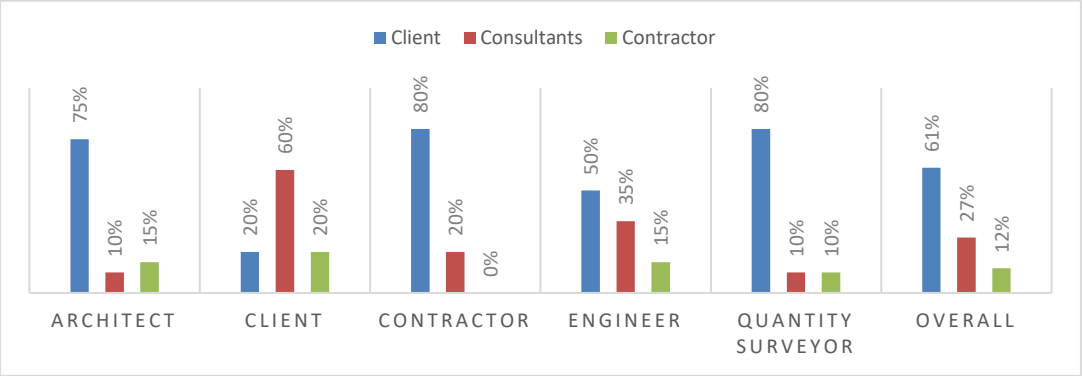


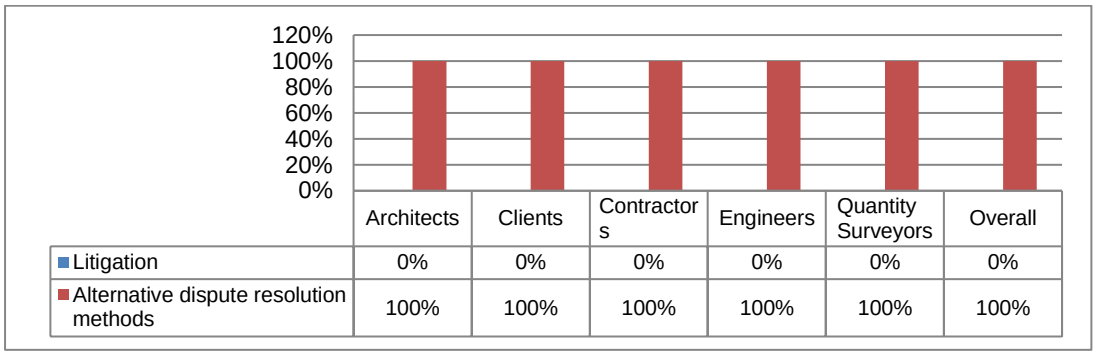
Figure 4: Highest contributors to cost overruns

Averagely, the client contributes most (61%) to the incidents of project cost overruns, followed by the consultants (27%) and the contractor (12%). Therefore, the perception amongst the participants is that the client is the highest contributor to cost overruns. These findings agree with that of the study by Baloyi and Bekker (2011), where they indicated that even though the contractor was responsible for cost overruns, the client is mostly agreed to be most responsible for project cost overruns.

Preferred method of dealing with disputes in the project

The study respondents were asked to indicate their preferred way of dealing with disputes arising from cost overruns in their projects. The options for the question were either litigation

or one of the alternative dispute resolutions (ADR) methods available, as illustrated in Figure 5.



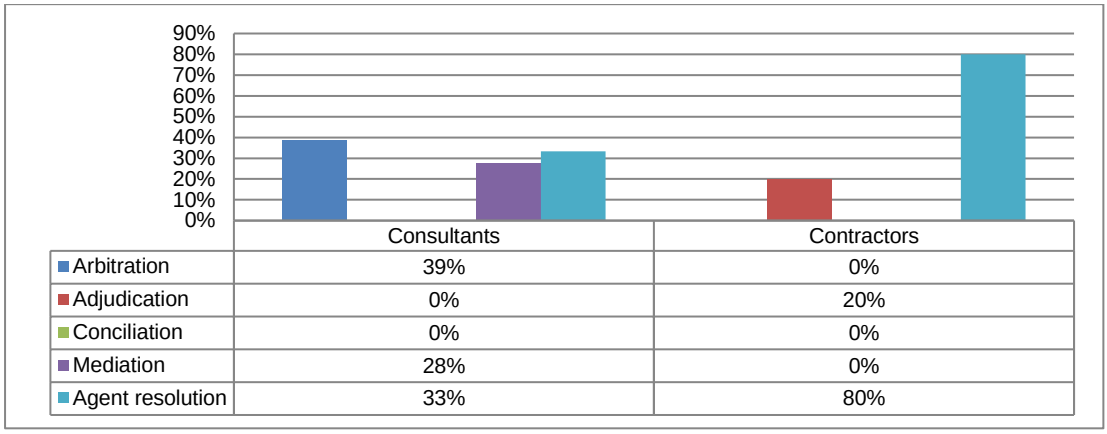
	Architects	Clients	Contractors	Engineers	Quantity Surveyors	Overall
Litigation	0%	0%	0%	0%	0%	0%
Alternative dispute resolution methods	100%	100%	100%	100%	100%	100%

Figure 5: Preferred method of resolving disputes in the project

Figure 5 shows the preferred method (between litigation and ADR methods) in dealing with disputes by the respondents is ADR. All (100%) of the participants agreed that ADR methods are the preferred direction to go when dealing with project disputes. This supports the findings of South African Politics (2019) and Verster et al. (2009), who stated that the alternative dispute resolution methods are proven to be more cost-effective, quicker, more confidential, and more controlled.

Consultants' and Contractors' preferred alternative dispute resolution method

Respondents from the consultant's and contractor's categories were asked what their preferred method of ADR was. The respondents were to select from ADR methods such as arbitration, adjudication, conciliation, agent resolution, and mediation, as shown in Figure 6. Figure 6 demonstrates what the preferred method of ADR is according to the consultants and contractors.



	Consultants	Contractors
Arbitration	39%	0%
Adjudication	0%	20%
Conciliation	0%	0%
Mediation	28%	0%
Agent resolution	33%	80%

Figure 6: Consultants' and Contractors' preferred alternative dispute resolution method

It is clear from Figure 6 that 39% of the consultants indicated that their most preferred method is arbitration, while 33% and 28% agreed that agent resolution and mediation is their preferred method, respectively. There is no definite preferred method, as all three methods are not separated by much. The findings were consistent with Verster et al. (2009), who also found the different methods are not separated by much. The findings, therefore, confirm that, although ADR is perceived to be more cost-efficient and quicker than litigation, the preferred method of ADR is uncertain. The overwhelming majority (80%) of the contractors said that agent resolution is their preferred method, while the rest (20%) agreed that adjudication is

their preferred method. Verster et al. (2009) again had similar findings, with agent resolution being the most preferred method amongst contractors.

CONCLUSION

The findings from the survey suggest that cost overruns occur very frequently in construction projects. The party most responsible for cost overruns is suggested to be the client. Where disputes occur, it is generally perceived that ADR methods are more cost-efficient and quicker than litigation. ADR methods are further preferred above litigation. Among the consultants, the preferred methods of ADR are arbitration, and agent resolution whilst the contractors prefer agent resolution. Therefore, it is recommended that specific project scope and requirements be thoroughly approved by the client and project stakeholders before commencement to prevent scope changes by clients at the later stage of the project to avoid project cost overruns. Good communication among the professional team should also be encouraged. Again, the alternative dispute resolution method should be encouraged as the best dispute resolution strategy as all the participants prefer that method over litigation. This will also reduce the cost and time required to resolve project disputes.

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KEY CONSTRAINTS TO OPTIMAL BIM PENETRATION AMONG NIGERIAN QUANTITY SURVEYORS

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Building Information Modelling (BIM) is an embodiment platform for collaboration to deliver value and efficiency in the construction industry. Its application is not limited to design efficiency for new construction, but it affects facilities management, maintenance, and renovation of buildings, among other applications. Despite the inherent benefits, implementation has been lopsided in the construction industry and among professionals. This study investigates the critical constraints to implementing BIM by the Nigerian Quantity surveyor; the impact of BIM technologies has not really been felt in the Nigerian construction industry. The research was exploratory in nature. A field survey was constructed with the use of a structured questionnaire, self-administered to quantity surveying firms within Lagos state. The questionnaire sought the perception of the respondents on barriers to BIM implementation of Quantity surveying firms. Cost and client's failure to demand the use of BIM are rated as the biggest barriers to implementing BIM among Quantity surveyors in Nigeria. The study concludes that for BIM to be fully implemented among Quantity surveyors in Nigeria, clients will be a significant driver and subsidy by the government will also play a prominent role.

Keywords: Barrier to BIM implementation, BIM implementation, Building Information Modelling, Global south, Quantity surveyor

INTRODUCTION

The construction industry is adjudged to be reluctant and a late adopter of technological development compared to other industries (Yang, 2007); the case of the Nigerian construction industry(NCI), however, is worse when compared to other countries (Oyediran, 2004; Oyediran and Odusami, 2005; Usman and Said, 2014). The Nigerian construction industry has been infamous for the late adoption and implementation of technological innovation. Thus, the NCI is among the late majority according to the Rogers technology adoption curve. This is considered bad for the industry in the 21st century when international boundaries to business are going into extinction(Ofori, 2001).

Consequently, for businesses and professionals not to become irrelevant in this technological age, being technology savvy is non-negotiable. The industry will not be better positioned to compete in the global industry if it does not move with technological advancement. This in extension, affects the professionals in the industry; primarily, the professionals make up the industry. Therefore, it is imperative for professionals, businesses, and industries to adopt the latest technology so as not to be left behind.

This paper seeks to establish the barriers to BIM implementation among quantity surveyors in Nigeria. The focus of this study is imperative because previous studies were focused on the construction industry, for instance (Amuda-Yusuf et al., 2017; Onungwa and Uduma-Olugu,

2017; Mansur Hamma-Adama and Tahar Kouider, 2018). Other studies conducted on a profession-based focus were on the architectural space (Ibem et al., 2018). Thus, there exists a dearth of literature articulating the challenges to BIM adoption for the Quantity surveyors. Considering the importance of the quantity surveying profession to the construction industry, adoption of BIM for more efficient service delivery, as opined by Raphael and Priyanka, 2014; Bukhary, Taihairan and Ismail, (2015), remains imperative for the profession.

THE QUANTITY SURVEYOR AND BIM

A quantity surveyor is a professional in the construction industry. According to RICS (2018), a quantity surveyor is an expert in the art of costing a building at all its stages, they are highly trained professionals they offer expert advice on construction costs essential for life cycle costing, cost planning, procurement and tendering, contract administration and commercial management. They are essential to the value management chain in the construction industry. According to Olanrewaju and Anahve, (2015), the quantity surveyors advise all stakeholders on financial probity, procurement and achieving the stakeholders' value systems. Additionally, it has been defined that Quantity surveyors are professionals trained, qualified and recognised to provide cost advice for infrastructural projects (Oke, Ogunsemi and Adeyelu, 2019). However it has been established that these roles have evolved over the years (Thayaparan et al., 2011), this is due to the necessity of the profession to respond to the dynamism in client and industry demands.

Therefore to remain relevant, quantity surveyors must harness the benefits of technology in the delivery of their roles (Adhikari and Keung, 2018). Consequently, for professionals to remain relevant in the present digitisation age they are expected to be knowledgeable in design modelling and manipulating models to extract required quantities and values. It has been established that technology adoption will produce efficiency and value for money(Newton and Chileshe, 2012; Gerbert et al., 2016; Adhikari and Keung, 2019).

Building Information Modelling (BIM) has increased in popularity and usefulness. The usefulness of BIM transcends professional barriers, especially in the construction industry. Its relevance is very much felt and acknowledged in the construction industry (Newton and Chileshe, 2012). Its benefits to the industry provided its full implementation by every stakeholder has been established. For the benefits of BIM to the Quantity surveying profession, studies have also been carried out. Bukhary, Taihairan and Ismail, (2015) carried out a study establishing the integration and overall advantage of BIM on the accuracy of cost estimates. The study established that there exist many flaws in the existing method of cost estimate preparation. However, BIM will add more value and provide accuracy to this aspect of the quantity surveying profession. Another quantitative study in Hong Kong by Adhikari and Keung (2019) established that the following quantity surveying functions were greatly impacted by BIM; namely: quantification of works, tender preparation, cost monitoring and control, value management, payment application preparation, life cycle costing, risk management, financial reporting, progress reporting and arbitration and dispute resolution. Furthermore, according to BIM@SG, (2015) using BIM for quantity surveying has the following benefits: auto computation of calculations thus reducing human errors, provide better visualisation of items for measurement and minimise omissions, improve communication and collaboration amongst project team members, improve cost database management which reduces the loss of information among other benefits.

Thus, the impact of BIM on the quantity surveying professionals is not in dispute based on these studies. It is only expected that Cost management professionals will be at the forefront in the implementation battle owing to the advantages the profession stands to gain.

However, despite the established benefits of BIM to the profession, its adoption has been noticed to be a challenge. A study by Jung and Lee, (2015) established that there exists an unequal level of BIM adoption across continents. The Nigerian construction industry, which is on the African continent, according to that study is referred to as being in the beginner phase. Many studies have been conducted to identify barriers to BIM adoption. The national report by the NBS (Waterhouse et al., 2015) of the UK construction industry identified the top five barriers to adoption in the industry to be lack of in-house expertise, lack of training, no client demand, cost and time of adoption restraint. It also established that there exists more coordination of record-keeping on projects where BIM was adopted. It is however worthy of note that this study wasn't profession-specific but an industry study. To identify the barriers of BIM adoption in Nigeria, Amuda-Yusuf et al., (2017) through a quantitative study, identified 21 barriers and established the top 5 plaguing the Nigerian construction industry. The barriers identified are clients' low level of awareness, lack of funding, poor power supply, legal uncertainty, and lack of transparency. Another study establishing barriers in the construction industry in Nigeria was done by (Onungwa and Uduma-Olugu, (2017), using a field survey of 2015, they establish the top five barriers to BIM adoption in Nigeria as: lack of skilled personnel, lack of internet connectivity, reluctance of other stakeholders to use BIM, lack of BIM object libraries and lack of awareness. This study is aimed at establishing the barriers to BIM implementation specific to among Quantity surveyors in the Nigerian construction industry. It seeks to establish the peculiar barriers to adoption, distinct from other professionals in the Nigerian construction industry.

Although BIM has been established to enhance the delivery of the quantity surveying duties, it, however, introduces new challenges for the quantity surveying profession. The challenge for the quantity surveying profession to keep reinventing itself and evolve to meet the ever-changing needs of the industry (Raphael and Priyanka, 2014). Also, the challenge of correctness of information and time spent in vetting such information (Olsen and Taylor, 2017). Thus, information management is important because "garbage in, garbage out" – the quality and accuracy of information fed to the system is a major determinant of the output.

RESEARCH METHODOLOGY

Questionnaires were designed and administered to obtain responses from consultant quantity surveyors in Lagos state, Nigeria. Lagos was chosen due to its status as a commercial hub of Nigeria and in the West African sub-region. The instrument measured the barriers to the adoption of BIM by the professionals. The review of the literature for the study was achieved through related journal articles and conference papers.
Barriers to the implementation of BIM by quantity surveyors in Nigeria were measured using an eleven (11) item construct measured on a Likert scale on a five-point level of agreement (Strongly disagree to Strongly agree).

The data for the study was obtained from primary sources. The primary data for this research was sourced from structured questionnaires self-administered to respondents through field surveys using random sampling. A total of seventy-three (73) copies of the questionnaire were distributed to consultant quantity surveyors in Lagos state, only fifty-five (52) copies were received from the field, which represents 71.23% as shown in table 1 below

Table 1: Response to questionnaires

Questionnaire	Number	Percentage
Administered	73	100
Received	52	71.23

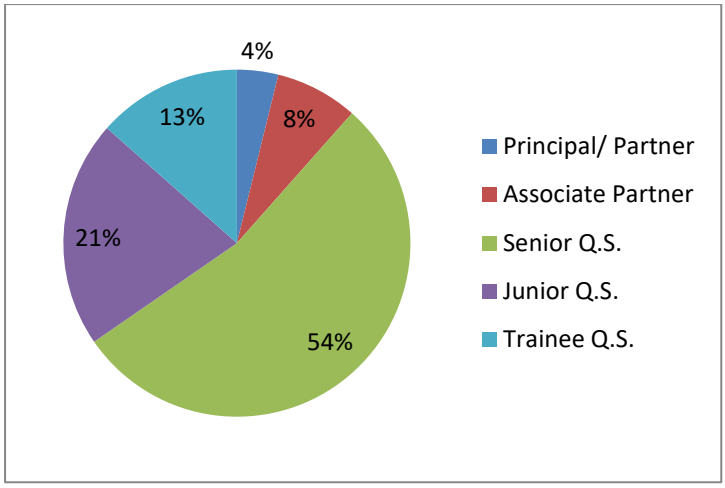

Figure 1: Designation of respondents

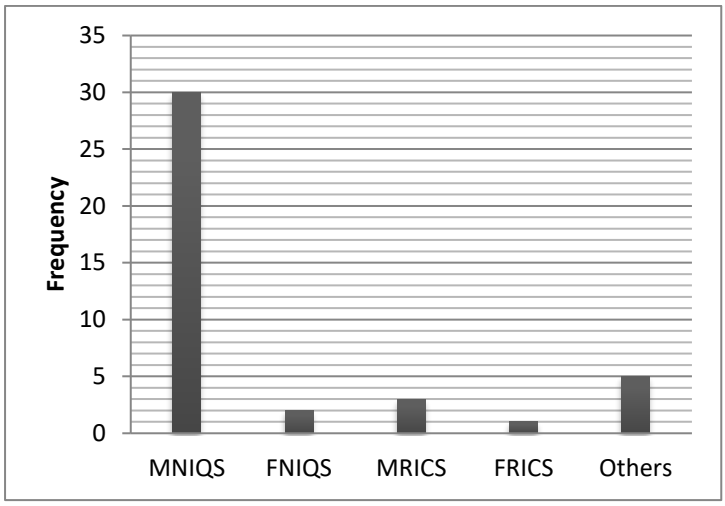

Figure 2: Professional qualification of respondent

Background Information

Table 2: Background information of respondents

Characteristics	Sub-Characteristics	Frequency	Percentage
Academic Qualification of respondent	HND	8	15.4
	B.Sc. /B.Tech.	30	57.7
	M.Sc.	11	21.2
	Others	13	5.7
Post-graduation industry work experience	0-10 years	36	69.2
	11-20 years	14	26.9
	21-30 years	1	1.9
	Above 30 years	1	1.9

Figure 1 above shows that only two (2) which represents 3.80% of the respondents were Principal managing partners, 7.7 % which represents four (4) respondents were associate partners. 53.8 % which represents twenty-eight (28) respondents were senior quantity surveyors 21.2 % which represents eleven (11) respondents were Junior quantity surveyors while the remaining 13.5% representing seven (7) respondents were trainee quantity surveyors. From Table 2, Eight (8) respondents who represent 15.4% of the sample have HND; thirty (30) respondents who represent 57.7% of the sample have BSc./B.Tech; eleven (11) respondents who represent 21.2% of the sample have MSc; three (3) respondents who represent 5.7% of the sample have other educational qualification. The qualifications categorised as others were; one (1) OND, one (1) PGD and one (1) M.P.M. It can be deduced that most of the respondents of this questionnaire are BSc. Certificate holder with 57.7%. Out of the fifty-two (52) respondents, only forty-one (41) of them which represent 78.8% were either professionally qualified or attached to professional bodies. From fig 2, out of the forty-one (41), thirty (30) which represent 57.7% were MNIQS, two (2) respondents who represent 3.8% were FNIQS one (1) respondent who represents 1.9% was MRICS while the remaining five (5) respondents (9.6%) fell under the category of others. This shows that a larger percentage of the respondents (78.8%) were professionally qualified, quantity surveyors. 69.2% which corresponds with thirty-six (36) respondents has post-graduation working experience of less than or equal to 10 years, 26.9% which represents fourteen (14) respondents has post-graduation working experience between 11 – 20 years while 1.9% which represents one (1) respondent has working experience between 21 – 30 years. 1 (1.9%) respondent had working experience of above 30 years. This shows that majority of the respondents are new in the industry and are expected to embrace technological advancement that will aid the services of quantity surveyors.

RESULTS

4.1 Barriers to the Implementation of BIM amongst Cost Management Professionals

Respondents were asked to indicate the level of agreement on barriers to the implementation of BIM in the Nigerian construction industry with eleven (11) constructs by ticking either strongly disagree, Disagree Neutral, Agree or Strongly agree. The result, presented in table 3 below, was analysed using the mean item score, reveals that the biggest barriers to the full implementation of BIM in Nigeria are “The cost of obtaining a BIM package is high” with mean item score 3.90. This statement “Clients do not demand BIM implementation on projects we are involved in” with mean item score 3.69 was ranked second while “Objects useful for BIM are not freely available.” ranked third with 3.46 mean score. The lowest ranking barrier was “BIM is irrelevant to projects we work on in our organisation” with mean item score of 2.46.

Table 3: Barriers to Implementation of BIM

Barriers to implementation of BIM	mean	rank
The cost of obtaining a BIM package is high	3.90	1
Clients do not demand BIM implementation on projects we are involved in	3.69	2
Objects useful for BIM are not freely available.	3.46	3
We are not sure of the government commitment to BIM’s implementation	3.33	4
BIM is not a strategic priority for the company I am working for	3.29	5

Personnel in my organisation lack training on BIM operation	3.19	6
The industry is not prepared for teamwork required by BIM	3.17	7
BIM files are large and complex to handle	3.08	8
BIM lacks standardised tools and protocols useful for its operation	2.60	9
My organisation is involved with small-sized projects which may not require BIM	2.46	10
BIM is irrelevant to projects we work on in our organisation	2.46	11

DISCUSSION OF FINDINGS

The ranking of the statement "The cost of obtaining a BIM package is high" as one of the biggest barriers to BIM's implementation amongst Nigerian cost management professionals is in accordance with the findings of Eadie et al., (2013). Also, Akerele and Moses, (2016) perceived that the barrier to BIM adoption is the high cost of BIM implementation necessities.

Client's lack of demand on BIM requirements on their project was supported, as a barrier to BIM's implementation in the construction industry, by Akerele, & Etiene. (2016). Also based on the findings of Akerele, & Etiene, they ranked the commitment level of the government as the second biggest barrier to BIM implementation as compared to it being ranked the fourth biggest barrier based on table 3 above.

CONCLUSIONS

The construction industry is experiencing a change in its process and product delivery due to the upsurge in technology adoption the world over. The adoption rate has significantly disrupted the processes. However, the barriers to its adoption have been identified to vary among countries and professionals.

This study has established the barriers to BIM adoption among quantity surveyors in Nigeria. The top five barriers to the adoption of BIM among quantity surveyors revolves around the high cost of installation, clients non-demand for BIM application on their projects, government commitment, and BIM not being a priority of the firm. Thus, this can be summarised under three primary headings: cost, government, clients, and professionals (industry). Therefore, the clients, professionals, and governments must collaborate in making BIM adoption a reality among the quantity surveyors in the NCI. The government should provide an enabling environment that will subsidise the cost of adoption by providing the basic infrastructures necessary for technological adoption. Professionals should make BIM adoption a priority and learn BIM tools required for the effective delivery of quantity surveying functions. This is imperative as other sectors will not accommodate the inability of quantity surveyors to meet up with the pace and level of professional service delivery required in the digitised construction industry environment. Professionals should not hesitate to invest in the adoption of BIM, but it should be seen as an investment for more efficient service delivery; the clients would pay if the value delivered by the professionals is evident. Clients should demand value and efficient delivery on their projects by requesting a total adoption of BIM on such projects.

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INFLUENCE OF ORGANISATIONAL VALUES AND BELIEFS ON SUSTAINABLE CONSTRUCTION PERFORMANCE IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Belief is a conviction that is generally accepted to be true, especially without actual evidence or proof. Beliefs are different from values; they are collective and outstrip circumstances because they are centred on what is essential to man. Values rise from the observations of human. Organisational values and beliefs vary from one organisation to the other within the construction industry, and it can also be viewed as a corporate personality. Sustainable development projects interconnect three socially concerned systems, which are environment, society and economy. Sustainable development adopts a systems approach to generate and manage a vigorous built environment centred on resource proficiency and environmental principles. This research adopted extensive literature review as its methodology. This research examines the influence of organisational values and beliefs in carrying out sustainable projects. This research analyses a wide range of literature on how values and beliefs influence construction firms' performance in carrying out sustainable projects. Findings from this research revealed that values and beliefs strongly influence the performance of firms carrying out sustainable projects. The study concluded that strong organisational values and beliefs aid the successful completion of sustainable projects. This study will contribute to the body of knowledge by making firms understand the importance of organizational value and belief on sustainable construction performance.

Keywords: Belief, Organisation, Performance, Sustainable Construction, Value

INTRODUCTION

Organisational culture incorporates values and beliefs which "contribute to the unique social and psychological environment of an organisation" (Watkins, 2013). Organisational culture is an array of communal assumptions that directs what transpires in an organisation by outlining appropriate values and beliefs for numerous conditions. This implies that any aspect of communal assumptions that steers what materializes in the establishment is a culture adopted by the establishment. It is similarly the configuration of such mutual behaviours and beliefs which are communicated to fresh organisational members to perceive and think and feel (Tipser, 2013). Thus, organisational beliefs and values affect how society and groups interrelate with one other. In addition, it might influence how greatly employees relates with an establishment (Carl et al., 2004). Organisational values and beliefs are replicated in the mode employees execute tasks, set goals, and control the necessary assets to realize the goals (Fey & Denison, 2003).

Organisational belief is often a result of possibilities and speculations among the employees (Bell et al., 2011). It is derived after inquisitiveness, scrutiny, and analysis that remodel assumptions into sentiments and sentiments into facts (Coraiola & Murcia, 2020). An organisation's typical employee addresses a fresh idea, data, rumour, proposition, or

clarification with a certain presumption (Michelson & Mouly, 2004). This presumption may vary from a very unpredictable, sniffy, and sceptical view to a precise and acceptable view (belief). To define the authenticity of a belief, an assessment of its correspondence with reality is checked (Mariano & Casey, 2015). Examples of beliefs in a typical construction establishment include individual responsibility, commitment, social responsibility, employee empowerment, innovative prowess, financial motivation, etc. (Smets, 2013).

Organisational belief differs from organisational values. Organisational value is defined as an ‘organisation's principles or standards of behaviour; judgment of what is important in life’ (WORKLOGIC, 2021). Core values are generally global (Denehy, 2001). Organisational values drive the way organisation influences its operations, and how employees interact (Lankau et al., 2007). Organisational value is not an illustration of the service done or the policies employed to achieve an 'organisation's mission; they are the hidden influencers of general behaviour centred on intensely grasped beliefs that influences decision-making (Lerro et al., 2012). The communal behaviours of the whole workforce become the establishment value and the way employees carry out activities to fulfil the organisation's undertaking to investors (Pitelis, 2010). The firm’s beliefs and values are embedded in construction firms’ performance in practicing sustainable construction (Alvesson, 2011).

Sustainable construction is defined as a construction procedure that integrates sustainable development's basic ideologies (Parkin, 2000). Such construction procedure would lead to ecological responsibility, social consciousness, and economic viability purposes to the fore in the built community and amenities for the wider populace (Shelbourn et al., 2006). Firms carrying out sustainable construction must perform as required, in accordance with the building standards (Rio Merino et al., 2010). Performance is the completion of a task by applying knowledge, skills, and abilities (Kantrowitz, 2005).

Organisational performance is a multifaceted conception, and astute managers depend on multiple performance processes when appraising the achievement or failure of their establishments (Richard et al., 2009). In a typical construction company, performance or work performance implies good standing with the hypothesised outset of necessities of the project done (Kong et al., 2007). Examples of factors that define the performance of a firm carrying out sustainable construction includes excellent service, profit maximisation, long-term survival of the firm, maximisation of balanced growth of the firm, increase number of clients etc. (Moon, 2007).

Extant studies have proven that organisational culture (belief and values) affects the performance of the organisations (Mousavi et al., 2015; Acar & Acar, 2014; Acar & Acar, 2012). However, the effect on sustainable construction performance remains unexploited in the South African Construction industry. Hence, this research focuses on measuring the influence of organisational beliefs and values on the performance of firms that execute sustainable construction.

RESEARCH METHODOLOGY

This study employs an extensive and all-inclusive literature review method to understand the influence of organisational values and beliefs on sustainable construction performance. According to Dune (2011), the effective address of research questions, development of research framework and findings evolvement is the definition of an effective literature review.

Performance of sustainable construction firms

Sustainable construction project success in South Africa hinges upon the labors and performance of an individual partaking in it and how sound they are performing in a group to realize the aims within the limits of scope, budget, time, and value (Lin, 2007). Projects are organised and it's generally by integrative crew because of the capacious level of complication that an individual cannot control (Ratcheva, 2009). These individuals function independently but in a string of order for a sole aim to attain a project's desire and objectives with limited resources (Baiden et al., 2006). Consequently, they are similarly accountable for the achievement and disappointment of the project. Performance conduct is a scheme in which employees are inspired to work effectually and proficiently in a team within the line required by an organisation (Ankrah & Proverbs, 2005).

Figure 1.0 shows the existing model and tools used to measure the performance of construction firms involved in sustainable projects. These models are classified into two categories; one emphasises assisting management in measuring and enhancing operational mechanisms. In contrast, the other emphasises on firm's self-assessment (Ahmed, 2018). A publication by the Federal Ministry for Environment, Nature and Nuclear Safety, Germany (2016) on sustainable construction in South Africa showed that the execution of sustainable projects has been relatively successful, thereby imploring for more investment into the sustainable construction industry. The report further analysed the benefits of sustainable projects in South Africa, such as effective land-use planning, empowerment of relevant stakeholders, improved construction education, advanced research, availability of funds, clarity in procurement and standardised mode of operation.

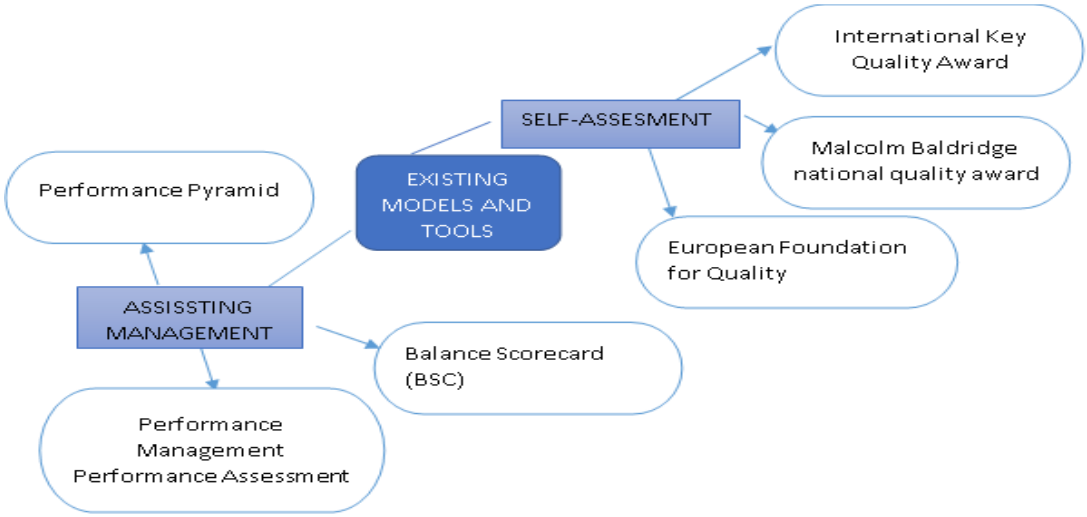

Figure 1: Existing Models and Tools for measuring performance (Developed by authors through literature review).

How does organisational value influence performance?

To make organisational value advantageous, the individuals that constitute that firm must believe in the matching values as the establishment and must contribute to the procedure of shaping and outlining the establishment's values (SHRM, 2021). Organisational values are expected to be communal and practiced by the staffs of the firm for the firm to be prosperous (Keene & Fairman, 2011). Values that are communal will influence performance in diverse ways. Employees could make improved choices because of the sagacity of communal values (Yaniv & Farkas, 2005). When employees understand and have faith in in the firm's values, they are most likely to create judgements that will align with those values (Kane, 2021). Real and communal values help in generating unification in a group and results in unswerving

behaviour (Kane-urrabazo, 2006). Furthermore, when values are communal, management understands what type of work and behaviour to anticipate, and contrarily individuals with differs values incline to highlight different results and are inspired to accomplish differs objective (Argandona, 2003).

The conformity of singular and organisational values can be very much encouraging for the workforce and, therefore, can clearly motivate their work commitment (Dylag et al., 2013). Employees, who perceives they share similar value with an organisation will probably have an attachment to that establishment (Amos & Weathington, 2008). These employees are most likely to possess optimistic attitudes and less probable to quit the organisation (Luthans et al., 2006). They are perceived to be loyal, dedicated and recognise more intensely with the organisation (McNaughton, 2003). The performance will be enhanced (Sharma et al., 2009). As many researchers who approve the importance of conformity between sole and organisational values, there are several others who argue mismatch as one of the causes for unsuccessful organisation (Finegan, 2006; Triana & Garcia, 2009; Bustinza et al., 2015). This occurs because the employees who perceive that their values are broadly dissimilar to those of their employer firm are most likely to resign from the organisation taking treasured knowledge with them or just gifted people backing out of the organisation (Klenke, 2005).

Values shapes all activity of an organisation and influence the organisation's behavior in all its projects, from monetary to upkeep to promotions to human assets (Biery, 2021). Values have a vital purpose in organisational operative systems in strategic administration (Lawler, 2006). All accomplished organisations need to have concise and well stated values, which motivate every member of staff (Jaakson, 2010). Organisations that centres on communal values are more probable to experience long-lasting success than the ones that do not centre on communal values (Barrett, 2010). Personnel of the organisation ought to be obliged by the organizational values to fashion long-lasting achievements for the organisation (Kale et al., 2002).

How does organizational belief influence performance?

The performance of a firm that carries out sustainable construction relates to its belief (leadership, balancing vision and execution, delivery inspiration, exhibiting confidence, accountability etc.) (Jackson et al., 2010). The relevance of this relation is that when diligently practised, the firm accrues success in its activities. Specifically, performance equals to belief in scenarios where the firm's beliefs are conditioned on measures known to the employees and clients (Drugowitsch et al., 2014). In cases where not all the firm's beliefs are conditioned on criteria known to the employees and clients, the performance on projects become relative (Haney et al., 2007). This implies that another client might reject a project accepted by a particular client. To relate belief and performance in an organisation, it is also assumed that the construction team have thoroughly learned the generative model of the task to be done (Charles, 2017). In other words, the project manager can infer the posterior distribution optimally over each of the scopes of work being suitable and applicable.

The firm's beliefs have been able to consistently predict the improved personal performance and accomplishment of each employee, aiding the success of the construction firm (Baker et al., 2014). In short, organisational belief can influence long-standing economic performance when the belief suitably suits with the construction setting and enhances corporate policies and orientation among organisational associates. Also, organisational belief is recognised as a germane input to functional expertise management and organisational education (Chen & Huang, 2007). This is so particularly when organisational beliefs are allied with expertise management behaviours and aftermaths (Alavi, Kayworth, & Leidner 2005).

Proposed framework to enhance the performance of sustainable construction in the South African construction industry

This study argues that strong organisational values and beliefs such as employee empowerment, workers' financial motivation, and the likes enhance the performances of firms carrying out sustainable construction in South Africa. The study proved that construction firms that do not have well-spelt organisational values and beliefs fall short of their client's satisfaction on the project undertaken. This is the crucial reason why firms need to adopt strong organisational beliefs and values for better performance, as displayed in the framework (Fig. 2); (Watkins, 2013). This framework shows that values (such as positive attitude, diligence, goal-oriented discipline etc.) and beliefs (such as accountability, social responsibility, employees' empowerment etc) when implemented in the firms carrying out sustainable construction, will enhance performance (such as excellent service, profit maximisation, increased number of client and firm's long-term survival).

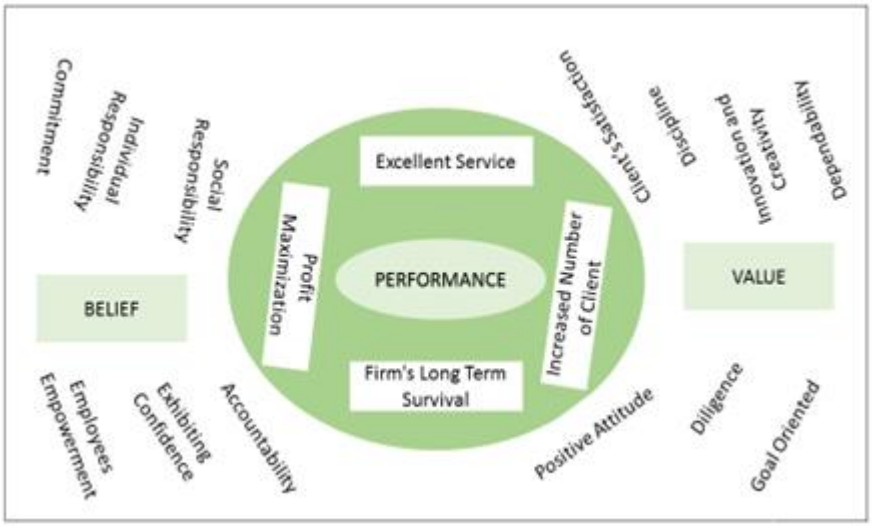

Figure 2: Sustainable Construction Performance Framework

CONCLUSION AND RECOMMENDATION

This research identified examples of beliefs and values a typical construction firm that carries out sustainable construction in South Africa should possess using a comprehensive literature review. This research established that beliefs and values influence the performance of firms that carry out sustainable construction. The study contributes to the body of knowledge as it showcase the pattern of beliefs and values of construction firms engaging in Sustainable construction in the South African construction industry. It gives an overview of the performance of these construction firms and develops a framework for the adoption of beliefs and values to enhance performance. The study recommends that for construction firm to enjoy economic relevancy and longevity, it must possess well defined and articulated organizational belief and values.

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QUALITY HOUSING DELIVERY IN SOUTH AFRICA: THE CONTRIBUTION OF BUILDING INSPECTORATE

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Quality management systems are designed to assist organizations to ensure they meet the client's needs and other stakeholders. Quality as a concern partly results from the human factor, therefore inspectors' role in assuring quality should be considered important. Limited research studies have looked at the inspector's contribution to assuring quality homes. Therefore, the study aims to examine how building inspectorate contributes to the level of housing quality achieved in Gauteng, South Africa. A mixed-method was adopted in this study, a questionnaire with open and closed-ended questions was distributed amongst inspectors, contractors, and homeowners in Gauteng housing projects. The data were analysed via SPSS version 23 and the findings revealed that poor workmanship contributes massively to quality as they are responsible for the building works. By examining inspectors' contribution to quality during construction, suitable measures may be developed to improve the inspections process (such as ensuring inspectors visiting sites frequently to monitor contractors, ensure that they are registered with the warranty scheme, assure compliance, quality control reports and tracking of construction deficiencies and ensuring timely corrective measures) which will improve the inspection and eventually the quality of homes in South Africa.

Keywords Quality assurance, building, quality, contribution, housing

INTRODUCTION

Poor quality in housing has been a concern to the built environment and government resulting from several factors. The Construction Industry Development Board (cidb), National Department of Human Settlements (DHS), Council for Scientific Industrial Research (CSIR), Public Protector, and other researchers have conducted studies to better understand, and address quality defects faced in these projects along with studies on factors affecting quality (Sibiya, 2018). This shows that there is poor quality housing although the homes are under warranty, leaving homeowners dissatisfied.

Poor quality in housing projects leads to the greatest loss in economic wealth, and thus poor performance particularly in terms of efficient growth productivity growth, charge economy shortage, poor customer service, quality innovations (cidb, 2011; Mahajan, 2016; Sibiya, 2018). Furthermore, studies have revealed that around 6-15% of waste is recorded because of poor quality, whereby 20 -40% of all site defects have underlying issues arising during the construction stage 54% of the construction defects are associated with human components such as inadequate supervision and unskilled laborers of construction work. Above that, 12% of the construction defects are a result of material and system failure (Waje & Patil, 2012). Moreover, poor communication between construction stakeholders, failure to check required standards, lack of information and procedures to be followed, lack of skilled and technical expertise, and feedback in recurring errors contribute to such problems (Mkuza et al., 2019). Although project success in construction is measured by quality and meeting client's expectations (Heravitorbati et al. 2011), compliance to quality standards in housing projects is the most crucial factor in the management and implementation of such projects.

Client and consumers dissatisfied with housing quality have also been concerned (cidb, 2011) and this poses a serious threat in sustaining the construction industry (Buys & Roux, 2013). In South Africa, quality concerns in housing projects partly result from the shortage of housing construction professionals and engineers, and quality inspectors to manage the housing development projects (Mkuza et al, 2019). Nevertheless, quality as a concern is not only the inspectors' responsibility but it is made up of several stakeholders. As studies have indicated, some of these defects are aligned to human errors. Akinyede et al. (2017) highlighted that construction stakeholders in public housing projects play a critical role in assuring quality; that is by involving all stakeholders in housing projects, enforcing statutory requirements as well as providing training workshops regarding quality standards, developing quality assurance departments within construction firms. Equally, severe penalties for non-compliance to quality standards must be enforced by government and professional bodies. Clients must demand proof of contractors and credentials for quality assurance capability before compiling their tender lists. Further, defects can be lowered through minimising a need for teamwork between employees and management with all departments, uniting to attain expected results of quality management to produce value for the company and good quality product (Ramezani & Gharleghi, 2013; Sibiya, 2018). The neglect of the use of quality management systems (QMSs) also results in a negative image in terms of achieving quality (Buys & Roux, 2013).

Similar studies have looked at quality housing. Meding et al. (2012) surveyed public and private personnel, where the findings have shown that management structures and responsible personnel are the key factors contributing to construction quality. However, the study focused on factors contributing to construction quality and the barriers that prevent organizations from achieving optimum quality outputs. Additionally, Ngquba (2017) looked at the effectiveness of quality assurance systems, thus a mixed method study on building inspectors, designers, contractors, and beneficiaries where the findings revealed that poor quality attributes from unskilled workmanship. This indicates that there is limited knowledge of quality assurance systems by the building inspector, contractor, and designer. Another study on analysing the persistent nature of quality issues in low-cost housing projects focused on quality management gaps and shortcomings within the low-cost housing sector, where the mixed methods findings and conclusions showed that the major cause of defects is poor workmanship (Sibiya, 2018). Therefore, it appears that there is limited literature on building inspectors' contribution in assuring quality.

LITERATURE REVIEW

Overview of literature on housing quality

Section 26 (1) of the South African Constitution states that everyone has a right to access adequate housing, and this is considered as one of the important basic rights (Selebalo & Webster, 2017). Moreover, the Housing Consumers Protection Measures Act 1958 (Act No. 95 of 1998) established a warranty scheme to protect the housing consumers and regulate the home builder’s industry. Quality promotes human health, wellbeing, and safety, and addresses today’s many cultural, social, economic, and environmental concerns (CIOB, 2017). Quality is a serious concern throughout the construction process; therefore, it must be improved.

Quality assurance system

Quality in this study is defined as meeting the clients' needs. Despite being assured quality, the construction industry continues to experience defects in their new homes. With that, the quality management systems were designed to assist organisations to ensure they meet the

client's needs and other stakeholders. However, to assess quality management processes, both quality assurance and quality control should measure and report the exact quality deliverables (Akinyede et al., 2017). Such requirements include management responsibility, planning, policy, and objectives; resources management and allocation; requirements for the quality management system and documentation; measurement, monitoring, analysis, and improvement; product realisation and process management (DHS, 2019). In South Africa, there was a need to implement QMSs in the construction industry as contractors were failing to implement the required quality standards. Although they are made well-informed of the systems and quality output, they still lack competent skilled management and organisational structure to implement and sustain the systems. An internal system includes activities directed to giving confidence to the management of an entity to ensure that quality is obtained. Successfully applying QMSs can result in a quality product, improve workmanship and efficiency, increase profit, and reduce wastage. On the other side, the external quality system focuses on the client in offering service or product that will satisfy the customer's quality need. Offering trust to the management of an organization that the expected quality must be obtained is the aim (Dharani & Ramasamy, 2015).

The quality system includes organizational structure, strategic quality management, management and training, quality policy, process, customer focus and market intelligence, ISO 9000 and ISO 9001, performance management plans, information management, benchmarking, quality manual and quality control (Davidkumar & Kathirvel, 2015). Lack of overall management systems to manage project feasibility assessment, pre-planning, readiness, and implementation was highlighted as one of the challenges of quality management (Sibiya, 2018). Interventions suggested to address these challenges include mentoring of improvement management systems, exploring bridge finance options, emerging contractors, and penalty clauses in contracts.

Quality is a concern partly resulting from the human factor; hence it is important to develop a quality assurance system to minimise the inefficiency that might result in poor quality of service and product to be delivered to the end-user (Adenuga, 2013). Akinyede et al. (2017) study indicated that the poor quality of homes partly resulted from a lack of pre-inspection and use of non-registered builders. A quality assurance system was developed by an international standard organisation (ISO) to assist in overcoming the quality-related issues and improving quality (Abas et al., 2015). To avoid poor results, which affect clients, it is important to develop built-in quality assurance systems (Dharani & Ramasamy, 2015).

Quality assurance is the scheduled and systematic activities applied in a quality system so that quality requirements for a product or service will be fulfilled. Quality assurance is spot-checking of contract compliance, test results, and ultimately making sure that the quality control process is working (Bhattacharjee, 2018). Moreover, it must be formulated from design and construction processes that assure quality from the inception, material and the elements and procedures used during construction for the communicating performance standards from the inception and effective monitoring and control and feedback mechanism. Quality assurance includes all those quality restrictions or guidelines that would ensure that a product meets its planned or targeted quality by its stakeholders or the producers (Ngquba, 2017).

Sibiya (2018) study identified three sub-systems and this approach is different from project to project; however, the fundamental themes should remain the same. Effective quality assurance will have an advantage in both the construction period and the design process. Therefore, management and delivery of public housing projects might contribute to acquiring higher quality of successful projects if they incorporate the quality assurance programs. Thus,

the quality assurance measures must be in place, as minor structural defects in the quality standards cause huge damage to human lives and the properties of the consumers. However, Sibiya (2018) argued that quality management barriers are the lack of information in the area, lack of effective supervision, lack of effective communication, lack of management's commitment to quality assurance, lack of proper equipment available for use and lack of a quality assurance team to lead the process. Management commitment, communication between managers and employees, employee involvement, detailed and logical work program, regular inspection and audit of the quality report, training and education of team members and review/analysis were also identified.

Warranty standards

In South Africa, the warranty scheme was introduced to monitor quality and regulate the construction industry. Quality concerns by shoddy contractors were common as they were cutting corners to make a profit (Sibiya, 2018)). The NHBRC mandate was "to protect the interests of housing consumers and to ensure compliance by contractors with regulated building industry standards, following the provisions of the Housing Consumers Protection Measures Act (Act No. 95 of 1998)". All builders in the country are compelled to register with the organization to be in business. The warranty scheme enforces correct building practices. The NHBRC dispatches home inspectors to building sites, long before houses are handed over to expectant homeowners (DHS, 2019). If the new homeowner notices a defect that requires attention, they are required to contact the warranty scheme provider and notify them of the identified defect and allow the warranty scheme provider to inspect the homes. Upon acceptance of a valid claim, the warranty provider makes the necessary arrangements to have the defect remedied (NHBRC, 2011).

Role of inspectors in warranty scheme

Quality management procedures in the implementation of the project include inspection that will take place at each stage, quality control testing on building materials, quality control testing reviewing results, the checklists that will be used to assure that there is compliance, quality control reports, tracking of construction deficiencies and ensuring timely corrective measure (DHS, 2019). The building inspector role is highly dependent on competency and professionalism for the project to be completed in a fit-for-purpose manner for sustainable future use and compliance (Hopkin et al., 2015).

During housing construction, an inspector's duties include inspecting construction work on-site, assessing if compliance with building regulation is obtained, checking non-compliance (identify defects), putting together a checklist of defects that need to be rectified, and requesting and attending to the identified defects (Hopkin, et al., 2015). The inspection process may be performed by a building inspector from the local authority on independent registered inspectors. The main purpose of the inspectors' section is to assure that they protect warranty fund by effective inspections audit and assure that all homes enrolled serve the purpose and that there is a need to proactively identify the potential structural defects and offer the remedial solution that will benefit the homeowners. NHBRC inspectors conduct home inspections using the Building Quality Inspection Index for Houses (NHBRC, 2020).

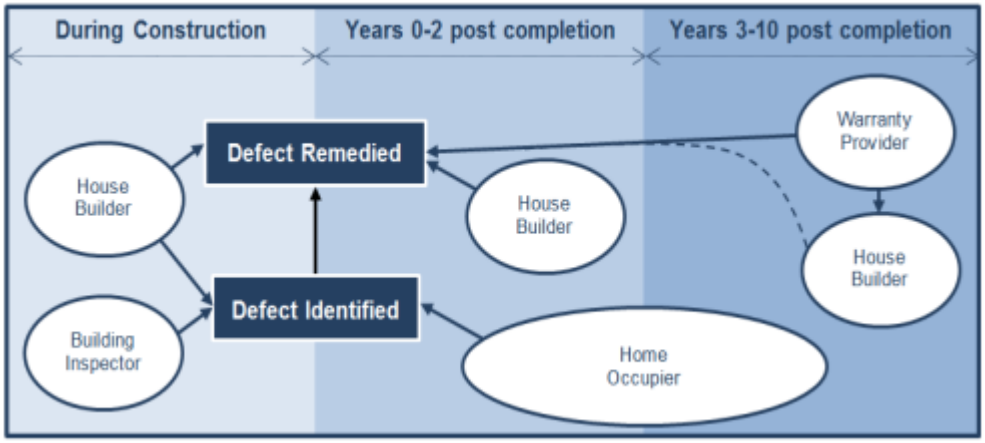

Figure 1: Typical defect detection and remediation process in the UK new house building (Source Hopkin et al., 2015)

Quality inspection is usually done in corresponding specific stages based on approved building plans and specifications (Rotimi et al., 2015). This means that inspection requires site inspections at key stages of the construction to ensure that all homes under warranty comply with the building manual and the required building standards (NHBRC, 2011). The building quality index for houses (BQIH), an 8-stage building assessment process, is used to ensure quality assurance at the various stages of house construction, i.e., sub-structure; superstructure; practical completion; stormwater; carpentry; plumbing; electricity; and waterproofing. The objective of this study is to examine inspector's contribution in assuring quality housing. The findings of the study will assist in developing ways to improve the role of inspection, and thus improve quality housing delivery.

METHODOLOGY

This research adopted a concurrent mixed-method approach of both qualitative and quantitative data collection methods. The study is in line with the pragmatism world view, which prioritizes the research question over methodological disputes to gain a deeper and broader understanding of the research topic and mutually strengthen the results and findings (Creswell, 2014; Saunders et al., 2019; Debs, 2017; Terrell, 2015). Primarily the qualitative approach was more focused on examining inspectors' performance, contribution, and behaviour in assuring quality in housing projects. Moreover, the contractors' and homeowners' views on how inspectors contribute to the poor quality were obtained.

The study was done in Gauteng, South Africa, as it is one of the developing provinces in the country and it has more inspectors than other provinces. The study focused on building inspectors, contractors, and homeowners under the warranty scheme provider. The study made use of questionnaires that had quantitative data to find statistical data on inspectors' contribution and qualitative data to explore participants' views (Leedy & Ormrodd, 2015). Questionnaires were designed with open and closed-ended questions to answer the research question. Ethical consideration was taken for those that took part in the study. Participation was voluntary and the consent form was part of the questionnaire.

The questionnaires were sent out to five metropolitans in Gauteng including the City of Johannesburg, City of Tshwane, City of Ekurhuleni, West Rand district and Sedibeng District. The study focused on ongoing construction projects on buildings inspectors, contractors, and homeowners. A total of 150 questionnaires were distributed to constructors and homeowners. The contractors and homeowners were identified upon the site visit and since some of these projects were megaprojects, more contractors were found on these sites.

Thus, those participated in his study were registered with the warranty scheme provider and employed by clients to undertake construction work. Although a case study or multiple case study seemed appropriate for this study, still it was not necessary as the study wanted the perceptions of inspectors, contractors, and homeowners in view in terms of inspections. Therefore, two questionnaires were prepared for this study and the expected sample size was 100 and out of that 35 inspectors, 35 contractors and 30 from homeowners. A total of 120 questionnaires was returned with 28 rejected and 92 acceptable questionnaires were analysed.

The respondents were asked to select which stages they conduct inspections, indicate the activities they undertake to inspect with a 5-point Likert scale ranging from 1 (strongly disagree,) 2 (Disagree), 3 (neutral), 4 (agree), 5 (strongly agree). The second questionnaire was for the contractors and end-users. The questionnaires were divided into two sections where the first section covered the demographic information of respondents and included a cover letter informing the respondents about the study purpose, the consent form that respondents sign to agree to participate. The respondents were asked to rate the service they have received from inspectors in the warranty scheme provider using a 5-point Likert scale and how they would rate the quality of housing under warranty and the satisfaction with the service received from the building inspectors using a scale of 1 (very unsatisfied), 2 (unsatisfied), 3 (neutral), 4 (satisfied), 5 (very satisfied). For the end-users' perception, the questionnaire had open-ended questions, where the respondents were asked to "kindly explain their experience with building inspector', rate the level of satisfaction with the quality of homes under warranty, comment on other defects they have experienced in the new homes, comment on other services they have experienced with quality inspection and share their view on how quality is affected by inspections.

The Statistical Package for Social Sciences (SPSS) software version 26 was used to analyse the quantitative data while the open-ended questions were analysed using thematic analysis and this is supported by Akawi (2019). Descriptive and inferential statistics and thematic analysis findings on the participant's knowledge and experience with the warrantee quality assurers were presented in this study (Braun & Clarke, 2006; Wilson et al., 2020). Multiple regression was used to analyse the inspector's contribution to quality. Multiple regression analysis (MRA) shows the predictive ability of a set of independent variables on a continuous dependent measure (Pallant, 2012). In interpreting the results, R square, which tells how much of the variance is in the dependent variable was used. The ANOVA table was also used to show the statistical significance of the results. This tests the null hypothesis that multiple R in the population equals zero (Sig= .000, this means $p<.0005$). The coefficients table shows how the variable in the model contributes to the prediction of the dependent variable. The co-efficient value in the standardized column indicated that the values of each of the different variables have been converted to the same scale to be compared (Field, 2009; Pallant, 2012). Open-ended questions were analysed using thematic analysis as supported by Wilson et al. (2020). Thematic analysis is a process for identifying and analysing patterns as data is collected and analysed (Braun & Clarke, 2006). The relationship and patterns found under these themes made up part of the research report (Akawi, 2019). The findings are presented in the next section.

FINDINGS

Profile of participants

The participants were 62 (60.8%) contractors, 24 (24%) inspectors, 15 (14.7%), homeowners and 24 (24%) did not respond; and they were from the City of Johannesburg (21.6%), City of Tshwane (9.8%), West Rand (9.8%), Sedibeng (3%) and 6% no response. Their

qualifications were mostly BTech/Honours and National Diploma with 10.8%, respectively. They mostly had 4-6 years of experience (6.9%) and 10-12 years of experience (5.9%).

Descriptive analysis results - Activities undertaken by inspectors

Respondents were asked to indicate whether the listed activities are undertaken by inspectors. The findings revealed that the top four activities were electrical and plumbing installation (MIS=4.96; SD= 6.075), followed by Structural quality (MIS= 4.30; SD= 0.926), Issue non-compliance poor quality structure (MIS= 4.17; SD= 1.204) and Floor and stairs quality (MIS= 4.04; SD= 1.160) (Table 1). The least score with the lowest mean was check materials for standard requirements, meeting arrangements to stakeholders when required, check tools used for construction work. The SD value indicates that the responses had different views with the common defects found in new homes.

Table 1: Activities undertaken by inspectors

Inspectors duties	N	MIS	SD
Electrical and plumbing installation	24	4.96	6.075
Structural quality (walls)	23	4.30	0.926
Issue non-compliance to a poor quality structure	24	4.17	1.204
Floors and stairs quality	24	4.04	1.160
Foundation quality	23	4.00	1.243
Check compliance per stage inspection	24	4.00	1.319
Check and record inspections	22	4.00	1.380
Require test of building material	24	3.96	1.268
Roof installation	24	3.96	0.999
Review building plans and specifications	24	3.92	1.283
Check materials for standard requirements	24	3.83	1.167
Meeting arrangements to stakeholders when required	24	3.75	1.294
Check tools used for construction work	22	3.32	1.460

Warranty scheme inspectors' services

The finding on services received from building inspectors in housing projects under the warranty scheme provider are presented in Table 2. The findings rated the satisfaction of the service from building inspectors as the quality of houses inspected (MIS= 4.380 and SD= 0.787), with the way they conduct an inspection (MIS=4.31; SD= 0.990) and value of warranty (MIS 4.27 and SD= 0.833). Availability of inspectors, staff knowledge of policy and regulations and number of site visits had scored the lowest although they are activities performed by inspectors. From the SD value it can be observed that the respondents had the same opinion on the services received from building inspectors.

Table 2: Inspectors' services

Inspectors services from the warranty scheme	N	Mean	Std. Deviation
Quality of houses inspected	64	4.38	0.787
The way they conduct inspection	64	4.31	0.990
The value of the warranty	62	4.27	0.833
Use of correct inspection tools	65	4.25	0.936
Attitude of staff and willingness to assist	64	4.23	1.035
Availability of inspectors	65	4.18	1.184
Staff knowledge of policy and regulations	65	4.18	1.088
Number of site visits	64	4.08	1.088

From the questionnaire the respondents were asked to comment on inspectors' services. The contractors have revealed that the building inspectors are friendly and know how to conduct inspection work in housing projects, some argue that the inspectors lack the technical experience. On the other side, the homeowners revealed that inspectors use incorrect tools to conduct inspection, also they are not familiar with inspection services as they have never seen inspectors and that there are missed or not done inspection work:

"they need to have more practical experience for them to demonstrate where there's a serious problem/mistake to be rectified"- Contractor 1

"Good communicator, inspectors know their jobs, advise in advance for accidents or errors that might occur"-Contractor- 2

"They provide good service"- Contractor 3

"Unavailability of inspectors on-site during daily production" Contractor-4

"non-monitoring of workmanship on site, supply of correct tools can affect quality" Contractor -5

"Site visit is important; If they don't come there will be short cuts which may affect quality poorly" Homeowner-1

"Site visit is important; If they don't come there will be short cuts which may affect quality poorly" Homeowner-2

Multiple Regression Analysis results - Inspectors' contribution to quality housing projects

From the literature, it was found that inspectors contribute to the quality as they perform inspection works although the role of inspection is dependent on contractors' response to compliance (NHBRC, 2020). Table 3 showed a significant relationship between quality and inspectors' activities in assuring quality. The model table shows combined findings of quality and building inspectors' activities and the R square value of 0.485, which indicates that inspectors contribute to quality in housing projects. Therefore, building inspectors positively contribute 49% to the quality and this is supported by literature (Rotimi et al., 2015). The coefficients table (Table 4) shows the significance test on the inspector's role in contributing to quality. The significance value (p) of 0.005 as it is not greater than 0.005 gives the test on the findings. This indicated that the findings on the relationship between inspectors' roles and performance and the quality achieved in housing and this is statistically significant.

Table 3: Inspectors' contribution to the quality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Chan
1	.485a	0.235	0.200	0.85999	0.235	6.765	1	22	0.016

Table 4: Coefficients table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.243	0.719		3.119	0.005
	CONQUAL	0.586	0.225	0.485	2.601	0.016

The findings conclude that some inspectors are professional and have good communication and technical skills. However, inspectors' site visits are important to minimise shortcuts from poor-performing contractors, unavailability of inspectors allows a gap for contractors to take short-cuts. This suggests that there are missed inspections, and the lack of monitoring could affect quality in housing projects. Additionally, the role of inspectors is dependent on workmanship, and response to building compliance and regulation. These findings are supported by cidb (2011) study on Construction Quality in South Africa and Mkuza et al. (2019), where it was reported that most inspection works are missed or not done, and this affects quality housing delivery. The findings in this study also echo Mkuza's (2019) findings that quality concerns in housing projects partly results from the shortage of quality inspectors to manage the housing development projects.

CONCLUSION

The study set out to examine inspectors' contribution in assuring quality housing, which in turn could inform part of improvement strategies in assuring quality and improve quality in housing projects. Quantitative and qualitative data were analysed. Several themes were developed focusing on how building inspectorate contributes to the level of housing quality achieved. The inspectors, contractors and homeowners were reached to answer open and closed-ended questions in the questionnaire. The study captured important facts in the data in connection to the relevant objective to create meaning within the data collected. The participants indicated their knowledge and experience with the warrantee quality assurers.

The study revealed that inspectors' role is critical in monitoring quality; however, it is dependent on contractors' ability to comply with the standards and regulations, missed inspections, availability of quality inspectors, and degree of compliance with regulations on the part of the contractors. When inspectors are not available, contractors may compromise on the quality. This means when inspections are done properly, no defects will be reported in new homes and missed inspections affect the quality of work. The quality can be affected as contractors may take shortcuts or be inexperienced to undertake the work. This was supported by the open-ended questions that have indicated that unskilled workmanship affects quality in housing projects.

Therefore, in improving quality, the role of inspection cannot be ignored. These findings will assist in terms of developing strategies in improving inspectors' role, and the overall quality of housing projects. The major limitation of the study is that it was conducted in only one province in South Africa and may not be generalisable to other parts of the country. Further studies can be undertaken to elicit the views of the participants in other provinces.

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BUILT ENVIRONMENT SKILLS SET LEVELS AND CONSTRUCTION PROJECT DELIVERY IN SOUTH AFRICA: AN EXPOSE' OF THE NEXUS IN RURAL MUNICIPALITIES AREAS OF FREE STATE

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The shortage of skills in the built environment largely contributes to the failure of construction projects in South Africa. It creates constraints on the limited resources available, resulting in poor designs, poor planning, poor management and completing projects late. Most studies on the shortage of built environment skills have focused on urban centres of South Africa. This study aims to investigate the impact of low skills sets in projects located in rural areas of South Africa. In particular, the study was conducted in the Free State, which is shunned by the more qualified built environment professionals. A quantitative research method was adopted which employed the descriptive research design to answer the research question of the study. A questionnaire survey was administered to built environment professionals in 20 municipalities with 64 valid responses used in analysing the findings of the study. Findings from the study showed that built environment skills shortage in rural areas of the Free State province of South Africa hurt construction projects. The top challenges identified, included: poor site management, poor project documentation and design specifications and failure to provide practical solutions on site. The current study recommends government incentives to be able to attract built environment professionals to rural areas such as the Free State of South Africa. Government should also focus is increasing the participation of the previously disadvantaged people in science subjects at high school to increase the chances of those coming from the rural areas to study built environment professions. Keywords: built environment, project delivery, skills shortage.

Keywords: built environment skills shortage, project delivery in rural areas

INTRODUCTION

The shortage of built environment skills is among the numerous challenges facing developing countries such as South Africa. According to the 2020 South African Institute of Civil Engineers President, the issues of skilled built environment shortages have existed for a long time need to be addressed as a matter of urgency (Marutla, 2020). According to the Engineering Council of South Africa's 2015 annual report, there were approximately 46000 registered engineers on their database of which 16500 and 5200 were professional engineers and technologists respectively. In 2019, the reports showed that the number of registered persons has reduced to 34000 of which 14800 are registered professional engineers (Marutla, 2020). However, most of these skilled built environment professions are found in major cities compared to the rural areas. For the successful completion of projects, the project team should be composed of experienced built environment experts who have managed many successful projects before. These will act as mentors to different junior staff who are still be registered with different professional bodies in the built environment. Unfortunately, the current situation on the ground in the rural areas of Free State has severe challenges leading to project delays, failures, or completed late with poor quality due to the limited resources

available. This kind of challenge has devastating effects on the project funders as well as the poor service delivery to the community. Mbande (2010) argued that a link exists between the delivery of services in South Africa and the shortage of skills in the construction industry.

The failure to complete works according to the required quality, within the planned budget and in the required time becomes evident mostly in the rural areas. In October 1995, three well-established civil engineering contractors in Western Cape went insolvent due to a lack of jobs (Ntuli and Allopi, 2014). After this drop in the construction industry, the demand in the skilled labour base also dropped until the period of 2004 when South Africa was awarded the right to host the 2010 World Cup. The drop could have also influenced more migration as more experienced would have started failing to secure the much-needed employment. In support of the Ntuli and Allopi (2014) argument on the decrease in construction projects, the CIDB estimates that formal employment in the construction sector steadily declined in the 1990s until 2001 low, when more than 200 000 workers were lost to the industry. Since 2003, the rise in spending on a construction project has seen a gradual increase in the number of jobs and skills gaps that follow those increases (Construction Industry Development Board, 2007).

The impact of the built environment skills set is regarded as one of the most significant institutional challenges faced by South Africa, which created a high demand for construction management skilled workforce, therefore, creating a shortage of both the private and public sectors in the built environment. A rapid increase in building activity within the UK occurred during the 1980s, preceded by a sharp but short-lived boom plagued by skill shortages (Agapiou, Andrew & McCaffer, 1995). McKenzie (2011) did research focussing on ways to attract the skills manpower in rural Australia but focussing on all skills and not the impact of the built environment skills set on service delivery in the rural areas. The theme of the research was targeting all professions and not targeting built environment professionals. McKenzie (2011) also identified reasons why the general working class does not favour rural Australia. Different authors have carried different studies forecasting demand for scarce skills in South Africa between 1994 and 2019. Their findings are based on urban areas of the country with more focus on Gauteng Province which makes the case for rural areas unknown in the body of knowledge. This study is, therefore, necessary to investigate the impact of built environment skillset levels on construction project delivery in rural areas of South Africa.

LITERATURE REVIEW

Built Environment skills shortage impacts productivity growth and reduces the investment of the country (Fitzhardinge, 2012. A skill disparity arises when the amount of a given skill produced by the workers and the amount required by employers vary according to current market conditions (Zurn et al. 2002). In South Africa, low levels of skills are seen as contributing to slow economic growth and a high unemployment rate of 25.2 percent, published by Statistics South Africa (2014), which would then impact the country's political stability and living standards (Department of Higher Education and Training, 2013). There is major scope for performance improvement in South African public works construction projects, especially in terms of the availability of technical and managerial skills in the construction project sector (Emuze and Smallwood, 2012).

According to Lawless (2005), both the private and public sectors are seeking experienced engineers. The supply side of the engineering career depends on the number of students going through a quality education program that will allow them to do so through a tertiary institution. There is a strong need for engineers (and technical professionals) of all sorts across several South African industries. However, this lack of skill still provides unskilled employees with a substantial incentive to fill the shortfall of skill. StatsSA (2015) found that

South Africa's unemployment rate is currently at 25%, and one of the main objectives that South Africa has set itself in the National Development Plan is to reduce the unemployment rate to 6% by 2030 (CDE,2010).

Reasons for shortage in South Africa

Several factors are contributing to the low skills set level in the built environment workforce within South Africa. The apartheid system is also a cause of South Africa's skill shortage, as blacks were racialized, gendered, and had no access to skill development (Akoojee and McGrath, 2007). The suggestion may therefore be that the low level of skills set in South Africa is directly linked to the quality and quantity of education offered, especially in the past, to the majority of South Africans.

According to Shah and Burke (2005), slow labour supply change may occur due to lags in the provision of education and training, or due to conditions for occupational licensing and registration that restrict supply relative to the optimal balance of the sector. This may relate to the slow rate at which engineers are registered by the professional bodies and the slow rate of graduates entering the market. The low rate in science subjects, poor carrier guidance in choosing engineering and science carriers at high school, lack of mentors for new graduates, lack of governmental support, low remuneration of built environment personnel in general are some of the reasons contributing to the skills shortage in the country (Akinshipe, Aigbavboa, Maake & Thwala, 2019).

Available solutions to address the low skills sets level in the built environment

The government of South Africa has put in place several initiatives to address the shortage of skills in the industry including the rural areas. Alphonsus (2015) cited in DHET (2013) states that the main stakeholder bodies established in line with the skills development act (97 0f 1997) were the Sector Education and Training Authorities (SETAs), the National Skills Fund (NSF) and a National Skills Authority. Below are some of the initiatives:

Skills Development Act.

National Skills Fund.

Sector Education and Training Authorities (SETAs) working well (Kraak, Jewison, Pillay, Chidi, Bhagwan & Makgolane, 2013).

Municipal Infrastructure Grant Initiatives.

Professionals Development Programme (PDP).

RESEARCH METHODOLOGY

Due to the nature of this research study, a quantitative research method was adopted which employs the descriptive research design to answer the research question of this study. Burns and Grove (2003) described the quantitative research method as research that uses research techniques such as experimental and surveys and gathers data on predetermined tools that generate statistical data. Creswell (2009), on the other hand, opined that the quantitative research method is a structured, analytical, systematic method in which knowledge about the environment is collected using numerical data. With this background, this research seeks to investigate the impact of the built environment skills set levels on construction project delivery in the remote areas of South Africa using rural municipalities in the Free State province.

The Free State province is made up of 20 local municipalities in five district municipalities of which one of which is the Mangaung metro which covers Bloemfontein. These rural areas

appear neglected or receive lesser attention from the media hence some challenges go on unchecked. Professionals in the built environment as well as the individuals leading organisations where the built environment professionals work were the focus demographic for this study.

New graduates were also not considered as skilled built environment professionals although depending on the background they might have a very sound knowledge of doing what they are expected to do. However, it was envisaged that responses from about 80 respondents will be sufficient for data analysis. To evaluate the impact of the built environment skills set on project delivery most data was collected from the built environment skills set using a well-structured questionnaire. Close-ended questions designed by the researcher as having the ability to extract data from participants were used. The questionnaire was designed to have two sections and all in simple English to make it understandable to participants. Section A of the questionnaire requested personal information about the participant, which is intended to assist the researcher about the participants' distribution. The section B of the questionnaire was designed to extract responses regarding the impact of built environment skills set levels on construction project delivery in rural areas of South Africa using a five-step Likert scale where level 1= Strongly Disagree (SD), 2= Disagree (D), 3= Neutral (N), 4= Agree (A), 6= Strongly Agree (SA). A total of 100 questionnaires were distributed through, WhatsApp, SMS messages, emails, and physical site/office visits to respondents and 73 responses were received. However, only 64 of the 73 received responses were usable for data analysis. Retrieved data was analysed from the questionnaires received from participants using the Statistical Package for the Social Sciences (SPSS). This involved the use of frequency tables and Mean Item Score (MIS). The reliability test is conducted to assess the degree of accuracy of the data collection tools, which is the questionnaire in this case. The alpha value of 0.87 which is suitable for the reliability measure was achieved from the received responses.

FINDINGS AND DISCUSSION

Having subjected the findings of the study to data analysis, the result of the findings was reported below. The demographic information of the respondents was as shown in Table 1 below.

Table 1: Distribution of respondents by the organisation they work for

Organisation	Frequency	Percent
Local/Metropolitan Municipality/Government Department	15	23.4
Consultant/Professional Service Provider	38	59.4
Contractor	9	14.1
Other	2	3.1
Total	64	100.0

From the information gathered, it is interesting to note that most of the respondents are experienced in a built environment with 16 years and more years in the industry. The category over 16 years' experience had a total percentage of 51.5%. The two groups with between 6 to 15 years' experience followed with more than 45.5% while the remainder were between 0 to 5 years as shown in the table below had only 3.1%. The level of experience of the respondents gives confidence in the results given.

Just like work experience, the level of education is important in judging the relevance of the information given. The level of education of built environment professionals who responded may influence their thinking about the impact of skills shortage in the construction industry in general. Education and training are considered to have a positive impact on the success and realisation of organisational goals and any other success factors influencing the industry. It is possible that the higher the qualification of the respondent, the greater the chance that the respondent will be well versed about factors affecting project success and failure. The results show that 95.4% of the respondents have a minimum of a bachelor's degree as their level of education. This means the greatest number of participants are within the years of experience considered as being very skilled in this research. Only 3.1 % are Diploma holders with only 1.6% with experience falling out of the given categories.

The contacted respondents reveals that most of the respondents (39.1%) are registered with the Engineering Council of South Africa while 29.7% are not registered with any professional board. While education and experience are important in the built environment, the most important aspect is being registered with the individual professional board in line with your qualification and experience. The remainder of the participants are different professional boards. The professional construction project managers (Pr. CPM/CM) had the second-largest number of registered personnel with 12.5%. Third of the registered built environment personnel were the Professional Architects with a 10.9% response. The comparison between those with the qualification only and those with qualification plus registration shows about 29.7% in the research area are not registered with any registration council. The results also reveal that there is more engineering work in the area than the other built environment professionals.

Having carried out a literature review to examine what has been done in the body of knowledge regarding the objectives of this study, the identified variables were used in developing a questionnaire survey. The response of the respondents was analysed using Mean Item Score alongside Standard Deviation. The result of the analysis is presented in the following sections. The descriptive analysis result for the assessment of the impact of built environment skillset levels on construction project delivery in rural areas is shown. From the table, all the identified impacts have a mean score above 3.0 which is the average of a 5-point Likert scale. This reveals that the respondents have an understanding that all the identified variables have a significant level of impact on construction project delivery in the study area. The questionnaire adopted a 5-point Likert scale however, the analysis result was presented in a 3-point scale by combining the two upper scales and the two lower scales to make the interpretation easier.

According to the respondents, delay in implementing projects ranked in the first position with a mean of 4.14 and standard deviation of 1.167. This was followed in the second position by a Poor maintenance plan with a mean of 4.09 and standard deviation of 1.165 while Failure to spend allocated project funds with a mean of 4.03 and standard deviation of 1.038 ranked third. The fourth and fifth-ranked positions have Poor quality on projects with a mean of 4.02 and standard deviation of 1.161, slow decision making on projects with a mean of 3.97 and standard deviation of 1.092 respectively. In the lower ranks, Payment delays to contractors with a mean of 3.75 and standard deviation of 1.297 are in the sixth position, Poor working relationship between the stakeholders (contractor, consultants, and the client) with a mean of 3.53 and a standard deviation of 1.259 is in the seventh position while Community unrest (strikes) with mean of 3.36 and standard deviation of 1.396 ranked lowest. The standard deviation values recorded for this section are above 1.0 which suggests that the answer of the respondents to these variables are not concentrated around the mean values.

Table 2: Impact of built environment skillset levels to project implementing departments

Description of Item		Disagree /Strongly Disagree	Neutral	Agree/Strongly Agree	Mean	Standard Deviation	Rank
Delay in implementing projects	Count	7	3	54	4.14	1.167	1
	N %	10.9%	4.7%	84.4%			
Poor maintenance plan	Count	8	4	50	4.09	1.165	2
	N %	12.6%	6.3%	81.3%			
Failure to spend allocated project funds	Count	4	12	48	4.03	1.038	3
	N %	6.3%	18.8%	75%			
Poor quality on projects	Count	8	6	50	4.02	1.161	4
	N %	12.6%	9.4%	78.1%			
Slow decision making on projects	Count	8	5	50	3.97	1.092	5
	N %	12.7%	7.9%	79.3%			

According to the findings from the descriptive analysis, the respondents opined that the low skillset level of built environment clients, consultants and contractors will result in a delay in implementing the project as there will be little manpower available to execute the projects. Mbande (2010) observes that skills shortage exists within the South African skills sector and in state-owned enterprises. According to South Africa's construction industry development board (CIDB, 2004), public-sector capacity is a key constraint on infrastructure delivery and sustainable growth in the South African construction industry (Windapo & Cattell, 2013).

Al-Kharashi & Skitmore (2009) proposed a link between inadequate participation of project members (including clients) and negative results of the project. Also, the result indicated that poor maintenance plan happens in the delivery of construction project due to the built environment low skillset levels. Chigangacha and Haupt (2017) agree that the successful participation of trained customers, consultants and contractors in their project requires flexible direction during the life cycle of the project (Alsolaiman, 2014). Furthermore, the findings revealed that the built environment's low skillset levels lead to failure to spend allocated project funds. This is because the required skill to understand how the funds should be apportioned appropriately is lacking in most cases. The findings showed that built environment low skills set levels also play a major role in the decision-making process of the construction project delivery. As postulated by Assaf & Al-Hejji (2006), as contractors are hired by consumers to behave or work in their best interest, there is the distinction between the contractor and the customer.

Table 3: Impact of built environment skillset levels on project success

Description of Item		Disagree / Strongly Disagree	Neutral	Agree / Strongly Agree	Mean	Standard Deviation	Rank
Vacancies are filled by inexperienced built environment professionals.	Count	2	5	57	4.34	.877	1
	Row N %	3.1%	7.8%	89.1%			
Cost overruns during projects execution	Count	6	6	52	4.16	.996	2
	Row N %	9.4%	9.4%	79.7%			
Uncoordinated project planning and implementation	Count	4	6	54	4.14	.833	3
	Row N %	6.3%	9.4%	84.3%			
Delay in issuing approvals on projects	Count	5	5	54	4.12	.968	4
	Row N %	7.8%	7.8%	84.4%			
Design changes leading to variation orders.	Count	7	6	51	4.11	1.025	5
	Row N %	11.0 %	9.4%	79.7%			

Table 3 reveals the descriptive analysis result for the impact of Built Environment Client, Consultant and Contractor Skills Set Levels on Project Success in rural areas. From the table, only the top 5 high-ranking results are shown. All the identified impacts have a mean score above 3.0 which is the average of a 5-point Likert scale. This reveals that the respondents have an understanding that all the identified variables have a significant level of impact on project success in the study location. According to the respondents, vacancies are filled by inexperienced built environment professionals ranked in the first position with a mean of 4.34 and a standard deviation of 0.877.

This was followed in the second position by Cost overruns during project execution with a mean of 4.16 and standard deviation of 0.966 while uncoordinated project planning and implementation with a mean of 4.14 and standard deviation of 0.833 ranked third. The fourth and fifth-ranked positions have Delays in issuing approvals on projects with a mean of 4.12 and a standard deviation of 0.968, Design changes leading to variation orders with a mean of 4.11 and standard deviation of 1.025 respectively. In the lower ranks, Inadequate practical solutions on projects with a mean of 3.91 and standard deviation of 0.988 is in the eleventh position, Poor project documentation such as BOQ's with a mean of 3.84 and standard deviation of 1.211 is in the Twelfth position while use of inappropriate construction methods with mean of 3.64 and standard deviation of 1.118 ranked lowest. The standard deviation values recorded for this section are mostly above 1.0 which suggests that most of the answers of the respondents to these variables are mostly concentrated around the mean values.

Comparison of the impact of skills shortage between rural areas and urban centres

While the study did not have a scientific way of measuring the impact of skills sets on rural areas against urban centres, other publications from other authors show that the magnitude of the effects of low skillset levels in rural areas is worse than in urban areas. In a study by Maake (2016) of the effects of skills shortage in Gauteng (which is 90% urban centre), the main challenges were lack of innovative technology changes within the industry, poor quality delivery and poor performance in the construction industry. Based on overall results done of another research done in eThekwini metro (Durban), the top five most important reasons for project failures are contractor's cash flow problems, delay in progress payments by the client, poor site supervision and management by contractor, inefficient quality control by the contractor during construction leading to rework due to errors, and contractor's difficulties in financing the project (Adugna, 2015). The conclusion drawn from the facts above is that while the issue of the scarcity of skills in the built environment is still serious in South Africa, urban centres seem less affected than rural areas. Most of the projects in the rural areas are designed and managed by engineers from urban centres who travel weekly to attend meetings and check quality.

CONCLUSION AND RECOMMENDATION

The study was aimed at investigating the impact of built environment skillset levels on construction project delivery in the remote areas of South Africa using rural municipalities in the Free State province. To achieve this, adequate literature on built environment skill set was reviewed from which a well-detailed questionnaire was designed. The designed questionnaire was distributed to the built environment professionals working within the rural municipalities of the study area. The retrieved responses from the professionals were analysed and the findings revealed that the scarcity of skillset in the built environment plays a big role in the stunted development of the industry. This can be observed as it results in a delay in implementing the project as there will be less manpower available to execute the projects; poor maintenance plan; failure to spend allocated project funds; poor decision-making process of the construction project delivery; among other impacts. The findings of this study, therefore, confirm previous studies carried out in urban areas of South Africa that there is a low level of built environment skill sets. It is hereby concluded that the South African built environment lacks adequate professionals to help the industry provide the needed construction project for the country.

To overcome this menace, this study recommends that the government of South Africa equip the education sector with science and mathematics facilities in the rural areas (where the previously disadvantaged stay) to facilitate the training of built environment students. These students upon passing high school can be given a bursary to study built environment professions at universities. Government and the private sector should provide incentives in monetary and non-monetary values to improve the migration of the built environment professions from urban centres to rural areas. Provision of good accommodation, quality education and medical facilities can also increase the migration of professionals to rural areas. Also, it is recommended that migration laws be relaxed to allow skilled built environment professionals to settle in those areas and mentor the local graduates. This can address the impact of skilled built environment professionals' deficit being experienced now. While this study was done in one province of South Africa, there is a lot of similarities in most of the provinces which might be a good reflection of what is happening in the whole country at large. Further studies can be carried out to assess the distribution of the available skills between the private sector and government departments in the rural areas of South Africa.

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THE VIABILITY OF SOLAR ENERGY TO IMPROVE EFFICIENCY IN THE RAILWAY INFRASTRUCTURE: A CASE STUDY

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The South African rail sector is facing countless challenges such as poor railway performance, aging railway infrastructure. The electrification of rail signalling, and rail set of points systems is constantly disrupted, as a result, the transporting of freights, and commuters have deteriorated profusely. This paper aims to establish how viable solar energy is to electrify the railway infrastructure. Although the renewable solar energy technologies being new in the railway infrastructure has been underrepresented in the literature. This study contributes to an approach of using renewable solar energy as a solution for electrifying the railway infrastructure, influenced by the viability, potential, and sustainability of solar energy as an alternative power supply of any habitable infrastructure in Southern Africa. The enacted case study focused on the project scope of Supplying, Installation, and Pre-Testing, of mini solar energy panels' substations to power the commissioning of two radio-controlled self-normalizing point sets and signalling controls at Matlabas railway sections in South Africa. This case study was done in depot on a piloted solar project of electrifying the rail signalling and set of points systems. There were thirty-eight (38) experienced participants which included the depot team from the freight rail company and project team responsible for the solar panels project provided insight into the state of operations and how receptive they were to the renewable technologies as a solution of creating viability and sustainability of the railway infrastructure.

Keywords: Solar energy efficiency, Railway infrastructure, Renewable technologies.

INTRODUCTION

The insufficient electricity power in South African railway infrastructure has becomes a habitual challenge. Rail signalling and set of points systems play a significant role in the rai railway operation and the lack of power supply to the systems can course deadly train crashes, lengthy delays to goods supply, and on many occasions, commuters are left stranded. Thus, it is important to reflect on the significant opportunities played by renewable energy in the railway infrastructure if it is introduced in the South African rail sector. The viability of solar energy in the railway infrastructure is essential with the view of augmenting the capacity of existing capacity of rail to make railway networks to be self-sufficient (Nazir, 2019). It appears these rare opportunities from renewable energy can be achieved fully if the end-user is willing to explore its efficiency and viability output. The viability of solar energy in the railway infrastructure project is steadily increasing compared to other renewable energies supply in any building project. In's market, the solar traction power supply can be technically feasible and economically attractive depending on the amount of scale distributed in the rail infrastructure. (Murray & Bottrell, 2017) alluded that solar energy in the railway infrastructure offers an important efficiency cost, engineering, and advantages over other renewable energy generation and supply models. A UIC Activity report by international union railways in 2019 cited the future of solar energy in the U.K. becoming one of the

primary sources of energy which provides a great opportunity in the railway infrastructure and financial benefits in the complex networks that rely heavily on the national grid.

Even though there are minor concerns with renewable solar energy in the railway infrastructure such as sustainability and maintainability, however, there are various positive developments from the literature that can counter mitigate all the concerns only if the processes are to be managed systematically including batteries backups and field maintenances (Asonov& Loktionov, 2018). To measure the desirable results of train operation, particularly using solar energy, the customer's quality performance service, and satisfaction can be identified and used as a tool that gauges the quality of the deliverable output. (Irfan et al., 2012) emphasised the organisational operation performance which can play a significant role to measure the customer's insight satisfaction with regards to the quality of service rendered. The literature has also emphasised that the railway infrastructure operations through renewable energy efficiency optimisation are driven by strategies that can reduce the operating cost significantly and contribute to increasing the sustainability of rail transportation (Scheepmaker et al., 2017). The researchers (Gielen et al., 2016) highlighted that the benefits of the renewable route in sustainable transportation are including the railway sector that has progressively substituted conventional electrified railway systems into fundamental renewable technologies. To substantiate that argument various studies have been done on the benefits and challenges of renewable energy in the railway infrastructure. For instance (Steele et al., 2018) addressed the railway-specific challenges hindering smart grid implementation and the lagged development of smart grid in the rail sector.

This paper addresses the following objectives: the viability of renewable energy in railway infrastructure, the implementation of renewable solar energy in railway infrastructure, the establishment of sustainability of solar energy in the railway infrastructure, and the potential of solar energy on railway infrastructure. Ultimately, the study should be able to provide the end-user with a positive insight into solar energy supply in the railway infrastructure. The other section will present a literature review conception of renewable energy supply in the railway sector. Methods and results adopted to conduct the research will be illustrated carefully. The study conclusion shall provide any improved efficiency in the railway infrastructure through renewable energy.

LITERATURE REVIEW

The viability of renewable energy in railway infrastructure

The fundamental role of the transport sector and its contribution to the economy is enormously entrenched in the viability, sustainability of the infrastructure with the policy and legislation, which can improve the public transport quality, efficiency, and viability (Cooke & Behrens, 2014).

Alnuman et al. (2018) alluded that the electric locomotives in railway transport get electricity from the natural grid. Some of the railway systems do not function optimally due to power outages and vandalism. Solar energy can be used to mitigate the challenges of power supply in the railway infrastructure. However, the literature suggested that to achieve that a typical solar power railway station would be designed to receive maximum solar insulation that will be suitable to electrify the railway systems (Jaffery et al., 2012). Again, for solar to be viable of railway systems will depend on two major factors, firstly, the direction of the sun and secondly, the route through which the train would pass. (Aliyu et al., 2017) confirmed that renewable energy (PV and CSP) viable produce electrical energy from radiation using the mirrors to concentrate the energy from the sun to drive traditional steam turbines or engines that create electricity.

The implementation of renewable solar energy in railway infrastructure

Renewable energy alternatives such as solar and wind power for electricity generation in remote mining areas are becoming more and more attractive. The literature alluded that railway infrastructure operating nearby the mining area can also benefit from the adoption of renewable energy in the railway (Paraszczak & Fytas, 2012). Again, the other argument suggests that the implantation of solar energy required a battery – backup to store a maximum amount of energy that can be used to power railway systems particularly at night (Nazir, 2019). Objectively on the other hand being an intermittent source of power, the Photovoltaic (PV) cannot always meet the load demand, 24 hours a day, 365 days per year (Lencwe et al. 2016). Yokoyama et al, (2002), and Ren et al, (2012) suggested that mixed-integer linear programming (MILP) has been widely applied to the optimisation of energy supply systems and the study presented herein also considers photovoltaic (PV) solar energy and other sources as available energy resources that can be implemented to improve the efficiency in the railway infrastructure. Zhongbei et al., (2016) have alluded that the whole range of railway infrastructure is used to operate and function either optimally or less optimally when it is connected either to the conventional electrical power supply or too powerful diesel engines for electrification.

The establishment of sustainability of solar energy in the railway infrastructure

The signalling systems and set of points played a significant role in ensuring there is safety in the railway infrastructure. In recent years there has been an increasing interest in using sensing technology for instrumentation in a variety of railway systems (Flammini et al., 2010). Therefore, in areas where there is no electricity the solar energy can be utilised to electrify the railway systems that consume less electricity to maintain railway sustainability. Renewable energy as an alternative has become a sustainable option that can significantly overdependence on fossil fuel (Aliyu et al., 2017).

As a result, the vital train systems like signalling and set of points systems operate manually due to non-supply of electricity, consequently, the train operation movement tends to be unsafely and compromises the integrity of the operation. Again, Blumefeld et al. (2019) suggested that in railway infrastructure safety is highlighted as a major concern and stated that safety on railways in low-income countries due to manual operations, malfunctioning of either signalling systems or set of points systems has been a matter of significant concern.

The potential of solar energy on Railway Infrastructure

The South African urban and rural railway overheads infrastructure has been severely affected by criminality and it appears the rail sector is losing the fight to curb the scourge of theft and vandalism. Given the complexity of railway systems, there is a genuine concern to seek an alternative source of energy that can potentially form part of a long-term effective railway infrastructure investment.

The evolution of solar energy in Africa has opened the opportunity to explore the potential of solar energy across sectors of society including the railway infrastructure sectoral. Rail signalling and rail set of points can potentially benefits from solar energy, the literature has highlighted that the utilisation of solar energy in the African continent provides the enabling platform for poverty alleviation and economic development (Amankwah-Amoah 2015). In contrast, the railway infrastructure has been largely dependent on the constrained conventional power supply and struggled enormously to uplift the economy of Southern African countries including South Africa.

However, it has been disturbing to witness the rail sector being reluctant to embark on a solar energy project. Whereas (Edkins et al., 2010) have noted that the global solar energy makers confirmed South Africa as a potential market of solar energy technology.

METHODS

A case study was Supplying, Installation, and Pre-Testing, of mini solar energy panels' substations to power the commissioning of two radio-controlled self-normalising point sets and signalling controls at Matlabas railway sections in South Africa, which the project took almost 6 months to be completed, has been used to substantiate the importance of electrifying the rail infrastructure with solar energy. An advantage of a case study is that it describes what has happened, when, to who, and with what consequence (Rowley, 2002). The added advantage of a case study is that the examination of the data collected is conducted within the situation where the activity takes place, further allowing a qualitative analysis (Zainal, 2007:4).

Concerning the objective on the sustainability of renewable energy projects for the railway infrastructure, the use of a case study had the advantage in that the case study offers verifiable data from direct observations of the individual entity involved. For instance, Ngar-yin Mah et al. (2013) used a case study to demonstrate the opportunity of integrating large smart grid projects in Japan.

Given the time and cost constraints of conducting the research when compared to other methods of research, the case study method is inexpensive. The researcher (Denscombe, 2017) suggests that the real value of a case study is that it offers the opportunity to explain why certain outcomes might happen – more than just find out what those outcomes are. Even when there is a person to personal interviews or if other on-site duties are involved, the costs of reviewing the implantation of solar energy in the railway sector are minimal.

Therefore, the case study was used to determine the potential of using solar energy in the railway infrastructure, to determine if renewable energy can sustain the operation of the railway, to evaluate the suitable implementation and application of solar energy in the railway infrastructure, and lastly, to explore how viable and reliable the solar energy in the railway infrastructure. By controlling how facts are collected, research can control the results in the method it generates (Rahman, 2016). In this instance, it's the participants, who control the outcome of the objectives of either solar energy has the potential to electrify the railway infrastructure or not. Participants can also influence outcomes by giving inaccurate or accurate answers to justify the objective of either solar energy is viable or not in the railway sector. Researchers must verify the information presented to ensure its accuracy, and that takes time to complete (Rahman, 2016).

Methods applied for data collection were:

Interviews with skilled and semi-skilled employees who had working experience on the plant operations who could assess the impact of the before and after solar project implementation.

Desktop analysis reviews of company information on similar companies that have implemented the use of renewable technologies for their industrial applications.

Observation of plant operations and Scrutinising company records such as the integrated annual reports, monthly depot performance reports

Interviews

Face-to-face contact also allows researchers to carefully select their potential respondents so that they get responses from just those people needed to fill necessary quotas (Denscombe, 2017). All interviews were conducted at the Thabazimbi depot close to operations; the

selection of the participants were depot team (Depot manager, Train section manager, Train operators) and Project Team (Project Manager, Electrical Engineer, Construction Manager, Supervisor, etc) based on their involvement in the pilot program including work experience and their role at the depot. The table below represents selected participants for this research from various divisions.

Table 1: Interview participants from Depot and Project Team

Division	No of Participants	Description of Participants
TFR Division - Depot Before Participants	12	Depot Manager, Technician 1, Crew Member 9, Section Manager 1, Train Coordinator 1
TFR Division - Depot After Participants	14	Depot Manager Assistance 1, Technician 2, Crew Member 8, Section Manager 1, Train Coordinator 2
Specialist Unit - Project Team Before Participants	7	Construction supervisor 1, Project Manager1, Planner 1, Quality officer 1, Senior Project Manager 1, Site Supervisor 1, Engineer 1
Specialist Unit - Project Team After Participants	5	Construction supervisor 2, Project Manager 1, Planner 2, Quality 2, Senior Project Manager 2, Site Supervisor 2
Total Number of Participants	38	

Pacho (2015) emphasised that researchers will go to the groups which they believe will maximise the possibilities of obtaining data on their question by talking to the most on relevancies and leads to track down more data.

The tool used to collect data was structured interviews. All consultations were conducted in the place of work in person during business hours.

During the interviews, the researcher handwrote notes.

Thirty- eight (38) participants participated in the interviews.

Data reliability quality and validity were accomplished through the utilisation of standard techniques to all members, with no predisposition or separation in roles.

Standard interview questions were given to all participants. The following main objectives questions were underpinned by broader sub-questions:

Describe the viability of solar energy in the railway infrastructure?
What is the potential of renewable energy to electrify railway systems efficiently?
How sustainable is solar energy versus conventional energy power in railway systems?
What are the implications of solar energy in the railway infrastructure?

Table 2: Interview participants from Depot and Project Team

FOCUS AREA	QUESTIONS AND PROBES
Train Operation Information	Describe the performance of train sticking to schedule and delivery targets of trains before and after the solar installation to the signal system
	Describe the level of productivity before and after the solar installation to the signal system
	Describe client level of satisfaction before and after the solar installation to the signal system
Schedule Management	What is the level of schedule efficiency achieved by trains before and after the solar installation?
	On average, how long do trains take from the depot to the mine
	Have the trips increased, reduced, or remained the same after the installation of solar to the signal system
Cost Management	Has there been an improvement, deterioration, or no change in the operation cost?
Quality Management	What is the level of derailments before and after the solar installation to the signal systems?
	What is the amount of maintenance relative to energy supply, before and after the solar installation?
Communication Management	How has the new installation affected the level of communication between the depot and head office?
Risk Management	What issues as a result of solar installation are you worried about that can impact negatively the train operations?
Safety Management	Describe the safety level before and after installation of solar energy to the signal system?
Stakeholder Management	What is the response of the stakeholders to the initiative of solar installation to railway infrastructure?
Human Resource Management	How would you describe the response and mood of the team working at the depot and on the railway line?

The interviews enabled the researcher to ask direct questions, further allowing for clarity and probing, (Cummings et al., 2015), during the sessions and also to ensure relevance and the depth of data.

Data Analysis

The content analysis method was done and found suitable for this case study because the key to secondary data analysis is to apply theoretical knowledge and conceptual skills to utilise existing data to address the research questions (Johnston, 2017).

The content analysis classified before solar energy the operation of the trains was very slow and unsafe. After the solar energy project, the content analysis highlighted operation improvement. This method made valid inferences from the transcript of analysis cost and time consumed before and after solar energy installation in the railway infrastructure. The idea in content analysis is that many words of the text are categorised into much fewer content categories (Webber, 1990). Another view is that this method is widely used as a qualitative research technique and involves the counting and comparison of keywords or content, followed by an interpretation of the underlying context (Hsieh & Shannon, 2005).

Hsieh et al (2005) identified three approaches to content analysis:

Conventional – coding categories derived directly from the transcript.

The directed – analysis starts with a theory or relevant research findings as guidance for initial codes.

Summaries – which involves the counting and comparison of keywords or content followed by interpretation of the underlying context.

The summative method was used to analyse data collected from the interviews, with common themes identified and grouped to find common views (Hsieh et al., 2005).

Data Validation

The validity of the collected data was because information was sourced from a large number of participants. Again (Pacho, 2015) suggests that the validity can address the honesty, depth, richness, and scope of the achieved through the participant's approach. Thirty-eight (38) participants were interviewed for this case study. Furthermore, the collected data was matched and supported by observations, depot plant performance reports, and official company documents.

Desktop analysis of company documents

In support of the data collected from the interviews, the analysis was done of depot information which was collected from depot reports. (Pacho, 2015) alluded to the analysis of documents provided by the participants including academic programs and calendars, brochures, minutes, and reports related to the provided are important sources of supplementary data. The depicted tables were on Transnet's annual integrated reports, depot performance reports, cost performance reports, surveys from the clients and customers. The documents used were the official signed documents and reports. This was to ensure the accuracy of the information. The quality of collected information through the analysis of reports was that the documents were sourced from the depot document controller, instead of individuals. Tables 1&2 illustrate the effect of running cost and time before solar energy and thereafter

Table 3: Cost management and time management before and after solar energy (2014-2016)

TRAIN NUMBERSCHEDULE	SCHEDULE ARRIVAL TIME		ACTUAL ARRIVAL TIME		CONSIGNMENT	TRAIN ORIGIN	DESTINATION	TRAIN NUMBER DEPARTURE	TYPE OF TRAIN	FUEL	COST	FUEL USAGE	CANCELLATIONS		DEPARTURE TIME
NMDSP (CPO)	SCHEDULE ARRIVAL DATE	SCHEDULE ARRIVAL TIME	ACTUAL ARRIVAL DATE	ACTUAL ARRIVAL TIME	TRUCK NUMBER	TRAIN ORIGIN	TRAIN DESTINATION	ITP TRAIN NUMBER	ACTUAL RAN (Y/N)	ACTUAL 6000 lt	11.45	95 lt	REASON FOR NOT RUNNING/ SCODES	SCHEDULE (1/2/3/V/P)	VACUUM/ AIRBRAKE / PASSENGER TRAIN (V/A/P)
8443	2014/04/14	00:01	2014/04/14	04:16	60144912	TZB	RTR	8429	Y	2000	R 13.29	120km		1	A
8443	2014/04/13	00:01	2014/04/14	04:50	63549085	EML	GGK	8415	Y	2000		120km		5	A
8491	2014/04/14	07:48	2014/04/14	06:05	60151382	TZB	MWR	8491	Y	2000		120km		1	A
								F/T	Y	6000		R 30 580.00			
9444	2014/04/15	06:40	2014/04/15	09:00	60164522	GGK	TZB	9476	Y	2000	R 13.29	119km		1	A
2010	2014/04/15	03:19	2014/04/15	05:00	84400218	TZB	MWR	2010	Y	2000		119km		2	V
8415	2014/04/15	07:30	2014/04/15	16:50	55017878	MWR	TZB	8473	Y	2000		119km		1	A
								F/T	Y	6000		R 30 580.00			
1102	2014/04/16	17:10	2014/04/16	18:09	86012754	TZB	STQ	2082	Y	2000	R 13.29	120km		2	V
8466	2014/04/16	19:55	2014/04/16	21:16	60160171	BIJ	TZB	8461	Y	2000		120km		1	A
8430	2014/04/16	17:00	2014/04/16	21:42	60534109	NCY	TZB	8407	Y	2000		120km		1	A
								F/T	Y	6000		R 30 580.00			

Table 4: Time before and after the solar project

THABAZIMBI DEPOT - BEFORE SOLAR ENERGY TRAVELLING TIME						
Train	destination_description	Plan Schedule/Tonnage	Date	Departing Time	Arrival time	*varieties*
A	RICHARDS BAY HARBOUR COAL TERMINAL	5800	2017/08/14	05:00	09:00	3 hours
B	HERCULES SDG.PRETORIA PORTLAND CEME	2900	2017/08/14	10:00	13:00	3 hours
Notes: Two similar trains Train A& B are reported on a turnaround time of 3 hours. On average it took a train of a similar distance 3 hours BEFORE the installation of the solar project						
THABAZIMBI DEPOT - AFTER SOLAR ENERGY TRAVELLING TIME						
Train	destination_description	Plan Schedule/Tonnage	Date	Departing Time	Arrival time	*varieties*
A	RICHARDS BAY HARBOUR COAL TERMINAL	5800	2018/08/19	06:00	09:00	2 hours
B	HERCULES SDG.PRETORIA PORTLAND CEME	2900	2018/08/19	11:00	13:00	2 hours
Notes: After the installation of the renewable solar energy project there was an improvement on the train turnaround time which contributed to system efficiencies and ensuring client satifisfaction						

Observations

Observations were also used as an additional tool in data collection for the case study. Driscoll, (2011:160) stated that observation forms an important part of any research study, and that history has shown that important scientific discoveries of human history were made through observations. The selected participants were chosen based on their direct involvement in the project, including work experience in the organisation to indicate if the solar energy project was implemented successfully or not. Their observations were important especially as these reflected on their inputs. Additionally, when evaluating the "after" the installation of the solar plant effect and when looking at the intended outcome.

•Depot Team reported stagnated trains operations before the installation of the solar energy project

•The project team reported train operations improvement after the installation of the solar energy project

The findings were discussed and presented in detail and the results were analysed and presented accordingly. From the two groups of participants from the depot and project teams, their responses to the interview question were analysed and presented with interpretation to confirm if the viability of solar energy can improve the efficiency of the railway infrastructure.

In answering the main research objectives, detailed secondary questions were categorised into the following main sub-sections:

The viability of solar energy to improve the efficiency of train operations after renewable installation

After the project execution surveys were conducted with clients and customers who recorded high levels of satisfaction and would have a slight adjustment in their operating costs since more trains could be operated with more capacity for revenue improvements.

The potential of solar energy in the railway infrastructure

The participants shared common views on quality management, though the project team leaned more towards the project meeting technical specifications and had adhered to quality specifications

The implementation of solar energy in the railway infrastructure
The implementation of a renewable energy project (solar project) at Thabazimbi for train signalling systems was seen by both groups as having improved operations and reduced human involvement in operations

To establish the sustainability of solar energy efficiency in the railway infrastructure
The newly solar energy introduced a way of doing business. Operations had maintenance plans, with operating specifications. With the depot team, the team members found it easy to engage and communicate with the client. The project team highlighted an opportunity to communicate the new project with stakeholders as a motivation for a nationwide renewable program for the railway infrastructure since the signalling systems improved the efficiency of train operations

Secondary question responses from project team and depot team
The following sections present the detailed secondary questions were categorised into the following main sub-sections from the depot and project teams.

Operations had no specifications, which highlighted an issue even with designs, as specifications would promote standardisation, the accuracy of the information, and operating plans. Railway infrastructure was commonly noted as aging with operational challenges.

The railway signalling and set of points systems were operated manually 24 hours and 7 days per week. This then highlighted the reasons behind train delays resulting in unreliable train turnaround times. An increase in an unreliable turnaround directly negatively affects operations. The literature further stated that the aging infrastructure has negative consequences on people and equipment. A contribution made by Blumefeld et al (2019) Introduced safety as a concern. They stated that safety on the railways in low-income countries has been a matter of significant concern and this is the case in South Africa.

Table 5: Discussions from depot team, project team before and after solar energy project

The railway infrastructure operations in South Africa (Thabazimbi – Lephalale)

Findings discussion from depot team and project team	Before solar energy installation	After solar energy installation
Train Schedule management	Schedule overruns due to lack of power supply to operate signalling systems and others	Turnaround time improves significantly after solar energy installation. Almost 2 hours achieved between the mines to the harbor proportional
Cost Management	Operating costs were not manageable due to inefficiencies signalling and rail set of rail systems, maintenance overhead cost was high.	Operating costs slightly increase since more trains could be operated. The was a potential capacity for revenue improvement from logistic companies and Mines
Quality Management	Manually operated infrastructure resulted in poor quality. Lack of power supply deterred the quality standards and records	Solar power supply improved the operation method and improve the quality of systems.
Communication Management	Costumers had no alternatives of service rendered. No impact recorded in communication between the supply and the customers	The solar energy installation highlighted the opportunity to communicate with stakeholders regularly, Railway infrastructure could be aligned and communicated efficiently.
Risk Management	Operationally the risks were cantered on the safety of employees who had to operate manual aging systems and as a result, employees who would then miss work especially during the night shift thus affecting operations	The risks to employees working at night- shifts were reduced as systems were becoming more efficient with less reliance on physical labour, the solar energy systems offered system improvements at a fraction of the cost when compared to conventional methods and would achieve sustainability in the long term.
Safety Management	The railway systems were found to be aging and unsafe. Since operations are daily for 24hrs, the effects of safety were in how there was a noticeable low availability of a workforce at night	The solar technology linked to batteries was also seen as a safety system that conventional energy technology used to power the railway infrastructure. Improved safety outlooks are a huge benefit at operations levels and can be a factor in motivating for funding and sustainability in railway systems.
Stakeholder Management	Stakeholder engagement came up as a concern in that stakeholders were not interested in the operational challenges of the railway any longer.	Stakeholders benefiting from the project at the depot expressed satisfaction. The depot team presented good reviews from their clients and customers. The role of management in taking these reviews and benefits to top management was highlighted
Human Resource Management	Human resources also affected the safety of employees during work and the concerns raised by employees on their working conditions at the depot.	With improvements in operations, both teams commended the role of management in making the project a reality and in how in the interest of the project rollout, incentives were offered to both the project team and the depot team for the successful implementation of the project.

FINDINGS DISCUSSION

The case study

The case study was a single case study on the Transnet Group Capital project in the Thabazimbi depot. Transnet is the sole logistic rail company in South Africa that has applied renewable technology on their railway network, for operation purposes of signalling systems and the setting of points systems. As Gustafsson (2017) stated, that the benefit of a single study is to richly describe the existing phenomenon better.

The railway line between Thabazimbi and Lephalale coal mines was operating only with diesel trains, without overhang traction electrification (OHTE). As a result, the manual operation of signalling and setting of point systems deferred the turnaround time of hauling commodities from the customers (mine operators). These challenges triggered the need for installing an alternative electricity supply to the rail infrastructure. The renewable energy project was undertaken to explore the viability of signalling and cross-levelling infrastructure through energy supplied from solar panels.

The consolidated findings indicated similar findings which summarised that solar energy was viable based on the participants (26 participants) and the project team (12 participants) that had similar views on how the system was difficult with challenges before solar energy substation, manual operations had challenges, increased overtime which pushed up operational cost due to systems delays and the system had risks and safety concerns.

Similar to the view expressed by the data collected from the depot team (26 participants) and the project team (12 participants) for after solar project that solar energy has potential because it showed improved safety, reduced cost overruns and the system operated efficiently with no delays.

Findings from Engineers indicated that the functioning efficiency of signalling systems and rail highlighted the sustainability of solar energy in the railway.

The conversations with the Signalling Engineer and Electrical Engineer who was intimately involved in the inception of the project until the project close-out emphasised that implementation and application of solar energy P.V. panels were based on the specification for installing signalling equipment systems which were clearly defined. However, due to the position of the solar energy substation changes in the installation design plans were made and extra material to suit the newly issued installation plans and – to achieve the project objectives.

According to the project team, electrical designs were very intricate and solar energy suppliers assisted immensely with the technical input during the compiling of the specification. Photovoltaic solar panels and eighteen batteries backup were recommended during the design. However, during the test and commissioning expected energy capacity was not achieved. Eventually, the new design was commissioned to evaluate the backup storage, and the new battery system called lithium-ion battery was introduced. Ultimately, the solar energy power supply to operate the signalling and set of points was achieved.

CONCLUSIONS

There is a growing trend of solar energy in railway buildings, at the same time, the rail sector fundamentally still relied on convectional energy to electrify the railway infrastructure. However, it is hoped that this paper can open a debate on the role of renewable technologies in South African railway infrastructure. The opportunities can be explored to aggressive rollout the renewable solar energy projects particularly in areas where railway systems have

no proper electrification. The case study presented in this paper only considers the operation time improvement, the depot team's broader performance, and safe working conditions since the electrification of part of rail infrastructure systems with solar energy at Matlabas in South Africa. The electrification of railway signalling, and rail set of points systems with solar energy reveals that the renewable technologies are viable, have potential, can be implemented, and be sustainable in the railway infrastructure.

Finally, this research has contributed to the body of knowledge in the railway (sector) particularly in the application of renewable technologies to railway control systems. Again, the study tried to highlight the benefits of renewable energy in the railway industry, of which there is the need to achieve sustainable energy, possible lower/sustainable cost compared to electrical, with zero emissions, ease of installation, etc. However, more research needs to be explored to evaluate the viability of solar energy to run the operation of railway infrastructure independently without the support of conventional electricity supply from the coal-powered station

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GREEN BUILDING COMPLIANCE-INDEX OF TERTIARY EDUCATIONAL INSTITUTION BUILDINGS (TEIBs) IN SOUTH-WESTERN NIGERIA

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Green buildings are healthier, more economical, energy-efficient with a lesser environmental footprint than conventional buildings. The purpose of the study is to assess the compliance level of Tertiary Educational Institution Buildings (TEIBS) in South-Western Nigeria with green building requirements. The study covered Forty-seven (47) Tertiary Education Trust Fund building projects executed from 2011- 2017 using the Leadership in Energy and Environmental Design scoring system. The compliance index with the requirements was established by collating the scores for the different LEED categories. The findings revealed a higher compliance index for some of the LEED requirements than others. The result also shows a significant variation in compliance among the Institutions. The Man-Whitney U-test showed no difference in the compliance level between University and Polytechnic buildings. Results of the study suggest that individual institutions should leverage the compliance level to improve the quality of education in Nigeria. by implication, the variation in the compliance level is due to a lack of policy direction for developing green TEIBS in Nigeria. The study recommended that the Federal government, through the Tertiary Education Trust Fund, should formulate policies to enhance compliance with green building principles in the development of TEIBS.

Keywords: compliance index, green building, sustainable construction, tertiary educational institution buildings, tertiary education trust fund

INTRODUCTION

Tertiary Educational Institution Buildings (TEIBs) represent a large chunk of the government's capital investment in Nigeria. There is also a large population of Nigerians below 45years of age demanding Tertiary education (Federal Universities and Polytechnics) (Kazeem, 2017). The Committee on Needs Assessment of Nigerian Universities (CNANU, 2012) reported that Tertiary Educational Institution Buildings (TEIBs) in Nigeria were inadequate and dilapidated. Unfortunately, the buildings were developed through conventional practices since Nigeria is yet to have a green building assessment tool to promote efforts towards green building development, as observed by (Onuoha et al., 2017; Dalibi et al., 2017). Consequently, there is no serious effort made to incorporate green principles in the development of TEIBS.

Considering the investments by the Federal government in recent years, specifically through the TETFund for the improvement of TEIBs, non-compliance with green building requirements is a challenge to the quality and sustainability of educational buildings in Nigeria. Effectively implementing green building requirements will guarantee the availability of quality buildings and infrastructure to support the aim of the Tertiary Educational Institution in Nigeria. It will ensure the sustainability of new ones and retrofit existing buildings for generations to come. Green TEIBs will boost the carrying capacity of the educational institutions to admit more students, especially in south-western Nigeria with a

high population of admission seekers. El Asmar et al. (2014) observed higher students' satisfaction compared to non-LEED seeking institutions with more conventional buildings. Bonde and Ramirez (2015) also corroborated this position. However, the university systems in Nigeria lack articulated vision and objectives in developing the TEIBs (Ewa, 2013). Other challenges observed include lack of adequate planning at the inception stage which is critical for green building development, lack of continuity, and institutions' long term strategic plan to drive the institutions (El Asmar et al., 2014; Fabbri & Tronchin, 2015; Mihai & Iordache, 2016).

Buildings are classified green when they meet the minimum certification criteria. Bragança et al. (2014) noted that a building does not necessarily need certification to be green. This statement corroborates the report of some buildings that were green compliant even though they were not subject to any form of green certification (Langdon, 2007). By implication, conventional buildings can achieve a certain level of compliance with green building standards without any intention for green certification. Therefore, this study proposes to assess the level to which the Tertiary Educational Institution Buildings (TEIBs) in South-Western Nigeria complies with green building requirements. This study believes that there is no significant difference in the level of compliance with green building requirements among the selected institutional buildings.

METHODOLOGY

The quantitative research design provides the opportunity to explore the area of interest using scientific methods (Mathers et al., 2009). The population consisted of 6 Federal Universities and five Federal Polytechnics within the study area (Table 1). These are publicly funded and provide the opportunity to assess the policy direction of the Federal government for green building development in Nigeria. FU1 to FU6 represents the Federal Universities while FP1 to FP5 the Polytechnics. The projects were executed under the Federal government policy on public procurement, thereby providing a viable source of project information required. There were 47 TETFund building projects completed between 2011- 2018 in the Federal Universities and Polytechnics in South-Western Nigeria during data collection. The FP2 had no completed building projects at the time of data collection because the institution was relatively new. Since the population is manageable in size, therefore, the study used a census survey. The data collection process involved physical assessment of the TEIBs individually to determine the LEED score in each category.

Table 1: TETFUND projects in Federal Universities and Polytechnics in South-Western Nigeria from 2011 to 2018

States	**Ekiti**		**Ondo**		**Osun**		**Ogun**		**Oyo**	**Lagos**		
Institutions	FU1.	FP1	FU2	FP2	FU3	FP3	FU4	FP4.	FU5	FU6	FP5	**Total**
TEIBs	3	8	5	0	7	3	6	10	4	4	8	**58**
Executed Completed	3	5	5	0	6	1	4	8	3	4	8	**47**

Source: Physical Planning Unit of each Tertiary Educational Institution (2018).

Data Collection Instrument

There are various green building assessment tools such as the BREEAM, CASBEE, amongst others. The data collection used the LEED certification system because of its ease of adaptation and flexibility. It is easy to adapt because the LEED uses performance-based criteria, and it can be self-administered. The assessment used the "LEED v4 project checklist for Building Design & Construction; LEEDv4 for BD+C: Schools. The LEED V4 system

utilizes a list of 57 performance-based credits worth up to 100points with Ten bonus points divided into Eight categories: Location and Transportation (LT), Sustainable Site (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), Innovation (INN) and Regional Priority (RP).

The Green Building Compliance Index (GB-CI) shows that the Educational Institution buildings have some level of greenness, although there was no intention for certification. The analysis includes the calculation of the compliance index for the individual institutions. The percentage compliance with each of the LEED categories was also determined as follows:

The compliance index is the average score for each LEED category calculated for all the buildings within each institution. The average LEED score used the arithmetic mean equation given as follows.\:

$$Ave\ LEED\frac{Score}{category} = \frac{bs_1+bs_2+\cdots+bs_n}{n} \quad \text{……..} \quad 1$$

$$Ave\ LEED\ Score/category = \frac{\sum bs}{n} \quad \text{……..} \quad 2$$

Where, bs is each building score for a LEED category while n is the total number of buildings assessed in each institution.

Therefore, the GB-CI for an institution equals the sum of the average LEED scores for all the LEED categories:

GB-CI = $(\sum_{n=1}^{8} SS + LT + WE + EA + MR + IEQ + INN + RP)$ ……3

Secondly, adding the average LEED category scores for all the institutions gives the average GB-CI for each LEED category. The average LEED category score placed on a percentage of the expected score for the LEED category is the percentage Compliance Index per LEED category. The percentage Compliance Index represents the general performance of the tertiary educational buildings for each LEED category.

For example: to calculate the compliance index for ss equals the sum of the average LEED scores for all the Institutions divided by the total credit Sustainable Sites by 100%

GB-CI ss = $GB - CIss = (100\,x \sum_{n=1}^{10} Ins)\%$ …… 4

Where, Ins is the average LEED scores for each institution.

The hypothesis used the Kruskal-Wallis Rank Sum test to determine significant differences in the GB-CI of the TEIBs (Hole, 2011; Cheng et al., 2014).

The Kruskal-Wallis test statistic for k samples, each of size n_i is:

$$H = \frac{12}{n(n+1)}\sum\frac{T_i^2}{n} - 3(n+1) \quad \text{……} \quad 5$$

Where: n is the total number (all ni), and Ri is the sum of the ranks (from all samples pooled) for the ith sample. The null hypothesis of the test is that all k distribution functions are equal. H is statistically significant if it is the same or larger than the critical value of Chi-Square for the given d.f. Therefore, Ho Rejected if H is greater than the chi-square Table value (Dupont, 2009; Cheng et al., 2014).

The null hypothesis was rejected at a 95% confidence interval at a p-value less or equal to the 0.05significance level. The Mann-Whitney U Test was therefore used to determine if there is a significant difference in the level of compliance of TIBs with green building requirements between Universities and Polytechnics in Southwestern Nigeria. The Mann-Whitney U test compares only two independent group means, and the samples are small. Mann-Whitney is good when examining rank differences.

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n_i+1}^{n_2} R_i \qquad \text{.....6}$$

Where:

U=Mann-Whitney U test, N1 = sample size one, N2= Sample size two, Ri = Rank of the sample size

Data presentation and discussion

Table 2 shows the Average Green Building Compliance index (Gb-CI) of the TEIBs in South-Western Nigeria using the LEED V4 for BD+C: Schools scoring requirements. FU3, FU4, FP4, and FU2 scored 10, 8.7, 7.7, and 6.6 points over 12points for Sustainable Sites. FP1, FP3, and FU5 have the highest scores for Location and Transportation as10, 7.7, and 7.0 over a total of 15 points. The highest requirement score for FU1 is in Materials and resources: 6.0 out of 13points.

The result shows FU3, FU4, FP4, and FU2 scores in descending order for Sustainable Sites. FP1, UI, and FP3 have the highest scores for Location and Transportation. The highest score for FU1 is in Materials and Resources. While FU3 had the highest aggregate, FU1 had the lowest points overall. As a relatively young tertiary Educational Institution just developing its building facilities for learning, the result showed that there is no consideration for sustainable building and infrastructural development.

Table 2: Average Green Building Compliance Index (Gb-CI) Score by Requirements of selected TEIBs in South-Western Nigeria

		TEIBs											
S/n	**Green Building Requirements**	**FU3**	**FP4**	**FU2**	**FP5**	**FP3**	**FP1**	**FU1**	**FU6**	**FU5**	**FU4**	Average Gb-CI	% compliance
1	Location and Transportation (15)	6.8	7.2	4.8	7.3	7	10	2	7	7.7	6.7	***6.7***	44%
2	Sustainable Sites (12)	10	7.7	6.6	3.1	5	5.8	5.3	5.8	7.6	8.7	***6.6***	55%
3	Water Efficiency (12)	3	4.7	3	2.6	3	3.8	2	3.3	3.8	3	***3.2***	27%
4	Energy and Atmosphere (31)	5.6	5.2	3.4	3.3	2	5.6	1.7	3.8	3.9	4.3	***3.9***	13%
5	Materials and Resources (13)	6	6.7	5.8	5.9	5	4.6	6	6.3	7.4	7	***6.1***	47%
6	Indoor Environmental Quality (16)	6.5	7.4	5.4	6.4	5	4.6	3.7	6.3	6.4	6.7	***5.8***	37%
7	Innovation (6)	2	2.3	0.1	1.3	0	0.8	0	0.5	0.8	1.3	***0.9***	15%
8	Regional Priority (4)	2	2	2	2	2	1.4	1.3	2	2	2	***1.9***	47%
	Total Average (110)	**41.9**	**43.1**	**30.9**	**31.9**	**29**	**36.6**	**22**	**34.8**	**39.6**	**39.7**		

Assessing the difference in the level of compliance (GB-CI) with green building requirements, the Kruskal-Wallis test in Table 3 shows a statistically significant difference in compliance with green building requirements among the selected TEIBs, $\chi 2(9) = 29.289$, $p = 0.001$ rejecting the null hypothesis at a 0.05 confidence interval. The implication is that the level of greenness varies from building to building.

Table 3: Kruskal-Wallis H Test on Gb-CI of selected TEIBs in South-Western Nigeria.

Institutions	Mean Rank	Rank	Chi-Square	df	Asymp. Sig.
FP4	37.08	1	29.289	9	0.001
FU5	36.00	2			
FU3	34.50	3			
FU4	30.67	4			
FP1	25.00	5			
FU6	20.38	6			
FP5	15.86	7			
FU2	13.13	8			
FP3	9.00	9			
FU1	3.33	10			

In addition, the Mann-Whitney U test in Table 4 shows that, with a U value of 0.483, there is no significant difference in the GB-CI of the University and polytechnic buildings in the study area.

Table 4: Mann-Whitney U Test on GB-CI of TEIBs in universities and Polytechnics in South-Western Nigeria

Type of Institution	N	Mean Rank	Sum of Ranks	Mann-Whitney U Statistics	Z	Asymp. Sig. (2-tailed)
University	26	21.83	567.50	216.500	-0.702	0.483
Polytechnic	19	24.61	467.50			
Total	45					

DISCUSSION OF FINDINGS

The lack of adequate and quality TEIBs has been responsible for the dismal carrying capacity of Nigeria TEIBs. The low level of compliance can be said to be responsible for the dwindling performance of the education sector in Nigeria. Thus, give credence to the claim that the unrest in tertiary education institutions in the country in recent times was due to the non-availability of water, electricity, and poor quality of the buildings and facilities needed for qualitative learning and academic environment ref. Consequently, this is a challenge for policymakers to holistically assess the appropriation of the TETFund money in developing TEIBs.

The average Gb-CI for the TEIBs has the score for Sustainable Sites followed by Materials and Resources, Regional Priority, Location and Transportation, and Indoor Environmental Quality. While Water Efficiency, Innovation, and Energy, and Atmosphere followed accordingly. The discussion of the compliance index is as follows.

Sustainable Sites (55%)

The compliance index for this requirement is on average. It is easy for buildings to earn higher scores for this requirement. Little or no effort is required to plant vegetation or at least restore vegetation being a rainforest zone. However, compliance with green building requirements requires more than having vegetation. The result is in tandem with (Nduka & Ogunsanmi, 2015) results that built environment professionals believe that green building is about being environmentally friendly. In the same vein, another study noted that the built environment in Nigeria is still hostile to the physical environment because most people do not care about protecting the environment on-site (Hussin et al., 2013).

Materials and Resources (47%)

This implies that the construction industry is quite aware of the necessity to manage construction waste in building development, up to 30-35% of production cost (Hussin et al., 2013). Hence efforts are made to manage construction wastes minimally. However, the choice of green materials is still poor.

Location and Transportation (44%)

This requirement ensures ease of movement and accessibility to public infrastructures to reduce carbon emission through vehicular movement. It includes the provision of walkways and encourages the usage of bicycles. The buildings are within a school system which allows ease of movement from one facility to the other. However, the bulk of the transportation system is still vehicular. Individuals drive personal cars to work, and there are no provisions for bicycles (Hussin et al., 2013). The availability of walkways increased the compliance index for this category. The provision of car-parking facilities generates heat highlands and the destruction of natural vegetation around the buildings. However, the walkways provided are to improve the layout and aesthetics of the institutions. It has nothing to do to reduce carbon emissions from cars or to encourage walking.

Indoor Environmental Quality (37%)

The IEQ is to enhance the comfort requirements for the TEIBs, thereby promoting a conducive learning environment. The 37% compliance rate is not encouraging when about 90% of the time is spent indoors (Jenkins et al., 1992). therefore, a poor-quality indoor environment impairs cognitive performance, negatively impacts occupant's health, and reduces performance (Altomonte & Schiavon, 201; Mihai & Iordache, 2016; Al horr et al., 2016). Developing green building TEIBs will provide the required IEQ to enhance learning and productivity. A recent study also attributed low mental capability to poor IEQ. Ackley et al. (2017) noted that the quality of the indoor environment influences learning performance. Therefore, improving some of the building parameters in planning, design, construction, operation, and maintenance of TEIBs will enhance students' satisfaction and improve performance (El Asmar et al., 2014).

Water Efficiency (27%)

The percentage compliance for Water Efficiency is also poor at an average of 27%. This index justifies the claim that lack of water has spurred a series of protests among university students in Nigeria in recent times (Afolayan, 2015; Craddock, 2017). The import of this is that the management of the institutions and the built environment professional in the TEIs need to develop capacity for implementing green building practices to enhance water efficiency. Such include water harvesting, grey-water management, and reducing wastage through improved technology.

Energy and Atmosphere scored (13%)

An average LEED-certified building uses less electricity and saves C02 emissions annually (Modular Building Institute, 2009). Nonetheless, the compliance index is instructive in addressing the persistent unreliable supply of electricity in the country. The result is imperative in solving the energy problem faced by almost half of the population in Nigeria (World Bank, 2018). The installation of prepaid meters after the privatization exercise gave a boost to energy metering. In contrast, the usage of renewable energy sources is still low (Ezema et al., 2016). Improving compliance with the IEQ category in the development of TEIBs will reduce carbon emissions and lifecycle costs arising from the usage of non-

renewable energy sources (Hawkins et al., 2012). The institutions should leverage the level of awareness to implement green building practices.

Innovation (15%)

There are few LEED accredited professionals in Nigeria since Nigeria is yet to develop its policy for green building development. The low compliance index with this requirement shows that the professionals are not innovative in the design and construction of the TEIBs. Implementing green building practices requires innovation. The result supports the claim that design professionals are reluctant to adopt green technology, materials, and resources necessary to reduce the cost of green building development.

Regional Priority (47%)

although the compliance index is below average. The percentage index implies that TEIBs have a reflection of the geographical location of the zone. South-western Nigeria is a rainforest zone with a high level of variation in temperature and humidity depending on the time in the year. However, more still needs to be done to improve concern for the immediate environmental conditions when designing the buildings (United Nations, 2015).

Apart from the variation in compliance with different requirements, there is also a difference in compliance across the institutions. However, there is no statistically significant difference in the level of compliance between Universities and Polytechnics within the study area. Thus, implying that universities and polytechnics are behaving the same way. Because the same body, TETfund, handles the projects and, most times, the same contractors, and professionals. Nduka and Ogunsanmis (2015) posit there is no difference in implementing green building requirements in Nigeria. The situation is more critical in some institutions than in others. It also shows the lack of articulated and strategic policies for the institutions thus, confirming Ewa's (2013) opinion. There is a need for articulated vision and strategies for green building development by governing bodies of these institutions to improve the sustainability of TEIBs and ensure value for money for the Federal Government through the TETFund. Otherwise, the large sums of money injected into the system will continue to be a waste. Apart from the wastage by using conventional practices, the level of satisfaction with the buildings will be poor, resulting in low academic performance and poor-quality education agreeing with Hussin et al. (2013) and El Asmar et al. (2014).

CONCLUSION

The study assessed compliance of TEIBs with green building requirements in South-Western Nigeria. The result confirms that a building does not need certification to be green. However, compliance with the requirements for green building development varies from one institution to another. In contrast, compliance with the requirements is the same for Universities' and the Polytechnics' buildings within the study area. The Compliance Index for each category shows there is room to improve the quality of FTEIBs in Nigeria by implementing green building practices. It is also clear that the institutions have comparative advantages in their compliance with the LEED categories. The compliance recorded should be leveraged by the management of each institution to improve the TEIBs. Though the study is limited to south-western Nigeria, the findings are instructive for developing green TEIBs in Nigeria. It also provides a robust base to develop a strategic policy for green TEIBs in Nigeria. The Federal Government, through the TETFund, should formulate and implement policies that will improve the level of compliance with green building development in TEIs and the country. A strategy for green building development should be made part of the criteria to access TETFund support for building projects. The result shows that the institutions have comparative advantages in the level of compliance with the requirements. The physical

planning units should build on the requirements, while developing the capacity to improve areas with low compliance indexes.

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CIRCULAR ECONOMY IN THE CONSTRUCTION INDUSTRY IN AFRICA: A BIBLIOMETRIC ANALYSIS

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Circular economy (CE) in construction remains a contentious issue which continues to evolve. To that end, scholars have explored the concept through literature review and Bibliometric analysis. There seems to be consensus that African research output on the subject remains low. To test that observation, this study adopted a Bibliometric analysis approach to explore the intellectual structure of CE in the construction industry in Africa. The authors collected 31 articles published between 2005 and 2021 from the Scopus database and used VOSviewer for data analysis. Findings showed that there are six clusters shaping the intellectual structure (1) demolition, material recovery and reuse (2) waste as a resource (3) cellulose and agro-based materials (4) resilience and low-carbon footprint (5) upcycling materials and (6) 4th industrial revolution. The two most cited scholars had three publications each while the top journal was Resources, Conservation and Recycling. The dominant concepts included sustainability, alternative materials, waste management, lifecycle, demolition, climate change, and valorisation. The study concludes that there is low CE research output in Africa which implies that the concept is either novel or facing resistance. It is suggested that future studies explore CE concepts using various databases and ascertain their barriers, drivers and level of implementation.

Keywords: Africa, bibliometrics analysis, built environment, circular economy, construction industry

INTRODUCTION

Circularity and sustainability have become buzzwords within the construction industry. The realisation that construction activities are largely dominated by linear practices of extract, make and dispose that deplete the natural resources and emit toxic gases has given circular economy (CE) its impetus in the construction industry (Benachio et al., 2020; Patwa et al., 2021). The Ellen MacArthur Foundation has in the recent past been a leading voice in advocating for circularity and defines CE as a system that is both regenerative and recuperative by design (Ellen MacArthur Foundation (EMF), 2013). The underpinning standpoint of the EMF and other circularity proponents is that the linear model is unsustainable. For that reason, the CE has been widely regarded as a concept that operationalises sustainability (Galvão et al., 2018). The CE practices are anchored on the principles of reduce, reuse, and recycle (Mahanty et al., 2021). In construction industry, principles such as designing out waste, biomimicry, material selection and flow analysis, designing for deconstruction or disassembly have also emerged (Rahla et al., 2021). All these practices are the industry's contribution to advancing circularity and sustainability.

Several scholars have extensively reviewed the CE practices adopted in the construction industry. Since 2016, there has been a steep increase in research output on CE within construction industry accounting for approximately 21% annually across the globe (Norouzi

et al., 2021). Contrary to the academic growth, Akhimien, Latif and Hou (2021) systematic review on the application of CE principles in buildings concludes that the level of awareness of the concept in Africa remains low. The authors attributed the low awareness level to scant research output from Africa (approximately 1.6%). Furthermore, material selection is an important CE practice determining how the construction industry contributes to circularity. Rahla, Mateus, and Bragança (2021) examined the issue based on articles published from 2015 to 2020 and revealed that Africa only contributed 2% publications. Evidently, these are worrisome statistics particularly in advancing the CE knowledge within the African context. Similarly, Desmond and Asamba (2019) and Rweyendela and Kombe (2021) also claim that circularity remains vague in Africa and conclude that CE is yet to yield tangible actions in most countries. For that reason, examining CE concepts within African construction industry is likely to give an indication of emerging practices and platforms where these concepts are being discussed which would potentially inform future researchers on how to venture into the scholarly debate. To date, to the knowledge of the researchers no studies have exclusively looked at the emerging circularity concepts, clusters, and authors from the African continent using a Bibliometric analysis approach.

This study employs a bibliometric analysis of the circular construction in Africa to respond to the following research questions: (RQ1) What is the current intellectual structure of CE in construction industry in Africa? (RQ2) Who are the most cited authors? (RQ3) Which are the top journals or conference publishing the most cited articles? (RQ4) What are the dominant practices and concepts that are shaping current CE trends in Africa? By answering these research questions, this study seeks to identify the concepts that are shaping circular construction on the African continent, while showing the circularity practices that can be adopted by the various construction stakeholders, such as governments, professionals, and contractors.

LITERATURE REVIEW

Transition from linearity to circularity in construction industry

The construction industry has for a long time been characterised by a linear model. A linear approach involves a sequential exploitation of natural resources through extraction, use and disposal (Benachio et al., 2020). The concept does not consider any form of recycling or reuse which subsequently leads to immense waste generation and pollution (Ranjbari et al., 2021; Akhimien et al., 2021). In response to these findings, Turner and Pearce (1990:35) coined the term “circular economy” in response to the necessity to extend the useful life of resources in order to reduce the burden for extracting virgin raw materials. For that reason, the CE is anchored on three fundamental principles reduce, reuse, and recycle (Kirchherr et al., 2017; Leising et al., 2017; Mahanty et al. 2021). However, Potting et al. (2017) identified 10Rs; recover, recycle, repurpose, remanufacture, refurbish, repair, reuse, reduce, rethink, and refuse which further gives in-depth perspective of the circularity approach.The ultimate goal of these principles is for the industry to rethink the design, operational and waste management strategies. The concept of circularity in construction is evolving as the practitioners and advocates push for a transition from linearity to circularity.

CE in the construction industry: Emerging concepts, practices, and trends

Of late, scholars across the world have been seized with a growing research interest of the CE paradigm. The interest has been largely hinged on the fact that the concept serves as an alternative to the linear model which is deemed unsustainable (Benachio et al., 2020). Buttressing that observation, Norouzi et al., (2021) and Akhimien, Latif and Hou (2021) note between 2016 and 2017 CE studies skyrocketed as academicians pursued the sustainability

agenda. As a result, several CE concepts and trends have arisen. Goyal et al. (2021) identified some of the leading CE concepts as measurement strategies and models, CE and sustainability, level of adoption (company, country and regional), 3R model (reduce, reuse and recycle) and the role played by project design. Furthermore, the study concludes that CE research has been characterised by interdisciplinary collaborations because of how its practices permeate across economic sectors.

On the other hand, Norouzi et al. (2021) and Mhatre, et al. (2021) identified emerging concepts in construction industry as energy efficiency, waste management, enablers and drivers, end of life management, alternative construction materials circular business models and recommended that smart cities and industry 4.0 were the future trends of the industry. In tandem with that, Tsai et al. (2020) add that incineration, separation and sorting solid waste have also gained focus. Contrariwise, Cimen (2021) argues that incineration produces toxic gases that in turn deter the circularity agenda. Rahla et al. (2021) augments the findings of Cimen (2021) by suggesting that instead of thinking about incineration and recycling, the industry should explore eco-friendly materials that are biodegradable. Nevertheless, Akhimien, Latif and Hou (2021) note that an increase in scholarly publications demonstrated heightened awareness of the concept. Despite these practices, Cimen (2021) argues that the construction industry still struggles to implement CE. Perhaps, the fragmentation of the industry has contributed to such. As a result, the concept continues to be explored and new practices are emerging at the same raising questions whether the industry would ever become fully circular.

CE practices in African construction industry: Opportunities and Challenges

The construction industry has for a long time been lagging in adopting new concepts and technologies. Recently, Cimen (2021) reviewed 2017-2020 articles and concludes that the construction industry is struggling to implement CE principles. Such a position could have been necessitated by the multiplicity of stakeholders in the supply chain.Mahanty et al. (2021) observed a structural shift from 2014 to 2015 in CE studies as more attention was being directed towards the social pillar of sustainability. Arguably, such a shift in research was imperative as it considered problems that bedevilled emerging economies like Africa. Furthermore, Ranjbari et al. (2021) linked waste management attributes with CE and concluded that with construction industry generating enormous waste, CE might prove as a game changer in enhancing sustainability. Charef & Lu (2021) argue that business models and supply chain integration provide the basis for the transition to adopt CE practices in construction industry. On the other hand, Tsai et al. (2020) and Norouzi et al. (2021) in a 2005-2020 Bibliometrics analyses suing both Web of Science and Scopus databases lament that although CE is receiving much scholarly attention, the African continent was being left behind. Since the construction industry is still emerging in Africa, ignoring the circularity principles could potentially have detrimental effects on the continent's contribution to the Sustainable Development Goals (SDGs).

The policy direction of the nation informs the direction of the practices within a country. In most cases, policies are informed by research. Contextually, Rademaekers et al. (2020) observe that approximately 96% of the African countries have incorporated CE practices within their policies. For that reason, there is a growing traction of the concept within the African continent which perhaps is informed by research in the area spearheaded by collaborations. With regards to collaborative initiatives, Türkeli et al. (2018), focused on CE scientific knowledge in the European Union and China and concluded that for the CE agenda to permeate globally, there might be a need for collaboration among scholars. Therefore, a series of EU-African collaborative studies were done across Africa and the findings indicated

that the following key CE practices: recycling, resource efficiency, use of secondary materials, local building materials, green public procurement, recovery of materials at demolition stage, efficient lighting, banning of single-use plastics, reduction of material importation, use of interlocking stabilised soil blocks (ISSB), shredded plastic waste and agro-based residues, low cost and natural building materials, value addition of local eco-friendly materials, informal waste management, use of sustainable materials energy efficiency, environmental performance, renewable energy, waste management, urban forests, building using compressed earth bricks (CEB), revision of building codes, alternative materials and waste sorting and segregation (Potgieter et al., 2020; Bonnaire et al., 2020; Whyte et al., 2020; Rajput et al., 2020; Diaco et al., 2020; Karcher et al., 2020; Hemkhaus et al., 2020; Mahmoud et al., 2020). Evidently, the African countries have adopted CE practices at different levels.

METHODS

The study adopted a quantitative research method, namely the Bibliometrics approach. A Bibliometric analysis method is a useful statistical technique that determines the knowledge base of a scientific area of study (Garfield, 1979). More so, the author further notes that the main assumption of the method is that to ascertain any intellectual structure of a topic of interest, publication citations are a true representation of the ongoing discourse in that study area. Nonetheless, Culnan (1986) argues that the use of citation counts to measure their impact in shaping a knowledge structure is dependent on their availability which potentially limits the effectiveness of the technique. However, in addition to citation counts, van Eck & Waltman (2014) complement that the method statistically analyses published articles and establishes networks based on co-citations, bibliographic coupling, co-authorship, and keyword co-occurrences. The study employed the citations, co-citations, and co-occurrence options to address its aim.

The study sampled data from the Scopus database. Mongeon & Paul-Hus (2015) suggest that Web of Science (WoS) and Scopus are the most popular databases and have a wider global coverage. However, Nobre & Tavares (2017) argue that Scopus has the largest collection of abstracts and citations. For that reason, the researchers used Scopus and followed five steps in data collection and analysis. Firstly, search query comprised of keywords, “circular economy” AND (“construction industry” OR “construction*” OR “building*” OR “built environment”) on the topic (Title, Abstract, Keywords). Secondly, the authors delimited to peer-reviewed articles and conference proceedings published between 2005 and 30 August 2021. Thirdly, the results were further filtered to include African countries only. Fourthly, the researcher read the articles to ascertain relevance of the article. Lastly, relevant data was exported to VOSviewer version 1.6.16 for analysis.VOSviewer software is a mapping tool that allows a visualisation of the networks that exists between the articles (van Eck & Waltman, 2010). In similar studies, Charef & Lu (2021), employed the the search query, “circular economy” AND (building OR “construction industry” OR “built environment”) AND “business model” OR “supply chain integration” while Mhatre et al. (2021) adopted “circular economy” AND (building OR “construction industry” OR “built environment”) AND “business model” OR “supply chain integration” and Norouzi et al. (2021), "circular econom*” AND "building OR construction ". Although the keywords from the previous studies were almost identical to the current study, the researchers differentiated this study by delimiting it to African countries.

RESULTS AND DISCUSSION

The dataset comprised of a total of 31 articles (27 journal articles and four conference proceedings). The data was drawn from eight African countries namely, Morocco, Egypt,

Nigeria, South Africa, Tunisia, Malawi, Kenya and Ghana. The oldest article was published in 2016. In 2020 a total of 15 articles were published and at the time of the presentation of the findings, nine articles were already published in 2021. The findings buttress the Norouzi et al. (2021) study which noted an exponential growth of studies in the area since 2016.

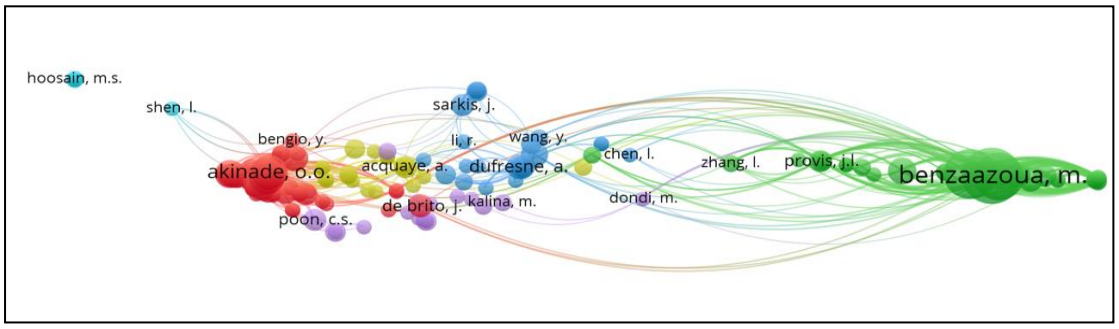

Figure 1: The co-citation and authors map showing the intellectual structure of CE in construction in Africa

Findings show that CE in African construction industry is still in its infancy and evolving. Cimen (2021) notes that although the concept is still novel, the main challenge with the construction industry is that it has been a technological laggard. However, the current intellectual structure of the CE in construction industry in Africa as shown in Figure 1 demonstrates that the sector has been forthcoming in this area. Arguably, these findings indicate that the policies put in place as highlighted by Rademaekers et al. (2020) are bearing fruit although the growth is marginal. Interestingly, Figure 1 shows that there are six common themes that are shaping the African research in CE: Cluster 1- red colour – "demolition, material recovery and reuse". It is the most dominant cluster with 52 authors and the leading scholars included Oyedele L.O, Akanbi L.A., and Akinade A.O. Notably, Hemkhaus et al. (2020) and Ranjbari et al. (2021) argue that the construction industry in Africa is contributing to a sizeable amount of demolition waste and there is little reuse of materials. Although, it seems there is activity in the research area, Mahmoud et al. (2020) argue that particularly in Egypt, the policies on CE with regards to demolition and waste management are new and are yet to yield any results and therefore they cannot ascertain their outcomes. A problem that is likely to inform future studies.

Cluster 2 – green colour – "waste as a resource". The concept is hinged on the beliefs held by the Ellen MacArthur Foundation (2013) and Goyal et al. (2021) that CE should be incorporated within the design stage. However, it seems in most African countries waste management is still informal which deters its use and establishment of secondary markets (Rajput et al., 2020; Potgieter et al., 2020). Such a situation creates an opportunity for reconfiguration of perceptions of individuals about waste through community engagement and workshops with stakeholders. Cluster 3- blue colour - "cellulose and agro-based materials". These authors seem to be tapping into the knowledge that Africa is largely agro based which presents a potential for innovative agro-based materials, Bonnaire et al. (2020) and Whyte et al. (2020) agree that in Africa the development of alternative materials from agricultural waste such as polysaccharides should be explored.

Cluster 4 – yellow "resilience and low carbon footprint". Carbon footprint is a significant contributor of climate change (Al-Hamrani et al., 2021). Therefore, a study in this direction is a commendable approach in the attainment of SDGs. Additionally, Mahanty et al. (2021) perceive that although CE has gained traction, the environmental sustainability has not been given much attention in the discourse. Cluster 5 – purple "upcycling materials". The recycling process has gained traction. However, Norouzi et al. (2021) and Mhatre et al.

(2021) are of the view that it is an inferior method than reusing because of the energy consumed during the recycling process. The study revealed that in Africa, upcycling is on the rise but there seems to be limited standards of the end products which deter its use. Cluster 6- turquoise colour- "4th industrial revolution". Lastly, technology is the central part of CE transition. The findings seem to contradict Cimen (2021) who claimed that construction was technological adverse. These six clusters demonstrate that Africa is contributing to the CE debate within the construction industry context.

Table 1: The most cited authors in CE in construction industry in Africa

Author	TP	TC	CPP
Akanbi L.A.	3	121	30.25
Oyedele L.O.	3	121	30.25
Ajayi A.O.	2	112	56
Akinade O.O.	2	112	56
Bilal M.	2	112	56
Benzaazoua M.	4	22	5.5
Hakkou R.	4	22	5.5
Mabroum S.	3	22	7.33
Taha Y.	4	22	5.5
Elmaraghy A.	2	14	7

Note: TP-Total Publications, TC-Total Citations, CPP-Citations per Publication.

Table 1 shows the leading top ten most cited authors in Africa. Akanbi L.A and Oyedele L.O. both had 3 TP respectively. The most cited authors per publication (56) were Ajayi, A.O, Akinade O.O and Bilal M. who published two articles each. The other crucial component is that the area is still in its infancy as evidenced by the total number of publications from the 10 authors which cements Cimen (2021) and Norouzi et al. (2021) positions that there was more to be done within the CE in construction. The study identifies the contemporary voices in Africa shaping circular building. These authors play a critical role in spreading the concept throughout the industry.

Table 2: The top journals or conferences that published most cited articles in CE in construction industry in Africa

Journal/ Conference	Number of Publications	Number of Citations
Resources, Conservation and Recycling	2	150
Journal of Cleaner Production	4	62
Annals of Global Health	1	18
Habitat International	1	13
Journal of Building Engineering	1	12
Environmental Research	1	9
IGLC 2018 - Proceedings of the 26th annual conference of the international group for lean construction	1	8
Cellulose	1	8
Sustainable Environment Research	1	8
Lean Construction	1	6

Table 2 highlights the top 10 journals and conferences that cited the most articles. Contrary to Nozouri et al. (2021) findings that the Journal of Cleaner Production was the most productive journal, in Africa the leading journal in terms of number of citations is Resources, Conservation and Recycling. Perhaps, that informs the reason why recycling and reuse have gained more traction than other circularity principles (Diaco et al., 2020). It is also interesting to note that circularity in the construction industry has also permeated other disciplines such as health. Again, conferences in Africa seem to be shaping the discussion of CE within construction as evidenced by the IGLC 2018 which linked CE with lean construction. Conferences provide a platform for convergence of both researchers and practitioners to debate emerging concepts. Cellulose is another journal that is worth noting because it seems more agro-based materials from waste are now being explored in Africa.

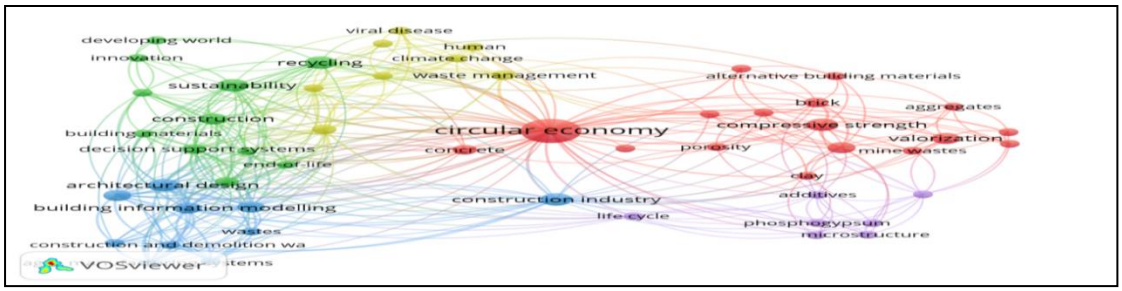

Figure 2: The map based on the co-occurrence on all the keywords

CE as an emerging concept is characterised by new principles and practices. Potting et al. (2017) noted ten principles and yet Cimen (2021) added the eleventh one. To ascertain the current trends and future areas to focus on in Africa, the study produced a co-occurrence map on all keywords. Five clusters emerged based on the number of keywords, Cluster 1 in red: 17 keywords included CE, compressive strength, wastes, and valorisation and alternative materials. The cluster confirmed the urgent call for the construction industry to think of alternative materials and waste management (Bonnaire et al., 2020). Cluster 2 – green: 11 keywords including end of life, recycling, sustainability, and innovation. Galvão et al. (2018) view CE and sustainability as complementary concepts. To put it another way, CE exists to make sustainability a reality in the construction industry. Furthermore, as CE is continually evolving, innovation appears to be its backbone.

Cluster 3 - blue: with 10 keywords including architectural design, construction and demolition and waste. CE principles appear to affect the entire lifecycle of the projects. Nonetheless, designing circular projects affords the concept a better chance of succeeding within construction (Goyal et al., 2021). The design stage detects the nature of waste products. Cluster 4 – yellow had 9 keywords including climate change, human and viral disease. Due to lockdown restrictions imposed to curtail the COVID 19 pandemic, supply chains were allegedly disrupted, resulting in the utilisation of local products. The restrictions may have had a favourable impact on decreasing carbon emissions that contribute to climate change (Hemkhaus et al., 2020). Finally, Cluster 5 - purple had 7 keywords inclusive of additives, life cycle and phosphogypsum. There is an ongoing debate about how to replace concrete as a construction material because of its climate-changing impacts due to carbon dioxide emissions (Al-Hamrani et al., 2021). The study suggests that Africa has also joined the discourse. However, contrary to Mahanty et al. (2021), who found a correlation between social sustainability and CE, such a link is lacking in Africa. Given the severity of Africa's social problems, it is critical to expand research in this area.

CONCLUSIONS

The CE in the construction industry remains inadequately explored in Africa. The study analysed 31 articles that were published from 2005 to 2021 which shows that the concept still remains relatively new in Africa. Although that is the case, it seems most African countries have incorporated CE principles in their policies. Nonetheless, these policies are still new for one to ascertain their effectiveness. Furthermore, of the analysed articles, the 6 clusters "demolition, material recovery and reuse", waste as a resource", "cellulose and agro-based materials", "resilience and low carbon footprint", "upcycling materials" and "4th industrial revolution" are shaping CE knowledge in the construction industry in Africa. The number of publications is quite low, ranging between two and four. This is, perhaps, a matter for concern, particularly in terms of furthering circularity. In theory, the study demonstrates that CE research output in the African construction sector is low, revealing possible gaps in the area that might be studied to expose circularity inclinations across the continent. In terms of practice, the study suggests circularity practices that might inform policy formulation and industry restructuring. This study made a significant contribution by articulating the CE intellectual structure, identifying prominent scholars, and highlighting platforms responsible for bringing Africa toward circularity, as well as providing concepts that will shape future trends. It should be noted that the current study used the Scopus database because of its enormous collection of abstracts and citations, which may have limited the number of articles reviewed. Finally, further study on CE in construction should be conducted using alternative databases such as Web of Science, Google Scholar and Dimensions, to ensure a comprehensive bibliometric analysis.

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A REASONABLY PRACTICABLE HEALTH AND SAFETY (H&S) PROGRAMME FOR MICRO CONTRACTORS (MCs) IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Micro contractors (MCs) in construction are pivotal to the growth of the South African economy. The South African construction industry has world-class health and safety (H&S) legislation and regulation; however, frequent accidents occur at an alarmingly high level. A study was conducted to determine the precipitating factors that influence H&S performance, and to establish a reasonably practicable H&S programme for MCs working in the South African construction sector. The study's findings indicate that MCs face a multitude of challenges that must be incorporated into a reasonably practicable H&S programme. Effective H&S performance in MCs require greater support from the Department of Employment and Labour (DEL), member organisations, and PCs in construction. It is only if firms embrace and enforce H&S legislation and regulations, that these can be effective. A 'check list' approach, focusing simply on H&S compliance, will not suffice. Effective H&S can only be realised if MCs undertake appropriate H&S training, and institute mentorship programmes.

Keywords: construction, health and safety, injuries, micro contractors, principal contractors

INTRODUCTION

According to Francisco et al., (2013:4), construction is one of the most hazardous industries. Data from several industrialised countries indicates that construction workers are three to four times more likely to die from accidents at work than other workers. Many construction workers suffer and die from H&S problems, including back injuries from handling heavy loads, respiratory diseases from inhaling dust, musculoskeletal disorders, noise-induced hearing loss, and skin problems. While the hazards and risks associated with construction work are high globally, the dangers and risks are estimated to be three to six times greater in developing countries than in developed countries. Although advances in legislation have been introduced, the sector's conditions are poor, and the enforcement of legislation is inadequate.

The objectives of the study are to determine the factors that lead to workers of MCs experiencing accidents and evaluate the extent of non-compliance with H&S legislation and regulations, the aim being to develop a reasonably practicable H&S programme for MCs that is likely to reduce accidents.

LITERATURE REVIEW

Definition of micro contractors in South Africa

The Minister of Small Business Development, Lindiwe D Zulu, acting in terms of section 20 (2) of the National Small Enterprise Act, 1996 (Act No. 102 of 1996), proclaimed on 15 March 2019, in matters about how to define small enterprises in South Africa. The size or class category `very small enterprise' collapsed into the `micro-enterprise' category. Schedule

1 of the National Small Business Act (NSBA) defines a micro contractor in construction as a business with ten or fewer employees and with an annual turnover of up to R10 million.

The interpretive view adopted for the study helped the researcher collect data related to the participants' lived experiences. Being a qualitative study of activity in a situation, the researcher was located on public construction projects (Denzin and Lincoln 2008). The primary source of data was face-to-face interviews conducted using a protocol of both closed-ended and open-ended questions. The data were obtained from people in the frontline of construction by visiting sites in two provinces (Mpumalanga and Limpopo) of South Africa.

Challenges experienced by MCs

Expansion in the South African construction industry has decreased due to the deterioration in business confidence and the volatile labour market. Strikes have reached a new level in terms of frequency, extent, and violence, and have resulted in significant harm to the economy. Non-compliance with employment equity could negatively impact a firm's ability to win tenders and increase the possibility of penalties imposed on South African projects. The construction industry in South Africa has a less than 50 percent H&S compliance rate. The wide scale and prolonged industrial action of the years leading up to 2016 placed increasing pressure on underlying contractual relationships. The increasingly complex regulatory landscape then requires entities to meet new regulatory requirements and stakeholder expectations. The challenge is to support performance objectives, sustaining the value and protecting the brand. The construction industry requires more investment (Price Waterhouse Coopers, 2016: 14).

Dlungwana & Rwelamila (2004: 5) identified the main problems facing construction SMMEs in developing countries, which included the high failure rate of local contractors due to the lack of competitive advantage which resulted in situations in which much of the construction work was performed by international contractors, with minimal involvement by the local industry. As a result, the base of viable contractors in many Southern African countries had been seriously drained by:

• socio-economic severe issues, such as rising unemployment;

• lack of resources resulting in an unsafe reliance on international resources to build much-needed social and economic infrastructure;

• lack of sufficient legislation to create an atmosphere in which contractors could expand sustainably;

• lack of well-structured training programs to equip businesses with technological or management skills and the lack of vital mentoring programmes;

• lack of performance management techniques and resources to promote a culture of quality improvement at a national and regional level, and

• weak construction procurement processes and lack of management capability and resources to equip managers to run their firms effectively and efficiently.

H&S practices of MCs

MCs typically perform poorly because their projects are generally less valuable and require less detailed H&S plans. Many H&S practitioners agree that implementing more rigorous occupational H&S management systems can lead to improved H&S results. Management commitment plays a crucial role in H&S success. Suggesting that small businesses lack both financial capital and management dedication to boost their H&S performance could be fair (Mills & Lin, 2014: 33).

Ying et al., (2015: 5) identified financial constraints, including lack of resources and equipment, and lack of negotiating power over key contractors, and short project timelines as the factors affecting the ability of small enterprises to concentrate on H&S. However, successful H&S practice requires extensive development, education, and training.

Lagging versus leading Indicators

While lagging indicators can alert construction entities to a failure or the existence of a hazard in an area of H&S programmes, leading indicators enable contractors to take preventive action to mitigate hazards and thus prevent incidents. To measure efficacy, a good H&S programme uses leading indicators to drive change. Leading indicators can play a vital role in preventing worker deaths, injuries, and illnesses and improving workplace H&S outcomes. Employers that use leading indicators as a tool to achieve these objectives have a significant advantage over their rivals (Occupational Safety and Health Administration, 2019: 2).

Legislation and regulations that relate to H&S in construction

The Occupational Health and Safety Act No. 85 of 1993 (OHS Act)
The Occupational Health and Safety Act (OHSA) was implemented in 1994 in South Africa. The OHS Act gives workers' rights in terms of H&S in the workplace. It requires management to appoint H&S representatives and to establish H&S committees in the workplace. The employer must make sure that the workplace is H&S compliant and must not allow any worker to do potentially dangerous work. The worker must know the dangers of the work, but it is always the employer who decides what the level of threat to workers' H&S is, and who takes precautions to prevent this. The OHSA falls within the ambit of the Department of Labour. Inspectors from the department have broad powers to search the workplace, question people, ask for explanations from an employer, and more.

Section 17 of the OHSA is essential to this study since MCs have a maximum of 10 employees; hence are not required, according to the OHSA, to appoint an H&S Representative. This is what the act stipulates in terms of Section 17.

The title of this study incorporates a 'reasonably practicable' H&S programme for MCs. 'Reasonably practicable' is defined in the OHSA as having regard to:

• the severity and scope of the hazard or risk concerned;

• the state of knowledge reasonably available concerning the hazard or risk, removing, or mitigating that hazard or risk;

• the availability and suitability of means to remove or mitigate that hazard or risk, and

• the cost of removing or mitigating that hazard or risk in relation to the benefits deriving therefrom.

Construction Regulations
There are specific regulations that apply to H&S in the construction industry. These are outlined in this section as this study focussed on determining whether MCs are competent in terms of working towards a practicable programme for H&S.

In terms of Section 43 of the OHSA, 1993 (Act No. 85 of 1993), the Minister of Labour promulgated the Construction Regulations 2014 Guidelines on 02 June 2017. The following regulations are pertinent to this study:

• Regulation 6 relates to the management and supervision of construction work. It states that contractors must appoint a construction H&S officer on the site who is registered with a

statutory body approved by the Chief Inspector and have the requisite competency and resources to be of service to the contractor, and

• Regulation 7 relates to the duties of the principal contractor and contractors. It indicates the importance of an H&S Plan for the PC and contractors. Regulation 7 (c) specifically requires the PC to appoint contractors with the necessary competencies and resources to perform the construction work safely. This study sought to establish whether MCs comply with these requirements. However, it should be remembered that MCs generally subcontract to PCs, and therefore are not required to appoint a Construction Health and Safety (CHS) practitioner who is registered with the SACPCMP.

The South African Council for the Project and Construction Management Professions (SACPCMP)
The SACPCMP is empowered by Section18 of Act No.48 of 2000. The SACPCMP is the designated registration body for construction H&S practitioners operating in South Africa. This council has been gazetted by the DEL as the registration body for the construction H&S professions and is a statutory organisation.

Registration with the SACPCMP is not a voluntary exercise and is a legal requirement in terms of the Construction Regulations of 2014. The regulations provide for this body to be known as the SACPCMP. In addition, it provides for the registration of professionals, candidates, and specified categories in the project and construction management professions. Thirdly it provides for regulation of the relationship between the SACPCMP and Council for the Built Environment.

The Compensation for Occupational Injuries and Diseases Act
The law applicable to the Compensation Fund was passed in 1941 (Act No. 30 of 1941) and repealed by the law passed in 1993 (Act No. 130 of 1993) ('The COID Act'). The COID Act aims to provide compensation in the form of payment and medical aid for disablement caused by accidents to or industrial diseases contracted by employees in the course of their employment and for death or disease resulting from such accidents.

RESEARCH METHOD

To meet the aim and objectives of this research, data and information was collected by undertaking a comprehensive literature review and through conducting a study of H&S practitioners working in the construction sector. The survey questionnaire included both closed- and open-ended questions.

The sample strata of the survey consisted of Construction H&S Practitioners in South Africa: SACPCMP registered persons; Saiosh members working in construction, and ACHASM members.

The survey was e-mailed to 16 183 Saiosh members; however, only 257 Saiosh members clicked on the link to complete the questionnaire. Notably, the CEO of Saiosh estimated that 2 000 Saiosh members work in construction. A total of 49 surveys of a likely 2 000 were received from Saiosh members in construction, resulting in an approximate response rate of 2.5%. The SACPCMP-related response included five completed questionnaires, and ACHASM-related response included five completed questionnaires. A total of 59 surveys were received. It should be noted that the study was conducted during the South African Government's lockdown in terms of the Disaster Management Act 57 of 2002, and COVID-19 restrictions. Most sectors, including the construction industry, closed operations during this period, which had a significant impact on the lead researcher's ability to elicit responses, or to contact potential respondents.

H&S practices of MCs

Table 1 indicates the frequency MCs undertake H&S practices relative to construction work in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of never to always.

It is notable that in terms of the mean of the three groups of respondents, 13 / 14 (92.9%) mean MSs are above the midpoint score of 3.00, which indicates that in general, the H&S practices can be deemed to be undertaken frequently, as opposed to infrequently.

It is notable that no mean MSs are > 4.20 ≤ 5.00, which would have indicated that the H&S practices would be deemed to be undertaken between often to always / always. 12 / 14 (85.7%) mean MSs are > 3.40 ≤ 4.20, which indicates that the H&S practices can be deemed to be undertaken between sometimes to often / often - monitor validity of Letter of Good Standing (1st), monitor validity of worker Medical Certificate of Fitness (2nd), identify hazards (3rd), conduct site meetings (toolbox talks or similar) (4th), review the client H&S specification (5th), avoid / eliminate hazards (6th), present H&S induction (7th), implement a procedure to report accidents (8th), monitor construction activities relative to the H&S plan (9th), monitor construction activities relative to fall protection plans (10th), conduct visual checks of H&S signage (11th), and screen workers during pre-employment (12th).

2 / 14 (14.3%) mean MSs are > 2.60 ≤ 3.40, which indicates that the H&S practices can be deemed to be undertaken between rarely to sometimes / sometimes - implement a procedure to report near misses (13th) and compile an H&S 'lessons learnt' report (14th).

Table 1: Frequency MCs undertake H&S practices relative to construction work

Practice	Saiosh	SACPCMP	ACHASM	Mean	Rank
Monitor validity of Letter of Good Standing	3.53	4.80	4.00	4.11	1
Monitor validity of worker Medical Certificate of Fitness	3.51	4.40	4.00	3.97	2=
Identify hazards	3.51	4.40	4.00	3.97	2=
Conduct toolbox talks or similar	3.67	4.20	4.00	3.96	4
Review the client H&S specification	3.22	4.40	4.00	3.87	5
Avoid / Eliminate hazards	3.33	4.60	3.60	3.84	6
Present H&S induction	3.43	4.60	3.40	3.81	7
Implement a procedure to report accidents	3.18	4.20	3.80	3.73	8
Monitor construction activities relative to the H&S plan	3.22	4.20	3.60	3.67	9
Monitor construction activities relative to fall protection plans	3.18	4.20	3.60	3.66	10
Conduct visual checks of H&S signage	3.47	4.00	3.40	3.62	11
Screen workers during pre-employment	2.73	4.80	3.00	3.51	12
Implement a procedure to report near misses	2.90	4.00	2.40	3.10	13
Compile an H&S 'lessons learnt' report	2.22	3.80	2.60	2.87	14

Most respondents indicated that MCs do not subscribe to the ISO 45001:2018 standard. In some instances, there are a limited number of MCs that do subscribe to the ISO standards. More SAIOSH (42.9%) and ACHASM (60.0%) members indicated that MCs could register for ISO, whereas 75.0% of SACPCMP respondents stated that MCs could not.

Most respondents indicated that MCs do not employ a Can. CHSM or a CHSM. More respondents indicated that Can. CHSO and CHSO officers were employed by MCs.

Table 2 indicates the respondents' degree of concurrence with respect to H&S practices undertaken by MCs in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (totally disagree) to 5 (totally agree).

It is notable that in terms of the mean of the three groups of respondents, 7 / 10 (70%) MSs are above the midpoint score of 3.00, which indicates that in general, the respondents agree that the H&S practises are undertaken by MCs, as opposed to disagree.

It is notable that no mean MSs are > 4.20 ≤ 5.00, which would have indicated that the respondents' concurrence is between agree to totally agree / totally agree.

1 / 10 (10%) mean MSs are > 3.40 ≤ 4.20, which indicates that the respondents' concurrence is between neutral to agree / agree in terms of H&S practices are undertaken by MCs - budgets are allocated for PPE, which is ranked 1st.

9 / 10 (90%) mean MSs are > 2.60 < 3.40, which indicates that the respondents' concurrence is between disagree to neutral / neutral - can conduct a risk assessment (2nd), H&S is prioritised by management (3rd), can implement a risk assessment (4th), reputation depends on H&S standards (5th), H&S communication amongst co-workers takes place on site (6th), budgets are allocated for H&S training (7th), workers trust the effectiveness of H&S systems (8th), workers prioritise H&S to prevent accidents (9th), and workers understand the importance of the H&S policy (10th).

Table 2: MCs' H&S practices

Practice	Saiosh	SACPCMP	ACHASM	Mean	Rank
Budgets are allocated for PPE	3.43	4.40	3.20	3.67	1
Can conduct a risk assessment	3.18	3.20	3.40	3.26	2
H&S is prioritised by management	3.22	3.40	3.00	3.20	3
Can implement a risk assessment	3.12	3.00	3.40	3.17	4
Reputation depends on H&S standards	3.06	3.60	2.80	3.15	5
H&S communication amongst co-workers takes place on site	3.06	3.00	3.00	3.02	6
Budgets are allocated for H&S training	2.63	3.40	3.00	3.01	7
Workers trust the effectiveness of H&S systems	2.88	3.20	2.80	2.96	8
Workers prioritise H&S to prevent accidents	2.82	3.25	2.80	2.95	9
Workers understand the importance of the H&S policy	3.00	2.80	3.00	2.93	10

CONCLUSION AND RECOMMENDATIONS

The COVID-19 pandemic marginalised the quantitative study as the construction industry was 'shut down' due to the lockdown restrictions prevailing in South Africa during the period the empirical study was being conducted.

The results of the study show that the South African construction industry has world-class H&S legislation and regulations, however, challenges facing MCs sets them up for failure. The study found that MCs in South Africa are challenged even with basic H&S. MCs lack the finance and capability to implement and maintain an H&S system. MCs make use of frequently changed temporary workers as defined in the standard, hence it would not be feasible to train new employees continually.

The findings suggest PCs also face the burden of costs, and are ill-equipped to train MCs, especially in terms of H&S. The study findings indicate that a reasonably practicable H&S programme is required to be developed for MCs due to the 'onerous' requirements arising from the OHSA and Construction Regulations.

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MANAGEMENT PRACTICES UNDERMINING HEALTH AND SAFETY IN CONSTRUCTION

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Increasing awareness of the importance of a healthy and safe work environment has contributed to the rising concern for the current unhealthy and unsafe practices in construction. Construction projects are complex, therefore, traditional methods of achieving the desired construction health and safety (H&S) objectives are fast becoming ineffective. Therefore, it is imperative to continue to rethink innovative ways to achieve H&S objectives during the execution of projects. The purpose of this study is to determine management practices contributing to H&S incidents during construction. The study entailed the administration of a questionnaire to gather data from 286 construction stakeholders in the Nigerian construction industry. Mean scores (MSs) were used to rank the influence of management practices that contribute to H&S incidents. The study established that contractors' poor H&S culture, unhealthy and unsafe practices largely influence H&S on jobsites. This correlates with the H&S attitudes, beliefs, perceptions, and values that management share at workplaces. The study concluded that poor H&S culture is a major challenge that undermines H&S performance in the Nigerian construction industry. To this end, the study proposed the need for the government to enact H&S laws that suit the peculiarities of the Nigerian construction.

Keywords: Contractor, health and safety, incidents, management practice

INTRODUCTION

Globally, the construction industry is growing largely due to the need for development, social, and demographic changes in all nations. However, unhealthy, and unsafe practices continue to occur, which affect project outcomes. Accidents resulting from unsafe practices contribute substantially to cost overruns and poor productivity (Shalini, 2009; Durdyev et al. 2017). Furthermore, a significant number of financial resources are spent on compensation and litigation due to accidents (Li & Poon, 2013). Poor productivity and an increase in project costs in turn, have a negative impact on, inter alia, clients' return on investment (ROI), contractors' profits, and their insurance premiums. Other consequences include the negative effects on the reputation of the construction industry, human tragedy, long-term illnesses such as musculoskeletal disorders, equipment damage, and demotivated construction workers. These factors highlight the need for a holistic identification of the underlying problems influencing H&S practices.

Management is defined by Du Toit et al. (2007) as a process that managers adopt to achieve set goals and objectives by planning, organising, leading, controlling, and coordinating resources to meet organisational objectives. Therefore, management can be said to be the process through which the available resources such as finance and human resources are combined efficiently to accomplish the set goals and objectives of an organisation. The primary responsibility of managers is, therefore, to combine, allocate, coordinate, and deploy

resources for the achievement of organisational objectives. This necessitates the need for managers to make the right decisions and effectively utilise the limited organisational resources. Besides, managers' ability to effectively plan, organise, lead, control, and coordinate the organisation's human resources cannot be overemphasised.

Extant literature suggests that improved H&S measures have a significant impact on workers' and projects' performance (Idoro, 2011; Adebowale et al., 2020). The improvement of H&S management practices in construction would contribute to the realisation of the industry's ability to meaningfully contribute to economic growth. By investigating the relationships and interactions among stakeholders, inter alia, clients, construction project managers (CPMs), designers, contractors, including their managers and supervisors, during the design, procurement, and construction phases of a construction project, respectively, and how these affect workers' H&S practices, the existing relationships within the construction site, the monitoring and control phase of a project life cycle will be understood. Thus, the decision making, and behaviour of workers can then be translated into desired H&S best practices.

The unhealthy and unsafe environments contribute to the poor execution of projects, which in turn leads to poor labour productivity on sites (Ikpe et al., 2012). Hence, this study seeks to investigate management H&S practices and its contribution to incidents during construction activities.

The significance of this enquiry is justified by the following. First, studies from sub-Saharan Africa report that H&S-related research has been limited (Laryea & Leiringer, 2012; Ejohwomu & Oshodi, 2014). Second, Zahoor et al. (2016) mentioned that there is an H&S knowledge gap among unskilled workers and construction professionals in the Nigerian construction industry. Lastly, Mahila et al. (2021) identified management as one of the barriers to H&S performance. Workers' unhealthy and unsafe work practices, such as the incorrect use of personal protective equipment (PPE), use of drugs while at work, unethical behaviour, and poor construction methods have continued to influence the image and performance of the industry. Hence, there are repeated calls to improve H&S practices on sites to attract newcomers to the sector. The central question of the study is therefore: "What are the management practices contributing to incidents during construction activities in Lagos, Nigeria?".

LITERATURE REVIEW

H&S management practices are the policies, procedures, and strategies implemented by the organisation targeted to the H&S of the workers (Smallwood, 2013). The implementation of H&S policies therefore influences the practices of workers. Furthermore, Yap and Lee (2019) opine that management commitment contributes to best practices and productive workers. According to Witcher and Yario (2014), H&S management practices influence workers' knowledge, skills, motivation, decision-making, attitudes, and perceptions. Construction workers need a healthy and safe environment to work in. Studies have shown the link between H&S management practices and work site H&S performance (Cheng et al., 2012; Yap et al., 2019; Adebowale et al., 2020). Several studies conducted in different parts of the world with respect to H&S management practices suggest different interpretations. Teo and Ling (2006) categorised H&S management practices into three groups, namely incentive factors, process factors, and personal factors. Cheng et al. (2012) view H&S practices as H&S management information, process, and committees. Ismail et al. (2012) reviewed studies conducted in different countries such as Australia, China, Finland, Jordan, Malaysia, and the USA and determined that H&S management practices were tailored and categorised to meet the industry's needs in each country. Various researchers interpreted H&S management practices in different ways. Yario and Watcher (2015) suggest that measuring

techniques, culture, work ethics, and the environment, could be factors responsible for the lack of consistency in H&S management systems.

Based on the information provided by the above studies, several strategies have been proposed as measures for improving H&S performance in the construction industry. For example, Tam et al. (2004) ague for the entrenchment of a legal framework that will enforce the 'best' H&S practices at construction sites. However, a critical look at the factors responsible for poor H&S performance shows that the identified factors can be classified into two main groups, namely internal and external. The external factors are beyond the control of the major stakeholders in the construction sector. In contrast, the internal factors can be addressed by project participants. For example, it has been reported that inadequate provision of PPE is one of the principal causes of occupational accidents in the Chinese construction sector (Tam et al., 2004). This can be addressed by the construction managers overseeing construction projects. Furthermore, other studies have shown that workers' H&S practices have a significant influence on H&S performance (Dedobbeleer, 1990; Agumba & Haupt, 2014). Similarly, Awwad et al. (2016) report that top management commitment, H&S regulation and enforcement, training competence, and workers' awareness of H&S are responsible for H&S performance gaps observed on projects. This suggests that stakeholders' influence with respect to H&S practices of workers is a key factor in achieving improved H&S. This is because, if the H&S practices of workers are not addressed, workers may not appreciate the need to obey H&S rules. Construction involves numerous ongoing activities and practices as work progresses on site.

Literature exists in different parts of the world with respect to workers' H&S. However, there has been little research with respect to management's H&S practices. One of the earliest authors include Dedobbeleer (1990). The author examined the relationship between workers' practices and individual and situational factors. Other authors such as Koehn et al. (1995) and Toole (2002) studied workers' H&S practices in relation to perception and performance. In addition, Dedobbeleer and German (1989) opine that there is a relationship between workers' H&S practices and management's H&S performance on site.

Management commitment involves the following: documentation and keeping records of accidents and near misses; detailed documentation of site activities; regulation and employment standards and communication and implementing training programmes on sites (Ismail et al., 2012). Management's inability to employ the right people for the right job and lack of respect for people may pose H&S problems, resulting in underreporting and under-documentation. The relationships that exist pose a threat to H&S when not managed effectively. For example, when H&S procedures or on-the job training are not communicated effectively to workers on construction sites, workers may engage in unhealthy and unsafe acts such as being violent and abusive, which may lead to undocumented fatal accidents. Adequate documentation and record keeping will provide adequate statistics for policy makers and stakeholders to deliberate, to improve H&S in the construction industry to realise sustainable infrastructure development. According to Makin and Winder (2008), management failure and inadequate enforcement of H&S rules and regulations by the government can affect workers' behaviour and attitude towards H&S practices on construction sites. Keeping workers abreast of legal obligations and changes in H&S standards will reduce or eliminate workers' unhealthy and unsafe behaviours. Hence, effective management commitment and adequate enforcement of H&S regulations reduce ill health and injury and enhance the H&S climate. This situation may in turn influence attitudes and behaviours related to H&S issues on construction sites (Liu et al., 2015).

A positive H&S culture within the work environment may influence how the workers relate to their duties, peer-pressure, and appropriate use of PPE, alcohol, drug and other substance use. Management practices can influence workers' H&S behaviour and attitudes. Management inadequacies and inadequate supervision in H&S training and procedures will increase H&S violations on site. These activities can lead to fatal accidents. Stakeholders' influence, which can be strong or weak or positive or negative has the tendency of affecting H&S practices of workers on site, hence contributing to H&S outcomes.

Table 1: H&S management practices in different countries

Author	Country	H&S management practices
Teo and Ling (2006)	Singapore	H&S policy, safe work practices, H&S training, group meetings, incident investigation and analysis, rules and regulations, H&S promotion, H&S inspections, H&S maintenance, machines and equipment, and hazard analysis.
Cheng et al. (2012)	Hong Kong	Written H&S policy, accident investigations and reports, H&S records, H&S manuals, accident statistical analysis, formal H&S organisation structure, H&S training scheme, H&S work practices, H&S audits, H&S promotion, and H&S meetings.
Ismail et al. (2012)	Malaysia	Management support, accident analysis, H&S environment, H&S motivation, H&S responsibility, H&S culture, H&S training, H&S policy, H&S codes and standards, and clear H&S instructions.
Watcher and Yario (2014)	USA	Employee involvement / influence, H&S reviews, safe work procedures, hiring for H&S, cooperation, training, communication and information sharing, accident investigations, detection and monitoring, and safe task assignment.
Awwad et al. (2016)	Lebanon	H&S amenities, subcontractor H&S, motivation, regulation, H&S communication, record keeping, training, H&S meetings, worker participation, and H&S investigation.
Raheem and Isa (2016)	Pakistan	H&S policy, training, organisation records, employment-based standards, substance abuse programmes, hazard analysis, emergency preparedness, housekeeping, inspections, H&S plans, and communication.
Ashebir et al. (2021)	China	H&S policy, training, and H&S inspection.
Zulkifle et al. (2021)	Malaysia	Reward, training, communication, and feedback.

Salvi (2021)	India	H&S policy, education and training, inspection, H&S auditing, and H&S meetings.

RESEARCH METHOD

This study was conducted to investigate management practices that influence H&S performance on construction sites in Lagos, Nigeria. The objective of the study required a review of literature and data collection. Data was collected from construction professionals with the administration of a questionnaire to 286 construction stakeholders in the Nigerian construction industry. 375 questionnaires were administered through hand delivery, and an online system, resulting in 286 responses, which equates to a response rate of 72.3%. This method was preferred due to the nature of the problem. Similar research, which includes that of Wadick (2010), Kukoyi and Smallwood (2015) and Kukoyi and Adebowale (2020) adopted a questionnaire survey approach. According to Sekaran (2003) and Creswell (2012), the nature of the problem under investigation determines the choice of the research approach.

The questionnaire was developed after a survey of the literature was conducted to determine the H&S management practices, which consisted of two sections. Section A captured the general information of the respondents, while section B captured the H&S management practices. A five-point Likert scale ranging from 1 (minor extent) to 5 (major extent) was used to determine the respondents' perceptions relative to the factors. Before the primary data gathering process commenced, the questionnaire was pre-tested and piloted with experienced construction stakeholders. Lagos State, being the commercial hub of Nigeria, and which is the hub of construction activities was preferred for the study (Dosunmu & Iyagba, 2012). The study adopted a purposive method of sampling arising from the need to gather data from respondents that work in management positions. The respondents comprised builders, architects, quantity surveyors, engineers, and project managers who work for their respective organisations. Descriptive statistics in the form of MSs were used to rank the factors obtained, while the Cronbach alpha was used to determine the reliability of the research instrument. The reliability coefficient was determined to be 0.74, which indicated that the instrument was reliable.

The results indicated that 98% of the respondents had construction-related degrees. 79% of them were males, whereas 21% were females. The participants had an average age of 41 years', and an average of 10 years' work experience in the construction industry. This suggests that the respondents possess the required experience to respond to the research questions.

DISCUSSION OF THE FINDINGS

Table 2 indicates the extent to which factors / issues contribute to incidents due to unhealthy and unsafe practices on construction sites on a scale of does not, and 1 (minor) to 5 (major), and mean scores (MSs) between 0.00 and 5.00. All the factors / issues have MSs $> 3.33 \leq 4.17$, which implies that these factors have between a moderate influence to a near major / near major influence on H&S incidents. Poor H&S culture, ineffective H&S monitoring, ineffective H&S inspection, and ineffective H&S training ranked first, second, third, and fourth, with MSs of 3.72, 3.69, 3.66, 3.62 respectively.

The most significant of these factors was the poor H&S culture, which correlates with the H&S attitudes, beliefs, perceptions, and values that workers share at the workplace. A poor H&S culture contributes to a high rate of incidents, and leads to the next factor, which is ineffective H&S monitoring and inspection. When the contractors do not engender an

optimum H&S culture on site, workers will engage in unhealthy and unsafe practices. This contributes to the high rate of incidents and accidents, and ill health. According to Kukoyi et al. (2020), accident rates are high, which is attributable to human error because of a poor H&S culture on construction sites. Developing a behavioural based H&S assessment tool on construction sites is a way forward in terms of reducing workers' unhealthy and unsafe practices. Lack of a project-specific H&S plan, and lack of project specific H&S specifications ranked sixth and seventh respectively, with MSs > 3.00. This implies that these factors contribute equally to H&S incidents on site. This finding is consistent with the results of Kukoyi and Adebowale (2021), and Wong et al. (2019), which investigated the impediments to H&S practices on construction sites. When contractors do not have a project-specific H&S plan and specification, it results in poor H&S management. As a result, workers engage in unhealthy and unsafe work practices during site operations.

Table 2: The extent to which factors / issues contribute to H&S incidents

Factor / Issue	Response (%)							MS	Rank
	Un-sure	Does not	Minor ……..Major						
			1	2	3	4	5		
Poor H&S culture	0.7	1.0	4.9	11.2	13.6	42.3	26.2	3.75	1
Ineffective H&S monitoring	1.0	1.0	4.9	12.6	17.8	33.2	29.4	3.71	2
Ineffective H&S inspection	1.4	2.1	7.0	6.6	18.5	40.2	24.1	3.70	3
Inadequate H&S training	2.4	0.7	7.3	15.0	16.1	30.1	28.3	3.59	4
Inadequate H&S officers	2.4	1.0	9.1	9.8	19.2	34.3	24.1	3.57	5
Lack of project specific H&S plan	2.4	1.4	7.7	7.7	26.2	33.2	21.3	3.55	6
Lack of project specific H&S specification	2.4	2.1	6.3	10.1	26.9	29.4	22.7	3.55	6

CONCLUSION

Management practices with the most significant impact on H&S in the Nigerian construction industry are poor H&S culture, ineffective H&S monitoring, and ineffective H&S inspection. Ineffective H&S monitoring and inspection reflect the poor H&S culture, hence H&S not being considered as important for construction workers. Inadequate management H&S culture results in, inter alia, projects not having a specific H&S plan. The lack of project specific H&S plans exposes construction workers to life threatening issues during construction activities.

The above management practices are generally related. All the practices result from a poor management H&S culture. A poor management H&S culture will contribute to a poor H&S culture on project sites. The need for a project specific H&S plan or specification will not be

emphasised, therefore, leading to ineffective H&S management during construction activities on site.

The findings of the study indicate the significant management practices that undermine H&S. A government understanding of the need to enact H&S laws that suit the peculiarities of the Nigerian construction industry may improve the H&S culture among construction stakeholders. Furthermore, optimum implementation and monitoring of the laws may improve H&S performance on construction sites in Nigeria.

Data was collected from construction professionals in Lagos, Nigeria. Although, the results of the study may not be generalised beyond Nigeria, they are likely to contribute to a research agenda for other countries. Furthermore, further studies are required relative to the role of H&S education and training of construction professionals, the findings of which may raise the level of awareness, which in turn, may enhance the general management H&S culture in construction.

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TOWARDS SUSTAINABLE CONSTRUCTION PROJECT DELIVERY: A REVIEW OF EFFECTIVE MANPOWER MANAGEMENT PRACTICES FOR SMES TO ENHANCE PRODUCTIVITY IN THE EASTERN CAPE

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Management techniques used by SME contractors impede project success. This study investigates the manpower management strategies used by construction SMEs at the project level to improve the long-term delivery of construction projects. To achieve the study's aims, a mixed method design comprised of quantitative and qualitative research approaches was used. A questionnaire survey was sent to purposively selected construction SMEs in the Eastern Cape Province of South Africa that were registered in Grades 1–4 on the cidb register of Contractors. The quantitative data was analysed using descriptive and inferential statistics, while the qualitative data was analysed using content analysis. The findings of this article demonstrated that the most successful manpower management strategies used by SMEs include treating all workers equally to prevent conflicts, involving team leaders in labour allocation decision making, and supporting employees' values and beliefs. The construction SMEs registered under the cidb grades 1 to 4 in the Eastern Cape Province are the subject of this study. The study's findings have practical implications for emerging contractors and SMEs in terms of project delivery when manpower is efficiently managed to boost labor efficiency at the project level. The research focuses on SMEs' manpower management to improve the long-term execution of construction projects and provide comprehensive human resource management at the project level.

Keywords: Construction, manpower management, motivation, sustainable construction

INTRODUCTION

Various researchers have consistently reported the lack of consensus regarding a clear comprehensive definition for construction SMEs (e.g., Muriithi, 2017). For this reason, Mohamed, Asmaa and Ichrak (2013) enlighten that there is no single, or uniform acceptable definition of SME contractors. For this study, SMEs are categorized based on the size such as number of employees, yearly turnover, and profitability (Aigbavboa and Thwala, 2014). Evidently, SME contractors are confronted by numerous challenges which hinders the growth and success of contractors. For instance, Vinten (1998) alludes that SME firms are less likely to have some clear employee development strategies. Kunz (2020) argues that SME firms are confronted by lack of motivation among employees to perform to their level best. According to Adendorff, Appels and Botha (2011), the challenges include inadequate business management, poor management competencies, lack of time management, poor cost management modalities, poor quality management, lack of health and safety management and inadequate resource management i.e., manpower, machinery, and material management. Notably, manpower contributes largely towards the success of construction project delivery

(Durdyev and Mbachu, 2018). Therefore, SME contractors need to discover the key success factors in managing manpower at project level by searching for key success factors such as improving flexible worksite environment (Mesu, Van Riemsdijk and Sanders, 2013), engaging and appointing skilled manpower and encouraging training of employees to meet the demand for different skilled labour. For instance, Anugwo and Shakantu (2020) reveals that SMEs firms need to engage and appoint competent and skilled manpower to increase project productivity to enhance sustainable construction project delivery.

Windapo (2016) adds that not only management skills, but training of employees is critical for the growth of the average SMEs. In this study, sustainable construction project delivery is viewed as SME firms being part of the modality of long-term construction project success and business survival (Opoku, Cruickshank and Ahmed, 2013). Against this background the problem to be investigated may be stated as follows: SME contractors' often fails to deliver construction project and meet client requirements as the result of ineffective manpower management practices, and subsequently business failure. To date manpower management will improve productivity and enhance SMEs sustainability. Hence, the aim of this research is to propose effective manpower management practices for SME contractors to enhance sustainable construction project delivery in the Eastern Cape Province.

LITERATURE REVIEW

Manpower management practices

SMEs create job opportunities as they primarily use manpower for construction. SMEs employ more people than the large contractors (Temtime and Pansiri, 2008). Lill (2008) points out that labour is affected by the working conditions and the control of the project in terms of management. For an SME to be successful in the industry, it should endeavor to employ skilled, trained, and experienced personnel to lead the firm to success. However, according to Olawale and Garwa (2010), these personnel can only be available when hired and the labour wage is within building regulations, which stipulate the minimum wage requirements which any firm must comply to. Nwachukwa and Emoh (2011) conclude that without sufficient manpower, a construction project cannot stand the test of time and may fail or suffer abandonment. According to Oluseyi and Fapohunda (2015), during the construction processes, the contractor must plan and direct the available workforce and always ensure efficient utilisation of available resources. Poor quality project delivery is caused by a shortage of labour skills required to perform each construction activity in South Africa. According to Windapo (2016), jobs in the construction industry are typically seen as being of low social standing, as the industry is notorious for severe physical demands and long working hours. The author further states that the industry does not attract the youth and certainly fails to replace any labour that has left the industry. However, Arefin, Hoque and Bao (2015) note that SME workers lack motivation, and motivation is one of the aspects regarded as a key element to increase productivity when managing people.

Motivation of SME contractor's employees

Motivation is defined as a characteristic of a particular person, a willingness to expend energy regarding achieving a particular set of individual behaviour (Tabassi, Ramli and Bakar, 2012). Thwala and Monese (2006) define employee's motivation as the ability to lead workers with common understanding and maintaining a continuing, good relationship among all employees. Dwivedula and Bredillet (2009) argue that incentives are used to promote creativity, a practice which has been adopted by many organisations to motivate their employees. Kazaz, Manisali and Ulubeyi (2008) opine that monetary motivation or incentives have proven to have influence on the productivity of workers. Furthermore, the authors point

out that the quality of human performance is significantly reliant on motivation, where an increase in motivation brings a corresponding increase in worker productivity. Tabassi, Ramli and Bakar (2009) suggest that effective employee motivation requires a leader to identify employee needs and to develop strategies that will meet those needs. Hence there is the need to understand motivational influences employed by SMEs regarding achieving continuous project productivity on available resources or workers.

Employees experience within SME contractor's

Regarding SMEs experience, Turner, Ledwith and Kelly (2012) argue that SME contractors are less likely to employ experienced personnel. Also, there is a concern regarding shortage of skilled labour in the construction industry due to construction site conditions, and the fact that construction jobs typically have low social standing and are lacking in attractiveness as the result of their physical demands, long hours, remote work sites and nomadic lifestyle (Windapo, 2016). Furthermore, the author points out that the changes in technological advancements within the construction industry have led to numerous changes regarding the demand for different skilled labour. However, Assaf and All-Hejji (2006) point out that construction SMEs fall behind schedule due to their inexperience in utilising the resources available to perform the project successfully within the stipulated time. Love, Irani and Edwards (2004) note that construction SMEs that suffer from a lack of project experience are always likely to experience unnecessary cost due to rework. Hence, there is a need to develop effective manpower management practices to successfully complete construction projects on time.

SME contractor's employees' development

According to Urban and Naidoo (2012), employee's skills development and experience regarding education general form part of human investment. Human investment is the asset that can improve SMEs productivity significantly during the project delivery stage. Training and skills development is defined as a process of developing and improving work-related skills and knowledge about the investment in employees for the benefits of the project and improvement of productivity (Tabassi, Ramli and Bakar, 2009). Also, Tabassi, Ramli and Bakar (2012) stipulate that training and development is defined as the strategy of ascertaining and assuring and helping to develop significant competent skills that enable employees to perform in current or future projects. Furthermore, Windapo and Cattell (2013) stress the national significance of skills development and training, which is further highlighted by Accelerated and Shared Growth Initiative for South Africa (ASGISA). However, Hameed and Waheed (2011) maintain that labour competence can be inferred from different attributes, which includes knowledge, skills and experience, personality traits, attitude, and the behaviour of employees. Bag and Gupta (2019) argue that unavailability of labour can arise either due to an absolute scarcity of the required skills or a relative scarcity. Absolute scarcity refers to suitably skilled people that are not available, a lack of sufficient or insufficient numbers to satisfy replacement demand, on the other hand, relative scarcity refers to a case where appropriately skilled workers exist, but do not meet the employment criteria of the contractor.

RESEARCH METHOD

This study investigates the perception of SME contractors with respect to manpower management practices in the Eastern Cape Province. A mixed method design comprising both quantitative and qualitative approaches (Creswell and Creswell, 2018; Creswell, 2012) was adopted for the study. A quantitative approach represents statistical data using survey questionnaire, while qualitative approach describes the collection of data adopting semi-

structured interviews. The questionnaire survey investigated 128 SME contractors regarding manpower management practices employed. This research focus-group interviews explored the experience of SME contractors. A total of 5674 Grades 1 to 4 SMEs, registered under cidb contractor list of Eastern Cape Province was obtained from the cidb database. This list comprises of 5000 registered under cidb Grade 1, with 339 registered under Grade 2, 171 under Grade 3 and 164 contractors registered under Grade 4. Prior to sending the email, SME contractors were contacted and informed about the purpose of the survey. The study population comprises contractors situated in East London, Port Elizabeth, Mthatha and Butterworth, clusters in groups of thirty-two (32), adding up to one hundred and twenty-eight (128) firms. A survey questionnaire was distributed among purposively selected SME contractors to achieve the objectives of this study. The survey questionnaires consisted of two sections. The first section containing biographic profile of the respondents, comprising gender, age, position in the firm, highest educational qualification, number of years' experience and cidb Grade of the firm. The second section comprised 14 statements relating to effective manpower management practices adopted by SME contractors. Furthermore, in section 2, closed-ended survey questions were selected to avoid bias (Akintoye and Main, 2007). Additionally, a 5-point interval Likert scale was adopted to measure the level of agreement of the respondents regarding the effective manpower management practices. Out of the 128 questionnaires administered, 59 questionnaires were duly completed and returned representing a response rate of 46%. The response rate is acceptable and within the domain of construction management research and in line with Moyo and Crafford (2010) suggestion that generally the response rate in the built environment ranges between 7% up to 40%. Qualitative interviews were conducted after the survey using a purposive sampling technique to select two participants. It should be noted that purposive sampling allows the researcher to choose participants based on availability (Bless, Higson-Smith and Sithole, 2013).

To analyse the data, the Statistical Package for the Social Sciences (SPSS) version 25 was adopted for the descriptive and inferential statistical analyses (Salkind, 2014; Field, 2013; Pallant, 2013). The frequencies and percentages of responses were generated and reported, in order to analyse and describe the respondents' profile (Naoum, 2007). The mean ranking techniques was adopted to rank the factors in a hierarchical order based on the mean scores. Subsequently, the analysis of variance (ANOVA) test was used to examine the differences in mean with respect to the CIDB grading and the effective manpower management factors that would engender sustainable performance of SMEs. It is instructive to note that the level of significance for the ANOVA test was set at 0.05.A content analysis was adopted to analyse the qualitative data. The Cronbach's alpha coefficient was adopted to check the reliability of the survey questions. It was noted that acceptable values of Cronbach's alpha range from 0.60 to 0.95. In this research, the Cronbach's alpha coefficient value for the 14 items was 0.86. The results were satisfactory as indicated in Table 1

Table 1: Reliability test

Question No	Heading	No. of items	Cronbach's alpha coefficient value	Rank
1	Effective manpower management practices	14	0.86	Moderate
Sum	All questions combined	14	0.86	

RESULTS AND DISCUSSIONS

Quantitative results

Background information of the respondents

Figure 1 depicts the age group of the respondents, it is evident that 54.2% of respondents are in the age group between 26 and 39, 23.7% are in the age group between 40 and 49. 11.9% are in the age group of 50 and 59 years whereas 10.2% are in the age group between 18 and 25. These results obtained indicate that an overwhelming majority (64.4%) of the respondents are less than 40years of age. In respect of relevant experience in the industry, it is noticeable that 37% of respondents have relevant experience ranging between 1 to 5 years, 25% of respondents have worked in the industry between 6 to 10 and 11 to 15 years, while 7% of respondents have worked in the industry between 16 and 20 years and only 5% have worked in the industry ranging from 20 years and above as indicated in Figure 2. With regard to Figure 3, most of the respondents (47.5%) hold a National Diploma qualification, followed by respondents with degree qualifications (25.4) and others with (13.6%). The results also show that there were about1.7% respondents below matric qualification. Regarding the role of respondents, it is evident from Figure 4 that 37.3% of the respondents are site agent, followed by a notable 20.3% of respondents who are project managers. In addition, 32.2% of the respondents have other roles such as site engineers, site representatives and directors. There is about 10.2% of Quantity Surveyors who participated in the study. It should be noted that both genders participated in the study with 63% and 37% of the respondents being males and females respectively.

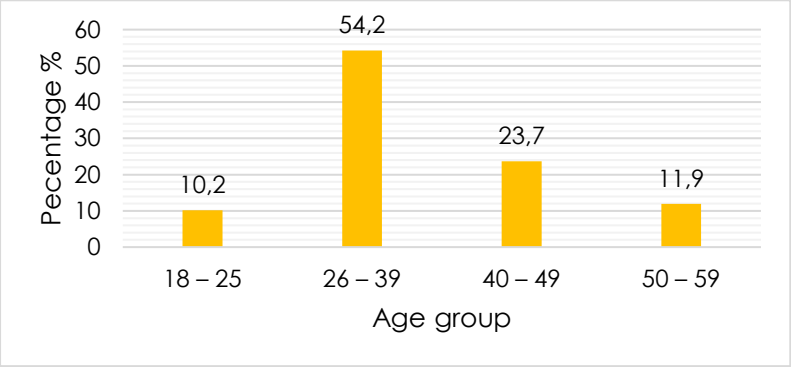

Figure 1.1: Age group of the respondents

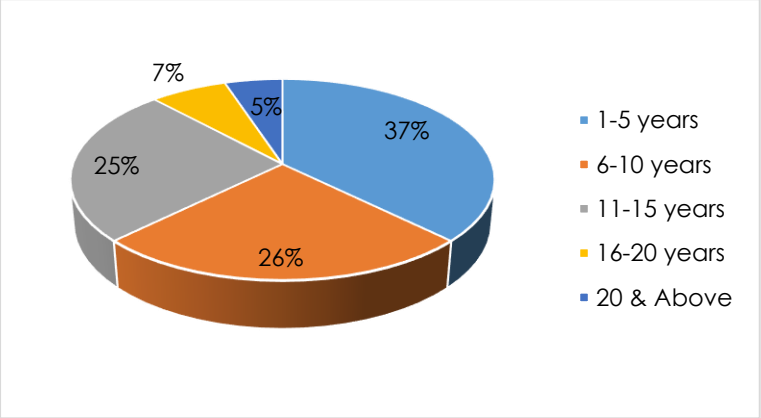

Figure 1.2: Relevant experience of the respondents in the industry

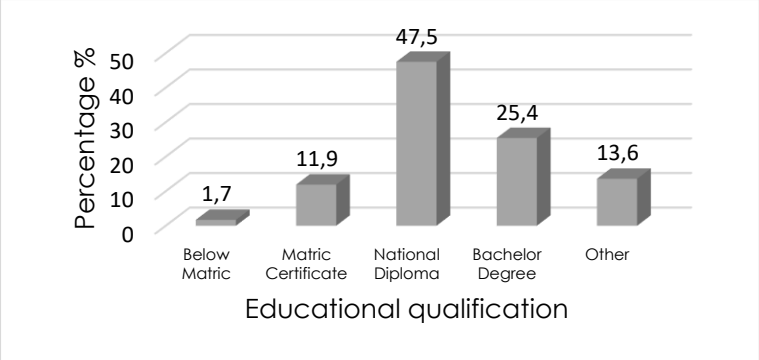

Figure 1.3: Educational qualification

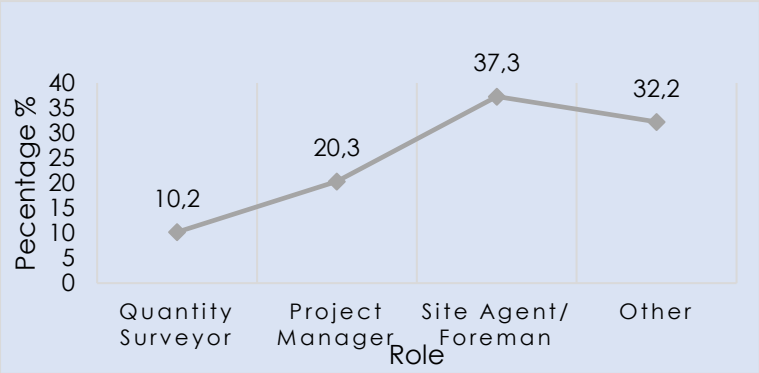

Figure 1.4: Role of the respondents

CIDB grade of the company

Table 2 presents the CIDB grading for the firms which the respondents are employed in. It should be noted that 35.6% of the firms are categorised as grade 3, followed by 32.2% of the firms who are classified as grade 4. 22.0% of the firms are in the category of grade 2 and only 10.2% of firms are in grade 1.

Table 2: CIDB grade of the company

CIDB Grade	No	Percent	Cumulative %
Grade 1	6	10.2	10.2
Grade 2	13	22.0	32.2
Grade 3	21	35.6	67.8
Grade 4	19	32.2	100.0
Total	59	100.0	

Effective manpower management practices

From Table 3, all workers are managed equally to prevent conflicts is ranked first, with MV=4.29, and thus the most important manpower management modality adopted by construction SMEs to achieve sustainable construction project success, with an overwhelming 91.5% of the respondents agreeing. 5.1% of the respondents were neutral and 3.4% of the respondents disagreed that equal management of workers should be adopted by construction SMEs as a strategy to achieve sustainable construction project success.

Involvement of team leaders in decision making of labour allocation is also significant and a notable effective manpower management modality, ranked second with a MV=4.24. It is also important to note that 88.1% of the respondents agreed, 11.9% of the respondents were neutral and no respondents disagreed on adoption of this modality. The descriptive analysis also revealed that 79.7% of the respondents agreed that their firm supports employees' values and beliefs, this factor is ranked third with a MV=4.20. 16.9% of respondents were neutral and 3.4% of the respondents disagreed that firm supports employees' values as the modality to achieve sustainable success rate in construction projects. It can be noted that the least ranked modality is allowing labourers to take initiative decision, with a MV of 3.75. Evidently, all the MVs are greater than the mid-point average of 3.00 and overall, the average MV is 4.08, indicating that these modalities are deemed to be significant for SMEs construction project delivery.

Table 3: Effective manpower management practices

	(N = 59)					Cronbach's alpha 0.84		
	1 = Strongly disagree (SD) ... 5 = Strongly agree (SA)					Descriptive statistics		
Statements	No	SD %	D %	N %	A %	SA %	Mean	Std.	Rank
All workers are managed equally to prevent conflicts	59	0.0	3.4	5.1	50.8	40.7	4.29	.72041	1
Team leaders are involved in decision making of labour allocation	59	0.0	0.0	11.9	52.5	35.6	4.24	.65229	2
The firm supports employees' values and beliefs	59	1.7	1.7	16.9	33.9	45.8	4.20	.90553	3
Training programme for all staff to ensure continuous growth of the company	59	0.0	3.4	16.9	39.0	40.7	4.17	.83364	4
Experienced labour to transfer skills	59	0.0	3.4	13.6	47.5	35.6	4.15	.78375	5
Labourers are transferred from one site to another to perform their trades when required	59	0.0	5.1	16.9	37.3	40.7	4.14	.88006	6
Labour wages is paid on time to avoid disruptions	59	0.0	5.1	15.3	40.7	39.0	4.14	.86016	6
Monitoring labour production on site	59	0.0	1.7	13.6	59.3	25.4	4.08	.67697	7
Favourable working conditions on site	59	0.0	3.4	15.3	52.5	28.8	4.07	.76258	8

All workers are happy on the job and there is no labour absenteeism on site	59	0.0	1.7	15.3	59.3	23.7	4.05	.68036	9
Artisans and unskilled workers take full responsibility of their duties	59	0.0	5.1	15.3	52.5	27.1	4.02	.79852	10
Incentives to motivate workers at all levels	59	3.4	3.4	20.3	40.7	32.2	3.95	.99001	11
Effective communication between management team and artisans	59	0.0	3.4	28.8	39.0	28.8	3.93	.84821	12
Allowing labourers to take initiative decision	59	0.0	8.5	32.2	35.6	23.7	3.75	.92089	13
Average	59						4.08		

DISCUSSION OF QUANTITATIVE FINDINGS

The quantitative results revealed that all workers are managed equally to prevent conflicts is considered the most significant manpower management strategy to enhance the success rate of SMEs. The result aligns with that of Lil (2008) and Loosemore et al. (2003), who reveal that simulation of human resource management increases the possibility of production on construction sites. Also, the involvement of the team leaders in allocation of labour is the second most significant modality in manpower management with a MV=4.24. Raiden et al. (2009) support this finding, noting that the fundamental requirement of selecting the team in construction is involving the team leaders in the team deployment to select the team members carefully on the basis of their skills and personality. Senaratne and Samaraweera (2015) add that allowing the management to perform to the best of their ability and inspiring them to cooperate when necessary is a major key to success in construction project delivery. Support of employee values and beliefs to increase productivity on construction projects is the third important modality (MV=4.20) adopted by SMEs in their construction projects. This finding aligns with Abdul-Rahman et al. (2010), who argue that the uniqueness of construction projects and the need for alignment among the employees is achieved through ethical practices and professionalism in an integrated framework

QUALITATIVE FINDINGS

Interviews results

The first interview was conducted with the firm's director (referred as Respondent A) on 05 September 2019 in King William's Town, a suburb of East London in the Eastern Cape Province, at 10:00 am in the construction site office during teatime. The second interview was conducted with the firm's director (referred as Respondent B), on 06 September 2019 in Southernwood suburb of East London at 14:45 pm in the meeting room of the SME contractor during office hours.

"Respondent A recommended that the labour or manpower is managed through effective allocation of manpower to each task and that labour should be managed by their supervisors, with allocation carried out based on their skills. In addition, the respondent disclosed that

project milestones are communicated with the foremen and that labour input on project gets recorded to ensure effective utilisation of labour".

"Respondent B recommended that the project manager available on site record the labour available on site and advise on the labour performance. The respondent also physically went to the site and observed the labour performance in order to be realistic on costing. The respondent stated that the company allowed the labourers when having problems to speak to the director directly, and that they were all treated equally, with no favoritism. Labourers were employed based on their skills, and an unskilled labourer always worked with a skilled labourer to facilitate a transfer of skills and training while keeping the production on site. Labour was allocated based on the requisitions made by the site manager or foreman on site, and the skilled labour was rotated from one site to another when required. The foreman on site was the one who grouped the labour in task allocation, based on their labour production observations".

DISCUSSION OF QUALITATIVE FINDINGS

The qualitative findings revealed that effective manpower management practices can be achieved by construction SMEs through, to mention but a few: project milestones being communicated, monitoring labour performance, transfer of skills during construction projects and labour allocation. In respect to communication of project milestones, the literature reveals that the subsections of the project work given to the operating time need to be clear and communicated with the team, so that the team can be responsible and accountable for the section of work (Van der Velde and Van Donk, 2002). However, construction SMEs also adopt monitoring labour performance as a modality to achieve sustainable success. This finding is supported by Al-Jibouri (2003) who recommends monitoring labour using quantitative information to control the action of the manpower. To add more SME contractors, adopt skills transfer from the skilled labourers to unskilled labourers as modality to always ensure availability of labours during construction project delivery. This qualitative finding is corroborated by Karim et al. (2012) who state that contractors who create a flexible working environment on job sites allow workers to work together in performing duties and stimulate skills transfer, while increasing productivity benefits as well.

ANOVA test

To determine whether there is a consensus regarding the effectiveness of the manpower management practices, ANOVA test was performed to check if there is a significant difference across the different cidb Grade 1-4 of SME contractors concerning the manpower management practices. Table 5 presents the ANOVA test results, and the results revealed that there are no significant differences relating to manpower management practices in terms of the different cidb grading since the significant level is $p > 0.05$.

Table 5: ANOVA test for SME contractor's management practices

		df	F	Sig.
Incentives to motivate workers at all levels	Between Groups	3	.316	.813
	Within Groups	55		
	Total	58		
Allowing labours to take initiative decision	Between Groups	3	.929	.433
	Within Groups	55		
	Total	58		

Training programme for all staff to ensure continuous growth of the company	Between Groups	3	.580	.630
	Within Groups	55		
	Total	58		
Labour wages is paid on time to avoid disruptions	Between Groups	3	4.027	.012
	Within Groups	55		
	Total	58		
Labours are transferred from one site to another to perform their trades when required	Between Groups	3	1.753	.167
	Within Groups	55		
	Total	58		
Monitoring labour production on site	Between Groups	3	1.826	.153
	Within Groups	55		
	Total	58		
All workers are managed equally to prevent conflicts	Between Groups	3	1.476	.231
	Within Groups	55		
	Total	58		
All workers are happy on the job and there is no labour absenteeism on site	Between Groups	3	.768	.517
	Within Groups	55		
	Total	58		
The firm supports employees' values and beliefs	Between Groups	3	.725	.541
	Within Groups	55		
	Total	58		
Artisans and unskilled workers take full responsibility of their duties	Between Groups	3	1.882	.143
	Within Groups	55		
	Total	58		
Team leaders are involved in decision making of labour allocation	Between Groups	3	.359	.783
	Within Groups	55		
	Total	58		
Experienced labour to transfer skills	Between Groups	3	.576	.633
	Within Groups	55		
	Total	58		
Favorable working conditions on site	Between Groups	3	.470	.705
	Within Groups	55		
	Total	58		
Effective communication between management team and artisans	Between Groups	3	1.770	.164
	Within Groups	55		

	Total	58

CONCLUSION AND RECOMMENDATIONS

In consideration of the study objectives, both quantitative and qualitative research approach, aided by administering questionnaire surveys as well as semi-structured interviews, were used to gather the information from management teams of SMEs in the Eastern Cape Province. The quantitative analysis revealed the importance of the following factors: that all workers are managed equally to prevent conflicts, team leaders are involved in decision-making regarding labour allocation and the SME contractors support employee values and beliefs. The qualitative findings align with the quantitative analysis, as the respondents noted that the effective manpower management practices adopted by construction SMEs involve labour allocation to each task, and during construction project delivery, project milestones are communicated with everyone involved. Also, the qualitative findings revealed monitoring labour performance during SME construction project delivery, SMEs adopt training of unskilled labour, effective labour production, effective communication between the management team and labour force and managing labour force equally during construction project delivery are the modalities that could be adopted by construction SMEs to achieve sustainable construction project success.

This study recommends that SME contractors adopt effective manpower allocation and ensure that the firm clearly communicate project goals with personnel on site. The literature indicates that most SMEs lack training and construction experience, which subsequently hinders their success. Therefore, further research should be conducted with respect to experience, competence, and training of SME personnel on modalities that can assist SMEs to achieve project success in South Africa, particularly in the Eastern Cape province.

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METHODS AND CURRENT PRACTICES ADOPTED IN VALUING GREEN BUILDINGS

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This study aims to examine the suitable methods of valuation for determining the impact of green building features (GBFs) on the value of buildings in South Africa. The inspiration for examining these methods is based on the perceptions concerning the current practice for valuing green building projects which basically may not differ among construction participants or professionals. A quantitative approach was adopted, involving randomly selected built environment professionals based in the Western Cape Province of South Africa. The data was analysed using a descriptive statistical analysis tool. Based on the descriptive analysis, the top ranked methods adopted in terms of valuing green buildings include Building sustainability assessment (BSA) method, Comparative market analysis (CMA - a computer-based method), and Cost method. Furthermore, the analysis revealed that there are other specific valuation techniques adopted by individual firms in valuing green buildings. This study was conducted and limited only to the Western Cape Province of South Africa. Nevertheless, the findings have practical significance to the generality of green building projects and may serve as a valuable guide for other provinces in South Africa. This study expands the perspectives of built environment professionals regarding the different valuation methods that can be adopted for valuing green buildings.

Keywords: Green building, South Africa, sustainability, value, valuation method

INTRODUCTION

A global study conducted by Dodge Data and Analytics (2018) reported that South Africa is one of the fastest-growing markets for green building in the world with enormous potential for growth in professionalism and technologies. Various authors have identified some of the challenges associated with determining the value of green building features (e.g., Shalley, 2008; Adomatis, 2015; IMT and AI, 2013). For instance, Adomatis (2015) revealed that the impossibility of comparing ratings from numerous rating organisations pose a challenge in valuing green buildings since different organisations adopt different rating systems. According to Shalley (2008), the lack of feasible increment in sustainable design in some markets and inadequate data for evaluators to draw conclusions on the impact of green building features are considered as the main factors frustrating the determination of the value of green building features.

Value, as a vital parameter in evaluating green building features, is determined through its capacity to generate a certain quantity of service flow to meet the requirements of the owners or occupiers (Marrjanovic-Halburd, 2015:25). Hence, the need for green building is evident because green building concept has influenced building value in countless ways over the years (O'Mara and Bates, 2012). Pitts (2008) opines that as the construction of buildings with green features become more common, appraisers may eventually be compelled to include green features in their valuations. It is probable that green or sustainable features will and do influence market values to a very large extent. Empirical data concerning the correlation

between green features and asset valuation, however, is still in its infancy amongst South African valuers and other built environment professionals (Pitts, 2008; Nurick et al., 2015). Arguably, this may be attributed to the fact that the green concept is evolving and as a result, GBFs and initiatives have yet to be fully integrated into the valuation models by South African commercial property valuers (Nurick et al., 2015); however, Warren et al. (2009) indicate that this is a global phenomenon.

It is instructive to note that since the introduction of this concept in South Africa, only a few contextual studies have been carried out to evaluate the different valuation techniques adopted by values in determining the value of green buildings. However, previous studies focused mainly on the barriers to green, green building legislation and cost benefits analysis of a green building (e.g., Simpeh et al., 2020; Hoffman & Cloete, 2014:67; Nurick & Cattell, 2013:92; Hoffman & Cowie, 2014:3; Cruywagen, 2013:79-80; Windapo & Goulding 2015). In view of this, this study will be extending its investigation into the different methods of valuation for determining the impact of green building features (GBFs) on the value of buildings in South Africa. This is because green building features can often be passive and implicit, making it less considered in the actual value determination of a building, hence the need for this study.

LITERATURE REVIEW

Mechanisms and information for determining the value of green building features Value, as a vital parameter in evaluating green building features, is determined through its capacity to generate a certain quantity of service flow to meet the requirements of the owners or occupiers. However, the concepts of value used in property valuation can either fall under the category of market value, which represents exchange value, or worth, which represents the use value depending on the purpose of the valuation. Thus, worth in this case, is defined as the value of the property to a particular investor, mainly for the purpose of investment, whereas market value is defined or shaped by competitive forces within the market, where property location determines the level of price offered for the asset exchange (Marrjanovic-Halburd, 2015).

Marrjanovic-Halburd (2015) asserts that the main objective of property valuation is to provide a financial measure of the function or service derived from the use and control of the given property. This process is guided by the international valuation standard (IVS), founded on three fundamental approaches. The first of the three approaches is called the direct comparison method (DCM), which specifically infers value by comparing properties to similar buildings; the second is the cost method (CM), which considers, in particular, the initial costs; and the third approach is called the income method (IM), which estimates net income generated through a direct capitalisation method or a discounted cash flow over an appropriate period (Marrjanovic-Halburd, 2015)

Traditional methods and practice of valuation

Building sustainability assessment (BSA) methods: According to Bragança et al. (2010), the process of managing and accessing building sustainability in green buildings is executed by building sustainability assessment (BSA) methods. This can be oriented to different scales of analysis, building material, building product, construction element, independent zone, building and neighbourhood. In the process of analysing the scopes of sustainability support with the assessment systems and tools, three types of assessment methods must be properly distinguished (Bragança et al., 2010), enumerated below:

Systems to manage building performance (Performance Based Design);
Life cycle assessment (LCA) systems; and

Sustainable building rating and certification systems (Bragança & Koukkari 2010).
The key sustainability indicators relating to the BSA method are linked to environmental sustainability, economic development, and social sustainability (Bombugala & Atputharajah, 2013). The sustainability indicators for a building project can be selected from various lists prepared by the government sector and communities. For a contractor or facility manager, it is important to differentiate between the criteria and tools for assessing technology at the global level, and the approach used at the site-specific application, or local level. In spite of several differences between the lists of indicators, most of them deal with the key issues including consumption of resources; environmental pressure; energy and water efficiency; indoor air quality; comfort, and Life cycle costs (Bragança & Koukkari 2010).

Income method

The income method estimates the value of a property or building based on the income it generates. This type of traditional method of valuation is commonly used with apartment buildings or leasable space. Concisely, a capitalisation rate for the property in each market is applied to the expected net income generated by the property to estimate the value. There are two different methods for determining this capitalisation value: direct capitalisation and discounted cash flow analysis (Goodman, 2014). The Direct capitalisation method involves the attractiveness of the income capitalisation model, applying direct capitalisation in its apparent simplicity. This method requires the specification of two items, one year's income and the overall capitalization rate (Goodman, 2014). On the other hand, the discounted cash flow (DCF) is a cash flow summary that requires adjustment to reflect the present value of money. DCF analysis determines the present value of an individual asset or portfolio of assets. This is equal to the discounted value of expected net future cash flows, with the discount reflecting the cost of waiting, risk and expected future inflation. (Arumugam, 2007).

The sales comparison method: This is also referred to as the market approach, estimates the value of a property based on a comparison of recent property sales in the same market area with similar characteristics. This approach is commonly used for single family residences, where there are typically many comparable sales and similar properties available to analyse (Goodman, 2014).

Cost approach: The cost approach estimates the value of a property based on the cost of building the property or the cost of replacing the property. This approach is most applied to newly constructed buildings as it requires knowledge of the cost of construction and materials (Goodman, 2014). Shalley (2008) posits that while basic valuation principles still hold, one approach leads the way. Among other methods such as income method, comparison method, cost method, it is noted that the cost approach to value can be difficult to quantify because of the scarcity of green cost information currently available (Shalley, 2008). In addition, the market value of the real estate 'in exchange' versus 'in use' is the direct requirement for a given local property. Green elements in any specified building would have to be evaluated, considering whether the market would pay a premium for the green components. Moreover, it is important to note that, though green building construction methods and their components are in early development the standards are changing rapidly. Green buildings, at this stage of their lifecycle, have more exposure for the re-evaluation of green products, high performance systems and accreditation standards that could potentially cause significant obsolescence in relatively new green buildings (Shalley, 2008).

METHODOLOGY

According to Leedy and Ormrod (2010), the selection of a research methodology should be based on the nature of the data required in resolving a real-world situation. The aim of the

study was achieved by collecting empirical data using a quantitative research approach coupled with a literature survey. The quantitative method simply implies research that accentuates quantification in the gathering, interpretation, and analysis of data. Germane literature pertaining to valuation techniques and methods used in determining the value of a green building was solicited based on journal articles, conference papers, reports, theses, and textbooks. Based on the review of literature, a questionnaire survey was compiled to examine the different valuation methods used in determining the value of a green building. The survey participants were required to indicate the extent of effectiveness of the valuation's techniques using a 5-point Likert scale where 1 = not effective, 2 = not so effective, 3 = neutral, 4 = effective, 5 = very effective. The sample strata consisted of built environment professionals based in the Western Cape Province including architects, engineers, green building designers, property developers and valuers, project managers, quantity surveyors, sustainability experts, and urban and regional planners. It is instructive to note that the sample strata were estimated to be 455 respondents. Thereafter, a simple random sampling technique was adopted to aid in terms of administering the questionnaire survey to the sample. A web survey approach was adopted, and the survey was distributed to the respondents via e-mail, frequent reminders were sent every fortnight to enhance the response rate. It is worth mentioning that a total of 107 completed questionnaires were received at the end of period allocated for the survey. The total number received equates to approximately 24%, which is considered acceptable according to previous studies undertaken by Takim et al (2004) and Simpeh et al (2021). The data was captured on SPSS version 25 and subsequently computed using descriptive statistical analysis. The mean values and standard deviations were adopted to assist in ranking the different valuation methods adopted in valuing the green building features in a hierarchical order.

RESEARCH FINDINGS

Methods used in determining the value of a green building

The assessment results of the valuation methods used in determining the value of a green building are presented in Table 4. The process was measured with the use of a Likert scale and dimensioned from 1 to 5, represented as 'not effective' to 'very effective' with a midpoint value of 3.00 to facilitate the grouping of the MVs. The table details disclose that five out of seven valuation methods have MVs above the midpoint of 3.00, illustrating the importance of using these methods in determining the value of a green building. Observations denote that building sustainability assessment method (BSA) is the top ranked valuation method with an MV of 3.79, followed by comparative market analysis (CMA) with an MV of 3.71, and cost method with an MV of 3.44. In accordance with the results, the first four valuation methods demonstrate high importance in determining the value of a green building, because their MVs fall within the mean score range of $> 3.40 \leq 4.20$, which is determined to be 'between neutral to effective/effective'. In addition, the MVs of the last three methods fall within the mean score range of $> 2.60 \leq 3.40$, determined to be 'between not so effective to neutral/neutral'. The methods include income method, direct capitalisation method, and discounted cash flow analysis.

Table 1: Methods used for determining the value of a green building

Valuation methods	1	2	3	4	5	SD	MV	Rank
B.S.A method	3.7	6.5	25.2	2.90	34.6	1.06	3.79	1
C.M.A method	5.6	7.5	27.1	29.0	29.9	1.15	3.79	2
Cost method	5.6	8.4	16.8	32.7	35.5	1.11	3.44	3

Market approach	3.7	13.1	18.7	22.4	41.1	1.06	3.42	4
Income method	14.0	15.9	16.8	18.7	32.7	1.27	3.03	5
D.C. method	4.7	9.3	24.3	27.1	32.7	1.04	2.88	6
D.C.F. method	2.8	9.3	17.8	27.1	41.1	0.95	2.77	7

Respondents were asked to indicate any specific technique(s) adopted by their firms in the process of implementing a green concept. With the objective of determining these techniques, options were provided to guide the opinions of the respondents. As indicated in Table 5, these options are formulated as 'unsure', 'yes', and 'no', to determine the valuation techniques.

Table 2: Specific techniques adopted by professionals

Specific valuation techniques	Frequency	Percentage (%)
Unsure	21	24.7
Yes	5	5.9
No	59	6.9
Total	85	100

Observably, 24.7% of the respondents disclosed that they are 'unsure' of any specific techniques, and a sizeable percentage (69.4%) of respondents do not know any specific technique, while a nominal percentage (5.9%) of the respondents affirmed that some specific valuation techniques were adopted, as outlined below:

Cost saving efficient method;
Building and material costing;
Use of eco-protect slabs between different floors to reduce heat loss on copper pipe conduits; and
Cost saving levels to justify the value of the building.

Background information

As displayed in Table 1, it is observed that 32.7% of the respondents are Matric holders, 28% hold a national diploma, 27.1% hold a BTech/BSc degree, 10.3% hold a BSc Honour Degree, and 1.9% hold an MSc/MTech degree. However, it is important to note that a total percentage of 67.3% of the respondents hold tertiary qualifications.

Table 3: Specific techniques adopted by professionals

Highest qualification	Frequency	Percentage (%)
MSc/MTech	2	1.9
BSc (Hon)	11	10.3
BTech/BSc	29	27.1
N/Diploma	30	28.0
Matric certificate	35	32.7
Total	107	100.0

As part of the findings gathered, as displayed in Table 2, 19.6% of the respondents are green building/sustainability specialists, 18.7% are engineers, 12.1% are estate surveyors and managers, while 11.2% are property managers. In addition, 8.4% of the respondents are architects, 6.5% are town planners, 5.6% are foremen, 5.6% are building technicians, 5.6% are quantity surveyors, 4.7% are project managers while a nominal 1.9% are site managers. It is important to note that the respondents who participated in the survey represent a broad spectrum of various professions within the built environment.

Table 4: Occupation of respondents

Highest qualification	Frequency	Percentage (%)
Site manager	2	1.9
Project manager	5	4.7
Quantity surveyor	6	5.6
Building technician	6	5.6
Foreman	6	5.6
Town planner	7	6.5
Architect	9	8.4
Property manager	12	11.2
Estate surveyor & manager	13	12.1
Engineer	20	18.7
sustainability specialist	21	19.6
Total	107	100.0

Table 5: Experience in construction

Duration of practice	Frequency	Percentage (%)
More than 10 years	7	6.5
5-10 years	35	32.7
Less than 5 years	65	60.7
Total	107	100.0

DISCUSSION

The assessment of the valuation methods used in determining the value of a green building demonstrated that some adopted methods yielded MVs above the midpoint of 3.00. This implies that these methods are more effective in determining the value of a green building. Among these methods, BSA, CMA, cost method, and sales comparison method yielded MVs of 3.79, 3.71, 3.44, and 3.42, respectively. The BSA method is ranked first and considered the most effective method according to the respondents. This is the case because the BSA method is adjudged to be the best valuation tool for green buildings as it can measure all the three dimensions of sustainability such as economic, environment and social. According to

the survey participants, the CMA- a computer-based method is also considered as one of the effective approaches in valuing green building.

The range of the MVs produced fell within the mean score range of > 3.40 ≤ 4.20, graded 'between neutral to effective/effective'.

The cost method follows with a ranking of 3.44 MV indicating that it falls between the mean score range of > 3.40 ≤ 4.20, which is between neutral to effective/effective. Sales comparison method also falls within mean score range of > 3.40 ≤ 4.20, with an MV ranking of 3.42.

Other adopted methods fell within the mean score of > 2.60 ≤ 3.40, determined as 'between not so effective to neutral/neutral'.

Some possible reasons for the difference between the first four and other three methods could be due to certain challenges that maybe faced regarding valuing green buildings as suggested by Adomatis (2015:28). They include:

- Impossibility of comparing ratings from numerous rating organisations, since different organisations adopt different 'rating systems;
- Since valuers depend on market data in valuing properties, a lack of data means lack of adequate information necessary for valuation;
- Using existing databases in green valuation assignments presents many difficulties;
- Residential properties constitute different problems due to relatively new occurrences of properties with green features in the market;
- Private databases cause problems in valuing green buildings;
- Risk and uncertainty abound.

Some challenges were however pinpointed in relation to the influence of a green building concept on the value of a building and impact of green features. These challenges are outlined below:

- Some respondents complained about the cost and uncertainty in meeting required standards set by the green building council and SABS, as some emphasised that these requirements are high;
- There are often difficulties with getting the right specialists for maintenance and even for installations of some special green building gadgets;
- The maintenance costs are high due to demand for technology specialist services;
- Respondents claimed that while some materials are not suitable for use when constructing a green building, they are used to achieve green star ratings and standards;
- Another claimed that the cost implication associated with implementing a green construction building is extreme;
- The comparative cost of green buildings to the traditional method is high, only paying off in long term.
- It is difficult getting the right contractors and maintaining required site regulations;
- There is a high cost of labour due to required specialists and skills;
- Green building is highly capital-intensive to execute;
- The cost of required building materials is high because imported materials are frequently used, and
- Registration of construction materials hinders green building completion because the process can be time consuming.

Compiling a supply list can be challenging as registered by the green building council of South Africa.

CONCLUSION

This study contributes considerably to the methods and current practices adopted and applied in determining the value of a green building. According to Guy and Shove (2000: 133), “it is not simply a question of transferring technologies upon people. Instead, knowledgeable actors creatively adopt and adapt strategies and practices that suit their changing circumstances. Sometimes this favour (the environment), sometimes not”. This study also aids the process of understanding the conventional or modern methods and practices, in terms of valuation methods, as it relates to determining the value of a green building, through adoption by necessary agents.

The findings that emanate from this study are practically applicable in comprehending the need to adopt valuation methods useful for determining the impact of green building concept on the value of a building.

The study provides awareness for a host of professionals – property developers, engineers, quantity surveyors, estate surveyors and valuers, architects, green building experts, research and educational institutions and contractors, with focus on the methods and current practises adopted in valuing of a green building.

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MANAGEMENT STRATEGIES FOR DELAYED PAYMENTS TO SMALL AND MEDIUM CONTRACTING FIRMS IN LAGOS STATE NIGERIA

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The study examined the extent of delayed payment, determined the effect of delayed payment on construction cost and time, and examined the management strategies for delayed payments to small and medium contracting firms in Lagos State, Nigeria. Data was obtained through structured questionnaires and records. Through purposive sampling, one hundred seventy-three questionnaires were administered to the small and medium construction firms registered at the Lagos state tender board. Data were analysed using frequency, mean score, relative severity index and document analyses and correlation. The study found out that all the contracting firm sampled in the study area has experienced delayed payment. The study revealed a weak positive relationship between delayed payment and construction cost (R = 0.341) and a strong positive relationship on construction time (R = 0.965). The most important management strategies for mitigating delayed payments were regular periodic payments (Ms = 4.49), payment of interest on delayed payment (Ms = 4.14) and working within the stipulated budget (Ms = 3.93). Hence, this study recommends that there should be a proper cost planning and contractual agreement between the client and the professionals before the commencement of the project to avoid delayed payment. The findings from this study would assist the relevant parties such as developers or government and the contractors to understand the problem of delayed payment in Lagos state, Nigeria.

Keywords: Construction, Contractors, Delayed payments, Nigeria

INTRODUCTION

It is a well-acknowledged fact that the construction industry is a significant economic driver in many economies, usually accounting for an average of about 10% of Gross National Product (GNP) (Chitkara 2010; Demissie 2020; Mbiti, 2008; Olusola 2019; Sagiyeva et al., 2018). It offers employment to consultants, contractors, artisans, the labour force, material suppliers, and plant and machinery suppliers. The practice of efficient and timely payment in construction projects is a significant factor in project success (Chong & Kashiwagi 2020; Asiedu et al., 2017; Hasmori, Ismail, and Said, 2012; Tripathi & Jha 2018). Payment refers to the total amount of money given to contractors, consultants, and suppliers once their work, services, and supplies have been accepted (Kifokeris & Koch, 2020; Rahman and Ye, 2010; Judi and Sabli, 2010). However, the construction industry, especially construction contractors, suffers from many problems that affect time, cost, and performance quality.

Delay in the completion of infrastructure projects due to delayed payment is a significant challenge with global dimensions facing the construction industry (Li, 2019; Olusola, 2019

and Owolabi et al., 2014). This set of circumstances often leads to increased construction costs due to time extension or acceleration, productivity loss, work disruption, revenue loss through lawsuits between contractual parties, and project abandonment (Olusola, 2019). Delayed payment, however, is defined as a case whereby the client is taking a more extended period than specified, that is exceeding the time of honouring of the certificate, issuing payment to the contractors (Antwi Afari & Baiden, 2021; Olusola, 2019; Rahman and Ye, 2010; Judi and Sabli, 2010). Extant researchers established that many contractors in Nigeria had raised concerns about running out of funds during their projects which affected their profitability and success (Ayodele and Alabi, 2011, Amoako 2011; Harris et al., 2021; Jiang, 2012).

Previous research proved that about 56.7% of conflicts in the construction industry were attributed to delayed payment, underpayment, and late payment (Abdul-Rasheed et al., 2007; Olusola, 2019). More so, Kadir et al. (2005) reported that delayed payment could cause slippages to material delivery, impacting labour productivity in the construction industry. In the construction industry, the problem of delayed payment remains widespread. There are propositions that the problem will persevere because of the shortfall in providing solutions or that the character of the industry promotes these sharp practices (Onoh, 2010). Given the enormous sums of money involved in the construction industry, construction projects must receive special consideration. As a result, the issue of delayed payment in the sector must receive special attention.

Delayed payment in construction has recently received several research attentions by various scholars (Vincent 2017; Thanjua 2003). However, studies examining the extent of delay payment in Lagos State are scanty. As a result, this study investigated the perceptions of construction professionals in small and medium contracting firms on the extent of delayed payments to contracting firms; investigated the effects of delayed payments on construction cost and time among small-scale construction firms in Lagos State, Nigeria; and evaluated management strategies for mitigating delayed payments in the study area.

RESEARCH METHOD

This survey research was undertaken in Lagos state because most construction firms in Nigeria are based in Lagos state (Oseghale et al., 2021). The population of the study comprised the small and medium scale construction firm within Lagos State, Nigeria. According to the Lagos State Tenders Board, in Nigeria, Contracting firms were categorised into five classes (Class A, B, C, D, and E) based on the cost of construction projects they undertake, as shown in Table 1 below.

Table 1: Classification of contracting firms according to the Lagos State Tenders Board

Class	Contract Value/Threshold	Category	Registered Firm
A	Up to N10million	Small-sized firms	115
B	Above N10million- N100million	Medium-sized firms	32
C	Above N100million-N250million	Medium-sized firms	59
D	Above N250million - N1billion	Large-sized firms	48
E	Above N1billion	Large-sized firms	50
Total			304

There were 304 registered firms with the Lagos State Tenders Board, 115 were small-sized contracting firms, 91 were medium-sized contracting firms, and the remaining 98 were classified as large. However, small and medium-size construction firms were selected for this study because they represent approximately 68% of all the registered construction firms in with Lagos State Tenders Board and the majority of the abandoned project due to delayed payment in Nigeria were handled by small and medium enterprises (Odenigbo, 2020, Akinsiku, 2016).

The sample frame comprises the registered contractors within the Lagos State Tender Board. A total of one hundred and seventy-three (173) well-structured questionnaires administered through a purposive technique to the targeted respondents was used. A total of One hundred and thirty-five (135) questionnaires was returned (Abuja 23, Lagos State 35) out of the one hundred and seventy-three (173) questionnaire that was administered to the respondents; this gives a rate of return of 78.03%. The questionnaire sought to gather information about the respondents, organisational background, and projects' characteristics. It also contains questions about the extent of delayed payments, their effects on construction cost and time in the study area, and the management strategies adopted by contracting firms in managing delayed payments in the study area.

The data obtained from administering questionnaires on respondents were using descriptive statistics and inferential statistics such as frequency, percentages, mean score, relative important index and correlation. Frequency and percentage were used to analyse the extent of delayed payments, correlation and document review were used to establish the effects of delayed payments on construction cost and time in the study area, mean score and the relative important index was used to determine the management strategies adopted by contracting firm in managing delayed payments in the study area.

The Relative Severity Index (RSI) was calculated as:

$$\text{RSI} = \frac{Mean}{i} \qquad \text{equation 1}$$

$$\text{Mean} = \frac{\sum_{i=1}^{5} WiXi}{\sum_{i=1}^{5} Xi} \qquad \text{equation 2}$$

Where, ‘i’ = response category index = 1, 2, 3, 4 and 5 for ‘Not responsible’, ‘Less Responsible’, ‘Responsible’, ‘Very Responsible’, and ‘Most Responsible’ respectively. Wi = the weight assigned to the ‘i'th response, as = 1, 2, 3, 4 and 5, respectively Xi = frequency of the ‘i'th response given as a percentage of the total response for each cause

DATA ANALYSIS AND DISCUSSION OF RESULTS

Table 2: The extent of delayed payments on contracting firms

Description	Frequency	Percentage (%)
0-10 projects	69	51.11
11-20 projects	37	27.41
21-30 projects	12	8.9
31-40 projects	17	12.58
Total	135	100

Table 2 above represents the extent of delayed payment on contracting firms in Lagos, Nigeria. This shows that all the contracting firms sampled have experienced delayed

payment, and 51.11 per cent of the respondents have experienced delayed payment up to 10, making them suitable for the research project.

Table 3: Numbers of projects undertaken in the last five

Description	Frequency	Percentage (%)
Private funded project	69	51.11
Government-funded project	66	48.89
Total	135	100

Table 3 above represent the Numbers of projects undertaken in the last five years by the respondent. This shows that all the respondents have been handling construction projects in the last five years, with 51.11% being a Privately funded project and 89.9% Government-funded project.

Table 4: Frequency of delayed payment

Description	Frequency	Percentage (%)
Not often	25	18.51
Less often	69	51.11
Fairly often	34	25.18
often	7	5.2
Total	135	100

Table4 above represent the frequency of delayed payment on the sampled contracting firm in Lagos, Nigeria. This shows that 81.5% of the contracting firm sampled has experienced delayed payment, while only 18.51%e of the respondents did not often experience delayed payment.

Table 5: Length of experience of delayed payment

Description	Frequency	Percentage (%)
0-3 months	75	55.5
0-6 months	56	41.5
0-12 months	4	3
Total	135	100

Table 5 above represents the length of delayed payment experience on the sampled contracting firm in Lagos, Nigeria. This shows that 55.5% of the contracting firm sampled has experienced delayed payment for 0-3 months, 41.5% (0-6 months) and 3 per cent for (0-12 months).

Table 6: Extent of time overrun on project sampled

Project Sampled	Category	Client	Project Duration	ACD-SCD	% Increase in Time
1	Class B	Government	Five months	96 days	62.7%
2	Class B	Government	Two months	38 days	61.3%
3	Class B	Government	Two months	68 days	73.9%
4	Class A	Private	2 months	100 days	65.8%
5	Class B	Government	2 months	170 days	69.8%
6	Class A	Government	2 months	45 days	51.2%
7	Class B	Private	2 months	155 days	63.3%
8	Class B	Private	2 months	133 days	61.7%
9	Class B	Government	2 months	19 days	20.7%
10	Class A	Government	2 months	99 days	53.8%
11	Class B	Private	2 months	37 days	29.8%
12	Class A	Private	2 months	33 days	54%
13	Class A	Private	2 months	67 days	54.9%
14	Class A	Private	2 months	27 days	29%
15	Class B	Private	2 months	75 days	49.4%
16	Class B	Government	2 months	51 days	38.6%
17	Class B	Private	2 months	65 days	52.3%
18	Class B	Private	2 months	69 days	65.7%
19	Class B	Government	2 months	26 days	33.7%
20	Class B	Private	2 months	52 days	32.8%
21	Class B	Government	7 months	189 days	87.8%
22	Class A	Government	5 months	65 days	42.7%
23	Class B	Private	4 months	67 days	54.9%
24	Class A	Private	4.5 months	90 days	69%
25	Class B	Private	5 months	75 days	49.4%
26	Class A	Government	8.4 months	92 days	36.07%
27	Class B	Private	4 months	65 days	52.3%
28	Class A	Private	3 months	68 days	65.7%
29	Class A	Government	2.5 months	26 days	33.7%
30	Class B	Private	6 months	52 days	32.8%

Table 6 above shows the extent of delayed payment data gathered from archival records. Thirty projects were sampled, which included both the government-funded project and the privately funded project. The document was checked to determine the extent of time overrun, the duration of the project, the difference between the scheduled completion date and the actual completion date, and the percentage increase in time of the project sampled. The time overrun experienced by the contractors' handling projects sampled was calculated as a percentage increase in time.

The result shows that the average percentage time overrun for all projects was 54.25%, while the extent of time overrun from private and government-funded projects were 49.40 and 54.25%, respectively. Out of the 30-project sampled and 123 invoices analysed, the study revealed that all the projects experienced time overrun and delayed payments which were contrary to a study by Vincent (2017). However, the result shows that there was no improvement made within the last five years on delayed payment

Table 7: Extent of cost overrun for project sampled

S/no	Class	Client	Project Duration	BC	AC	AC-BC	% Increase in Cost
1	Class B	Government	5 months	85000000	99000000	16000000	16.47
2	Class B	Government	2 months	9000000	11000000	2000000	22.22
3	Class B	Government	2 months	18000000	24000000	6000000	33.30
4	Class A	Private	2 months	15000000	18500000	3500000	23.33
5	Class B	Government	2 months	14500000	17600000	3100000	21.38
6	Class A	Government	2 months	9870000	11960000	1900000	21.18
7	Class B	Private	2 months	150000000	220000000	70000000	48.00
8	Class B	Private	2 months	16100000	17400000	1,300,000	8.070
9	Class B	Government	3 months	27000000	28100000	1,100,000	4.070
10	Class A	Government	3.25 months	24,700,000	29,200,000	4,500,000	18.22
11	Class B	Private	4 months	85000000	99000000	16000000	16.47
12	Class A	Private	2 months	48000000	54000000	6000000	12.50
13	Class A	Private	4 months	13000000	14800000	1800000	13.80

14	Class A	Private	3 months	15700000	19000000	4300000	27.40
15	Class B	Private	5 months	62209000	86110000	23901000	38.42
16	Class B	Government	4.3 months	14870000	16960000	2090000	14.18
17	Class B	Private	4 months	13000000	15200000	2200000	22.80
18	Class B	Private	3 months	16510000	19420000	2910000	18.07
19	Class B	Government	2.5 months	9500000	11700000	2200000	24.70
20	Class B	Private	5 months	56700000	79200000	22500000	24.82
21	Class B	Government	7 months	18345600	24680000	63344000	34.50
22	Class A	Government	5 months	18000000	24400000	5600000	31.10
23	Class B	Private	4 months	73600000	108000000	34400000	46.70
24	Class A	Private	4.5 months	18700000	24000000	5300000	28.30
25	Class B	Private	5 months	16220900	18611000	23901000	38.42
26	Class A	Government	8.4 months	11487000	14696000	32090000	27.80
27	Class B	Private	4 months	13000000	15200000	2200000	22.80
28	Class A	Private	3 months	16510000	19420000	29100000	18.07
29	Class A	Government	2.5 months	9500000	11700000	2200000	24.70
30	Class B	Private	6 months	56700000	79200000	22500000	24.82

Findings revealed the extent of cost overrun in all projects sampled, as the least additional cost due to delayed payment was over a million naira. These cost overruns are even skew towards the maximum cost difference of seventy million naira. However, of the 14 sampled projects, which were from private establishments, the least cost difference experienced by the contractors due to delayed payment was 1,300,000 naira and maximum been 34,000,000 naira (median = 1,900,000; 3rd quartile = 23,551,000). This analysis showed that the projects sampled experienced an increase in construction cost due to delayed payment, which

indicates that there is no improvement in effective and timely payment. This research did not agree with the findings of Vincent (2017).

Relationship between delayed payment and construction cost

The relationship between the delayed payments and cost overrun was evaluated using regression analysis and hypothesis formulated as follows:

Hypothesis 1
Ho: There is no significant relationship between delayed payments and cost overruns (in other words, cost overrun is not dependent on delayed payments).

Alternative hypothesis

HA: There is a significant relationship between delayed payments and cost overruns (in other words, cost overrun is dependent on delayed payments).

Table 8: Correlation coefficient between Delayed payment and Construction cost

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.341a	0.117	0.095	42052579.363

a. Predictors: (Constant), Delayed in payment days

The effect of delayed payment on construction cost was determined using the regression analysis at a 5% significant level. Table 8 shows the correlation coefficient, R = 0.341, indicating a positive but weak relationship between delayed payment and construction cost.

Table 9: Significant level of relationship between delayed payment and construction cost

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	9563363197344016.00	1	9563363197344016.00	5.408	0.025 b
Residual	72505196673093744.00	41	1768419431051067.00		
Total	82068559870437760.00	42			

a. Dependent Variable: Difference between budgeted cost and the actual cost
b. Predictors: (Constant), Delayed in payment days

Table 9 revealed that the significant level (0.025<0.05) ruled out the possibility that delayed payment did not affect building costs; thus, we accept the alternative hypothesis that there is a significant relationship between delayed payment and construction cost overruns. Therefore, delayed payments would have an appreciable effect on cost overruns of building construction projects. According to a literature survey, one of the most common causes of cost overruns in building construction projects is late payments. As a result, the high ranking of delayed payments as a cause of cost overruns depended on the respondents' perceptions, which were subjective to a considerable degree. The results from this study showed that delayed payments do cause cost overruns to an appreciable extent. This result did not support the high-ranking position of delayed payments among the factors responsible for cost overruns. This finding is consistent with the findings of Asiedu et al. (2017) and Harris et al., 2021 who also noted that delayed payment causes cost overrun to a reasonable.

Relationship between delayed payment and construction time

The relationship between the delayed payments and time overrun was evaluated using regression analysis.

Table 10: Correlation coefficient between Delayed payment and construction time

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.965a	0.931	0.929	44.781

a. Predictors: (Constant), Delayed in payment days

Table 10 shows the correlation coefficient between delayed payment and construction time, R = 0.965, indicating a strong positive correlation (strong relationship) between the two variables; the significant level rules out the possibility that delayed payment has no impact on construction time (0.00010.05)

Table 11: Significant level of relationship between delayed payment and construction time

Model	Sum of squares	Df	Mean Square	F	Sig.
Regression	1108202.359	1	1108202.359	552.633	0.0001b
Residual	82217.827	41	2005.313		
Total	1190420.186	42			

a. Dependent Variable: Difference between scheduled date and actual completion date

b. Predictors: (Constant), Delayed in payment date

Table 11 depletes a significant relationship between delayed payment and construction time overruns, which implies that delayed payments result in time overruns.

Management strategies for mitigating delayed payments

Table 12: Showing the Management strategies for mitigating delayed payments

Management Strategies	Av. Mean	RSI	Rank
Regular periodic payments	4.489	0.8978	1
Payment of interest on delayed payment	4.14	0.828	2
The definite time frame for payment	4.083	0.8166	3
Working within the stipulated budget	3.931	0.7862	4
Entering into a partnership agreement	3.880	0.776	5
Discounting facility	3.767	0.7534	6
Turn-key contract	3.721	0.7442	7
Credit financing	3.698	0.7396	8
Employer to seek a loan to pay off debt	3.650	0.73	9
Employer to issue a promissory note	3.605	0.721	10

Mandatory creation of trust account for payment of retention money	3.547	0.7094	11
Increase of percentage for advance mobilisation	3.287	0.6574	12
Funds from contractor's business	3.185	0.637	13
Balancing of financial risk among suppliers and subcontractors	3.092	0.6184	14
Support from friends or relatives	2.861	0.5722	15

Management strategies for mitigating delayed payments

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Table 11 above revealed the ranking of the management strategies that contracting firms can adopt in managing delayed payment in the study area. Among the management strategies, regular periodic payment was the most crucial strategy (MS = 4.49). Findings reveal that regular payment was the principal remedy for mitigating delayed payment in the Nigerian construction industry. This result is consistent with a study by Friedberg (2018) that a right to regular periodic payment was perceived as the most favourable option in reducing the effects of delayed payment to ensure effective project delivery. Payment of interest on delayed

payment was ranked as the second most favourable strategy (Ms = 4.14). Respondents believed that contractors should work within the stipulated budget as part of the strategies for mitigating delayed payment. This strategy was ranked third (MS = 3.93). The least ranked out of the strategies are support from friends (Ms = 2.86), balancing of financial risk among suppliers and subcontractors (Ms = 3.09) and funds from the contractor's business with (Ms = 3.12).

CONCLUSION AND RECOMMENDATION

The study investigated the extent of delayed payment, determined the effect on construction cost and time, and examined the management strategies for delayed payments to small and medium contracting firms registered under the Lagos State Tenders Board, Lagos State, Nigeria. The study found out that all the contracting firm sampled in the study area has experienced delayed payment. 55.5% of the contracting firm sampled has experienced delayed payment for 0-3 months, 41.5% (0-6 months) and 3 per cent for (0-12 months). More so, the study established that all the projects experienced time overrun due to delayed payments. Hence, the study established a significant relationship between delayed payment and construction cost and time overruns. The study found a strong positive correlation between delayed payments and construction time overruns but a weak positive correlation between delayed payments and construction cost overruns. The study revealed that the regular periodic payment, payment of interest on delayed payment, definite time frame for payment, working within the stipulated budget and Entering into a partnership agreement was the most important strategies for mitigating delayed payments in the study area. Hence, this study recommends that there should be a proper cost planning and contractual agreement between the client and the professionals before the commencement of the project to avoid delayed payment. The findings from this study would assist the relevant parties such as developers or government and the contractors to understand the problem of delayed payment in Lagos state, Nigeria.

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ASSESSMENT OF SUITABILITY OF MOLTEN PLASTIC AND SAWDUST MIXTURE FOR THE PRODUCTION OF LIGHT WEIGHT COMPOSITE BUILDING MATERIALS

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This study aimed to assess the suitability of molten plastic and sawdust mixture to produce composite building materials. The study was carried out by assessing the bind-ability property of molten plastic using sawdust as a constituent material. In addition, the compressive strength, physical properties, and mechanical properties of the resulting composite material were examined. A comprehensive literature review was conducted to gather information on the extent of damage and measures set in place on how the problem can be solved, together with various characteristics of the material. The review was followed by experimental research of the study's objectives, serving as the primary data collection for analysis. The data obtained were analysed using a mean score, percentile, and various formulas. The specimen size used throughout was 100mm x 100mm x 100mm, with at least three samples made for each test carried out that requires its usage. Four different mix designs were carried out, with the compressive strengths were 2 N/mm2, 2.4 N/mm2, 2.68 N/mm2, and 2.3 N/mm2 accordingly. The water absorption rate was carried out for 10 minutes, 20 minutes, and 30 minutes and the results for the water absorption test are 8.75%, 14.29%, and 24% accordingly. Similarly, exposure to a 0.5 molar concentration of sulphuric acid drastically reduces the strength of the cube by 44%, and the density gotten was 1157 kg/m2. In conclusion, the study recommends accepting the molten plastic and sawdust composite material for non-load bearing walls. Using plastic for the material will facilitate the repurposing of the environmental headache as a substitute for expensive building bind-ability materials. In addition, further study on plastic in molten form as a cementitious material is recommended by examining the mixture of the plastic with cement and sand.

Keywords: Environmental impact, pollution, recycling, sustainability

INTRODUCTION

Environmental degradation hampers the quality of life by the threat posed to organisms. Minimal control over the heat radiation, resulting in climatic change, is one of the severe adverse effects of improper waste disposal mechanisms (Bauer, Mosle, and Schwarz, 2007; Syed, 2006). Alongside climatic change, improper disposal causes eco-system destruction and disruption, unattractive environmental sight view, pollution of water bodies, and air pollution (Arimoro, Ikomi, and Osalor, 2007).

Similarly, a drastic increase in population, urbanization, lifestyle, and throw-away culture has resulted in the proliferating heap of solid waste in developing countries (Minghua, Rovetta, Qichang, Vicentini, Bingkai, Giusti, and Yi, 2009). Mountainous waste sites and other improper disposal mechanisms of waste contradict sustainable waste management tenets,

which encourage proper management of waste to attain the environmental, economic, and social goals of sustainable development (Pianosi, 2012).

Specifically, the use of PET has grown due to the drastic increase in population, urbanization, and the wide acceptance of the means of fluid packaging (Agunwamba, 1998 as cited in Abila and Kantola, 2013). Despite the reusability, PET poses serious environmental challenges of industrial and domestic scale in terms of the disposable volume. PET is a municipal solid waste form of waste. This material is not readily biodegradable and is generated in large quantities daily. Millions of dozens of plastic wastes, in general, are floating in large water bodies globally. In water bodies, plastic wastes are broken into microplastics, which pose a danger to aquatic life in the oceans, as they feed on those microplastics. (Prasad and Jaysawal, 2017). Recent research by Irish-based researchers has shown that 73% of the fishes in the Atlantic oceans have digested microplastics (Sullivan, 2018). Besides, the significant floods reported in recent times around the world and Nigeria have been attributed to the blockage of river channels and the drainage path of flood flow by solid waste (Abaje and Giwa, 2005; Olofin, 2010).

Furthermore, the report given in the year 2017 concerning the global situation of plastic bottles shows that humans buy a million plastic bottles every minute, with the statistics confirmed to go above 20% by 2021. This voluminous purchase will exacerbate the current environmental crisis in addition to climate change (Laville and Taylor, 2017). It is estimated that 9% of 8.3 billion metric tons of plastic produced are being recycled globally, 12% incinerated, and the rest in existence constitute environmental nuisance (Parker, 2017).

Furthermore, solid waste materials causing environmental nuisance and indirect health risks alongside plastic, such as sawdust, pose more significant problems in tropical countries where their availability is in excess. Therefore, discovering the use to which sawdust and other wood waste generated can be essentially becomes paramount. This discovery is paramount because incineration of the waste, landfill, and open burning of waste birth to hazardous pollution of the environment. However, sawdust is a lignocellulosic material, does not deteriorate quickly but is somewhat unruly in the climate and odorless throughout its existence (Frombo, Minciardi, Robba, Rosso and Sacile 2009).

As means of proffering a solution to the problems, recycling has been one of the available solutions leading the ranks (Subbo and Moindi, 2008). Developed countries effectively practice the scheme due to cost implication and literacy of citizens towards the adverse effect of improper disposal of solid waste (Rakib, Rahman, Akter, Ali, Huda, and Bhuiyan, 2014).

However, water bodies and land are made impure with plastics and sawdust waste despite the recycling scheme. Therefore, this has led to various research on other usages of waste such as plastic and sawdust waste to eradicate littering. Notable ones amidst multiple kinds of research carried out see the conversion of plastic waste into fuels, monomers, and other precious materials through thermal and catalytic cracking processes and the use of plastic waste to produce bricks. In addition, research was carried out on plastic waste in shredded form, used as aggregate with kaolin and resin to produce wall panels. Also, plastic waste in an acceptable form mixed with cement in the production of plastic concrete has been researched. Sawdust used as a partial replacement for fine aggregate in concrete mix and sawdust in the form of ashes possibility of use as a stabilizer for soft clayey soils is the notable ones carried out as regards to sawdust waste utilization (Khatri, 2015; Shrimali, 2017; Purwanto, 2017; Prasad and Jaysawal, 2017).

Although research were carried out to find a practical use for plastic waste, none has looked into the potential of the plastic in molten form to serve as a binder for the production of

composite material. The absence of research work into the usage of molten plastic in this manner suffices as a gap this research work intends to fill. This study aims to assess the suitability of molten plastic and sawdust mixture to produce lightweight composite building materials. The study will be carried out by assessing the cementitious properties of molten plastic using sawdust as the composite material. Also, the mechanical properties, physical properties, and the reaction of the composite material in a chemical environment will be examined.

MATERIALS

Polyethylene was discovered by Reginald Gibson and Eric Fawcett in 1933. It was first formed into low-density polyethylene (LDPE) in 1935. As polyethylene is the second widely used resin globally due to its cost-effectiveness, about 25 different processes are available for manufacturing the products. Under polyethylene class, Nathaniel Wyeth discovered polyethylene terephthalate in 1967. However, the first polyester film was found by chemists Whinfield and Dickson in 1941. The PET was widely accepted due to its 100% balanced properties for transparency, gloss, lightweight, and resistance to carbon dioxide penetration. The properties make possible nearly 100% replacement of glass in Europe, constraint only of oxygen resistance and ultraviolet resistant. The world demand for PET is 14.5 million tonnes annually due to its level of acceptance globally, which is still on the increase (PlasticsEurope, 2018).

Figure 1: Cleaned plastic bottle

On the other hand, sawdust is a waste from wood processing produced in wooden industries. It is gotten from timber sawing into wood shaving sizes (Ogunleye, 2009, Onwuka et al., 2013). The type of wood and the machine saw teeth size determines the size of the sawdust waste generated (Afuwape, 1983 as cited in Okoroafor et al., 2017). The total volume of wood trunks converted in wood processing is 10-13% in milling operations. Nevertheless, the percentage is dependent on the average width of the saw teeth and the diameter of the timber sawed (Paulrud, Mattson, and Nelson 2002). The abundance availability of sawdust in tropical countries is responsible for its cheapness (Adebakin et al., 2012).

METHODOLOGY

A preliminary study will be carried out on the material mixture to ascertain the feasibility of the research. It will be done on the principle of controlled randomization of the mix to get a workable-with mix design from which the main experiment will take off.

Sample Preparation

Waste PET bottle gathered for the project was cleaned to ensure removal of impurities before its being weighed by batch and made ready for melting. The mix design from the pilot study

will be worked with the 265oc temperature recorded from the pilot study to be the temperature the plastic dissolves. After melting the plastic, the sawdust proportion will be poured and mixed while still under the heat source. The mix will, after that, be poured into desired cubes, preferably steel cubes, and allowed to cool off properly before demolding the samples.

Tests Methods

The tests were carried out to determine the compressive strength, density, water absorption, and chemical environment effect on the prepared samples. The thickness was calculated with similarity to ASTM C642. The procedure for others is explained below.

Compressive Strength Test

This test will be carried out to determine the compressive strength of the sample. Three specimens earlier prepared will be crushed, and the peak pressure at which the sample failed between the compressors is recorded for each of the three specimens. The average of the three results is the composite material's compressive strength for a unique mix design.

Mathematical expression for calculating compressive strength

$$\text{Compressive Strength}\left(\frac{N}{mm^2}\right) = \frac{Maximum\ Applied\ Force\ (N)}{Cross\ sectional\ area\ (mm^2)} = \frac{Fmax}{A}$$

The compressive strength of the composite material results in N/mm2 will be represented graphically.

Figure 2: Compressive strength test machine

Water Absorption

This test will be carried out to determine the porosity level of the composite materials under circumstances. The elements that affect water absorption level consists of the material type, temperature, and the extent of submersion. Three specimens emerge in water, with each will be used to determine the water absorption rate for ten, thirsty, and sixty-minute intervals. The results will then be analysed with the use of a mean score.

Acidic Test

This test will be carried out by crushing the sample not subjected to a chemical environment effect to have a controlled figure. First, three specimens will be exposed to sulphuric acid of 0.5M concentration for 24 hours. After that, the three specimens will be crushed to get three data, of which its average will be taken to get a suitable singular figure. The percentage difference between the controlled sample compressive strength and those exposed will be the

extent of the acidic effect on the composite material. Below is the mathematical expression of the percentile that will be used for the analysis.

$$\frac{Nf - Nn}{Nn} X\ 100\%$$

Where Nf = The initial specimen characteristic

Nn = The specimen characteristics after exposure

RESULTS AND DISCUSSION

Compressive Strength Result

Table 1: Ratio 1 to 4 of sawdust to plastic

	Cube 1	Cube 2	Cube 3
Weight (Kg)	1.09	1.09	1.09
Stress (N/mm2)	2.13	1.97	1.93
Load (KN)	21.33	19.7	19.31

Table 2: Ratio 1 to 5 of sawdust to plastic

	Cube 1	Cube 2	Cube 3
Weight (Kg)	1.09	1.14	1.09
Stress (N/mm2)	2.13	3.01	2.28
Load (KN)	21.33	30.10	22.27

Table 3: Ratio 1 to 5.5 of sawdust and plastic

	Cube 1	Cube 2	Cube 3
Weight (Kg)	1.14	1.14	1.19
Stress (N/mm2)	2.60	2.55	3.04
Load (KN)	25.96	25.46	30.36

Table 4: Ratio 1 to 6 of sawdust and plastic

	Cube 1	Cube 2	Cube 3
Weight (Kg)	1.09	1.14	1.09
Stress (N/mm2)	2.10	2.53	2.35
Load (KN)	21.02	25.32	23.52

In Table 1 to 3, the strength of the composite material increased as the proportion of the molten plastic increased. The molten plastic volume in the composition leads to an increase in the strength of the composite material. However, the strength of the composite material peaked when the sawdust to molten plastic ratio was 1 to 5.5. The result of the compressive strength of the best mix (1:5.5) was 2.68 N/mm2 with other mix designs such as 1:4, 1:5, and

1:6 are 2 N/mm2, 2.4 N/mm2, and 2.3 N/mm2. The sample size used throughout is 100mm. x 100mm x 100mm.

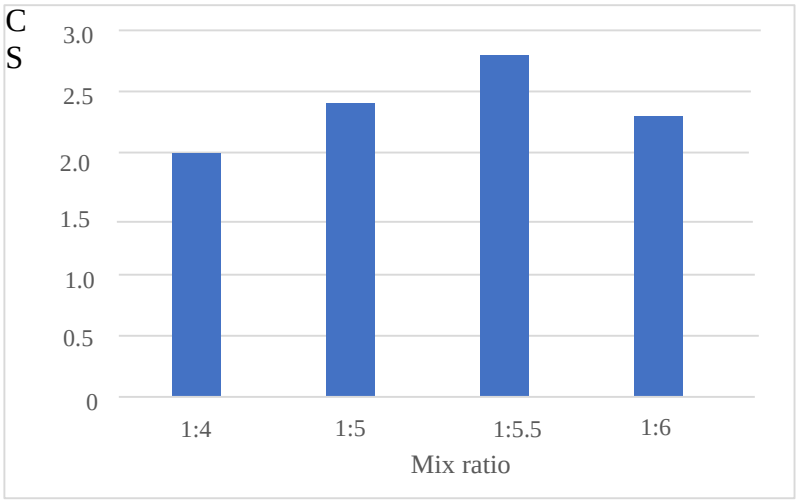

Figure 3: Bar chart showing the compressive strength for various mix ratio

Water Absorption Result

Table 5: Water Absorption

Time interval (Min)	Initial Weight (Kg) W0	Weight (Kg) W1	Weight (Kg) W2	Weight (Kg) W3	Average $\frac{W1+W2+W3}{3}$
10	0.80	0.85	0.85	0.90	0.87
30	0.70	0.75	0.80	0.85	0.80
60	0.75	0.90	0.95	0.95	0.93

The pores present within the samples had a significant stake in the percentage rate of water absorption of the specimen. Therefore, the water absorption rate was determined for the 30-, 90- and 180-minutes time range. The result gotten in percentile was 8.75%, 14.29%, and 24% accordingly. The result explains how the composite material is not fit for outer usage because it absorbs too much water in a small duration of time.

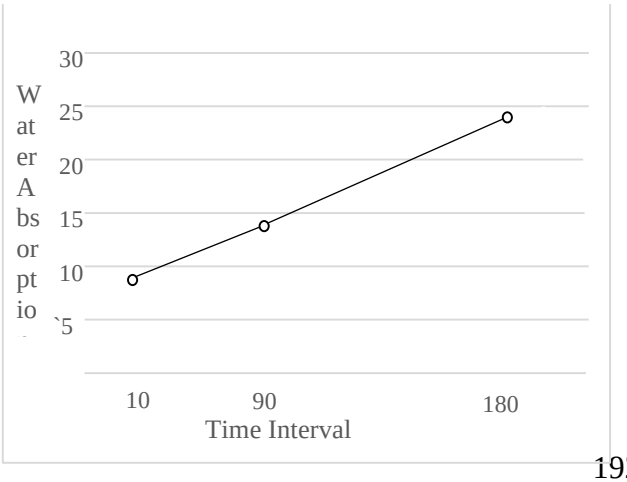

Figure 4: Line graph showing the rate of water absorption

Acidic Test Result

Table 6: Compressive strength of specimens

	Compressive strength after acidic test
Cube 1	1.48
Cube 2	1.15
Cube 3	1.86

The composite material exposure to sulphuric acid of 0.5M proves to be catastrophic to the product. With a span of exposure been 24 hours, the breakdown of the compressive strength of the specimens on average is 44%.

CONCLUSIONS

This study determines the suitability of the molten plastic and sawdust composite material for building material. The data analyzed showed the best mix design of the composite material, which is 1:5.5 of sawdust to molten plastic. The average strength attained in terms of compressibility for the mix design was 2.68 N/mm2. According to Nigerian Industrial Standards specifications, the minimum requirement for building block strength is 2.5 N/mm2 which, based on this standard, the composite material will function well when considered for block making. Also, according to British Standards Institution (2011), the minimum requirement for non-bearing internal wall strength is 2.9 N/mm2. Although 2.68 N/mm2 is not up to the minimum requirement of the standard, the addition of some additives to the composition can spike up the strength of the lightweight material above the minimum stated in the British Standards Institution. In addition, the density of the material gotten is 1157 kg/m3, while the water absorption rate carried out for 30, 90, and 180 minutes are 8.75%, 14.29%, and 24%. In general, molten plastic showed an excellent property for binding other constituent materials. Though flakes sporadically for some minutes at first, before consolidating and eventually hardens as time passes. Regardless of its strength, it can be liquidated again at a more extended range of time with an increase in melting point. The properties will make it conducive for locations distanced from heat, water and require the carriage of no other load apart from its self-weight.

Based on the findings of this research work, plastic in molten form is an excellent cementitious material. Therefore, the study recommends further study into plastic in molten form, especially by checking the material's performance when mixed with cement, sand, and other materials that lead to the birth of low-cost solid composite material for construction purposes.

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ASSESSMENT OF COMPETENCE OF NIGERIA INDIGENOUS CONTACTORS IN HANDLING LARGE SCALE CONSTRUCTION PROJECTS

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Most large-scale construction projects in Nigeria are executed by foreign contractors. Questions have then been raised about what could be the reason for this. One hypothesis is whether construction managers of local construction companies actually possess the needed competencies for the execution of large-scale projects. This research has therefore identified various competencies required for handling large scale construction projects. Competencies possessed by local construction managers in selected construction site in Lagos state were also researched. A qualitative and quantitative research approach was adopted to achieve the objectives of the study which are to identify Construction Managers' competence areas required for large scale construction projects and compare Construction Managers' possessed competencies with required competencies for large scale construction. 100 questionnaires were distributed to construction managers of selected Building construction projects in Lagos state, Nigeria who were handling one project at the time or the other. Data obtained were analysed using frequency, percentages, and Mean score. Results revealed that Digitalization, Cost Management, Quality Management, Communication, Team Motivation, Technical Knowledge, Material Management, Labour Management, Contract Management and Time management were the three highest ranked competencies from qualitative analysis. The study also reveals that only five of the highly ranked competencies are possessed by local construction managers. It is then recommended that local construction Managers should improve on Digitalization, Cost management, Contract management, Quality management and Time management competencies to be able to present themselves as capable to actively take up challenging roles in country's building construction industry.

Keywords: Construction managers, competence, local, large scale

INTRODUCTION

According to Adamu, Lowe and Manase (2015), the construction industry includes those firms saddled with the responsibility of the execution of building and civil engineering works whether public or private projects. The structure of Nigerian construction industry is such that it has a wide range of different types of clients, contractors and contracts consisting of public and private clients, main contractors and subcontractors, one-man firms and international companies, low technology firms and sophisticated specialists within the industry (Adamu et al. 2015). Construction contracts are categorized by several criteria which include: the scope of operation (local, regional, national, and multinational); specialization (building and engineering); size and category of contracts (small, medium and large) and the company

owner's nationality (foreign and indigenous) according to (Muazu and Bustani 2004; Idoro and Akande, 2008; Idoro 2011).

Aniekwu and Audu (2010) stated that foreign firms which constitute just 5% of the total number of contractors in the formal sector control about 95% of the major large-scale projects in the construction market which is an unbalanced apportioning of business opportunities in the Nigerian construction industry. Large scale construction projects basically have a correlation with the complexity of the project characterized with the need for a construction manager with a wealth of construction knowledge, technical skills, and managerial competencies. In contrast, many developing countries suffer from having shortage in providing this essential competence.

LITERATURE REVIEW

Nigerian Indigenous Contractors and their participation in construction

Adams 1997 and Ogbebor 2002 expressed that Nigerian indigenous construction managers are largely incompetent and inexperienced. Olateju (1991) and Ademoroti (1997) also emphasized, that relative to the volume of work available in Nigeria, the percentage in value of contract handled by the indigenous contractors is low compared to those handled by foreign and multi-national companies.

To examine how much of the construction projects executed in Nigeria are given to indigenous contractors, their management strategies, and the adequacy of these strategies in preparing them for the future challenges of the industry, Olateju (1991) embarked on a study of 1133 projects costing N11.25 billion awarded by the Federal government between 1994 – 1998, a period when construction activities were highest in the country. The results showed that while the indigenous contractors got awarded 77.2 percent of the number of contracts, they only had 6.95 percent of the value of the contracts. The study also showed that the indigenous contractor had created virtually no impact in the areas of heavy infrastructural development such as civil works in refineries, hydroelectric dams, airports etc. In fact, the foreign contractors averaged N40.75million per contract, as against an average of N890,000 per contract by indigenous contractors. The study attributed this low level of participation to perceived inability of construction managers of local construction industries to effectively manage large projects.

Research undertaken by Ugochukwu and Onyekwena (2014), have identified the extent of indigenous contractors' participation in public construction. Patience et al. (2016) researched about project management competencies of indigenous contractors in Nigeria and in another similar research work talked about the factors that affect the competence and project delivery of small sized indigenous contractors in Lagos. Babatunde et al. (2019) also identified that mechanization impacts positively on cost of construction and hence on participation of contractors in large scale construction. None of these studies although relevant and resourceful, succinctly channelled its course towards identifying effects of competence of indigenous contractors on their participation in the activities of the nation's construction sector. This work hence builds on this research in assessing Nigeria indigenous contractors' competence and the effects of these competence areas on their participation in large scale construction projects.

Large Scale Construction Projects

Different terms are used in literature to describe large projects such as complex projects, major projects, giant projects, and mega projects. There are several different statements that claim to be a definition of large-scale construction projects and there are different

perspectives on what large scale construction projects are. However, all these definitions and perspectives agree that large scale construction projects are huge investment projects aimed at supporting governments and certain individuals in achieving their social and economic development objectives (Ayman 2013).

Required project execution competencies

Many studies have focused on the required competencies of project managers in construction projects (Mutijwaa P et al 2007; Serpel A et al 2007; Muller R et al 2010; Chen P et al 2008). The appropriateness of project managers' competencies with the project type was taken into account by Muller R, Turner J (2007) and they also identified important leadership competencies in the areas of construction, IT, organization and business. Edum-Fotwe and McCaffer (2000) identified certain project management competencies needed for construction activities. Sina Moradi et al (2020) identified Project Managers' Competencies in Collaborative Construction Projects. Abdullah et al (2017) researched on Construction manager's technical competencies in Malaysian construction projects. Shenhar A.J (2001)'s research also considered the necessity of matching the project type and project managers' competencies. More recent studies conducted suggest that the focus on investigating and identifying project managers' competencies in construction projects has been continued (Patience et al, 2016; Blixt C. et al, 2017; De los Ríos-Carmenado I, 2014; Omar M et al, 2016). Dainty et al (2004), Cheng et al (2005), Lee et al (2011), Dogbegah et al (2011), Hwang and Ng (2013), Zhang et al (2013), Omar and Fayek (2016) and Moradi et al (2018) have also discussed various required project management competencies some of which were identified and ranked for the purpose of this study. Reviewing relevant studies resulted in a synthesis of 84 competencies of construction managers for construction projects. The following Table 1 presents the top 22 competencies based on that synthesis. Ranking (R) of the listed competencies have been calculated based on their frequency of appearance.

RESEARCH METHOD

A mixed research approach using both qualitative and quantitative was best suited to accomplish the aims and objectives of this research.

Qualitative analysis

The research was started using a qualitative approach to achieve the first objective of identifying key competencies needed for large scale construction. The move was deemed effective to yield exhaustive and holistic results. This was performed through a systematic review using specific keywords in high impact research journals. The search period was considered from 2010 to 2019, covering a period of 10 years. After finding the key competence areas from the existing literature associated with the construction managers' competencies, a quantitative approach was adopted to rank the essential competencies that play a significant role in the execution of large-scale projects. Ranking was done based on frequency of appearance in literature. A similar approach was also adopted by Umar T. (2020) in his research related to making future floating cities sustainable.

The interviewees comprised of 10 construction professionals from foreign construction companies who were undertaking key large-scale projects in Lagos state involving six Construction Managers, one Project Manager and three Engineers. All interview respondents have aptly followed criteria set and were able to rank Construction Managers' competency needed for large scale construction projects. Each interview session averagely lasted for thirty minutes and were conducted within the convenience of the interviewees. For close-ended questions, results demonstrated that all respondents agreed with the Construction Managers'

competencies derived from the prior conducted literature analysis. The aim of this interview session was to establish the ranking of the competence areas.

At the final stage of the research, a quantitative approach using questionnaires was used to achieve the second research objective which is to examine if local Construction Managers possess the identified competencies for large-scale construction projects. A total of hundred (100) well-structured questionnaire administered through a purposive sampling technique to a targeted respondents who are construction managers of building construction projects in Lagos. A total of sixty-five (65) were retrieved. This gives a rate of return of 65%. The questionnaire sought to gather information about the respondents, organizational background, and projects characteristics. Self-evaluation of competencies in form knowledge and skills possessed is the most effective way for identifying construction managers' competencies. The categories of the studied construction projects in this study comprised residential building projects (housing construction) and institutional construction (multi-story buildings). 22 competencies of construction managers were evaluated through 110 linguistic statements. Respondents were asked to identify the competencies that they currently possess. This is presented by each linguistic statement on the following scale: very low/ low/ average/ high/ very high. A cut-off point means score > 3.5 on a 5-point Likert-type scale have been declared to be sensible to decide critical or noteworthy variables (Oseghale, Adetooto and Oseghale 2021). The data obtained were analysed using descriptive statistics such as frequency, percentages, Mean Score. Frequency and percentage were used to analyze the data regarding the respondents, academic qualifications, gender, and years of experience. Mean item score was used to rank the respondent perceptions on the competence areas being possessed by Nigeria indigenous contractors and Cronbach's test was used to test the reliability of the research instrument for the intended objective. The numeric values of the possessed competencies from the self-evaluation results are presented in Table 3 and 4.

RESULT AND DISCUSSION

Qualitative analysis.

The authors have selected and analysed several closely related literatures. A total of 87 research articles published between a 10-year period of 2010 and 2019 were downloaded. Subsequently, all items were reduced into 22 elements. Hence, Table 1 summarizes the identified Construction Managers' competencies that resulted from the process which was able to offer simplistic and perceptive views.

Table 1. Summary of Construction Managers' Competency

Competency	Appearance in Literature	Rank	Competency	Appearance in Literature	Rank
Digitalization	8	1	Health and Safety	4	4
Cost Management	7	2	Leadership	4	4
Quality Management	5	3	Client Management	4	4
Communication	5	3	Decision Management	4	4
Team Motivation	5	3	Site Management	3	5
Technical Knowledge	5	3	Risk Management	3	5

Material Management	5	3	Logistics Management	3	5
Labor Management	5	3	Procurement Management	3	5
Contract Management	5	3	Supply Chain Management	3	5
Time Management	5	3	Analytical thinking	3	5
Plant and Equipment	4	4	Dispute Resolution	3	5

Validation

Interview

A total of ten experts were involved in the interview sessions. Interviewees were asked to identify what competencies were important on a scale of 1 to 5. Data gotten from this were used as a basis of validating competencies gotten from the literature. In the close ended questions, all the 22 competence items interviewed about recorded a 'yes' response as requirement for large scale projects. During the open-ended question section, most respondents highly ranked several competence areas which they said have contributed immensely to success in their management of large-scale construction projects. These competencies include Digitalization (which some respondents identified as Computer and IT), Cost management, Quality management, Time management and Communication, this resonates well with the ranking earlier calculated from literature therefore validating results from the qualitative approach. Transcripts of these interviews were analysed through content analysis. This match between two types of results is seen as an indication of conformance between findings.

Questionnaire survey

Reliability analysis using SPSS was conducted to test the reliability of questions in the questionnaire which had resulted in Cronbach α of 0.618 for all questions. This indicates that they would be able to measure the research's intended objectives (Gliem and Gliem, 2003; Tavakol and Dennick, 2011). A total of 100 questionnaires were distributed to indigenous construction Managers at selected construction sites in Lagos. A response rate of 65 per cent had been achieved through 65 collected and completed questionnaires.

Table 2. Summary of Respondents' Demographics

Test/Data		Result	Total
Crombach's Reliability Test		0.618	-
Accepted Responses		65	100
Percentage of Response		65%	
Academic Qualification of Respondents	Civil Engineering	30	65
	Building Construction	14	
	Project Management	21	

Years of Experience of Respondents	Below 10 years	17	65
	10-15 years	34	
	16-20 years	12	
	Above 20 years	2	
Gender of Respondents	Males	57	65
	Females	8	

The findings are presented in two groups based on the ranking of mean score of different variables. Competencies with mean score of 3.5 and above are presented in the table 4 to show the most significant of local construction managers' competencies. Also, competencies with mean score of less than 3.5 were presented in table 5 showing the least significant local construction managers' competencies.

Table 3. The 10 highest significant competencies possessed based on respondents' perception.

Competence	Mean	Rank	Competence	Mean	Rank
Procurement Management	4.14	1	Decision Management	3.85	6
Team Management	4.08	2	Logistics Management	3.77	7
Material Management	4.05	3	Leadership	3.77	8
Supply Management	4.03	4	Communication	3.62	9
Technical Knowledge	3.89	5	Labour Management	3.52	10

Table 4. The 10 least significant competencies possessed based on respondents' perception.

Competence	Mean	Rank	Competence	Mean	Rank
Digitalization	2.51	1	Plant and Equipment	2.83	6
Site Management	2.58	2	Health and Safety	2.86	7
Time Management	2.58	3	Cost Management	3.09	8
Contract Management	2.78	4	Quality Management	3.18	9
Risk Management	2.78	5	Client Management	3.23	10

DISCUSSION

Qualitative methods

Table 1 showed the list of required construction managers' competence for large scale construction. Digitalization, Cost Management, Quality Management, Communication, Team Motivation, Technical Knowledge, Material Management, Labour Management, Contract

Management and Time management were the three highest ranked competencies from qualitative analysis. This seems to be in line with the expectations from the construction managers in modern day and large-scale construction projects. Some of the elements require proper embedment of knowledge before the inclusion of skills and experience. Within the "required competency" cluster, Digitalization offer the convenience of day-to-day management efforts and facilitates multitasking nature of Construction Managers. From general computer applications like word processing to rather specific applications for construction such as Building Information Modelling (BIM), scheduling and Computer-Aided Design (CAD), Construction Managers are reckoned to have the adequate knowledge and skills. Also given that the selected contractors are bonded to the agreed contract between stakeholders, the administration of a particular contract throughout the construction phase is crucial Abdullah et al (2017). Regarding construction "Objectives", the common analogy of money, quality and time has now become commonplace since elements of economy and urgency have gained great concerns. Similarly, with safety and environment, sufficient knowledge regarding health and safety equipment and associated manuals and guidelines, and important concepts of environment are deemed paramount for the Construction Manager.

Given that a large proportion of contractor's works is executed onsite, competency regarding those elements is considered mandatory. Staff, materials, labour, and plant management competency are required. As a key representative of the main contractor, often, engagement through a proper contract with the client and their representatives is inevitable. By not just having adequate competency related to construction site management, broad knowledge on civil and structural, construction systems, mechanical and electrical, and quantity surveying which are encapsulated in technical knowledge are seen helpful to the construction manager.

Quantitative methods

Regarding the questionnaire survey, 65 responses (65 per cent of response rate) from various construction managers of construction sites were retrieved (Table 2). All of the respondents came from construction managers of building construction sites. 78% of respondents had over 10 years of experience. In general, all respondents have the appropriate eligibility to substantiate the findings. The combination of their academic qualification, positions, and experience were believed to have strongly given acceptable results.

Specifically, by referring to Table 3, ten items of possessed Construction Managers' competency have scored between 3.50 (above average) and 5.00 (very high). This list of competencies contains only five out of the ten top three highly ranked required competency. Highly ranked required competencies that are not found in possessed competence table (table 3) are: Digitalization, Cost management, Contract management, Quality management and Time management. Highly ranked required competency presents in table 3 include: Team management, Material management, Technical Knowledge, Communication and Labor Management.

Table 4 then shows items of competencies that score below 3.5 mean score which are interpreted as competencies poorly possessed.

CONCLUSION

A rigorous qualitative analysis process was considered adequate in identifying required competency of Construction Managers. The application of interview sessions involving international industry expatriates were reckoned to accentuate the findings from literature. Then, mass distribution of questionnaire surveys within the study area were paramount to obtaining first-hand data regarding the current status of local construction managers.

In summary, since sizes of contracts are largely determined by their cost and complexity, it is a hereby concluded from this research that large sizes of construction projects require dexterity of local construction managers who should possess a robust competence prowess. All competencies identified as required in the Table 1 must be adequately possessed. Meanwhile improvements are most significantly essential in these competence areas (in that order) namely: Digitalization, Cost management, Contract management, Quality management and Time management to meet up with the current demand for local construction Managers who can successfully execute large scale construction projects in Nigeria.

This study contributes to the body of knowledge as it showcases the various competence areas needed for large scale construction projects and then highlights the competence status of Nigerian local construction managers. However, despite the immense contribution the study brings, care must be taken in generalizing its findings as it is limited based on the sample size. The study was conducted in Lagos, hence further studies can be conducted in other states within the country, to compare results and source for information from a larger sample size. Further studies can be done to assess local construction organization's capacity for large scale construction projects since mere improvement in construction managers' competence, even though very important is not the only factor that will facilitate a better participation and performance of indigenous construction organizations in large scale construction projects.

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SUSTAINABILITY CONCERNS AFFECTING TRADITIONAL RURAL HOUSING IN KWA-ZULU NATAL AND EASTERN CAPE SOUTH AFRICA

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This paper looks at sustainability concerns affecting rural housing in the Kwa-Zulu Natal and Eastern Cape provinces of South Africa. These provinces stand out in the country, having the most traditional dwellings than any other province in the country. Using a mixed method approach, of administering this study to 'built environment' experienced people who are familiar with rural areas, and conducting interviews with local people living in traditional rural houses, the paper examines traditional rural housing sustainability with respect to the type of building materials commonly used, their accessibility and their durability over time. Results suggest that the types of building materials used in traditional rural housing are not sustainable, often built without following standards and regulations that enforce ecological observance. National Home Builders Registration Council (NHBRC) and Agrèment South Africa can be utilised to embrace indigenous knowledge and enhance traditional technologies through training initiatives for better construction techniques that could enhance traditional housing longevity. Collaboration between local communities and built environment students is recommended to harvest indigenous knowledge. This opens avenues of sharing basic sustainable techniques that provide mutually beneficial knowledge exchange.

Keywords: Building materials, construction, durability, recyclability, rural housing, sustainability, traditional housing

INTRODUCTION

In South Africa, people still live-in houses constructed from natural resources commonly known as roundel traditional housing. The total traditional dwellings for all provinces in South Africa are estimated at about 831 000 while Kwa-Zulu Natal and Eastern Cape together constitute about 710 000, 85 % of the total traditional dwellings in the country (Statistics South Africa, 2018). The houses in these provinces show deterioration. These provinces stand out in the country, having the most traditional dwellings than any other province in the country. The problem is that traditional houses built from available local materials usually require continuous maintenance which raise sustainability questions. The use of locally available materials is criticised by many to be a major driver of environmental degradation. The paper seeks to address the problems associated with the use of local materials considering durability and sustainability. The paper explores sustainability concerns affecting rural housing through three research objectives:

1) To examines traditional rural housing sustainability with respect to the type of building materials commonly used.

2) To evaluate quality considerations and accessibility of building materials used in traditional rural housing.

3) To assess durability conformance of rural housing to building regulations.

Rural housing sustainability is a concern as traditional rural housing is often built without following standards and regulations that enforce ecological observance.

Orumu and Yabefa (2018) are of the view that modern European architecture and imported building materials do impair youth from learning their old and tested building technologies causing homelessness due to the high cost of modern conventional building materials. National Home Builders Registration Council (NHBRC) and Agrèement South Africa can be utilised to embrace indigenous knowledge and enhance traditional technologies through training initiatives for better sustainability in the built environment is a high agenda because construction industry is one of the main contributors to environmental degradation and the depletion of natural resources. Construction activities are a major source of pollution and waste and buildings account for a large percentage of the world's energy consumption and construction can have major social and economic benefits for society (Darko et al., 2017). Sustainability in urban development and construction is often tackled by introducing new government regulations, although for cities in developed countries, change generated by new regulations is slow (Loosemore and Reid, 2019). Slow progress and rapid urbanisation in cities have led many local authorities to address sustainability in traditional rural communities. An interview-based study was used to explore durability, quality, materials, standards, and regulations in traditional rural housing.

LITERATURE REVIEW

The history of traditional rural houses indicate that people use natural resource materials without any knowledge and guidance of standards on how the materials should be used and techniques on how the materials can be tested for quality and durability. Extant literature suggest that sustainable construction implies use of highly innovative technologies that are in harmony with local ecology, geology, and climate (Ragheb et al. 2016). One would expect that traditional rural housing construction is sustainable in terms of the site, material and resource conservation, energy conservation, maintenance and building operation, occupant health and safety, water conservation, recycling, and waste management (Ndukaa, 2015; Dayaratne, 2018). However, it has become a challenge to define sustainability when looking at traditional housing that should meet our own needs without compromising the ability of future generations to meet their own needs (Neyestani, 2017). Emas, (2015) further emphasize that sustainability is about maintaining the ecological balance by avoiding the depletion of natural resources and preserving the environment for the future. Ragheb et al., (2016) find that natural resource materials are cost-effective and environmentally friendly when used in traditional housing and the materials are not costly to replace and are recyclable.

Ngowi (1997) vouches for traditional construction methods as they use natural resource making housing affordable for the people in the rural areas. There are some sustainability concerns in that the materials would need to be replaced regularly because they are low in durability. Amasuomo and Amasuomo (2016) recommend the aim is to improve durability of rural buildings and that will require appropriate technology to produce materials from the readily available raw materials to more durable materials. Though the houses built in the rural areas have existed throughout the years, they lack maintenance, and the neglect of structures shows that the structures would have been in a better condition if they had been properly maintained. Danja et al., (2017), states a few reasons why traditional housing is not sustainable, such as human neglect, high cost of maintenance, durability of materials, weather, and climate conditions. Poor quality of construction also contributes towards the buildings not being sustainable.

According to Gunnell (2009) durability is a concept that should enable the building to serve its intended lifespan, have the capacity to stand alone without technological assistance but with access to channels allowing upgrading and future technology. Durability relates to the building systems in terms of their component products and materials. Yost (2005), shares the same sentiments, stating that "If you double the life of a building, you halve the environmental negative impacts". Amasuomo and Amasuomo (2016) finds that thatch, mud, timber is not durable and deteriorate quickly, with a lifespan of between three and five years. Although the maintenance element in the durability of the building cannot be eliminated, the quality of the materials will determine the maintenance of the building (Akadiri et al., 2012). One needs to understand the type of materials required for the building at the design stage as some materials easily wear out.

Lstiburek (2004), recommends that everything should be done right in the design and construction phase for the house to last for a longer period of years. Lstiburek, (ibid) elaborates those durable buildings are determined by the correct knowledge and attention to detail during design, application of specifications and construction. Thus, durability is one of the cornerstones of sustainability addressed through design and construction. Construction in rural housing must maintain coherence between natural and the built environment from planning, design, construction, and the type of materials used into the life cycle of the building (Akadiri et al., 2012). There is need to minimize the consumption of natural resources and harmful emissions. There exists a gap in literature on the sustainability of traditional rural housing with respect to the type of building materials commonly used, building materials accessibility, durability over time and recyclability during renovations. Adegun and Adedeji (2017) concluded that using earthen construction materials for housing are generally cheaper, cleaner, and more thermally comfortable in Africa, but the level of use in house building is currently low where the earthen materials' strength and durability are key limitations.

METHODOLOGY

This paper used a qualitative approach to interview data. The target group for this research was the experienced built environment professionals who were familiar with traditional rural housing. The study considered both males and females within the built environment profession from the Department of Human Settlement, NHBRC and Agrèment South Africa including Architects and Engineers in the construction industry. Together with students who live in the rural villages, were considered to explore the issue of sustainability in rural housing.

Through the interview guide and photos of rural housing shown to interviewees a discussion on sustainability concerns of such housing was done. The interview guide was based on those characteristics previously identified from the literature, which could be used to explore housing sustainability in Kwa-Zulu Natal and Eastern Cape provinces of South Africa. These two provinces can be used as examples to provide a cross-section sustainability in South Africa.

The interview guide was piloted both with students from the University of the Witwatersrand in South Africa during the months of August and September 2020. The pilot provided a realistic assessment of the practical difficulties of the main interview, mainly in judging the time required for completing and administering the questionnaire. Purposefully selected participants totalled 170 in the two provinces. The total valid sample was 64 participants where 30 (46%) of them were built environment professionals, 19 (29%) were students, and 15 (23%) were locals living in traditional rural housing who participated in interviews.

Of these 64, only 10 were done face-to-face with local while 54 were done via WhatsApp calls and video calls. This also provided an opportunity to investigate the poor quality observed in some housing structures in the rural areas. The approach offered rich data like the one used by Nduka (2019).

DATA ANALYSIS

The recorded interviews were transcribed verbatim, and all transcriptions were red back to participants through WhatsApp online telephone platform for confirmation. These transcriptions were imported into NVivo Pro 2011 software, to identify prominent words and phrases, as well as key themes across these transcripts. All significant text was coded into nodes of interest to rural housing sustainability. Through NVivo software, nodes were clustered along three themes. These themes formed the final output of this paper study.

RESULTS AND DISCUSSION

The findings of the study are broadly grouped into three key themes that include (i) sustainability of building materials in tradition rural housing, (ii) quality considerations and choice of building materials used in tradition rural housing and, (iii) conformance to building regulations in rural housing

Sustainability of building materials in traditional rural housing

Results revealed that the frequently expended materials for rural housing are mud and thatch. Mud is utilised for flooring and building walls and thatch is used as a form of a roof structure of the building. The materials are usually sourced locally and are easily accessible in most cases. This choice of materials is believed to be driven by easy access of these materials in rural areas and the lower to no cost associated with sourcing them. Burford and Robertson (2021) encourage rural communities that are autarkic (self-sufficient) that respond to local landscape qualities, hybrid land-use, urban densities and local renewable energy production rather than mass housing that disturbs nature.

Quality and choice of building materials used

The materials used were found to be less durable often leading to maintenance challenges as often repairs are needed frequently. The findings further revealed that there are no known techniques that are utilised to assess the quality of materials used. This results in the inadequacy of quality of both construction materials and methods utilised in rural housing. Additionally, the insufficient skilled resource in rural areas intensifies the problem of poor quality. Darko et al., (2017) highlighted that construction activities are a major source of pollution and waste. Despite this, the use on natural and sustainable materials in the construction of rural housing is commended and further education and support may benefit the construction of sustainable housing in rural areas.

Conformance to building regulations in rural housing

Results revealed that experience and knowledge obtained from building similar structures in the past is the primary guidance used to gauge the standard of rural housing construction. Some respondents believed that standards and regulations were insignificant and were not in agreement that implementing regulations and standards would offer any enhancement to sustainable development of rural housing. This is in conformity with Loosemore and Reid (2019) who found that change generated by new government regulations is slow thereby curtailing sustainability.

CONCLUSION AND RECOMMENDATION

Construction of traditional houses in the recent years using natural resource materials has decreased and gradually the use of conventional materials was introduced to promote sustainability of rural housing developments.

There is lack of adherence to building standards for traditional house developments in rural areas. The cost of maintenance and non-durability of materials, poor quality materials and lack of guidance in design of houses are some reasons people move away from using natural resource materials for rural housing development.

It is recommended that standards and regulations should be introduced in the rural areas when planning for the development of buildings to address the problems of strength and durability. Using entities like NHBRC and Agrèment South Africa, that have systems in place to monitor the construction of houses, the monitoring of standards may be extended to rural areas. These entities can be utilised to embrace indigenous knowledge already being used to construct houses and enhance traditional technologies to better improve the housing structure. It is recommended that training initiatives from the industry, especially entities with systems in place introduce innovations of different assessment methods to be applied in rural housing areas for sustainable development as new construction techniques could enhance building longevity. Additionally, a form of in-service training or University student and community collaborations may be beneficial to local communities to offer improvement. These built environment students may aid in educating communities about basic construction planning, sustainable building methods and choice of durable materials among others.

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